U.S. DEPARTMENT OF COMMERCE • ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION APRIL 1969

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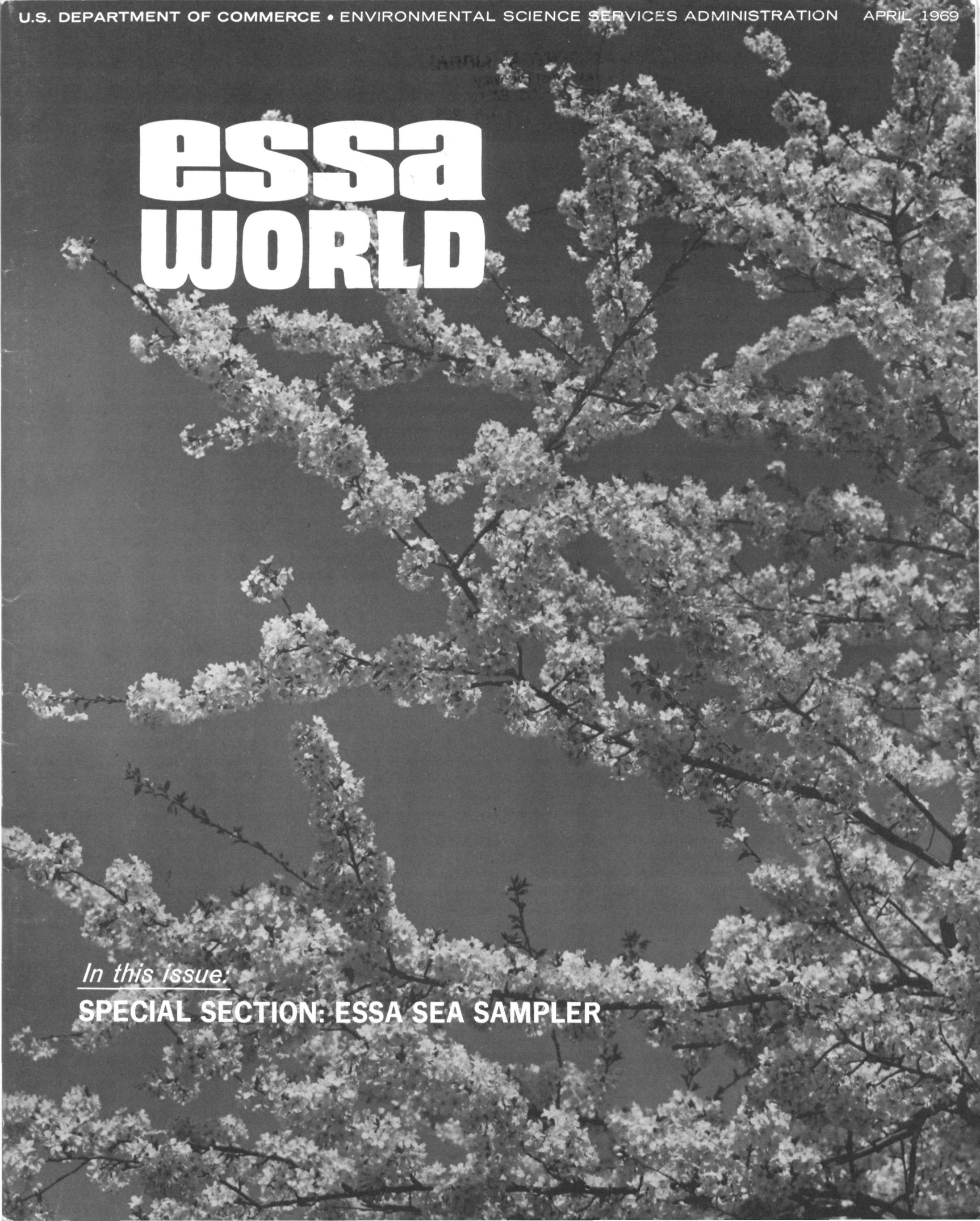

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National Oceanic and Atmospheric Administration

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essa WORLD

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U.S. DEPARTMENT OF COMMERCE, MAURICE H. STANS, Secretary
ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION, Dr. Robert M. White, Administrator
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"Blossom by blossom the spring begins."
—Swinburne

Photo by Harold M. Lambert

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DR. ROBERT M. WHITE
ADMINISTRATOR

A Message from the Administrator

The President's Commission on Marine Science, Engineering and Resources has issued its long-awaited report.* Commission members were drawn from all segments of marine effort in the Nation; I was privileged to serve as one of the three members chosen from the Government.

The report evaluates the present national effort in oceanography and related fields, and proposes a comprehensive program to achieve national goals in these fields. Its recommendations call for significant changes in the programs and management of our oceanic, atmospheric, and other geophysical activities. The growing importance of these activities to the Nation's welfare is forcefully pointed out.

If the Commission's proposals were adopted, it would create a national oceanic and atmospheric agency—reporting directly to the President—which would be responsible for the functions now discharged by ESSA as well as by certain agencies in other Federal departments.

The purpose of this new organization would be not only to give impetus and broad-gage management to the Nation's effort in these fields but also to inaugurate new and far-ranging programs. The organizational proposals have attracted much attention. They will undoubtedly be debated at length in the Congress and in the executive branch of the Government. Whether the organizational proposals of the Commission or other possible organizational proposals are eventually adopted, any changes will be neither immediate nor sudden, and I am convinced that we in ESSA will have every opportunity to present our views.

The program proposals of the Commission go to the heart of the things that we do in ESSA. They strongly support much more vigorous action in many of our program areas. Among their objectives are the development of a comprehensive national environmental monitoring and prediction system and associated research in the environmental processes; a greater effort in the mapping and charting of the oceans; a continuing and intensive investigation of the problems and potential of environmental modification; and a more vigorous effort to modernize our data centers.

While it is impossible to predict the impact of these proposals, the study is sure to bring many of the Nation's environmental problems into sharp focus, to generate thought and discussion, and to make the citizens of this country more aware of the Nation's needs in vital areas of the geophysical sciences. I urge everybody in ESSA to read this Report and to become familiar with its recommendations, for they bear directly on what we are doing and what we hope to do.

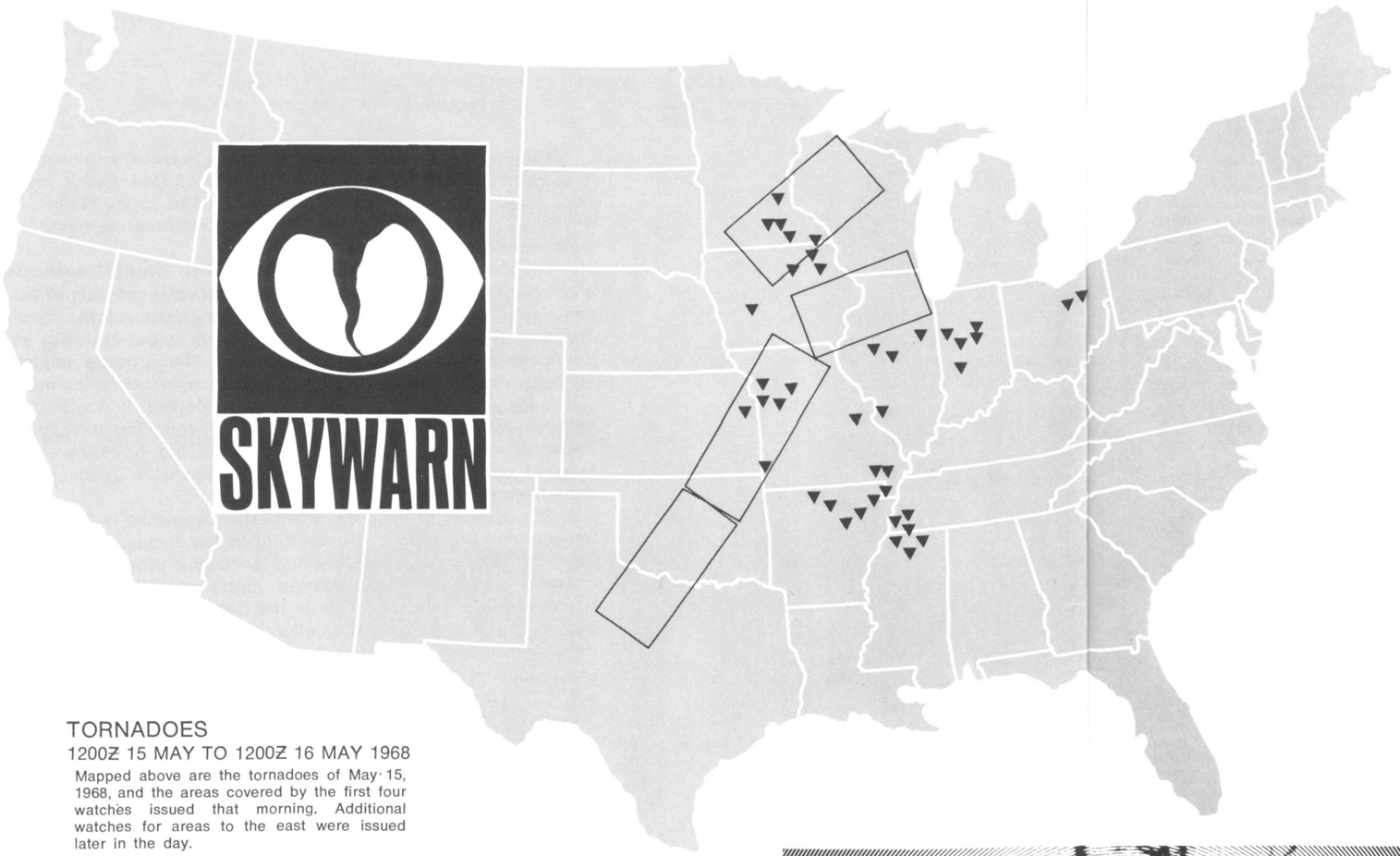
R M White

**A few copies of the report—"Our Nation and the Sea"—have been sent to major line components. It is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $2.75.*

Why SKYWARN? Because of lethal days like

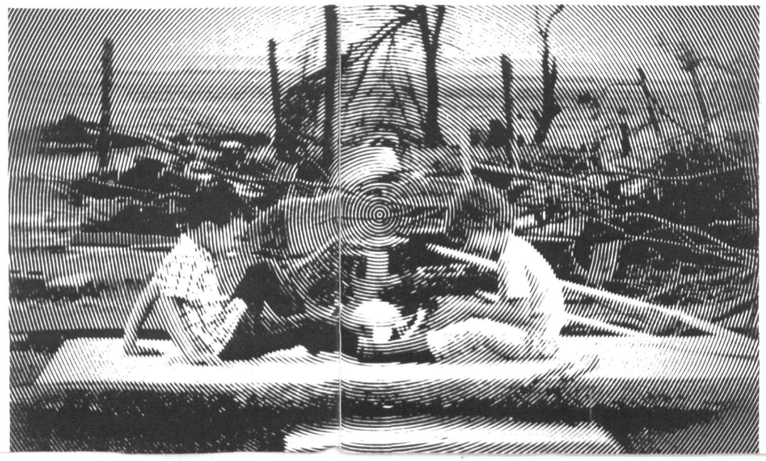
THE FIFTEENTH OF MAY

By ANN K. COOK



TORNADOES
1200Z 15 MAY TO 1200Z 16 MAY 1968

Mapped above are the tornadoes of May 15, 1968, and the areas covered by the first four watches issued that morning. Additional watches for areas to the east were issued later in the day.



Early in the morning of May 15, 1968, the forecaster entered Kansas City's stark new Federal Building to begin his day's work in the Weather Bureau's National Severe Storms Forecast Center.

As he rode the elevator to the 17th floor, he had no premonition that the day would be different from any other.

His job, as always, was to watch for weather developments that might foretell the development of severe thunderstorms and tornadoes. He—and the other forecasters on the same shift in this component of the Department of Commerce's Environmental Science Services Administration—were responsible for predicting the outbreak of tornadoes and severe storms anywhere in the continental United States.

Before this day was over, tornadoes were to dip from the skies over 12 states, killing more than 70 people and injuring upwards of one thousand.

Of all the storms in nature, the tornado packs the most concentrated violence. It is a swiftly rotating column of air dropping thousands of feet from a thunderstorm to rake the ground—trees, homes, vehicles—anything that lies in its path. A single storm system may produce many tornadoes, or none at all.

Tornadoes do their destructive work through the combined action of their strong rotary winds and the partial vacuum in the center of the vortex. As a tornado passes over a building, the winds twist and rip at the outside at the same time the abrupt pressure reduction in the tornado's "eye" causes explosive over-pressures inside the building. Walls collapse or topple outward, windows explode, and the debris of this destruction is driven through the air in a deadly barrage.

Like other meteorologists, the Kansas City severe storm forecasters know that tornadoes form when a certain combination of weather conditions exists—when adjacent layers of air have vastly different characteristics of temperature, moisture, density, and wind flow. But they do not know precisely what process occurs in some storms to cause tornado funnels to form and stretch their ominous swirling lengths toward earth. Or why it is that other, similar storms do not spawn twisters.

So the forecaster and his colleagues cannot say exactly when or where tornadoes will be born. But they can—by maintaining a constant alert for the menacing mixture of weather patterns—identify areas approximately 120 by 240 miles where conditions suggest a high probability of tornado formation.

When they identify such an area, the severe storm forecasters issue a tornado watch, the first alerting message to areas potentially threatened by tornadoes. Their message specifies the area covered by the watch and the period of time in which tornado probability will be high. The watch is transmitted from the National Severe Storms Forecast Center to local Weather Bureau offices, and from these offices, it reaches the public through radio and television stations.

A tornado *watch* does not indicate that tornadoes exist. It alerts the public and officials responsible for public safety that tornadoes are possible in a specified area during a specific time period. A tornado *warning*, on the other hand, means that a twister has actually formed and been reported.

On the morning of May 15, the Kansas City meteorologist's first step was to review the weather charts produced by the forecasters on the midnight shift. Their outlook for thunderstorm activity that afternoon and evening was for scattered severe storms in an area from northern Texas to Wisconsin, including parts of Oklahoma, Kansas, Nebraska, Missouri, Iowa, and Illinois.

Studying the profusion of weather maps covering the office walls, he noted that the chart of surface measurements, taken at 7 a.m. (Central Daylight Time) by weather stations across the nation, showed an area of low pressure centered in east central Nebraska. By evening, he calculated, the low should have moved to a position near Waterloo, Iowa. A warm front would be located southeast of Peoria, Illinois, and Evansville, Indiana.

Using the data on the 7 a.m. chart of surface weather conditions, the forecaster projected the 7 p.m. position of significant weather factors—pressure centers, cold and warm fronts, and instability lines, as well as a dry line—a surface or line separating parcels of air with vastly different moisture content. Such a line, also called a moisture discontinuity, increases the instability of the atmosphere and favors the formation of severe storms. By 7 p.m., he believed, the dry line would reach from Des Moines, Iowa, to Dallas, Texas.

This projection was his first approximation of the day's developments, a means of zeroing in on the problem areas. It would be adjusted as additional information—

continued

gathered by upper-air, radar, and surface instruments—poured into the Center. But it served to focus the forecaster's attention on certain threatened areas.

Since the processes that favor tornado formation occur, for the most part, far above the earth's surface, the severe storm forecasters rely heavily on data gathered in the upper air by balloon-borne instruments and on radar observations.

Twice each day, at 7 a.m. and 7 p.m. (CDT), about 70 weather stations on the United States mainland launch balloons carrying small instruments called radiosondes, which measure the vertical distribution of pressure, temperature, humidity, and winds up to about 100,000 feet. The 7 a.m. measurements are teletyped to the National Severe Storms Forecast Center, and swiftly analyzed by the Center's computer. But these upper-air sampling stations are spaced some 200 miles apart, and many significant weather developments may be occurring in the unmeasured gaps between. Then, too, the Center's forecasters will have to wait another 12 hours for new data—12 hours when most of the severe storm activity normally occurs.

Every hour, the Center's Radar Unit receives and plots data reported from weather radars throughout the nation. Weather radar information represents an important and valuable addition to the surface and upper-air measurements because it gives the meteorologist the ability to look electronically far beyond the visual horizon and to obtain vital information on hazardous weather. It is a continuous and almost instantaneous means of detecting precipitation within range of the set, and is the best method now available for identifying and tracking squall lines and other storms which might breed tornadoes.

As the day's data mounted, it reinforced the forecaster's conviction that the coming afternoon held a strong and widespread threat of severe weather from Texas northward to Minnesota and eastward to Arkansas and Illinois, the same area that had been outlined by the forecasters on the mid-shift.

His next step was to plot a composite chart of all the major weather elements which combine to produce severe weather. This composite weather chart showed that conditions would be critical over southern Missouri, Iowa, northern Illinois, northwestern Missouri, eastern Kansas, Oklahoma, and north central Texas in the early afternoon. And these conditions could be expected to move eastward during the afternoon and evening.

After further analysis to narrow down the areas where the threat was greatest, the Center staff determined that two tornado watches and one severe thunderstorm watch should be issued for the afternoon. Tornado watch was announced for a rectangle extending from south of Ottumwa, Iowa, to a point 20 miles north of Chicago, and for another from the Tulsa, Oklahoma, area to 20 miles from Kirksville, Missouri. This latter rectangle included Kansas City. The severe storm watch extended from Abilene, Texas, to 20 miles west of Tulsa.

These watches were issued from the National Severe Storms Forecast Center at 11:39 a.m. Central Daylight Time, through a special Weather Bureau communications link used only for radar reports and storm warning information, and through nationwide teletypewriter and facsimile circuits.

At 11:50 a.m., the first of many severe weather reports arrived at the Center. A funnel cloud was reported near Munday, Texas. Ten minutes later, tornadoes were reported near Goree, Texas. These reports later were found to be in error but, because of them and also because of the very unstable weather conditions existing over the area, the severe weather watch was changed at 12:22 p.m. to include tornadoes.

A surface chart based on 1:00 p.m. weather measurements aroused the forecaster's concern for a fourth area, where tornadoes appeared to be extremely likely. So, at 3:33 p.m., a tornado watch was issued for a rectangle extending from 60 miles west of Mason City, Iowa, to 40 miles north of Wausau, Wisconsin. As severe storm activity developed and moved eastward during the late afternoon and evening, additional watches were issued.

The first confirmed tornado of May 15, 1968, swooped down on Hickory Hills, Illinois, at 1:25 p.m. The devastation unleashed by these storm systems continued for more than 13 hours, ending only after a twister touched earth near Memphis, Tennessee, at 2:50 a.m. the next morning.

Altogether, the Center received 151 reports of severe weather that day, making it one of the most active on record. The reports detailed the occurrence of hail, high winds, funnel clouds, and tornadoes. The tornado reports came from such tranquil-sounding locations as Marble Rock, Iowa; Pleasant Hill, Missouri, and Mountain Home, Arkansas.

By next morning, the extent of the disaster was apparent. Arkansas was hardest hit, with 45 dead. Iowa was next with 18 fatalities, then Illinois with eight, and Missouri and Indiana with one death each.

Residents of Charles City, Iowa, heard a tornado warning broadcast by radio at 4:20 p.m. At 4:52, a funnel that had been tracked for 20 miles as it approached Charles City, struck the town leaving virtually total destruction in its path and 14 dead and 367 injured.

Within minutes a funnel was spotted approaching the Iowa town of Oelwein, following the main highway, uprooting trees and demolishing homes as it swirled forward. Two miles outside of town, a citizen spotted the funnel and called the local radio station, KOEL, which takes an active interest in providing weather information and warnings. The sighting was broadcast, and engineer Dean Meyers, on duty at the transmitter, made repeated visits outside to observe the approaching tornado. Each time, he returned to relay the information to the announcer on the air. With a cry, "God help us!" the station went off the air—its transmitter antenna blown down by the violent winds. The town's fire siren was sounded as a warning for two minutes, until it too was silenced by power failure.

The Oelwein tornado was exceptionally violent. A home eight blocks west of the tornado track was unroofed and its attached garage separated from the house by winds exceeding 100 miles per hour. From Oelwein, it moved eastward toward Maynard, six miles distant, where it struck shortly after 5 p.m. Three entire blocks in the town of Maynard were totally demolished, including a new church scheduled to be dedicated the following Sunday.

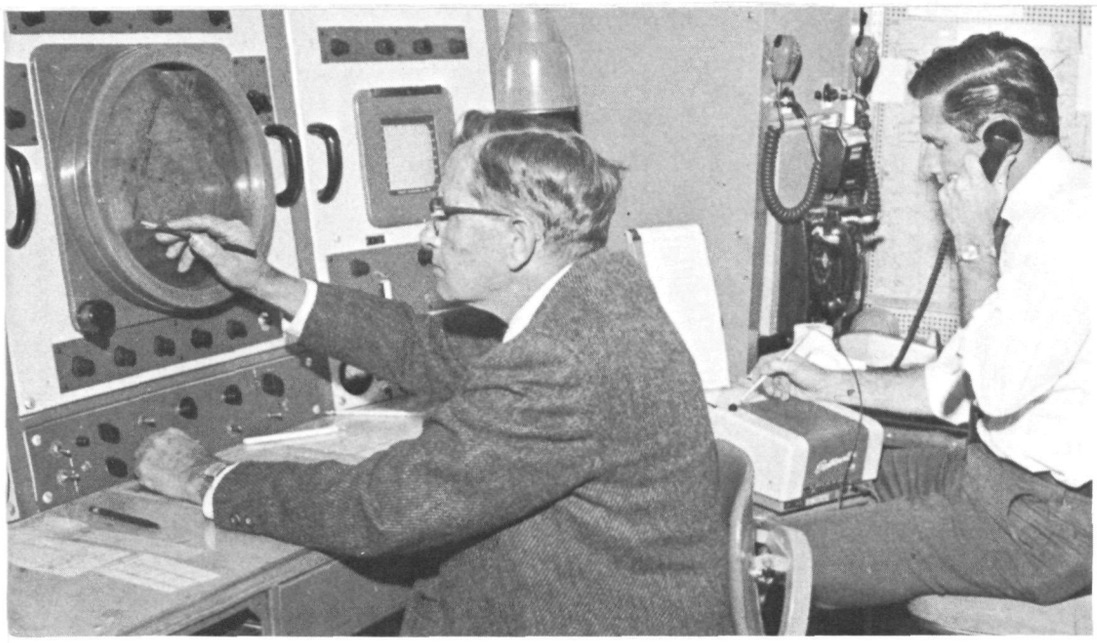
At 8:35 p.m., a funnel was sighted over Jefferson Barracks Bridge, some 35 miles west-southwest of Freeburg, Illinois. Thirty minutes later, the same funnel entered the town of Freeburg and passed through the entire length of the mile-long community. Four people died, forty-eight were injured, and property damage was estimated at one million dollars. Two of the dead and forty of the injured were in trailers. A tornado warning had been issued for the county at 7:45 p.m., and had been broadcast to civil defense units, fire departments, police departments, hospitals, and to the general public, more than 45 minutes before the twister struck the town.

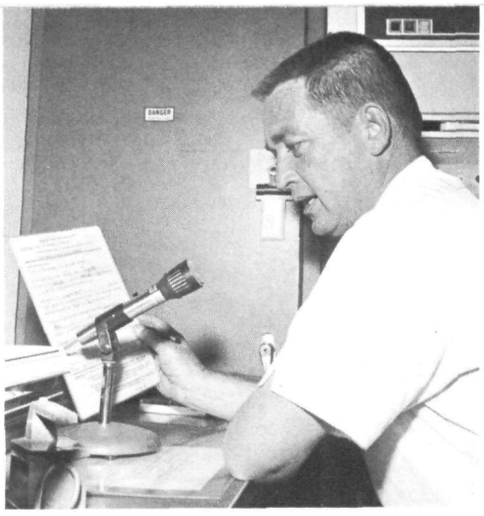
To the south, a squall line was spawning a series of killer tornadoes in Arkansas that evening. About 7 p.m., a tornado struck Mountain Home, leaving three dead and fifteen injured. At 8:36 p.m., another killed five and injured fifty-two people in Oil Trough. At 9:25, one death occurred when a funnel dipped into Tuckerman. At 9:52, a tornado swept into Jonesboro, Arkansas, from the west southwest, cutting a path of destruction from 200 to 400 yards wide and 10 miles long. This tornado caused 34 deaths, injured some 350 persons, and did major damage to residential and suburban business districts.

All of these tragedies occurred in or near areas for which the National Severe Storms Forecast Center had issued tornado watches, dramatic testimony to the need for the Weather Bureau's new SKYWARN program launched this year.

SKYWARN is the name given to the Bureau's intensified campaign to lower the death toll exacted by natural hazards from the atmosphere. During the five-year period from 1963 through 1967, tornado-caused deaths averaged 124 annually, injuries 2,019, and property damage $180 million. In some years, this toll is much higher. Although the property damage cannot be avoided, many of the deaths could be prevented if everyone were adequately prepared.

The greatest single hope for saving lives when a tornado strikes is preparedness—by national, state, and local government, by private organizations, schools, and hospitals,





(Left) Douglas Barclay traces radar echoes, while Donal Davis relays the information to warning centers. (Above) Allen Pearson, Center Director, broadcasts a tornado warning.

and, most important of all, by each member of the general public.

SKYWARN is an effort to save lives during tornado emergencies by expanding networks of volunteer spotters and by developing the widest possible participation in preparedness programs.

Tornadoes affect relatively small areas, but they strike faster and harder than any other natural storm. When a funnel billows toward the earth from a storm cloud, every second counts. Everyone involved in spreading warnings, everyone responsible for others' safety, every single individual should know, without hesitation, the appropriate action to take. Indecision, panic, and confusion cost lives.

The Weather Bureau issues tornado warnings only when a tornado has actually been sighted or its presence indicated by radar. The warning states where the tornado was discovered, its direction of movement, and the period of danger. When a tornado warning is issued, all people in the path of the storm should take immediate safety precautions.

At the present time, there is only one instrument—the human eye—which can positively identify a tornado. Most tornado sightings are made by private citizens or by volunteer storm reporters who serve as the Weather Bureau's "eyes" across large areas of the Nation. There are about 500 networks of tornado spotters composed of thousands of public-spirited citizens and organizations who report tornadoes to the Weather Bureau or to a designated warning center. Each report of a tornado sighting sets in motion a warning to communities in the path of the storm. One aspect of the SKYWARN program will be the recruitment of additional storm spotters where they are needed.

The second aspect of SKYWARN is the development of tornado preparedness plans at the state, county, and local levels. In addition to observer networks, community preparedness plans include the designation of 24-hour warning centers to receive and disseminate tornado watches, warnings, and reports. Schools, hospitals, factories, and other places where people congregate in large numbers also should have tornado preparedness plans.

Of the first two tornado watches issued on the morning of May 15, one included the area around Kansas City. Five tornadoes struck to the south and east of Kansas City; the death toll was one. The residents of this region are familiar with the tornado's menace and are prepared to act instantly when a warning is issued.

Working with the Weather Bureau's public service unit, the Kansas City area has established an excellent system for spotting tornadoes and communicating warning information throughout the region.

The Kansas City Weather Bureau office has warning responsibility for 38 counties in eastern Kansas and northwest Missouri. Spotted fairly evenly within this area are four 24-hour warning centers manned by police and fire departments or by other organizations which operate around the clock. Each center has radio contact with sheriffs and police in surrounding counties. Each also has established its own network of volunteer spotters who will call the center upon sighting a tornado.

When a tornado watch is issued for any or all of these counties, the Bureau immediately notifies the warning centers by two-way radio. Throughout the watch period, the Weather Bureau regularly provides the latest available information to the warning centers.

If a tornado is sighted and reported to one of the four centers, the center has the authority to issue a warning for its area. Otherwise, precious time would be lost in calling the Weather Bureau, which would then announce the warning.

Each spring, before the onset of the peak tornado season, Weather Bureau men from Kansas City meet with members of the four warning centers and their volunteer observers to review procedures and keep everyone informed.

In the metropolitan Kansas City area itself, 1000 tornado spotters report by radio to the local civil defense organization which provided the radio equipment.

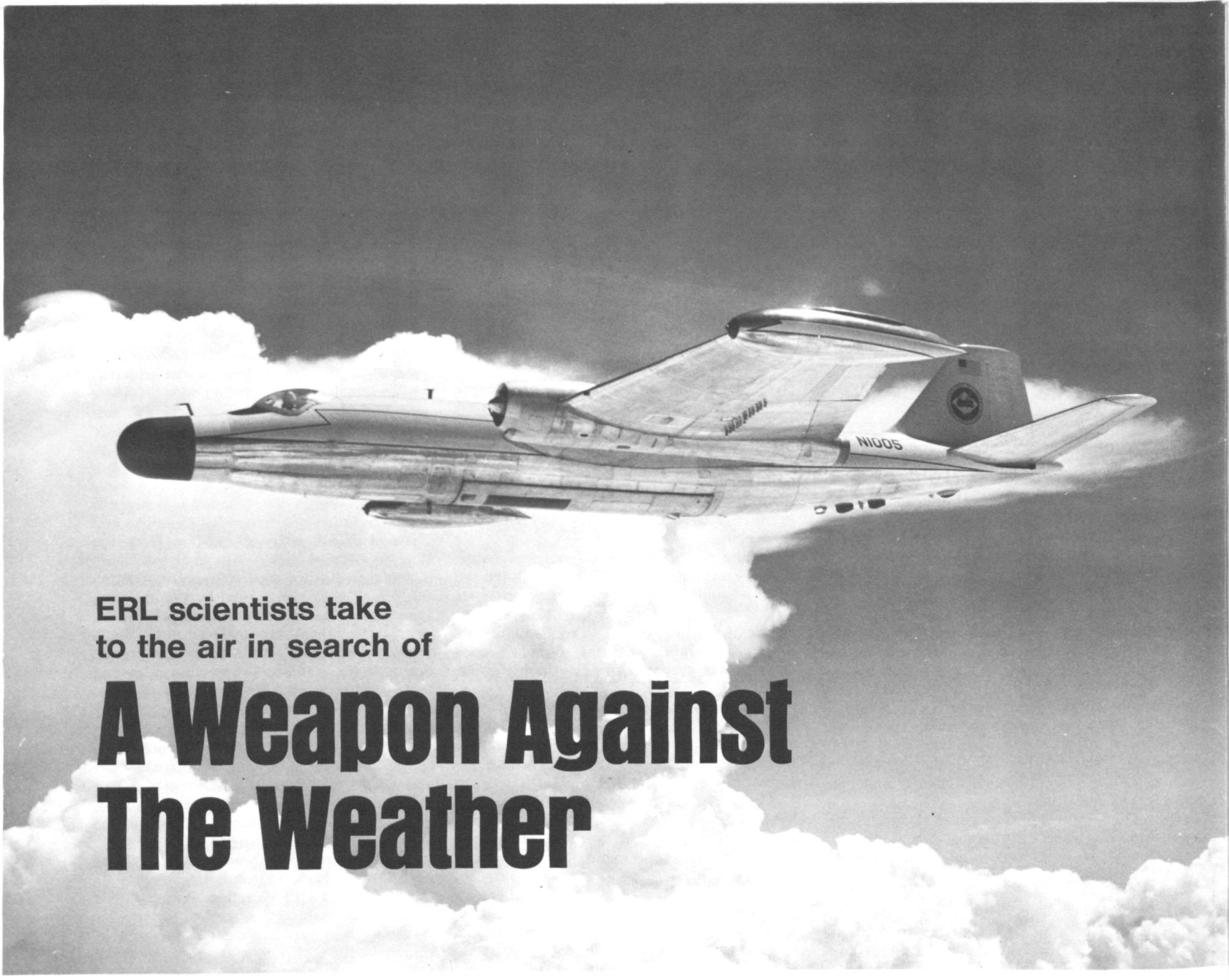
Each spotter in the system has a number which indicates the azimuth, direction, and distance of his assigned location from the Weather Bureau radar. All participants are given tornado location charts duplicating the actual work sheets used by Weather Bureau radar meteorologists to track severe storms. The charts are centered at the location of the Kansas City radar equipment, and give the distance in nautical miles and the direction in degrees from that point.

Thus, when a spotter reports a tornado sighting, the radar meteorologist quickly can pinpoint the location on his worksheet. The charts are also published by Kansas City and northwest Missouri newspapers so that individual citizens can refer to the charts when a warning is broadcast. They can see precisely where the tornado is, in relation to their own position. Many post the charts next to their radio or television sets.

The Kansas City Weather Bureau office also has a swift and effective method of spreading warnings throughout its area of responsibility. With a maximum of seven calls, the public service office can reach all 38 counties. In the city itself, one call will reach police, civil defense, and fire departments. The same call goes to Kansas City's KCMO radio station, which activates a signal in all schools, so that the schools will receive a direct voice broadcast from the Weather Bureau when a warning is issued.

Another special warning feature in Kansas City is its Tornado Emergency Warning Network. Through this network, the Weather Bureau is connected directly to 16 radio and television stations. With 60 seconds' warning, the stations will preempt all programming to broadcast a warning spoken by a forecaster from the Weather Bureau.

The Center's severe storm and tornado watches are growing more and more accurate with advancing technology and increasing knowledge. But their effectiveness in saving human lives depends on community and individual preparedness for the moment when the deadly funnel twists from the thundercloud and approaches earth with a roar. □



ERL scientists take to the air in search of

A Weapon Against The Weather

By JOANN TEMPLE, ESSA Research Laboratories

WHEN MAN sets out to modify the weather, he takes on the role of giant-killer. The vast energies in great storms are far past his puny powers of reproducing. In a single day of its life, for example, a hurricane can release enough energy to supply the United States' electrical needs for six months.

Virtually all scientific approaches to weather modification rely either on redistributing energy already available in nature, or on changing the timing of nature's own energy release. Relatively small changes in various storm structures can make large overall differences, and it is in this vital trigger-area that man can attempt to intervene.

This attempt has been made in recent experiments by two ESSA scientists.

Our global weather is driven by the atmosphere's heat engine. When atmospheric water vapor condenses into cloud and then aggregates into particles of precipitation, a tremendous amount of heat energy is released. When heat is released by condensation and freezing of water, the cloud grows and becomes more buoyant. In effect, this release of heat could be considered the throttle which drives the earth's engine.

Control of precipitation may imply control of heat release in the atmosphere, so most weather modification is aimed at this one vulnerable point—precipitation control. Changing the nature of precipitation is one of the few things we can actually attempt, and that only under limited circumstances. The character of precipitation in any region is the result of complex interactions between a large number of factors—physical, chemical, meteorological, geographical, topographical. These factors vary significantly in space and time. Effects range from submicron dimensions to a global scale, and substantial changes occur over time periods from milliseconds to centuries.

In theory, precipitation can be changed in several ways. For precipitation to form or condense inside a cloud, condensa-

tion or freezing nuclei must be present in the cloud. Natural nuclei come from a variety of sources such as sea salt, dust, smoke, and air pollution. The familiar term "cloud seeding" means adding artificial nuclei to the natural nuclei population in a cloud.

Clouds can be seeded with trillions of extra freezing nuclei to cause instability in what had been a colloidally stable cloud. This should then result in rain or precipitation that would not otherwise form and fall. Or, in the case of thin, layer-type clouds and fog, such seeding should totally dissipate them. Cloud seeding can be employed to lengthen or shorten the life cycle of individual clouds by encouraging them to grow to showering thunderheads or discouraging the formation of precipitation and inhibiting the cloud's growth. Seeding can also change the rate of conversion of cloud water to precipitation. This can be used to control the size of precipitation particles for such purposes as affecting the production of hail, for example.

In cumulus clouds, where isolated explosive growth can create severe thunderstorms or even tornadoes, competing convective systems in the vicinity can be helped to compete when cloud seeding gives the non-threatening clouds heat energy.

Cloud seeding and weather modification are not exact sciences. There are many difficulties in using the atmosphere as an experimental laboratory. Stratus clouds, which provide only a small fraction of the world's total precipitation, can be modeled remarkably well in the laboratory deep freeze. This is not true with the more important convective clouds. They cannot yet be reproduced satisfactorily in a laboratory. Experimental meteorology is further hampered by the inability to specify or control the initial conditions of any particular experiment. Researchers must simply accept the cloud systems and weather conditions which nature provides.

Attempts to change the clouds started in 1946 when Vincent Schaefer, then with General Electric, dropped dry ice into a supercooled stratocumulus deck and changed the seeded path into falling snow. A clear-cut case of successful weather modification? Yes, but with this first weather modification experiment came the bugaboo that has plagued scientists since: "Is the seeding effect real or would it have occurred naturally?"

In studying the cumulus cloud, scientists must contend with complex interactions between cloud microphysics and cloud dynamics. Within each of these areas are many unanswered questions and numerous variables. Adding interactions between the two further compounds the problem. A definite answer is possible with careful statistical controls incorporated in the experiment.

Since precipitation control may be the key to ultimate weather control, research continues with elaborate statistical analyses to help compensate for the uncertainties in atmospheric work. The ESSA Research Laboratories' Atmospheric Physics and Chemistry Laboratory, headed by Dr. Helmut K. Weickmann, conducted two cloud-seeding research projects last year. One was aimed at a study of seeding effects on individual tropical cumulus clouds, and the other was designed to study the possibilities of redistributing heavy snowfalls along the shores of our Great Lakes.

Seeding Florida Cumuli

Last May, scientists from APCL's Experimental Meteorology Branch and the U.S. Navy's Naval Research Laboratory joined forces in a seeding study. Dr. Joanne Simpson, director of EMB in Miami, Florida, directed the study of cumulus seeding over southern Florida in cooperation with Robert Ruskin of NRL.

Dr. Simpson explains: "A study of natural cumulus clouds is basic to and prerequisite for all seeding experiments. After nearly three decades of cumulus study, some general characteristics of natural cumuli are emerging. A cumulus cloud is born when small water droplets gather together at a concentration of about 100 million per cubic meter. Cloud droplet concentration is highest near the base of the cloud and the older the cloud, the more likely it will be to have frozen droplets or ice. The microstructure of cumuli varies with their geographical location, the season of the year, and the air mass in the cloud. These microstructure differences are presumably related to the availability of suitable nuclei—both condensation and freezing, the nature of the underlying surface, the availability of moisture, the intensity of the updraft, and cloud depth."

In 1965, STORMFURY studies resolved the 20-year-old problem of whether overseeding supercooled cumuli with silver iodide could promote cloud growth. STORMFURY is a joint ESSA/U.S. Navy project for basic research work in hurricanes. After the 1965 STORMFURY research, the problem was one of finding the minimum seeding rate necessary to produce cloud growth and the effect that such seeding has on precipitation.

In the multi-aircraft seeding research program over southern Florida, 19 clouds were studied on a randomized seeding basis. That is, 19 clouds were chosen as seeding candidates, but onlly 14 were actually seeded. Five were left in their natural state to serve as experimental controls for comparison with the seeded clouds.

William L. Woodley, of EMB, described this work before the American Meteorological Society meeting recently: "There was one obvious effect of seeding on Florida cumulus which needed no analysis. Seeding caused explosive cloud growth—both vertical and horizontal—of a magnitude never observed in any cloud-seeding experiment."

All but one of the seeded clouds grew to cumulonimbus or "thunderhead" stature, growing an average of 11,750 feet and reaching an average maximum height of 35,400 feet after seeding. The unseeded control clouds grew an average of only 1,600 feet, topping off at 26,300 feet.

Changes in rainfall from the seeded clouds were deduced by changes in echoes from long-range radar and compared with calculations made from the aircraft circling at cloud base after seeding. On this basis, the seeded clouds produced an average of 100 to 150 acre-feet more water than the controls within 40 minutes after seeding. This represents an increase in precipitation of 100 to 150 percent and, although the small number of clouds in the experiment makes statistical significance difficult, the results are promising.

The seeding research was restricted to three pre-selected areas over southern Florida. Two of these were over the Everglades extending into the Gulf of Mexico, and the third covered some 6,000 square miles of the Atlantic out toward Andros Island. These areas were chosen for the availability of free air space.

When a likely cloud was found in one of the three areas, it was surveyed by ESSA and Naval Research Laboratory (NRL) scientists aboard their various aircraft. A specially instrumented DC-6, operated by ESSA's Research Flight Facility (RFF), and a Constellation operated by NRL under the direction of Robert

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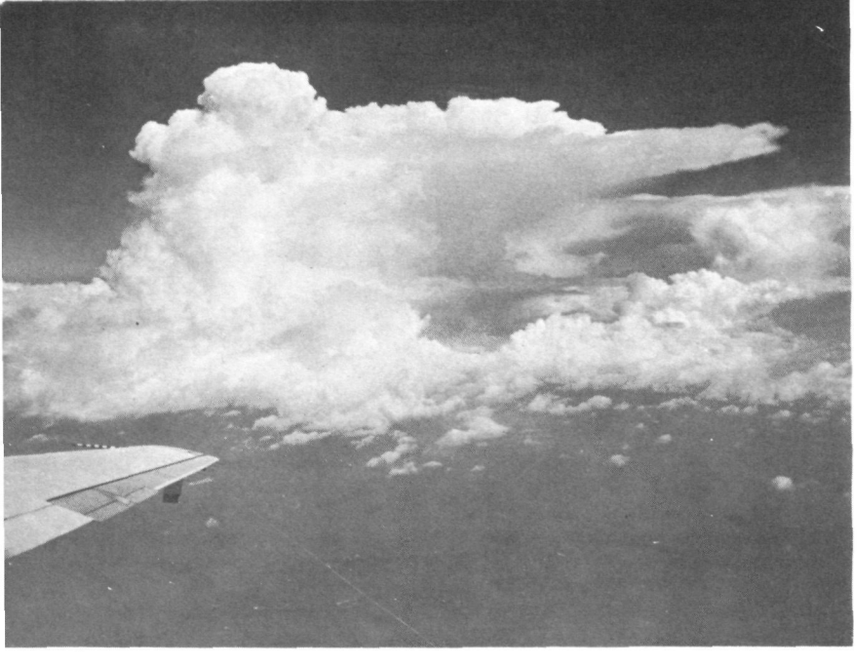

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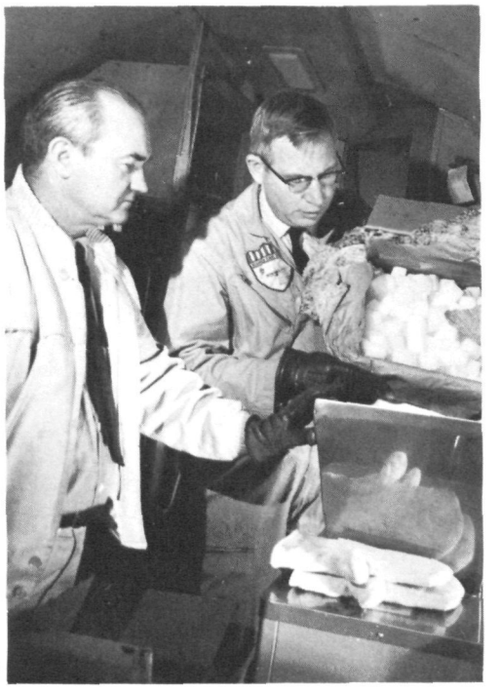

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In ESSA's Florida Cumulus Seeding Project, seeded clouds grew explosively. 1. Before seeding. 2. After seeding. 3. Byron B. Phillips (right) and John Kelly of the Atmospheric Physics and Chemistry Laboratory poured dry ice into the "hopper" atop the clouds during the Great Lakes Snow Redistribution Project. 4. Howard Mason, Jr., (left) is Director of the Research Flight Facility, and Dr. Joanne Simpson directs the Florida Cumulus Seeding Project. 5. Keeping track of one experimental cloud in a cloud-filled sky can be a complex task—especially with four aircraft studying the same cloud at the same time. Here, William S. Callahan, RFF navigator, coordinates the research aircraft and assists the University of Miami in vectoring its ground-based radar onto the right cloud. 6. In the Great Lakes project, remote temperature sensing by means of infrared equipment allowed airborne scientists to take the temperatures of surrounding clouds, lake surface, or the ground below. Using the equipment aboard an ESSA RFF plane are Dr. Helmut K. Weickmann (left) and Dr. Peter M. Kuhn. 7. A solid cloud deck over Lake Erie's shores was seeded on December 3. The broad trough of fuzzy precipitating cloud beneath the aircraft's wing was created by the seeding. The bright spots also are a seeding effect—glaciation in the seeded section of the cloud reflects sunlight in this manner.

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Ruskin, made scientific measurements inside the cloud. Meantime, a Navy S2D surveyed the bottom of the cloud, and a U.S. Air Force C-130 made meteorological measurements with dropsondes from 30,000 feet. These drops, being restricted to overwater areas, were made at the closest possible point to the experimental cloud.

To qualify for further study, the cloud top had to be located between 19,000 and 26,000 feet in altitude and had to be supercooled. That is, the cloud had to contain water below the freezing point which had not yet turned to ice. Nineteen such clouds were found, and 14 of them were seeded with silver-iodide flares dropped from the ESSA/RFF B-57 jet aircraft. As the flares burn and fall through the cloud, they leave a trail of silver-iodide smoke particles which act as freezing nuclei.

The five clouds left untouched to serve as controls were chosen by a randomization scheme to eliminate human bias. After receiving airborne instructions to seed a specific cloud, the meteorologist aboard the B-57 opened an envelope which gave him his first instruction to seed or not seed. Despite the randomized envelope instruction, the B-57 aircraft performed its seeding pattern run, and the project scientists studied the cloud after the seeding runs without knowing whether the seeding flares had actually been dropped.

Post-seeding studies of the experimental clouds included further "fly-throughs" by the research aircraft and extensive photography of the clouds' growth and behavior. In addition, two fixed, calibrated radars at the University of Miami probed and recorded the radar echoes from the clouds. This radar facility measured rainfall rate from the clouds with a special radar method and yielded quantitative rain measurements for both the seeded clouds and the other cumulus around them.

Cloud rainfall derived from radar reflectivities was part of the ESSA project, because meteorologists wanted to improve their mathematical model of what happens to a cumulus cloud after seeding. This process of "modeling," common to all scientific fields where the scientists attempt to "synthesize" a physical situation with mathematical equations, is most important to meteorology where experimental results can never be repeated under exactly the same atmospheric conditions.

Dr. Simpson says: "We have a whole zoo of models. With data from the 1968 project, we hope to design a new model which will account correctly for the effects of seeding. Each correct modeling step brings us that much closer to understanding and predicting the physics and structure of cumulus clouds. And, of course, once we have done that, we will have taken a long step toward modifying severe storms."

Great Lakes Snow

APCL's second project in 1968 involved a totally different seeding concept. Concentrating on the eastern and southern shores of Lake Erie in late fall, APCL scientists seeded cloud lines to study the feasibility of inhibiting the massive snowfalls that traditionally fall in these regions. Dr. Helmut K. Weickmann, director of APCL and project director, says: "About half of the shore cities' snow burden is a result of a relatively local meteorological phenomenon called the 'lake effect.' This phenomenon may create as much as 100 inches of snow a year."

Typical lake-effect snowstorms form in late fall and early winter when intensely cold air flows over the still-unfrozen waters of the Great Lakes, picking up heat and moisture from the water and producing bands of precipitating clouds along the downwind shores. Such meteorological conditions may exist for several days, and snow accumulations can exceed three feet a day.

APCL's contractors and co-participants in this year's project—Cornell Aeronautical Laboratories, State University of New York at Albany, State University of New York at Fredonia, Pennsylvania State University, and the Desert Research Institute, Reno, Nevada—had made extensive observations of lake-effect storms in past years.

These studies indicated that, in their developing stage, the clouds consist primarily of supercooled liquid water. Ice crystals that form naturally in the cloud tops can then grow rapidly as they fall through the supercooled cloud, because there is so much liquid available to them. The growth process is called riming, and the heavy snowfalls from the lake-effect storms are characterized by heavily rimed ice crystals, large aggregates of crystals, and graupel or snow pellets. Winds do not carry such heavy forms of snow very far, and consequently almost all of the snow falls out in deep accumulations very near the lake shore.

The APCL experiment was aimed at introducing sufficient artificial nuclei into the clouds so that all the supercooled droplets would be changed into small ice crystals. Thus, the water necessary to form heavily rimed crystals would no longer be available. The resulting smaller snowflakes and crystals would then fall more slowly and be blown farther inland.

In short, APCL's research was aimed at studying the feasibility of redistributing heavy snowfalls more thinly over a wider region. The project was envisioned as a broad step toward understanding and possibly modifying lake-effect storms. Such storms are not limited to the Great Lakes regions. Similar phenomena occur over the Sea of Japan, the Adriatic Sea, and the Gulf Stream.

The actual experiment lasted five weeks, ending on December 14. Some 60 scientists, meteorologists, radar specialists, and aircraft crew members participated in the experiment. They used an RFF four-engine DC-6, two twin-engine aircraft, three weather radars, and many ground observing and collecting sites.

Fifteen flights were conducted, of which thirteen were seeding missions using silver iodide or dry ice. Considerable scientific information was obtained, but Dr. Weickmann says further lake-effect snowstorms need to be studied for a total appraisal of the influence of cloud seeding on such storms.

Tests of the basic seeding hypothesis were made during three periods of short-lived cold air outbreaks which were accompanied by light natural snowfall. Seeding effects on clouds were observed from aircraft, on radar, or on the ground. A thorough analysis of all data collected will be made to reveal the response of the cloud to the treatment.

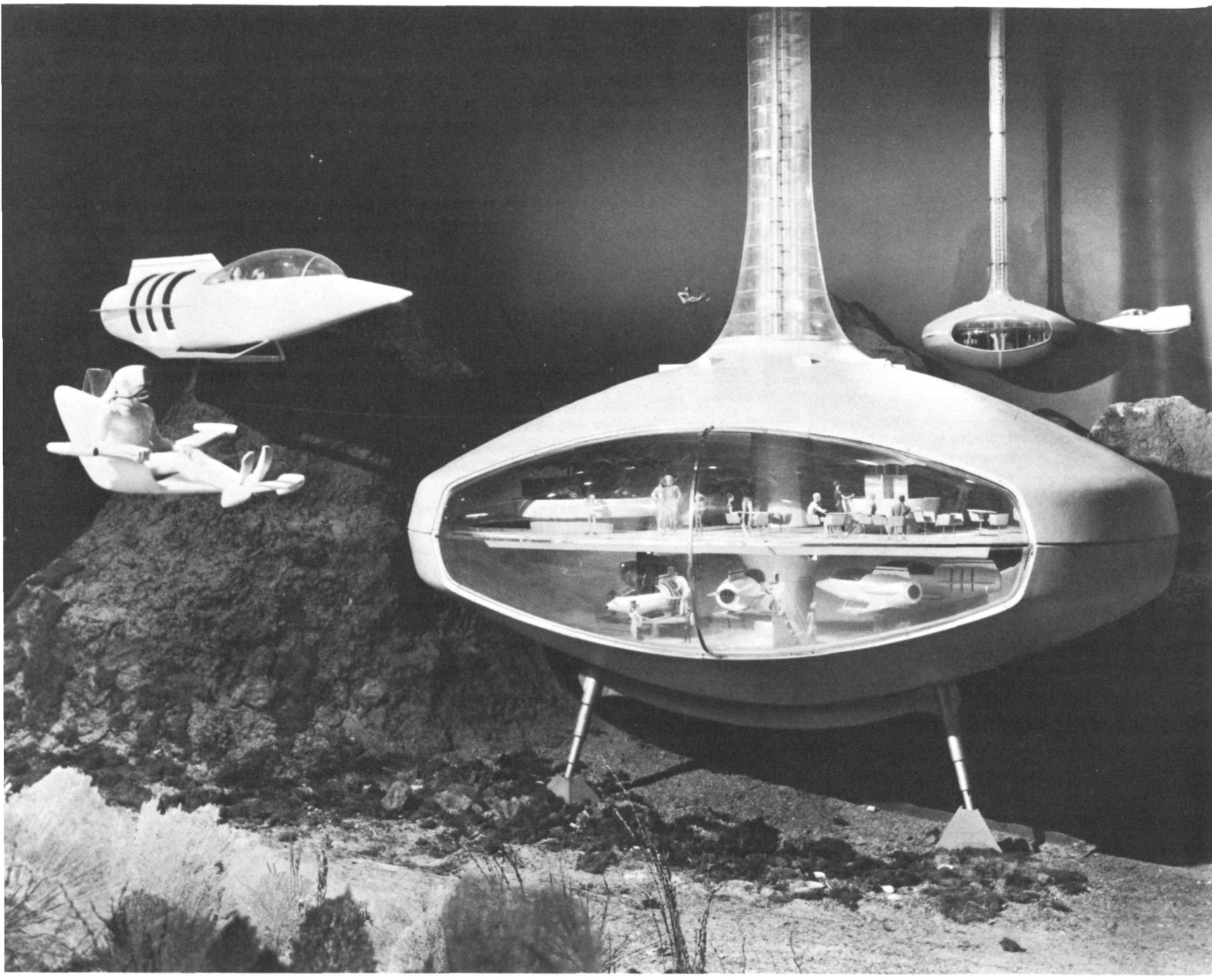
Other cloud-seeding experiments were performed to collect pertinent supporting scientific data. On six days, seeding experiments lasting up to 30 minutes were carried out on non-precipitating cloud decks. It was established that substantial snow and rain showers could be released either by dry ice or silver iodide, if the cloud deck were thicker than 5,000 feet. Data was obtained on the drift of a seeded area with the wind, to determine whether effects of treatment can be "targeted" over stationary ground instrumentation. Other studies showed that natural turbulence effectively distributes the seeding material throughout the thickness of the cloud.

These two major projects—the ESSA Florida Cumulus Seeding 1968 and the Great Lakes Snow Redistribution—are part of ERL's major research responsibility in weather modification. This work is conducted on many fronts besides the "glamorous" airborne experiments. Modeling, mathematical work, laboratory studies, and detailed observations of natural weather phenomena are all part of ERL's weather modification work—work which someday may give mankind an effective weapon against the capriciousness of the weather. □

SPECIAL SECTION: ESSA SEA SAMPLER

With underwater ballets and a wreck for a view, tomorrow's undersea hotel will be

A GREAT PLACE TO VISIT



BY HARRIS B. STEWART, JR.
Director, Atlantic Oceanographic Laboratories

Probably an early use of the manned habitat idea will be in the construction of an undersea hotel. A model of an underwater hotel was featured in General Motors Futurama at the 1964 World's Fair.

OVER the next 50 years, probably the greatest wave of public interest in the oceans will be generated by the exploits of scientists and engineers who as "aquanauts" will actually live and work at great depths in the sea.

Exotic equipment for remote sensing of the environment and gleaming white research ships are of limited interest to the general public, but somehow the imagination is captured by the idea of men rigged out in underwater "space suits," living in isolated underwater "space stations," with their physical responses and even their daily routines monitored back on land.

The analogy with man's activities in outer space is intentional. Although the unmanned space probes are fascinating scientifically and technically,* they hardly are competitive with the manned space flights when it comes to attracting the public interest. There is a tremendous personal excitement and vicarious involvement in following the exploits of the pioneers—be they pioneers in outer space or in the so-called "inner space" of the world ocean.

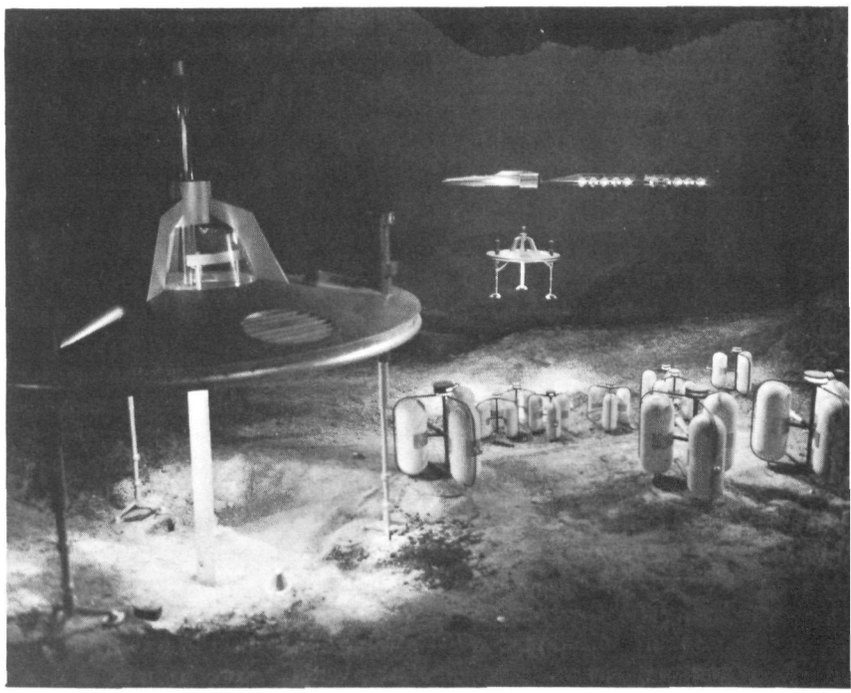
Projects are even now on the drawing boards that would bring tears of joy to the eyes of Jules Verne. The University of Miami, working with several major industrial firms, has developed a plan for a manned habitat at 1000 feet, off the southeast coast of Florida. Unlike the Navy's SEALAB experiments, this one—called Project ATLANTIS—will not use an "umbilical cord" to the surface, but will have its own power and life support system as an integral part of the habitat itself. Scientists and engineers will commute to ATLANTIS in small manned submersibles that will mate to the habitat structure far below the sea surface, and the men will move dry from one to the other. By the time ATLANTIS is fully operational, we will have passed the point where man is concerned primarily with his own reactions and physiology in this alien environment, and the men of ATLANTIS can concentrate on research and engineering projects in and around their undersea "space station."

Recent work on the use of mixed gases for underwater breathing is opening up new ocean depths to the individual diver. Breathing the normal atmospheric mixture of about 79 percent nitrogen and 21 percent oxygen, divers are subject to a nitrogen narcosis called "rapture of the deep" or "the martini effect" at depths ranging from 60 to 200 feet, depending on individual tolerances.

Attempts have been made to substitute helium for the more narcotic nitrogen in the breathing mixture, but recent work by diving physiologists from the Wrightsville Marine Biomedical Laboratory in North Carolina indicates that, even using this mixture, they experience tremors and intermittent uncon-

continued

** This article is excerpted from a chapter in "The Challenge of Science and Technology in The World of Tomorrow," a book to be published this year by John Wiley & Sons, A. B. Brownell, editor. It may not be reprinted without permission of the publisher.*



There are many reasons for man to visit the underwater world. (Top) Undersea mining and oil drilling may become a big business on our continental shelves. (Below) Pleasure divers will still enjoy exploring the flora and fauna of the sea.

sciousness at depths of just over 1000 feet. Switching from man to monkeys, they discovered that the monkeys went through similar reactions at about the same simulated depths, and that at pressure depths of 1600 to 1900 feet all monkeys tested went into convulsions. Changing the breathing mixture to 98 percent hydrogen and 2 percent oxygen for three other monkeys, they found that these animals showed no ill effects at pressures equal to those at depths of 2100 feet of water. Perhaps there is a human "pressure barrier" at about 1000 feet that will make this the practical limit for diving except in pressurized suits or special environmental capsules that protect the diver from the surrounding pressure.

Other recent work has shown that animals can, in fact, take oxygen directly from a highly oxygen-saturated liquid while totally submerged and with the lungs filled with the surrounding liquid. In effect, the lungs operate as gills. Once removed from the liquid, the lungs are drained and normal air breathing resumes. Someday, grafted gills or artificial gills may be possible for divers, but at present the requirement for a very large area of water-membrane interface in such gills would make them too big for the diver to carry around comfortably.

Although these possibilities are exciting to contemplate and even more so to work on, we need not look for a mass migration of air-breathing, land-loving, generally claustrophobic man into the dark, cold, inhospitable world of the sea. Exciting though the prospects may be, we just prefer to live in the sunlight, to walk on the grass, to live all bunched up in busy cities or all spread out across our mountains and prairies. In brief, the ocean is a nice place to visit, but nobody wants to live there. Even with the horrendous projections of crowding on land in the years ahead, man will build his living spaces up into the air and out over the surface of the water before he moves as a civilization into the sea.

There are, however, many reasons for him to visit the underwater world for varying lengths of time, even though he might not want to move his family there on a permanent basis. Probably oil well completions and routine wellhead production maintenance will be accomplished by engineers and technicians living for periods of weeks in undersea habitats. When—and if—undersea mining becomes a big business on our continental shelves, certainly much use will be made of man himself operating beneath the sea. Mass undersea fishing techniques will probably utilize divers, and undersea defense bases could well be built out on the edge of the shelf to be manned by rotating teams of military personnel.

However, the first routine use of such habitats will probably be for the marine scientist and ocean engineer. Even now, they want a facility from which they can monitor the subsea environment to see how the animal population varies with time and as a function of natural variations in the environment. They want to watch the mechanism of sediment transport under varying wave and current conditions. They want to monitor changes in underwater visibility and sound transmission as the content of suspended material varies. The engineers want to watch the slow corrosion and biological fouling of various kinds of material placed on the seafloor. They want to see how long it takes to scour out around the legs of bottom-mounted structures and how this actually is acomplished. They want to watch marine life in the intriguing food web of the sea. (Actually, "food web" is a much more accurate term than the more popular "food chain," for the relationship of food to eater is anything but the straight line implied by the "chain" analogy.)

A seafloor facility of this sort could be of great assistance in testing new undersea equipment and would prevent gear getting into production that worked beautifully on the bench, even seemed to work on test lowerings from a ship, but in general use at sea just failed completely. If man is to understand the delightfully complex environment of the ocean, he can make giant strides in that direction by going there himself and observing and measuring when and where the action is—in the sea itself.

Probably an early use of the manned habitat idea will be in the construction of an undersea hotel. The technical capability is presently available for such a venture, and all that is required is someone with a good deal of money to spend on something exciting without particular concern for any return on his investment. Perhaps in the long run the venture would be profitable, but the initial cost would be so high that—even with a continuously full occupancy at as barbaric prices as the market could stand—it would be some time before the construction costs could be amortized to the extent that a profit was realized. And by then it would probably be time for a shutdown for expensive repairs or modifications. It is, however, an interesting concept to speculate on, and it may very possibly be done in the very near future—and profits be hanged.

The guests to our first undersea hotel would probably reach it by way of a small cart on rails, much like the Senate Subway in Washington. The tunnel would be lighted and attractively painted inside as it descends at a low angle through the inshore area, where it should be buried beneath the sediment to avoid the scouring and filling that take place in the near-shore areas. The tunnel would emerge onto the floor of the ocean at a depth of about 50 feet, and the tunnel material should become transparent and the tunnel diameter greatly enlarged at a distance of some 100 feet before the hotel lobby is reached. In this way, the visitor will have his first impressive view of the hotel in its watery environment before the cart deposits him and his luggage in the lobby. Both the dining room and the cocktail lounge would have at least one entire wall of glass or other transparent material. Here one could sit for hours watching the world of the sea.

Suitable locations for the hotel might best be in areas of good visibility and with interesting flora and fauna. A coral reef environment would be ideal. A "wreck" could be added to the "landscape," especially interesting fish could be chummed to the area with food, and a lock-in, lock-out room would allow the more adventurous guest to don his SCUBA gear and go for an evening swim among the corals. Underwater ballets could be performed outside the dining room window with even the most inept ballerina able to top Nijinsky's record for the number of entrechats, for the density of the water imparts a graceful slowness to all her vertical movements that is totally unknown on land. Underwater floodlights would illuminate the area at night and would attract more fish. Large bubble windows in each room would allow the visitor an unobstructed view of the sea, and summer students could be hired to keep the outside of the windows free of algae and sediment.

If the venture flopped as a hotel, it could always be used as an underwater research facility for a coalition of universities. It will take engineers and architects with boldness and vision, but the underwater hotel is indeed a challenge. □

ESSA Profile

Where does the Coast Survey fit in the oceanography explosion? Its director takes

A Look Toward Tomorrow

The young ensign was thrilled. He had been given a launch with five men aboard and directed to conduct survey operations along the coast. It was his first command.

That was almost three decades ago. Today, looking back, Rear Admiral Don A. Jones, Director of the Coast and Geodetic Survey, still recalls the episode with nostalgia.

"I was very proud when I took out a launch for the first time," he said. He was a junior officer aboard a major hydrographic survey ship, and being given command of a launch was something he would never forget.

But that was 1940 and, while the Director is still proud of the Coast Survey's achievements during its 162 years of existence, he is quick to point out that "the future will demand much more of us than the past, and that is as it should be."

"We face a veritable explosion in oceanography," he said, "and the Environmental Science Services Administration, as one of the government's foremost civilian agencies in this field, will undoubtedly play a major role, and so will we, as an important component of ESSA."

He spoke of the things he would like to see done. "There is a great need," he stated, "for a more accurate determination of sea boundaries, such as those of the territorial sea, the states, the contiguous zone, the continental shelf's treaty limits, plus state and international boundaries."

"To do this," Adm. Jones explained, "the base line (mean low water line) along our entire coast would have to be determined very accurately. Performing the surveys required to assist the determination of these boundaries on the sea bottom is one of the most important activities in which we could engage and one which we haven't been able to accomplish to any great extent so far."

continued

BY RAYMOND WILCOVE
Coast and Geodetic Survey

He would also like to examine further the feasibility of using submersibles to promote the Coast Survey's objectives. "If submersibles have developed, or can develop, the necessary capabilities, we could possibly employ them to make better bathymetric maps of the sea bottom, for tidal and current work, for gravity, magnetics, and other geophysical determinations at sea."

Admiral Jones noted that a ship now under construction for the Coast Survey, the USC&GSS RESEARCHER, is designed in anticipation of the possible future use of undersea vehicles. The vessel is being built in Toledo, Ohio, and is slated for completion this year.

The Coast Survey chief pointed out also that the agency now amasses a tremendous amount of data concerning the ocean which should play an increasingly meaningful role as the national oceanographic program reaches new proportions.

Admiral Jones said Coast Survey emphasis in the future should also be directed toward extending "our basic nautical charting to greater depths."

"This is becoming necessary because of the increase in the draft and size of surface craft, notably oil tankers, and the expanded activities of commercial and oceanographic submersibles," he said.

"Underwater navigational hazards in the deeper waters ought to be noted on our charts. Basic surveys in our coastal waters do not extend sufficiently far out and with sufficient density of soundings to take care of these deeper-draft vessels."

He stressed the great need also in the marine environment for "real-time, 24-hour-a-day, accurate and economical systems for positioning vessels at sea."

"We need it primarily," he said, "to do our work with the accuracies required in the future. But all who work in the marine environment need better positioning control."

"If we had such a system," the Director continued, "we would not have to establish marine geodetic markers at the bottom of the sea, one of the methods now being discussed to provide accurate positioning at sea."

Admiral Jones, sixteenth Director of the Coast and Geodetic Survey, examines a nautical chart—just one of the agency's many products.

Surveying from the Arctic to Africa. (From the top) Jones aroused the curiosity of the Ethiopian highlanders; Alaska's Arctic coast was lonelier.

Admiral Jones sees a need also in the future for expanding the Coast Survey's responsibilities in furnishing "sea platforms" to support the activities of ESSA's research laboratories. Conversely, he added, research laboratory developments will "pass on to the Coast Survey more products and services arising from their activities, which it will be up to us to put to use." As the Director noted, "the Coast Survey is essentially a service organization and it is our job to pass on to the public the fruits of the labor of ESSA's research laboratories."

A further step which would enhance the Coast Survey's ability to carry out its responsibilities, said Admiral Jones, would be to equip ESSA's oceanographic survey vessels "with a total oceanographic capability to help ESSA carry through with its concept of the total environment."

"Our ships should be equipped so that they can fully participate in ESSA's study of the earth, sea, and air interactions which are so vital to our understanding of the weather," he said. "Our foremost oceanographic vessels, the USC&GSS OCEANOGRAPHER and DISCOVERER, are not now equipped to enable them to carry out the more advanced programs in which ESSA will be participating in the future. Our ships need more sophisticated equipment for future missions."

In 1962, he won the Commerce Gold Medal for his work on the Ethiopian geodetic control project. Secretary Luther Hodges presented the award.

Reminiscing about his early days in the Coast Survey, the Director recalled that while at college he was encouraged to join by a former Coast Survey officer, Professor C. M. Cade of Michigan State University.

"I'd always had an interest in surveying and engineering," he explained. "At college, Professor Cade encouraged me to seek employment with the Coast Survey, regaling me with stories about his service in the agency. So I did, working initially as a civilian in the Washington office." In 1940, he was commssioned an ensign in the Coast Survey.

Admiral Jones said the commissioned corps, which became part of the Environmental Science Services Administration in 1965, offered him the opportunity he sought.

"It enabled me to pursue the many varied activities that go with working for a scientific organization like this," he stated, "activities on shore, at sea, and throughout the world.

"It provided security, which was especially important in the 1930's, and still is. I had no desire to make a million dollars. I just wanted a good life and enough to provide for my family.

"The Coast Survey also offered a professional challenge. The opportunities for assuming responsibilities early in a career are very great, more so comparably than in private industry and many other federal agencies. It is a common thing for a junior officer to be detailed to an assignment that requires him to assume responsibility and show what he can do."

Admiral Jones said the considerations that induced him to join the Coast Survey in 1933 are still as valid as they were then, with one exception: ESSA is a bigger organization, with greater tasks and responsibilities. Since this is so, the commissioned corps is sure to expand, and this expansion will bring with it greater opportunities for advancement.

"Finally," said the Director, "there is the opportunity of serving your country in peacetime as well as in war and the satisfying feeling that you're playing a part, small though it may be, in serving the greatest government on earth."

Admiral Jones said there would undoubtedly be changes in the commissioned corps, now in its 52nd year. "One of them," he predicted with a smile, "would be the commissioning of qualified women as officers."

"There's a place for women in the commissioned corps," he stated, "and the commissioned corps is going to have to recognize that this is bound to happen sooner or later."

The Director said women have already been employed on C&GS field parties as observers, light keepers, and computers "and worked out very well."

Admiral Jones pointed out also that ESSA's new ships, including the OCEANOGRAPHER, DISCOVERER, and the RESEARCHER, are designed to accommodate women scientists and certainly could accommodate women commissioned officers.

"The products and services of this old-line agency are essential to the public welfare and economy," said Admiral Jones. "The Coast Survey is unique because of its long history of activities in these services. I believe that this is recognized in the federal government and the Coast Survey will therefore continue to have these responsibilities."

Admiral Jones, who became Director of the Coast Survey last September 1 after serving as Associate Administrator of ESSA, said he felt "greatly honored" in being selected for the post.

"Sam Rayburn, when he was Speaker of the House, was often urged to run for President," the Director recalled. "To the urgings of his friends, he would always reply, 'To me, being Speaker is the greatest job in the world; I have no desire to be President.' "

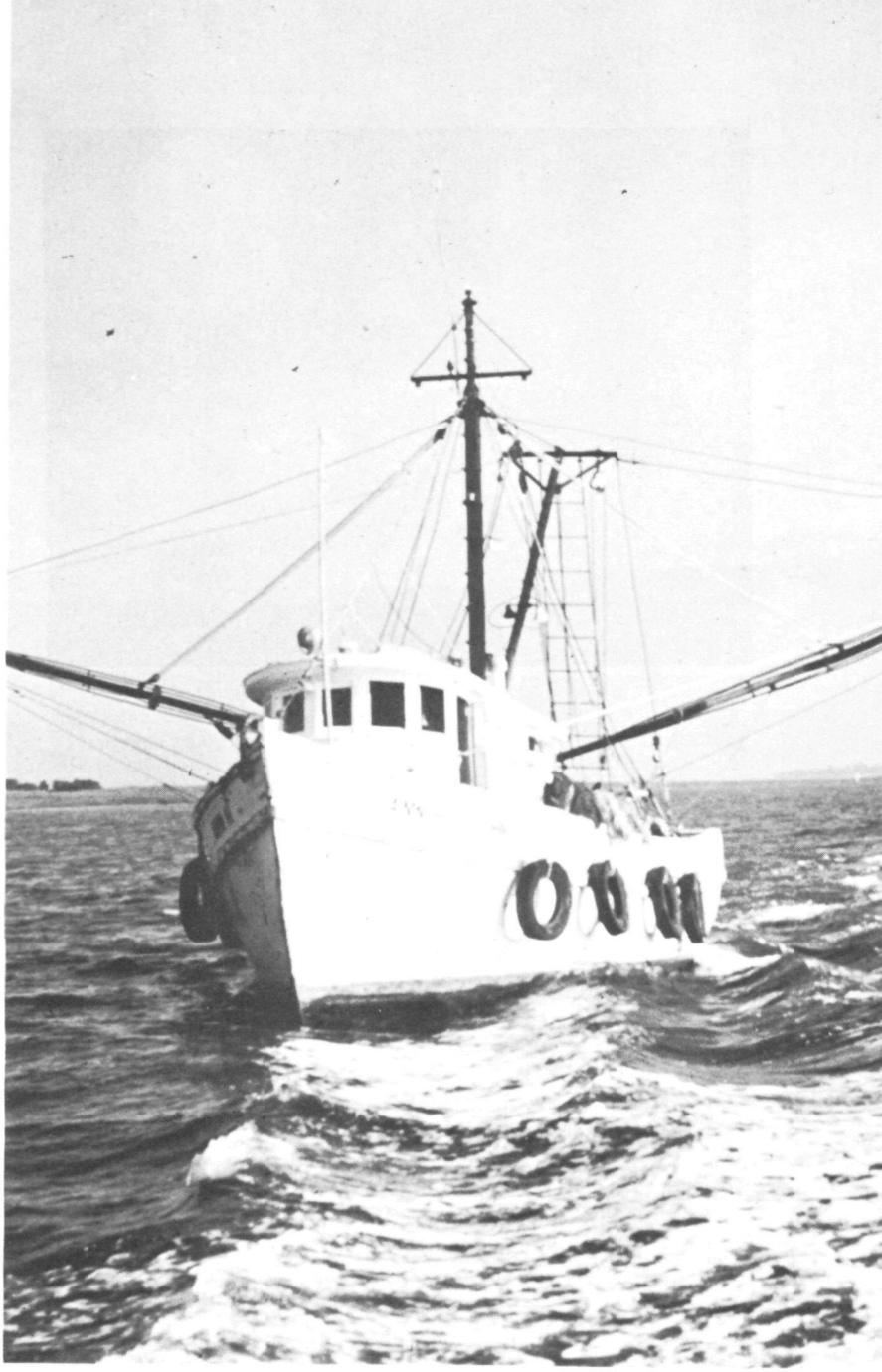
He laughed. "No one," he said, "has urged me to run for President. But if I may paraphrase Mr. Rayburn, being Director of this great organization is a fulfillment of my life's ambition.

"I shall do everything in my power to better the organization and improve not only its products and services, but also its working conditions and the *esprit de corps* of the 2400 men and women who make it what it is today.

"We have in the Coast Survey extremely talented and capable people, leaders in their fields and experts in their specialties. The contribution they make to their country is not always recognized, but I want them to know that I recognize the importance of their work and applaud their contributions to our organization. I shall do my best to merit their confidence in the years ahead." □

Admiral Jones became C&GS Director in Sept. 1968. (L. to r.) Adm. Jones, Guy Dorsey, and Dr. Robert M. White.

Ever listen to Radio ESSA? No rock, no pop, just something thousands need



Instant Weather

BY CHARLES THOMAS
Weather Bureau

A radio station that plays records all day with no commercial interruptions is bound to be popular with the public, so it's no surprise that listener response to the 19 Weather Bureau-operated VHF-FM radio stations has been enthusiastic.

The records, of course, aren't soul, pop, or even classical; they're tape-recorded packages of weather information, forecasts and, when necessary, warnings.

The stations are on the air day and night, year round *, beaming continuous weather

** The weather radio station at Chicago is an exception. It transmits from 6 a.m. to 10 p.m., May through October only.*

Photo courtesy of Louis A. Michael

shows to boatmen, and also to farmers, construction planners—everyone who needs to know what the weather is and what it's going to be.

These transmissions—produced, directed, and announced by Weather Bureau personnel—are packed with information.

Routine programs, repeated every four to six minutes and frequently updated, may include climatological observations, marine conditions (at coastal stations), river stages (at inland stations), and general area weather forecasts and weather summaries.

Special weather-related messages may be aired to meet area needs.

In San Francisco, travelers' warnings of heavy snows in the Sierras may give a vacationer second thoughts about a planned trip east.

In St. Louis, freight-barge operators who ply the Mississippi listen carefully to the river-stage observations and forecasts which so greatly affect their shipping operations.

In Honolulu, listeners can hear a well-modulated woman's voice with a charming trace of an island accent giving surf conditions for wave riders.

The information and forecasts transmitted from these stations are undoubtedly a great convenience to listeners. A Florida radio station records a portion of the VHF transmission from Tampa and replays it as part of its news shows. A Coast Guard Auxiliary station located in a large New York marina was constantly asked for weather information by boatmen. It installed an FM receiver, and now the boatmen get their information directly from the Weather Bureau.

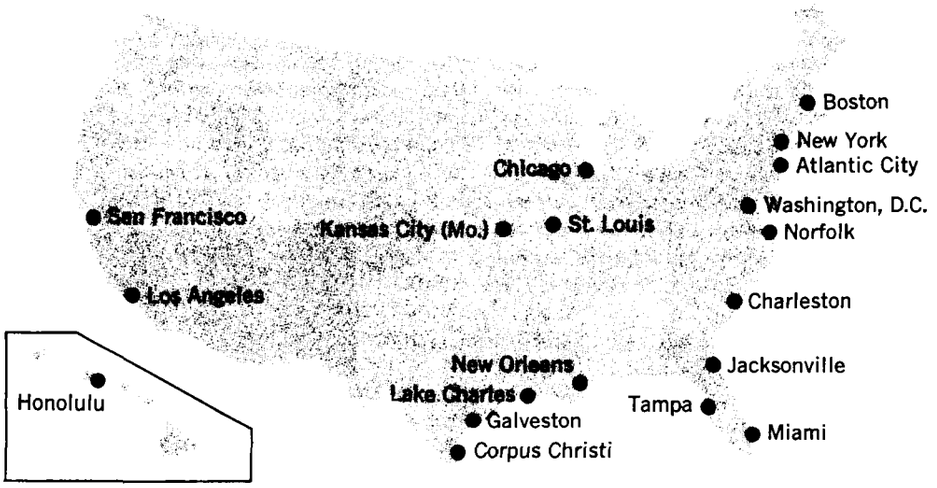
The fact that tomorrow may be a good day for boating or the surf's "getting up," however, is strictly fair-weather operation for the Weather Bureau. The most important function of these weather radio stations is *warning*—the life-saving link between ESSA and the public during emergency situations.

Each station is part of the nationwide Natural Disaster Warning (NADWARN) system. When severe weather develops, or any other hazards of nature threaten, routine transmissions are interrupted and messages are devoted exclusively to emergency warning operations.

But, before you start twirling your radio dial to learn whether that dark-looking cloud to the west is bringing snow, there are a few facts you should understand about these weather radio stations.

The initials VHF-FM stand for Very High Frequency and Frequency Modulation. Without going into technical details, this means that a special receiver is required to pick up these broadcasts. The weather radio frequency is very high indeed. All transmissions are broadcast on 162.55 megahertz.

ESSA VHF Weather Radio Stations



The very high frequency of weather radio transmissions isn't much of a problem for the average listener, though. Radio sets capable of receiving in this range can be bought for just under $20. In many areas fire, police, and taxi radio messages also liven up the 150-175 megahertz band.

The freedom from static and faithful reproduction of sound that characterizes FM broadcasting is gained at the expense of range. The transmissions are "line-of-sight" (not further than the horizon) and usually can be received within a radius up to 40 miles from the transmitting antenna. Reception distances vary, depending on terrain features, antenna height, and receiver quality. At Los Angeles and San Francisco, for example, where the antennas are on mountain tops, broadcasts have been received at distances of more than 100 miles over the ocean and along the coastline.

Studies are underway to find a way to patch the Weather Bureau's transmissions "live" through Coast Guard transmitters several times a day. In Hawaii, this extends the reception range out to a thousand miles from Honolulu.

It all started nearly 20 years ago in New York with the Weather Bureau's age-old problem—overloaded telephone lines and overworked pilot briefers. The solution was the forerunner of today's radio weather service.

In the fall of 1950, New York went on the air after distributing a number of VHF radio receivers to some of the small airports around the metropolitan area. The taped transmissions were geared strictly for aviation. Some minor problems developed—in the early days of television some sets were not precisely aligned and viewers sometimes found they were getting weather information along the air route to Buffalo mixed in with their favorite show—but, all in all, the program was a success.

In 1960, the Federal Aviation Administration took over the "show" and moved it down into its own assigned frequencies. (Then as now the Weather Bureau operated on 162.55 megahertz.)

The Weather Bureau retrieved the receivers it had installed at the small airports, reissued them to a number of local marinas, and began broadcasting marine observations and forecasts for the New York City area.

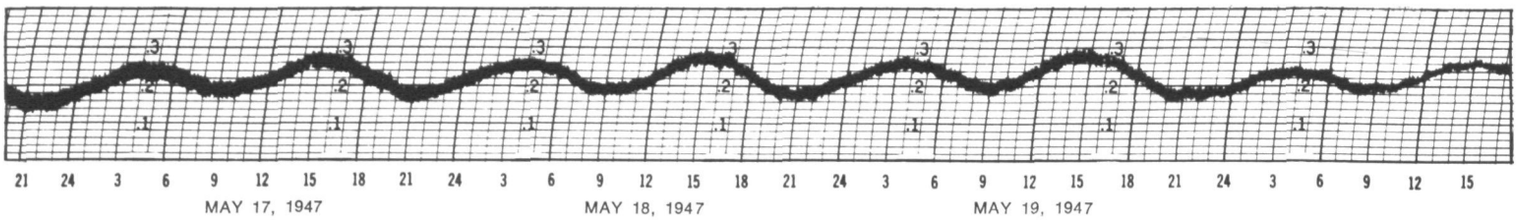
It's hard to say what the future holds for VHF weather radio, but its potential seems unlimited. New stations will be commissioned as funds become available, and eventually stations will be centered in all heavily populated areas.

Already engineers are at work developing and testing mechanical refinements to the program.

A radio signal controlled by the Weather Bureau office can turn up the volume on all specially equipped receivers in range of the transmitter, giving a positive alert to schools, news media, hospitals, and emergency forces when hazardous weather begins to develop.

A device is available that converts a television set to a radio weather receiver (using an unassigned channel for the broadcast).

VHF weather radio has come a long way from the days it competed with Howdy Doody. Twenty years from now you may never be far from instant weather reports —any time—anywhere. □



THE WEATHER LOG OF THE KON-TIKI

(Top) *Kon-Tiki* hoisted the tricolor as she approached Polynesia at the end of her voyage. (Center) A section of the barograph trace taken on the raft. The breadth of the line was caused by the swing of the instrument's pen with the waves. (Below) *Kon-Tiki's* crew members were (l. to r.) Knut Haugland, Bengt Danielsson, Thor Heyerdahl, Erik Hesselberg, Torstein Raaby, and Herman Watzinger. (Photos from *Kon-Tiki* by Thor Heyerdahl. Copyright 1950 by Thor Heyerdahl. Published in the United States by Rand McNally & Company.)

BY WILLIAM T. HODGE
National Weather Records Center
Environmental Data Service

It takes all kinds of knowledge to understand the ways of weather and of oceans. Surely one of the most unusual collections of knowledge was gathered by six men bobbing for 4,000 miles on a raft over the surface of the Pacific. Their adventure of some 20 years ago is now regarded as one of the classics of the sea.

The stark facts rest in a file of well-thumbed pencil and ballpoint reports in the Environmental Data Service's National Weather Records Center in Asheville, North Carolina. Behind these reports lies the story of how Dr. Thor Heyerdahl, a Norwegian anthropologist, staked his life on his theories in the face of scoffing by a few eminent scientists and explorers.

The purpose of Heyerdahl's voyage was to prove that the Polynesian Islands might have been populated by immigrants who drifted from South America—rather than from Asia as commonly assumed. Heyerdahl noticed similarities in the legends, traditions, sculpture, and physical characteristics of South American and Pacific natives and attributed them to a common ancestry. But the distances between are so vast that some authorities thought it impossible for non-seafaring natives to have traversed it. Although the early South Americans had no boats, they are known to have used rafts for fishing. It seemed out of the question for a slow-moving raft to travel so far, but Heyerdahl considered the ocean currents and thought otherwise. He decided to make the trip himself to prove that it could be done.

Weathermen had a fair notion of the average mid-ocean conditions in the South Pacific, but needed to learn much more. Ships passed infrequently through this area off the shipping lanes. Their measurements were taken from the comparatively secure height of the ship's bridge, perhaps 40 feet above the waves. How different would the same weather appear from a platform at the ocean's surface? What features would seem important if your survival depended on the elements? A raft trip could answer some vital questions and, with this in mind, the Weather Bureau supplied instruments, forms, and instructions for observing.

Outfitting the expedition drained Heyerdahl's resources. He and the five others who had volunteered for the voyage had many difficulties to solve in a short time. Their raft was to be like those shown in ancient drawings; otherwise nothing would be proved. No metal was permitted. Huge balsa logs had to be found from cutover forests and floated to Callao, Peru, where the trip was to begin. Nine logs were lashed together to form the base. A woven bamboo cabin was designed to be folded during the worst storms. An A-frame mast held the mainsail. Steering was accomplished by a long sweep plank rudder.

Christened Kon-Tiki, after the Inca sun god, it was a primitive, almost comical, raft. The logs strained against the ropes with every wave, yet they were expected to hold together for months. Some seamen predicted that the ropes would saw the soft balsa logs in two. Other prophets of gloom said that the ropes would not last two weeks, and that the balsa would absorb water and sink. Whatever happened, there could be no turning back, for the raft would be carried by the currents and the trade winds. Steering could achieve only minor deviations.

Heyerdahl's momentous voyage began on a propitious date—158 years to the day after Captain Bligh began his famous voyage in a small boat after the mutiny on H.M.S. Bounty. Few weather observations were taken during the first days; all hands were occupied keeping the raft in line with the wind. By trial and error, the crew learned sailing techniques forgotten hundreds of years ago.

Generally the raft rode the waves as smoothly as could be expected, but with higher seas the waves came foaming over the stern. Now the raft had a clear advantage over a boat. The water guttered between the logs and, instead of being swamped, the craft was ready for the next breaker.

Radio messages did not get through from the Kon-Tiki for the first three weeks; thereafter, amateur radio operators punctually relayed her weather messages to Washington twice a day. Dr. Francis W. Reichelderfer, Weather Bureau Chief, sent greetings by shortwave radio, with thanks for the data being collected. Later, when the coded radio messages were checked against the manuscript observations, the lack of garbling during transmission was remarkable considering the adverse conditions.

Kon-Tiki drifted northwestward from the cold Humboldt Current into the milder South Equatorial Current which first parallels the Equator, then sweeps southwest. The weather was squally at times, and there were occasional crises during storms. The Weather Bureau's instructions for weather observing could not be carried out in all circumstances and had to be modified.

The wind instruments showed speeds somewhat lower than estimates obtained from the appearance of the sea. Wave heights could be measured accurately simply by climbing the masts and noting the distances from crest to trough. The barograph pen swung up and down with each wave, giving a fuzzy-appearing trace that varied in size with the roughness of the seas. After three months, the barograph clock mechanism began to rust and slow down, but did not stop.

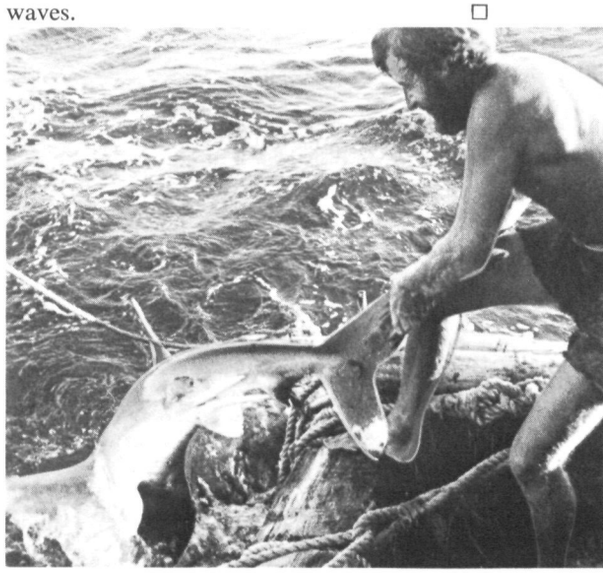
When weather is reduced to numbers, something is lost. Codes may interest the meteorologist, but only the original narrative conveys a vivid description of the environmental elements in this empty expanse of the South Pacific. Becalmed seas under a glaring sun changed to towering brine that almost reached the low scudding clouds. Starry tropic nights were interspersed with flashes of lightning. And the men did not see a single ship after leaving the coastal traffic.

Though the balsa logs became waterlogged in the outer inches, sap slowed the penetration and they continued to float, covered with barnacles and trailing long tentacles of seaweed. The ropes creaked and groaned with every wave, but ate into the wood and remained intact.

Tahiti was the goal, and the winds and current were on course until Raroia Atoll appeared dead ahead. Unable to steer around it. Heyerdahl and his companions could only turn the raft to let its stern take the first crashes on the jagged reef.

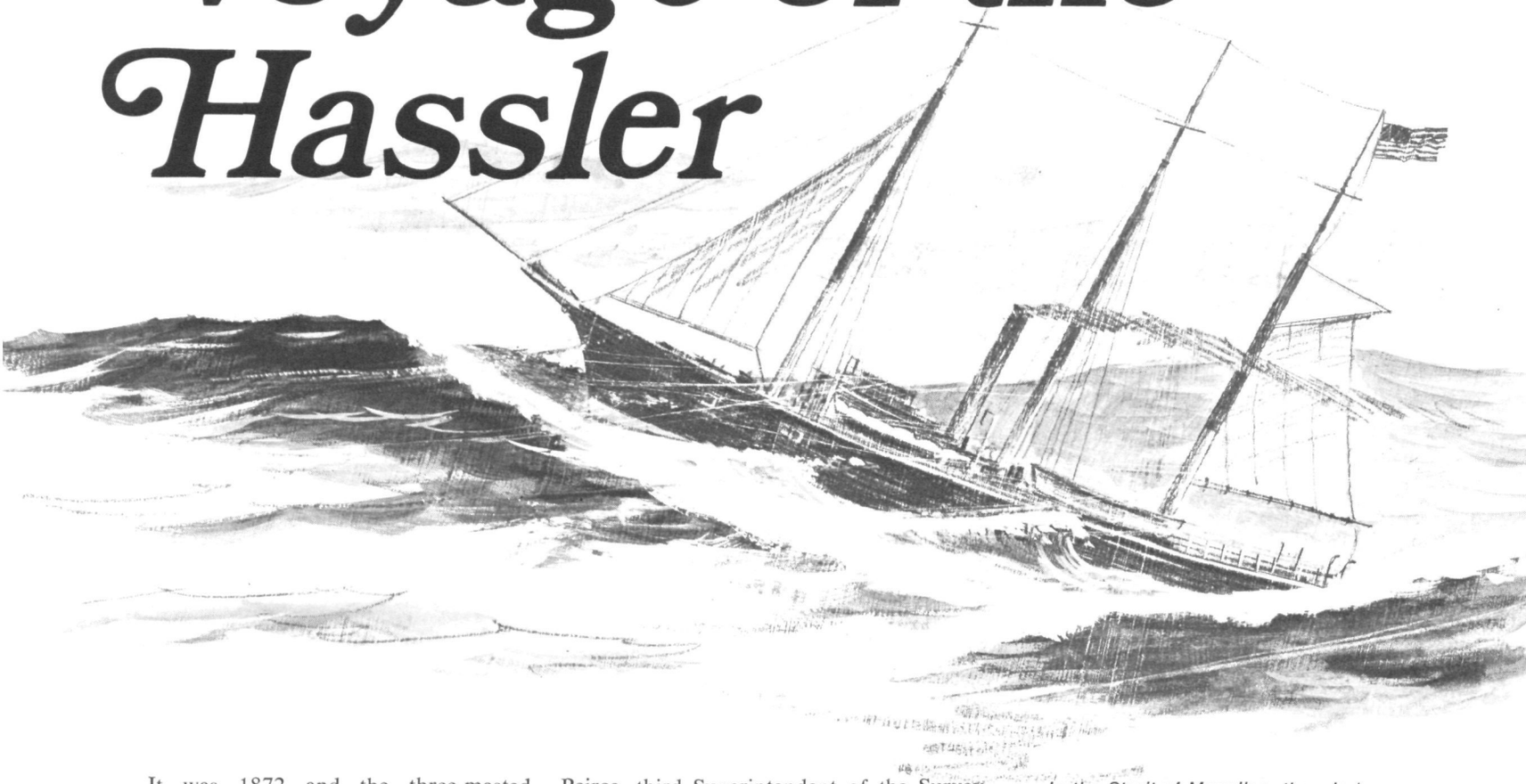
The story of a shipwreck on a deserted isle, the hospitality of natives from another island, and the adventurers' eventual return to civilization cannot be found in our weather records, but does make absorbing reading as reported in narratives of the expedition.

ESSA's satellites now span the 4,000-mile route of the Kon-Tiki's odyssey in a single pass. Their survey from space is vital to an understanding of the seas, but there is still a need for the kind of detail that can be seen only from a platform a few inches above the waves. □



Thor Heyerdahl caught sharks with his bare hands. Once the shark was on deck, the crew kept out of range.

The Hectic Voyage of the Hassler



In the Strait of Magellan, the wind whipped the water to a sheet of solid white foam. A sail was torn loose, and the blast nearly capsized the tiny vessel.

It was 1872 and the three-masted schooner HASSLER, destined for west coast survey work, was to make her maiden voyage from Boston around the tip of South America and up to San Francisco.

On the surface, it was just a routine voyage. But it had another purpose, closely watched by the nation's scientific community. For on the HASSLER, a great naturalist was to wrestle once again with his reservations about the theory of evolution. Many hoped that when he stepped ashore at San Francisco, his ideas would have changed.

The scientific community of that era was strongly influenced by an organization called the "Scientific Lazzaroni," patterned after a famed Neapolitan study group typifying the Italian free spirit of the period. It was given the name by Alexander Dallas Bache, second Superintendent of the Coast and Geodetic Survey, and his Cambridge friends. One of its first achievements was the establishment of the Florentine Academy at Cambridge, and among its objectives was support of the Coast Survey's operations. The Lazzaroni originally comprised Bache, Benjamin Peirce, third Superintendent of the Survey, Benjamin A. Gould, and Cornelius Felton, all potent figures on the American scene.

The trip of the HASSLER, the Survey's newest ship, provided an excellent opportunity for enrichment of the nation's store of scientific knowledge sought by the Lazzaroni, then led by Peirce. The new ship was specially built under the direction of Captain C. P. Patterson, Chief Hydrographer of the Coast Survey, later to succeed Peirce as the fourth Superintendent. It was equipped with double-cylinder compound engines, of the same design as those used on the White Star fleet of transatlantic steamers.

The HASSLER, built to make hydrographic surveys on the Pacific coast of the United States, was launched at Keighn's Point, New Jersey, on September 12, 1871. She was a three-masted schooner of 350 tons, driven by screw propellers. The first trial run was made from Philadelphia to Boston in October of that year. The performance was satisfactory, and it was reported that the vessel had a speed of about 7½ knots. The rigging, outfitting, and the final adjustment of the

BY ALBERT STANLEY
Coast and Geodetic Survey

machinery of the steamer for its long voyage around South America was completed at the Charlestown Navy Yard.

Frank B. Pourtales, who later succeeded to his father's title of Count, had passed the previous five years in deep-sea dredgings for the Survey and had always maintained close ties with Professor Louis Agassiz and his Museum of Comparative Zoology at Cambridge. The renowned Agassiz was persuaded to head the scientific contingent of the expedition with the expectation of adding to his knowledge through the greatly improved dredging equipment that the HASSLER would carry. In fact, Agassiz referred initially to the voyage as the Deep-Sea Dredging Expedition.

The deep-sea soundings to be obtained were expected to reveal the relationship existing between the currents and natural channels of the ocean. Also to be investigated through dredging would be marine life that might shed new light on natural history. Other investigations would include "temperature-densities" of sea water at various depths and at different localities.

The crew and passengers numbered about 50 persons. Commander Philip C. Johnson, USN, then on duty as an assistant in the Coast Survey, commanded the HASSLER, assisted by other specially assigned Navy personnel and the group of scientists headed by Professor Agassiz. In addition to Professor Agassiz and his wife, the scientific party included Dr. Thomas Hill, former president of Harvard University; Count Pourtales, assistant in the Coast Survey; and a corps of specially selected scientific observers.

The voyage began on the afternoon of December 4, as the HASSLER left the Charlestown Navy Yard in a snowstorm and a heavy sea. She passed the Boston Light before she was compelled to anchor in Nantasket Roads due to bad weather. The next day, she passed Cape Cod and anchored in Vineyard Haven in company with a large fleet of weatherbound ships. She remained there until December 7, experiencing stormy and cold weather. After leaving the anchorage, the HASSLER was soon in the warmer waters of the Gulf Stream where the work of collecting specimens in the Sargasso Sea was started. Agassiz, with other scientists and naturalists of that period, had many unanswered questions about the Sargasso Sea which he hoped to investigate in detail.

During the first few days, the roughness of the voyage fatigued the ailing scientist, and it appeared that the task would be beyond his endurance. After passing Cape Hatteras and reaching the West Indies, his health improved and he was encouraged by the progress being made. A highly successful dredging in 80 fathoms near the coast of Barbados brought up deep-sea life of great rarity, which so delighted him that he forgot much of the unpleasantness of the early days of the voyage.

After that, the HASSLER navigated along the coast from one port to another, with frequent stops to take on supplies and make

necessary repairs. She sailed from Barbados to Pernambuco (now Recife, Brazil), thence to Rio de Janeiro, Montevideo, and the Strait of Magellan, stopping at Punta Arenas. Pourtales dredged as often as practicable and succeeded in collecting a large number of rare species; Agassiz studied glaciers in the region.

One of the most terrifying episodes of the entire voyage occurred in the Strait, when the HASSLER faced a sudden headwind of unbelievable intensity. The usually strong breeze increased with sudden fury, just as the small ship was passing through a rather narrow channel which added to the force of the wind. In moments, the channel was a solid sheet of white foam, and the roar of the wind was so great that all other sound was wiped out. To add to the confusion, a sail tore loose with that violent rending sound which only a broad spread of canvas could make.

It was impossible to hold the vessel against the blast but the captain showed great skill in turning, although the full broadside force of the wind almost capsized the tiny vessel. Once safely turned, the ship flew before the wind for a short distance until the mouth of a small bay was reached. There could never have been a more sudden transition from chaos to serenity as she turned from the tumult in the main channel to the quiet waters of the bay.

The HASSLER almost filled the tiny harbor shut in between mountains. She lay there, safe and sheltered in breathless calm, while the storm raged and howled outside. The many nearly landlocked coves in the Strait were of vast importance as safety factors in navigating those treacherous waters almost 100 years ago.

The vessel was weatherbound for several days in the exquisite mountain-ringed harbor. Research continued, however, with Count Pourtales making many trips to the summits of the surrounding mountains. Up to 1500 feet the rock was smooth and rounded, but above that level the terrain was broken and rugged with a line of demarcation as well-defined as on any valley wall in Agassiz' native Switzerland. These findings strongly indicated that an ice sheet had advanced from south to north, grinding its way over the northern wall to the plains beyond.

For many days after this, the HASSLER moved along past a seemingly endless panorama of mountains and forests rising into pale regions of snow and ice. Glaciers were observed in many of the rifts and crevasses, as well as the many cascades flowing down to join waters beneath. Every night, the ship anchored in convenient harbors framed by inlets and fiords which indented the base of the rocky walls. Often narrow ocean defiles were observed penetrating into the deeper heart of the great mountains.

These were weeks of delight for Professor Agassiz before the HASSLER reached Talcahuana, Chile. After remaining there for the next three weeks, the expedition sailed northward to Valparaiso where he re-embarked after making a brief trip inland to Santiago. Shallow-water dredgings were made along the coast of Peru, and the ship then headed for the Galapagos Islands. Ever since Darwin had explored these islands in 1835, Agassiz had wanted a like opportunity. The collections made in the Galapagos were important and valuable.

When the ship arrived opposite Taboga in Panama Bay, fishermen and pearl traders came aboard to find with astonishment that the noted scientist preferred to purchase common fish from the city market, giving hardly a look at their pearls.

The scientific world was especially interested in the voyage, hoping that Professor Agassiz would have an opportunity to use his great talents in productive research. In recent years, his opposition to the theory of evolution as expounded by Darwin had moderated. He was exchanging ideas with Darwin and other advocates of evolution, and it appeared that he would be more receptive to the Darwinian hypothesis than he had been in the past.

Agassiz was not a convert to the Darwinian doctrine, but he seemed willing to seek new insight into the subject of evolution. He was open to argument when it could be substantiated by evidence that his researches as a naturalist would tend to prove or disprove. Agassiz' main interests aboard ship were with sea animals, his main purpose for making the voyage. He resolved to study the whole Darwinian theory free from all environmental influences and without his former prejudice.

It was on a similar voyage that Darwin himself had come to formulate his theories. Agassiz seemed ready to admit that Darwin's ideas might be true, if evidence gathered from all parts of the world showed a genetic relationship between species he had previously considered distinct and separately created. He indicated that he would take pains to assemble collections containing sufficient material to allow thorough compari-

continued

sons to relate living types of the northern and southern hemispheres.

Agassiz realized that the deepest waters of the ocean represented the only natural environment where scientists might discover what life was like millions of years ago. If specimens could be obtained from the deep ocean for comparison with those of the upper oceanic levels, it would establish a basis for possible discovery of any genetic relationship that might exist between species from varying levels. Also to be sought was some indication of a way in which various types had adapted to different environmental conditions.

Tragically, the technology of that day failed in this crucial stage of Agassiz' thinking. As it turned out, Agassiz was never able to gather evidence of the sort that he had anticipated from the journey. It remained for his son Alexander to demonstrate later that the sea offered fundamental information concerning evolution.

The HASSLER was not able to perform the planned operations. The new dredging equipment did not always work properly and when it did, the anticipated depths were not reached. Thus, life in the deep water of the ocean floor could not be investigated with the facility envisioned by Professor Agassiz.

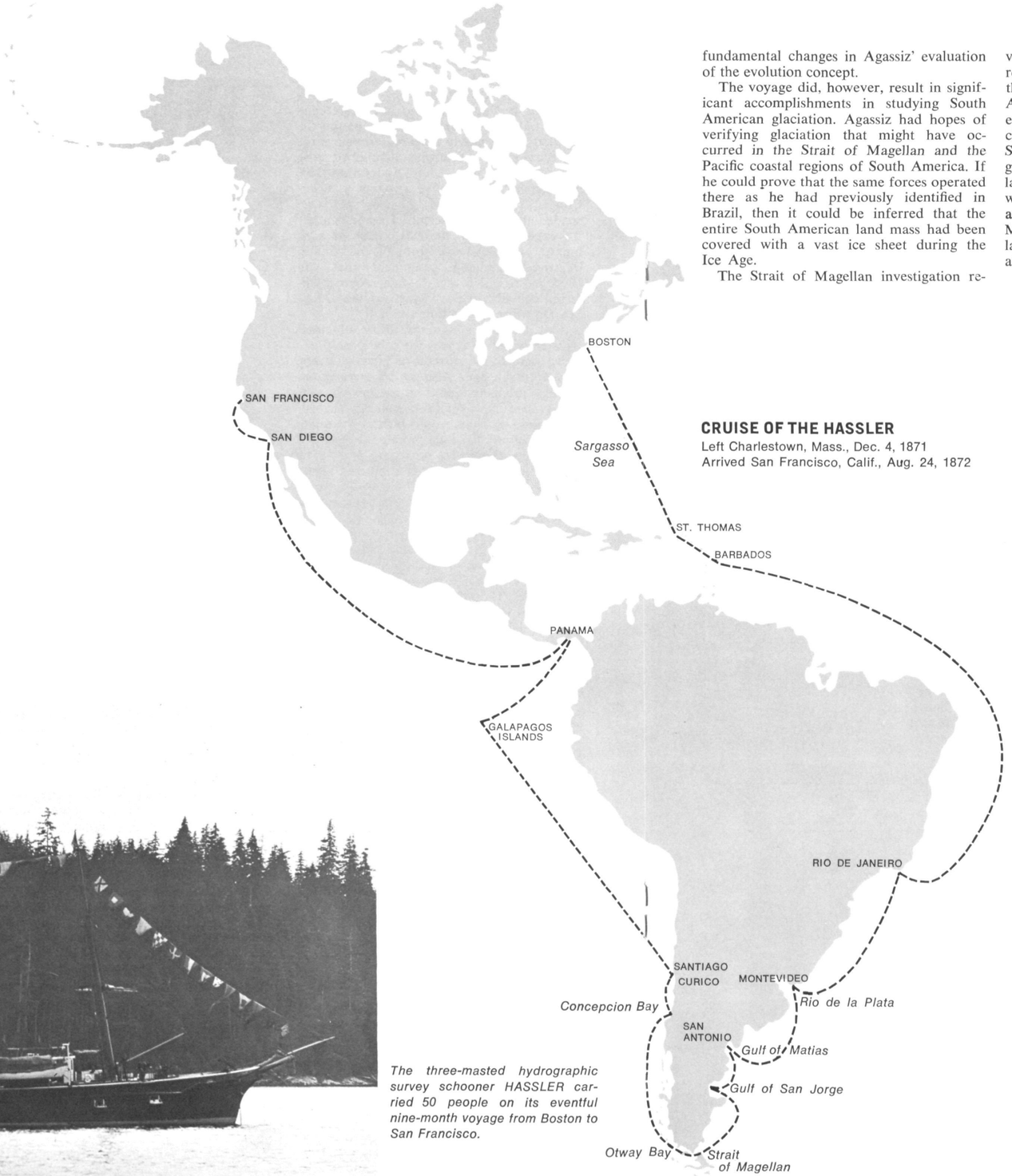
The poor health of the noted naturalist during the trip limited severely his efforts in directing the scientific operations. Thus, the scientific program of the expedition was not carried out sufficiently to support any fundamental changes in Agassiz' evaluation of the evolution concept.

The voyage did, however, result in significant accomplishments in studying South American glaciation. Agassiz had hopes of verifying glaciation that might have occurred in the Strait of Magellan and the Pacific coastal regions of South America. If he could prove that the same forces operated there as he had previously identified in Brazil, then it could be inferred that the entire South American land mass had been covered with a vast ice sheet during the Ice Age.

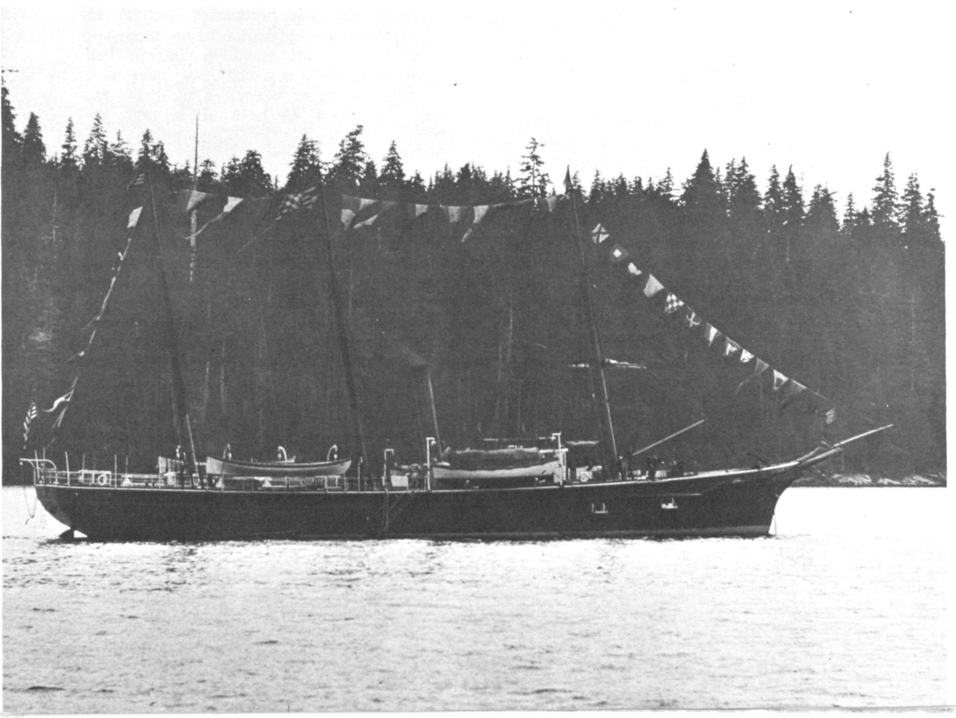
The Strait of Magellan investigation revealed evidence of moraines, scratched rocks, and erratic boulders; the glaciers of the region were primary evidence of the Ice Age. The most significant part of the voyage, especially for Agassiz, was the visits to glaciers in the Strait of Magellan and in Smithe's Channel. There, he found great glaciers like those he had known in Switzerland. On his return to Cambridge, Agassiz wrote: "If I had done nothing else but see and study the glacial phenomena at the Magellan Strait and among the Chiloe Islands, this would have amply repaid me for all my trouble and fatigue."

North of the 37th parallel, glaciers were discovered that had not reached the sea, although they had occupied the valleys of the Andes Mountains. Scattered traces of glacial action were found almost as far inland as Santiago. The net result was the identification of the continuous former glacial chain extending from south to north. These findings were never made public, but Agassiz' wife gave a partial account of the results after his death in 1873.

On August 24, 1872, a little less than nine months after leaving Boston, the HASSLER arrived at San Francisco, and there was assigned to regular hydrographic survey operations along the coast of California. □



CRUISE OF THE HASSLER
Left Charlestown, Mass., Dec. 4, 1871
Arrived San Francisco, Calif., Aug. 24, 1872



The three-masted hydrographic survey schooner HASSLER carried 50 people on its eventful nine-month voyage from Boston to San Francisco.

LIST OF OFFICERS

Attached to and on board of the U. S. Steamer Hassler (Coast Survey), command Commander P. C. Johnson, U. S. N., at the time of leaving the anchorage at Boston the 4th day of December, 1871.

NAME.	RANK.	~~RATE.~~ Prior	~~WHEN.~~ Date
Philip C. Johnson	Commander	15th Oct. '70	15th October 1871
Charles H. Kennedy	Lieut. Commander	28th Apl. '71	28th April 1871
Murray G. Lay	Lieutenant	28th Apl. '71	28th April 1871
Henry S. Mansfield	"	25th July '71	25th July 1871
Edward H. Romer	"	28th Apl. '71	28th April 1871
H. T. Tilton	Surgeon	9th Oct. '71	9th October 1871
J. E. Martin	Captains Clerk		
M. W. White	Apothecary (Ic)		
Frank V. Lee	Paymaster's Asst. (Ic)		
J. L. Mansfield	Engineer		
J. L. Englebert	"		
Prof. Louis Agassiz	Passenger		
Dr. Thomas Hill	"		
Lieut. L. F. Pourtales	"		
Dr. J. X. Steindachner	"		
James H. Blake	"		
Mrs. Agassiz	"		
[illegible]	"		

COMPLEMENT of Petty Officers, Seamen, Ordinary Seamen, Landsmen, Boys, and Marines on board the U. S. C. Survey Steamer HASSLER, at first commission Boston, Mass. 1st December, 1871.

RATES.	NUMBER.	RATES.	NUMBER.
Captains Clerk	1		1
Paymaster's Writer 1st Class	1		1
Apothecary 1st Class	1		1
Carpenter's Mate	1		1
Boatswain's Mate	1		1
Quarter Masters	4	Reduced one	3
Master at Arms	1		1
Cabin Cook	1		1
Ship's Cook	1		1
Cabin Steward	1		1
Seamen	26	Reduced six	20
Machinists	4	Reduced one.	3
Seamen Extra - Engineers Force	6	Reduced two.	4
[illegible]	[illegible]	[illegible]	[illegible]

Coast and Geodetic Survey experts keep the nation's tide stations in action

From Maine to Mokuoloe

BY DAVID STUART
Coast and Geodetic Survey

EVER SINCE the oceans were formed upon the earth, the surface of the seas has been subject to the rise and fall of the tides. Sir Isaac Newton first developed the theory of tides mathematically, and all research since then has stemmed from his original studies.

Since tides are not constant, man has devised a system which enables him to establish their occurrence with considerable accuracy. The heart of this system in the United States is a network of approximately 115 stations which measure the rise and fall of the restless sea along the coasts of the United States, its territories, and possessions.

To maintain this network, four men, each a trained tidal technician, travel nearly 200,000 miles a year, up and down the Atlantic and gulf coasts of the United States and across the reaches of the Pacific. Their task is to service the recording equipment at the stations.

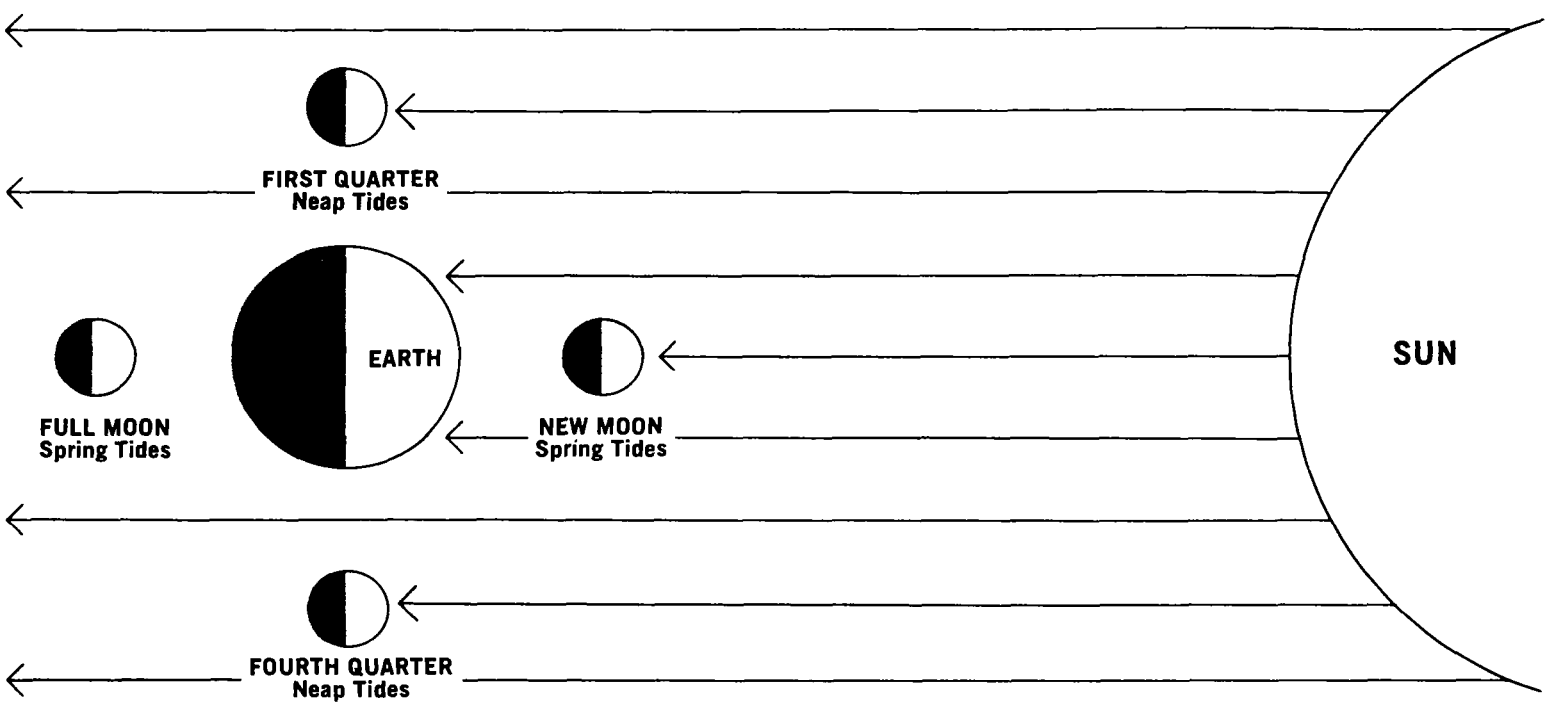
The continuous recording of the tide is made possible with the aid of an observer at each station. But equipment breaks down, due largely to bad weather and sea erosion, and must therefore be constantly serviced.

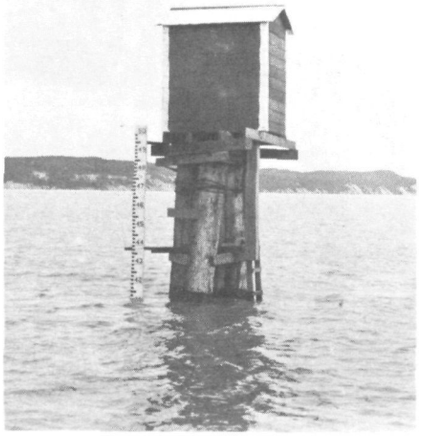
This task is performed by the U.S. Coast and Geodetic Survey. The two tide parties are assisted by personnel from four Coast Survey offices on the Pacific and Alaskan coasts.

They have been doing this since 1940, when stations became too numerous for regular personnel at the Coast Survey's east coast and Honolulu offices to handle. The task is arduous. It requires frequent changes in living accommodations, and the men have to brave blizzards, gales, zero weather, severe storms, and the possibility of earthquakes and tsunamis.

The work of these four men—one of whom has been on the job for 12 years—is important to literally millions of people who have come to depend on advance knowledge of the tides. It is also important to oceanographers in the Coast and Geodetic Survey, who require tidal data for the prediction of the tides and for maintaining accurate mean levels of the sea.

Tides result from attractive forces of the moon and sun acting upon the rotating earth.





Since tides are not constant, man has devised a system which enables him to establish their occurrence with considerable accuracy. The heart of this system in the United States is a network of approximately 115 stations which measure the rise and fall of the restless sea. Literally millions of people—including mariners, fishermen, engineers, military strategists, swimmers, and surfers—depend on advance knowledge of the tides. (Left and above) Low and high water at a single Coast and Geodetic Survey tide station in Alaska show the wide range of tidal variations. Tide gages are used in the Seismic Sea Wave Warning System to detect the presence of potentially destructive tsunamis, such as that which damaged the Alaskan coast (below) in 1964.

People in many walks of life use the information. Mariners in small craft and deep-draft vessels need it to keep from going aground. Fishermen plan trips based on feeding habits of sea life at the different stages of the tides. Surveyors measure land elevations and correct charted depths, based on a determination of the mean level of the sea. Engineers and military strategists must know when high tides occur for designing waterfront construction, dredging channels, determining a legal base line on shore for locating waterfront boundaries, and planning military landing operations. Even swimmers and surf riders rely on the time of high or low water at their favorite haunts.

In order to assure that information is furnished on a continuing basis, a two-man East Coast Tide Party inspects 66 stations, over half of those operated by the Coast Survey, along the Atlantic and gulf coasts. In so doing, it travels over 25,000 miles a year. The Pacific Tide Party has 15 stations to service, but these are located on 15 islands in the central, south, and western Pacific, requiring over 150,000 miles of travel each year. Alaska office personnel are responsible for the operation of 15 stations in their area and cover about 10,000 miles to service them. Most of these stations are accessible only by plane or ferry. The three west coast offices log about 500 miles in servicing 17 stations on the Pacific coast.

Each station is established in a location representative of the area's tidal conditions and serves as a link in the control tide station net. The stations are mounted on public and private fishing piers, commercial docks, and independently built platforms in open bodies of water. Waves from severe storms or tsunamis may destroy them, moisture and salt air deteriorate their instruments, marine growth and mud clog the intake of the float well where the water enters, or ships dislodge instrument mountings while loading or docking, thus causing inaccurate readings.

A station's accuracy and longevity are extremely important for showing tidal fluctuations in a particular area, for studying sea level, and for providing a basis for the geodetic level net.

The sea alternately rises and falls in response to the gravitational attraction of the sun and moon upon the face of the rotating earth and, simultaneously, to an equal force on its opposite side. The tide also varies in height and the time of its occurrence over a period of years, according to the location of the sun, moon, and earth in relation to each other.

Tides also change because of the size and shape of the nearby ocean basin, its shoreward slope, and other factors involving fluid dynamics. To measure these changes, including those made in the ocean bottom by man or nature, is a never-ending task. It has been so, since the initial tide gage was installed at Governor's Island, New York, in 1844 for hydrographic surveys along the southern Long Island coast.

The numerous stations which have been installed since then on the Atlantic and gulf coasts are those handled by the East Coast Party, based at Norfolk, Va. This party services stations between Eastport, Me., and Padre Island, Tex. To take advantage of favorable weather, the party works in the South from January to July and in the North from July to December. During the winter, it checks 30 stations in North Carolina, South Carolina, Georgia, Florida, Alabama, Louisiana, and Texas. During the summer, it investigates 36 stations in Maine, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Virginia, and the District of Columbia.

The party is headed by Wayne J. Creed, of West Haven, Conn., aided by William L. Outlaw, of Grandy, N.C. Creed has been with the party for over 12 years and has traveled over 300,000 miles by truck and trailer. Outlaw joined the party in

continued

1962 and has clocked about 150,000 miles. As they drive the familiar routes year in and year out, they are accompanied by their wives and children. Their most difficult problem has always been to find a trailer park about every four days, the maximum time required for normal servicing. The party travels during the tourist season, making places hard to obtain on short notice.

Commenting on unusual maintenance problems, Creed said: "Hardly a year goes by without some kind of damage to tide stations. In 1967, three stations were completely wiped out, and three others were partially damaged by the hurricane that hit the Texas coast." The party was able, however, to cope with the problem for it carries all the equipment necessary for a complete servicing job, including building a shed to house the equipment, installing a tide staff and station well and, if necessary, constructing a new platform.

"Normal servicing keeps us busy all year," said Creed. "It's primarily a job of painting, replacing broken windows and damaged siding, realigning tide staff mountings and well bracings, and resetting disturbed bench marks located within a mile from the station.

"The Fiberglas staff and the float well always have to be a certain distance below the lowest tide level and secured in a vertical position. The importance of the tide staff cannot be overemphasized, since it is the basis for the datum of tabulated heights which, in turn, are referenced to tidal and geodetic bench marks."

The tide's stages are recorded by gages as punched holes on small rolls of paper. These indicate water levels at six-minute intervals. In other places, the stages are recorded on wide rolls on which the rise and fall of the tides are traced as a continuous curve. The latter is known as the standard tide gage and has been in use by the Coast Survey for well over a century. The clock-driven instrument is positioned above a float well, in which a float rises and falls with the tide. Through an assembly of gears, the float actuates the tide curve pencil on a drum which rotates at the rate of one inch per hour. In this manner, a continuous curve is recorded and preserved for future reference and study. The height at different stages is determined with the help of the tide observer.

One duty of all servicing parties is to train each observer to mark on the roll, every day or two, the time of the recorded tide and its height at that instant shown on the tide staff. Later, all heights are determined from the staff, and mean water level values are computed at C&GS headquarters in Rockville, Md.

Nearby bench marks (bronze metal disks set in concrete posts in the ground) serve to reference these values permanently. The party determines the relationship between the tide staff and tidal or geodetic bench marks in the vicinity of the tide station every year to ascertain if there has been any movement in the staff or bench marks.

The work of the Pacific Tide Party requires a tremendous amount of traveling. The party, which operates out of Honolulu, is headed by Lt. Gerald M. Ward, of Orlando, Fla., and includes Mickey K. Moss, of Bountiful, Utah. Another member of the party is stationed in Honolulu as a liaison officer with the Navy.

The party's servicing domain includes stations on the islands of Guam, Oahu, Mokuoloe, Hawaii, Kauai, Maui, Midway, Johnston, Christmas, Wake, Marcus, American Samoa, Truk, Eniwetok, and Kwajalein.

Ward said that transportation is the major problem encountered in maintaining the stations. As the men travel from

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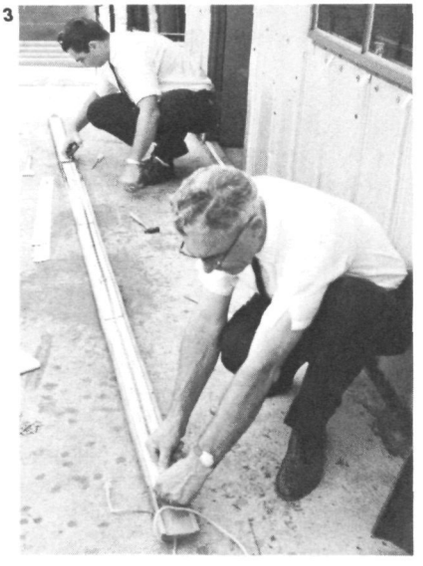
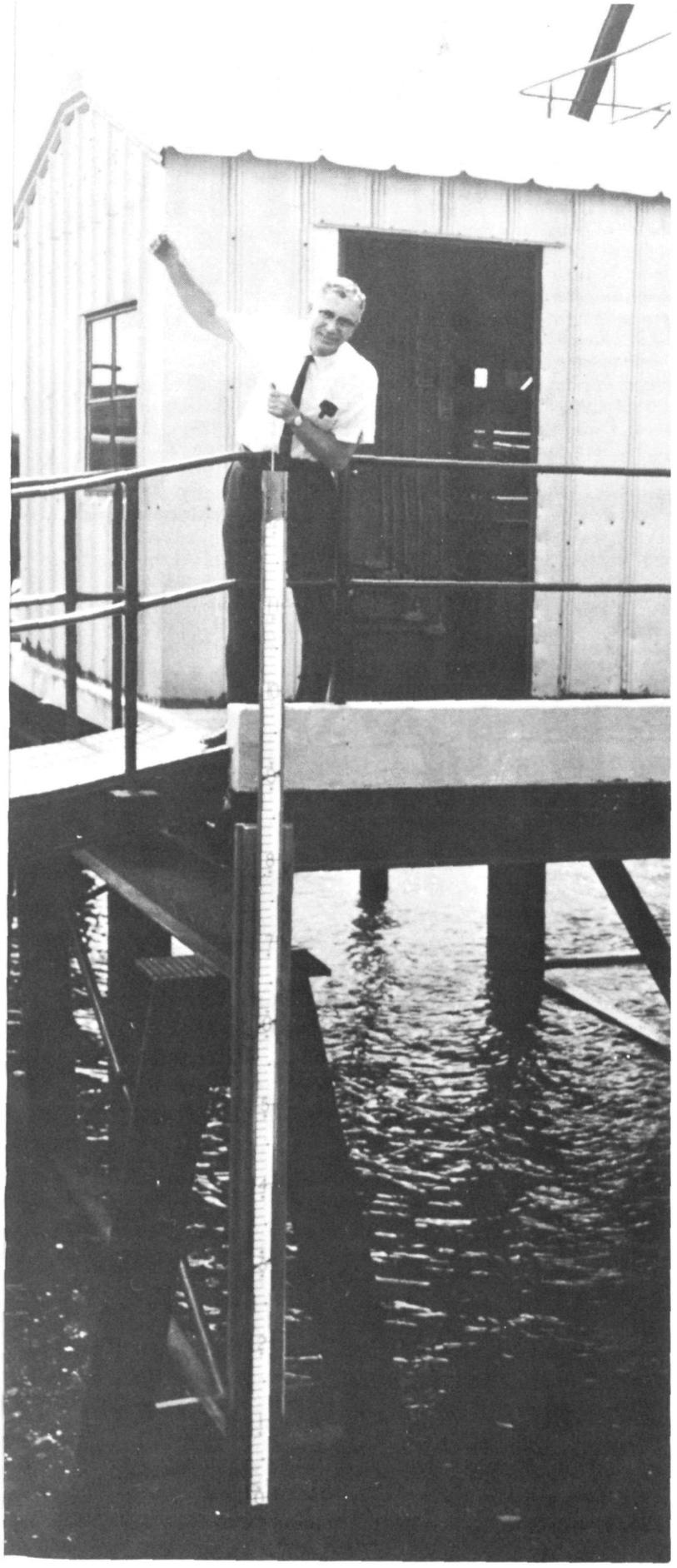


U.S. Coast and Geodetic Survey tidal technicians travel nearly two hundred thousand miles a year to service equipment and ensure accurate readings for determining the area's tidal fluctuations and the mean sea level. 1. Clem E. Arens, of C&GS headquarters, finds the lower end of a staff fouled, making it impossible to read below the three-foot mark. 2, 3. Arens and Tom K. Orlowski, Supervisor of East Coast Tide Party operations, secure new scales to a portable staff at the Piney Point, Md., tide station. 4. Arens places the completed staff on its support at the correct elevation.

(Below) Orlowski loads equipment on a rented plane. In emergencies, parties fly to fix damaged gages.



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island to island they use any planes going their way, including cargo-carrying aircraft. A 9,000-mile round trip from Honolulu to inspect two tide stations is not uncommon, and several days may elapse awaiting transportation from one island to another.

Twelve stations are part of the tsunami warning system operated by the Coast Survey in Honolulu. The system alerts Pacific Basin nations to a potentially dangerous tsunami, caused by undersea earthquakes. The alert is initiated by seismologists at Coast Survey observatories and radioed to tide observers over the Pacific Ocean. Instruments may then be checked for continuous operation in order that seismic sea waves may be recorded. Arrival of these waves at the tide stations will confirm that a tsunami has been generated. The system relies upon tide stations near the open coast, which record continuous curves and thus the tsunami's large waves.

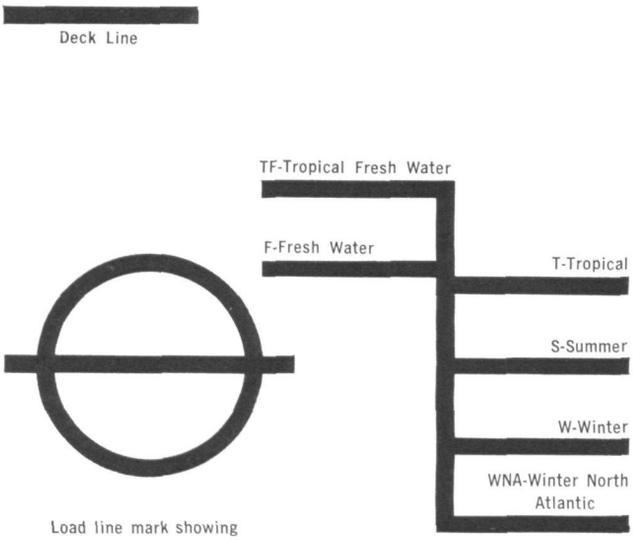
Servicing the Alaska stations involves problems quite dissimilar from those in the warmer climes of the Pacific. These problems in the nation's largest state are the responsibilities of Alaska Field Director Cdr. Gerard E. Haraden, of Bar Harbor, Me., and his assistant, Sidney Henderson, Jr., of Anchorage, Alaska. The men are aided by Virginia Wood, of Roswell, N. Mex., who reviews tide records in the Alaska office at Anchorage and forwards them to Coast Survey headquarters. She also furnishes routine supplies, such as paper rolls or spare clocks, and fills emergency orders. Personnel from the Palmer Seismological Observatory serve as tide observers at two Alaska stations.

"When you talk about Alaska," Haraden said, "you're talking about below-zero weather during a large portion of the year. When a tide observer notifies us that his station has stopped recording, it may take two or three weeks before a plane is able to reach him. It is not uncommon for servicing personnel to wait out a storm before work can proceed."

The difficulty which transportation and weather impose in Alaska is alleviated to some extent by Coast Survey ships, whose personnel service stations during their regular hydrographic surveying operations. These men install temporary gages in the working area so that an accurate low-water level can be determined. Later, the records are compared with a nearby station whose low-water values have gone through the variations of long-range astronomic origin, including those caused by unpredictable meteorological and oceanographic forces.

The 17 tide stations on the west coast are inspected each year by available personnel from Coast Survey offices there or by Coast Survey ships. Five in the Washington-Oregon area are serviced by the Seattle office. The Los Angeles and San Francisco offices are responsible for 12 stations in California, eight in the vicinity of Los Angeles and four near San Francsco.

Special applications are made of tide data obtained from the Astoria, Oreg., and Seattle, Wash., stations. The Astoria station telemeters the information to the U.S. Geological Survey's remote recorder for monitoring the water level, by comparison with predictions, of the Columbia River. The agency is conducting a study of radioactive material in the river for the Atomic Energy Commission, which uses water for cooling reactors at its Hanford works. The data is also telemetered to the Astoria Weather Bureau at Clatsop County Airport for Columbia River flow forecasts. Another remote recorder was installed recently in the Weather Bureau's Seattle Forecast Center for the same purpose. By combining tidal and meteorological data, weather forecasters can include in their broadcasts a warning of extreme high tides which might cause flooding or storm damage, especially in low-lying areas. This service was also inaugurated along the east coast in 1955. □



Load line mark showing assigned summer freeboard measured vertically from upper edge of deck line.

EQUALS

End Of The Coffin Ships

A sailor's life was an invitation to disaster until Plimsoll's crusade for safe ship loading

BY RICHARD DeANGELIS
Environmental Data Service

WHEN a ship is overloaded, even slightly, it becomes frighteningly susceptible to the winds. During one black era in maritime history, overloading caused nearly half of all disasters at sea.

The day of the "coffin ship," however, is past. Last year, although 166 vessels went down in rough weather and heavy seas, not one sank because it was overburdened.

Why? Because of the knowledge embodied in an inconspicuous design on the side of every ship. Resembling a cross between a fraternity name and a medical symbol, the Plimsoll mark, or load line, identifies the vessel's safe loading capacity.

Behind the Plimsoll mark on today's ships stand many skills, among them those of the Environmental Data Service, which has contributed to safety—and savings—at sea by providing information helping maritime experts to establish safe corridors for major routes and ports.

The load line first appeared in the Middle Ages as a cross on the sides of ships, symbolizing salvation from the sea as well as marking the safe draft. For two centuries after its initial appearance in the Mediterranean area, the load line disappeared. It was revived after ship insurance began to breed careless attitudes toward loading.

A ship owner in 1872, seeking a large profit, accepted an offer to sail a load of iron from England across the Baltic Sea long after the shipping season was ended by winter weather and ice. Another owner had turned down the same offer when his captain pleaded: "For God's sake, don't send us into the Baltic at this time of the year. You might as well send us all to the bottom of the sea at once." The ship sailed overloaded and went down when it encountered rough weather just 20 miles off the English coast. Because of overloading, it was unsafe in any water where the weather might be rough.

Another ship owner in the 1870's was said to be morally responsible for the loss of seven oceangoing steamers and more than 100 lives in less than two years. Although most ship owners in this period were conscientious, the unscrupulous ones caused many disasters in their quest for quick profits.

Of course, a sailor could always refuse to sail once he saw the condition of the ship—provided he didn't mind spending two or three years in jail. Many, during the late 1800's, gratefully accepted a jail term rather than sail one of the coffin ships.

The tragedies caused by overloading were common throughout the maritime world. In England, however, they had not gone unnoticed.

"A great number of ships are regularly sent to sea in such a rotten or otherwise ill-provided state that they can only reach their destination through fine weather, and a large number are so overloaded that it is nearly impossible for them to reach their destination if the voyage is at all rough. And I can show you that from these causes alone rather more than a full half of our losses arise."

This passage from "Our Seamen: An Appeal" was written by Englishman Samuel Plimsoll, in 1872. Plimsoll, an 18th-century Ralph Nader, aroused the public with his writing and oratory. He spent years as a member of the House of Commons trying to get load-line legislation through Parliament. Since these merchant ship disasters were never investigated, evidence was difficult to collect; he wrote to those likely to provide information, traveled to interview widows of sailors lost at sea, and questioned ship owners, underwriters, and stevedores. Plim-

soll was not above the use of sensationalism to achieve his ends, and he embroidered on cases that he knew would tear at the heartstrings; at speaking engagements he would often show photographs of a group of sailors' widows or a deceased seaman's family. Though sued for libel, reprimanded for outbreaks in the House of Commons, and nearly driven to emotional breakdown, Plimsoll remained relentless through failure after failure. He was finally able to bring such public pressure that a temporary measure was passed in 1875, followed by a permanent one the next year, and a more responsible law by 1890. The "sailor's friend" had established the Plimsoll mark.

The load-line movement grew in other countries, and by 1916 the United States was the only major maritime power without loading regulations. Its case was pleaded here, but without the benefit of a Samuel Plimsoll. It took the sinking of the heavily overloaded U.S. steamship EASTWAY, in October 1926, to stir action here. The EASTWAY, loaded till its deck was nearly submerged, encountered rough weather off the English coast and sank, taking 23 crewmen with her. The Load Line Act went into effect in 1929—just one year before the first International Conference on Load Lines.

The 1930 International Load Line Conference laid the foundations for present-day regulations and zones. In many areas, weather data was sparse and broad zones had to be established. These zones were based on wind frequencies.

A ship must be loaded for the worst zone it will encounter. In a winter zone, where winds reach force 8 (34 knots) and above more than 10 percent of the time, a ship can load only to its winter marks. A ship can load to its summer marks (S) if it stays in a zone where winds are force 8 and above less than 10 percent of the time. In a tropical area, winds reach force 8 and above less than one percent of the time. (Now, also, not more than one tropical cyclone can be recorded in any 5 degree square for the month in question.)

The marks on the Plimsoll scale represent climatic zones as well as loading limits. There are also allowances for fresh water loading (F and TF) and restrictions for smaller ships traveling the northern North Atlantic in winter (WNA).

Since the 1930 conference, tremendous developments in ship design, construction, size, and operation have antiquated many of the loading regulations, while a wealth of marine data has dated the zone charts.

Marine climatological data is an Environmental Data Service specialty. Recently EDS put its data to work and made an important contribution to safety at sea, when it helped update the load-line zones at the 1966 Load Line Conference.

The detailed amount of marine data provided by the Environmental Data Service made it possible for the Zones Committee to construct climatological corridors that allow access to major ports and routes without loading to a lower mark. The corridor established along the east coast of the United States is a good example. Large ships sailing from New York to the Canal Zone or South America can now load for a summer zone all year round. This cuts five months off the winter season as it appears in the surrounding offshore waters. For a ship loading to 100 tons per inch, these extra inches translate into thousands of dollars. The new boundaries also permit ships sailing around the Cape of Good Hope and the south coast of Australia to remain within the summer zone. The Baltic Sea, the Black Sea, the Mediterranean, and the Sea of Japan are now considered within the summer zone for larger ships.

This new convention took effect in July 1968. The Coast Guard has the responsibility in this country for load-line regulations and, while every effort is made to enforce them, much still must be left to ship owners and captains.

In December 1964, the SS SMITH VOYAGER set out from Houston, Tex., for Calcutta, India. When the ship was five days out of Freeport, Grand Bahama, her first refueling stop, she took on a 2° to 5° list to starboard in 25-knot winds and rough seas. The list increased to 10° when the winds reached 50 knots and seas were 20 feet. After the engines were stopped for repairs, the list reached 30° and an SOS was sent out; the MV MATHIDE BOLTEN responded. Most of the SMITH VOYAGER's crew had put out to sea in a lifeboat. The MATHIDE BOLTEN spotted them and moved in for the rescue. Gales and rough seas swamped the lifeboat, and it capsized close to the rescue vessel. Four men were crushed between the two vessels and drowned; the others climbed to safety. The captain and the remaining crew aboard the SMITH VOYAGER, now listing at 35°, were picked up the following day by the U.S. Coast Guard Cutter ROCKAWAY. The evidence sank a few days later while being towed to port.

Unlike the old days when these tragedies went unchecked, the Coast Guard launched a full investigation into the SMITH VOYAGER disaster. It found that the ship had been loaded to her maximum safe capacity at Houston, but in the opinion of the National Cargo Bureau surveyor there, she should have sailed light of her marks in order to be at proper draft after refueling at Freeport. This is an isolated incident; for the most part load lines today are adhered to, and the safety of the ship and her crew are of paramount concern.

The next time you get a chance, take a close look at the Plimsoll mark. To the marine fraternity, it is a symbol of safety. □

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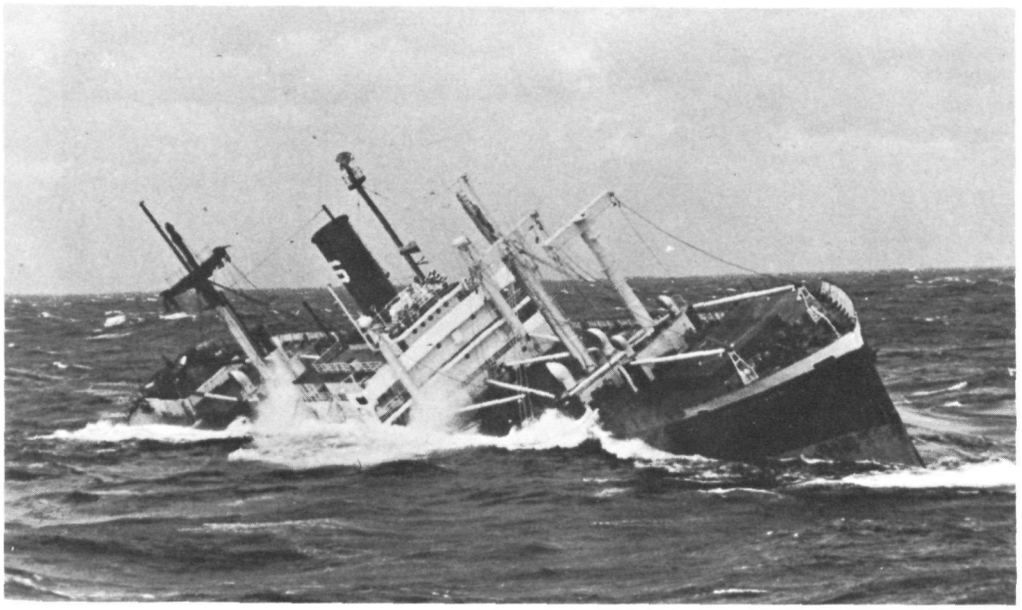

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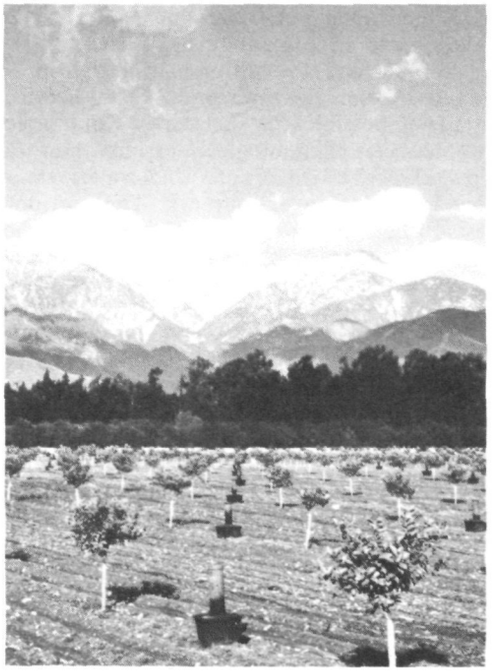
When the overloaded SMITH VOYAGER went down at sea in 1964, it was an isolated incident. 1. Battling for their lives, 38 crewmen struggled toward a rescue vessel (World Wide photo). 2. The men remaining on the ship were picked up by the Coast Guard (Coast Guard photo). 3. Arthur Cooperman (left), who served as ESSA representative to the 1966 International Load Line Conference, and Dr. Woodrow C. Jacobs, EDS Director, review marine data provided to establish the load-line zones.



The Weather Bureau plays the central role in one of the biggest games in the West. It's called

BEAT THE BIG FREEZE

BY DALE R. HARRIS
Meteorologist in Charge
Weather Bureau, Pomona, California

PRELIMINARY FROST WARNING: "Saturday, December 21, 1968, Clear and cold with light winds all districts tonight. In southern California districts, lowest temperatures will be 20°. Central California districts: Fresno-Madera counties 24°, Tulare County 23°, Kern County 22°. Coachella-Imperial valleys 20°. Yuma district 20°, and Salt River Valley 20°."

The message goes out early in the morning from specialists in 14 districts to Pomona, California, heart of the Weather Bureau's Western Region Fruit-Frost Service. By 9:30, people throughout the West are hearing it over television, radio, or recorder-phone.

Prosaic words—but they are eagerly awaited, not only by citrus growers but by vegetable farmers, nurseries, home gardeners, and even used-car lots, where radiators must be protected.

For big money rides on these forecasts, and a difference of a few degrees can send legions of men into emergency action.

At the close of 1968, total citrus acreage in California and Arizona stood at 325,000. This includes more than 50,000 acres of young, one- to four-year-old trees, which are most susceptible to tree damage or loss in the event of a severe damaging freeze. The total investment represented in this citrus acreage, including the cost of development, is in excess of $1.3 billion. Delivered sales value of production from this land exceeds $315 million annually. A bad freeze could reduce the value of the crop by at least $75 million.

Without the minimum temperature forecasts provided by the Weather Bureau, millions of additional dollars of citrus would be lost to the freezing weather. These losses are, of course, severe blows to citrus growers; but, in addition, they have a very real effect on the national economy.

Lettuce shippers and growers benefit directly from frost forecasts probably more than any other single group. Lettuce freezes

quite readily, and the leaves or parts of the head are easily broken if handled while the cells are frozen. Harvesting cannot be started while there is ice in the head or leaves without causing serious damage. Using data he developed during 1959, frost forecaster Bill Allen is able to forecast the time of morning at which thawing will have occurred and the harvest may safely start.

Lettuce is produced on 45,000 acres in Imperial County, and the harvest extends from late November to March. Labor used in harvest crews varies from 2,900 to 3,800 men, plus truck drivers, cooler operators, buyers, office personnel, government inspectors, and others who would be affected by the time of day the harvest begins.

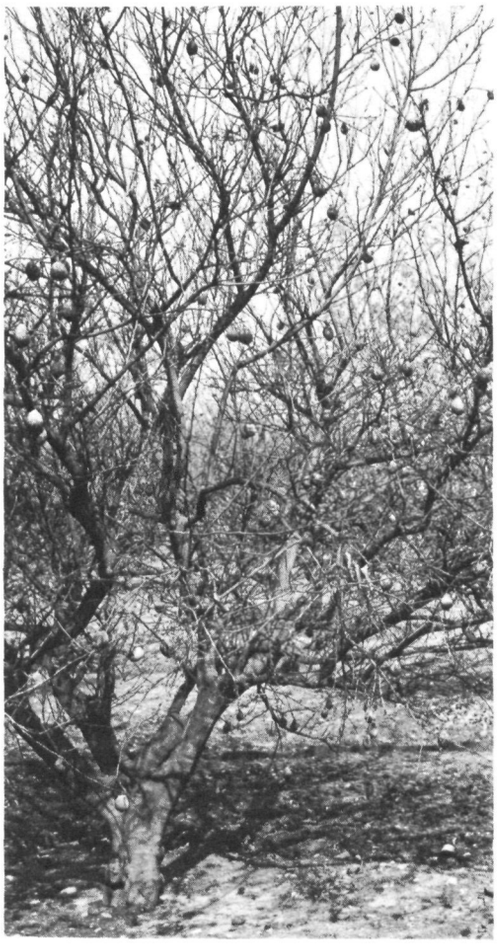
During a typical year such as 1966-67, this industry's harvest was delayed 172 hours by low temperatures. These hours were accurately forecast by the fruit-frost forecaster; and, as a result, very little labor or time was needlessly used. Adding an average figure of $3 per hour and using 4,000 men as the labor force (including all categories), the savings effected by not calling this force to work until needed would amount to $2,064,000 in wages and salaries. Adding the potential in lost produce, confusion, discomfort, and labor problems that would result without an accurate forecast gives an idea of the value of this frost forecast service. On the receiving end of the lettuce harvest, the market reacts rapidly to frost forecasts. During periods of low temperatures, the supply is reduced and is reflected in prices.

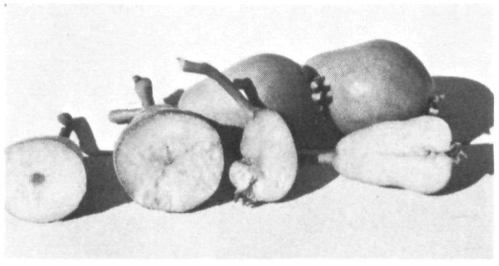
The threat of frost brings quick action on the part of the growers. That action can best be illustrated by quoting from a paper presented to our Fruit-Frost Conference in 1966 by V. H. Craig, Jr., general manager of the Limoniera Ranches, Santa Paula, California:

"It is on the basis of the preliminary (warning) that the grower must prepare his defense against frost damage. In his decision he must consider the value of the fruit, the cost of oil, equipment, and labor. Under moderately severe frost conditions, heating costs about $5 per acre per hour, and it can readily be seen that a few hours of unnecessary heating results in enormous dollar losses.

"The Fruit-Frost Service has made major contributions to a more effective and efficient operation. To indicate the duration of low temperatures—whether one night or several nights' duration—or the nights that will be free from frost—this is referred to as strategic information. Tactical information is important in deciding the best course of action for the night, whether the low temperatures will be of long or short duration below the critical values, the time of occurrence of the low temperatures, and the time when firing is likely to be necessary. All of this information is part of the frost-warning forecast. . . .

"The morning forecast, as issued by the Weather Bureau Frost-Warning Service, gives a summary of local weather conditions and the preliminary temperature outlook for the night ahead. On the basis of this forecast, the grower must make the following evaluation: Are enough heaters in place, fueled, and ready for lighting? Are torches ready, safe, and filled? Is the fuel supply reserve adequate? Are all wind machines fueled, tested, and ready? Are the fruit thermometers in place, examined for breaks, and the index run down? Are the radio-equipped vehicles ready and working? Are there enough men available, and are they trained to light and refuel heaters quickly and safely? Is there food on hand for a long night of frost protection? These questions must be answered and the required action taken on the basis of the morning forecast. It is essential that the forecast be accurate and detailed enough for the grower to make the determination.





A bad freeze can reduce the value of the citrus crop by at least 75 million dollars. Weather Bureau frost warnings may send legions of men into action to prevent the damage pictured above.

"The evening forecast, made available to the grower by the local forecaster at 7 p.m., predicts temperature estimates for specific temperature stations in his district. But along with these estimates is the forecast of the weather for the night: dew-point, winds and clouds, duration of low temperatures, anticipated time of firing, and the outlook for the following night.

"On the basis of the evening forecast, the grower must plan the night's operation: How many men will be needed and when; what areas of the orchard will need protection first? The course of the operation is conducted on the judgment of the supervisor, and his judgment is founded on the basis of the forecast and the current conditions. Without the forecast he has no basis for judgment. His choice, then, would lie between excessive expenditure in overprotection and premature action, and the excessive risk of blind gambling that no action is needed. His objective is to have started no wind machine, called out no man, or lighted no heater more than a few seconds before protection is needed, to have at no time continued operations a minute longer than necessary, and at the same time to have incurred no damage. A tough objective indeed!

"The weather forecast system, then, is seen as the keystone of reasoned and hopefully economical operations. Growers have come to depend on the type of weather service now provided by the Weather Bureau. This Fruit-Frost Service exists because men in it are dedicated, skillful, experienced, and interested—interested in the 'micro-weather' of their districts. This knowledge is acquired by knowing the local topography, local winter weather, and the interrelationship of the two with the general weather situation.

"A most important ingredient in the success of the Fruit-Frost Service is the opportunity for personal acquaintance and contact between the forecaster and the grower customer. The forecaster learns first-hand the verification between his estimate and actuality, to the improvement of subsequent forecasts. The grower knows the forecaster and learns to interpret the forecasts specifically to his individual problems."

The Pomona Valley Orchard Protection Association began its career as a cooperative frost-fighting organization on May 15, 1912, and in the winter of 1911-1912 about 750 acres of citrus were equipped with heaters. A system of telephoning the growers was started as a warning service in 1912. At the fruit growers' exchange building, a large map of the Pomona Valley was posted on the wall, with pins showing the location of thermometers throughout the valley. A watchman at the packing house made temperature readings every half hour through the night when temperatures neared the danger point. Motorcycle riders made

continued

BEAT THE BIG FREEZE *continued*

the rounds, reading thermometers scattered through the valley; and growers were warned of dangerous conditions.

In the warning system, each grower informed of the temperature was asked to phone 10 to 20 other growers and give them the information. This system proved unworkable since it imposed a hardship on a few, when they should have been protecting their own orchards. So numerous became the telephone calls that the telephone office arranged special calling devices so that five-bell signals could be sent on ten lines at a time. Whenever temperatures threatened, calls were sent to the list of growers in the cold area.

In 1912, efforts were made to have the Weather Bureau take an active interest in the details of frost protection. The first definite step was the establishment of a local cooperative weather station at Pomona. The records began on January 1, 1913, with Edgar Adamson, Sr., the cooperative observer, and this became the Pomona key temperature station. It is still the key station; and Dr. George P. Cressman, Director of the Weather Bureau, presented a special citation to Edgar Adamson, Jr., for following in his father's footsteps and keeping weather records since 1913.

The season of 1917-18 brought Weather Bureau-trained men to the Pomona area—William G. Reed and Floyd D. Young. Mr. Reed departed Pomona on January 22, 1918, and Floyd D. Young took charge—a position he held until his retirement on March 1, 1956.

Those early years required enormous expenditure of time and energy by Floyd Young. Temperature stations had to be installed, and temperature surveys made. In addition, studies had to be made on air drainage, inversion data, and types of heaters. The formulas had to be developed for forecasting minimum temperatures. The morning weather map was received from the Los Angeles Weather Bureau late in the afternoon, though often not until the following morning. From these weather maps, a minimum temperature forecast was made. It was found that, without exception, all severe freezes were preceded or were accompanied by a peculiar pressure distribution—either a long ridge of high pressure over the entire country, or a double high over the Northern Pacific and the Rocky Mountain States.

In 1921, additional forecasters were assigned to Pomona and then detailed to Redlands and Corona, California, for the winter season. In 1922, new districts were opened at Yakima, Washington; San Gabriel Valley, Whittier, Santa Paula, and Lindsay, California. More districts have been added over the years, with the latest in 1965 at Lakeport, California. At the present time there are 22 winter and spring districts served by Weather Bureau offices.

In 1925, broadcasts of temperature estimates were started over radio station KHJ by "Uncle John," the announcer, and, in 1931, the frost warnings were broadcast directly from Mr. Young's residence in Pomona over radio station KNX. In 1941, radio station KFI began broadcasting the frost warnings at 8 p.m. each evening from November 15 through February 15. (We are now in our 28th year with radio station KFI; the time has been changed to 7 p.m., and the period extended from November 1 through February.) Eight o'clock was prime time, and the frost warnings cut into nationally scheduled programs.

Perry Como's sponsors objected to their show being cut into by a local program. Earl C. Anthony, owner of KFI, asked the public to indicate by cards and letters their preference. The response was overwhelmingly in favor of the frost warnings; so during the winter months the Como Show, already in progress, was not cut in until after the frost warnings, which might take 30 seconds or three minutes.

The frost-warning broadcast became an integral part of southern California's radio listening, although radio coverage extended to Alaska and eastward beyond the Mississippi. Rochester, on the Jack Benny Program, with his "Anaheim, Azusa, and Cuc-a-mon-ga," borrowed the names from key temperature stations used in the frost-warning broadcast. Benny himself had a caustic putdown to other comedians: "I've heard funnier stuff than that on the frost-warning broadcast."

But the esteem and the importance of the Weather Bureau's frost warning service are best summarized by this excerpt from the program, "At home with Lionel Barrymore," released over KFI on Friday, June 15, 1951:

". . . and that's what everyone in radio is trying to do—boost their Hooper. So right now, I want to talk about a certain program that beats us all, a show with the highest popularity rating in the listening area. It costs practically nothing and has yet to involve a nervous breakdown. It consists of one man who has no music, and he never cracks a joke. He broadcasts for as long, or as short a time as he needs, and the most sobering fact of all is the material this man uses. All he ever says is Pacoima 26, Saugus 23, Etiwanda 24, Dew Point 15. He reads lists of towns followed by an announcement of lowest possible temperatures for each area. No dramatic story of the eternal triangle, no gleeful suspense while we wait for the comedian to fall down stairs. Just Pacoima 27 and Saugus 23. Roll-call read without passion, and yet it is the perfect mating of program and audience—the perfect marriage of what is said with who wants to hear it. Something that the greatest minds in radio have been striving to obtain for 20 years, and the man who discovered it—he is the chap who reads the frost warnings to the orange growers in California."

The only difference between the Pomona operation and the service performed from other Weather Bureau offices is that Pomona-based men are detailed to frost districts away from the Pomona headquarters. California winter districts operated from Pomona are located at El Centro, Coachella, Escondido, Orange, Corona, Redlands, Upland, Santa Paula, Lindsay, and Chico. With the same service, but operated from the local first-order Weather Bureau offices, there are frost districts at Fresno, Bakersfield, Yuma, and Phoenix.

Following the winter season, Pomona men are detailed to spring frost districts at Tehachapi, Hollister, Napa, and Lakeport, California; Medford, Oregon; and Okanogan, Washington. The Portland Weather Bureau Forecast Office details a man to operate the Hood River District, and the Boise, Idaho, Weather Bureau Office sends a man to operate the spring district at Fruitland. Spring districts served by local first-order stations are located at Wenatchee, Yakima, and Walla Walla, Washington. WBO Eugene, Oregon, provides a frost service; and Weather Bureau frost specialists at WBOs Sacramento, Fresno, Bakersfield, Pomona, Yuma, and Phoenix operate nearby spring frost districts. Technical direction of the Western Region's frost program is under the supervision of the Meteorologist in Charge at Pomona, covering some 28 districts with total value of frost-sensitive crops in excess of one billion dollars.

Winter and spring frost districts operated by Pomona meteorologists are one-man operations seven days a week, November through February, then March through May. The routine is rigorous. A typical day might be illustrated by the Coachella District. The Weather Bureau office is small, but neat and well lighted. A Service C teletypewriter, a microbarograph, a distance thermograph, two telephone tape recorders, an amplifier, and a microphone make up the office equipment.

The day begins at 5:30 a.m. The teletypewriter is cleared, a weather map is entered and analyzed for the area west of the Mississippi, western Canada, Alaska, and the Pacific Ocean area to about 160°W. Small upper-air charts are made for the 850-, 700-, and 500-millibar levels from the UXUS data. By 6:30 a.m., a forecast is prepared and put on the telephone recorders. This forecast consists of the preliminary temperature estimates for the following morning, a 24- to 48-hour forecast, and the five-day outlook when available.

At 7:25, a radio broadcast is made over

two of the valley stations, and at 7:30 this same broadcast is phoned to a radio station at Blythe, California, for the Palo Verde Valley. These broadcasts are from two to three minutes' duration, and, in addition to the forecasts, they feature local and national weather, and a map description, as well as the outlook from data available on Service C. By 8 o'clock the morning's office work is done.

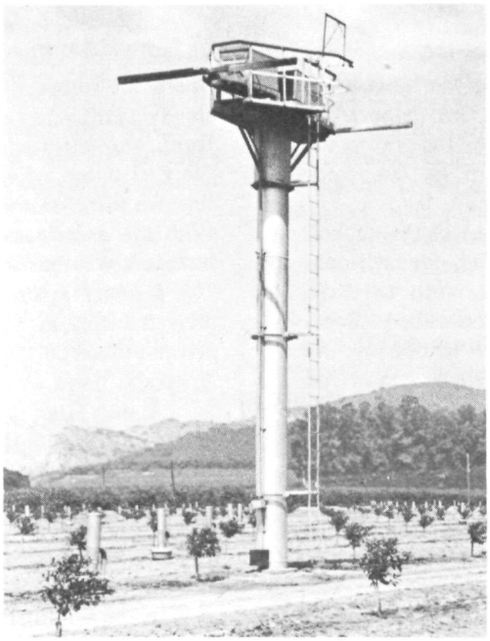
On two days of the week, the meteorologist will "ride route," changing thermograph sheets and resetting thermometers. In the process, he will make contact with growers and packing house managers. The Coachella Valley frost district has 23 key temperature stations, and the Palo Verde Valley has three. These stations are in selected locations in citrus, grape, and vegetable plots. Making the rounds requires three to four hours.

On other days, the work is varied. There are temperature reports to be kept up to date, instruments to be checked and serviced, and growers to be contacted. By 3:30 p.m., the meteorologist is back in his office preparing for the evening's forecasts. Prognostic positions of fronts and pressure systems are plotted on the evening map, and at 4 o'clock a weather observation is made that will serve as the basis of his temperature estimates.

From the Donnel Formula, originated around 1915, to the formula developed by Floyd Young, it has been known that there is a close relationship between dewpoint and humidity in the late afternoon and the following morning's minimum temperature. The hydrometric formula still serves as a guide in making the temperature estimates.

The 4 o'clock map is entered and analyzed, and at 4:45 a short radio broadcast is made outlining the forecast and giving maximum temperatures from stations around the valley. This is done, because 5 o'clock is the latest that a grower can phone in for irrigation water for frost protection. At 6:30 p.m., the meteorologist phones Pomona with his temperature estimates for eight temperature stations, which will be included in the Pomona broadcast over KFI. At 6:50 the meteorologist makes his radio broadcast over the two local stations. Forecasts and temperature estimates are put on the telephone recorders with one-minute tapes. These recordings can then be called by growers as needed. On cold nights the lines to these recorders become overloaded, and there is often a long delay before getting through. By 7:30, the office work is finished and the meteorologist goes home—often to answer phone calls from growers.

With some variation this routine is carried out at all of our one-man operations; and, except for the work and the forecast responsibility being shared by two meteorologists at regular Weather Bureau offices, the pattern is much the same. In many districts, growers assist in the operation by reading thermometers, taking observations, and phoning the information to the fruit-frost specialist. In all cases, a close relationship exists between the user and the forecaster. There are few forecast positions in the Weather Bureau that provide the challenge or the sense of personal involvement that the Fruit-Frost Service does.



Winter districts are concerned with citrus, lettuce, corn, and tomatoes; the spring forecasts in those same districts are concerned with tender spring vegetables, grapes, and so on. The Frost-Warning Service provides growers in California, Washington, and Oregon with forecasts for pears, cherries, peaches, grapes, prunes, walnuts, and almonds. In these states, many other frost-sensitive crops are grown. In addition to minimum-temperature forecasting, the fruit-frost specialist furnishes forecasts of precipitation, winds, maximum temperatures, humidity, and sky conditions.

In the twenties and thirties men on assignment to Pomona were detailed to relief work during the summer months. They reported to one-man Weather Bureau offices to relieve, for a few weeks, the regular Weather Bureau observer. It was in the 1930's, with the expansion of the fire-weather program in the Western Region, that fruit-frost meteorologists were first sent on fire-weather detail.

At the present time, nine of the Pomona forecasters are detailed to fire-weather assignments in the Western Region during the summer months. All of the Pomona personnel, with the exception of the Meteorologist in Charge, have winter, spring, or fire-weather assignments. Of our present 14-man staff, eight men have two assignments, and five men have three assignments each year. These are not easy, for it means uprooting families, searching for housing, and providing a weather service to a community of growers. One of the Pomona men, Harold Rathbone, lays claim to having substituted in over 40 states, and for a number of years was carried on the Weather Bureau's rolls as "unassigned."

The Pomona office has never had a backlog of applicants for frost work. And yet, men engaged in this work have found it extremely rewarding. Our roster has included the names of D. M. Little, Assistant Bureau Chief; Dr. Woodrow Jacobs, Director of EDS; Erle Hardy, Jack Thompson, and many more, and all will tell you that their years in the Fruit-Frost Service were among the most enjoyable in the Weather Bureau. This can be only because of the close relationship between the forecaster and the user—the knowledge that the forecasts are valued and appreciated. □

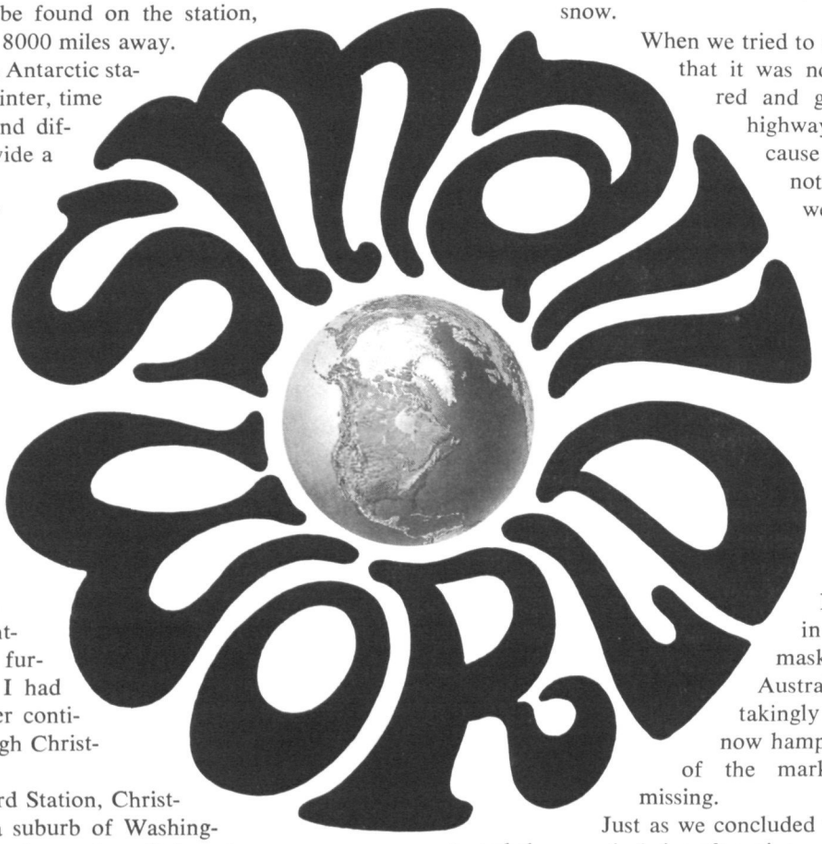
Orchard supervisors plan operations to prevent damage to tender peach blossoms (top) or to avoid the loss of fruit nearly ready for the market (center). (Left) Wind machines and smudge pots protect year-old fruit trees from frost damage.

By WILLIAM O. DAVIS
Chief, ESSA Plans and Requirements Division

Nowhere is the principle of the unity of environmental science on which ESSA was founded more clearly evident than at Byrd Station, Antarctica.

Here I found ESSA in microcosm—specialists in meteorology, seismology, geomagnetism, glaciology, telecommunications, and aeronomy. All but one of these specialties were represented by ESSA personnel who were working closely together with a great deal of intercommunication and mutual assistance.

It must be said at once that conditions at Byrd Station are conducive to this type of cooperation and exchange of information. First of all, there are normally only one or two specialists in a given field on the station, at least in the winter, and most jobs from time to time require more than one or two pairs of hands. Second, when a problem arises with instruments or communications, if help cannot be found on the station, the nearest assistance may be 8000 miles away. Third, in the remoteness of an Antarctic station during the long austral winter, time may hang heavy, and new and different types of challenge provide a stimulating change.



One cannot completely get the feeling of the true remoteness of Antarctica merely from looking at a map or reading a story. But before I reached Byrd Station on what was to be a brief staff visit, I had found it a tangible physical thing. After three days and twenty hours of flight in a Military Airlift Command C-141 jet transport, I had only arrived in Christchurch, New Zealand, the staging area for our Antarctic bases. Already, I felt further away from home than I had ever felt in visits to the other continents of the earth, even though Christchurch is a charming city.

By the time I got to Byrd Station, Christchurch seemed almost like a suburb of Washington. After a day of indoctrination and outfitting, the passengers for the next flight to McMurdo Base in Antarctica gathered in the clothing warehouse, where we "suited up" for the trip in the specialized clothing developed for the program by the Arctic Institute of North America.

All of our civilized clothing was left behind in the locker, and like astronauts approaching the launch pad, we self-consciously filed through customs and out on the ramp to climb aboard an aging Navy C-121 Super Constellation called "Pegasus." Some 2500 miles and ten hours later, we landed on the ice at Williams Field near McMurdo Base, feeling very much as though we had arrived on the moon.

The trip had been arranged for me by Dr. Tom Jones of the National Science Foundation, Director of the Division of Environmental Sciences and of the United States Antarctic Research Program (USARP) managed by that agency. The Foundation coordinates all United States scientific activities in Antarctica and funds all programs there, including ESSA's. The purpose of my visit was to gain understanding of ESSA's programs in Antarctica and the problems associated with performing research under polar conditions, so as to provide background for our planning activities and cooperation with NSF.

My original plan was to spend a few days at each of the stations in Antarctica having ESSA programs. Since this was late October, which is early spring in Antarctica, the South Pole station was not yet open, because severe cold made aircraft operations extremely hazardous; so, I elected to go first to Byrd Station, some 850 miles south and east of McMurdo.

On the first attempt to depart McMurdo, I learned personally that Antarctica is indeed a primitive and dangerous continent. Halfway from McMurdo Base to Williams Field where we would catch the airplane, our truck was caught in a sudden windstorm which reduced visibility to about 50 feet in blowing snow.

When we tried to return to base, we discovered that it was no longer possible to see the red and green flags which mark the highway across the ice, and that because of the low visibility it was not even possible to be sure that we were traveling in a straight line.

It was necessary for someone to walk in front of the truck, finding the flags one by one while never losing sight of the vehicle behind, and I was elected. Since the temperature was well below zero and the wind blowing 25 to 30 knots, I had ample opportunity to test the effectiveness of Antarctic clothing. Looking like men from Mars in our balaclavas and face masks, Dr. Philip Sulzberger of Australia and I led the truck painstakingly back towards McMurdo, now hampered by the fact that several of the marker flags were apparently missing.

Just as we concluded we were thoroughly lost, we heard the sound of aircraft engines and realized that a plane was slowly taxiing towards us. Fortunately, he too had a walker in front, and after exchanging greetings we directed him towards the fuel dump which we had just left and discovered from him that we were on the taxi strip, not the road as we had thought! With this information we were able to retrace our steps and return safely to base.

I never again took Antarctica for granted. After we had arrived safely at McMurdo, I was somewhat startled when the driver remarked that he was happy to have had an experienced Antarctic hand along, since this was his first day on the ice!

A day later, after flying over 850 miles of snow and ice in a Navy C-130 Hercules, Dr. Sulzberger and I finally arrived at Byrd Station. Everyone has seen pictures of Byrd—a few antenna masts and bleak structures above ground and tunnels filled with laboratories and quarters below—but a true appreciation of the station can be had only after the six-day adventure one must go through to reach it.

In the comfortable science building, surrounded by appara-

A group of us drove in a Trackmaster to old Byrd Station.

tus interspersed with travel posters and assorted pinups, Dr. Sulzberger and I were briefed by the Station Scientific Leader, ESSA's Gregory Richter, on the programs underway at Byrd. We had arrived only a week or so after the opening of the station after the long winter, so that scientific personnel from the previous winter were still on board, and most of the staff for the next had arrived.

Mr. Richter had been on the ice for nearly 13 months, and like all of the others of the winter crew was eager to return home, but his enthusiasm was strong for his work and it was important to him that his successor be fully indoctrinated before he left for home. I found this to be an almost universal attitude.

Assisted by Steve Andrews from Stanford University, next year's Station Scientific Leader, he outlined the USARP scientific projects at Byrd Station. With the exception of oceanography, most areas of environmental science were represented. Projects included a seismology and geomagnetism program operated by ESSA's Coast and Geodetic Survey, a tripartite seismograph array operated by Stanford Research Institute, the ESSA-Weather Bureau meteorology program, several programs in aeronomy and telecommunications performed by the ESSA Research Laboratories, a group of telecommunications projects performed by Stanford University personnel, a University of Washington telecommunications project, and the Army's glaciology program.

Stored in tunnels under the snow are enough food and fuel for the base to sustain both life and operations for up to three years in the event that unforeseen difficulties should prevent resupply. In addition, the base is kept self-sufficient through its own power-generating system, a well-equipped garage and utility shop, and a versatile communication center with facilities for everything from code communications to radio-facsimile. Adjoining the communication center is a ham shack, where facilities are provided for personal calls home during the long winter months by way of phone patches performed by radio amateurs.

The dining hall was first class with food both plentiful and well-prepared. Steaks and lobster were no strangers to the table. Fresh water, always a problem in the Antarctic, is produced by melting snow in the cooling system of the diesel electric generators, and everyone on the station, including the Officer-in-Charge and the Station Scientific Leader, takes his turn in shoveling snow to provide it.

Quarters are warm and comfortable, and there is an excellent library and club room provided for off-duty hours, The science building is the hub of most USARP activities, equipped with an excellent photographic darkroom which is available for hobby purposes as well as official use, a hi-fi system and large supply of records, and comfortable chairs and couches which provide a warm and cheerful atmosphere during the evening bull sessions.

We visited first the deep-core drilling rig operated by Dr. Lyle Hansen of the Army's Terrestrial Sciences Center. This is a summer project, and Dr. Hansen and his assistant, Emmett Herbst of Holmes and Narver, Inc., were thawing out the massive rig preparatory to beginning operations when the rest of the summer staff arrived. Last year, a team of nine successfully drilled through the glacial ice to a depth of 7100 feet, when bedrock was encountered more than 2000 feet below sea level. Traces of volcanic ash, rock debris, granite, and shale were recovered. The ice at the bottom is estimated to be 40,000 years old.

This summer the team will drill another 50 to 100 feet into the rock to obtain geological cores. Analysis of the core samples will be largely performed at Byrd Station, because of the virtual impossibility of transporting the huge volume outside. Temperature sampling and gas analysis are used to determine the climatological history of the region with remarkable accuracy. When the results at Byrd Station are compared with similar findings from a core taken at Camp Century in Greenland, a great deal can be determined concerning the earth's climatological history.

The ESSA-Weather Bureau program was headed by Greg Richter who served as Meteorologist-in-Charge as well as Station Scientific Leader. During the winter season, he had been assisted by Mike Kramer, Senior Meteorological Technician, and George Thode, Senior Electronics Technician. Chuck Dziura, who had arrived just before I did, will be Meteorologist-in-Charge during the next winter season, and will be the only Weather Bureau representative there during the season. In addition, since during the summer the Weather Bureau station must provide meteorological support to Navy flight operations in Antarctica, its complement was augmented by two summer personnel, Perry Steinman and Charles Dake.

The goal of meteorological research in Antarctica is to gain a better understanding of the relationship of the continent to the weather regimes of the Southern Hemisphere and the world. The objectives of the ESSA program are to monitor changes of meteorological parameters and provide data for research, develop the climatology of Antarctica, and provide meteorological information for the International Antarctic Meteorological Research Center in Australia and for the World Meteorological Organization.

Regular surface observations include temperature and pressure, wind direction and speed, cloud types, precipitation, blowing snow, and other phenomena. These observations are made at three- and six-hour intervals. The temperature, wind fields, total ozone distribution, and radiation data in the free atmosphere are measured by means of radiosondes, a Dobson spectrophotometer, and radiometersonde flights. Various individuals, led by their own curiosity, used the basic data for further study. For example, bearded Mike Kramer was looking for possible correlations between magnetic and ionospheric events and sudden stratospheric warming over Antarctica. Since the magnetic and ionospheric data were available at the station, he had an unusual opportunity to review all these data in very nearly real time.

ESSA-Coast and Geodetic Survey programs in seismology and geomagnetism were carried out during the winter by Al Buennagel. Next winter they will be continued by Bob Mallis, who two years ago ran the same program at the South Pole for the

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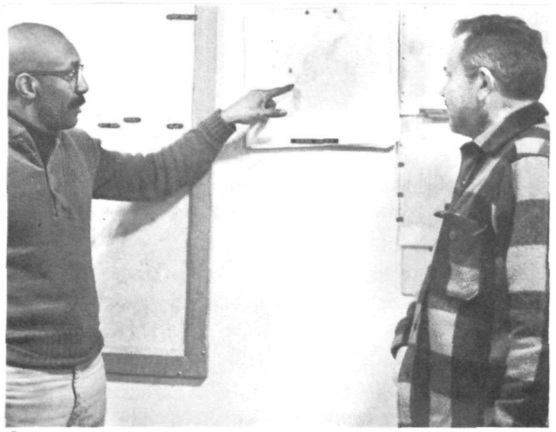

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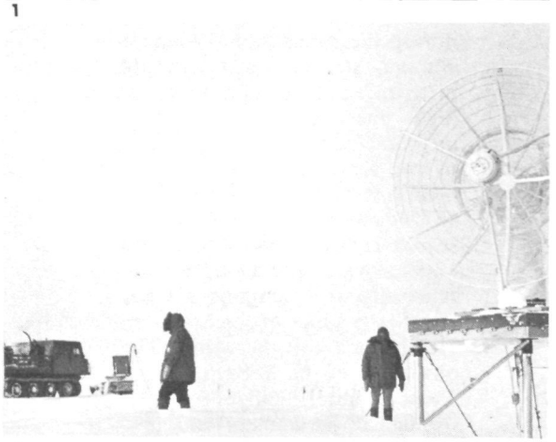

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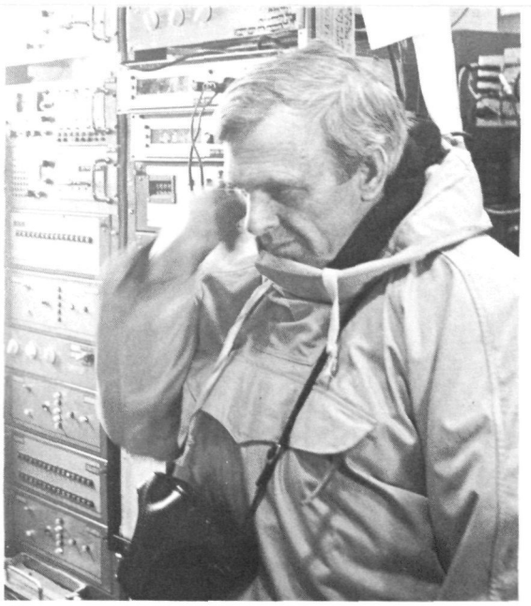

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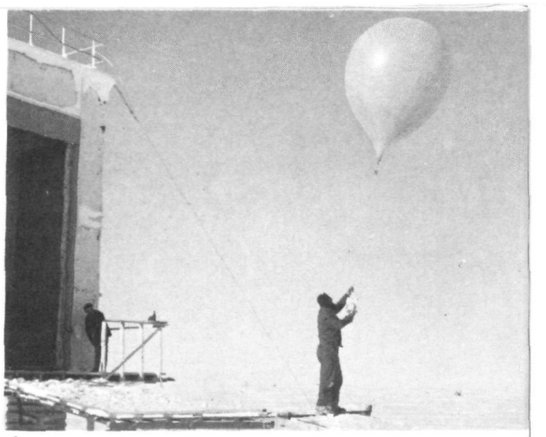

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1. Gregory Richter was Byrd Station Scientific Leader and Meteorologist in Charge at the time of Dr. Davis' visit. 2. A trip to the remote VLF station. 3. Deep beneath the snow in the VLF station, Dr. Sulzberger listens to the signal from a satellite. 4. George Thode, Senior Electronics Technician at Byrd Station, prepares for balloon launch. 5. Navy C-121 "Pegasus" discharges passengers at McMurdo after flight from Christchurch.

Survey. This program collects continuous magnetic data and records information on earthquake activity as part of the World-Wide Standard Seismograph Network, which provides data for the location of epicenters and study of the structure of the earth.

Another program in seismology, utilizing a tripartite array to measure travel times in the ice, was operated last winter by Bill Isherwood for Stanford Research Institute. Next winter, this experiment will be continued—to the extent that time permits—by Mallis. To minimize disturbances due to human activity, the seismometer is located at the end of half a mile of tunnel from the main laboratory area, and the magnetometer is positioned nearly as far away. These tunnels, like all of the tunnels at Byrd Station, are walled with snow and are stabilized at a temperature of approximately 0 degrees F.

At the beginning of my visit, I carefully donned my parka and thermal boots to visit the facilities. After I had been at Byrd for several days, like everybody else, I seldom bothered to wear more than a wool shirt when going about in the comparatively warm tunnels.

The ESSA Research Laboratories' program at Byrd Station was operated by Fred Cady and included a variety of data collection and experiments covering both ionospheric activity and various aspects of telecommunications. Fred's successor, Bob Mutel, had not yet arrived when I left. The program included the study of Very Low Frequency propagation and the absorption of radio waves at the conjugate stations Byrd-Great Whale River. A photometer was used for the study of particle-wave disturbances in the outer magnetosphere. In addition, a number of other smaller experiments were carried out at this ERL station approximately a mile from the main Byrd Station. To help with equipment repair and calibration, Dick Przywitowski of ESSA-ERL, who had been Station Scientific Leader at McMurdo for the winter, had delayed his departure for the States and joined Fred at Byrd for several weeks.

A related Stanford University program was investigating the correlation of VLF propagation and other geophysical phenomena, including both natural and artificially produced VLF signals. This included the readout of satellite measurements of VLF and related ionospheric phenomena from the OGO and ALOUETTE satellites.

A related experiment being performed by Jim Hannah of the University of Washington involved the use of the 21-mile Longwire Antenna Facility, 12 miles northwest of Byrd Station. Jim was injured at this station during the middle of a windstorm which had reduced visibility to 100 feet or less, and in the absence of the station doctor a Navy medical corpsman, accompanied by Greg Richter, braved the elements in a Snowcat to go and patch him up and bring him back to the station. His wound, which had been caused by running into a lab rack inadvertently, was superficial but required sutures, and I was impressed at the ability of the corpsman.

Living and working at Byrd Station brings many opportunities for learning about the other fellow's specialty and even helping him with his work from time to time. There are frequent informal colloquia in the science building after dinner where one specialist or another discusses aspects of his work with those who are present—sometimes to the crackle of depressurizing ice from deep-core samples, the standard source of ice cubes on the base.

There is extensive use of common facilities, such as the darkroom or the electronic lab. There is always a need for an extra hand from time to time. I remember the day we visited the Stanford University VLF Lab. Mike Olsson of Stanford was simultaneously recording signals from both the OGO and ALOUETTE satellites, monitoring antenna tracking of both systems, while also keeping an eye on another ten channels or so of information.

I was originally scheduled to leave Byrd the morning of my third day at the station, in order to visit other ESSA activities in Antarctica, but as it turned out, I spent eight days there due largely to an event which probably taught me more about life and science in Antarctica than I could possibly have learned from a routine visit.

In temperate latitudes, a magnetic storm is an environmental event which is principally of scientific interest, aside from the inconvenience it may cause to the comparatively few systems which depend upon ionospheric telecommunication. In Antarctica, so close to the magnetic pole, such a storm has immediate and practical impact. The first effect was that the airplane which was to take us back to McMurdo did not arrive, since flight operations are not conducted except in case of emergency in the absence of ground-to-ground communications. Secondly, in the absence of communications, there was no way to send messages even to McMurdo, much less to the States, in order to make a change of plans. Finally,

the call home by amateur radio to my family, which I had been planning to make to let them know of my safe arrival, could no longer be made.

Now we were truly on our own. It was three days before communications were resumed, and then weather prevented aircraft operations for another two days. As it turned out, after overcoming the initial frustration, these five days proved to be the most valuable part of the trip.

There was plenty to do on the station. In the midst of the magnetic storm, there was data to look at from a variety of sensors. The recorder on the magnetometer, which normally progresses sedately at an inch an hour, was literally flinging red ink across the laboratory in its violent response to the storm. The ionosonde recordings or "ionograms" showed 100 percent absorption of radio signals during a large portion of the period. Also available were magnetotelluric current data, seismograph recordings, and upper-air soundings, all of which were carefully scrutinized for any sign of correlation with the magnetic disturbance.

It was not all work, of course. One day, a group of us drove in a Trackmaster over to old Byrd Station, approximately six miles away. This station, abandoned about six years ago, was originally on the surface, but is now buried beneath approximately 30 feet of snow. The only way in was to dig about 5 feet to uncover an old escape hatch. We climbed down a rope ladder to the floor of the old station. Using gasoline lanterns, we crept under sagging beams and stepped over pressure ridges in the floor to investigate.

Because the cost of removing equipment would have been prohibitive, the station remained essentially as it was the day it was abandoned, deep-frozen at a perpetual 30 degrees below zero F. In the kitchen hung a perfectly preserved leg of lamb, and on the counter were several loaves of bread, frozen solid. In the wardroom on the bar were glasses still foamy from the last glass of beer, not even covered with dust, since there is no dust in Antarctica, although a slight hoar frost covered everything. We could hear the creaking of beams in the adjoining rooms giving way to enormous pressure of snow and ice. There was little doubt that the station will not be visited much longer before it is closed off, perhaps to appear again only in 100,000 years encased in an iceberg afloat in the Ross Sea.

(Left) In the abandoned Byrd Station, 30 feet under the snow, the foam was still on the beer glasses. (Top) Mike Kramer had a shave and haircut before leaving Antarctica.

Thanks to the magnetic storm and the windstorm which followed, I was not able to complete my visits to the South Pole and to other Antarctic stations, but was forced by my schedule to return to the United States immediately upon leaving Byrd Station. Although I can only speak in any depth from direct experience about that one station, I am sure conditions are very similar at the other locations on the ice.

In a way, I was almost glad that the delay had taken place, because through it I was able to gain real understanding of what it was like to live and work at an isolated station. I don't think I have ever felt so strongly the essential oneness of environmental science as I did during the two storms at Byrd Station. The meteorological storm developing immediately after the magnetic storm probably was pure coincidence, but to those of us there it seemed almost intuitive that there ought to be a relation between the two events. Perhaps there is, perhaps there isn't; but if such interactions are ever studied, Antarctica is certainly a place to do it.

Antarctica is a readymade geophysical laboratory where boundary conditions are comparatively simple. Since it never rains over much of the continent and virtually all water exists in frozen form, heat-balance studies are comparatively simple, for example. There exist huge areas of synoptic size where the radiation properties and other surface characteristics are very nearly uniform, and which may from time to time be covered by a single air mass.

There are unique advantages to other environmental science disciplines in Antarctica as well. For example, since there is virtually no seismic activity on the continent, the signals from distant earthquakes may be received from all over the world almost free of local disturbance. The South Magnetic Pole and Geomagnetic Pole are both located in Antarctica, and the southern auroral zone provides a readymade opportunity for ionospheric studies in the winter, while the sun is observable twenty-four hours a day during the austral summer.

Byrd Station was in a very real sense a "pilot plant" for the ESSA of the future, quite apart from the importance of Antarctic data in completing our understanding of the behavior of the environment of the earth as a whole.

Antarctica has been internationalized by treaty, and is one of the few places on earth where true international cooperation is real and continuing. As such it represents another kind of "pilot plant" for nations. Dr. Philip Sulzberger, my traveling companion, was in charge of Antarctic scientific programs for the Australian Ministry of Supply. At McMurdo, I attended a seminar presented by the resident Soviet geologist. Similarly, U. S. scientists are stationed at Russian and other bases. In fact, because of the high level of satellite triangulation activity this year, ESSA will have more personnel on foreign bases next winter than on our own Antarctic stations!

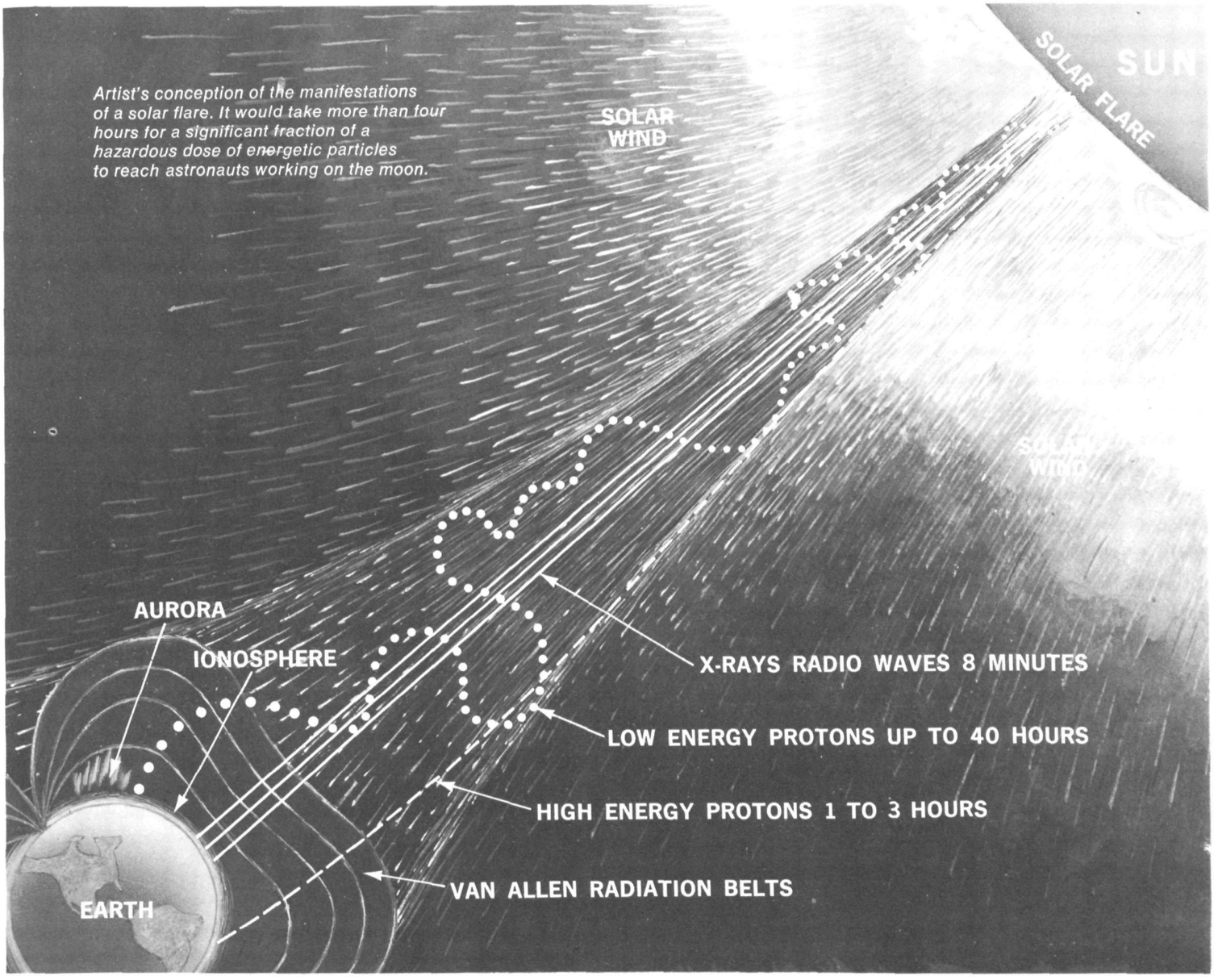
Another factor which struck me strongly was the comparative youth of our personnel in Antarctica, in the light of the responsibilities they bore. It reminded me of World War II, where 24-year-old squadron commanders made life-and-death decisions. Here again is an opportunity for a man in the early stages of his career to find an opportunity for achievement and responsibility along with more than a touch of adventure.

When you read this, it will be April and the long Antarctic winter will have set in. Our ESSA people, along with their colleagues from other agencies and other nations, will now be totally isolated physically, left on their own resources until next October or November. From the lessons they will learn in the pilot plant—the small world of Antarctica—let us hope that we may someday not only be able to better describe and forecast man's global environment, but also to develop at full scale the kind of cooperation between scientific disciplines and between nations that they are pioneering "on the ice." □

When an astronaut sets foot on the moon with only his space suit between him and solar radiation, his protection will be virtually nil.

BY RALPH SEGMAN
ESSA Research Laboratories

essa will help protect american spacemen WHEN WE LAND ON THE MOON



Artist's conception of the manifestations of a solar flare. It would take more than four hours for a significant fraction of a hazardous dose of energetic particles to reach astronauts working on the moon.

Ordinarily, people don't worry about solar flares that erupt out of the sun and accelerate energetic particles into space. Sometimes, when the earth happens to be in the flare's path, the onrushing particles disturb the upper atmosphere, causing interference with long-distance radio communications and lighting up the northern and southern skies with splendid auroral displays. These are technical and scientific problems for specialists who are paid to worry about them.

Now, however, with Apollo astronauts preparing for a landing and egress, as the National Aeronautics and Space Administration calls it, on the surface of the moon, away from the protection of the earth's magnetosphere, solar flares have become a potential hazard to humans. The chance of a hazardous flare occurring while an astronaut is vulnerable is quite small, but not negligible.

Out of respect for this small but real possibility of damaging solar radiation, three federal agencies—NASA, ESSA, and the Air Force—have cooperatively organized an elaborate system for forecasting and observing solar flares and their emissions of energetic particles. The system, operated by the NASA Manned Spacecraft Center, is called SPAN for Solar Particle Alert Network. The Space Disturbance Forecast Center of the ESSA Research Laboratories in Boulder, Colorado, has had a major role in SPAN's development and operation.

Visually, solar flares are sudden intense brightenings in the vicinity of magnetically complex regions of the sun. The visible brightenings are accompanied by x-rays, radio waves, plasma clouds, and energetic protons. Radiation from solar flares can disrupt high-frequency radio and long-distance cable systems on the earth; black out radio communications in the polar regions; injure delicate sensors, solar cells, and other precision instrumentation aboard unmanned spacecraft; fog photographic film on satellites; and can occasionally affect long-distance power transmission lines. Energetic protons constitute the chief radiation hazard faced by astronauts when they are outside the protective walls of their spacecraft.

The frequency of occurrence of solar flares gradually increases and decreases in an 11-year cycle. The sun is presently near a cyclical peak. Although these cycles have been observed for about 200 years, no one can explain their cause. They were

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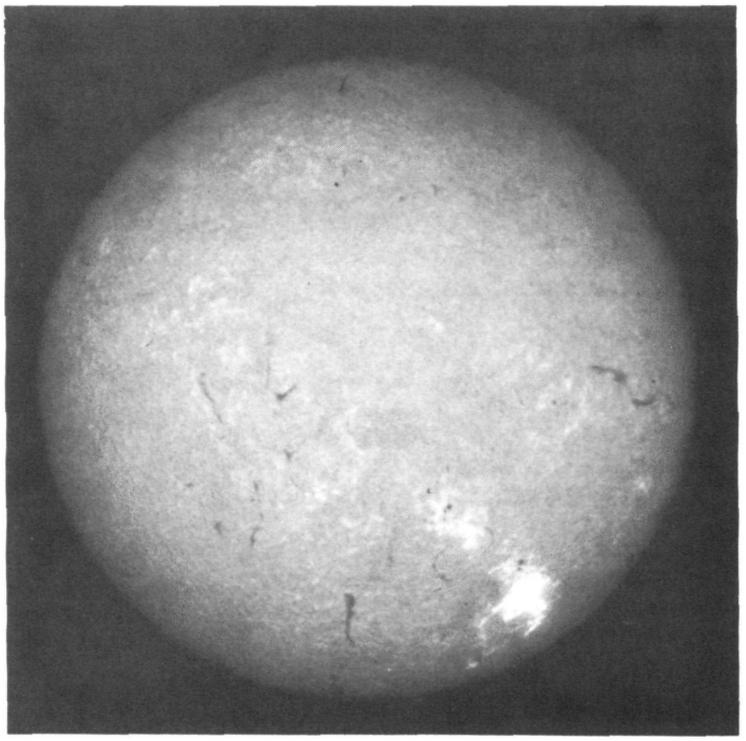


Visually, solar flares are sudden intense brightenings in the vicinity of magnetically complex regions of the sun.

Patrick S. McIntosh, solar astronomer for ESSA's Space Disturbance Forecast Center, watches for sudden brightening of the sun.

WHEN WE LAND ON THE MOON *continued*

first recognized by the simple counting of visible sunspots, which are related to flares. Plages (bright regions visible in hydrogen light) and radio emissions, both correlated with sunspot groups, also increase during solar maximum.

While the process is not entirely clear, according to Robert Doeker, Space Disturbance Forecast Services chief, scientists are aware that complex clusters of sunspots are accompanied by interacting magnetic fields that may lead to flare outbursts. The largest known flares have extended over as much as two billion square miles of the sun's surface—ten times the area of the earth's surface.

The sun does not behave with an easily defined logic. At times a flare may appear without warning. Sometimes a flare will emit a comparatively dense plasma cloud that will reach earth in one to three days. At other times, the ionized cloud will be preceded by a stream of energetic protons which may reach our planet in 20 minutes. In the past 11 years, a complete solar cycle, proton emissions were detected in about 100 of a total of some 2,000 large flares.

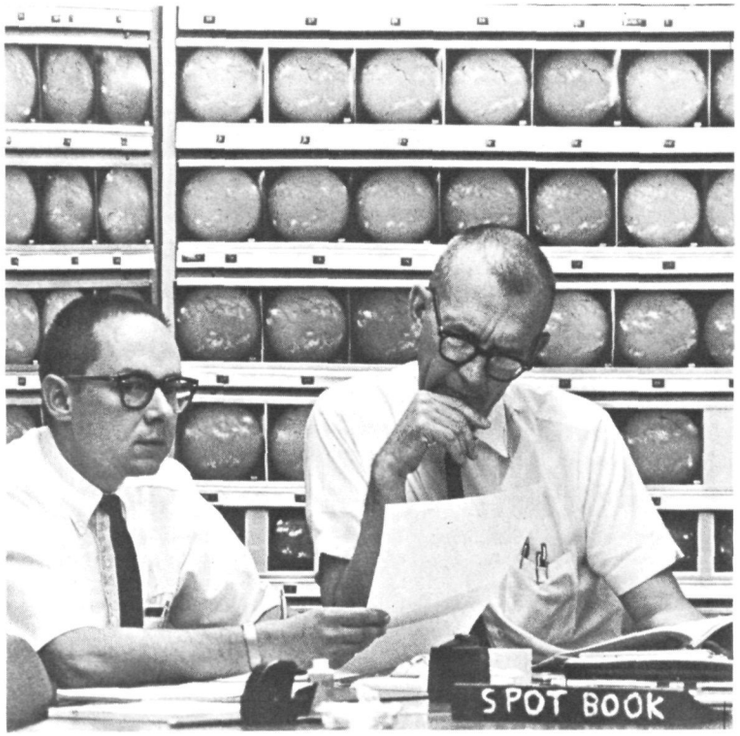
Although the Apollo 8 astronauts were heavily shielded in their command-and-service module and had little to fear from solar flares, their lunar orbital flight last December was occasion for the first exercise of the SPAN system under full field conditions. Later this year, when an astronaut sets foot on the moon with only his space suit between him and solar radiation, his protection against energetic particles will be virtually nil. SPAN and other observatories of SDFC and the Air Force will have the critical role of alerting Houston's mission control center of the occurrence of potentially hazardous streams of energetic particles accelerated by solar flares.

The SPAN system consists of seven solar observatories, operated cooperatively by NASA, the Air Force, and SDFC, and located at Houston; Canary Islands; Carnarvon and Culgoora, Australia; Hawaii; Tehran; and Boulder. (Australia operates the Culgoora station.) The geographic locations were selected chiefly to provide 24-hour optical and radio coverage of the sun. All seven have optical telescopes for observing the sun in hydrogen-alpha light, and the Canary, Houston, and Carnarvon stations also operate radio telescopes. SDFC-trained observers man the Boulder, Culgoora, Canary, and Carnarvon instruments.

When a flare erupts, at least one SPAN site detects it when the light and radio waves reach the earth about eight minutes following the occurrence. How this information gets to Apollo Mission Control in Houston is a complex and diverse communications process. Here is the process in the case of Boulder making the initial observation.

Joseph Sutorik, at his telescope inside a white-domed ESSA observatory on the roof of the Radio Building, sees the flare developing in red hydrogen light as a sudden brightening on the solar disc. It rapidly grows, and Sutorik telephones forecaster Bruce Renneke in the forecast center on the floor below. Renneke logs in the information and passes it along to Donald Baker, one of SDFC's forecasters.

After analyzing the data, Baker decides that the Apollo Mission Control Center at Houston should know about it. He



Every six hours, the Center issues forecasts of solar activity. Dale Bucknam (left) and Roger Olson keep a "weather eye" on the sun.

If the astronauts are in danger of severe radiation exposure, the information is relayed to Apollo Mission Control in Houston, Texas.

prepares a message for teletypewriter operator Frank Heffentrager to send on an urgent basis through the Solar Flare Reporting Network at Tinker Air Force Base, Oklahoma, to NASA's Goddard Space Flight Center, Greenbelt, Maryland. The message also includes x-ray, neutron, proton, ionospheric, and other data from SDFC's Global Solar Flare Patrol and Space Environment Monitoring System, which are not part of the SPAN system although they have some common facilities. Goddard relays the data via the NASA Communications System to the Space Environment Console at Apollo Mission Control. Baker meanwhile has contacted the Space Environment Console on the Boulder-Houston hot line with a fast summary of the situation.

The Space Environment Console is located in the Weather Support Room together with the Houston section of ESSA's Spaceflight Meteorology Group. It is a three-place arrangement, manned by NASA personnel from the Flight Control Division, the Space Physics Division, and the medical team. The flight control man is responsible for the operation of the console. Incoming data is analyzed by the space physics representative and discussed with the medical man. Most of the time their function is a negative one; that is, they anticipate no problems and the space environment data does not pass beyond their console.

If, however, they suspect that the astronauts are in danger of severe radiation exposure, the information is relayed to the flight surgeon's console in the central mission control room. The flight surgeon must then decide whether the event is significant enough to inform the mission director, who is occupied with far too many flight control matters to be bothered with noncritical information.

Should a hazardous condition exist, the Apollo mission director would order a change in the "mission profile." For example, an astronaut collecting rocks on the lunar surface might be ordered to take shelter in his lunar lander. And, depending on the flux of energetic particles, the astronauts might be forced to end the mission and hurry back to the more adequately shielded orbiting command-and-service module.

Additional data comes to the Space Environment Console and SDFC from several earth and sun satellites: Orbiting Geophysical Observatories, Orbiting Solar Observatories, Pioneers, Interplanetary Monitoring Platforms, Applications Technology Satellites, VELA, and SOLRAD. The Apollo spacecraft and the astronauts themselves are instrumented with radiation detectors; radiation dose rates are telemetered back to the console routinely every three or four hours or whenever necessary.

According to NASA, the logic of the solar flare protection system rests on the fact that it would take over four hours for a significant fraction of a hazardous dose of energetic particles to reach the astronauts. The space physics scientists feel that within four hours after flare occurrence they would have enough optical, radio, and proton flux data for the medical staff to make a good estimate of the potential danger. Then, if necessary, protective actions could be taken.

The Apollo experts are alerted to the probability of solar flares and energetic-proton emissions on a routine four-times-daily basis by SDFC and the Air Force Solar Forecast Facility.

Project Apollo is a fantastically complex enterprise, and one may wonder why the astronauts have an almost sublime confidence in a giant system that no one individual could ever understand. Perhaps it is through an awareness of the technique, the dedication, and the intellect shown by NASA and non-NASA people who operate the subsystems devoted to keeping the machinery running and keeping the astronauts safe. □

essa NEWS BEAT
U.S. DEPARTMENT OF COMMERCE ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION

Keys to extended prediction sought

BOMEX Study of Air-Sea Interaction To Begin in May

The United States, in cooperation with the Government of Barbados, is mounting a massive study of the links between sea and air. ESSA has been designated as the lead U.S. agency for the project.

The mechanism of sea-air interaction is almost unknown, yet it is the primary process which drives the atmosphere's circulation and its weather systems. Unless this process is explored and understood it will be impossible to extend weather prediction to more than a few days.

Called BOMEX—Barbados Oceanographic and Meteorological Experiment—the project is the most intensive scientific investigation ever made over a large ocean area.

In May, June, and July, 24 planes, 10 ships, several satellites, and a dozen buoys—as well as a vessel that "flips" from horizontal to vertical position—will gather data from a parcel of atmosphere and ocean covering 90,000 square miles of the Atlantic east of Barbados, and stretching vertically from an altitude of 100,000 feet to the sea floor at a depth of 18,000 feet. About 1500 people will be involved in the data-gathering program. More than 80 separate projects are included in the overall program.

BOMEX is the first of a series of large-scale research projects planned by the nations of the world under the Global Atmospheric Research Program (GARP) and directed toward the development of the World Weather Watch.

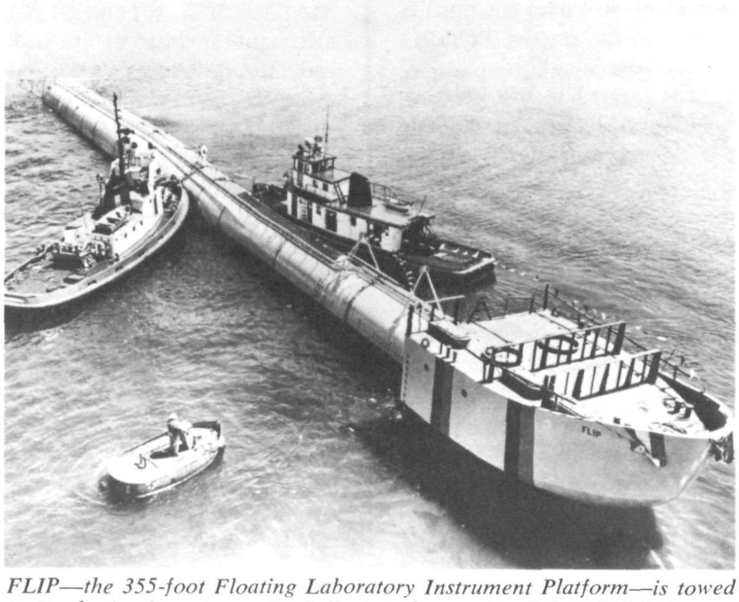
BOMEX combines the efforts of the oceanographic and meteorological scientific communities, with seven Federal departments and independent agencies, 19 universities, and seven industrial laboratories taking part. The U.S. Government participants are: Department of Commerce (Environmental Science Services Administration); Department of Defense (U.S. Air Force, U.S. Army, U.S. Navy, and the National Guard Bureau); Departpartment of the Interior (Bureau of Commercial Fisheries); Department of Transportation (U.S. Coast Guard); Atomic Energy Commission; National Aeronautics and Space Administration; and the National Science Foundation. Universities and independent research laboratories in the United States, Canada, and Barbados are involved.

Vessels participating in the experiment are: the U.S. Coast and Geodetic Survey Ships OCEANOGRAPHER, DISCOVERER, RAINIER, and MT MITCHELL; the U.S. Coast Guard Cutters ROCKAWAY, LAUREL, and COURAGEOUS; the U.S. Navy Ship GILLISS; the Bureau of Commercial Fisheries Research Vessel UNDAUNTED; and The Cape Fear Technical Institute's SS ADVANCE II.

The OCEANOGRAPHER, DISCOVERER, RAINIER, and MT. MITCHELL will be stationed at the four corners of the 5-degree-square experimental area, with the ROCKAWAY positioned in the center of the array. Special mooring systems will be installed on these five vessels to enable them to anchor at their stations, the first time that ships of this size will have anchored in 18,000 feet of water for such lengths of time.

A unique stable platform, called FLIP (Floating Laboratory Instrument Platform), is being made available for BOMEX by the U.S. Navy and Scripps Institution of Oceanography during May.

A large variety of aircraft—from ESSA's Research Flight Facility, the USAF Air Weather Service, U.S. Navy, NASA, Woods Hole Oceanographic Institution, Colorado State University, the University of California, and the National Center for Atmospheric Research—will provide frequent measurements both close to the ocean surface and at very high altitudes in the atmosphere.



FLIP—the 355-foot Floating Laboratory Instrument Platform—is towed to its destination at sea. Its ballast tanks are flooded to "flip" it to a vertical position. A 55-foot section remains above the water.

Five ESSA satellites and two Nimbus spacecraft will phototograph cloud cover over the BOMEX area.

The National Aeronautics and Space Administrations' Mississippi Test Facility is playing an important role in BOMEX—designing, installing, maintaining, and operating a computerized data-management system.

Dr. Joachim P. Kuettner, ERL Advanced Research Projects Officer, was named as Director of BOMEX following the death of Dr. Benjamin Davidson. Before joining ESSA, Dr. Kuettner played an important role in NASA's manned spaceflight program, directing the Mercury-Redstone Project and serving as Deputy Director of the Saturn-Apollo Systems Office. He became Chief Space Scientist of ESSA's National Environmental Satellite Center in 1965, and moved to the ESSA Research Laboratories in 1967.

Dr. Benjamin Davidson, who died Dec. 20 in New York City, had served as BOMEX Director since June 1968. Previously, he had been research scientist, professor of meteorology, and director of the Geophysical Sciences Laboratory at New York University.

Other BOMEX project officials include: Dr. Joshua Holland of the Atomic Energy Commission, Chief Scientist for the Air-Sea Interaction Program; Dr. Jule G. Charney of the Massachusetts Institute of Technology, Scientific Director for the study of tropical convection systems; Dr. Arnold Glaser of ESSA, coordinator of the scientific program; William S. Barney, Project Manager; and Capt. Howard S. Cole, USESSA (retired), who will be recalled to active duty to serve as Deputy Project Manager.

all in the family PERSONNEL NOTES

Dr. Robert M. White, ESSA Administrator, received the Cleveland Abbe Award—for distinguished service to atmospheric sciences by an individual—at the annual banquet of the American Meteorological Society, held in New York City. Dr. White was cited "for distinguished scientific contributions to a better understanding of the general circulation, for exceptional administrative leadership in both the private and public sectors, and for wide and imaginative statesmanship in the international aspects of the atmospheric sciences." Dr. George S. Benton, Director of ERL and President-Elect of AMS, officially assumed the presidency during the Society's annual event.

R. Adm. Allen L. Powell has been appointed Director of the Coast Survey's Atlantic Marine Center and East Coast Field Director, succeeding the late R. Adm. John C. Bull. R. Adm. Powell, former chief of the Coast Survey's Ship Construction Group, is a 1938 graduate of the University of Texas. He joined the Coast Survey in 1942, and served during World War II as a regimental survey officer. R. Adm. Powell is a 1968 recipient of the Department of Commerce Gold Medal.

James K. Huntoon, Executive Assistant in the ESSA Office of Aviation Affairs, has been named special assistant to the Director of the WB's Executive and Technical Services Staff. Mr. Huntoon will coordinate the innovation and establishment of personnel planning policies for the Weather Bureau.

Capt. Merlyn E. Natto has assumed command of the USC&GSS OCEANOGRAPHER, based at the Coast Survey's Pacific Marine Center in Seattle, Wash. A 19-year veteran of C&GS, Capt. Natto has served aboard seven other vessels, with various field parties, and at Coast Survey offices in Norfolk and Washington, D. C. He received a civil engineering degree from Iowa State University in 1949.

Joseph H. Strub, Jr., has been named meteorologist in charge of the Weather Bureau Forecast Office at the Minneapolis-St. Paul International Airport, where he had been principal assistant for the past four years. Mr. Strub entered the WB in 1947 and, in 1965, received the Department of Commerce Silver Medal for his outstanding flood warning activities.

Cdr. Eugene A. Taylor is the new commanding officer of the USC&GSS PATHFINDER. Cdr. Taylor joined the Coast Survey in 1950, after receiving a civil engineering degree from the University of Massachusetts. He recently completed graduate studies at Ohio State University. Prior to attending graduate school, Cdr. Taylor was chief of the Coast Survey's Satellite Triangulation Division. For his work in this field, he was awarded the Department of Commerce Gold Medal.

A. Glenn Jean, Jr., former chief of an ERL research section, has been appointed assistant director for engineering at the Space Disturbances Laboratory. A graduate of Vanderbilt University, he joined the Department of Commerce in 1948. Mr. Jean received the Department of Commerce Silver Medal for meritorious service in 1959.

Lt. Cdr. Ray E. Moses has assumed command of the Coast Survey's hydrographic survey vessel USC&GSS DAVIDSON. Lt. Cdr. Moses, formerly attached to the staff of the ESSA Office of Plans and Programs, joined the Coast Survey in 1958. He has served aboard the USC&GS Ships EXPLORER, SURVEYOR, and PIONEER, and also as the Coast Survey's Program Planning Officer. He is a graduate of the University of Kentucky.

Capt. Alfred C. Holmes has succeeded Cdr. George M. Poor as chief of the Coast Survey's Pacific Marine Center Operations Division. Cdr. Poor, who had been Projects Officer and Acting Operations Officer, now heads the Center's Processing Division.

Jack Murphy, forecaster in the WB's Los Angeles office since 1961, has become meteorologist in charge of the Pacific Missile Range Weather Station at Barking Sands, Kauai, Hawaii. Mr. Murphy, who holds a bachelor's degree in meteorology from the University of California, joined the Bureau in 1958 at San Francisco.

Cdr. Jack E. Guth is the new head of the Coast Survey's Ship Construction Group.

Lt. Christian Andreasen has been appointed commanding officer of the Coast Survey's wire-drag ships, the RUDE and HECK. Lt. Andreasen joined the Coast Survey in 1963 following graduation from the University of Illinois. During the past six years, he has served aboard the USC&GSS EXPLORER, with geodetic field parties, and, most recently, as executive officer of the twin vessels.

Grayson Cordell, Weather Bureau meteorologist at Havre, Mont., is the new State Climatologist for Montana.

Lt. Cdr. Gerald C. Saladin has been appointed the executive officer of the USC&GS Ship FAIRWEATHER. Lt. Cdr. Saladin was previously associated with the Research Flight Facility in Miami.

Bruce C. Barnes, supervisory meteorological technician at WBO Wake Island, has been selected official in charge of the Kahului, Maui, WB station. Mr. Barnes served for more than two years at Kahului when the station opened in 1962.

John W. Hertel has been assigned as official in charge of the Cold Bay, Alaska, station. Mr. Hertel has held OIC positions at Bethel and St. Paul Island in the WB Alaska Region and at Truk, Guam, Canton, Yap, and Pago Pago in the WB Pacific Region.

Douglas C. Dodge, who served as a Captain in the Judge Advocate General's Corps of the U. S. Army, has been appointed an ESSA Staff Attorney. His office will be located in the Gramax Building. Mr. Dodge holds a bachelor's degree from Western Michigan University and a Doctorate of Law from Wayne State University.

Ray R. Casada has been selected the official in charge of the Chattanooga, Tenn., Weather Bureau office. Mr. Casada's most recent assignment was at Tallahassee, Florida.

Gregory Stanley Richter has been appointed meteorologist in charge of the Nome, Alaska, WB station. Mr. Richter, a former Air Force weather officer, served as MIC at Byrd Station, Antarctica, as well as Station Scientific Leader from 1967 through 1968.

Earl M. Bates has been assigned to the WB's Agricultural Service Office, Corvallis, Oreg., as advisory agricultural meteorologist. Earlier assignments included Eugene and Portland, Oreg., and Walla Walla and Olympia, Wash.

Milo P. Monson has been named official in charge at WBO, Havre, Mont. Mr. Monson, who entered the WB in 1937, has served at Seattle, Portland, and Missoula.

John Hoehn has become official in charge of the Weather Bureau Office in Pago Pago, American Samoa, after serving extensive tours of duty in the Arctic and Pacific regions.

Warner L. Ecklund, ERL physicist, has been appointed to supervise the completion and operation of the Solar Proton Detection Network of the Space Disturbances Laboratory. Mr. Ecklund joined the Department of Commerce after graduation from Nebraska Wesleyan in 1959. Before joining ESSA, he conducted ionospheric research for the National Bureau of Standards. He has served as field site chief at Baie St. Paul, Quebec, and as supervisor of the Anchorage monitoring station since 1967.

Dr. Ernest K. Smith, formerly the acting Director of the Institute for Telecommunication Sciences, has been named acting Director of ERL's Office of University Relations. He is also a visiting Fellow to the Cooperative Institute for Research in the Environmental Sciences, a joint ESSA-University of Colorado venture, and a lecturer in the Department of Astro-Physics at the University. Dr. Smith joined the National Bureau of Standards in 1951, and has held several important positions in the Department's research structure.

Richard C. Kirby is the new Director of the Institute for Telecommunication Sciences. Formerly acting Deputy Director of the Institute, Mr. Kirby holds a degree in electrical engineering from the University of Minnesota. In 1965-66, he was assistant in telecommunications to the Assistant Secretary of Commerce. He has served on numerous national and international committees in the telecommunications field and, in October 1968, was awarded the Department of Commerce Gold Medal for his exceptional service.

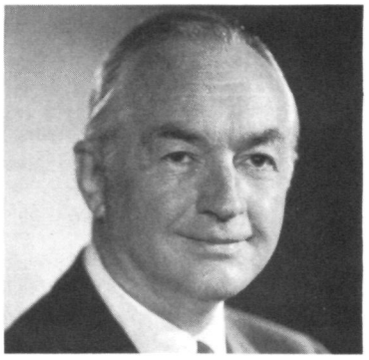
Maurice H. Stans Is New Commerce Secretary; Rocco Siciliano Appointed as Under Secretary

Maurice H. Stans became Secretary of Commerce on Jan. 22, upon appointment by President Nixon. Rocco C. Siciliano was named Under Secretary.

Secretary Stans resigned as president of Glore Forgan, Wm. R. Staats Inc., investment bankers, on becoming a Cabinet Officer. Previously he was president of Wm. R. Staats & Co., Inc., which merged into the present company. Prior to this (in 1961 and 1962), he served as vice chairman and a director of United California Bank for two years. During that period, he was also president of Western Bancorporation, Los Angeles.

The Secretary was no stranger to government when he assumed his new position. He served as Director of the Bureau of the Budget under President Eisenhower from March 1958 to January 1961. Before his appointment to this post by the President, he had been Deputy Director for six months.

Before moving to the Bureau of the Budget in September 1957, Mr. Stans had been deputy Postmaster General for two years. During his service in the Post Office Department, he took a major part in planning and directing the reorganization of the postal service and the modernization of the Department's management structure and operating practices.



Maurice H. Stans

Rocco C. Siciliano

His first experience in the federal government was in 1953, when he served on a task force which assisted the House Appropriations Committee in reviewing the federal budget for the fiscal year 1954. Subsequently, he was engaged for more than a year in a special study of postal fiscal systems and accounting practices for the Postmaster General.

Prior to 1955 he was executive partner in the national accounting firm of Alexander Grant & Company, with which he had been associated since 1928. He holds the degree of certified public accountant from eight states.

For outstanding professional achievements, he received the American Accounting Association Annual Award in 1952, the American Institute of Certified Public Accountants Annual Award in 1954, and was elected to the Accounting Hall of Fame in 1960. He received the Tax Foundation award for distinguished public service in 1959.

Mr. Siciliano came to the office of Under Secretary from the presidency of the Pacific Maritime Association, an organization of approximately 120 west coast shipping companies, terminal, and stevedore operators. The Pacific Maritime Association negotiates and administers the collective bargaining contracts covering both offshore maritime and west coast onshore employees, serves as paymaster for all longshore employees, and has the employer responsibility for the administration of health, welfare, and pension plans. He had held this position since April 1965.

In addition, he was a partner in the law firm of Wilkinson, Cragun & Barker of Washington, D. C., since December 1959.

From August 1953 to September 1957, Mr. Siciliano served as an Assistant Secretary of Labor in charge of employment and manpower, directing the nationwide employment and manpower activities of the Department. He was then appointed by President Eisenhower as Special Assistant to the President for Personnel Management, and was responsible for advising the President on policies affecting the personnel management of all federal civilian employees. He resigned in December 1959.

RICHARD O. QUILL, ESSA DEPUTY ASSISTANT ADMINISTRATOR, DIES

Richard O. Quill, ESSA Deputy Assistant Administrator for Administration and Technical Services since 1967, died Jan. 4 in Severna, Md.

Richard O. Quill

Born Aug. 3, 1915, in Werner, North Dakota, Mr. Quill attended the University of North Dakota and George Washington University.

He joined the Department of Agriculture as a clerk in 1939, and the War Production Board as an administrative analyst in 1941. He went to the Office of Price Administration as a field personnel officer in 1942, and enlisted in the Army the following year.

After discharge from the Army in 1945, Mr. Quill joined the Office of Military Government in Germany as an executive officer, and in 1945 went to the agency's Berlin office as Chief of Secretariat. In 1947, he became budget officer and program coordinator for the Philippine War Damage Commission, serving until 1950 when he joined the United Nations' Korea Reconstruction Agency. In 1958, he joined the Department of Commerce, becoming Associate Chief of its Budget Division.

Mr. Quill became Deputy Director of ESSA's Office of Administration in 1965. In 1966, he was appointed an executive assistant to the Administrator, and in 1967 became Deputy Assistant Administrator.

C&GS Develops Maps of U.S. Areas Vulnerable to Earthquakes

The development of a seismic risk map, showing areas of the conterminous United States most vulnerable to earthquakes, has been announced by the Coast and Geodetic Survey. It was prepared by a group of research geophysicists headed by Dr. S. T. Algermissen.

The map is a revision of one first issued in 1948, and withdrawn from circulation in 1952 because it was considered overgeneral. It divides the Nation into four zones: (0) areas where there is thought to be no reasonable expectancy of earthquake damage: (1) areas of expected minor damage; (2) areas where moderate damage could be expected; and (3) areas where major destructive earthquakes may occur.

The zones are based principally on the known distribution of damaging earthquakes, their intensities (observed effects of earthquakes), and geological considerations. The zones were delineated after a two-year study of 28,000 earthquakes in the conterminous United States, including 16,000 in California.

Algermissen emphasized that the map is subject to continual revision as new research developments occur. "Our objective has been to determine where earthquakes may be expected to occur in the reasonable future, their frequency, and the potential damage they will cause," said the ESSA scientist.

The frequency with which damaging earthquakes may occur is not included on the map. The Risk Map shows only the nature of the earthquake risk over a very long time span. However, in a paper which accompanies the map, Algermissen has included tables which give a general idea of the frequency of damaging earthquakes across the United States. For example, portions of California and Missouri are both rated in Zone 3 on the map, but the probable frequency of occurrence of large, damaging earthquakes in certain parts of California is much greater than in Missouri.

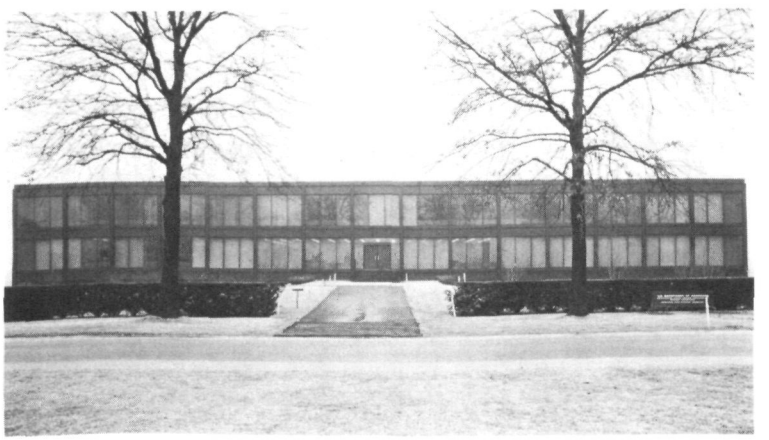
Geophysical Fluid Dynamics Lab Dedicated at Princeton University

ESSA's Geophysical Fluid Dynamics Laboratory was dedicated Jan. 24, on Princeton University's Forrestal Campus. The laboratory, headed by Dr. Joseph Smagorinsky, moved from Washington to Princeton last fall.

"This dedication," said Dr. Robert M. White, ESSA Administrator, at the ceremony, "is different. It implies less a beginning than a recommitment to a unique and far-ranging scientific program with meaning for all mankind. The group here will address a simple, but difficult, problem: how to calculate the future course of the weather over the entire globe on the basis of physical law.

"The problem was considered insoluble for almost a century, and not until very recently have we had the technological capabilities to attack it. Today, however, the tools are on hand or in view and the question no longer is whether, but when, it shall be accomplished."

Sharing the platform was Dr. Robert F. Goheen, Princeton's President, who said the GFDL-Princeton affiliation was unique in the University's experience: "The University has built the building which the Laboratory now occupies and has leased it to the Department of Commerce. The Laboratory itself has been and will remain a part of ESSA. But this is not simply a government laboratory occupying university real estate for a fee. On the contrary, it is a government laboratory located on a university campus under an arrangement designed to provide continuous, mutually desired and mutually beneficial interactions. It may be that we see here a prototype of new and even more fruitful developments in university-government relationships."



Princeton has approved the establishment of an interdisciplinary instructional program in geophysical fluid dynamics involving its departments of aerospace and mechanical sciences, of civil and geological engineering, and of geological and geophysical sciences, headed by Prof. George L. Mellor. Four members of the GFDL—Drs. Smagorinsky, Kirk Bryan, Syukuro Manabe, and Kikuro Miyakoda—have accepted faculty appointments and will serve on the interdepartmental program's staff.

The dedication coincided with a two-day international scientific symposium focused largely upon the Global Atmospheric Research Program, with numerous distinguished speakers and panelists.

Richard Hallgren Wins Flemming Award

Dr. Richard E. Hallgren, Director of ESSA's Office of World Weather Systems, received the Arthur S. Flemming Award, Feb. 13. Sponsored by the D. C. Junior Chamber of Commerce, the awards honored the ten outstanding young men in government during 1968.

Dr. Hallgren is the first ESSA recipient of the coveted honor, although Deputy Administrator John W. Townsend, Jr., won it before coming to ESSA.

Dr. Hallgren received his bachelor's degree in meteorology from Pennsylvania State University in 1953, and, following service with the U. S. Air Force, he returned to the University to earn his doctorate. He joined IBM's Space Guidance Center in 1960 as an operations research analyst and, from 1963 to 1964, managed IBM's Washington System Center's Meteorology Systems Department. From 1964 to 1965, when he assumed his present position, he was scientific advisor to the Assistant Secretary of Commerce for Science and Technology.

Dr. Richard Hallgren (left) accepts the Flemming Award from Supreme Court Justice Thurgood Marshall.

Four Ships Drift Across Atlantic in Air-Sea Study

Scientists of three nations—the United States, Great Britain, and West Germany—spent three weeks in February aboard four vessels drifting across the equatorial region of the Atlantic Ocean.

The purpose of the Atlantic Tradewind Experiment (ATEX) was to study in detail the interaction of the sea and air in a region of the globe where the so-called tradewinds generate much of the weather for North America and Europe. By drifting, rather than sailing, the scientists were able to conduct their sea/air experiments and measurements of air and water motions without the complicating factor of ship movements.

The American research phase of ATEX was coordinated by the Sea-Air Interaction Laboratory of ESSA's Atlantic Oceanographic Laboratories in Miami, with Feodor Ostapoff as the Chief U. S. Scientist for the project.

Vessels participating in the study were the USC&GSS DISCOVERER, the British Navy hydrographic survey ship HYDRA, and the West German research ships METEOR and PLANET.

The four ships met off the African Coast approximately 850 miles west of Dakar and about 600 miles west of the Cape Verde Islands to synchronize their instruments to insure uniform data acquisition. Three vessels then stationed themselves at the corners of an equilateral triangle approximately 435 miles on a side, with the fourth centered on the downwind (South American) side, and began drifting in a southwesterly direction with the prevailing winds and currents. The ships drifted about 550 miles towards the mouth of the Amazon River off Brazil. At the end of the drift period, the ships regrouped to compare their results.

One of the more interesting aspects of ATEX was a study by German scientists of the number and size of raindrops. The results could lead to a better understanding of the different kinds of rain.

Another study of considerable interest involved the concentration and mineralogy of the suspended sediment being transported by ocean currents. This study is expected to provide information on the source of deep-sea deposits. It was carried on in conjunction with airborne particle studies.

Still a third study involved internal waves, the mysterious underwater undulations of the sea about which little is known.

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HURRICANE!

Thousands of Americans soon will view a new film, designed to inform them about a major natural hazard, ESSA's role in it—and what to do about it.

The new production is "Hurricane!" a half-hour color film sponsored by Aetna Life and Casualty of Hartford, Conn., and co-produced by ESSA and Aetna. Public release will be prior to the onset of the 1969 hurricane season.

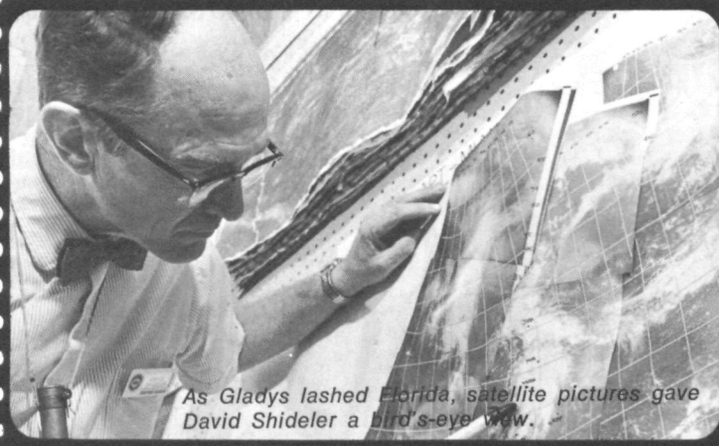
Approximately a year in preparation, "Hurricane!" was filmed during the 1968 season, with on-the-spot shooting in the Caribbean and at the Weather Bureau's National Hurricane Center in Miami.

During the filming, Hurricane Gladys almost became a movie star; temperament was her undoing. Cameramen did their best to feature her—but she wouldn't stick to the script. In mid-October, Gladys began to move toward the Florida peninsula. Knowing it to be a prime opportunity, Aetna and ESSA flew teams to the National Hurricane Center. It was decided that one crew should remain there to film the emergency activities. Even under the tension of forecasting a major storm, staff cooperation resulted in some excellent action footage. Cooperation, however, ended there. Fickle Gladys continued to elude a mobile crew, lying offshore while the unit traveled up and down the Florida coast trying to second-guess her landfall.

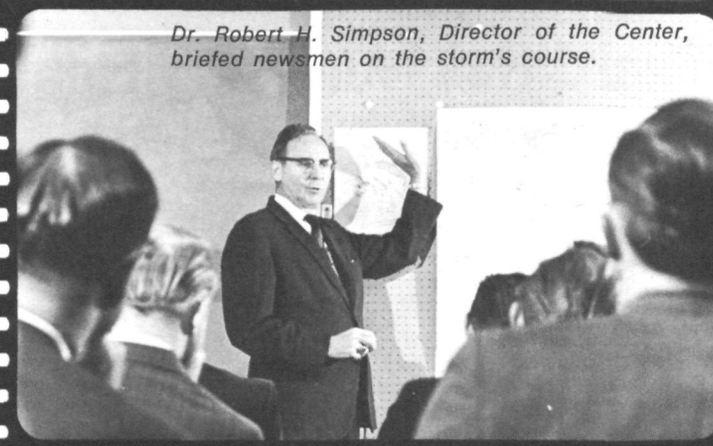
Finally, she came ashore—at night, when color film is useless.

Nevertheless, "Hurricane!" has excitement aplenty to make more interesting its message of public safety. The film is a successor to "Tornado!" made in 1967 and the recipient of several major awards.

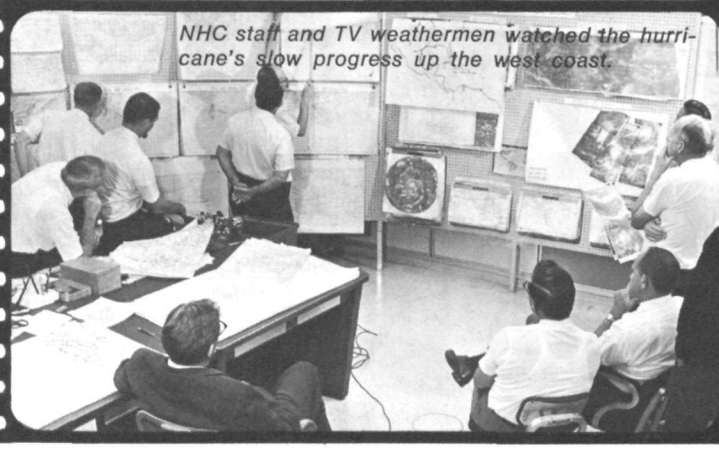
Aetna producer for "Hurricane!" was Malcolm Snyder; ESSA producer was Jeff Baker, radio-TV-film officer.



As Gladys lashed Florida, satellite pictures gave David Shideler a bird's-eye view.



Dr. Robert H. Simpson, Director of the Center, briefed newsmen on the storm's course.



NHC staff and TV weathermen watched the hurricane's slow progress up the west coast.

Hurricane flags were raised over the [illegible] in Sarasota, Florida, as Gladys threatened the area.