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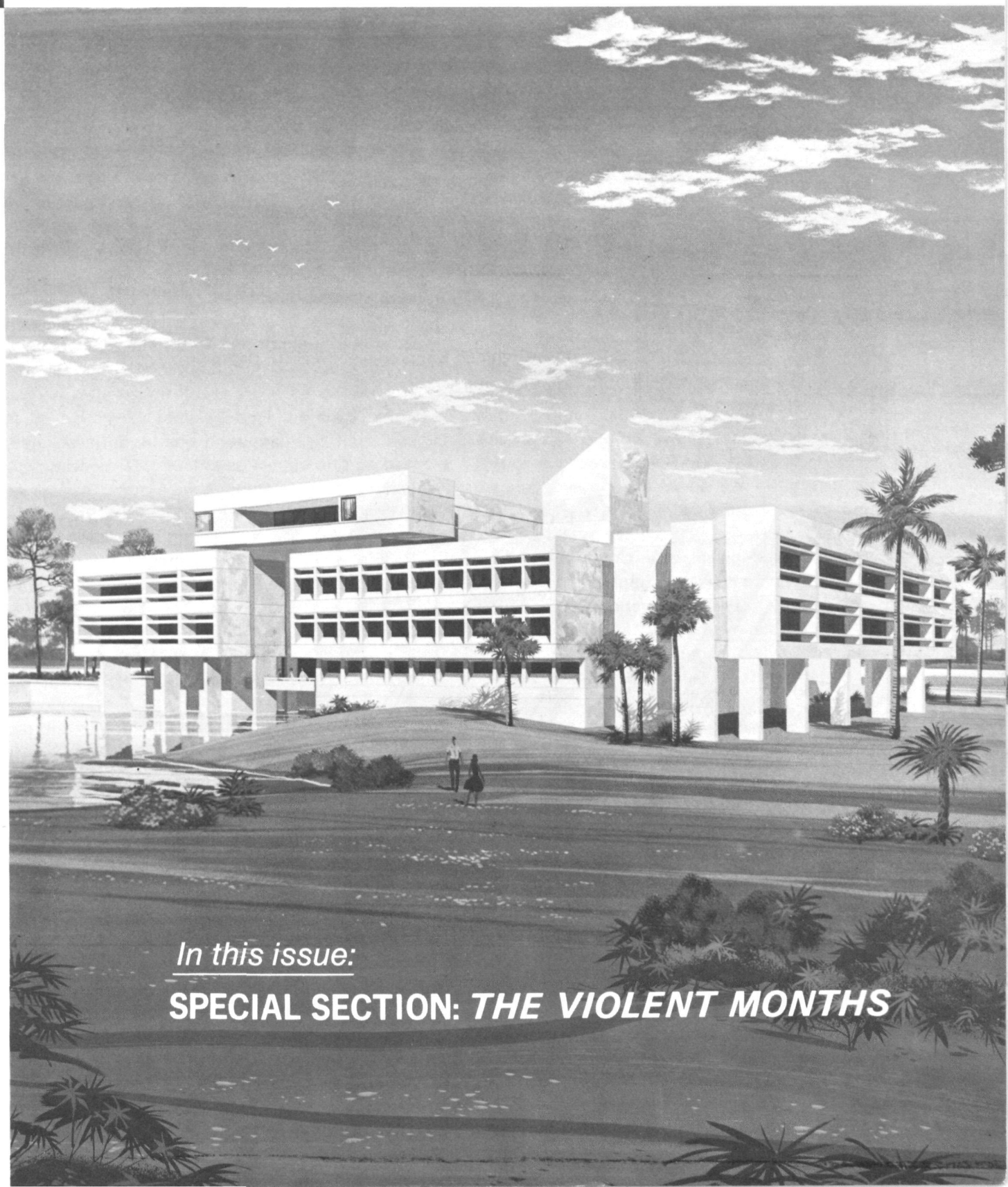

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VOLUME 5
NUMBER 3

National Oceanic and Atmospheric Administration

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COVER
Artist's drawing of the building on Virginia Key, Miami, Florida, that will soon house the now-scattered units of the ESSA Research Laboratories' Atlantic Oceanographic and Meteorological Laboratories. See story on page 36.

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In plain language . . . . .

We talk of the importance of the sea for innumerable uses, but the truth is that the sea is so little explored and its magnificently complex processes so poorly understood that we have been unable to utilize it for much of anything, other than the same uses to which it has historically been put.

The recovery of food and minerals, the improvement of marine transportation, better national defense, improved forecasts, and all the other ways in which the sea will be utilized cannot be effectively realized until the basic exploration, description, and understanding have been accomplished. This fact is so simple and so basic that it has been almost completely overlooked in the rush to glamorize the eventual benefits to accrue to man from the sea. Exploring, describing, and understanding are perhaps less exciting in some ways than commerce, weather, food, minerals, and defense, but they are the *sine qua non* of all man's efforts to reap the harvest of the seas.

One hears a lot of talk about marine ecology—the study of the interrelationship of marine organisms, their life cycles, their eating habits, even the number of vertebrae in their backbones, but we know very little about the environmental variations to which they are subjected. You can detail their comings and goings with great precision, but to know "why" you must know what changes are taking place in the world they live in. How does the visibility vary, how does the temperature of the water vary? What sort of current regime is in the area and how does it vary? Do the dissolved oxygen, salinity, or nutrient material vary with time, and if so how do the organisms react to these changes? We talk a great deal about ecology and tend to neglect the environmental half.

Pollution and pollution control are fast becoming the watchwords for the seventies. Man eyes the sea and its estuaries as convenient places to get rid of the wastes he creates on land. And in fact it may be that one of the great resources of the sea is that it is just this. But we do not know.

We want to protect our beaches and improve our harbors, we want to dispose of the cooling waters from our coastal power plants, we want to fish and play in the nearshore waters, we want to harvest fish commercially in our offshore waters and our rivers and estuaries, we want to launch our pleasure boats, to build our marinas, to develop our coastal lands for living and for industry, we want to build causeways to our offshore islands, we want to set aside coastal preserves and maintain our navigable waters. But to do these things intelligently, we must first explore, describe, and understand the entire nearshore and estuarine regime. This we have not done.

Let us stop kidding ourselves that we can just go to sea and harvest its resources. It is absolutely essential that our approach to utilizing marine resources be comparable to that for harvesting our resources on land. First we must do the mapping and description and understanding or the attempts at the harvesting will continue to be the hit-or-miss, catch-as-catch-can, approach we have used to date.

Once we know our marine environment better, this information must be conveyed to the decision makers, so that environmental judgments can be made on the basis of fact rather than on emotionalism, financial pressure, political influence, and the other grounds on which decisions are so often made in the absence of facts.

Then, at last, we may be in a position to practice what we preach. □

SPECIAL SECTION:
THE VIOLENT MONTHS

Hurricanes

Battling the Big Ones

Alma was queen for a day—for less than 24 hours on May 20 and 21, when the tropical storm blossomed briefly into a hurricane and thus became the second hurricane in this century to develop in the Atlantic, Caribbean, or Gulf of Mexico before the first of June.

An improved hurricane warning system and an intensive modification effort were ready for the precipitate 1970 season.

The new aids available to the Weather Bureau's National Hurricane Center include timely photographs from NASA's Applications Technology Satellites, an improved pattern for aircraft storm reconnaissance, and a computer program to identify the coastal area most likely to be affected by a given storm.

Project Stormfury—the ESSA/Navy hurricane research and modification program—will attempt to seed hurricanes massively and repeatedly, to learn whether the force of these storms can be diminished. The Project's major goal this season is to repeat the eyewall-seeding experiments conducted in 1969, in the hope of confirming the results. Other experiments planned for the 1970 season include seeding of hurricane rainbands and rain sectors, and continuation of experiments on lines of tropical cumulus clouds not associated with hurricanes.

Project Stormfury's 1970 season will open July 23 after a "dry-run" rehearsal by participating aircraft from the Research Flight Facility, the Navy, and the Air Force. Thereafter, Stormfury scientists, planes, and flight crews will be on 48-hour alert for hurricane seeding through October 31.

Experiments will be conducted on storms in the southwestern Atlantic, the Caribbean, and the Gulf of Mexico, when the probability is small—10 percent or less—that the hurricane center will come within 50 miles of a populated area during the ensuing 24 hours. The 24-hour period gives Project aircraft ample time to measure the effects of seeding before they are obscured by the proximity to land.

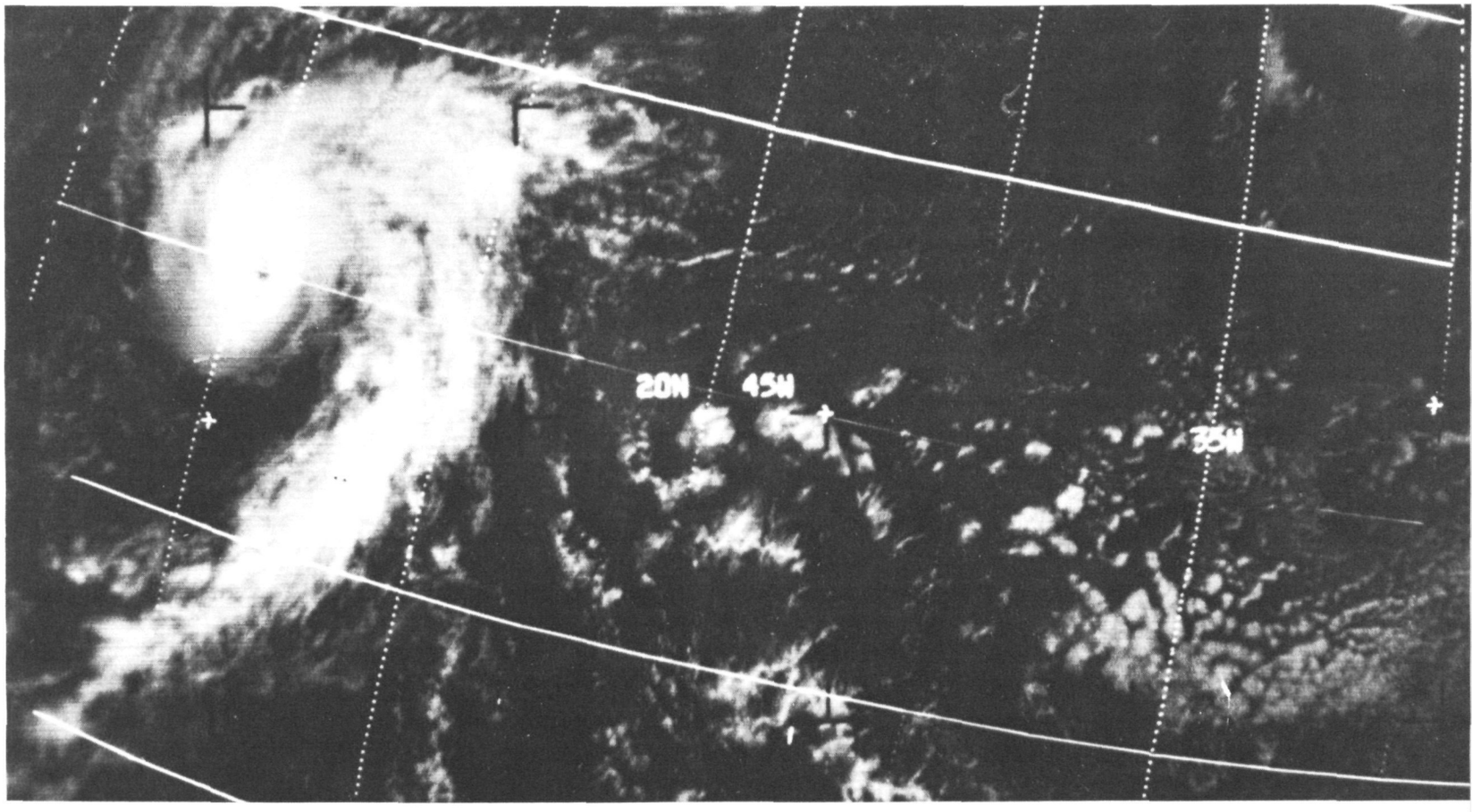
In 1969, on August 18 and again on August 20, Hurricane Debbie was seeded five times during an eight-hour period. These were the first such experiments conducted since 1961 and 1963, and the first ever to seed a storm more than once per day.

On August 18, Debbie was a mature hurricane with maximum winds exceeding 100 knots, located about 650 nautical miles east-northeast of Puerto Rico and moving toward the west-northwest.

Waiting for Debbie at Roosevelt Roads Naval Air Station, Puerto Rico, were 13 Project Stormfury planes—nine from the Navy, two from ESSA, and two from the Air Force. Debbie appeared to be an ideal subject for the Stormfury hurricane seeding experiment, except that the distance from Puerto Rico was an extreme range for heavily instrumented weather aircraft.

With the 13 available aircraft, 14 flights were made. Of these, five carried the pyrotechnics to seed the hurricane, and ten monitored the storm for changes in structure and intensity, from four hours before the first seeding until six hours after the last seeding.

In the two earlier experiments in 1961 and 1963, seeding began directly at the eyewall with a single line of 80 large canisters of silver iodide dropped into the hurricane. In 1969, the seeding aircraft—a U.S. Navy A-6 Intruder flying at an



Hurricane Debbie, with eye clearly visible at left center of picture, photographed by ESSA 9 satellite.

altitude of 33,000 feet—penetrated the eyewall to the area of maximum winds before starting to seed. Then, 208 smaller but more efficient silver iodide generators were dropped on a line extending across the outer wall and into the adjacent rainbands which help to fuel the storm. Each of the five seeding runs lasted two to three minutes, covering a path 14 to 20 nautical miles in length.

The seeded storm was monitored by specially instrumented planes at several levels from 1000 to 37,000 feet. Flying at 12,000 feet, the two DC-6 aircraft of ESSA's Research Flight Facility made repeated passes across the storm. In previous mature hurricanes, winds at the 12,000-foot level have been about 95 percent as strong as those near the surface.

Before the first seeding on August 18, maximum winds at 12,000 feet were 98 knots. After the second seeding, and again after the third, measured winds showed a decrease in intensity. Five hours after the fifth seeding, they were 68 knots—31 percent less than before the experiment began.

There was no seeding on August 19, and the hurricane reintensified. On August 20, the storm had a double eye, an unusual structure in hurricanes and complicated to handle with present seeding techniques. However, maximum wind speed at 12,000 feet before the first seeding was 99 knots, and after the final seeding it had dropped 15 percent, to 84 knots.

According to the theory on which these experiments are based, injection of silver iodide just outside the storm's ring of maximum winds sets in motion a series of changes which cause the tremendous forces within the hurricane to work against each other. The silver iodide particles provide freezing nuclei for the large quantities of water that exist within the storm at temperatures far below freezing. As the supercooled water is converted to ice, the freezing process releases heat energy into the storm system. Heat added in the proper sector of a hurricane should lower atmospheric pressure in the area next to the storm's low-pressure center. When the pressure differences within the hurricane are diminished, the strongest winds should weaken, and the energy formerly concentrated around the storm's center should disperse over a larger area.

Stormfury scientists are not certain whether the decreases in wind speeds after the 1969 experiments were caused by the seeding, or whether they resulted from natural changes in the hurricane. But analyses of past storms show that the rate of decrease in wind speeds observed on August 18 would be very rare in an unseeded hurricane. The smaller decreases observed on August 20 could be expected to occur naturally in fewer than half of the unmodified storms. The fact that the storm's winds diminished on both seeding days strongly suggests that at least some of the changes were caused by the modification experiment.

Both death and damage may be reduced substantially if the wind speed of hurricanes can be diminished as they approach land.

Since 1900, there has been a spectacular rise in hurricane-caused property damage, primarily because of the increasing concentration of expensive buildings along vulnerable shorelines. During the 1960's, hurricane damage in the United States alone has exceeded 4¼ billion dollars.

According to Dr. R. Cecil Gentry, Director of ESSA's

continued

"Storm room" of the National Hurricane Center where advisories and warnings are first issued.

National Hurricane Research Laboratory and of Project Stormfury: "If Federal hurricane modification research continues at the present level for a decade and if, in that time, one severe hurricane such as Camille in 1969 can be weakened so that its damage is reduced by as little as 10 percent, the investment will have been returned tenfold."

While the property damage has risen sharply, the death toll exacted in the United States by hurricanes has shown a tremendous decrease, as tracking, forecasting, and preparedness have improved. Hurricanes no longer sweep ashore without warning, as they once did, to snuff out thousands of lives.

During summer and autumn, the Atlantic Hurricane Warning Service, headquartered at the National Hurricane Center in Miami, and ESSA Weather Bureau Hurricane Warning Offices at San Juan, New Orleans, Washington, and Boston, maintains a watch on tropical disturbances which could develop into destructive storms. (A similar watch on Pacific hurricanes and typhoons is kept by Weather Bureau offices in San Francisco and Honolulu.)

The Miami Center analyzes and monitors the progression of disturbances as they form half a world away and as they develop into full-fledged hurricanes about to strike the east or gulf coasts.

The Center's Storm Room receives a constant flow of information from satellites, ship reports, air reconnaissance, radar, and other sources as the great storms move closer to the mainland.

A key element in the 1970 hurricane watch is the weather satellite, which enables forecasters to spot storm systems on a global scale, while they are still in the formative stage. The Center monitors cloud photographs from ESSA satellites and NASA's Advanced Technology Satellites—ATS-1 over the Pacific and ATS-3 over the Atlantic. From the ATS, in stationary earth orbit 22,300 miles over the Equator, photos of the same geographic area are received every 23 minutes. Operational use of the ATS pictures in hurricane forecasting was made possible by the recent installation of a new antenna at ESSA's Wallops Island, Virginia, facility, and of a photo-facsimile circuit to transmit the pictures to Miami. There, they are displayed on screen in still and movieloop form, so scientists can study both the shape and direction of storms.

When disturbances are within the range of aircraft, though still far out in the Atlantic, they are probed by reconnaissance planes of the Air Force, the Navy, and ESSA.

This year, for the first time, each plane probes not only the center but also each of the four quadrants of the storm system, following flight patterns which are oriented to the movement of the storm center. Data on such vital factors as temperature and pressure changes is transmitted directly to the Center. Constantly updated portraits of each storm's vortex tell whether it is gaining or losing intensity.

As storms, tracked both by satellites and aircraft, move closer to shore, a radar "fence" covering the entire gulf and Atlantic coastlines and the lesser Antilles probes the atmosphere more than 200 miles over the ocean, providing another view of the systems on the Storm Room screens.

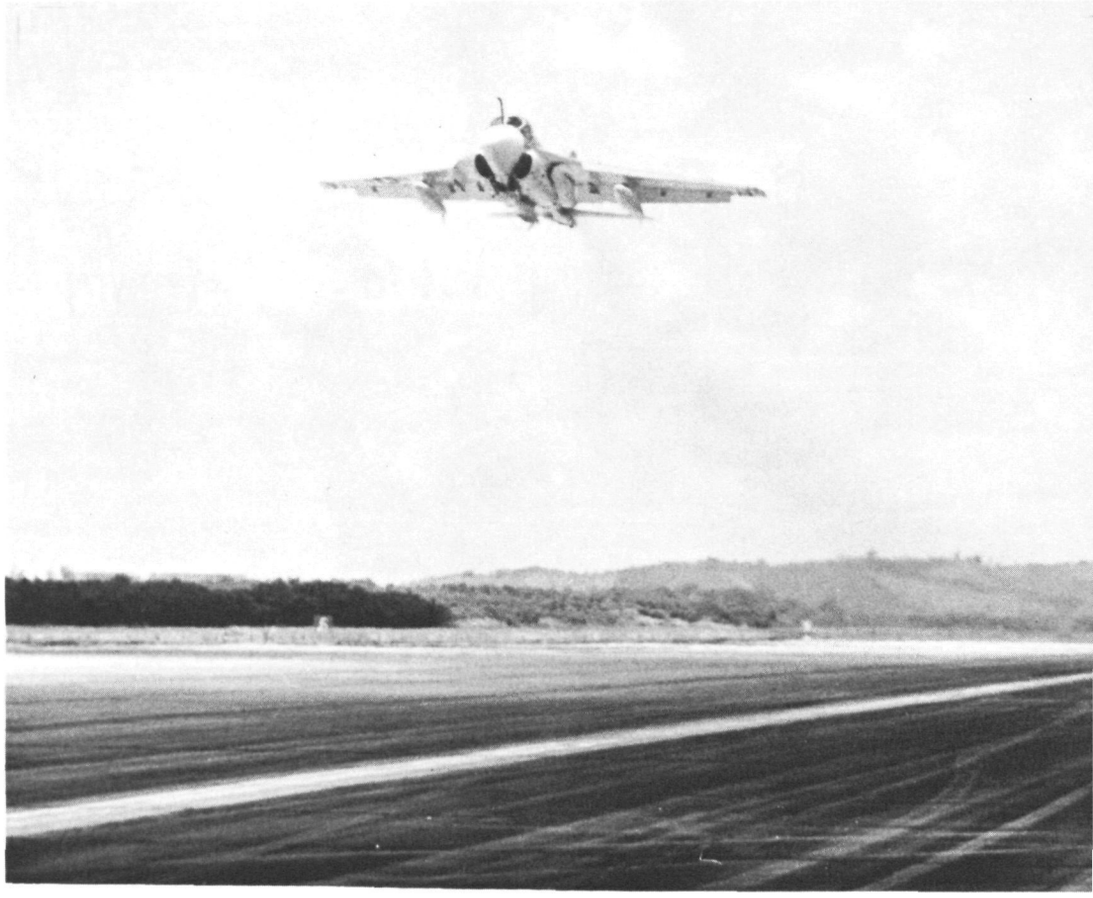
In previous years, the decision to raise a hurricane watch has been a matter for the forecaster's subjective judgment. This season, a computer storing the history of all Atlantic hurricanes uses this data to project the probable track of an approaching system.

When the center of a hurricane is between 24 and 36 hours of possible landfall, a new hurricane analogy technique—HURRAN—will be called into action. This is a computer program which analyzes the behavior of all previous hurricanes located and moving in a manner similar to the one approaching the coast and computes the sector of the coastline which historically has at least a 50-50 chance of being mauled by winds and storm surge. This will become the area for which the National Hurricane Center will announce a hurricane watch. It is expected that watch times of up to 36 hours, and warning times of 15 to 18 hours, may be achieved by this technique.

The Miami Center offers local guidance to the offices at San Juan, New Orleans, Washington, and Boston with hurricane warning responsibility. These offices, and the National Meteorological Center at Suitland, Maryland, are linked by special communications which focus on hurricane warning action from June 1 through November 30.

Each of the four hurricane warning offices is assigned a specific coastal area for which it issues public advisories and bulletins on hurricanes and tropical storms. This is a team effort between the warning offices and the National Hurricane Center.

Hurricane Emergency Information Centers will be established this year in cities threatened by hurricanes. The service is a program of the ESSA Office of Public Information, in cooperation with the Weather Bureau's Emergency Warnings Section, National Hurricane Center, and Eastern and Southern Regions. Manned by information officers working under the direction of the local meteorologist in charge, the centers will provide a constant flow of official, accurate information and



Project Stormfury Director R. Cecil Gentry confers with Cdr. L. J. Underwood, U.S.N., Assistant Director of the Project, during the August 1969 experiment to seed Hurricane Debbie. (Right) Seeder aircraft taking off.

advisories to the news media during the weather emergency.

Last year, the Weather Bureau set a record, by preparing the largest number of hurricane advisories ever issued to the public in one season. Hurricane reconnaissance aircraft of the Air Force, Navy, and Research Flight Facility devoted more flight hours to storm tracking than in any previous year.

The storms themselves prompted this high level of activity. For the first time since 1953 when the Weather Bureau began giving hurricanes girls' names, enough tropical storms occurred to use the names through the letter M. Of these 13 storms, 10 reached hurricane intensity—winds of 74 or more miles per hour. And one—Camille—was the most destructive in the history of Atlantic hurricanes.

Debbie will be remembered as the subject of Project Stormfury's seeding experiments.

Other oddities made last year's season unique in hurricane history. A sounding balloon was released into the eye of Francelia as it crossed Swan Island in the Caribbean, a feat accomplished only four times before.

Inga was the longest-lived Atlantic hurricane on record, drifting for 25 days within a relatively small area over the open Atlantic.

Kara couldn't decide where she was going, and became the first hurricane to cross her own path three times.

Laurie was the first ever to enter the Gulf of Mexico and die without bringing winds of at least gale force to any shoreline.

Martha, the year's last storm, was the first observed to move inland on the north coast of the Republic of Panama.

But the season's big one was Camille—a hurricane that set new marks for storm tides, barometric pressure, and property damage.

Reconnaissance aircraft measured a minimum pressure in the storm of 905 millibars (26.61 inches)—the lowest of record measured by aircraft instruments in an Atlantic storm. Crossing the coastline along the Gulf of Mexico, Camille created record high storm tides of 24.6 feet, and there is evidence that the water level actually may have been a few feet higher than that.

One of the most destructive storms ever to hit the United States, Camille caused a total of 256 deaths, and damage estimated at $1.42 billion. The damage equalled that of Hurricane Betsy which struck southern Florida and Louisiana in September 1965, and its death toll was the highest since Hurricane Audrey took 390 lives in Texas and Louisiana in June 1957.

Thus, Camille became one for the record books, the name being retired from the four-year rotating list of hurricane names. This is the rule for all major hurricanes affecting the United States.

In the 1970 season, Alma has come and gone. The other names awaiting storms in the Atlantic, Caribbean, and Gulf of Mexico are Becky, Celia, Dorothy, Ella, Felice, Greta, Hallie, Isabel, Judith, Kendra, Lois, Marsha, Noreen, Orpha, Patty, Rena, Sherry, Thora, Vicky, and Wilna. No one knows how many of these names will be used before the season ends, or which ones—if any—may make history this year.

But the nation's hurricane warning system is ready for them. □

SPECIAL SECTION: *THE VIOLENT MONTHS*

HEAT WAVE

This article is excerpted from a new ESSA brochure, "Heat Wave." Sources for the medical and first-aid information include: Burch, G., and DePasquale, N., *Hot Climates, Man and His Heart,* Thomas Books, Springfield, (Ill.) 1962; Meyers, J., Calonje, M., Parrino, P., and Snyder, M., U. S. Department of Health, Education and Welfare, Public Health Service, Division of Health Mobilization, *Heat Syndrome Data From Selected Hospital Record Survey,* Contract OCD-OS-62-100, Subtask 1221A, Washington, 1965; American National Red Cross, *First Aid Textbook,* 4th Ed. Rev. 1957, Doubleday, Garden City, 1968.

FOR MOST CREATURES, spring is the season that quickens the spirit after winter's short, cold, pale-sunned days. But the North American human usually defers his celebration, waiting until summer to begin his rest, or play, or travel.

At the summer solstice, June 21, the sun's direct rays reach their northernmost point at the Tropic of Cancer, and there is least atmosphere between the narrow zone of life and the pounding radiation of our star. By July, the continent is as hot as it will get, with temperatures running in the mid-seventies, averaged nationwide; August is usually a few degrees cooler. Not until September does the season's hot grip release us.

For many, it is too late.

In a "normal" year, about 175 Americans die from summer heat and too much sun—"excessive heat and insolation" is the vital statistics category. Among the family of natural hazards, only the excessive cold of winter—not lightning, hurricanes, tornadoes, floods, earthquakes, or tsunamis—takes a greater toll in the United States.

In the period 1950 through 1967, more than 8,000 persons were killed in the United States by the effects of heat and solar radiation. The 1,401 dead in 1952, the 978 in 1954, and the several years with death tolls closer to 600 push the yearly average for this period to about 452 deaths.

These are direct casualties. It is not known how many deaths are encouraged by excessive heat or solar radiation—for example, how many diseased or aging hearts surrender that would not have under better conditions. Heat waves bring great stresses to the human body; among the aged or infirm are many who cannot run another summer race.

Given terrain and geographic situation, North American summers are bound to be hot. As the advancing sun drives back the polar air, the land is opened up to light and solar heat, and occupied by masses of moist warm air spun landward off the tropical ocean. With these rain-filled visitors come the tongues of dry desert air that flick northward out of Mexico, and, occasionally, the hot winds called chinooks which howl down the Rockies' eastern slopes.

Inequalities of atmospheric heating and cooling, of moistness and aridity, are regulated at middle latitudes by horizontal and vertical mixing. The mixing apparatus is the parade of cyclones (low-pressure centers, or Lows) and anticyclones (high-pressure centers, or Highs) which lie at the heart of most weather, good and bad.

The cyclones and anticyclones drift in the mid-latitude westerlies, the prevailing eastward-blowing winds which follow a scalloped path around the Northern Hemisphere. The large-scale undulations of these winds may extend for thousands of miles, and are called planetary waves. Their high-speed core is the jet stream, which snakes across the continent some six to eight miles up, keeping mainly to the cool side of Highs and Lows as they form and spin and die below it.

The kind of weather predominating in an area over a period of time depends largely on the prevailing position and orientation of the jet stream. As the continent warms, the jet stream shifts northward, along with the tracks of surface weather disturbances. Cyclones like the ones which brought April rains to the Gulf states bring June thundershowers to the Plains; the humid spring of Georgia becomes the muggy summer of Illinois.

These semi-regular alternations of instability and equilibrium, hot and cool, moist and dry, combine—year in and year out—to generate the average June-to-September climate for North America.

When these alternating processes somehow are interrupted, the climatic "norm" of summer is marred by a heat wave. The anomaly is usually associated with a change in the planetary waves, so that the prevailing winds from the southwestern deserts sweep farther north than usual, and blanket a large region with hot, often humid, air at ground level. An upper-level High may settle over the mid-continent, destroying cloud cover with its descending, compression-heated, currents, until the blessing of fair weather turns to the curse of drought. In addition, heat from the hot, dry ground feeds back into the atmosphere, tending to perpetuate the heat wave circulation.

Most summers see heat waves in one section or another of the United States. East of the Rockies, they tend to be periods of high temperatures and humidities—those oppressive, muggy days when human comfort is just an expression—although the worst have been catastrophically dry.

Among the big ones are the hot summer of 1830, which scorched the north central interior, and that of 1860, which dried up the Great Plains. July 1901 may still be talked about by old timers in the middle west, remembering high temperatures, or thinking about someone the heat killed—there were 9,508 heat deaths in that year.

But nothing in American climatological annals touches the heat waves which came with the Dust Bowl droughts of the 1930's. The years 1930, 1934, and 1936 brought progressively more severe summer weather. Record highs of 121 degrees in North Dakota and Kansas, and 120 degrees in South Dakota, Oklahoma, Arkansas, and Texas were observed in the ugly summer of 1936; July and August of that year saw record highs of 109 degrees or better tied or broken in Indiana, Louisiana, Maryland, Michigan, Minnesota, Nebraska, New Jersey, Pennsylvania, West Virginia, and Wisconsin.

These were cruel years in terms of heat deaths. From 1930 through 1936, ranging from a low of 678 deaths in 1932 to 4,768 in 1936, heat killed nearly 15,000 persons. The toll is consistently high, but tends sharply upward with increases in average July temperatures. This relationship between excessive July heat and significant jumps in heat deaths persists to the present day, despite the softening effects of modern technology.

Because of this relationship, one can detect years in which heat waves occurred by looking at either July-August average temperatures or the number of deaths in the excessive heat and insolation category.

The first half of the 1950's was on the hot side, and its heat death toll is correspondingly high. Many states had their hottest summer of record in 1952; that year's death toll, 1,401, is the highest for the 1950-1967 period. The summer of 1954, a year when heat killed 978, was almost as bad.

In the far southwest, heat waves are children of the desert, occasional intrusions of warm air which make the mild sea-cooled California climate more like that of Agadir. Sometimes they are general and persistent, like those which gave the area very hot summers from 1955 through 1961.

But California's worst heat waves ride in on the Santa Anas. Produced when a High over the Nevada desert sends its compression-heated, sand-warmed currents of descending air southwestward, the Santa Anas boom into the Los Angeles basin late in the summer season, usually in September, bringing air that is almost too hot and dry to be breathed. Santa Ana heat waves in 1939, 1955, and 1963 lasted a few days, brought maximum temperatures of 100-110 degrees (at night the mercury plummets to the high, dry eighties), and, like heat waves anywhere, pushed mortality rates upward.

Heat produces several clinically recognizable disturbances of the human thermoregulatory system. The disorders generally have to do with a reduction or collapse of the body's ability to shed heat by circulatory changes and sweating, or a chemical (salt) imbalance caused by too much sweating. Ranging in severity from vague malaise to the extremely lethal heat stroke, heat-caused disorders share one common feature: the individual has overexposed or overexercised for his age and physical condition for the thermal environment. Sunburn plays a role, for ultraviolet radiation burns can retard the skin's ability to shed excess heat.

Heat affects all ages of man, but, other things being equal, the severity of the disorder tends to increase with age—heat cramps in a 17-year-old may be heat exhaustion in someone 40, and heat stroke in a person over 60.

Heat waves are dangerous, no matter what your age or physical condition, but they are worst for senior citizens, and for those with a history of cardiovascular and pulmonary disease.

Human beings are homoiotherms—warm-blooded creatures who maintain an essentially constant body temperature regardless of the thermal environment.

To keep on the cool side of their upper thermal limits, our bodies dissipate heat by varying the rate and depth of blood circulation, by losing water through the skin and sweat glands, and, as the last extremity is reached, by panting. Under normal conditions, these reflex activities are kept in balance and controlled by the brain's hypothalamus, a comparatively simple sensor of rising and falling environmental temperatures, and a sophisticated manager of temperatures inside.

The hypothalamus responds to the temperature of the blood. A surge of blood heated above 98.6 degrees sends the hypothalamus into action. As its orders go out, the heart begins to pump more blood, blood vessels dilate to accommodate the increased flow, and the bundles of tiny capillaries

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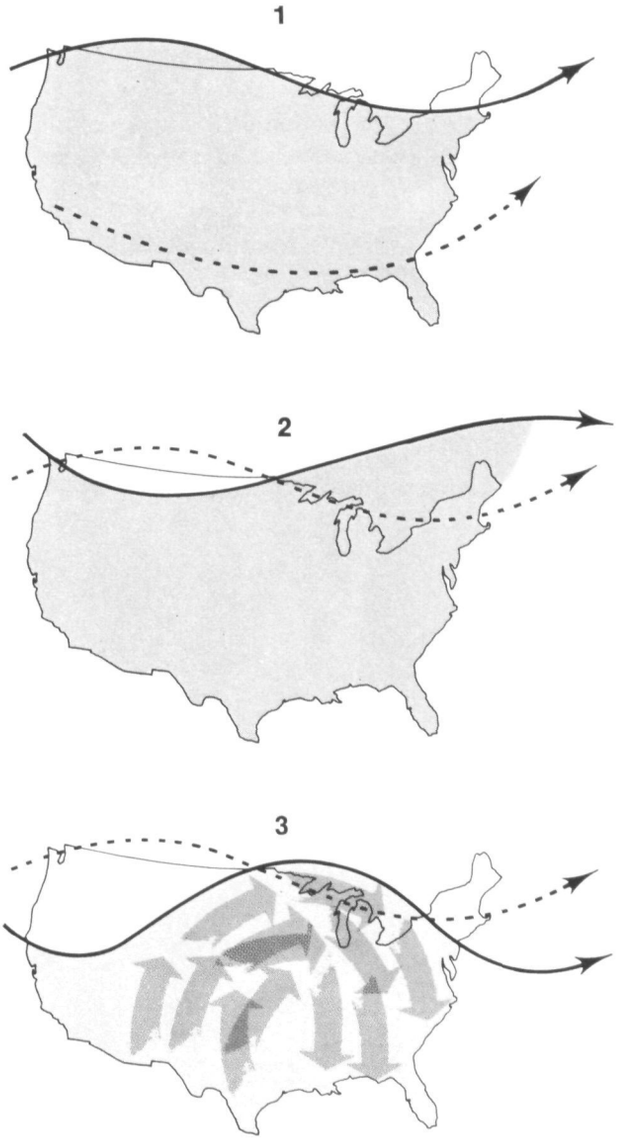
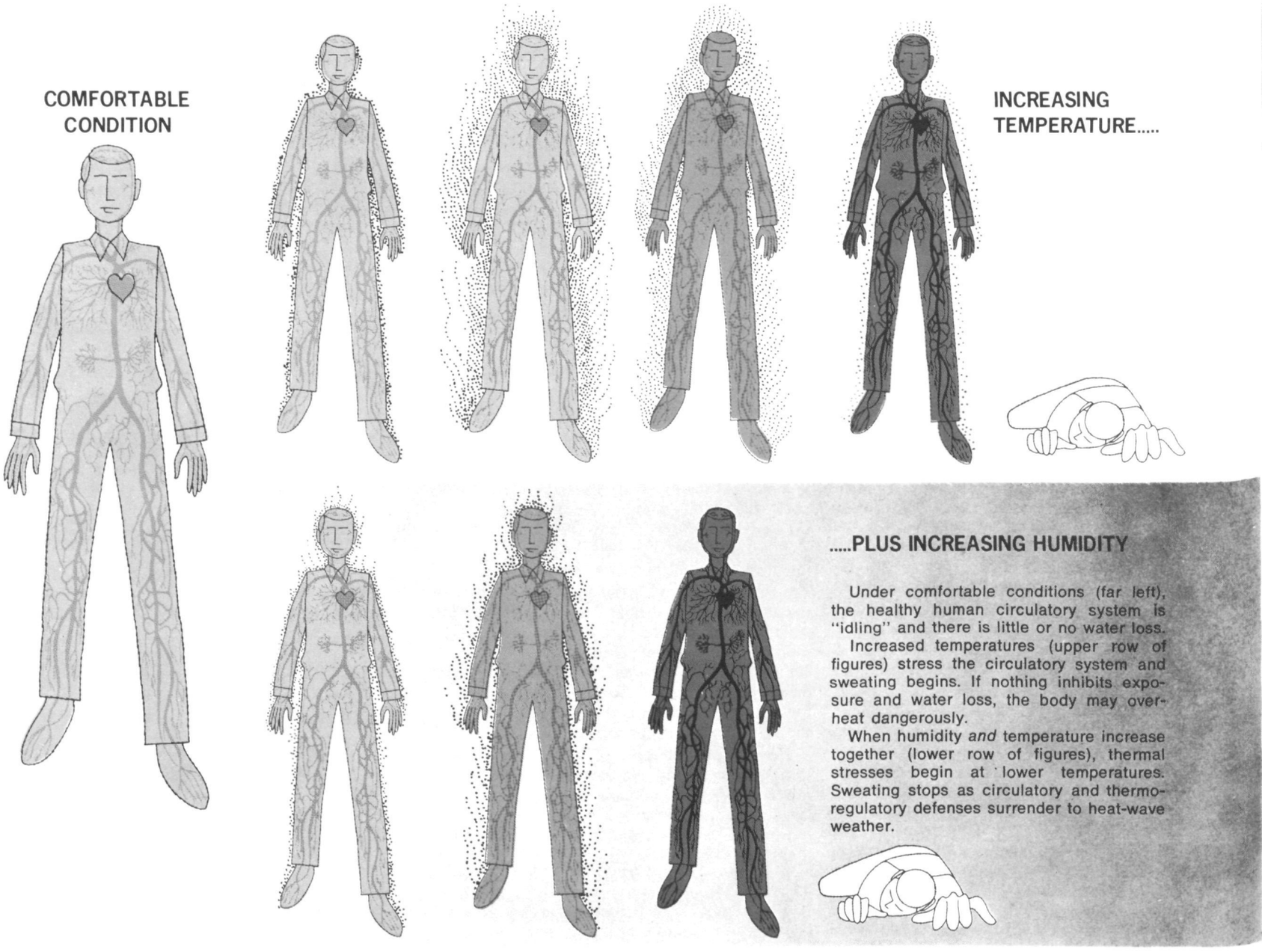


In summer, the jet stream can be an ill wind indeed. As the sun drives the polar front back into Canada, the jet stream keeps to the cool side of the boundary, and shifts northward (1). The summer is a "normal" one—hot but not too hot; humid but not too humid. But the *polar front and jet stream may be oriented so* that their eastern segment is displaced farther to the north (2), setting the atmospheric stage for a midwestern and eastern heat wave. A persistent High can block the jet stream northward (3), its clockwise, sinking circulation drawing in hot dry air from the southwestern deserts, and dry air from the northwest. This classical Dust Bowl pattern brings hot, dry weather to the mid-continent, but often means cooler-than-normal conditions in New England and the far northwest. (Jet stream position at 500mb level is shown here.)



threading through the upper layers of the skin are put into operation. The body's blood is circulated closer to the skin's surface, and excess heat drains off into the cooler atmosphere. At the same time, water diffuses through the skin as insensible perspiration, so-called because it evaporates before it becomes visible, and the skin seems dry to the touch.

Heat loss from increased circulation and insensible perspiration is a comparatively minor correction. If the hypothalamus continues to sense overheating, it calls upon the millions of sweat glands which perforate the outer layer of our skin. These tiny glands can shed great quantities of water (and heat) in what is called sensible perspiration, or sweating. Between sweating and insensible perspiration, the skin handles about 90 percent of the body's heat-dissipating function.

As environmental temperature approaches normal body temperature, physical discomfort is replaced by physical danger. Tne body loses its ability to get rid of heat through the circulatory system, because there is no heat-drawing drop in temperature between the skin and the surrounding air. At this point, the skin's elimination of heat by sweating becomes virtually the only means of maintaining constant temperature. Now it is not the heat but the humidity, as they say.

Most water enters the atmosphere via the process of evaporation, the jump from liquid to vapor phase; to do this, a water molecule must absorb enough energy to break the tenacious clutch of its fellow molecules. Evaporation, consequently, has the effect of absorbing large quantities of energy in the form of latent heat, which cools the parent body. This is familiar to anyone who has stepped from a bath into a dry room. The breakdown of the evaporation process when one steps from a bath into a hot, moist room is just as familiar.

Sweating, by itself, does nothing to cool the body, unless the water is removed by evaporation—and high relative humidity retards evaporation. Under conditions of high temperature (above 90 degrees) and high relative humidity (above 75 percent), the body is doing everything it can to maintain 98.6 inside. The heart is pumping a torrent of blood through dilated circulatory vessels; the sweat glands are pouring liquids—and essential dissolved chemicals, like sodium and chloride—onto the surface of the skin. And the body's metabolic heat production goes on, down in the vital organs.

When the thermal limits are exceeded by very much or for very long, the warm-blooded organism dies. □

Play It Safe!

1. **Slow Down**. Your body can't do its best in high temperatures and humidities, and might do its worst.

2. **Dress for Summer.** Lightweight, light-colored clothing reflects heat and sunlight, and helps your thermoregulatory system maintain normal body temperature.

3. **Put Less Fuel on Your Inner Fires.** Foods (like proteins) that increase metabolic heat production also increase water loss.

4. **Don't Dry Out.** Heat wave weather can wring you out before you know it. Drink plenty of water while the hot spell lasts.

5. **Stay Salty.** Unless you're on a salt-restricted diet, take an occasional salt tablet or some salt solution when you've worked up a sweat.

6. **Avoid Thermal Shock.** Acclimatize yourself gradually to warmer weather. Treat yourself extra gently for those first critical two or three hot days.

7. **Vary Your Thermal Environment.** Physical stress increases with exposure time in heat wave weather. Try to get out of the heat for at least a few hours each day. If you can't do this at home, drop in on a cool store, restaurant, or theater—anything to keep your exposure time down.

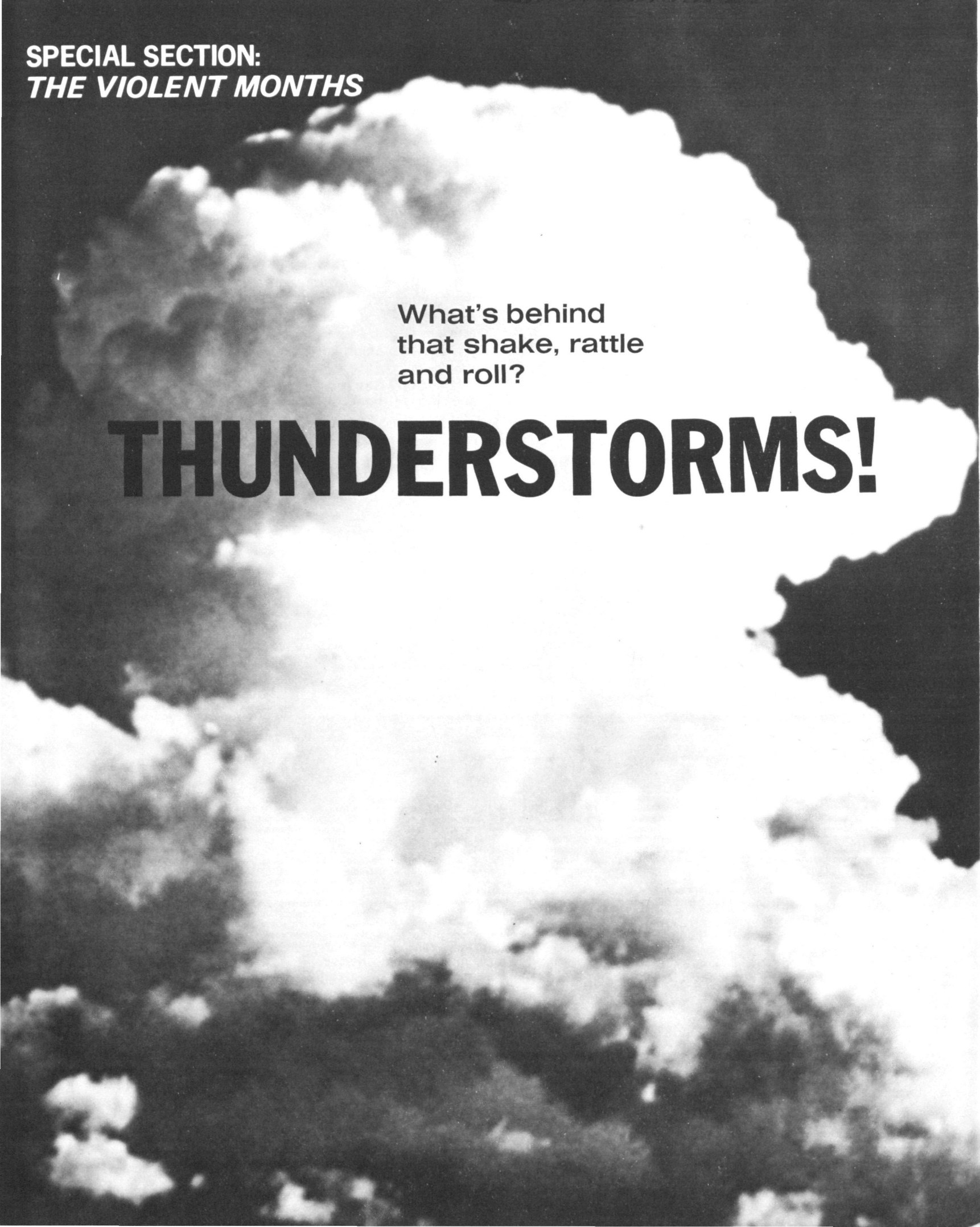
8. **Don't Get Too Much Sun.** Sunburn makes the job of heat dissipation that much more difficult.

9. Know these symptoms and the appropriate first aid:

Heat Disorder	Caused by	Symptoms	First Aid
Heat asthenia	Excessively hot, humid environment.	Easy fatigue, headache, mental and physical inefficiency, poor appetite, insomnia, heavy sweating, high pulse rate, shallow breathing, and sometimes circulatory stress in the ill.	Respite from high heat and humidity, plenty of fluids, and, if sweating is heavy (and no dietary restrictions prevent it), a salt tablet and rest.
Heat cramps	Strenuous activity under conditions of high heat and humidity, when evaporative cooling is impaired, stimulating excessive sweating and loss of salts from blood and tissue, causing cramps.	Painful spasms of voluntary muscles, contractions in flexor muscles in fingers, then larger muscles in legs and abdominal wall. Pupils dilate with each spasm, there may be heavy sweating, skin becomes cold and clammy. *Unlike severe abdominal disease symptoms, heat cramps are intermittent.*	Usually respond better to firm pressure on cramping muscles than to vigorous kneading. Application of warm wet towels also gives relief. Three or four doses of salt solution (½ teaspoon dissolved in 4 fl. oz. water) administered at 15-minute intervals. *Large quantities of water without salt may precipitate the disease.*
Heat exhaustion	Prolonged hot spell, excessive exposure, physical exertion cause thermoregulatory breakdown involving loss of vasomotor (blood vessel diameter) control, and circulatory shock.	Profuse sweating, weakness, vertigo, and sometimes heat cramps; symptoms similar to heat asthenia may herald by several days. Skin is cold and pale, clammy with sweat; pulse is thready and blood pressure is low. Body temperature is normal or sub-normal. Vomiting may occur. Unconsciousness is rare.	Move to cooler environment immediately. Provide bed rest, salt solution (see above); victims, sometimes nauseated at first, can usually take fluids after a period of rest. *Seek medical help for severe heat exhaustion.*
Heat stroke (or sunstroke, heat collapse, thermic fever, heat hyperexia)	Failure of thermoregulatory and cardiovascular systems brought about when intensive sweating under conditions of high heat and humidity restrict heat-dissipation by sweating, which finally ceases. Advanced age and hot, humid, windless environment are factors.	Weakness, vertigo, nausea, headache, heat cramps, mild heat exhaustion, excessive sweating. Sweating stops just before heat stroke. Then temperature rises sharply, often to 106° or more, pulse is bounding and full, blood pressure *elevated. Delirium or coma is common.* Armpit and groin areas are dry (they are wet in heat exhaustion). Skin is flushed and pink at first; however, in later stages, it appears ashen or purplish.	*Heat stroke is a very serious emergency.* Medical care is urgently needed. Move the victim into cooler, indoor environment, remove his clothing, put him to bed. Primary objective is to reduce body temperature, preferably by iced bath or by sponging the body with alcohol or lukewarm water, until a tolerable level (about 103° or a pulse rate below 110 per minute) is reached. Caution is necessary here. Temperature may continue decline or it may rise again. Cease sponging and observe patient for 10 minutes; if temperature rises, renew sponging cautiously. Give no stimulants, administer fluid and salt in small doses when consciousness is assured. Later provide cover according to comfort.

Heat stroke is a severe medical emergency.
Summon a physician or get the patient to a hospital immediately.
Delay can be fatal.

Sunburn	Overexposure to ultraviolet radiation.	Redness and pain caused by dilation of small blood vessels in skin. In more severe cases, tissue injury brings swelling of skin, blisters, and often fever and headache. Because it impairs thermoregulatory efficiency, sunburn may be accompanied by other heat disorders.	Prevent severe sunburn by limiting the time of initial exposure, depending on comfort and conditions. Treat mild sunburn with cold cream or certain oils or greases (*e.g.*, salad oil, shortening). Wash hands before applying. Do not apply butter or oleomargarine. Dressing should be used if blistering appears, injured area should not be exposed to sunlight until healed. *Medical care is needed for extensive or severe cases.*



SPECIAL SECTION:
THE VIOLENT MONTHS

What's behind
that shake, rattle
and roll?

THUNDERSTORMS!

For most Americans, the Fourth of July, 1966, was an average summer holiday; hot; the end of a long weekend. The weather was about normal for the time of year.

Early that morning, hail, heavy rain, and high winds struck a path some 75 miles long and 15 miles wide in northeast Montana, while hail rattled roofs at LaCrosse, Wisconsin. Panama City, Florida, reported a funnel looping out of dark clouds, and north and central Georgia bucked damaging winds. Back in the Middle West, two men were injured by lightning on a Greenfield, Indiana, golf course.

Just after noon, Beaumont, Texas, reported a funnel cloud, and Lake Pontchartrain, Louisiana, reported funnel clouds and a waterspout north of New Orleans International. Lightning-set fire destroyed a house in Smithville, Tennessee. An afternoon of thunderbolts and high winds settled on Ohio. A tornado destroyed two parked aircraft and damaged four others at a Pennsylvania airfield as wind and rain and electricity raked the state. Mason County, Kentucky, had much of the same, as did western Maryland.

Wind and heavy rains tore at North Carolina in the late afternoon; lightning injured a Winston-Salem woman, and the wind destroyed some crops and buildings. In West Virginia, lightning struck two caddies, knocked a man unconscious, burned a girl on the hip, and ignited buildings. At about the same time, a 13-year-old Virginia boy was killed when lightning struck the tree which "sheltered" him.

Late in the day, Minnesota began an evening of hail, tornadoes, high winds, and heavy rains that lasted past midnight. And hail covered the ground near Tyndall, South Dakota, and Belmar, New Jersey.

An average July day. In 18 states, eight persons were injured and two were killed, and some $5 million in property and crop damage was done by some of the atmosphere's most familiar and most dramatic events — thunderstorms and their destructive offspring: hail, lightning, high wind, heavy rain, and, smallest and most violent of all, the tornado. It is estimated that at any given instant some 1800 thunderstorms are in progress over the earth's surface. The frequency with which these giant generators of local weather occur, the quantity of energy they release, and the variety of forms this energy may take, make thunderstorms great destroyers of life and property; the rainfall they bring makes them great benefactors as well.

ESSA, through its Weather Bureau, keeps a round-the-clock, round-the-calendar watch of atmospheric conditions to provide routine forecasts for the United States and to provide timely warning of severe storms. The conditions which set up a major thunderstorm may ultimately lead to tornado formation, and to hail. But lightning, high winds, and heavy rains are part of any thunderstorm; for a single household, a single family, they can produce as much tragedy as a war.

Thunderstorms are generated by thermal instability in the atmosphere, and represent a violent example of convection — the vertical circulation produced in a fluid made thermally unstable by the local addition or subtraction of heat and the conversion of potential to kinetic energy. The convective overturning of atmospheric layers that sets up a thunderstorm is dynamically similar to convective circulations observed in the laboratory, where distinct patterns are generated in liquids by unequal heating.

The orderly circulations produced in the laboratory are rarely encountered in the atmosphere, where areas corresponding to the rising core of laboratory convective cells are marked by Cumulus and Cumulonimbus clouds. Clouds are parcels of air that have been lifted high enough to condense the water vapor they contain into very small, visible particles. These particles are too small and light to fall out as rain. As the lifting process continues, these particles grow in size by collision and coalescence until they are large enough to fall against the updrafts associated with any developing convective clouds. Cumulus (for accumulation) clouds begin their towering movement in response to atmospheric instability and convective overturning. Warmer and lighter than the surrounding air, they rise rapidly around a strong, central updraft. These elements grow vertically, appearing as rising mounds, domes, or towers.

The atmospheric instability in which thunderstorms begin may develop in several ways. Radiational cooling of cloud tops, heating of the cloud base from the ground, and frontal effects may produce an unstable condition. This is compensated in air, as in most fluids, by the convective overturning of layers to put denser layers below less dense layers.

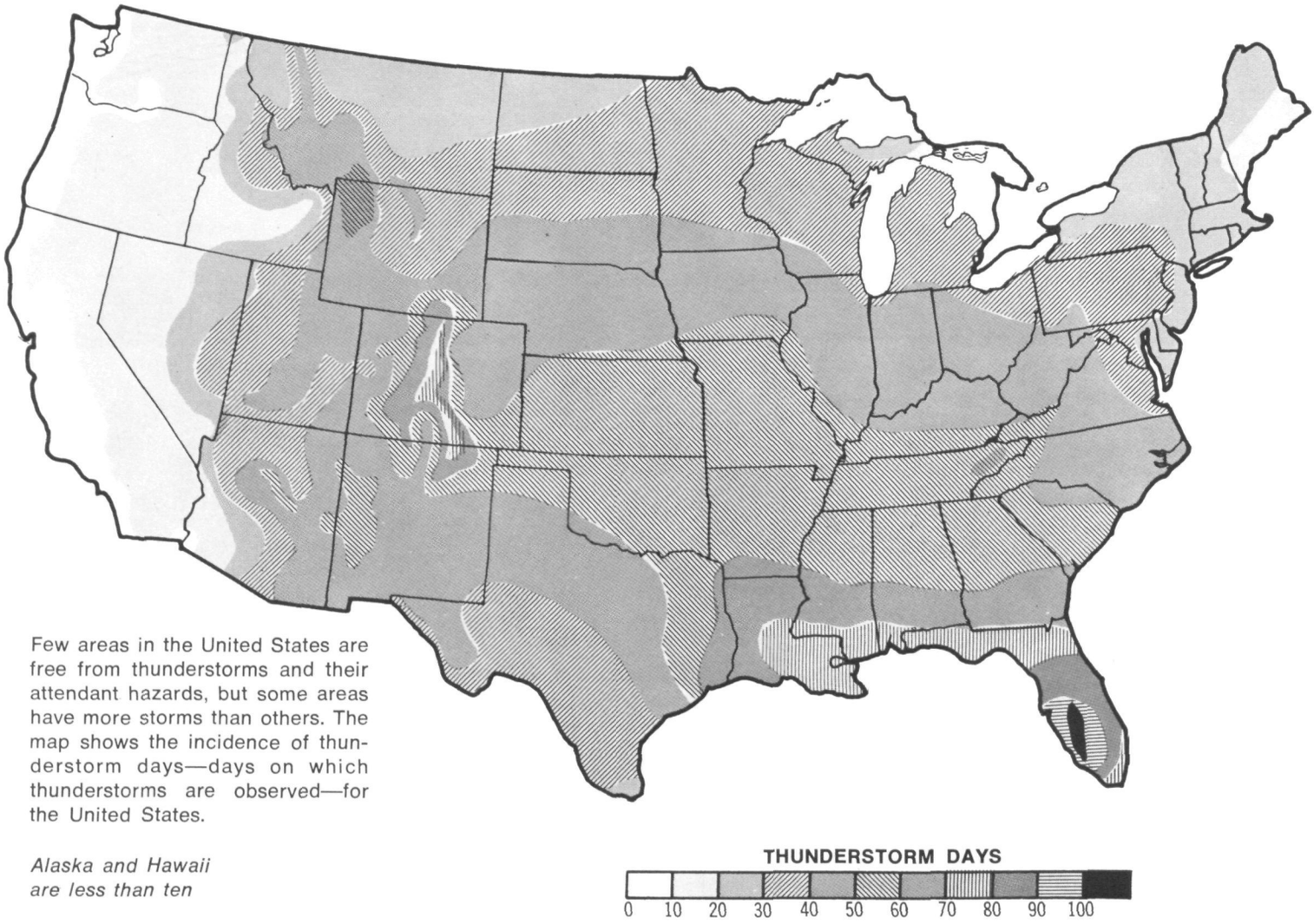
Mechanical processes are also at work. Warm, buoyant air may be forced upward by the wedge-like undercutting of a cold air mass, or lifted by a mountain slope. Convergence of horizontal winds into the center of a low-pressure area forces warm air near that center upward. Where these processes are sustained, and where lifting and cooling of the moist air continues, minor turbulence may generate a Cumulus cloud, and then a towering Cumulonimbus system.

The history of the vertical movement of air in the center of the Cumulus or Cumulonimbus cloud system is the history of each convective cell. Most thunderstorms have, at maturity, a series of several cells, each following a life cycle characterized by changes in wind direction, development of precipitation and electrical charge, and other factors.

In the first stage of thunderstorm development, an updraft drives warm air up beyond condensation levels, where clouds form, and where continued upward movement produces Cumulus formations. The updraft develops in a region of gently converging surface winds in which the atmospheric pressure is slightly lower than in surrounding areas. As the updraft continues, air flows in through the cloud's sides in a process called entrainment, mixing with and feeding the updraft. The updraft may be further augmented by a chimney effect produced by high winds at altitude.

continued

* *This article is excerpted from the ESSA-Weather Bureau brochure, "Thunderstorms," in the interest of public safety.*



Few areas in the United States are free from thunderstorms and their attendant hazards, but some areas have more storms than others. The map shows the incidence of thunderstorm days—days on which thunderstorms are observed—for the United States.

Alaska and Hawaii are less than ten

But a developing thunderstorm also feeds on another source of energy. Once the cloud has formed, the phase changes of water result in a release of heat energy, which increases the momentum of the storm's vertical development. The rate at which this energy is released is directly related to the amount of gaseous water vapor converted to liquid water.

As water vapor in the burgeoning cloud is raised to saturation levels, the air is cooled sufficiently to liberate solid and liquid particles of water, and rain and snow begin to fall within the cloud. The cloud tower rises beyond the level (3-5 kilometers) where fibrous streamers of frozen precipitation elements appear; this apparent ice phase is thought to be a condition of thunderstorm precipitation. The formation and precipitation of particles large enough and in sufficient quantity to fall against the updraft marks the beginning of the second, mature stage of the thunderstorm cell.

A thunderstorm's mature stage is marked by a transition in wind direction within the storm cells. The prevailing updraft which initiated the cloud's growth is joined by a downdraft generated by precipitation. The downdraft is fed and strengthened, as the updraft was, by the addition of entrained air, and by evaporational cooling caused by interactions of entrained air and falling precipitation. The mature storm dominates the electrical field and atmospheric circulation for several miles around. Lightning — the discharge of electricity between large charges of opposite sign — occurs soon after precipitation begins, a clue to the relationship of thunderstorm electrification and formation of ice crystals and raindrops.

At maturity, the thunderstorm cloud is several miles across its base and may tower to altitudes of 40,000 feet or more. The swift winds of the upper troposphere shred the cloud top into the familiar anvil form, visible in dry regions as lonely giants, or as part of a squall line.

On the ground directly beneath the storm system, the mature stage is initially felt as rain, which is soon joined by the strong downdraft. The downdraft spreads out from the cloud in gusting, divergent winds, and brings a marked drop in temperature. Even where the rain has not reached the ground, the thunderstorm's mature stage can be recognized by this cold air stream flowing over the surface.

This is nature's warning that the thunderstorm is in its most violent phase. It is in this phase that the thunderstorm unleashes its lightning, hail, heavy rain, high wind, and — most destructive of all — the tornado. But even as it enters maturity, the storm has begun to die. The violent downdraft initially shares the circulation with the sustaining updraft, then strangles it. As the updraft is cut off from its converging low-level winds, the storm loses its source of moisture and heat energy. Precipitation weakens, stops, and the cold downdraft ceases.

And the thunderstorm, violent creature of an instant, spreads and dies.

THUNDERSTORM SAFETY RULES

1. Keep an eye on the weather during warm periods and during the passage of cold fronts. When Cumulus clouds begin building up and darkening, you are probably in for a thunderstorm. Check the latest weather forecast.

2. Keep calm. Thunderstorms are usually of short duration; even squall lines pass in a matter of a few hours. Be cautious, but don't be afraid. Stay indoors and keep informed.

3. Know what the storm is doing. Remember that the mature stage may be marked on the ground by a sudden reversal of wind direction, a noticeable rise in wind speed, and a sharp drop in temperature. Heavy rain, hail, tornadoes, and lightning generally occur only in the mature stage of the thunderstorm.

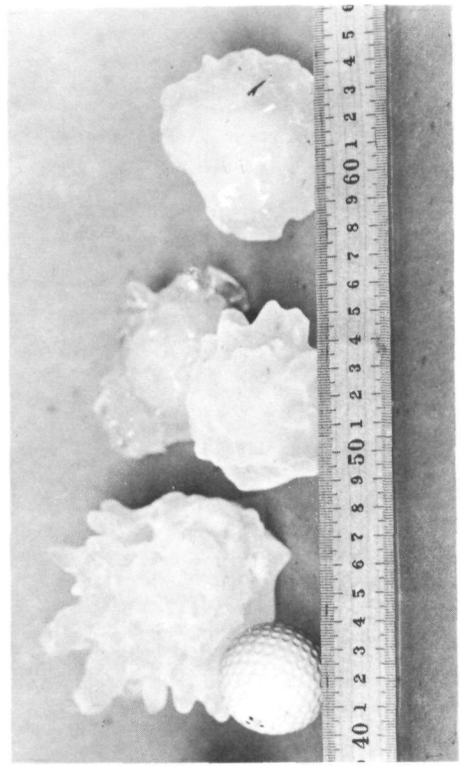
4. Conditions may favor tornado formation. Tune in your radio or television receiver to determine whether your Weather Bureau has a tornado watch or tornado warning out for your area. A *tornado watch* means tornado formation is likely in the area covered by the watch. A *tornado warning* means one has been sighted or radar-indicated in your area. *If you receive a tornado warning,* seek inside shelter in a storm cellar, below ground level, or in reinforced concrete structures; stay away from windows.

5. Lightning is the thunderstorm's worst killer. Stay indoors and away from electrical appliances while the storm is overhead. If lightning catches you outside, remember that it seeks the easiest — not necessarily the shortest — distance between positive and negative centers. Keep yourself lower than the nearest highly conductive object, and maintain a safe distance from it. If the object is a tree, twice its height is considered a safe distance.

6. Thunderstorm rain may produce flash floods. Stay out of dry creek beds during thunderstorms. If you live along a river, listen for the Weather Bureau's flash flood warning.

Unique, destructive offspring of thunderstorms

Lightning is a secondary effect of electrification within a thunderstorm cloud system. As a thunderstorm induces growing positive charge on the ground, the difference between the positive charge on the ground and negative charges in the clouds becomes great enough to overcome the resistance of the insulating air, and forces a conductive path for current to flow between the two charges. Lightning strokes represent a flow of current and may proceed from cloud to cloud, cloud to ground, or, where high structures are involved, from ground to cloud. In the United States, lightning kills more people each year, on the average, than hurricanes or tornadoes.



Thunder is the sound produced by explosive expansion of air heated by the lightning stroke. The distance in miles to a lightning stroke can be estimated by counting the number of seconds between lightning and thunder, and dividing by five.

Hail is precipitation in the form of rounded lumps of ice, called hailstones, and indicates an intensely active thunderstorm system. The layered inner structure of hailstones indicates that the stone grows by accretion of below-freezing liquid water on a growing ice particle, either by repeated lifting to freezing levels or by the long descent through strata of supercooled water.

Tornadoes are violently rotating columns of air that descend in the familiar funnel shape from thunderstorm (Cumulonimbus) cloud systems. A tornado vortex is normally several hundred yards in diameter, whirls usually in a counterclockwise direction (in the Northern Hemisphere), and contains winds which are estimated to exceed 300 miles per hour. Tornadoes occur on all continents, at any time of year, at any hour of the day. In the United States, their greatest frequency is in the spring during the afternoon. These small, shortlived storms are the most violent of all atmospheric phenomena, and, over a small area, the most destructive. □

SPECIAL SECTION: *THE VIOLENT MONTHS*

lightning

science strikes back

BY JOANN TEMPLE DENNETT, ESSA Research Laboratories

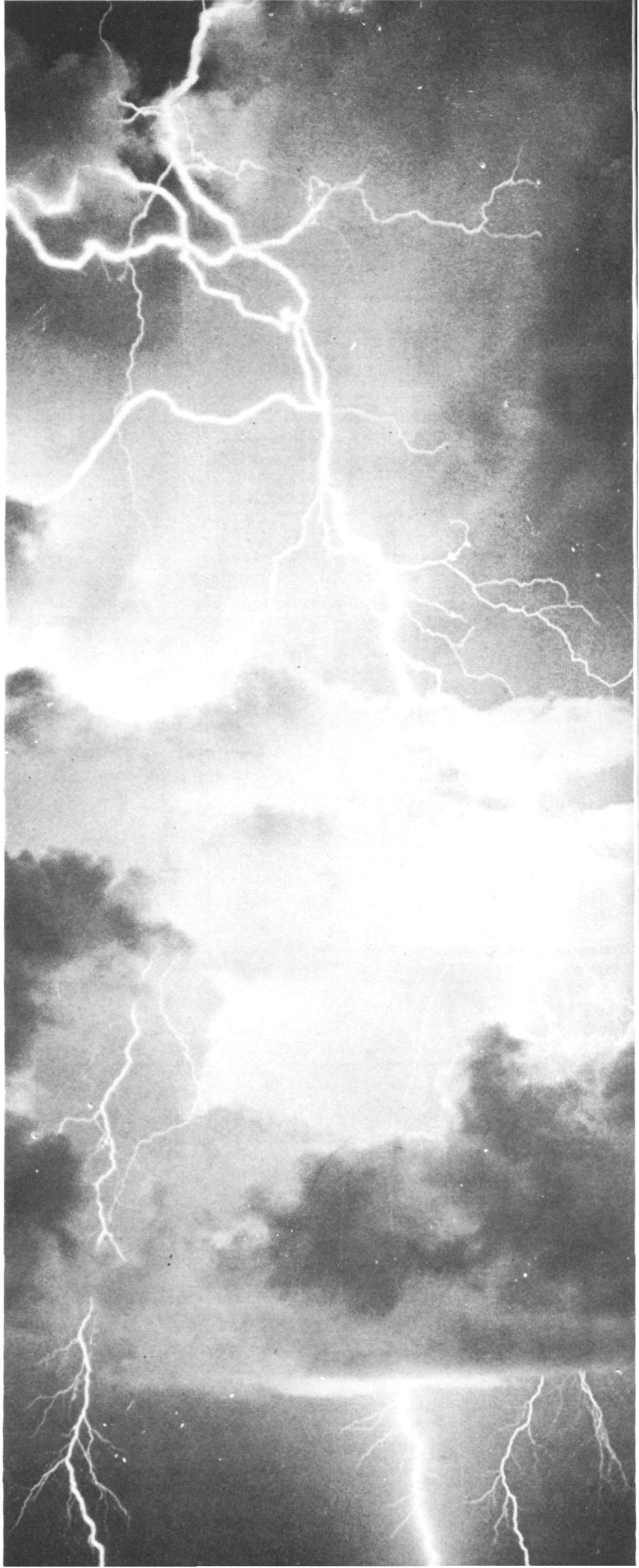
WHILE APOLLO mooncraft are readied for launch, lightning experts from the ESSA Research Laboratories probe nearby clouds with a specially instrumented aircraft.

Support of manned spaceflight is only a tiny facet of ERL's total interest in lightning—an awesome atmospheric phenomenon that strikes the earth 100 times every second. Lightning is nature's most devastating weapon causing, in an average year, more deaths and more property damage than tornadoes and hurricanes.

Four ERL elements—the Atmospheric Physics and Chemistry Laboratory (APCL), the National Severe Storms Laboratory (NSSL), the Research Flight Facility (RFF), and the Institute for Telecommunication Sciences (ITS)—are studying lightning as it affects their particular fields of interest. In line with its responsibility for research in weather modification, APCL is gathering the data and laying the groundwork necessary to provide warnings and eventually to suppress or control lightning. RFF, the airborne research arm, is helping in APCL's experimental work, as well as in NSSL's detailed documentation of severe storms. The Institute for Telecommunication Sciences, charged with research on the quality of long-distance communications, is centering its lightning effort on studying the electromagnetic signals of lightning and associated weather phenomena.

Dr. Heinz W. Kasemir, of the Atmospheric Physics and Chemistry Laboratory, explains his interest in lightning during rocket launches: "Flying a plane or launching a rocket through thunder or rain clouds can be hazardous, not so much because the vehicle will be hit accidentally by natural lightning, but because the moving metallic structure may trigger a lightning stroke from the storm."

A physicist specializing in atmospheric electricity for more than three decades and one who has concentrated on lightning suppression work since 1962, Dr. Kasemir cautions that "much basic research on atmospheric electricity needs to be done before lightning hazards can be adequately evaluated or protected against." Kasemir and his group, working under a National Aeronautics and Space Administration contract, are gathering the atmospheric electricity data necessary to assess accurately the lightning hazards to rocket boosters.



(Above) Dr. Heinz W. Kasemir, of ERL's Atmospheric Physics and Chemistry Laboratory, demonstrates how lightning can be suppressed by dropping chaff in thunderheads. The chaff, represented by the rod in Dr. Kasemir's hand, drains away the cloud's electric charge. (Left) An ESSA DC-6 was struck three times by lightning during a thunderstorm research project in Arizona.

The Apollo 12 Saturn rocket encountered two lightning discharges in its first minute of flight. The first, about a half-minute after launch, occurred when the rocket and its exhaust plume triggered a lightning discharge which reached the ground. The second stroke, which was triggered higher up in the cloud, did not strike the ground. However, such a cloud discharge can be as hazardous as its more impressive cousin, the lightning bolt that reaches ground.

The suspected triggering effect of metallic vehicles in thunderheads was well documented during the Laboratory's thunderstorm research project near Flagstaff, Arizona, when an ESSA DC-6 research aircraft was struck by lightning on three separate occasions.

Each time lightning struck the aircraft, similar meteorological conditions existed—the plane was in a dissipating thunderhead or cumulonimbus near the freezing level and in an area of the cloud that contained both ice and water.

The DC-6 aircraft, operated by the Research Flight Facility, is a well-equipped airborne system capable of measuring and recording most meteorological and electrical conditions. Thus, much information was available on the electrical state of the atmosphere surrounding the aircraft before the lightning struck.

This information suggests that the aircraft itself, moving through the thunderhead, may have triggered the discharge. Although lightning strikes to aircraft are not uncommon, it is unusual to have them so well documented with meteorological and electrical measurements.

Kasemir now is attempting to gain similar knowledge of the meteorological and electrical conditions which pose a lightning hazard to rockets. On Apollo launch days, Kasemir will measure the electric fields inside any existing clouds along the launch vehicle's flight path before liftoff. This is done from a specially equipped aircraft.

Actual measurements of the electric field produced on a rocket in flight have never been made, so Kasemir's team laid plans to measure the unknown quantity. Staying aloft through Apollo's launch phase, Kasemir sought to measure the charge on Apollo's Saturn booster on the flight of Apollo 13, April 11, but was unsuccessful in the first attempt. This work is part of a NASA/ESSA effort to develop a lightning warning system and, ultimately, techniques for lightning suppression.

Defining dangerous clouds is the first step. Knowing that the nature of charge production and its distribution within different sorts of clouds may vary, meteorologists use a "tripolar

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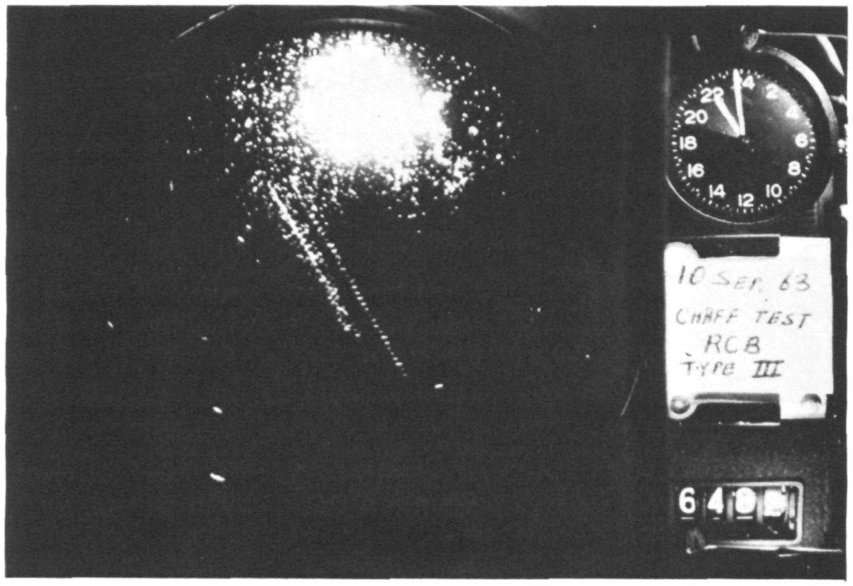
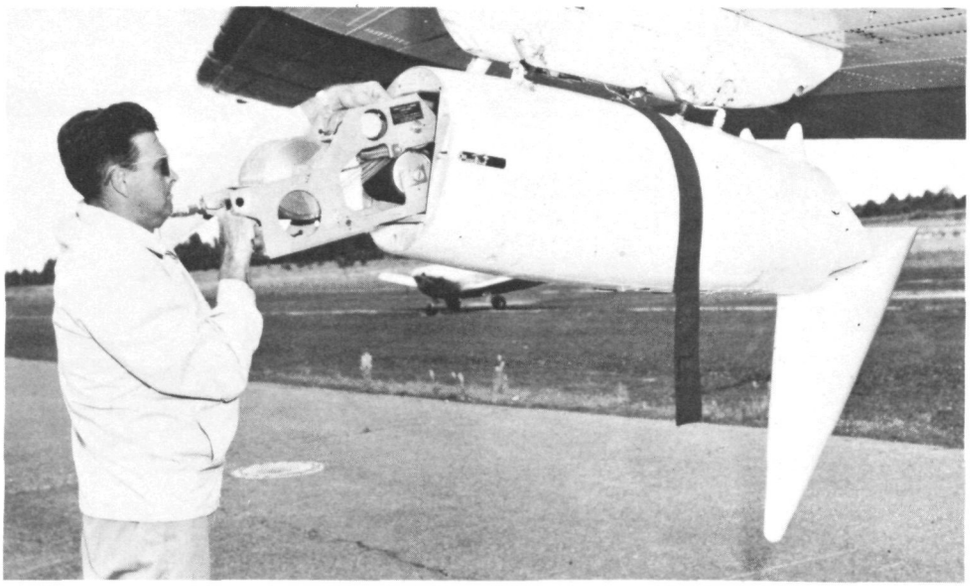


In preliminary experiments, chaff packages (upper right) were released from planes (right) into thunderheads. The radarscope photograph (above) shows two streams of chaff packages dropped 10 seconds apart by a research aircraft. These tests indicate that lightning suppression by chaff seeding is a sound procedure.



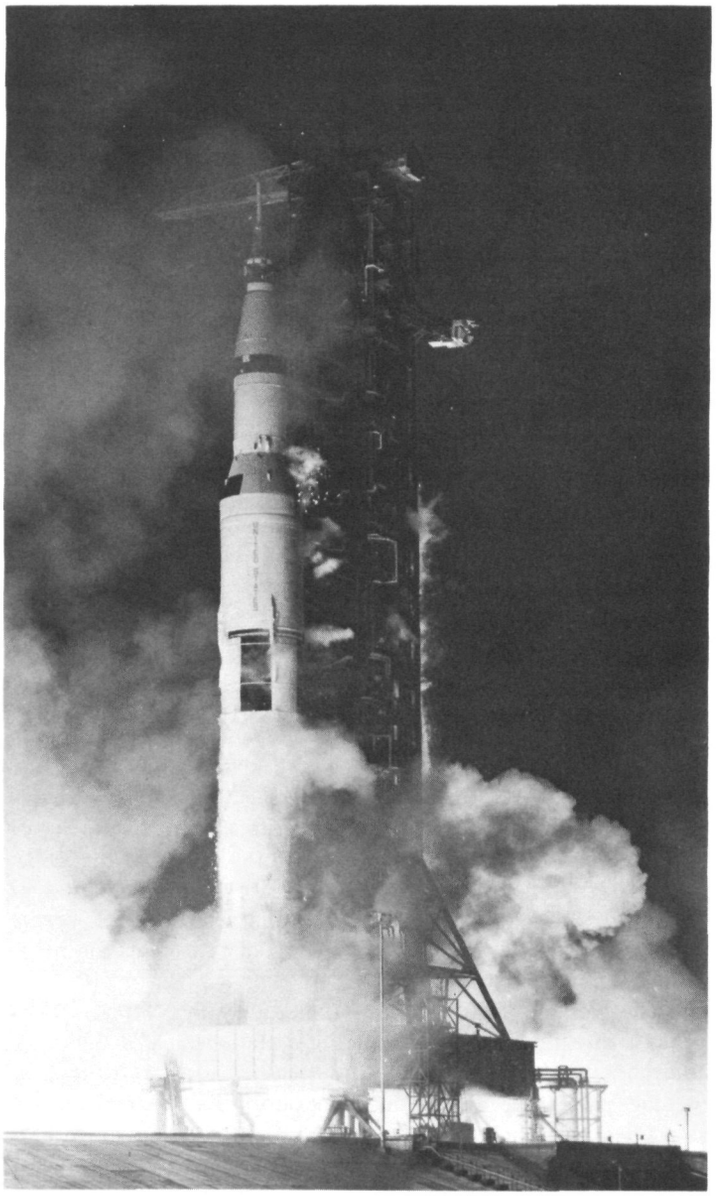
model" of a thunderstorm to describe the charge distribution of a generalized storm. This simplified model can be used to understand some of the problems in predicting, protecting against, and preventing lightning. The frozen upper layers of the cloud generally harbor a concentration of positive charge, while the bottom layers are divided between a big bulk negative charge and a final, lower pocket of positive charge. The earth itself is usually negatively charged with respect to the atmosphere, but, as the cloud passes over the ground, it induces a positive charge on the ground for several miles around the storm.

This positive "electrical shadow" on the ground grows stronger as the negative cloud charge above it increases. As charge builds, the electric field and the potential difference between cloud and ground rises. With large amounts of highly insulating air in between, lightning, the discharging flow of electrical current between the two opposing voltage potentials, does not begin easily. Before lightning strikes, the potential difference must overcome the resistance of the air in between. Previous research showed that electric fields of 300- to 500-thousand volts per meter were necessary within a cloud before a natural lightning strike could occur. However, introducing a large metallic object into the cloud changes the whole picture, because a lightning discharge can be triggered from a much smaller electric field than that required for natural lightning.

Calculations based on theoretical considerations indicate that fields as low as 10- to 30-thousand volts per meter are capable of producing lightning when a rocket vehicle penetrates the cloud. If these calculations agree with data gathered during Apollo launches, then virtually any non-thundering rainshower must be considered a possible launch hazard.

The electric field built up on a rocket as it speeds through the atmosphere, trailing its massive tail of hot burning gases, should vary with rocket size, velocity, and the characteristics of each individual exhaust trail. When the actual charge on Apollo's Saturn booster has been measured, Kasemir will have one unknown pinpointed.

The other unknown—the electric field of each cloud—is a constantly changing factor, but one which is measurable. Deducing electric fields in clouds from measurements made on the ground is very difficult because the electric field at the ground is caused by many charges which, being far from the ground



On Apollo launch days, the Atmospheric Physics and Chemistry Laboratory will measure the conditions which pose a lightning hazard to rockets.

stations, have effects that are extremely difficult to sort out. For example, if charges in the cloud are not too far apart, ground readings of the electric fields will be very low compared to the field inside the cloud. Similarly, if the cloud is at a high altitude or if its differing charges are spread more horizontally than vertically, ground readings again will be misleading. Ground measurements of the field of a cloud can be further falsified by other electrical disturbances, such as space-charge pockets from exhaust fumes, corona discharge of power lines, or even nearby pounding surf which generates small areas of electric charge in the atmosphere.

Thus, even though ground measurements are continuously available at relatively low cost, they alone cannot be relied on to determine launch safety. ESSA's flight studies on Apollo will be compared with simultaneous ground data to better define the exact limitations of the ground-based atmospheric electricity measuring network. Then, further research and improvements in ground-based equipment may increase the accuracy of ground measuring networks.

Until then, the best way of measuring a field inside a cloud is to fly instruments inside the cloud itself. It is easy to measure the electric field at right angles to an airplane's flight and considerably more difficult to measure the electric field along the path of the aircraft. Also, maximum fields inside the cloud are difficult to locate once an aircraft has penetrated the cloud and begins to feel the effects of the overwhelmingly large fields caused by the charges closest to it, which tend to blank out other more distant charges.

A second aircraft, flying outside the cloud at about 20,000 feet, can sense all of the electric charge centers more easily and guide the monitoring aircraft to those portions of the cloud which contain the highest fields. With accurate knowledge of the charge the rocket will carry into the cloud and with similarly accurate measurements of existing fields inside particular clouds, the ESSA team would be able to tell NASA specifically which clouds pose hazards to a launch.

Kasemir says: "Once we have these basics in hand, we hope to proceed to some controlled experiments in lightning suppression." Already, APCL has done research on a method of suppressing lightning by dropping chaff in thunderheads. This concept is based on the assumption that the artificially created corona discharge on a large number of chaff fibers should drain the electric charge faster than it can be restored by the cloud.

If the storm's charging mechanism grows to "breakdown potential," either an intra-cloud or cloud-to-ground lightning stroke will occur. If, however, the chaff particles—which are good generators for glow discharge—are added, it is possible that current will flow through that portion of the cloud's "electric circuit" and never allow sufficient buildup for lightning to occur.

Both these theoretical considerations and preliminary tests show that lightning suppression by chaff seeding is sound and well-founded. Furthermore, it would provide a method of keeping a cloud harmless over a long period of time. Conclusive tests in the real atmosphere, however, remain to be done, and chaff could conceivably interfere with necessary radio communication between ground control and a rocket.

Another possible means of suppressing lightning for the specific problem of safe rocket launches would be to discharge the cloud by inducing a lightning strike just before launch. This could be done with small rockets trailing sufficiently long wires to simulate the entire length of the Saturn-Apollo launch vehicle. But this is far from an operational procedure. It will be necessary to fire a number of test rockets and study their effects on various clouds. Among the important outstanding questions are: Can a small rocket trigger the discharging lightning in fields small enough to allow the larger rocket to follow safely through the cloud? And, how long will a cloud remain discharged after a small rocket dissipates its charge?

Electric fields at the ground are known to recover their pre-strike value within 10 seconds of a lightning stroke. And a medium-sized thunderstorm may produce lightning once every 20 seconds. However, the charge buildup after artificially triggered lightning may not be the same as after natural lightning, since the lightning will be induced as much lower electric fields than that necessary for natural lightning.

continued

Much work remains before ESSA's ultimate goal of protecting rockets from induced lightning is reached. But, the work is begun, and the atmospheric electricity measurements made during Apollo 13's launch were an important first step.

While Kasemir studies the voltage buildup from the separation of electric charges which precede a lightning stroke, other ERL scientists with different objectives are approaching the same broad problem: How can a lightning-producing storm be defined and can it be accurately predicted which clouds will produce a lightning stroke?

In the Institute for Telecommunication Sciences, scientists are concentrating on measuring the electromagnetic signal produced by the discharge of a lightning stroke. William L. Taylor explains: "We are primarily concerned with long-distance communications and with anything that affects the quality of such communications. Lightning has a drastic effect on radio communications.

"Although our fundamental research centers around natural lightning, it is applicable to the problem of lightning induced when a conductor penetrates a storm. Aircraft and rockets do pass through potential lightning-producing storms, and there are many cases of aircraft damage from lightning strikes. Any increased understanding of intra-cloud lightning could be a help in predicting which clouds are unsafe."

Intra-cloud lightning, such as the second bolt encountered by Apollo 12, has been of particular interest in recent ERL telecommunications research, because intra-cloud lightning measurements have been elusive. Visual and photographic observations are virtually impossible through the weather conditions associated with such lightning.

However, recent ITS work has produced a new technique for observing intra-cloud strokes and measuring their height in the atmosphere. A lightning stroke is a discharge of electrical energy, and it affects the atmosphere in many ways. One obvious effect is sound waves or thunder. Counting the time between a lightning flash and the following thunder is a good way to judge how far away the lightning occurred (about one mile for each five seconds of delay). The ITS scientists applied a similar principle in a much more sophisticated way to calculate the height of intra-cloud lightning strokes.

The lightning discharge radiates electrical energy in all directions. The energy that moves upward toward space encounters the earth's ionosphere—a region of the atmosphere where many of the molecular constituents have been transformed into electrically charged ions.

Here, some of the energy from the lightning stroke is reflected back towards the earth. Scientists can pick up this reflected energy, called sky waves, with various antennas. Taylor's studies showed that cloud-to-ground lightning strokes produced a single waveform return from the ionosphere, whereas intra-cloud flashes caused a double return in the sky wave component. Energy moving upward from the lightning stroke and reflecting off the ionosphere does not arrive at the antenna receiver simultaneously with the energy moving downward from the same stroke. The downward-directed energy bounces upward off the earth, reaches the ionosphere, and then is reflected downward again toward the receiver. This double reflection process takes longer and produces a distinct time lag. Measuring the time lag between the two sky waves and knowing how far away the lightning stroke occurred, scientists can then calculate the height of the intra-cloud stroke.

The ESSA scientists gathered their data with a vertical antenna to monitor wideband sky wave components of the atmosphere's vertical electric field, wideband crossed-loop antennas to define directions of arrival of the wave, and an intricate system of oscilloscopes and timing marks which were photographed on continuously moving 35 mm. film. This equipment was located near Lafayette, Colorado, at the foot of the Rocky Mountains.

A mobile unit maintained close surveillance of thunderstorms to tabulate the direction and time of each lightning flash. These last data were used with the photographic records of the crossed-loop responses to determine the distance from the Lafayette station to each lightning stroke. With this information, scientists could then use the delay times for the sky waves to calculate the height of the lightning stroke.

Taylor notes that the practical range of this method extends from a few tens to several hundred kilometers for the once-reflected ionospheric wave to as much as 500 or 600 kilometers for the twice-reflected wave. Thus, a large region of thunderstorm activity can be monitored from a single location.

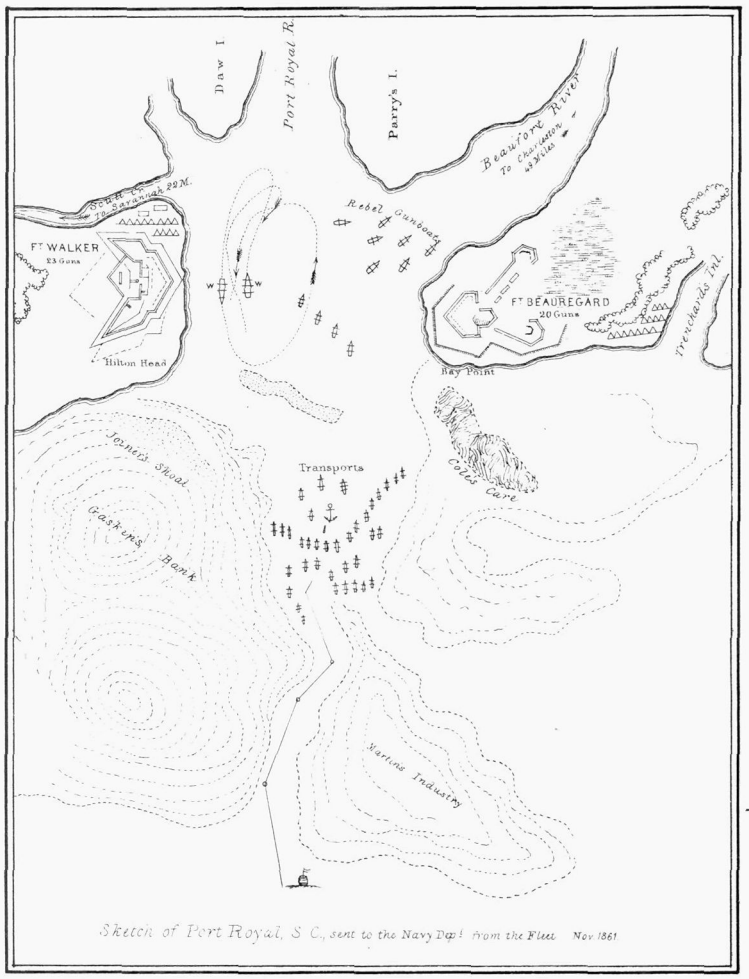
This new method of differentiating a cloud-to-ground stroke from an intra-cloud discharge and determining the height of the electrical discharge itself may be useful in many research areas. Relationships between thunderstorm activity and the quality of radio propagation is one immediate area for application of Taylor's new technique—both as a research tool and for predicting the quality of radio propagation on a given day or along a particular flight path. Scientists seeking to predict or prevent aircraft or rocket-triggered lightning may find the ESSA intra-cloud lightning data useful. Studies of the distribution of the world's thunderstorms and the characteristics of severe storms should also benefit from being able to pinpoint intra-cloud lightning bursts.

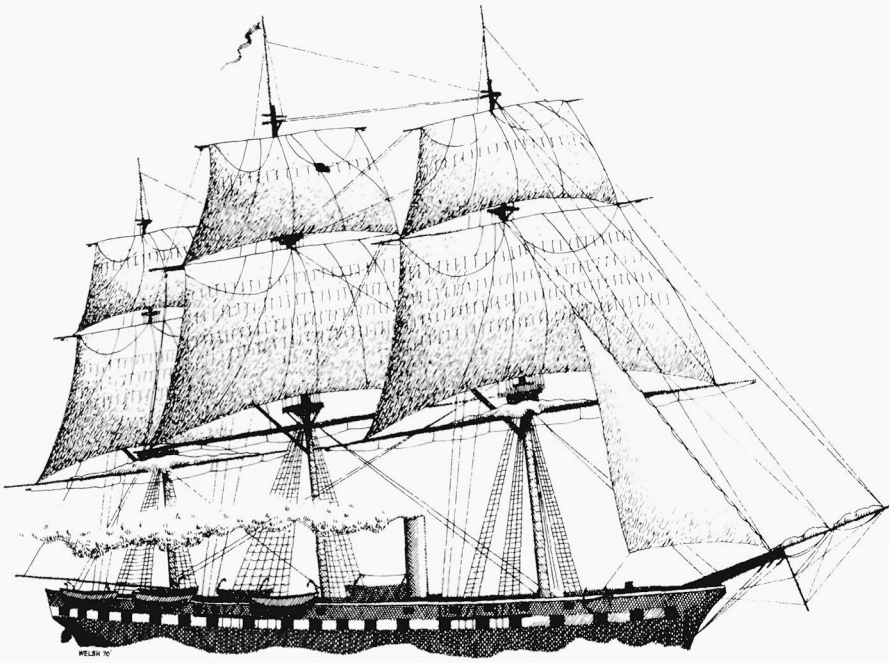
The National Severe Storms Laboratory in Norman, Oklahoma, is investigating the possible interrelationships of lightning, atmospheric electricity, and severe weather such as tornadoes. For the past three years, the Laboratory has carried on an atmospheric electricity project, which gathered much storm data and information on the association of electricity with other features of severe storms. Of particular interest to this group is the spatial relationship between the position of lightning, precipitation areas, and the inflow and outflow regions of storms. The movement and development of storms is also being related to atmospheric electricity data.

Joining the annual NSSL spring storm studies this year, scientists from the Institute for Telecommunication Sciences observed and recorded electromagnetic signals from severe storms and squall lines over Oklahoma. Past studies indicate that the energy from individual lightning discharges peaks at frequencies around 5 kilohertz. It is possible that another discharge mechanism operates in a tornado. Conceivably, atmospheric electric energy may be obtained from surrounding clouds and subsequently discharged down the main vortex of the tornado much as a neon light operates. If this hypothesis is true, the observations should show different electromagnetic frequencies from tornadoes and simple thunderstorms. Bill Taylor explains: "We observed frequencies from 5 kilohertz to 45 megahertz. This frequency range should indicate any differences between the electromagnetic signals sent out by thunderheads and those sent out by tornado-bearing storms."

As the work of these laboratories progresses, lightning—one of the most familiar of atmospheric phenomena—will be better documented and better understood. □

MAPPING the REBELLION





A Coast Survey party guided Union warships through shoals and marshes at the mouth of the Beaufort River to knock out Fort Beauregard and rebel gunboats.

BY WILLIAM A. STANLEY
Coast and Geodetic Survey

IN THE MORNING of November 8, 1861, a Union flotilla circled South Carolina's Beaufort Harbor like an Indian war party harassing a covered wagon, raking Confederate defenses. When it was over, Fort Beauregard and Confederate gunboats guarding the Beaufort River had been shelled into submission, and another link had been forged in the southern coastal blockade.

It was a spectacular moment, but for sheer, suspenseful melodrama it could hardly rival an event of the night before. Then, a tiny launch with a signal lantern suspended from its bow slipped quietly through the corridors approaching the harbor, guiding past deadly shoals and marshes two gunboats of the flotilla which was to make history in the morning.

The story had begun some time earlier, when the U. S. Coast Survey steamer VIXEN had plotted the harbor's approaches and surveyed the region to determine water depths. The VIXEN and the schooners BAILEY and CASWELL had been attached to the blockade drive; during this assignment Coast Survey engineers had charted Charleston Harbor for such vital information as the location of sunken vessels, and the relocation of buoys destroyed by rebel forces or moved by the Confederacy to confuse Union ships in the coastal zones.

On November 5, the VIXEN joined in forming a great "V" of ships. The formation included transport vessels carrying some 13,000 men and logistics material, under the command of General William Tecumseh Sherman. Two miles south of Bay Point and west-southwest of Fort Beauregard nestled behind its 20 cannon, the flotilla slowed and stopped.

It was a tense time. Heavy weather, with violent gales, had moved in. The Union gunboat AUGUSTA and the sloop-of-war DALE were some distance to the rear of the main contingent. Fearful of going aground on the coastal shoals and marshy areas, they waited for help.

Commodore S. F. DuPont, commanding the flotilla, assigned to Charles O. Boutelle, the assistant in charge of the Coast Survey party, the job of guiding the ships through.

At 8 p. m. Thursday, Boutelle and his men anchored a small launch from the VIXEN at the channel entrance. The AUGUSTA took the DALE in tow. Led by the VIXEN and her launch, they inched safely up the narrow entrance.

On the morning of the 8th, the warship WABASH moved toward Beaufort River and Fort Beauregard, with the entire flotilla following in its wake. Boutelle left the VIXEN and joined General Sherman aboard the gunboat ATLANTIC to witness the engagement.

The fleet sailed in a circle under slow steam, each vessel delivering its fire as the ships approached and then passed the fort and Confederate gunboats blocking Beaufort River.

The WABASH, with her batteries of 8-inch guns on two decks, reeled from side to side as each of her gun divisions fired their volleys in succession. Mr. Boutelle in notes made at the time stated, "The air was filled

continued

Fort Sumter, the scene of the Civil War's first battle, was sketched by W. T. Crane of the Coast Survey on August 23, 1863.

with the smell of gunpowder which darkened the morning sun." He continued, "As they came around the second time, fewer and fewer Confederate guns were able to return their fire. Until at last only one gun continued to repel and then it too was silent."

Mr. Boutelle and his assistants Platt and Jones watched as the Confederate flag fell, and it was then that they saw a launch from the warship WABASH pull alongshore and in a few minutes up went the Stars and Stripes over the besieged fortress. The account from the Coast Survey's log continued: "Such shouts as rent the air were never heard before in South Carolina. The whole transport fleet was soon in motion with bands playing and soldiers shouting. They went up into the bay and anchored around the flagship."

With the battle over, the dead and wounded were counted. The Coast Survey lost one man, and two others had suffered minor wounds. In the entire fleet of 13,000 men, only 12 had been killed. The South had received heavy casualties and the Confederates retreated, leaving behind large stores of guns and equipment.

In such a war, father fought against son and friend against friend. The 800 men of the Confederacy, who bravely held Fort Beauregard as best they could, were under the command of Brigadier General Thomas F. Drayton whose brother Captain Percival Drayton was a member of the Coast Survey vessel VIXEN and among the Union forces which besieged the Fort.

After the battle, the Coast Survey party resumed the task of making preliminary reconnaissance surveys of the immediate area. Moving up Beaufort River and Scull Creek, it observed large numbers of Confederate forces in the area. The party was within 47 miles of Charleston itself.

General Sherman, on the second day after the battle, called Boutelle to his quarters to express his extreme gratitude for the services rendered by the U. S. Coast Survey. General Sherman was quoted as saying, "A large share of the success and credit is due to the Coast Survey and its men, which I will reflect in my report to General Grant." Commodore DuPont also expressed his appreciation for a job well done in providing the Union forces with valuable data and maps for the use of his ships. He added a special note of thanks to another Coast Survey man, Mr. Willenbucher, whose labor in providing three sketches of the Hilton Head area and channel approaches, along with an excellent sketch of the actual attack, aided greatly in the success of the operation.

An extract of the letter General Sherman forwarded to Washington reads: "Headquarters Expedition Corps, Port Royal, South Carolina, November 8, 1861. It is my duty to report the valuable services of Mr. Boutelle, Assistant, U. S. Coast Survey, in aiding me with his accurate and extensive knowledge of this country. His services are invaluable to the Army as well as to the Navy and I earnestly recommend that important notice be taken of this very able and scientific officer by the War Department. Signed, W. T. Sherman, Brig. General, Commanding."

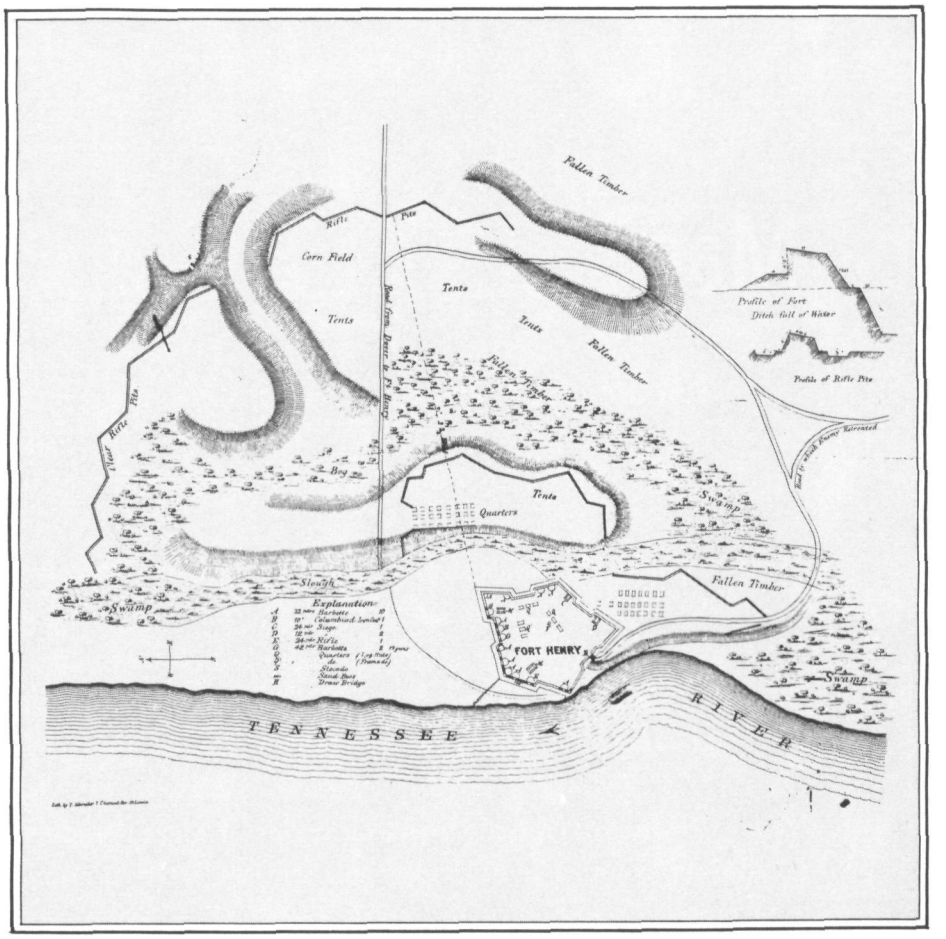
The Coast Survey and its men were used to the fullest by the War Department during the Civil War. At the outset of the struggle between the states, the Union Army requested that a survey be made of Washington's defenses, including all the detailed features of ground occupied by the Army under Brigadier General Irvin McDowell. The work began in 1861, with F. W. Dorr and Cleveland Rockwell working under the protection of guards. Although Rockwell was forced to interrupt his field surveys when Confederate forces approached his camp, the project was completed in July 1861, before the first Battle of Bull Run.

During 1862, 49 Coast Survey officers served in military operations; Dorr narrowly escaped death, and two members of his party were killed during a survey before Yorktown. Thousands of nautical charts were reproduced throughout the war for military use. In 1864 alone, the Coast Survey produced and distributed 37,000 copies of its regular charts, 23,000 of them for the Navy.

At about the time of the Beaufort Harbor incident, other Survey parties, assigned to Major General W. B. Franklin's 19th Union Army Infantry, moved into the gulf coast for field reconnaissance along a route for the invasion of Vermilionville and Washington, Louisiana. Mapping also was undertaken to pave the way for Major General Nathaniel P. Banks' march and the ensuing Red River Campaign.

Coast Survey men witnessed numerous major engagements, such as the Battle of Chattanooga and Chickamauga. On Sept. 17, 1863, the Union, advancing on Chattanooga, used Survey information produced by field parties with General W. S. Rosecrans' Federal army of 60,000 men.

At the same time, the Confederate forces, having evacuated the city upon seeing Rosecrans' forces approaching, lay along the Lafayette road from the town of Lafayette to the vicinity of Lees and Gordons Mills. Meanwhile, General James Longstreet's Corps from Virginia was arriving at Ringgold. Rosecrans, bent on occupying Chat-



(Above) A sketch of Confederate installations at Fort Henry in 1863. (Right) The battleground of Pleasant Hill and disposition of troops on April 9, 1864.

tanooga, directed Coast Survey field parties to provide reconnaissance data and a layout of the city itself, to update older surveys.

At daylight on the 19th, the battle was on. By 1 p. m., the fighting on the Union left had ceased; the South had withdrawn to the vicinity of Jay's Mill. There, the battle raged for several days. At daylight on October 27, General Rosecrans executed final maneuvers against the rebel forces. The Confederate Army then withdrew, first to Chickamauga Station and Ringgold, and then to Dalton. The Union pursuit continued to Ringgold where, on November 27, it ended.

While Rosecrans' forces were on the move, two Coast Survey officers were accompanying General Sherman on his famous march, but it was so rapid that surveys were rarely made. When the march ended at Savannah, Georgia, Survey officers prepared a map of the route. During this and other Union campaigns, battle sketches were made which now repose in the permanent archives of the Coast and Geodetic Survey.

Superintendent Bache, whose admiration for his forces' work was enunciated many times over, was not one to be confined to a Washington desk when history was in the process of being made. During the summer of 1863, when Philadelphia and other eastern cities appeared vulnerable to attack, he personally directed a survey party assigned to Philadelphia. That June, he reconnoitered an 80-square-mile area, including construction sites for several small field works which were to be built if the Union needed them.

It was, perhaps, one of the saddest periods in all of America's history. Many Coast Survey officers were divided in their loyalties, as was the rest of the nation. At the start of the war, 12 Army officers and 11 naval officers were on assignment with the Survey, commanding small vessels and field parties. Most of them returned to their Union posts; others joined the Confederacy. Lieutenant Matthew F. Maury, a Navy officer with close ties to the Coast Survey, served during the rebellion as a Confederate admiral; he was one of the great oceanographers of all time.

Other Coast Survey men involved in the war included Lieutenant John Maffitt, who commanded Confederate blockade runners, and Lieutenant Ambrose P. Hill, who became a Confederate general. Major Isaac Stevenson, a Union officer, later was known for his improvement of chart reproduction processes, and eventually became governor of the Washington Territory.

It was a period of exceptionally distinguished service by the Survey, founded as the nation's first scientific agency by President Jefferson in 1807. Many plaudits came its way. The men themselves, however, took a craftsman's view of their performance. George Davidson, one of the greatest Coast Survey engineers of the era, spoke for many in his letter of July 18, 1868, to Acting Superintendent Julius E. Hilgard concerning a bill before Congress to provide for recognition of Survey officers' wartime service.

He wrote: "I believe that at this late date it will not add additional credit to the work done during the rebellion to provide fancy titles. In fact, I think it will rather bring a smile of contempt upon the Survey in seeking cheap glory. In my judgement we have a higher plane of reference, that of a thoroughly practical scientific organization and in the self satisfaction of a job well done." □

Designing a seeding device
or diving for sunken treasure...
Brad Patten gets results.

An Environmental Man

WHETHER AT WORK in the air or relaxing underwater, Bradley T. Patten's accomplishments are out of the ordinary.

Pursuing his skindiving hobby, he has made the largest registered find of sunken treasure off the coast of southern Florida.

On his job as a flight engineer with the ESSA Research Laboratories' Research Flight Facility, Patten has put together a device that filled a gap in modern cloud-seeding equipment.

He designed and built a quasi-jet engine that burns a mix of acetone and silver iodide. Slung under the wing of an aircraft, the burner can be controlled from inside the plane. Thus, the project director can decide exactly where and how much he wants to seed, and have his airborne instruments on the spot when seeding occurs.

Patten started developing the silver iodide generator in November 1967 as a result of a gentlemen's bet. Patten thought a basic jet engine scheme or "mini-jet" should be able to give scientists flexibility and control in the timing and concentration of seeding materials put into the atmosphere.

He also believed he could build a unit that would not flame out at high speeds or experience silver iodide buildup inside the engine. Howard J. Mason, Jr., Chief of the RFF, bet a steak dinner on the idea, and Patten started working on his mini-jet in odd moments between other assignments at RFF's home base in Miami International Airport.

ESSA Profile

Patten's burner received its first field use in the 1969 Great Lakes Snow Redistribution Project. The burner was the main seeding device used in the five-week project to study the feasibility of redistributing heavy snowfall from lake-effect storms. Dr. Helmut K. Weickmann, director of ERL's Atmospheric Physics and Chemistry Laboratory and director of the Great Lakes project, says of the burner:

"This burner is the brain child of a mechanical genius. It burns with little adjustment and modification almost exactly the way it was designed. Ignition of the silver iodide mixture is much more difficult at flight altitude as there is less oxygen than near the ground. However, even with this potential problem, the burner fires on command. The output of seeding material is most efficient."

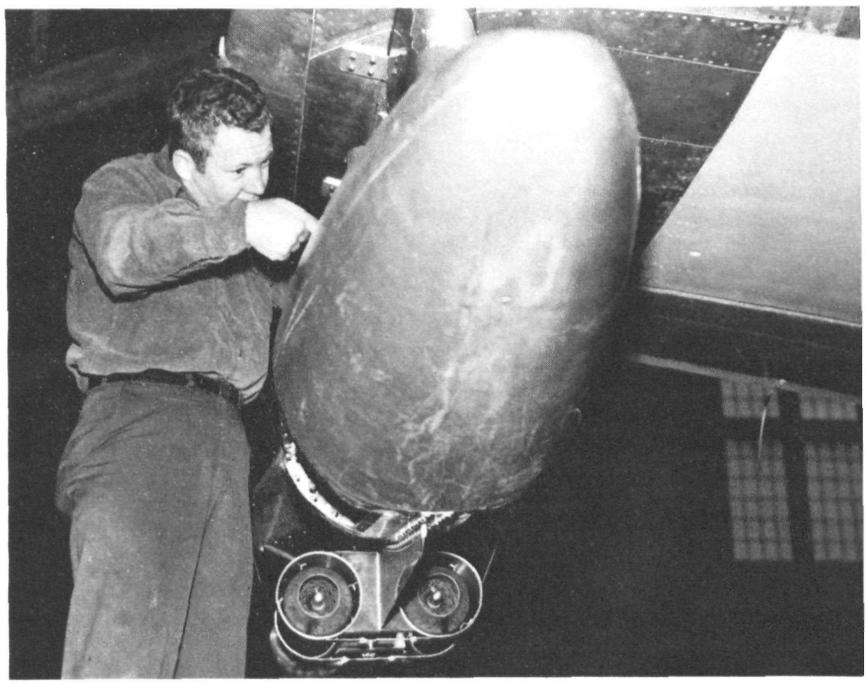
When Patten becomes interested in something, results usually follow. He is an avid skin diver and, in 1965, discovered sunken treasure off the coast of southern Florida, the largest find registered for this area. During his dives at this wreck, he found 350 silver Spanish coins valued at $30,000. Silver coins, he explains, are more valuable than gold ones, because silver deteriorates in sea water much faster and is therefore more rare. The following year, he logged in the second largest—both in value and number—find of coins and artifacts. Patten and his three associates in this venture called themselves the "Royal Fifth," from the term used in Spanish colonial days when one-fifth of all treasure was returned to the king.

During the past decade, Patten's work for ESSA and the Weather Bureau has taken him around the world. With his RFF colleagues, he has probed tropical storms, monsoons, an Arabian Sea cyclone, hurricanes, midwestern squall lines, severe turbulence over the Rocky Mountains, and the breeding grounds of hurricanes over the Atlantic near Barbados.

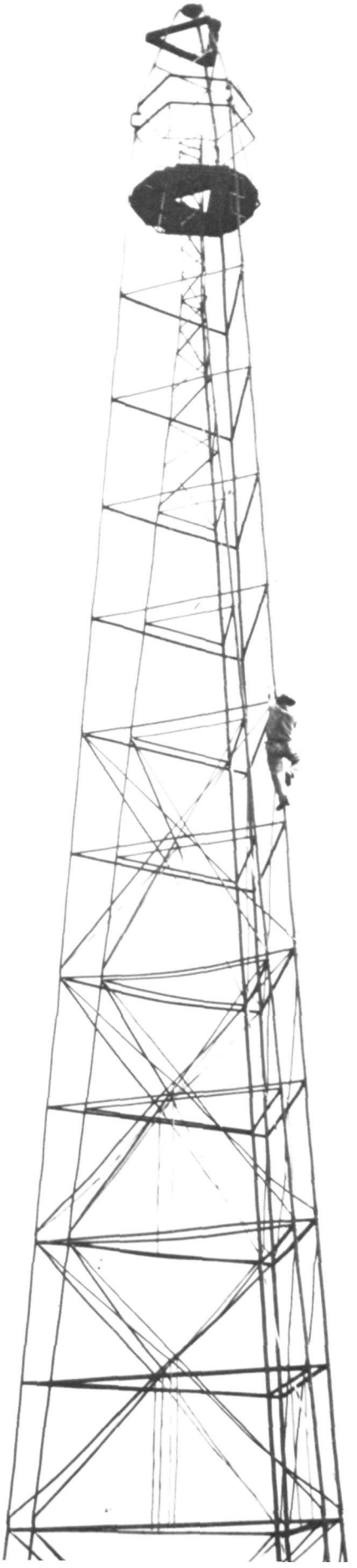
One hurricane, Inez in 1966, saw Patten seven times, as the RFF planes repeatedly probed the storm. During one of these flights, Patten's aircraft recorded hurricane winds of 197 miles per hour, the highest hurricane winds ever measured in flight.

In between such assignments, Patten finds time for his hobbies. As in his work with RFF, he has a long list of credits in his special interest fields. His diving experiences have rated Patten a recognized explorer, a published author, and a photographer of some note. His photographs of both weather and undersea exploration have appeared in such publications as *National Geographic*, *Life's Weather Book*, *Saga*, *Argosy*, and *Skin Diver*.

Patten's latest honor is membership in the exclusive Explorers Club of New York. His nomination to this select group was based on a diverse set of accomplishments—weather research, diving, undersea exploration, photography, and inventiveness. □



(Above) Patten adjusts his silver iodide generator during the 1969 Great Lakes Snow Redistribution Project. (Below) Slung under the wing of a Research Flight Facility aircraft, the burner can be controlled from inside the plane. It was the main seeding device used in the five-week snow modification project. ***(Left)*** *Patten holds silver coins retrieved from a sunken Spanish galleon.*



These eleven-story steel towers may be here today and gone tomorrow.

Jasper Bilby's Brainchild

THEY rise from the ground like oil derricks or something out of science fiction. They appear suddenly on the landscape and then as suddenly disappear. At night, lights blink back and forth between them. Spies? Men from Mars?

Not at all. The towers and the blinking lights are part of a vast program which has been going on for years—to survey very accurately the length and breadth of the United States.

The portable structures—called Bilby steel towers—are used by triangulation parties of ESSA's Coast and Geodetic Survey to see over obstacles and compensate for the earth's curvature. The triangular towers range in height from almost four stories to more than eleven stories.

Each consists of a tower within a tower, neither of which touches the other. The outer structure supports an observer and recorder, and signal lamps to be observed from other points. The inner tower supports the observing instrument. Originally, this instrument was a theodolite, but in the present era electronic distance-measuring instruments, including lasers, also are used. The electro-optical instruments utilize the speed of light for measuring, and some are so accurate that distances can be determined to within one part in a million.

From atop the towers, the men often communicate with each other by Morse code, producing the blinking lights which mystify observers.

Wherever the towers are set up, they and the men who work on them excite the interest of area residents.

"They (the Coast Surveymen) know where they've been and where they're going and can find out exactly where they are

BY RAYMOND WILCOVE
Coast and Geodetic Survey

when they get there," wrote an Oklahoma City paper.

"If it weren't for them, you wouldn't know where you are," said another.

"Big Brother?" conjectured a New York newspaper. "No, Big Brother is not watching from those tall steel towers with a 'Cyclops eye' that sprang up almost overnight."

"Who's putting up those metal towers?" inquired another New York paper. "They're just standing there."

"Not really," it added. "By day, maybe, but sneak out some night and watch the men climb to the top and flash little lights from tower to tower. Actually, the men are part of a 30-man Coast and Geodetic Survey team that will complete a two-year survey."

"The men on top of the towers won't be actors in a science fiction film," explained a Washington, D.C., newspaper to its readers. "They'll be Coast and Geodetic Survey experts busy establishing a more accurate network of surveyors' control points for this region."

And at Hamilton, Texas, the local newspaper hastened to tell its readers that "there is no cause to be alarmed" by the strange goings-on.

First used in 1927 and now employed by surveyors throughout the world, the portable steel towers were designed by Jasper S. Bilby, Coast and Geodetic Survey signalman, and the Aermotor Company.

In a book published in 1929, Bilby explained the need for the towers: "In many regions it is not possible to select stations (sites) for a scheme of triangulation and have the stations intervisible from the ground, as trees, buildings, and other objects obstruct the line of vision between adjacent points.

"On geodetic surveys, covering wide expanses of territory, the curvature of the earth must also be taken into consideration. Towers are therefore necessary to elevate above intervening obstructions the observer and his instrument at one station and the signal lamp or object on which he makes his observations at the distant station."

"Wooden towers were used exclusively for triangulation towers for a great many years," continued Bilby, "but in recent years the cost of lumber and labor has become so high as almost to prohibit their use."

Building the wooden towers often meant backbreaking labor. H. C. Denson, commanding offer of the USC&GS Steamer PATHFINDER, commenting in 1916 on work being done in the Philippine Islands, disclosed that towers built by his party ranged up to 23 stories. "All of the timber used was cut in the adjacent forests and some of it had to be transported by hand as much as two miles to the site," he wrote. Denson said the tallest tower, which rose 235 feet, took five officers and eighteen men 19 days to erect.

In his book, "Bilby Steel Tower for Triangulation," Bilby explained in minute detail just about everything there was to know about the towers and their operation.

"Care should be taken in selecting for the building party men specifically fitted for the work," he admonished. "Men working aloft should be from 5 feet 10 inches to 6 feet in height, should weigh not more than 170 pounds, and should not be more than 35 years of age. They should be of the athletic type and not given to talking while at work, except when they have something important to say. . . . When any member of a party becomes grouchy and does not show a proper disposition to cooperate with other members of the party, it is advisable to replace him."

Bilby cautioned the officer in charge to obtain the permission of property owners before erecting a tower. There have been occasions when those who neglected to do so were sometimes rewarded with a load of buckshot.

Charles A. Whitten, the Coast Survey's chief geodesist, said that "it often took considerable psychology to induce owners of land, some of whom were suspicious of the federal government, to grant permission to erect towers. One Coast Surveyman used this approach: He would tell a farmer that he would like a drink of water from his well. 'Best water I ever drank,' he'd say, smacking his lips. The farmer would beam and then the engineer would ask permission to erect a tower. It invariably worked."

On another occasion, Whitten recalled, it was necessary for a party to set up a tower in a cornfield. The men knew the farmer would never permit them to drive their trucks into the field, so they hired the farmer to carry their equipment on his wagon. "The horses ate the tassels off the corn and trampled part of the crop, but the farmer didn't mind because he had $25 of ours in his pocket," said Whitten.

Whitten recalled two "old-timers" who always left their trademark. "When we visited points after the preliminary surveys had been made, we could always tell who had done the work," he said. "One of the old-timers always placed the station mark on the front lawn. He felt that everyone should see it. The other chief of party thought differently. He felt the marker wouldn't do the lawn any good, so he invariably put it in some out-of-the-way place."

Climbing the tall towers, even when they rise some 11 stories in the air, does not pose too much of a problem to the Coast Surveymen who use them. Very quickly, they become accustomed to clambering up and down. One party once had a woman employee with enough courage to do so. She was geodesist Jeanne L. Holdahl, who climbed a nine-story tower. She admitted, however, that she was so scared that her fingerprints probably are still embedded in the metal.

There have been occasions, however rare, when employees balked at going up a tower. One employee, reporting for work his first day, was directed to climb.

Craning his neck at the tall structure, he responded: "I quit."

Erecting the Bilby steel towers is all part of a day's work, and Coast Survey crews will sometimes put up a score or more of the structures within a matter of weeks. On one occasion, however, local officials were so intrigued with the task that a tower raising ceremony was held to which county and city officials and the public were invited. The ceremony took place at Los Lunas, New Mexico.

The chief of party ensures that the steel-tower building and teardown operations are progressing safely and smoothly. Each party has a field foreman who supervises the activities of the building and teardown parties and the steelhaulers, and coordinates the construction and dismantling of towers with the schedules of the observing units.

A steel-tower building party is ordinarily composed of five men: a building foreman, a ladder-leg man for the No. 1 leg, back-leg men for the No. 2 and No. 3 legs, and a marksetter/takeoff man. A sixth man (usually the steelhauler) is required on all 103- and 116-foot towers to help construct the heavy bases and assist in passing up steel to the leg men. Under normal conditions, the party sets up one tower and establishes a complete set of marks (i.e., surface and under-

continued

ground station marks, two reference marks, and an azimuth mark) in a day's time.

A separate team, known as the teardown party, dismantles the tower. It ordinarily consists of four men: a teardown foreman, a ladder-leg man (No. 1 leg), and back-leg men for the No. 2 and No. 3 legs. The steel-hauler usually assists the party when 103- and 116-foot towers are dismantled. Under normal conditions, the teardown party breaks down two towers per day.

A 1965 revision of Bilby's book, written by Lieutenant Commander James K. Richards, prescribes the manner in which the construction and dismantling of the towers should be conducted. Considerable space is devoted to safety precautions that must be followed in this hazardous work.

"Supervisory personnel must take the necessary precautions to protect the local populace from accidents or injuries which may be attributed to party activities," cautions Richards. "When towers are erected in school yards, campuses, public parks, playgrounds, residential areas, or any other place where children may be present, protective fencing should be placed around the base of the towers for the purpose of preventing or discouraging children from climbing the towers."

A 5-foot-high snow fence was suggested as being very good for this purpose. Richards added that "fencing will not prevent a determined child from climbing a tower, but it should discourage most children, especially small ones."

Some parties have discovered, however, that instead of discouraging children, the fences apparently are a challenge to those who desire to climb the towers. Since the towers are not occupied by the party during the day, preventing children from climbing them has proved difficult, especially in populated areas.

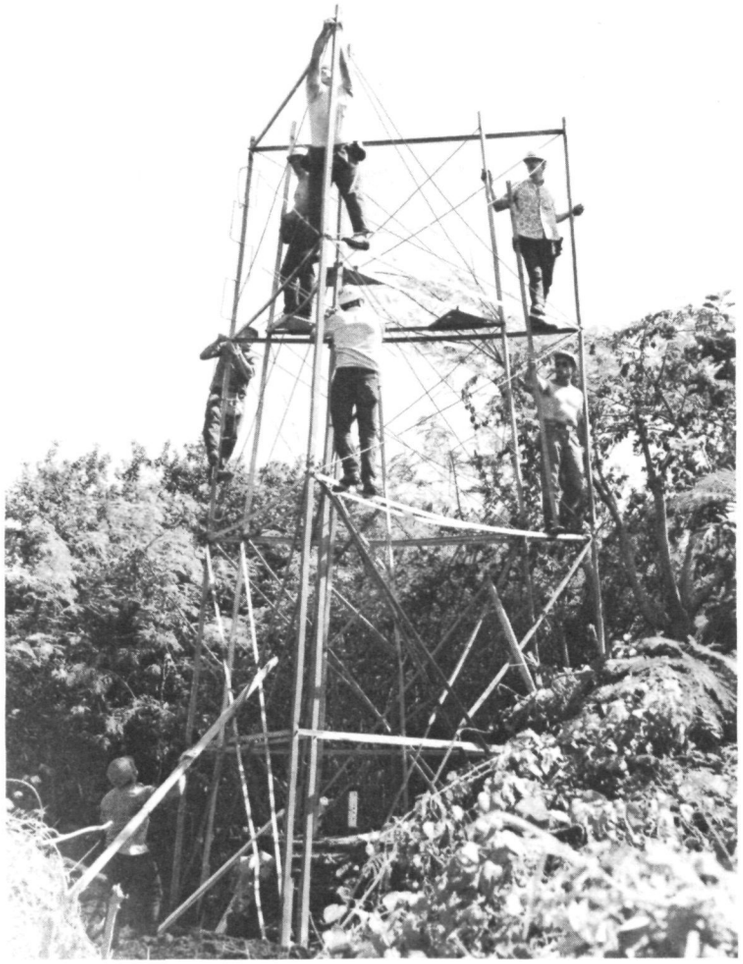
"The wooden fences sometimes don't last very long," remarked one chief of party ruefully. "As for the warning sign we put up, that's often the first thing to disappear, a souvenir for someone." Chain link fences are being erected in some populated areas to discourage tower-climbing.

One party in a Washington, D. C., suburb was beset by a band of hippies, who threatened to climb the towers and build a bonfire on the top or even tear down the tower. "You're the establishment, man," said one of them, "and we've got to tear you down." However, they contented themselves with watching the operation.

The Bilby tower was honored in December 1968 on a Christmas greeting card issued by the Geographic and Cadastral Institute of Portugal. Whitten explained that a tradition observed by many geodetic survey organizations is the exchange of greetings at the Christmas and New Year season. Frequently, the greeting card will consist of a photograph of some phase of the work of the particular organization.

Whitten termed the Bilby tower a symbol of progress, of growth and development, and of an expanding economy. "It is a symbol," he stated, "which should tell those who see it on the horizon that precise surveys are being made, surveys that are required for growth and that will serve as a base for more accurate maps and major engineering construction programs."

The Bilby tower has found wide usage in foreign countries. Soon after the towers were first used in the United States, survey organizations in other countries started to acquire them. These countries include Canada, England, Denmark, Poland, the Soviet Union, New Zealand, and numerous countries in Africa, Central America, and South America.



Setting up four- to eleven-story steel towers is all part of a day's work for Coast Survey building parties. These crews sometimes raise more than a score of the structures within a matter of weeks. A building party is composed of five men—a sixth is added for towers higher than 100 feet. Actually a tower within a tower, the inner structure holds the observing instrument, while the outer tower supports an observer, recorder, and signal lamps. The distances between towers can vary from hundreds of yards to miles.

There are three essential requirements for the design and construction of a portable survey tower. It must be rigid and stable against vibration and twist. It must be possible to erect and take down with a minimum amount of manpower and time. Finally, it must be light enough to be transported on a single truck. All these requirements are met by the Bilby tower.

The first season in which the towers were fully utilized was in 1928. Fourteen had been purchased the previous year, and by the end of the 1928 season each had been set up, dismantled, moved forward, and re-erected an average of 20 times. The cost of these operations represented a saving of about 75 percent of the amount required to construct comparable wooden towers.

With the introduction of the Bilby tower, the rate of progress of survey units increased by more than 300 percent. During the intervening years, some 700 towers have been purchased. Today, more than 200 are being used by Coast Survey field parties. Depending on height, the cost per tower runs from $2000 to $2500, and their average lifetime is estimated at 10 years.

The modest pay and hard work make it difficult to recruit personnel for the parties. People hired for mobile field parties are paid $70 to $86 a week, plus $9 to $11 per day while in the field, and must be prepared to work anywhere in the United States or abroad. In remote localities, they may live for extended periods of time on canned or dried provisions. Party personnel provide their own living accommodations, such as board and room in small towns, trailers, or tents, and must be free to move on short notice. "Persons who are unwilling to travel frequently should not apply," says a Civil Service Commission announcement.

The majority of the positions on field parties are filled by Civil Service examination. In describing the work, the Commission notes that the duties include, in addition to erecting and dismantling towers, the following: "Prolonged walking and climbing, carrying heavy packs of instruments and equipment weighing as much as 60 pounds up mountains and observation towers and clearing lines of timber and undergrowth; driving trucks over rough terrain; maintaining and operating small boats and related activities."

The examination includes tests of "spatial perception, vocabulary, reading comprehension, basic arithmetic, finger dexterity, and following oral directions." Suitable experience or, in lieu of that, high school or college education, is required to take the examination.

Applicants must "possess emotional and mental stability" and must be at least five feet ten inches tall to work on towers.

Temporary employees are hired in the field to fill vacant positions. They do not have to take an examination, but must be high school graduates, meet the height requirement, and be able to do the work. Temporary employees can stay on the job for eight months, but then must take the examination to remain as permanent employees.

Despite the difficult work and the modest pay, some field party personnel have worked for the Coast Survey for many years. They are often accompanied in their own house trailers by their wives and children. J. D. Rigney, for example, is a family man who's been traveling around the country for 18 years. He's pulled his big custom-built family trailer, or its predecessor, through every one of the 48 conterminous states.

"I enjoy it," said Mrs. Rigney of their way of life. "I'd hate to live in one place." The Rigney children feel the same way about it. Bobby, 10, has already attended 16 schools and David, 7, is in his sixth school.

But their record is surpassed by other families. In one family, Rita, a high school senior, has attended 57 schools; Pat, a junior, 42; Jean, a fifth-grader, 19; and John, in his first grade, two.

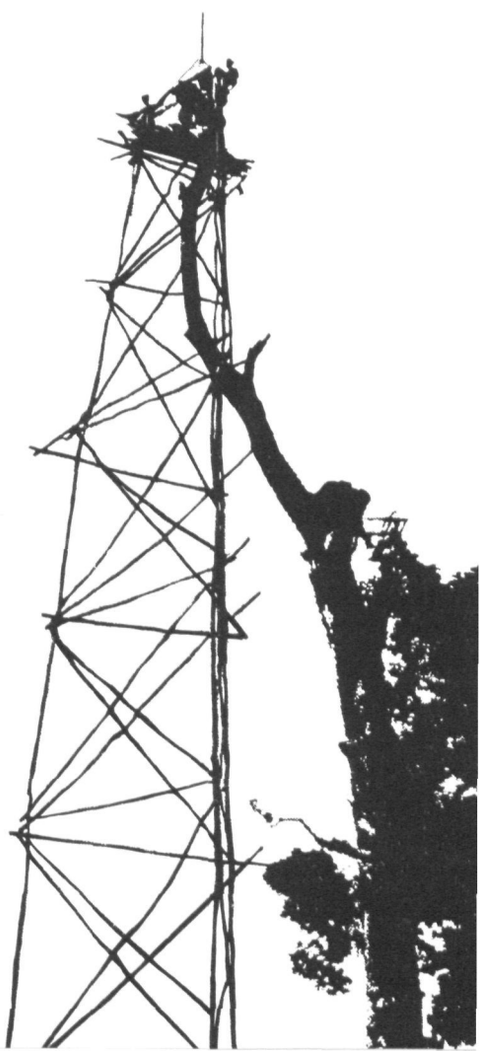
The school record of the children has been generally good, despite their constant moving about. However, in many instances, children are placed permanently in one school once they reach high school age.

Several men have been with survey parties for 28 years or more, and second-generation crewmen are not unusual. They and their families lead an active life as they follow the sun from one place to another. The summer warmth takes them to northern climes. When the air grows blustery and cold and snow dots the landscape, they move south.

There are now 25 to 30 mobile parties, although not all are engaged in survey work requiring the use of Bilby towers. Each party consists of from two to thirty Coast Surveymen. Including women and children, some parties may contain as many as 70 people, equipped with scores of government trucks and office trailers and privately owned house trailers.

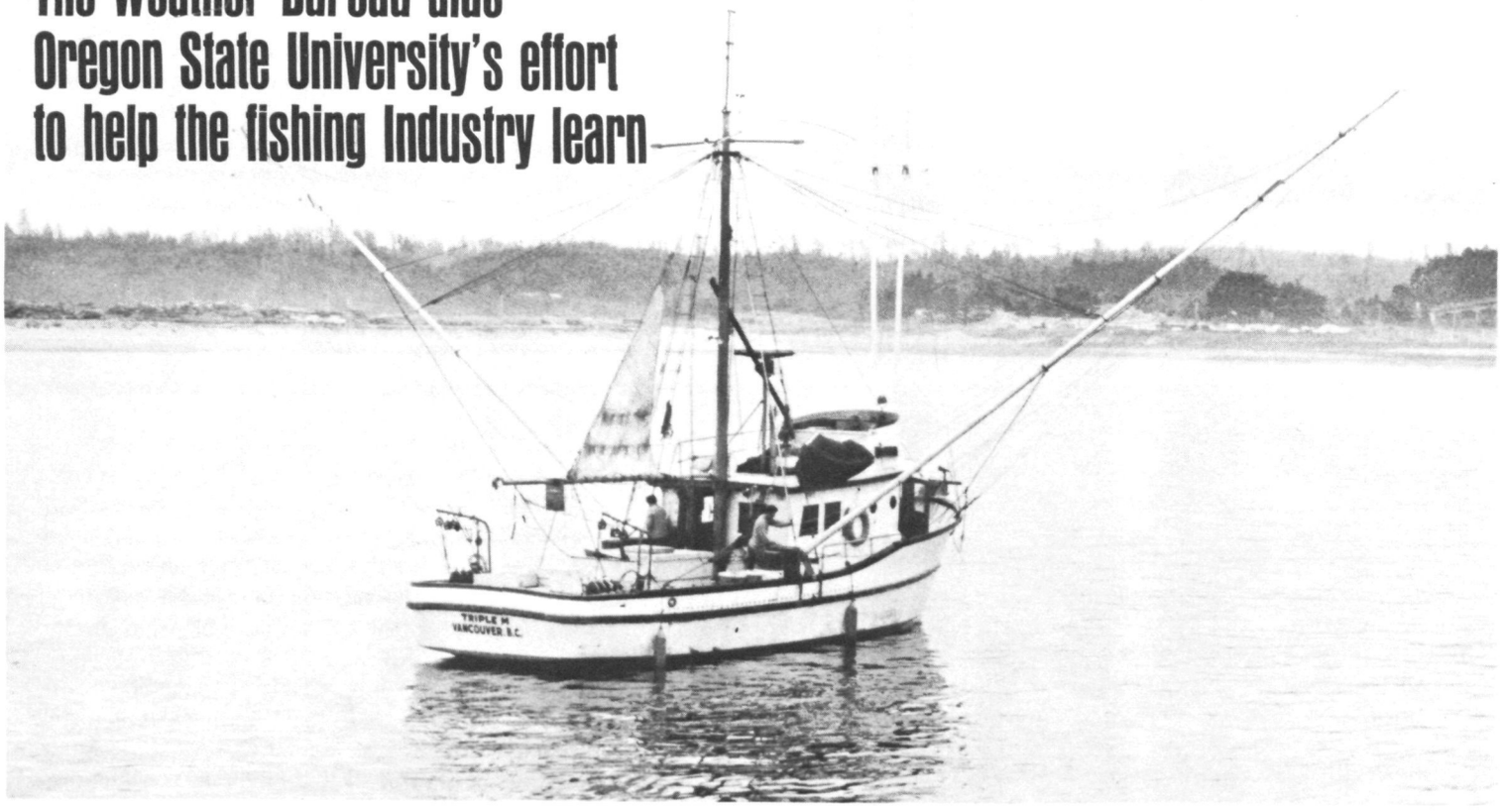
The large parties may remain at one location from one to three months. During their stay at each locale, they become part of the community, attending its schools and houses of worship, participating in its civic events, and adding substantially to the economic well-being of the community.

The arrival of a party in a small community is sometimes a major event. Childress, Texas, a community with about 6400 population, gave a banner front-page headline in the local newspaper to one party: "22 men, 17 with families, move here." □



Before Jasper Bilby devised the portable steel tower, wooden structures were built for triangulation. (Right) This tower was built around a 143-foot tree which supported the theodolite. A scaffold built of poles served as the outer tower.

The Weather Bureau aids Oregon State University's effort to help the fishing industry learn

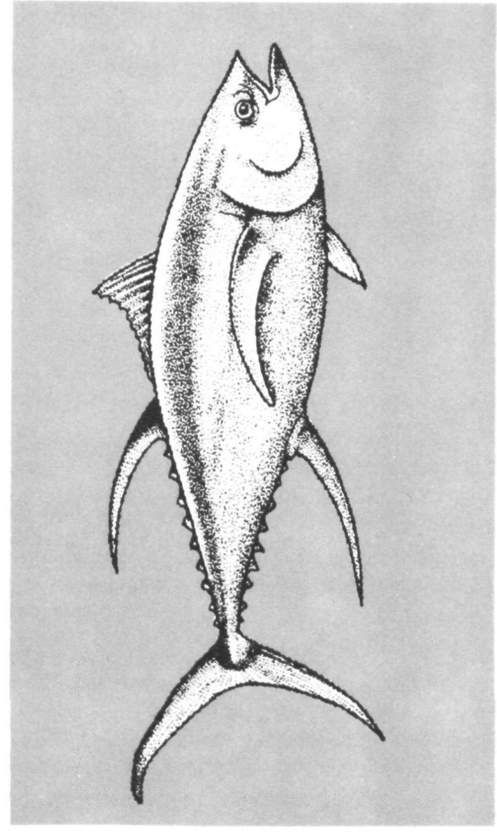


WHERE THE FISH ARE

BY DANIEL A. PANSHIN
Sea Grant Oceanographer
Oregon State University
Corvallis
and
GERALD B. BURDWELL
Weather Bureau Advisory
Marine Meteorologist
Newport, Oregon

Elusive, fast-swimming albacore tuna are the object of a concentrated commercial fishing effort each summer in the northeast Pacific Ocean.

Oregon's albacore tuna industry is large and valuable. From July into early October, albacore are found from 50 to 150 miles off the Oregon shore. In 1968, the last year for which final figures are in, the catch amounted to nearly 38 million pounds, worth about $7.5 million at dockside, the result of fishing by a fleet of some 750 boats.

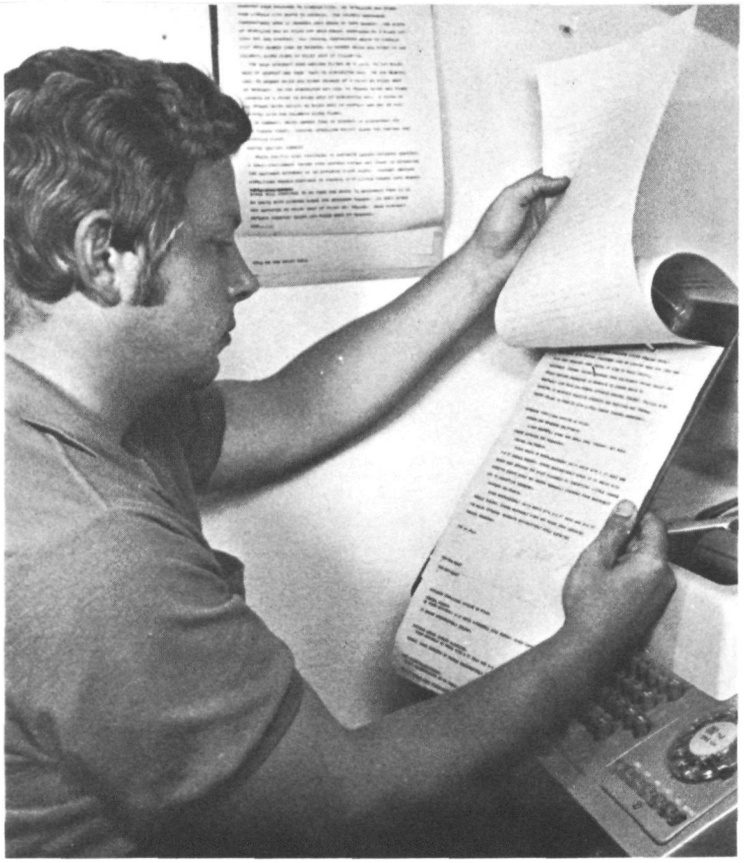


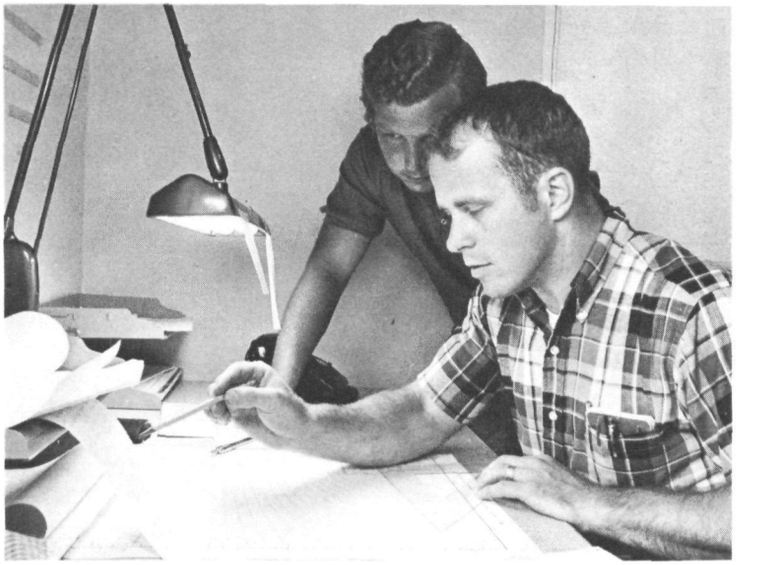
Despite the commercial importance of albacore, little is known about the complex factors which determine their abundance and distribution. Scientists and fishermen alike know that albacore are sensitive to temperature, and prefer surface waters in the temperature range of 59 to 65 degrees Fahrenheit. But water within this temperature range does not guarantee the presence of albacore. Scientists and fishermen would like to know more about just what conditions control albacore distribution within this acceptable band of temperature.

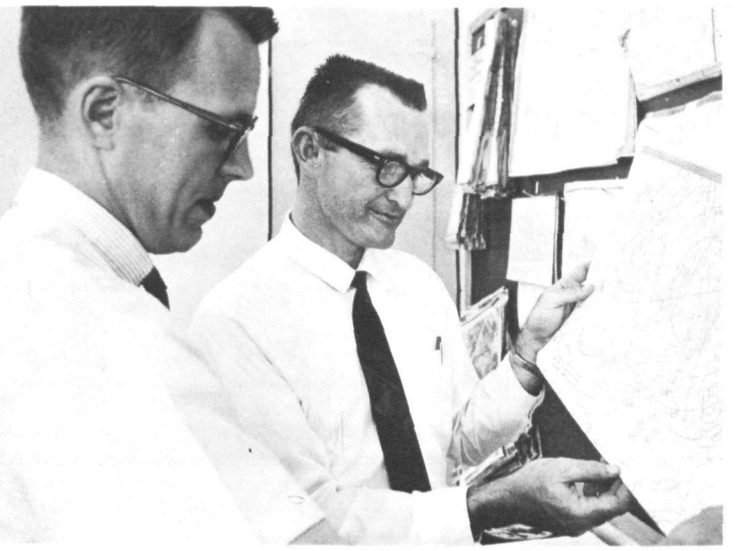
Clearly, there is a need to investigate the albacore tuna in relation to physical and chemical environment, predators and competitors, and food supply, in an attempt to derive workable methods of predicting when and where albacore will be found and in what quantities.

During the summer of 1969, Oregon State University organized and directed an extensive albacore oceanography project in the northeast Pacific Ocean. A major effort was made to obtain synoptic observations of ocean conditions out to 150 miles off the Oregon coast. Eleven federal and state agen-

(The Sea Grant program, administered by the National Science Foundation, is the ocean equivalent of the long-established land grant program. It supports training in fields related to marine sciences, information programs similar to those of the land grant cooperative extension services, and research on problems of resource development. The Weather Bureau's participation in Oregon State University's Albacore Tuna Project is one example of the cooperation of ESSA components in the Sea Grant program.)







Oregon State's Albacore Central broadcasts information on ocean conditions and marine weather during the albacore fishing season. (Above) Oceanography student Dave Gosser checks one of the twice-daily broadcast messages prepared by the four-man staff. (Upper right) Dick Evans, assistant director of Albacore Central, plots sea-surface temperatures, with Gosser's help. (Lower right) The article's authors, Daniel Panshin (left) and Gerald Burdwell.

cies and private companies contributed to this cooperative scientific effort, including such diverse participants as the Weather Bureau, National Aeronautics and Space Administration, Bureau of Commercial Fisheries, Sippican Corporation (an instrument manufacturer), and Fish Commission of Oregon.

The fishermen themselves were a key source of data. More than 400 selected tuna fishermen from Oregon, Washington, and California were given logbooks and asked to keep records of their locations, tuna catch, concurrent information on sea-surface temperature and water color, as well as notes on "tuna signs" such as presence of birds and forage animals. Of these, 123 boats submitted logsheets, reporting a total of 359 fishing trips. Eleven fishing boats were also equipped with bathythermographs, oceanographic instruments which measure temperature versus depth and thus record vertical temperature soundings.

OSU's Department of Oceanography assigned its two largest research vessels, YAQUINA and CAYUSE, to 98 days of ship time at sea in support of the project. Buoys provided information on currents. Research vessels of other agencies contributed data. Aircraft flew more than 10,000 miles using infrared techniques for remote sensing of the distribution of sea-surface temperatures. In addition, aerial photography and multispectral scanners provided comprehensive information on water color.

The scientific investigations also focused on upwelling phenomena near the coast and on the Columbia River "plume," the two dominant oceanographic features off Oregon during summer months. Upwelling is the wind-induced movement of deep, cold, salty water to the surface along the coast, creating an ocean front where it borders the warmer water offshore. The plume, or water outflow from the Columbia River, is warmer, less salty, and less dense than the surrounding water, and is sometimes detectable as far as 500 miles from the mouth of the river. Wind shifts were found to bring quick changes in both upwelling and plume.

From the outset, there was a dedicated effort to make real-time operational use of the data that were gathered. The immediate concern was to improve the efficiency of the tuna fleet, which required rapid data collection, editing, analysis, and dissemination to the fishermen. This function was performed by Albacore Central.

Albacore Central was run by OSU's Marine Advisory Program, extension arm of Sea Grant, and part of Oregon's Cooperative Extension Service. The objective of Albacore Central was to provide all types of information of operational value to Pacific Northwest albacore fishermen. Albacore Central attempted to meet this objective by making available material from the Bureau of Commercial Fisheries, and by supplementing this material with local information. Much of the local information was research-derived and acquired by OSU from aircraft, research vessels, Fish Commission of Oregon, fish plants, the Weather Bureau, Marine Advisory Program coastal agents, and fishermen themselves.

Fishermen are a hard-to-reach audience. During fishing season, fishermen are where the fish are. They don't receive mail regularly, if at all, as most of them are not operating out of their home ports. They aren't available to attend meetings. And they can't be visited.

The primary product of Albacore Central was thus a daily radio message on ocean conditions and marine, or open-ocean, weather. OSU's Marine Advisory Program agents collected information on ocean conditions and wrote that portion of the message. Jerry Burdwell, Weather Bureau Advisory Marine Meteorologist, arranged for the Weather Bureau Forecast Office in Portland to prepare a daily weather map discussion. Seven days a week, from July 1

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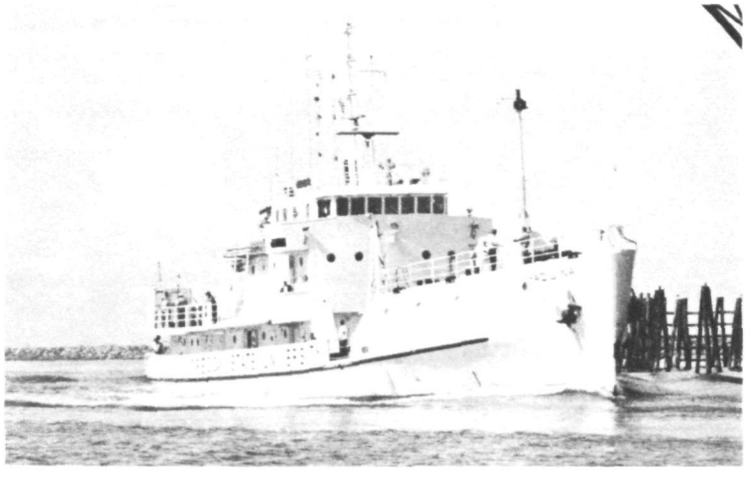
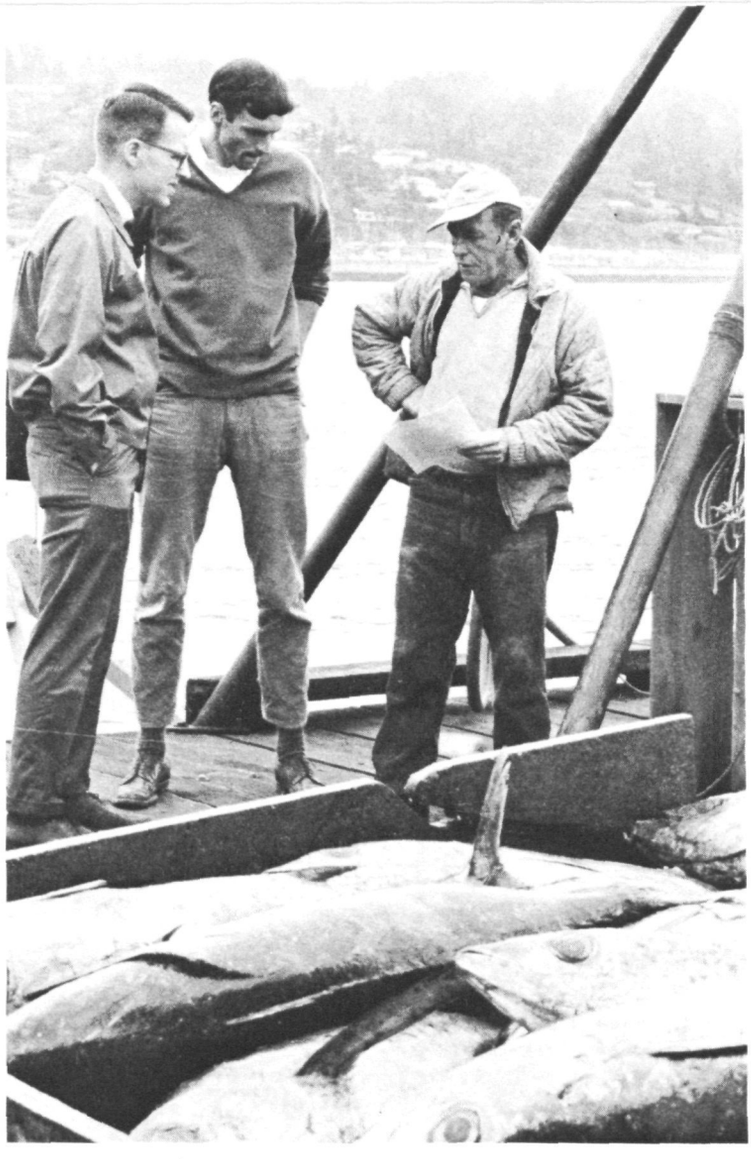




(Top left) Operator broadcasts Albacore Central summary over a marine radio frequency. (Bottom left) OSU's ***Yaquina*** *and other ships provided vital data for the project. (Right) Daniel Panshin and extension agent Robert Jacobson (center) discuss the tuna broadcasts with a fisherman.*

to October 1, Albacore Central transmitted 92 consecutive messages through the Astoria Marine Operator, a radio station operated by Pacific Northwest Bell Telephone Company.

The Astoria Marine Operator acts as a radiotelephone service for ships at sea. In addition to this telephone function, twice each day (at 10:15 a.m. and at 10:15 p.m., PDT), there are broadcasts on hazards to navigation and coastal weather forecasts. Fishermen listen to this station regularly at these times because of the importance of the information to them, and the long reception range of 300 to 500 miles. By permission of the Federal Communications Commission, Pacific Northwest Bell made public-service time available to OSU at the end of these broadcasts for the Albacore Central messages.

A secondary, or supporting, product of Albacore Central was a weekly printed bulletin which discussed oceanography and meteorology as they pertain to albacore, and which was accompanied by a sea-surface temperature chart. Changes in wind direction and velocity strongly affect the distribution of ocean temperatures, particularly in the vicinity of the Columbia River plume and near the coastal upwelling zone. Coordinated efforts of oceanographers and meteorologists including Mr. Burdwell, were able to explain some of the processes and trends of change in the ocean environment.

The disadvantage of bulletin and chart, of course, is that it must be mailed, and somehow delivered to the fishermen in order to be useful. The first place fishermen go on entering port is to the fish plant to sell their fish. So the Marine Advisory Program agents contacted all fish plants along the Oregon coast and enlisted their cooperation. Each week for 13 weeks, bulletins and charts were bulk-mailed to fish plants for hand distribution to fishermen. In this way, fishermen received the bulletin and chart upon reaching port. The information may have been a little older than that in the messages, but it was much more detailed and thorough, and thus supported the radio messages.

The Marine Advisory Program coastal agents were vital in getting feedback from the fishermen. These agents are stationed in or near each of the major Oregon fishing ports, and may be likened to "county agents in hipboots." The agents contacted fishermen to encourage them to keep logbooks for research purposes and to share practical information which might be of value to other fishermen. They interviewed fishermen as they came into port so that Albacore Central could be evaluated continuously and made as responsive as possible. They assisted in distribution of charts and bulletins.

Evaluation was a regular part of the program. In addition to interviews during the season, OSU's Marine Advisory Program mailed out questionnaires in November to logbook recipients. In December, evaluation and planning meetings were held in four Oregon ports.

Albacore Central, and the whole albacore project, would have been impossible without the help of fishermen and processors, and would also have been impossible without the cooperation and encouragement of federal and state agencies and private companies. The Bureau of Commercial Fisheries was especially helpful because of its long experience with this special kind of fisheries service. And the Weather Bureau provided the needed marine weather support.

Was Albacore Central a success? In general, fishermen approve of Albacore Central. Mistakes were made in 1969; changes are being made in 1970. Without question, however, the project represents a giant stride forward in data collection and understanding of the offshore and nearshore environment in the ocean adjacent to the Pacific Northwest. □

EIGHTEEN HUNDRED AND FROZE-TO-DEATH

This past summer and fall have been so cold and miserable that I have from despair kept no account of the weather.

—Adino Brackett, 1816

BY PATRICK HUGHES, Environmental Data Service

THE YEAR 1816 is legendary in the annals of weather. It has been called "the year without a summer," "poverty year," and "eighteen hundred and froze-to-death."

From May through September, an unprecedented series of cold spells chilled the northeastern United States and adjoining Canadian provinces, causing a backward spring, a cold summer, and an early fall. There was heavy snow in June and frost even in July and August. All across the Northeast, farmers' crops were repeatedly killed by the cold, raising the specter of widespread famine.

The amazing weather of 1816 is well documented in the diaries and memoirs of those who endured it. Benjamin Harrison, a farmer in Bennington, Vermont, termed it "the most gloomy and extraordinary weather ever seen." Chauncey Jerome of Plymouth, Connecticut, writing in 1860, recalled:

I well remember the 7th of June . . . dressed throughout with thick woolen clothes and an overcoat on. My hands got so cold that I was obliged to lay down my tools and put on a pair of mittens . . . On the 10th of June, my wife brought in some clothes that had been spread on the ground the night before, which were frozen stiff as in winter. On the 4th of July I saw several men pitching quoits in the middle of the day with thick overcoats on, and the sun shining bright at the time.

Since relatively few settlers had yet crossed the Mississippi, most of our weather observations for 1816 come from the eastern United States, particularly the Northeast, where there was a tradition of weather watching and a general disposition to record whatever occurred. The best observations available were made at Williamstown, in the northwestern corner of Massachusetts.

April and May 1816 were both cold months over the Northeast, with frost retarding spring planting. Flowers were late in blooming, and many fruit trees did not

continued

blossom until the end of May—only to have their budding leaves and blossoms killed by a hard frost which also destroyed corn and some other plants.

Warm weather finally came to all parts of the Northeast during the first few days of June. Farmers forgot the frosts of May and began replanting their crops. But even as they labored, a cold front was approaching that was to bring disaster.

Following the frontal passage, temperatures tumbled dramatically under the onslaught of Arctic air. At noon on June 5, the temperature at Williamstown was 83 degrees. By 7 a.m. on the 6th, it had dropped to 45 degrees—the highest temperature recorded for the day. All across central New England, early morning temperatures were the highest recorded for the day.

From June 6 to 9, severe frost occurred every night from Canada to Virginia. Ice was reported near Philadelphia, and "every green herb was killed, and vegetables of every description very much injured." In northern Vermont, the ice was an inch thick on standing water while elsewhere in the state "icicles were to be seen a foot long . . . corn and other vegetables were killed to the ground, and upon the high lands the leaves of the trees withered and fell off."

People shivered, dug out their winter clothing, and built roaring fires. Farmers watched helplessly as their budding fields and gardens blackened, and in northern towns newly shorn sheep, though sheltered, perished. Thousands of birds also froze to death, as did millions of the yellow cucumber bug.

The culmination of this remarkable cold wave came early on the 11th of June. At Williamstown the observer noted, "Heavy frost—vegetables killed—at 5 o'clock temperature 30.5 degrees." Overall, frost killed almost all the corn in New England, the main food staple, as well as most garden vegetables.

There were two snowfalls. The first, on the 6th, brought relatively light snow to the highlands of western and northern New York State and most of Vermont, New Hampshire, and Maine. The second occurred during the night of June 7-8, following the passage of a second cold front. It brought moderate to heavy snow to northern New England, with lighter snow and snow flurries extending eastward to the coast and southward through northern Massachusetts and New York State's Catskill Mountains.

The following account appeared in the Danville, Vermont, *NORTH STAR*:

Melancholy Weather . . . On the night of the 7th and morning of the 8th a kind of sleet or exceeding cold snow fell, attended by high wind, and measured in places where it drifted 18 to 20 inches in depth. Saturday morning [8th] the weather was more severe than it generally is during the . . . winter. It was indeed a gloomy and tedious period.

In Canada, Montreal had snow squalls on both the 6th and 8th of June, while 12 inches of snow accumulated near Quebec City from the 6th to the 10th, with some drifts "reaching to the axle trees of carriages."

This first summer cold spell was followed by four weeks of relatively good weather. Farmers again replanted, and crops were growing well when, at the end of the first week in July, a new cold outbreak came. Although not as severe as the one in June, it killed corn, beans, cucumbers, and squash in northern New England, and soon had local farmers talking about the threat of a general famine.

Once again, the remainder of the month was more seasonable, though there was another cool spell around the 18th. The hardier grains such as wheat and rye, however, came along well, and by August farmers were joking about their earlier "famine fever."

On August 20, another cold wave arrived, tumbling temperatures in New Hampshire some 30 degrees. During the next two days, frost was reported as far east as Portland, Maine, and as far south as East Windsor, Connecticut. Travelers between Albany, New York, and Boston reported most of the corn in low-lying areas destroyed.

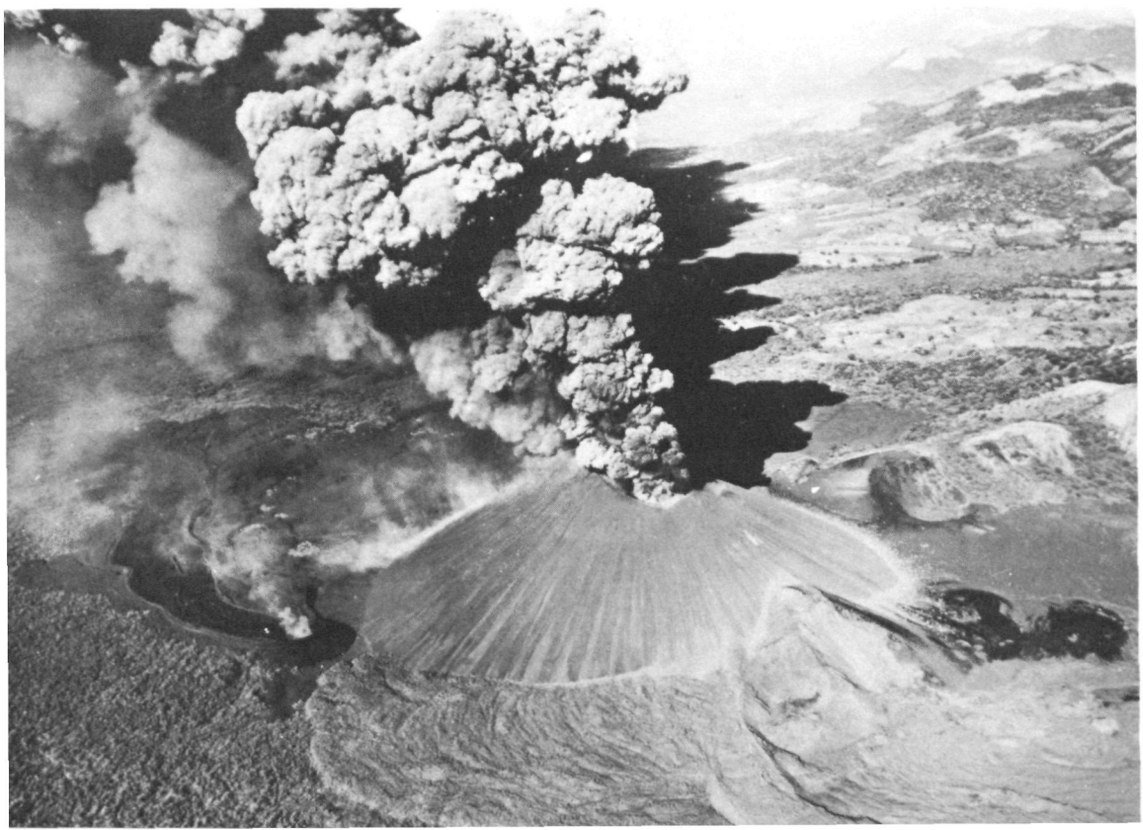
A more severe frost came at the end of August. In Keene, New Hampshire, it put an end to the hopes of many corn growers, and whole fields had to be cut up for fodder.

The first week of September was relatively warm, but around the 11th and 12th a cold outbreak again visited the Northeast, with hard frost reported in northern and central New England. It was the widespread and killing frost of September 27, however, which irrevocably closed out this dismal growing season and destroyed all hopes of even a small corn harvest in northern New England.

A Concord, New Hampshire, paper reported: "Indian corn on which a large portion of the poor depend is cut off. It is believed that through New England scarcely a tenth part of the usual crop . . . will be gathered." In Montreal it was said that ". . . many parishes in Quebec must inevitably be in a state of famine before winter sets in." During the severe winter of 1816-17 which followed, the threat of starvation or semi-starvation became a reality for many.

The first general migration from New England to the Middle West occurred the following year. Although there were other factors involved, it is interesting to note that the three northern states of Vermont, New Hampshire, and Maine, which bore the brunt of the cold weather, suffered the greatest exodus.

In summary, the chief weather abnormalities of 1816 were the series of totally unexpected cold spells that occurred continuously through the late spring, summer,



William Humphreys, a Weather Bureau scientist, documented the relationship between volcanic eruptions and periods of low temperatures around the world. According to Humphreys' theory, volcanic dust in the atmosphere partially shields the earth from the sun's rays, but permits heat to escape, thus lowering the temperature. During the cold years from 1812 to 1817, three major volcanic eruptions took place—Soufriere on St. Vincent Island in 1812; Mayon in the Philippines in 1814; and Tambora in Indonesia in 1815.

THE COLD SEASON

Extracts from History of Madison County, New-York, by Mrs. L. M. Hammond Pub. 1872.

"Town of De Ruyter, Madison Co. N.Y.

"In 1816 came the 'cold season'. There was a frost in every month. The crops were cut off, and the meagre harvest of grain was nowhere near sufficient for the needs of the people. The whole of the newly settled interior of New-York was also suffering from the same cause. The inhabitants saw famine approaching. (The alarm and depression so wrought upon the feelings of the community, that a religious revival ensued.) What little grain there was that could be purchased at all, was held at remarkable prices, and this scant supply soon failed. Jonathan Bentley at one time paid two dollars for a bushel of corn, which, when ground, proved so poor that it was unfit for use; throwing it to his swine, they too refused the vile food. Every resource for sustenance was carefully husbanded; even forest berries and roots were preserved. The spring of 1817 developed the worst phases of want. In various sections of the county, families were brought to the very verge of starvation! One relates that he was obliged to dig up the potatoes he had planted, to furnish one meal a day to his famishing family; another states that his father's family lived for months without bread, save what was obtained in small crusts for his sick mother, and that milk was their chief sustenance. When the planting season arrived there was no seed grain in De Ruyter, so the inhabitants combined and sent Jeremiah Gage to Onondaga County to canvass for wheat and corn. He was absent several days, and the people, all alive to the importance of his mission, grew discouraged, fearing there was none to be found. At length he was seen approaching along the road where the head of the Reservoir now is, his wagon loaded, his handkerchief fastened to a pole and hoisted, fluttering in the breeze, a signal of joy and plenty. A crowd quickly gathered; there was great rejoicing and tears stood in strong men's eyes. Each family repaired to Gage's house to receive their quota of grain, and every household that day was glad." □

and early fall—and, of course, the June snow.

New England temperatures averaged 3 to 6 degrees below normal in June and July, and 2 to 3 degrees below in August. May also had been below normal, as was the following September. It has been just as cold (or even colder) in each of these months in other years, but never consecutively. More significant, however, is the fact that, in 1816, the low temperatures occurred in a region where even a few degrees' difference in the minimum temperature can mean a severe frost.

Although the New England farmer considered it a local tragedy, the abnormal weather was widespread throughout the Northern Hemisphere. In England it was almost as cold as in the United States, and 1816 was a famine year there, as it was in France and Germany.

Actually, 1816 was just one of a famous series of cold years. From 1812 to 1817 it was cold over the whole world. In the United States, the depression of summer temperatures was the most remarkable on record.

According to William Humphreys, a Weather Bureau scientist writing almost a century later, the cold years were caused largely by volcanic dust in the earth's atmosphere. Such dust partially shields the earth from the sun's rays, but permits heat to escape from the earth, thus lowering the temperature.

Three major volcanic eruptions took place between 1812 and 1817. Soufriere on St. Vincent Island erupted in 1812; Mayon in the Philippines in 1814; and Tambora on the island of Sumbawa in Indonesia in 1815. The worst was Tambora, a 13,000-foot volcano that belched flame and ashes from April 7 to 12, 1815, and rained fiery stone fragments on surrounding villages.

It has been estimated that Tambora's titanic explosion blew from 37 to 100 cubic miles of dust, ashes, and cinders into the atmosphere, generating a globe-girdling veil of volcanic dust.

The idea that volcanic dust suspended in the atmosphere might lower the earth's temperature has been around for a long time. Like many other scientific firsts, it can be traced to Benjamin Franklin, although the thought may not have been original with him. In 1913, William Humphreys published a now-classic paper documenting the correlation between historic volcanic eruptions and worldwide temperature depressions.

According to Humphreys, volcanic dust is some 30 times more effective in keeping the sun's radiation out than in keeping the earth's in. And once blown into the atmosphere—more specifically, the stratosphere—it may take years for the dust to settle out (the finest particles from Krakatoa's eruption in 1883, for example, took 2½ to 3 years to reach the ground). During this period, the average temperature of the whole world may drop a degree or two, while local losses can be considerably greater.

The chief effect, however, as in 1816, seems to be the dramatic depression of minimum temperatures during the summer months.

A weak sunspot maximum also preceded the cold summer of 1816. During May and June, these blemishes on the face of the sun grew large enough to be seen with the naked eye, and people squinted at them through smoked glass.

In Humphreys' day, sunspots were thought to reduce the amount of solar radiation emitted and, during a period of maximum occurrence, to depress the earth's average temperature by as much as a half degree. As a result, sunspots also were blamed for the trials of the New England farmer in 1816. Humphreys showed, however, that whatever the historic correlation between the earth's average temperature and the occurrence of sunspot maximums, the most pronounced dips in the world temperature curve were, without exception, associated with violent volcanic eruptions that exploded great quantities of dust into the stratosphere.

An example is the famous cold year of 1785, which followed the frightful eruptions of Mount Asama in Japan and Skaptar Jökull in Iceland. These produced a widely observed "dry fog," the phenomenon that led Benjamin Franklin to suspect a relationship between cold weather and volcanic eruptions.

Volcanic dust is believed to have played a role—and perhaps a major one—in the great climatic changes of past ages. Even relatively small variations in the earth's annual mean temperature can cause widespread changes in Arctic ice packs and world sea levels, in desert boundaries, and in the geographic limits of plant, animal, and human life. According to Humphreys, volcanic dust blown into the stratosphere once a year or even once every two years, would continuously maintain temperatures low enough to "cover the earth with a mantle of snow so extensive as to be self-perpetuating . . . and thereby initiate at least a cool period, or, under the most favorable conditions, even an ice age."

More recently, Dr. J. Murray Mitchell, Jr., of ESSA's Environmental Data Service has associated our current modest worldwide cooling trend with a series of latter-day volcanic eruptions which began in 1947. He associates most, if not all, of this cooling effect with the presence of volcanic dust in the stratosphere.

The New England farmer of 1816, of course, knew nothing of such theories; he knew only that something had gone wrong with the weather. And when that dreadful summer was followed by a winter so severe that the mercury froze in the thermometers, he must surely have thought the change had become permanent. □

essa NEWS BEAT

U.S. DEPARTMENT OF COMMERCE ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION

AOM Laboratories Will Be Built On Virginia Key, Miami, This Year

Construction on the ESSA Research Laboratories' Atlantic Oceanographic and Meteorological Laboratories is expected to start this year. The facility will be situated on Virginia Key, Miami, Florida.

The laboratories, headed by Dr. Harris B. Stewart, are now dispersed in numerous temporary locations in Miami. The planned facility will bring together under one roof the employees from various scientific disciplines—the Physical Oceanographic Laboratory, National Hurricane Research Laboratory, Marine Geology and Geophysics Laboratory, Experimental Meteorology Laboratory, and the Sea-Air Interaction Laboratory.

They will draw upon the collective strength of several ESSA groups in the Miami area, including the Research Flight Facility, the Weather Bureau's National Hurricane Center, and the Coast and Geodetic Survey's Engineering Development Laboratory.

Virginia Key was chosen as the Laboratories' site in 1967, after an investigation of 115 east coast locations. The Dade County Commissioners provided land on the Key for the facility without charge.

Dade County also provided space at nearby Dodge Island for several ESSA Coast Survey ships—the USC&GSS DISCOVERER, the USC&GSS RESEARCHER (to be commissioned next fall), and a coastal survey ship. All will play an important role in the work of the laboratories.

AOML's new building will be erected on site indicated on Virginia Key, Miami. In background: Dodge Island, where C&GS ships will be berthed.

ESSA Units Aid Astronauts On Apollo 13's Mission

The services provided to Apollo missions by the Weather Bureau's Spaceflight Meteorology Group and ERL's Space Disturbance Forecast Center had become almost routine, but the in-flight explosion aboard Apollo 13 changed that.

With the sudden emergency on April 13, the Spaceflight Meteorology Group began forecasting for a dozen or more possible landing areas, all in the Southern Hemisphere. Eventually, NASA decided on a landing near 21 degrees South, 165 degrees West, an area where moderate weather disturbances are frequent and persistent. During most of the earthward flight there was shower activity there, and Tropical Storm Helen, not far away, was watched closely. The Group's 42-hour and subsequent forecasts called for good weather, with a chance of scattered showers in the landing area. Both the predictions and the weather were good.

In preparing its analyses and forecasts, the Spaceflight Meteorology Group used surface and upper-air observations, reconnaissance aircraft reports, NMC guidance material, and products of several weather satellites, particularly ESSA 9, ATS-1, ITOS-1, and Nimbus-4.

To assist in forecasting for the Apollo 13 recovery, the National Meteorological Center prepared the first global numerical analyses and forecasts ever made for operational purposes. The global predictions were especially helpful as a guide to the motion and direction of disturbed areas near the landing point.

After the vehicle damage to Apollo 13, there was a possibility that the astronauts might have to traverse the outer radiation belt in the lunar module, which is thinly shielded. NASA therefore requested information on electron densities in the Van Allen belts.

The Space Disturbance Forecast Center and the National Environmental Satellite Center teamed up to provide this service. ITOS-1 (Improved TIROS Operational Satellite) was in orbit within the belts, carrying a solar proton monitor and associated sensors. Raw data was transmitted immediately to the Boulder forecast center each time ITOS passed over the Command and Data Acquisition station at Gilmore Creek, Alaska. Since the spacecraft passes in and out of the Van Allen belts, the data had to be interpreted to determine where it had been gathered.

The National Environmental Satellite Center at Suitland, Maryland, processed the solar proton data on its computers and sent the products to the Boulder group. Based on these two sources of information, the Space Disturbance Forecast Center then provided advisories to NASA's Manned Spaceflight Center, giving continuous information on conditions in the Van Allen belts during Apollo 13's flight home.

Low Tsunami Year Recorded in '69

Of five seismic sea waves, or tsunamis, which struck Pacific, Atlantic, and Caribbean coasts in 1969, one resulted in fatalities.

Robert A. Eppley, Chief of the Tsunami Services Coordinating Branch of the Coast and Geodetic Survey, said the number of Pacific tsunamis—three during 1969—was below average and half that of the previous year, when six occurred in the Pacific.

The most devastating tsunami of the year was caused by an earthquake in the Celebes Islands of Indonesia, February 23. The earth tremor generated a tsunami on the west coast of Celebes which was reported to have caused at least 600 deaths and demolished four villages. In contrast to the tsunami, the earthquake resulted in about 20 deaths.

Two other tsunamis in the Pacific were caused by earthquakes in the Kurile Islands and off the coast of Kamchatka Peninsula, Siberia, August 11 and November 22, respectively. No serious damage was reported from either. The tsunami from the Kurile earthquake was observed in Japan and recorded at tide stations in Hawaii, Peru, Ecuador and many other Pacific localities, while the Kamchatka tsunami was observed by tide gages in Alaska, Hawaii, Midway Island, Wake Island, and American Samoa.

ESSA Publications Honored by FEA

Four ESSA publications won Blue Pencil Awards in the Federal Editors Association's 7th Annual Contest for government publications issued in 1969. "Clouds," by Carl A. Posey of the ESSA Office of Public Information, took first prize for leaflets in two or more colors. Another first prize winner was a press release, "ESSA Initiates Skywarn Campaign To Lower Tornado Death Toll," by Ann K. Cook of the ESSA Office of Public Information. *ESSA Monograph 2*, the 416-page "Mathematical Geodesy" by the late Martin Hotine, placed second in the category for technical publications in one color, of more than 50 pages. The monograph was editorially produced by the Editorial Branch, Scientific Information and Documentation Division, with John Bernick serving as its technical editor. "ESSA World," published by the ESSA Office of Public Information, took third place in the one-color popular magazine competition.

all in the family PERSONNEL NOTES

Capt. Miller J. Tonkel, formerly C&GS Associate Director for Hydrography and Oceanography, is now commanding officer of the USC&GS Ship OCEANOGRAPHER. Captain Tonkel, a 26-year career officer in the ESSA Commissioned Corps, has served with hydrographic operations in waters off the North American continent and in the North Pacific. In addition to service with geodetic field parties in 14 states, he has been district officer at Baltimore; field officer at New York; assistant to the chief, Geodesy Division; and chief, Continental Shelf Coordinating Group at C&GS headquarters. Captain Tonkel holds a civil engineering degree from Purdue University.

Jerome Goldenberg, former head of the Navy Department's Resources Branch, Special Projects Office, has been appointed chief of ESSA's Budget Division. Mr. Goldenberg entered government service in 1941 with the Bureau of Internal Revenue, and has since held other positions with the Department of Commerce and the U.S. Geological Survey.

Arthur H. Hosick, Weather Bureau Central Region User Services Representative since 1964, is now meteorologist in charge of the Boise, Idaho, Weather Bureau Forecast Office. Mr. Hosick, who joined the Bureau in the early forties, has served at Omaha, Nebr.; Washington, D.C.; and Cheyenne, Wyo.

Michael Maish and **Dr. Victor Hessler,** ERL scientists, are the first American recipients of the 150th year medal of the discovery of the Antarctic continent, awarded by the U.S.S.R. National Academy of Sciences. The medal commemorates the voyage of Fabian Gottlieb Von Bellinghausen in 1819-21. Mr. Maish received the medal in recognition of his work in the Antarctic and as an expression of international scientific cooperation. Dr. Hessler was recognized for his extended cooperative research program at Vostok investigating rapid variations in the earth's magnetic field.

Lt. Merritt N. Walter is now commanding officer of the USC&GS Ships RUDE and HECK. Lt. Walter served as executive officer of the two vessels before his present appointment. His service in the ESSA Commissioned Corps includes assignments aboard the USC&GS Ships EXPLORER and DISCOVERER.

Stanley G. Holbrook has been designated ESSA State Climatologist for Oregon, succeeding Gilbert Sterns. Mr. Holbrook served as State Climatologist for Oklahoma for eight years and for Idaho during the past year. He received a bachelor's degree in meteorology from the University of Washington in 1957.

Emil S. Kurtz has been named meteorologist in charge of the San Diego Weather Bureau Office, succeeding A. W. Anderson, who retired. Mr. Kurtz's last position was as a guidance forecaster at the Weather Bureau Forecast Office, Los Angeles, where he had been assigned for the past 20 years.

David P. Barnes, formerly a senior forecaster at Oklahoma City, Okla., is meteorologist in charge of the Austin, Tex., Weather Bureau Office. Mr. Barnes, who entered the Bureau in 1962, subsequently held posts at Baton Rouge, La.; Jacksonville, Fla.; and Savannah, Ga. He earned a master's degree from the University of Oklahoma in 1969.

Jack Bottoms, forecaster at the Weather Bureau Forecast Office, Honolulu, has devised a convenient and rapid method to compute the nature of wind-generated waves and the resulting swell in the ocean. The wave and ocean swell computing board consists of a set of nomograms, from the U.S. Navy Oceanographic Office Publication H. O. 601, encased in plastic with two cursors for easy reading.

Lt. Cdr. Archibald J. Patrick, who joined the Coast Survey in 1960 has become the new Operations Officer of the USC&GS Ship DISCOVERER. His previous assignments have included service aboard the PATHFINDER, SURVEYOR, HODGSON, and BOWIE. His most recent position was with the Atlantic Oceanographic and Meteorological Laboratories in Miami.

James C. Fidler, former meteorologist in charge of the Weather Bureau station at Austin, Tex., is now an instructor at the Federal Aviation Administration Academy, Oklahoma City, Okla. Mr. Fidler, who recently earned a master's degree in aerospace education, is instructing air traffic control trainees and other FAA personnel in advanced aviation weather.

Cdr. Ray M. Sundean has become Director of the National Tsunami Warning Center in Honolulu. During 11 years with the Coast Survey, he has served as an aide to the Coast Survey Director, with a photogrammetric mapping unit on the east coast, aboard the USC&GS Ships PATHFINDER, HODGSON, and FAIRWEATHER, as chief of the Pacific Tide Party in Honolulu, and with the Honolulu Observatory.

T. J. Sheehan, weather service specialist at the Weather Bureau's Lubbock, Tex., office, recently won a Federal Aviation Administration award for a series of air safety cartoons he drew as part of an FAA accident prevention program.

Stephen J. Rigney is now meteorologist in charge of the newly established Weather Bureau office at Portland, Me. Mr. Rigney was formerly MIC at Madison, Wisc.

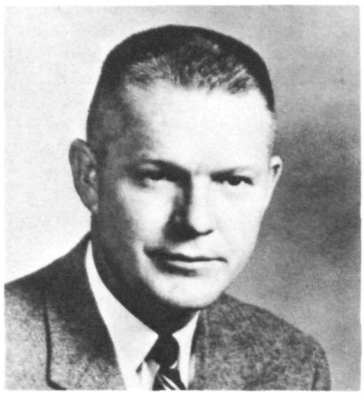
Lt. Richard V. O'Connell has assumed the position of Magnetics and Communications Officer at the Coast Survey's Honolulu Observatory. Lt. O'Connell, who served in 1966-67 as magnetic and seismological observer at the South Pole Station, was the first commissioned officer to be assigned to the U.S. Antarctic Research Program.

William L. Exley is the new official in charge at Majuro in the Pacific Region. Mr. Exley served the first six years of his Weather Bureau career at Lihue, Canton Island, Koror, and Honolulu, before transferring to the Alaska Region in 1960, where he headed stations at Bethel, St. Paul Island, and King Salmon, Alaska.

Cdr. Ray E. Moses and the officers and crew of the USC&GS Ship DAVIDSON recently rescued 13 men whose 130-foot tuna boat—the HIGH SEAS—sank in 100 feet of water two miles south of Point Loma, Calif. The DAVIDSON was conducting hydrographic surveys off the coast of southern California, and her crew witnessed the sinking. The rescued men were taken to San Diego.

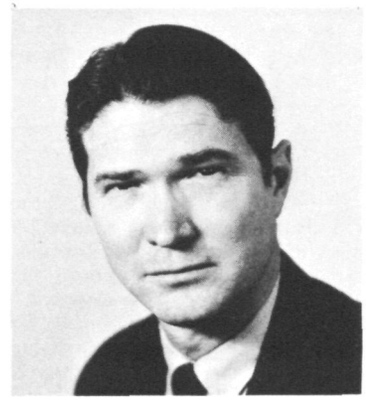
Samuel Sigurdson, a former member of the Missoula, Montana, WSR-57 radar staff, heads the recently established Air Route Traffic Control Weather Radar Unit at the Seattle ARTC Center. Mr. Sigurdson served in the Air Weather Service before joining the Weather Bureau in 1959.

Three Major Appointments For ESSA, WB, and C&GS



DR. GORDON G. LILL

FRANK W. BURNETT



ROBERT L. CARNAHAN

Three major appointments have recently been announced.

Robert L. Carnahan has been named Deputy Assistant Administrator for Administration and Technical Services.

Dr. Gordon G. Lill has been appointed Deputy Director of the Coast and Geodetic Survey.

Frank W. Burnett has been named Deputy Director of the Weather Bureau.

Mr Carnahan was formerly Vice President for Plans and Programs and Secretary of The Travelers Research Corporation of Hartford, Conn.

He was graduated from the University of California at Los Angeles in 1950 with a Bachelor of Arts degree in meteorology and received his master's degree in hydrology from Johns Hopkins University in 1951. He also attended St. Louis University and New York University.

Mr. Carnahan will share with Theodore P. Gleiter, ESSA Assistant Administrator, the direction of the Computer, Budget, Management Systems, Personnel, Finance, Administrative Operations, and Scientific Information and Documentation divisions.

Mr. Carnahan is a member of the American Meteorological Society, American Geophysical Union, American Association for the Advancement of Science, and the American Management Association, and serves on the Board of Directors of the Council of Industrial Meteorologists.

Dr. Lill will assist the Coast Survey Director in carrying out the scientific and administrative responsibilities of the agency.

A World War II Navy veteran, he served with the Office of Naval Research for 12 years, as head of the Earth Sciences Section of the Geophysics Branch; chief of the Geophysics Branch; and Earth Science Advisor. Subsequently, he was a corporate research advisor for the Lockheed Aircraft Corporation and the Director of the National Science Foundation's Mohole Project.

Born in Mt. Hope, Kans., Dr. Lill received a bachelor's degree in geology in 1940 and a master's degree in 1946 from the Kansas State College of Agriculture and Applied Science, Manhattan, Kans. From 1946 to 1947, he was a graduate instructor in geology at the University of California in Berkeley.

He is a member of a number of professional organizations, including the Marine Technology Society and the American Geophysical Union, and a Fellow of the Geological Society of America and the American Association for the Advancement of Science. Among the awards received by Dr. Lill is an honorary doctor of science degree from the University of Miami.

As Weather Bureau Deputy Director, Mr. Burnett will be primarily responsible for the direction and administration of the agency's day-to-day activities. The Office of Meteorological Operations, National Meteorological Center, Office of Hydrology, Systems Development Office, six Regional Offices, and the Bureau's Administrative and Technical Services will report to the Deputy Director.

Mr. Burnett has been Deputy Director of the National Meteorological Center since 1965. Coming to Washington, D. C., in 1953, he served as supervising analyst, leading analyst, assistant chief of the National Weather Analysis Center, and as Associate Director for Weather Analysis and Forecasting at NMC.

After joining the Weather Bureau in 1940 at Roswell, New Mexico, Mr. Burnett saw service as an observer, forecaster, and supervisor at Pueblo, Colo.; Albuquerque, N. Mex.; Pendleton, Oreg.; and New York City before coming to Washington.

A native of Dickenson, N. Dak., he earned a bachelor's degree from the University of New Mexico in 1940. He attended the University of Chicago in 1943 on a Weather Bureau scholarship, and did graduate work at the Massachusetts Institute of Technology in 1961-62. From January to February 1969, Mr. Burnett attended the Federal Executives Institute program at Charlottesville, Va.

In October 1969, Mr. Burnett, together with Harlan K. Saylor, Chief of the Analysis and Forecast Division of NMC, received the Department of Commerce's highest award—the Gold Medal—for distinguished federal service. They were cited for their work in the development of a new technology, the mixing of man and machine (computer) methods to produce central guidance weather forecasts. Mr. Burnett also received the Department of Commerce Silver Medal in 1959 for his outstanding work in improving analyses at the National Weather Analysis Center from 1954 to 1959.

Weather Satellites Writing History In Ten-Year Span

Ten years ago, a new era in meteorology began with the launching of the world's first weather satellite, TIROS I (Television Infrared Observation Satellite), by the National Aeronautics and Space Administration from Cape Kennedy, Florida.

Since April 1, 1960, 24 meteorological satellites—ten TIROS, four Nimbus, nine ESSA, and one ITOS—have been placed in orbit, returning more than a million pictures of the earth's cloud cover and other data for weather forecasting and research. In addition, two Applications Technology Satellites carrying meteorological cameras were placed in synchronous orbit.

In a decade of spectacular progress, weather satellite technology has advanced from the early spacecraft that viewed only 20 percent of the earth each day, to vehicles that continuously photograph nearly half the globe and instruments that take soundings down through the atmosphere.

Weathermen have steadily expanded the operational uses for satellite data, learning to extract from the pictures estimates of atmospheric moisture, pressure, and wind that can be used in computer forecasting. The photographs themselves have become essential to predictions for coastal areas, especially in tracking storms approaching from the sea. Since the advent of weather satellites, hurricane reconnaissance has changed from a search operation to one in which satellite pictures guide aircraft to storms for detailed measurements.

Satellite photographs taken 22,300 miles above the earth are being studied to see if they might help in the prediction of tornadoes.

NASA's Nimbus-4 spacecraft carries an improved version of the Satellite Infrared Spectrometer (SIRS), developed by ESSA's National Environmental Satellite Center. In addition to providing data on vertical temperature distribution in the atmosphere beneath the satellite, the new instrument—known as SIRS B—is designed to measure the distribution of water vapor in the atmosphere. Also, it looks to the left and right of the orbital path, obtaining greater geographical coverage than the original SIRS on Nimbus-3, which always looks straight down.

Weighing a record 1,366 pounds, the newest satellite in the Nimbus series is expected to transmit the most information on the atmosphere ever returned from space.

Techs', Mets' School Is in Operation In Kansas City, Mo.

A school for Weather Bureau technicians and meteorologists has been dedicated in Kansas City, Mo.

The Weather Bureau Technical Training Center is an expansion of the National Meteorological Maintenance Training Center which has been at its 601 Hardesty Street address since 1962.

The expanded facility will offer Weather Bureau meteorological technicians a number of classes designed to sharpen their skills in providing a variety of weather services. The WBTTC also continues to offer courses to Bureau electronics and facilities technicians to help them keep abreast of the latest procedures for installing and maintaining Weather Bureau equipment.

The newly established part of the training center conducts classes in the provision of services to aviation, the general public, agriculture, marine, forestry, air pollution control, hydrologic, and other interests. Included are classes in how to prepare short-range forecasts, warnings, and weather statements from guidance material received from the National Meteorological Center in Maryland where, with the aid of high-speed computers, broad-scale predictions are developed and sent to weather offices around the country for adaptation to smaller, more localized scales.

The engineering section is headed by senior instructor Charles Webster. Acting Superintendent is Lawrence K. Eide.

Weather Services Upgraded in Ohio

The Weather Bureau has begun 24-hour-a-day continuous radio broadcasts of weather forecasts and warnings and has opened a new hydrologic services office in northern Ohio.

A Weather Bureau River District Office with a professional hydrologist has been established at Akron to serve the Lake Erie drainage areas in Ohio east of the Sandusky River Basin and also the Muskingum River Basin. The office will serve as a focal point for the gathering and dissemination of information on rivers and streams in the approximately 12,000-square-mile area. Hydrologic data will be collected from a network of observing stations, and river forecasts and warnings will be prepared and issued to affected communities.

A new VHF-FM radio station operated by the Weather Bureau at Cleveland provides continuous weather forecasts and warnings to much of northern Ohio and the lower half of Lake Erie. The Weather Bureau Forecast Office at Cleveland prepares two separate taped broadcasts, one applicable to the Cleveland and Canton-Akron areas and one for the Sandusky area. The weather transmissions—all on 162.550 megahertz—are beamed from antenna sites near Cleveland, Sandusky, and Akron for maximum coverage. VHF installations at other key locations are being added as resources permit.

Another innovation at the Akron Weather Bureau, scheduled for operation shortly, is "dial-a-radar" capability.

Society of American Military Engineers Honors 50 Men of the Coast Survey

Fifty Coast Surveymen have been honored by the Society of American Military Engineers.

Cdr. Clinton D. Upham has been awarded the Colbert Medal, an achievement award named for Rear Adm. Leo O. Colbert, former Coast Survey Director, and given annually to a Survey member for "the most outstanding contribution to military engineering through achievement in design, construction, administration, research or development." He was honored for supervising an experimental program in high-speed hydrography.

Forty-nine members of the Coast Survey's Satellite Triangulation Field Parties received the Karo Plaque for 1969. The award was presented in recognition of the contribution made by the parties' officers, geodesists, electronics technicians, surveying technicians, surveying aids, geodetic technicians, radio operators, and mechanics to the successful completion of the Worldwide Satellite Triangulation Network. The survey program covered four years. The award is named for Vice Adm. H. Arnold Karo (Retd.), former Director of the Coast Survey and Deputy Administrator of ESSA. Personnel assigned to the Satellite Triangulation Field Parties during the project were:

Officers
Lieutenants B. C. Eversole, L. Genzlinger, T. E. Gerish, R. T. LeRoy, B. N. Mandelkern, R. K. Matsushige, H. B. Milburn, C. Y. Molyneaux, L. K. Nelson, G. W. McGill, T. Ballentine, and R. Lawson.

Geodesists
R. D. Bakula, R. S. Cohen, L. D. Hothem, J. W. Johnson, W. F. Miller, B. M. Putziger, D. S. Snellgrove, P. R. Spofford, and J. H. Till.

Electronics Technicians
J. D. Byrd, S. A. Cofer, J. R. Cromwell, H. F. Douglas, G. M. Edwards, J. Fried, H. G. Hair, B. D. Holland, S. P. Kuhn, B. A. Nichols, W. A. Reinke, D. D. Simmons, M. O. Wellons, and H. W. Wood.

Surveying Technicians
E. S. Alsop, R. W. Anderson, J. W. McClure, and M. L. McGinley.

Surveying Aids
J. E. Mezyk, F. M. McCarthy, R. H. Moyer, and L. L. Pomeroy.

Geodetic Technicians
K. Drehmann, S. A. Frizzell, and F. A. Wright.

Radio Operators
C. H. Lloyd and K. L. McClure.

Mechanic
K. G. Kerr

NSSL Radar Is Tracking Rain In Flood Program

A unique experimental forecasting tool, being tested at ERL's National Severe Storms Laboratory in Norman, Oklahoma, may improve flash-flood warnings over small, remote watersheds.

In two months of tests this spring, NSSL's radar has tracked storms on 10 separate days. Rainfall estimates, made by the radar, were digitized for immediate transmission to a time-share computer which used the data to predict storm motion and its total water output.

Information from the existing raingage network will be used to determine the accuracy of the experimental system, which passed its first operational tests last year. In those field tests, 77,420 records of radar data on rainfall were gathered in Oklahoma and transmitted directly to the Weather Bureau's River Forecast Center in Fort Worth, Texas.

The radar and its associated digitizing system were developed by the National Severe Storms Laboratory in a joint project with the Weather Bureau's Office of Hydrology, to meet the needs of accurate river forecasting.

Seven ESSA employees have completed a special course, qualifying them to advance to positions as computer operators, under the direction of ESSA's Computer Division. Front, from left: Esther J. Brown, Wilbur R. Boone, Jr., Carol L. James. Rear: Aaron H. Hacker, instructor; William O'Bryant Hall, David L. White, Jr., Robert D. Bowen. Not pictured: John E. Regan.

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The party's over.

The hurricane party. They have them every year. This is the morning after at Pass Christian, Mississippi; 24 died here, celebrating Hurricane Camille. Many others who held no parties but disregarded hurricane warnings also became tragic statistics last year—victims of raging tides, hurricane-driven floods, and the unfortunate belief that these great storms are harmless wind and rain. If a hurricane strikes your community this year, you will not be asked to leave your home unless your safety is at stake. When the word comes, **go.** If there is no call for evacuation, there is still much you can do.

When a Weather Bureau watch tells you a hurricane may hit your town, start planning. When a warning tells you the storm is on its way, go into action. Store plenty of drinking water and non-perishable food. Get your battery-powered equipment in working order. Move outdoor things inside. Board, tape, or shutter your windows. And when the storm strikes, stay inside. Keep tuned to Weather Bureau bulletins until the hurricane passes. Afterward, stay out of disaster areas and away from fallen wires and debris. Then, if you feel like it, have a hurricane party. Celebrate survival.

This message from the U.S. Department of Commerce's Environmental Science Services Administration is published in the interest of public safety.