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VOL. 118, No. 5 NOVEMBER, 1960

*Powered by the atom, the largest
United States submarine makes naval history
by circling the globe submerged*

Triton Follows Magellan's Wake

By CAPT. EDWARD L. BEACH, USN

Illustrations by National Geographic photographer J. BAYLOR ROBERTS, Comdr., USNR

THERE she stood, alone on a rock where the river meets the sea, the chill February wind whipping the red scarf about her head, the old but still useful coat wrapped tightly around her.

I waved my white cap until I could no longer bear to look. That blue-eyed girl had joined her life to mine during the flaming years of World War II and had watched me sail over the horizon many times since. But this time was like no other.

I was taking the U.S.S. *Triton*, the largest and most powerful submarine in the world, out of Groton, Connecticut, on the voyage submariners had been dreaming of ever since nuclear energy had made it feasible.* Our mission was secret and unprecedented: To circumnavigate the globe along the route Ferdinand Magellan took 441 years before; to do so submerged, unsupported, and unde-

tected; and to bring back new knowledge about the oceans, our ship, and ourselves.

We say ship—not boat, as submarines are generally called—because *Triton*, the first vessel carrying two nuclear reactors, has the horsepower and size of a light cruiser. We need a flying bridge to see in all directions when conning her in a crowded harbor, and when I stand up there, my eye level is 41 feet above water, the height of a modern four-story building. The ship's length is 447½ feet—more than two blocks along Fifth Avenue in Manhattan. Her power supply is a grapefruit-sized chunk of uranium.

From Groton, across the Thames River from New London, it took *Triton* 3½ hours to cross the continental shelf and reach water deep enough for diving. I scrambled down

*See "Our Navy's Long Submarine Arm," by Allan C. Fisher, Jr., NATIONAL GEOGRAPHIC, November, 1952.

At U.S.S. *Triton's* periscope, Capt. Edward L. Beach sights a gaff-rigged merchantman, her decks laden with lumber, in Makassar Strait between Borneo and the Celebes.

A modern Magellan, Captain Beach this year wrote a new chapter in the epic of man against the sea when, running submerged, he conned *Triton* around the world.

After graduation from the United States Naval Academy in 1939, second in his class of 381, Beach saw duty aboard three submarines in the Pacific during World War II. Cited for extraordinary heroism and conspicuous gallantry, he earned the Navy Cross, two Silver Stars, and two Bronze Stars. Out of these experiences came his book *Submarine!* and the best-selling novel *Run Silent, Run Deep*. From 1953 to 1957 he served as naval aide to President Eisenhower. He took command of *Triton* when she was commissioned last November.

At the request of the Department of Defense, the National Geographic Society lent one of its crack photographers, Joseph Baylor Roberts, a commander in the U. S. Naval Reserve, to sail in *Triton* and record her epoch-making voyage.



Tall-masted survivor of the days

into the control room, where the executive officer, Lt. Comdr. Will M. Adams, grinned cheerfully: "Here we go at last!"

I thought, Yes—and we won't surface again for a quarter of a year.

The men were not yet aware of this. They simply knew that we were on our shakedown cruise, to weld ship and crew into a unit.

Traditionally, a shakedown cruise includes a stop at some pleasant foreign port such as Lisbon or Rio. But our crew had already had hints that we were in for a lot more than

that. We had loaded 40 tons of food, including compressed turkey, the bones removed to save space and weight. Though income tax deadline was still two months off, the men had been advised to file their returns before leaving. We had also told them to renew their automobile license plates.

The second day out I requested the officer of the deck's permission to use the general announcing system. The ship gathered itself together in silence. I revealed the full extent of our mission, the contribution we were ex-



HIGH SPEED EXTRACTOR BY NATIONAL GEOGRAPHIC PHOTOGRAPHER J. BAYLOR ROBERTS © N.G.S.

of sail—photographed through the periscope of a nuclear submarine

pected to make to science, to the Navy's Polaris program, and to the prestige of the United States.

Whenever I paused, I had the feeling that a penny dropped anywhere in the ship would have sounded like a hammer blow on an anvil. Around the world without surfacing!

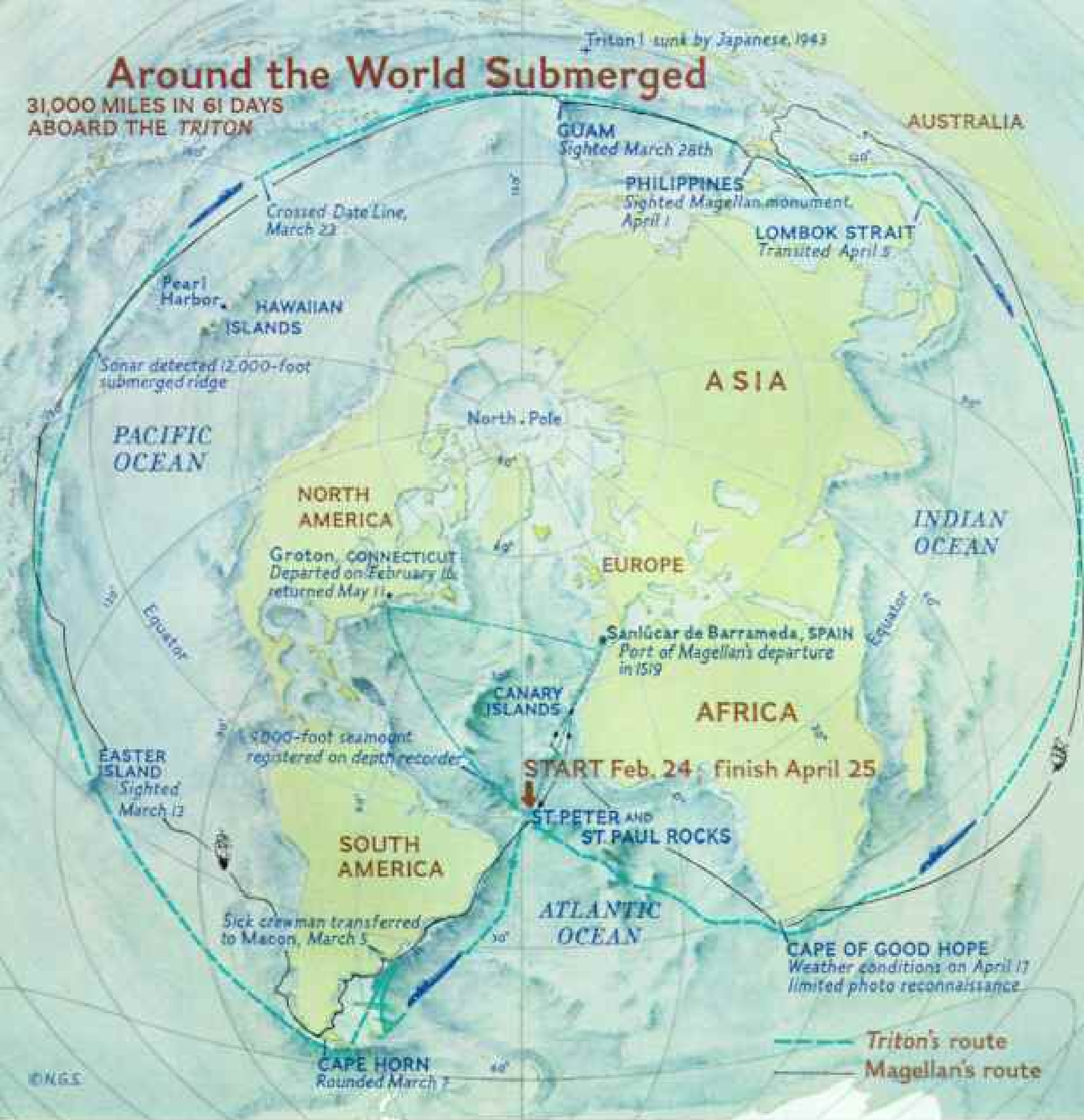
Lively discussions followed. Everyone suddenly realized the importance of the three scientists from the Navy Hydrographic Office and their gear, now installed in our combat information center; of Comdr. Joe Roberts,

USNR, a veteran photographer recalled to active duty to record our voyage for the Navy and the National Geographic Society; and of Dr. Benjamin Weybrew, the psychologist from the Navy's Medical Research Laboratory of New London.

Dr. Weybrew needed 50 volunteers for an especially intriguing task. Every day he would collect confidential questionnaires from them, listing each man's rating of himself in 51 categories: from "Bored stiff" and "Homesick" and "Don't feel like eating," to "Energetic"

Around the World Submerged

31,000 MILES IN 61 DAYS
ABOARD THE TRITON



Triton, on a Super Shakedown Cruise, Circles the Earth Under Water

Averaging 18 knots submerged, the U. S. Navy's longest, heaviest, and most complex submarine followed approximately the course charted by Ferdinand Magellan's expedition of 1519-22. With 184 officers and men, including half a dozen scientists and technicians, *Triton* sailed out of Groton, Connecticut, February 16, 1960. Eight days later, about 600 miles off the tip of Brazil, she reached St. Peter and St. Paul Rocks (page 591), which served as "home plate" for the around-the-world voyage.

From leave-taking to home-coming, the world's first twin-reactor submersible recorded a grand total of 41,814 statute miles in 84 days, 19 hours, 8 minutes. In girdling the globe, she logged 30,752 miles in 60 days, 21 hours. Magellan's expedition took three years. Never once did *Triton* ride atop the waves, but she twice broached—partly surfaced—once off Argentina to transfer an ill crewman to the cruiser *Macon*, and again off Spain to honor the country for which Magellan sailed. National Geographic cartographic artist William N. Palmstrom designed the illustrative maps that trace *Triton*'s voyage. Antarctica's icy fingers appear here in white.



EDDACHHINE © NATIONAL GEOGRAPHIC SOCIETY

Forty tons of food, including 1,820 pounds of coffee, jammed every inch of usable space. Black-eyed peas appeared often on the menu, because—*Triton's* skipper suspects—his executive officer hailed from Texas. These sailors stow sacks below forward torpedo tubes.

and "Happy" and "Want action." Within an hour Dr. Weybrew had his quota.

We traveled at varying depths. Our oceanographer, Nicholas Mabry, recorded temperature and salinity profiles from the surface to below 400 feet. Periodically we rose to periscope depth to listen for messages on the radio, to make our observations, and to revitalize our atmosphere without using our precious oxygen bottles.

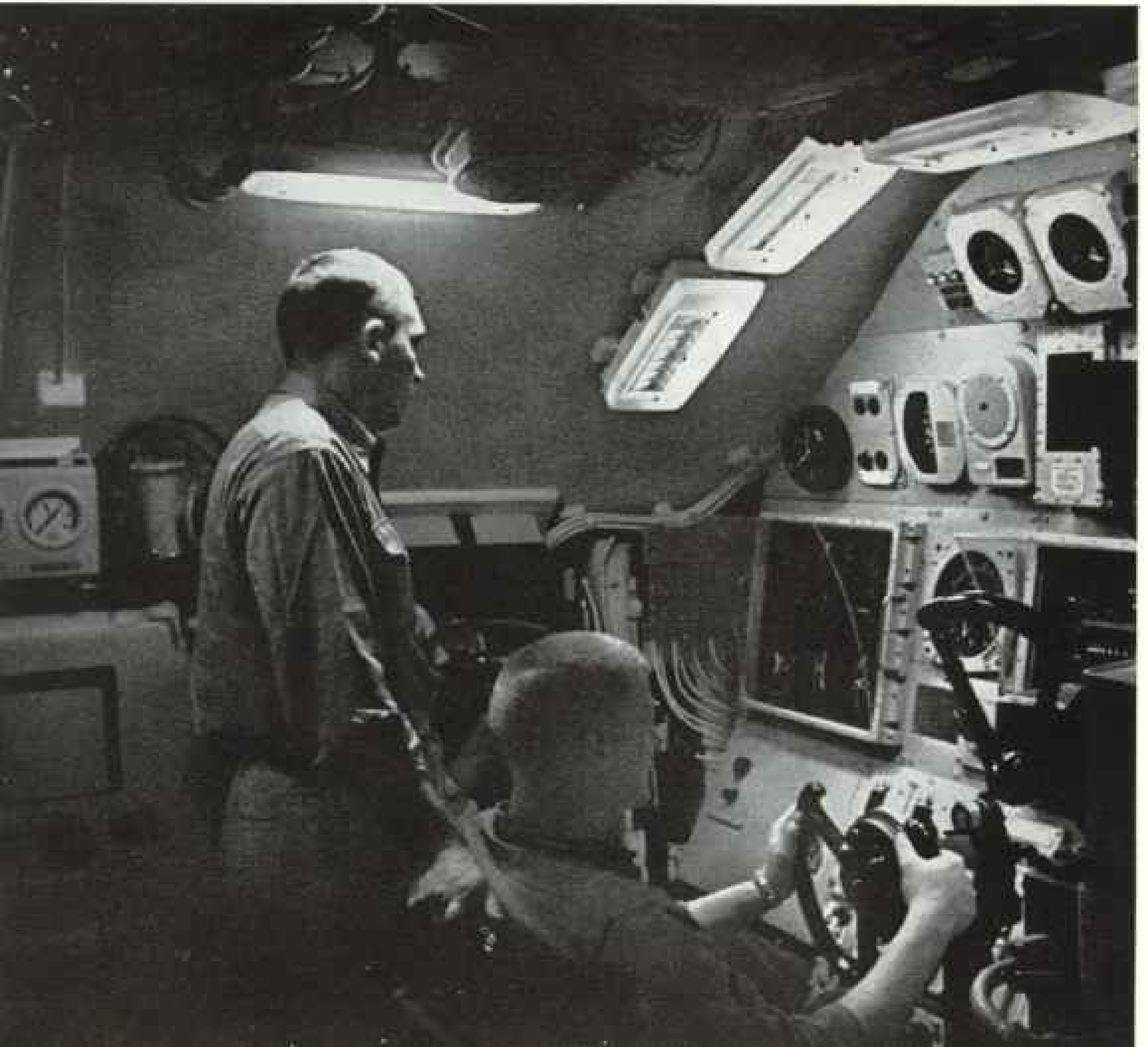
All this necessarily slowed us down. Were *Triton* to make all the speed of which she is capable and at the same time raise her periscopes, masts, and antennas while submerged, they would be bent over and ruined, or snapped off where they emerge from the sail

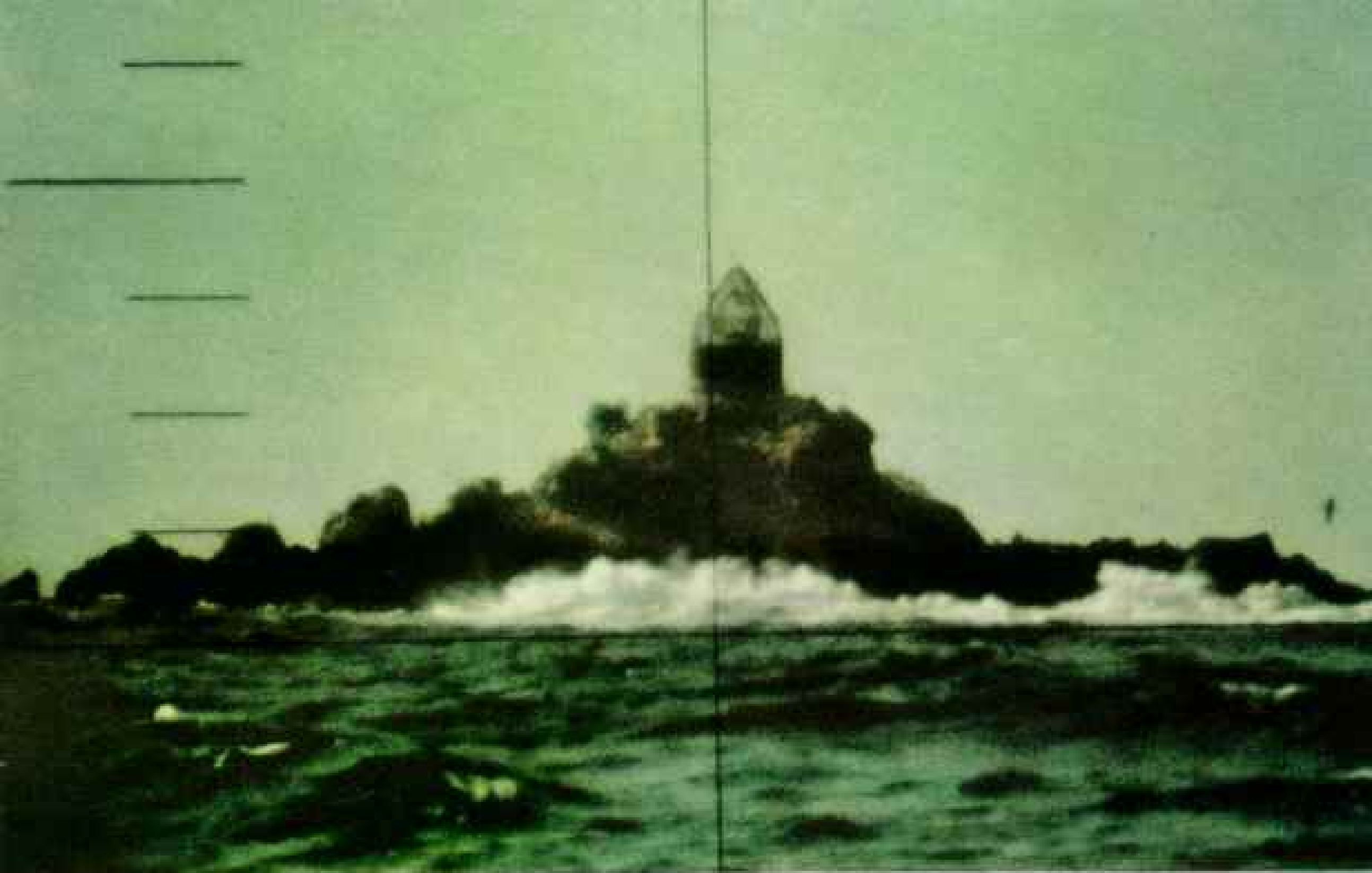
—the tower for periscopes and antennas.

Coming to periscope depths takes time, too, because we must first listen cautiously, at slow speed, for fear of crashing into some innocent ship above. Thus our progress was a bit like that of a heavy truck on a highway—lickety-split on the straightaway (deeply submerged), much slower on the upgrades (to periscope depth).

On February 23, the depth recorder registered a 9,000-foot seamount, one of the two highest encountered on the voyage. And next day our enthusiasm reached a peak when we made our first landfall on St. Peter and St. Paul Rocks, off the coast of Brazil just north of the Equator. The "Rocks" are jagged peaks

Like airplane pilots, planesmen manipulate the diving and rudder controls. Chief of the watch checks gauges that register speed, course, and depth. *Triton's* top speed is secret, but Captain Beach's log points out: "Almost with disbelief, we note what speed we are registering. And, looking at the various gauges of the propulsion equipment, we realize we have but scratched the surface of *Triton's* real potential." A single charge of nuclear fuel about the size of a grapefruit sufficed for the entire run.





68 SEYALIHORRE © NATIONAL GEOGRAPHIC SOCIETY

where the Mid-Atlantic Ridge rises above the surface. (See map on page 588, and the new 10-color Atlas Map *The World*, a supplement to this issue.)

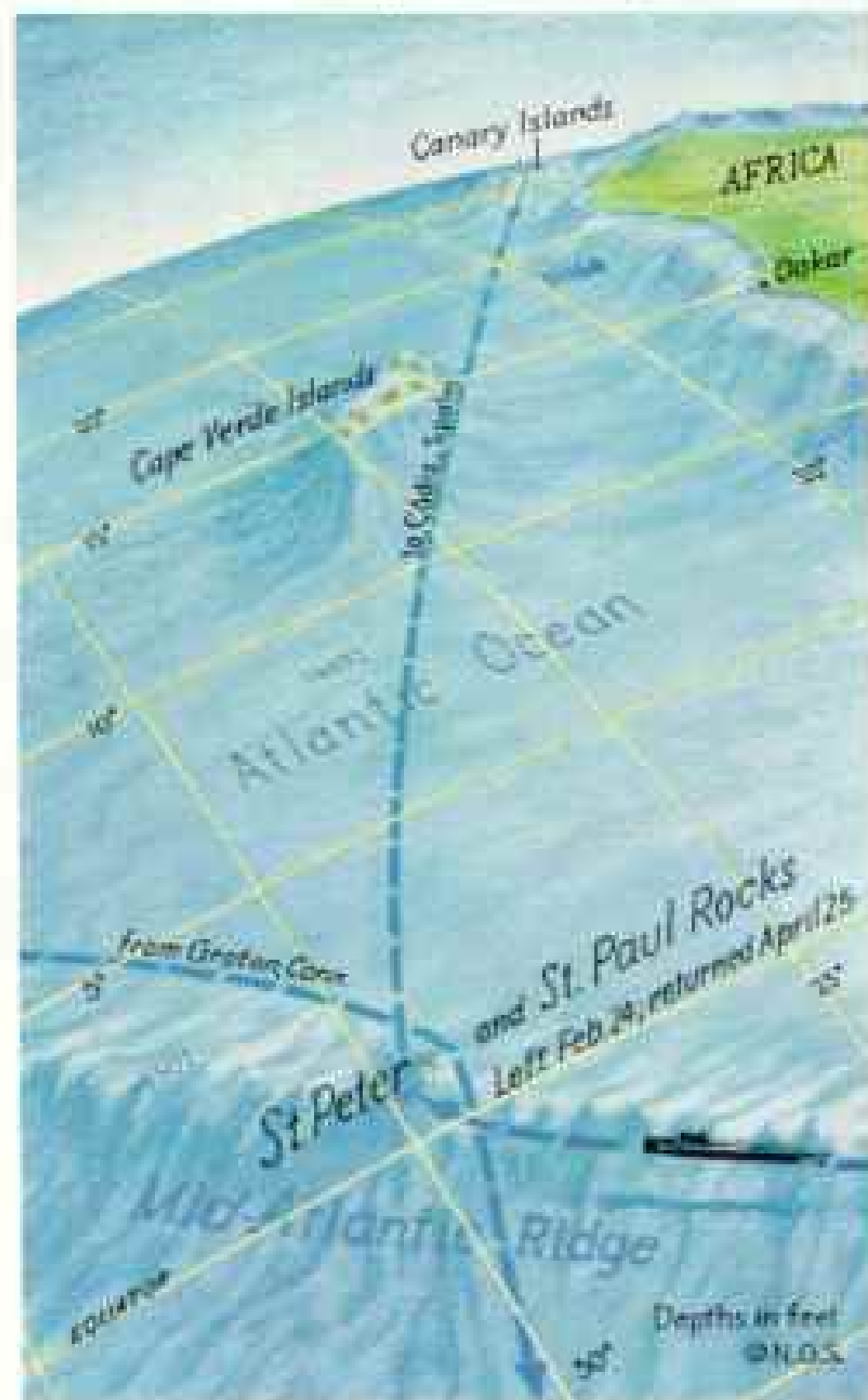
We passed the Rocks to the eastward and set course for the Falkland Islands. The second long leg of the trip and the first leg of the submerged circumnavigation was now underway—and we were in for our first emergency.

On March 1, Chief Radarman John R. Poole suddenly developed a kidney-stone attack, and for the next three days my big worry was what to do about it. Poor Poole was often in extreme pain, and *Triton's* doctor, Comdr. James E. Stark, kept him under heavy sedation during his attacks. Many kidney stones take care of themselves without surgical treatment, but not all. To give Poole proper medical care would require X-rays and other equipment that we did not have.

Captain Faces a Calculated Risk

As if a sick man were not enough to worry about, our echo sounder chose this time to lose sensitivity. Once clear of shallow water, surface ships seldom run their echo sounders, since they are rarely concerned with how deep the water is, provided it is known to be deep enough. But a deep-diving submarine can easily strike bottom on a seamount—like the one northwest of the Rocks—over which surface ships have passed in ignorance for centuries.

Abandoned lighthouse crowns one of the St. Peter and St. Paul Rocks, jagged tips of the Mid-Atlantic Ridge. "It looked," says the author, "like a damaged ship laboriously proceeding at slow speed." Periscope cross hairs center on crashing surf. Other lines help estimate range.





Bearded King Neptune, his cigar-smoking queen, and hefty royal baby (right) take over *Triton* on the first of four Equator crossings. Captain Beach (center) gave Neptune free rein to punish lowly polliwogs—sailors crossing the Equator for the first time—who dared to enter the sea king's realm. As polliwogs knelt before the royal court, the queen broke out a water pistol to squirt the accused in the eye. Crew's mess hall served as a courtroom.

Triton takes its name from a large marine snail, and indirectly from the merman son of Poseidon, Neptune's Greek equivalent.

Royal barbers carve a groove in the hair of an oil-smearing polliwog. Bald-headed initiates got free toupees from hair swept off the floor and stuck fast with grease.

At our speed of 20 knots the impact could crumple our bow like an accordion.

Failure of an echo sounder is so rare that spares are not ordinarily carried. Should we lose ours for good, the cruise would be endangered. But giving up now is unthinkable. Here is the perfect example of the "calculated risk." We shall be calculating it from here on.

Luckily, Lt. Milton Rubb and his electronics technicians put the recalcitrant echo sounder in operation again within a day. A great weight lifts from my mind.

U. S. Cruiser Comes to the Rescue

All during the second of March we drive on toward Cape Horn, while Poole wrestles with his kidney stone and I wrestle with the problem of Poole.

On the morning of the third, with the Falkland Islands visible in our radarscopes, Poole has his fourth attack, by far the most severe. I finally decide to turn back.

The nearest place where help might be available is Montevideo, Uruguay, 1,100 miles north, where the cruiser *Macon* is visiting. We race toward Montevideo with all the furious energy of our twin nuclear plants.

There is only one place in this ship roomy enough for a sick man to have an attendant, and that's my bunk. Jim Stark moves Poole there and warns me before I make a visit: "You'll have trouble talking to him, he's so changed by pain and sedation."

All hands in the ship share the burden, as is customary among submarine crews. The whole tone of the ship lowers perceptibly and tension is evident in a hundred small ways. I catch many sober eyes turned in my direction. My slightest desire, whether for an extra cup of coffee or for some report, is carried out with even greater alacrity than before.

No one in *Triton* will ever forget the instant elevation of our spirits when at last a message assures us that *Macon* is sailing to meet us, and we decide that we can transfer Poole to one of her motor whaleboats without surfacing. Our shipmate will be safe. And our submerged cruise will not be broken after all.

On March 5, at two in the morning, *Macon* and *Triton* made rendezvous in the waters off Argentina; and at ten minutes to three we eased our conning-tower upper hatch out of water (page 595).

Everyone in the transfer party, including Jim Stark, was soaked by the water sweeping over the submerged main deck. Poole,

bundled and swathed for protection against just this eventuality, stepped groggily from the arms of his shipmates into those of the *Macon's* boat crew. We learned later that he recovered without an operation.

Now we could head again for Cape Horn, and once more *Triton's* turbines roared. Compared to the 36,335 nautical miles now charted for the entire trip, our diversion to meet *Macon* looked small. But it was a pretty good run, about as far as from Newfoundland to the British Isles.

On March 7 *Triton* entered Estrecho de Le Maire, between Staten Island and Tierra del Fuego (map, page 596). Just before noon we at last sighted Cape Horn. I directed that all men aboard file up into the conning tower and look at this landmark, so important in our country's history. At 1408 we passed from the Atlantic to the Pacific Ocean.

The sea was unusually rough topside. We were safely submerged and comfortable enough, but our ship, even though 65 feet down, rolled from side to side.

"Imagine what this must have been like in the old clipper days," said Quartermaster Curtis K. Beacham, recently nicknamed Pappy. (I had summarily abolished his former nickname, which was Beach.)

"This is supposed to be good weather for Cape Horn, but the waves look about 12 feet high, the current is setting us back three knots to the east, and the wind comes at 25 knots from the west. What would a windjammer do in a real storm?" No wonder old-time sailors cursed this place!

Three Times Around the Horn

It was my first glimpse of Cape Horn. The promontory was bold and forbidding, like the sway-backed profile of some prehistoric sea monster (page 596). Partly overgrown with straggly vegetation, it was washed clean and undercut by the sea down low. The water, deep as we approached the Cape and deep on the far side, was quite shallow over the actual passage.

Our sole problem was that the ship had only two periscopes. To give everyone a chance, we went by the Cape twice more.

Why did we not follow Magellan's route in this instance and pass through the Strait of Magellan? This would have involved threading narrow Chilean waters. Permission would have had to be obtained, and, as I have said, our mission was secret.

In a Dramatic Night Rendezvous, *Triton* Transfers a Sick Crewman

As the submarine neared the Falkland Islands off South America, her medical officer informed Captain Beach that a sailor needed immediate hospitalization. Radioing the U.S.S. *Macon* in Montevideo harbor for assistance, the skipper swung about and raced north at maximum speed submerged. The two ships met off Argentina at 2 a.m. March 5.

Staff artist Nicholson, working from eyewitness accounts, depicts *Macon* standing off as her rescue party in a motor whaleboat comes alongside the submarine. *Triton* lifts her sail high enough to open the conning-tower hatch. Captain Beach, on the bridge, directs operations, while a crewman beams a light on the sea-washed deck. Members of the line-handling party, in life jackets and safety rigs, ring their ill shipmate, bare-headed Chief Radarman J. R. Poole, who is bundled in protective clothing.

Minutes later *Macon* flashed the welcome message: "Poole safely on board."

Early in the morning of March 13, as we near Easter Island, 2,900 miles northwest of Cape Horn, our sonar equipment picks up a submerged peak, previously unknown. Its highest point reaches within a few hundred fathoms of our hull. Evidently it is a part of the geological formation that created Easter Island, itself rising 1,969 feet above the surface of the sea.

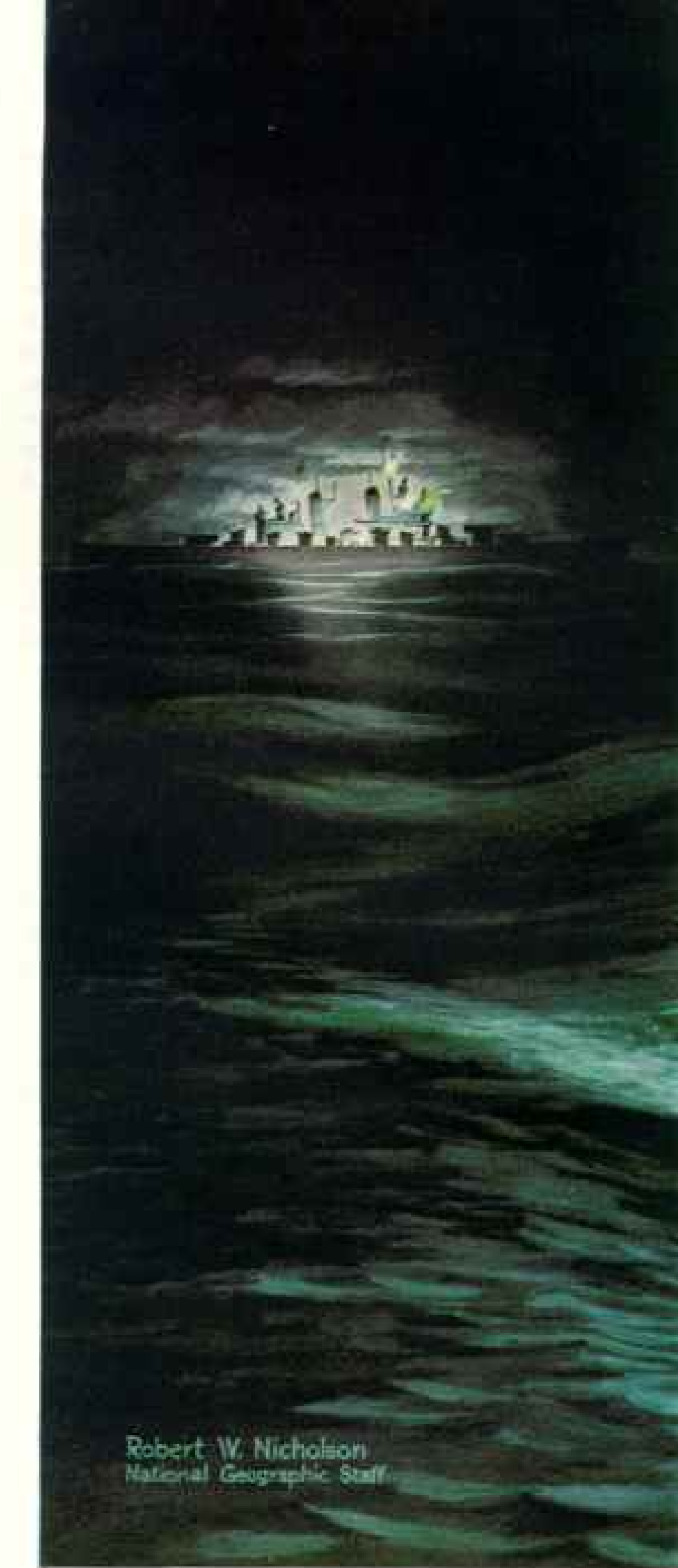
"Monkey" Works for Scientist

This great undersea feature also is detected by geophysicist Mike Smalet and his "monkey in a cage"—a metal box about a foot square, suspended from gimbals in a big wire framework to keep it steady.

"It's a very sensitive sea gravity meter," Mike tells curious crewmen. "It measures the varying pull of gravity as we go along. If you've got to do such measurements at sea, a submerged submarine is best because it gives you a good, steady platform, not affected by surface conditions. Besides, you don't get seasick."

Mike's gravity survey will eventually help the Navy to place electronic navigation aids in remote areas, but right now his equipment has a more immediate utility: When we approach a land mass, the device records increased gravity values.

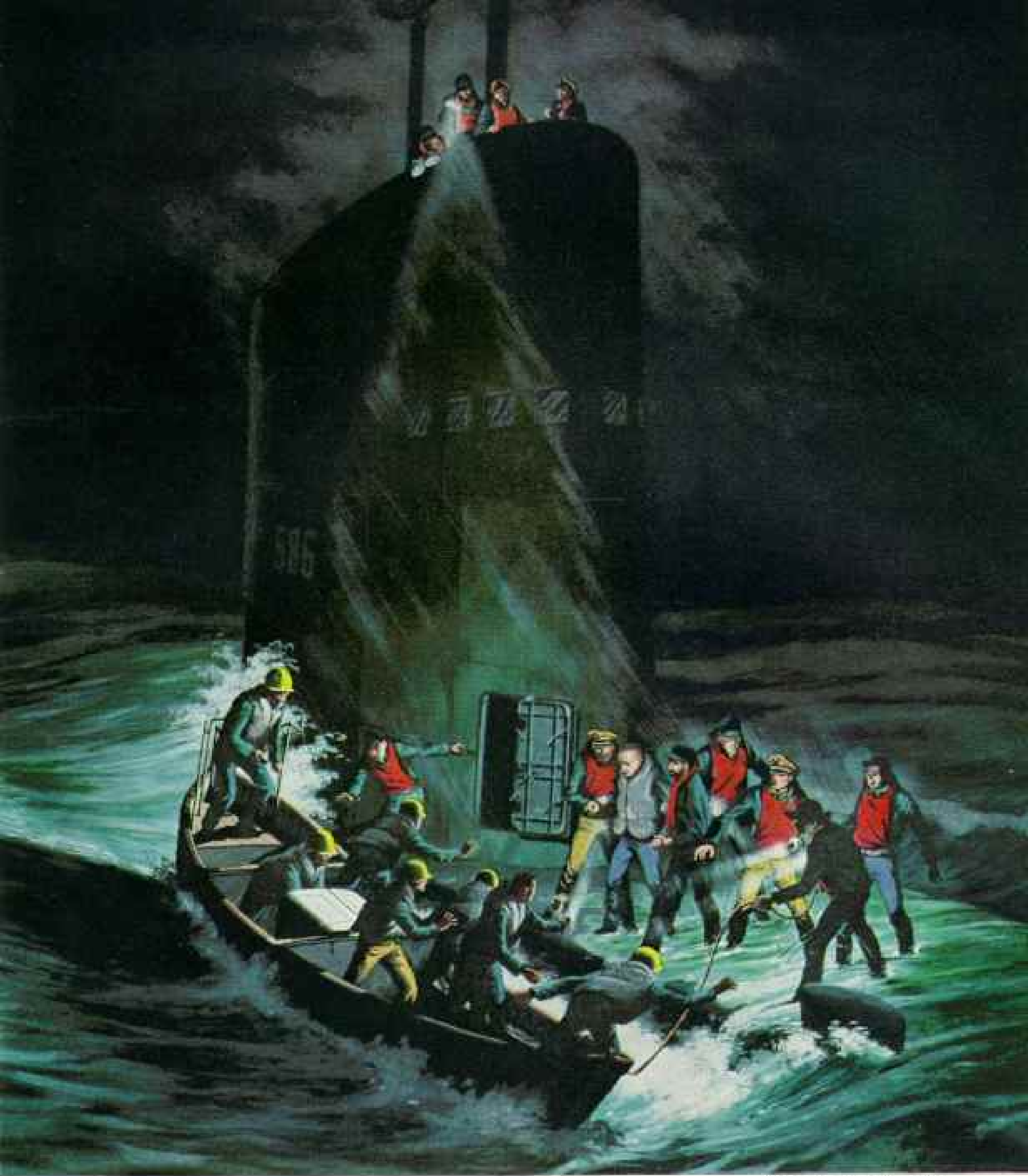
We come to periscope depth for Easter Island. "Find me one of those big stone heads!"



Robert W. Nicholson
National Geographic Staff

shouts Lt. Tom Thamm, who has the watch in the control room, directly below the conning tower. "I've always wanted to see one!" He means one of those mysterious giant statues we have read about, left by some unknown sculptors.*

*See, in the NATIONAL GEOGRAPHIC: "The Yankee's Wander-world," by Irving and Electa Johnson, January, 1949; and "Great Stone Faces of Easter Island" (11 illustrations), February, 1944.



© NATIONAL GEOGRAPHIC SOCIETY

I search and vaguely discern vertical shapes amid the rolling hills. But they look more like trees. Then the morning sun glints in orange and crimson on a huge piece of angular volcanic rock. My imagination fills in the details.

Word passes through the ship that anyone wishing to see the statue had better come to the conning tower. We call it "periscope liberty."

From now on, the trip across the Pacific becomes a long, almost interminable journey. Deeply submerged most of the time, staying out of the sight and ken of man, 8,000 tons of nuclear warship teeming with activity passes unnoticed from one end of the Pacific to the other.

What keeps us occupied? We work a 12-hour day—eight hours of watch, and then training, because carrying your weight on this

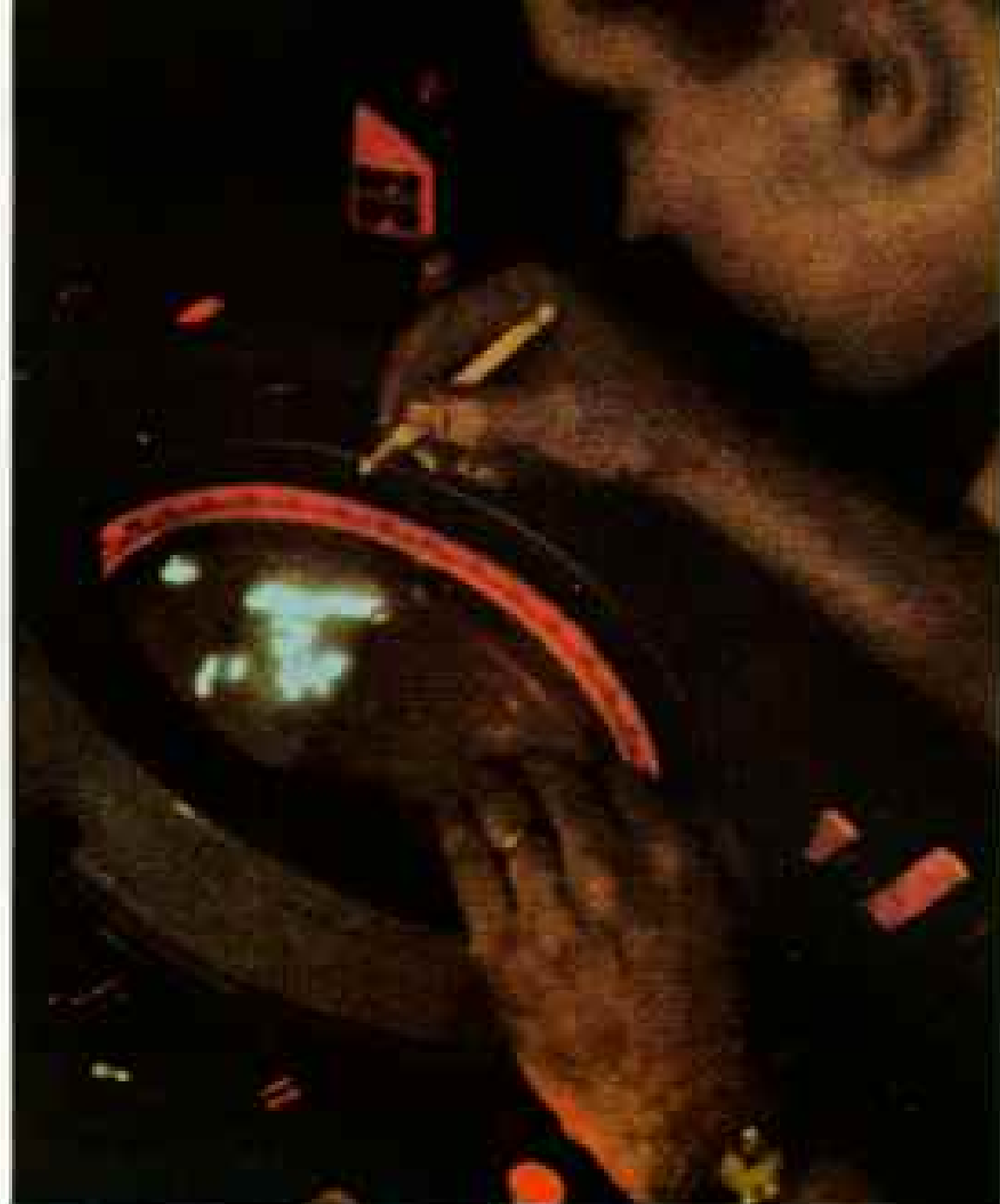


Map shows 2,200-mile dog-leg *Triton* took to meet *Macon*. Resuming course, the submarine sailed west of the Falklands, rounded the tip of South America, and passed into the Pacific.

Radarscope in the combat information center shows mountainous Cape Horn clear and bright.

Periscope view reveals rain squalls and 10- to 12-foot waves kicked up by 25-knot winds.

BY STACCHONE © NATIONAL GEOGRAPHIC SOCIETY



ship means a lot more than knowing your job alone.

Everybody must know as much as he can about the next man's job, too: you'll find an electronics technician or a cook making his way the length of the ship, up and down our three decks, periodically looking up from a blueprint. He's "walking pipe"—perhaps tracing out the 400-pound air system amid our 86 miles of pipe and thousands of valves.

This system supplies air under 400 pounds of pressure per square inch to the internal salvage air valves, one on each side of our 10 bulkheads. If a compartment should be flooded, we would use air to force out the water. The man on the spot might be a cook.

Other men attend classes in English, French, Spanish, mathematics, or civics at *Triton's* "College of Undersea Knowledge."

Commissaryman Ramon Baney, one of our five cooks, tools a leather holster for his Western-style six gun. Electronics Technician Martin Docker paints a New England seascape. Seaman Jim Smith models a head of the Chief of the Ship, Chester R. Fitzjarrald, in green clay.

Electrician's Mate Richard Brown and Torpedoman's Mate Tom Schwartz assemble plastic models of cars and planes—without the plastic cement that came in the kit.

This is significant. No plastic cement may be used while the ship is submerged, no paint or lacquer. These materials contain chemical solvents which in small quantities are harmless in a well-ventilated ship. But they could be toxic if allowed to accumulate in our closed-off atmosphere, along with the carbon dioxide we breathe out, and the odorless carbon monoxide caused by smoking, hydrogen generated by the batteries, and the Freon-12 gas that sometimes leaks from our air-conditioning system.

Germs Lose Grip on *Triton's* Crew

To cope with all this, we have filters, air-regeneration machinery, and four corpsmen under Commander Stark, an experienced physician with a master's degree in radiation biology. Aside from Poole's kidney stones, there has been little sickness aboard. Living closely together as we do, everybody quickly gets everybody else's cold, but after a couple of weeks we are immune to our own germs. Thus Jim Stark's main business is health physics and atmosphere control: to see that our air is wholesome and to monitor nuclear-radia-

tion levels with compact Geiger counters and other instruments.

"You might actually receive less radiation here than if you stayed home," he says. "Our reactors are well shielded, and deep in the water we get less radiation from cosmic rays than we would on the surface. Water itself is an excellent shield."

Lighted "Candles" Give Off Oxygen

Jim Stark and his crew help in highly important detective work. They sample the air with foot-long vacuum cleaners, whose filters pick up tiny particles for laboratory examination ashore later. We want to know precisely what floats around here, how much, and is it toxic? How can it affect men? Where does it come from? How can it be controlled?

For extra oxygen, we carry one of the Navy's newest marvels: chunky black "candles," combining powdered iron and sodium chlorate. If we light them, they will give off oxygen, not consume it.

We have plenty of fresh water. In contrast to World War II submarines that used electricity, *Triton* has steam evaporators. These can distill thousands of gallons a day, enough for unrestricted use by all hands.

As we crossed the Pacific, attendance at our submerged Sunday services in the crew's mess increased. It was perhaps natural that this ocean should evoke, for submariners, so many thoughts of the past and the hereafter.

On March 27 we passed due north of the spot where our namesake, U.S.S. *Triton I*, was lost in action in 1943. It was her sixth combat patrol. Three Japanese destroyers attacked with depth charges. I was a few miles away, as engineering officer on the submarine U.S.S. *Trigger I*, and remember those explosions now, distant but angry. Somebody, we realized, was taking a beating.

We held a memorial service for *Triton I*. A ship on the surface would fire a salute, with guns. This we could not do. But it occurred to us that the only salute we could fire was one the people of the old *Triton* would best have appreciated.

With the crew at attention, the forward torpedo tubes were discharged three times in rapid succession. We heard the echo of the water ram—a slug of water which in our newest submarines ejects the torpedo from the tube, leaving no telltale air bubbles. We

(Continued on page 601)



Running by dead reckoning, *Triton* glides silently beneath brightly lit fishing boats and interisland freighters in Bohol Strait, the Philippines. To check position, the ship utilizes all her senses. Sonar shows bottom topography. Periodically the submarine rises to periscope depth, and navigators crowd the conning tower to observe shore lights and landmarks. Setting the scope on previously computed bearings and altitudes, they mark the bright stars as they appear. The "fix" confirms *Triton's* remarkably accurate dead-reckoning course.



● Castor

● Capella

● Aldebaran

● Pleiades

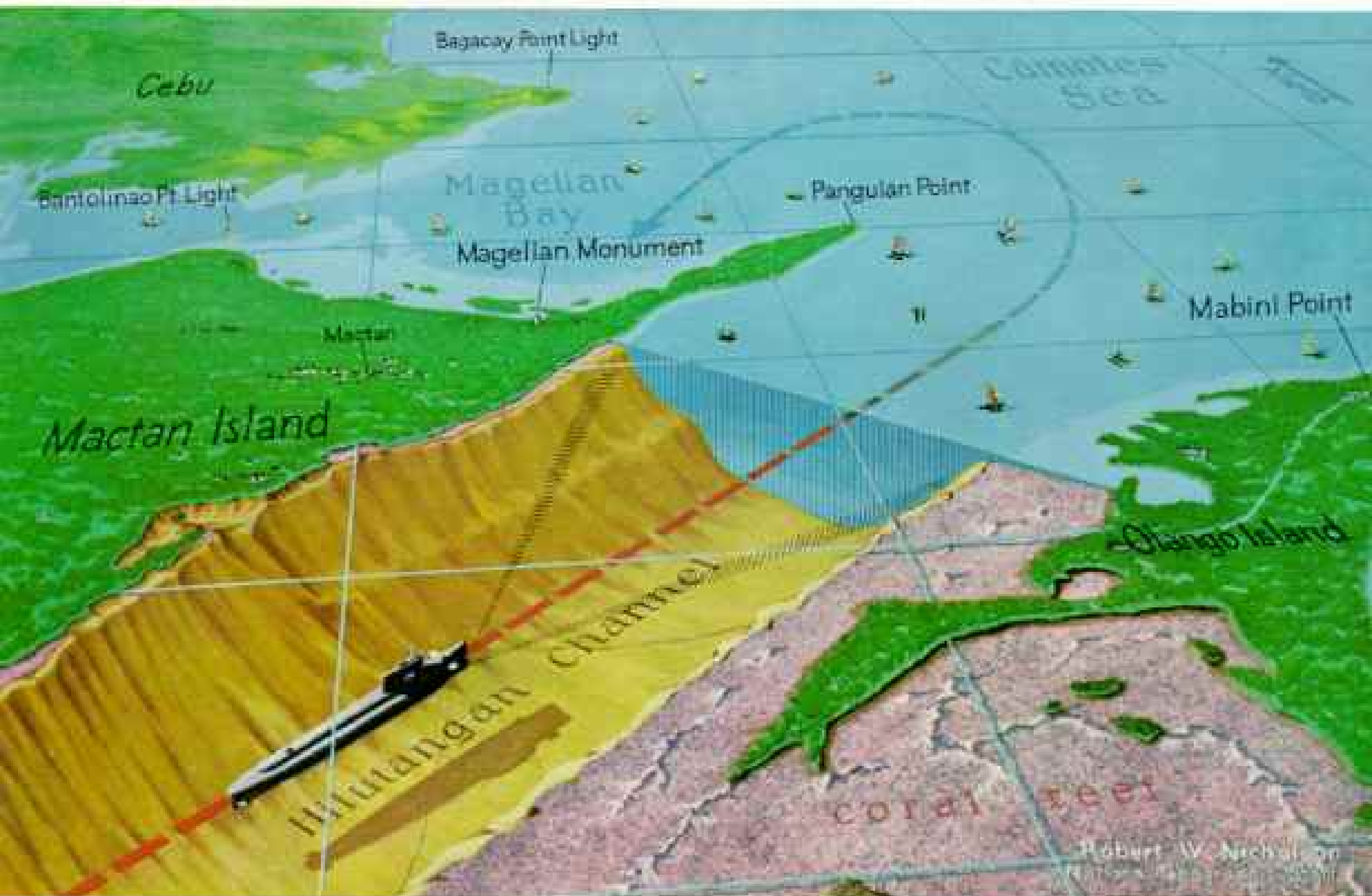
Robert W. Nicholson
National Geographic Staff



Triton's track led across the Philippine Trench and through Surigao Strait, graveyard of Japanese warships sunk in World War II. Crossing the Mindanao Sea, the submarine turned north through Bohol Strait (page 598) and Hilutangan Channel (below) and reached Magellan Bay on the north shore of tiny Mactan. Here Ferdinand Magellan died April 27, 1521, at the hands of native warriors.

Using periscope and probing with instruments, *Triton* makes a slow passage up Hilutangan Channel. Her echo-ranging sonar flashes a picture of the waterway's shape, as illustrated by the artist's cutaway. The visual repeater, the sonarscope in the conning tower, clearly defines the depth of the channel and warns of coral reefs near shore. Later *Triton* returned down the channel, using instruments alone. The monument to Magellan, on Mactan Island, was sighted through the periscope.

600



felt the fluctuation of air pressure on our ear drums. Then sounded the clear notes of taps.

We sighted Guam on March 28 and headed for the village of Agat, where one of our crew, Edward C. Carbullido, had been born. Carbullido's service spans 14 years and he has never been back to Guam. But he has sent virtually all his money home to help build a new house for his parents and to pay college tuition for his younger brothers and sisters.

"Pass the word, Carbullido to the conning tower!"

Carbullido scrambles up, beaming. Chief Quartermaster Bill Marshall asks, "Captain, how about shooting him out through a torpedo tube?"

"Negative," I say. "He might scratch the paint."

Carbullido happily takes over one of our periscopes.

Cars drive on the road along the water. My only worry is that somebody may spot us. People ashore rarely look to sea, however.

We stay in Agat Bay long enough for Carbullido to get a close look.

"Many more people," he says, "so many more houses. There's my father's house! I know it from the pictures he sent me."

When we finally turn *Triton* west and Carbullido disappears down the ladder into the control room, there is a lump in everyone's throat. Fourteen years away, and now so near—and so far!

Periscope Picks Up Suspicious Lights

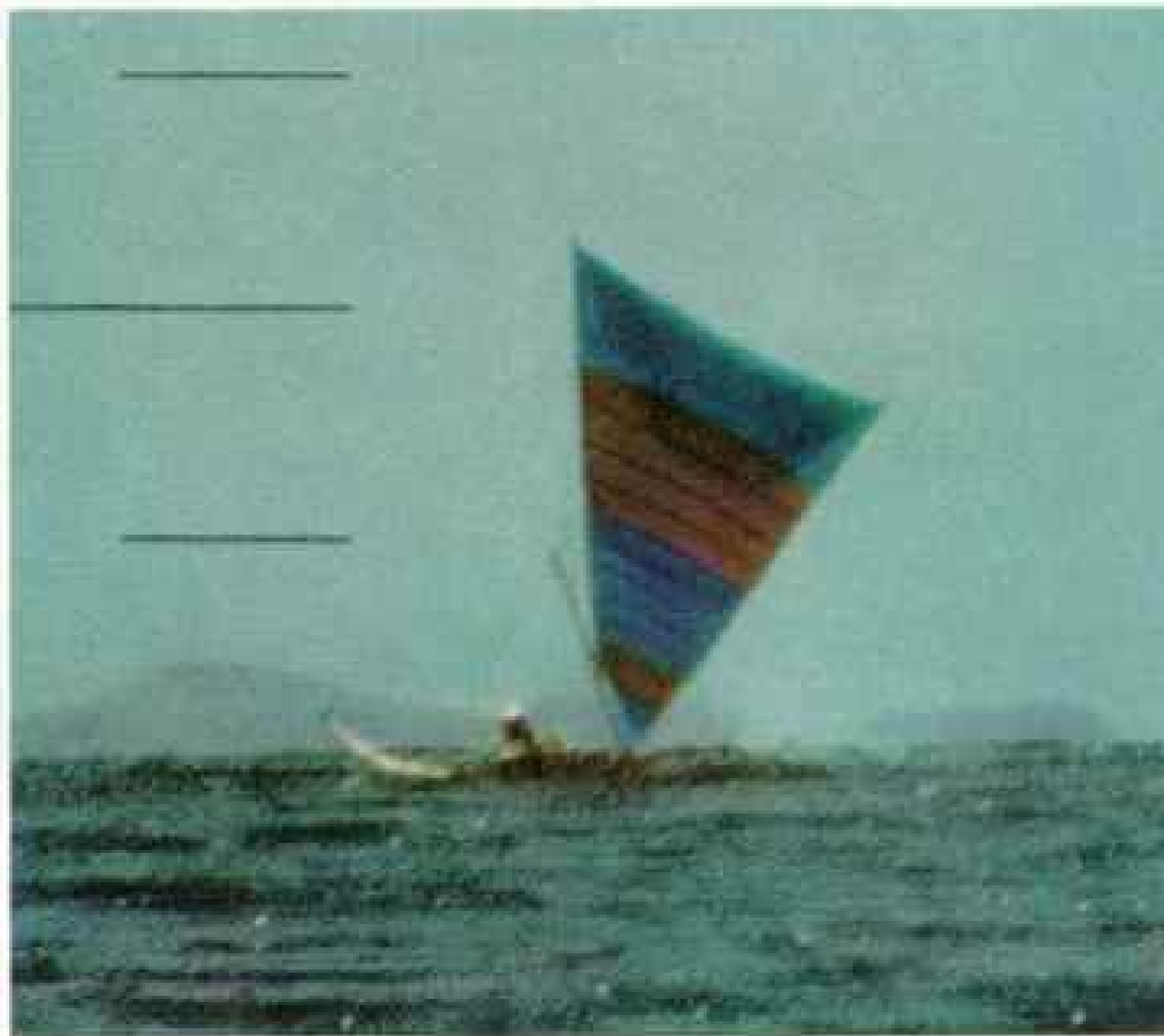
Late that night, while ventilating, we spotted what we believed to be an aircraft flashing red and green lights and apparently closing in. We dived immediately.

The following evening those lights followed us again. Had we been detected? Had our routine been figured out?

We became even more cautious with our periscopes, taking only short observations and spacing them out, in case the plane had a particularly sensitive radar. The bearing of the plane appeared constant.

"Let's check the star charts," someone muttered, and all at once it hit me. I ran the periscope all the way up and left it there.

In a moment, sure enough, Marshall reported from the chartroom below: "Arcturus



HE SETCHMORE BY NATIONAL GEOGRAPHIC PHOTOGRAPHER J. BAYLER ROBERTS © N.G.S.

Skimming before the wind, a high-prowed Philippine boat shows its striped triangular sail to the periscope's eye. To avoid hitting such craft, Captain Beach made frequent observations while navigating Hilutangan Channel. This view catches a hazy glimpse of mountainous Bohol Island.

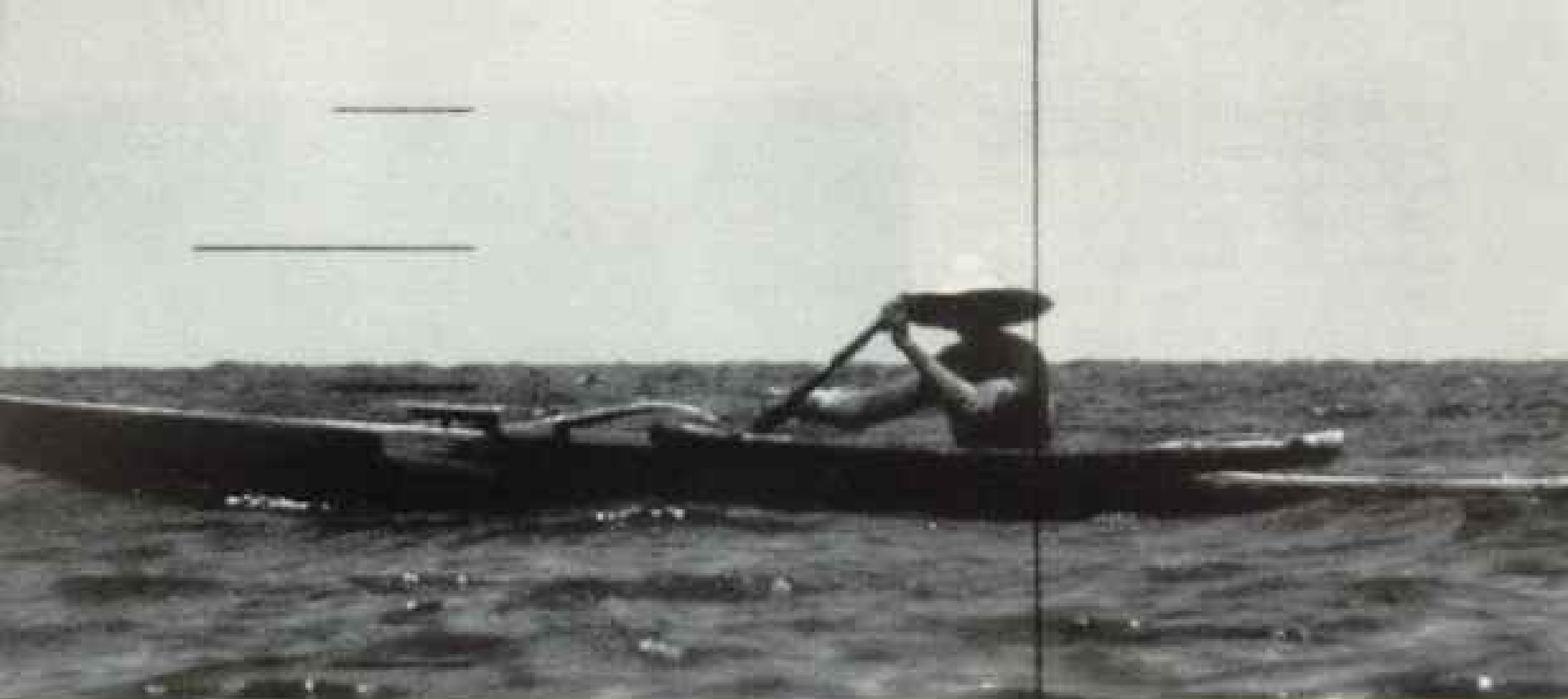
bears 070 at this time of night, at the altitude we have sighted the aircraft." Furthermore, Arcturus is known to have a red glow occasionally. Our red and green lights were the results of refraction through the spray and dampness of our periscope lens.

On March 31 *Triton* crossed the fantastically deep chasm in the ocean bottom known as the Philippine Trench and entered Surigao Strait, site of a dramatic naval engagement of World War II. Here America's battle force, crushed into the mud of Pearl Harbor, had its turn at destiny.

Vengeance is not a pretty word. But U.S. Navy men exult in the salvos of hot armor-piercing shells those old battleships—the *California*, *Tennessee*, *Maryland*, *Mississippi*, *West Virginia*, and *Pennsylvania*—hurled upon the Japanese fleet they had caught in confined waters. Of these U.S. ships, all but the *Mississippi* had been at Pearl Harbor; three had been damaged and two sunk.

Here we took more than our usual number of water samples—with the thought that we might send some to Adm. Jesse B. Oldendorf, now retired. He commanded U.S. forces at the Battle of Surigao Strait. Perhaps he will detect some Japanese rust in that water.

Among the islands forming the northern



PHOTOGRAPHED THROUGH TRITON'S PERISCOPE BY J. BARLINA ROBERTS

Terrified fisherman thought *Triton* a sea monster

WHEN CAPTAIN BEACH raised periscope in Magellan Bay, he found himself looking into the eyes of the Filipino fisherman above. Although he did not realize it, the canoeist was the sole unauthorized person to detect *Triton* during her round-the-world voyage.

With only the periscope picture and Captain Beach's description (opposite page) as a guide, the NATIONAL GEOGRAPHIC undertook to find and interview the fisherman through a Society member, Edison H. Canova, of Cebu City. Finally came the triumphant cable: "Have found needle in haystack." At Punta Engaño on Mactan Island, Mr. Canova had located and identified the fisherman as 19-year-old Rufino Baring.

When the periscope appeared, the youth recalled, he first thought it was a piece of wood. Then, seeing its wake, he wondered if it might be the fin of a fish. As the periscope dipped beneath the surface, he decided that his eyes were playing tricks. When it suddenly reappeared, Baring imagined he was sharing the bay with a sea monster.

"I was very frightened," he said. "I tried to get away as fast as I could." Baring never looked back as he paddled for home, and he concealed the incident from his family, though he later confided it to a friend. His last trace of dread vanished only when Mr. Canova told him what he had really seen.

Putting on the clothes he wore the day of his encounter, Baring climbed into his freshly painted *banca* for the portrait below. To protect the craft from further meetings with sea monsters, he had added the names of saints. By coincidence, he chose the apostles who gave their names to St. Peter and St. Paul Rocks, the Atlantic outcropping where *Triton* began and ended her circumnavigation.

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EDISON H. CANOVA



boundary of the Mindanao Sea are Bohol and Cebu. Between them Bohol Strait extends northward to the tiny island of Mactan, where Magellan fought a skirmish with natives and was killed (map, page 600).

This part of our trip was a pilgrimage. In darkness, we turned north into heavily traveled Bohol Strait to work our way up the channel toward Mactan.

We ran deep as we headed northward, our sonar picking out the channel for us, probing ahead for ships. Twice, when heavier-than-normal screw noises were heard, we came to periscope depth and saw the brightly lighted decks of coastal steamers proceeding southward. After daybreak we also saw log sailing rafts—an easy means of getting newly cut trees across Bohol Strait. A log tripod covered with tree branches stood at one end, a sweep or steering oar at the other. Usually only one figure could be seen, presumably the capitalist who would dismantle and sell his craft at the trip's destination.

After we entered the Hilutangan Channel—between Mactan Island on the west side and smaller islands on the east—we saw fishing and pleasure boats too, the latter carrying colorful and artistic sails (page 601).

A curious sight was a decrepit ferry powered by an old one-lung steam engine with a tall stack extending up through the large awning that covered the entire craft. It carried a number of people, but the only one looking in our direction was a young woman with a child on her lap. The other passengers and the steersman looked toward Cebu, their destination. She faced us directly, so close that I thought she might spot our periscope. But she seemed lost in her thoughts.

Magellan Bay, in northern Mactan, was the place we had come so far to find. On its shores we sighted a monument to the Portuguese navigator and explorer who dreamed so greatly and here lost all (page 614).

Periscope Meets Canoeman Eye to Eye

The placid waters of Magellan Bay contained its quota of small boats, also—and just before noon, as described in the log:

“Upon raising the periscope, I am looking right into the eyes of a young man in a small canoe, close alongside. Perhaps he has detected the dark bulk of our hull in the relatively clear waters of the bay, or he may have sighted our periscope earlier.

“He and I study each other gravely. His boat is a small outrigger, perhaps 12 feet long, innocent of any paint and without mast or

sail (which is why he got so close in on us). He has a paddle with which he easily maintains a position abeam of us at our present slow speed. He looks ahead and looks behind, looks down in the water and maintains position about 25 yards abeam with occasional muscular sweeps of his paddle [opposite].

“Our friend is a dark-complected, moon-faced young man with a well-fed physique. His clothing is tattered, and he wears some kind of a battered hat for protection from the sun.”

“Down periscope!” The bright steel tube slides down into its well as I describe the scene above to the people in the conning tower.

Right man, wrong expression. “After we made sure that Baring was the fisherman we sought,” writes correspondent Canova, “we showed him his photograph [opposite] taken from the ‘sea monster.’ What I wouldn’t give for a picture of Baring’s face! Unfortunately, we were in his dimly lit *nipa* house, and I had no flash.”

EDDIE H. CARROLL



A few seconds later I motion for the scope to be raised once more. Sure enough, there is our friend, impassively leaning on his gunwales and staring right at the periscope as it rises barely two inches out of the water.

It is a ludicrous situation: On the one hand an impassive Asian, staring with curious concentration at an unusual object in the water; on the other hand, a U. S. Navy officer, equipped with all the technical devices money and science can procure, looking back with equally studied concentration. On one end of the periscope, an outrigger canoe propelled by the brawny arms of its builder; on the other end, a \$100,000,000 submarine, the newest, biggest, most powerful in the world, on a history-making cruise.

What an abyss—what centuries of scientific development—lie between him and me!

"All ahead two-thirds, right full rudder!" I snap up the periscope handles as a signal to start it down. *Triton* slips neatly ahead and away. A few minutes later, slowing for another look, I spot our friend many hundreds of yards away, paddling rather strongly in the opposite direction.

Ship Plunges in a Watery Downdraft

Back in the Hilutangan Channel, we ran 150 feet deep at 10 knots, relying entirely on our highly developed sonar—a feat no ship would have attempted a few years ago. Once clear and in Bohol Strait, *Triton* further increased depth and speed and raced out into the Sulu Sea.

Well before noon the next day we reached Pearl Bank Passage, a narrow and tricky spot (map, page 608). Fortune smiled: A good-sized freighter was heading for the same point. We swung a wide circle to allow him to catch up, and kept throttled well back to stay astern. With him for a guide, the passage was easy.

Three days later, after traversing the Celebes Sea and Makassar Strait, we approached Lombok Strait. I recalled what our wartime operations orders had said about this spot. "A most hazardous passage because of unusual currents and strange variations in water density." Many a submariner has extraordinary tales to tell of this passage.

The view was spectacular, with cloud-shrouded mountains on either side of the strait. We favored the island of Bali, to the west, although we could see no more of it than terraced hillsides on the steep sides of a volcano.

Shortly after noon we sighted a ridge of

All hands worked a 12-hour day. As *Triton* approached a landfall, Captain Beach conferred with his operations and executive officers in the wardroom (upper right).

Painted bottles (center row, left) were ejected to aid the study of ocean currents. A slip in each bottle requested the finder to note position and date and to report to the U. S. Navy's Hydrographic Office in Washington, D. C.

Electronic instruments (right)

water up ahead, several feet high. A few minutes later *Triton* slipped a few inches below periscope depth, blinding me.

"I'll have her back up in a moment, Captain," Lt. Jim Hay, diving officer of the watch, announced confidently.

But no. First gradually and then rapidly, the depth gauges spun around. *Triton* was falling. At last a surge of increased speed pulled us out.

I cut short Jim's crestfallen attempt at explanation. "Now we know what those old-timers were talking about," I said.

Analysis of the data later revealed that at this point the deep and colder waters of the Indian Ocean met the shallower, warmer waters of Lombok Strait with tumultuous vertical currents. We had never been in real difficulty. But we could imagine the serious position of a diesel-electric submarine hazard-ing this passage with low batteries.

Turbine Makes Music for Crewman

Triton entered the Indian Ocean on April 5 and set a great-circle course for the Cape of Good Hope (map, page 588). The ship was steady as a church, as solid and as quiet.

But not to everyone. Electrician Raymond Comeau, for example, heard a whole symphony of sounds. Young Comeau bunked in the aft torpedo room, only a few feet from our right screw, and his usual watch was at the right turbine throttle. He confided to his diary:

"When you have time on your hands, it doesn't mean that you are bored; you think of all sorts of things. How does the turbine feel? After a while the noise becomes a

measured the ocean floor for a precise chart along *Triton's* track.

Nucleonics laboratory (lower left) developed and checked the crew's film badges once a month to determine whether any man had endured excess radiation.

Ship's cook concocted a crew-sized cake to surprise the skipper. Summoned with a false report of trouble, Captain Beach was greeted by popping flash bulbs and a raucous "Happy birthday!"



RODOLPH WOODS NATIONAL GEOGRAPHIC SOCIETY



King Neptune initiates crewmen crossing Equator first time

Ship passes Cape Horn three times to give every man a look

Hawaiian aloha party raises spirits 1,200 miles from Pearl Harbor

Double babygram states two fathers and entire crew

Periscope liberty allows crew to scan Easter Island

Friday house cleaning

Sunday's leisure hours increase nostalgia

MORALE

Chief Radioman Poole has severe kidney-stone attack

HOMESICKNESS

Psychological Ups and Downs of the Triton Crew

FEBRUARY 16 DEPARTURE

MARCH 1

7

14

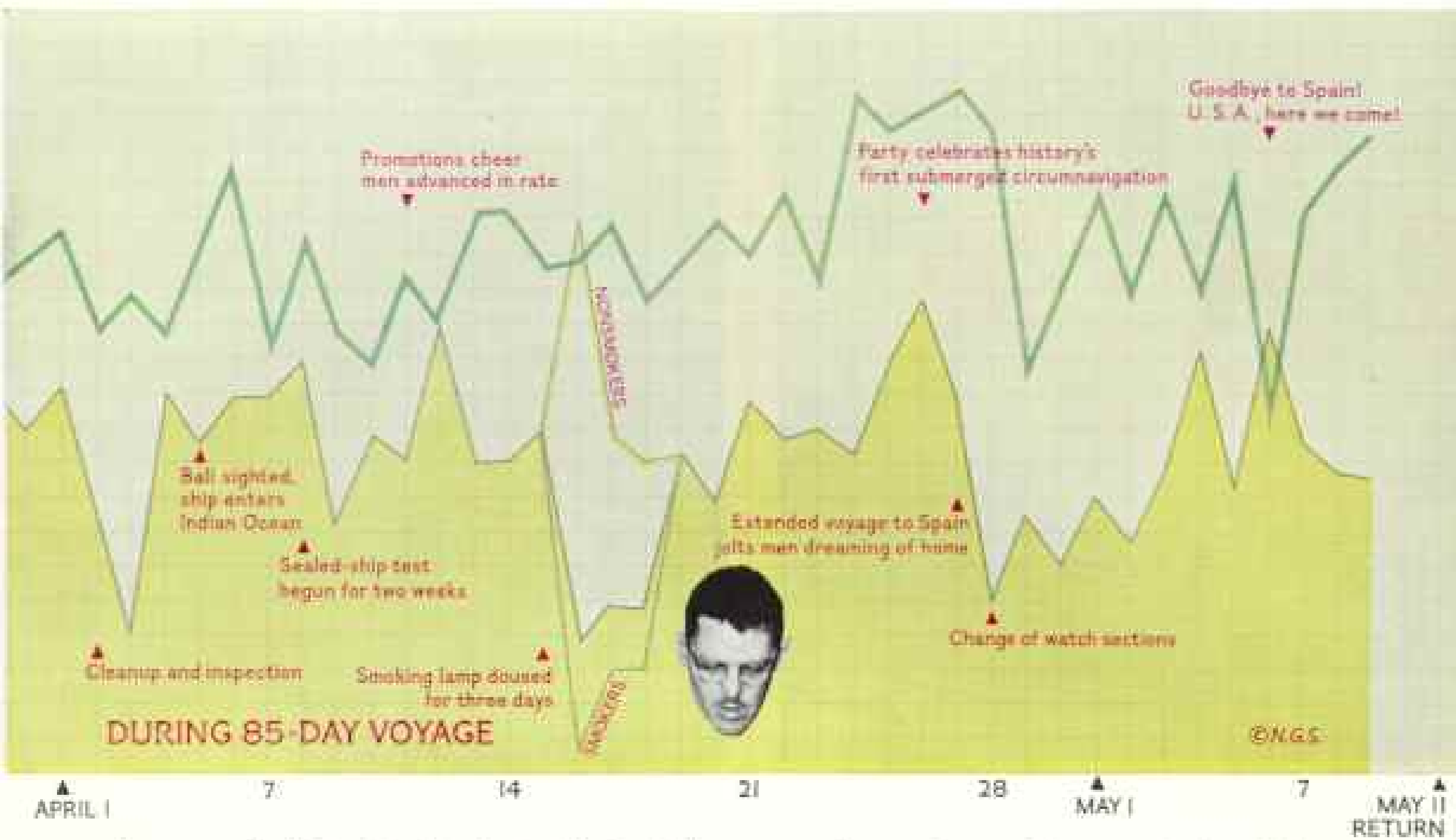
21

"Fireroom Four" and an Aloha Party Combat Boredom and Boost Morale

"Babygrams" announcing the birth of a child lifted crew spirits, but a three-day ban on smoking produced mixed reactions in the morale graph above. Navy psychologist Dr. Benjamin Wey-

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brew compiled data for the chart with the help of questionnaires distributed among 50 volunteers. The reactions of men confined for 85 days may guide those who will later venture into

space. Bongo drums and homemade French horn (lower left) celebrate completion of the world cruise. Party at right marks the closest approach to the Hawaiian Islands—1,200 miles.





Periscope "liberty" (opposite, lower), given at every opportunity, enabled crewmen to see such spectacles as Mount Agung, Bali (above), a dormant volcano towering above Lombok Strait, and the planes on a Guam airstrip. In the Indian Ocean they observed the masts of a wallowing tanker.

While transiting Lombok Strait (below), between the islands of Bali and Lombok, *Triton's* depth gauges suddenly began to spin, and the ship involuntarily dived to 125 feet in 40 seconds. "It was as though we had hit a hole in the water—similar to air pockets encountered by planes," says Captain Beach. An abrupt change in water densities apparently caused the phenomenon at a point where currents from the strait met those from the Indian Ocean. Powerful engines quickly regained control.



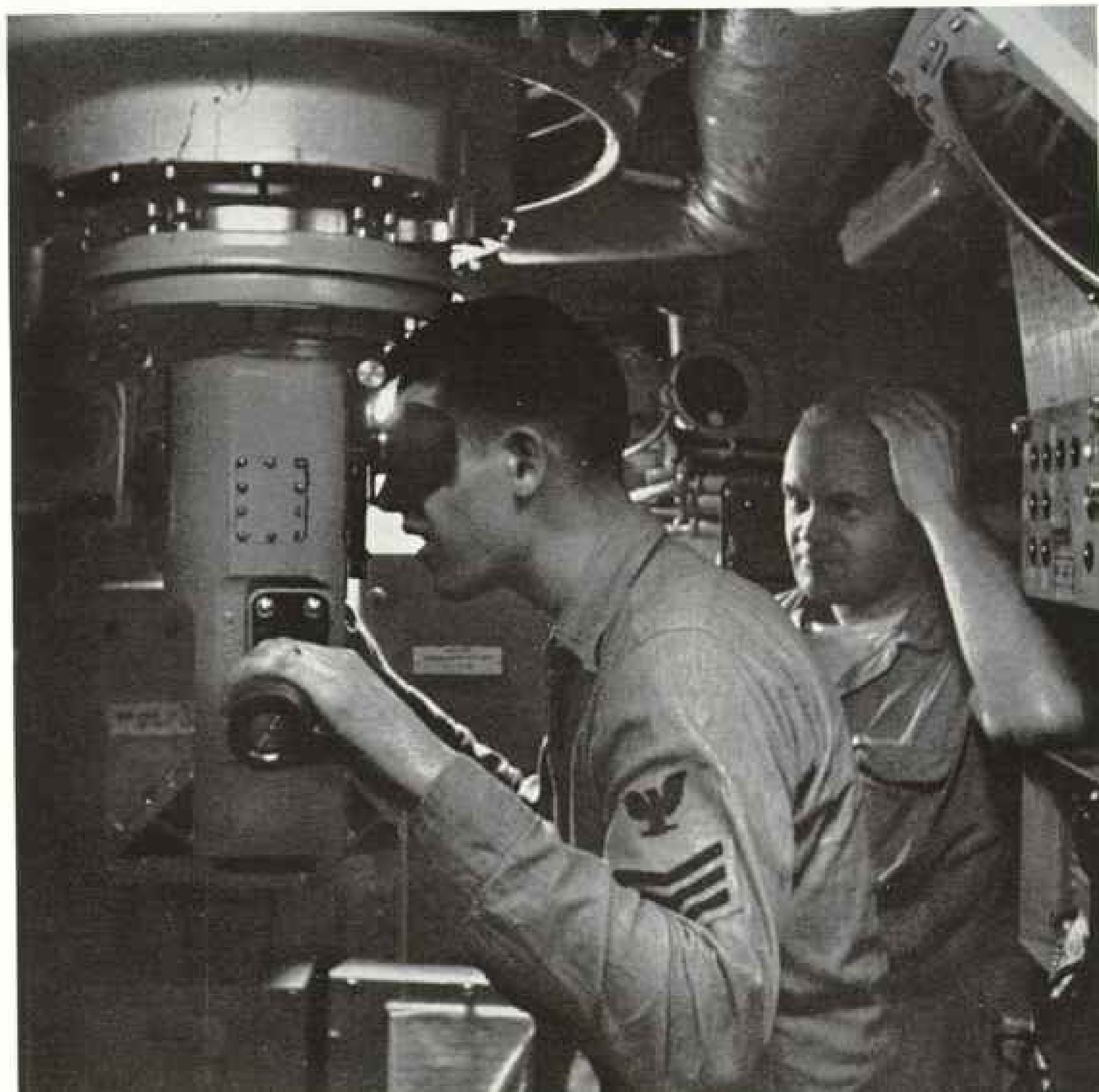
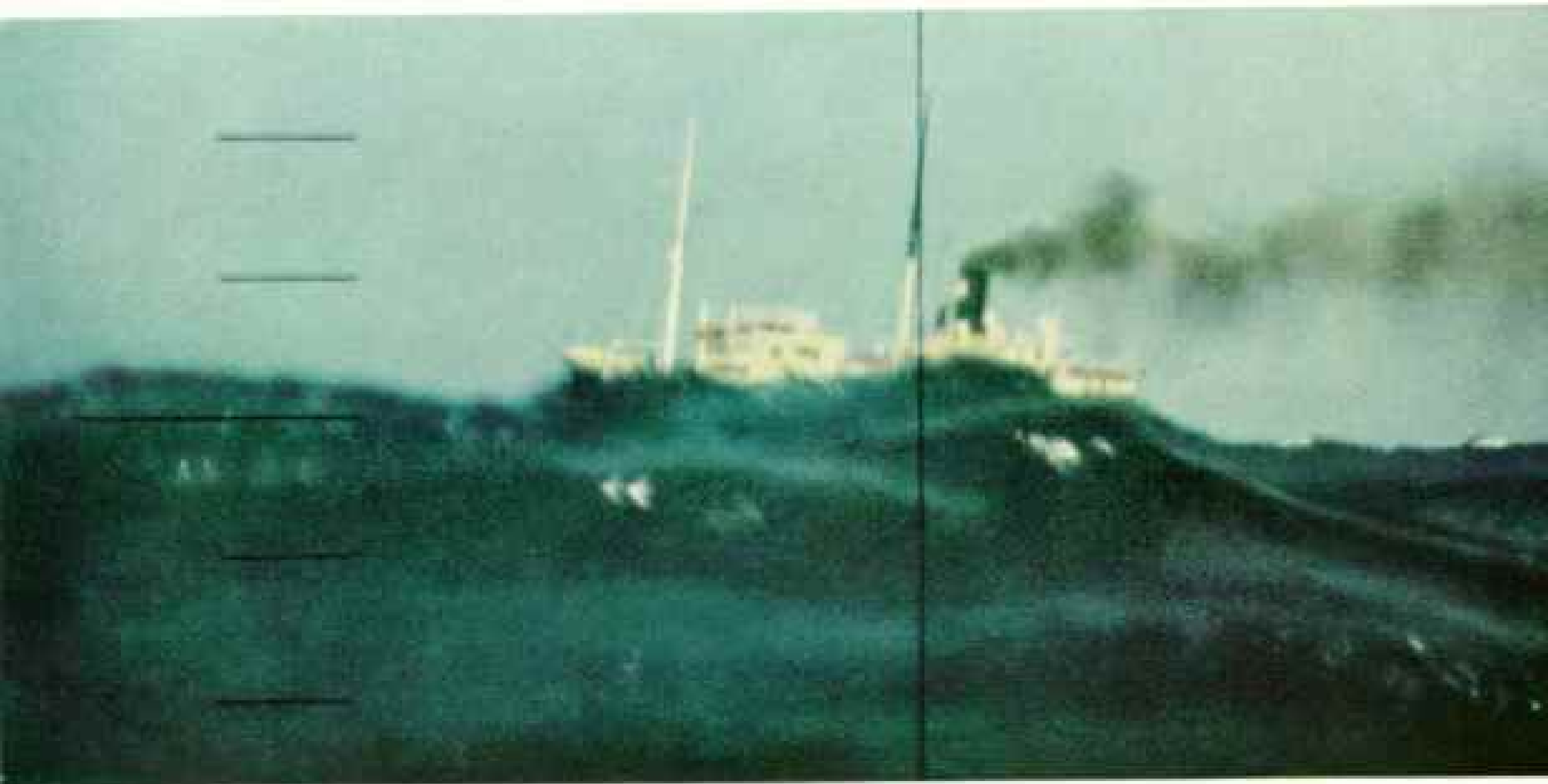
melody, different melodies. And you can tell when the turbine is happy, and when it doesn't care, and when it whines as if it were crying.

"After a while I realize that the turbine sounds sad when I feel sad and happy when I feel happy. Does that mean that I have become, somehow, part of the machine? No! It is the slave and I am the taskmaster; I can make it purr and I can make it whine. This gives me a feeling of power, that the 160 pounds of me help to control all these tons. It's a good feeling..."

No-smoking Test Tries Crew's Nerves

The big events of this leg of the voyage were our sealed-ship test and the no-smoking period. For two weeks we did not ventilate the ship, but refreshed our atmosphere with our chemical candles when necessary. Later, smoking was prohibited. It was a trying time for many.

I am not a smoker, except for an occasional cigar, and felt little difference beyond a certain heightened well-being—due, probably, to





62 INTALHAKRE © NATIONAL GEOGRAPHIC SOCIETY

Lofty buildings of Santa Cruz hug the hills of Tenerife Island in the Canaries. "Far and away the most spectacular scenery we saw on our cruise," reports Captain Beach.

lessened tobacco fumes in our atmosphere. Most everyone else hated it.

The nonsmokers felt elated at first. Some would kid their suffering shipmates. "Got a light?" But soon the nonsmokers also were on edge as men chewed unlit cigarettes and cigars cut into small pieces. Irritability grew in little ways.

Bad Movie Has Good Effect

We carried 45 movies aboard and we had already seen them all—but word leaked out that one film was lost. This was a horror story starring an unearthly monster, and suddenly there was wide demand to see that one film again. Why?

"Because it's so bad," I was told. "A good movie you forget fast, but a thing like that you can talk about for days." Curious what ideas people get under tension.

After three days we decided to end the test. Instead of passing the word to relight the smoking lamp, I strolled about the ship, puffing on a cigar and blowing smoke in people's faces, saying pleasantly, "Don't you wish you could do this?" It took about 40 seconds for the word to get around.

Meanwhile Doctors Stark and Weybrew

kept track of our physical and psychological condition with periodic vision tests, questionnaires, and interviews. In our close quarters, less than three square yards of deck space per man, Dr. Weybrew found a tendency toward excessive projection.

"You may say to the man next to you, 'Boy, are you irritable this morning!'" Dr. Weybrew told me. "Chances are that it's you who are on edge. You tend to perceive the same state in others, and so justify your own irritability to yourself."

But Dr. Weybrew also surmised that such a cramped and comparatively monotonous passage may not be a bad thing. He notes:

"For some younger men of the high caliber of the *Triton* crew, prolonged confinement may be beneficial. For some it provokes a kind of life-reorientation process. One told me, 'Now I've had a chance to think over where I've been and where I am going. I've decided I'd like to be a school teacher.'

"Living in a relatively unchanging environment, such as the submerged submarine, seems to evoke novel, ofttimes creative thinking. Some men are writing poems. One man described to me an original electronic circuit for an air-conditioning system. . . ."

We sighted the Cape of Good Hope on April 17, Easter Sunday. It seemed a particularly good omen to make this landfall on that holy day. Our spirits rose as our ship once again clove the waters of the Atlantic. We set *Triton's* course northwest, toward St. Peter and St. Paul Rocks, on the last leg of our circumnavigation.

Shortly after eight on the evening of April 24, a valve burst in our after hydraulic system. As Torpedoman Allen Steele described it later, there was a loud report and then a heavy spraying noise. Clouds of oil vapor rose from beneath the deck plates on the starboard side.

"The stern planes aren't working, sir!" reported Comeau at the diving controls. Lt. "Whitey" Rubb ordered: "Shift to emergency!" We had trained for this many times.

Torpedoman Steele truly distinguished himself. His compartment was filled with oil vapor and he could see nothing. But he plunged into the high-pressure spray and found the two quick-closing valves to the supply and the return pipes. He struggled desperately to close them, and finally did, with the help of Engineman Arlan Martin.

Not until afterward, with repairs well under way, did we reflect on what might have happened. The heavy concentration of oil

Visiting Sailors Get an Unexpected Bath as Their Whaleboat Careens

Rendezvousing off Cádiz, Spain, a boat from the destroyer U.S.S. *John W. Weeks* swept above *Triton's* submerged deck: A subsiding swell slammed the craft against the deck. Tossed head over heels into the brine, the men scrambled back wet but unharmed. NATIONAL GEOGRAPHIC photographer Roberts captured the action from the bridge.





A touching welcome for Commissaryman Earl E. Bruch, Jr., and new mustache



NATIONAL GEOGRAPHIC PHOTOGRAPHER J. SAYLOR ROBERTS © N.G.S.



Home to Connecticut's Thames River Comes the Great Steel Whale

A cold, drizzly day failed to mar the welcoming party last May 11 at New London. As crewmen made ready the landing lines, Navy officials, wives, children, and other well-wishers crowded the pier (below). To them *Triton* exposed the 447½-foot silhouette she had hidden from the rest of the world for 85 days.

Last person seen by Captain Beach as *Triton* sailed was his wife Ingrid, "alone on a rock where the river meets the sea." And when the submarine came home, "that blue-eyed girl" was on the dock, with their three children waving signs of welcome.

At the White House in Washington the day before, Mrs. Beach had seen her husband awarded the Legion of Merit by President Eisenhower. Off Rehoboth Beach, Delaware, *Triton's* captain had been picked up by helicopter and flown to the White House lawn, returning to his ship the same day.

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RHODES BULLETIN (ABOVE AND BELOW)





ESTABLISHED © NATIONAL GEOGRAPHIC SOCIETY

"Hail Noble Captain, It Is Done Again." In honor of Ferdinand Magellan, *Triton* presented a plaque bearing these words to Spain, in whose service he undertook the first world voyage 441 years ago. The Portuguese navigator's portrait hangs in Mariners Museum, Newport News, Virginia. Freely translated, the Latin inscription reads: "Ferdinand Magellan, most famous for having conquered the difficulties of the Antarctic Strait."

vapor might have caused a fire; there might have been a severe explosion.

Had Steele's action not been so instantaneous and so precisely correct, *Triton's* main hydraulic system would have been lost in a few more seconds—with the momentary loss of all diving-plane controls, and steering as well. Even with our quick shift to emergency control, we might have been in serious trouble because we were going so fast.

Speed Averaged 21 Miles an Hour

"Monday, April 25," said the log. "St. Peter and St. Paul Rocks in sight, bearing due west. First submerged circumnavigation of the world is now complete."

We circled the bleak islets again, as we had done two months before. The sun was shining brightly. Our mileage, Rock to Rock, was 26,723 nautical, or 30,752 statute, miles. It had taken us 60 days and 21 hours. Dividing gives an average speed of just over 18 knots, or 21 statute miles an hour. No other ship—and no other crew—could have done better.

After passing St. Paul Rocks—on the west-

ern side this time—we set course, still submerged, toward Cádiz, Spain, lying 17 miles from Sanlúcar de Barrameda, where Magellan set sail on his historic circumnavigation.*

En route we passed close to the island of Tenerife, Magellan's last stopping point before crossing the Atlantic. There he quelled his first mutiny. We came upon the island in the early morning and were rewarded with a spectacular view (page 610). Roads, lined with new buildings, led back from the city of Santa Cruz toward a high mountain and many peaks on the skyline.

Two days later we were off Cádiz and in contact with the destroyer U.S.S. *John W. Weeks*. We wished the *Weeks* to deliver a plaque, designed by Lt. Tom Thamm, as an offering to the country from which Magellan set forth on his historic voyage. The inscription was in Latin and English: *Ave Nobilis Dux, Iterum Factum Est*—"Hail Noble Captain, It Is Done Again."

At 6 a.m. *Triton* broached, just as we had while transferring Poole to the *Macon* two months earlier (page 611). Joe Roberts was taken off to fly his pictures to Washington.

Of the remainder of our voyage back to port, there is little to tell. We crossed the Atlantic Ocean clear of steamer lanes and U. S. Navy exercise areas. We had eaten steak once a week before, and now we could have it twice as often. There was enough food left to go around the world again at half rations. Those of us who had tried to diet on the cruise surveyed mixed results.

A lieutenant said proudly: "I think I lost ten pounds." A chief answered, "Turn around, sir. I think I've found it."

After hearing the doctors talk, I warned the men to use special care while driving during their first day back home. For months most of us had looked at nothing farther than 10 feet away, and it might take a little time to get our eyes accustomed to focusing quickly from near to far objects.

Before dawn of May 10 we surfaced off Rehoboth Beach, Delaware. After daybreak, boats and planes came to photograph us. A helicopter hovered with sacks of mail.

Following radioed instructions, I was ready in my unaccustomed dress khaki uniform, and in a little more than an hour the helicopter had put me down in Washington, D. C., on the back lawn of the White House. Soon I would see the President of the United States.

* See "Greatest Voyage in the Annals of the Sea," by J. R. Hildebrand, NATIONAL GEOGRAPHIC, December, 1932.

Waiting, I thought of what *Triton* had accomplished. For one thing, we had proved that a submarine can go around the world undetected. It can go wherever there is deep enough water—and that's about 65 percent of the globe—unknown to any but those ordering its movements. In a way, it is potentially the world's fastest weapon. Until the moment it strikes, it simply isn't there.

I also thought of long-range submarine exploits to come. Fuel would be no problem; our piece of uranium could have taken us around the world several times more.

Navigation problems would diminish with the improvement of inertial-navigation apparatus that tells position constantly, without the need of any external observations.* And machinery to produce oxygen from sea water would soon be ready—allowing a submarine to stay down deep as long as rations and the nerves of the crew held out.

To this question of human endurance,

* See, in the NATIONAL GEOGRAPHIC: "Submarine Through the North Pole," by Lt. William G. Lalor, Jr., USN, January, 1959; and "Up Through the Ice of the North Pole," by Comdr. James F. Calvert, USN, July, 1959.

Triton had perhaps made its greatest contribution. I imagined the electronic sorting and computing machines busy at the Navy Medical Research Laboratory of New London, sifting the data we had gathered about ourselves (graph, page 606). This information about men shut off from the world was urgently wanted for the Polaris-missile submarines already operational—the *George Washington* and the *Patrick Henry*. Their crews might have to stay submerged as long as we did.

Submarine Findings Aid Space Scientists

The same information would also be prized by the scientists who look ahead to explorations in fathomless space above. For nothing so resembles a spaceship as a submarine in inner space—the sea.

My thoughts were interrupted when a pair of feminine arms encircled my neck and a firm kiss was planted on the side of my face. Swiftly I swung about.

She had discarded the red scarf, and the old coat was replaced by a fur wrap; but the blue eyes and the smile were exactly as I had remembered them.

"A line inching its way across a National Geographic map," Captain Beach recalls, "was our only visible sign of progress." To a crew sealed in their submarine for 85 days, the map, hung in a passageway, became a window on the world. "We all knew a lot more about geography by the time we arrived home," he admits. 615

ILLUSTRATION © NATIONAL GEOGRAPHIC SOCIETY



*In this 500th anniversary year
the world honors Portugal's illustrious
son, whose genius opened a remarkable
era, the Age of Discovery*

Prince Henry, the Explorer Who Stayed Home

By ALAN VILLIERS

*Illustrations by National Geographic
photographer THOMAS NEBBIA*

THE PORTUGUESE are an astonishing people. Dias, Da Gama, Cabral, Magellan—all were Portuguese. Theirs are the big names. There were hundreds more like them, seafaring pioneers upon the routes of the world. Many achieved fame, but more did not.

Names such as Zarco and Teixeira exploring the Madeiras in 1418-20; Cadamosto keeping a careful record of his voyage along Africa's west coast 35 years later; the Corte Reals groping in the dark mists of the Grand Banks of Newfoundland four and a half centuries ago; and the mysterious Antonio de Abreu, who in 1512 ventured beyond the Malay Peninsula to the Spice Islands of the East Indies—these names are known to few but scholars and geographers.

Where Serpents Swam in Boiling Seas

In a century of quietly persistent, courageous, and unpublicized endeavor, men like these explored the west, south, and east coasts of Africa, sailed to India and much of Indonesia, Malaya, the Moluccas, and opened up the modern world.

The more one thinks about it, the more amazing does the achievement become. Where the Portuguese first sailed, other men had feared to go, with seeming good cause. South of Africa,

(Continued on page 622)

Stern first, oars at work, a Portuguese craft seeks shelter from a storm approaching Albufeira. The fishermen, who cast off beneath cliffs at dusk and tended lines all night, sail home at dawn. Their boat's painted eye, a good-luck charm of ancient origin, scans the sea for fish. The lateen sail is of the type used on caravels designed by Prince Henry the Navigator, who died exactly five centuries ago this month.







EUROPA

ASIA

PERSIA

MARE MEDITERRANEUM

TIGRIS

MADAGASCAR

GRAN CANARIA

DESERTO

These lands are inhabited by men having faces like dogs

Africa takes its name from one of the descendants of Abraham who was called Affar

LIBIA

EGYPTO

PALESTINA

Tablenna almost impossible that human mind could think such a beautiful thing and that human power could bestroy it

DESERTO

PERSIA

ARABIA

DESERTO

INDIA PRIMA

AFRICA

ASIA

Here the Nile pours down with great impetus and rises and also with great dignity

MARE ARABICUM

Inhabitants practice sacrementy calling to callers their knowledge of prosperous winds

Here stands a column with a tank showing in writing that begins thus point one should not go

ETHYOPIA AFRICA

The Abyssinians narrate many things about this land bestial habits of the people dragons and other things which I cannot mention

ARABIA

OCEANUS ATLANTICUS

ETHYOPIA OCCIDENTAL

according to sailors experts in navigating this Indian Sea there are 12,000 islands

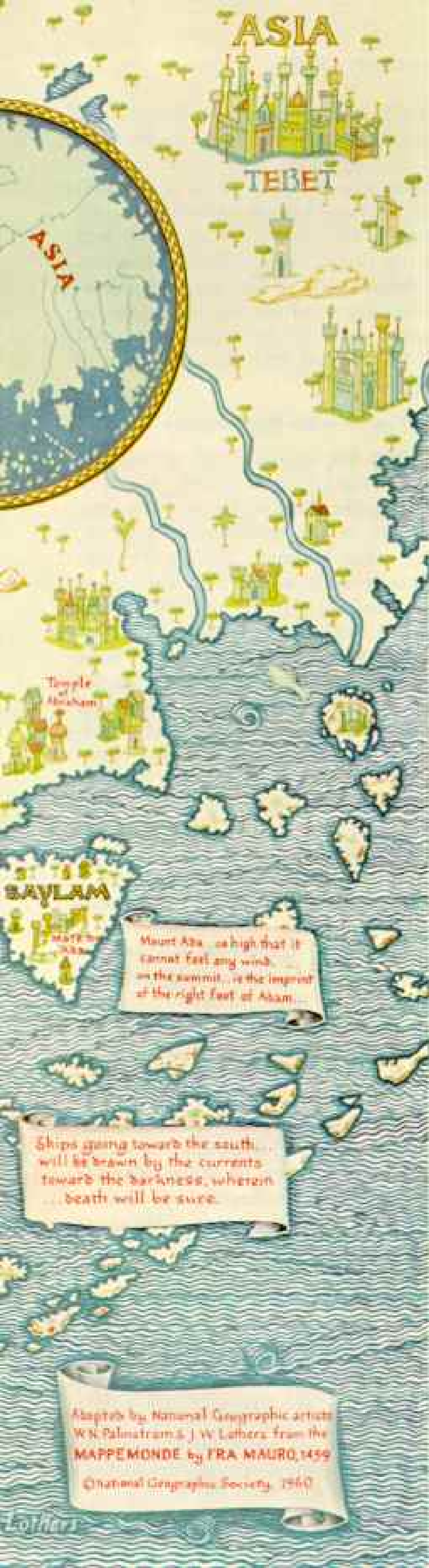
Here the water ends

MARE INDICUM

Only a little distance from the foreign islands the darkness begins to appear

If may cause wonder to see in Europe cities as small, while in Asia they appear as large, where able to do so I made the places large and where I had no room I made them small. Let them who are not pleased with what I did have patience. *Tia Mauro*

DA GAMA, 1497-8



Prince Henry the Navigator, from a court painting attributed to Nuno Gonçalves in Lisbon's Museum of Ancient Art.

THE WORLD OF PRINCE HENRY'S TIME, a dark and fearful realm of ship-devouring sea monsters, everlasting nights, and boiling oceans, is reflected in this illustrated 15th-century *mappemonde* by the Venetian cartographer Fra Mauro. The complete six-foot, four-inch circular chart (inset) may have been used by Prince Henry at Sagres.

NATIONAL GEOGRAPHIC's adaptation of the chart's southern section shows the distorted image of the world that prevailed until Henry's intrepid caravels braved the unknown and forever replaced myth with fact.

Fra Mauro's own annotations, gleaned from reports by travelers of his day, sprinkle the map, revealing the massive ignorance and superstition that Henry faced in his search for the truth.

Epic voyages by Bartholomeu Dias and Vasco da Gama, whose routes are superimposed on the chart, grew out of the Navigator's theories, though they took place years after his death. Dias, drawing on knowledge amassed at Henry's center of navigation, rounded Africa's tip in 1488. Ten years later Da Gama, sailing with Dias's helmsman, charted the ocean road to India.

According to one of the notes on this fascinating map, Africa took its name from Affer, possibly another spelling for Ephraim, who was a grandson of Abraham. Modern scholars believe the word comes from Afer, the Latin form of the Carthaginians' name for their own land.

OPPOSITE PAGE FOLDS OUT

they thought the sea boiled. To sail there meant slipping over to the underside of the earth (if not right over the edge) where the body could not function and there could be no return. Sea serpents and other fantastic and ravenous beasts dripped fiery tongues waiting for victims. Ships were cockleshells. Navigation was by guess and by eye.

Why was it that small Portugal nurtured so many early sea heroes, inspired them to the making of such voyages as never had been made before or even dreamed of?

The answer is stranger than the problem. Most of the credit belongs to one remarkable man—a man who, except for short trips to Morocco, never went to sea at all. We know him today as Prince Henry the Navigator, though he did not acquire this title until after he had been dead more than 400 years!

Prince Henry Changed World History

Henry was a genius. No swashbuckling seafaring man but a quiet scholar, he led the ascetic life of a monk; yet his imagination roamed the earth, and his determination changed the history of the world. It was he and the men he gathered around him who began the great series of sea voyages which were to make little Portugal a dominant sea power for centuries after them. Dias, Da Gama, Magellan—all their fame, all their accomplishments stem ultimately from Prince Henry (see foldout map of Prince Henry's world, pages 619-621).

I have long studied the life of this quietly astonishing man, this celibate Prince of Sagres Point—philosopher, thinker, religious devotee, son of the great King John I of Portugal and a clever, extraordinary mother.

Alan Villiers, one of the foremost living writers of the sea, has spent most of his 57 years sailing the oceans in ships of every rig. For three decades the Australia-born author's salty articles have delighted NATIONAL GEOGRAPHIC readers: accounts of rounding the Horn in a windjammer, of sailing the square-rigged *Joseph Conrad* around the world, of crossing the Atlantic in the Coast Guard's lovely bark *Eagle* and later as master of *Mayflower II*. New assignments for the magazine have recently taken Captain Villiers to Scotland, to India and East Pakistan, and to England's southwest coast.

Queen Philippa from England. It may well have been that mother who first inspired the Prince's driving force, which was to send frail Portuguese caravels again and again and again to extend the limits of the known earth, until at last there were few limits left.

What the Prince began, others continued. He laid foundations of his country's world-sailing influence so firmly that to this day, at the remotest ends of the Asian world and much of the African, men speak of ships in Portuguese words.

Nau Sails the Brahmaputra

"We call a big ship like this a *nau*," an Indian shipwright told me on the banks of the Brahmaputra River in January this year. The best part of a thousand miles from sea, at a place called Neamati, in India, the shipwright was at work on a large planked boat of a type I had not seen before. *Nau*! That is the word for ship in Portuguese.

No Portuguese venturer had been in those parts, I knew, for at least two centuries; yet the word persisted. I asked the shipwright his own name. Rodriguez, he said, Pedro Rodriguez. And he was as Indian as they come!

I recalled that upon landing in the Maldiv Islands, the first thing I saw was a Portuguese stone fort with some beautiful bronze guns marked with the Portuguese royal arms. Near Calcutta, on my way toward Neamati, I visited the Portuguese church at Bandel, founded there in 1599.

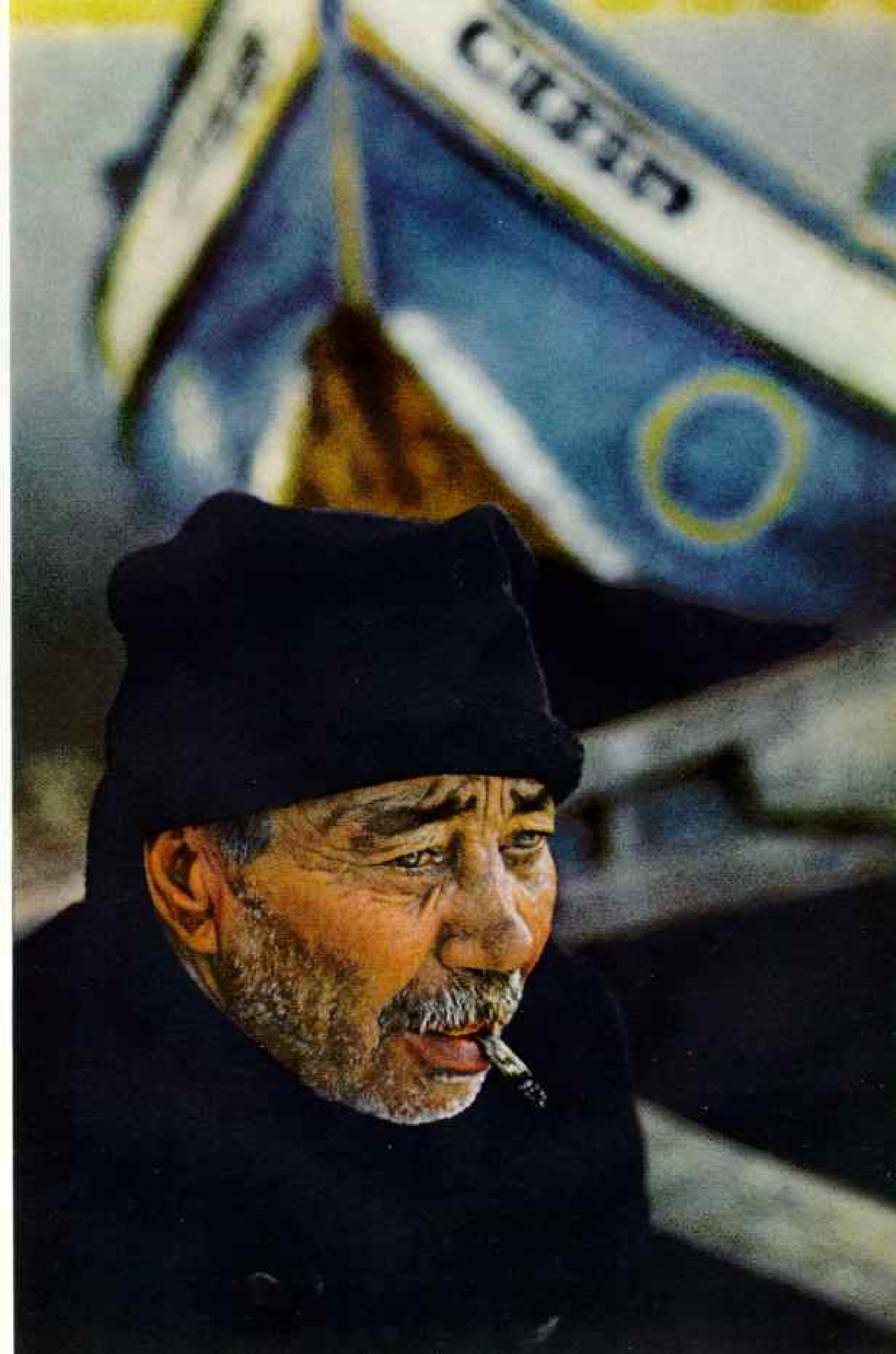
When I called by Arab dhow at Mombasa on the coast of Kenya, there stood the great Portuguese fort of Jesus, protecting the entrance to the ancient harbor as it had done through the preceding four centuries.

At Damão on the Gulf of Cambay, at historic Diu and golden Goa on the west coast of India, at Macao in China, Timor in Indonesia, Mozambique and Angola in Africa, the Portuguese flag still flies. At Malacca on the coast of the Malay Peninsula, by Ramree Island off the coast of Burma, near Chittagong in East Pakistan, I saw centuries-old Portuguese ruins. Over shops in Zanzibar, Colombo, Calcutta, Dar es Salaam, I read Portuguese names.

(Continued on page 626)

Furrowed Face and Grizzled Beard Bespeak an Old Man of the Sea

Scorning modern methods, Portugal's coastal fishermen pit their skill and strength against the sea as did their ancestors. Many wear funereal black in memory of relatives or friends who sacrificed their lives in the endless battle with wind and wave.





Pôrto, Birthplace of the Navigator

WATERFRONT lights cast candle-flame images on the Douro River, and the glowing tower of Clérigos church becomes a beacon at the opening of a nationwide observance of the 500th anniversary of Prince Henry's death. Pôrto, often called Oporto, was known to Rome as Portus Cale, origin of the name Portugal. Here in 1394 the English queen of King John I gave birth to the Prince whose navigation studies opened a new world.

Here, too, Prince Henry equipped the expedition he helped lead to Ceuta (page 639). Because their ancestors lived on tripe so that every ounce of meat could be salted for the Ceuta expedition, Pôrto folk still call themselves *tripeiros*—tripe eaters.

Pôrto also gave its name to port wine, one of Portugal's most valuable exports. Shipped downstream from vineyards in the Douro valley, the wine matures in vats in Vila Nova de Gaia, on the near side of the river. Girls at the upper right carry casks of insecticide to spray vines near Pêso da Régua, in the grape district.

The dreamy-eyed boy leaning on his staff stares out to sea, as the visionary young Prince must have done. Another youngster with a toy boat plays in the alley just around the corner from the house where the Navigator was born.



How is it that so small a nation still could have so large an impact upon so great a world? Just what is the secret of the strange endurance of Portuguese enterprise, begun by Prince Henry?

Not much is known about him, for that matter. These are the bare history book facts:

He was born at Pôrto in 1394 (page 624), fourth son of King John I of Portugal. His mother Philippa was daughter of the English Duke of Lancaster known as John of Gaunt. Prince Henry won his knighthood in the capture of the stronghold of Ceuta from the Moors in 1415, distinguishing himself by his courage and outstanding qualities of leadership in the field.

Urged by his advisers, King John I decided to lead an expedition, together with three of his sons who were eager for battle, to take the great Moslem fortress on the African coast opposite Gibraltar. Morocco's chief port and a pirate haunt, Ceuta had also been a muster point for past invasions of Europe by the Moors.

Queen Philippa was dying of the pestilence when the time came to sail. She called the three warrior sons to her and made them promise to carry out their Christian duties.

"We promise!" all three declared.

The wind stirred the draperies in the bedchamber.

"What direction is the wind, my sons?" the Queen asked.

"North, mother. It's the *nortada!*" cried the youthful Henry.

"It is the wind for your voyage. Sail, my sons, sail!" declared the Queen. "Do not wait on me!"

Wind Gives Victory to Henry's Armada

Philippa was right—a favoring wind held until they reached Africa. Then the wind became so strong that the heavy-laden ships drove by, unable to bring up there as they intended. The Moors, seeing the fleet dispersed, concluded that the armada would be unable to reassemble. So they sent home many of their soldiers.

In the night the wind dropped, then went to east. A squadron of the ships, Prince Henry in one of them, led the armada in the dead of night back to Ceuta, entered the harbor, and at daybreak fell upon the city. Beaten back by the fiery Portuguese, the Moors fled after a day of bloody street fighting, and all their efforts afterward could not regain the city.

In this fighting Prince Henry was the outstanding leader, the most resourceful and courageous of them all, flailing with the great sword his mother had given him, taking strong point after strong point, and relentlessly pursuing the wind-given advantage of surprise.

Centuries afterward, standing in a hilltop field above Ceuta, I thought of that wild, triumphant night. Below me the strong stone walls of the Moslem fortress stood, solid and seeming as impregnable as they had been 500 years earlier, and I wondered at the courage and sheer military ability of the stripling Prince who had stormed and taken this place so long ago. No wonder he had impressed his countrymen (page 639).

For his victory Henry was created Duke of Viseu and Lord of Covilham, and later granted the beautiful southern province of Portugal still known as the kingdom of the Algarve. He might have had a distinguished military career, or lived the life of an idle prince. Instead, when in his early twenties, he retired to a rocky cape known as Sagres Point, at Portugal's—and

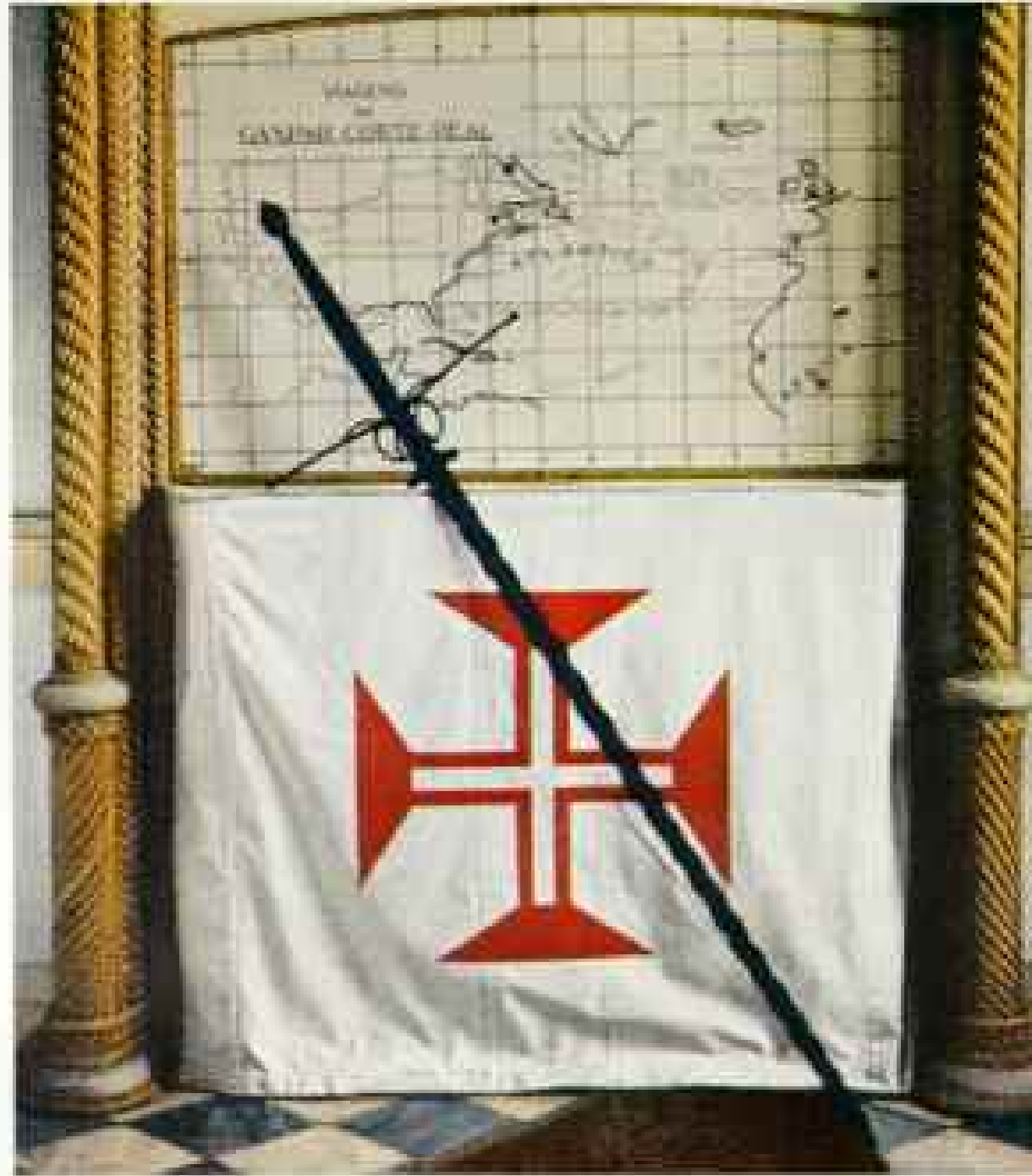
Henry's Heritage

PRINCE HENRY left Portugal only on four short crusades to North Africa—barely out of sight of Europe.

The Church of the Valley in Ceuta still shelters a Madonna (opposite) carried to the city by the Portuguese. Henry's sword (upper right), shown in the Naval Museum at Lisbon, flashed against the Moors in 1415. With this blade the king knighted his son after the battle. Banner behind the sword bears the Cross of Christ, emblem of a military order that succeeded the Knights Templar. For years the Prince served as grand master of the order, whose enormous wealth helped to finance his long and costly search for new sea routes along the African coast.

Navigators of Prince Henry's era determined latitude with astrolabes similar to the one exhibited in the Naval Museum (lower left). An instrument for measuring the altitudes of celestial bodies, the astrolabe gave way to the quadrant and the modern sextant.

Prince Henry's statue was erected this year at Lagos, the port where the Navigator fitted out his vessels. Sculptor Leopoldo de Almeida exhibits a model of the work in Lisbon.







Wash-day woolens fly like flags from lines strung on the beach at Nazaré. Few houses in the town possess back yards or clothes-drying space. Like most Nazaré women, the laundress wears layers of petticoats beneath her voluminous skirt.

When Storms Toss the Waters off Nazaré, Bathtub Boats Park on Rollers in the Street

For centuries Nazaré has sent its intrepid fishermen to reap the riches of the Atlantic. When luck and weather smile, the men return at dusk and haul heavily laden boats onto the sand; when fortune frowns, they may not return at all. But risks seldom deter the men of Nazaré, who claim descent from ancient Phoenician mariners. From ports like Nazaré, Prince Henry recruited his caravel crews.

Red tile roofs and turrets announce the town from afar. Stone sea wall protects houses from tides and waves. Summer vacationists pitch tents on the sand and share the beach with the fisherfolk.

Europe's—southwest extremity (pages 636-7).

Here Prince Henry lived most of the time until his death in November, 1460. He never married. The few paintings of him show an austere man, almost melancholy (page 621).

Azurara, his chief contemporary historian, described him as "big and strong of limb, his hair . . . of a color naturally fair, but which by constant toil and exposure had become dark. His expression at first sight inspired fear in those who did not know him, and when wroth, though such times were rare, his countenance was harsh.

"Strength of heart and keenness of mind were in him to a very excellent degree, and beyond comparison he was ambitious of achieving great and lofty deeds. . . . All his days were passed in the greatest toil. . . . his palace was a school of hospitality for all the good and high-born of the realm, and still more for strangers. . . ."

Prince Henry's purposes were manifold: to increase geographical knowledge, extend Portuguese trade, discover the extent of Moslem power, and spread Christianity. His plan was to push ships south along Africa's west coast and chart the unknown. As his captains ventured farther and farther, doubtless his vision grew to encompass the eventual sea route around Africa to India!

To do these things, Prince Henry had first to revolutionize the entire maritime world.

Navigation Becomes a Science

The first step was to improve methods of navigation. At Sagres, therefore, the Prince assembled experts in this art, an extraordinary and unique body of mathematicians, chart makers, astronomers, pilots, master mariners, students, and chroniclers of voyages. They came and went, leaving their contributions; they included Portuguese, Spaniards, Jews, Arabs, Italians. With these men as faculty, the Prince set up the first navigation school in Europe, its task to establish ocean navigation as an exact science.

Until then, small ships had groped in small voyages, and navigation consisted mainly of piloting—making well-established coastwise passages with a few brief jumps from well-known departure point to equally familiar

landfall. Prince Henry conceived the idea of making voyages where no man had been before.

How could these things be done without knowledge of navigation? What use was it for discoverers to sail on voyages they could not plot, to return not knowing where they had been? European voyages, both in the Mediterranean and out of it, were all coasting voyages then. Where sailors could not coast, they did not go.

A thousand Asian ships sailed the monsoonal waters of the Indian and China seas in much the same way, though they were better off. They had a dependable system of ocean winds, which they had merely to understand in order to be blown both ways—from Arabia to India at the right time of the year and back again; from the Persian Gulf to Ceylon and back again; from the China Sea to the Bay of Bengal and back again.

Arabs Controlled Early Trade Routes

Europe's seamen had no such advantages. And they sailed with trepidation in dangerously small ships barely fit for the coastwise passages they made. The working seaman's was a low-caste calling. Knowledge of coasts and ports and harbors, of landfalls, departures, distances, and courses was a personal matter, the stock in trade not of mates and masters, but of individual pilots who had painfully attained to it and preserved it in closely guarded manuscript books.

In 1939 I was given just such a book, a sort of periplus or navigator's guide of the Indian Ocean, by the Arab pilot of a big Persian Gulf dhow in which I sailed from Zanzibar to Kuwait.* It was handwritten, with small pen pictures of every important headland between the coast of Tanganyika and the mouth of the Euphrates. Officials at the British Museum found its older pages were made of paper several centuries old.

In the maritime world as Prince Henry knew it, Europe's supply of the rich Eastern trade came overland to Italian ports, where rich merchants grew richer in its distribution. Sources of supply were dominated by the

*See "Sailing with Sindbad's Sons," by Alan Villiers, NATIONAL GEOGRAPHIC, November, 1948.

Yoked Oxen at Vieira Tug a *Barco do Mar* From the Thundering Surf

When other boats are wavebound, the bulky craft cleaves the breakers without swamping. Upright prow and stern proclaim its ancient origin. Beamy enough for three or four men at each sweep, the craft can be rowed out to sea from harborless shores.





Arabs, who were then the great seamen of the Indian Ocean and—more than that—a threat to Christian Europe.

Prince Henry's idea was to outflank Arab control by sending ships southward along Africa's unknown west coast to find new ways to the sources of wealth.

Genoese Explorers Never Returned

Others had experimented. Once, more than a century before Prince Henry was born, two Genoese ships had sailed through the Strait of Gibraltar and headed south "that they might go by sea to the ports of India." That was the last heard of them. There was a record among the Greek geographers of a Phoenician circumnavigation of Africa made the other way, west-about.

But most geographers regarded Africa as a sort of infinite land which could not be sailed

around, and the whole of the unknown world as unconquerable and unlivable. To think or to plan otherwise in the 15th century was comparable to suggesting breaking the sound barrier, say, in 1903.

Prince Henry did not accept such ideas. His plan was to send seamen on voyages of discovery the like of which the world then had never known, to open up the sea route from west Europe to African and Asian waters, and all the world beyond!

He achieved these things, though not in his own lifetime. He died three decades before his compatriot Dias found the Cape of Good Hope and the Genoese Columbus stumbled upon a New World across the western sea. Prince Henry provided the inspiration and the idea. Others made the voyages.

He was a prince, a quiet and unusual prince, almost a recluse. He distinguished himself in



KODACHROME BY NATIONAL GEOGRAPHIC PHOTOGRAPHER THOMAS REEBER © N.G.S.

Toiling oarsmen beach their surfboat at Vieira with a plume aloft to announce a successful run. Each giant sweep was hewn from a pine log.

Launched through surf, the craft runs seaward while paying out a line fastened to a seine. Making a turn, the men lay the net while rowing parallel to shore. Then they head in with a line from the other end of the net and, beaching their boat, haul in both lines. The seine scoops up everything in its path.

Fishermen's families throng Nazare beach. Women and children help haul in the catch and unload returning boats.

Child in one hand, a fish in the other, the mother above tempts shoppers at the seaside market. Bareback rider below surveys the scene from his parent's shoulder.



action; he revolutionized navigation. He sent seamen in a new sort of ship to find the route around Africa into the Asian seas. He died before they had groped halfway down Africa's long west coast. He is buried at Batalha, 60 miles north of Lisbon.

This, then, is a summary of the bare facts in the history books. What about the man behind the printed pages?

I chose Sagres as a good starting point to study the sea-minded Prince. It is an extraordinary place. Offshore the liners, the oil tankers, and the cargo ships pitch upon their voyages in a constant line, northbound and south. They seem to turn of their own volition at the appointed distance off Cape St. Vincent, almost as if they have no crews—as if voyages to the ends of the earth are now so commonplace that the ships may sail unattended.

This gray, flat rock within sight of Sagres has long been one of the principal turning points of the sea-borne world. I listened to the beating of the restless sea, questing into the deep caverns which millions of years of its wild onslaught have torn into these gaunt cliffs. I watched the spray break, flinging itself with defiant roars on the rocks (page 636).

Here at Sagres I walked the lookout point which, tradition says, Prince Henry once had used, and I thought of all that waste of wild sea tumbling there in the 15th century, with no ships at all—no ships, and no knowledge, and no daring mariners to venture beyond sight of land.

Ships Improved for Exploration

The crying of the sea birds, the sighing of the west wind, the scud of the low clouds over the treeless point were fit setting for this Prince of Navigators, discoverer of discoverers. Turning my back upon the kingdom of the Algarve distantly behind me, shutting from my mind's eye the steaming ships, I thought back five centuries to the days when the wild Atlantic was a sea of danger and mystery, not to be sailed upon for fear of death.

The Prince had changed all that!

He had three great problems to overcome. First, he had to develop better ships, for frail barks scarce able to survive a few days of coasting, never far from haven or base, would not be fit for real ocean-going voyages. Simultaneously, methods of navigation had to be worked out and perfected, for point-to-point sailing would not get ships far into the unknown.

Finally, with the improved ships and the methods available, he had to inspire seamen to sail where seamen had never been before. They must keep on sailing, not only until the great pioneering voyages were successfully made, but until they had been reduced to the commonplace.

First let us consider the ships: What could Prince Henry know about such things? He was not, of course, a trained shipbuilder. The answer is that he could not know. But he could assemble men who were competent to make contributions to the solution of that problem.

Caravel Spreads Her Sail

In the early 15th century there were simple square-rigged vessels, round-bellied cargo carriers, often with one big sail. They spread this before the wind when favorable and managed to sail somewhere, sooner or later, as the Lord might will.

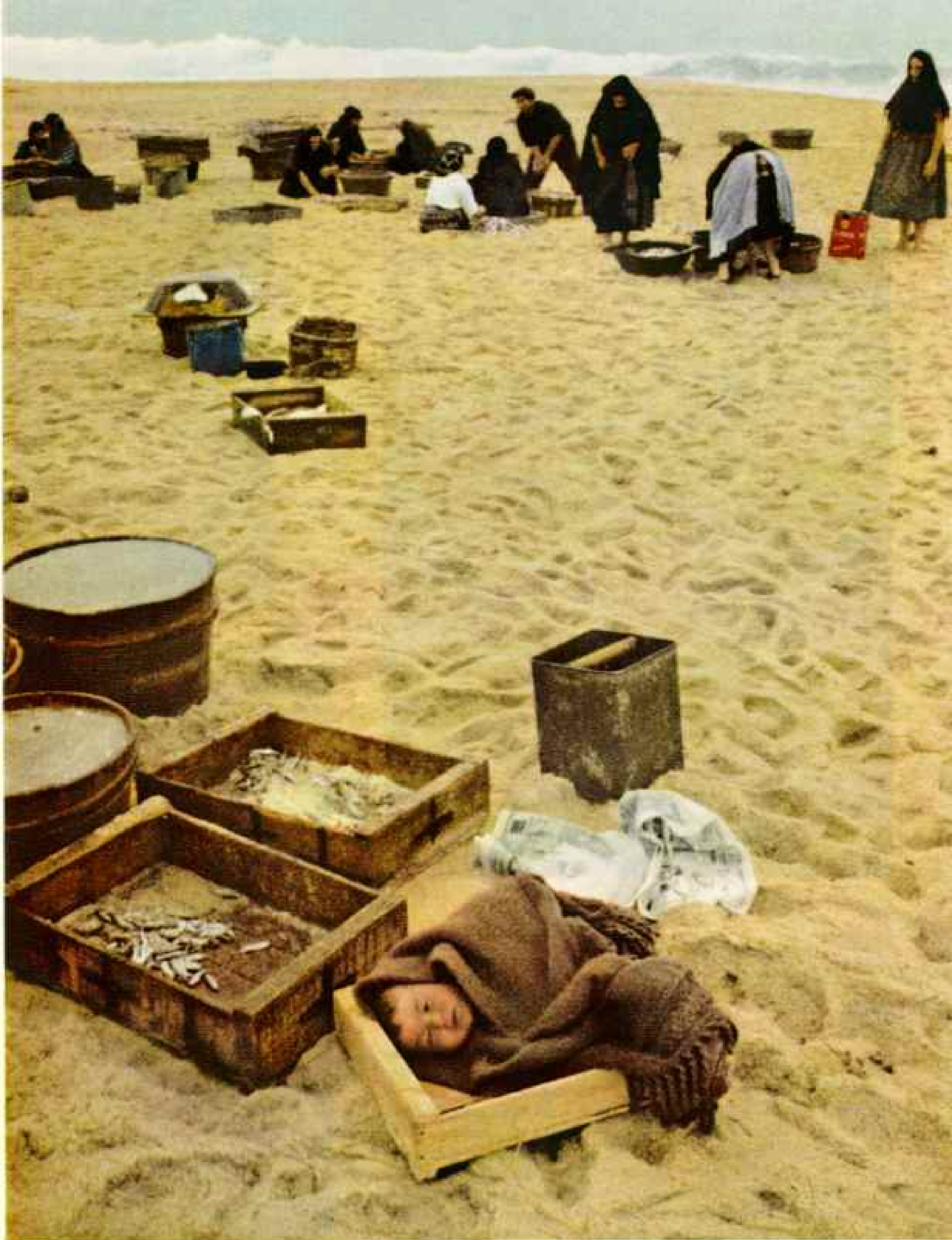
There were fast ships, too. Those fantastic seamen, the Arabs, backed by their Indian Ocean experience over thousands of years, had long known the merits of the lithe dhow with its lateen sails. Early Greeks and Romans may also have used the lateen. A lateen is only a modern Bermuda mainsail with its leading edge set to a long yard on one short mast; instead of the mast standing upright to carry the sail, the mast carries the yard and the yard carries the sail (page 617).

Such craft are fast, able, weatherly; but they are also weak. Developed against a background of azure seas to sail before the gentle monsoon winds, the lateen-rigged dhow was a wonderful vessel in its own waters, but no ship of discovery for the unpredictable western sea.

Arabia is notoriously short of timber. Arab dhows were necessarily built with minimum materials, were often undecked, used cordage laid up from coconut husks, sails of lightest cotton. All these things they still did when I sailed in them in 1938 and 1939. They were so completely designed for good-weather sailing that the upper bulwarks consisted of a row of frond matting, set up to keep the spray out. But their lines were good, and they were beautiful sailers.

Why not combine the merits of the two kinds of ships? No one knows whether this idea sprang full-blown from the mind of some master mariner or whether it evolved over years or centuries. Whatever its nautical

(Continued on page 638)



BY GUY AROCHÉ © NATIONAL GEOGRAPHIC SOCIETY

Boxed and Bundled, a Future Fisherman Sleeps on the Sand at Nazaré

"Roaming the beach as fog overhung the surf," recalls NATIONAL GEOGRAPHIC photographer Thomas Nebbia, "I saw the bundle move. When I investigated, a woman said, 'That's my baby,' and pulled aside a flap so I could snap his picture." Boxes hold sardines.



Somber Sagres

SEA AND SKY compose a blue infinity at Sagres, where land ends and ocean begins. On this rocky promontory Prince Henry built his home and spent much of his life, far from the glittering royal court. From his self-imposed exile, he sent out the expeditions that pushed back man's horizons.

Many times the Navigator must have looked out across the inlet at right toward distant Cape St. Vincent, the southwestern extremity of Europe. Now topped by a lighthouse, the Cape provides a landmark for the ships that pass close offshore.

To Sagres came the 15th century's foremost geographers, cartographers, mathematicians, astronomers, and shipbuilders. They revolutionized map making and tutored the Prince's captains. Few traces of Henry's school of navigation remain save for a curious circle of stones; the huge compass dial on the ground. Here Henry may have stood while conducting his classes in seamanship. Restored barracks date from a more recent era.

Henry worshiped at Guadalupe church (above) in Raposeira, near Sagres. Geraniums bloom beside the road.





Gibraltar Looms Across the Strait From Sunny Ceuta

Prince Henry in 1415 led a Portuguese armada against Ceuta, a Moorish outpost in North Africa. Overwhelmed, the Moors surrendered. Henry's victory closed a refuge for pirates, ended a threat of Moorish invasion, opened trade routes, and led to Portugal's glorious age of discovery. Here the 21-year-old Prince conceived his vision of sea routes along Africa's west coast.

Fourteen miles of sea separate Morocco and Gibraltar. Spain has owned Ceuta since the 16th century. Goats graze a slope overlooking an army outpost.



Titian-haired beauty of modern Ceuta traces her ancestry to Spain.

Peekaboo locks frame the face of a teen-ager in Tangier, scene of one of Prince Henry's crusades. Many of her neighbors descend from Moors who conquered Portugal in the 8th century.

pedigree, this ship, the caravel, proved best able to carry Prince Henry's bold navigators to unknown parts of the world.

The caravel's combination of the stronger European hull and the fore-and-aft lateen rig, alone or together with square-rigged sails, gave Prince Henry's mariners a ship with more endurance, speed, and maneuverability than any previous craft.

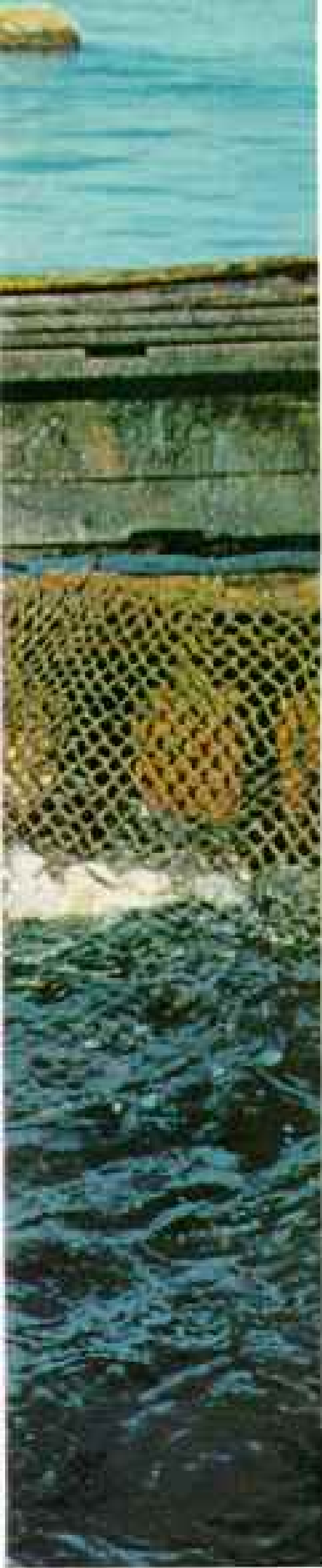
A large caravel had the big square sail, surmounted by a topsail, on her foremast, because this was the perfect rig to drive a ship before favorable winds. She had either one or two more masts, each carrying one large lateen sail.

Such sails were useful either off or on the wind. Lacking the area and the cumbersome rigging of the large square sail, the lateen sails could "point" up to the wind better, like a modern yacht. So the Portuguese caravel was









Fishing craft with sail furled accepts a tow into Tavira. By hitching a ride behind a motor launch, the master speeds his catch to market.

Gaffs stab a tuna in a trap off Tavira. Bound for spawning grounds in the Mediterranean, Atlantic tuna blunder into a net tended by Portuguese fishermen. After herding the captives into a corner, the men raise the bottom of the web by pulling ropes to lift the mesh. Then, leaning over the gunwales, they spear the struggling fish with steel hooks. One impatient man leaps into the swirling water in pursuit of a victim.

Human centipede hauls a boat onto Albufeira beach. Many Portuguese seamen wear checks and plaids that conjure up thoughts of Scotland.

Albufeira and Tavira face Africa from the Algarve, Portugal's southernmost province. Moors who clung to a foothold in the Algarve until the 13th century knew it as El Gharb—Arabic for the west.



an ideal sort of sailing ship for the new ocean voyages.

Where the first improved caravel was built, or what her name was, nobody knows. It could have been at Lisbon, or the pretty port of Lagos, near Sagres, whence many of Prince Henry's ships were to set out.

That it was well built there is no doubt. Solid timbers, careful workmanship, centuries of woodworking experience went into it. You

may see, as I have seen, such methods still in operation in many a fishing village around the Portuguese coast today—the great trees sawed into stout logs in medieval saw pits, the swinging adz used as a sharp ax or skillful plane, the shape of the wooden ship growing strong and fast and beautiful upon a pile of wood, a heap of shavings.

I have seen such ships being built in the great codfishing ports of Portugal, the stately,



able hulls sea-kindly as Prince Henry's caravels, still built in clear line of descent from the brave little ships of those days. I recall the schooner *Aviz*, of Porto, rolling and pitching through a wild night off the Greenland coast in 1950. We were aboard another ship, riding out the same storm near her. It was still daylight north of the Arctic Circle, and I had ample opportunity to admire the grace of her lovely caravel lines as she rolled.

Gingerbread castle perches on a wooded pinnacle overlooking Sintra, northwest of Lisbon. Built in 1840 for Prince Consort Ferdinand of Saxe-Coburg and Gotha, the Castle of Pena suggests a Wagnerian stage set. Here, within sight of the distant Atlantic, sojourned Portugal's last king, Manuel II, who fled the country in 1910.



By today's measurements, caravels were small—about 100 to 200 tons—but they were large enough for their job. They had one other merit: They were comparatively cheap to rig and to man. Their gear was simple and could be maintained at sea.

While such vessels were being developed, the experts in navigation were getting together to see what they could do. At that time, the use of the compass was well understood, and pilots could establish latitude with reasonable accuracy. Seamen kept the most careful reckoning of how their ships progressed through the water.

Constant care at the helm and the most thorough conning were the prerequisites of watch keeping. The compass might be lighted by the feeble glow from a candle, but two skillful men watched it as long as the vessel was under way at sea—the helmsman and the pilot, or his assistants.

A painstaking record was kept by means of pegs on a traverse board marked with distances and compass courses. We used such a board on the crossing of the new *Mayflower* in 1957, and found it surprisingly simple and accurate to use.*

There were charts called portolanos, often decorated affairs of elaborate workmanship. These showed coasts and compass courses. Each pilot had his own and sailed by them.

Sagres Gave Navigators New Tools

Prince Henry's school at Sagres worked to improve charts, compasses, and shipboard instruments, and also devised superior astronomical tables. At that time, the more important pilots generally carried calibrated brass instruments which were forerunners of today's sextants. These instruments were known as astrolabes, and many still in existence are of excellent workmanship (page 627).

Astrolabes could be used both for finding altitudes of the sun and stars and as surveying instruments. They had been known in Asian waters for many centuries. Using tables of the sun's declination, worked out in advance by the astronomers, pilots could compute a ship's latitude from the data provided by the astrolabe.

The difficulty was to use such instruments accurately and to provide the necessary

nautical tables. Prince Henry's mathematicians, astronomers, and instrument makers worked on this problem. To use a brass astrolabe on the pitching deck of a small sailing ship is a very difficult art. I know, because I have tried that, too.

The nearest position we could arrive at with such instruments on the *Mayflower* 1957 voyage was 20 or 30 miles from the positions given us by more modern methods.

South to the Orient

One problem the Prince did not have. That was where to go.

At his very front door lay the whole of the watery world. What lay beyond that gray and tumbling sea stretching westward from the Point of Sagres? Nothing? There were old stories of lost lands somewhere to the west—fabulous, mysterious islands. Legends, perhaps, but named on charts, and named with a curious consistency. St. Brendan's Isle, an ill-defined place called Brazil (no connection with the real Brazil, then undiscovered), a group of islands—maybe mythical, maybe not—called Antillia, and another known as the Isle of the Seven Cities—these were on many early Atlantic charts.

Who put these places there? There is a chart known to have been in existence in 1424 which shows Antillia about where the West Indies actually are. Scholars had long known of the existence of some land out there beyond the sea, and had put forward a theory that ships could reach the east by sailing west. This was an old Greek idea, conceived a thousand years and more before the school of Sagres was thought of or Columbus sailed that way.

It is unlikely that we will ever know much about transatlantic voyages made, or attempted, in ancient times. It is sufficient to know that Prince Henry's scientists were aware of the possibility of finding a way toward India over the western sea, and probing voyages were made leading to the discovery, or re-discovery, of the Azores, by 1432.

Beyond that lay an interminable stretch of water harassed periodically by great storms. What else these early voyages westward may have discovered can only be conjectured now, for records of them are lost. But it is obvious that the Portuguese court, 24 years after Henry's death, knew sufficient of the Atlantic Ocean to turn down Columbus's proposals eight years before he sailed

*See, in the NATIONAL GEOGRAPHIC, "We're Coming Over on the *Mayflower*," May, 1957; and "How We Sailed the New *Mayflower* to America," November, 1957, both by Alan Villiers.



Diners at Nazaré Survey a Boat-clogged Beach

Oars and sails still propel many Portuguese fishing craft, but motors are growing more popular. Yet, whatever the power, the boats continue to land choice fish.

"No matter where we went in Portugal," reports photographer Nebbia, "we found the seafood marvelous." Nebbia made this photograph at the Mar Bravo, where he dined with his wife Sallie (center) and Joaquim Maia Aguas (left), their guide to Nazaré.

Santa Claus cap hides one eye of a lounging seaman on Nazaré beach. Tasseled end of his black stocking cap, a *barrete*, holds his money and tobacco.



to the West Indies with the backing of Spain.

The way to the real Indies was not by that direction. One spectacular, brilliant voyage would not discover it. No, the way was by constant, searching sailings to the south, and Prince Henry sent his ships that way—ship after ship.

It was slow, costly, difficult. Scholars might say the torrid zone was endurable, but it was sailors who had to go there, and they feared it. Seamen were superstitious men; to them the sea was immense and its dangers real. Time after time, year after year, small caravels sailed from Lagos or from Lisbon to venture a few hundred miles or so and return with fearsome stories. It took 19 years for Henry to get his first ship past Cape Bojador, just south of the Canary Islands, not a thousand miles from Sagres (see Atlas Map **The World**, a supplement to this issue).

"Beyond this there is no race of men or place of inhabitants; nor is the land less sandy than the deserts of Libya, where there is no water, no tree, no green herb—and the sea so shallow that a whole league from land it is only a fathom deep, while the currents are so terrible that no ship, having once passed the Cape, will ever be able to return."

This commonly accepted view is recorded by the 15th-century historian Azurara. That was the trouble: The seamen feared that if they did pass the Cape they would never come home again. Wind and current there came from the north; no ports existed, and they could get no help ashore.

Exploding the Myth of a Boiling Sea

"Go back, go back while we may!" was always their cry, until one braver than the rest sailed on. Such a one was Gil Eannes, conqueror of the myth of Bojador, whose name is honored now by the beautiful Portuguese hospital ship which sails annually to the Grand Banks and Greenland.

Gil Eannes had to make two attempts. On his first he came in sight of the Cape, but his sailors refused to round it. They could see the water boiling on the other side, they declared, and indeed it was obvious from the mastheads that some disturbance was causing a great upset and swirling in the sea. Boiling waters, adverse currents, no place to go! Go back, go back!

Gil Eannes was a courtier, not a pilot; a leader, not a seaman. Not knowing the answer to the sea's strange appearance, he returned.

The disappointment that his failure brought to Prince Henry can well be imagined.

One can almost hear the courtier offering his excuses. "But the sea was boiling," he might well have said. "I saw it myself from the masthead!"

"That was not the sea boiling, but racing at ebb tide over coastal shoals," explains the Prince. "Have you not seen it doing this along our own coasts?"

Indeed Gil Eannes had. And so in 1434 he sailed back to the much-feared Cape once more, this time with a different crew, and when he saw the water boil, sailed bravely on, skirting it. And indeed there were shoals there, just as the Prince had said!

Seamen Who Dared Other Unknowns

Having defeated one myth and found it baseless, why not sail on to conquer others? But there was the problem of finance, too. Portugal was a little country. Its total population did not exceed a million and a half souls. Its revenues were limited and could not be extended. Prince Henry's caravels were becoming costly, small though they were, and seamen had to be fed and paid.

Still the little ships pressed on, though for years the Prince's voyages were ridiculed as expensive absurdities. His personal courage never failed, and it is a tribute to his genius that he never lacked good seamen to take out his ships. Portugal's fishing industry was a fine recruiting ground for courageous and able mariners.

I can well understand that. So could anyone who ever watched the great *barcos do mar* going out through the wild Atlantic surf at Costa Nova, Furadouro, Caparica, or a dozen other Portuguese beaches, to wrest a living from the reluctant and frequently tumultuous sea (pages 631 and 632).

No breakwaters shelter these long, exposed beaches. Every Atlantic gale blows mercilessly home on them. Even on the quietest days the sullen surf roars and the rollers break threateningly. Over these beaches and through that surf the Portuguese fishermen must launch their 30- and 40-foot boats, by hand, aided by nothing but their own strength and skill and great lion hearts. The sea roars, the huge boats leap to life, the spray drives; but the fishermen keep on, riding through the surf with their huge sweeps—three or four strong men to a sweep!

So it was in Prince Henry's time, and so it



Skirts and Caps Fly as Santarém Dancers Spin and Whirl

Dressed as *campinos*, or Portuguese cowboys, these youngsters perform at the annual Fair of the Ribatejo, a prairie region along the Tagus River.

Campino costumes retain 18th-century style—tight-fitting breeches, red-flannel waistcoats, cummerbund-like *faixas*, and green caps called *barretez verdes* or *carapuças*. Sometimes campinos dance with half-full glasses of wine atop their heads, never spilling a drop.

Teen-ager at left waits her turn to take the floor.

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Sickle-swinging farmers harvest barley from a slope near Mafra. Setting sun

still is. I reflected that if such a leader as the noble Prince were to live again and had need of such men, why, here they still are, as they have been down the centuries. Sea bravery is a living thing to the Portuguese mariners.

I had seen this, too, in my six-month voyage with the Portuguese dorymen working from their schooners on the Grand Banks of Newfoundland and off Greenland.* That is a very brave business, of man pitting himself day after day, week after week, month after

month, alone in puny craft, against the might of the ocean—against fog, gale, blizzard, and the ever-present risk of being run down.

The Portuguese are the last Grand Banks deep-sea dorymen, as they were the first. They operate the last big schooners on the Banks, as they operated the first, with the same quiet courage and unapplauded heroism that their ancestors showed in so great an

*See "I Sailed with Portugal's Captains Courageous," by Alan Villiers, NATIONAL GEOGRAPHIC, May, 1952.



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gilds the grain and shadows the distant fields.

abundance when they shipped out cheerfully year after year in Prince Henry's caravels.

The court and Henry's mariners provided the leaders. All the revenues of the Algarve went into these endless ventures—the money from the rich tuna fishing, from the olive trees and the cork trees, the almonds and the grain.

The Prince's personal wants were simple. He kept up no grand establishment. A chapel, a lookout, a rough bed—these were his few

needs. He fasted six months of the year.

It must have been profoundly discouraging to have his trusted discoverers come back from voyage after expensive voyage to report that the land still stretched away as far as they could see. In fact, it was not until 1441 that Cap Blanc was reached, inside the Tropic.

In the three years from 1444 to 1446, the Prince licensed 30 voyages in his service. Dinis Dias rounded Cape Verde in 1445; Alvaro Fernandez was almost at Sierra Leone a year later. The discovery of the Cape Verde Islands—in 1960 still Portuguese—naturally followed the West African comings and goings.

Voyages Bring New Riches

The colonization of the rich and fertile islands of Madeira and the Azores, the discovery of gold dust on the Guinea coast, the beginnings of the slave trade—all these provided new means of finance, but they also created a distraction. For now many captains began to take more interest in trading than discovery. It was hard to pass a source of profit, gained the hard way.

The Prince's orders remained unchanged.

"Go south! Go on!"

The Cape Verdes were colonized, and the little ships pressed on, round the bulge of Africa, past Cape Palmas and eastward there—could this be the end of land?—past the Ivory Coast, the Gold Coast, the Slave Coast, only to be brought up after a thousand miles by the great bulk of the land

again, stretching interminably to the south.

Would it never end?

When Prince Henry died in 1460, the questing voyages did not end. The real fruits of his work came after him. African sailings became more difficult, but his seamen-discoverers persevered. At first, in the Northern Hemisphere, wind and current had been with them. Voyages to the south were simple; getting back again was the difficulty. Once in the Southern Hemisphere, conditions changed.

Flowers and Swans Grace a Pool Beside the Monastery of the Jeronimites

Domed and spired, the monastery occupies the site of a chapel founded at Lisbon by Prince Henry. Near this spot Vasco da Gama spent his last night before embarking on his epochal voyage to India. Fulfilling a vow, King Manuel I built the monastery to commemorate the expedition's success.

A masterpiece of Manueline architecture, a style named for the king, the structure blends Gothic and Renaissance characteristics, embellished with tropical and nautical ornamentation. Tombs of Da Gama and the Portuguese poet Luis Vaz de Camoëns lie within.

Square-rigged model representing Da Gama's flagship, the *São Gabriel*, rides the waves in the Naval Museum at Lisbon. The sails of this *nav* bear the Cross of Christ (page 627).

Ship's figurehead at left portrays Da Gama. Cross at rear surmounts a stone column erected by Diogo Cão near the mouth of the Congo River in 1482.



The wind was from the south and southeast—the famous trade winds—and the coastal current set at the rate of 10 to 30 miles a day toward the north.

It says a great deal for the weatherly qualities of the little Portuguese caravels that they were able to forge ahead under such conditions. By the early 1480's, Diogo Cão had sailed to within 1,000 miles of the Cape of Good Hope, nearly 6,000 miles from Sagres Point.

The passage to the Indian Ocean still eluded the Portuguese. There was no mystery now of their purpose. A Papal bull as early as 1454 described Prince Henry's intention as being to render the ocean navigable as far as the Indies, and the foreseeable consequence of this was to destroy the power of the Moslems



ALDACHROMES © NATIONAL GEOGRAPHIC SOCIETY

at its source. The Crusades had not affected their threat to Europe, nor dislodged them from their position in the Mediterranean. Well, Prince Henry's voyages could help the cause.

And they did, in the end, though it was not until 1488 that the Portuguese navigator Bartholomeu Dias finally rounded the Cape of Good Hope, and 10 years after that before another Portuguese, Vasco da Gama, sailed to India (map, page 619).

Mystery Shrouds Dias and Da Gama

These achievements are in the history books. What is *not* in the books is a mystery.

Dias, an obscure mariner of whom very little is known, finally came to the Cape of

Good Hope by striking off boldly from the African coast and sailing steadily southwards, out of sight of land, for a week and more before turning east. By that time, he was already south of the Cape of Storms (as he called it) and had to turn north to find the coast again.

Such record as survives informs us that a storm drove him off the coast. Yet it is very odd that, because of a "storm," he should have taken the step which then made rounding the Cape possible.

It is even odder—indeed, very much odder—that, a decade later, the great Vasco da Gama, possibly acting on instructions from the royal center of navigation (by that time in Lisbon), should have rounded the same Cape, not by any sort of coasting at all but by the



Washed by Tagus Waters, the Tower of Belém Guards the Approaches to Lisbon

Built in 1520 to protect river traffic, the tower evokes memories of Portugal's golden age. Once Da Gama reached India and Pedro Alvares Cabral discovered Brazil, decades of patient groundwork begun by Prince Henry bore dividends beyond the wildest dreams. Almost overnight Portugal became a world sea power and one of Europe's richest nations.

Silt changed the channel of the Tagus, leaving the tower on the sandy north bank; the structure originally rose from an islet in the stream. A lighter, moving upstream, passes the fortress.

Fishmongers pick and choose as boats unload at the Ribeira Nova, Lisbon's seafood market. After making a selection, vendors speed away to cry their wares. To the swiftest generally go the sales.

Her feet a blur, cargo balanced on her head, the fishwife at right rushes along a Lisbon street.



STICHENOWSKI © NATIONAL GEOGRAPHIC SOCIETY

bold and proper route of standing right out into the South Atlantic from the Line, and sailing south with the trade wind abeam.

That is the way we sailed in the last of the windjammers. That is the way recommended in the Admiralty directions, *Ocean Passages For the World*, still in use. A vessel bound for the Cape of Good Hope should "stand across the South-East Trade wind on the port tack . . . for the wind will draw more to the eastward as the vessel advances . . ."

[A vessel] "when to the southward of the South-East Trade will meet with fresh winds variable in direction . . ." but generally from the west. The sailing ship, having reached the latitude of Good Hope, simply runs to the east.

We called it running our easting down, and it was the most stimulating part of the voyage. We could continue on to Australia, or pull out of the west winds and stand up for East Africa or India.

But how did the route plotters for Vasco da Gama know about this mid-ocean route? How *could* they know? For no one



FRANCISCO SANTOS

Monument of the Discoveries shows Henry on the prow of a granite ship, holding a miniature Portuguese caravel and leading the way to the sea; knights who carried out his dreams kneel at his feet. Continelli Telmo and Leopoldo de Almeida designed this proud memorial for the 500th anniversary of his death. Belém unveiled it last August 9 (page 656).

had sailed it, according to the records now extant.

The answer, I have long concluded, is that voyagers must have sailed that way not once but many times, for sailing directions so accurate and sound to be prepared. A great many of the ocean voyages launched by Prince Henry are not recorded at all; at least, no records have come down to us.

At some time between 1488 and 1498—between Dias and Da Gama—the Portuguese had not only found a way toward the Cape of Good Hope, but may have solved the riddle of Atlantic sailing in its entirety. Seamen now know that in that ocean the trade winds and the wind system north and south, once understood, make possible regular voyages north, south, east, and west, with almost the reliability of the monsoon voyages of the Indian Ocean.

Spies Sought Prince Henry's Secrets

Just who first discovered these things we do not know, nor are we likely to find out. Prince Henry and his successors had to guard their secrets.

Lagos and Lisbon teemed with spies from ports and countries with a vested interest in seeing that a route around the Cape was not discovered or, if it were, that it was not a Portuguese monopoly. Genoese, Venetians, Castilians, Florentines were alike determined to profit from Portuguese enterprise, if none of them could stifle it. So the more important voyages were made stealthily and their results kept secret.

Not only did Da Gama take the best possible route in sailing to India, but there is evidence that, by then, the Portuguese knew of the existence of Brazil and the east coast of South America. They fished upon the Grand Banks off Newfoundland (their guild of codfishing shipowners dates back at least to 1501).

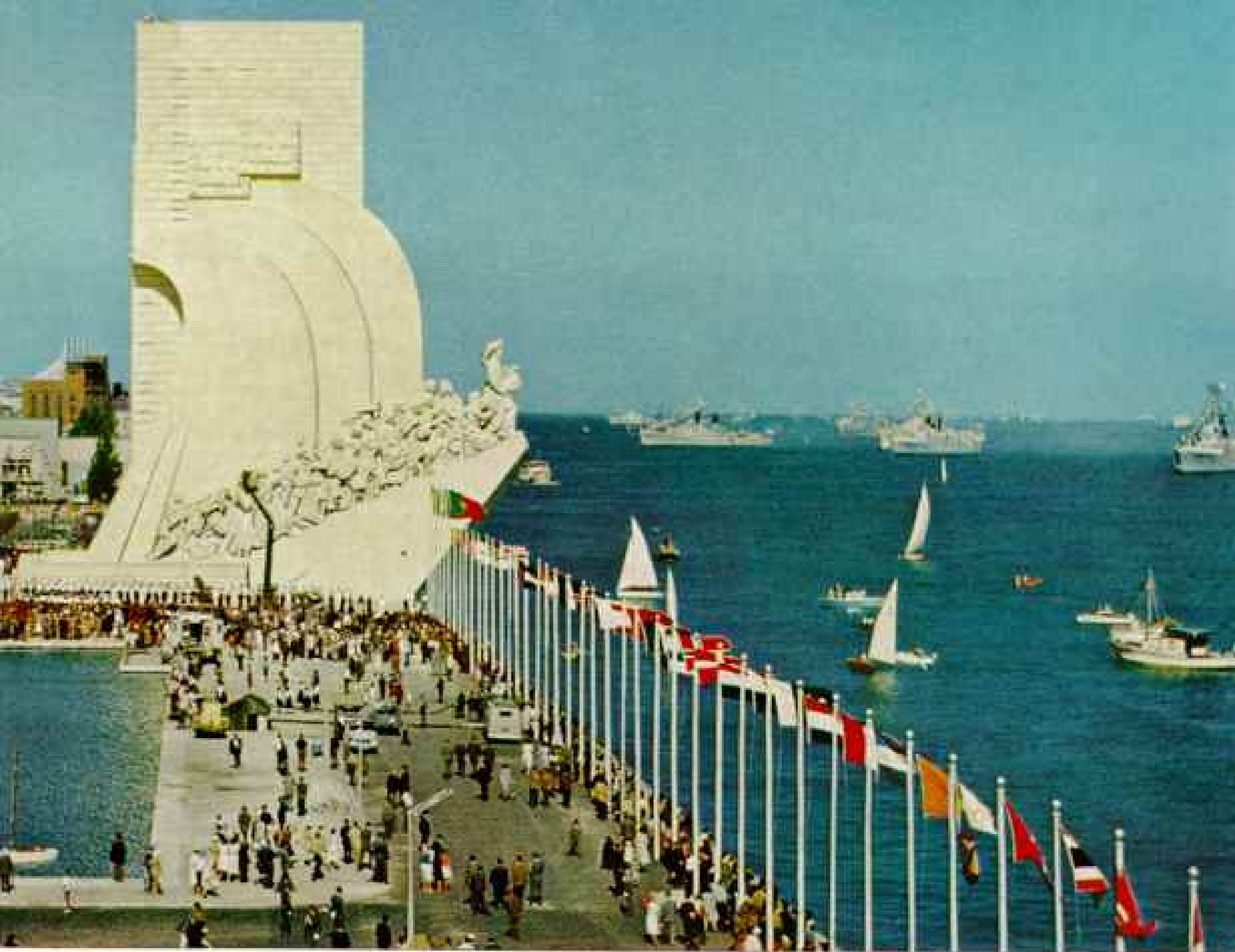
Some scholars surmise that the Portuguese knew there was no usable northwest passage around America to the Indies, nor a northeast way around Siberia of use to sailing ships. They may even have had an idea where the tip of South America lay, where their compatriot Magellan later discovered it.

They knew then—and vastly profited by the knowledge—that Prince Henry had been right. The way to the East was by first sailing south, and they had found it with their caravels and their brave seamen. First around Africa, first to Brazil, first upon the Grand Banks, first around South America, first



BY EXTRACTION BY NATIONAL GEOGRAPHIC PHOTOGRAPHER THOMAS NEEB © N.G.S.

Street lights dispel the gloom of a staircase alley in the Alfama, Lisbon's old quarter. Here time stands still; shadowy cul-de-sacs preserve an aura of Prince Henry's day. 655



PHOTOGRAPH BY ALAN VILLERS © NATIONAL GEOGRAPHIC SOCIETY

Flag-decked Belém dedicates the Monument of the Discoveries on the bank of the Tagus for all to see who sail upriver to Lisbon. Leaders from mother Portugal's far-flung dominions join the throng on shore, where the flags of the nations flutter in the *nortada*, the summer breeze. Warships of 33 nations, among them the United States Navy's heavy cruiser *Des Moines*, fire salutes. Private yachts join in the tribute.

across the Pacific, first to East Africa, India, China, Japan — what a record!

A million and a half Portuguese — led and inspired by a recluse Prince great among navigators though not himself a seafarer — encompassed half the earth and helped lay the foundations of the modern age.

Portugal's Prestige Spread to Asia

After the pioneering caravels, emblazoned with the Cross of Christ, came the carracks and the galleons, the great naus of the passage to India, which sailed on their stately voyages for the next 200 years.

After the discovering voyages came the pioneers of sea power, Affonso de Albuquerque and the rest, who soon found that they must establish Portugal's sea supremacy throughout the whole Indian Ocean and all the eastern seas.

Hence the Portuguese settlements in West Africa, at Mozambique, Mombasa, the Mal-

dives, Cochin and Calicut, Hormuz and Diu, Goa and Galle, Calcutta and Chittagong, Malacca, Macao.

They impressed the Africans and the Asians with the excellence of their ships and the inspiration of their enterprise, establishing a new Rome at Goa and the fabric of empire throughout eastern seas.

And so, 500 years after Prince Henry's death, it is understandable to find an Indian master shipwright far up the Brahmaputra River who calls a large ship a nau. It makes sense to see the Portuguese names upon the Singhalese shops, the Portuguese churches in the Asian sun, the cannon in the sand, the ruined fortresses in so many places.

It makes sense, too, that this year Portugal set aside eight months to commemorate the fifth centenary of the death of her most illustrious son, initiator of the greatest era of discovery the world has known — a Prince of Navigators indeed!

Centuries of Global Exploration

TWO WORLDS UNFOLD before the two and a half million members of the National Geographic Society who receive this issue of their magazine.

One is the world of Prince Henry the Navigator, with such 15th-century map-makers' notes as "Here the water ends" and "These lands are inhabited by men having faces like dogs" (see foldout map, pages 619-621).

The other is today's stranger-than-fiction world in which 18 new nations have been born in 1960 alone and even the floor of the sea is revealing its contours to cartographers. All the countries of the earth appear on this new 10-color supplement, the National Geographic Society's latest Atlas Series Map *The World*.

New Sea Ranges and Depths Charted

Since Prince Henry the Navigator launched the Age of Discovery and Magellan's scurvy-ridden sailors made the first circuit of the earth, innumerable men and explorations have added to the volume of knowledge concentrated on this 25-by-19-inch sheet.*

Thanks to modern oceanographers and seamen of many nations, the two-thirds of the earth's surface covered by salt water has been mapped by The Society's cartographers more extensively than ever before. Vast expanses of shading—the darker the deeper—give a three-dimensional view of the oceans.

The Mid-Atlantic Ridge, an underwater spine of mountains once thought to end off the southern tip of Africa, is now shown connected with other ridges to form a continuous chain snaking thousands of miles into the Indian Ocean. In the western Pacific the Mariana Trench, deepest known hole on earth, shows a new reading of 36,198 feet.

Seaweed symbols over a wide area of the Atlantic off the southeast coast of the United States represent the patches of floating gulfweed that cover the Sargasso Sea.

On land, new countries appear in a profusion that kept Society cartographers working to within hours of the map's printing deadline. Since 1957, when the NATIONAL GEOGRAPHIC's previous World Map was issued, 20 new countries—most of them formerly under French rule—have joined the roll call of sovereign states, which now total well over 100. The new Atlas Map shows even tiny Monaco, occupying only half a square mile on the French Riviera, and the even smaller Vatican City, its 109 acres surrounded by Rome.

Cease-fire Lines Split Uneasy Areas

New capital cities include such tongue-twisters as Ouagadougou, Upper Volta; Yaoundé, Cameroun; and Abidjan, Ivory Coast. The West Indies Federation, with its seat of government at Port of Spain, Trinidad, obtained home rule for its 10 British colonies last August 16. On the same day, the island of Cyprus won independence from Britain, and fireworks blazed over Nicosia.

Cease-fire lines noted on the map show how Korea and Viet Nam are divided into Communist north and non-Communist south. Another uneasy border splits Kashmir, where Indian and Pakistani troops have faced each other since 1949.

Arctic and Antarctic insets complete the map. Other panels record members of the United Nations and the Communist bloc as of September 6, 1960; list regional pacts and alliances; and enable the map user to tell at a glance the time of day anywhere around the world.

* This new map forms Plate 2 in The Society's Atlas Series and is the 20th uniform-sized Atlas Map issued since the series began in January, 1958.

To bind their maps, more than 240,000 members have ordered the convenient Atlas Folio, at \$4.85. Single maps of the series, at 50¢ each—or a packet of the 14 maps issued in 1958 and 1959, at \$5.50—may be ordered from the National Geographic Society, Dept. 35, Washington 6, D. C. A combination of map packet and folio is available at \$9.95.



Magellan's tiny *Victoria* and U.S.S. *Triton* drawn to scale

With patience, skill, and high-speed photography, a noted engineer and executive produces an extraordinary study of the bird world's living gems

The Hummingbirds

By CRAWFORD H. GREENEWALT

Photographs by the author

I PHOTOGRAPHED my first hummingbird one sultry summer afternoon in 1953. It was a male ruby-throat, come for courtship to Delaware after a bachelor's winter in Mexico.

Now it is 1960. Perhaps if I had known what the intervening years were to bring, I would not have had the courage to begin. But I had caught hummingbird fever, and with what now seems to me complete and utter rashness, had set out to make a series of photographs representative of the various species of these darting acrobats.

The photographs involved traveling some 100,000 miles. There were three trips each to Brazil and Ecuador, two to Venezuela, and excursions to Cuba, Jamaica, Panama, Arizona, California, and Colorado. Each voyage had its quota of adventure, triumph, and frustration.

In retrospect, I wouldn't have missed a

Hungry hummingbird hovers before a nectar-laden hibiscus. Pennant-tailed *Trochilus polytmus*, which lives only on Jamaica, is one of some 320 species, all native to the Western Hemisphere. Hummingbird feathers, which have no counterpart in the entire avian population, produce iridescent colors characteristic of the family.

1/16 LARGER THAN LIFE SIZE

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Shrewish Ruby-throat Sometimes Pours Her Fury on the Male (opposite)

Where females predominate in number, they attack males that are trying to feed. Only hummingbird of the eastern United States, *Archilochus colubris* winters in Central America. The male sports a ruby gorget, but his mate bests him in size. To fuel its 500-mile flight over the Gulf of Mexico, the bird adds fat up to half its weight.

mile, or an hour, anywhere along the way.

What is a hummingbird?

When first I became interested, I put the question to my ornithological friends, hoping that the answer would pave the way to greater knowledge and understanding.

Here—in part—is what they supplied, as embodied in Prof. Charles Sibley's highly reputable compilation:

Suborder Trochili—Hummingbirds

Schizognathous anisodactyle Apodiformes with 8 pairs of ribs; bill long and slender, gape not deeply cleft; tibial bridge absent; nostrils lateral, broadly operculate; tongue extensile . . . syrinx with 2 pairs of special intrinsic muscles; no Sterno-tracheal muscles . . . no gall bladder; no adult down . . . no claw on manus.

And so on. Even though "gape not deeply cleft" has a fine Shakespearean swing, I must say that the definition leaves the lay student

little the wiser. I had to search elsewhere.

Without their working clothes, ornithologists become much more lyrical. To Audubon, the hummingbird was a "glittering fragment of the rainbow . . . [a] lovely little creature moving on humming winglets through the air, suspended as if by magic in it, flitting from one flower to another, with motions as graceful as they are light and airy; pursuing its course . . . and yielding new delights wherever it is seen."

Hummingbirds, Mr. Greenewalt's brilliant book on the Trochilidae to be published this month by Doubleday and Company, appears under the auspices and copyright of the American Museum of Natural History. Simultaneous NATIONAL GEOGRAPHIC publication of this article and photographs from the book's extraordinary portfolio of high-speed color portraits has been made possible by the gracious permission and cooperation of the author and Dr. James Oliver, Director of the Museum.



Comte de Buffon, a French naturalist of the 18th century, considered the hummingbird "of all animated beings . . . the most elegant in form and brilliant in color. . . . [Nature] has loaded it with all the gifts of which she has only given other birds a share."

This is much more pleasant and far less alarming than "schizognathous anisodactyle Apodiformes"!

The common name of the family varies with different language areas. We call them hummingbirds, which certainly does not do justice to Audubon's lyric description. The French, with uncharacteristic lack of imagination, say *oiseau-mouche*, or fly-sized bird. The Spanish and Portuguese do a bit better with, respectively, *pica flor*—peck the flower—and *beija flor*—kiss the flower. In some of the Lesser Antilles they are called *murmures*, the murmurers; and in Cuba, *zum-zum*—phonetically, an apt description.

Indians Likened Birds to Sun and Stars

The Indian populations of Central and South American countries have done a great deal better. Their common names, *ourissa*, *huitzitzil*, *guanumbia*, *quinde*, signify "rays of the sun," "tresses of the day-star," and the like. Even in scientific nomenclature, the sun, the stars, and precious stones appear frequently. The name *Topaza pyra*, for example, means the "fiery topaz"; *Stellula*, the "little star"; *Chrysolampis*, the "golden torch"; *Sapphirina*, the "sapphire."

All this begs the original question: "What is a hummingbird?" As a layman, I would say that if you see a very small bird hovering, body motionless, before a flower—then you have seen a hummingbird, whether you are in Saskatchewan, Ecuador, or Tierra del Fuego.

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MALE LIFE SIZE / FEMALE 2/3 SMALLER THAN LIFE SIZE

Topaza pella:
the Crimson Topaz

This fellow's scientific name reflects his gay plumage, among the most gorgeous of his family. He feeds in flowering tree-tops a hundred feet high in the jungles of British Guiana, Surinam, and Venezuela. Netted while descending to a stream to bathe, he consented to mount a perch for his portrait only with the utmost reluctance.

Female topaz showed no sign of shyness. Mr. Greenewalt finally shooed her away so that other birds could pose.



GRANTON G. GREENEWALT © 1966 AMERICAN MUSEUM OF NATURAL HISTORY

It is the method of flight that is unique. All hummingbirds hover; no other bird hovers as consistently or as efficiently.

Hummingbirds are creatures of the Western Hemisphere. They are found in North, Central, and South America, and in islands of adjacent seas—nowhere else.*

There are many species and subspecies; just how many is difficult to state precisely. The last comprehensive survey of the family was made by James Lee Peters in his *Check-List of Birds of the World* (1945). He recognizes 123 genera, 319 species, and 656 forms.

The geographical distribution of species varies with the latitude, the largest number being found within a band 5° north and south of the Equator. The geographical center of the family, if that is a proper term in this connection, is in Ecuador, where about half the known species are found.

There are hummingbirds at all altitudes and in all climates—there are birds of the forest, of the garden, of the plains, of the mountains, and of the desert. In fact, one can say that wherever and whenever flowers bloom in the Western World, hummingbirds will be found. A ubiquitous and adaptable family.

Some Birds Migrate 2,000 Miles

Perhaps I should say a special word about the species of the United States. In the entire area east of the Mississippi there is only one nesting species—the ruby-throat, *Archilochus colubris*—which most easterners see in their gardens during spring and summer (pages 660-61). The West does quite a bit better, with eleven breeding species, but several of these barely get across the Mexican border.

As a general rule hummingbirds do not migrate far. The notable exceptions are three that breed in North America—ruby-throat in the East, rufous and calliope in the West.

Ruby-throat and rufous migrate at least 2,000 miles from breeding site to winter quarters. How they manage it still remains a mystery. But they do manage, apparently without great numerical losses. The ruby-throat is even said to cross the Gulf of Mexico; a dis-

tance of 500 miles—a remarkable accomplishment for a creature whose length measures scarcely 3 inches.

The hummingbird family includes the smallest bird known to man: *Calypte helenae*, a Cuban hummingbird called the “bee,” a tiny creature about 2¼ inches long. Many other hummingbirds, perhaps two-thirds of the species, are smaller than the smallest birds of other families, but here again there are exceptions. The largest is *Patagona gigas*, an inhabitant of the Andes, about 8½ inches in length and roughly equal in bulk to a large swift (page 672). Hummingbirds, then, can certainly be called small, but by no means

Hummingbird population centers in Ecuador, where 163 of the 319 known species have been reported. One subspecies lives only on Ecuador’s Mount Chimborazo, at altitudes of 12,000 to 15,000 feet. Other varieties range from Alaska to South America’s toe.



* Earlier studies of these birds in the NATIONAL GEOGRAPHIC include “Freezing the Flight of Hummingbirds,” by Harold E. Edgerton, R. J. Niedrach, and Walker Van Riper, August, 1951; “Hummingbirds in Action,” by Harold E. Edgerton, August, 1947; and “Seeking the Smallest Feathered Creatures,” by Dr. Alexander Wetmore, July, 1932.

The author and his motion-stopping camera

WHEN Crawford H. Greenewalt ranges the hemisphere for hummingbird pictures, he pays two plane fares. The extra ticket loads 250 pounds of camera gear, which sometimes rides first-class while its owner goes tourist. Mr. Greenewalt's equipment is unique; nothing like it is commercially available. He and his associates perfected it in seven years and 100,000 miles of travel devoted to photographing hummingbirds.

Ornithology and photography are hobbies; the presidency of E. I. du Pont de Nemours & Company occupies Mr. Greenewalt's working time. As a Life Trustee of the National Geographic Society, he helps guide The Society's educational and scientific activities.

His study of birds began years ago when Mrs. Greenewalt placed a feeding station on a balcony of their home near Wilmington, Delaware, and the antics of the winged diners fascinated him. Deciding to film the balcony dramas, he fell prey to a challenge that led him to hummingbirds; those chesty flyweights whose elusive colors and blurred wingbeats frustrated old-time photographers. Proof of his success appears on these pages and in his notable new book, *Hummingbirds* (footnote, page 660).

"The bulky gear you see below presents a problem," says the author. "With so much weight to carry, chasing hummingbirds is impossible; they must come to me. Two lures draw them into camera range: their own nest, or a feeder filled with sugar water.

"No camera shutter can freeze a hummingbird's flight. Only an extremely short, bright flash of light will stop the wings' rapid motion. Standard equipment has a flash lasting about a thousandth of a second, allowing the bird to complete a twentieth of its entire wingbeat. The solution: a three-lamp, battery-powered unit that produces a flash lasting 30 millionths of a second.

"The principal function of the camera shutter is to exclude sunlight. Its action must be fast enough so that only the electronic flash registers on the film; too much daylight exposure would blur the image. As for camera, many makes could be used, but I prefer a specially modified Hasselblad.

"Birds rarely pose prettily in the center of the picture, and for that reason I prefer a film I can crop. I use a 2¼-inch-square format, cropping the resulting transparency to fit the standard 2-by-2 slides.

"For adequate perspective at a reasonable working distance, I use a 135-millimeter lens, not a long telephoto. The birds in effect take their own pictures by flying through a beam of light shining on a photocell.

"When the beam is interrupted, an electrical impulse trips shutter and flash. Total reaction time: about a fortieth of a second.

"If I tried to trip the shutter manually, my slower reaction time—more than a tenth of a second—would result in a view of departing tail feathers, or no bird at all."



are they invariably the smallest of the avian population.

The hummingbird family is notable for its contradictions. Consider the brilliant iridescent colors, a sort of trademark for the family. While it is quite proper to say that if you see a very small bird with highly iridescent colors you have seen a hummingbird, there are so many that have no iridescence that the definition omits more birds than it includes.

When the iridescent colors do occur, they are really striking, and Audubon's "glittering fragment of the rainbow" is, if anything, clearly an understatement. No other bird is so brilliant.

There are two notable things about these colors. The first is that they are structural and not pigmentary. The blue sky, a rainbow, a drop of oil on a wet pavement, the brilliant flash from a diamond are structural colors; a red tie, a blue dress are pigmentary.

The second is that they are highly directional, and in a living bird one must have a quick eye to see them at all. For one to see iridescence, the bird must receive direct lighting, the source of which must be behind the observer. Then the colors flash with astonishing intensity and beauty. If the bird turns its head a few degrees, the colors disappear. Thus a quick eye is needed, but patient observation is amply rewarded.

To residents of the United States the colors will be largely reds and purples. Farther south this spectrum enlarges, and the colors cover the whole range from brilliant red to brilliant blue, with all the intervening possibilities of hue and shade.

Not all hummingbirds are brilliantly colored. Most of the females, for example, are relatively dull, although a few are quite as gorgeous as their consorts.

Hummer's Secret: Its Power Plant

Perhaps the most extraordinary thing about the hummingbird is its power plant. For energy output per unit of weight it outperforms any living warm-blooded animal. In discussing hummingbirds' extraordinary activity, figures are fairly meaningless unless they can be related to something we all recognize. Let us take man.

A hummingbird while hovering has an energy output per unit weight about ten times that of a man running nine miles an hour. This is pretty close to the highest possible output of human energy, and a pace that a

man can maintain no longer than half an hour. A hummingbird, on the other hand, can fly for much longer periods. A man doing the same work per unit weight would be expending 40 horsepower!

A man's actual daily energy output is about 3,500 calories. The daily output of a hummingbird leading its ordinary life—eating, flying, perching, sleeping—if calculated for a 170-pound man, is equivalent to approximately 155,000 calories.

Ruby-throat Fattens Up for Long Flight

If we convert these figures to food intake, the results are astonishing. A normal man will consume 2 to 2½ pounds of food per day. If his energy output were that of a hummingbird, he would have to consume in a day 285 pounds of hamburger, or 370 pounds of boiled potatoes.

Actually, hummingbirds use sugars as their principal food (supplemented by insects and small spiders), and sugar has a much higher energy content than the items listed here for the human larder. Even so, the average hummingbird consumes half its weight of sugar daily, an extraordinary intake. This leads us quite naturally to what we might call the "migratory fuel supply."

As we have said, few hummingbirds migrate, but those that do show an astonishing capacity to put on fat against the period of their strenuous migratory exertions. Studies made of the ruby-throat immediately before migration indicate that this little bird can add 50 percent to its normal weight, all of it fat, to provide an extra fuel tank, so to speak, for its long nonstop flight across the Gulf of Mexico.

To make once again a human comparison, it is as if our 170-pound man could in a few weeks put on enough fat to increase his weight to 255 pounds, against some extraordinary and short period of exertion during which he could neither eat nor sleep.

Let me recite one more statistic. The hummingbird's surface temperature is normally slightly higher than ours. If a man were expending energy at the rate of a hovering hummingbird, and could perspire freely, he would have to evaporate about 100 pounds of perspiration per hour to keep his skin temperature below the boiling point of water. If his water supply ran out, his skin temperature would rise to 750° F., well above the melting point of lead, at which temperature he would glow, and probably ignite. There



Whistling wing tips announce the unique broad-tail, even though he may be hidden from view. Leading feathers in each wing of the male taper at the ends, leaving slots (visible at left). Flight forces air through the slots, producing a high-pitched tone. *Selasphorus platycercus* dwells in mountains from Wyoming to Guatemala.

Starlike gorget of iridescent purple distinguishes the male *Stellula calliope*. *Stellula* aptly means "little star," and *calliope* translates as "beautiful voiced," a misnomer. *Calliope*, like most hummingbirds, makes doubtful melody. Smallest of North American birds, *calliope* also proved the most elusive for the author, who got this picture on his third trip to California.

ALL THREE 1/16 LARGER THAN LIFE SIZE

Emerald vest and red beak give a jaunty air to the broad-bill. Photographs must achieve just the right angle to record the feathers' iridescence. The color results from structure, as do the rainbow's hues, and not from pigment, like the color of a red tie or blue dress. *Cyananthus latirostris* ranges the mountains of Mexico, Arizona, and New Mexico.



FRANKLIN H. GREENHALF © 1960 AMERICAN MUSEUM OF NATURAL HISTORY





Blue-throat brakes in mid-air, his fan-shaped tail arresting speed like an airplane's flaps. The range of *Lampornis clemenciae* includes Mexico, southern Texas, New Mexico, and Arizona. Among the largest of American hummingbirds, he haunts waterfalls and streams.

BOTH BIRDS 2/3 LARGER THAN LIFE-SIZE

DRAWING BY H. GREENHALGH © 1933 AMERICAN MUSEUM OF NATURAL HISTORY

With a temper to match his flaming neck, *Selasphorus rufus* takes on all challengers to his established feeding ground. One of the migratory hummingbirds, he winters in Mexico and may summer as far north as Alaska. His Latin name means "rufous light bearer."

No other bird can hover and fly backward as does the hummingbird. Unique wings, which lack flexible joints at wrist and elbow but move in any direction from the shoulder, give lift on upstroke as well as downstroke.



is much to be said for our relatively sedentary existence.

Hummingbirds must feed abundantly and regularly to keep up their energy supply. If artificial feeders are provided, they come in for their snack once every 10 or 15 minutes. We humans can get along on a charge of fuel three times a day.

Nighttime Torpor Conserves Energy

After all this, it might well be asked what hummingbirds do at night. Here nature, with her customary ingenuity, has found an unusually efficient solution. She has given the birds the ability to pass into a state of suspended animation, during which the body temperature drops and the energy output sinks to a very low figure. In this state the birds can be handled without taking the slightest notice. The factors inducing them to enter this torpid condition are not yet completely understood. Confusingly, it is not a regular nightly occurrence.

My own view is that passage into torpor is in some way connected with the energy reserves of the bird at nightfall. If, for example, the bird has fed well during the day and its energy reserves are high, it will sleep normally. If, however, food is scarce and our bird goes to sleep without sufficient nourishment, it will stretch out its energy reserves by becoming torpid. Arousal from the torpid state, when it comes, is almost instantaneous.

The energy output of the birds when torpid is only one-twentieth that associated with

normal sleep. If this seems to get them back into the human area, let me say that even in the torpid state they still put out about as much energy proportionately as a man taking his early morning constitutional.

In view of the high energy requirement, getting the necessary 50 or 60 meals a day is a pressing problem. For this also the birds are well equipped. They have an unusual and highly extensible tongue with which they can reach deep into a flower for their supply of nectar. The tongue is tubular, and with what must be much like an internal suction pump they can consume their fuel quickly, efficiently, and in adequate supply.

Unique Wings Have "Reverse Gear"

Next we come to flight techniques. Although the flight of birds and insects has been studied for hundreds of years, very little is known with certainty, and as to hummingbirds, even their speed has not been precisely measured.

Hummingbird flight is different from that of any other bird, and the anatomy of their wings is unique. They are the only birds that can hover with body motionless. They are also the only ones that have a "reverse gear" which enables them to fly backward as prettily and as efficiently as they can fly forward.

Much has been written about the extremely rapid wingbeat rate of hummingbirds, and in some cases it is indeed high. A male *Calliphlox amethystina*, for example, registers 80 beats a second, a rate far higher than any

CRAWFORD H. GREENWALT © 1958 AMERICAN MUSEUM OF NATURAL HISTORY



Black-chinned hummer shows off his iridescent purple neckband, an elegance rarely recorded on film. *Archilochus alexandri* winters in Mexico and summers in the north.

In hovering, hummingbird wings move, not up and down, but forward and backward, pivoting like semaphore flags. On the backstroke, wings turn at the shoulder nearly 180° so that topside becomes bottomside and supplies lift. Like helicopters, hummingbirds can rise vertically. Weight for weight, they use about half as much power.

2 1/4" LARGER THAN LIFE SIZE



1/2 LARGER THAN LIFE-SIZE

CRAWFORD H. GREENEWALT © 1940 AMERICAN MUSEUM OF NATURAL HISTORY

Two male Anna's hummingbirds (*Calypte anna*) battle at a feeding station in California. Apparently hummingbirds also fight for the sheer joy of a rough-and-tumble. Diving and striking, they have been known to rout hawks a hundred times their size.

recorded for what might be called an "ordinary" bird. *Calliphlox*, however, weighs less than a tenth of an ounce (page 672).

On the other hand, the largest hummingbird, *Patagona gigas*, beats its wings only 8 to 10 times a second. By way of contrast, a mockingbird, which is much larger, registers 14 per second.

All in all, I think it safe to conclude that, given an equal wing length or weight, hummingbirds stroke *less* rapidly than ordinary birds. This surprising conclusion is based on the fact that while ordinary birds generate power only on the downbeat, hummingbirds get propulsion and lift on downbeat and upbeat both.

North American hummingbirds have been more thoroughly studied than the others, and since these are all small with a correspondingly high wingbeat rate, the generalization has been made that *all* hummingbirds beat their wings with great rapidity.

Hummingbird wing muscles are very large and account for 25 to 30 percent of the entire body weight. The birds depend almost wholly upon their wings to move from one place to another; in fact, their legs are so underdeveloped that they cannot walk at all in the ordinary sense. I have seen a hummingbird sidle along on a perch, but even for the shortest distances, it is much more apt to use wings than feet.



A hummingbird is much like a helicopter in its flight performance. To be sure, the wings go backward and forward, more like the oars of a boat than the circular whirl of the helicopter rotor. The effect, however, is much the same. If a helicopter hovers, the rotor is in a plane parallel to the earth's surface. So are the wings of a hummingbird. As the helicopter moves forward or backward, the rotor tilts in the appropriate direction. So do the wings of the hummingbird. The helicopter can rise directly without a runway for take-off. So can a hummingbird.

In studying the flight characteristics of these small birds, I needed first of all a high-speed motion-picture camera of a very special type. Many such cameras are commercially available, but unfortunately all require an appreciable time—half a second or so—to reach full speed. Since within this interval the bird would long since have departed, some new method had to be devised to ensure an instantaneous start; that is, to have the film accelerate from zero to 1,500 frames per second in not more than a few thousandths of a second.

Starting from scratch, and with much kindly assistance, we finally evolved a camera dubbed "Mark I." The successful result is neither

elegant nor compact, and I doubt that any camera manufacturer would find it a marketable product. But it does start instantly, permits film speeds up to 1,500 frames per second, and can be triggered by interruption of a beam of light shining on a photocell. With this device the birds in effect become their own photographers.

Test Flights in a "Torture Chamber"

A second problem was to devise a method that would induce the birds to fly at various controlled forward velocities, from zero to the top speed of which they were capable. For a long while this represented a stumbling block, but inspiration finally came: The principle represented might be described as that of an aerial treadmill.

Our solution was a homemade wind tunnel about 18 inches in diameter with a powerful fan at one end. The fan's output could be varied to produce a head wind of any required velocity. We placed a feeder at the exit end of the tunnel, its spout centered in the air stream.

A bird coming in to feed, confronted with a head wind of any given velocity, would perform precisely as if it were flying at a similar

Rockabye-baby Nest Sways on a String of Grass

Most hummingbirds build cup-shaped nests and anchor them firmly, but birds of the tropical American genus *Phaethornis* prefer conical homes that hang by strips of vegetation. Lumps of dirt woven into the bottom counterbalance mother and young, who sit on top.

This bird suspended her home from the bottom of a bridge. Half-built nest at right shows she exercised the female's prerogative of changing her mind. Her species is *pretrei*.

Racket tail and powder-puff leggings identify *Ocreatus underwoodii*, which ranges the Andes from Venezuela to Bolivia. Another rackettail, *Loddigesia mirabilis*, curves his tail under himself so as to frame his face with the rackets while he hovers in courtship.

STANFORD H. GREENHALF © 1965 AMERICAN MUSEUM OF NATURAL HISTORY



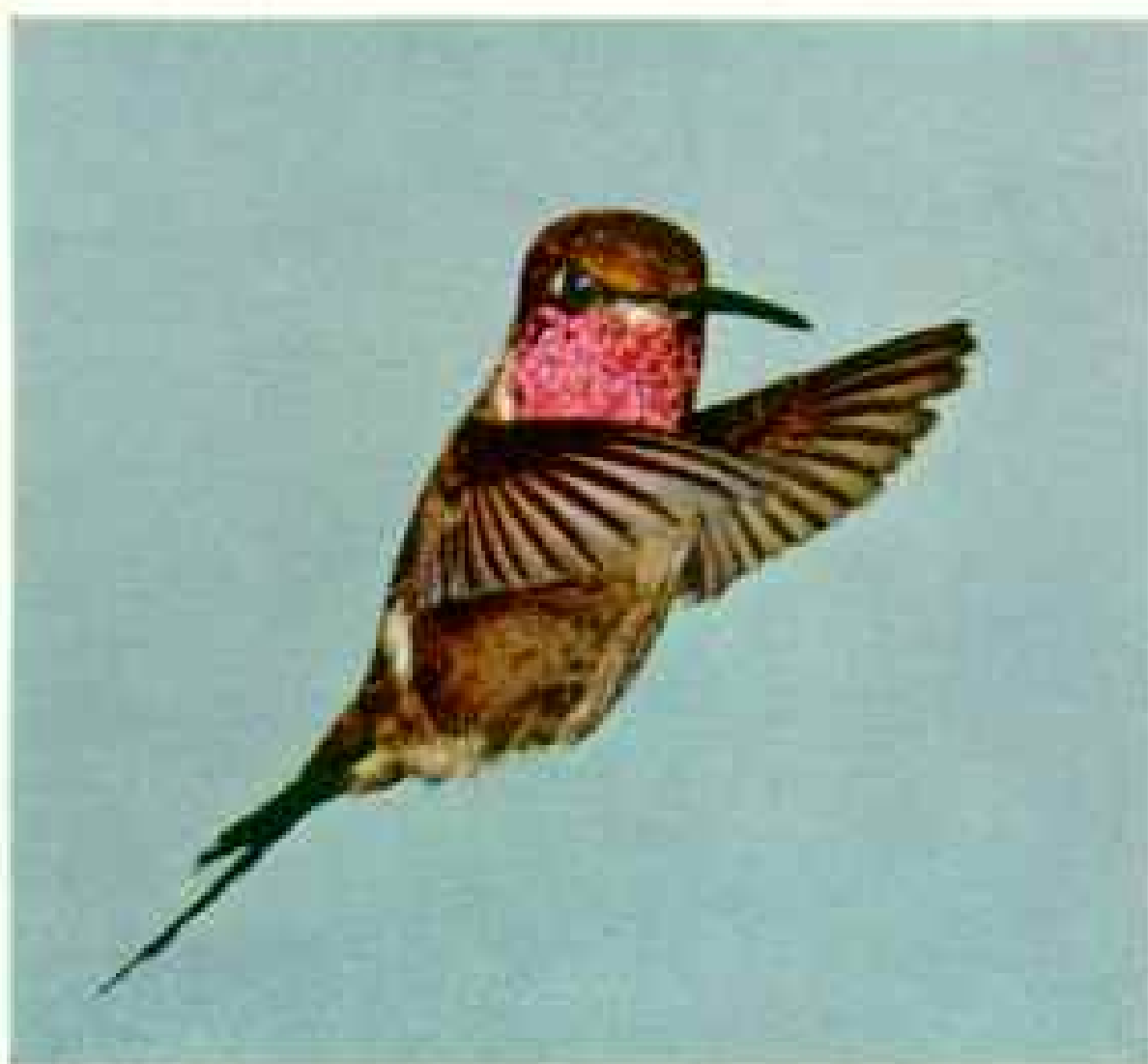
Hummingbird Giant Weighs Less Than an Ounce

Ten times the size of the family's smallest member, *Patagona gigas* ranges the Andes. To tip a one-pound scale, he would need the help of 20 brothers. The same balance would accommodate 150 North American ruby-throats.

Almost as light as a dime, *Calliphlox amethystina* ranks among the smallest of bird-dom's tiniest family. It would take 162 of these birds to make a pound.

This tropical South American beats his wings 80 times a second, the fastest stroke recorded by the author. In contrast, giant *Patagona* makes 8 to 10 strokes a second. Other hummingbirds fall between these extremes. Size regulates the frequency of wingbeat.

Other small birds, gaining lift only on the downstroke, have to move wings faster per unit of weight. For example, mockingbirds, which are much larger than *Patagona*, register 14 beats a second.



speed, although its position with respect to feeder and camera would remain stationary.

Camera, tunnel, fan, and the electronic equipment to produce a flash for each frame on the film must have presented an awesome aspect to a tiny hummingbird looking for an easy meal. My children, lacking their father's thirst for scientific knowledge, speedily christened the setup "Daddy's Torture Chamber."

I hasten here to plead not guilty to torture, for the birds seemed actually to enjoy the challenge. With the noisy fan going at full blast, the buzz of the



camera affected them scarcely at all, and at high wind velocities they seemed almost to make a game of it.

It was amusing to note the difference between the wisdom of maturity and the brashness of youth. The adult females soon learned to line themselves up with the feeder about eight to ten feet downwind from the tunnel exit. They would then work their way in fits and starts until the goal was eventually achieved. At first the impatient young birds would fly diagonally up into the wind stream, only to be blown head over heels when they encountered the full blast. But under their mother's efficient tutelage, they soon learned the trick and were finally taking nourishment

with as much aplomb and zeal as their parent.

After two years of experimentation and several hundred high-speed sequences, it seems clear that the top speed of which these birds are capable is something just under 30 miles an hour. When the wind tunnel was boosted to that speed, the birds would try repeatedly to reach the feeder. They would enter the slip stream well downwind and fly to within a tantalizingly short distance of the feeder, only to find themselves unable to make the grade.

We can also see in slow motion the technique of the fast getaway. When the birds are hovering with the fan turned off, they take flight when the camera starts its buzzing and depart as rapidly as possible. As the



CHARLOTTE H. GREENHALGH © 1980 AMERICAN MUSEUM OF NATURAL HISTORY

first act in the getaway routine, the tail opens and makes a quick forward scoop. Simultaneously the wings assume the position for backward flight.

As a result of these two motions, the bird appears to rotate about a horizontal axis until it is flying on its back—feet up, tail toward feeder, head pointed in the opposite direction. The bird then executes a half-roll and darts off as fast as it can go.

Sometimes, when not too frightened, the bird simply backs away from the feeder, giving us the opportunity to observe what happens when the gears go into reverse. Here again the answer is what one might expect:

The plane of the wings tilts backward, just as with a helicopter rotor, to give a combination of lift and rearward thrust.

I did not investigate backward flight quantitatively, but this might have been done by reversing the fan so that it produced suction rather than a blast of air.

But the thought of one of these birds being drawn into the fan was much too horrible to contemplate, so I contented myself with several voluntary flight reversals. After all, I certainly did not want to risk making "Daddy's Torture Chamber" a reality.

Leaving flight characteristics, I must now deal, however reluctantly, with a serious defi-

Appetites of Hungry Twins Allow Mother No Rest

For their size, hummingbirds burn more energy than any other warm-blooded animal. To supply the fuel, they must eat prodigiously.

This mother, known to ornithologists as *Lesbia victorinae*, scurries constantly to fend off starvation. Her mate helps neither in the nest building nor in the feeding. The author despaired of photographing her nest, 16 feet high in an araucaria tree in Quito, Ecuador, until an airline supplied a platform used to service its planes.

Two pearl-like eggs yield the babies, whose time in the nest varies according to food supply. Ruby-throat nestlings, for example, fly after 10 to 30 days.

1/8 LARGER THAN LIFE-SIZE

Flying acrobat of Venezuela, Trinidad, and Tobago defends his territory with uncommon valor. The audacity of *Amazilia tobaci* calls to mind a legend of Venezuela's Arawak Indians, who say their forebears broke a Trinidad tobacco monopoly by sending a hummingbird on a stork's back to seize precious seed.

ciency in this otherwise striking creature, and that is its vocal performance. In the sense in which our songbirds have a voice, the hummingbird has none at all. It does indeed chatter, particularly when it is annoyed and chasing another hummingbird, but the sound is scarcely musical. There are also records of courting sounds by groups of aspiring males of some species, but these are puny efforts indeed and can't begin to approach the musical offerings of even our poorest songbirds.

There seems rarely to be a generalization to which there are no exceptions. Having now demolished hummingbirds as songsters, I must admit to one, with the improbable name *Schistes geoffroyi*, that has quite a decent song—nothing to make a thrush jealous, but to which an English sparrow, for example, might well aspire. So far as I am aware, among hummingbirds *Schistes* stands alone.

Finally we come to a discussion of hummingbird behavior. Ornithologically speaking, behavior means the manner in which



LIFE-SIZE

CRAWFORD H. GREENWALT
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No-perching sign might help *Heliomaster jurcifer*; the author saw smaller hummingbirds try to land on its long beak. Iridescent blue breast, red gorget, and green crown show in this life-size portrait of "seeker of the sun," a native of Brazil, Paraguay, Uruguay, and Argentina.



Beak with a bird attached describes *Eusifera ensifera*, the "sword bearer" of the Andes. No other hummingbird can match his bill for length. A long, tubular tongue, characteristic of the family, adds to the swordbill's reach. Thus equipped, he sips from the deepest blooms.



Skimpiest bill belongs to another Andean, *Ramphomicron microrhynchum*. Rare purple cloaks his back.

If food is scarce, ever-voracious hummingbirds may spend the night in a torpid state; otherwise they might starve before dawn.

Beak like a crescent gives a common name to the sicklebill. *Eutoxeres aquila* ranges from Costa Rica south to Peru.

Hummingbird lore still holds many secrets, including the life span. Individual birds have been known to live 12 years.

birds meet the major crises of their lives. In human terms, and here the analogy is very close, we would speak of adolescence, maturity, courtship, marriage, and the rearing of young.

In their day-to-day living the outstanding characteristics of hummingbirds are their fearlessness, pugnacity, and curiosity. They seem fully aware of their unusual aerial capabilities and understand that they can sense danger and get away much more rapidly than larger, slower-moving enemies can close in to the attack.

We see this in their almost complete disregard for the presence of humans; even in the wilderness a hummingbird will approach within five to ten feet of a man. In more civilized surroundings they become so used to people that they will feed from the hand, and I have even seen them perch on a finger. This is not at all because they have love and affection for humanity. It is only a reflection of complete confidence in their ability to make a fast getaway should anything untoward happen.

They are said to be attracted by anything that is bright red in color, although this has been disputed by some observers. My own experience is that red is indeed their favorite. I have seen them on many occasions explore the red plastic knobs of my camera tripod, and on one occasion when I was rash enough to



ALL THREE 1/4 LARGER THAN LIFE SIZE

CHARLES W. GREENWELL © 1956 AMERICAN MUSEUM OF NATURAL HISTORY



be wearing a red tie they prodded at it, doubtless to see whether it contained anything good to eat. When we were photographing caged birds in Ecuador, someone had hung a thermometer filled with red alcohol on the wall of the cage, and each of the hummingbirds in turn tested it for nutritional value.

Like most other birds they establish territories which they defend vigorously, whether or not the intruder is of their own family and quite regardless of size. A hummingbird will chase a catbird, routing him quite successfully from the territorial boundaries. Their belligerence, however, goes far beyond the simple needs of territorial defense: I suspect that they engage in their aerial jousts more for the fun of it than for any other reason.

Courtship Inspires Acrobatics

When it comes to courtship and mating, I am afraid I can tell no tales of marital fidelity and "growing old together." Each male is a feathered Don Juan with interests limited to food, fighting, and courtship.

His courtship display is a veritable aerial circus. I have seen it myself for only a few species, but the literature indicates that all males behave in much the same way.

The female ruby-throat settles herself on a twig fairly near the ground. The male rises high in the air and launches a power dive that ends immediately in front of his dazzled mate-to-be, then rises precipitously so that his course resembles a large U with the female at its base.

In this performance she chooses her position, or he may choose it for her, in such a way that she can see the light reflected from all his iridescent feathers, and so has the joy not only of his aerial acrobatics but of a beautiful color display as well. If she succumbs, he dashes off to other conquests, ungallantly abandoning her to deal alone with the consequences of their union.

Leaving the male to his philandering, the female who has been courted and won proceeds immediately to her nest building (page 670), with apparently no thought, aside from a casual battle or two, for anything except the procreation of her race.

The egg quota of a hummingbird is almost

invariably two, and the incubation period on the order of 12 to 16 days. In nest building, as well as in incubation, the females are usually fearless.

I have had camera, flash lamps, and myself within four feet of a nest under construction, and the lady went on building, paying no more attention to me or my equipment than if I had been merely a part of the scenery.

Nestlings Become Sword Swallowers

Eventually the young hatch and the feeding process begins. This is a fearsome sight. The mother arrives at the side of the nest; the young stretch out their gaping mouths, whereupon she inserts her bill to a depth that makes one certain it will come through on the other side, and literally pumps nourishment into the young one.

The longer the bill, the more terrifying the process. I have never seen the swordbill hummingbird in action, but I should think that would be a sight to shock the hardiest soul (page 676). The process, however, seems to work, for there is no record, in literature or out, of a baby bird being impaled by an over-assiduous mother.

The time the young are in the nest is quite variable, much more so than for most small birds. In the case of the ruby-throat, for which there is an abundance of data, the nestling period varies from as few as 10 to as many as 30 days.

The young, whatever their sex, when they leave the nest and for some time thereafter, resemble the female. The males do not acquire their resplendent iridescence until after their first molt, about a year after they have hatched.

When the young are old enough to fend for themselves, they become individuals in their own right and are quite as likely to do battle with their mothers as they are with young from a neighboring nest.

Here then are the hummingbirds as I found them—striking little creatures, gay, fearless, pugnacious, and colorful. Perhaps, after all, the Comte de Buffon did not exaggerate, and nature did indeed load them "with all the gifts of which she has only given other birds a share."

Cold Shower Washes Away the Cares of One Who Bathes on the Wing

By preference, hummingbirds spend much of life in flight, their daily baths not excepted. To wash, they plunge into clear pools, flutter through dewy leaves, or fly under a small waterfall, as does this blissful Ecuadoran, *Coeligena wilsoni*.







*From Cairo to the Gulf,
Old Big Strong rules
with a muddy hand*

The Lower Mississippi

By WILLARD PRICE

*Illustrations by National Geographic
photographer W. D. VAUGHN*

THE MISSISSIPPI, they say, changes sex at Cairo. And indeed, as I followed it from birth to marriage with the Ohio at Cairo, in Illinois, the sweet upper river had seemed unmistakably feminine.*

But winding along the lower river a thousand miles to the Gulf of Mexico, I was to find it just as surely masculine—a broad brute of a waterway that demands respect, and sometimes fear. Little wonder that Negro and Indian gave it names like Old Man River, Old Devil River, and Old Big Strong.

On the upper river, the superstitious say, you can see the ghosts of lovelorn Indian maidens who leaped to their deaths from bluffs through which the Mississippi River cuts its way. But the great legendary figure of the Lower Mississippi is not a maiden. It is Old Al, the River King.

Old Al was created by Negro roustabouts of

* See "The Upper Mississippi," by Willard Price, NATIONAL GEOGRAPHIC, November, 1958.

Below the gleaming towers of New Orleans, gateway to the mid-continent, ships await quarantine clearance and assignment to berths. The port, second in the Nation only to New York in value of foreign water-borne commerce, lies at the southern end of a vast watershed draining part or all of 31 States. Here the Mississippi begins a broad loop that inspired New Orleans's nickname, the Crescent City.



SCENERY BY WILLARD PRICE © NATIONAL GEOGRAPHIC SOCIETY

Silvery streamers of Spanish moss overhang Bayou Barataria, where author Willard Price and his wife pause for a picnic. Exiled Acadians from Nova Scotia settled this bayou-fretted marshland. Barataria-based pirates led by Jean Lafitte operated a fleet of ships in the early 1800's, sold captured slaves and other loot at public auction, and helped Andrew Jackson win the Battle of New Orleans. Today oil and gas wells ring the bayou, sports-fishing boats sally from its marinas, and barges on the Intracoastal Waterway ply a section of it.

Ontario-born author of 20 books and 13 previous NATIONAL GEOGRAPHIC articles, ranging from Japan to the Thames River, the inquiring Mr. Price has traveled the Mississippi from headwaters to mouth by canoe, towboat, steamer, plane, and car.

The Lower Mississippi, as if seen from 230 miles above the Gulf of Mexico, meanders south from Cairo, Illinois. Concrete mattresses, emergency spillways, and levees restrain Old Man River, whose wanderings have dotted old courses with oxbow lakes cut off from the main stream.

the steamboat age, but the deckhands of the modern towboats sometimes declare that they have seen him. Folklore describes Old Al as an alligator bigger than a barge. He wears a gold crown on his head and holds a huge pipe of tobacco in one of his scaly forepaws. With the other he takes delight in humping up a sand bar to block a passage, or in plucking a riverman off a barge for his dinner. With his tail he switches currents this way and that to throw a tow up against a bridge pier, smash a levee, or toss floods over farms and villages.

Lower River Rides High

The hoodoo doctors of the Deep South still sell good-luck charms guaranteed to keep Old Al in his place. In days gone by, when roustabouts grew weary loading and unloading cotton bales, they would furtively drop some tobacco into the water. For it was well known that whenever Old Al smoked his pipe, the fumes rose from the river and made a dense fog. This brought the old-time radarless steamboat to a halt, and the roustabouts could rest.

The stretch north of Cairo is a dug-out river. It has carved a trench for itself over the ages, and the rock walls rise as high as 600 feet. The lower river rides brazenly atop the land, almost like an aqueduct.

While you look down upon the upper river from its precipices, you often look up to the lower river from land behind levees. New Orleans, for example, lies five feet below average river level; in floodtime it is 14 to 18 feet below the river. Rainfall in the city does not drain off—it must be pumped up and away.

Following the levees through the kingdom of Old Al, my wife Mary and I traveled south, sometimes by boat, sometimes by car. A French voyageur had



MISSOURI

ILLINOIS

KENTUCKY

TENNESSEE

ARKANSAS

MISSISSIPPI

LOUISIANA

Gulf of Mexico

©NGS

St. Louis

Kaskaskia

Thebes

Cairo

New Madrid

Arlington

Reelfoot Lake

Presidents Island

West Memphis

Memphis

Cat Island

Helena

Terrene Landing

Arkansas City

Scott Island

Greenville

Monroe

Vicksburg

Delta

Champion's Hill

Jackson

St. Genevieve

Natchez

Hattiesburg

Morganza

Baton Rouge

Lake Pontchartrain

Gulfport

Biloxi

New Orleans

Algiers

Caernarvon

Lake Lery

Delacroix

Mississippi River-Gulf Outlet (Under Construction)

Bonnet Carre Floodway

Boutte

Barataria

Port Sulphur

California Bay

Freeport Sulphur Co.

Lake Grand Ecaille

Empire

Main Pass

Barataria Bay

Venice

North Pass

Grand Isle

Pilottown

Pass a Louvre

Head of Passes

Wildlife Station

South Pass

Southwest Pass

Burrwood

long ago described the Mississippi most aptly, I thought: "a wild, furious, whirling stream."

We came to New Madrid, a Missouri town that has had to shift its ground repeatedly to escape the caprices of Old Al. Here, in 1789, an American Revolutionary colonel named George Morgan proposed setting up a new colony with the help of Spain. Hence the name New Madrid.

It was to be a utopia, the most beautiful city in America, with streets 100 feet wide, a 12-acre park in the center, churches of every creed, and no taxes. The dream was shattered when Spain revoked the land grant, but New

Madrid continued as a trading and agricultural community.

Not, however, without interference from the troublesome river. Time after time New Madrid had to gather itself up and move back as the Mississippi changed course and gnawed into its Missouri banks. The original site now lies under water, near the Kentucky shore.

"All the buildings on the river," said Mrs. Laura Hunter, an old resident, "were kept on rollers during my girlhood. Their owners kept rolling them back."

When we had Tennessee on one side of us and Arkansas on the other, we felt that we



were getting into the real South at last. There was a delicious languor in the air, a sense of relaxation, the opiate of flowering trees and sultry heat.

Memphis Booms to Rock-and-roll Beat

But if the northerner supposes his city to be more brisk and crisp than the towns of the Old South, Memphis will come as a shock to him. For here is a city as clean and new as a freshly minted silver dollar (page 688). Its dozens of stately old mansions are almost lost among the thousands upon thousands of spanking new homes. There can be few cities

in the Nation that are growing more tastefully.

Memphis is the largest spot cotton market in the world. It is the world's largest hardwood lumber market. It has one of the finest river ports. And it is also one of the South's largest livestock and meat-packing centers.

But Cindy, my 17-year-old cousin graduating from a Memphis high school, pointed out the really important thing about her city: It is a rock-and-roll center of the world. Elvis Presley, born in Mississippi, went to high school in Memphis and made his home here. Singer Pat Boone, too, is a Tennessean.

Two generations earlier, on famous Beale



BILLALPHORN © NATIONAL GEOGRAPHIC SOCIETY

Paddles churning foam, *Mississippi* keeps alive the memory of a bygone era. Once hundreds of stern-wheelers plied the river, some offering luxurious staterooms and fine food and wines. Others carried cotton bales stacked several stories high. Today the *Mississippi*, whose superstructure dates from 1922, is one of the last of her kind afloat. Between tours of duty for the Mississippi River Commission, she works as a towboat. At left she pushes an oil barge. Casting off her charge (above), she waves a veil of spray at a barge hand. Next year the boat faces retirement.



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Smoked to a Golden Turn, Kentucky Hams Hang to Age

When autumn cools the Mississippi Valley, the scent of burning hickory pervades the air near Arlington, Kentucky. Last winter the smoke gave flavor and color to 11,000 country hams cured by Mr. and Mrs. Curtis Harper. This winter the hams, properly aged, will sell at 85 cents a pound. Here Mrs. Harper weighs a 14-pounder. Pepper blackens the hams' faces.

A Boatman on Reelfoot Lake Explores a Cypress Forest

In the predawn dark of December 16, 1811, an earthquake shook the Mississippi Valley. When morning came, terrified inhabitants of northwest Tennessee looked out across a new lake. During the night the quake caused a land upheaval that dammed a creek and formed Reelfoot Lake.

Spiked with trees, stumps, and clumps of grass, shallow Reelfoot Lake proved a natural hatchery for fish and a haunt of waterfowl. Sportsmen boating on the lake use small boats sheathed in metal for protection against snags.

Street, center of Negro life in Memphis, a more melancholy music was born and made famous by W. C. Handy, who wrote "Memphis Blues" and "Beale Street Blues."

Memphis is the scene of the annual Cotton Carnival (page 692). It is a brilliant affair with its king, queen, and royal court; its royal barge; its fireworks and dazzling parties; also its four great parades, with dozens of floats and bands.

Shantyfolk Fade From the River Scene

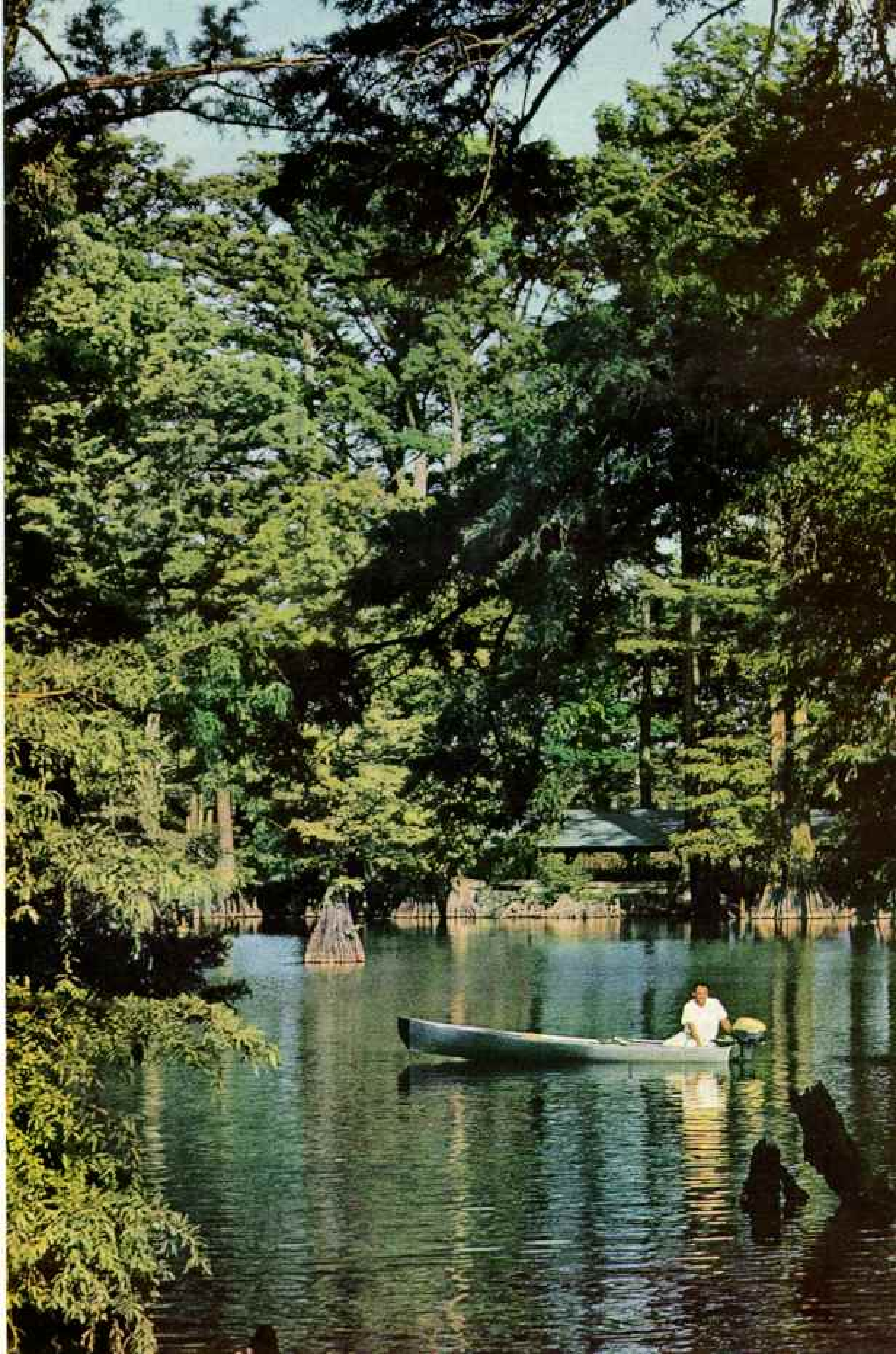
All along the Mississippi's lower reaches we were surprised at how few shanty boats we encountered. The carefree water gypsies who dwell in these floating homes once numbered about 30,000; now only a few remain.

Most shanty-boaters are English-Irish and have the love of adventure of both breeds. They enjoy the life because it gives them the

outdoors and freedom. Planks and packing crates floating down the river provide material to build or repair their shanties. The owners like to put on a porch behind; there they can sit and fish and chew tobacco. There is no rent to pay. No bills for water, gas, or electricity. Fuel can be picked up along the shore. Food can be hauled out of the river, or fish can be traded for groceries.

Especially in floodtime is the river a generous provider. It brings barrels and boxes; tables, chairs, and beds; rowboats, clothing, and shoes; chickens and pigs. But as engineers have gradually straightened the river, it has become a less congenial landlord to the shantyfolk.

"I used to be able to paddle my skiff straight across to the other shore," said Guy Jones at Terrene Landing in Mississippi. "Not now—current's too fast."





Bluff-top Memphis enjoys the boon of river commerce without the bane of flood;

Nor is fishing what it used to be. The swifter current has washed away many quiet breeding spots.

Our next stop, Greenville, Mississippi, had grim and tragic experiences during the great flood of 1927. But William T. Wynn, a Greenville attorney, recounted one of the lighter incidents to us.

When the town was inundated, 10,000 lowland residents were evacuated to temporary camps on the crest of the levee. They were divided according to precincts, and each person had to report to the medical tent of his own precinct to get typhoid shots. One woman who came to the wrong place was flatly told:

"You don't belong here. You've got to get vaccinated in your precinct."

"But why can't I get vaccinated in my arm, like everybody else?" the woman asked.

From Greenville we drove 150 miles back to Memphis, where we boarded the southbound towboat *Wake Island*. We had made the acquaintance of these craft during our travels on the upper river. Diesel-powered work horses of the Mississippi, they hustle their staggering loads, some of them equal to the cargo of two ocean-going freighters, up- and downstream in a fraction of the time it once took the romantic but cumbersome old stern-wheelers.



WHEELING BY NATIONAL GEOGRAPHIC PHOTOGRAPHER W. B. BROWN © W. B. B.

bank-paving towboat and barges push upstream to keep the restless river within bounds

Like most Mississippi towboats, the *Wake Island* pushed rather than pulled its load, a string of barges stretching hundreds of feet beyond its bulldog-blunt bow. From the pilot-house of the boat we were to glimpse the mighty Mississippi in its blackest mood.

When Old Al is riled up, he creates a memorable scene. A blinding thunderstorm sweeps up the river. It is impossible to see even to the end of the barges. Our pilot talks over the radiophone with the captain of the *Sam Houston*, a towboat farther downriver, invisible except on the radar screen.

"Skipper, how you situated down there now?"

"Not so good. Can't make the bend in this wind. Think I'll just lay by for a while. It can't stay this bad for long."

Both tows stand by. The masters discuss not the river but their homes and families and what they planted in their vegetable gardens the last time they were on leave. Then our pilot:

"Well, I'm in a pretty bad place here by Cat Island. Apt to get pushed aground. I think I'll ease on down."

"Okay. It's clearing a bit anyhow. I'd better stay right here till you pass."

"Well, I'll be seeing you."

They do see each other, or rather, each

Sand Bar in Mid-river Gives Memphians a Beach With a Skyline View

Although the Mississippi often rages at the city's door, Memphis people hold it in deep affection. Businessmen see it as a "stream of gold" that attracts new industry. Others regard it as a playground where they can race small boats, swim, water ski, or laze in the sun. Everyone agrees, however, that the river is a sight to see, and thousands go out to look at it from the deck of the paddle-wheel excursion boat *Memphis Queen II* (right). Playing recorded callopie music, the *Queen* up-anchors daily for a 75-minute cruise. Here she stops to let passengers wet their feet. One night last summer the *Queen* hauled 1,400 conventioners to this sand bar for a catfish fry.

Bathing beauties and water skiers cavort on McKellar Lake, a onetime bed of the river. Now cut off from the down-coursing Mississippi by a causeway, the channel provides a still-water access to Memphis's new \$50,000,000 harbor and industrial park on Presidents Island.



other's boats, but only as indistinct blobs in the storm. There's nothing indistinct, though, about their conversation, which crackles on for some time.

The turmoil of the river is fantastic. Big logs swirl by, then stand up on end and are sucked down. A small boat would be safer in mid-Atlantic; this powerful current heaves and struggles against a violent wind. We see a barge torn loose from its moorings and turned about like a toy vessel, the plaything of the Mississippi. And it is one of the big boys, 300 feet long and nearly 50 feet wide.

We wait till the storm moderates before we pass under Greenville Bridge. River pilots have great respect for this and the Vicksburg Bridge, particularly during high stages



EDDIE BROWN © NATIONAL GEOGRAPHIC SOCIETY

when swift currents increase the hazards of navigation. A few years ago the tug *Natchez* struck a pier of the Greenville Bridge and sank with 13 men.

When we reach Vicksburg, we see one of its bridge's hazards: a strong cross-current, or "set," from the Louisiana shore. All the officers are in the pilothouse to watch our captain take us through. He heads straight for a pier and apparent destruction. At the last moment the set carries the enormous tow sidslipping to port just enough to miss the pier, and we pass through with room to spare.

Riverboat Pilot Still Is King

This would be no trick for a maneuverable motorboat, but try it with 21,500 tons of tow stretching nearly a quarter of a mile ahead of your steering levers!

The skill and responsibility of the Mississippi pilot make him cock of the walk among

rivermen. It was so in steamboat days; it is still so. The only change is that there is less bluster and swagger now. Profanity used to be an art carefully cultivated by every pilot.

"What's the use of being a steamboat pilot," lamented one old-timer, "if you can't tell people to go to the devil!"

We left the *Wake Island* at the hill city of Vicksburg, famous "Gibraltar of the Confederacy," perhaps the hardest nut General Grant ever had to crack. Vicksburg cherishes the memory of that gallant defense; an extensive national military park preserves the lines of the siege of Vicksburg (page 702).

But at Vicksburg one sees evidence of a different kind of campaign. It is the conquest of the Father of Waters by the United States Army Corps of Engineers.*

Near the city is a gigantic model of the

* See "Men Against the Rivers," by Frederick Simpich, NATIONAL GEOGRAPHIC, June, 1937.





Mississippi system, spread out over 800 acres, with real water running through its channels to simulate the rivers. This model enables the Engineers to determine just what should be done next, and where (pages 704-5).

In Vicksburg we met the monarch who rivaled Old Al as the river king. Maj. Gen. John R. Hardin, then President of the Mississippi River Commission, had to his credit a string of impressive victories over his wily opponent. A studious man with a habit of precise speech and a kindly wrinkling at the corners of the eyes, he believed present control measures could handle not only a flood like that of 1927, but a superflood 20 percent greater.

One Flood Left 700,000 Homeless

This does not mean that the Mississippi will cease to give trouble. But the disasters of the past are not likely to occur again.

The 1927 flood drove 700,000 people from their homes. For months heavy rains poured upon the Mississippi watershed, which stretches to within 225 miles of the Atlantic and 500 of the Pacific, an area of about one and a quarter million square miles. It was estimated that 240 cubic miles of water fell on this area. Much soaked in, much evaporated, but more than 60 cubic miles of water drained off to swell the big river.*

Terrific currents chewed holes in the levees and surged through to inundate towns, carry away houses, and bury farms under muddy water as deep as 18 feet. The river broadened in some places to 80 miles. Many people were trapped and drowned. Animals fled to the high places—mounds, trees, chimneys. Natural enemies forgot animosities and huddled together in terror—rabbits, foxes, muskrats, herons, chickens, raccoons, and deer. Horses swam until they were exhausted or found refuge; cattle stood impassively in the water until they drowned or starved.

New Orleans saw the river threatening to roll over her. Thousands of sandbags in-

* See "Great Mississippi Flood of 1927," by Frederick Simpich, NATIONAL GEOGRAPHIC, September, 1927.

Exploding rockets spangle the night sky as the king and queen of the Memphis Cotton Carnival arrive by barge at the city's river gate. Thousands on the bluff welcome the royal couple and their court. The ceremony marks the opening of a five-day party honoring King Cotton. Usually held early in May, the festival presents four parades, a plantation tour, and regatta.



CHARLES WINKLER, THE COMMERCIAL APPEAL, MEMPHIS

creased the height of the levees, but still the river continued to rise. Was there no way to save the city with its half a million people?

There *was* a way.

Officials talked about it in whispers. But word got out. The countryfolk were horrified! The idea was to make a cut in the levee, through which the river could pour over southern parishes and thus relieve New Orleans.

Farmers, trappers, fishermen protested. Yet there was no alternative. Soldiers were sent to superintend the blasting of the levee at Caernarvon. Trucks came to haul away household goods and people who were about to lose their homes. All evacuees would be compensated. But could money pay for such loss?

A few lowland dwellers refused to leave. Some had faith that prayers and charms would avert the flood. Others preferred to risk drowning rather than to have to abandon their homes.

The levee was dynamited, the angry Mississippi poured through the breach, and a shocked official of the low country said: "You are witnessing the public execution of a parish."

But New Orleans survived.

When State boundary lines were first drawn along the river, many people did not realize that the Mississippi would not stay put. Instead, it loops and uncoils like a tortured snake. It used to be not at all uncommon for the river

White gold of the South, cotton goes on sale in Memphis, the world's largest spot market for the commodity. Small samples taken from various bales show the customer what his money will buy. But he must be skilled in recognizing the fiber's quality.

The Memphis Cotton Exchange quotes more than 250 grades and staples, and that, says one official, "is just a start when it comes to variations in cotton."

Here Berry B. Brooks (left), president of the exchange, discusses samples with A. E. Hohenberg, president of Hohenberg Bros. Company, cotton suppliers.

A mechanical harvester, doing the work of 25 field hands, gathers cotton at the Delta and Pine Land Company near Scott, Mississippi. Varieties pioneered here account for more than 25 percent of all United States cotton acreage. These workers draw off a seed-cotton sample to determine the yield of a particular strain.

Cotton flies as a picker empties half a day's work into a collection trailer on 5,000-acre Trail Lake Plantation near Greenville, Mississippi. Hand-picked cotton takes longer to harvest, but makes a better grade and brings a higher price.



KODACHROME BY DAN SHAYKH (KROCK) AND EUGENE FISHER © NATIONAL GEOGRAPHIC SOCIETY





EDDALARHORES BY NATIONAL GEOGRAPHIC PHOTOGRAPHER W. D. BRUCKER © N.G.S.

to make a great detour and come back to within a few hundred feet of itself. Then the current might cut through the narrow neck, and a big circle of land belonging to Mississippi would find itself on the Arkansas side of the river.

This sort of thing has happened dozens of times. But the law draws a distinction between slow changes and quick ones. When the Mississippi changes its course by eroding one bank and silting up the other, the boundary moves with the river. Thus a State may gradually lose or acquire land from year to year. But if the river changes its course by what the law calls avulsion, a sudden plucking out of an entirely new path for itself, the boundary

would remain exactly where it was before.

The results can be highly confusing. A man who owns a farm in Mississippi may suddenly find himself on the Louisiana side of the river, but still a Mississippi citizen. From now on his loyalty is divided. He is still qualified to vote in Mississippi, but his new friends are Louisianians, and he drives to a Louisiana town to do his shopping. At any time, too, the stream may resume its old channel, and then back again goes our Mississippian to the old country!

Greenville used to be on the river, which then assumed another course, leaving the city on the abandoned loop, two miles away. The Louisiana town of Delta used to be three miles

Crop-dusting Planes Spread a Poison Cloud to Kill Boll Weevils in a Field Near Memphis

Slipping across the Mexican border into Texas in 1892, the boll weevil soon invaded the entire cotton-growing South. Attacking the fruiting buds in spring, the ravenous insect later infests the bolls and may produce seven to eight generations by harvest. Before controls were devised, planters failed, cotton gins closed, and land values fell. Many sections switched to other crops. Farmers around Enterprise, Alabama, had so much success growing peanuts that they erected a statue to the weevil that forced them to diversify.

These planes spread an insecticide near Memphis's new Thos. H. Allen Electric Generating Station. The field is destined to provide industrial sites as soon as new levees protect them from high water.

Wheeling down a floating landing, locomotive and gondolas board the *Pelican*, a rail-car ferry that shuttles between Trotters Point in Mississippi (background) and Helena, Arkansas.



downstream from Vicksburg; after a cutoff, it found itself two miles upstream. St. Genevieve in Louisiana and Arkansas City in Arkansas, once river towns, are now inland.

But there are worse fates. Napoleon, Arkansas, was completely swallowed; boats now sail over it. Prentiss, Mississippi, was buried in mud. Kaskaskia, "an outpost of civilization and culture," was the first capital of Illinois and a town of considerable size. House by house, street by street, it



BOATWORKERS BY W. ROBERT MOORE (ABOVE AND LEFT)



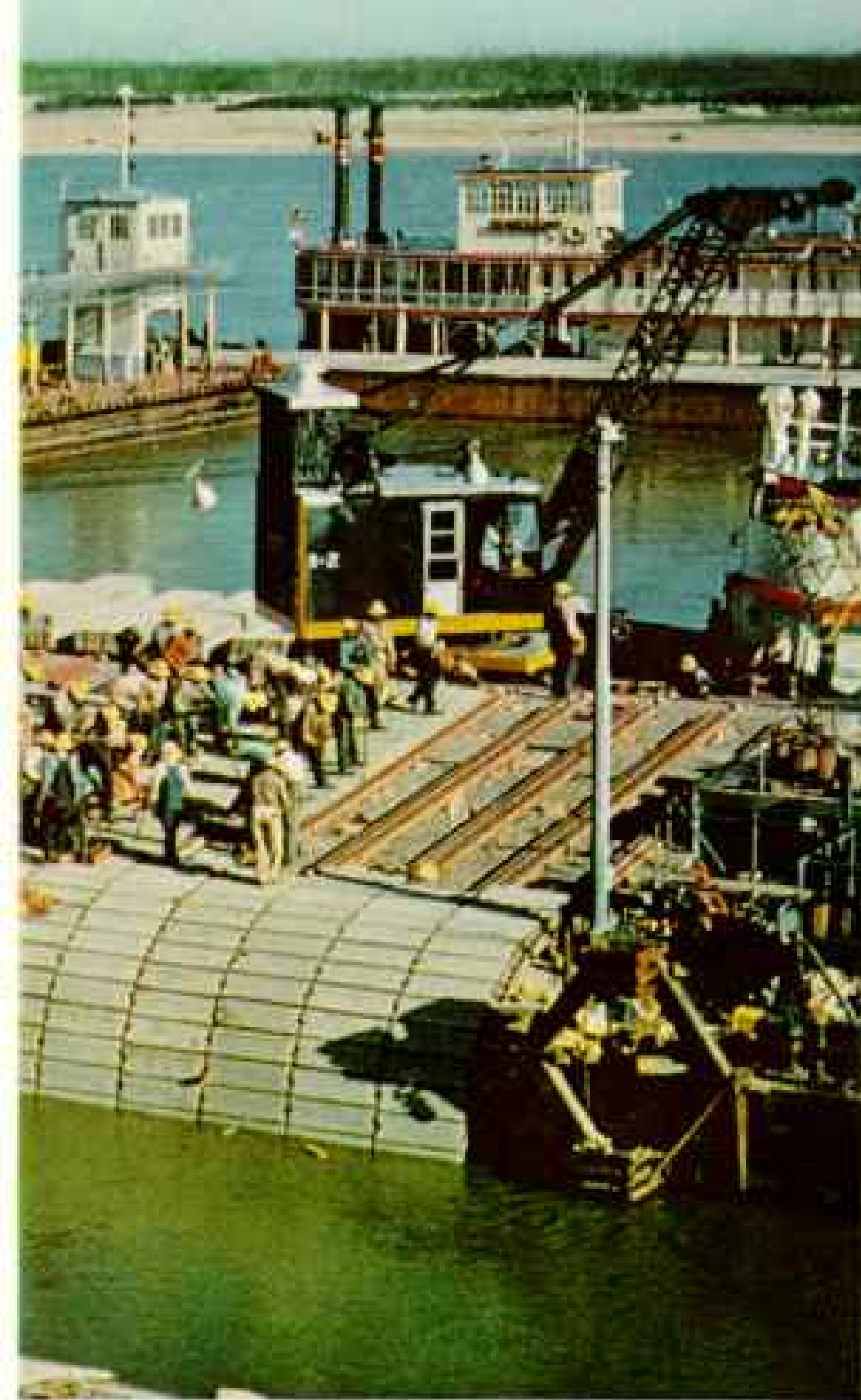
disappeared into the Mississippi's maw.

So great have been the changes in the channel of the Mississippi that much of the 1,300-mile course down which La Salle floated in 1682 is now solid ground!

The Army Corps of Engineers has transformed the river, which had made many cutoffs even before 1883, when Mark Twain's *Life on the Mississippi* was published. The humorist and onetime pilot calculated that if the river continued to shorten at the same rate, "any person can see that seven hundred and forty-two years from now the Lower Mississippi will be only a mile and three-quarters long, and Cairo and New Orleans will have joined their streets together, and be plodding comfortably along under a single mayor and a mutual board of aldermen."

The river is not yet reduced to a mile and three-quarters, but it is considerably shorter than when Mark Twain knew it.

Until 1928 the Engineers had been seriously hampered by lack of funds. The



AND W. D. SUGHRU, NATIONAL GEOGRAPHIC STAFF © N.G.S.

A "Sinking" Barge Paves the Bank With a Mattress of Concrete Slabs

The Mississippi, lurching from side to side, slams into banks and crazily shifts course. To tame the stream, the U. S. Army Corps of Engineers shackles the river with wire-reinforced blocks of concrete called mattresses.

Here, below Memphis, a barge hidden under concrete lays a flexible armor that, like chain mail, will conform to the contours and protect the riverbed against erosion. As towboats pull the barge out, the mattress rolls off like a conveyer belt. Cranes swing prefabricated sections into place on the barge; men at lower left twist together inlaid wires that bind the slabs.

Bridge builders at Helena, Arkansas, prepare to sink a willow mattress that will prevent currents from eating away soil around the caissons.



disaster of the previous year stung Congress into the passage of the Flood Control Act of 1928 and the appropriation of enough money to implement it.

Between 1933 and 1942 U. S. Army Engineers made 15 cutoffs, shortening the Mississippi River 142 miles.

The cutoffs have merits. Less mileage between St. Louis and New Orleans means quicker towboat passages. Many hours, even days, are saved. The straightened channel carries flood crests more directly and quickly to the Gulf. Since the grade is steepened, the runoff is faster.

But on some loops a cutoff is not practicable. The great New Madrid Bend of 20 miles could be reduced to a mile by a short cut through the neck of the bend (page 705). This has not been done and perhaps never will be. The river stands 13 feet higher above the bend than below it at high water, and a cutoff could cause serious navigation problems.

Building the levee walls also devolves upon the Engineers. These earthen breastworks,

A train of oil barges, pushed by the *Cypress*, passes by the mouth of the Yazoo River near Vicksburg, Mississippi (page 703). Making the run from Baton Rouge, Louisiana, to Louisville, Kentucky, the tow moves upstream at 10 miles an hour.

Radar enables the tow to operate in darkness or fog.

Cattle graze clover on the riverside Ross Ranch near Vicksburg. In the past 22 years the Mississippi has gnawed 400 acres off the 700-acre property. Flatlands support luxurious stands of Johnson grass. "When we raised cotton," says rancher William B. Ross, "we fought Johnson grass as a pest; now we feed it to cattle." His son Fred here checks the herd.

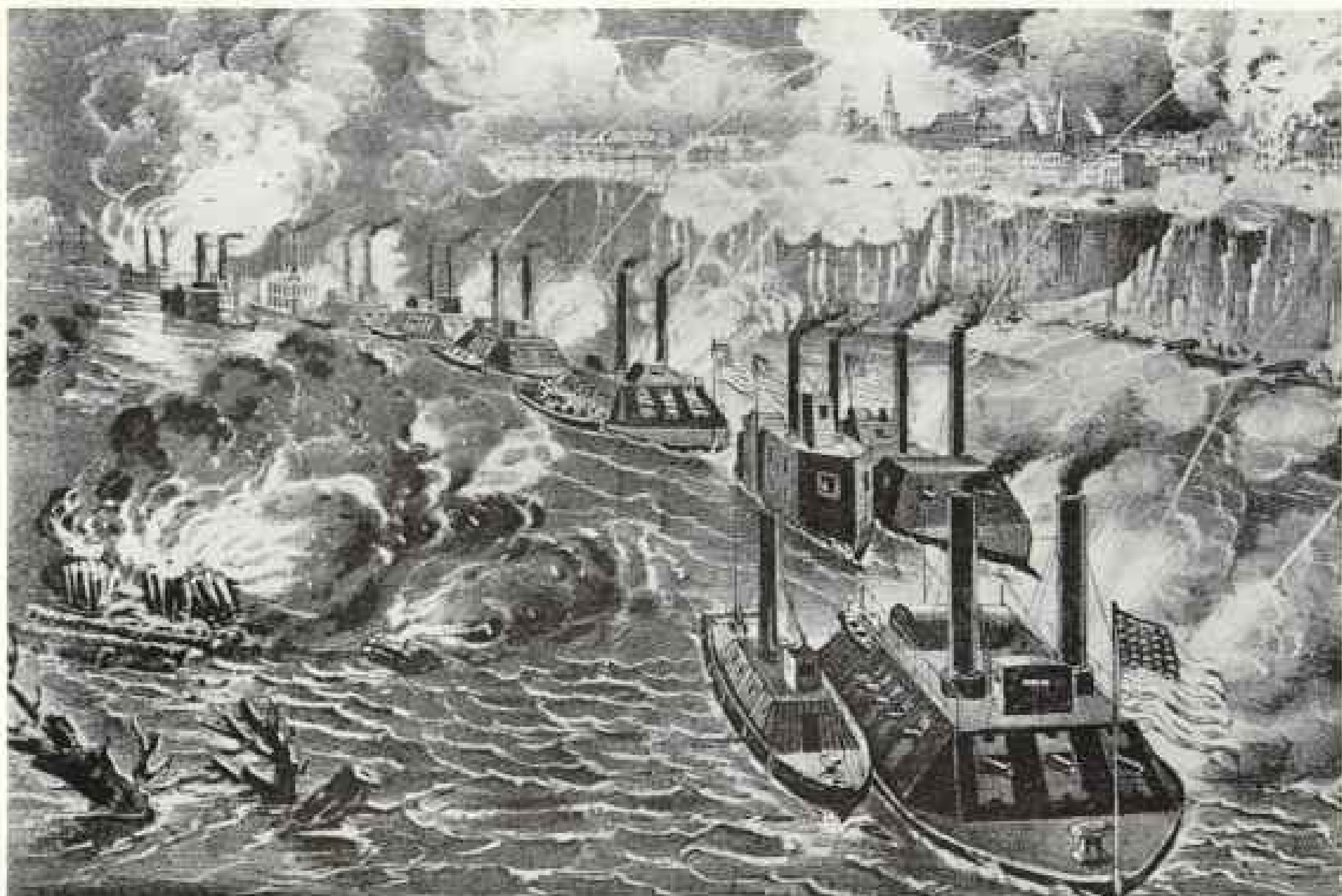
700



BOATCREWERS BY NATIONAL GEOGRAPHIC PHOTOGRAPHER ROBERT F. GILSON © N.G.S.







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Union Gunboats Run the Blockade at Vicksburg, Gibraltar of the Confederacy

In 1863 only this southern stronghold stood between the Union and control of the Mississippi. On the night of April 16, Adm. David Dixon Porter took ships and supplies to Gen. Ulysses S. Grant, who waited south of heavily fortified Vicksburg. At Stockade Redan (below), Union troops charged up Graveyard Road into withering Confederate fire from the hill in foreground. The Federals lost the day, but Vicksburg lost the campaign and surrendered on July 4, after a 47-day siege.

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PHOTOGRAPH BY NATIONAL GEOGRAPHIC PHOTOGRAPHER W. H. YAGGER © N.G.S.

Vicksburg Still Stands Atop the Bluffs But Not Beside the Mississippi

In 1876 the river capriciously carved a new channel and left the town three miles off water. In time engineers diverted the Yazoo River into the old bed, giving the city its present harbor. Vicksburg is Mississippi State's chief river port.

as high as 50 feet, stretch for more than 3,500 miles along the lower river and subordinate waterways. The project rivals the Great Wall of China, another dike raised in ancient times against a different kind of flood—one of men rather than of water.

These levees, lining both sides of the river, must be placed with great care. They do not, as one might imagine, sit on the bank of the river. Sometimes they stand five miles or more back from the water. This is to give the river king room to thrust out his elbows at floodtime. The wide flood plain acts as a relief valve. The water spreads over the lowlands and loses much of its force before it reaches the levees.

The great battlements themselves, 200 to 300 feet thick at the base and three or four stories high, look invulnerable. But in the early days before they attained such massive size, so small a thing as a pocket gopher could destroy them.

The gopher would make a small burrow, perhaps add an internal system of runways, side branches, and storage chambers.

One day the water would rise, enter the burrow, and gradually reduce the solid bank to a mound of mush. The slopes sloughed off and slid down. The seepage worked through to the other side, and there was no small boy handy to stop the drip of water with his finger.

The drip became a dribble, the dribble became a continuous stream, the hole broadened with amazing speed, and the stream became a Niagara that poured into the back country, sending people to rooftops or into boats or to precarious refuge on the crest of the remaining levee.

Levee Patrols Spot Danger Signs

Even today, during high water, guards patrol the levees and watch for "boils," small geysers marking the beginnings of breaks.

One of the greatest achievements of the Engineers is Louisiana's Bonnet Carre Spillway and Floodway. If necessary, it can carry almost two million gallons per second out of the river and through Lake Pontchartrain to the Gulf, side-stepping New Orleans.

In 1937 the work of the Engineers was put to the acid test. Floodwaters poured down the Mississippi. Authorities were ready to evacuate a million people if the levees broke. Cairo, trapped between the Ohio and the Mississippi Rivers, pumped water out of town as fast as it seeped through the levees. The river was three miles wide at Memphis and climbing into town.

It was a near thing. In many places the water was levee high. Hodding Carter, editor of the *Delta Democrat-Times*, looked from his newspaper office window in Greenville to see Coast Guard cutters moored 20 feet above street level.

But the levees held. Above New Orleans, the Bonnet Carre Spillway, completed only two years before, was opened, one gate at a time. Through it enough water spilled off to cover 1,250,000 acres 10 feet deep. This lowered the river level for more than a hundred miles, and New Orleans was safe.

Engineers Anticipate Superfloods

The Engineers were not satisfied. This had been a giant among the big floods. But suppose there should be one still bigger? Plans were made to cope with it, should it ever come.

One of the more ambitious projects was the Morganza Floodway, completed in 1954 to divert floodwaters from the Mississippi down the basin of the Atchafalaya to the Gulf. Today such floodways, reservoirs on tributary streams, cutoffs on the river, bank revetments, strengthened levees—all are insurance against possible superflood.

A constant challenge to the Engineers is the maintenance of a channel 9 feet deep all the way to Minneapolis. Eventually they will deepen it to 12 feet. From Baton Rouge down, a channel at least 35 feet deep is maintained for ocean-going vessels.

We rode one of the patrol boats, sounding to determine where dredging must be done. No deckhand stood on the bow, dropping a lead line. A Fathometer at the captain's elbow sent an impulse to the bottom, and the time it took to bounce back indicated the depth, which was recorded on a graph.

Most modern towboats are equipped with Fathometers in the pilothouse to show the depth at the head of the tow. Otherwise, the captain blows a sounding signal on his whistle, and a deckhand runs out to the end of the tow to heave the lead in the time-honored way. But no longer does the leadsman call out in the colorful manner that gave Sam Clemens his pen name.



Lower Mississippi in miniature attracts visitors to the United States Army Engineer Waterways Experiment Station at Vicksburg. The model represents ten million acres. Feeding controlled amounts of water into it, engineers can simulate floods and study river improvements. White sticks serve as mileposts to gauge the river's speed. Hardware cloth lining the banks retards the water, as trees and brush do in nature.

Largest hydraulic model in the world, near Jackson, Mississippi, experiments with flood-control problems throughout the Mississippi's entire drainage basin—40 percent of the 48 States. Here, in a reproduction of the 1950 flood, engineers observe conditions at New Madrid, Missouri. Brass pegs on the river bottom provide resistance to flow, as eddies do. A gauge straddling the stream keeps a continuous record of its depth.



REARRANGED BY WILLARD PRICE (BELOW); AND NATIONAL GEOGRAPHIC PHOTOGRAPHER ROBERT F. Sisson © W. S. S.

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"Mark twain" meant two fathoms, or 12 feet. Some of the other calls were "quarter less twain," "quarter twain," "half twain," "mark three," "half three," and "mark four." The calls were not spoken but sung, with a different tune for each depth. Even if the master could not hear the words, he might still understand the call.

The Teletalk has changed all that. The leadsman speaks softly into a phone. A man five feet away may not hear him, but his report is clearly audible in the pilothouse.

When a soft-bottomed channel needs deepening, a dustpan dredge swallows the mud with a sucking mouth 32 feet wide. Where the bottom is hard, a multi-bladed cutterhead chews up the clay and gravel before it is sucked away by a gigantic vacuum cleaner. A tube a thousand feet or longer carries the soupy debris to the

shore. Thus the dredge resembles an oversized elephant with a huge trunk stretching halfway across the river.

Another necessary vessel of the Mississippi is the snag boat. Snags once were among the chief perils of the big river. Undercut by the current, a bank occasionally caves in, toppling big trees into the water. The roots of the trees, heavily encrusted with dirt, sink to the bottom. The tops, being lighter, float on or near the surface, and the current points them downstream.

The snag that stays in a fixed position is called a planter. One that keeps lowering

Columned Melrose Evokes the Charm of Ante Bellum Days

Before the Civil War, cotton built many mansions in Natchez, Mississippi, and filled them with furnishings from Europe. Battles and fire swept away much that was beautiful in the South, but Natchez preserved its pillared treasures. Thirty historic homes go on display each March; some are shown by hoop-skirted great-great-granddaughters of the builders.

Reared in the mid-1840's with brick made by plantation slaves, Melrose still keeps its spacious park, where moss drapes venerable trees.

Echo of Byzantine Grandeur, Longwood Stands Unfinished

Dr. Haller Nutt, a Natchez cotton planter and inventor, started this home in the late 1850's. Plans called for 32 octagonal rooms surrounding a five-story rotunda. Work on the interior was just starting when the Civil War broke. Heeding the call to arms, carpenters dropped saws, and painters left brushes in buckets. Tools and pails remain to this day, mute evidence of the death of an era.





REPRODUCED BY NATIONAL GEOGRAPHIC PHOTOGRAPHER
BATES LITTLEDALES © N. G. S.

Natchez honors its own—Miss America of 1960. Twenty-year-old Lynda Lee Mead smiles her delight at a home-coming reception. Mississippi National Guardsmen form her escort.

and raising its head is a sawyer. Either can stove in a boat bottom, but the sawyer is the more dangerous. Its rhythm may be so slow that it is out of sight for minutes at a time. The steersman looks out upon perfectly smooth water, only to see a monster rear its head 10 feet above the surface when it is too late to avoid it.

Chicots—the teeth of the river—the French pioneers used to call these hazards. It is the business of the snag boat, or the newer,

general-purpose work boat, to pluck them out of the channel.

We boarded the big stern-wheeler snag boat *West* for the trip from Vicksburg to Greenville. Though it was a steamboat soon to be replaced by a diesel patrol boat, it provided good quarters for its men and the finest of food. Rivermen vie for jobs in the fleet of the Engineers.

From a high A-frame on the bow of the vessel dangled a gigantic pair of tongs which could grip and haul out a log as easily as a dentist pulls a tooth.

We made for what seemed to be a small stick projecting from the water. It was no thicker than my arm and rose but a few feet above the surface. Surely, I thought, this huge tooth puller would not bother with such a trifle.

The *West* slowed up to the stick, and the tongs descended and bit in. Up came the stick, foot by foot. It grew thicker and heavier, and still it came—10 feet, 20 feet, 30, and still more. At length the top of it rose above the lofty pilothouse, and the roots rested on the deck. It was a cottonwood trunk no less than 100 feet tall! The men cut it into short lengths with power saws and dumped the logs overboard to float harmlessly away with the current.

Concrete Slabs Pave Riverbanks

One of the most extraordinary feats of the Engineers is the paving of much of the Lower Mississippi's riverbed. The pavement usually does not floor the central channel, but covers the banks where current and wave action would otherwise wash them away.

This reinforcement once consisted of willow trees bound together with wire into mats, some a mile long. Most of today's mats are concrete slabs linked together with stainless-steel wire, the whole forming a flexible mattress (page 698). Old Al, who rules the Mississippi with a mighty will, can chew up even concrete in time, but such a mat may normally last 30 years or longer.

Natchez is one of the musts of any Mississippi journey. Nowhere on the continent are the life and manners of ante bellum days better preserved.* In the era of the great cotton planters, Natchez was a millionaires' town.

That was Natchez's golden age. Plantation owners built imposing mansions and filled

* See "History Repeats in Old Natchez," by William H. Nichols, NATIONAL GEOGRAPHIC, February, 1949.



KODACHROME BY NATIONAL GEOGRAPHIC PHOTOGRAPHER ROBERT F. FISHER © N.G.S.

Children's hour at Lansdowne finds Mrs. George Marshall III reading to her six granddaughters. The girls are the fifth generation of the same family to live in the Natchez mansion, which was completed in 1853. In her book for youngsters called *Six Little Girls of Lansdowne*, Mrs. Marshall describes the life of a modern cotton plantation. "The little girls," she writes, "all like the trundle bed [foreground] in the daytime, but when night-time comes and the lights are turned out . . . they always want to climb up on the big bed with Mimmy" (Mrs. Marshall).



them with furnishings from Europe. The glory faded after the Civil War.

Today the golden age has returned with the discovery of oil and gas and the coming of large industries. The mansions have been restored, some of them occupied by descendants of the original owners (pages 706-7).

The stretch between Natchez and New Orleans we covered by automobile, by plane, and by boat. This time the vessel was not a towboat, but a steamboat, the *Delta Queen*, which makes regular cruises out of Cincinnati—downriver to New Orleans, or turning upriver at Cairo to St. Paul.

Churning downriver, the *Queen's* great stern wheel threw up big waves and carried a veil of spray occasionally crowned by a rainbow. For 20 miles and more at a stretch we saw nothing but forest on both sides—not a house, not a human. It looked much as it probably did in La Salle's day.

Hidden by the trees, a mile or several miles from the river, lies the levee, and behind the levee there is life aplenty. But the great flood plain is a place of solitude, birds, and peace.

New Orleans Booms as No. 2 Port

At Baton Rouge, Louisiana, however, the scene changes (opposite). Here the city crowds in upon the river, and from Baton Rouge to New Orleans great industries are developing that will make this part of the river somewhat like the Ruhr Valley.

Entering New Orleans, we passed under the Greater New Orleans Bridge, the longest cantilever bridge in the United States, flinging into the air a center span of 1,575 feet between piers (page 714).

Boats were all around us, and large ocean-going ships as well, for we were now in one of America's greatest ports. New Orleans has moved to second place (after New York) in value of foreign water-borne commerce—one and a half billion dollars' worth annually.*

As gateway to the mid-continent, the city taps 40 percent of the total area of the 48 conterminous States. And down some 17,000

miles of inland waterways come thousands of vessels each year, with cargo to be transhipped to almost 5,000 ships and carried to ports around the globe.

One of the great forces behind this miracle has been International House, a foreign-trade promotion project. A sister organization is the International Trade Mart, a market place for businessmen from all over the world.

But the tremendous activity of the old-new port does not disturb the Vieux Carré, the French Quarter, with its iron lacework balconies, Spanish and French courtyards, and restaurants that serve some of the most delicious food in America (page 713).

Watery Maze Reaches to the Gulf

New Orleans is thought by many to be at the southernmost end of the Mississippi. But the river continues on more than 100 miles below the city, and this is one of the most fascinating stretches of all its course. Here the Mississippi has laid down its most modern delta—modern, that is, compared with the alluvial plain it has deposited over long geologic ages, from Cairo south.

The deep delta country is unique and fabulous. It is a bewildering mosaic of winding waterways, lakes, bayous, and swamps. The levee is the highest land hereabout; yet it seldom lies 20 feet above the water. The river is broad and tranquil in its old age, but it still has enough force to carry its tremendous burden of silt on toward the Gulf.

Visitors to New Orleans may sample part of the deltal river on the excursion boat *President* or on a chartered yacht. It is possible to drive 80 miles south along the riverbank to Venice, which has none of the glory of its Old World namesake, but seems to have an even wetter setting.

Here the road stops. The stream still has 30 miles to go, but travelers beyond this point

* See, in the NATIONAL GEOGRAPHIC: "New Orleans: Jambalaya on the Levee," by Harnett T. Kane, February, 1953; and "Louisiana Trades With the World," by Frederick Simpich, December, 1947.

Louisiana's Skyscraper Capitol Reviews the River Parade at Baton Rouge

In March, 1952, Huey P. Long proudly saw the completion of the 450-foot-high structure he began as Governor. Three years later an assassin mortally wounded Long, a United States Senator, in one of the capitol's corridors. Formal gardens in foreground surround Long's tomb. Since his day Baton Rouge has boomed. Humble Oil's Esso refinery at upper right ranks as the Nation's largest and most versatile; it manufactures more than 700 products ranging from alcohol to jet fuel. Distant bridge carries U. S. Highway 190 westward across the Mississippi.



St. Louis Cathedral: a New Orleans Landmark

When New Orleans was being laid out in 1721 by founder Sieur de Bienville and his architect, they gave the parish church the most prominent place on the town square.

New Orleans spread far beyond the French colonists' site, now known as the Vieux Carré, but the cathedral remains its spiritual heart.

After the Battle of New Orleans, Andrew Jackson stood at attention here during the solemn *Te Deum*. And when the city entertained French President Charles de Gaulle last April, a stop at the cathedral proved a high light of his tour.

A photographer in Jackson Square records the visit of these young sightseers.

Scent of magnolias, flicker of gas lamps, and sound of violins lure diners to the patio of the Court of Two Sisters in the Vieux Carré. Couple in foreground feast on lobster thermidor and Rock-Cornish hen baked in gold foil. Waiter in background serves red snapper adorned with sparklers.



STYLING BY STAFF PHOTOGRAPHERS ROBERT F. GIBSON AND JOHN E. FLETCHER © R.S.L.

must rely on boat or plane or marsh buggy—an amphibious monster with such bloated balloon tires that it can run over soft mud and even swim.

Below New Orleans the dry ground along each side of the river gradually tapers to a swampy point. Here the inhabitants live in danger of storm-driven tides surging up through the marshes. Towns may require a rear levee as well as one in front. When these barriers are overswept, or heavy rains flood the land between the levees, large pumps work day and night to send the water back beyond the dikes.

Delta people do not live only on these slivers of land. The marshes are full of islands, and many fairly solid ones bear houses perched on posts.

Even farther south, one comes to the region of the "trembling earth," where geology can be seen at work; nature has not yet quite decided what to do with all the mud poured out by the great river. The land may suddenly sink beneath your feet, or swell up into a small hill.

At the river's mouths, land under water may rise to 10 feet above it. These "mud lumps" have not been completely explained. Probably they result from the tremendous weight of silt delivered by the river. The silt bears down upon the soft sediments in one area, causing a push-up in another.

The folk who make this strange region their home were described by a visitor a century ago as "aquatic men, with fins like fishes, noses like alligators, feet like ducks." We



Greater New Orleans Bridge, opened in 1958, clears the Mississippi by 170 feet, linking

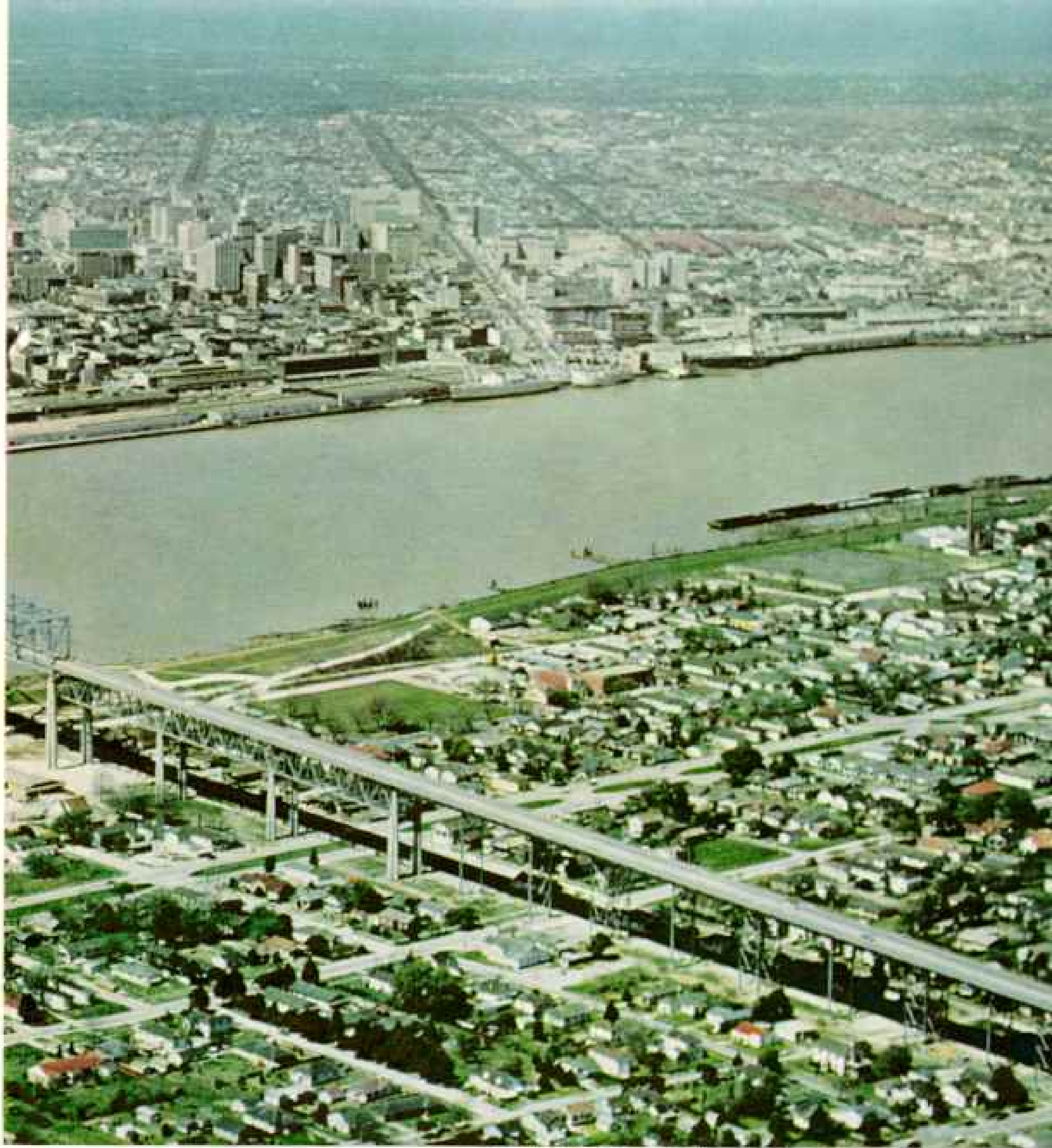
did not see any who answered this description, but certainly it does take a peculiar talent to make a living in such surroundings. Jean Lafitte and his band—19th-century buccaneers of the bayous—did well as pirates and smugglers. More recently the area was a corridor for contraband cargo—liquor, for example.

Now honest men like to go fishing in this region, even braving the eight-foot alligator gar. The savage fish wears a scaly coat almost as hard as bone; full-grown gars are about one-seventh jaw. Yet some ardent sportsmen

go after them with only bows and arrows.

Real alligators are sometimes wrestled out of the water by hand (page 720), after being brought to the surface with a long pole tipped by a hook. Since most gators are killed for their skins, hunters more commonly shoot them in the head. Some Louisiana natives even grunt like the alligator to lure him within range.

One day we witnessed the skinning of an alligator, a job to be done with much care since the thick hide is valuable and can be



STYLING BY NATIONAL GEOGRAPHIC PHOTOGRAPHER ROBERT F. SISON © N.G.S.

the city's heart with Algiers. Both lie below water restrained by banks and levees.

tanned into excellent and expensive leather. The teeth can be carved into ornaments. The flesh can be eaten, if you have a strong stomach and an insensitive palate. Some delatans claim that the tail of an alligator is a morsel for the gods, but that to be really flavorsome, it should be buried in the ground for several days until it ripens.

Shrimping is big business in the delta, as are the trapping of muskrats and the raising of delicious oranges.

And so, of course, is oystering.

We went by launch through the mazes of Barataria Bay to visit the oystermen. We expected their island homes to be shanties and cabins. Instead we were ushered into a large white frame house with three bedrooms, two modern bathrooms, and well-equipped kitchen. It was the home of Kuzma Tesvich, who came from Dalmatia in 1929 with nothing, and is now a prosperous oysterman, working in the vicinity of Port Sulphur. With gracious hospitality he served us glasses of refreshing Dalmatian wine.



BOBACKBORT © NATIONAL GEOGRAPHIC SOCIETY

Fishing camps with jutting piers perch on strips of land dredged from Lake Pontchartrain's shallows. In summer thousands quit the heat of New Orleans for the cool of the lake. U. S. Highway 11, at upper left, streaks across the lake on pilings.



KODACHROME © NATIONAL GEOGRAPHIC SOCIETY

Scanning the Mississippi with his binoculars, a lookout at Pilottown sights a ship approaching from New Orleans. A signal alerts a bar pilot, who will then go aboard to replace the river pilot. Beyond Head of Passes the bar pilot will navigate the vessel through narrow, jetty-walled channels of South or Southwest Pass. At the Gulf he will debark and await his turn to take the next ship upriver to Pilottown.

Built on stilts, with catwalks for streets, Pilottown is the river's southernmost village. No street crosses it; no automobiles endanger these racing children.

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PHOTOGRAPH BY NATIONAL GEOGRAPHIC PHOTOGRAPHER ROBERT F. DYER © N.G.S.

Whirling in for a landing, a helicopter delivers a work crew to the Freeport Sulphur Company's mine in the Gulf of Mexico. A derrick tops the production platform where Freeport expects to work 108 wells. Large pipes beneath the ramp carry hot water to melt the sulphur in its limestone bed below the Gulf; smaller ones return liquid sulphur to a depot where it is pumped seven miles under the sea to Grand Isle. For this first deepwater sulphur mine, Freeport has built a town on platforms, with offices, a 60-room dormitory, recreational lounges, and cafeteria—all air-conditioned.

There is money in oysters, and the Dalmatian oystermen have found it. But there is trouble, too, and need for great skill and patience—as we learned when we went out on the oyster luggers and saw the complicated steps that go into producing what many gourmets call the world's finest oysters.

The biggest fishing operation of the delta is for a species rarely seen on the dinner table; yet we come into contact every day with products in which it is used. It is the menhaden, a member of the herring family.*

Many detergents contain menhaden oil, as do linoleum, paint, varnish. The chicken and pork that we eat may have been raised on feeds containing menhaden meal. Much menhaden oil is exported to Europe, where it finds wide use in cooking. More of these silvery "pogies," averaging a foot long and close to a pound in weight, are taken from our waters than any other fish. Last year the catch of more than two billion pounds was almost ten times that of the second-place tuna.

Planes Spot Menhaden Schools

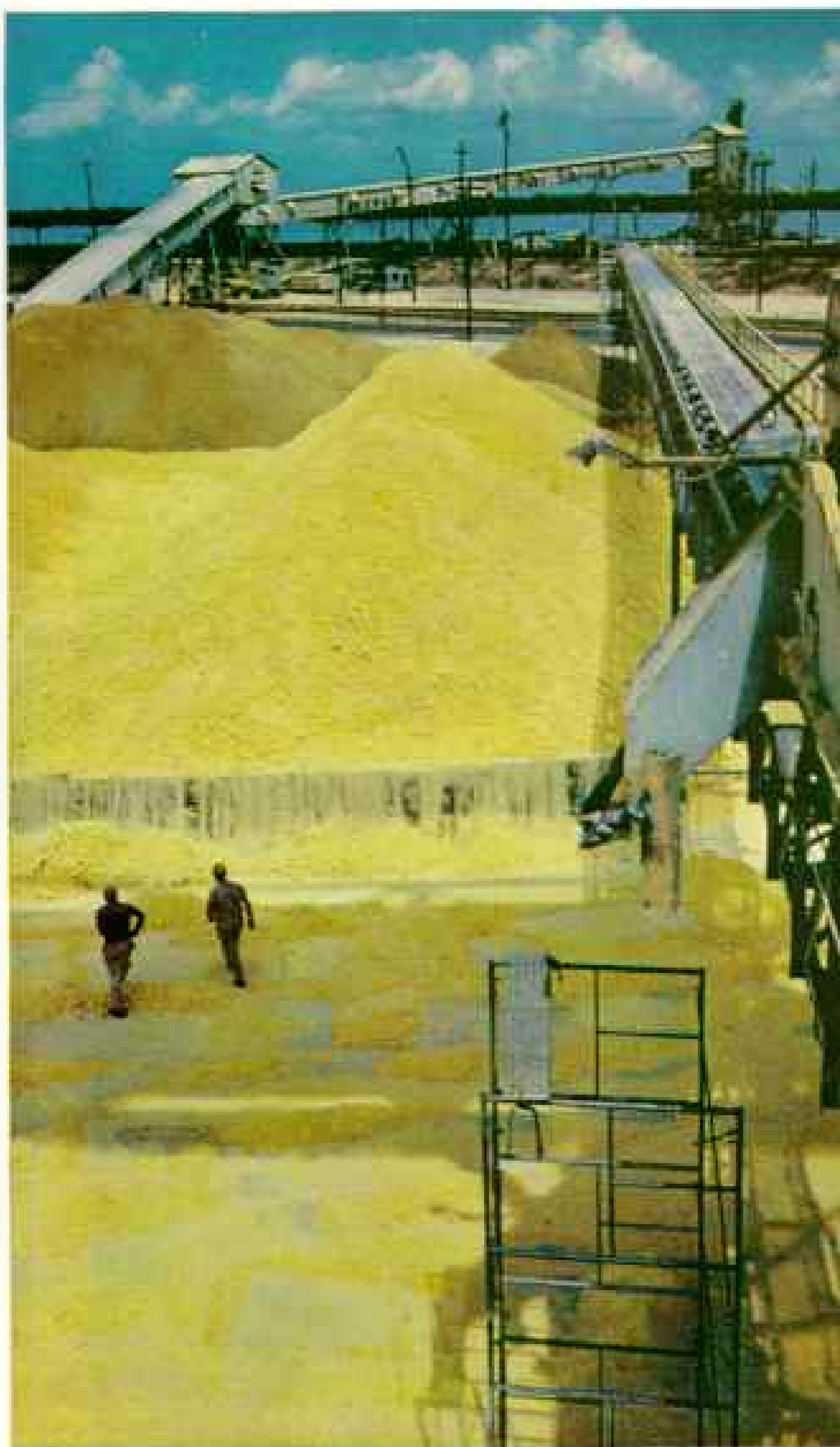
The schools are located by low-flying planes. I took off in one, a Piper Super Cub belonging to the Empire Menhaden Company of Empire, Louisiana.

We flew east over the marshes to open water. The pilot called my attention to a shadow in the sea. It was a school of menhaden. About a mile away was the ship, a tender with two smaller vessels called purse boats, by reason of the purse seines they use to trap the fish (pages 722-3). The pilot reported to the ship by radio. Almost immediately we saw the two purse boats turn and come in our direction.

We kept circling above the school. When the purse boats came close, the pilot guided them toward the school, and told them when to let down their net.

The purse net is a monster 1,200 feet long and 60 feet deep. One end was held by each boat; with a neat maneuver they wrapped its meshes around the school. Then the haul was transferred to the mother ship by means of huge suction hoses.

At Grande Ecaille, near Port Sulphur, in



ILLUSTRATIONS BY NATIONAL GEOGRAPHIC PHOTOGRAPHER W. D. FALLER © N.G.S.

Mountains of sulphur pile up beside the Mississippi at Port Sulphur. Yellow mineral in foreground has been cleaned of a trace of oil that tans the pile beyond. Conveyer belts whisk the element to waiting tankers.

mid-delta, one of the world's largest sulphur mines lies deep under marshy ground. Herman Frasch, an engineer as inventive as Jules Verne, devised a way of piping superheated water into the sulphur deposits; the water melts the sulphur, and compressed air then lifts the molten sulphur to the surface.

From a plane belonging to the Freeport Sulphur Company, we looked down upon a vast area of sulphur. Some of it appeared in

* See "Menhaden—Uncle Sam's Top Commercial Fish," by Leonard C. Roy, NATIONAL GEOGRAPHIC, June, 1949.

An Island in a Watery Wilderness, Delacroix Clings to the Rim of a Bayou

Viewed from an airplane, the sole of the Louisiana boot appears like a vast mosaic, endlessly patterned with curling waterways and patches of marsh grass. Here and there oil rigs stand above the flat; occasionally a boat makes a lonely passage. Strangers regard the land as a place of primeval desolation, but bayou men see it as a hunting ground teeming with wildlife. Winter finds them trapping muskrats; in spring and fall they go shrimping. Summer is the season for fishing. Between times some take alligators; others serve as guides to sportsmen. No one gets rich, but poverty is rare.



FOURTEEN BY NATIONAL GEOGRAPHIC PHOTOGRAPHERS
W. D. BRADY (ARROW) AND ROBERT T. GREEN © N.G.S.

Wrestling an alligator, Louis Reno holds the tail in an iron grip. Keeping the head forward, he flicks the body from side to side until he lands the animal.

A professional alligator hunter for many years, Mr. Reno can read a marsh like a book. Muddy water with rising air bubbles usually means an alligator lair. Probing with a stick, the hunter entices a gator to surface, then engages it in hand-to-claw combat. The skin of this 150-pound, 7-foot bull sells for about \$18.

Muskrat trappers return to camp after a day in the marsh. Skins hang on racks to dry.

Ten years ago a trapper might expect to take 6,000 pelts a season, but since hurricane Audrey destroyed many muskrat nests in 1957, he is lucky to take 4,000.





the form of solid cakes; some in storage tanks was kept molten by steam. From these tanks it drained off into "thermobarges," which keep it hot during the trip up the Mississippi and throughout the mid-continent where it is put to a thousand uses.

The really colossal wealth of the delta, however, is in its oil and gas. We flew over oil and gas wells in the marshes and in the Gulf itself as far as 30 miles from shore. Oil workers fly to and from offshore platforms by helicopter. On our plane radio, like that of a taxi, we overheard constant instructions to the drivers of these air jitneys.

"The deepest producing oil well in the world is here in the marshland near Lake

Grande Ecaille—it goes down 22,500 feet," our pilot told us. Now over the Gulf of Mexico, we could see a gigantic drilling rig. These rigs cost money—as much as \$5,000,000. When one is towed into place, it will lower its legs to the bottom, then jack itself out of water to tower 100 feet or higher.

We took another plane, this time an amphibian belonging to the Louisiana Wild Life and Fisheries Commission, to tour the strange watery waste south of New Orleans. Following the river, we came at last to Head of Passes. Here the Mississippi splits up into many rivers, spreading out like the webbed foot of a duck, each pass finding its own way to the Gulf of Mexico (map, page 683).



REARRANGED BY WILLARD PRICE (BELOW) AND W. E. VERNON © N.A.S.

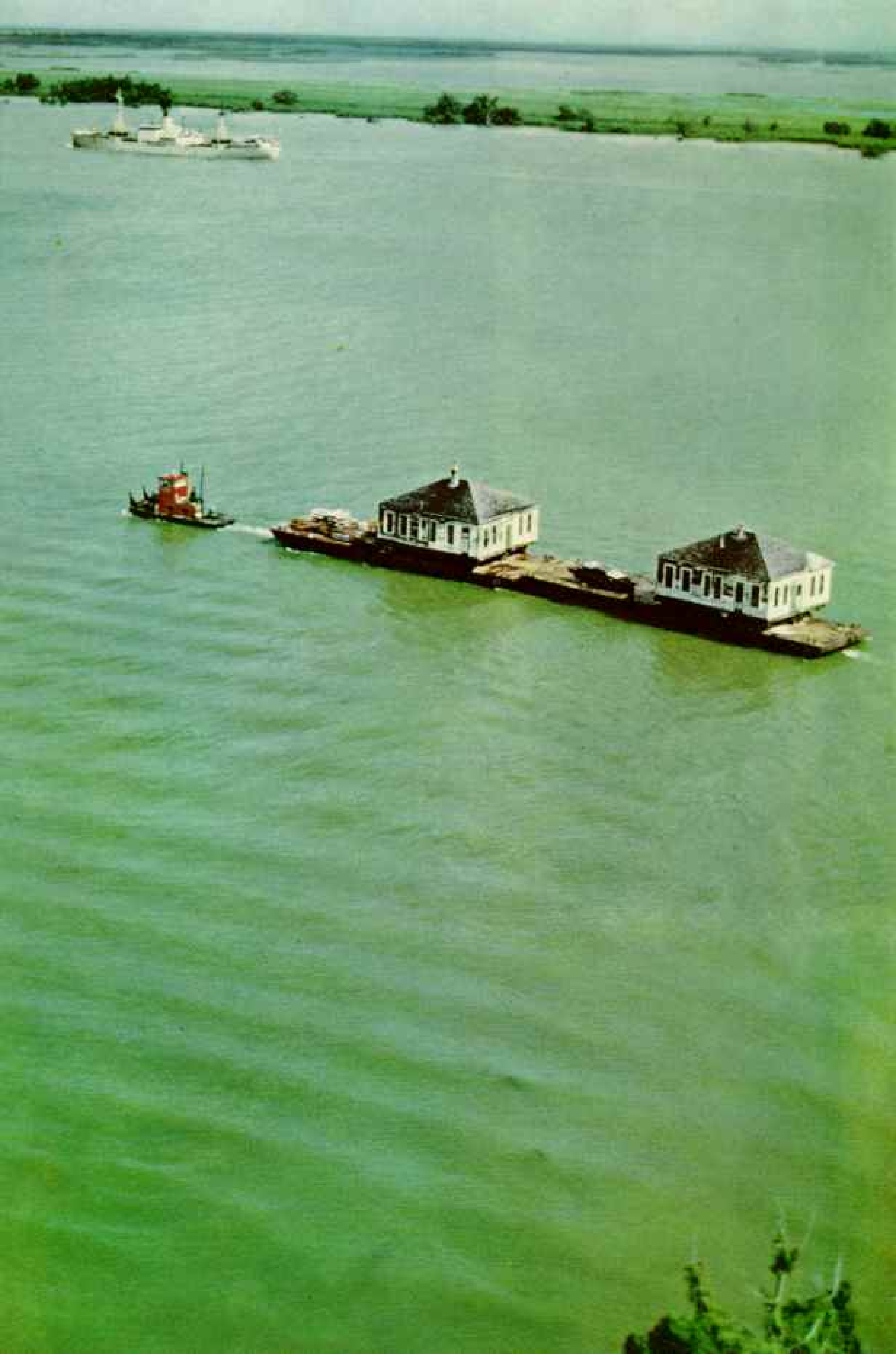
A Shadow Writhes Across the Gulf. Menhaden!

The spotter plane radios the school's position. Within minutes boat crews tighten a purse seine around the fish.

Chanting crewmen pull in the net. They called this a feather-white strike because the large catch made a feathery line around the floats in trying to escape.

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On Pass a Loutre we came down at the wildlife station, which stands on a small wedge of land besieged by water on every side. Its few buildings are connected by catwalks high enough to be clear of cottonmouth moccasins that lurk in marsh weeds. The station has quarters for duck hunters; the region abounds in great white cranes, pelicans, and other waterfowl; nutria, marsh deer, and alligators.

Weary River Drops Its Burden

Near by we visited Pilottown, an amphibious settlement perched on stilts, where ship pilots stand ready day and night (page 717). They are divided into two camps. In one building are the river pilots and in another the bar pilots. Though they are friendly enough, their work seldom brings them together. They are two separate aristocracies.

The rules are strict. A ship must have a bar pilot below Head of Passes, a river pilot above it. We went out in the pilot boat to a freighter arriving from the Gulf. A river pilot would take the ship as far as New Orleans. Still another pilot association takes care of shipping on the river above New Orleans. It is not as crazy as it sounds; each part of the river has its own problems and requires its own experts.

All the way downstream from New Orleans, the river had been more than 70 feet deep. Here, at Head of Passes, it was very tired. It was dropping its load of silt, bucking against the same sediment that it had laid down in centuries past.

This is in a sense the end of the river. This is point zero. The Corps of Engineers counts Mississippi mileage from here.

But a river can hardly come to a dead end. The waters still have somehow to reach the sea, five to twenty miles away. So from Head of Passes or near it, they set out in all directions over the old river deposits, seeking the Gulf. Some of the channels are Main Pass (which is by no means the main pass), Octave Pass, Dead Women Pass, Raphael Pass, Martins Pass, Pass a Loutre, Scarabin Pass, Contrariete Pass, North Pass, Grand Pass, Tiger Pass, Red Pass, Twenty Seven Pass, Flatboat Pass, South Pass, and Southwest Pass. The

two last named are most used. They have been "stabilized"—so engineered that, with frequent dredging, they provide a 35-foot-deep access to the sea.

In March, 1958, U. S. Army Engineers began work on a seaway canal 36 feet deep, 500 feet wide, and 77 miles long. This land-and-water cut will extend in a straight line from New Orleans southeastward to the Gulf of Mexico; and it will be 36 miles shorter than the Mississippi River route between these points. The project, estimated to cost \$105,000,000, is scheduled for completion in June, 1967. It will be known as the Mississippi River-Gulf Outlet. A 250-foot-wide interim channel, however, will open for shipping sometime around June, 1963.

We flew down the 20-mile Southwest Pass to the Gulf. The tang of salt water was strong. Gulls, terns, cranes, and pelicans filled the sky. But the mighty Mississippi was not done. Beneath us for miles out to the sea the water was still tinged with brown. Flying fish and porpoises seemed quite at home in the brackish mixture.

Gradually the color faded, and the last grains of soil from as far away as Montana and New York were laid down. The "great sewer," as some have ungraciously called the majestic Mississippi, pours into the sea about a cubic mile of mud a year.

Flood Control Breeds Complacency

Has the great, temperamental, erratic, murderous river finally been licked? Perhaps not. Some old-timers say it never will be. But the effort is worthwhile.

It is estimated that since 1928 flood control has prevented losses of about six billion dollars and countless lives. The conquest of the Mississippi has been called "one of the most ambitious undertakings ever conceived by man."

The success of this mammoth project to date has given valley dwellers a new confidence—in some cases a dangerous complacency. No doubt the river still has many tricks in its bag. All experience warns man that nothing but eternal vigilance will checkmate the infernal ingenuity of Old Al, the River King.

Surplus Houses Go for a Ride in the Mississippi's Broad Mouth

During World War II a finger of land at Burrwood held a Corps of Engineers station and a Navy submarine-hunting installation. Today only a small weather post remains. These two Army dwellings move upriver for sale.

The Crescent City conjures fantasy. On Mardi Gras day the populace takes to the streets, where devils dance with angels, Betsy Ross curtsies to Dracula, and chained convicts turn out to be members of the family next door.

At City Hall even a bird can meet the mayor (on the reviewing stand in background).

Merrymakers on Canal Street (opposite) engulf the Rex Parade depicting the Adventures of Marco Polo.



SHOOTING © NATIONAL GEOGRAPHIC SOCIETY

Mardi Gras IN NEW ORLEANS

By CAROLYN BENNETT PATTERSON

Photographs by ROBERT F. SISSON and JOHN E. FLETCHER

National Geographic Staff

“MARDI GRAS,” says one New Orleansian, “is a private party given by private individuals for their friends.” Says another: “Mardi Gras is a spirit; a time when you meet no strangers because all are friends. It belongs to everyone—and no one.”

No one knows when the European Mardi Gras—literally “Fat Tuesday,” the day of feasting before the Lenten fast—got its start in Louisiana. In New Orleans’s early years, masquerade balls and street pageants were spontaneous; almost nothing was organized until 1857, when the Mistick Krewe of Comus was born. A secret society, the Krewe staged an annual torchlight parade in honor of Comus, god of mirth, until the outbreak of the Civil War.

With peace, Comus resumed his rule. In 1872 he was joined by Rex, King of Carnival, and the Knights of Momus. That year also gave Mardi Gras its official song, “If Ever I Cease to Love,” inspired by a romance between the Grand Duke Alexis of Russia and the American actress Lydia Thompson. Miss Thompson, performing during Mardi Gras with her royal admirer in attendance, sang a

current hit song. The crowd paraphrased it:

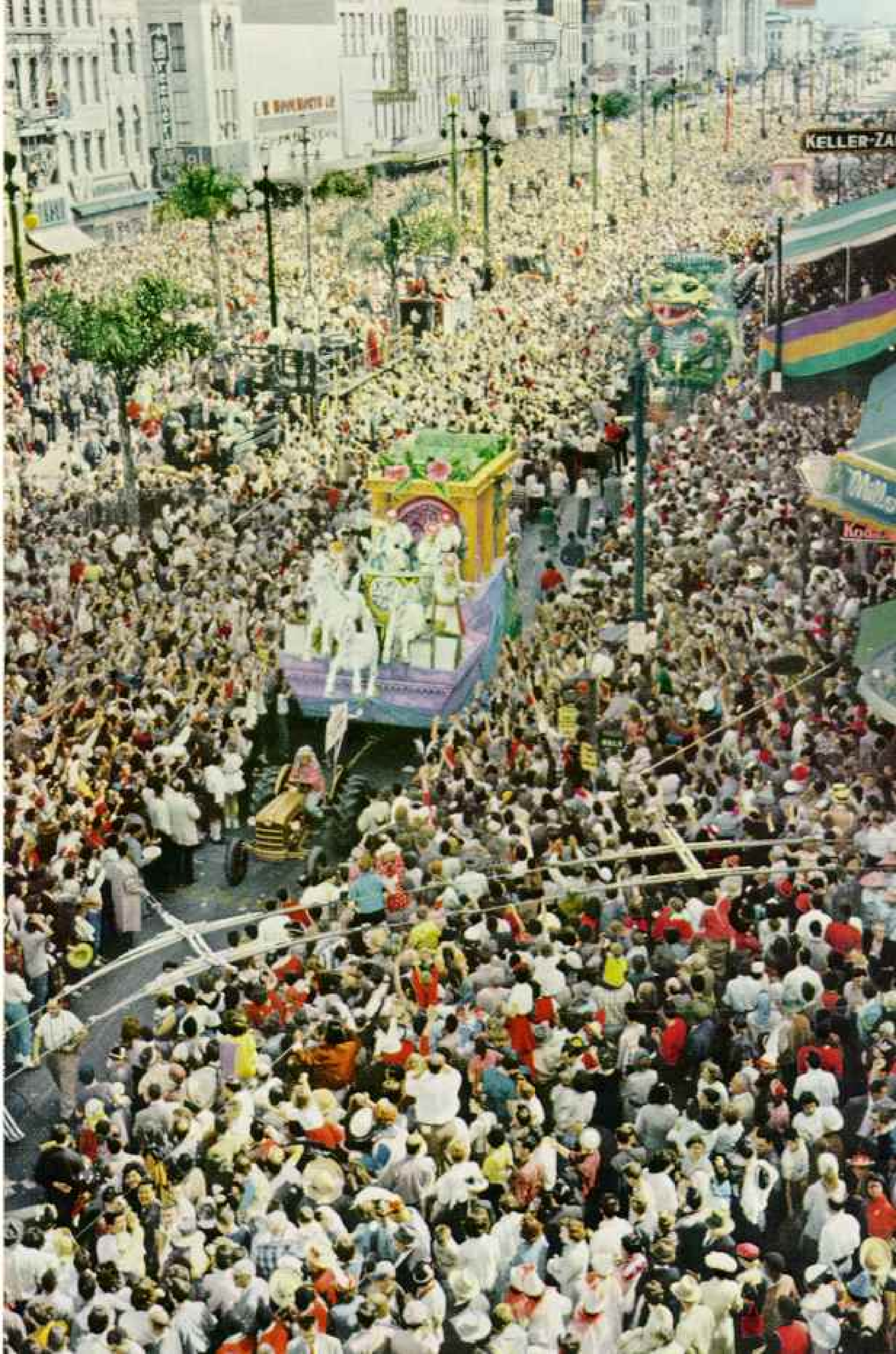
*If ever I cease to love,
If ever I cease to love,
May the Grand Duke Alexis
Ride a buffalo in Texas,
If ever I cease to love.*

An instant success, the song has been played ever since at the appearance of Rex.

Today 65 organizations give carnival balls, starting on Twelfth Night, January 6. The carnival season builds up to the parades of Mardi Gras week, when the celebration flows out into the streets.

On the final day before Lent, Mardi Gras itself, New Orleans folk turn out in mask and fancy dress. King Zulu, the Negro ruler, arrives by river barge and leads a rollicking parade over a meandering, uncertain route. Rex rides in splendor along Canal Street, and Comus comes by night to command that joy be unconfined. After watching the Comus parade, the late Louisiana author Lyle Saxon wrote: “It was something apart from life as I knew it. It was magic itself.”

Mardi Gras! What is it? Merely magic in the City That Care Forgot,



L.B. BARNETT

KELLER-ZA



River of flame flowing down Royal Street is a time exposure of torches carried by white-robed mummers. Jigging steps produce ripples in the stream of light.

Sightseers crowd the balcony of Brennan's Restaurant. Lighted letters, KOP, stand for Krewe of Proteus, here on parade.

Atop a golden throne, dazzling Momus wins the adulation of his subjects in the French Quarter. Greek mythology proclaimed Momus the god of ridicule; New Orleans changed his character. Ever since he appeared on New Year's Eve, 1872, the ruler has inspired merriment alone.

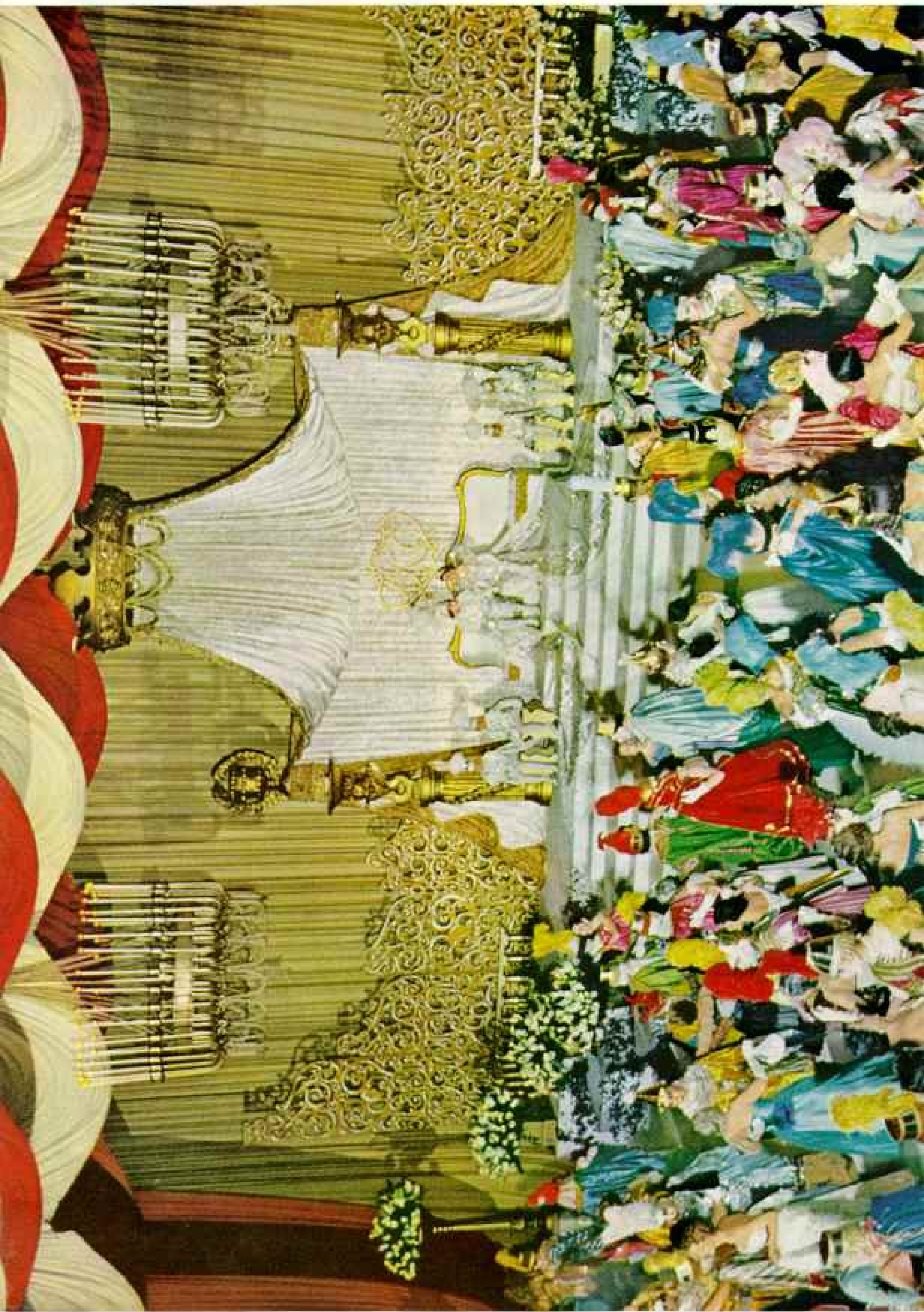
Floats following Momus instruct the crowd in the philosophy of Omar Khayyam.

RODACHRONES © NATIONAL GEOGRAPHIC SOCIETY



A blue-faced merman emerges from the depths of the sea. He wears a headdress of tinsel seaweed hung with sequined crab and tropical fish. Sea horses ride his legs.

Masked Krewe of Comus, in plumed helmets and shining capes, swirl their partners before the eyes of enthroned Comus and his beautiful queen. Dressed in their finest ball gowns, the ladies sit in a guest section until they are called out by a member of the Krewe. His identity remains a secret.







Mardi Gras finale: Rex, with his queen and courtiers, visits Comus and his court a few minutes before midnight. Here the god of mirth, who never reveals his face, leads the Queen of Carnival in a glittering promenade. Rex and the Queen of Comus follow. Carnival organizations spend about \$25,000, on the average, to produce such a spectacle.

Twilight solves the mystery behind the masks. Except at the Comus ball, faces go uncovered for the revels of Mardi Gras night.

At dawn on Ash Wednesday, New Orleans lays aside its carnival capers. Church bells call the exhausted faithful to worship. But the flame of carnival spirit still smolders. Within a few days ball and parade committees meet to plan the next year's Mardi Gras.

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COVER: Pennant-tailed Jamaican hummingbird sips nectar from a hibiscus (page 638).

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The Society's President spoke with veteran staff photographer Joseph Baylor Roberts, Comdr., USNR. Roberts hastily packed his camera gear. Soon he was merged (and submerged) with a shipful of proud submariners inside a dark-gray hull. The Department of Defense had requested an official photographer for *Triton's* highly classified undersea cruise around the world.

Topside here, *Triton's* commanding officer, Capt. Edward L. Beach, USN, pins the ship's Presidential Unit Citation on Roberts,

who is the one with the wider smile. With Captain Beach escorting and Roberts illustrating, you'll step below into twin-reactor *Triton* in a matter of moments. It's typical of the unusual experiences that come through Society membership.

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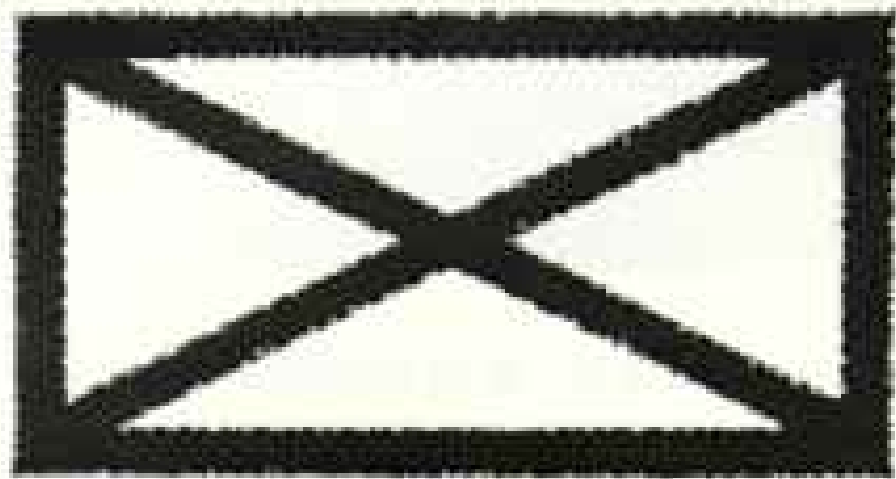
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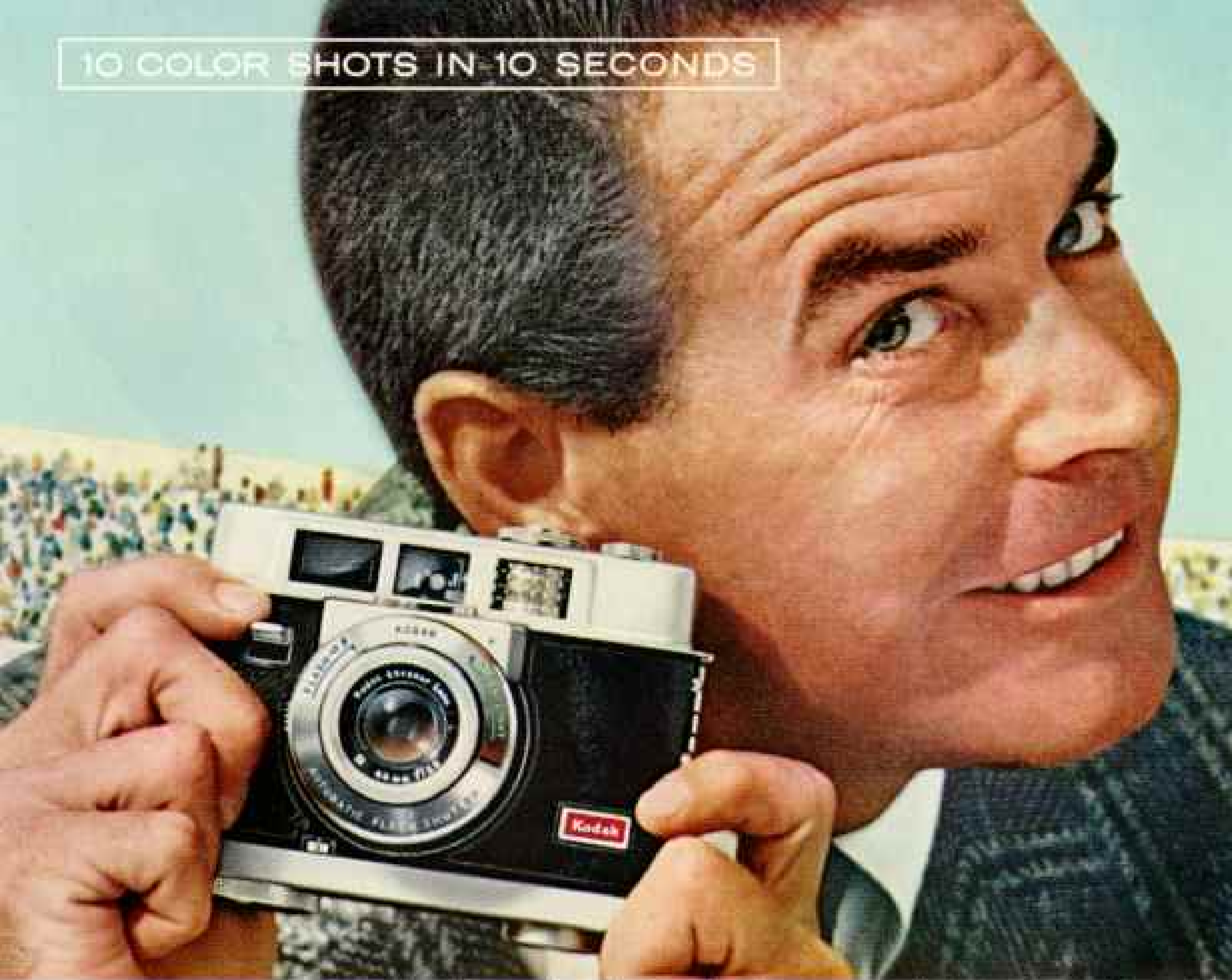


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Is car used in business other than to and from work?	Yes <input type="checkbox"/> No <input type="checkbox"/>	Yes <input type="checkbox"/> No <input type="checkbox"/>
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Additional male drivers under age 25 in your household:		
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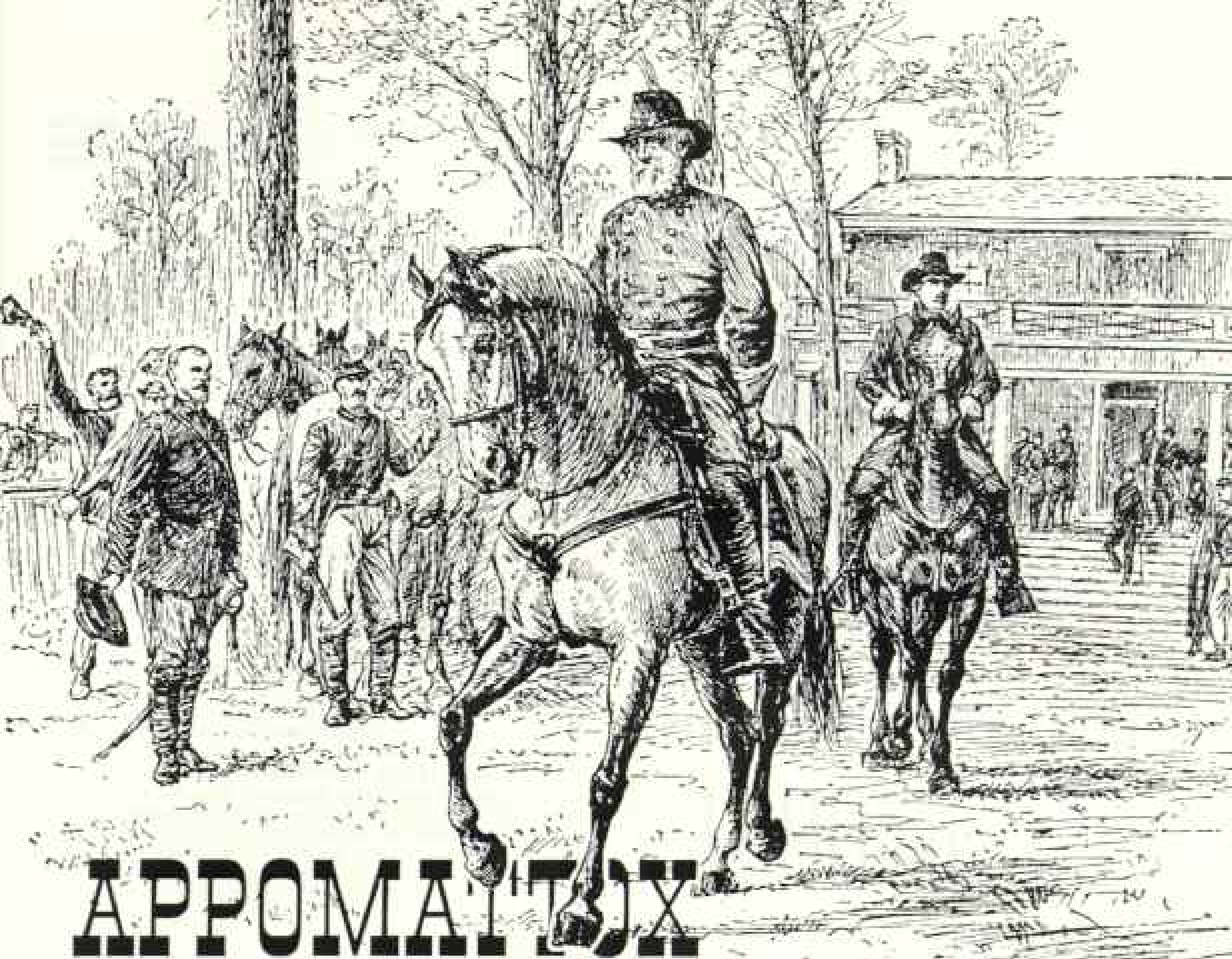
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By LUCIA LEWIS

Travel Editor, Chicago Daily News

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Westbound, you start along the Burlington; through Illinois' serene farms and villages that seem a world away from Chicago's skyscrapers. As night falls, you cross the Mississippi—and when dawn comes, the Rockies rise along the western horizon. Breakfast time finds you in Denver, about to begin the Rio Grande Railroad's spectacular climb up the Rockies, and suddenly you find yourself in a mountain wonderland.

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...This is "space travel" in the comfortable sense of the word. The extra seats in domes and recreation cars actually provide a second seat for each passenger, at no extra fare.

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...Just get to the station on time. Trains do leave when they say they will.

All day long, the train winds through Byers, Gore, Glenwood and other Colorado canyons. Only when you gaze up at the peaks from way down here can you truly grasp their grandeur.

A blaze of glory winds up your day, on the Colorado-Utah border, in Ruby Canyon... aptly named for its crimson cliffs and pinnacles. The whole canyon is bathed in a rosy light; even the gray-green sagebrush turns pink in the afterglow as the sun sets behind the red rocks.

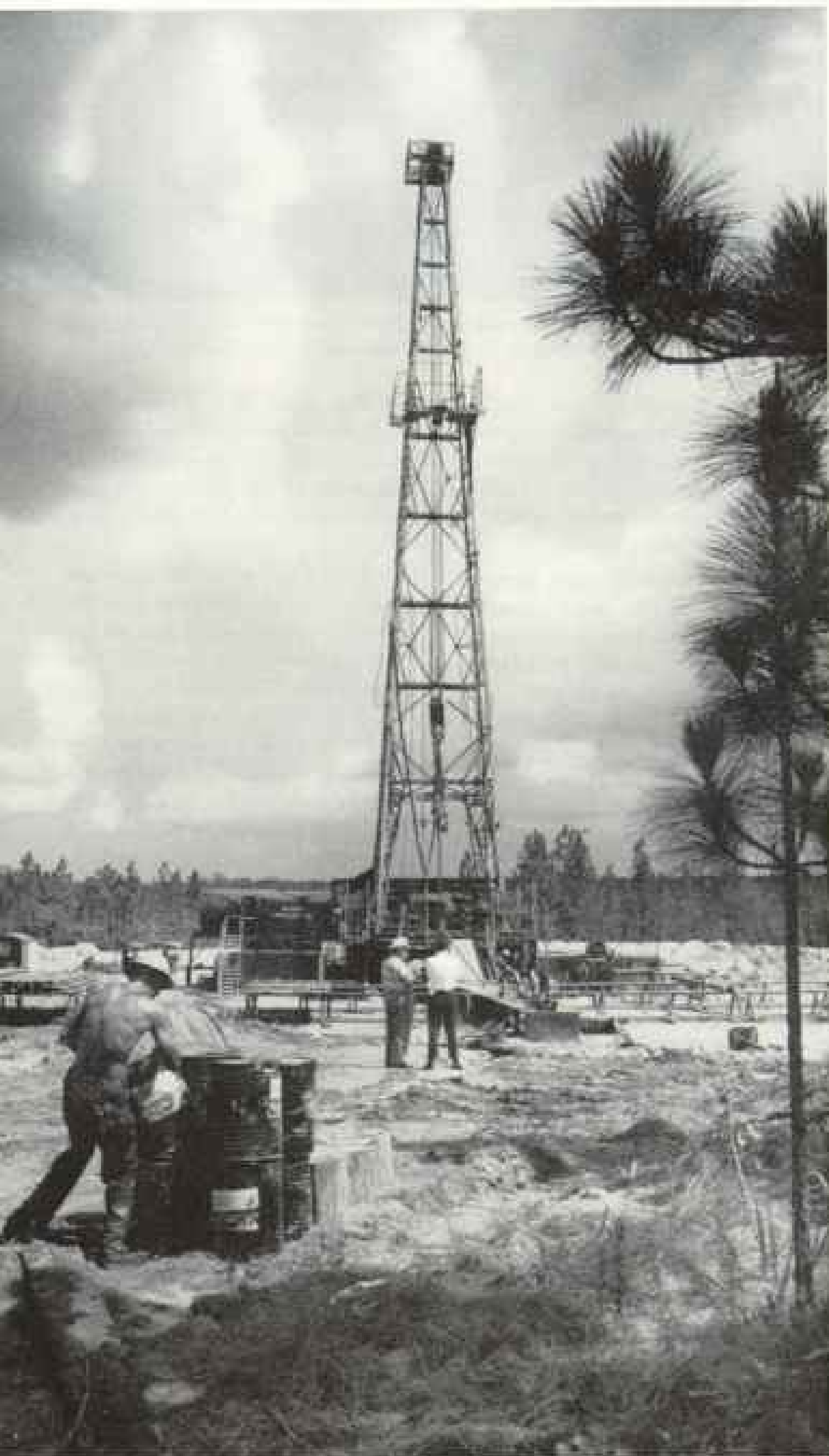
Next morning you discover the pine-cloaked beauties of California's Feather River Canyon. In this 118-mile canyon, the river tumbles fiercely around rocky islands and over many-colored boulders. Foam flies in white plumes, reminiscent of the wild pigeon feathers that gave the river its name. And the Western Pacific shows it to you for hour after hour.

Finally you roll out on the Central Valley, across California's second band of wealth. Here fruit trees blossom when there's still snow back home. You gaze out at rice fields and vegetable farms from Marysville to Sacramento to Stockton, and roll into Oakland by mid-afternoon. The white towers of San Francisco shine on their hills, welcoming you across the great Bay Bridge.

This is the way to use time—on a land-cruise for rest or for undisturbed work—and always for joy in communion with 2,500 miles of your country at its splendid best.

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OIL DERRICKS amidst the pine trees make a comparatively new sight in Alabama. The state's four oil fields include the largest east of the Mississippi River at Citronella. Since 1955, when "Donovan No. 1" began commercial production, over 17,000,000 barrels of oil have been pumped from this field. Even with 247 wells drilled, the full potential of the area has not yet been determined.

The last half of the twentieth century belongs to the South!

From its mountains to its flat sandy beaches, the South possesses rich and diverse natural resources. With research revealing new ways to utilize this natural wealth, Southern industry has become a vital supplier for its own flourishing region, the nation and the world.

Since 1950 the rate of growth in the four-state heart of Dixie — Alabama, Florida, Georgia and Mississippi — has outdistanced that of the nation, 98% to 58% in value added by manufacture . . . 61% to 44% in per capita income . . . 93% to 48% in bank deposits.

An abundant supply of electric power is a major element in this growth. In the ten-year period, 1950-1959, the investor-owned affiliates of The Southern Company have spent over one billion dollars for electric facilities. Continuing this program of expansion, these companies will invest another one-half billion dollars in the three-year period ending 1962.

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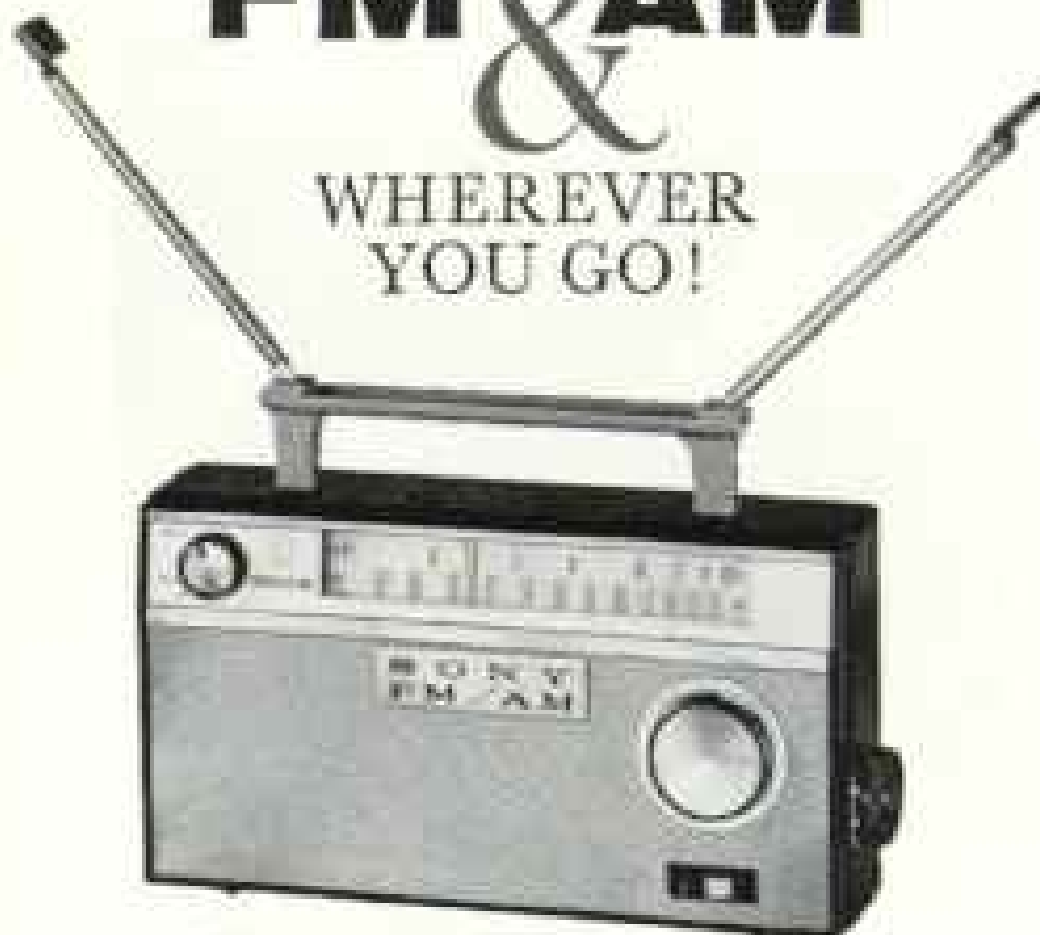


PRIZE SANTA GERTRUDIS BULL at Ruri-Mar Ranch near Lucedale, Mississippi, symbolizes the flourishing Southern cattle industry. The South's mild climate with year-round green pastures provide natural advantages to livestock farmers.

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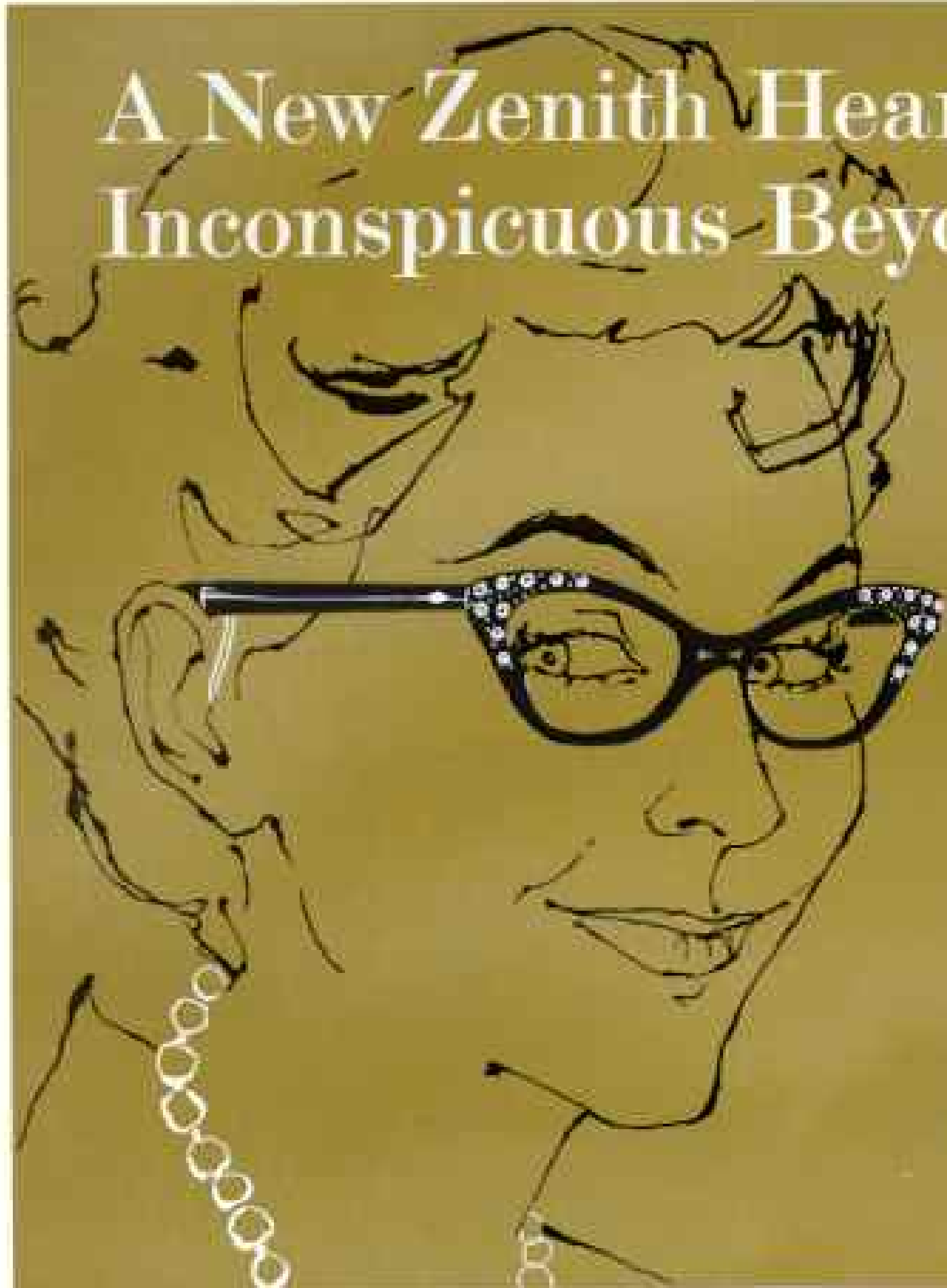
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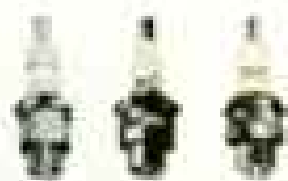


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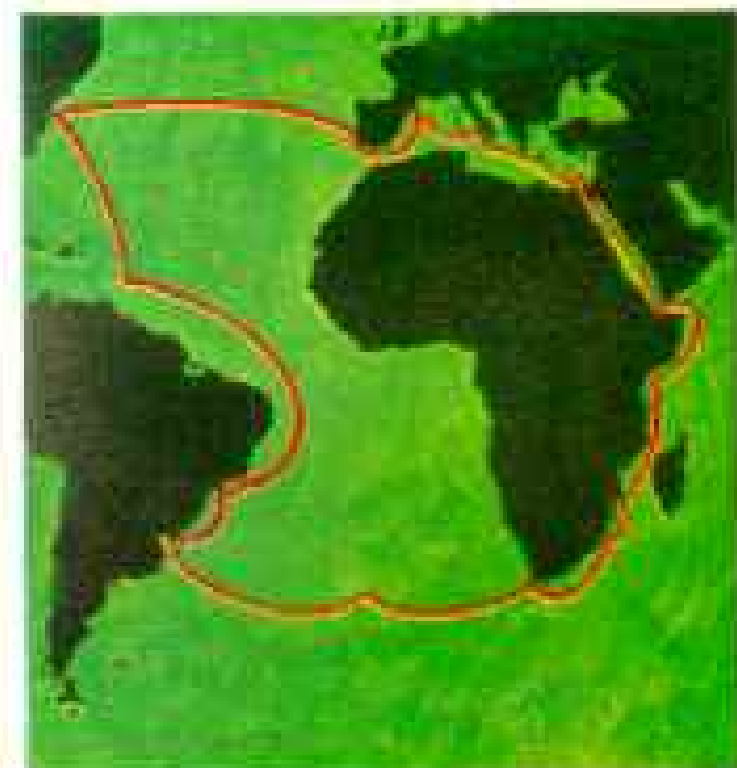
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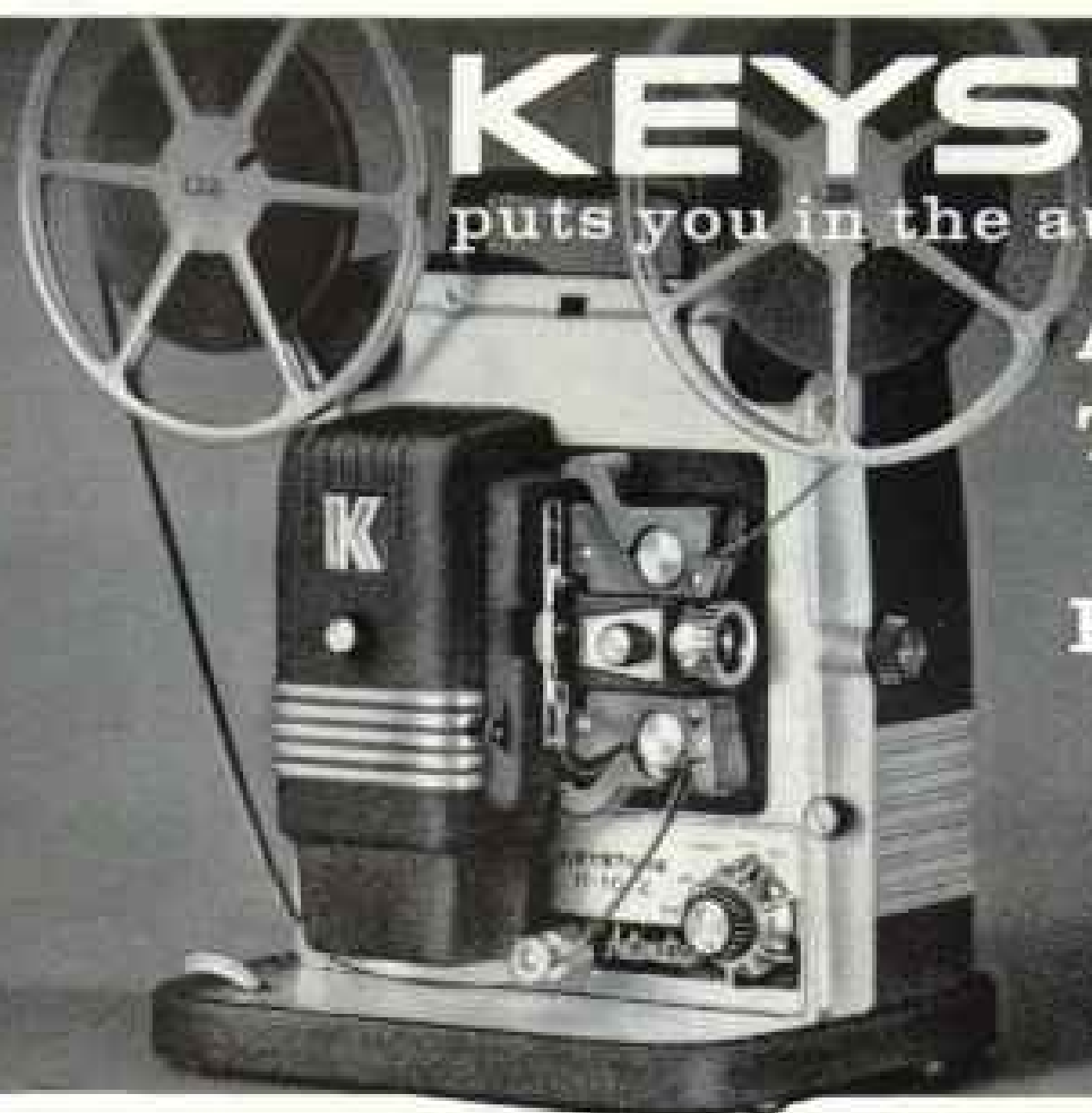
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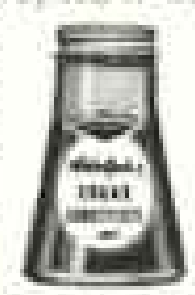


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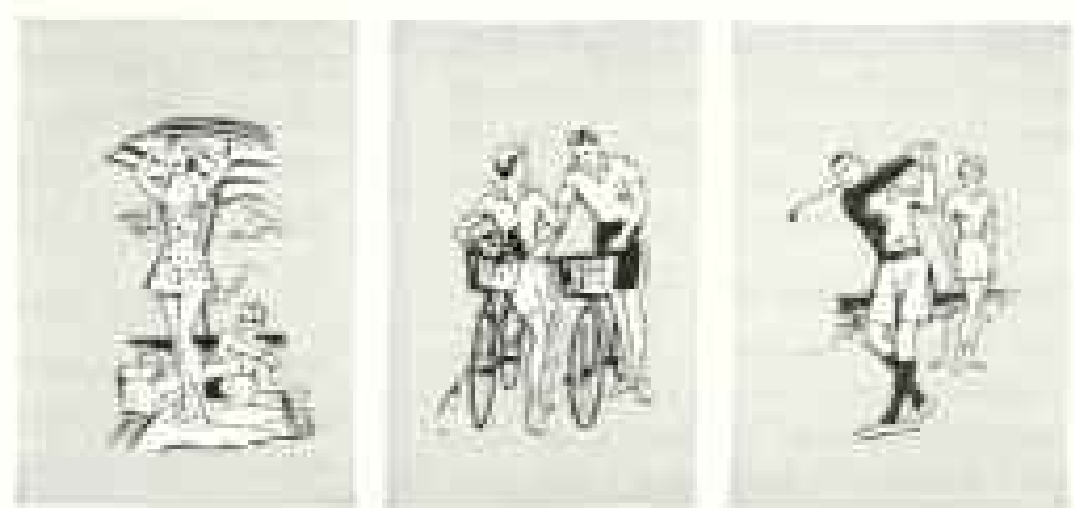
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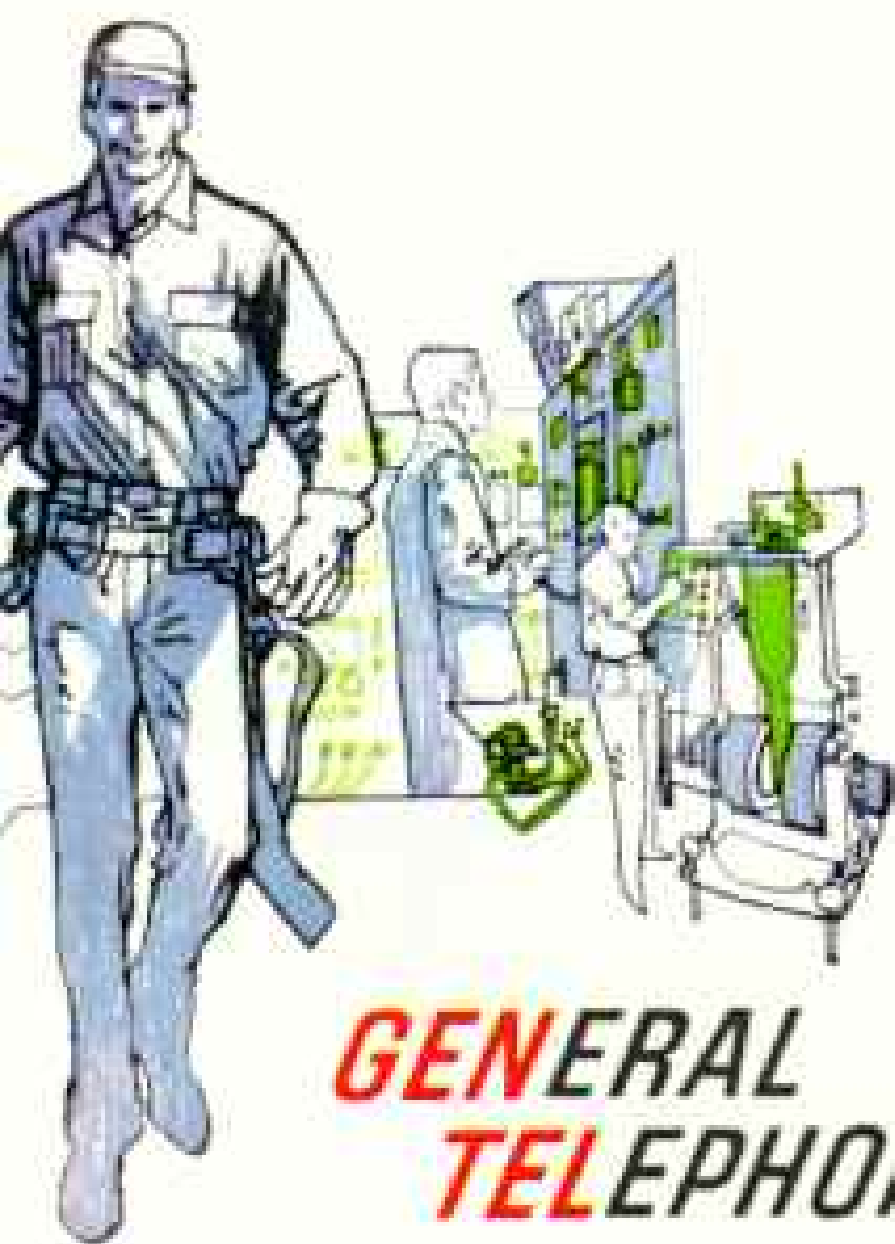
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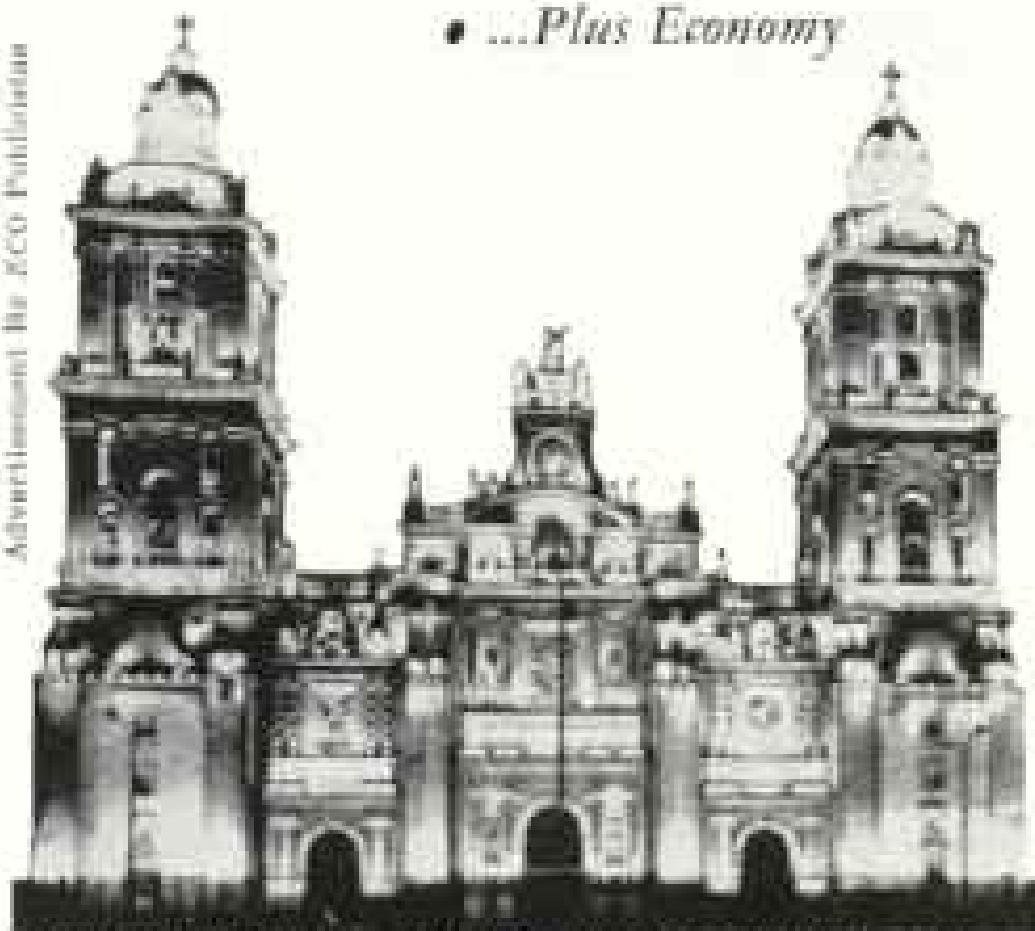
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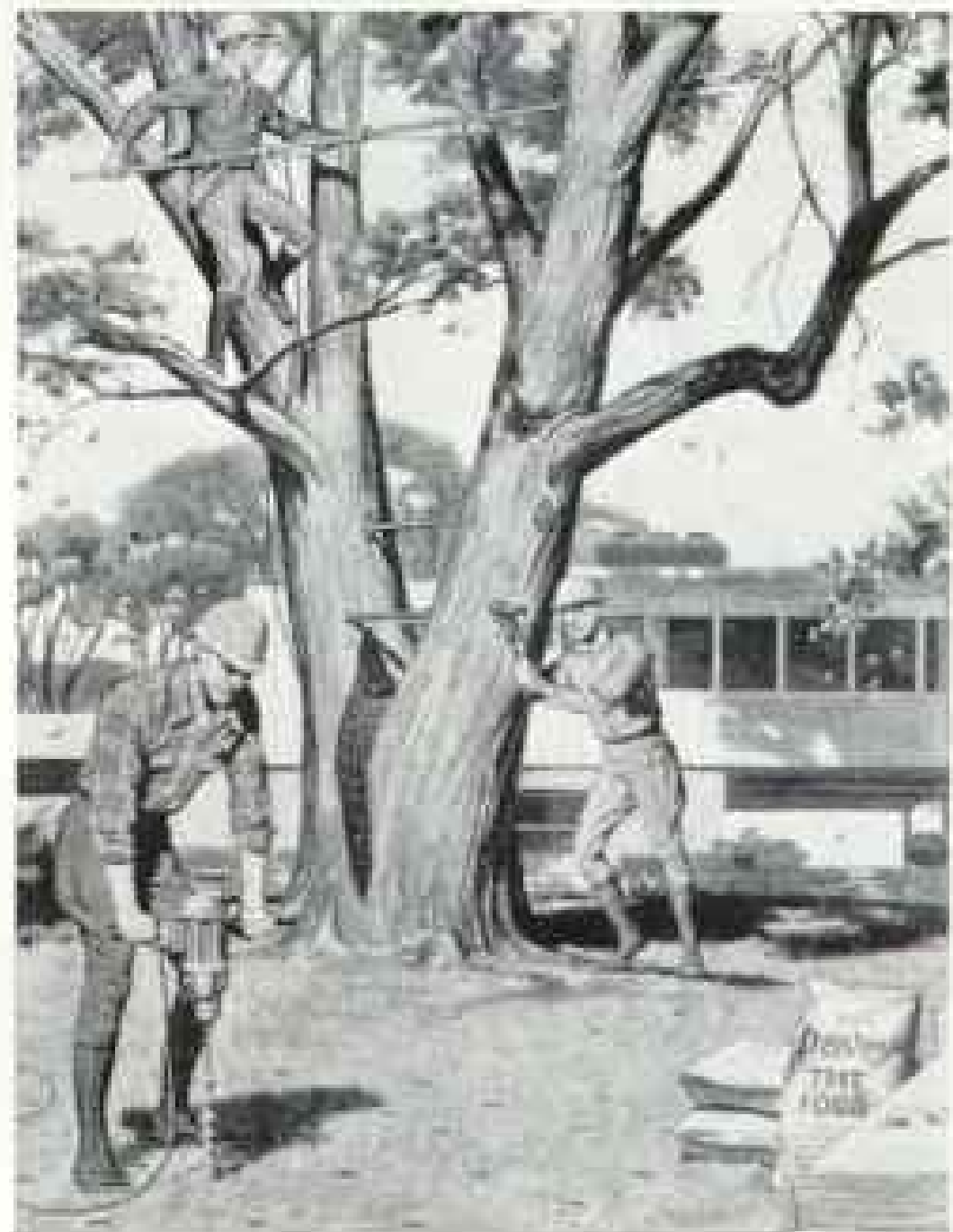
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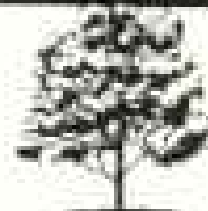
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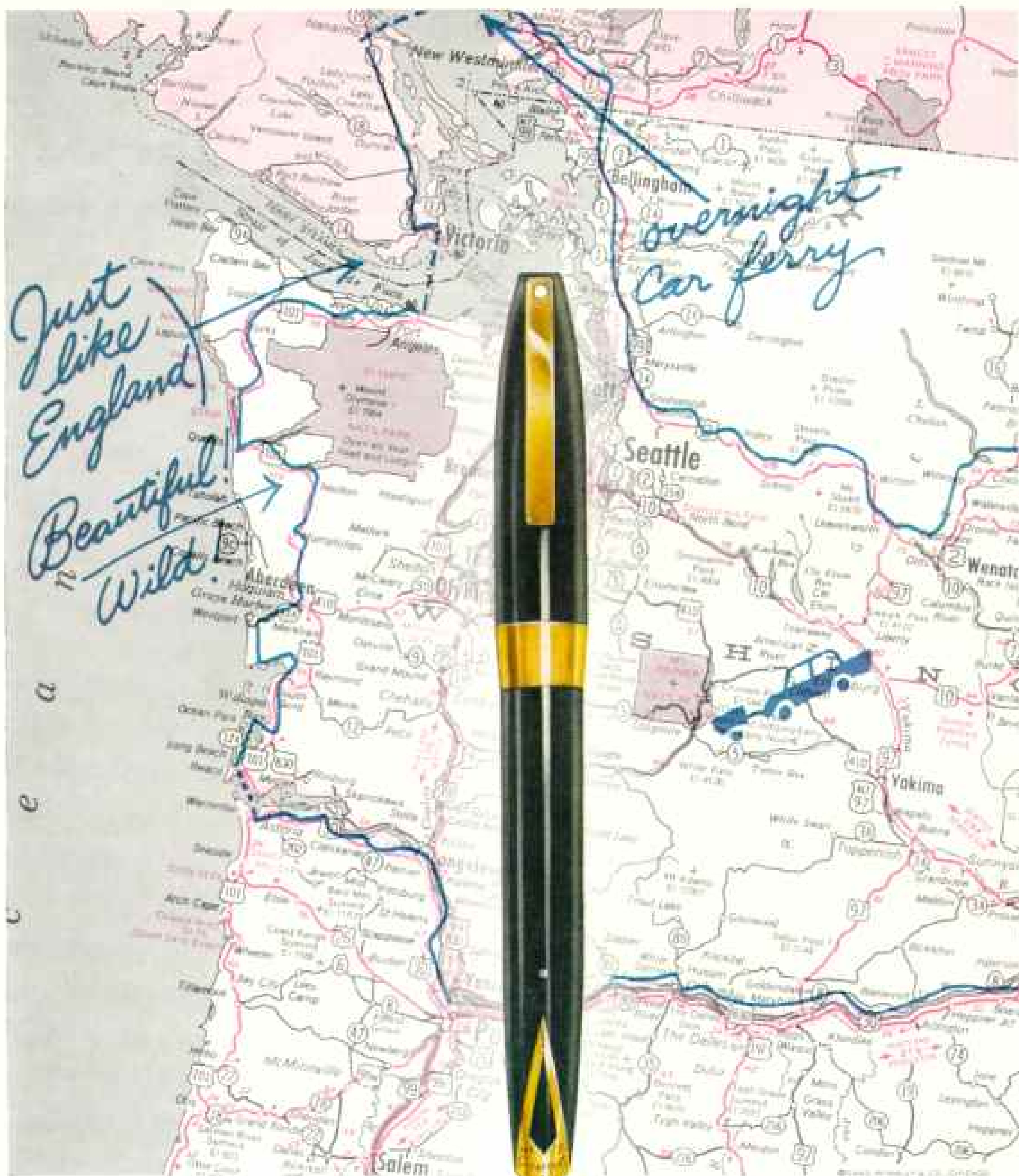
Serving the Gulf South Headquarters, Shreveport, La.

(Right) The snowy white sands of the Gulf of Mexico attract visitors by the thousands to historic Pensacola, on the northwest tip of Florida.

(Right below) Fabulous New Orleans, with its iron lace-work balconies, quiet courtyards and history-laden French Quarter, is a year-round vacation mecca.

(Left below) Drilling barge owned by United's producing subsidiary probes for new reserves of gas and oil off the Gulf coast of Louisiana.





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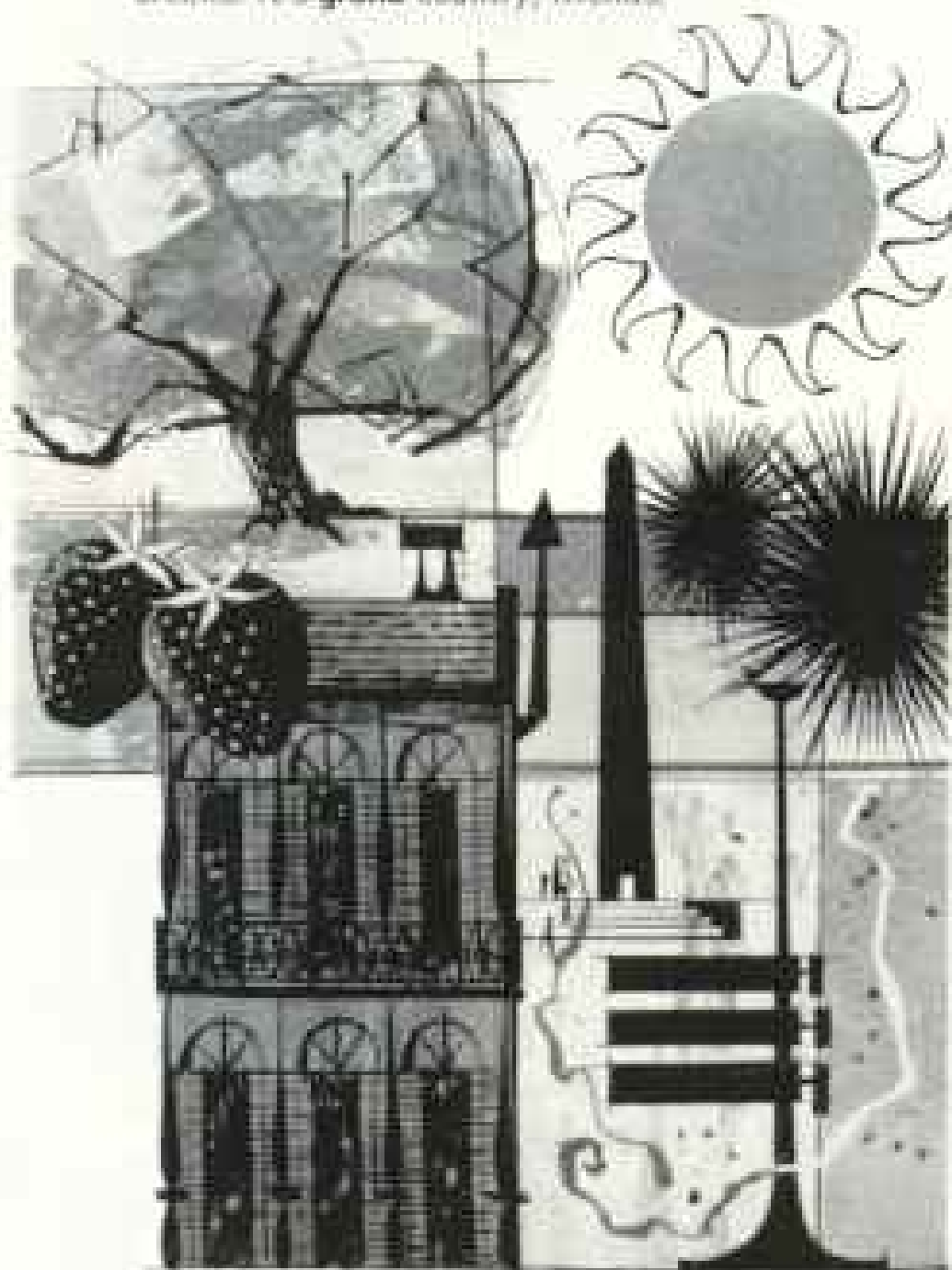
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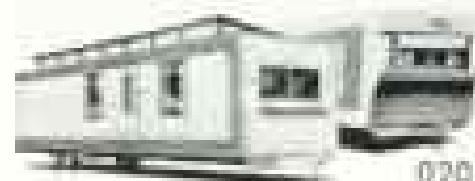


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There are many little traditions and kindnesses and habits that combine to make a marriage happy. We don't have to tell you what they are. You know.

We have found that happily married people seem to get great satisfaction out of selecting a family monument and cemetery lot while both partners are young and healthy. Like buying insurance, a house or a car, it is an important purchase they can make together.

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ing a monument ahead of time, each is sure that the right choice has been made as to material, size, design and price—a choice that the other approves of.

Then, too, each one is sure he has not delayed this purchase until the day when it must be made in grief and anguish by the one person in the world he is most anxious to spare.

It takes real maturity to face the facts of life and death and buy a monument before the need for it. But then, maturity is the most important ingredient in a happy marriage.

If you would like to know how to go about buying a monument now—while you are still together—see the Authorized Rock of Ages Dealer in your community (he's listed in the Yellow Pages) or write to us for a free copy of "Before The Need Arises . . ."—an informative booklet that discusses the matter in detail. No obligation in either case.

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information about

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for industrial
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Des Moines has one of the country's best public school systems as well as excellent cultural and recreational facilities.

The Rock Island has many choice industrial sites available in Des Moines and other Iowa cities. If the following information about Des Moines interests you, get in touch with us for more specific details. We'll work with you in strictest confidence.

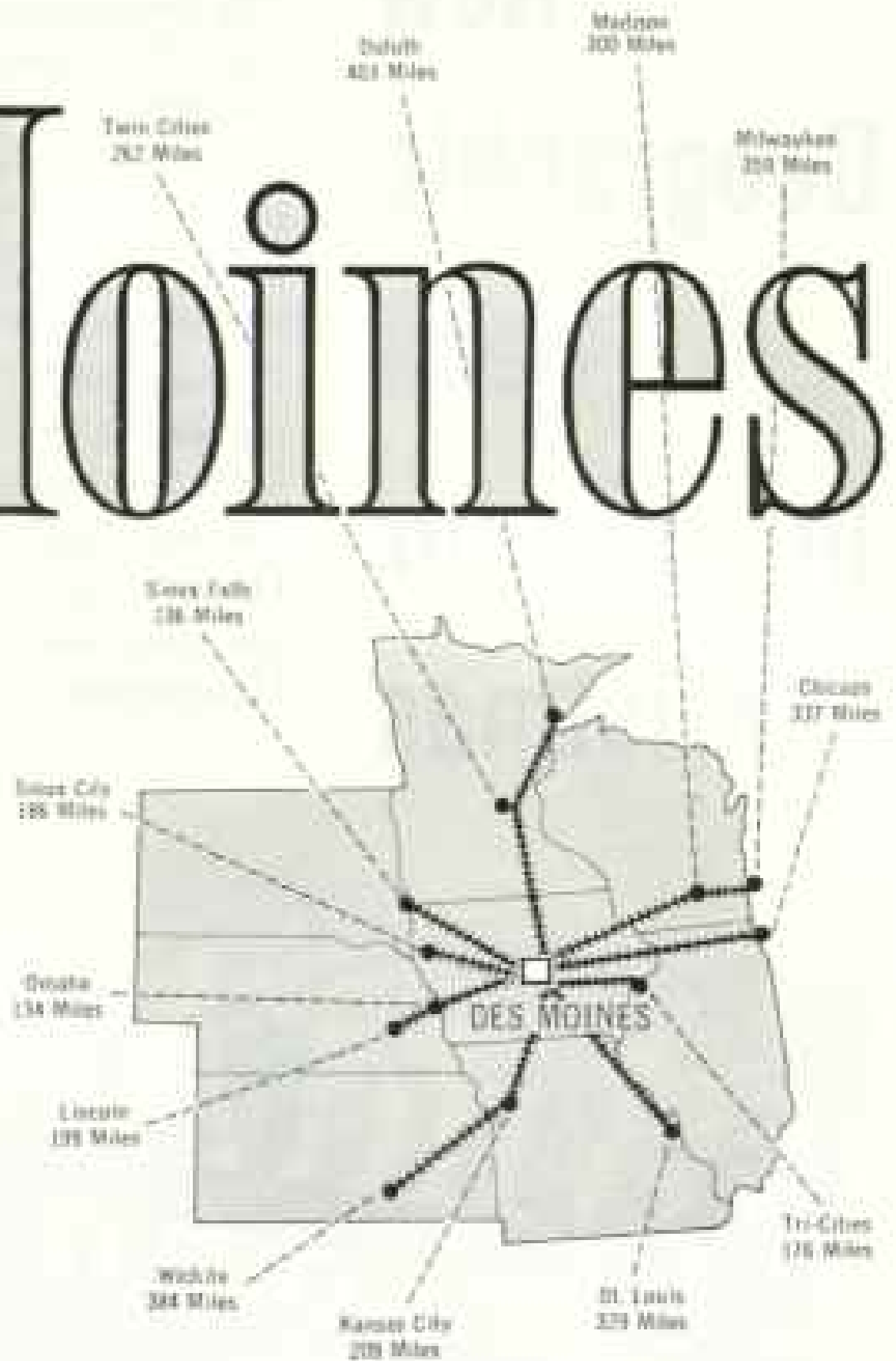
LABOR: Skilled stable labor force of approximately 100,000 available in Polk County; increase in employment of 10,300 in 8 years; average education 11.4 years.

POWER: Two main electric generating plants with a capability of 360,000 KW per day; unlimited supply of natural gas; pipeline capacity of 72,300 bbl of fuel oil per hour.

TRANSPORTATION: The Rock Island and 9 other railroads; 40 interstate truck lines; 45 local truckers; 3 airlines with 83 in-and-out flights daily; 4 bus lines.

HOUSING: 16,533 new housing starts in nine years ('51-'59); four attractive residential suburbs within a six mile radius of downtown; average sale property value is \$14,459; monthly rentals average \$15 per room unfurnished; Des Moines is engaged in a very aggressive Urban Renewal Program involving a total of 662 acres.

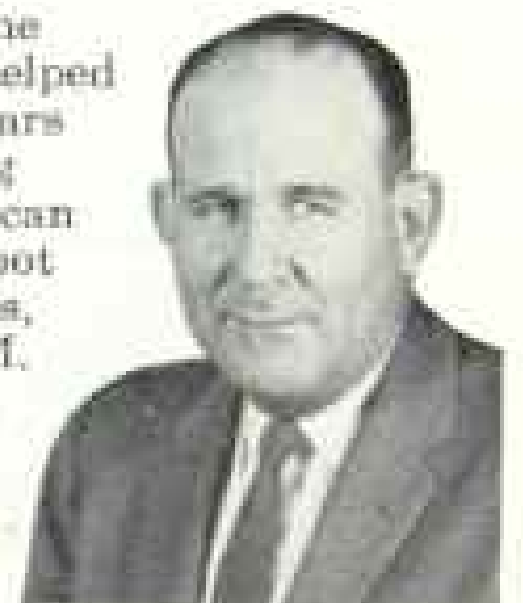
THE COMMUNITY: 70 elementary and high schools with an average of 29.5 students per classroom; Drake University and Grand View College, as well as several commercial colleges giving complete courses in business training; 56 parks and community centers; 12 hospitals staffed by 443 doctors; annual budget of \$17½ million for welfare; lovely art center; good community theater program; city auditorium which presents many fine entertainment and athletic events.



COMMERCIAL SERVICES: 51 classifications of industry with 361 manufacturers, 550 distributors and wholesalers; 19 contractors for new plant construction; exceptionally wide diversification of commercial activity.

CLIMATE: Average mean temperature is 49.8°; average monthly rainfall 2.64" (31.68" average annual rainfall).

The man who knows Des Moines industrial sites like the back of his hand is B. M. Schwartz, Rock Island General Freight Agent. Mr. Schwartz and his staff are typical of Rock Island specialized personnel who, during the past three years, have helped locate over a billion dollars of private industry along Rock Island tracks. He can help you find just the spot you need. For full details, write, wire or phone B. M. Schwartz, 5th and Vine, Des Moines, Iowa, or Industrial Department 152, Rock Island Lines, Chicago 5.



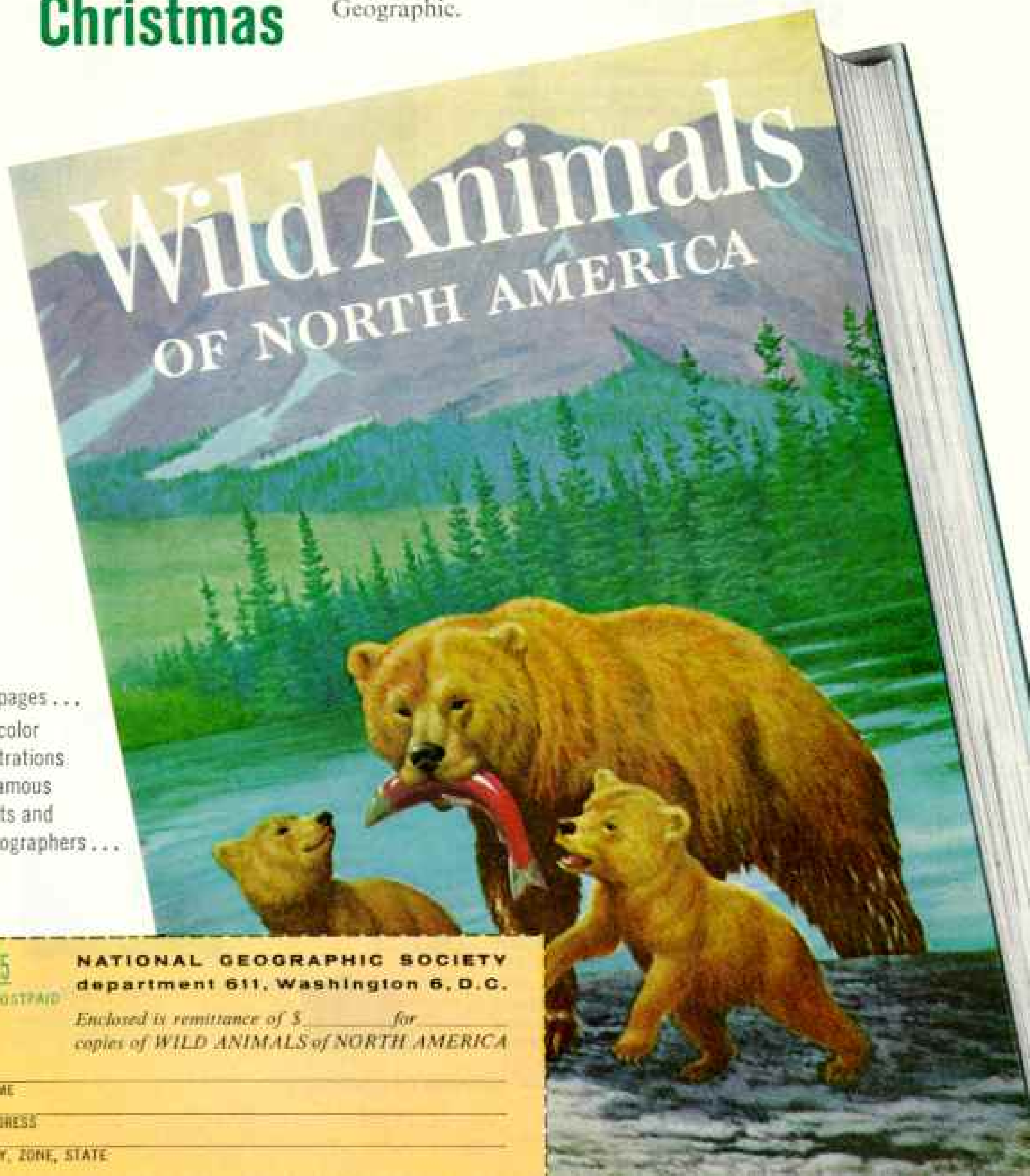
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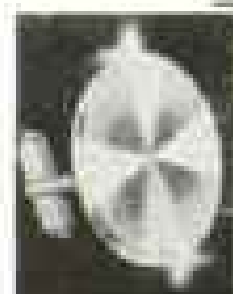
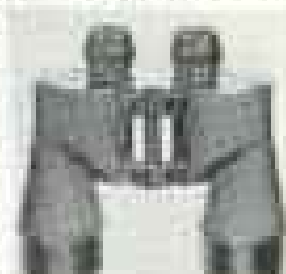
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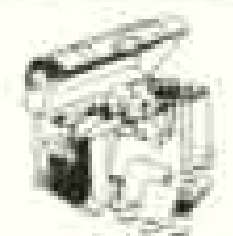
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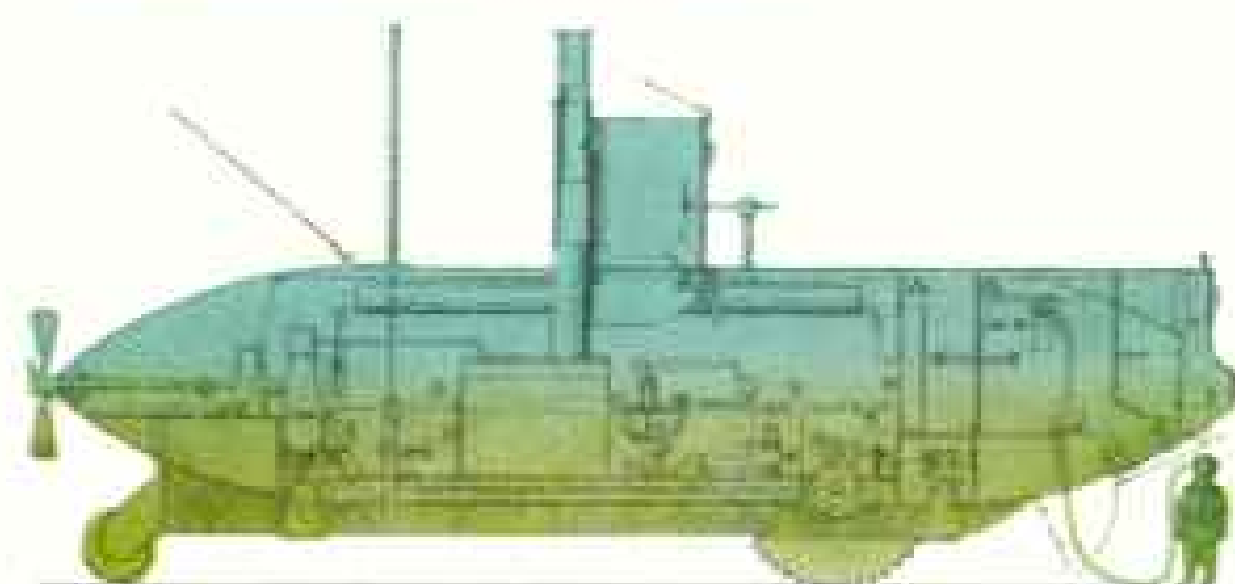
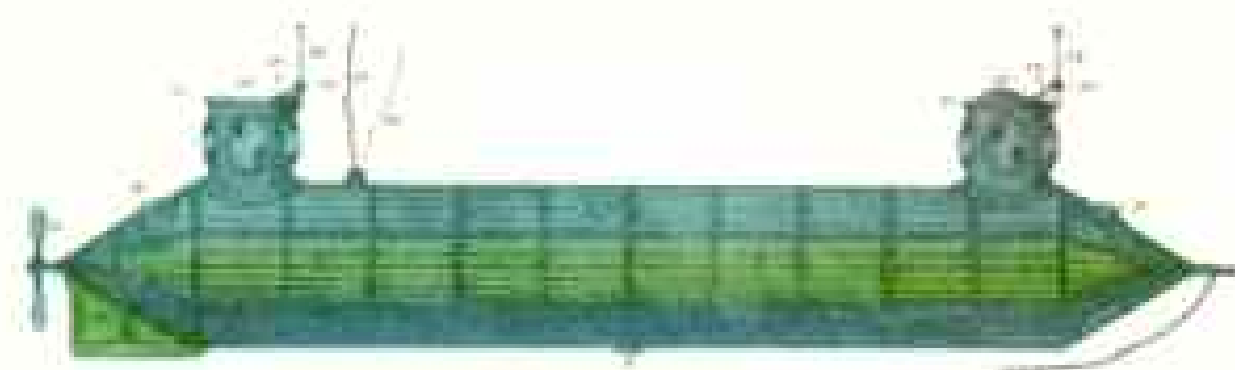
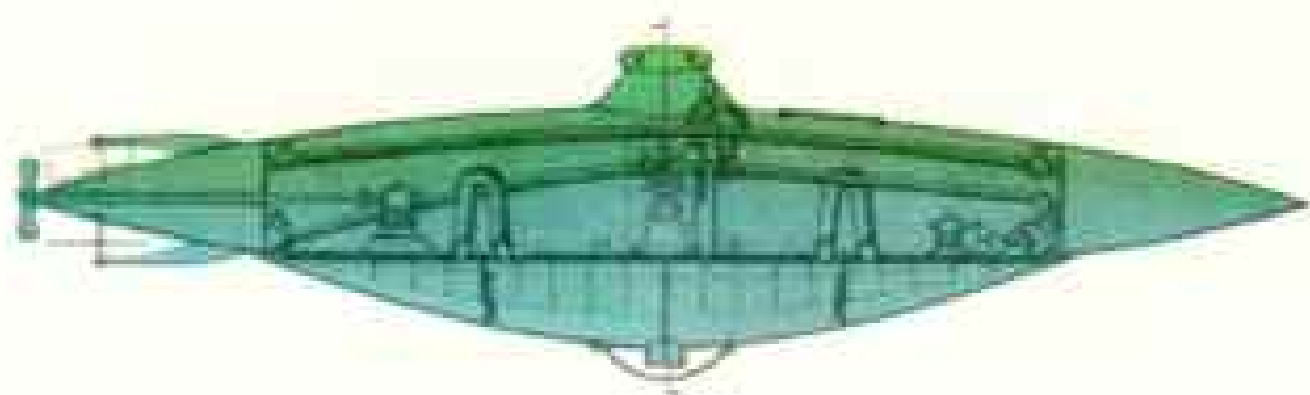
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