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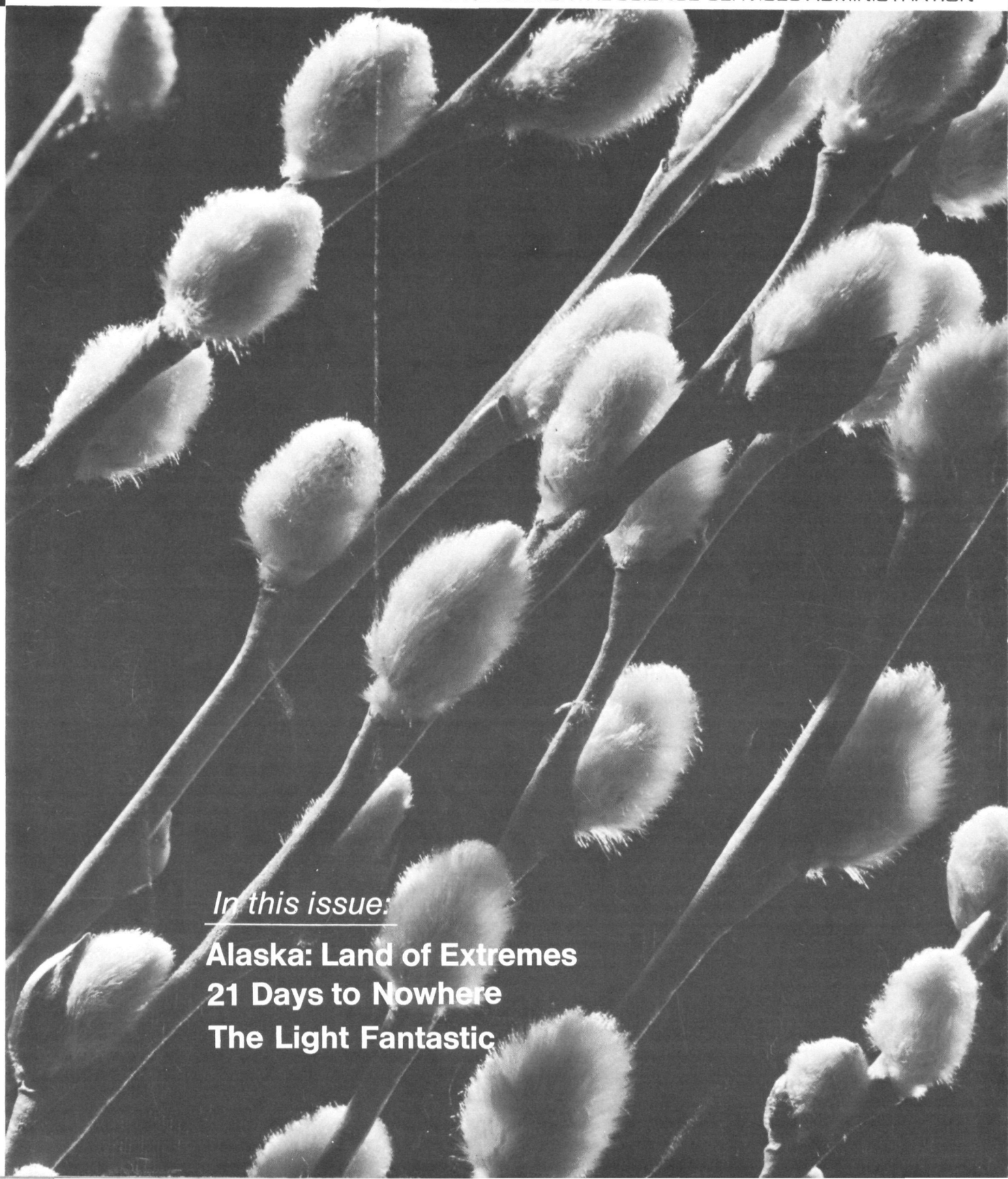

In this issue:

Alaska: Land of Extremes
21 Days to Nowhere
The Light Fantastic

VOLUME 5
NUMBER 2

National Oceanic and Atmospheric Administration

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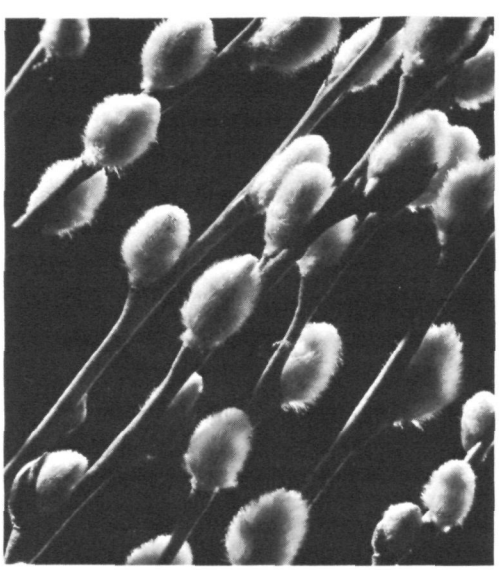
COVER
Pussywillow blooms burst forth to herald the approach of spring.



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Paradox in Antarctica

My recent trip to the Antarctic was both stimulating and disquieting. Those who have followed the history of polar exploration would be surprised to see the methods and practices now being used, and to contrast them with those of yesteryear.

Dogsleds, fur clothing, hardship, and privation are largely things of the past, especially in the main camps. The United States now has a fully civilized base at McMurdo Sound, with permanent buildings, a well-equipped hospital, a nuclear power plant, and efficient communications. Large vessels land cargo and petroleum products into warehouses and tank farms that would be the pride of any small coastal town. A large and efficient support force provides all the necessities of life in abundance.

And yet the picture has its grim side. In spite of all the amenities provided, only five "scientists" (three from ESSA) are wintering over at Pole Station, supported by a dozen or more Navy personnel. Several reasons were given for the less-than-full utilization of this base, so difficult to build originally and so expensive to maintain as a facility; first, the lack of funds for the National Science Foundation to grant to scientists and, second, a lack of interested researchers willing to stay over the austral winter.

Surely, this nation has the will to carry on with the studies still needed on this giant continent, whose effect on the rest of the globe is so fundamental.

21 days to nowhere

BY ANN K. COOK

Sixty-one observers sail on Coast Guard ships recording the weather at sea

"Don't try to tell people what you do. They never understand."

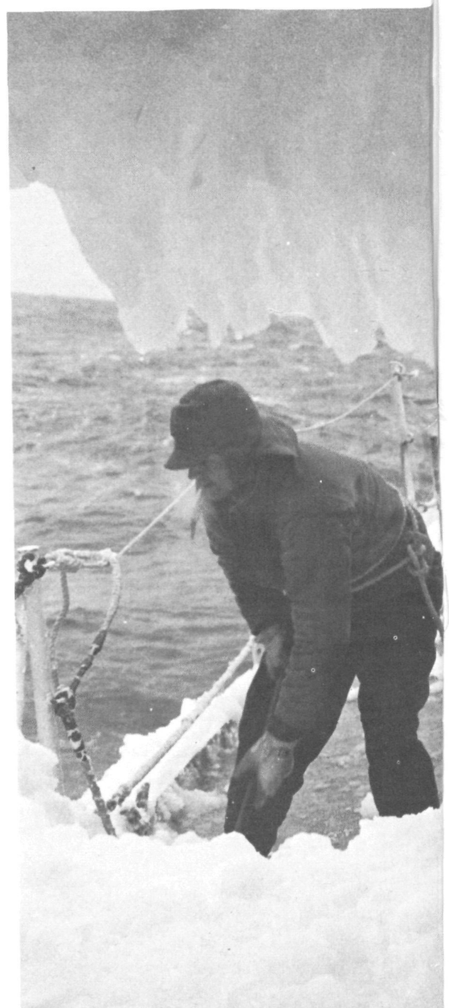
That's the advice Robert Bottom, Atlantic Weather Project Port Supervisor at Norfolk, Virginia, gives to weathermen who go down to the sea in ships.

He knows the frustration of trying to explain a job that takes a man to sea more than 250 days each year, to observe the weather in a prescribed block of ocean hundreds of miles from land.

The 61 Weather Bureau observers who staff the ocean station vessel weather measurement program provide the only complete information available on weather conditions from the surface to the upper air, over vast areas of the ocean. Some data is available at aircraft flight levels from planes crossing the oceans, some at the surface from merchant ships, and some from satellites, which now furnish temperature profiles and cloud-cover pictures. But the seagoing weathermen conduct a full program of regularly scheduled surface and upper-air observations, providing continuing measurements of temperature, humidity, barometric pressure, and wind speed and direction . . . information still so vital in the space age that an additional station was added to the program this winter. The reoccupation of ocean station Hotel brought the number of such stations manned by the United States to seven—five in the North Atlantic and two in the North Pacific.

Current weather over the three-quarters of the earth covered by oceans is vitally important to mariners and pilots, and especially to forecasters, who must know what the weather at sea is like today in order to predict tomorrow's weather ashore.

To furnish this information, the nations of the world operate a network of 14 ocean-going ships, each reporting the weather from an assigned location at sea. On the seven stations manned by the United States, the meteorological program is conducted by the Weather Bureau aboard U. S. Coast Guard vessels. (The ocean station weather observing effort is supported by the Navy except in the case of station Hotel, which is funded directly by the Weather Bureau.) The daily "on station" weather measurement program consists of two rawinsonde observations, two winds aloft observations, hourly surface weather observations, and — on station Hotel—hourly radar observations.



On winter patrols in the North Atlantic all hands turn out to free the ship of her shroud of ice.

The data is radioed to shore where it serves as the basis for analyses of current weather and forecasts of future conditions at various levels over the ocean. The predictions then are used in dispatching aircraft and ships to catch tail winds and following seas and to avoid storms.

Ocean weather observations are a vital part of the hemispheric weather picture, the starting point for all weather forecasting. Weather events recorded aboard ships in the Atlantic and Pacific oceans eventually affect people and industry throughout the United States. North Pacific storms move over the west coast of North America, often as far as the Mississippi Valley. Similarly, Atlantic storms strike severe blows at the eastern United States throughout the year.

Station Hotel, 180 miles south of Nantucket at 38°N, 71°W, was added to the United States' program this year. Because of the need for improved warning of storms approaching the east coast from the Atlantic, Congress authorized funds specifically for manning this station. From February 20 through March 31, it was occupied by the U. S. Coast Guard Cutter GRESHAM, and plans are to man it continuously from August 1 through March 31 hereafter.

The weather program aboard ocean station vessels and on 15 moving merchant ships is administered by the Weather Bureau Overseas Operations Division. Field management is divided geographically into the Atlantic Weather Project and the Pacific Weather Project. The Atlantic and Pacific programs are further subdivided into sections of the coasts.

Robert Bottom is responsible for staffing and equipping ocean station vessels departing from Norfolk and ports to the south. James H. Dew, Jr., is port supervisor at New York, while George Poole covers the New England area from his Boston headquarters and also is supervisor of the Atlantic Weather Project.

From San Francisco Ronald White supervises the Pacific Weather Project, aided by Victor Davis at Seattle, Richard L. Unruh at Honolulu, and Anthony Rippo at Long Beach, California.

The port supervisor must be sure that Coast Guard cutters sailing for ocean stations from ports in his area are properly equipped, and staffed with at least three observers, the minimum needed for round-the-clock operations. He orders the supplies and equipment and usually delivers them himself to the ships. He can't take the chance that a sufficient supply of balloons, for example, is not aboard when the ship sails.

According to Ronald White, Pacific Weather Project Supervisor: "Final preparations for a patrol on an ocean station vessel are generally made on the day prior to sailing. The Observer in Charge must ascertain that all necessary equipment and supplies are aboard and in good working order; once the cutter has put to sea, it is too late to obtain additional instruments or have a faulty receiver checked out.

"On sailing day and on the way out of harbor," White continues, "last-minute preparations are made for the patrol. Equipment is secured for sea; helium is properly stowed; instruments, batteries, balloons, and so forth are securely lashed in an appropriate area; personal gear is stowed in a seamanlike manner, and quarters and office space are put in ship shape."

The trip from port to ocean station takes from one day to two weeks, depending on the distance and sea conditions. "Although the observational program enroute is nearly the same as on station," Ronald White explains, "the shipboard environment is somewhat different, in that the ship is going someplace rather than just maintaining a position.

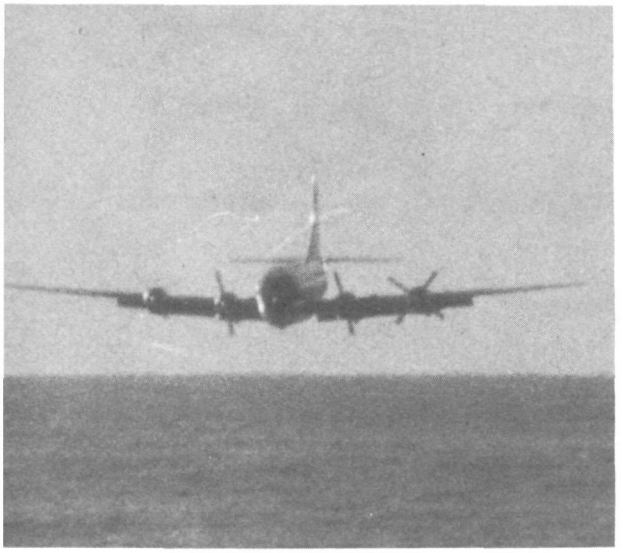
"Upon visual sighting between relieving and relieved vessel on station, mail is passed by boat, or by high-line in rough weather. An official message is radioed by the relieving vessel indicating formally that it has assumed the role of manning the station. Then begins the long 21 days on station, during which the weather observers are busy with their schedule of surface and upper-air observations.

"The boredom that sets in during leisure hours is usually broken up by nightly movies, reading, and card playing. Occasionally, a ship's barbecue is arranged during appropriate weather. In summertime, when air and sea temperatures climb enough to make swimming comfortable, 'swim call' is given a few times weekly, provided no sharks have been spotted in the area.

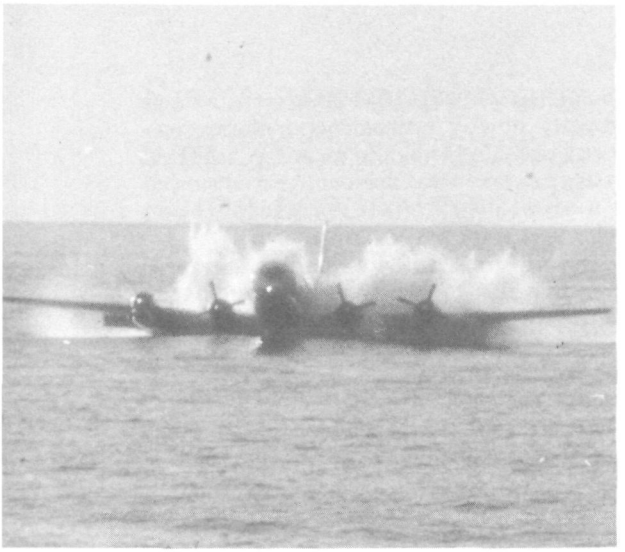
"Recreational activities on deck include fishing, sunbathing, volley ball, and albatross-watching. During favorable weather, boats are sometimes put in the water to give those who feel the ship too confining an opportunity to take temporary leave by riding around the ship."

Most patrols run their 21-day course uneventfully. At other times, the weather itself breaks the monotony. If winds become too strong, it is difficult—and some-

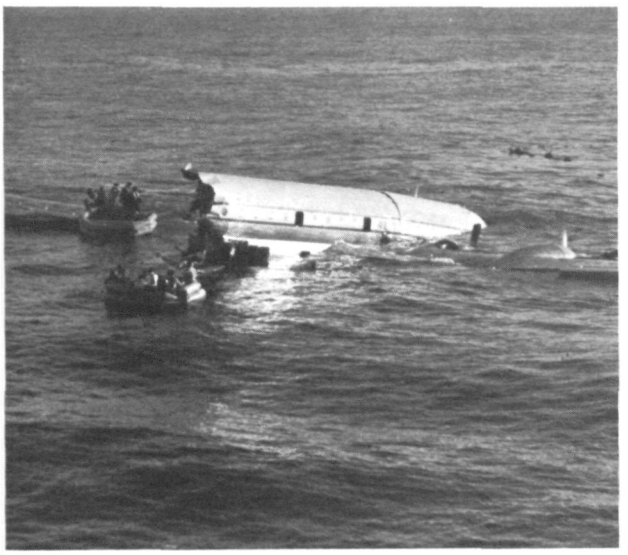
continued



In 1956, an airliner was forced to ditch by mid-Pacific station November.



The pilot made a perfect landing next to the Coast Guard Cutter PONTCHARTRAIN.



Within minutes, all 31 people aboard the plane had been helped into life rafts.

times impossible—to launch the weather balloons and even for the ship to turn and maintain its box pattern around the station. An actual series of daily reports from one patrol in the Atlantic testifies to the hardships of winter weather at sea:

> **January 2.** Due to heavy seas, ship could not maneuver for radiosonde release. Three attempts were made to release radiosondes without success. Raob program secured until weather improves.
>
> **January 3.** Ship still unable to maneuver for radiosonde release. Seas estimated 50 feet and wind 60 knots with gusts to 80 knots. Rawin taken. Balloon shelter door jammed open at release. Coast Guard Coxswain washed over the side during the height of the storm. Ship unable to come about. Rescue attempt was ineffective. Rawin program discontinued, live water being taken over release deck.
>
> **January 4.** Ship came about because of extensive damage to hull and superstructure from pounding into the seas. Ship now running with sea.
>
> **January 5.** Because of extensive damage to the ship and for the safety of the ship and personnel aboard, request was made to proceed Hamilton Inlet, Labrador, in lee of land and conduct station duties from that position.

From time to time, there are calls for help from planes or ships. The primary mission of the Coast Guard cutters—even those on ocean stations—is search and rescue, and the ocean station vessels have participated in many dramatic and dangerous sea rescues. More frequently, there are calls for medical aid to the sick and injured aboard other vessels.

On September 15, 1957, Pacific station Victor was being manned by the Coast Guard Cutter BERING STRAIT. With the approach of typhoon Della, the cutter took precautions for the safety of the ship and its personnel. The typhoon's arrival created a seascape in which it was difficult to distinguish sea from flying spray. Occasional 40-foot waves were observed, but the tops were blown off almost as soon as they formed. The highest one-minute wind speed was logged as 97 knots; nevertheless, a rawinsonde release was made in winds exceeding 60 knots, and all observational schedules were kept.

After the passing of Della, the BERING STRAIT intercepted a distress call from the Liberian freighter CYGNET. The freighter had sustained heavy damage and injuries to her crew. When a large wave carried away part of the bridge structure, the third officer suffered severe facial injuries and a severed artery from the flying glass. After a 36-hour search for the damaged ship, the BERING STRAIT put her doctor aboard to treat the injured officer and others who needed medical assistance.

One of the most dramatic events in the program's history occurred in 1956, when an aircraft ditched beside an ocean station vessel in mid-Pacific.

The airliner had left Honolulu at 9:30 a. m., October 15, bound for San Francisco with 24 passengers and seven crew members. At 3:20 a. m.—halfway across the Pacific, past the point of no return, and 1,150 miles from her destination—the plane's number one engine on the extreme port side began to run away. The pilot was able to regain only partial control of the propeller. Then, the engine on the extreme starboard side faltered and failed completely.

The pilot was faced with a grim decision—whether to try to limp on two engines to San Francisco, or to ditch at sea where help awaited aboard the U. S. Coast Guard Cutter PONTCHARTRAIN, occupying ocean station November. The risks were great in either case, but the pilot elected to ditch.

After consultation with the cutter's officers, he decided to try to keep the plane in the air until daylight. He dumped most of his fuel, organized the passengers for the safest possible landing, and circled the PONTCHARTRAIN awaiting the light of dawn.

Aboard ship, the officers and crew prepared for the emergency. They marked the planned ditching path with water lights, and spread fire-extinguisher foam along its 2500-yard length. The water, fortunately, was calm and warm. Fire hoses were readied in case of fire and explosion, and the ship's boats and life rafts were lowered.

Aboard the plane, passengers and crew rehearsed for the biggest drama of their lives.

At 8:13 a. m., the plane hit the water. Within minutes the PONTCHARTRAIN's boats and life rafts came alongside, and the passengers made a rapid and efficient exit from the sinking plane. Twenty minutes after the plane hit the sea, its occupants were safe aboard the Coast Guard ship. In another minute, the plane sank. Although five people had been injured slightly, everyone survived in a miracle of modern times.

Another major purpose of the ocean station program is to provide radio beacons for ships and aircraft.

In the days before the introduction of high and fast-flying jet aircraft on intercontinental flights, plane crews routinely queried the ships for weather and position information as they flew overhead. Veteran shipboard observers recall that, 10 or 15 years ago, aircraft swarmed above the ocean stations during the mid-shift, en route to morning arrival at their destinations.

Today, the scheduled passenger-carrying aircraft are less dependent on the information provided directly by the ocean vessels. But the shipboard weathermen say that an amazing number of propeller aircraft, including small single-engine planes, still flies the ocean. And ships frequently radio the ocean station vessels for position information.

Special aid to navigation was given to an unusual vessel in August 1965, by the

Coast Guard Cutter DUANE. The DUANE was occupying station Delta, 600 miles east-southeast of Newfoundland, when a lookout on the flying bridge sighted a rowboat on the horizon.

The boat pulled alongside the DUANE and proved to be an unsinkable craft, in which two Englishmen were attempting to cross the ocean from Norfolk, Virginia, to England, on a route navigated in 89 days by another rowboat before the turn of the century.

The voyagers had been two months at sea and were falling far behind the record set in the 19th century. The DUANE provided water, milk, bread, fruit, canned goods, and reading material, and the two men departed in their rowboat under a threatening sky. They were never seen again. Their boat was found later, capsized far east of Delta, with no one aboard.

Year after year, the Weather Bureau's shipboard observers spend about two-thirds of their life at sea, more time, in fact, than the Coast Guard officers who sail the ships. These officers marvel at the sea-time logged by the Weather Bureau men, and the number of years they remain on the job.

Aboard ship, the observers' time is divided between tedium and the twice-daily struggle to inflate and release a nine-foot weather balloon from a rolling, pitching ship. Occasionally, there is a moment of high adventure.

The observers are neither recluses, misfits, nor wanderers. Most are family men, and they are about normally gregarious—some more, some less.

They just like the sea—and perhaps prefer to battle the elements instead of rush-hour traffic. □

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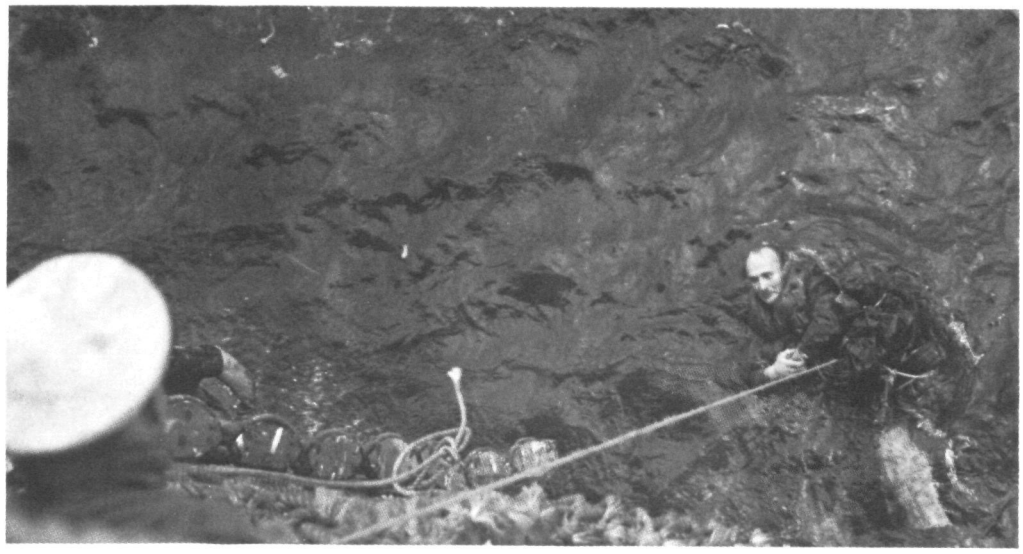

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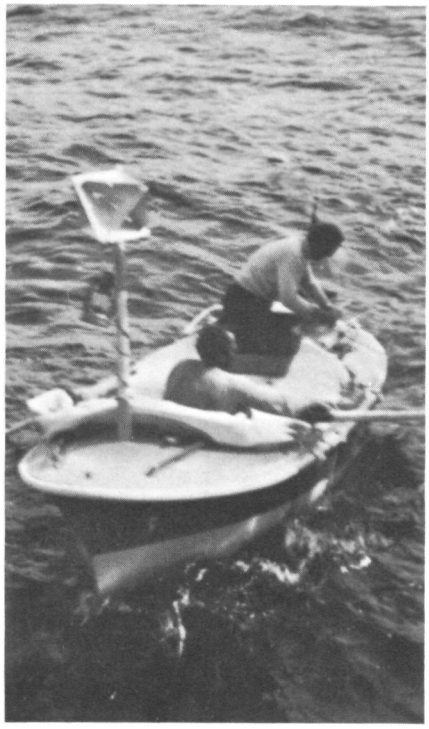

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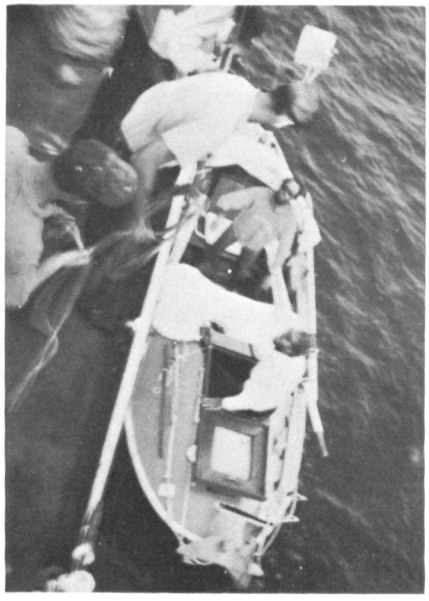

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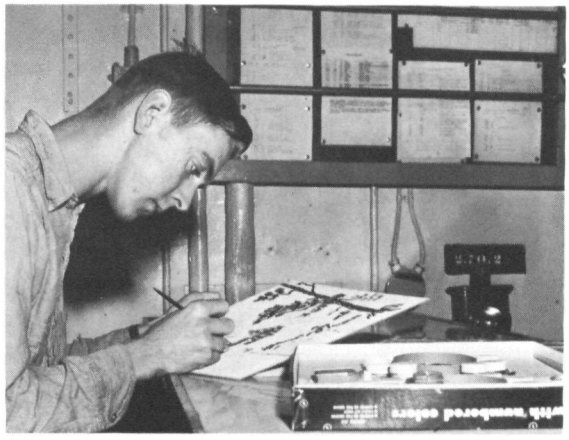


The nations of the world operate a network of 14 ocean stations which serve as weather observing platforms, aircraft checkpoints, and rescue ships. On the seven stations occupied by the United States, the meteorological program is conducted by the Weather Bureau aboard Coast Guard ships. 1. A survivor of a shipwreck is pulled from the sea. The primary mission of the Coast Guard cutters —even those on ocean stations—is search and rescue. 2. A new "locate system," which employs Loran C to provide minute-by-minute information on the position of weather balloons, is undergoing operational evaluation by the Weather Bureau aboard the CGC CHINCOTEAGUE. 3, 4. In 1965, a rowboat pulled alongside the CGC DUANE on station Delta, 600 miles from land. Two Englishmen attempting to row from Virginia to England were given supplies. They rowed away and never were seen again. 5. Weather observer Allen Tusing prepares a radiosonde instrument for the twice-daily launch. 6. Hobbies help to pass the time during the long ocean station patrols.

ESSA scientists are searching for the pieces missing from

The World's Biggest Jigsaw Puzzle

BY RAYMOND WILCOVE
Coast and Geodetic Survey

"Oh, East is East, and West is West, and never the twain shall meet . . ."

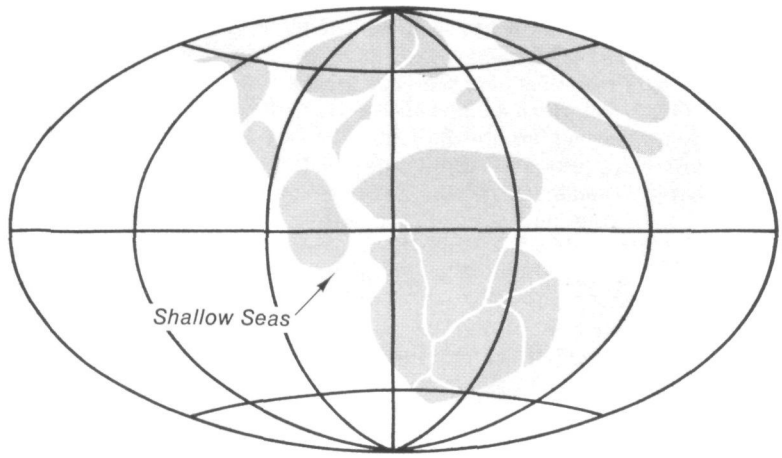
. . . at least not for another 150 million years, as the continents drift.

For drift they do.

Inexorably and interminably, the continents creep from epoch to epoch, scientists estimate, at a rate which varies from about two inches a year in some locations to about the width of a dime in others. The inches and dimes mount up over 170 million years or so to thousands of miles—the distance between South America and Africa, for example.

Difficult as it is to credit the idea that the world's continents wander—some east, some west—the theory that they are footloose has been in existence for more than three centuries. Even now, not all scientists agree on the point, but it has wider acceptance today than ever before.

One of the foremost exponents of the continental-drift theory is Dr. Robert S. Dietz, of the ESSA Research Laboratories' Atlantic Oceanographic and Meteorological Laboratories in Miami. Dietz' pursuit of proof to support the theory has taken him to all corners of the world, including the coasts of South America, Africa, and Australia to study their continental margins.



UPPER CARBONIFEROUS

He believes that there were once two supercontinents which joined together about 350 million years ago to form a universal continent (Pangaea), and that this universal continent split about 175 million years ago to form again two supercontinents of equal area. The two supercontinents have been named Gondwana, (or Gondwanaland) and Laurasia. According to Dietz, Gondwana and Laurasia broke apart to form the existing continents. Gondwana was composed of what is now Australia, New Zealand, Antarctica, Africa, India, South America, and Malagasy, while Laurasia consisted of North America and Eurasia. According to this theory, when what is now the Indian subcontinent hit the Eurasian land mass, it burrowed under and formed the Himalaya Mountains.

Dietz said that Cape Hatteras, North Carolina, and Dakar, West Africa, were once "adjacent points," but have separated during the past 175 million years or so. "To put it another way," he explained, "the Atlantic Ocean has opened up by 3800 statute miles, the distance between Cape Hatteras

and Dakar." He said the continents opened up even greater distances in the Pacific.

Alfred Wegener, a German meteorologist, formally advanced the one-continent drift theory in 1912, although it had been discussed since the 17th century. He believed that the supercontinent was surrounded by a supersea. His theory was predicated in part on the similarity in the coastlines of North and South America when matched with those of western Europe and Africa.

Wegener's theory fell into disrepute until the post-World War II period, when new oceanographic aids made possible more meaningful research of the ocean. It has regained ascendancy in the last few years.

He bolstered his beliefs by pointing to the discovery of similar plants and animals on widely separated continents and islands, to the existence of tropical fossil plants in northern climates, and to glacial markings on southern continents.

But opponents of the theory contended that this might be due to other natural causes, such as possible land connections aeons ago between the continents and the distribution of the species by wind and floating objects. As for the glacial markings, these could have been caused during the recurring ice ages to which the earth has been subject over the years.

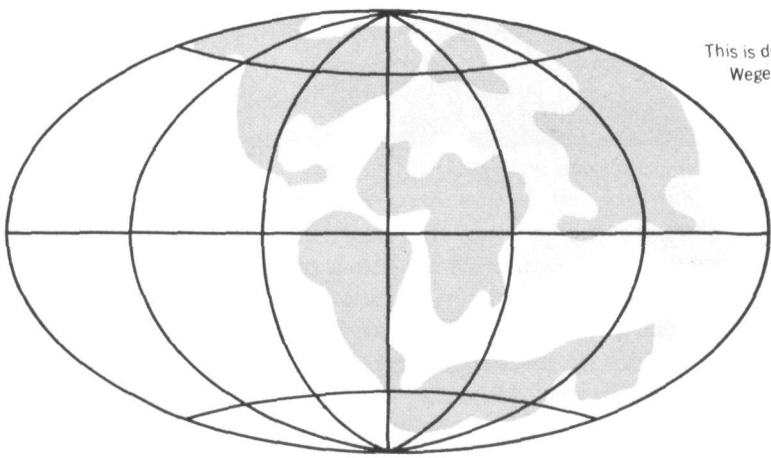
But the most telling point against Wegener's theory was the argument of geophysicists that the earth was too rigid to permit huge land masses to go drifting about. Wegener had no proof to dispute this or the added argument that there was no known or imagined force that could have caused a giant land mass to split.

But supporters of continental drift have come forward with a theory of how it all could have happened. It goes something like this: the continents rest upon the earth's mantle, that part of the earth's interior which lies between the molten central core and the crust on which we live. The mantle, so the theory goes, is only quasi-solid, or acts like a fluid under long-acting forces. Subcrustal heated rock rose from the depths of the mantle and forced the primeval land mass or masses apart. This subcrustal heated rock continues to rise, spreads laterally, and then descends into the earth again. This rise and fall of the heated rock is referred to as a convection current.

Allied with the continental-drift theory is that of ocean floor spreading, which Dietz originated. As the convection currents rise to the bottom of the sea, they cause the sea floor to spread. The continents are locked into this spreading which affects large platelike segments of the earth's outer shell.

There are those who believe that the ancient supercontinent, or at least one of them, existed in the mid-Atlantic. There, they say, is to be found the evidence of what caused the continent to split. It is a giant undersea mountain range, known as the Mid-Atlantic Ridge, which extends from the Arctic Ocean the entire length of the North and South Atlantic and continues around Africa into the Indian Ocean.

This mountain range, which is covered by about two miles of ocean, is split by a rift or valley and through this valley, so the theory goes, molten fluid continues to rise. The same process goes on, it is added, in other portions of the globe, where the sea bottom is split by giant mountain ranges and fractures.



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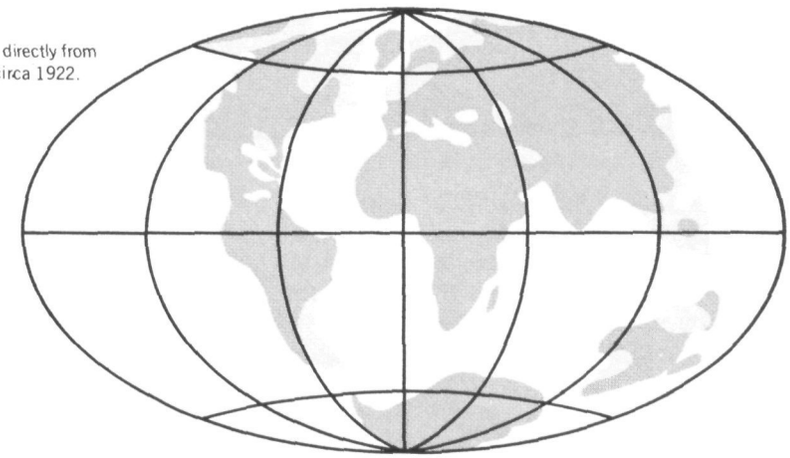
This is drawn directly from Wegener circa 1922.



OLDER QUATERNARY

Dietz frankly terms the continental-drift theory an "outrageous hypothesis." But then, he adds, so was the theory that "the earth is round and that it spins in space supported by nothing at all."

"Until a decade ago," he said, "most scientists were inclined to dismiss all drifters with disdain as biased zealots. The results of modern studies in paleontology, the science dealing with ancient plants and animals, appear to support in great measure the concept of continental drift. If continents were once together, this should be reflected both in fossil and in modern floral and faunal distribution patterns."

Such dispersion of plants and animals, Dietz conceded, could have come about through other causes, including the existence of large land masses which then sank beneath the ocean; land bridges—such as the Panama Isthmus—which once connected continents, but later became submerged; or closely spaced islands in the ocean.

"The strongest paleontological support for the theory of continental drift," said the ESSA scientist, "has come from the now-extinct *Glossopteris* flora which formerly flourished, as revealed by fossilized leaves, at places now within 200 miles of the South Pole, as well as in tropical India, Australia, South America, and Malagasy.

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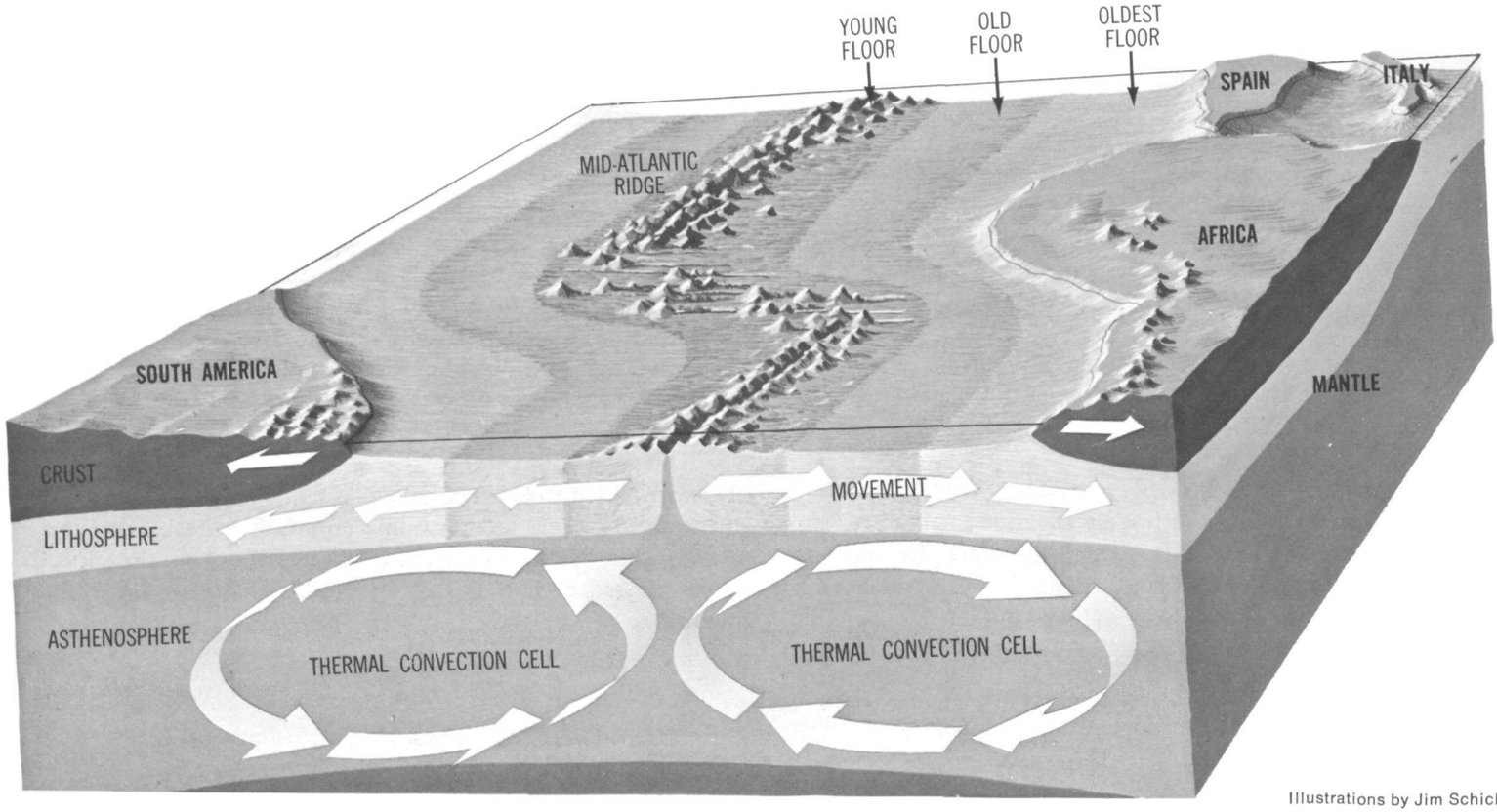
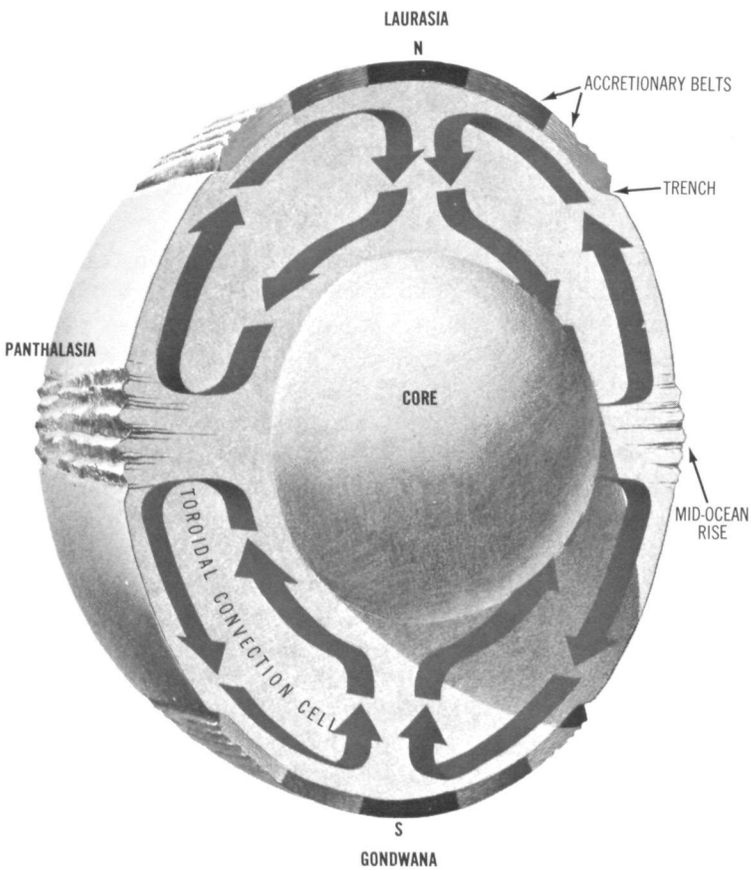


Illustrations by Jim Schick.

According to the theory of ocean-floor spreading, convection currents rising to the bottom of the sea cause the sea floor to spread and continents to split.



A theoretical cross-section of earth shows the continents Gondwana and Laurasia drifting apart on the earth's quasi-solid mantle.

"One may argue that this really means a more equable climate in late Paleozic times. But a telling objection is the unlikelihood that any highly developed plant can adapt itself to the even day-night cycle of the Equator as well as to a region within the Antarctic Circle where darkness persists continuously for many months each year."

The strongest impetus to the theory in recent years has not been the evidence of paleontology, but results arising from the study of magnetic rocks. When the molten flows rose from the earth's mantle to the bottom of the sea and cooled, the iron mineral magnetite in the newly formed rocks becomes magnetized by the force of the earth's magnetic field. This magnetized mineral serves as a natural compass and indicates the latitude of the magnetized rock when it was formed. The magnetized rocks point in the direction of the magnetic pole at the time they were formed. Consequently, if the continents were always in a fixed position, and if the magnetic pole has always been near the geographic pole (or axis of rotation), the ancient rocks should all point toward the North Pole. "But old rocks do not and this," said Dietz, "strongly suggests that the continents have moved about."

His efforts to fit the continents together have differed greatly from those employed by Wegener and his supporters. Early efforts concentrated on matching the Brazilian bulge of South America with the sharp indentation on the west coast of Africa. As early as 1859, A. Snider of France sketched the juxtaposition of the two coasts in his treatise, *La Création et ses Mystères Dévoiles.*

In 1912, Wegener wrote: "The first notion of the displacement of continents came to me in 1910 when, on studying the map of the world, I was impressed by the congruency of both sides of the Atlantic coasts." Doubt was cast on this visual evidence, however, by the noted English geologist, Sir Harold Jeffries, in his book, *The Earth,* in which he wrote:

"A moment's inspection of the globe will show that there is actually a misfit between Africa and South America of 15 degrees."

Dietz has approached the problem in another way. It is his contention that the "true continental edge" is not the shoreline nor even the edge of the submerged continental shelf which juts out from the continent, but rather the 1000-fathom (6000-foot) depth contour of the continental slope. It is here that the shelf ends and the continents begin their descent to the deep ocean, the abyssal sea.

Using this criterion, he said, the matching of Africa and South America "has produced a remarkable result. They fit with precision far beyond any previous expectation. Jeffries was apparently comparing shorelines. Not only is there a general fit of the bulge of South America into the recess of Africa, but the various bumps fit, and so do the bumps on the bumps. There seems to be no interpretation, other than drift, to explain this."

Science, in the shape of electronic computers, has now been put to work in support of the continental-drift theory. In 1967, the Coast and Geodetic Survey Ship OCEANOGRAPHER, while engaged in a global expedition, surveyed the 1000-fathom contour along the west and south edges of the Australian continent. Dietz and an associate, Walter Sproll, fed the data into a computer at the University of Miami. The result, they stated, was a precise fit of the continents of Australia and Antarctica, which are now separated by about 2000 miles of water.

Even when the continents are joined together by Dietz' method, there still remain large gaps in the fit. He maintains this is due to the fact that parts of the now-fragmented supercontinents are still lost, submerged within the Indian Ocean, and has suggested that a search be launched for these microcontinents.

"Any reconstruction of the Gondwana supercontinent results in several Texas-sized missing pieces to this jigsaw puzzle," said Dietz, adding that the Seychelles Islands group in the Indian Ocean is certainly one of these.

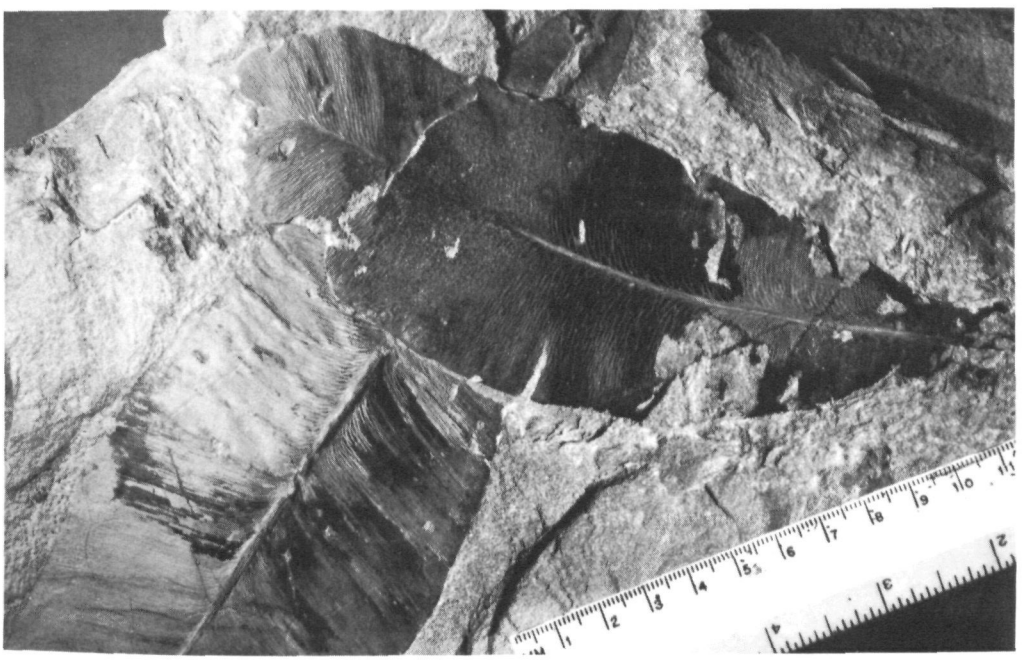
"The discovery of these microcontinents is crucial to the drift theory," he said. "These missing pieces constitute the 'lost Atlantis' of the continental-drift theory. Once these pieces are found and the true edges (the continental slopes) of the Southern Hemisphere continents are precisely surveyed, the Gondwana jigsaw puzzle will fall nicely in place."

Recently, deep-sea drilling in the Caribbean revealed the presence there of granitic rock, the stuff of which continents are made. It was the first time such rock has been found at the bottom of the sea. Its finders concluded that they had found the remains of a submerged microcontinent or the beginnings of a new continent.

The discovery was made by Bruce C. Heezen of Columbia University's Lamont-Doherty Geological Observatory and other oceanographers aboard the EASTWARD, a vessel operated by Duke University. The granitic rocks were dredged up from depths of 3000 to 8000 feet at 50 locations between Barbados and Jamaica. Heezen said they could indicate the discovery of a microcontinent at least 100 miles long and 150 miles wide, with the alternative possibility that a new continent was forming. In any event, the discovery strengthened the continental-drift and sea-floor spreading theories.

Earlier this year, confirmation of the drift theory was claimed by the GLOMAR CHALLENGER, a deep-ocean drilling ship which found that the sediments were youngest (geologically speaking) where they emerged from the Mid-Atlantic Ridge and grew older as they spread away from the ridge toward North America and Europe.

The continental-drift theory has brought in its wake several interesting possibilities for the future. One of these is that the Arabian Peninsula is drifting away from Africa so that the Red Sea will eventually become an ocean. Another possibility is that Los Angeles and San Francisco, which are moving toward each other inch by inch, will be at the same latitude. If so, Los Angeles may be well out in the Pacific Ocean, for a third possibility is that California west of the San Andreas Fault (a geological split in the earth) will eventually move out to sea in the direction of Japan. □



(Above) Robert S. Dietz is one of the foremost exponents of the continental-drift theory. (Right) This fossil leaf found from the tropics to polar regions supports the theory.

Early American Weathermen

BY PATRICK HUGHES
Environmental Data Service

Antique weather records work for modern science

The American Revolution interrupted John Jeffries' weather journal.

During the winter of 1775-76, General George Washington laid siege to Boston. The British Army evacuated the city in March and Dr. Jeffries, a Loyalist, went with them.

John Jeffries was a Boston physician who recorded two series of notes on that city's weather between 1774 and 1816. He made daily entries from December 15, 1774, through March 4, 1776, then resumed his weather observations upon his return to Boston in 1790. The second series is an intermittent record of daily observations from May 27, 1790, through September 19, 1816, prefaced by a summary of the winter of 1790.

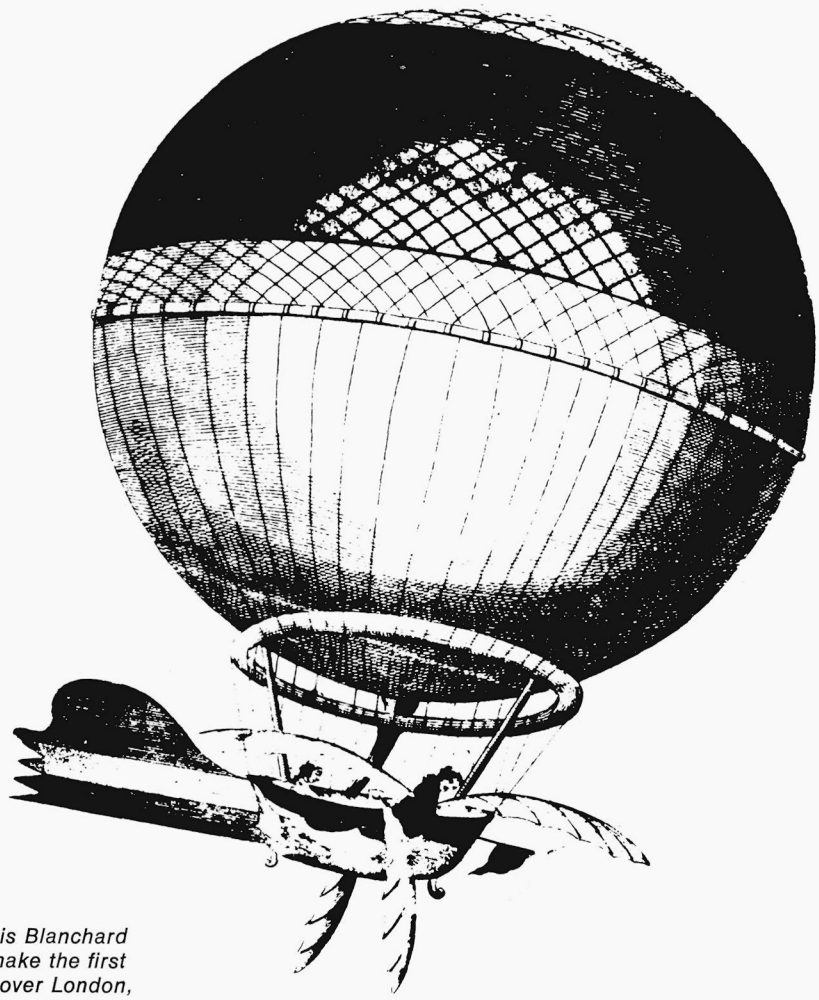
Long before there was a U. S. meteorological service, and before the first American weather observer network was established by the Army's Medical Department in 1814, citizen scientists and students of nature were recording the climate of our country. These included such giants of American history as Benjamin Franklin, Thomas Jefferson, and George Washington, as well as hundreds of other less famous Americans. Collectively, their records constitute our principal source of information concerning the weather and climate of the United States from colonial days through the War of 1812.

John Jeffries was extraordinary, even in an age of exceptionally gifted men. After the evacuation of Boston, he served as a surgeon with the British Army in America. Then, when Cornwallis surrendered, he left to live in England, where he soon became interested in levitation or aerostation—the brand-new art of operating a manned balloon.

Jeffries flew with the French aeronaut, Francois Blanchard. Together, they made the first scientific measurement of the free air over London on November 30, 1784. The crowd watching included the Prince of Wales and the Duchess of Devonshire, among other notables. (The oars the men attached to the balloon to steer it must have been as much of an oddity as the flight itself.)

On this ascent, the balloonists measured pressure, temperature, humidity, electrical potential, and the chemical constituents of the air to a height of 6,560 feet. The values they obtained agree closely with those of today's observations.

Jeffries and Blanchard also were the first men to make an international voyage by air, crossing the English Channel from Dover to the forest of Guines, France, on January 7, 1785. Celebrated as heroes (a monument was erected in their honor near Calais), they reached Paris on January 11, where Jeffries



John Jeffries and Francois Blanchard took to a balloon in 1784 to make the first upper-air measurements over London, England.

dined with Benjamin Franklin, the American Ambassador to France and himself a pioneer meteorologist.

Jeffries returned to Boston in 1789, where he gave the first public lecture in New England on anatomy and, in 1790, resumed his weather diary.

John Winthrop was another early American weather observer active during the Revolution. A descendant of the first Governor of Massachusetts, Winthrop was a personal friend and advisor of George Washington and Benjamin Franklin and one of the Colonies' leading scientists and scholars.

In 1738, when he was only 24, Winthrop was elected professor of mathematics and natural philosophy at Harvard. He was America's first astronomer, as well as a physicist and mathematician. He established the first laboratory of experimental physics in America in 1746, and in 1751 introduced "the elements of fluxions"—now known as differential and integral calculus—into the Harvard curriculum.

Winthrop, a patron of Benjamin Franklin's lightning experiments, was also a student of atmospheric phenomena. He kept a daily record of the weather at Harvard from December 1742 until his death on May 3, 1779, during the fourth year of the Revolution.

In 1959, Harvard University's Blue Hill Observatory donated its collection of original 18th and early 19th century weather diaries and journals to the National Weather Records Center in Asheville, N. C. These journals include John Jeffries' observations and come largely from the New England area. One of the more interesting was kept by William Plumer of New Hampshire.

Plumer, a teenager when the Revolution began, was born at Newburyport, Massachusetts, on June 25, 1759, and moved to a farm in Epping, New Hampshire, in 1768. He served in the New Hampshire legislature intermittently between 1785 and 1800, and was Speaker of the House in 1791 and 1797. During this period, he drafted major revisions to the state's constitution, creating the form of government under which New Hampshire still operates.

From 1802 to 1807, Plumer served in the United States Senate, then declined to stand for reelection, preferring instead to return to the New Hampshire legislature. After serving as president of the State Senate in 1810 and 1811, he was elected governor the following year. During the War of 1812, Plumer was the only New England governor actively to support the national government. A candidate for governor in the three

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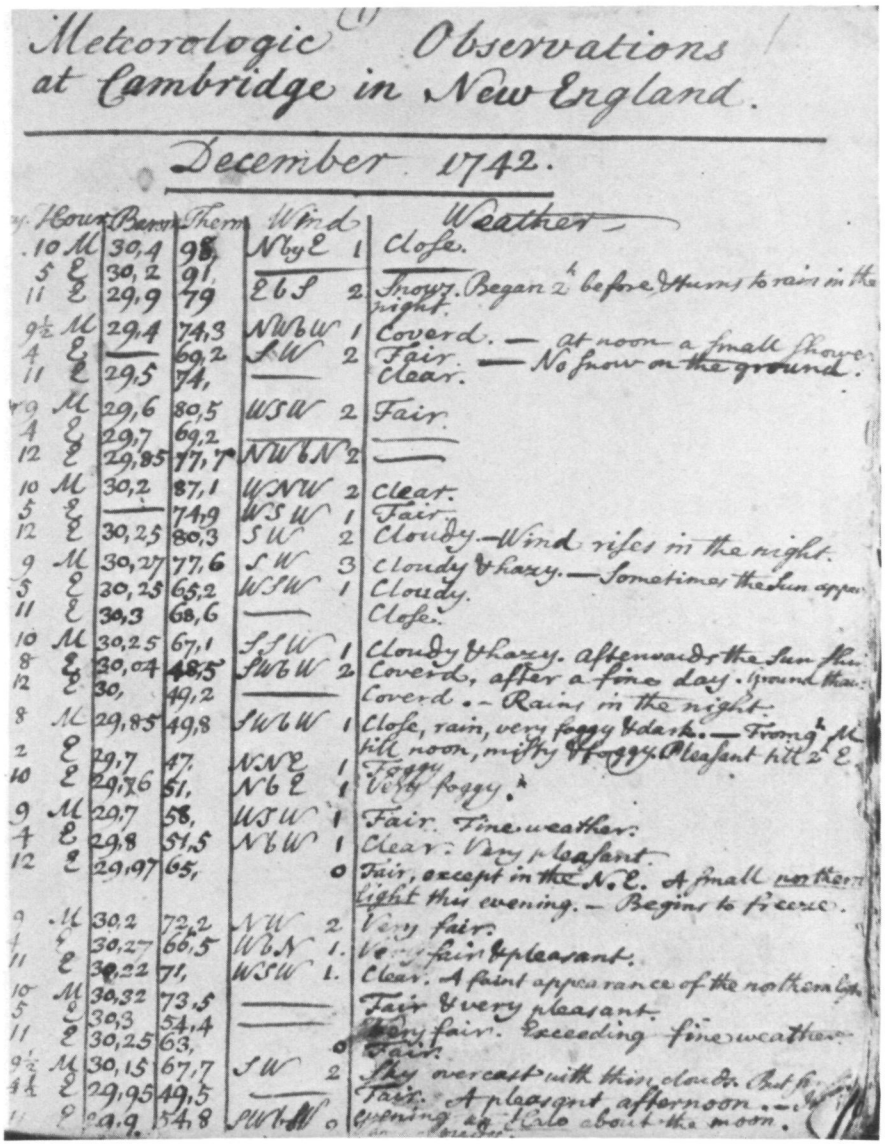


Meteorologic Observations at Cambridge in New England.

December 1742.

Hour	Barom	Therm	Wind		Weather
10 M	30,4	98,	N by E	1	Close.
5 E	30,2	91,			
11 E	29,9	79	E b S	2	Snowy. Began 2h before. Turns to rain in the night.
9½ M	29,4	74,3	NWbW	1	Coverd. — at noon a small shower
4 E		69,2	SW	2	Fair. — No snow on the ground.
11 E	29,5	74,			Clear.
9 M	29,6	80,5	WSW	2	Fair.
4 E	29,7	69,2			
12 E	29,85	77,7	NWbN	2	
10 M	30,2	87,1	WNW	2	Clear.
5 E		74,9	WSW	1	Fair
12 E	30,25	80,3	SW	2	Cloudy. — Wind rises in the night.
9 M	30,27	77,6	SW	3	Cloudy & hazy. — Sometimes the Sun appe
5 E	30,25	65,2	WSW	1	Cloudy.
11 E	30,3	68,6			Close.
10 M	30,25	67,1	SSW	1	Cloudy & hazy. afterwards the Sun shi
8 E	30,04	48,5	SWbW	2	Coverd, after a fine day. Ground tha
12 E	30,	49,2			Coverd. — Rains in the night.
8 M	29,85	49,8	SWbW	1	Close, rain, very foggy & dark. — Frong M
2 E	29,7	47,	NNE	1	till noon, misty & foggy. Pleasant till 2 E
10 E	29,76	51,	NbE	1	Foggy
9 M	29,7	58,	WSW	1	Very foggy.
4 E	29,8	51,5	NbW	1	Fair. Fine weather.
12 E	29,97	65,		0	Clear. Very pleasant.
					Fair, except in the N.E. A small northern light this evening. — Begins to freeze.
9 M	30,2	72,2	NW	2	Very fair.
4 E	30,27	66,5	WbN	1.	Very fair & pleasant.
11 E	30,22	71,	WSW	1.	Clear. A faint appearance of the northern lig
10 M	30,32	73,5			Fair & very pleasant.
5 E	30,3	54,4			Very fair. Exceeding fine weather
11 E	30,25	63,		0	Fair.
9½ M	30,15	67,7	SW	2	Sky overcast with thin clouds. But fa
4½ E	29,95	49,5			Fair. A pleasant afternoon. —
11 E	29,9	54,8	SWbW	0	Evening as Halo about the moon.

John Winthrop's weather record began in December 1742 (above) and ended in 1779.

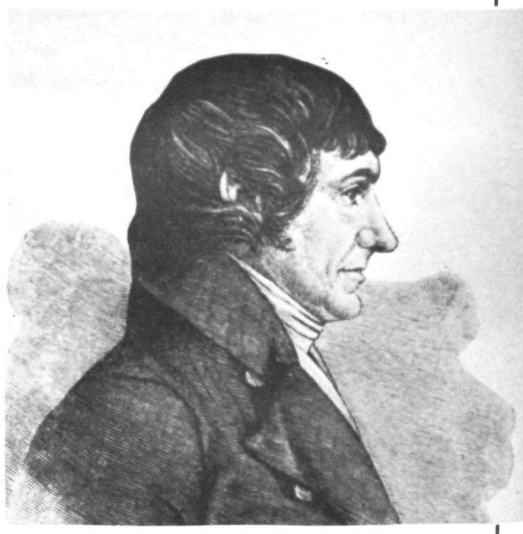
succeeding years, he was defeated by narrow margins in bitter campaigns. When peace came, however, he was reelected and served from 1816 to 1819.

William Plumer recorded daily weather conditions during most of the period 1796 through 1823. His observations were made at his home in Epping, in Washington, D. C., while he was a U. S. Senator, and at Concord, during his years as governor.

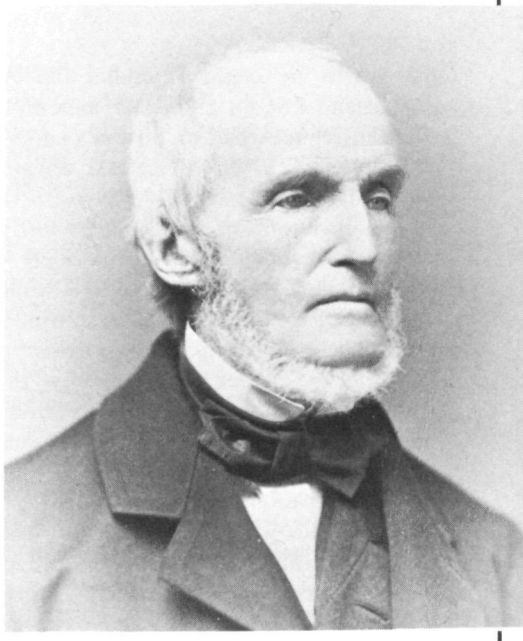
Following his retirement from public life, Plumer began a writing career, and is credited with more than 1,900 articles and sketches of American biography. He died in his childhood home in Epping on December 22, 1850, at the age of 91.

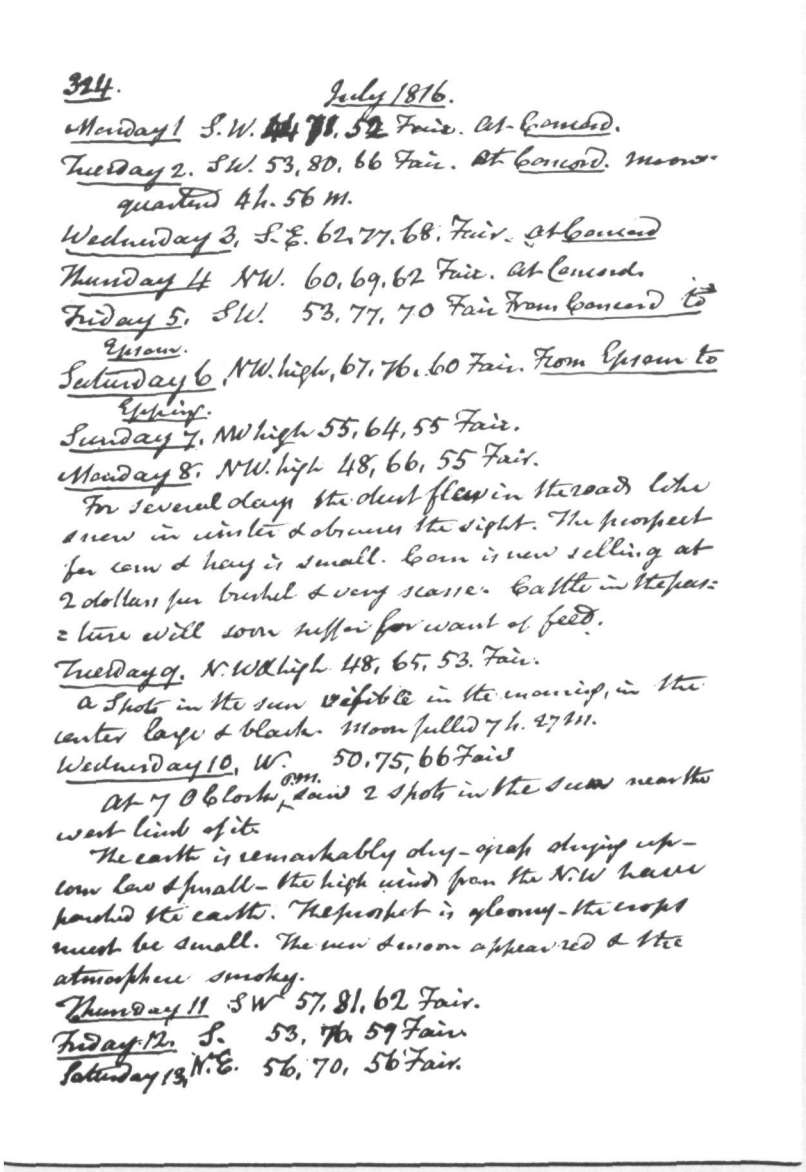
Like Plumer, Samuel Rodman, Jr., took weather observations during the War of 1812. A leading merchant and manufacturer of New Bedford, Mass., Rodman was also a member of the Society of Friends, an anti-slavery advocate, and a leader in local charities. He began a daily weather journal in New Bedford in 1812, when he was 20, and continued it until his death in 1876, when his son Thomas took over his meteorological observations.

William Plumer (below) reported extremely dry weather at Concord, N.H., in July 1816 (right), during his second term as governor. "For several days the dust flew in the road like snow in winter and obscured the sight. The prospect for corn and hay is small. Corn is now selling at 2 dollars per bushel and very scarce."



Samuel Rodman, Jr., (below) of New Bedford, noted in his journal for 1812-13 (right): "The Moons age in this & subsequent journals is noted, not from any belief that the Phases of that Planet have any sensible influence upon our Atmosphere, but to furnish data by which to disprove the opinions generally prevalent . . . ."





324. July 1816.
Monday 1 S.W. 71. 52 Fair. At Concord.
Tuesday 2. SW. 53, 80, 66 Fair. At Concord. Moon quarter 4h. 56 m.
Wednesday 3, S.E. 62, 77, 68. Fair. At Concord
Thursday 4 NW. 60, 69, 62 Fair. At Concord.
Friday 5. SW. 53, 77, 70 Fair From Concord to Epsom.
Saturday 6, NW. high, 67, 76, 60 Fair. From Epsom to Epping.
Sunday 7. NW high 55, 64, 55 Fair.
Monday 8. NW. high 48, 66, 55 Fair.
For several days the dust flew in the roads like snow in winter & obscured the sight. The prospect for corn & hay is small. Corn is now selling at 2 dollars per bushel & very scarce. Cattle in the pastures will soon suffer for want of feed.
Tuesday 9. N.W. high 48, 65, 53. Fair.
a Spot in the sun visible in the morning, in the center large & black. Moon fulled 7h. 27 m.
Wednesday 10. W. 50, 75, 66 Fair
At 7 O Clock p.m. saw 2 spots in the sun near the west limb of it.
The earth is remarkably dry - grass drying up - corn low & small - the high wind from the N.W have parched the earth. The prospect is gloomy - the crop must be small. The new moon appeared red & the atmosphere smoky.
Thursday 11 SW 57, 81, 62 Fair.
Friday 12. S. 53, 76, 59 Fair
Saturday 13, N.E. 56, 70, 56 Fair.

N. B. The Moons age in this & the subsequent journals is noted, not from any belief that the Phases of that Planet have any sensible influence upon our Atmosphere, but to furnish data by which to disprove the opinion generally prevalent with practical men upon that Subject: & which had then when forming their judgments in anticipation, of the Weather constantly to have reference to the Position of that Luminary with respect to us and the Sun. — S. Rodman Jr.
11 mo. 1816

In 1889 Adolphus W. Greeley, Chief of the Signal Corps' weather service, wrote to Thomas Rodman that for continuity and homogeneity, his father's rainfall record was "the most remarkable record in this country, and perhaps in the world." Later, in thanking Rodman for a copy of an unbroken record of mean temperature kept at New Bedford from 1813 to 1890 by both father and son, Greeley praised it as affording "an opportunity seldom presented for the study of the variations of our climate. . . ."

Today, ESSA's Environmental Data Service is charged with documenting changes in the climate of the United States, whether natural or manmade. As indicated by Mr. Greeley, this is largely a matter of the period of reliable record; the longer the record, the easier and more meaningful the measurement of variations. In this regard, the weather journals of private citizens dating to the colonial period can add significantly to our knowledge of the climate of our country in earlier days.

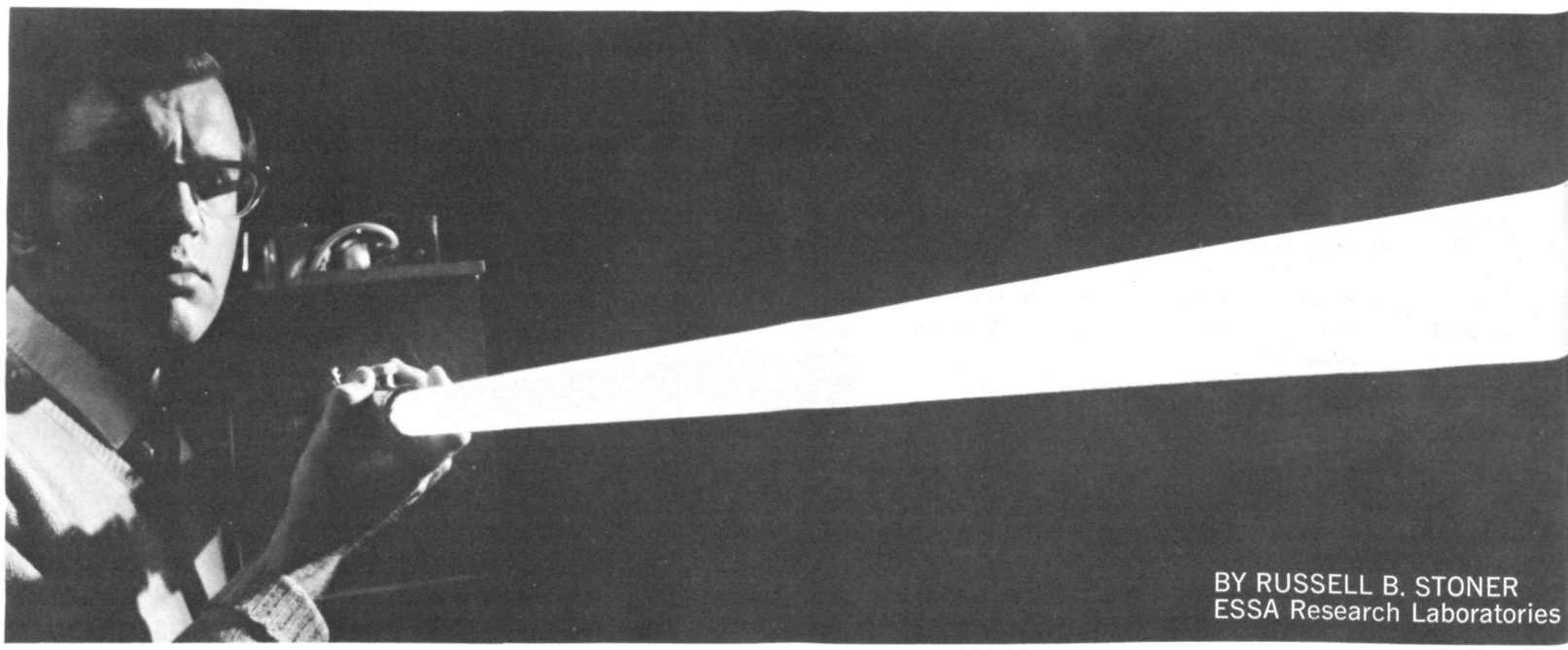
The original Rodman, Jeffries, and Plumer records are archived at the Environmental Data Service's National Weather Records Center, a gift of the Blue Hill Observatory. A microfilm copy of the Winthrop record was provided by the Harvard University Library. Altogether, there are approximately 300 18th and early 19th century weather journals and diaries on file at the Center; most are the original manuscripts, the rest, microfilm copies.

This invaluable archive is not a mere collection of quaint curiosities for historians to ponder. It is put to work every day, to unravel the mysteries of our nation's climatic past and to provide benchmarks for environmental programs of the future. □

Clyde Collier, principal archivist at the National Weather Records Center, is responsible for its climatic data collection, including these and other early American weather documents. Altogether, there are approximately 300 18th and early 19th century weather journals and diaries on file at the Center.

ERL scientists mix optical and radio waves to attain more accurate distance measurement.

THE LIGHT FANTASTIC



BY RUSSELL B. STONER
ESSA Research Laboratories

Lockett E. Wood, physicist for the Institute for Telecommunication Sciences, focuses the dual laser beam used to measure atmospheric dispersion. The combined red and blue light are separated by filters at the receiver.

THE THICKNESS of this page is 100 times greater than the theoretical error in a measured 10-mile path using lasers or microwave techniques. Both optical and radio measuring systems could achieve this magnitude of accuracy—one twenty-five-thousandth of an inch—over a line-of-sight path in a vacuum.

Unfortunately for the geodesist or geophysicist interested in precise distance measurement, the ocean of air which surrounds and sustains us also interferes with the signals from the electronic measuring devices. The resulting measurement errors over a 10-mile path, if no atmospheric correction is applied, might be as much as 10 feet.

A few feet in many miles is not important to most people. The odometer on your car is not that accurate. While millions watch on television, football referees measure carefully, but not too precisely. Even vital statistics like 36-22-36 accurate to a quarter of an inch are acceptable, even though that tiny fraction would magnify to a 366-foot error if expanded to 10 miles.

The scientist who wants to determine the exact size and shape of the earth through satellite geodesy, monitor earth movement along a seismic fault line, or observe continental drift needs extreme accuracy. He may need to detect changes of hundredths of an inch over long paths. Somehow the errors resulting from atmospheric effects upon his electronic signals must be reduced before he can achieve meaningful results.

Dr. Moody C. Thompson, Jr., of the ESSA Research Laboratories' Institute for Telecommunication Sciences, and his coworkers have been studying the problem for 15 years. Their original effort was to define the problem in support of U. S. Air Force missile tracking systems. Once the effect of the atmosphere on the measuring

signal had been demonstrated, the next logical step was to develop techniques for predicting what the effect would be and correcting for this effect.

If the atmosphere were homogeneous, predicting its effect on an optical or radio signal would be fairly straightforward, and the correction could be applied. But this is not the case. The gaseous mass changes constantly as weather systems move through an area, with the time of day, and with changing seasons. The signal transmitted by the various remote measuring devices will travel at substantially different speeds as the atmospheric conditions change.

Harris Janes, one of the original members of Thompson's research team, recalls the various methods used to determine the atmospheric conditions along the signal path. During the early studies, measurements were made at the transmitter and receiver and averaged for the total path. Corrections to the signal based on these averages brought considerable improvement in the accuracy of the final determination.

It became apparent that atmospheric changes over a large area were not the only cause of inconsistencies. During the measurements, many different conditions could exist along the path simultaneously. Localized heating due to changes in ground cover, wind flows resulting from mountains and hills, evaporation from streams, lakes, and transpiration from green fields could all give rise to varying conditions with a cumulative effect quite different from the average of the conditions at the transmitter and receiver.

Measurements of conditions at several points along the signal path would improve the average used in computing the atmospheric effect on the signal. Flying instruments along the path while measurements were in progress would also give a clearer picture of what the current conditions were. Both techniques were used with some success, but both had obvious drawbacks in that they were time-consuming and inefficient in use of men and equipment.

A superior solution was obvious to many people working with the problem. Why not an instrument that could remotely sense the relevant conditions while the distance measurements were in progress? ERL scientists have pursued this approach with promising results.

This approach was first successfully demonstrated by the ERL group in 1967, when a radio-optical device developed by Lockett E. Wood and Thompson became operational. By measuring the difference in transit time between a microwave and a red laser signal, the average water vapor density over the path could be established within 0.1 percent.

This instrument was built in 1966 and tested over a 40-mile path from a transmitter atop 10,000-foot Mount Haleakala in Hawaii to a receiver at sea level. In addition to measuring the water vapor density, this system proved an instrumentation technique capable of making optical distance measurements for paths up to several hundred miles. This great distance capability is due to the fact that the light needs to be sent over the path in only one direction.

Although sensitive to water vapor, this device did not measure the other necessary element, dry air density. Another technique was necessary to obtain this part of the data.

Based on the knowledge that two optical signals of different colors would be affected

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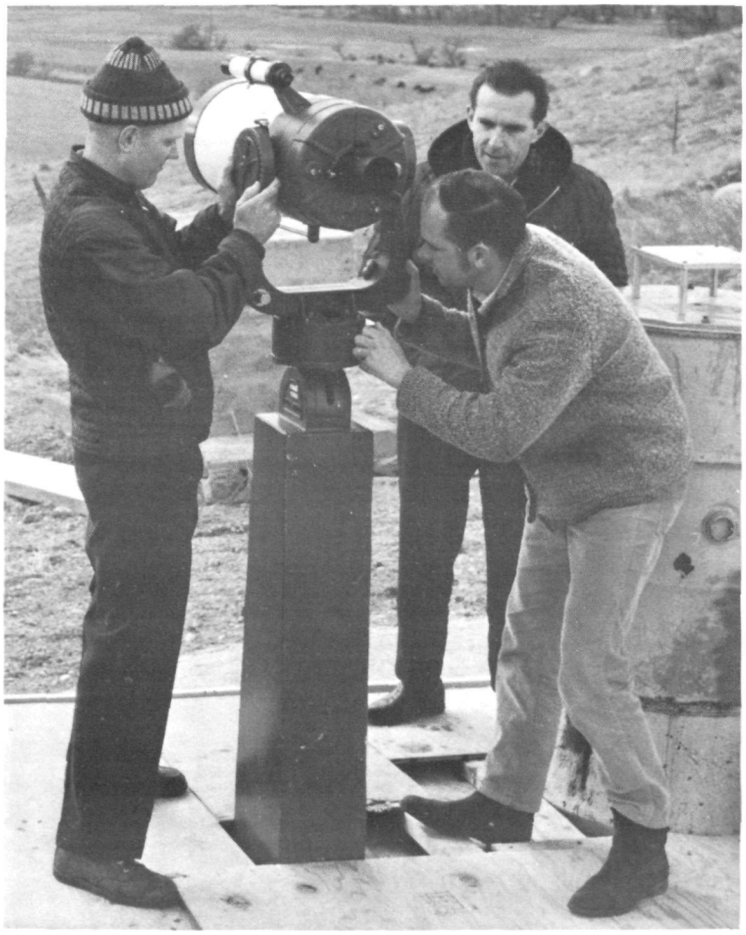
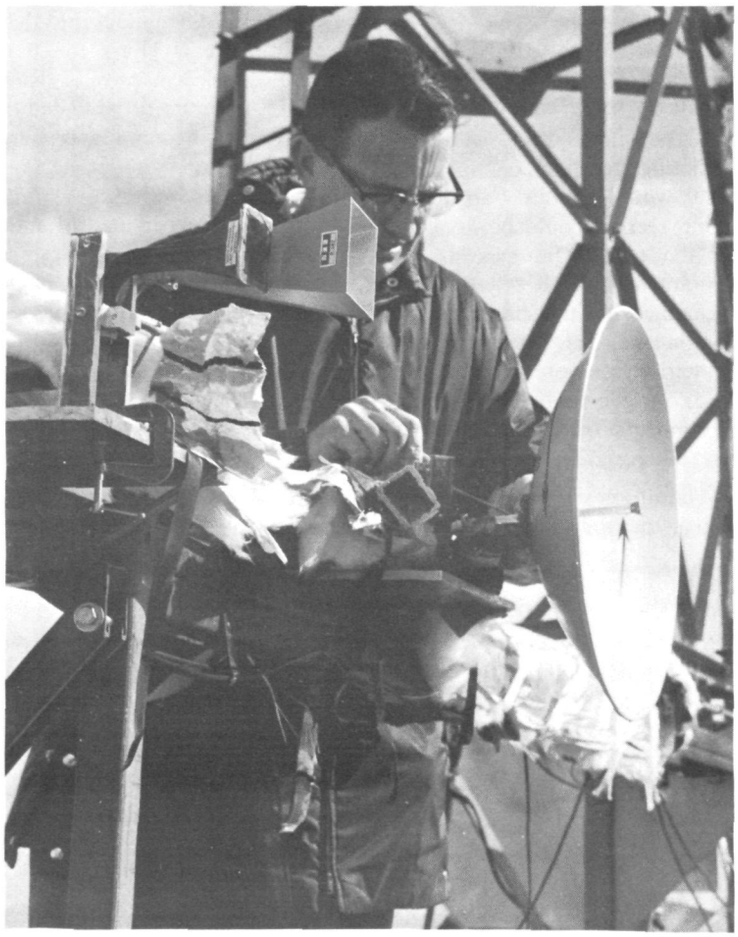
As the first light of day outlines the front ranges, the laser beam blazes over Boulder's street lights.





(Above, from left) Hans Ericson, Milton Johnson, and Dr. Moody C. Thompson, Jr., place a receiving telescope on its turret atop Table Mountain before beginning a test series. (Right) Dean Smith checks the receiving antennas used to measure dispersion of radio signals by the atmosphere. Microwave signals overcome the visibility limitation of the optical systems.

differently by the same dry air density conditions, two groups at Boulder began experimenting with devices which transmitted two continuous wave laser beams, one red and one blue, over the path at the same time. By comparing the results from each laser measurement, it is possible to compute the contribution of the dry atmosphere.

Dr. James C. Owens and Kenneth B. Earnshaw of the Wave Propagation Laboratory developed a device using two optical beams to measure distance. The instrument appears to have good potential for measurements over ranges up to 6 miles. The laser beam is aimed at a reflector which returns it to the transmitter/receiver site. Greater distances are possible by increasing the laser power or by modifying the system so the laser beam has to travel the path only one way.

Lockett Wood took a different approach. By adding a blue laser to his microwave-red laser system, he devised a unit that measures the dispersion of the light and radio waves by the atmosphere. This provides the necessary data to correct the results from a laser Geodimeter.

The two laser signals are combined and travel down the path as one beam. The radio signal is superimposed on this beam and also transmitted over the path. At the receiver the three signals are separated, and the difference in the times required for them to cross the path is measured. This measurement contains the necessary information to determine both of the essential atmospheric properties.

Optical systems are practical for distance measurement from a few feet to more than 100 miles. The visibility requirement is the chief limitation on their use. They could not be used in fog, heavy rainfall, or blowing dust, for example, with much success.

A major obstacle in the development of the optical part of the system was the lack of a suitable blue laser. Continuous-wave blue lasers with the required stability and dependability were not readily available. The scientists' theory had outrun the equipment, and until this gap had been closed, development of the optical distance measuring systems which could remotely sense the atmosphere was stymied.

Indications that this gap has indeed been closed are in evidence. Coupling of the theory and the new electronics is expected to result in a device that will solve the atmosphere dispersion problem to a point where measurements over 10-mile paths with accuracies to better than one-tenth of an inch are possible.

Wood has recently conducted limited tests using such a device. He secured a blue

Hans Ericson replaces the antenna feed in one of the dishes which serve as microwave signal receivers. In the background are, from left, Harris B. Janes, Dr. Thompson, and Lockett E. Wood.

laser for a short period in early January and operated the system between the ERL field site on Table Mountain, north of Boulder, and Green Mountain, which sits just behind the main laboratories in town. The operation for a short period established the feasibility of the technique and identified refinements which will be developed. When a blue laser becomes available for regular use, the necessary refinement of the device will proceed.

Remote sensing of atmospheric dispersion is also possible with microwave techniques. Such a device has the advantage of not being limited by visibility. Radio systems are principally sensitive to water vapor in the atmosphere. At 22 billion cycles per second (22 gigahertz), a water vapor absorption line occurs. Signals transmitted at frequencies just above and just below 22 gigahertz are affected by the water vapor in the atmosphere by significantly different amounts. This difference permits a determination of the vapor changes just as the difference in optical signals indicates changes in atmospheric density.

Dean Smith, another of Thompson's staff, is pursuing this approach to the problem. Such a system would be effective to the same maximum ranges as the optical system, but the minimum effective range would be greater (about 12 or 13 miles). This system can resolve the water vapor density along the path to 1 percent.

Another member of the group, Dr. Hans Liebe, is doing laboratory work on radio techniques to determine dry air density. While the radio-laser system and the two-microwave system are still in the development stage, the next generation of these devices is already being planned. By improving the radio and two optical systems, the scientists predict that it is possible to increase accuracy on a 10-mile path to hundredths of an inch.

When such devices become an operational reality, measurement of minute movement of the solid earth along major seismic fault lines will be possible. This might lead to a better understanding of seismic activity and perhaps meaningful earthquake predictions.

Practical applications in missile tracking, determination of satellite altitudes, remote sensing of air and water vapor density, and geodetic distance measurement are anticipated. These uses, and others not yet envisioned, could result in the devices' affecting our lives directly and indirectly. To the non-scientist, however, possibly the ultimate in practical application will come when George Halas of the Chicago Bears uses such a device to prove that Gayle Sayers really did make that first down. □

They Broke a Data Bottleneck

The story of two can-do Coast Surveymen

BY RICHARD H. MEYER
Coast and Geodetic Survey

They call it "The Iron Ensign." It's an electronic-mechanical marvel which does the work of many people, and in much less time, plotting hydrographic survey data at the Coast and Geodetic Survey's Pacific Marine Center, Seattle, Washington.

Through its intricate system of circuits and machinery pass thousands of bits of information, the innumerable soundings and other oceanographic data gathered by the Coast Survey's hydrographic survey ships. What comes out are the hydrographic surveys which provide the key data from which cartographers fashion nautical charts.

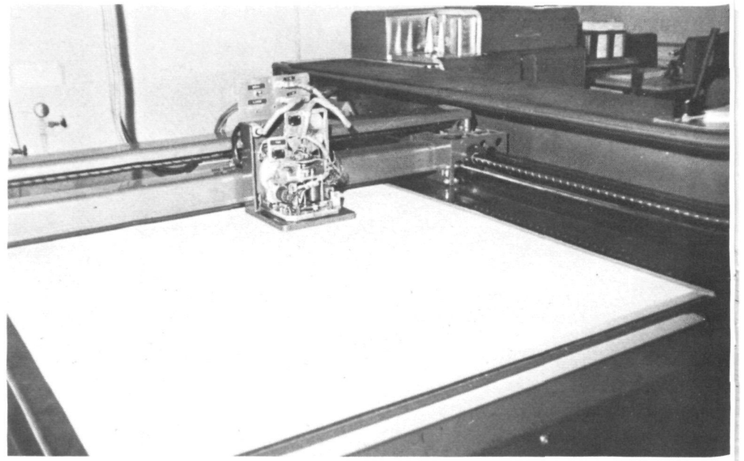
But "The Iron Ensign" had an Achilles heel—its plotting head, a critical link in the complicated process of converting raw data into a more finished product. It kept breaking down. The result was frustration and delay, as the raw data came pouring in from the ships in the Atlantic, Gulf of Mexico, and Pacific.

This is the story of two men at PMC who conquered the problem: Earl Hosking, an instrument maker, and Glen A. Atwood, an electronic technician.

The digital plotter, working in conjunction with a computer, has been in operation at the Pacific Marine Center since 1964. Purchased at a cost of $65,000, the plotter reads information contained on punched cards provided by the computer and plots it on survey sheets up to 42 by 60 inches in size. It consists of a large table on which a vacuum holds the survey sheet in position, while a movable supporting carriage travels across it on tracks. The supporting carriage in turn carries the plotting head, which moves to the exact position of each piece of information to be plotted and prints water depths and other required information in its proper place. The head is positioned and the point plotted with an accuracy on the plotting sheet of five-thousandths of an inch.

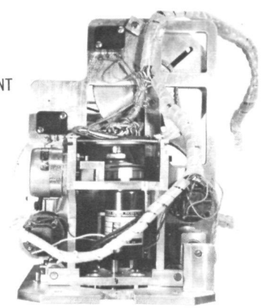
After the digital plotter was delivered to PMC, it was found that the plotting head did not operate satisfactorily, so Coast Survey engineer Charles Shay in Washington, D. C., built another. The basic design of the second head was very similar to the original unit, but incorporated important changes designed to improve its reliability and accuracy. Additional modifications were made by PMC personnel. Although a vast improvement, the complex electronic-mechanical device still would break down frequently.

It became apparent that a third plotting head was necessary if the processing of data were to continue uninterrupted. Attention centered on obtaining a duplicate of the modified and much-improved second head, the idea being that while one was in use, the second could be kept ready.



With breakdown problems overcome, the Pacific Marine Center's "Iron Ensign" now can plot accurately about 1000 individual points per hour.

FRONT



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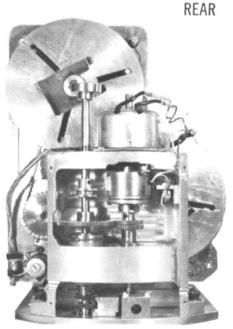


Several Seattle concerns estimated informally that the new device could be built locally for $8,000 to $12,000. But a full set of revised drawings would be needed, since so many modifications had been made. This was done, several improvements being added to increase the unit's efficiency, and the project was advertised for bids.

Not one response was received. No one was interested in producing one unit of an extremely complex item involving machine work, metal fabrication, and electronic components.

The only recourse was to manufacture a new plotting head at the Pacific Marine Center. The task was undertaken by Hosking and Atwood. Construction was on a time-available basis between other assigned projects.

Hosking and Atwood quickly discovered that the revised drawings were inadequate, for no provision had been made for the many improvements incorporated into the second head. The two therefore utilized the working head as a model to build their product. Components were further modified as they progressed to build in additional desirable features.

Part by part, the project continued. Hosking and Atwood observed the functioning of the parts they were building as they progressed, ensuring that a new modification would not hinder them at a later stage. The new head gradually took shape while the processing of data continued with the existing model.

Six months after they had started, the device was completed and tested. After minor adjustments, it worked perfectly. The total cost of materials: $1500.

The problems which had hampered processing of hydrographic data have now been largely eliminated. With two productive plotter heads, an efficient maintenance program has been developed to service one while the other is in operation.

This program, together with other revisions made periodically to the plotter (such as improving the efficiency of the vacuum pumps or the electronic circuitry), have increased production and improved the quality of hydrographic survey sheets and other manuscripts required by the ships. Hosking and Atwood have played an important role in the continuing effort to improve on the automated support to the cartographers and the ships of the Coast and Geodetic Survey.

The use of "The Iron Ensign" has meant tremendous savings in time. The work done by machine requires one-tenth the time required to plot the same material by hand. The use of this plotter, and of automated methods aboard the ships, has revolutionized the tedious processing of hydrographic survey data in this decade.

It became clear in 1960 that some automated system had to be devised to handle the increasing input of raw data. The work done by hand was too time-consuming. The processing of the data was handled by survey technicians and junior officers, often ensigns (thus the name "The Iron Ensign.") In 1961, studies were initiated toward that end.

As a result, a data logger was developed for shipboard use. It was essentially a semi-automatic method of recording hydrographic data gathered by the ships on to punched paper tape. A computer and the digital plotter were purchased, and programs were written to compute and convert the data onto punched cards to instruct the plotter.

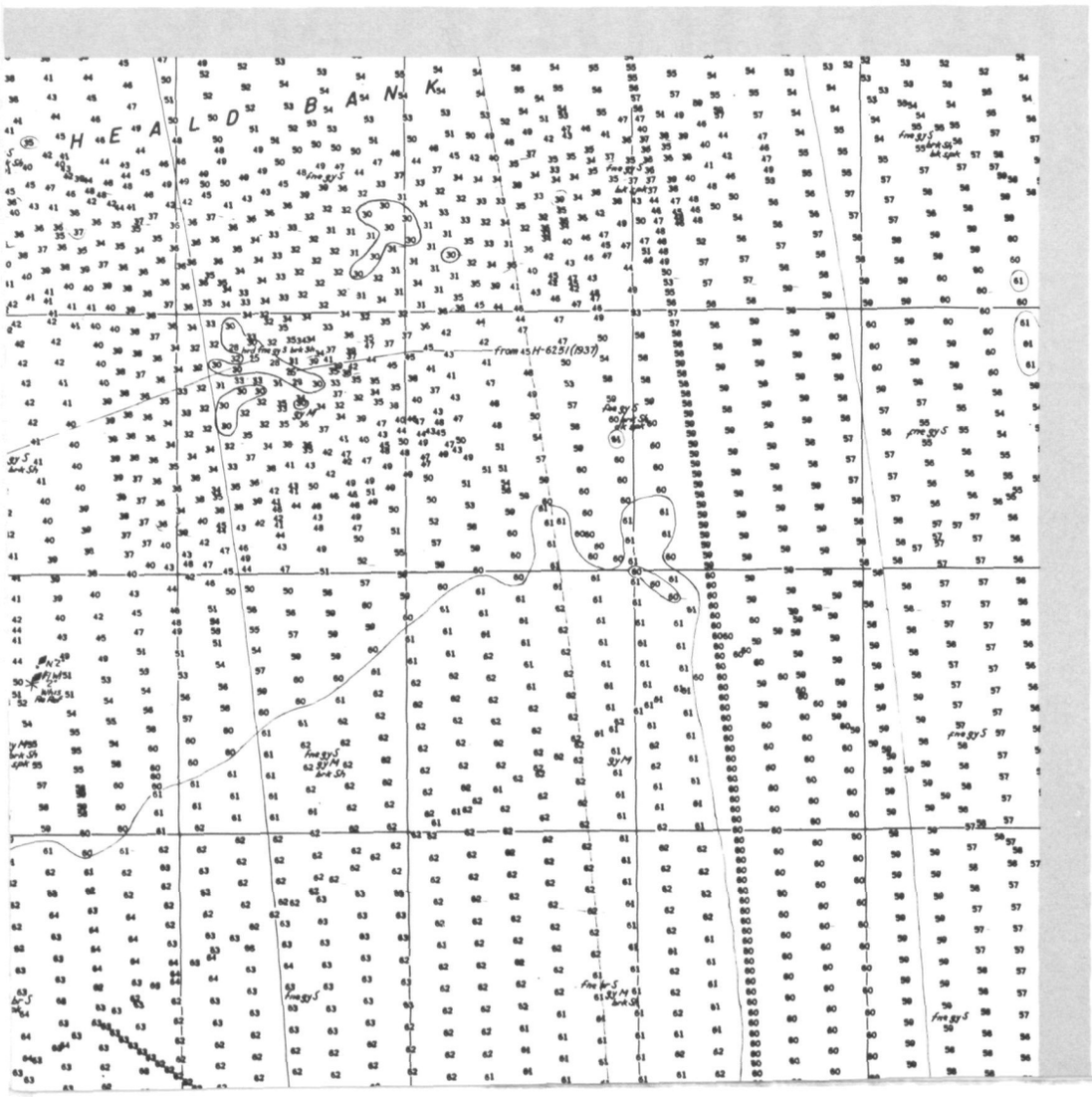
Testing of the complete system began in Washington, D. C. A semi-automated data logger was installed on the ship HYDROGRAPHER in July 1962, and this electronically controlled data logger eventually replaced the traditional method of hand recording.

The HYDROGRAPHER was commanded by Captain Raymond M. Stone, now the Coast Survey's West Coast Field Representative in San Francisco. Stone used the original data logger in August and September 1962 to record data collected along the Texas and Louisiana coasts. The data were recorded on punched paper tapes which were mailed to Coast Survey headquarters in Washington, D. C. These tapes represented the first actual survey input to the system.

continued

Glen Atwood (left) and Earl Hosking put the finishing touches on the new plotting head they built in six months, between other assignments, for $1500.

The USC&GSS HYDROGRAPHER (above) was the first of the fleet to be equipped with an electronic data logger. It was used in 1962 to record hydrographic survey data along the Texas and Louisiana coasts. The "Iron Ensign" produces a smooth sheet (below) from the automatically recorded soundings.



In 1964, the complete system was transferred to the Pacific Marine Center. Cdr. Wayne L. Mobley was given the task of establishing the system in its new quarters and making it fully operational. The first operational hydrographic survey to be logged on a Coast Survey vessel, automatically processed, and machine plotted in a field office was officially received by the Marine Chart Division in Rockville, Md., in July 1964. By January 1967, the Pacific Marine Center was utilizing "The Iron Ensign" to process the majority of new surveys from all Coast Survey hydrographic survey vessels.

Surveys being processed now include those conducted by the USC&GS Ships HYDROGRAPHER, MCARTHUR, WHITING, PEIRCE, RAINIER, FAIRWEATHER, MT MITCHELL, DAVIDSON, PATHFINDER, SURVEYOR, and OCEANOGRAPHER and by two land-based hydrographic survey parties which operate in shallow coastal waters.

The data are received on punched paper tape. After position computations are completed, the computer applies tide, velocity, draft, and instrument corrections to the raw soundings to reduce the field data to mean values, and puts the data on punched cards.

After the soundings are edited, the punched cards serve as input to "The Iron Ensign." A preliminary sounding overlay is plotted and verified to ensure that the data are valid and complete prior to making the finished hydrographic survey, commonly called a smooth sheet.

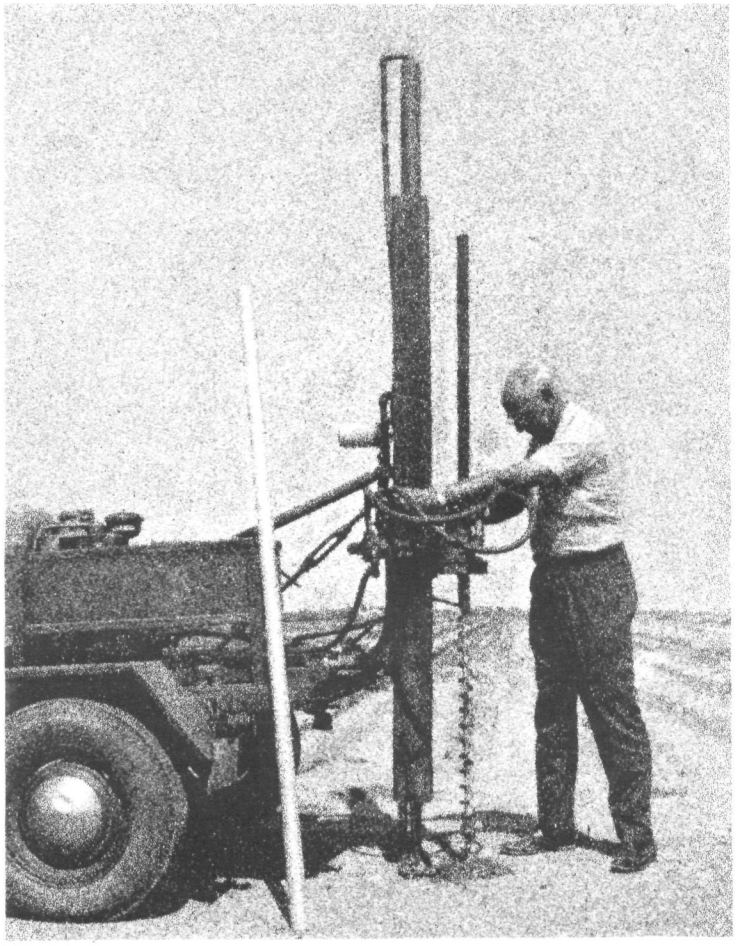
The finished survey provides a detailed picture of the ocean and its bottom. It includes information on water depths and soundings, including the Mean High Water Line, Mean Low Water Line (Atlantic and gulf coasts), the Mean Lower Low Water Line (Pacific coast), rocks, piers and pilings, bottom characteristics, aids to navigation, and many other features. Shoreline is applied from air photographic surveys. After verification, the final data are submitted to Coast Survey cartographers in Rockville for review and compilation into nautical charts.

"The Iron Ensign" is capable of plotting accurately about 1000 individual points or numbers per hour. By comparison, only 150 to 200 can be plotted by hand in an eight-hour day. The machine has greatly increased the efficient preparation of hydrographic surveys and in turn has increased the effectiveness of Coast Survey ships.

The operational success of the entire system is the work of many persons. But special credit must go to Hosking and Atwood for ensuring that "The Iron Ensign" is a dependable and trouble-free link in the automated processing of hydrographic surveys at the Pacific Marine Center. □

An atom-age water dowser is Texas' newest

HIGH PLAINS CIRCUIT RIDER



In search of water, Oliver Newton drills into Texas soil. A neutron counter, lowered into the hole, measures moisture at various levels.

BY CHARLES G. THOMAS
Weather Bureau

The sun glares down from the cloudless Texas sky, making the road ahead look like a shimmering sheet of water.

The mirage is especially painful to Oliver Newton, the Weather Bureau's agricultural advisory meteorologist in the west Texas High Plains area. Newton is looking for water—the real wet kind that makes the High Plains one of the most productive agricultural regions in the country—and it's getting harder and harder to find.

So several times each year Newton sets out in his car to crisscross a 14-county area in search of moisture—a modern day diviner with a neutron moisture-measuring device instead of a forked stick.

The watery mirage at which Newton squints as he drives to one of the hundred stops on his itinerary is something of a paradox; about 130 million years ago, when dinosaurs still roamed the earth, the dusty land he travels was covered by a shallow sea. Today, hydrologists predict that if man continues to draw on the area's water resources at the current rate, the High Plains' water supply for agriculture will, for all practical purposes, be gone in 30 years. Rainfall alone will not provide enough moisture for the crops. Irrigation water drawn from a deep underground source known as the Ogalalla formation is becoming scarce. Each year wells must go deeper and deeper to reach this irreplaceable resource.

The situation has reached the stage where solutions are being proposed which seem fantastic.

One scheme has a pipeline from the Mississippi running over 600 miles, across the breadth of northern Texas, through a series of pumping stations, and terminating in the High Plains.

Another proposal, noting that in the northwestern section of North America billions of gallons of water flow almost unused into the sea each year, calls for the diversion of water from Canada and the northwestern U. S. through a series of dams, lifts, tunnels, and canals to the southwestern states and Mexico.

But these are long-range construction projects, the need for water is now—this year—next year—and the land is drying out. The trend is, perhaps irreversible, but Newton and a number of fellow scientists at the Texas A&M Agricultural Research and Extension Center in Lubbock are doing their best to slow it down.

An ever-increasing number of mouths to feed and an ever-decreasing amount of land on which to grow food has produced remarkable changes in agricultural practices.

Oliver Newton's search for water in west Texas is an example of modern techniques which bring tangible, high-economic value returns from a modest investment in manpower and materials under the Weather Bureau's agricultural weather program.

Basically, what Newton is doing is this: After devoting much effort to developing reliable methods for soil moisture measurements, he and his associates have demonstrated that for the pre-plant irrigation, a very substantial reduction in water use is feasible if available soil moisture is known and the climatologically expected rainfall is taken into account.

This means that the High Plains cotton growers, who normally apply four to six inches of irrigation water prior to planting, may be wasting water if Newton's measurements show there is a certain amount of soil moisture already available.

The farmers must trust Newton, for there is little evidence of moisture in the dry Texas topsoil after several rainless months. But in spite of the dry and dusty look of the ground, Newton's neutron moisture-measuring device probes deep, and if there is water it is detected.

The results of Newton's surveys are plotted on maps which show the available soil moisture. These maps are available to farmers through county agricultural agents.

With the soil moisture data and information on the type of soil—hard, sandy, or mixed—Newton, assisted by Dr. Otto C. Wilke and Shelby Newman of Texas A&M, also prepares general irrigation recommendations.

Like the Texas mirage, Newton's job is paradoxical. As a meteorologist, he is nominally concerned with atmospheric phenomena (meteor—things in the air), and yet he delves underground for signs of water.

Agricultural services provided by the Weather Bureau are not limited to forecasting the weather, however, as Newton demonstrates by dowsing with radium beryllium. □

a manmade disaster

BY BURTON H. KIRSCHNER
Weather Bureau

Polluted air endangers human health and costs ten billion dollars a year

THE WEATHER appears to be lovely—the sky is blue and cloudless, temperatures are mild, and there's hardly a breeze! Sound like a day to be romping in the sun? Yes—but if this kind of weather persists for a few days over an area having a large number of pollution sources, serious problems can occur. The combination of seemingly idyllic weather and availability of pollution sources creates an insidious form of environmental hazard—the steady buildup of high concentrations of air pollution.

The atmosphere has a tremendous capacity to dilute contaminants emitted into it. Generally, the dilution rate is more than sufficient to reduce pollution concentrations below critical levels for the health and comfort of human beings. However, there are times when this capacity is severely reduced. This usually occurs when a high-pressure system settles over a particular area. High pressure foretells fine weather, but atmospheric motions (i.e., airflow)) are so weak in the vertical as well as the horizontal direction that the air fails to do its thing.

Air pollution potential is a measure of the ability of the atmosphere to dilute and disperse emitted contaminants. When the dilution and dispersion characteristics are severely reduced, meteorologists say that a condition of high air pollution potential (HAPP) exists.

If we didn't use fossil fuels to heat our homes in winter, cool them in summer, and power our vast industrial activities . . . if we didn't need automotive vehicles to transport ourselves and our things around . . . if we didn't have to incinerate manmade and natural wastes, HAPP would be an interesting but socially and economically useless meteorological concept. Man, however, does pollute his atmosphere with his myriad of activities, and the rate of pollution keeps pace with technological advances and the constant demand for more goods and services.

Though the problem of air pollution is universal, cities are the greatest offenders and suffer the worst consequences of environmental pollution. The urban complex can be considered as a huge single source of pollution which often becomes entrained in its relatively small geographic area.

Recognizing the relationship between weather factors and pollution concentration, ESSA, through its Research Laboratories, developed a method (or model) whereby episodes of HAPP can be predicted with precision. Back in 1960, ESSA began making experimental forecasts of HAPP and in 1967, with the model considered fully operational, the program was turned over to the National Meteorological Center (NMC) of the Weather Bureau. Using computer-produced predictions of the height to which pollutants will be vigorously mixed and of the average wind speed within this layer, NMC disseminates advisories of HAPP if the condition is expected to last over a large area of the contiguous United States for 36 hours or more.

With these forecasts, ESSA took the first steps toward a meteorological supporting service to the national air pollution control effort. Armed with daily advisories, pollution control officials can alert the public and, where the authority exists, can inaugurate control procedures to reduce emissions during episodes.

When the "Air Quality Act" was passed in 1967, it became apparent that ESSA would have to expand its activities in air pollution meteorology. The Act noted the importance of weather factors such as inversions on the disposition of pollutants and established the concept of Air Quality Control Regions which would be areas, generally containing a central core city, where emission and air-quality levels would be standardized to protect the air resource. The meteorological services required to help maintain these standards had to consider the complications introduced by the cities, as well as the large-scale weather systems.

An urban complex exerts a strong effect on its climatology. In New York City, for example, the diverse layouts and sizes of large buildings, the solar-heat storage capacities of concrete and pavement, and the energy and effluent emissions from daily activities act in concert to create a unique atmospheric temperature system. Thus the city is called a "heat island" with respect to its surrounding countryside. Add the heat island effect to the complex wind structure created through channeling, deflection, and impedance of airflow by tall structures and cavernous city streets, and we have a small, self-generating meteorological entity.

In 1968, the Department of Commerce and the Department of Health, Education and Welfare developed a plan for the establishment of urban meteorological services to the Air Quality Control Regions. The plan indicated that there is a strong requirement to make small-scale (mesoscale) predictions of weather parameters which determine the transport and dispersion characteristics over urbanized areas and, to accomplish this successfully, observations of the vertical distribution of wind, temperature, and humidity would be necessary. Thus ESSA and the Weather Bureau embarked on a new and exciting endeavor. Environmental Meteorological Support Units (EMSU) were established in the core cities of five Air Quality Control Regions. The first unit opened in St. Louis in April 1969. By June 1969, additional units were in operation in Chicago; Washington, D. C.; Philadelphia; and New York City.

The first order of business for each EMSU meteorologist was to get to know the air pollution control officials in the area and determine their specific needs for meteorological information. In the meantime, sites were selected for taking radiosonde observations on a daily basis within the city limits. The response to the program was so favorable that in several cases automatic data phones and telephonic recordings were set up to speed the information to user groups. During recent episodes of air pollution potential, radio and TV stations continued to broadcast the advisories and asked the air pollution meteorologists to appear on their programs to help people understand the services being rendered.

The radiosonde observations, which have documented the heat island and turbulence effects of the city, are used to make the forecasts of high air pollution potential and help the meteorologists predict city temperature and wind distributions which are needed for day-to-day pollution control decisions.

Good observational and prediction schemes, coupled with rapid and efficient communications, are the nucleus of any weather service program. The Weather Bureau believes it has these ingredients in the urban air pollution weather service. If this is true, the program will help reduce the $10 billion annual cost and the immeasurable health dangers of polluted urban air. □

C&GS teams use cameras and a satellite to find out where in the world they are.

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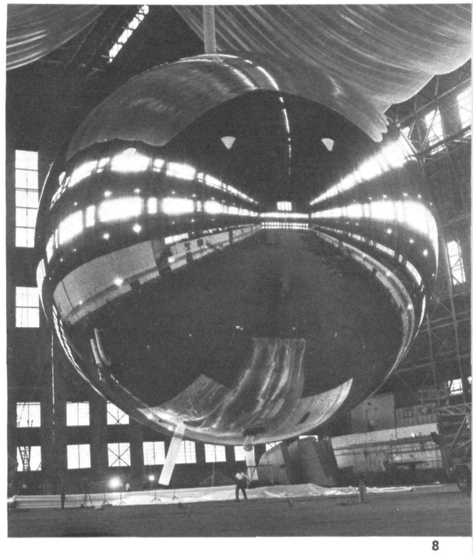
C&GS satellite triangulation parties have journeyed to the earth's most remote outposts. 1. Abandoned Air Force quarters, Christmas Island. 2. Typical home, Tristan da Cunha. 3. Pago Pago, American Samoa. 4. Bus terminal, Seychelles Islands. 5. Statues, Easter Island. 6. Ice cap, Palmer, Antarctica.

A satellite, a camera, and the stars are the working tools of a satellite triangulation team. 7. Accurately timed shutters interrupt the star and satellite trails as they traverse the camera's field of view, producing a photographic record of as many as a thousand stars and 800 satellite images across the plate. 8, 9. The 100-foot PAGEOS satellite is the target for observations by complex cameras.



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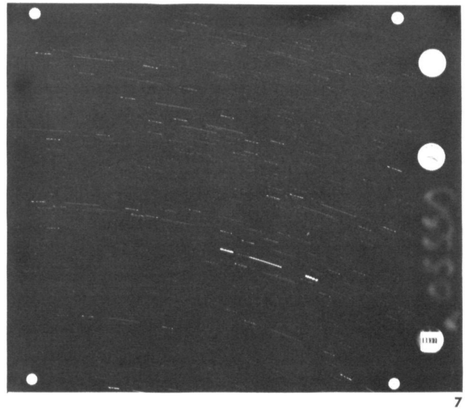

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taking the earth's measure

(The worldwide satellite triangulation program is a joint endeavor of the U.S. Army Topographic Command, the ESSA Coast and Geodetic Survey, and the British, West German, Australian, and South African governments. This article concerns the field operations of the ESSA teams.)

Senegal, Surinam, Samoa, Christmas Island, Tristan da Cunha, Easter Island, Mauritius, and the Seychelles . . . it sounds like the itinerary for a tour of exotic places. Actually, these are just a few of the spots where Coast and Geodetic Survey teams have lived and worked in the course of the worldwide satellite triangulation program.

Field work on the worldwide program which began in 1966 will be completed this June, having spanned the oceans to link, for the first time, the geodetic networks of the world's land masses.

The completion of the worldwide triangulation network will mark a major advance in man's understanding of the earth's size and shape. As a result of this project, maps will be more accurate, distances will be known more precisely, and man's space probes will be aimed more accurately toward the moon and more distant goals.

Already, satellite triangulation has revealed numerous errors in earlier maps. Bermuda, for example, was found to be 220 feet further north and 105 feet further west than had been believed.

During the four-year project, Coast Survey parties have journeyed to the earth's most remote outposts, carrying with them elaborate cameras and precise timing and synchronization systems, just to photograph an orbiting balloon against a starry night sky.

To understand satellite triangulation, you have to recall some high-school geometry, specifically that three points define a plane. Cameras at two triangulation stations are two points. The third is the PAGEOS satellite. As this silver balloon orbits over the two points on the ground, it creates an infinite number of planes in space. The intersection of these planes is a direct line between the two points on the earth's surface. To define the orientation of these planes, satellite triangulation teams at two or more locations simultaneously photograph the satellite against its background of stars whose positions are known. Their photographs provide the data which makes it possible, through complex computations, to determine the precise direction of the line between the stations. Satellite triangulation results are most accurate when the distance between the ground stations approximates the altitude of the satellite, so that the three points form a nearly equilateral triangle.

Camera observations alone do not produce a measure of distance, only of direction. Therefore, long-scale base lines, measured by conventional line-of-sight techniques, are used to establish a scale for the satellite triangulation observations. In the worldwide program, these surface measurements will be made in Australia, Europe, Africa, and North and South America, over distances of two to three thousand miles.

Satellite triangulation, together with precise Geodimeter traverses, is accurate within 18 feet in the horizontal components and within 30 feet in height. This is akin to horizontal measurement with an accuracy of one foot in approximately six to eight hundred thousand feet. The worldwide system established through the international program not only links the continental networks, but also will allow continental networks to be refined to a still higher order of accuracy as they are adjusted to and within the global scheme.

The Coast and Geodetic Survey's satellite triangulation effort began in 1960, with feasibility experiments at the Aberdeen Proving Grounds in Maryland, under the direction of Dr. Hellmut H. Schmid, then working for the U.S. Army. Dr. Schmid joined the Coast Survey in 1963 and has directed the development of the camera system and the technical aspects of the overall geodetic satellite triangulation program.

At Aberdeen, the capabilities of a ballistic camera to perform satellite triangulation were proven on small test triangles. The first large-scale triangle was established in 1963, with stations in Minnesota, Mississippi, and Maryland. The network was later extended to Florida, Bermuda, and Antigua. With the acquisition of additional camera units in 1964 and 1965, the network was enlarged once more to include eight stations in Canada—a cooperative program—and two others in New Mexico and Washington.

June 1966 brought the launch of

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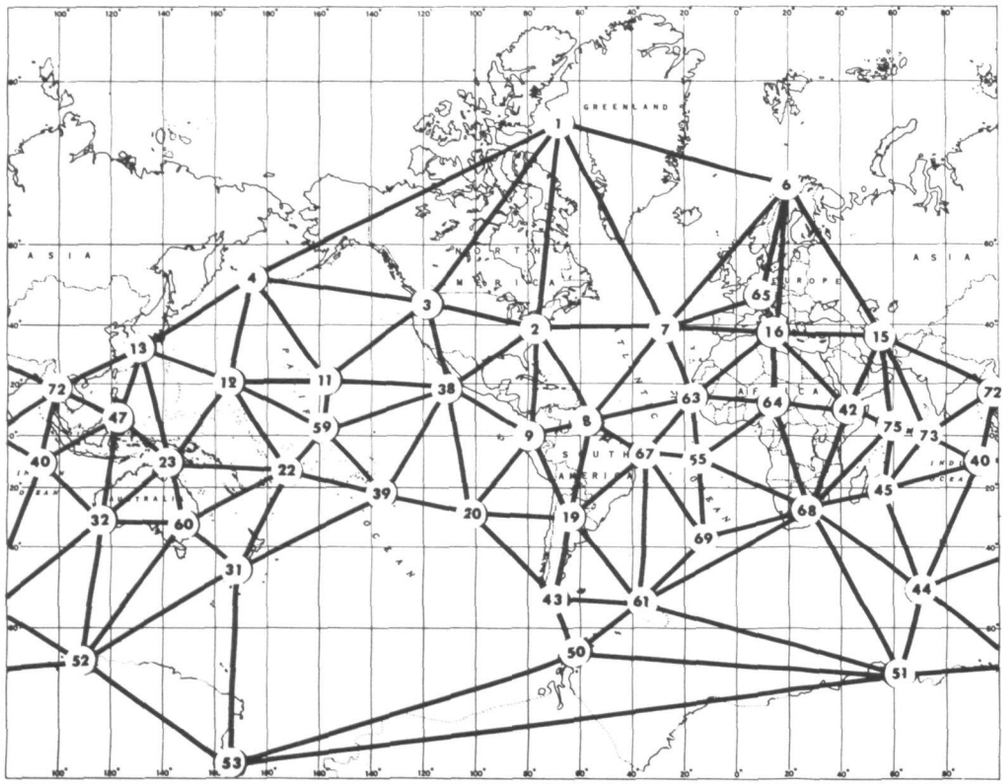

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PAGEOS (Passive Geodetic Satellite), and work began on the worldwide network. PAGEOS, which still serves as the target for the camera observations, is a balloon—100 feet in diameter—orbiting in a nearly circular path 2200 nautical miles above the earth.

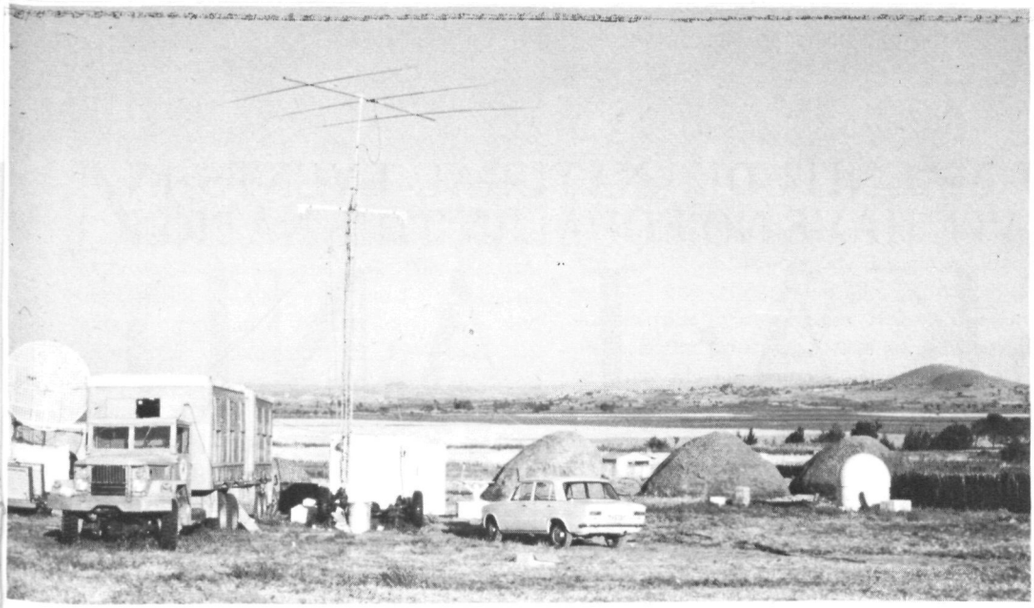
The worldwide satellite triangulation program is a joint endeavor of the U.S. Army Topographic Command, the ESSA Coast and Geodetic Survey, and various host countries around the world. The British, West German, Australian, and South African governments have furnished personnel for data acquisition. C&GS project manager for the program is Lawrence W. Swanson; Captain H. R. Lippold heads the Coast Survey's Satellite Triangulation Division. Other ESSA units involved in the program are the C&GS Photogrammetry Division, the ESSA Computer Division, and the C&GS Geodetic Research and Development Laboratory.

The field operations are carried out by 16 teams, normally consisting of three men each. (In remote, uninhabited areas, cooks, mechanics, and other support personnel are added to the parties.) Of the 16 teams, four are completely staffed by the Army Topographic Command and seven by the Coast Survey. The remaining five groups are headed by Coast Survey personnel with participating men from the host countries.

By the conclusion of the project, the field parties will have occupied and permanently marked 44 sites. They have worked in the stifling 125-degree heat of Fort Lamy, Chad, Africa, and the numbing cold of 50 degrees below zero at Tromso, Norway. They have endured winds of 140 to 150 miles an hour in the Pacific and in Antarctica. They have established stations 9300 feet above sea level (Maui, Hawaii), three feet below sea level (Invercargill, New Zealand), and on islands as small as two square miles (West Island in the Cocos Islands of the Indian Ocean). They have operated as far north as 77 degrees at Thule, Greenland, and as far south as 78 degrees latitude at McMurdo Station, Antarctica.

To move their bulky scientific equipment, they have used giant U.S. military air transports; such seagoing transportation as the Military Sea Transport Service Ship WYANDOTTE, the USC&GSS DISCOVERER, the U.S. Army's FS-216 and FS-392, launches, and barges; and on land, trains, trucks, and goat-drawn carts.

They have stood godfather to a Mexican child; helped the British on Tristan da Cunha celebrate the queen's birthday; and temporarily colonized isolated islands.



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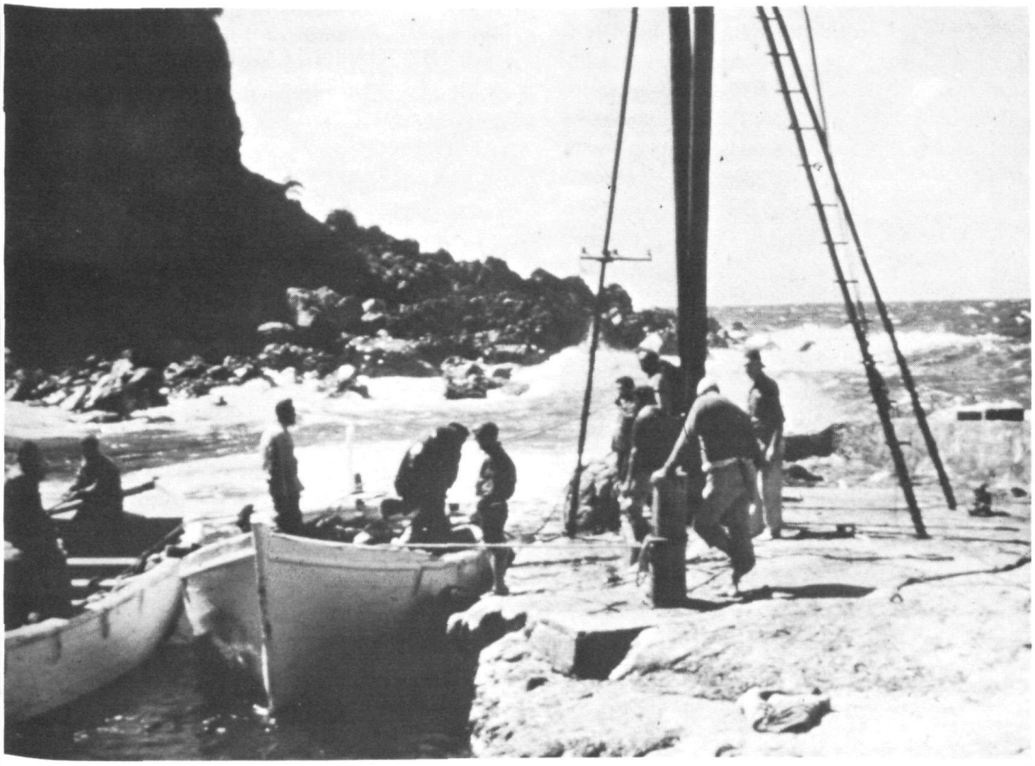

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1. The completed worldwide satellite triangulation network will link, for the first time, the geodetic networks of the earth's land masses. The stations occupied at Thule, Greenland (2) and Addis Ababa, Ethiopia (3) illustrate the contrasting environments in which the satellite triangulation teams lived and worked. 4. Living quarters, generators, equipment shelter, and astrodome were loaded on the deck of the USC&GSS DISCOVERER for the trip to Tristan da Cunha. 5. In some places, the parties must be entirely self-sufficient. To establish the station at Isla Socorro off the coast of Baja California, the team brought complete living facilities and a bulldozer to clear the camp site. 6. Permanent markers, like this one at Palmer Station, Antarctica, identify each site in the network. 7. At Pitcairn Island, equipment was unloaded from boats and transported to the station site by means of a high line.

Nine members of satellite triangulation teams have been married to foreign women while on assignment. The marriages took place in Canada, Japan, Portugal, Australia, Sicily, the Seychelles, and on Easter Island, where the wedding was the first between an American and an island girl.

In several areas, the observing party had to be completely self-sufficient. These included the stations at Isla Socorro, Tristan da Cunha, and Heard Island, where portable housing units and sanitary facilities had to be brought along.

Setting up the station on Isla Socorro, off the coast of Baja California, was one of the most complex undertakings. In addition to the party complement of four Coast Survey personnel plus cook and generator mechanic, the Mexican government sent six recent college graduates and a college professor to be trained in satellite triangulation. A bulldozer was brought in with the team to prepare a landing area and to clear space for the station and living quarters. The bulldozer also was used to transport supplies from the landing site to the encampment.

During the team's stay, the first priest ever to set foot there visited Isla Socorro. He performed marriages and baptized the children. The chief of party served as padreno (godfather) to one of the children.

At Tristan da Cunha, a British possession, the satellite triangulation party arrived aboard the DISCOVERER a few days before Queen's Day. The islanders quickly inveigled the Coast Survey men into forming a soccer team to play the local soccer group. The islanders defeated the novice newcomers, 6-0. The game was followed by a dance to music played by a small band from the Coast Survey vessel.

A party normally stays at one site for six months or more. The stays are long because, after the complex equipment has been set up and adjusted, the teams must obtain repeated photographic sightings of the satellite—observations simultaneous with those at other stations, taken at times when the satellite is sun-illuminated and when skies are clear at each of the widely scattered sites working together.

In all, the worldwide program will produce about 2500 usable star plates. It will take two more years to complete the data reduction program for the world network. By 1972, after the Photogrammetry Division has scaled and processed the 2500 photographic plates—making more than 3000 measurements on each plate—we will have a truer picture of the earth than ever before in man's existence on this planet. □

FOR VARIETY AND MAGNITUDE, NATURAL EVENTS IN THE NORTHERN STATE HAVE NO EQUAL IN THIS NATION

ALASKA: LAND OF EXTREMES

BY JOANN TEMPLE DENNETT
ESSA Research Laboratories

"Nowhere else in America are the quality and success of human life so closely tied to processes in the physical world."

"The more developed the northern state becomes, the more active its economy, the more it will need the information provided by environmental scientists."

NOTHING IN ALASKA is routine, neither the size of the northern state, nor the scale of its opportunities, nor the extremes of its environment. This last, environment, is the wild card, presenting natural events in a variety, magnitude, and abundance unknown in the lower 48. Nowhere else in America are the quality and success of human life so closely tied to processes in the physical world.

It is a harsh setting. Alaska's 375 million acres stretch some 2,000 miles east to west, reaching with its Aleutian Island arc almost to the International Dateline, and, from a latitude near that of Oslo, Norway, 1,100 miles north into the Arctic. This enormous area is home to a dozen major rivers, two huge, young, still-forming mountain ranges (20,320-foot Mount McKinley, North America's highest, is in the Alaska Range), and a tidal coastline half as long as that of the rest of the United States.

Tropical cyclones may be the only natural hazard Alaska is spared. The Aleutian Trench is the northern crescent of the earth's most active seismic feature, the circum-Pacific earthquake belt, and there are storms with the winds (if not the warmth) of hurricanes. There are also magnetic storms and blackouts of radio communications, tsunamis, floods, snows, slumps, and what you will.

Agriculture in Alaska is like almost everything else—possible, but difficult. Fewer than 2 million acres are under cultivation, partly because the season is short, partly because the northern third of the State is covered with permafrost.

The big industries are the "traditional" ones. Alaska is the first state in commercial fishing, and mines the nutritive wealth of shrimp, salmon, scallops, halibut and crab along the 34,000-mile coast. There are also fur-trapping, timber, and production of such minerals as gold, silver, mercury, uranium, platinum, and petroleum.

If these are traditional, they also symbolize the way technology is pushing back the heavy hand of the northern environment. Fishing is no longer seasonal, but proceeds along the foggy, icebound coasts through the long Arctic winter, servicing the string of canneries which spreads from Kodiak out through the Aleutian Island arc.

The search for petroleum and heavy metals has lost its traditional look as well. Oil production nearly doubled in Alaska in 1967, when oil-well platforms were emplaced in Cook Inlet. Today this rush for black gold takes men and rigs into the Arctic icelands. Modern prospectors are mounting a large-scale search for gold and other heavy metals in the shallow continental shelflands below the cold water of Norton Sound.

The alliance of technology and enterprise is pervasive. With only 5,000 miles of highway and one railroad, the 285,000 people of Alaska take to the air and water. The airplane is the principal means of transportation in Alaska; one in 50 Alaskans is a licensed pilot, compared to about one in 500 for the other 49 states. The interisland steamers and small shipping boats which cruise the coastal waters are the other indispensable method of transportation in this rapidly growing state.

Still landlord of 98 percent of Alaska, the Federal Government has been a strong partner in the Alaskan achievement. ESSA has been a major contributor, providing the charts and maps, weather reports and predictions, natural hazard alerts and warnings, and research projects that help support the life, commerce, and opportunity of Alaska. It is an effort that blunts the impact of a potentially cruel environment—an effort that began more than a century ago.

Generations of Coast and Geodetic Survey ships have plied Alaskan waters, gathering data for new charts, then data with which to revise them, as the active mountain-building, river-cutting world of the north changed shoreline, navigable passages, and harbors. In 1867, between the March signing of the treaty and the October transfer of territory from Russia to the United States, Coast Survey ships reconnoitered Sitka Harbor, Saint Paul Harbor, Kodiak Island, and Captain's Bay on Unalaska Island. The first two *Coast Pilots*—the narrative descriptions of coasts and harbors familiar to all who follow the sea—for this area were published between 1869 and 1883. Gold discoveries near the Klondike River, in 1896, generated new interest in charting Alaska's long, fjord-frayed coastline, and, from the turn of the century onward, the Coast Survey has worked the short Alaskan seasons, providing the nautical charts so essential to safe coastal commerce.

Today, ships like USC&GSS OCEANOGRAPHER, SURVEYOR, PATHFINDER, RAINIER, FAIRWEATHER, MCARTHUR, and DAVIDSON, mounting instruments uninvented when this immense charting task began, are telling Alaskans about their shoreline, coastal waters, and continental shelf.

It is a colossal task, and there is little time in which to do it. The Alaska ship operating season is only six months long in the southeastern part of the state, and as little as two and a half months long in the Arctic. A century of effort has produced 225 nautical charts, most of them since 1915. Given the accelerating Alaskan boom, the Coast and Geodetic Survey has a larger century coming up.

Charting is more than defining shoreline and depths, especially in a region where everything is on the extreme side. Measurements and prediction of tides and tidal currents are an important part of the marine environmental services performed by ESSA here.

Much of the Alaskan coast has large tidal variations, running about 10 feet between mean high and mean low water along the northern Gulf of Alaska, and slightly more in the southeastern part of the state; the shallow Arctic Ocean coast has small tidal variations of about a foot. Cook Inlet, where oil platforms tap into large and profitable reserves, has a notably large tidal range; at Anchorage, the mean tidal range is 25.1 feet, with spring tides ranging considerably more. When the inlet is choked with ice, the multi-knot tidal currents can be a bludgeon for ill-prepared ships and oil rigs in its path.

Surface water temperature, density, and salinity measurements are made at many tide stations, and published in the form of monthly statistical summaries. While much of this information is of use principally to scientists, it is used routinely by seafarers to correct their ships' loadings for actual conditions.

Not all of a coastline can be reduced to graphic or tabular form. The seasoned eye still sees more than the seasoned instrument.

The *Coast Pilot* series produced by the Coast and Geodetic Survey is an eight-volume narrative description of navigation regulations, outstanding landmarks, channel and anchorage peculiarities, dangers, weather, ice, freshets, routes, pilotage, and port facilities. Two of the eight books are devoted to Alaska, an indication of how this picturesque and hazardous coastline compares with the rest of America's coastal waters.

A new type of cartographic product looks ahead to the large-scale opening of continental shelf resources in Alaska. Bathymetric maps do for the seafloor what topographic maps do for the land, with the difference that land features may be measured photographically, and undersea terrain must be inferred from depth soundings.

Six maps issued by the Coast and Geodetic Survey in 1966 cover 30 degrees of longitude (170°E to 160°W) and about five degrees of latitude (from 50°N) at a scale of 1:400,000, straddling the island arc from the area west of Attu to that east of Unalaska.

Other bathymetric maps have followed for portions of the Atlantic and Pacific

continued

coasts. But the first full, operational description of this type was not issued until 1969, and it was another in the Alaskan series.

Norton Sound, Alaska, is the site of rich mineral reserves, and of much exploratory activity by Federal and private organizations. ESSA's three-map coverage of Norton Sound (much of the data for which was obtained in 1968 and 1969 by the ships OCEANOGRAPHER and SURVEYOR provides for the first time a full geophysical as well as bathymetric description. Gravity and magnetic measurements and seismic reflection profiles have been converted into overlays and other correlative displays for the bathymetric map. Additional surveys will be made to fill gaps in the preliminary maps, the first of a bathymetric/geophysical series which will ultimately show America's coastal seafloor at a scale of 1:250,000.

Because so much of life in Alaska is tied to the sea, it is difficult to say where the benefits of oceanographic activities begin and end in the northern state. SEAMAP (for Scientific Exploration and Mapping Program) began in 1961, when the now-retired USC&GSS PIONEER sailed out of San Francisco to begin the first full-scale, systematic, accurately controlled oceanographic and geophysical survey ever attempted in the deep ocean. Since then, SEAMAP has occupied much of the ship time available to the Pacific Oceanographic Laboratories. Although two seasons were essentially forfeited to the urgent post-earthquake survey of Alaska, some 60 percent of the Pacific SEAMAP area has been covered by reasonably detailed hydrographic and geophysical surveys. This represents an area of about 1.5 million square miles. It is no accident that scores of undersea features in the Pacific and Alaska area are named for ESSA ships and men.

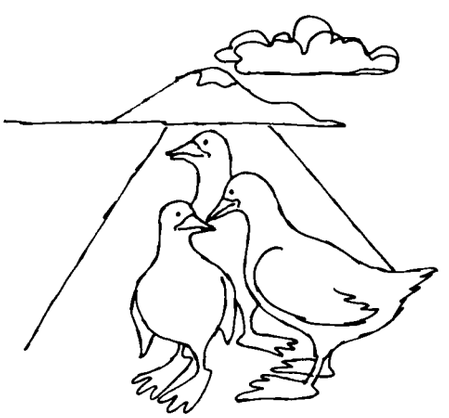
The first regional aeronautical charts for Alaska were published in 1939, some 13 years after the Coast and Geodetic Survey was given the United States aeronautical charting mission. These were somewhat limited by the lack of good topographic data, a deficiency corrected by the Alaskan emphasis and new technology of World War II.

Today, Sectional Aeronautical Charts of Alaska are available at a scale of 1:500,000, designed for VFR flying. They include a specially designed topographic base overprinted with air navigation data, and cover the state in 17 detailed segments. Designed for slow to medium speed aircraft, they are available from authorized aeronautical chart agents, FAA Flight Service Stations in Alaska, and the sales office of the Coast and Geodetic Survey.

But the new charts are only part of a large family of products for Alaskan aviation, including World Aeronautical Charts (WAC) for Visual Flight Rules (VFR) navigation by moderate-speed aircraft; Alaska Enroute Low Altitude Charts for enroute navigation under Instrument Flight Rules (IFR) at altitudes up to 17,999 feet; Alaska Enroute High Altitude Charts for enroute instrument navigation (IFR) at 18,000 feet and above; Standard Instrument Departure Charts for departure routing clearance in graphic and textual form, for the state's IFR-equipped airports; and Alaska Instrument Approach Procedure Charts which portray the aeronautical data required to make instrument approaches to airports under conditions of restricted visibility.

The Alaskan Chart Supplement, an invaluable aid to the aviator, is published in book format every 28 days. It combines flight data, procedures, operational information, facilities and services into a single listing for each airfield in the state. The chart supplement also covers such general but necessary information as procedures for civil use of military airfields, emergency procedures, U.S.S.R. interception signals, and aerodrome drawings of every active airfield in the state. A recent issue had nearly 100 descriptive pages on available airfields in Alaska. At some 2 to 12 airfields per page, ESSA has a big job keeping up to date on Alaska's many airfields.

Many airport descriptions read "unattended." Others provide such useful information as "seadrome float, has no walkway to shore." Or "area subject to heavy swells." "No beaching available. Fine sand." Or, "Unattended. Fish nets on beach in summer. Birds on runway."



Birds on runway.

Since Alaskan pilots can encounter incredible compass readings, ESSA uses the chart supplement book to caution that extreme variations in compass errors may be encountered due to local magnetic anomalies and to magnetic storms as far south as Kodiak and St. Lawrence Island. This ties into a service of the ESSA Research Laboratories, whose Arctic Solar Proton Monitoring Network helps warn the many private pilots against a compass-directed flight through the auroral zone at the wrong time.

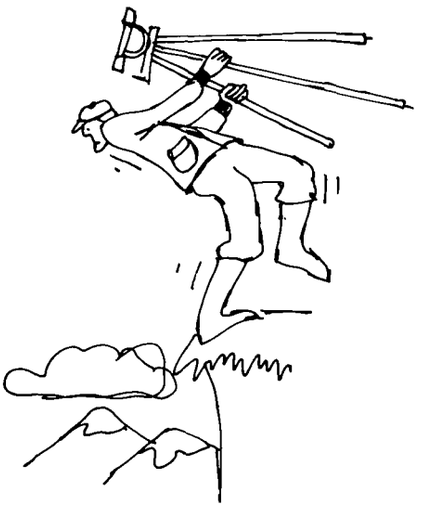
Charts and maps are only pictures unless they are properly referenced to the actual surface of the earth. Geodesy is the geophysical branch of applied mathematics which provides this control, through precise surveys, astronomic observations, measurements of the earth's gravity field, and theoretical expressions of the exact size and shape of the earth.

Since the early 19th century, the Coast and Geodetic Survey has strung a precise network of geodetic control across America. The Alaska geodetic surveys began in the last century, and took until the mid-1950's to complete even in basic form. The last, large unsurveyed section of Alaska was the Arctic coast between Point Barrow and Demarcation Point at the Canadian border. The survey teams traveled in tractor-drawn sleds over the frozen tundra to complete this work in the early Arctic winter.

The completed network, which connects with that covering the lower 48, provides the essential core of accuracy for all mapping and civil engineering operations, and is the standard from which surveys and engineers at the local and regional level begin. For a developing state, geodetic control is an invisible and necessary link with a strong future.

Alaska has seen geodetic surveys run their entire technological spectrum, from the early theodolites to the laser-equipped Geodimeters used in geodetic distance measurement today. What has not changed is the terrain and the climate. The precise network in Alaska crosses some of the toughest country in the world, and generations of surveyors have balanced on the granite lips of cliffs to add one more point to one more triangle, one more step to a series of level measurements.

When the task of charting Alaska began, shoreline and topography were mapped by plane table surveys and freehand sketches. Aerial photography came into general use here during and after World War II, and soon became the principal means of describing topographic and coastal detail for cartographic purposes. Photogrammetry, the science which combines precise measurement with photography, has since developed into a highly polished discipline in its own right, and now has some impact on virtually



Generations of surveyors have balanced on the lips of cliffs.

every Coast and Geodetic Survey activity. Much of the pioneering field work behind this evolution was part of Alaskan operations.

Among the innovations that have benefited Alaska are techniques of taking aerial photographs at the precise time when the tide is at a given stage—mean sea level, for example. Ground personnel observe tide staffs and radio the pilot when the water is at the specified level. Infrared photography produces a sharp contrast of nearly jet black water and light-gray beach. Color aerial photographs taken simultaneously with the infrared facilitate mapping the infrared waterline, and help detect navigation hazards. Tide-controlled photography permits determination of true mean low or mean high water shoreline to within an inch or so, and also permits synoptic measurements over an entire estuary.

Along parts of the Gulf of Alaska adequate charting of irregular and hazardous shore areas is mainly the result of photogrammetry.

Aerotriangulation, which entered operational status in the mid-1960's, is a method of providing geodetic control over large areas using aerial photography and a complicated computed program. The importance of the photogrammetric system lies in the fact that a control system, having sufficient accuracy for mapping and certain engineering applications especially, can be established rapidly and at a relatively low cost.

Photogrammetric techniques have been used to develop the Coast and Geodetic Survey's present satellite triangulation program. In this system, widely separated cameras simultaneously photograph a sun-reflecting satellite against its background of fixed stars, and the resulting view is translated into precise geodetic data through an elaborate computer program. In effect, the technique uses the satellite image to bridge intercontinental distances. As this network develops, the positional relationships of land masses will help all nations bring their geodetic networks into global adjustment, and will materially help less developed areas get a strong start in their essential surveys.

Nowhere is there a greater variety and a larger scale of atmospheric events than in Alaska. Extremes come routinely and suddenly in this land of storms and fogs, heavy snows, sudden freezes, high winds, and inundating rains. Because life in Alaska takes man into the environment more than in the lower 48—to fish, hunt, mine, explore, survey, trade, fly, sail—weather is an integral part of everyone's day-to-day life in the northland. This gives the ESSA Weather Bureau's services a special urgency.

From the Weather Bureau regional headquarters and forecast center in Anchorage, weather reports, forecasts, and warnings move out through the 24 first-order Weather Bureau stations located across the state. Of these, 14 provide two to four upper-air soundings daily, in addition to standard surface observations.

The Anchorage Forecast Center provides services for the public, domestic and international aviation, and marine interests; a fire-weather forecast service also originates here. Marine environmental services are provided by five oceanographically trained meteorologists in the Anchorage office. At Fairbanks, services include both fire-weather forecasts and river services — hydrologic services are a big part of the weather service in Alaska, as in the other states, and are concerned both with water resources management and with river forecast and warning services.

The lack of adequate public communications is one of ESSA's biggest problems in collecting meteorological information and disseminating warnings. Communications facilities and population are concentrated in small and widely separated areas. Reaching people beyond these areas depends on radio. Anchorage, Cordova, Fairbanks, Ketchikan, Nome, Sitka, and Juneau all have radio stations. The strongest of these is at Anchorage. It is 50,000 watts at maximum power but this is directional and does not cover the whole state. The Coast Guard Alaska Communications System and other government and public service agencies aid in spreading weather warnings on a timely basis. ESSA's Intra-Alaska Facsimile Network distributes graphic weather products to users around the state.

Gathering meteorological observations from outlying field sites is also a potential communications problem — one usually solved by two-way radio. In addition to the first-order stations, ESSA operates some 200 other observing sites ranging inward from the extreme points of Shemya in the western Aleutians, Barter Island, Barrow, and Annette Island in southeast Alaska. Weather information also comes in from the Air Force Communications System, DEW Line stations, and FAA stations.

But even the seemingly routine work of collecting observations can be exceedingly non-routine in Alaska. A fur trapper along the Yukon makes a daily check of the river's height by a centuries-old method of water depth measurement and radios his day's reading to the ESSA hydrologist in Fairbanks. This ESSA-Weather Bureau scientist or his counterpart in Anchorage then interpolates from this necessarily crude reading to ascertain how much water is flowing down the Yukon and whether there are new or more massive ice dams upstream. If such dams exist, he must attempt to determine where and when the ice will break and whether it will cause a flooding hazard when it does.

Satellites are making life easier in this respect. Photos come directly from weather satellites to the command and data acquisition station in Fairbanks. This station is the counterpart of a second satellite receiving station at Wallops Island, Va. The Point Campbell Meteorological Observatory at Anchorage acquires and disseminates APT photographs from ESSA and Nimbus satellites.

When the Improved TIROS Operational Satellite (ITOS) becomes operational, Arctic and Alaskan forecasting will begin to depend even more on satellite information because it will provide usable nighttime photographs. Since winter is synonymous with constant night in the Arctic, this will give ESSA forecasters their first bird's-eye view of the Arctic winter. Although night is constant only north of the Arctic Circle, daylight observations are limited throughout Alaska. Anchorage, for example, has only 5½ hours of daylight in mid-winter.

The normal Alaskan storm track follows the Aleutian Island chain toward the Alaska Peninsula, crossing the Gulf of Alaska coast to the North Pacific. Winds frequently exceed 50 miles per hour, and wind recorders at Shemya on the western tip of the Aleutians have gone offscale at the maximum 128 miles per hour more than once. Such strong winds take their toll of merchant and fishing vessels as well as land-based structures.

Occasionally a storm will develop in the Bering Sea and move north or northeast-

continued

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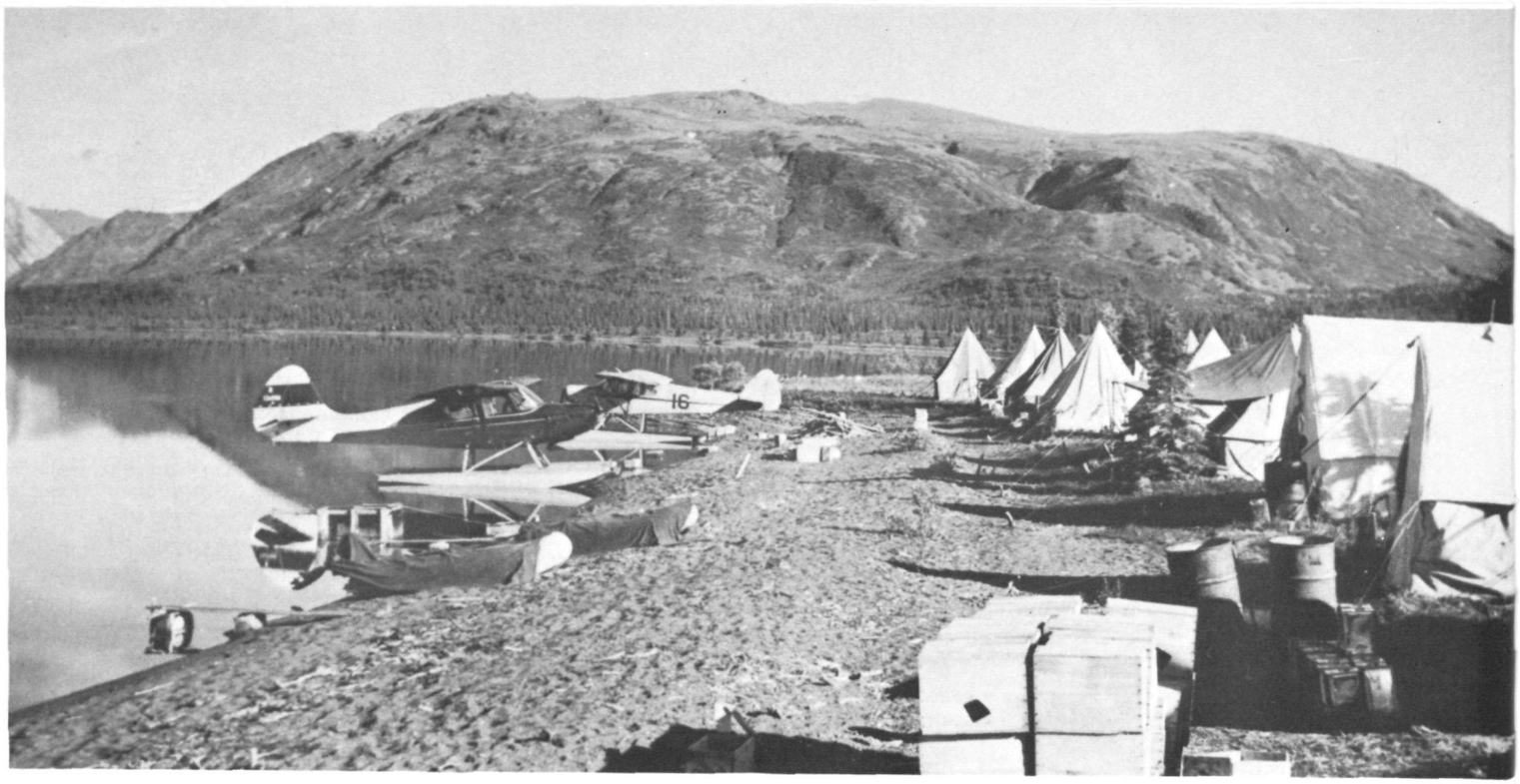

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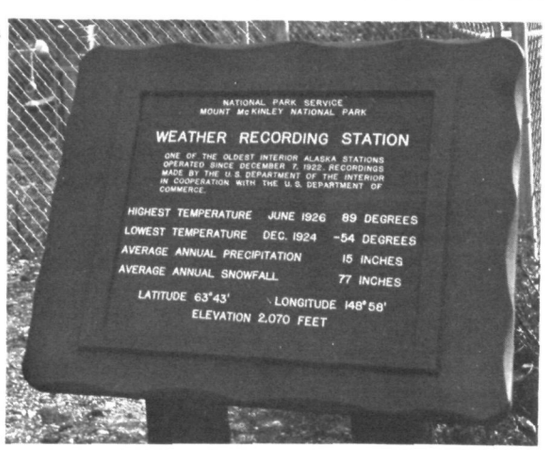


1. The airplane is the principal means of transportation in Alaska. It is as vital to C&GS survey parties as it is to most other activities in a state with only 5000 miles of highway. 2. The USC&GSS SURVEYOR near Valdez. Generations of Coast and Geodetic Survey ships have plied Alaskan waters, gathering data for new and revised charts of the shoreline, waterways, and continental shelf. 3, 4. Nowhere is there a greater variety of atmospheric events than in Alaska. Mount McKinley National Park is the site of one of Alaska's oldest weather recording stations, where the Department of Interior has taken observations since 1922.

ward. This creates strong winds along the western coastal area, an area of low-lying flat ground which can ill afford the flooding which frequently accompanies excessive winds. Winter storms in the southern Arctic Ocean are equally a wind hazard. The Arctic winds which frequently exceed 50 miles per hour add a huge minus to the chill factor of already devastatingly cold temperatures.

Specialized weather information is required for effective protection of forest and range lands. The fire weather program in Alaska attempts to monitor the possibility of a fire being started, especially by lightning. The likelihood of its being detected, its behavior, the readiness of an organization to suppress a fire, the planning of suppressive action, and the prevention of other fires are dependent upon weather and the use of weather information.

In 1969, the ESSA Weather Bureau began to supply Alaskan fishing and shipping with special marine and ice forecasts. With 800 fishing boats registered in Kodiak alone and 2,600 small fishing boats projected for the Bristol Bay area, accurate marine and ice forecasts assume tremendous economic importance to Alaska.

This, the first such service of the Weather Bureau anywhere, is invaluable to mariners attempting to operate through the Alaskan winter, when nature really intended that nothing should move through those cold, fog-shrouded waters.

Cook Inlet presents a unique ice problem because of its large tides. ESSA is collecting climatology on ice in the Inlet. Cargo ships and small (140-160 foot) boats are successfully using the Inlet the year around as a waterway to Anchorage, to resupply the oil platforms dotted through Cook Inlet, and to pick up petroleum products destined for refineries in the United States and Japan.

During the summer of 1969, ESSA assigned two specialists in weather and ice forecasts to aid task force operations on the North Slope. A temporary weather broadcast station was also established at Point Barrow to disseminate weather and ice information to vessels operating in the Chuckchi and Beaufort Sea areas.

With this ESSA boost, a major resupply mission was successfully made by sea into Prudhoe Bay. Some 100,000 tons of cargo traveled up the Alaskan coast and around into the Arctic Ocean. Estimates for the next season's sea cargo needs run as high as 200,000-300,000 tons in the 30- to 60-day shipping season.

Winter regulates the flow of Alaska's rivers. In late October, the rivers begin to freeze and soon most heavy equipment can be moved on solidly frozen rivers, some of which cease to flow completely in the winter months. Spring flooding when the ice breaks up is a fact of life.

But there have also been hydrologic surprises. Long after the ice breakup in 1967, in August, the Chena River left its banks and inundated Fairbanks, a town of 30,000. Final damage estimates approximated $100 million in the Tanana Valley.

Fortunately, the flood was not of the swift, rampaging water type. Rather the river rose steadily but smoothly out of its banks. The most damage to structures occurred when water-filled basements were pumped while deep water still surrounded the building. The resulting pressure differences caused many cave-ins.

Following this unique, disastrous summer flood, ESSA began hydrologic forecast plans which included an automated river and rainfall reporting network in the Tanana Valley. The network, a joint endeavor of ESSA, the Geological Survey, and the Corps of Engineers, was installed prior to the 1968 spring breakup. Six water-level recorders with a radio and associated electronic equipment were installed on the Chena River at Fairbanks, the Little Chena near Fairbanks, the Chena River near Mile 38, the Salcha River near Aurora Lodge, the Tanana River near Harding Hill, and at Nenana.

With this new network, the summer flood will never take Fairbanks by surprise again. Forecasting procedures and data now allow a solid 48 hours' lead time in flood forecasting for Fairbanks. The only remaining hydrological problem is that of spring floods. Equipment in water does not survive ice jams; during the spring breakup of ice on the rivers, there is no automatic network to tell hydrologists or forecasters about ice jamming or the size of the cakes. This must be observed first-hand by air or ground reconnaissance.

This problem is being attacked by a system of slope profile gages along the Yukon River and other major streams. The slope gages are really just a series of rods driven into the ground at various elevations up the slope of the bank. This crude but reasonably accurate water level measuring system is centuries old but it has the desirable attribute of being largely impervious to changing ice conditions. Local observers were recruited at each station site and provided with a single-sideband radio, if telephones were not available.

The river observer measures the straight-line distance down the bank from the nearest rod to the water edge with a tape. During low water, a 3-foot section of staff gage, wired to a steel fence post, is read in lieu of taping down the bank. Should an unexpected rise wash out the fence post, tape measurements are used until low water again permits resetting the vertical staff gage and fence post. By surveying the bank section, all slope measurements and staff gage readings can be equated to a standard datum. This is particularly important because flood stage must be determined for each community for the forecasts to have meaning.

This information, relayed to ESSA hydrologists in Anchorage, forms the present backbone of Alaska's flood forecasting network. Still, the seasonal frost conditions and permafrost of Alaska make conventional river forecasting an impossibility. There is almost a complete absence of information on groundwater retention and discharge characteristics of high-latitude areas.

Besides these basic problems, Alaska has some peculiar geography that, coupled with the winter, create unusual flooding situations. The Kenai Peninsula, for example, has several "self-dumping reservoirs" which are more or less permanent ice dams on rivers. More or less permanent, that is, until one suddenly breaks in the middle of winter. When this happens, a wall of water—extremely cold water but nonetheless fluid—can engulf a peninsula settlement. The flood water, trapped by such things as house walls, will freeze solid until the spring thaw. Several residents of the Kenai Peninsula have faced a house full of ice and had to abandon their homes for the remainder of the winter.

Forecasting a flood of this sort is virtually impossible as it has little to do with rainfall, river flows, or hydrology. But ESSA does try to "babysit" these self-dumping reservoirs and warn nearby residents when a sudden shift in the ice jam appears likely.

In addition to special research studies for development projects such as proposed dam sites upstream of Fairbanks, the Weather Bureau (with other Federal and state agencies) has undertaken a large-scale research project aimed at making accurate forecasting in Alaska a reality.

This is an intensive study of high-latitude hydrological factors in the Caribou-Poker Creek watershed. In addition to characterizing the hydrologic behavior of a small sub-arctic drainage basin, this watershed research should enable hydrologists to develop predictive and modeling techniques. Microclimatology, soil moisture relations, nutrient cycling, and biological productivity may also be studied here. In short, anything that will provide information about high-latitude landscape and its hydrology are of interest in the Caribou-Poker Creek project.

Alaskan airports, both large and small, are constantly busy with aircraft.

continued

The aurora borealis heralds the arrival of energetic radiation particles from the sun. With the familiar northern lights come fluctuations in the earth's magnetic field, communications blackouts, and, occasionally, magnetic disturbances of long-line transmission wires and other public services. Because these solar effects are strongest at high latitudes, the ESSA Research Laboratories probes the secrets of aurorae by means of a special radar at Anchorage, Alaska.

In Fiscal Year 1969, 147,880 flight plans originated at Alaska's 36 largest airports. Fairbanks ranks fourth in the nation in total number of aircraft contacts and 36th in the number of flight plans originated. Anchorage, Cold Bay, and Shemya ranked in the top dozen U. S. airports in number of international flight services in the same year. ESSA's aviation weather services and aeronautical charts are the main shield between this strong aviation industry and a tricky, dangerous environment.

International flight briefings at Anchorage average over 1000 a month with an additional 100 or so at Cold Bay. In the first nine months of 1969, ESSA personnel in Fairbanks averaged some 500 pilot briefings a month. In August 1968, a time of exceptionally good summer flying weather, the Weather Bureau briefed 978 pilots outbound from Fairbanks, most of them private aircraft, and many of them bound for Prudhoe Bay.

ESSA's computer at the National Meteorological Center, Suitland, Maryland, plays a role in Alaska. Wind and temperature forecasts at a number of different flight levels for 25 Alaskan locations are issued routinely by this Weather Bureau analysis and forecast center. International carriers flying over Alaska receive flight level winds and temperatures, and forecasts of significant weather for westbound flights to the orient, southbound flights over the Gulf of Alaska to Seattle, and polar flights to Europe.

If the northland gets less benefit than lower zones from the sun's warming rays, it gets more than its share of the invisible, troublesome emanations. These solar particles are trapped in the earth's magnetic field and shunted poleward, into the Alaskan neighborhood. With them come wild fluctuations in the magnetic field, blackouts of radio frequency communications, and the "northern lights," or aurora borealis.

ESSA provides descriptive and predictive services which help Alaskans cope with troublesome bombardments from the sun, and also conducts a broad range of related research projects.

Alaska is the best place in the United States for certain magnetic observations and studies because it is traversed by the auroral zone where fluctuations in the earth's magnetic field are more intense and more rapid than anywhere else. The advantage of Alaska in this respect has been recognized for nearly a century—a Russian magnetic observatory operated at Sitka before the territory changed hands. Special observations were made at Barrow during the first Polar Year in 1882, at Barrow and Fairbanks in the Second Polar Year (1933), and also at Healy, Big Delta, and several other Alaskan sites during the International Geophysical Year (IGY) of 1957-1958. Today, Coast and Geodetic Survey observatories at College, Sitka, and Barrow monitor the erratic geomagnetism of the high latitudes, along with its regular daily fluctuations and the gradual changes of such importance in mapping the main magnetic field.

The auroral zones offer real opportunity for study. Here the multicolored displays of the aurora borealis herald the arrival of energetic radiation particles from the sun. This radiation, flowing outward from the solar surface at all times but with special violence during solar eruptions, arrives in the polar atmosphere some 30 hours later. With the familiar northern lights come fluctuations in the earth's magnetic field, communications blackouts, and, occasionally, magnetic disturbances of long-line transmission wires and other public services. These solar effects can be seen and felt far beyond the high-latitude auroral zones, but, as they are strongest in those regions, they are best studied here.

The ESSA Research Laboratories, headquartered in Boulder, Colorado, probe the secrets of aurorae with VHF radio waves from an auroral radar located in Anchorage. This project is being done concurrently with a similar southern pole project in New Zealand. Scientists at both locations, operating their radars at the same time, same power, and same frequency, should obtain a good picture of auroral activity in both hemispheres. Since the frequency of the auroral radar is similar to those used for

television, this project may also improve understanding of how aurorae interfere with television reception.

A second Arctic project of the ESSA Research Laboratories monitors protons arriving from the sun. This network, strung from Thule, Greenland, to Anchorage was designed to provide early warning, not prediction, of the arrival of energetic proton streams.

The solar proton net includes a variety of riometers, forward scatter radio circuits, and VLF phase and amplitude circuits, all of which detect changes in the electron density of the atmosphere. In short, the network detects incoming energetic protons indirectly by observing their effects on the ionospheric electron density.

A unique aspect of the ESSA network is the "on-line" computer processing of data coming in from each individual sensor. A central data processing computer in Anchorage receives data from these far-flung sensors, and automatically identifies the time that each sensor sees a solar proton event.

The solar proton monitoring network is one component of a worldwide effort aimed at forecasting disturbances in space. Another component is the Global Solar Flare Patrol which has stations strung around the world. This cooperative system is designed to provide timely, accurate warnings of major solar events and any related geophysical happenings. These warnings are useful to manned spaceflight programs, satellite experimenters whose film or electronic equipment may be damaged by solar radiation, as well as the communications and aviation industries in Alaska and other affected regions.

Alaska is a young state in every sense of the word, including the geological one. Its mountains are still growing, heaved up by the process called orogeny along a folded, fractured section of the earth's crust. To seaward, the Aleutian Island arc and the deep trench which borders it represent the downward thrust of this process. Adjustments in this continuous series of geologic events touch the lives of Alaskans in the form of earthquakes, which are more frequent here than in California, the other highly seismic state.

The earth's most active seismic feature, the circum-Pacific seismic belt, brushes Alaska and the Aleutians. More than 80 percent of the planet's largest earthquakes occur in this belt, and about six percent of its large, shallow earthquakes occur in Alaska and the Aleutians. As many as 4,000 earthquakes of all depths and sizes are detected in the northern state each year. The worst in recent history was the Prince William Sound, Alaska, earthquake of 1964, the largest ever recorded on the North American continent.

Seismologists from ESSA's Coast and Geodetic Survey and Research Laboratories are conducting a variety of data-gathering projects on Alaskan earthquakes, including field studies in the region of the epicenters —the point of the earth's surface directly above the subterranean source, or hypocenter, of the tremor. Observatories at Sitka, Palmer, Fairbanks (College), and Adak monitor seismic activity in Alaska and the Aleutians. A minimum service unit operates at Barrow, using one vertical-motion seismometer. Unmanned outpost stations are operated at Gilmore Creek, near Fairbanks, and Kodiak and Middleton Islands, out in the Gulf of Alaska. Data from these outpost stations are telemetered to Palmer Observatory, where they are recorded in real time.

Field work is also important in this highly seismic area, and special strong-motion sensors are installed at selected locations around the state, along with clusters of seismoscopes—instruments which simulate the response of a building to ground motion. Instruments are located at Adak, Cordova, Cold Bay, Juneau, Ketchikan, Kodiak, Homer, College (at the University of Alaska), Kodiak, McKinley Park, Seldovia, Seward, Shemya, Sitka, Yakutat, and several Anchorage locations. A tiltmeter is operating at Kodiak. Data from these sources, from the observatories, and from the research in earthquake theory will help unlock the mechanics of earthquakes, and possibly lead to prediction or mitigation of their effects.

The destructive effects of earthquakes in oceanic or coastal areas are often extended far beyond the felt area of the tremor by the tsunami—the so-called "tidal wave." Tsunamis are series of traveling ocean waves of extreme length and period generated by disturbances associated with earthquakes occurring below or near the ocean floor.

The Coast and Geodetic Survey's Pacific Tsunami Warning System was impelled by the disastrous waves of April 1946, which surprised Hawaii and took heavy toll in life and property. This system, operating since 1948, provides Pacific-wide warnings of potentially tsunami-generating earthquakes and tide-gage confirmation that a tsunami has been generated.

The locally disastrous tsunami caused by the March 1964 Alaska earthquake impelled the development of another type of warning apparatus—the Regional Tsunami Warning System in Alaska.

The Regional Tsunami Warning System is headquartered at the Coast and Geodetic Survey's Seismological Observatory at Palmer, Alaska. This is the nerve center for an elaborate telemetry network linking Palmer with remote seismic and tidal stations along the Alaska coast and in the Aleutian Islands. Seismograph stations in the network are at Palmer Observatory, and its two remote stations 25 miles south and west, and at Biorka, Sitka, Gilmore Creek, Kodiak, and Adak. Tide stations are at Seward, Sitka, Kodiak, Cold Bay, Unalaska, Adak, Yakutat, and Shemya. Data from these stations are recorded continuously at Palmer, where a 24-hour watch is kept.

Subsidiary warning centers have been established at Sitka and Adak Observatories. These facilities operate small seismic arrays and have a limited warning responsibility for local areas.

In a region where people still speak of things happening before or after The Earthquake, where oil rigs are drilling down through ice and permafrost to tap new reserves, where a rich, young state is just getting started—economically, technologically and geologically—the role of environmental science has barely begun.

The benefit to Alaskans of ESSA's programs in oceanography, geophysics, weather analysis and prediction, and natural hazards warnings are immediate, and growing. The more developed the northern state becomes, the more active its economy, the more it will need the information provided by environmental scientists. In the distance are still more exciting prospects—earthquake mitigation or prediction is one of these elusive goals.

Those who contend with the Alaskan environment are not alone. The farther they push into the Arctic, the more extensive will be the environmental science services and research that go with them. □

Taking the earth's pulse may lead to earthquake prediction.

Pioneers at Prudhoe Bay were, from left, Stanley Jeffers, Abe Simmons, Harley Nygren, Jerry Gray, Ted Shanahan, and Harry Lantzy.

Twenty Years Later

BY REAR ADMIRAL HARLEY D. NYGREN

TWENTY YEARS AGO this summer, I was a member of a small Coast and Geodetic Survey crew, engaged in a straightforward hydrographic operation in a desolate and seldom-visited part of Alaska.

Our camp consisted of two war surplus tents pitched on a gravel bar which rose all of 7 feet above the high water line. To the north of us lay a practically unbroken expanse of ice which extended, as far as we knew, to the North Pole. To the south about 10 miles and over the horizon lay the flat marshy mainland of Alaska.

Our mission was to complete a series of hydrographic surveys for some vitally needed navigational charts. Accelerated activity in the area had brought increasing numbers of vessels to fight the fog and ice on their way to eastern Alaska and Canada, and the ships were regularly suffering grief and damage in the offshore ice. South of a string of barrier islands lay a potential ice-free channel waiting to be charted. The project had been underway since 1945 and was half completed by 1949.

The survey season usually started in early February, with moves to base camp by tractor train and work on the vital geodetic control network. After the ice breakup in July, the parties split into single launch units which remained relatively independent of each other until just before the ocean froze over in the fall.

Our particular unit consisted of a 36-foot launch, a six-man crew, one cook, and two Shoran camps of two men each. The Shoran camps were installed at strategically placed sites, and each was operated by a technician and an Eskimo. The launch crew was made up of one C&GS officer (myself), two Eskimos from Pt. Barrow (Harry Lantzy and Abe Simmons), and three college students (Stan Jeffers, Jerry Gray, and Ted Shanahan) hired for the summer.

A typical day in our area found us out of our bunks for an early breakfast, then out to the launch by skiff. Because of the ice, this region was almost perpetually fogbound, which made electronic (Shoran) navigation almost imperative. If the wind blew from the north, it brought the ice down into our area. If it blew from the south, we had a good chance of rain, and some risk of being caught in a closing lead in the ice. If there was no wind (which was seldom), it might be pleasant. After checking the weather, we would start our operations where the ice conditions permitted, usually working until late in the evening. After that came maintenance, preliminary processing of the records, dinner, and then into the damp bunks. Day after day of work under these conditions took its toll on our morale and good humor.

After one continuing stretch of northerly weather, one of our Shoran camps requested a new supply of gasoline and water. Their camp, on an island similar to ours, was difficult to service with a north wind blowing onshore. With the wind stopped, we suspended operations and ran down to them. Once away from the ice, we quickly left the fog and came into the clear, calm, almost warm, coastal region. The incredibly clear sky and warm sun was almost as refreshing as a day off. After servicing the camp, we were reluctant to head back into the fog, so we looked for some other alternatives.

Immediately south of the Shoran camp lay a large bay, about five miles long and five miles across, surrounded by rather high banks. During the winter, we had built wooden hydrographic signals (towers) around the shores, and most of the bay was adequately covered by our Shoran network. Although we had no properly prepared survey sheet for the area, we improvised one and headed in. After crossing a shallow shoal, we found ourselves in relatively deep water, with a sand, mud, and clay bottom and gentle gradients. For the balance of the day, we crossed and recrossed the bay, sounding out the depths, enjoying the good visibility, the fine strong Shoran signals, and the pleasant weather. Our program was unimpeded by ice, fog, or uncharted and unexpected shoals. It was one of those days when work is a pleasure, if only by comparison with our usual experience.

Late in the evening, we finished near the western bank and found a deep channel leading to the open ocean and home. It was impossible to complete the plot of all of the work until months later and, because of the high priority work in the main channel, we never did go back to bring the job completely up to Coast Survey standards. The day was ended with a two-hour run back to our island home, the fog, the ice, the soggy tents, and the gloom that accompanied the ice pack.

Much later, this work was replotted to its proper scale, and the smooth sheet was used to produce a chart which I did not see for 18 years. As time went on, the economic importance of this coastal region reached a point that required the release of these charts to the general public. I, of course, moved on to other duties and returned only once to this desolate place. Few people had heard of it, and fewer had been there. There was little reason to believe that many ever would.

Today this bay, Prudhoe Bay, is the site of one of the most frantic oil searches in the world. Dozens of oil rigs, barges, camps, and vehicles dot the low marshy ground.

A continuous stream of planes flies over the Brooks range, delivering mail, supplies, technicians, and executives from Fairbanks and points south.

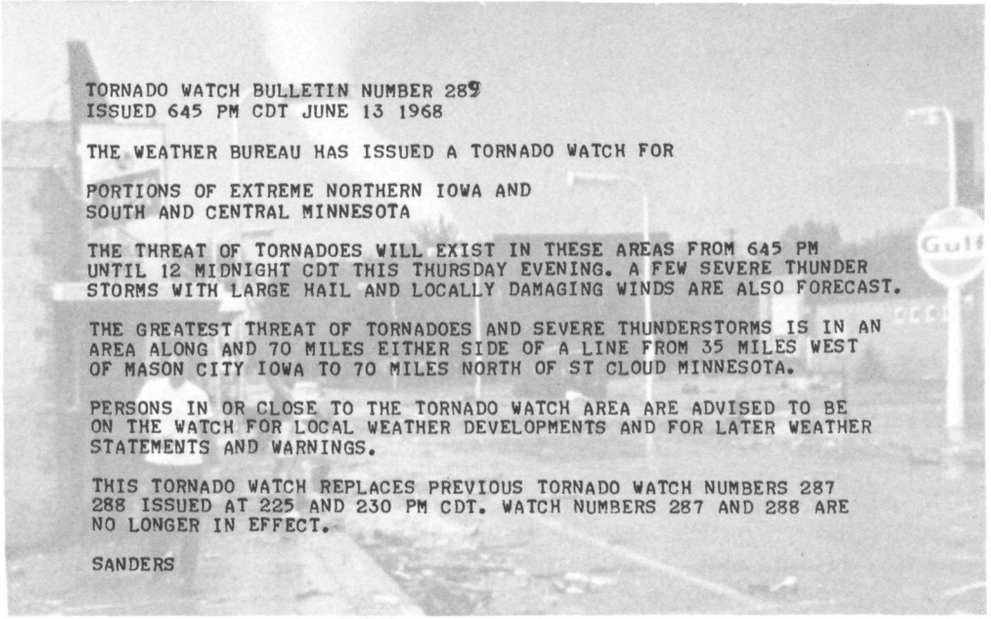
The largest ship in the U.S. Merchant Marine, the MANHATTAN, has shown the feasibility of carrying oil to the lower 48 states from Prudhoe Bay through the Northwest Passage in the Canadian Archipelago.

Oil men all over the world are watching the results of lease sales and exploratory drilling around Prudhoe Bay.

Those who ask "Why geodetic control?" and "Why a hydrographic survey?" would do well to put the questions to the oil men of northern Alaska. They know why. They have been there, and so have we. □

When a tornado strikes minutes make the difference between life and death

Tracy Showed the Way



The Tracy tornado (photo by Kermet Christianson).

What would you do if you knew that in five minutes a tornado would plow into your community . . . its debris-laden funnel spinning at 300 miles an hour, flipping automobiles and railroad freight cars end over end like matchsticks, exploding houses with sudden pressure changes, leaving a path of almost total destruction?

If you had five minutes would you know where to go—what to do—how to stay alive? Is five minutes enough time?

It can be, when you are prepared.

The experience of the town of Tracy, Minnesota, on June 13, 1968, is an example of how alert community action can save lives.

Although nine people perished when the deadly tornado struck the town with only five minutes' notice, the toll probably would have been much higher had the town been without its effective warning system or had its citizens not been primed to use those five minutes in the wisest possible way.

The Tracy tornado occurred at 7 p.m. Only five minutes earlier, when Mrs. Melvin Koch of nearby Garvin, Minn., spotted the twister racing toward Tracy, about six miles to the east, she telephoned Tracy police dispatcher Julius DeBliech, and began passing on second-by-second observations of the tornado's progress from her husband and sons, Allen and Bruce. DeBliech knew how to alert the public that a tornado was at hand. He immediately sounded the Tracy Civil Defense sirens, whose use for tornado warnings only recently had been proposed and instituted by I. J. Baumann, Lyon County Civil Defense Director.

The story of how Tracy coped with the June 13 tornado actually started about three months earlier, when Joseph H. Strub of the Minneapolis Weather Bureau held a seminar on tornado spotting and the value of spotter networks in southern Minnesota. Representatives of five counties present included Mr. Baumann.

When Strub visited Baumann in Tracy the next day to talk more about tornado hazards, the groundwork was laid for the system that is credited with saving many lives on that fateful June 13.

In the weeks preceding the tornado, Baumann was hard at work recruiting a network of spotters in Lyon County and training them in procedures to follow in the event of a tornado. He talked to people in the Tracy city government and plugged tornado safety whenever he had a chance.

The Koch family was among those who received the spotter information. Their phone call gave the citizens of Tracy literally only five minutes to take cover and put into use their pre-arranged survival rules.

However, they had had much longer than that to realize the possibility existed that they might be forced to do this.

During the afternoon bad weather had been brewing in the Midwest.

Forecasters at the Weather Bureau's National Severe Storms Forecast Center in Kansas City, where tornado predictions for the whole nation are prepared, had put much of the area on alert with tornado watches. A watch is issued when conditions are favorable for severe storm formation. It means that the public should stay alert for further information from the Weather Bureau, keep an eye to the sky for threatening conditions, and start thinking about how they will react if a tornado actually comes their way.

No instrument but the human eye is able to identify a tornado positively. When the Weather Bureau learns that a tornado has formed—from alert citizen spotters like the Kochs or from any other source—a tornado warning is issued. The warning means that immediate action should be taken to protect oneself from the storm. The warning contains such information as the tornado's current location, its forward speed, the direction in which it is traveling, the area warned, and the time interval covered by the warning.

Although there was no tornado warning as such for Tracy, it was included in the Weather Bureau's tornado watch in effect for the area. The tornado, like many of its breed, was there and gone in a few minutes. But the Weather Bureau's influence was felt—through the decisive action of the police dispatcher who sounded the siren, and through the county civil defense director whose foresight and cooperation with the Weather Bureau undoubtedly saved a number of lives in Tracy.

Five minutes wasn't much time for the people of Tracy to get ready for a tornado, but it gave them a chance. For Tracy, it was time well spent.

SKYWARN

Tracy Headlight-Herald photo.

The Melvin Koch family first reported the tornado to the Tracy police. From left, Joseph Strub, who now heads the Minneapolis Bureau office; Mrs. Koch; Mr. Koch; Bruce and Allan Koch; and P. W. Kenworthy, former Minneapolis MIC, now retired.

The day is warm and humid. A tornado watch has been issued by the Weather Bureau.

The sky darkens ominously, with the approach of a thunderstorm.

Suddenly a funnel swings eerily from the thundercloud to the ground, and roars toward you with a sound like a fleet of planes.

Winds in the funnel whirl at speeds that may exceed 300 miles per hour. As it touches a building, the winds twist and rip at the structure, while the vacuum in the funnel's center causes windows to explode and walls to collapse outward.

This is a tornado—the most violent of all earthly storms. It could strike your town today, tomorrow, or anytime.

When it does, will you and your neighbors be ready to take the correct life-saving actions instantly, automatically? If your community is one of those with tornado preparedness plans, your family and everyone in town will have a better chance of survival.

The Weather Bureau is stressing tornado preparedness in its SKYWARN '70 campaign to enlist all citizens in the effort to reduce the human toll taken by these vicious storms. In an average year, tornadoes kill more than 100 people in the United States.

A tornado watch is issued by the Weather Bureau's National Severe Storms Forecast Center in Kansas City, Mo., to identify an area where conditions favor the formation of tornadoes. A watch alerts you to keep on with your daily routine, but to be ready to respond to a warning.

A tornado warning is issued by your local Weather Bureau facility, and means that a tornado has been sighted or indicated by weather radar. Persons close to the storm should take shelter immediately, and remain there until the danger has passed. Others should be prepared to take cover if a funnel is sighted.

Tornado preparedness has many aspects. The broadest is the overall community action plan for coping with the twister's onslaught. Then, there are schools, hospitals, nursing homes, and institutions where administrators have a special responsibility to plan carefully for the protection of the young, the old, and the sick—those who cannot save themselves. Offices, factories, theaters, sports arenas, and other places where large numbers of people gather should have their own action plans for tornadoes. And preparedness, like charity, really begins at home.

You can work for the development of an effective community preparedness plan, if your town does not have one. All adequate systems include a network of volunteers who report tornado sightings, a designated 24-hour center to receive reports of tornadoes and spread warnings, channels for communicating these warnings throughout the area, detailed plans for protective action before the tornado strikes, and arrangements for post-disaster rescue and relief.

A detailed planning guide, titled "Tornado Preparedness Planning," and published by the ESSA-Weather Bureau, is available for 25 cents a copy from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. (Community officials may obtain a free copy from the Emergency Warnings Branch, Weather Analysis and Prediction Division, ESSA Weather Bureau, Silver Spring, Md. 20910.)

Perhaps you serve a local hospital or nursing home as a volunteer or board member. You can urge administrators to

SKYWARN

AT TORNADO TIME, MANY LIVES MAY BE

In your keeping

Cartoons by Bill Welsh.

1. Tornado preparedness begins at home. Teach your children what to do when a tornado strikes.

be ready to respond in natural emergencies. These institutions should be prepared not only to treat disaster victims, but also to protect the patients already hospitalized. Employees should be drilled in emergency procedures. Shelter areas—lower floors, inside corridors, or bathrooms with shielding walls—should be selected to protect patients, visitors, and staff. Bedfast patients can be shielded from flying debris with thick blankets, and their beds moved against inside walls.

Schools hold a terrible potential for tragedy when tornadoes strike. Working through the Parent Teachers Association or the school board, you can help guard the safety of your children by ensuring that local schools are prepared. School systems should have a plan for swift internal dissemination of tornado watches and warnings, and special tornado alarm signals that sound throughout every building. After safe shelter areas have been selected, teachers and students should be drilled so that they learn to respond to the tornado signal quickly and correctly.

It is especially important to establish standard procedures with regard to the release of children and the use of school buses during severe weather situations. For example, if a tornado warning is in effect for the area at school closing time, it is wisest to keep the children in school shelter areas until the danger has passed. Parents should know that this will be done.

Other decisions should be made in advance as to whether or not school buses will be used during tornado watch and warning situations. In any event, school bus drivers should know how to protect their young passengers—by leading them to cover in a ditch or ravine—should the bus be caught in the open by a tornado.

Guidelines for schools, hospitals, and other institutions are included in the "Tornado Preparedness Planning" brochure.

In the home, your family's safety is in your hands. Develop a home preparedness plan to prevent panic when every second counts. Find the safest shelter area in the house.

If you don't have a storm cellar, the basement usually offers the greatest protection. A sturdy workbench or heavy table placed in the basement will shield you and your children from falling debris.

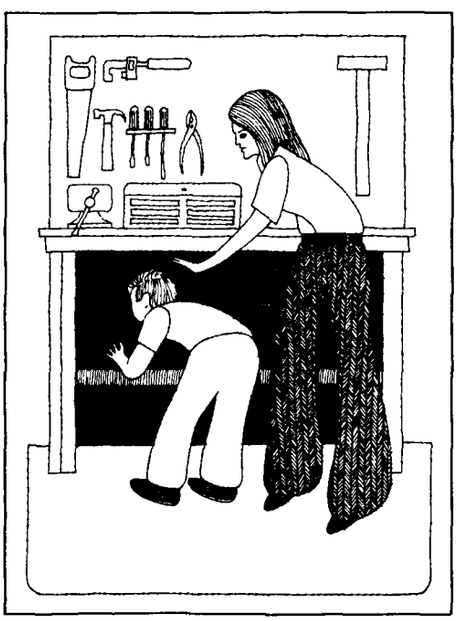
If your home has no basement, plan to take shelter in a room in the center of the house, under the heaviest furniture available.

If you live in an apartment, look for a protected area in the basement or interior hallways on lower floors.

In any case, when you have found or prepared a shelter area, be sure each member of the family knows where it is and what to do when a tornado threatens.

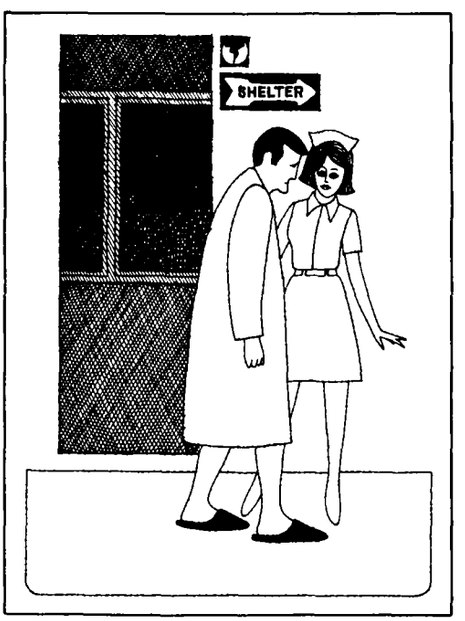
Last year, on May 9, an Indianapolis woman asked the head of the local Weather Bureau office where to take shelter from a tornado since her home had no basement. The weatherman advised her to go to an inner hallway or to a closet with no wall that was also an outer wall of the house. Only the next day—May 10, 1969—she saw a tornado approaching and followed the weatherman's advice. When she emerged from the closet, she found the remainder of the house in ruins around her.

Preparedness pays off. It is the greatest single hope for saving lives when a tornado strikes. So act now. When a tornado approaches, time is running out. Preparedness gains seconds, and seconds save lives. □

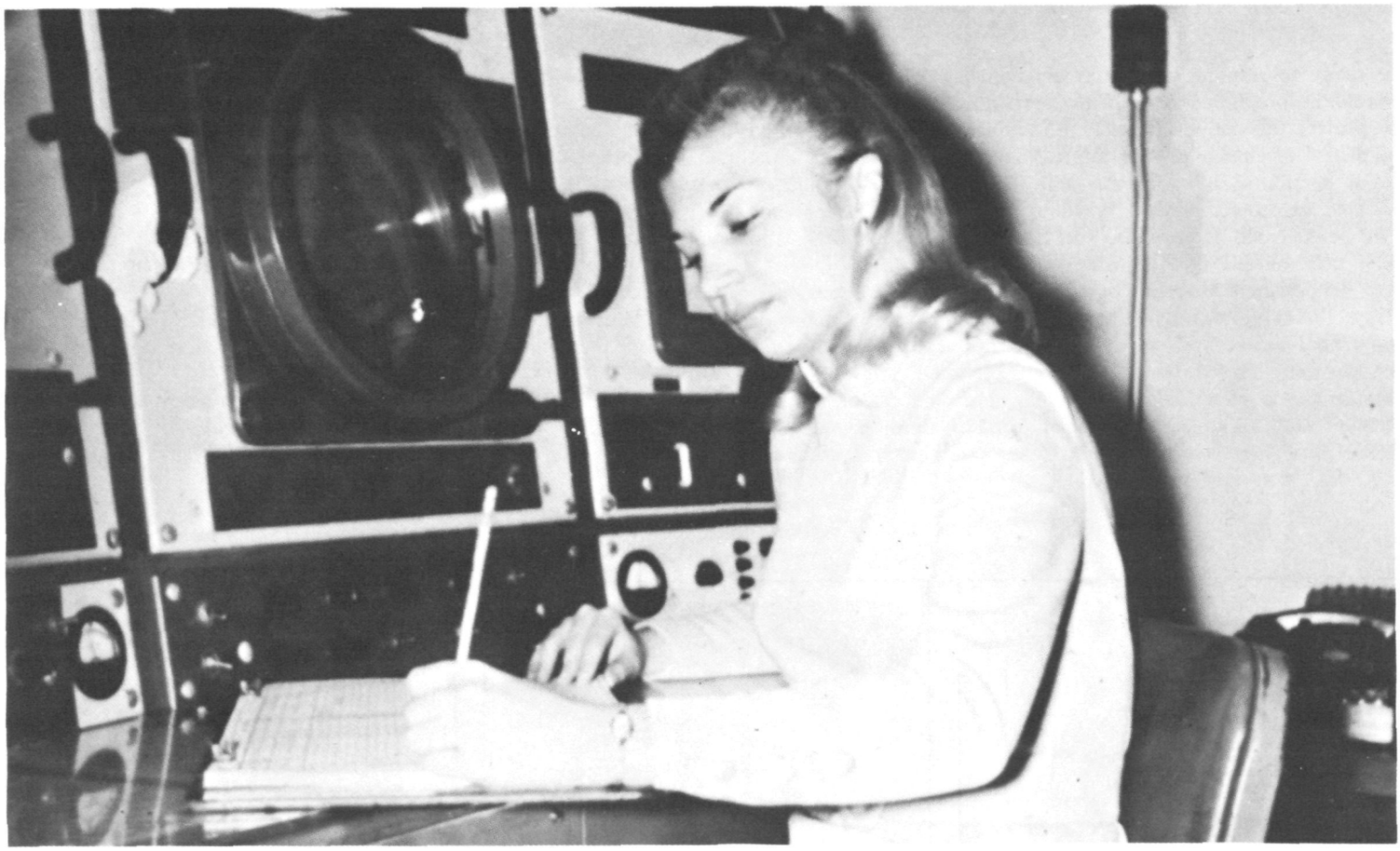


2. A sturdy workbench or heavy table placed in the basement will shield you and your family from falling debris.

3. School bus drivers should know how to protect their young passengers by leading them to safety in a ditch or ravine.



4. Your community's hospitals, nursing homes, and similar institutions have a responsibility for protecting the old and the sick.



St. Louis student trainee Patricia Ann Buder

When summer comes to ESSA, so do the students

it's the young season

Thoughts of the summer season ahead bring to mind visions of beaches, outdoor activities, relaxation.

But for many high school and college students, summer is the time to acquire career experience, and to earn money needed to continue their education.

Each summer, ESSA employs close to 400 students—about four for every hundred regular employees—and hopes to be able to hire more in future years.

In addition to their paychecks, the students gain valuable work experience related to their career goals; ESSA gains the assistance of an intelligent group of young people, with a high probability of retaining them in the agency after graduation.

Whenever possible, they are given challenging, productive assignments related to their interests and capabilities. At weather stations they learn to make precise scientific measurements of temperature, atmospheric pressure, visibility, cloud heights, and upper level winds. They reduce data, learn weather codes, and work with communications systems.

"I can't recommend the program heartily enough," says Patricia Ann Buder, a junior meteorology major at St. Louis University, who was appointed to a student trainee position at the St. Louis Weather Bureau last year.

Student trainee appointments are limited to college students majoring in physical science or mathematics who have completed at least one full year of college-level work. The initial appointment qualifies the student for employment in succeeding summers until graduation, and thereafter the employee may be given a full-time professional appointment without another examination. This program has proved to be an effective means of recruiting for professional positions, with 65 to 70 percent remaining with the agency. Although most of ESSA's student trainees are meteorology majors, plans are to expand hiring in other scientific fields and to increase the number of appointments.

After Patricia Ann Buder passed the student trainee examination, a position was allotted for her at the St. Louis Weather Bureau Forecast Office. She was assigned to work in communications, collection of river data, public service activities, and weather observations. Patricia easily passed the tests qualifying her to take aviation and surface weather observations, and will probably qualify next summer as a pilot weather briefer.

"The student trainee program is an excellent opportunity," Patricia says. "It is seldom that a student finds summer employment in his chosen field, as he does not as yet have enough background to be of much value to a company. Thus, the Weather Bureau summer program is unique in that it allows a relatively inexperienced person to begin training in meteorological capacities."

Describing her work at the St. Louis Weather Bureau, Miss Buder continued: "I found my student traineeship a valuable and rewarding experience. Basically, the training program was rather informal, but well organized. The arrangement was for a combination of personal instruction from various employees, individual study, and on-the-job training. This proved to be more than satisfactory. The administration and employees were quite generous with their time and extremely patient with the multitude of questions I asked. Someone was always there to help out; the cooperation and friendliness soon made me feel an integral part of the operation. I was given time to study observational techniques and, when qualified, placed in positions to train under supervision.

"This summer, I was trained in three capacities: observations, communications, and some hydrological duties. I found each of these quite interesting, and in retrospect I must say that I am grateful for having trained in more than one position. To be valuable to the Weather Bureau, an employee must be able to perform in various capacities, and I think it is very important that the trainee is initiated to appreciate this.

"At the St. Louis Forecast Office, I found the working conditions to be most pleasant. The employees' morale is high, there is cooperation between administration and employees and unified effort in trying conditions, such as severe weather.

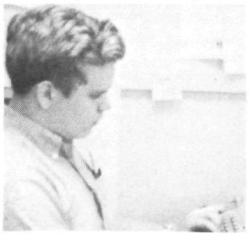
"I feel fortunate indeed to have participated in the program, and I eagerly anticipate returning next summer."

Of interest to the high school student is the ESSA Junior Fellowship Program. To qualify as a Junior Fellow, a candidate must be a high school senior in the upper 10 percent of his graduating class, in need of financial assistance to continue his education. Furthermore, the student must have applied or been accepted for admission to a four-year college and be interested in a field of study related to ESSA's mission, such as mathematics, computer science, engineering, or the physical sciences. Candidates are nominated for these positions by their high school principals or counselors, and from among the nominees the most qualified are selected for appointment. A Junior Fellow can earn more than $1300 in his first year of employment, and the rate of pay rises in each of the following two years of employment.

During the past summer, ESSA supported 34 Junior Fellows in Washington, D. C.; Boulder, Colo.; Asheville, N.C.; and Norfolk, Va. In the Washington area, they are Department of Commerce Junior Fellows; those appointed elsewhere are ESSA Fellows. In 1970, appointments may be extended to other field locations.

The 17 Junior Fellows who worked last summer at ESSA's Research Laboratories in Boulder, Colorado, performed such tasks as computer programming, preparing topographical maps from aerial photographs, operating field antennas and other electronic equipment to observe thunderstorms, and observing activity on the surface of the sun.

Among the Junior Fellows was Leonard Broline, a 1969 graduate of Boulder High School, who entered the University of Colorado in the fall. A top scholar, he already had developed interests in astronomy and computers and had learned Fortran IV computer language.



Leonard Broline

Leonard began working part-time in the World Data Center in April. (Junior fellowship appointees may begin their employment during the Easter holidays, if they wish.) Initially, he was assigned to assist the Center's computer programmer, and to perform key punching, sort and pack data for storage, and to do general clerical work. By the beginning of July, he was writing programs and using the CDC 3800 computer. According to his supervisor, "His performance exceeded all expectation. He can be given a problem which he analyzes and then is able to write a program to solve it."

The college senior who coordinated the 1969 Boulder Junior Fellowship program reported: "The program, as employed at the Boulder Laboratories, could be considered an outstanding success. High school graduates were able to gain experience far superior to that they could find elsewhere in Boulder, a university community. Since there are so many students needing temporary and part-time employment, many find it necessary in their junior and senior years to take jobs as clerks and carryouts in grocery stores or as waiters and busboys in restaurants—often at wages lower than the minimum wage. Most students complete their formal education without any practical experience in the field in which they receive their degrees. The Junior Fellows were able to contribute meaningfully to the efficiency of the Boulder Laboratories, as well as to improve themselves."

By far the largest group of ESSA's summer employees is hired under the disadvantaged aid program, designed to encourage needy high school or college students to continue their education. Candidates are certified by local employment services on the basis of relative economic need. This program is particularly valuable in that it introduces disadvantaged youth to a work environment, overcomes some of their basic fears or misconceptions, gives them the satisfaction of earning needed money through productive effort, and develops work habits that help them to obtain and hold jobs in the future.

In 1969, 247 young people worked for ESSA under the disadvantaged summer aid program. According to the coordinator of this program: "The most amazing thing was the initiative those youngsters had in seeking jobs for the summer. In many cases, they were the only ones in the family earning a salary. In almost every case, they worked very hard to learn the job. Absenteeism and tardiness were at a minimum, and their conduct and dress was something to be proud of. It was evident from our first meeting that these boys and girls wanted to be introduced to the world of work.

"Summer aids were assigned such jobs as operating copying machines, serving as office secretary when the regular secretary was on vacation, typing, registering field survey records, operating teletypewriters, tabulating climatological data, taking radar observations, filing, and operating card punch machines, mimeographs, and fork lifts. The disadvantaged were a real advantage to ESSA."

Christopher Davies has been an ESSA aid for three years, working full-time during the summer and part-time in the winter. A graduate of Roosevelt High School, Christopher attends the Washington Technical Institute, studying aeronautical technology. After completing the Institute's two-year course in August of 1970, he plans to work as an aircraft mechanic. He hopes eventually to study for a degree in aeronautical engineering.

Christopher Davies

At ESSA, he works in the Distribution Division, filling orders for aeronautical and nautical charts. With his salary, he pays for all his schooling.

Now, as spring begins, ESSA looks forward to summer 1970, and the return of Patricia Ann Buder, Leonard Broline, Christopher Davies, and their fellow students.

Those who would like to join their ranks may obtain further information from the following sources:

Junior Fellowship Program—Contact your nearest ESSA installation or write Chief, Employment, ESSA, 6010 Executive Boulevard, Rockville, Maryland 20852.

Summer Aid Program—Apply at your State Employment Service and, if determined to be eligible, contact your nearest ESSA installation.

Student Assistant position—Write to the nearest U. S. Civil Service Office for CSC Announcement #414. After taking and passing the examination, contact your nearest ESSA installation.

Student Trainee positions—Write to your local U. S. Civil Service Office for their current CSC Announcement for Trainees in Vocation Work-Study Programs. When you have received a Notice of Rating, contact your nearest ESSA installation.

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

ESSA Scientists Honored by AMS At Weather Services Centennial

The Weather Bureau's hydrologic services were given a special award by the American Meteorological Society at its honors luncheon, held in connection with the Centennial of the Weather Services in Washington on February 12.

WILLIAM E. HIATT, Weather Bureau Associate Director for Hydrology, accepted on behalf of his service. The award cited the Weather Bureau for "providing early forecasts and warnings of the spring floods of 1969 in the upper midwest part of the nation, thereby permitting advance cooperative action by federal, state, and local authorities and preventing great damage and loss of life."

Other ESSA scientists honored by the AMS at the luncheon:

DR. KIRK BRYAN, of the Geophysical Fluid Dynamics Laboratory, received the Harald Ulrish Sverdrup Gold Medal, last awarded in 1966, for "his outstanding contributions to the numerical solutions of the general circulation of the oceans based on non-linear, three-dimensional models of the oceans driven by wind stress and differential heating."

HARLAN K. SAYLOR, chief of the National Meteorological Center's analysis and forecast division, received the Award for Outstanding Service by a Weather Forecaster, for "the extraordinary synoptic insight and forecasting skill which he has applied over many years to the effective blending of human judgment with machine calculation of the National Meteorological Center."

WILLIAM L. SMITH of the National Environmental Satellite Center received the Meisinger Award for "developing a technique for converting satellite spectrometer measurements to vertical temperature profiles which permitted immediate operational use of the data."

DON T. HILLEARY and DAVID Q. WARK of the Satellite Center shared with RUDOLPH HANEL of NASA and LEWIS D. KAPLAN of the Jet Propulsion Laboratory the Second Half-Century Award for pioneering in "the development of the technique of procuring upper air soundings from earth-orbiting satellites, culminating in the success of the infrared spectrometer on the Nimbus III satellite, which for the first time has provided data for global analyses of the temperature-pressure structure of the atmosphere."

William E. Hiatt

Dr. Kirk Bryan

Harlan K. Saylor

William L. Smith

Don T. Hilleary

David Q. Wark

Bronze Medals Given To Sixteen Employees

Sixteen ESSA employees are winners of the Department of Commerce Bronze Medal for significant contributions to the agency. The Bronze Medal is the highest award a Commerce agency can give an employee. Those honored are:

KENNETH C. TILLOTSON, meteorologist at the Weather Bureau Forecast Center, Denver, Colo., "for significant improvement in aviation training methods and briefing procedures which contributed to the safety of the flying public."

MRS. JULIA H. BANKOVSKY, supervising operating accountant in the ESSA Finance Division, "for dedicated service and valuable contributions to the accounting operations of ESSA."

MRS. LUCILLE R. WILLIAMS, supervisory distribution assistant in the Coast Survey's Office of Aeronautical Charting and Cartography, Distribution Division, "for outstanding leadership through the initiation and implementation of progressive chart distribution policies."

KENDALL L. SVENDSEN, chief of the Analysis Branch of the Coast Survey's Office of Seismology and Geomagnetism, "for his outstanding ability and accomplishment in promoting international cooperation in the field of geophysics."

Continued on next page

Sixteen ESSA Employees (continued)

VAIL P. SCHERMERHORN, supervising hydrologist in the Weather Bureau's Portland, Oreg., River Forecast Center, "for his outstanding knowledge and skill in the field of applied hydrology and for developing subordinate hydrologists to a high degree of proficiency in streamflow and flood forecasting."

SIDNEY O. HOWICK, meteorological technician at the Portland, Oreg., Weather Bureau Forecast Office, "for sustained superior performance in the technical direction of climatic and hydrologic substations in the state of Oregon."

CHESTER L. GLENN, service operations evaluation meteorologist, Weather Bureau Western Region headquarters, Salt Lake City, "for sustained superior service to the Weather Bureau spanning a period of three decades."

JOE M. SASSMAN, meteorologist in the Operations Division of the Weather Bureau's Southern Region headquarters, Fort Worth, Tex., "for expertise in both meteorology and aviation services and an unusually high degree of devotion to duty."

JAMES B. ELLIOTT, meteorological technician in the Weather Bureau Forecast Office, Birmingham, Ala., "for outstanding performance of duties and his contributions in the area of public service."

ALBERT C. FLAHIVE, meteorologist in the Weather Bureau Forecast Office, Boston, "for exceptional ability in forecasting severe storms contributing to the prevention of possible injury or loss of life."

JOSEPH T. HARDEN, meteorologist in charge of the Richmond, Va., Weather Bureau Office, "for outstanding leadership and commendable and dedicated public service over a long period of years."

ERNEST C. JOHNSON, meteorologist in charge of the Albany, N.Y., Weather Bureau Office, "for commendable and dedicated public service over a long period of years."

ALFRED B. KLINE, meteorological technician at the Williamsport, Pa., Weather Bureau Office, "in recognition of many years of dedicated and effective service to the Weather Bureau and to the general public."

FLOYD H. PEARSON, meteorologist in the Weather Bureau Office, Detroit, Mich., "for extremely competent fulfillment of forecasting, supervisory, and user contact responsibilities for a prolonged period."

MRS. LILLIAN V. COTTONY, librarian at the ESSA Research Laboratories, Boulder, Colo., "for a decade of meritorious library service and superior contributions to the scientific program of the Boulder Laboratories."

PAUL W. SORENSON, official in charge of the Flagstaff, Ariz., Weather Bureau Office, "in recognition of dedicated and superior service to the Weather Bureau and to the citizens of Arizona."

all in the family PERSONNEL NOTES

Dr. Harry P. Foltz, former chief of the Weather Bureau's Public Weather and Warnings Branch, is now chief of the Weather Analysis and Prediction Division. A native of Tacoma, Wash., Dr. Foltz joined the Weather Bureau at Los Angeles in 1944. He served in the Weather Bureau facilities at Washington, D.C.; Seattle, Wash.; and Anchorage, Alaska, before joining the Bureau's headquarters staff in 1967.

Jerrold A. La Rue has succeeded Reinhardt C. Schmidt as meteorologist in charge of the Washington, D.C., Weather Bureau Forecast Office. Mr. La Rue, who has worked in the Analysis and Forecast Division at the National Meteorological Center, Suitland, Md., since 1957, was formerly chief of the division's Surface Analysis Branch. He joined the Weather Bureau in 1951 at Peoria, Ill.

John Thomas recently became the Weather Bureau Eastern Region's Regional Hydrologist. Mr. Thomas was formerly assigned to the Office of Hydrology located at Weather Bureau headquarters. His other assignments were at Columbia, Mo.; Louisville, Ky.; Fort Wayne, Ind.; and at the River Forecast Centers at Hartford, Conn., and Fort Worth, Tex.

Lt. William M. Noble has been named Command Pilot of the Coast Survey's DeHavilland Buffalo aircraft. Lt. Noble joined the Coast Survey in 1964 and has logged over 600 hours of multi-engine pilot/co-pilot time, including 191 hours as pilot of the Buffalo. The Buffalo is operated by Photo Mission I, which Lt. Noble heads.

Richard M. Reesor, a veteran of 14 years with the Weather Bureau, has been appointed official in charge of the Rockford, Ill., weather office, succeeding Wendell A. Porth, who is now meteorologist in charge at Shreveport, La. Mr. Reesor served at Chicago, Ill., and at Flint, Mich. Mr. Porth, whose Weather Bureau career began at Elko, Nev., in 1955, served at Reno, Nev.; Sacramento, Calif. Juneau, Alaska; Duluth, Minn.; and Detroit, Mich., before moving to Rockford in 1965.

Lt. John O. Rolland has become the new executive officer of the USC&GS Ships RUDE and HECK. Lt. Rolland was formerly assigned to the ESSA Computer Division at Suitland, Md. He joined the Commissioned Corps in 1965.

Lt. Cdr. Raymond L. Speer is serving as operations officer aboard the USC&GS Ship SURVEYOR. Lt. Cdr. Speer's last assignment was as chief of the Coast Survey's Flight Operations Group.

Donald L. Carte, former supervising observational specialist at the Great Falls, Mont., Weather Bureau Office, has assumed the position of official in charge of the Quillayute, Washington, weather office.

Melvin K. Hull was recently named named meteorologist in charge of the Eureka, Calif., Weather Bureau Office. He assumed his new position after serving as leading fire-weather forecaster at Eureka since he joined the Bureau in 1966.

Cdr. Wayne L. Mobley now heads the Processing Division at the Coast Survey's Atlantic Marine Center, Norfolk, Va. Cdr. Mobley was formerly commanding officer of the USC&GS Ship WHITING.

Lt. Cdr. William R. Curtis is the new operations officer of the USC&GS Ship MT MITCHELL, based at Norfolk, Va. His previous assignments were at the National Environmental Satellite Center and aboard the USC&GS Ship EXPLORER. He joined the ESSA Commissioned Corps in 1965.

Vincent F. Callaway has been transferred to Winnemucca, Nev., as official in charge. He entered the Weather Bureau in 1947 at Portland, Oreg. Subsequent assignments included several stations in the Pacific and Western regions.

John Marsh, Reno, Nev., meteorological technician, has been selected as the new official in charge of the Red Bluff, Calif., Weather Bureau Office. Mr. Marsh joined the Bureau in 1945 at Winslow, Ariz. His later assignments were at Bishop and Santa Maria, Calif., and, for the past 14 years, at Reno, Nev.

Jack J. Cobb has accepted a two-year assignment as official in charge of the Weather Bureau Office at Koror in the Caroline Islands. When he completes his assignment, he will return to Pacific Region headquarters as upper air specialist.

Paul E. Woolard, 19-year Weather Bureau veteran, is official in charge of the Norfolk, Nebr., Weather Bureau Office. His experience includes more than three years as head of the Guam weather office in the Pacific, and one year in charge of the Pacific Missile Range Unit of the Bureau at Barking Sands, Kauai, Hawaii.

Cdr. Melvin J. Umbach, USESSA, has assumed command of the USC&GS Ship WHITING. Cdr. Umbach joined the Coast Survey after graduating from Northeastern University. His most recent assignment was as executive officer of the USC&GS Ship MT MITCHELL.

Earthquake Publication Issued by Coast Survey

A reminder that earthquakes are still very much part of living on a restless planet comes from the January-February 1970 issue of the EARTHQUAKE INFORMATION BULLETIN, a new ESSA bi-monthly periodical.

Compiled and edited by seismologists and editors of the ESSA Coast and Geodetic Survey's National Earthquake Information Center, the BULLETIN attempts "to bridge the long-existing gap between the technical reports of the seismologist and the need of the layman for earth science information he can understand and use."

The March-April 1970 issue discusses a new magnetic sensor and what it could mean to earthquake prediction, seismic and magnetic observatory work in Alaska, and shake tables that test instruments by simulating seismic motions. Departments feature an earthquake history of Alaska and a roundup of world earthquakes from July through December 1969.

The EARTHQUAKE INFORMATION BULLETIN is available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 20402. Annual subscriptions are $1.50 with 50 cents additional for foreign mailing. Single copies are 30 cents each.

Twenty ESSA Scientists Join Antarctic Research Program

Twenty ESSA scientists are participating in the 1969-70 U.S. Antarctic Research Program, and will be conducting experiments and research on various aspects of the Antarctic environment over the year. Their work is financed by the National Science Foundation, which coordinates and funds the overall U. S. Antarctic program, in which about 230 American and foreign scientists are participating.

Seven ESSA men will spend the Antarctic winter on the continent; the remainder will conduct their research during the Antarctic summer. Two will serve as scientific leaders during the winter at the South Pole and McMurdo stations. They are Frank H. Merrem, Jr., at the Pole, and James R. Webb at McMurdo. Both are from the ESSA Research Laboratories. C&GS personnel will operate seismological and magnetic observatories at the South Pole and Byrd stations. Weather Bureau men will take meteorological observations at South Pole and Byrd stations. Special measurements of solar and long-wave radiation and of ozone, both at the surface and aloft, will be made at the South Pole station. Weather Bureau meteorologists will also provide operational weather support to U. S. Navy aircraft during the summer flying season. Scientists of the ESSA Research Laboratories will study the propagation of very-low-frequency radio waves as they travel over long distances; ultra-low-frequency disturbances in the outer magnetosphere; the causes of short-term fluctuations in ionospheric phenomena; and the radio wave absorption properties of the ionosphere. F. Michael Maish will continue research he carried out at Vostok during the 1969 winter. A Soviet scientist will operate the equipment after Maish's departure.

ESSA scientists participating in the Antarctic Research Program are:

Wintering Party 1970
C&GS—Charles R. Hutt (South Pole); Robert Kohler (Byrd). Weather Bureau—Marvin Kempton (South Pole); Dennis Walts (South Pole). ERL—Madison J. Post (Byrd); James R. Webb (McMurdo); Frank H. Merrem (South Pole).

1969-70 Summer Party
C&GS—Clyde J. Beers (Byrd). Weather Bureau—Robert D. Grass (Byrd); Henry Meyer (Byrd); Robert Newland (Byrd); Reginald Preston (Byrd); Henry Smoot (Byrd); Harold Emery (South Pole); Donnie Musgrove (South Pole); Norris Nielson (South Pole). ERL—Warner L. Ecklund (Byrd); John E. Jones (Byrd); Allan H. Shapley (Byrd); F. Michael Maish (Vostok). Shapley is the Research Laboratories' Antarctic Coordinator and the Director of its Office of Programs.

In addition, eight technicians of the Coast Survey continued their work in the worldwide satellite triangulation program, completing the Antarctic phase in February 1970.

C&GS Expands Tsunami System In the Pacific

The Coast Survey is expanding and improving the Tsunami Warning System in the Pacific by the addition of 14 seismic observatories and tide stations and by the installation of new instrumentation at various sites in the network. The system furnishes warnings to 14 countries and territories in the Pacific Basin of the danger of the great waves spawned by earthquakes beneath the ocean.

Participation of six seismic observatories at Wellington, New Zealand; Port Moresby, New Guinea; Suva, Fiji Islands; Tacubaya, Mexico; Antofagasta, Chile; and Easter Island is expected to expedite the determination in certain areas of earthquake epicenters and provide a greater degree of accuracy.

The addition of eight tide stations at the Galapagos Islands off Ecuador; Marsden Point, New Zealand; Rikitea, Gambier Isles in the South Pacific; Okinawa; Amchitka, Aleutian Islands; Salina Cruz and Manzanillo, Mexico; and Talara, Peru, should help reduce tsunami detection times and provide additional data for tsunami evaluations.

New instrumentation will include visible recording seismograph systems and electronic recording tide gages. In addition, remote recording systems will be supplied to all tide stations in the network which do not have them and which have a need for them. U. S. support consists of technical assistance in the installation of loaned equipment, which will then be operated by the recipient stations at their expense.

NEW WB FORECAST OFFICE AT N.Y.U.

A new Weather Bureau Forecast Office has been established on the Bronx campus of New York University.

The move to N.Y.U. took place on Jan. 5, when the aviation forecast facilities, formerly at Kennedy International Airport, were merged with the public, marine, and agricultural forecast operations formerly located at Rockefeller Plaza. (The Weather Bureau Office at Rockefeller Plaza will remain as the weather service office to the news media and public for the greater tri-state metropolitan area).

The Bronx office will provide the basic aviation, public, and marine forecasts for the greater metropolitan New York area, including Long Island, northern New Jersey, and Connecticut; marine forecasts for coastal waters and aviation terminal forecasts for the surrounding airports, and in addition, domestic aviation briefing service and documentation for international flights to Europe, Canada, and the Caribbean.

David L. Coveney, formerly principal assistant at Kennedy, has been appointed Meteorologist in Charge of the Weather Bureau Forecast Office.

Milton J. Fayne is Mr. Coveney's principal assistant. He moves to the Bronx office from Rockefeller Plaza, where he served as principal assistant and supervisory forecaster since 1965.

Over 300 Quakes Felt During 1969 In United States

More than 300 earthquakes strong enough to be felt or cause some damage were reported in the United States last year, but for the fourth successive year there were no fatalities, the National Earthquake Information Center has disclosed.

The last earthquake fatalities in the U. S. resulted from a 1965 tremor in Seattle, Wash., in which seven died.

Of 303 earthquakes felt in 22 states, California had the most, with 91 reported. Runner-up for this dubious honor was Montana with 83. The NEIC said this was unusual for Montana and resulted from a series of small earthquakes. The last serious tremor in Montana occurred in 1959 at Hebgen Lake, when 28 died.

Alaska was third on the list of felt earthquakes with 51. The NEIC said there were more and stronger earthquakes in the 49th state in 1969, as in previous years, than in California, but fewer were reported because of the sparse population. California, on the other hand, is the nation's most populous state. California and Alaska are usually first and second, but not necessarily in that order.

Hawaii was fourth with 43 earthquakes, caused largely by the state's two active volcanoes, Mauna Loa and Kilauea. These tremors rarely cause damage or fatalities.

Washington was fifth with five earthquakes, and Texas and Idaho were tied for sixth with four each. Utah had two earthquakes and 13 states reported one each. These were Arizona, Arkansas, Missouri, Nevada, New Jersey, New Mexico, New York, North Carolina, Oklahoma, Oregon, Tennessee, Virginia, and West Virginia.

Extended Outlook Now Issued Daily

On the 100th anniversary of the United States national weather services, the Weather Bureau inaugurated a new public service.

Supplementing their usual predictions for today and tomorrow, Weather Bureau offices throughout the nation now issue—every day—outlooks for the third, fourth, and fifth days in the future. For example, the local forecast issued Monday evening gives the weather for Monday night, Tuesday, and Wednesday; the new extended outlook adds the weather and temperature trends for Thursday, Friday, and Saturday. Previously, five-day forecasts were released only three times a week.

The extended outlook program has been made possible by advances in computer prediction at the Weather Bureau's central forecasting facility—the National Meteorological Center. These advances permit more specific forecasting for extended periods.

Every day, the National Meteorological Center prepares and disseminates to Weather Bureau field stations maps of expected 24-hour precipitation, departures from normal maximum and minimum temperatures, and the forecast positions of highs, lows, and frontal systems for three, four, and five days ahead. These maps serve as the basis for the extended outlook released by local Weather Bureau offices.

Improved Satellite Launched and Operating; Expands Environmental Observing Capability

The National Aeronautics and Space Administration's ITOS-1 (called TIROS-M before launch) spacecraft was successfully launched from the Western Test Range, Lompoc, Calif., January 23 at 6:31 EST.

The ITOS-1 spacecraft is a prototype of the Improved TIROS Operational Satellite (ITOS), which will become the vehicle for ESSA's operational system.

ITOS-1 and the first three spacecraft in the operational ITOS series include: two Advanced Vidicon Camera Systems (AVCS); two Automatic Picture Transmission (APT) systems; two dual-channel scanning radiometer systems; a low-resolution flat plate radiometer; and a solar proton monitor.

The new satellite combines in one vehicle the Automatic Picture Transmission and the global picture storage capabilities that require the launch of separate spacecraft in the present operational system. Thus, fewer launches will be needed to keep the system in operation.

The scanning radiometer systems will provide data in both visible and infrared channels. The infrared data—the first to be available on an operational basis—can provide cloud pictures at night as well as during the day.

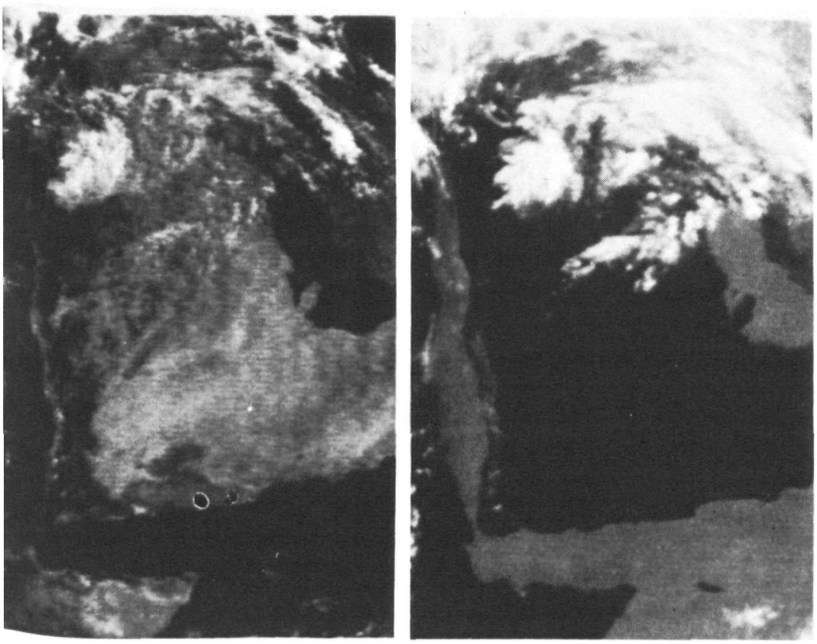
The infrared channel of the scanning radiometer provides temperature measurements at the surface in clear air, or at the tops of clouds. Its signals can be fed into a computer to convert the cloud-top temperatures into cloud-top heights and to prepare a map of cloud-top topography.

In addition, the radiometers will provide surface temperature readings necessary for computation of atmospheric temperature profiles from soundings made by the Satellite Infrared Spectrometer aboard Nimbus III.

The low-resolution flat plate radiometer system is similar to those included in previous ESSA spacecraft and will continue gathering data on the earth's heat balance.

Addition of the solar proton monitor in the ITOS series presages the expansion of the environmental sensing capabilities planned for future operational satellites in the ESSA series. The solar proton monitor will count the energetic particles encountered in orbit. Tape-recorded data will be relayed via an ESSA Command and Data Acquisition station to the National Environmental Satellite Center for processing and calibration. The information will be used by the Space Disturbances Laboratory in Boulder, Colo., for detection and warning of solar storms.

Unlike the existing operational satellites, the ITOS spacecraft, is large enough to hold additional environmental sensors. Among those planned for later spacecraft are vertical temperature profile sounders—similar to the Satellite Infrared Spectrometer—to obtain global temperature data for use in numerical weather prediction programs.



The versatile scanning radiometer aboard ITOS-1 shot pictures of the Caspian Sea and Saudi Arabia area during daylight hours (left) and again during total darkness (right) February 11. For the first time, relatively inexpensive ground stations all over the world now are receiving nighttime as well as daytime cloud cover pictures directly from an orbiting spacecraft. In addition, the infrared channel of the scanning radiometer provides temperature measurements at the surface in clear air, or at the tops of clouds. Housing improved technology in one spacecraft rather than in two as in the previous ESSA spacecraft and with a new stabilization system that keeps it constantly pointing toward the earth, ITOS is expected to be longer-lived as well as more economical.

Skywarn '70 is Under Way Through Tornado Areas

"SKYWARN '70" became the Weather Bureau's watchword in January, in an effort to save lives during tornado emergencies. Inaugurated in advance of the 1969 tornado season, SKYWARN is part of ESSA's nationwide Natural Disaster Warning system which provides warnings of impending natural hazards, including hurricanes, floods, winter storms, seismic sea waves, and solar disturbances.

On the state, county, and community levels, Weather Bureau representatives are meeting with public safety officials in areas where tornadoes occur most frequently, to discuss preparedness.

Deep Sedimentary Layers Found Under Bering Sea

A detailed survey of the seabed beneath northern Bering Sea in the area between Alaska and Siberia has uncovered new evidence of the existence of deep sedimentary formations of the type in which oil is often found.

Seismic (sound wave) studies made in the summer of 1969 by the Coast and Geodetic Survey Ship SURVEYOR probed into sedimentary formations estimated to be as deep as 7000 feet.

The findings were disclosed in a preliminary report by the Coast and Geodetic Survey, in collaboration with the U.S. Geological Survey. The seismic studies were made by four geophysicists—Richard B. Perry, the expedition's chief scientist, Fred W. Walton and Harold E. Kaufmann of the Coast and Geodetic Survey, and H. Gary Greene of the Geological Survey. A paper interpreting the seismic studies, including a map showing the estimated depth of the sedimentary formations, will be published jointly later.

Systematically explored during the survey was Norton Basin, which underlies northern Bering Sea with extensive sedimentary deposits containing many geological structures that could trap oil and gas. Norton Basin was discovered during reconnaissance studies conducted in 1967 by the Geological Survey and the University of Washington. The new data obtained by the SURVEYOR will allow a much more accurate appraisal of the petroleum possibilities of Norton Basin and also throw new light on the history of the Bering Sea.

The 1969 studies were spaced 10 miles apart and were not intended to show the details required for the development of petroleum and mineral resources. More refined surveys, usually run by geophysical exploration companies at a closer line spacing, would be necessary. However, a knowledge of the configuration of different geological strata would enable them to determine the areas considered favorable for the accumulation of oil. Actual determination of the type of sediment to be found beneath the northern Bering Sea would require extensive exploratory drilling.

CORRECTION

On page 23 of the January 1970 *ESSA*, the reply to the question, "Do you foresee that aircraft storm reconnaissance will still be necessary?" should have read:

"Unless there is a change in our understanding of hurricanes which would obviate the need for detailed information on pressure, wind, and temperature within the storm, I do *not* think that satellites will do away with aircraft reconnaissance."

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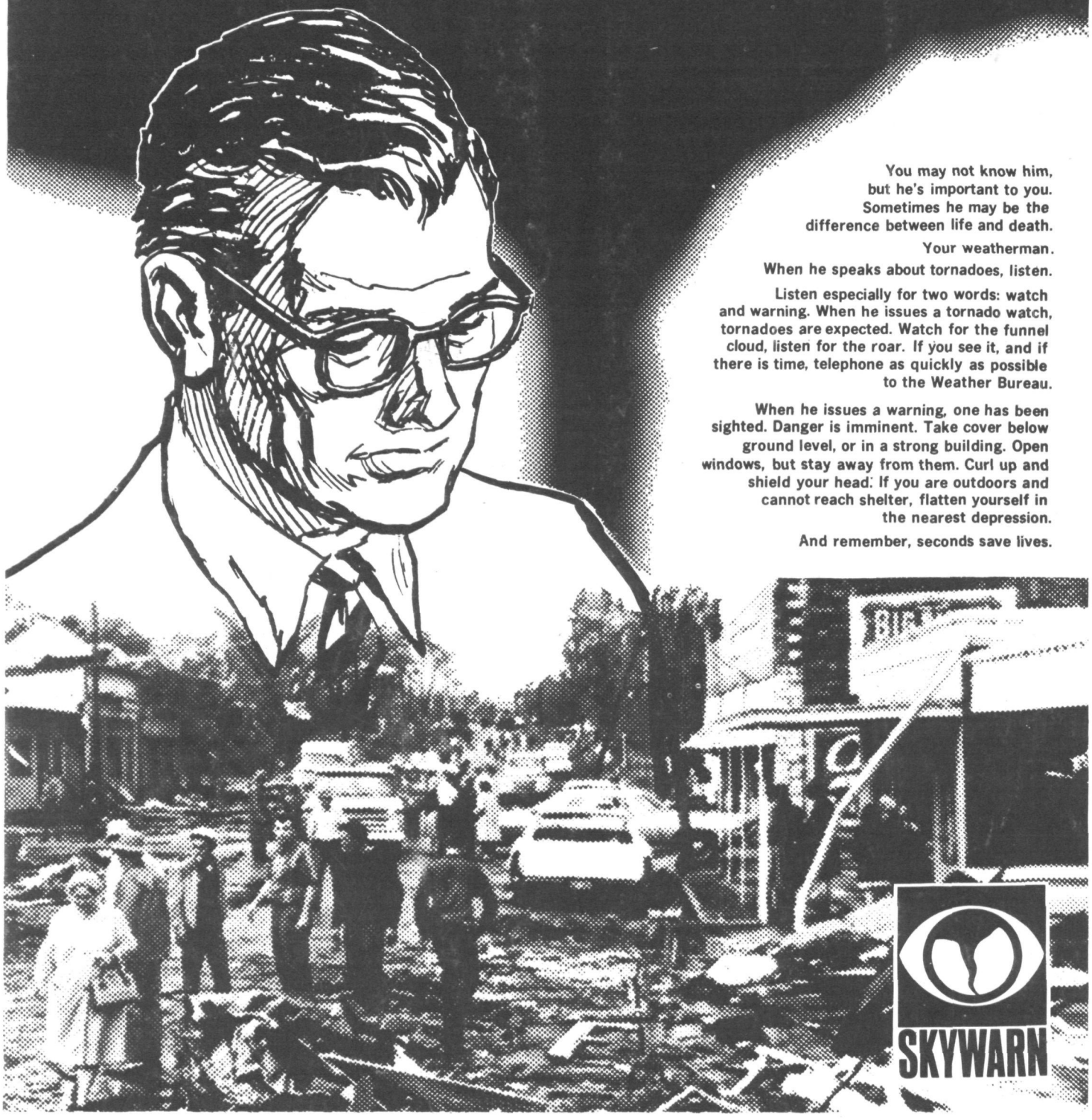

You may not know him, but he's important to you. Sometimes he may be the difference between life and death.

Your weatherman.

When he speaks about tornadoes, listen.

Listen especially for two words: watch and warning. When he issues a tornado watch, tornadoes are expected. Watch for the funnel cloud, listen for the roar. If you see it, and if there is time, telephone as quickly as possible to the Weather Bureau.

When he issues a warning, one has been sighted. Danger is imminent. Take cover below ground level, or in a strong building. Open windows, but stay away from them. Curl up and shield your head. If you are outdoors and cannot reach shelter, flatten yourself in the nearest depression.

And remember, seconds save lives.