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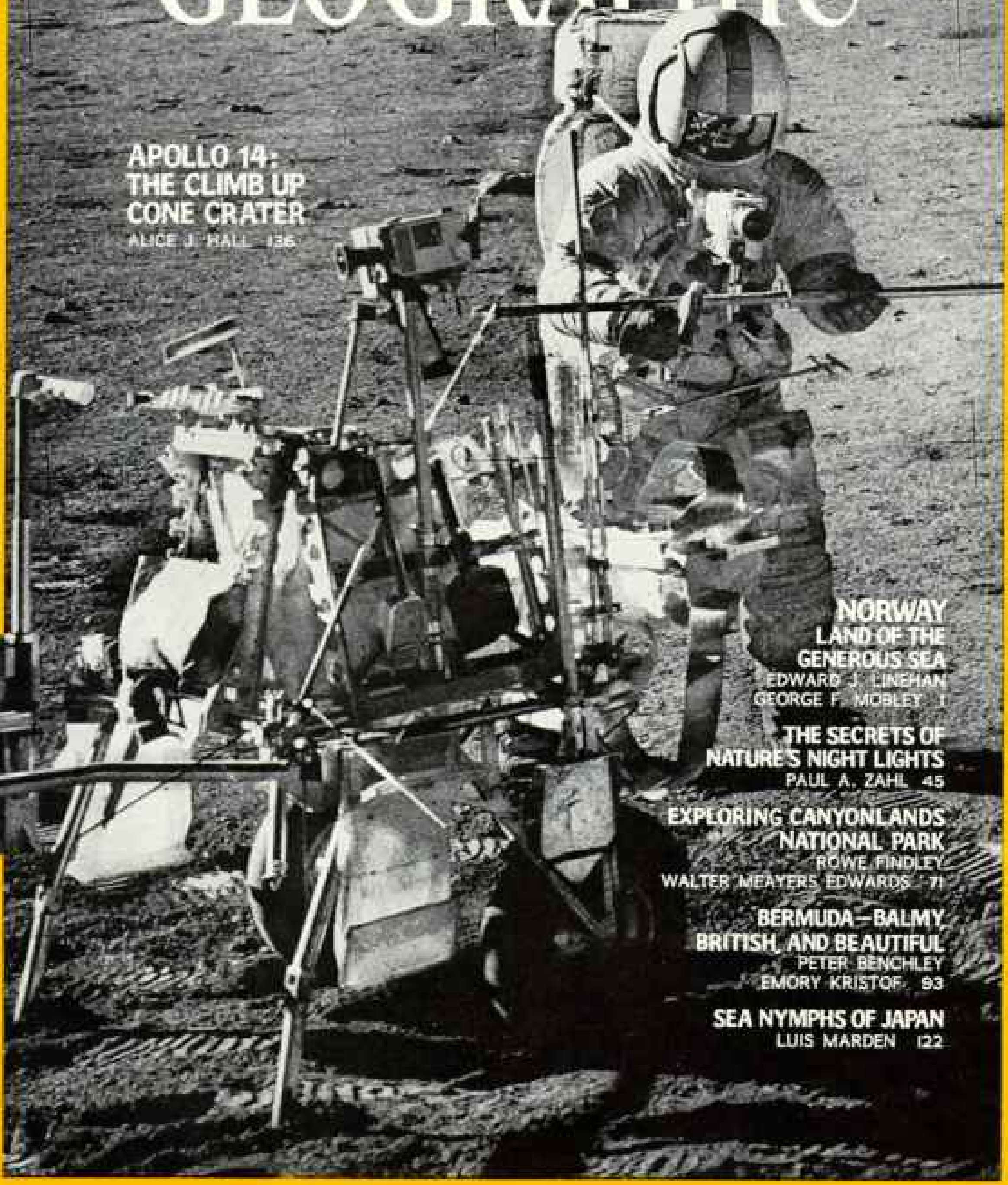
NATIONAL GEOGRAPHIC



OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY WASHINGTON, D.C.

COVER: Astronaut Alan B. Shepard, Jr., assembles a core tube to sample moon soil (pages 136-48). NASA

POSTMASTER: SEND CHANGE OF ADDRESS FORM 3579 AND UNDELIVERED COPIES TO NATIONAL GEOGRAPHIC MAGAZINE, 17TH AND M STS. N.W., WASHINGTON, D.C. 20036

The gift that costs $12 an ounce

It's the Parker 75 Classic Ball Pen. In solid sterling silver. Yet so slim and so carefully made it weighs just an ounce.

But what an ounce! It includes an ink supply that lasts and lasts and lasts. It will write better months longer—three times longer than the ordinary ballpoint.

That ounce includes a ball tip that writes cleanly from the start, and puts down a crisp track at less than four ounces of pressure.

That ounce can be had with five distinctive point styles: broad, medium, fine, extra-fine and even extra-extra-fine. This feature makes the 75 Classic an especially thoughtful gift; the pen can be custom-fit to match the recipient's own personal writing style.

And that ounce is guaranteed against defects in material or workmanship for the owner's lifetime or Parker will repair or replace it—free.

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Unless it's an ounce of perfection. The Parker 75 Classic Ball Pen.

PARKER

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The sterling silver Parker 75 Classic Ball Pen is $12. With matching Cartridge Pencil, $24. A memorable gift for personal or business friends. Other fine Parker pens to own or give, from the $1.98 Jotter Ball Pen to the $150 Parker 75 Presidential Pen.

VEGA KAMMBACK. IT'S A WAGON AND THEN SOME.

The Vega Kammback wagon is three things. It's a Vega. It's a Kammback. And it's a wagon.

Let's start backwards. As you can see by the wagon-like shape, the Vega Kammback is a wagon. The back end lifts up. The back seat folds down. And while it's no giant, it'll easily hold plenty of groceries and rose bushes and antiques and cub scouts.

But the Vega Kammback wagon is more. It's a Kammback.

Kammback is not just another fancy word. It refers to the aerodynamic shape of our little wagon. A shape that contributes meaningfully to both the stability and the handling of the Kammback.

Which means you may feel the desire to forget the rose bushes and the cub scouts and just go for a ride. Just for the fun of it.

Our clincher: the Vega Kammback wagon is also very much a Vega. So without even asking, you'll get an overhead-cam aluminum engine, front disc brakes, front bucket seats and lots lots more.

The Vega Kammback wagon. It's a lot more than you bargained for.

GM

MARK OF EXCELLENCE

Buckle your seat and shoulder belts.
It's an idea you can live with.

VEGA

CHEVROLET

Ten years in an astronaut's life

DETAIL IMAGES FROM NASA AND (YELLOW LEFT) BY JON SCHNEEBERGER

NASA'S "OLD MAN" AT 47, Alan B. Shepard, Jr., has twice soared beyond earth's atmosphere. In 1961 he rocketed to fame on America's first manned venture into space—the 15-minute flight of *Freedom 7* (**upper left**). A ticker-tape parade and NASA's Distinguished Service Medal greeted his return.

Ten years later he commanded Apollo 14 on man's first visit to the lunar uplands (**above** and page 136). A world made nonchalant by earlier landings rated this one as it might an eclipse—awesome, but not unique.

NATIONAL GEOGRAPHIC will continue to chronicle milestones in space. Invite your friends to enjoy such high adventure; nominate them for membership below.

Good news about bumpers.

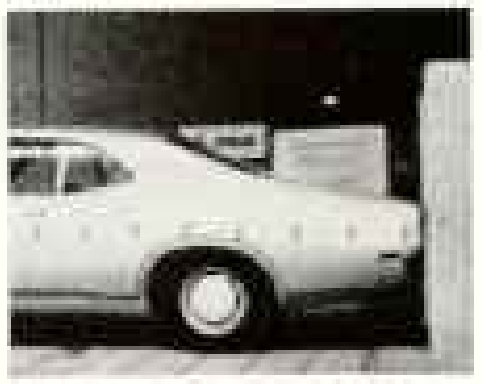
All 1973 model cars will have better bumpers, to comply with a new Federal standard.

Allstate will cut collision insurance rates 10% on cars that meet this new standard.

The U.S. Department of Transportation recently issued a standard that requires all 1973 cars to have bumpers that can take a five mile an hour front-end crash and 2½ mile an hour rear-end crash into a test barrier without damage to safety systems. Safety systems include such items as lights, cooling systems, hood latches, fuel lines. This is a fine step forward. To recognize this progress—and help hold down the cost of auto insurance—Allstate initially will give a 10% discount on collision insurance on cars that meet the new standard.

5 mph front end damage $331

Insurance Institute for Highway Safety conducted tests on 1971 U.S. standard sedans. Front end crashes at 5 miles an hour averaged $331.



5 mph rear end damage $329

Same tests revealed average damage in 5 mph rear end crashes was almost the same—$328. (IIHS photos.)

But, even better bumpers are needed. So here's what we continue to offer: Allstate will cut collision insurance rates 20% for any car the manufacturer certifies, through independent tests, can take a five mile an hour crash into a test barrier, *front and rear*, without any damage. For some time we have made this offer, and we will continue to make it . . . for we will continue to be concerned about the big cost of little bumps.

Allstate®

Let's make driving a good thing again.

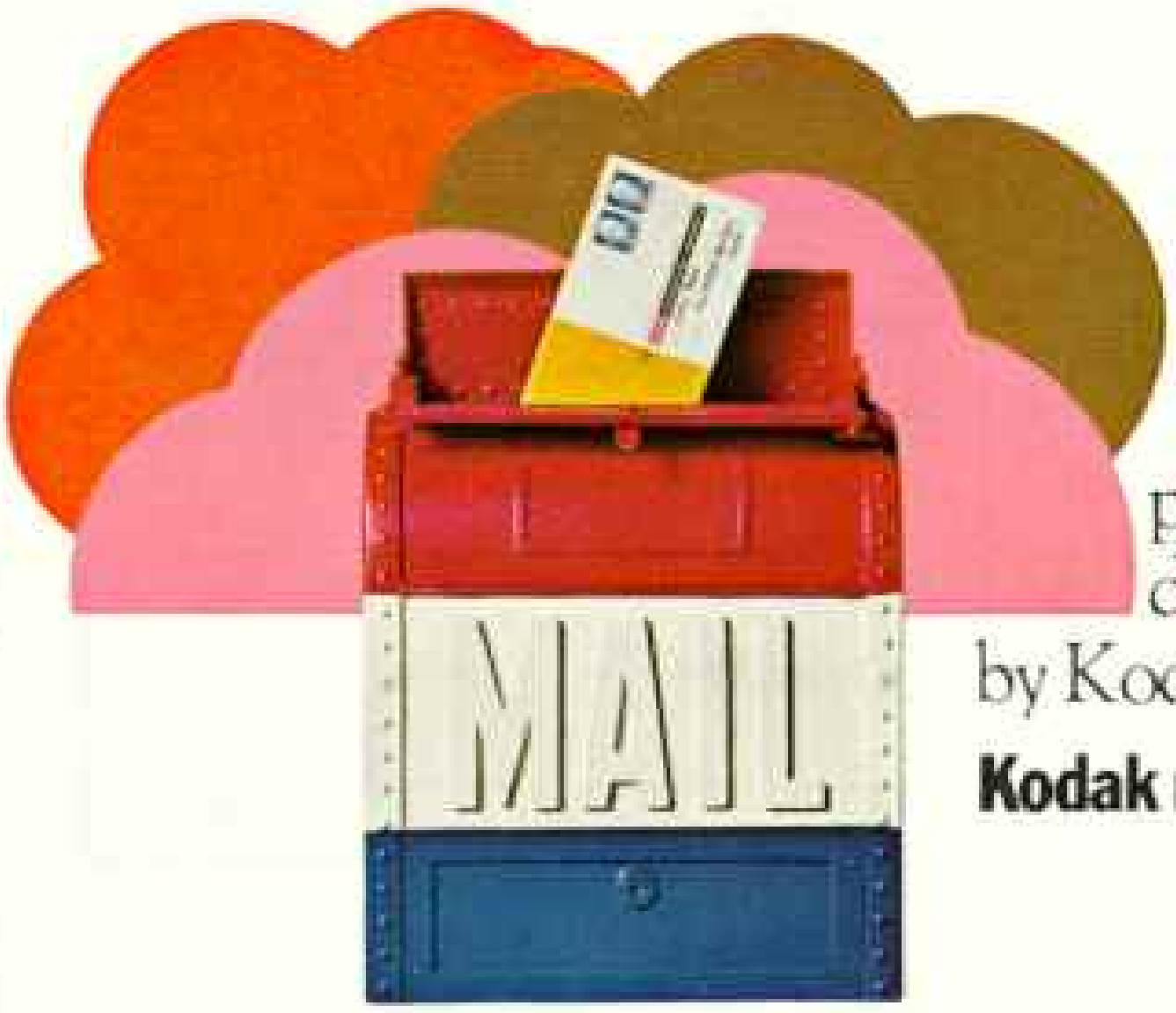
In a few states where rates are standard, discounts cannot apply.

Traveler's Aid

Kodak Prepaid Processing Mailers

1 Why carry exposed film around?
Get a *Kodak* Prepaid Processing Mailer, instead.

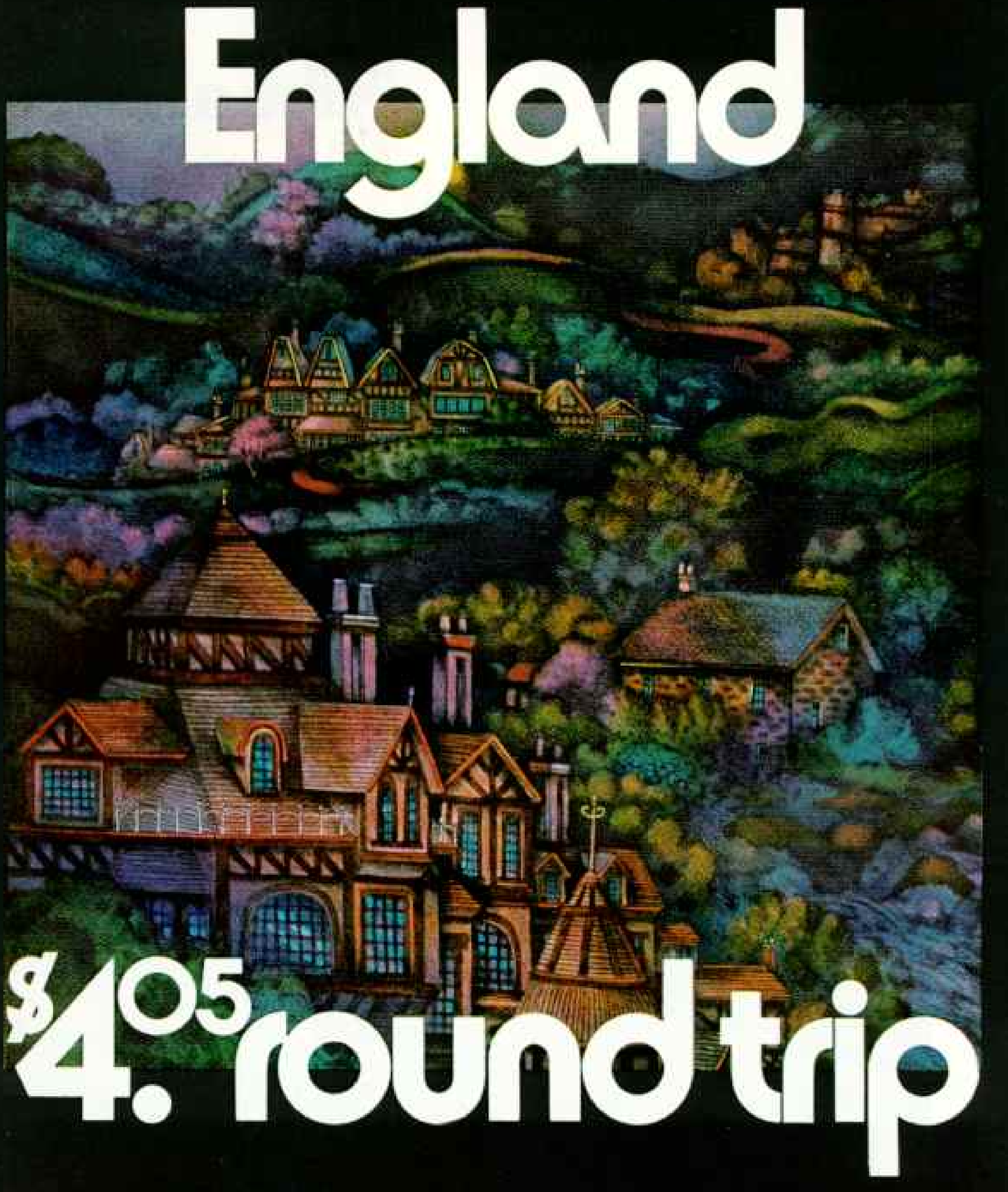
2 There's a Mailer for Kodak color film—for prints, slides, or movies. Just slip your exposed film into the Mailer and mail it to us.



3 We develop your Kodak color film and mail your pictures back to you. Your film deserves quality processing by Kodak—and this way, it gets it.

Kodak makes your pictures count.

Kodak



When you have the urge to cross the pond for business or pleasure, but can't get away, keep a stiff upper lip and call.

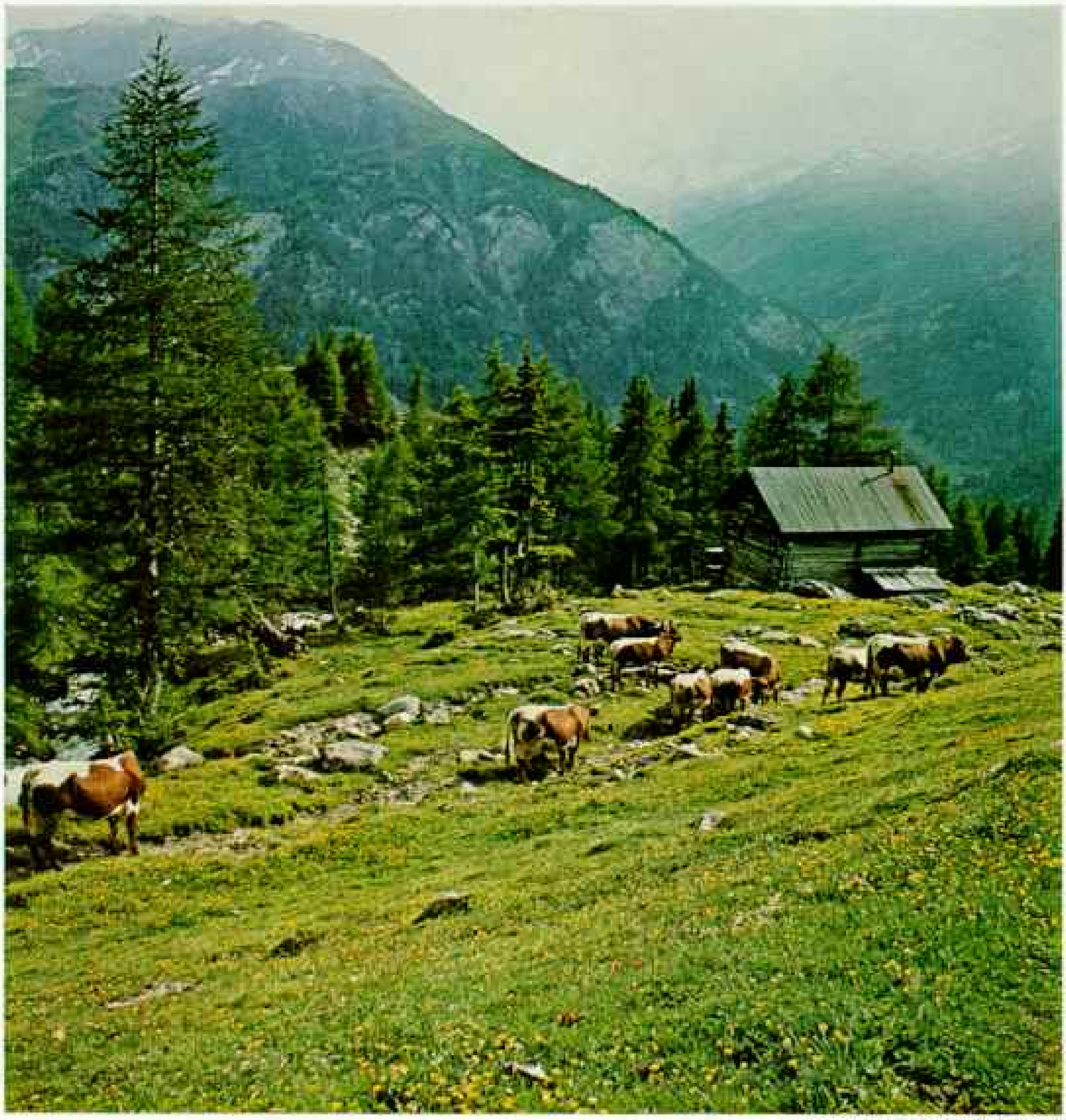
It's easy—just telephone, and you'll be there in no time.

$4.05 plus tax is all it costs for a three-minute station-to-station call between 5 p.m. and 5 a.m., Monday thru Saturday and all day Sunday.

$5.40 plus tax is all you pay for calls between 5 a.m. and 5 p.m., Monday thru Saturday.

So, telephone. It's the cheapest way out of the country.

The almost



The pipeline runs through the lovely Grossglockner Pass. The cows don't know it. Nor would you.

invisible pipeline.

In rocky terrain, the pipe is laid on a cushion of sand to protect it from jagged projections.

It runs for 289 miles. It cost $210 million. Even now it is pumping over twenty-five million gallons of crude oil a day across the Alps. And you scarcely notice it.

The pipeline burrows its way through thirteen miles of alpine tunnels. It snakes underground through valleys and along mountainsides. Excavation scars have been smoothed and healed. Flowers and grass grow above it. And farmers plow across it as if nothing had happened.

The Hahnenkamm Tunnel is a detour specially built to avoid the ski resort of Kitzbühel.

What might have been an ugly varicose vein across the landscape is now an almost invisible artery, quietly feeding energy to the expanding industries of Austria and Southern Germany.

When Jersey and twelve other oil companies first faced the challenge of pumping oil from the Adriatic to Central Europe, it seemed an almost impossible task. Consider the problems.

The governments of three countries had to agree before the project could get started. One hundred and fifty-four roads, twenty-six railroads, thirty major river barriers and three mountain ranges had to be crossed. Forty thousand 40-foot sections of pipe had to be welded. And the oil had to be pumped as high as five thousand feet. Thirty times higher than Niagara.

Stretching 289 miles, over mountains and under rivers, the pipeline brings energy to the heart of Europe.

To get things going, Trieste had to be turned into a deep-water port to receive giant tankers. Rights-of-way had to be negotiated with thousands of individual landowners. Fifty major contracts of half-a-million dollars or more had to be worked out. And forty companies were involved in construction.

Italians, Austrians, Germans, Frenchmen, Dutchmen, Englishmen and Americans all got behind the project. And all helped to build it.

When the costs were added up, it turned out to be the largest single private investment in Europe.

But what impresses us most has nothing to do with money. In our view, the transalpine pipeline is a remarkable example of how different governments, different people and different businesses can get together. Settle their differences. Solve their mutual problems. And get a huge job done without unduly disturbing the good things of earth.

The experience has taught us a lot.

Standard Oil Company
(New Jersey)

Esso

A-T-O.
Champions know us.
And so do boys.

If they don't know us as A-T-O, they know us for sure as Rawlings and Adirondack. Because we make a big percentage of their gloves, bats, shoes, baseballs and uniforms. In fact, we make a full line of quality equipment, for just about every sport played, tailored to the needs of everyone from beginner through seasoned pro. A-T-O is also known by more than twenty other names outside the sports world. Each name, from American LaFrance to Ward Hydraulics, is synonymous with excellence, "the finest in the field." ATO

Norman Rockwell

For a 12 x 18 print, suitable for framing, of this Norman Rockwell painting of Brooks Robinson, MVP of the '70 World Series, send name, address, zip code and check or money order for $1.00 to: A-T-O Inc., P.O. Box 710, Willoughby, Ohio 44094. (Full color 25 x 38 poster available at $2.00).

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NATIONAL GEOGRAPHIC

July 1971

NORWAY

Land of the Generous Sea

By EDWARD J. LINEHAN
ASSISTANT EDITOR

Photographs by GEORGE F. MOBLEY
NATIONAL GEOGRAPHIC PHOTOGRAPHER

WOOLEN SKY, PEWTER SEA. Somewhere above the overcast an Arctic sun circled ceaselessly, denying us earth's primal pulsebeat, day and night. It was a time of no time, an endless silver-gray dimension I had come to measure only by the space between meals and shuffling changes of the watch.

Stolidly, *Star III* steamed toward the coast of Norway, a hundred miles east. For a time I relieved the bearded helmsman on the old whale catcher's exposed bridge. He stomped against the chill and crooned tunelessly:

"*Midnattssol, o midnattssol. . . .*"

Midnight sun. Ashore others would be singing, celebrating Midsummer's Eve with beer and bonfires amid the fjords from North Cape to Lindesnes in the south. Norwegians savor the pale nights of June, as if to store up cheer against the gloom of next December.

I swung the wheel a couple of spokes. *Star III* listed wearily, burdened with a 63-foot whale lashed alongside by its great gray flukes. The glistening carcass, quivering in the bow wash as if alive, seemed determined to tug the ship off her course for Tromsø. There, at the last whaling station left in Norway, flensers waited with long pole knives for this 60 tons of prime whale meat and oil-rich blubber. A week's hunt in the Norwegian Sea had given *Star III* a fin whale worth 60,000 kroner—about $8,600.

The helmsman finished his coffee, lit a pipe, and took the wheel again.

"How much longer can it last?" I asked. "How many more seasons of whaling?"

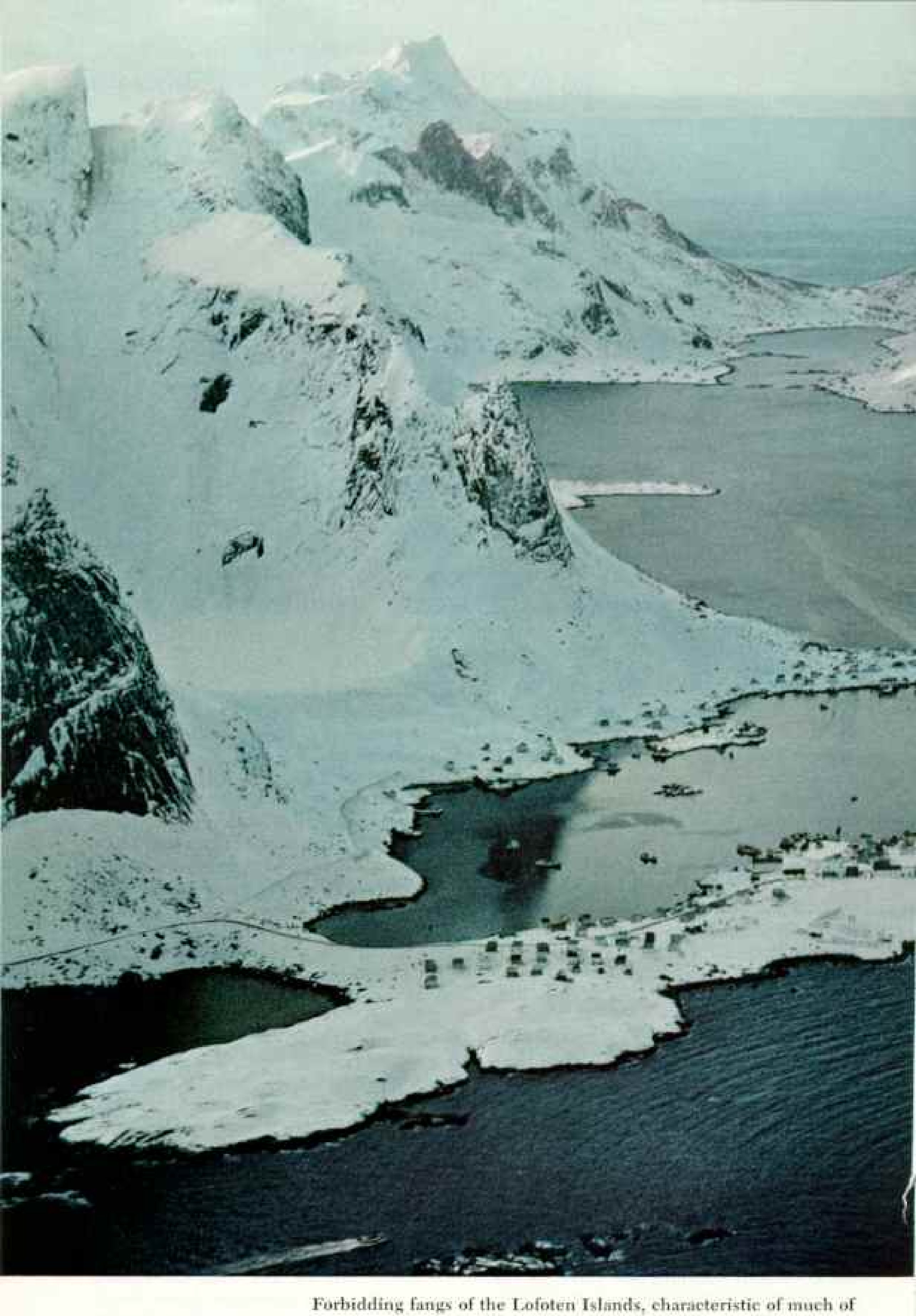
"Not long now, I think. Every year fewer whales," he replied. Like the rust-stained ship, he had weathered more than twenty seasons in Antarctic waters, before that distant chase ceased to be profitable for Norway.

"We should stop anyway, before we kill them all," he added, and fixed me with an earnest blue-eyed gaze. "The sea is good to us. Do you understand?"

I UNDERSTOOD. The sea has always been good to Norway, and Norwegians have always respected it for that. "What would we be without the sea?" another sailor had once said to me. "Just a handful of people on a pile of rock."

And now that I have finished weeks of roaming Norway in summer daylight and winter dark, I have to agree. But, I must add, what an admirable, handsome handful of people! What a starkly beautiful pile of rock!

Consider first the land: long, lute-shaped, strung with snowy mountain chains, deeply fretted with majestic fjords. Three-fourths



Forbidding fangs of the Lofoten Islands, characteristic of much of

ROSCHROME © NATIONAL GEOGRAPHIC SOCIETY

rugged Norway, guard a fishing hamlet shivering within the Arctic Circle.

is rocky slope or vast *vidde*—bleak plateau—or lake or glacial ice. Forests cloak nearly a fourth in conifers and birch; scarcely 4 percent is flat and fertile enough to take the plow. In length Norway spans 1,100 miles, more than a third of it above the Arctic Circle; yet across its bony throat, from fjord's end to Swedish frontier, the country is less than four miles wide (map, pages 10-11).

So deeply does the sea insinuate that it carves a coastline almost as long as Australia's and strews 150,000 islands along the shore. Little wonder that 80 percent of Norway's 3.9 million people live less than a dozen miles from salt water.

"The land divides us; the sea unites," Norwegians have said for centuries, knowing how sharply geography has shaped their nation and themselves.

Land barriers long kept the country broken into petty kingdoms. Land hunger sent Norsemen *viking*—plundering—and colonizing far corners of Europe and North America a thousand years ago.* And today farmers from remote mountain and fjordside homesteads are leaving the land for swelling industries in Oslo and Bergen, Kristiansand and Stavanger.

BRASS BANDS and a great parade had heralded my own arrival in Oslo, Norway's unpretentious seat of government, cultural capital, and largest industrial center and port. It was Constitution Day, May 17, the anniversary of Norway's proclaimed independence in 1814 after nearly four centuries of Danish rule (following pages).

Every last one of the capital's nearly half-million inhabitants seemed to be lining Karl Johansgate, Oslo's abbreviated version of Fifth Avenue or the Champs Elysées. A blizzard of red-white-and-blue flags fluttered as school children by the thousands marched toward Slottsparken—the Palace Park—for benevolent royal review. Many teen-agers wore scarlet caps and joked and pranced in ragged ranks like half-broken colts; they were the *russ*, students anticipating a traditional month of merriment and hijinks now that their secondary schooling was almost over.

"It is like a happy children's crusade, *ikke sant*—is it not so?" An elderly spectator beside me at the curb had taken me, correctly, for an American. "Look at them," he said with an almost paternal pride. "No soldiers, no guns. No old war veterans with sour faces. Just children!"

It was so, and fittingly. For all of Norse antiquity, the modern nation is one of Europe's youngest, born in 1905. (After the break from Denmark, it took 91 years more to shake off union with Sweden.) And the most reserved Norwegian observes the national birthday with a young and unabashed fervor.

My curbside comrade ("Larsen," he said simply) acquainted me with the street vendors' *varme pølser*—slim tender hot dogs slathered with mustard and ketchup. As we munched our way along the greening Studenterlunden—Students' Grove—near Oslo University, he outlined methodically what every visitor to the capital must see.

In time I saw them all: The thousand-year-old Viking ships, sweetly curved, eggshell thin, redolent of violence and glory. *Kon-Tiki*, the cumbersome balsa raft that conquered half the Pacific. The sturdy sailing vessel *Fram*, that carried Fridtjof Nansen north toward one Pole and Roald Amundsen south to the other. All these, I reflected—Norway's most famous relics—were things of the sea.

There were others, of course: the brooding medieval Akershus Castle; Holmenkollen ski jump, poised like a great broken fishhook in the hills above the city (page 13); the art and folk museums (pages 8-9 and 42). And the incredible life's work of sculptor Gustav Vigeland—75 acres of controversial unclad bronze and granite statuary in Frogner Park.

Most often I found myself drawn to the waterfront near the Rådhus—the Town Hall—to watch the interweaving wakes of ferries, freighters, workboats, and yachts. Osloites

*Their tale is told in "The Vikings," by Howard LaFay, NATIONAL GEOGRAPHIC, April 1970.

Generations without a gap: Camping on a busy sidewalk, a skylarking student wins a friendly word from a more senior citizen in Bergen, tourist hub for Norway's fjords. Red cap identifies the girl as a *russ*, a secondary-school senior awaiting final exams. Each May the russ launch a month of fun and foolishness that the rest of the populace good-naturedly accepts in a land remarkably free of social tensions.

Parades—and pranks! Crowds line the way as school bands blare along Oslo's Karl Johansgate on May 17—anniversary of the signing of Norway's constitution in 1814. The capital's procession heads for the Royal Palace and review by Norway's popular king (page 15).

Constitution Day triggers antics of the russ. Manning a "cherry-picker" crane (**above**), they place a red cap on a statue of 19th-century patriot-poet Henrik Wergeland. Oslo school symbols emblazon tasseled caps and a student's back (**right**).


BRØDRENE
HALLÉN
NOMOTUNE
Schous

stroll there too, and from them I learned to buy a bag of delicious pink shrimp, caught a few hours before and cooked on deck, from one of the stubby little trawlers at the dock.

Once, as I sat shelling and eating, a sandy-haired businessman leaned his briefcase against a bollard and settled down to enjoy his own shrimp and ships. "*Goddag*," he said, and we exchanged introductions gravely. He was Per Johansen, accountant.

"It is good to feel the sun," he said, and made a satisfied sound. "You know, in winter sometimes we Norwegians become unhappy. The days are so short and the sky is gray, and we grow angry over little things. *Værsyk*, we call it—'weather sick.' But always the spring sun cures us."

We admired the trim three-masted cadet training ship *Christian Radich* moored nearby, and watched the passenger liner *Bergensfjord* ease into drydock for repainting.

"That is our pride," Herr Johansen said. "Our ships. We never even see most of them—they are always sailing between foreign ports. But we know that every one of them is first class, the best."

Norwegian pride is understandable. Their merchant fleet of some 1,400 ocean-going vessels totals nearly 20 million gross tons—much of it in new supertankers—and ranks fourth in the world, behind Liberia (a flag-of-convenience country), Japan, and Great Britain. Reckoned on a per-person basis, Norwegian ship tonnage is fifty times that of the United States.

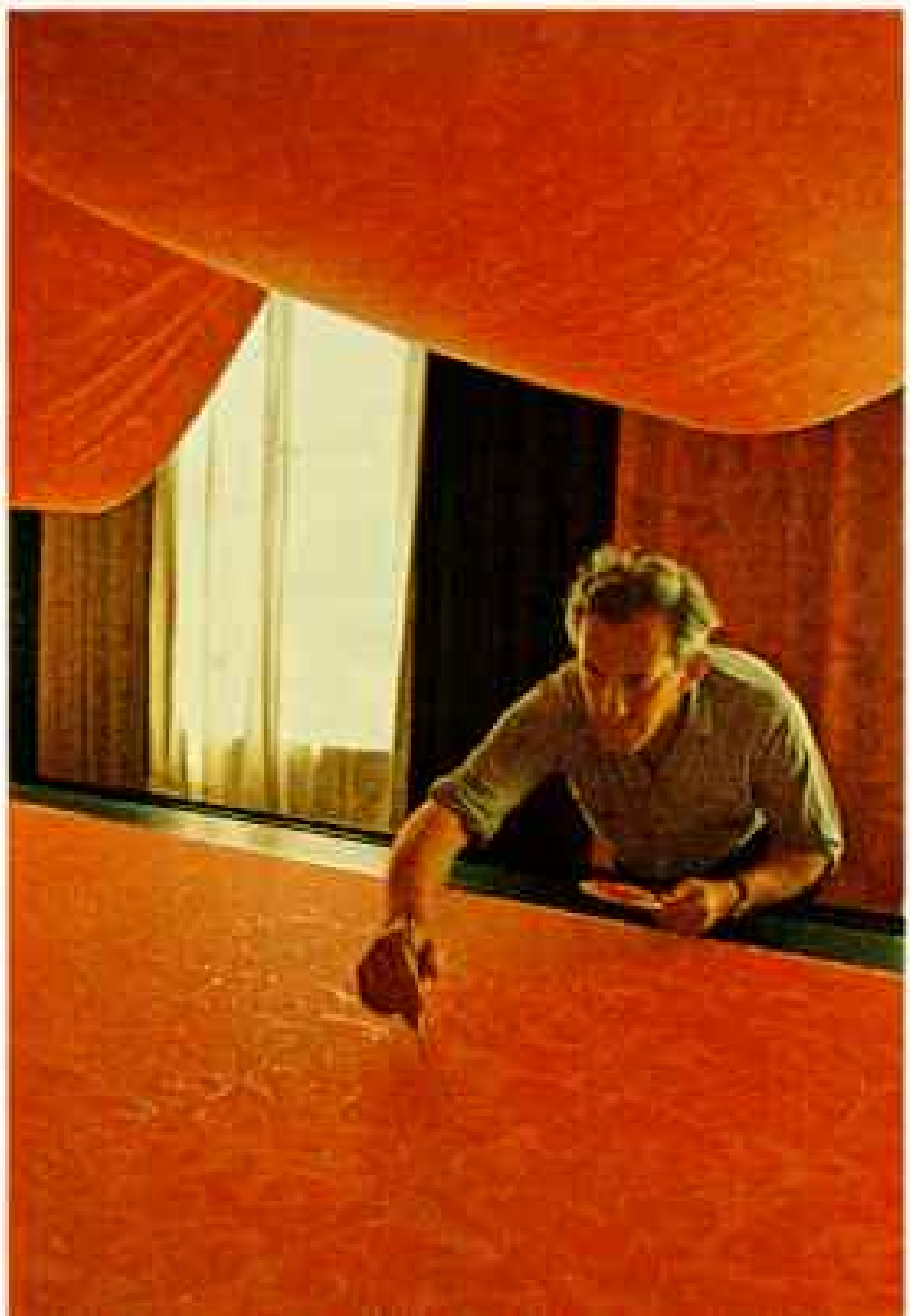
How does Norway do it? I visited the offices

EKTACHROME (LOWER RIGHT) AND KODACHROMES © N.G.S.

"You look while I mosey around." A toddler finds romping room in Oslo's Henie-Onstad Art Center, an avant-garde museum endowed by the late skating star Sonja Henie and her husband.

Hue of the midnight sun glows in a gown created by PLUS, a colony of craftsmen in Fredrikstad. In the medieval town's workshops, visitors can watch artisans ply trades ranging from pewter-casting to bookbinding.

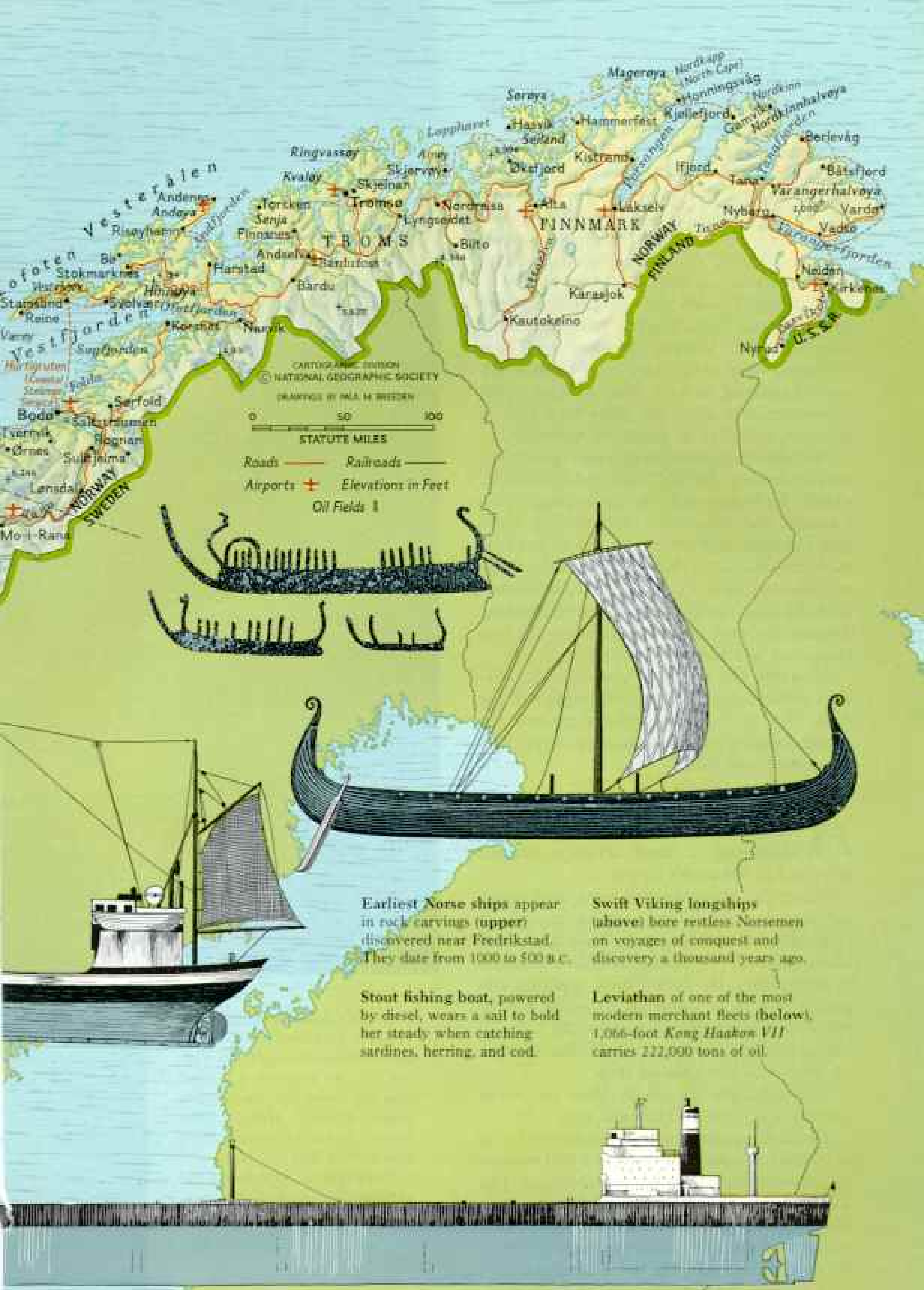
Final flourishes by hand embellish a pattern printed by textile worker Arne Østensvik of PLUS. The colony takes its name from a plus-sign trademark.



NORWAY

FJORD-FRETTED COAST and rugged interior have turned Norwegians toward the sea since prehistoric times. Less than 4 percent of the nation's land is tillable, while the country's merchant fleet ranks as the world's fourth largest. Warm ocean currents keep much of Norway's climate mild, despite latitudes equal to Alaska's. Temperature in Oslo seldom drops below 10° F. Slightly larger than the British Isles, Norway has only a fifteenth of Britain's population.

AREA: 125,053 square miles. **GOVERNMENT:** Constitutional monarchy. **POPULATION:** 3.9 million. **RELIGION:** Evangelical Lutheran (state church). **LANGUAGE:** Two forms of Norwegian official. **ECONOMY:** Industry and mining employs 27 percent of work force; commerce and shipping, 20 percent; agriculture, fishing, and forestry, 13 percent; remainder in public administration, services, and construction. **CITIES:** Oslo (capital), 487,000; Trondheim, 126,200; Bergen, 115,600; Stavanger, 87,600; Kristiansand, 56,200.



Earliest Norse ships appear in rock carvings (**upper**) discovered near Fredrikstad. They date from 1000 to 500 B.C.

Swift Viking longships (**above**) bore restless Norsemen on voyages of conquest and discovery a thousand years ago.

Stout fishing boat, powered by diesel, wears a sail to hold her steady when catching sardines, herring, and cod.

Leviathan of one of the most modern merchant fleets (**below**). *1,066-foot Konig Haakon VII* carries 232,000 tons of oil.

of the Norwegian Shipowners' Association, overlooking Oslo harbor, and asked one of its directors, Mr. David Vikøren.

"We have to rely on skill and know-how," he replied. "We are always trying to anticipate new markets and trade routes, and find new ways to carry cargo more cheaply. When our older ships can no longer compete, we sell them and build better ones. Right now half our tonnage is less than five years old."

To compete with the world's subsidized and low-wage fleets, Norway must constantly innovate, Mr. Vikøren stressed over our *smørbrød*—the ubiquitous open-faced sandwich. Lunching at their desks enables Oslo's businessmen to leave the office by 4 p.m. in summer, with five or six daylit hours left.

"We concentrate on tailor-making ships for specific trades," he said. He cited Norwegian vessels built especially to carry paper from Canada; auto transports with folding decks that can ship Volkswagens one way and coal the other; the LASH (lighter-aboard-ship) vessel that can pick up loaded barges in New Orleans and relaunch them in Rotterdam. Among the most important now are the OBO ships—oil and bulk-ore carriers.

"Tankers are one-way vessels," Mr. Vikøren pointed out. "They travel empty half the time. But an OBO can voyage around the world, picking up oil here, coal there, iron ore somewhere else."

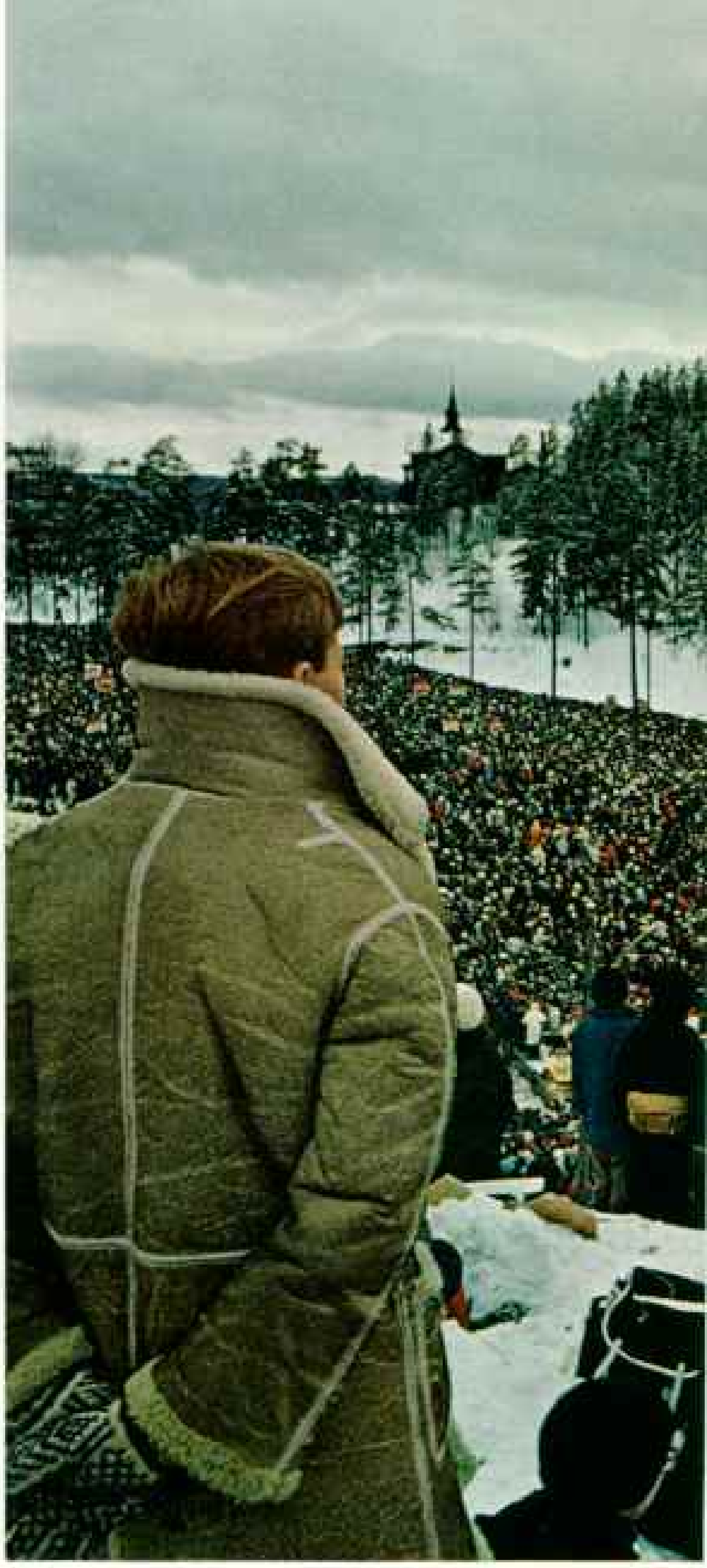
A FEW DAYS LATER in a pasture near Larvik, where the Oslofjord meets the Skagerrak, I came across a curious echo of Mr. Vikøren's theme.

"Since the Stone Age we have used boats, we have needed boats, and we have been rather good at building boats," said Arne Emil Christensen, Jr., a curator of Oslo's Museum of Antiquities. He pulled back a plastic tarpaulin in a rectangular pit, exposing a jackstraw scattering of oak planks the color of strong tea—the remains of a Viking-age vessel known as the Klåstad ship.

"We estimate she dates from the ninth century A.D.," the archeologist said.

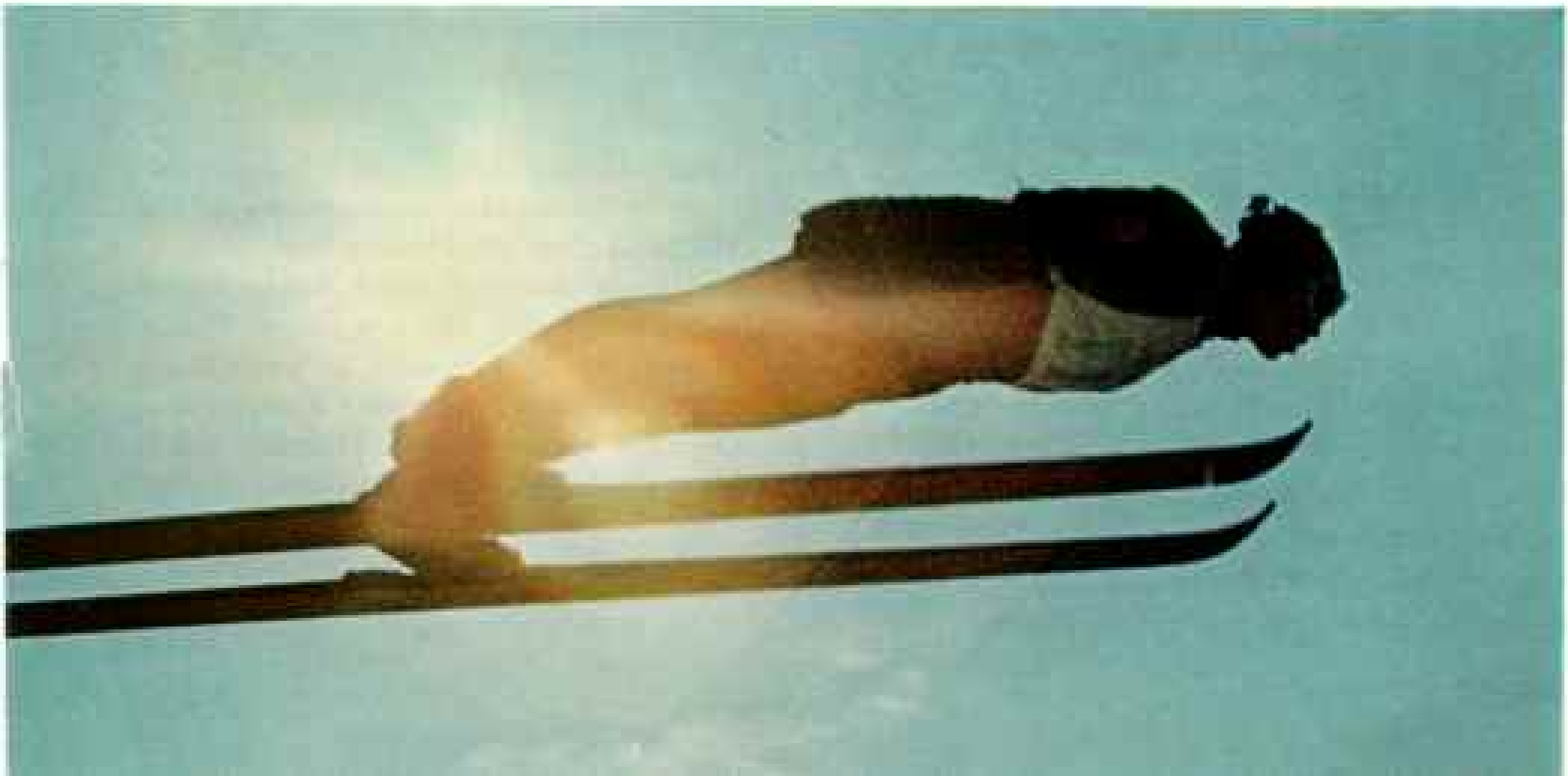
The hulk appears to be a merchantman, 60 to 70 feet long, probably wrecked and washed ashore here more than ten centuries ago. The Klåstad ship has yielded few artifacts; even her iron rivets have corroded to mere black stains. But enough timbers remain to reconstruct a classic vessel of the Viking era.

"I suppose we have the only drive-in excavation in Norway," Mr. Christensen said



Norway's national sport lures 100,000 avid fans to Holmenkollen ski jump near Oslo. Visible only as a speck, a jumper touches down on the landing slope. Another (**right**) shows perfect form on a soaring flight that carries him 250 feet.

Norwegians introduced the exhilarating sport of ski jumping to the world a century ago.



"Even the local bus stops here to let the passengers watch us dig."

I headed my rental car toward Sørlandet—the Southland—a region as lovely as it sounds when spoken in the melodic Norwegian tongue. In summer this coastal strip is suffused with warmth and the faint aura of forgotten grandeur.

Quiet towns like Lillesand, Mandal, and Farsund, with their narrow, crooked streets and white-painted houses, seem still to reflect clouds of canvas, for these Lilliputian ports bustled during the age of sail. Here, too, impulsive young rivers tumble to the sea, and thousands of skerries—rocky islets—shelter tranquil coves and beaches.

A Foreign Office spokesman in Oslo told me that the rural population of the south coast is shrinking, and indeed I passed a few boarded-up farmhouses along the way. But the powerful Norse longing for sun and scenery won't let Sørlandet sleep; vacation huts abound, and campers' colorful tents spring up like wild flowers.

To assure everyone access to an unspoiled coast, a law prohibits new buildings within 100 meters of the shore. By tradition, campers and hikers roam freely over unfenced farms and private lands; few abuse the privilege.

I was surprised, on a Sunday afternoon in Sørlandet, by the number of picnic parties I passed near the edge of the road; they could easily have chosen more pleasant and secluded spots. When I mentioned it later to a Norwegian friend, he laughed.

"It wouldn't do to boast," he said, "but one can't help it if others see the family's brand-new car as they lunch beside the road!"

Curving around the southern bulge of Norway and up the western coast, the road led me to Stavanger, the fourth largest city (after Oslo, Trondheim, and Bergen).

"Think of it, 80,000 people and only two *Vinmonopol*—state liquor stores," said Mr. Erling Herstad, a lifelong resident who offered to show me around Stavanger. "You should see the queues before Christmas!"

We drove a short way out of town to a windy knoll above a broad bay that opens on the sea. This was Hafrsfjorden, where a crucial page of Norse history was written.

Here, about A.D. 900, Harald Fairhair engaged other Viking chieftains in a climactic sea battle. A *skald* sang of "the wolf-coated warriors howling, and the irons clattering." When the wild death sounds had stilled, Harald had, for the first time, united all Norway.

Looking before he leaps, a youngster vies in an Oslo jumping competition. Donning skis almost as soon as they can walk, Norwegians traditionally excel in the jump and in cross-country treks.

Sports-loving king, center, congratulates the victor of a cross-country race at Holmenkollen. As a young man, Olav V, Norway's monarch since 1957, was a noted ski jumper. His son, Crown Prince Harald, in background between King Olav and skier, has twice competed in Olympic sailing events. Harald's sister, Princess Astrid, stands at right.

Back through the center of Stavanger, past Breiavatnet—a downtown lake where wild ducks and sea gulls paddled, serenely integrated—Mr. Herstad led me to the Christian Bjelland fish cannery, Norway's largest. The company annually processes some 70 million tins of the savory sardines called brisling.

Impressed as I was with the huge, spotless plant, I found myself for the first time considering a Norwegian sardine's true sacrifice on the doughy altar of a canapé.

This graceful silvery creature, I reflected, is rudely wrested by purse seine from the sea. Impounded (by law) in a lock seine near the shore, it fasts for three days to purge its digestive tract. Scooped aboard a freezer vessel as tidy-white as a hospital ship, the little fish succumbs to instant, impersonal refrigeration.

In huge storage freezers—which keep the cannery busy year round despite the seasonal nature of the fisheries—tons of sardines await the final rites. In their icy slabs they huddle and intertwine. Released at last by thawing jets of water, they surrender their scales. Only the unblemished ascend the conveyor belts beyond. I winced as they were skewered through the heads, half a hundred in a row, and hung on racks like tiny icicles for a slow procession through smoke ovens.

"The chief executioner," Mr. Herstad said gravely, sensing my own solemnity. A worker triggered a knife blade, decapitating a regiment of smoked sardines at a stroke.

Then, with nervous motions, white-smocked women tucked the abbreviated fish into little aluminum tins. Nozzles anointed the procession with precise squirts of olive oil or tomato sauce. A clanking monster stamped lids on the tins.

Depressed, I followed the remaining ritual: a benediction of steam, a key placed on the lid, a trademarked paper shroud bearing the stern visage of King Oscar, and the can was consigned with others of its kind to a cardboard carton. Ocean-going freighters calling at Stavanger would carry them to New York and Sydney and Hong Kong and Tokyo.

"The sea giveth, and the sea taketh away," I murmured, and Mr. Herstad glanced at me oddly. I cleared my throat. "Let's go look at the shipyard," I said.

STEVEDORES swung my car aboard the M.S. *Stavanger* amid pallets of carrots, margarine, and copper tubing. The trim white ship tooted once and sailed into a lingering sunset to thread its way along the frayed west coast to Bergen.

"I don't like to boast," residents have been known to say, "but I *do* come from Bergen." Whether influenced by geography, climate, or history—or all three—Bergensers seem to stand apart, even in the more lilting cadence of their speech.

A phalanx of seven mountains crowds the city against its harbor (next pages); and for centuries Bergensers found it simpler to sail to England or the Continent than to Oslo. Only in 1909 did a rail line finally link the two cities, 300 rugged miles apart. Winter snows still close the main connecting highway.

As for the weather, some foreigners complain, but Bergen's youngsters play their sidewalk games in slickers, oblivious of the rain. My own three visits were wet ones, and I tend

EMBRACING THE FJORD *that funnels its wealth, dusk-dimmed Bergen laps against mountain walls. Deep inner harbor, foreground, pokes past medieval and modern buildings to the city's market center.*

Isolated from eastern Norway until the Oslo railway reached it in 1909, cosmopolitan Bergen reflects the flavor of trade ties with England, the Netherlands, and Germany.

to believe the tale that a Bergen businessman years ago was proclaimed a public hazard because he insisted on walking *without* an umbrella, thereby frightening the dray horses.

Bergen's charm I could not dispute. The city was celebrating its 900th anniversary with a music festival that included concerts at Troldhaugen—the gingerbread-trimmed Victorian villa of Edvard Grieg, Norway's foremost composer (below, right).

In Norse mythology, beautiful maidens—the Valkyries—ride swift horses and conduct slain heroes from the battlefield to Valhalla. Today, in trim blue coveralls, they ride sputtering motor scooters and lead confused foreign motorists through the streets of Bergen. A major oil company provides the service.

My young Valkyrie wore wheat-colored braids that refused to be confined beneath her crash helmet. *"Ja, Bryggen,"* she said with a magical smile. "I show you—yust follow me!"

After several blocks she waved toward my

Caught in a melodic spell, visitors hear the music of Edvard Grieg at his beloved home, Troldhaugen—Hill of the Trolls—just outside Bergen. Recitals there each June recall Grieg's own informal summer concerts, when he accompanied his wife Nina as she sang songs he had written for her. In the villa's quiet setting the 19th-century composer found inspiration for such works as his *Peer Gynt Suite,* world-famed as one of the finest expressions of the Norwegian spirit.

destination and wheeled off to help someone else. Had I been a Viking—and 20 again—I would cheerfully have fallen before a battle-ax to follow those braids to Valhalla.

King Olav Kyrre, it is said, founded Bergen in A.D. 1070, but excavations at picturesque Bryggen—the Quay—have revealed evidence of settlement even earlier. "The deeper we dig, the older Bergen becomes," a mayor once remarked. "Since excavating is extremely expensive, it might be said that the age of Bergen is a matter of finance."

Despite half a dozen disastrous fires through the centuries, the old waterfront area still preserves the heavy-timbered antique flavor of the Hanseatic League—merchant-monopolists from north German cities who dominated Norwegian trade between about A.D. 1350 and 1550. Into these now-quaint wooden warehouses (pages 26-7) flowed vital grain from the Baltic states in exchange for Norse *stokkfisk* and *klippfisk*—dried and salted cod.

SEVERAL APPOINTMENTS called me back to Oslo. As I drove eastward along magnificent Hardangerfjorden, I passed workmen blasting new tunnels through the cliffs. Near Eidfjord I stopped to chat with John Myklathun, a tall, taciturn man who, like many Norwegians, combines farming with another means of livelihood. Usually it is fishing or forestry; Mr. Myklathun teaches school. His ten-acre farmstead—a fairly typical holding—produces mostly hay and fruit.

I asked him about several farms I had seen perched on an impossible slope across the Eidfjord, accessible only by boat. "They are not worked now," he said. "People from Bergen have bought them for summer places."

Was he sorry to see this change?

"No—not in places like that," he replied. "The life was too hard; there is no need for us to live that way any more."

Driving on, across the high Hardangervidda—a rocky, lake-strewn plateau where some

15,000 reindeer still roam wild—I encountered another motorist standing beside his car, miles from anywhere. I pulled up.

"*Kan jeg hjelpe Dem?*" I asked in my fragmentary Norwegian. "Can I help you?"

"No, thank you," he replied in English. "I was only looking." He nodded toward the horizon, then got into his car and left.

I gazed at what had held his eye: The great Hardanger Glacier in the distance had turned to a sheet of molten gold in the afternoon sun. Norwegians seem never too busy to admire their surfeit of scenery, I reflected, and lingered there, just looking, for many minutes. At last another car drew up alongside.

"*Kan jeg hjelpe Dem?*" its driver inquired.

"*Nei, takk,*" I said, gesturing toward the glacier, and drove off. He, too, stayed there drinking in the view, and, for all I know, the chain went unbroken until I reached Oslo.

TWO YOUNG GUARDSMEN with plumed hats and shouldered rifles paced before the entrance to the Royal Palace. I tested one of them with a wink and won my mental bet—he grinned broadly. As a constitutional monarchy, Norway must have its royal trappings, but sometimes prefers them worn in a loose-collared way.

His Royal Highness, Crown Prince Harald, had a busy schedule occasioned by the illness of his father, King Olav V (page 15), but had kindly granted my request to be received.

A tall, strong-jawed man in his early thirties, His Highness wore a dark pin-stripe suit and an admirable tan from sailing on Oslofjorden. He excels at the sport, having twice competed in the Olympics, and he spoke of his new boat—a Soling-class racing craft, about 25 feet long, designed in Norway.

Among many other things, we discussed Norwegians' love of the outdoors and their national character, which His Highness found somewhat similar to that of the British, especially in their sense of humor. Throughout our hour-long conversation he spoke in flawless, unaccented English; during the German occupation in World War II, he spent part of his boyhood near Washington, D. C.

When I asked what major problems face his country, the Crown Prince cited inflation (about 4½ percent a year), the influx into the cities of people from rural areas, and pollution.

Sometimes in winter, he said, the snow is gray from industrial fallout from the Continent, so Norway's pollution is really international. Once, a few years ago, the snowfall was reddish, tinted by sand blown all the way from the Sahara.

If Norway's problems are similar to those of other countries, they seem less severe than most. And I could find only one that provoked more than mild controversy among phlegmatic Norsemen.

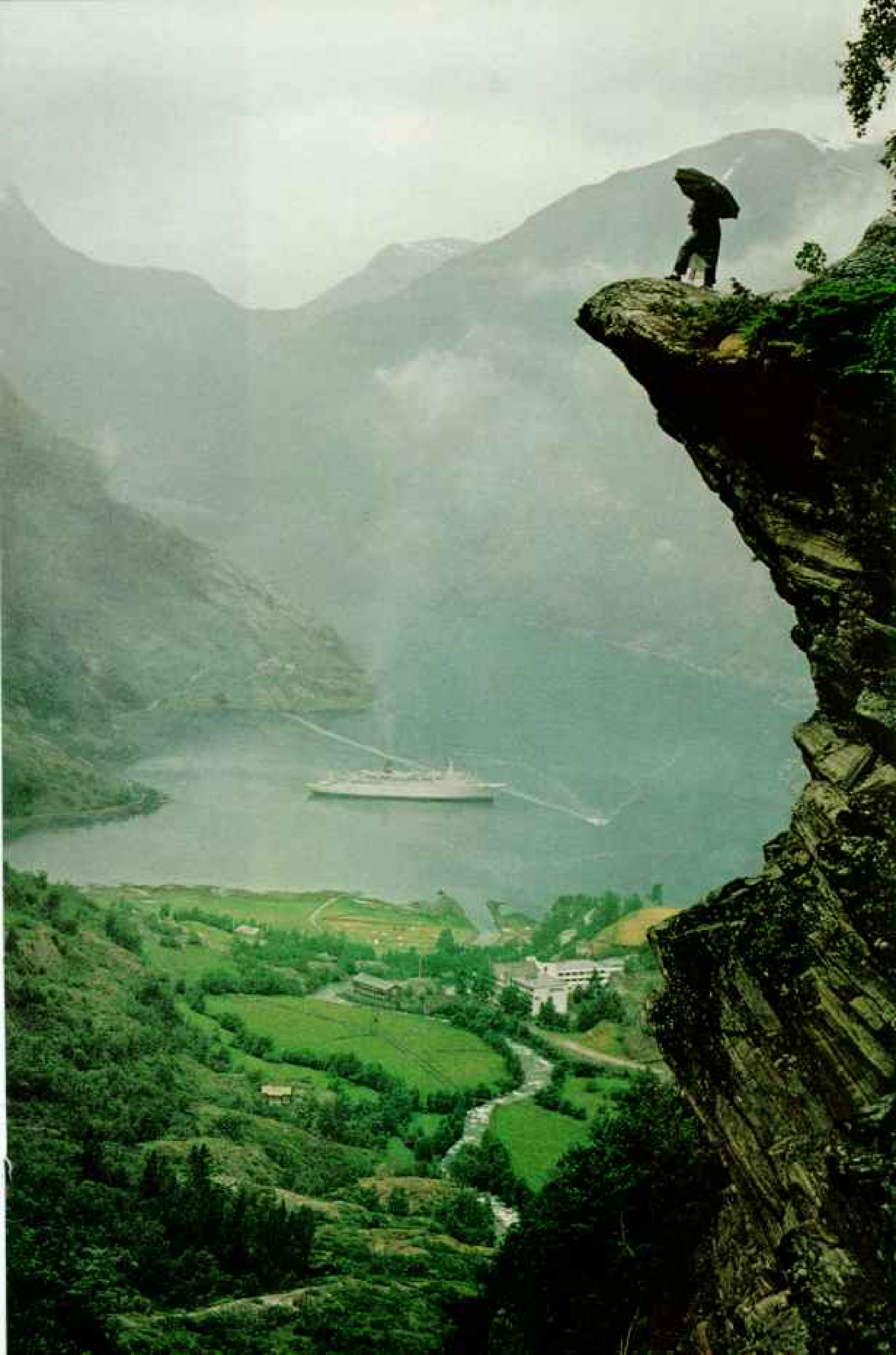
It is an oft-told joke that "everyone in Norway speaks at least four languages, and three of them are Norwegian." For years debate has sounded in the Storting—the Parliament—over Norway's official tongue.

The most commonly used language is Riksmål—also called Bokmål—basically Danish in root. Many Norwegians, however, prefer not to be reminded daily of the "400-years' night," when their land was a poor stepchild of Denmark. They advocate Nynorsk—New Norwegian, based on various regional dialects—which, paradoxically, is closer to the old Viking tongue. Still others are crusading for an amalgamation of Riksmål and Nynorsk, called Samnorsk. Most newspapers publish in Riksmål; radio and TV stations broadcast a portion of their programming in Nynorsk; both are officially recognized, and both are taught in schools.

"But even the teachers who instruct pupils in Nynorsk go home and speak to their families in Riksmål," said a hitchhiking university student I picked up on my way out of Oslo. "It is silly, the whole thing."

He left me at Eidsvoll, where Norwegian statesmen wrote their constitution in 1814. I continued up the 60-mile length of Mjøsa, Norway's largest lake, then up Gudbrandsdalen, the lovely valley that was birthplace of Peer Gynt, dramatist Henrik Ibsen's rascally anti-hero. Long into the twilit night I drove, enjoying the brooding beauty of the Rondane and Dovre Mountains. My tape recorder

Side road of the sea, majestic Geirangerfjorden thrusts between steep-walled mountains. Beyond a resort hotel waits the German liner *Hanseatic*, one of a flotilla of European cruise ships that ply Norway's fjords. Ice-free the year round because of warm Gulf Stream waters brought by the Norway Current, these arms of the Atlantic serve the nation as vital highways.



Cold quest for cod: Regular as the return of the winter sun, spawning cod begin migrating each January into Vestfjorden off the bleak Lofoten Islands. Simultaneously, fleets of fishing boats, many manned by part-time farmers, stream from the fjords to converge on the Arctic islands. For three months, in a ritual practiced since Viking times, thousands of fishermen haul up a lucrative harvest that today yields 140 million pounds of fish.

Through driving snow and spumy sea, a fishing boat (**right**) churns toward the codbanks from Svolvær, capital of the Lofoten group. Home from a numbing day, crewmen of another boat unload their catch (**lower right**). Carrying net-marker buoys like carnival balloons, fishermen (**below**) ascend Svolvær's main street, still slushy with mid-April snow.

played full blast, submerging me in the poignant strains of "Solveig's Song" from Grieg's *Peer Gynt Suite*. I began to feel almost Norwegian, and thoroughly at home.

By the time I reached Sunndalsøra—the most spectacular natural setting for a modern industry I have ever seen—I had begun to regard Norwegians as the luckiest people alive.

"It must be pure joy to live in a place like this," I said exuberantly to Finn Sørum, an official of Sunndal Verk, one of Western Europe's largest aluminum smelters. He, too, looked out his office window, and brought me slightly closer to earth.

"Yes," he conceded, "if you can get used to these mountains. Some can't. A few of our employees, born in flatter country, say they feel always as though the rock walls are caving in on them. And the winters: In Norway we're not so much used to the sun anyway, but in this valley we don't see it at all for more than five months."

Mr. Sørum took me on a tour of the pot-lines—long ranks of electric furnaces—after cautioning me to leave my wrist watch and recorder behind. He demonstrated why by picking up an iron bar and touching the side of a pot. The bar stuck fast, gripped by

Curtain of cleaned cod dries on huge racks near Svolvær, awaiting

a powerful magnetic field from the electrical current surging through the furnace.

The Sunndal smelter—owned jointly by the Aluminum Company of Canada Ltd. and the Norwegian Government—employs about 1,100 people. Their working conditions are fairly typical of Norway's modern industrial society, which stresses social welfare.

Wages average about 35,000 kroner ($5,000) a year—somewhat above the national norm. Workers receive four weeks' paid vacation, and are entitled to three of them during the desirable spring and summer months. Hospitalization and medical insurance covers virtually all such costs, and employees while ill draw 90 percent of their normal pay for nearly a year. A liberal pension plan provides roughly two-thirds of a worker's salary upon retirement. Low-cost mortgage loans make it relatively easy for Sunndal's family men to build their own homes, and the company provides neat bachelor apartments.

Nor can a man be laid off if automation eliminates his job, said Mr. Sørum. "By our agreement with the labor union, we must retrain him." Strikes in this highly unionized country are all but nonexistent.

All through the year ships sail up ice-free Sunndalsfjorden with alumina from Jamaica and Guyana, coke from the United States, and cryolite from Germany and Italy. They leave with 120,000 tons of aluminum billets, ingots, and sheets annually. Norway furnishes none of the raw materials—only skilled labor and electricity.

The same crumpled terrain that hampers transportation also cradles a multitude of lakes and rushing streams. Many former waterfalls now slip submissively through penstocks and turbines, and this abundant "white coal" has drastically altered the country's age-old fish-forest-and-farm economy. Today manufacturing heads the list.

Nearly half of Norway's hydroelectric power feeds factories like the one in Sunndalsøra—electrometallurgical and electrochemical industries whose products range from nickel, copper, and ferroalloys to plastics and nitrate fertilizers.

shipment to markets around the world.

HALF A DAY'S DRIVE separates the stacks of Sunndalsøra from the spires of Nidaros Cathedral—Norway's national shrine, where its kings are crowned and buried—in Trondheim. This busy port and former capital city in the heart of the Trøndelag district is a natural gateway between north and south Norway. Here I turned in my rental car and flew north above sullen clouds pierced by snowy peaks.

"We are now crossing the Arctic Circle," the pilot of the SAS jet announced, and shortly set down at Bodø on the coast (map, page 11).

I debarked to visit nearby Saltstraumen, Norway's most famous tidal race. Coalfish, as Norwegians call pollack, congregate here in vast numbers, and I watched anglers haul them, flopping, onto the rocks. The channel's currents sometimes reach 16 knots, and boatmen warily skirt each swirling *malstrøm*.

Watching those powerful eddies, I found it

no trick at all to conjure up a *draug*—a grotesque and terrible creature that sails forever in half a boat, and portends death to any hapless fisherman who sees it. Nature in Norway is not always benign, and it is easy to fathom how peasantfolk of generations past could glimpse fearful man-killing trolls looming among moss-clad boulders or in the misty shadows of the forest.

I learned about trolls from an unlikely source: a sandy-haired Norwegian army officer with the soul of a poet and the surname of a Scot. Maj. Henry Crawford-Currie was driving me to Bardufoss, Norway's defense headquarters above the Arctic Circle, for a brief visit to Brigaden i Nord-Norge—the Northern Brigade.

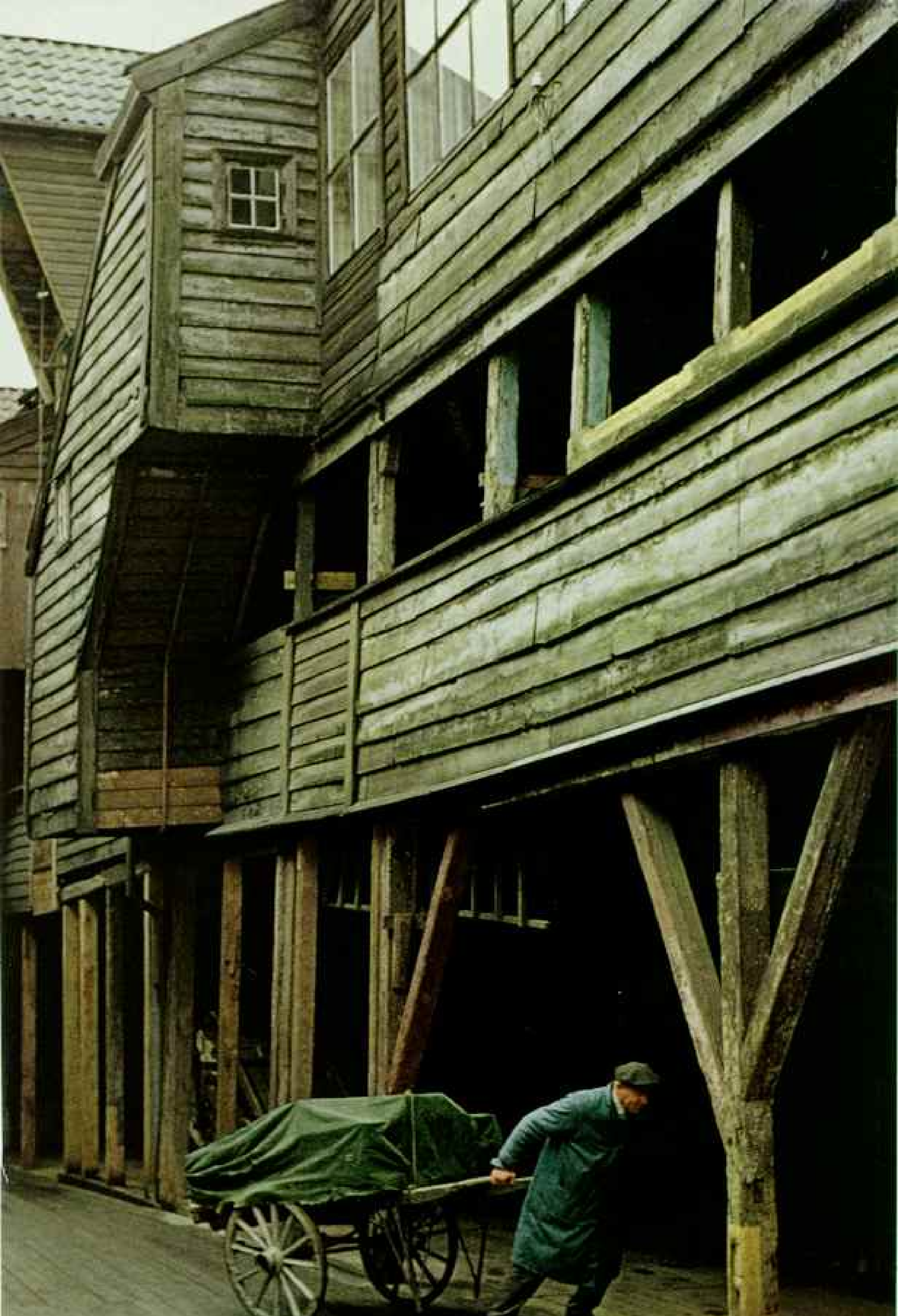
"Ah, yes—you asked about trolls," he said, and a smile softened his aquiline profile. "Trolls are usually very large, like your giants, and very ugly, except to other trolls. They like to capture princesses and carry them off to their castles inside the mountains."

Trolls grow so old and slow, it is said, that when one calls to another it may take a century to get a reply. Some are as tall as a church tower and brutishly strong—but fortunately rather stupid.

Major Crawford-Currie told me the tale of a farm boy, Askeladden, whose life was at stake in a porridge-eating contest with a huge troll. "Askeladden cleverly concealed a rucksack beneath his shirt, and poured the porridge into it while pretending to eat. When the rucksack was full, he slit his 'stomach' open with his knife so that he could eat still more. The slow-witted troll did the same thing—and perished, of course."

Built to hold the wealth of the Hanseatic League, stark warehouses near Bergen's quay echo the creak of a drayman's cart. Largely destroyed in a 1702 fire, the buildings rose again on their original lines. Today sheltering small shops, they constitute one of the kingdom's architectural treasures.

Norway's largest city in the Middle Ages, Bergen fell prey to the Hanseatic League about 1350, when German merchants ousted townfolk from the quay and set up a trade colony. Methodically they monopolized the city's commerce, cramming the warehouses with cod, furs, wood, and metals for export to other Hanseatic cities. In the mid-1500's competition broke the monopoly—whereupon the Bergensers amiably absorbed the Germans.



We drove through the gates of brigade headquarters at Bardufoss, astride the narrow mountainous neck of Norway. Here stands the main line of defense against possible attack from the northeast, across the open wastes of Finnmark, which stretches to the border with the Soviet Union.

It is also a training base for army recruits, most of whom spend 9 of their 12 months of compulsory service here.

"Few of them like it," the brigade commander, Col. Ivar Frøystad, told me candidly. "We are not a military-minded people, and this is tough country up here, especially in winter. But the troops accept it as a chore that has to be done."

My arrival coincided with a brigade dress parade on the broad concrete airstrip at Bardufoss. As I watched Norwegian armor and infantry pass in review, I was struck not by spit-and-polish elegance, but by a more impressive air of ease, the swing of confidence.

DECK HANDS aboard *Star III* showed the same self-certainty as they cast off from the Skjelnan whaling station near Tromsø. And for a week I lived the life of a Norwegian whaleman: in good weather, a life of numbing boredom spiced only by the infrequent glimpse of a distant, elusive spout. In unkind seas it is a cold, wet, pitching nightmare of grasping for the next handhold.

As the nightless summer days slid by, a vague sense of urgency grew aboard *Star III*. The ship was fueled and provisioned for ten days—a costly voyage if we should return empty-handed. I, too, found myself scanning the eternally silver sea for hours on end.

KODACHROMES © N.G.S.

In the wardroom the first mate, Olav Morsund—a rangy man whose gray hair tossed and fell like the choppy seas off Vesterålen—deftly dismantled a boiled cod's head for morsels of sweet white flesh. I asked when he thought we would catch a whale.

"Not today, I think. Tomorrow, maybe. Only Yesus knows."

It turned out to be tomorrow.

Napping in the fo'c'sle, I heard muffled shouts. I reached the crow's-nest just as Capt. Lars Breivik, braced wide-legged on the foredeck, fired the harpoon gun.

An incredible bang jolted the ship. The barbed iron missile, weighing some 200 pounds, arced out lazily and buried itself deep in the whale's back.

The great gray creature shuddered once and sounded, taking out fathom after fathom

Vanishing into its own smog, the half-mile-long smelter of the Alnor Aluminum Plant near Haugesund spawns potfuls of molten metal. A cartborne metalworker stirs a caldron at the mammoth works.

Hoppers lining both walls feed the pots with powdered alumina—refined bauxite. Rods arrayed like organ pipes and carrying 125,000 amperes of electricity generate heat that liberates pure aluminum. Drawn off into crucibles, the metal goes to a casting room to be poured into ingots for export (**above**).

Aided by vast hydroelectric resources, Norway's industry burgeons, adding to the returns from forests, farms, fisheries, and a giant merchant marine.

CRASHING DOWN *from mountains near Stalheim, Sivlefossen explodes in a misty drama that dwarfs a spectator. Countless lakes and huge glaciers send thousands of streams plunging toward the sea, creating the kingdom's priceless wealth of hydroelectric power.*

of heavy line. The captain's aim had been mercifully true. Two minutes later the whale broached, sharp nose pointed skyward, and sank again, dead.

A clanking donkey engine winched the carcass up from the depths, and crewmen made it fast alongside. Olav plunged a hollow lance into its vitals and pumped in air to keep it afloat. Throughout the drama, aside from a few terse commands, no one spoke. Even to those who have made it their life's work, the death of a whale is no spectacle for banter.

Black smoke smudged the sky as the ship headed at full speed for Tromsø. Unless it reached port within 20 hours for butchering and freezing, the fin whale's tons of dark-red flesh would be food fit only for Norway's mink farms, instead of a beef-like delicacy.

When I jumped to the dock, *Star III* had won the race by five hours.

TROMSØ IS AN ISLAND CITY of some 38,000 linked to the mainland by Norway's longest bridge. But even more impressive is Tromsø's role as the gateway to the Arctic.

It was from Tromsø in 1928 that Roald Amundsen, discoverer of the South Pole, took off in a seaplane to search for a fellow explorer, Gen. Umberto Nobile, missing on a North Pole dirigible flight. Nobile later was found alive; Amundsen never returned.

I had often wondered how a country of fewer than four million people could produce so many daring explorers—men like Amundsen and Nansen, and others more recent, like Helge Ingstad and Thor Heyerdahl.*

A friend of mine, one of Norway's finest young journalists, finally gave me a clue.

As we lounged before a crackling birch fire in his vacation cabin near Oslo, he told me of a narrow escape he had had while diving in search of an old treasure ship in Trondheimsfjorden. Overcome at great depth by the deadly lethargy of nitrogen narcosis, he barely managed to fight his way to the surface. Yet the memory seemed more to elate than disturb him.

"Every man wants to test himself to the limit, to reach out toward death—and return, of course," he said with quiet conviction.

Five months later he was dead—entangled in the wreckage of a German ship at the bottom of Oslofjorden. His legacy to me was a brief but valued friendship—and perhaps a rare insight into the nature of Norwegians.

Dr. Tom Andersen gave me another. He is a youthful-looking psychiatrist, Chief of Male Therapy at Tromsø's Åsgård Sykehus—a modern mental hospital that serves the 213,000 people of Norway's northernmost counties, Troms and Finnmark. I asked how he would characterize his countrymen.

"We are overcontrolled; we restrain our smiles and our anger," Dr. Andersen said. "We are basically skeptical, yet we feel secure. You find little hunger in Norway today. People have enough money to live, and their medical needs are met. Perhaps that's why we are quick to sympathize with others—we're always sending aid to victims of floods or famine somewhere in the world."

I had seen Norwegians' deep affinity for nature—the lemming-like weekend rush from the city to the mountain hut and hiking trail.

"I think it is because we depend on nature so," he said, fingering his brown beard. "Nature can be very hard to us at times, so we must be able to interpret it, to know everything we can about it.

"Up here in the north," the psychiatrist went on, "the people do as nature does—sleep in winter and awaken, very suddenly, in spring, like the flowers. They awaken hungry for warmth, for the sun, for work, for living. Our year begins in the spring, when the dull time is over."

ALL OSLO had been vårtrøtt for weeks when I paid a second visit to Norway in February. Sunshine had been scarce enough, and the muddy trench of new subway construction that disfigured much of Karl Johansgate did nothing to lift the city's spirits. But worst of all, there hadn't been a respectable snowfall since November. Until now.

"Yesterday," my taxi driver said, beaming. "Not here," he gestured at the scant inch of slush on the streets. "Higher in the hills. All over Oslomarka!"

Skiing is Norway's national sport, but in Oslo it approaches a religion (pages 12-15). Little wonder. Oslomarka—a hilly belt of lake-strewn forests and farmlands—sprawls over 460 square miles, almost all of it within city limits. On a sunny winter Sunday you can find upward of 100,000 skiers, more than a fifth of the population, out on some 1,200 miles of trails around the capital.

While the city worked and waited for the

*Archeologist Helge Ingstad wrote "Vinland Ruins Prove Vikings Found the New World" for NATIONAL GEOGRAPHIC, November 1964. Thor Heyerdahl, of *Kon-Tiki* fame, told of his subsequent reed-ship Atlantic crossing in "The Voyage of *Ra II*," January 1971.

weekend, I reacquainted myself with Oslo and with hearty Norwegian foods, and warmed again to the charming phrase, *"Vær så god"*—literally, "Be so good." Norwegians contract it to a cheery *"S'goo!"*, and use it to say "May I help you?" "Here you are!" "You're welcome!" and "Make yourself at home!"

When Sunday dawned, late and gloomy, crowds converged on the underground tram station behind the National Theater. They strapped their skis outside each tram until it bristled like a porcupine.

Most Norwegians are cross-country skiers, who eschew chair lifts and rely on light skis, bamboo poles, and their own good legs. For a nonskier like myself there is only one way to keep up with them on the trails of Oslomarka. I swallowed my pride and took it.

Near Frognerseteren tram terminus, two young ski patrolmen, Eric Rustad and Anders Torp, waited with a quartet of Eskimo dogs and their rescue sled. I climbed aboard and we lurched off.

Even on this gray, sleety day the fresh snowfall gleamed; shaggy firs slumped their shoulders under heavy white epaulets. Anders trilled softly like a bird, urging the dogs uphill. The trail rolled and twisted, and in minutes we might have been a thousand miles from anywhere—except for the skiers.

There were old ones, young ones, couples, whole families with rucksacks; occasionally a father towing a tot on a little plastic toboggan. They poled uphill silently, saving breath, and slid down around sharp curves with the skating turn cross-country skiers use. Typically, Eric told me, they would cover 15 to 20 kilometers—9 to 12 miles—that day.

Most politely refrained from staring, presuming me, sitting atop the rocking sled, to be an accident victim. Dog teams pick up eight or ten fracture or heart-attack cases in Oslomarka on an average weekend.

But once, as we rested the dogs, a lad of eight or so gave in to curiosity. *"Hva har det hendt med ham?"* he asked in a small voice. "What happened to him?"

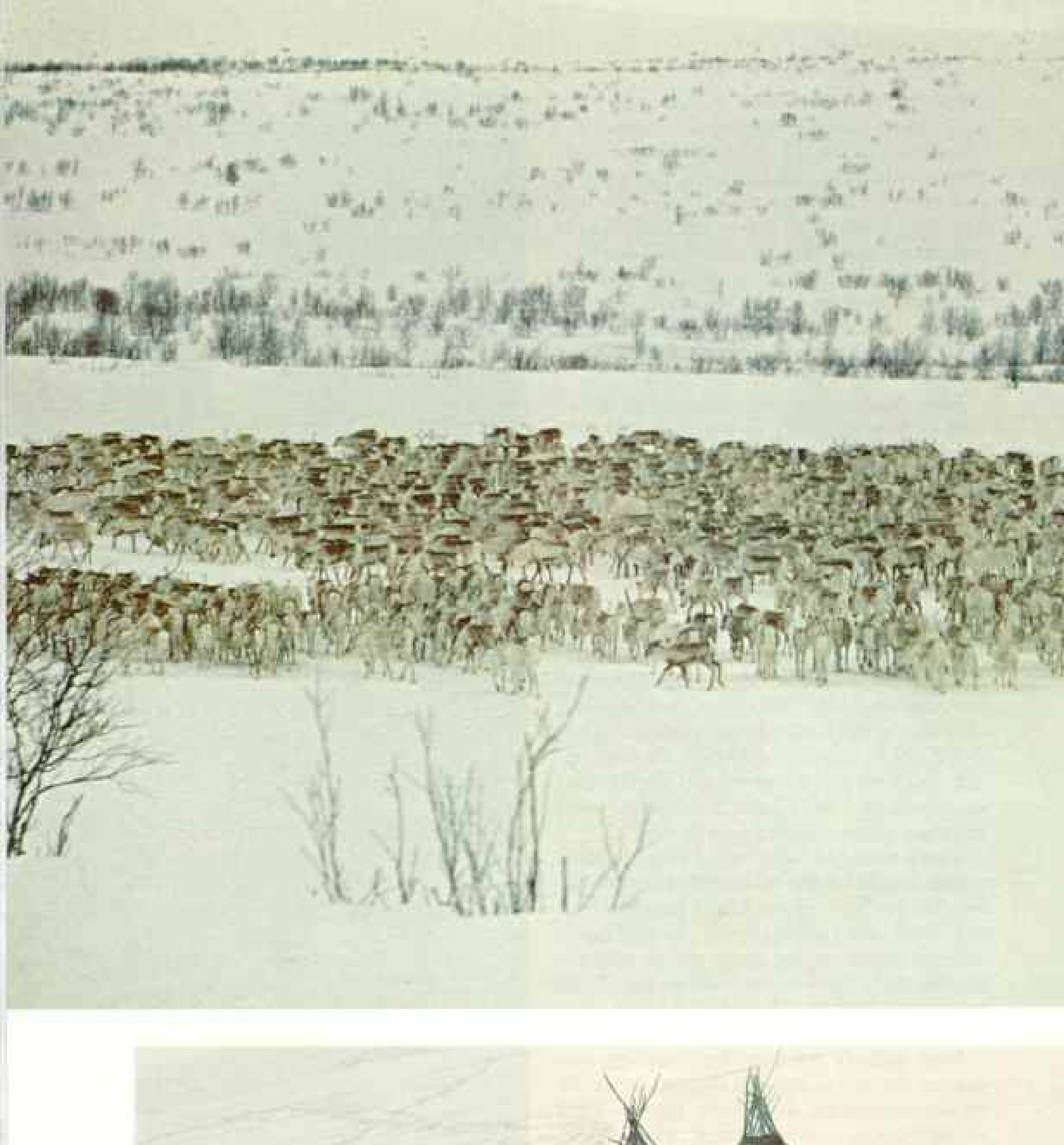
"Tell him I broke my back but I am too proud to lie down," I instructed Anders, and donned the brave, crooked smile Humphrey Bogart used to wear whenever he took a bullet in a bad place.

The boy's eyes widened wonderfully as we took off down the trail. I didn't feel half as guilty as I should have.

I felt less lighthearted a few days later as

(Continued on page 39)

Nordic pagoda, the Fantoft stave church sprouts from a knoll near Bergen. Dating from the 12th century, the wooden shrine bristles with dragon gables that resemble Viking figureheads. Only Fantoft and a couple of dozen other stave churches—named for the massive upright timbers supporting them—survive of an estimated 900 built during the Middle Ages.



Lapps depart for greener pastures

ROUNDED UP for a snowy trek, a herd of 1,500 reindeer awaits marching orders near Kautokeino, 170 miles north of the Arctic Circle; a herdsman riding a motor sled turns back strays. Their destination: summer foraging grounds on the isle of Arnøy, a month's journey—including a chilling fjord swim—to the north.

For centuries Lapp families have migrated with their reindeer to and fro across northern Norway. They travel by sled, skis, and on foot, camping in teepeelike *goattes* (**left**). Here the nomads load provisions on reindeer sleds for the journey.

Joining a Lapp family on its trek to Arnøy, photographer Mobley survived a hazardous odyssey that included a near-fatal spill from an overturned motorboat. He also endured unseasonable late-spring blizzards that engulfed herd and herders in a white nightmare.

Gathered round the dinner pot, a Lapp family gets a welcome respite from the cold outside. As the father repairs harness, his son plays with a telescope that herdsmen use to spot straying reindeer. Subsisting on dried reindeer meat, coffee, bread, and butter, the

EXTACHROME © NATIONAL GEOGRAPHIC SOCIETY

nomads press on without rest during good weather, raising tents only during storms or heavy fogs. Although some 1,500 Norwegian Lapps still migrate with the herds, many women and children now make the trek by truck, rejoining the men at their destination.

Dizzying drive in a realm of twisting roads, Trollstigveien—Trolls' Path—staggers 2,600 feet down a mountainside near Åndalsnes, disappearing finally into a mist-filled valley. Norwegians whimsically attribute the engineering feat to their trolls, which still live in the nation's folklore. The road snakes through the celebrated Romsdal, a region of towering mountains, 1,000-foot cascades, and picturesque resorts.

In language clear to all, the road sign (**above**) warns of lack of a railing at one of many small ferry landings.

Campers raise their tent on a traffic island near Mjøsa, Norway's largest lake (**below**). With the arrival of summer, Norwegians flock to their out of doors; traditionally they camp on any unfenced, uncultivated land, whether publicly or privately owned.

45-knot winds whipped ribbons of snow across the airstrip at Bodø, far to the north. The big Sikorsky helicopter lumbered into the air and flew over a spume-streaked sea toward Værøy, a remote southerly island in the Lofoten chain.

These craggy isles are the epicenter of Norway's age-old codfishing industry (pages 22-25). Some 1,600 vessels and nearly 5,000 men had converged on Svolvær and other Lofoten ports, and the fishing was good. Already they had caught 15,000 tons of *skrei* —plump cod, at least seven or eight years old, that had migrated from northern seas to spawn in these waters warmed by remnants of the Gulf Stream.

"Warmed?" I thought wryly, slithering in half darkness across the ice-plated deck of *Janny*, a 43-foot wooden vessel manned by Capt. Olav Olsen, his son Einar, and Heiberg Varheim.

"We go outside today," Einar said. That meant off Værøy's west coast, with open sea all the way to Greenland. "Sometimes a little rough. You get seasick?"

I gave the wise reply, "Maybe," with a shrug. An hour later, as I slammed against the wheelhouse, drenched with spray, I appreciated the Norse knack for understatement. "Fine day," yelled Einar through the freezing wind. Indeed, a broken armada of clouds scattered before the advancing dawn.

In steep confused seas ten miles offshore, Captain Olav unerringly picked up the orange

flag that marked *Janny*'s longline, laid the day before. Einar engaged a winch that fed the line into wooden tubs, and leaned over the side with a short-handled gaff.

Every six feet a hook emerged from the sea, some bare, some still baited, some tugging reluctant brown-green cod up from the depths. Most of the fish Einar flung into the wooden bins on deck weighed 7 to 10 pounds. Now and then came a 20-pounder ripe with roe; such older females may bear several million eggs. In minutes the cod lay blank-eyed and frozen.

I clung to the swaying mast and quivered with cold through five layers of clothing. *Janny*'s engine thumped somewhere deep inside my drum-taut stomach.

Einar glanced up and grinned. "Fine day!" he shouted, and chipped more ice from the rail with his gaff.

When the deck bins filled, Heiberg began pitching cod into the open hold. I calculated the day's labor of a Lofoten fisherman. Some 3,600 hooks; four miles of line to haul. Four miles of freshly baited hooks and line to lay. And then cleaning the catch at the fish-buyer's shed. Tomorrow the same cycle.

As the last tubful of line slid over the stern, followed by the marker buoy, Einar swung his arms, flogging his sides. "*Ja*, fine day," he said, contented. I knew he did not mean simply the ton of cod he had hauled aboard, although counting livers and roe the catch would bring nearly $300.

But would it not be an easier life ashore —say, working in a factory?

Einar frowned. "I have never worked one hour on land," he replied.

"You love the sea that much?"

"I could not live without it."

THE FISHERMEN OF FINNMARK feel the same age-old bond. The sea grips Norway's northernmost and largest county (bigger than Denmark) with five great fingerlike fjords. It levies its wintry price in cold and darkness, but offers livelihood to those sturdy enough to dwell along this wild, bleak coast.

Several weeks before I arrived, a storm had driven dozens of fishing boats into Honningsvåg, near North Cape. When it abated, they went out as a fleet and struck an incredibly rich shoal of *lodde*—a little Arctic fish related to the salmon.

In a single day they netted 700,000 hectoliters—about 70,000 tons—of fish. Some boats had to sail halfway down the Norwegian coast to find factories enough to process the huge catch into meal and oil.

But Finnmark in winter wears another face, and one must turn south into the vast snow-blanketed plateau to find it. This is the land of the reindeer Lapps, an ancient, enigmatic people who speak a tongue related to Finnish and—curiously—Hungarian.

Among some 20,000 Norwegian Lapps, the majority have always lived along Finnmark's seacoast and rivers, fishing or farming. But a handful of nomadic Lapps still follow their reindeer herds on twice-yearly grazing migrations (pages 34-37).*

In February the reindeer Lapps center on Kautokeino, and in February Kautokeino is a Christmas card no one can bear to take down from the wall. Framed by your hotel window, a scattering of snow-roofed houses —painted red, or blue, or yellow—lies flung across a wide, white valley. In the motionless morning air, smoke stands like tufts of cotton tucked into the chimneys. And at this distance moving figures seem oddly, cheerily gnomelike.

Step outdoors and inhale: An icy blade probes the lungs. It is 30 degrees below zero, Fahrenheit. It can reach 50 below.

Go down to the town and mingle with the Lapps as they bustle about Saturday morning's business. The impression of gnomes persists, for many are short and walk with a rolling gait. The men in traditional garb wear a handsome blue tunic-like jacket with red embroidered trim, reindeerskin boots turned up at the toes, and cylindrical hats streaming multicolored ribbons.

A red-bonneted woman yanks the starter cord of a motor toboggan, and it snarls to life. A similar machine whizzes by, towing a sled built—who knows how long ago?—to be pulled by a reindeer. Five Lapps, resplendent in red and blue, pile out of a Volkswagen at the tiny post office to collect their mail.

A wizened elder in reindeerskin leggings nods as he pushes past on a little kick-sled.

"*Hvor kan jeg finne rensdyr?*—Where can I find reindeer?" you ask him.

His Norwegian, too, is limited, but at last it is clear that the reindeer are foraging far afield. Sedately he kicks off on his sled, a

*The life of these roving people is described by photographer George Mobley in the recent National Geographic Special Publication *Vanishing Peoples of the Earth* (available from the Society for $4.25 plus postage) and by Jean and Franc Shor in "North With Finland's Lapps," GEOGRAPHIC, August 1954.

plastic shopping bag slung from its handle.

Drive south looking for reindeer, and find patches of snow they have trampled in search of moss, and many tracks. A red fox stares insolently, then trots into a birch thicket. At the little customs post that marks the Finnish border turn back, defeated. No reindeer.

Later you meet a Norwegian Air Force sergeant from the nearby radar station and ask if he speaks Lapp. "Oh no—it is much too difficult," he says. He tells you, though, that Kautokeino means "halfway between"—that is, midway on an old reindeer migration route from Sweden to the sea.

Look again at February's Christmas card, and see an old, strange culture overlaid with skimobiles and autos and television antennas sprouting from the rooftops. And it appears that Norway's reindeer Lapps are, indeed, *kautokeino*—halfway between.

MAN LIVED IN NORTH NORWAY at least 9,000 years ago, artifacts found near Alta have revealed. Yet I saw no building in Finnmark more than 25 years old. The paradox is rooted in Hitler's invasion of Norway during World War II.

On April 8, 1940, a column of warships steamed up Oslofjorden. Surprised shore batteries managed to sink the heavy cruiser *Blücher*. (That vessel struck the Third Reich's ironic final blow 30 years later, taking the life of the courageous Norwegian journalist-diver who was my friend.)

The Wehrmacht withdrew from Finnmark in 1944, burning all that would burn and leveling the rest. Not even telephone poles remained standing to greet advancing Russian troops. And that is why Hammerfest, Alta, Lakselv, Kirkenes, and dozens of other northern towns look neatly planned and newly built. They are.

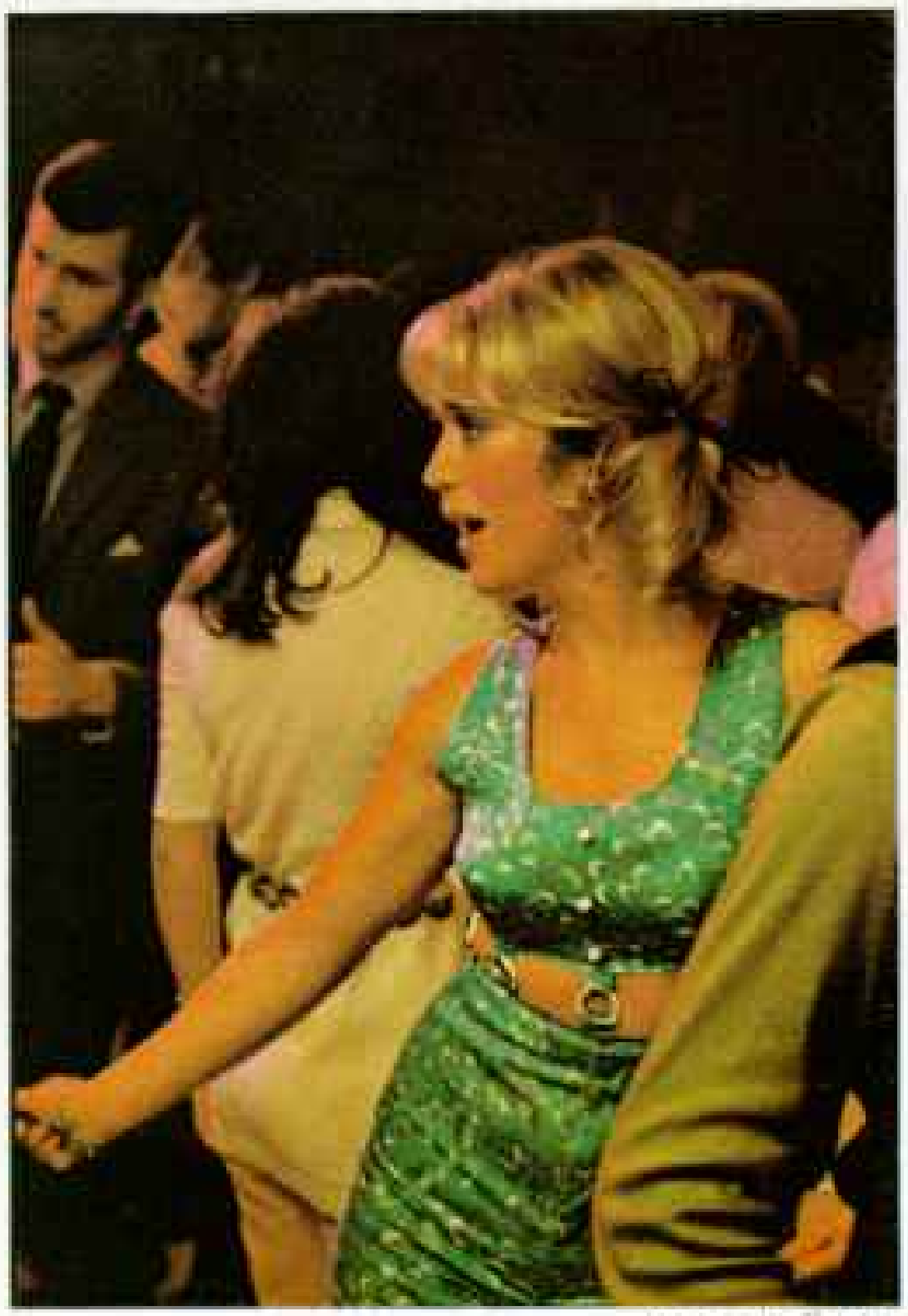
The Russians too withdrew, in 1945. But one still feels their presence in wooden watchtowers near the iron-mining town of Kirkenes. When I reached a gate across the road and a yellow sign that proclaimed "SOVJET SAMVELDET"—Soviet Union—the birch-stippled snowscape rolled onward toward Murmansk, a mere four-hour drive. But I had reached the end of Norway: north of Nome, east of İstanbul.

Does the proximity of the Russian border worry the people of Kirkenes? I asked a workman at the A/S Sydvaranger iron-ore concentrating plant.

"*Nei*," he replied with a cryptic Norse

Lilliputian flensers cut up an ocean Gulliver at Norway's last whaling station, near Tromsø. The sperm whale's 50-ton carcass will yield oil from the blubber, animal food, and fertilizer; Norwegians do not eat sperm-whale meat.

In years past, Norse whalemen fanned out from their fjords to earth's far corners. Today they have all but given up the chase for the leviathans.



Tradition and transition: Dancers twirl at Oslo's Norwegian Folk Museum, each wearing a festive *bunad*, the national costume (**left**). Richly embroidered with designs that vary from valley to valley, the outfits are still worn on special occasions.

At the Folk Museum a cluster of reconstructed log buildings nestled amid grass and trees provides authentic settings for sturdy peasant furniture, intricate tapestries, painted and carved altars, and colorfully decorated bridal chests.

In a more modern setting (**above**), an attractive blonde twists to rock rhythms in a Bergen discotheque.

wisdom, "we are too near to be nervous."

They are not a nervous people, these Norwegians. But in ways they are eminently cautious. "Praise no day until evening, no wife before her cremation, no sword till tested, no maid before marriage, no ice till crossed, no ale till it's drunk," exhorts the *Hávamál*—the ancient sayings of Odin.

"And no oil till it's in the refinery," I added mentally as I alighted onto the helicopter deck for a look at *Ocean Viking*, on the final leg of my Norwegian journeys.

This huge drilling platform, floating on great half-submerged pontoons and anchored 185 miles off the coast in the Norwegian sector of the wintry North Sea, was preparing four holes for an initial production of 40,000 barrels of petroleum a day.

Discovery of Norway's giant Ekofisk oilfield had been announced by the Phillips Petroleum Company in June 1970. It may contain as much as a billion barrels of recoverable oil, and by 1973 is expected to yield 300,000 barrels a day, twice the petroleum Norway now consumes, in addition to rich royalties and tax revenues, Ekofisk could lead to a brand-new petrochemical industry. And oil exploration along the country's coast has scarcely begun.

Yet in my travels I found Norwegians firmly heeding the *Hávamál*.

I recalled a clothing manufacturer in Molde: "We are not sheiks, yet."

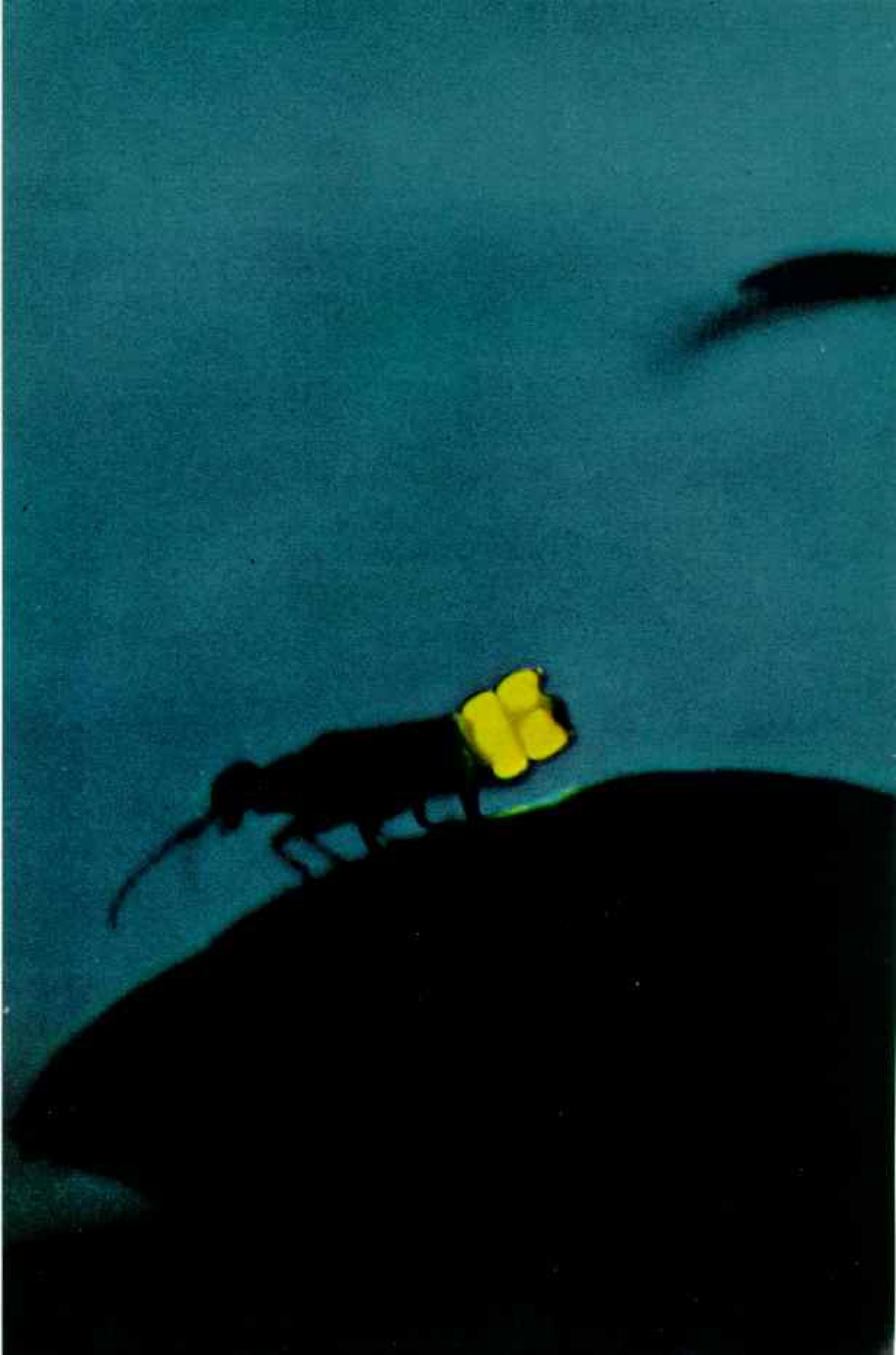
A waiter in Trondheim: "Well, maybe it is good, but can they get it out of the sea?"

A summer hiker on Hardangervidda: "I think it will mean more taxes, somehow."

A crown prince in Oslo's Royal Palace: "Perhaps it is a little dangerous to get something for nothing."

BLUSTERY SKY, PETULANT SEA. On the long flight from *Ocean Viking* back to Stavanger, the helicopter lurched through snow squalls and probed low cloud banks. The North Sea was serving notice that it will not surrender its riches easily. Earlier a winter storm had battered the rig, built in Oslo and now manned mostly by Norwegians, with 60-foot waves.

But, I reflected, this is the price Norway has always expected to pay for its generous harvest from the sea: a fair exchange in toil, hardship, respect, and no little danger. And as every Norwegian knows, nature—at once harsh and beneficent—demands no more, no less, of man than that. □



Nature's Night Lights

PROBING THE SECRETS OF BIOLUMINESCENCE

By PAUL A. ZAHL, Ph.D.
NATIONAL GEOGRAPHIC SENIOR SCIENTIST

"THE FIREFLY TREE?" Ahmad bin Khamis's face crinkled into a proud grin. "It is closer than you think—just there, across the creek. Nothing special, sir, nothing special . . . that is, not until nightfall, when the *kelip-kelip* start their happy time."

I am an inveterate firefly-watcher. My preoccupation with bioluminescence, not only in fireflies but also in hundreds of other organisms—including fishes, squids, and mushrooms—has led me around the world. This time my quest had brought me to the State of Johore in Malaysia and the jungle home of the thatchmaker Ahmad. On his property stood a remarkable tree, one that harbored swarms of a firefly different from any I had ever seen. Ahmad knew that intriguing insect as the kelip-kelip; to scientists it is the synchronously flashing firefly *Pteroptyx*.

"Do the kelip-kelip come and go with the seasons?" I asked, as Ahmad drew me to a window.

"Not a bit," he replied. "They are with me every night

Turning on with a mighty flash, a Malaysian firefly signals from its perch on a mangrove leaf. Amazing *Pteroptyx malaccae* and a constellation of other night lighters illuminate the author's memorable adventures in the strange world of bioluminescence.

of the year, and in that very same tree. But black nights are best."

We looked out. It was still daylight, and no more than 75 feet away stood the tree of promise, a mangrove about 18 feet high (right).

As daylight waned, Ahmad, his wife, his daughter-in-law, and several youngsters watched from their porch while I set up tripod and camera. Occasionally I glanced speculatively at that ordinary-looking tree. Would I again be disappointed?

Earlier, at the University of Singapore, I had met Dr. Ivan Polunin, who for some years had been interested in the synchronous flashing and social behavior of Southeast Asian fireflies. Together we had prowled the mangrove swamps that clog stretches of Singapore's northwestern shore. But our luck was bad. Finally Dr. Polunin suggested that I move on into Malaysia, and he told me where to find Ahmad and his tree.

Now, with night upon us, a single beacon flashed high in the tree. In a short time branches and leaves were full of lights blinking away, but without any particular pattern or rhythm. The first sign of a change came when fireflies clustered on a single branch began flashing on and off in unison, as though they were wired together and someone were snapping a switch at regular intervals. Other areas picked up the synchronization, until most of the fireflies in the tree flashed in perfect time.

Insects Follow Christmas Tree Lights

In my years as an observer of bioluminescence I have witnessed many unusual phenomena, but this was far more spectacular than anything I had ever seen.* Something mysterious was making those multitudes blink at the same instant. According to measurements by Dr. Polunin, the frequency varies somewhat, depending on species and temperature. *Pteroptyx malaccae* turns on its light about once a second. The human eye detects only one flash; in fact, the insect produces two, spaced a scant 1/30th of a second apart (pages 48-9).

In a Singapore laboratory I had watched Dr. Polunin release synchronous fireflies in a darkened room strung with blinking Christmas tree lights. Each time a firefly flashed, a photomultiplier picked up the impulse and recorded it on the screen of an oscilloscope.

*Dr. Zahl has written about bioluminescence in other NATIONAL GEOGRAPHIC articles, including "Bizarre World of the Fungi," October 1965; "Wing-borne Lamps of the Summer Night," July 1962; and "Unsung Beauties of Hawaii's Coral Reefs," October 1950.

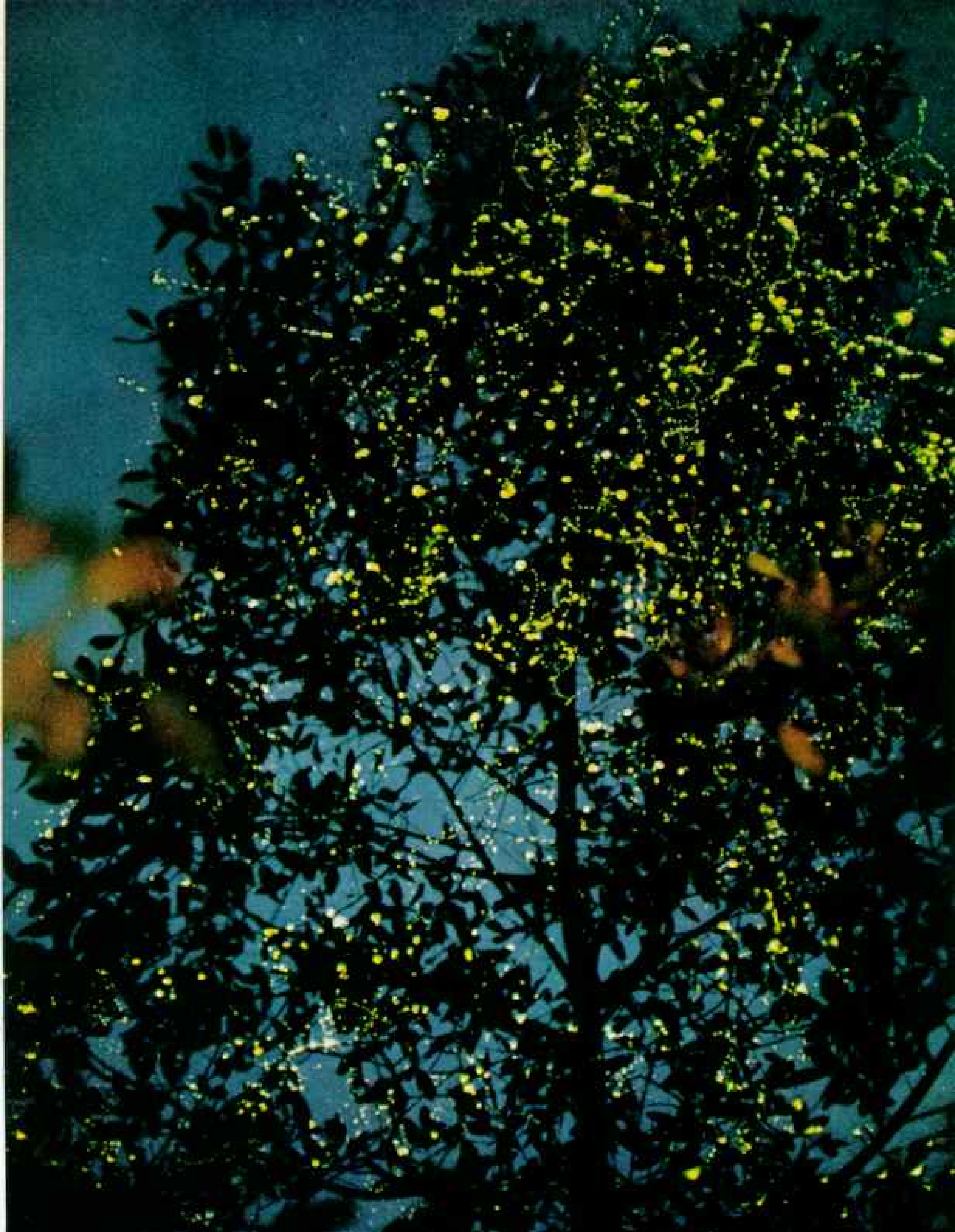
EXTACHROME (OPPOSITE) BY IVAN POLUNIN, KODACHROME BY PAUL A. ZAHL © N.G.S.

Closing in on his quarry, Dr. Zahl bags specimens of *Pteroptyx*. He enlists the aid of Ahmad bin Khamis, a Malaysian thatchmaker whose home in Johore looks out on this scene.

Creating a tropical Christmas tree, fireflies blaze on a mangrove. Most male beetles flash together, as if activated by a single switch; generally, the females blink out of step.

As dusk settles, one firefly signals the start of the evening's performance. Others flash, though not all at once, and soon the entire tree twinkles. Then lights in one area begin flaring in unison. Others pick up the rhythm, and almost all flick on and off together. Biologists speculate that the male fireflies pool their luminosity to give females emphatic notice of their whereabouts.

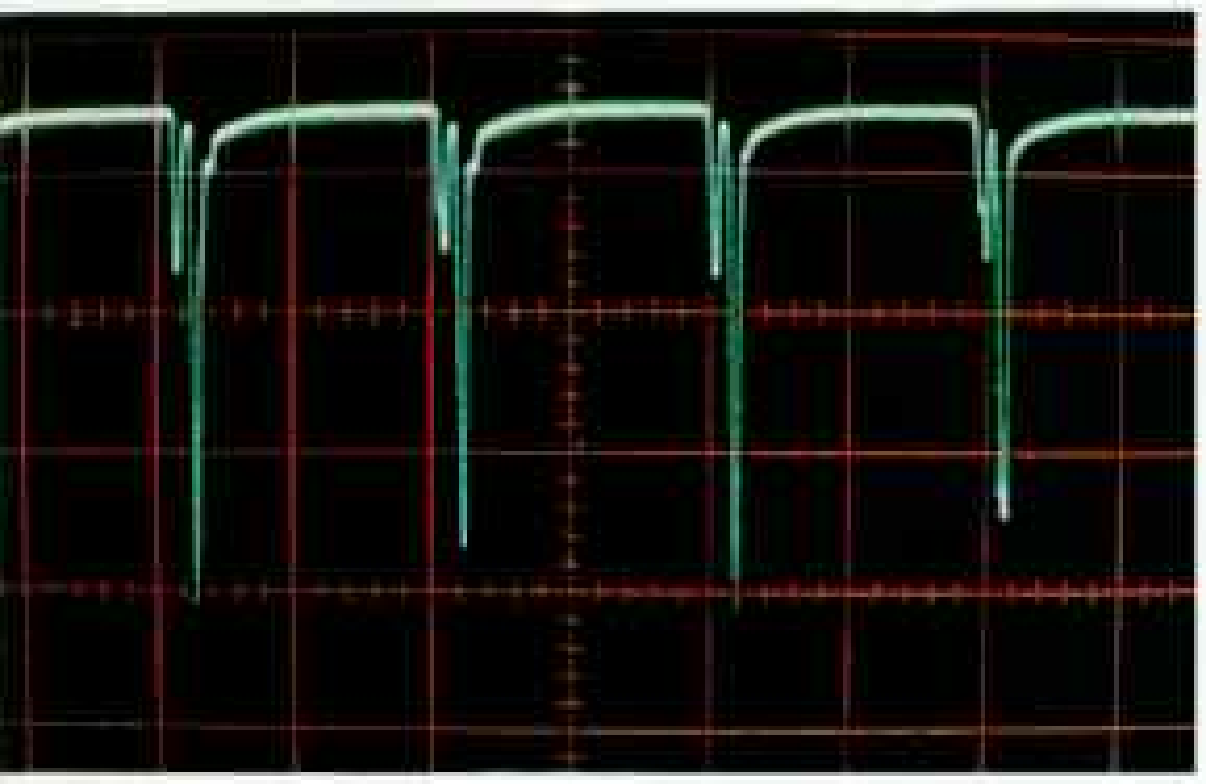
Fireflies and many other luminous creatures fuel their lanterns with a compound called luciferin. When the substance comes in contact with oxygen, an enzyme catalyst known as luciferase sparks the oxidizing process that creates nature's cold light.

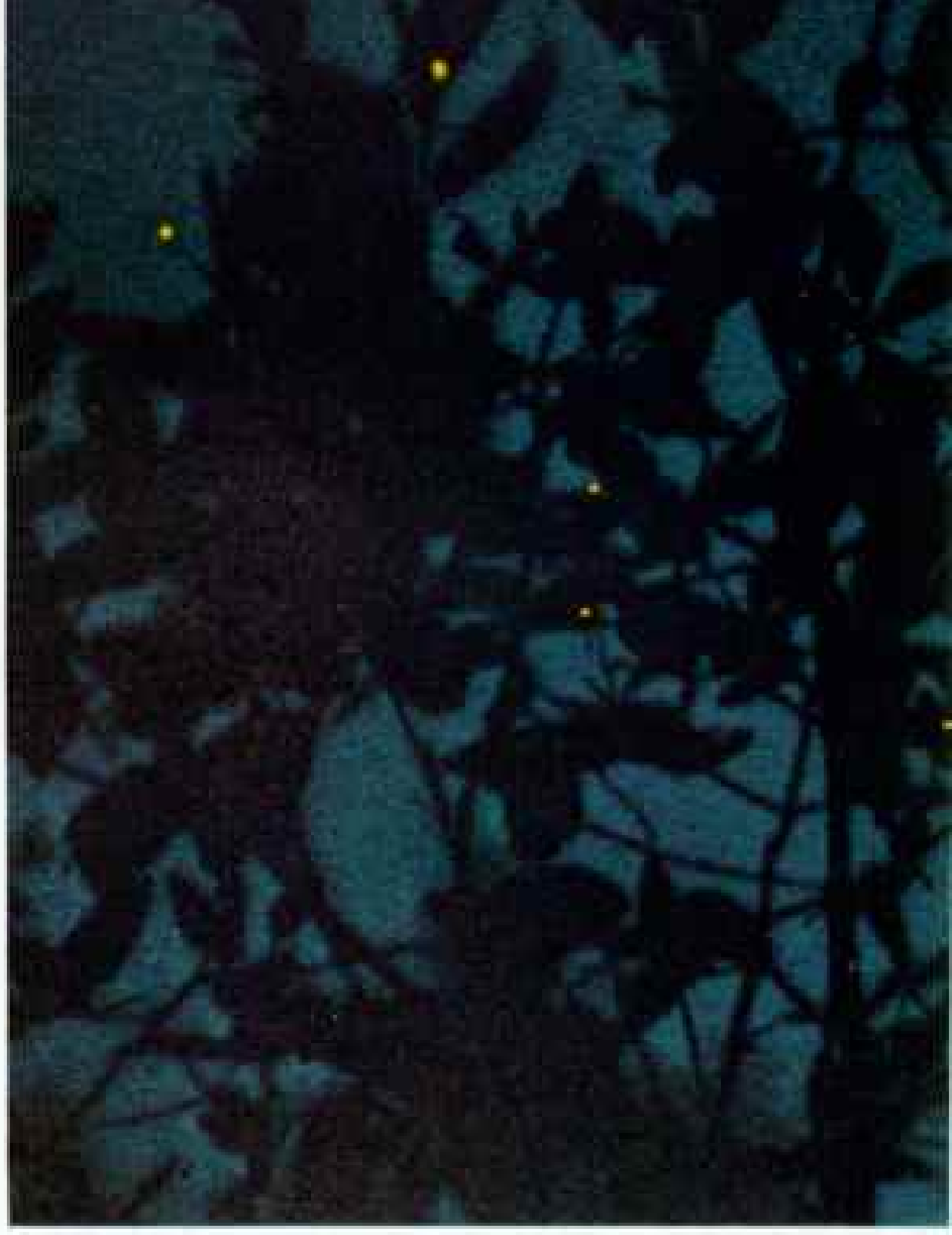


Backlighted by evening's afterglow, a male *Pteroptyx malaccae* records distinctive double flashes in this time exposure as it leaves the mangrove. The twin blips, only 1/30th of a second apart, appear to the eye as single bursts. Dr. Ivan Polunin of the University of Singapore, who made this photograph, has discovered that all males of this species conform to the same pattern.

An oscilloscope in Dr. Polunin's laboratory (**below**) records the beetles' signals. The first of the twin flashes shows as a short upside-down "peak"; the second, brighter flash as a long one. Nearly a second elapses before the cycle repeats. Crisp outlines of the flashes testify to the insects' uncanny precision.

Like all fireflies, *Pteroptyx* are adults of a wormlike larva, probably similar to this Malaysian glowworm (**bottom right**). Flashing only at night, they shun the limelight by day, seeking shade on the undersides of leaves (**bottom**).





KODACHROMES (OPPOSITE) AND EKTACHROMES BY IVAN POLUNIN © N.G.S.

The Christmas lights also registered on the oscilloscope. The frequency and duration of their blinking was determined and altered by Dr. Polunin, so that the effect on the fireflies could be measured. He demonstrated that, to a limited extent, a firefly will follow the rhythm of the flashing bulbs.

Dr. and Mrs. John Buck of the National Institutes of Health, who have done research on bioluminescence in Thailand and New Guinea with aid from the National Geographic Society, have made a number of interesting observations about fireflies. They have found that only the male occupants of a firefly tree are involved in synchronous flashing. Females are there, or may soon be attracted, but their dimmer flashes do not coincide with those of the rhythmic males.

From movies and photometric records of *Pteroptyx* in Thailand, the Bucks have shown that the insects' ability to flash together is much more precise than it would be if each firefly had to see another's flash before producing his own. Somehow, each insect seems able to match his flash with that of neighboring fireflies.

In related experiments, Dr. and Mrs. Buck have shown that blindfolded human beings have a similar ability to tap telegraph keys in unison. The Bucks suggest that large congregations of synchronously flashing male fireflies attract mate-seeking females just as a theater marquee arrests the human eye with huge numbers of bulbs and insistent rhythms.

"Glowworms" Are Not Worms at All

The precise life cycle of *Pteroptyx* remains unknown. But on the basis of well-established facts about North American fireflies, one would assume that the eggs are laid on or near the ground, and that these hatch into larvae which, for a year or so, gorge on minute snails. The larvae turn into pupae, then hatch into adults. The latter probably do not feed. Their main activity is to join their fellows in one of those flashing trees to mate and, within a few weeks, to die.

All fireflies are beetles, members of the order Coleoptera, and most glowworms—actually beetle larvae—also belong to this order. Fireflies are members of the Lampyridae family, while the spectacular railroad worm belongs to the Phengodidae (page 62).* Among these and other beetle families, several dozen genera exhibit luminescence, both in the mature and immature stages. There is yet another light-producing insect—the New Zealand glowworm—that is neither worm nor beetle but a cousin of the common housefly.

Regardless of its source, the biological production of heatless light is perhaps the most efficient energy-emission system known.

Scientists study how certain cells and tissues produce the critical light-making compounds, how these interacting substances are governed and related one to another, how drugs, enzymes, oxygen, pressure, temperature affect light-producing reactions. Physiological principles underlying these problems involve the metabolic building blocks common to all living things.

Ancient Mariners Awed by "Sea Fire"

Robert Boyle, a pioneer in the laboratory study of bioluminescence, showed in 1667 that the light of luminous bacteria and fungi goes out if the organisms are deprived of oxygen. Raphaël Dubois demonstrated in 1887 the existence of a specific compound he called luciferin, which interacts with an enzyme, luciferase, and oxygen to produce light.

The late American physiologist Professor E. Newton Harvey spent a lifetime investigating light production by living organisms. He and his students showed that there are many kinds of luciferin and luciferase—in fact, a different substance and enzyme for nearly every luminous species—which upon interacting undergo minute changes and release energy in the visible part of the spectrum, but without appreciable heat.

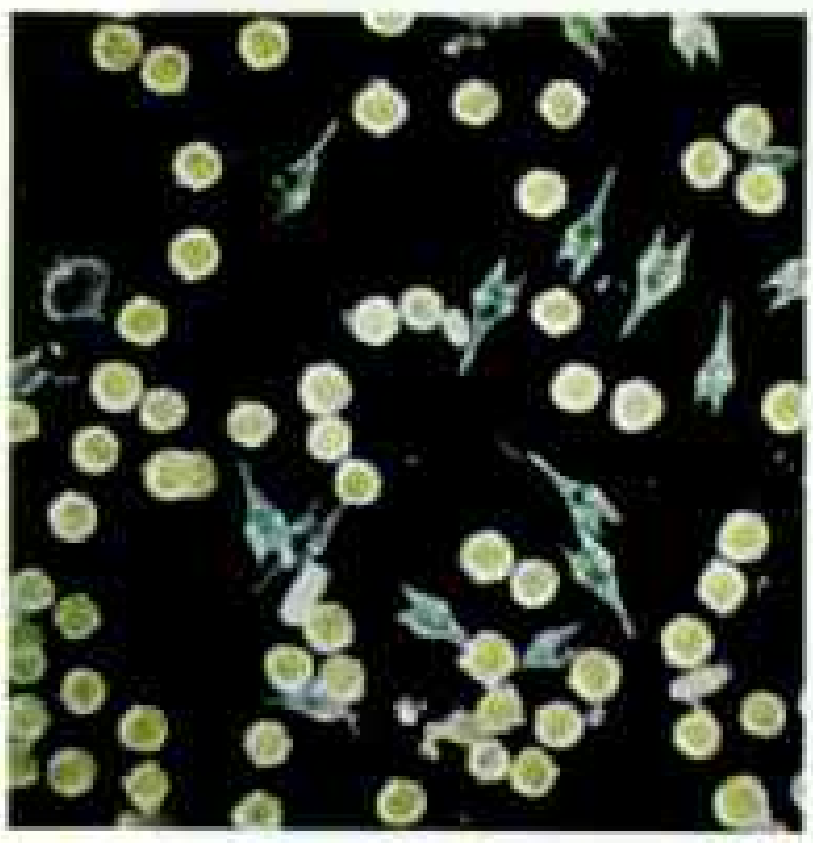
Firefly luminescence involves energy-laden molecules of adenosine triphosphate—ATP—a compound found in all living cells.† Recent experiments have indicated that cancerous cells contain less ATP than healthy ones, and thus produce a less intense light when combined with extract from firefly lanterns. Scientists believe that firefly chemicals may someday become important tools in the detection of the disease.

The ancients, too, were impressed with bioluminescence. Nearly 2,300 years ago Aristotle wrote: "... some things, though they are not in their nature fire nor any species of fire,

*A National Geographic Society research grant supported Darwin L. Tiemann's study of this fascinating creature, which he described in "Nature's Toy Train, the Railroad Worm" in the July 1970 GEOGRAPHIC.

†See Frederick G. Vosburgh's "Torchbearers of the Twilight," in the May 1951 GEOGRAPHIC.

BRUSHSTROKE SKETCH AND WATERCOLOR BY PAUL A. ZAHL © N.G.S.



BIG TIMES LIFE-SIZE

Unmasked by a microscope, Phosphorescent Bay's dominant light producers (*Pyrodinium bahamense*) glisten as yellowish single-celled orbs. They swarm amid other irregularly shaped dinoflagellates. *Pyrodinium*, like plants, possess chlorophyll but can propel themselves by flailing two threadlike tails.

Phantom sailor on a star-dust sea, a boatman churns a wake of fire in Puerto Rico's famed Phosphorescent Bay. His outboard motor, agitating micro-organisms that teem in the almost landlocked bay (**below**), stirs it into a maelstrom of luminescence.

Brilliant buttons adorn scaly vests of *Vinciguerria*, inch-long denizens of Mediterranean depths. Minute reflectors direct the lights' glow downward. With light-producing organs called photophores, hosts of marine fishes glimmer in abyssal darkness, possibly to identify themselves to others of their species, to signal danger, or to attract prey.

yet seem to produce light." Others noted with awe how the sea would glow during certain seasons, or flash when disturbed by an oar or by winds. They of course could not have known that "sea fire" is produced by minute living organisms.

For centuries men ascribed magical or sacred powers to tree trunks that shone at night without being consumed, unaware that the cold "fire" came from bacteria or fungi growing within the rotting wood. Scientists have identified several dozen luminous species among the fungi (pages 60-61).

Smallest among luminous organisms are certain species of bacteria about 1/20,000th of an inch in diameter. Growth of such bacteria sometimes causes a rotting fish, a piece of old meat, or a dead caterpillar to glow. Tales of glowing corpses on a battlefield could only be based on the presence of luminous bacteria growing on the decaying skin.

Certain noninjurious bacteria, cultured in special organs, light up some squids and fish. Others produce their own light. Among invertebrates, luminescent marine creatures also include shrimp, jellyfish, sea pens, comb jellies, worms, mollusks, tunicates, hydroids, protozoans, and dinoflagellates.

The last, in particular, can be spectacular. I recall a voyage I made as a college student many years ago from Ketchikan, Alaska, south through Queen Charlotte Sound to Bellingham, Washington. The vessel was a small salmon-fishing boat; it was mid-July and the sea was rough. I became violently seasick in the middle of the night and lunged from my bunk onto the deck.

Ill though I was, I shall never forget the spectacular blaze on the crest of each breaking wave. The cause of this was a concentration of luminous single-celled dinoflagellates no bigger than needle points. Now in midsummer, they had reached the peak of their "bloom." Generally found in coastal waters rather than on the high seas, trillions of these minute gleamers were uniting to produce the amazingly fiery effect.

Tiny Organisms Light Up a Bay

Even smaller dinoflagellates can light up the sea. One of the most spectacular, *Pyrodinium,* swarms year round in a 60-acre bay near Parguera, Puerto Rico, on the island's southwest coast. Here on a moonless night the wake of a boat burns so brightly that the inlet has been named Bahia Fosforescente—Phosphorescent Bay. Reach overboard, cup a handful of water, and your palm fairly dazzles. Fish dash away through the water, leaving cometlike trails (page 51).*

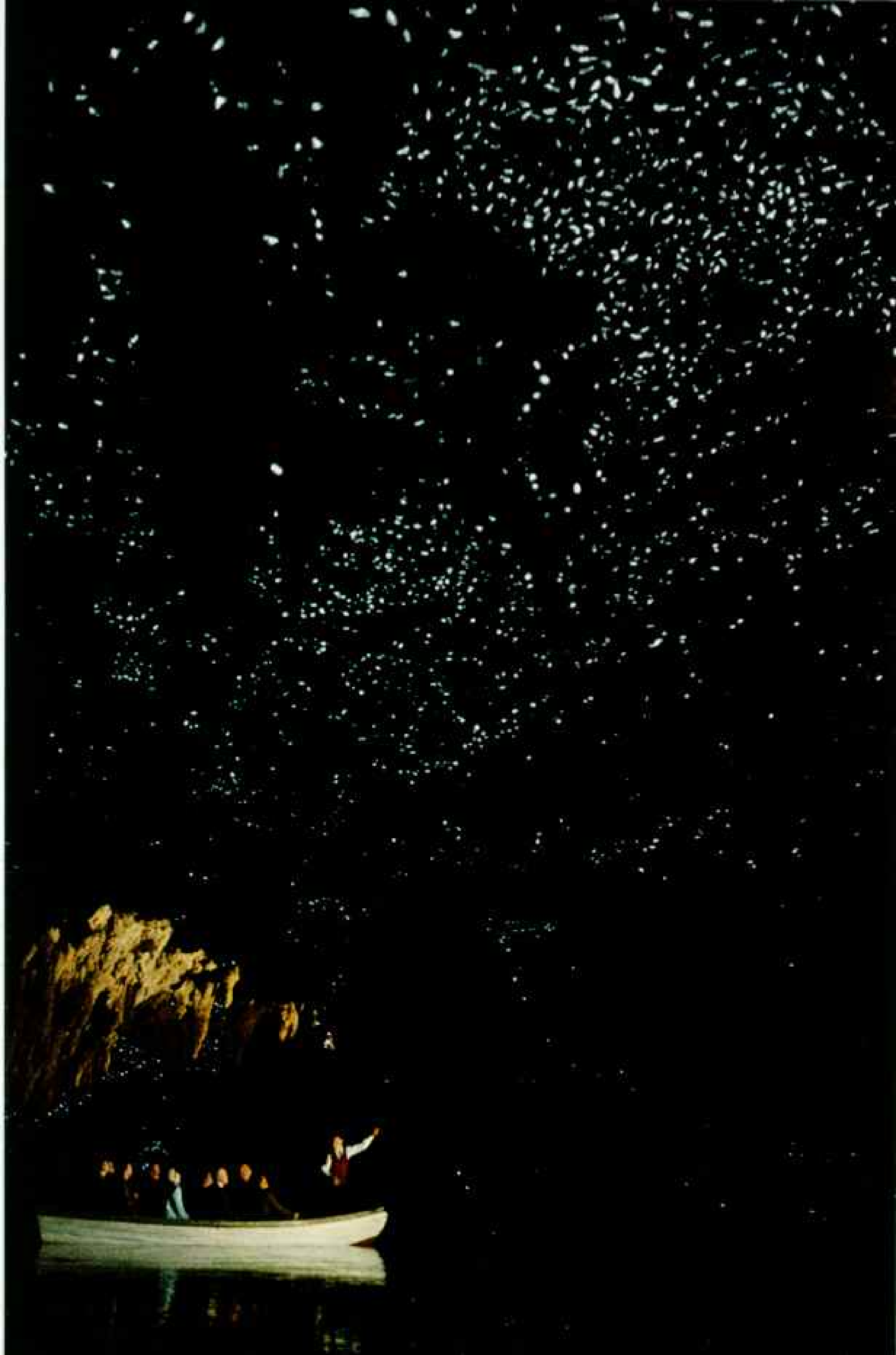
Columbus, on his first trip to the New World, saw in Bahamian seas "a candle in motion," as he described it. This was possibly the marine fireworm *Odontosyllis,* whose ability to manufacture heatless light actually serves to preserve the species.

A few days after the full moon, especially during the summer months, the female of this inch-long worm breaks out of her burrow in the coral and rises to the surface, glowing brightly. It is reasonably well established that her glow attracts the male, whose pursuit triggers frenzied circling on the part of the female and the release of eggs in a luminously visible wake. The male, in turn, emits his sperm-bearing fluids into this bright cloud of eggs.

Some years ago, while working at the University of Hawaii's Coconut Island Marine Laboratory, I met author and biologist Dr. Frank Johnson of Princeton University, an authority on bioluminescence. Frequently during their summer-long stay, he and his wife Mary would set out at low tide to collect

Paired belly lights beam from *Argyropelecus,* which dwells in quarter-mile depths of the Mediterranean. Among the vertebrates, only fishes luminesce.

*Puerto Rico's Phosphorescent Bay was described and photographed in the author's July 1960 NATIONAL GEOGRAPHIC article, "Sailing a Sea of Fire."



tiny reef dwellers suspected of being luminescent. They would deposit their chock-full buckets in a workroom equipped with a bewilderingly complicated set of electronic gear.

"Watch the dial," he told me on one occasion, as he slipped a small chunk of coral into a box totally sealed from light. Immediately the needle on the dial moved.

"But corals aren't luminescent," I said, somewhat puzzled.

"You're right," Professor Johnson replied, "but tiny hydroids inhabiting the corals are. The amount of light they give off is not easily perceptible to your eyes and mine. But a photomultiplier tube can pick it up and allow us to measure its intensity quite accurately."

Experts Ponder Varied Theories

Light intensity and wavelength, which determines color, are of interest to researchers studying the action of enzymes. Other scientists simply want to know which species produce light. This involves exhaustive collecting, surveying, and classifying.

Then there are researchers who ponder the value of self-created light to the organism. This is a more difficult problem that continues to stump the experts. Function appears to vary widely from species to species, and in some cases the luminescence seems purely fortuitous. The value of its own light to a luminous marine microbe milling among myriads of its nearly identical brothers, or to a mushroom glowing in the dark, is not easily understood.

It has been suggested that deep-sea fishes use their luminous organs as searchlights in the black depths of the sea. But there are other reasonable theories: help in keeping schools together, attraction of prey, identification and courtship, escape. Why one species possesses light-producing equipment while another very closely related species does not is still a mystery. Equally perplexing is the extreme rarity of luminescence among fresh-water forms of life.

Recently I visited New Zealand, where dramatic displays of luminescence lure tourists to the famed Waitomo Caves, a hundred miles south of Auckland. I could not resist making my first inspection as one of a group of visitors who, led by a guide, were filing through a cliffside doorway.

As the guide turned on lights ahead, we proceeded along a winding path, then down two flights of concrete steps to a wide boardwalk. The guide switched on another series of floodlights illuminating scores of stalactites and other formations, which imagination easily turned into elephant heads, crouching lions, organ pipes, and cathedral spires.

We were led slowly through dimly lighted underground corridors. The human eye needs about twenty minutes to become fully adapted to the dark, and now we were being paced to allow for this.

Heavens Above—and Reflected Below

At one point we stopped on a platform overlooking a pool of black water that disappeared into pitch darkness. "Watch the ceiling above the water while I turn off the switch," the guide directed in hushed tones. At that moment the limestone ceiling five or six feet above the water shone with hundreds of blue-white scintillas, each a New Zealand glowworm, *Arachnocampa luminosa*. Their reflections shimmered gently in the pool. It was like seeing heaven both above and below.

"Now watch the spot of my torch," the guide whispered, sweeping a narrow beam across the spangled ceiling. Instantly the stars

Living galaxy shimmers above a boatload of visitors in New Zealand's Waitomo Caves. The glowworm, actually the larva of the fly *Arachnocampa luminosa*, clings to the ceiling in a tubular transparent home (**right,** life-size). Restlessly moving about, it leaves a beaded light trail in this time exposure.

The famed glowworms lure so many visitors that a hotel flourishes near the cavern entrance on the North Island. Here a guide cautions utter silence, for noise might cause the insects to quench their lights.

Glowing with a purpose, Waitomo's worms use their lights to lure the cave's flying insects into their snares, which are as ingenious as a spider's. Secreting a sticky substance, the larvae extrude it in threadlike fishing lines (**left**); one worm may dangle 70 such threads. Attracting prey with their lights, the glowworms trap the victims with the strands, then reel them in and devour them.

A worm in its tube home (**below left**) poises above a catch—a winged adult of its own species. Threads radiating from the tube suspend the fisherman's home from the grotto ceiling.

Snarled in another line, a hapless fly (**below**) dangles on a strand, at the mercy of its hungry captor.

Though best known as residents of Waitomo's renowned caves, the glowworms abound throughout New Zealand in caverns, under bridges, and even amid ferns in damp ravines.

KODACHROMES, BOTH 4 TIMES LIFE SIZE, BY PAUL A. ZAHL © N.G.S.

disappeared, and thousands of silken threads became visible. Since there was no perceptible air current, they hung straight down in lengths ranging to about twenty inches, each beaded with pearly droplets that glistened in the beam of the torch. They made up a sticky veil deadly as a spider's web to midges and other small flying insects attracted by the glowworms' lights. As many as seventy such strands have been known to dangle from a single worm's nest (preceding pages).

Noise or Light Turns Off Shy Larvae

We moved on to another section of the cavern. "Ladies and gentlemen," the guide announced, still in a whisper, "we are about to enter the main grotto. I must request that all conversation cease and that we move in utmost silence. The slightest noise tends to disturb the glowworms, causing their lights to diminish or go out entirely."

We followed to a dimly lit wharf where a flat-bottomed boat sat on the ebony water. An aide joined our guide, and the two silently helped us board. The aide untied the line and with a gentle shove eased the boat out into the jet-black unknown.

The silence and darkness were total. Our guide, now standing unseen on the bow, caught hold of a cable fixed along a wall of the grotto and pulled us, hand over hand, until I sensed we were turning a corner.

At that moment we were aware of great space overhead, a dome softly brilliant with thousands of lights. No flickers, flashes, flares, or sparkles; just steady wondrous stars in a subterranean firmament, like the heavens on a clear night in the desert—except that these stars were packed together and only 40 feet above us (page 54).

Like each of my 19 companions, I was hypnotized. Odes were being composed, no doubt, and "oh's" and "ah's" breathed—but soundlessly. Not a word, not even from the guide. The spectacle spoke for itself.

We crept along the edge of the silent sea for perhaps five long minutes, then turned for the trip back.

Waitomo actually consists of three caves, including the one with the major grotto. They underlie a bucolic valley contoured with green sheep-grazed hills, accented with rows and clusters of Lombardy poplars, and slashed with ravines jungled with giant ferns. The clean beauty of the valley and a stay at the pleasant Waitomo Hotel are in themselves worth the visit.

I returned to the grotto repeatedly to take pictures. The cave management has a trust to guard, and hence wisely rules against any activity that may disturb the glowworms. But I really needed to get closer to my subject, so I called on Ian Stringer, a 25-year-old graduate student in biology at the University of Waikato, in Hamilton, who for some years had been studying the *Arachnocampa*.

"Many foreign visitors think these glowworms exist only at Waitomo," he said, "but

actually they are found all over New Zealand —in the bush, on highway embankments, under bridges, in scores of other caves, and in any damp and sheltered place. I've kept specimens for months in plaster of Paris 'caves' down in my cellar."

Ian joined me for a few days of field work. Our first stop was a cave near the village of Waipu, about 65 miles north of Auckland. We parked at the edge of a cow pasture, pulled on rubber boots and checked our flashlights, then made off to an opening on a hill slope. We moved into gloom, then darkness, as we followed a slippery trail along a winding stream. Here and there we waded, but mostly we skidded on the stream's muddy banks.

Smaller Cave Makes Close-ups Easy

Finally we came to a pool opening into a grotto not nearly as extensive as Waitomo's, but starry with the little light producers. The effect was charming rather than magnificent. With many of the larvae fastened at eye level, close-up observation was easy.

While Ian wandered off on his own, I focused on a single larva, whose light quickly went off in response to my flashlight. Both the tube which the worm occupied and the creature's skin were so transparent that I could make out the inhabitant's internal organs. This tubular nest extended horizontally about two and a half times the length of the inch-long tenant and was roomy enough to allow it to glide back and forth on an inner lining

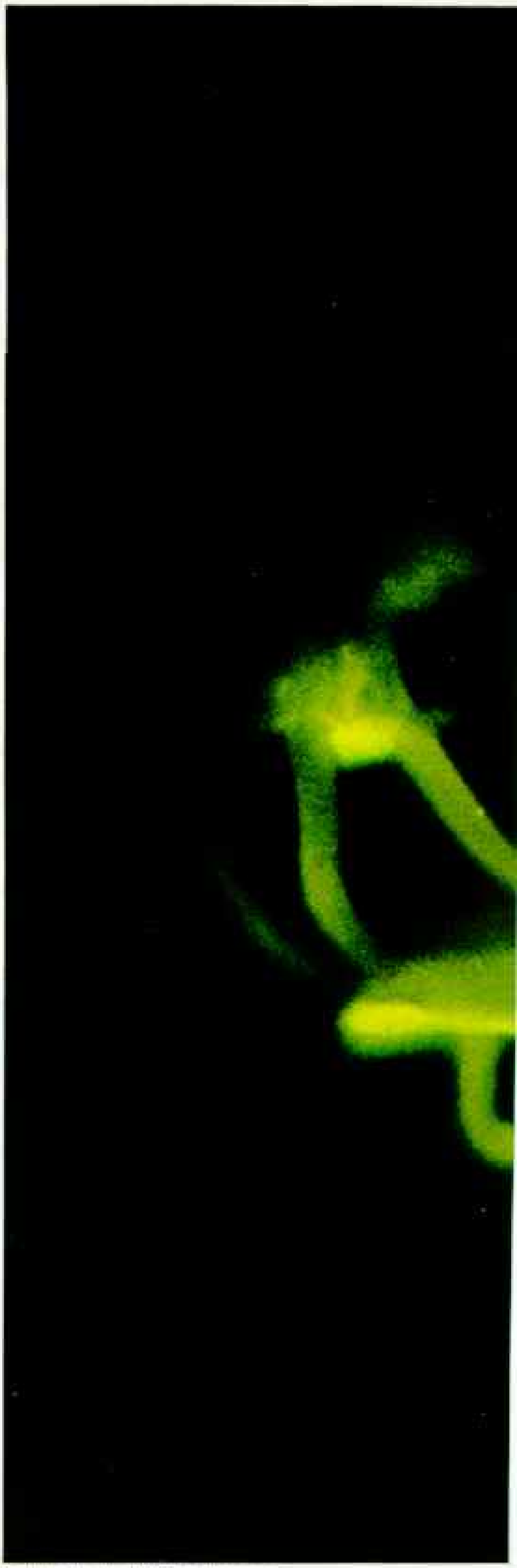
Fireflies yield pocket money at Oak Ridge, Tennessee, where *Photinus pyralis* abounds. Pursuing the familiar creatures with nets (**left**), expert foragers may capture as many as 250 an evening; a collector (**below**) eyes her catch.

Each morning the youngsters market their fireflies (**above**), which the buyer will freeze in dry ice and air express to Johns Hopkins University in Baltimore, Maryland, where scientists probe the mysteries of bioluminescence.

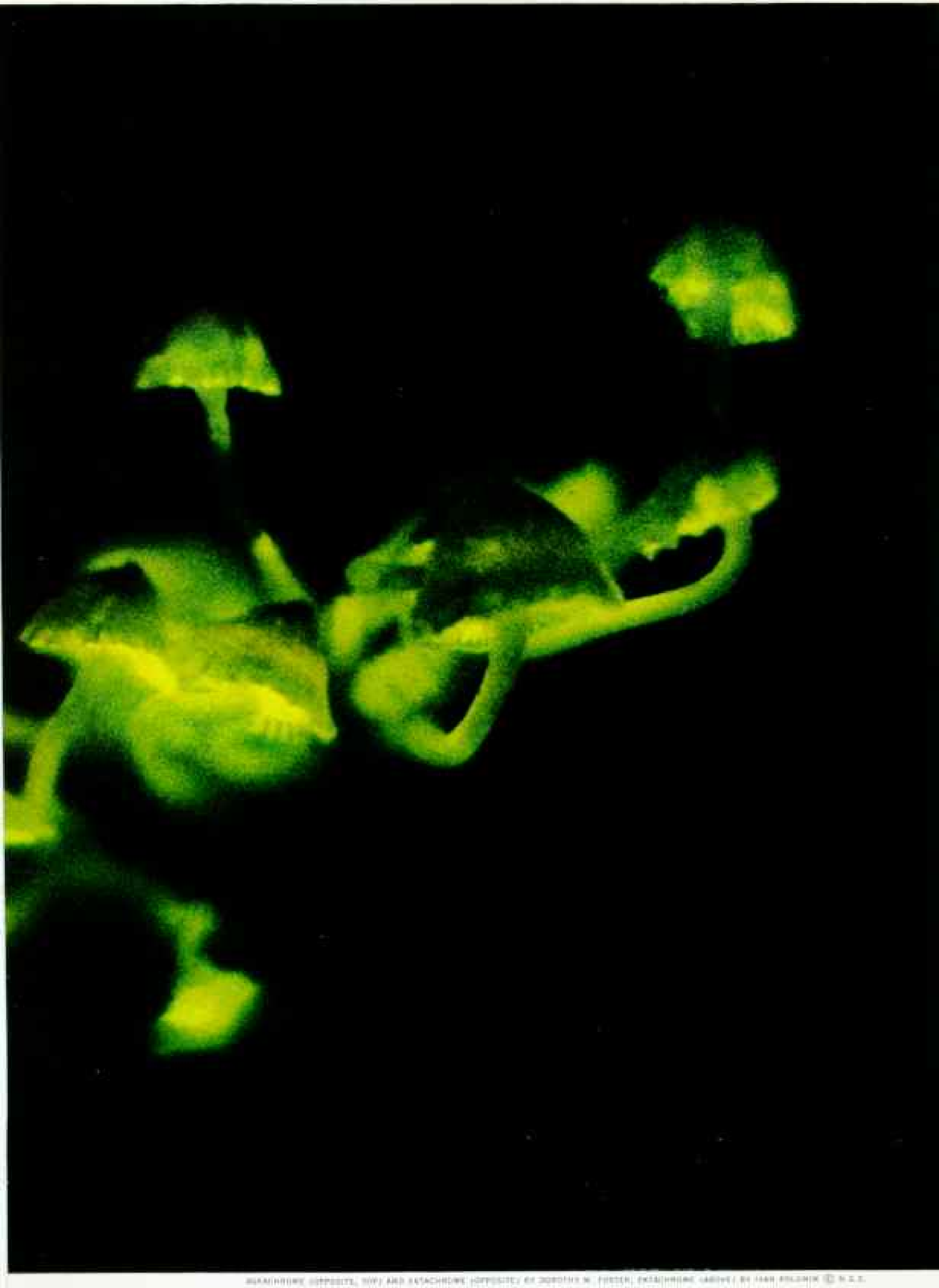
Pleurotus lampas, ½ LIFE-SIZE (TOP)

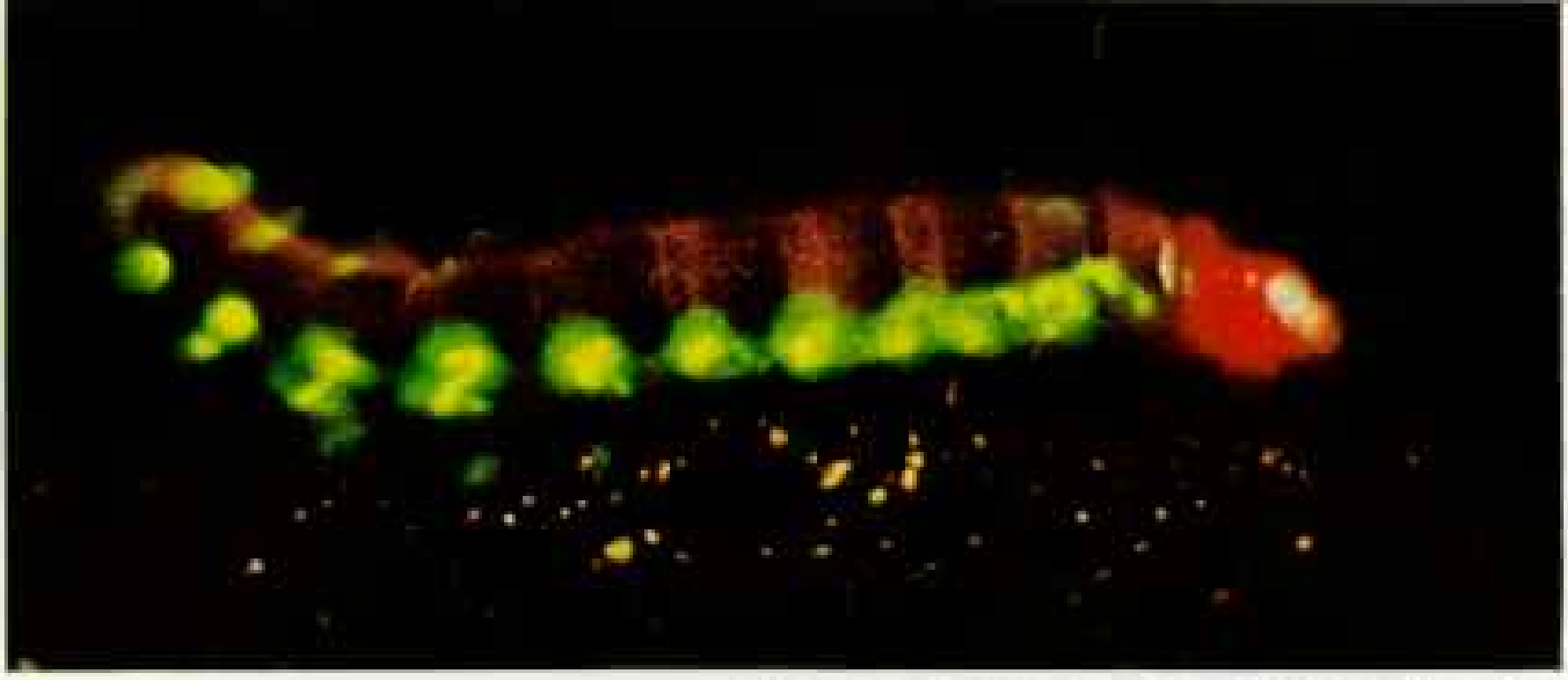
Bizarre mushrooms, photographed by day (**top**) and then after dark (**lower**), emit enough light to record their shapes on film. Numerous species of light-producing fungi and bacteria glimmer in damp, shadowy nooks around the world. To luminesce, plants probably use the B vitamin riboflavin. Scientists are uncertain of the light's biological function.

Candelabra of the forest night, graceful mushrooms hide their "light bulbs" under greenish "lampshades." This species, photographed in Borneo, was visible at 40 yards.



Pterenyctina manipularis, 4 TIMES LIFE-SIZE





Smoldering "headlight" and gleaming "windows" give a name to the railroad worm of Central and South America. Inch-and-a-half-long *Phrixothrix tiemanni* is one of the few insects known to emit red light.

Fare for biologists rather than for gourmets, a platter of shrimp and fish glows eerily. To study luminous bacteria, scientists inoculated the raw seafood with *Photobacterium phosphoreum*, which quickly multiplied by the billion. Related single-celled organisms often glow naturally in rotting wood. It would take 50 trillion such bacteria, each about 1/20,000th of an inch across, to generate one candlepower of light.

Photograph without a camera: Western banded glowworms (*Zarhipis integripennis*, shown 2½ times life-size) writhe on a sheet of color film, making their own portrait. This species and the related railroad worm, each equipped with 11 pairs of body lanterns, turn on their garish flares only when aroused, as if to warn or bluff intruders.

of mucus (page 55). Upon arriving at one end of the tube, the larva would fold back on itself and slide in the opposite direction.

A dozen or more exceedingly fine silken threads held the tube fast to the ledge. I counted 18 fishing lines hanging down from this larval case, each strung with pearls of deadly glue.

When a victim becomes entangled, the worm bites a hole in the tube, seizes the line with mandibles and minute ventral bristles, and draws it up by successive waves of the body muscles. The worm bites its prey to quiet its thrashing, then eats it.

Glowworms hatch 22 days after the adult female deposits about 130 eggs on a dark or shady moist surface, I remembered from a report published by Dr. A. M. Richards. The larval stage is the feeding and growing portion of the insect's life cycle and lasts for almost a year, the length of the period probably depending on the abundance of food.

The larva next changes into a pupa the size of a large grain of rice. The pupal case hangs from ceiling or ledge by one silky thread, remaining thus for about two weeks. Finally the adult emerges—a fragile long-legged fly. The female measures about half an inch from head to tail with a slightly longer wingspread; the male is a bit smaller.

Male Waits Patiently for Emerging Mate

Ian, who had been searching the cave for adults, suddenly called to me in a stage whisper. "Something you should see," he said as I waded to his side shin-deep in water. "The male of the species waiting for a mate!"

There in a crack in the cave wall was a mosquitolike insect, absolutely still, clinging to a pupal case. A female heavy with eggs bulged within the case.

"It's not rare," Ian added, "to see several males waiting for one adult female to emerge. Sometimes after mating and egg laying, the weakened adults get caught in the feeding lines, by which they're drawn up to be eaten by the larvae."

Adults are seldom seen by the casual visitor to Waitomo, not only because the observer is too far away, but also because the mature insects are so small. Furthermore, their days are numbered—probably no more than three or four, even if they succeed in avoiding those lethal pearls.

By now the intensity of our beams had caused most of the grotto's larvae to extinguish their lights, and it was time to go.

PHOTOGRAPHS BY CHARLES A. JOHNSON © N.G.S.

Radiant "sea fireflies" spill from three thimbles. Tiny crustaceans the size of tomato seeds, *Cypridina hilgendorfii* teem in sandy shallows off Japan, secreting a luminous fluid which they discharge when disturbed. Clustered around a pair of darning needles (**below right**), dried *Cypridina* wear transparent shells. They fluoresce in the ultraviolet light used to make this photograph.

Another phase of my bioluminescence field work took me to Japan. There Dr. Yata Haneda, a noted specialist on the subject and Director of the Yokosuka City Museum, accompanied me on a field trip in search of *Cypridina*, a crustacean of the order Ostracoda, about the size of a tomato seed, with tiny swimming legs at one end. It lives in the sand of shallow seas along many parts of the Japanese coast.

One moonless night Dr. Haneda and I, in the company of a rather ancient fisherwoman, plodded to the end of a creaky old pier at Tateyama, about 50 miles south of Tokyo. The woman carried two buckets, one empty, the other full of smelly fish heads. In the light of our flashlights, she looped twine around one of the heads, then tossed it off the pier where the water was about fifteen feet deep.

She kept up a running conversation with Dr. Haneda, who translated for me. The fish head now lay on the bottom, we were assured, and the smell, so delicious, would surely tempt the little fellows. Out of the sand they would squirm, moved by only one impulse—to gorge on the fleshy source of that divine scent.

The old woman continued to talk for

BLACK AND WHITE BY JAMES L. STANFIELD (ABOVE); PHOTOGRAPHS BY PAUL A. ZAHL © N.G.S.

Moisten dried *Cypridina*, then gently rub them in your hand, and they glow as if once again alive. During World War II, the Japanese harvested these creatures by the gallon for soldiers to use when reading maps and messages at night. Here a hand smeared with *Cypridina* and cupped over a National Geographic map lights Iwo Jima, one of the Pacific war's bloodiest battlegrounds.

several minutes, then drew up the cord slowly, in order not to dislodge what looked like tiny stars studding the surface of the bait. A few fell off on the way up, and, darting back to the bottom, released delicate trails of a luminous secretion that gave them the appearance of shooting stars.

Sea Creatures' Light Undimmed by Death

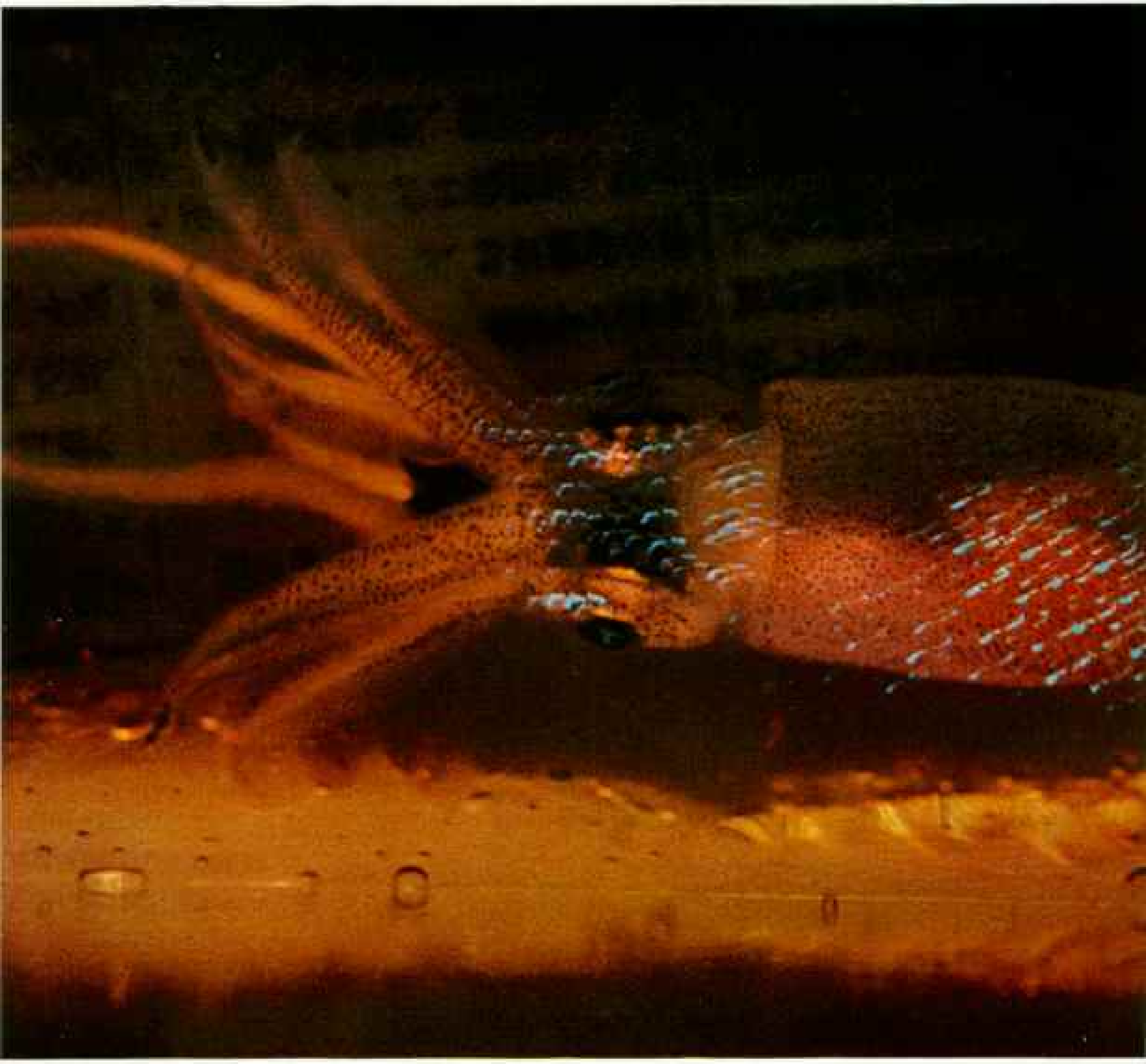
Our fisherwoman rested the glittering bait only briefly on the pier, then lowered it carefully into the other bucket, now full of sea water. Up and down, up and down, she rinsed the head to wash off several score *Cypridina* still clinging fast. With each rinse the bucket's interior flared, and soon lights quivered on the bottom like diamonds on showcase velvet.

Fishing for *Cypridina*, Dr. Haneda told me, was once encouraged in Japan, especially during World War II; then Japanese soldiers used the creature's low-intensity light in jungle warfare for map reading. This was possible because the tiny crustaceans, even when dead and dried, retain their luminous capabilities.

Before my visit to Japan I had purchased dried *Cypridina* from a biological supply company in the United States. They came in a small plastic vial, showing no light whatever, even in the dark. But when I poured a few of the kernels onto the palm of my hand, added a drop of water, and rubbed them with the other palm in order to break the fragile outer shells, both my palms glowed with a strange, unearthly light (below, left). These specimens, which might have been sitting on the shelf of the supply company for years, showed how amazingly stable were *Cypridina's* light-generating chemicals.

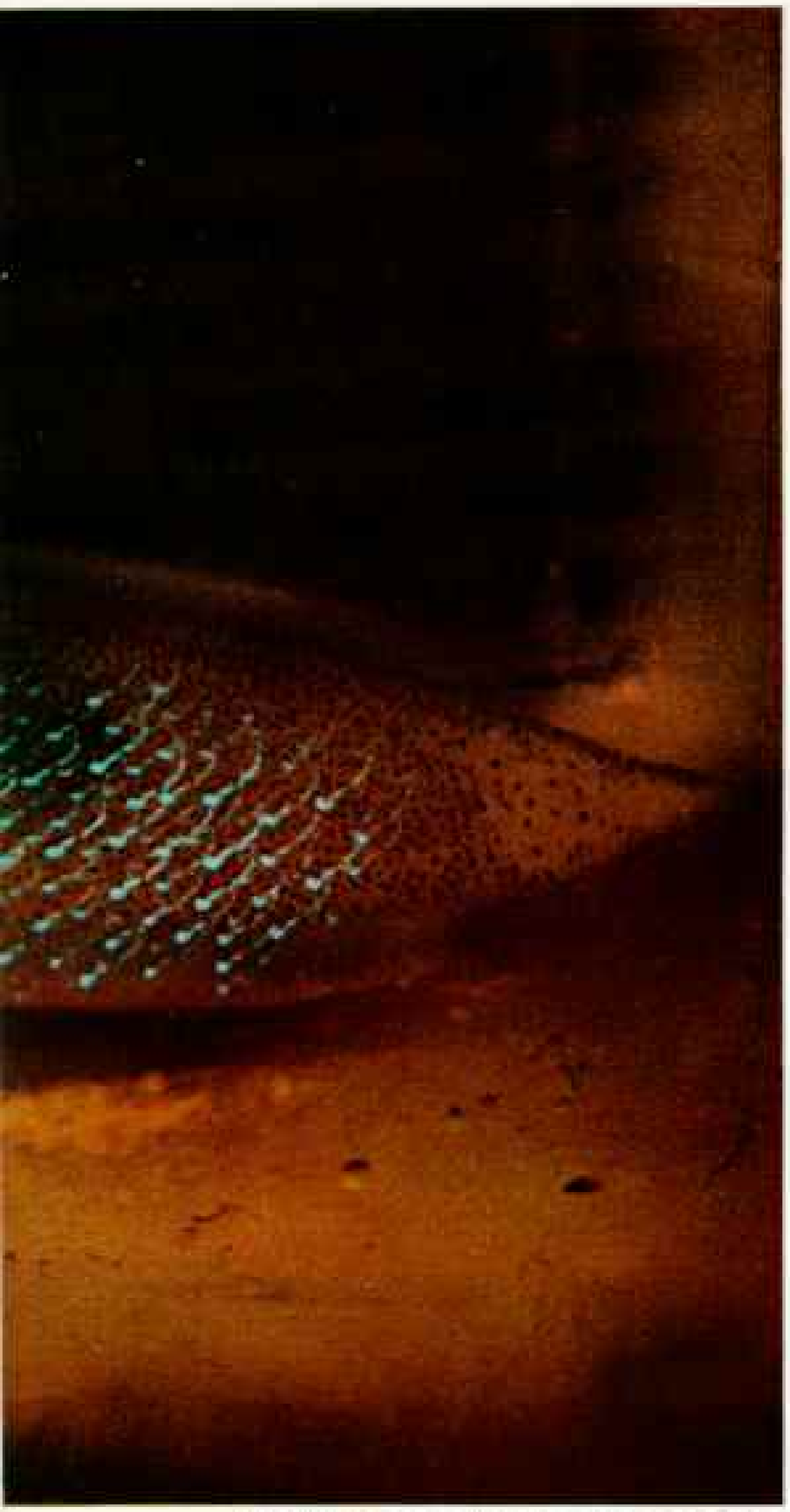
"But you haven't seen anything yet," claimed Takashi Shimoda. He and his brother Yutaka, both in their twenties, were particularly helpful during a visit I made to the Japanese west coast. "Tonight we will show you some squid that make light."

The species—called *Hotaru-ika* in Japanese and *Watasenia scintillans* in Latin—is the seasonal pride and profit of fishing towns along the shores of Toyama Bay. There, for a brief period each spring, billions of these finger-long members of the squid family swirl up from the depths to breed near the surface (following pages). They are set upon by local fishermen who, during several weeks from late April into June, ignore every other sea crop to harvest a virtually self-delivered



Jeweled pin studded with blue diamonds, a Japanese squid *(Watasenia scintillans)* glitters with photophores. A light triggered at the end of this time exposure reveals the animal's body.

Diadems of bright photophores adorn *Watasenia*'s eyes (**left**). When netted, the squid shrivel, leaving their eyes grotesquely extended (**right**).



EXTACHROME (ABOVE) AND KODACHROMES BY PAUL A. ZAHL © N.G.S.

bounty. Netted ton upon ton, the small squid are eaten locally—boiled, fried, broiled, sun-dried, or salted—and in larger amounts end their careers on gourmets' tables in distant Tokyo, Osaka, and Yokohama.

It was about seven that evening in April when the Shimoda brothers and I arrived at the seaside town of Namerikawa. Already so many automobiles had gathered that it took us half an hour to find a parking place. Hundreds of people milled about, each carrying a dip net. Pushing and jostling like suburbanites in a Tokyo railroad station, the crowd good-naturedly eased toward a barrier near the edge of the wharf, where they purchased tickets to go aboard any of several beamy flat-bottomed boats. These were about thirty feet long and festively rigged out with Japanese lanterns.

Gleeful Fishermen Net Sparkling Prizes

An attendant opened the barrier, and the crowd piled into the craft—men, women, and children, forty or more into each. One by one the boats were towed out into the gloomy bay, where a barge with a dozen or more rubber-aproned men on board lay at anchor a quarter of a mile offshore. Our boat and two of the others formed a sort of square with the barge, hemming in a great net previously set and about to be lifted. I thought our boat would capsize any minute, for the passengers had rushed to one side in a body and were leaning out over the gunwale as far as possible for positions of best advantage, dip nets at the ready.

Shouts of glee went up as luminous squid began to appear near the surface within the slowly rising mesh. Dozens of dip nets swept down as everyone sought to catch the sparkling creatures, now swirling and shooting through the surface water like torpedoes (following pages). First one, then another and another of the little nets would swish up with five or ten glittering beauties. Excited comments accompanied the maneuvers, rising to a forte when a dozen or more nets would break water simultaneously, to be shaken and swirled aloft like Fourth of July sparklers. Included in the price of admission was the right to keep whatever squid one caught.

On a subsequent night, from fishermen farther out in the bay, I obtained live specimens for close-up observation. I placed them in tanks of running sea water provided by Akira Sakashita, Director of the nearby Uozu City Aquarium. I sat in a darkened room and

waited for my eyes to adapt, while the squid accustomed themselves to their new surroundings.

Feeling like a William Beebe, half a mile down in a bathysphere and gazing through a porthole into the blackness of an abyss, I became aware of a torpedo shape easing through the water. It gleamed with scores of tiny blue-white lights. I tapped the glass and a flash of almost blinding intensity surged from the tips of the creature's two main arms. These flashes were immeasurably brighter than the steady lights on the squid's body (below). Like two ignited match heads, they glowed for an instant, then faded away.

Many Mysteries Remain to Be Solved

Other squid in the tank became more active, revealing the outlines of their jewel-studded bodies and occasionally flashing their two stronger lights. Aptly, the Japanese biologist Shozaburo Watasé, whose name the creatures bear, described their light as "stars in heaven. . . . a sunbeam shot through a tiny hole in a window curtain."

But the stars were short-lived; in less than 15 minutes their intensity waned. Although many attempts have been made, rarely has one of these migrants from the deep been kept alive in a surface aquarium for more than a few hours.

This is only one of the many mysteries surrounding these and all the other organisms that light nature's nights with their cold fire. As in so many other endeavors, the more we learn, the more there is to learn.

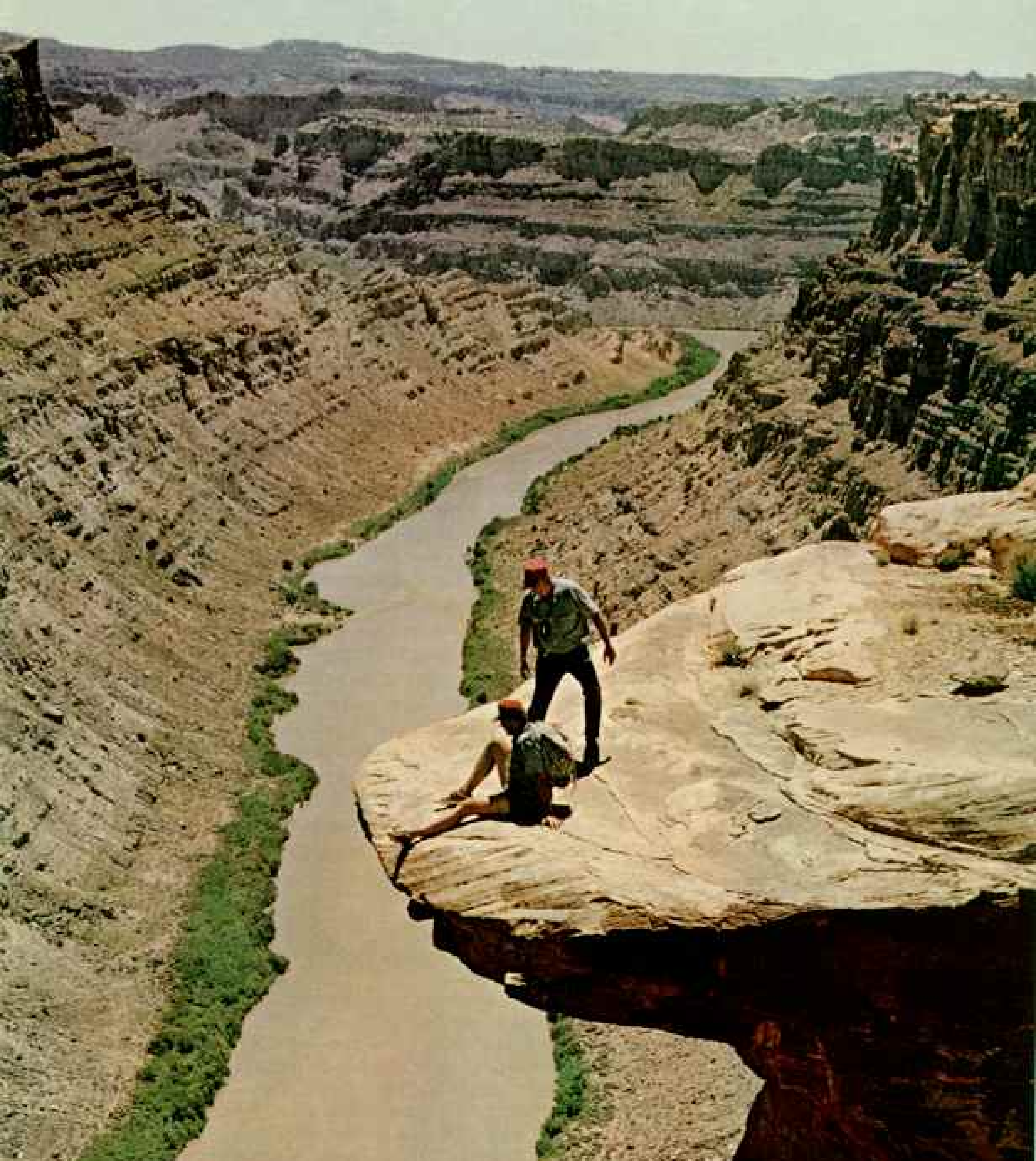
Some day, when the intricacies of bioluminescence are fully understood, it is conceivable that cold light will brighten our homes and cities, provide a safe source of illumination in tunnels and mines, and serve with peerless efficiency in spacecraft piercing the black unknown of outer space.

Pending that future day, we must admit that nature is still far ahead of us. □

Nearly capsizing their boat as they crowd the rail, amateur fishermen dip squid from Japan's Toyama Bay. Nets laden with the bright cephalopods weave lacy trails of blue. The harvesters will eat their catch dried, fried, or broiled.

For scientists, the abundant light organs of *Watasenia* (**below**) and other squid species provide exciting food for study. Their complex lanterns sometimes come equipped not only with lenses and reflectors but also with membranes that switch them on and off; some can even change color.

EXTACHROMES BY PAUL A. ZAHL © N.G.S.



Realm of Rock and the Far Horizon

Canyonlands

By ROWE FINDLEY

PHOTOGRAPHS BY

WALTER MEAYERS EDWARDS

BOTH NATIONAL GEOGRAPHIC STAFF

TUGBOAT VANISHED before my eyes, a sure-footed packhorse and all our pots and pans gone rattling over the cliff.

But it was just a trick of the Utah terrain. The only pack trail into Horse Canyon looked like a leap into space until I got right on top of it. Then I could see the notch in the overhanging white rim, and below that the switchbacks looping down the boulder-choked slope to the canyon floor.

"No one rides this stretch of trail," packtrain master Art Ekker said. I gladly slid off a quarter horse named Buck and watched him drop from sight through the notch.

The Horse Canyon trail snakes for five miles into a labyrinth of rust-red, off-white, and cream-striped chasms called the Maze (following pages and map, page 74), a place of pristine solitude and mysterious ancient pictographs that flanks Canyonlands National Park in southeast Utah.

Now, just below the notch in the rim of the cliff, Tugboat had run into trouble. Two other horses—eyes wild and ears twitching—edged him toward the brink of a trailside ledge and a 200-yard plunge. Art's son A. C. Ekker soothed the frightened animals, praised them, got them safely off the ledge and down the switchbacks with the other horses.

Down into the dust their hard hoofs raised, we hoofless humans clambered, a party of nine led by Lorin J. Welker, district chief of the Bureau of Land Management, and his wife Eva. On the canyon floor we mounted our horses and strung out along the dry wash, past stream-bed dunes laced with lizard trails and signatures of the wind—swirling grooves traced by breeze-blown stems of grass.

Such packtrain trips are commonplace in Canyonlands country, where most roads ultimately turn into dubious trails, and travelers have frequent need of jeeps, horses, and their own two feet. Because the Green and Colorado Rivers meet in the heart of the park, the area also draws hundreds of boaters. To sample their experience I bucked through

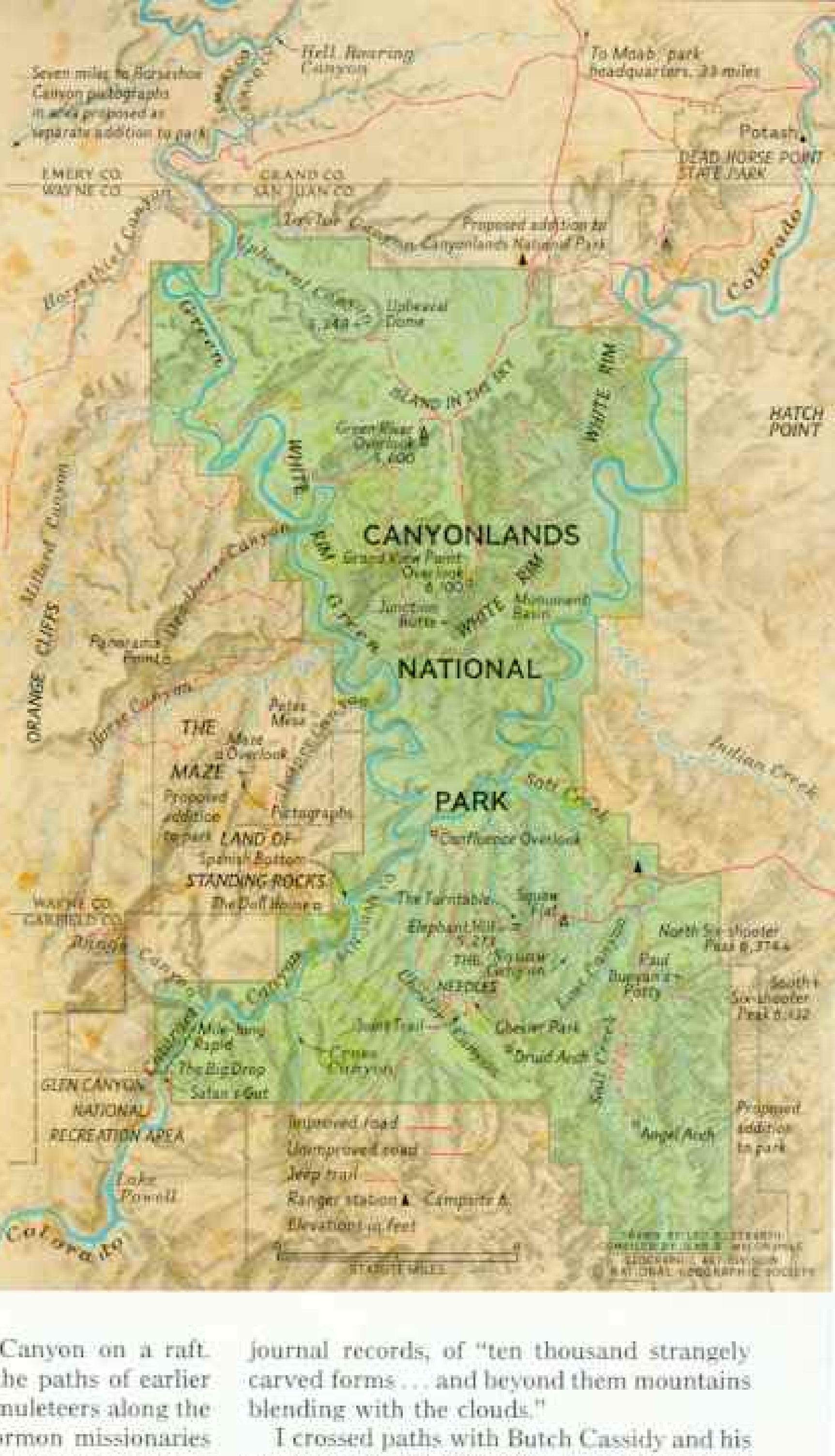
Balcony in space rewards climbers with a breath-catching view of the Colorado River, a quarter of a mile below, surging through Canyonlands National Park in southeast Utah. On his epic 1869 descent of the river, Maj. John Wesley Powell gazed over this wilderness of rocks and exclaimed: "What a world of grandeur is spread before us!" The downstream vista looks toward a bend at Spanish Bottom—supposed ford of Spanish muleteers—where Cataract Canyon's thundering rapids begin.

Thirty-square-mile puzzle in sandstone, the Maze crinkles the landscape with swirling chasms hundreds of feet deep (following pages). No roads enter the labyrinth, site of a gallery of prehistoric pictographs (page 83) and part of a proposed 100-square-mile addition to Canyonlands Park. Hardy visitors go in by clambering and roping down the rock, or by following a tortuous horse trail.

CANYONLANDS NATIONAL PARK

"MOST UP-AND-DOWN terrain in the world," says a geologist of Canyonlands' rugged heart—roadless except for a few crude jeep trails. The Colorado and Green Rivers, cutting awesome, winding chasms, carved the park's dizzying vertical geography.

AREA: 257,640 acres. **HISTORY:** Prehistoric Indians, Spanish and Mexican colonists, and U. S. pioneers knew the area in turn but left little imprint. A uranium rush of the 1950's threatened but did not destroy its solitudes. Congress made it a park in 1964. **CLIMATE:** High, dry desert, with annual rainfall of 5-10 inches. Average summer daily high and low, 92° and 59° F.; winter, 44° and 21° F. **FACILITIES:** Only two roads suitable for passenger cars enter the park's fringes, to Island in the Sky, a lofty mesa, and Squaw Flat. Campsites are few and primitive.



the Colorado's Cataract Canyon on a raft.

Everywhere I crossed the paths of earlier travelers—of padres and muleteers along the Old Spanish Trail, of Mormon missionaries and ranchers, of mountain men and explorers.

I crossed the trail of Capt. John N. Macomb, who in 1859 viewed the confluence of the rivers from a lofty overlook, but saw no way to descend into their deep-shadowed gorges. "I cannot conceive of a more worthless and impractical region," he said. A decade later one-armed Maj. John Wesley Powell solved the descent problem by boating down the Green. At the confluence he scaled a 1,200-foot butte and gazed out on a rock world, his journal records, of "ten thousand strangely carved forms . . . and beyond them mountains blending with the clouds."

I crossed paths with Butch Cassidy and his Wild Bunch, who robbed turn-of-the-century trains and banks with blasting powder and good humor, and with those wild uranium hunters of just 18 years ago, who filed claims that totaled three times the area of San Juan County, in which most of Canyonlands lies.

But this Maze trip was special. We climbed over sandy hillocks and found ourselves in cactus gardens abloom in lavenders, limes, and creams. Stone shapes like stetsons, boots, and Indian heads loomed on our skyline.

I was in a rock world, and I knew from an earlier visit with Dr. William Lee Stokes, Professor of Geology at the University of Utah, that it was virtually all sandstone. "Even the Arabian Peninsula can't match this country for quantity of sand, though most of it here is stabilized in stone," Dr. Stokes said. "Winds and rains dump the loose sand into canyons, and the rivers carry it downstream, keeping this basin from becoming a mass of dunes."

His geological imagery kept coming back to me, and now in Horse Canyon I suddenly saw the monolithic sandstone all around me as separate bits, attached to each other, grain by grain, in the time frame of the infinite.

Through the day Tugboat straggled far back, cropping the Indian ricegrass and overtaking us now and then at a clanging trot.

"Good old Tugboat," said A. C. "Nothing spooks him. That's why he carries the pots and pans."

But when it came time to camp, and the other horses were glad to shed packs in a grove of cottonwoods, Tugboat rattle-banged around in wide circles. At last A. C., on steady Senator Dan, lassoed Tugboat, showing us a bit of the roping style that helped win him the National Intercollegiate Rodeo Association title of All-Around Cowboy in 1967.

Soon Bates Wilson, Superintendent of Canyonlands Park and volunteer chef for our trek, was digging a fire pit, while his wife Robin unpacked the pots and pans and cousin Austin King gathered dry juniper bark for tinder. We feasted on steak as the last sunlight fled a high pillar of cloud.

Pictographs Reflect a Lost Way of Life

Next dawn my GEOGRAPHIC colleague "Toppy" Edwards had his photographic gear packed for an early start to the pictographs. While the others broke camp, he and I rode ahead up a winding chasm, entertained by the cadenzas of canyon wrens. Just when I was convinced we had taken a wrong turn, we rounded a bend and faced the huge pictographs on a sandstone wall.

In ancient inks of brown and ocher and black and white, an army of figures, some with shieldlike bodies, stood in ghostly array. There were desert sheep, flitting birds, and scurrying rodentlike animals.

But taking the eye from all other figures was a six-foot man with raised right hand, one finger giving root to a graceful tree, full as a spring-fed cottonwood. A tree of life?

"Nobody knows for sure," Bates told me as our party overtook us. "But these artists had imagination—and an eye for realism. Look."

His finger outlined a crouching figure on the stone, holding a pair of sticks (page 83, lower), and a similar figure nearby, wielding a sickle. From a talk I'd had earlier with Dr. Dean R. Brimhall, retired professor and government official-turned-archeologist, I knew the significance: These were the Maze's famed harvesters—the reaper with the sickle, the seed beater with the sticks—pictorial proof of prehistoric gathering of wild grain in the area. This picture gallery, together with a panel of towering figures in Horseshoe Canyon, 20 miles to the northwest (pages 82-83), would become part of Canyonlands Park under a bill before Congress.

Legend Clouds the Cassidy Saga

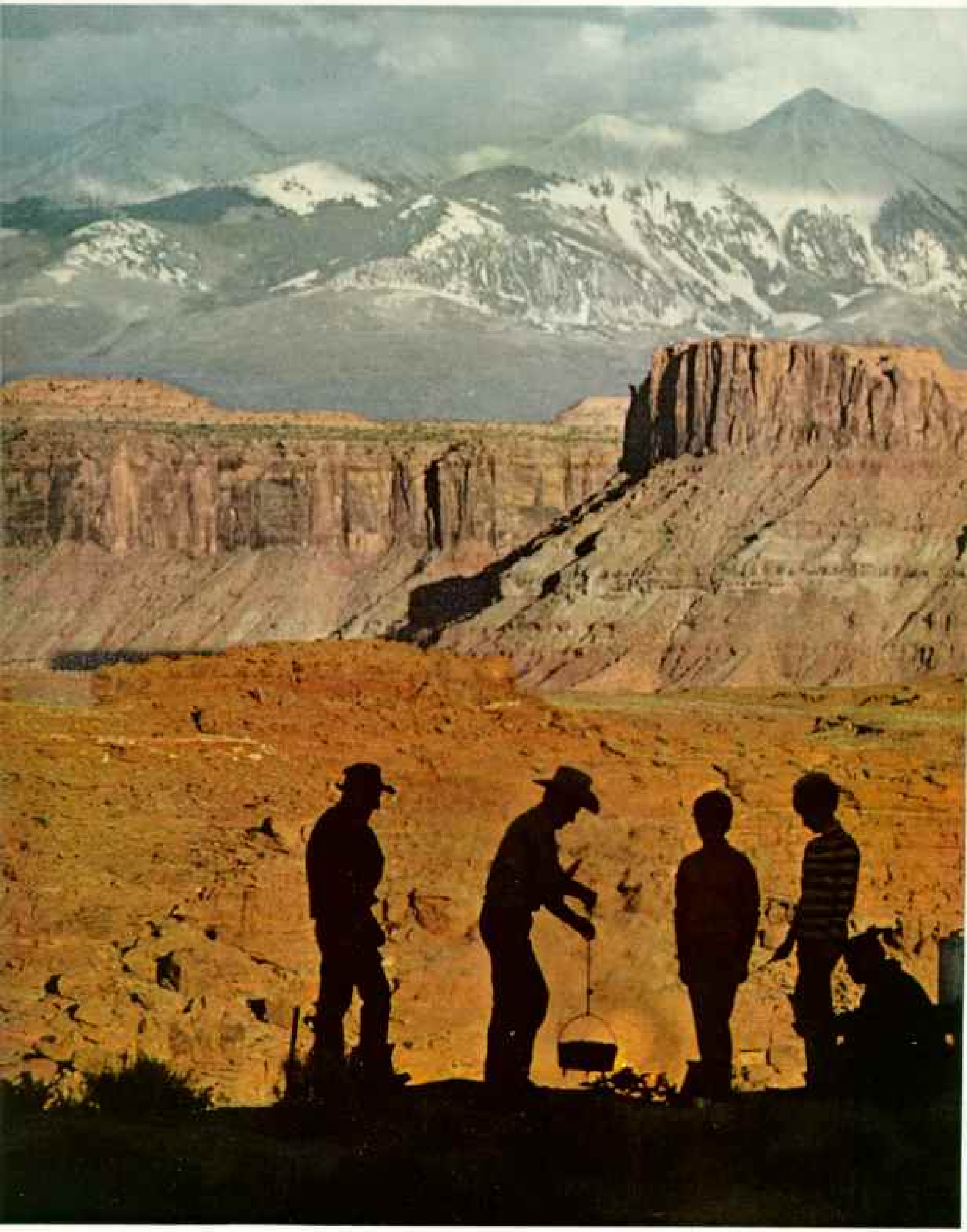
Almost everywhere I went in southeast Utah, I crossed the tracks of Butch Cassidy, rustler of cattle, blaster of railway express cars, bad gambler, and good guy. How he managed to fill all these roles is part fact, part legend, and laced through with a spirit of fun that tends to obscure the wrong that he did.

Not even Art Ekker, whose Robbers Roost Ranch is named for the fact that it encloses Butch's former hideout, could filter out the fiction for me. As he put it, "The hot-air merchants got too much of a head start."

On our way to the Maze, Art detoured us to Robbers Roost Draw, a red-rock ravine with a slow-dripping spring where Butch Cassidy and his Wild Bunch hid out.

Butch was born Robert LeRoy Parker in 1866 into a respected Mormon family, and grew up on a ranch near Circleville, Utah. But as a teen-ager he found his hero in a hell-bent cowboy called Mike Cassidy, who taught him a fast draw and how to rustle cattle. One night Mike left—some say to Mexico to avoid a jail cell—but Bob had found his life-style and a new last name. He picked up the "Butch" elsewhere along the way.

The law in southeastern Utah had shallow roots in those days, and in the Robbers Roost country it had no roots at all. Zealous sheriffs hounded many a man into this redoubt of desperadoes. Elzy Lay, Silvertip, the Sundance Kid, and the murderous Kid Curry—all funneled here, and gradually they learned to let Butch mastermind their crimes.



White as the salt that inspired their name, the 12,000-foot La Sal Mountains begin to don autumn caps of snow. Spanish explorers christened the peaks in acknowledgment of the vast saline deposits that underlie the area.

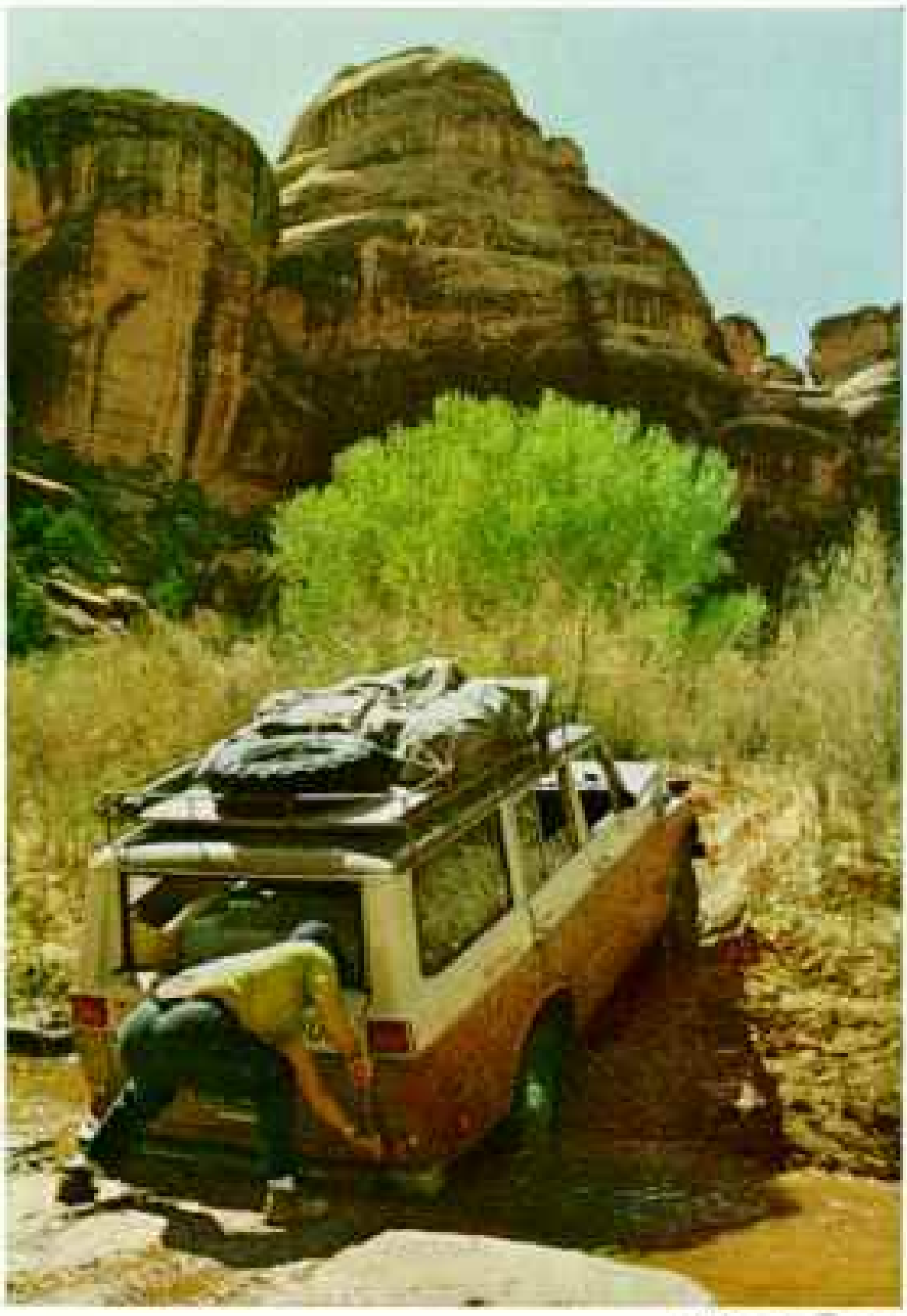
EXTACHROME © NATIONAL GEOGRAPHIC SOCIETY

Between these campers, silhouetted at suppertime, and the distant red-rock plateau called Hatch Point, lies the Colorado River, locked in the windings of the awesome gorge that it cut as the land gradually rose through the eons.

Measuring a mighty pillar (right) in Monument Basin, whose stone spires have never been surveyed, hikers let out a line attached to a helium-filled balloon. A dead calm favored their project. The column's height: 305 feet.

Grotto with a skylight (far right) shelters the snaggled ruins of cliff dwellings. The Anasazi, or Ancient Ones, tilled corn in the valley below and retreated to the heights at night. Whether fleeing enemies or a prolonged and widespread drought, they disappeared from Utah by about 1300. This canyon, near Salt Creek, also shows evidence of disastrous flash floods at that time. Visitors today know the huge alcove as Paul Bunyan's Potty.

The price of solitude: digging out of a gravelly ford on Salt Creek (below), with pockets of quicksand as added hazards. Travelers who risk such obstacles find reward in a winding, watered canyon dappled with the generous shade of cottonwoods and studded with the abandoned cliff homes of the Anasazi.



One evening when I was comfortably full of Art Ekker's "flour-sack biscuits" (mixed right in the sack without a bowl and baked in a Dutch oven), we lingered by the fire to talk about Butch, how people saw him as a sagebrush Robin Hood, whose bold holdups infuriated rail barons, whose thoughtful acts toward common folk won him many friends.

"Occasionally a rancher around here would find he had traded horses during the night with Butch and his boys," Art said. "The gang would wear out their own horses hightailing it from the law, and stop at his corral for fresh ones. If the horses they left weren't as good as they took, they'd trade back again later, or the rancher would receive some money to make up the difference."

There is a story that Butch took the time while fleeing with the $8,800 Castle Gate coal mines payroll to return a borrowed horse and pay a bar bill, and that during that same flight he stopped off at a dance in Hanksville and whirled a few reels with the ladies.

But finally the law did come to southeastern Utah, and Butch went to South America, accompanied by the Sundance Kid and an ex-schoolteacher named Etta Place. The robbing was good for a while, but at last a resolute band of Bolivian cavalry surrounded Butch and the Kid and cut them down.

At least, that's one story. Another has it that they somehow slipped away from this bloody trap and that Butch ultimately got back to the United States. Butch had become a legend, and legends are hard to kill.

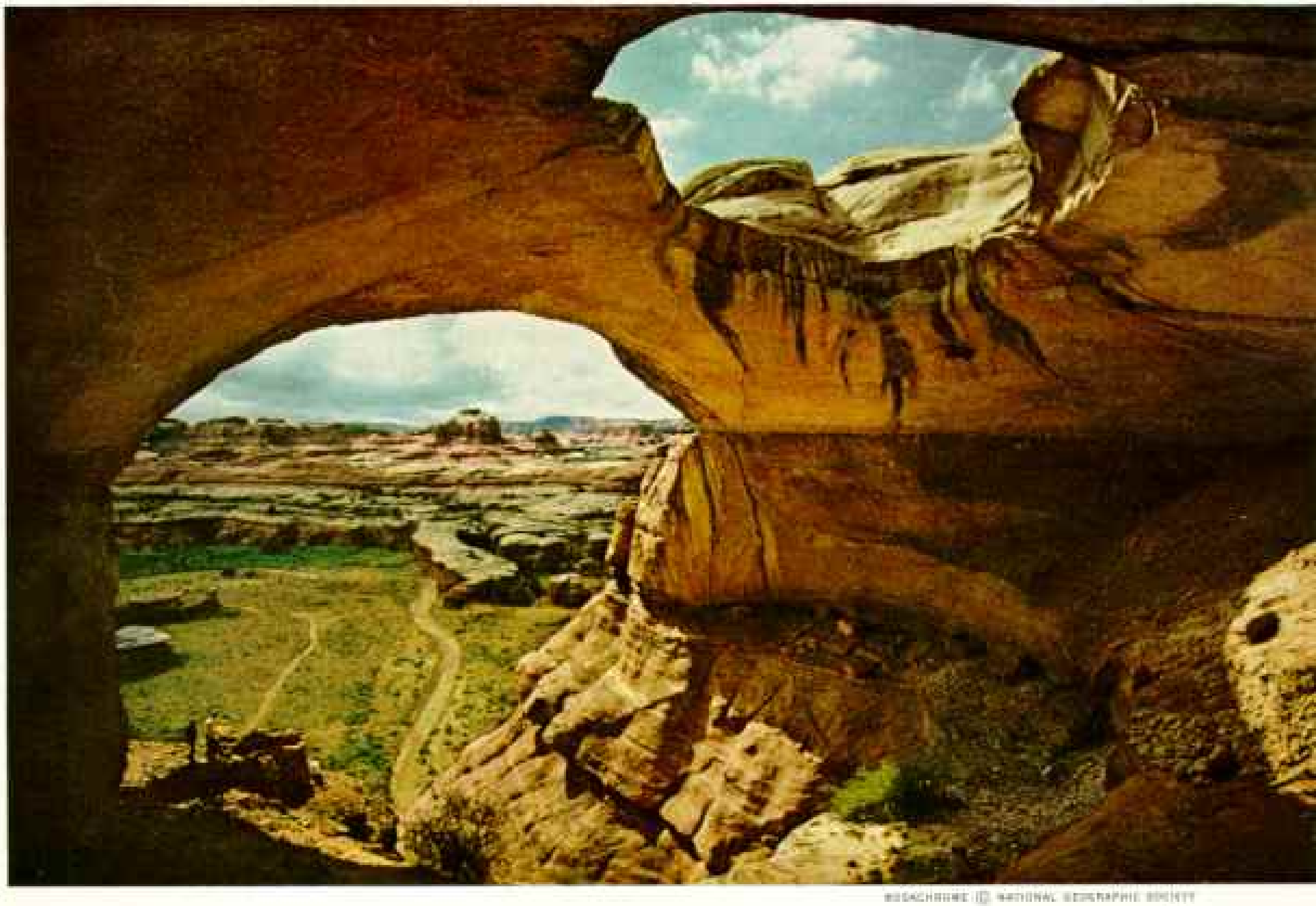
The part of the legend that gives Art the most trouble has to do with buried loot.

"A lot of people are sure that Butch and his gang buried some money around Robbers Roost," Art told me. "Every so often somebody turns up with a map or a metal detector and wants to start digging. They've found a lot of rusty tin cans and old horseshoes."

Camp Chef Proves His Skill in a Blizzard

Art's ranch operation and Bates Wilson's style in running Canyonlands Park bore certain similarities, and the coincidence was not surprising in view of Bates's New Mexico ranch boyhood. His workaday outfit often includes faded jeans and scuffed boots, his drawl and easy smile mask a fierce resolve on behalf of wild things and wild places.

While serving as Superintendent of nearby



Arches National Monument in the 1950's, Bates advocated a new park to protect the grandeur of the confluence country. When Congress made it a park in 1964, Bates was a natural to run it. He still runs Arches, too.

But if Bates had no other talents, his campfire cooking should win him fame. I became his booster during an April field trip with the park's advisory board of scientists. A driving wet snowstorm caught us in high piñon and juniper country at dusk, and Bates wheeled our jeep caravan into a wind-blunting hollow. Soon his fires made the Dutch ovens rattle and steam. Then through the swirling flakes came his cry of "Chiniago!"—from a Navajo word for "Come and get it!"

Gullet-warming coffee . . . sliced potatoes . . . blistering-hot biscuits. And as I held out my plate for beef, he asked me: "Rare, medium, or well done?" He's the only camp chef I know who can offer that choice in a blizzard.

Dune Buggy Conquers Elephant Hill

A traffic jam on Canyonlands' jeep tracks requires only two vehicles, especially if they meet on Elephant Hill, a mile of stone stairs that lead into the Needles, a forest of skyscraper-size stone spires.

Mitch Williams of Moab was piloting me down the steepest part of the hill in his four-wheel-drive station wagon when he abruptly turned off the trail. A dune buggy bounded past us up the slope like a grasshopper on roller skates, its oversize tires biting more sky than earth. The ruddy-faced driver, in his seventies, I judged, hunched close to the wheel, elbows straight out, wearing a smile of bliss.

Partisans of four-wheel drive regard Elephant Hill as their own. Dune buggies lack the traction and low-gearing to climb over it at a sane crawl. They must get up momentum, jeopardizing clutches, axles, and tires.

We didn't expect the resolute dune-buggy driver to make it, and stood ready to give him help and sympathy. But we swallowed our condolences as he rammed and skittered and hopscotched over the crest and out of sight.

And though veteran guides like Mitch question his prudence, they do not question the exhilaration he got from triumphing over such topography. In fact, Mitch himself resents each battle lost to the guardrail and the gentle grade. As we inched along one of Elephant Hill's switchbacks onto a rock turnaround shelf called the Turntable, Mitch pointed to sizable boulders placed near the brink to prevent a plunge should brakes fail. "Chicken rocks," snorted Mitch. "Somebody always wants to take the fun out of things."

Uranium Rush Makes Moab Boom

Back in Moab, home base for my Canyonlands wanderings, I paused on the eastern outskirts and found the city dump marring an otherwise splendid view of the snow-covered La Sal Mountains.

"But Moab doesn't have an unscenic spot for a dump," a friend told me. He's right.

The first settlers found the scenery marred by unfriendly Indians. Mormon missionaries in the 1850's failed to convert the Utes, and were driven out of their Elk Mountain Mission. About 1875 other Mormons came from Salt Lake City, their New Jerusalem, and founded Moab as a ranching and farming center, like the Old Testament Moab a "far country" on the edge of Zion.

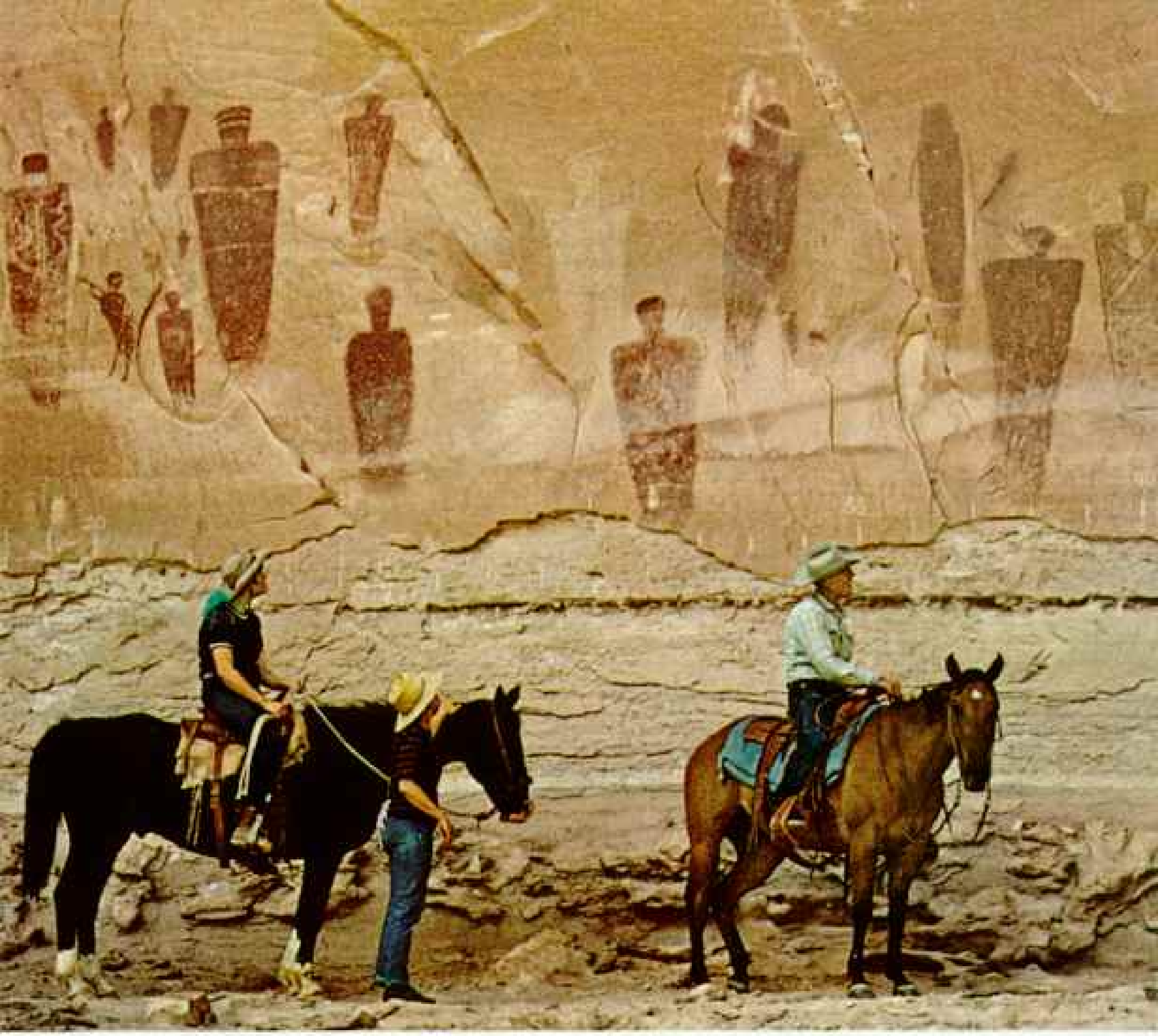
Moab became a pleasant cluster of stores, houses, peach orchards, and alfalfa fields beside the Colorado, complacent with its few hundred souls—until pandemonium struck in the early 1950's. Charlie Steen, a down-on-his-luck oil geologist, triggered it all in 1952 by discovering his famous Mi Vida Mine, a 60-million-dollar bonanza in uranium.

"This town went crazy," uranium buyer and mine owner Howard Balsley told me. "People lived in tents, cars, barns, and caves. You had to get in line to buy a meal or cash a check, and at times the general delivery line at the post office wound for half a block."

The lure of sudden wealth skyrocketed the population to 5,500.

"Moab became the 'city of millionaires,'" Mr. Balsley said. "We were supposed to have more millionaires per capita than any place in the world. One report put the number at 20, with me among them." He chuckled at the recollection. "I never did know more than three or four, and I wasn't one of them."

Profile reminiscent of Stonehenge gives a name to Druid Arch, whose 360-foot height dwarfs a human viewer. No one knows exactly how many natural arches bulk against the horizons of Canyonlands country; a young journalist from Moab, Utah, who investigates them as a hobby, has tallied 150.



Ore seekers blanketed the country with claims, sometimes staking the same ground three or four deep. Speculators fattened; mining companies proliferated. Trading and prices of stocks outran comprehension.

Ore output caught up with demand by the late 1950's, and the boom tapered off. Some oil wells and a big potash mine helped take up the slack, but Moab lost about a thousand of its swollen population—and the fever edge of its faith in instant fortunes.

Upheaval Dome Resembles a Moonscape

Every property owner in Moab would be a millionaire if salt became dear, for only 300 feet or so of alluvial deposits separate their basements from solid salt.

A salt deposit as big as Maryland and as much as two-and-a-half miles thick underlies southeast Utah and part of Colorado, a legacy of landlocked seas. Lighter than the rock above it and like putty under pressure, the salt rises into faults or other weakened areas, warping the surface upward. Where subsurface water invades the salt, it dissolves, letting the surface drop. The vast cracks in the surface make it vulnerable to the erosive forces of sun, wind, rain, and the two great rivers, creating the land's fantasies in stone. Thousands of columns, spires, buttes, arches, alcoves, and headstanding stones pepper the map with curious names—the Doll House, Angel Arch, Six-shooter Peaks, Paul Bunyan's Potty (page 79), Land of Standing Rocks.

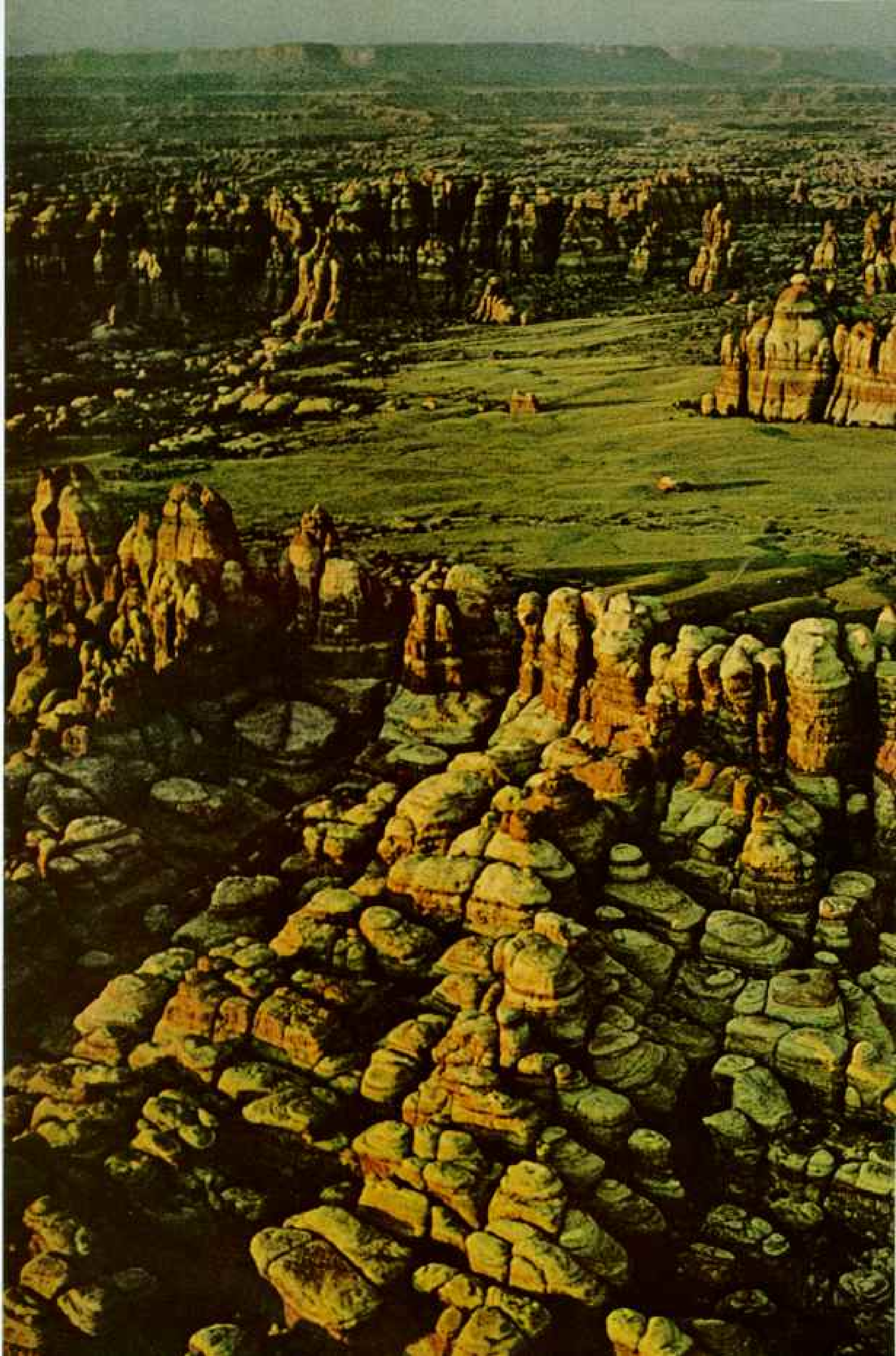
Salt in fact is responsible for Moab's valley; welling up along a fault, it lifted and fractured the surface. The salt later receded, leaving a vast sheer-walled trench.

But the salt's most awesome creation is a three-mile-wide bull's-eye called Upheaval Dome. "Some scientists thought it was a meteor crater," Dr. Richard B. Mattox told me.

ROCK ENSEMBLES (INCLUDING FOLLOWING PAGES) © N.G.S.

Who were they? Little-known Indians painted a host of ghostly figures on a sandstone wall of Horseshoe Canyon perhaps a thousand years ago; a copyist added the chalk marks for scale in 1940. In the Maze, a stooping harvester (**left**) wields seed beaters, providing pictorial evidence of the reaping of wild grains by prehistoric bands west of the Colorado. Upraised hand gives root to a "tree of life." These picture panels would be included in the proposed enlarged park.

Pocket of rangeland in a world of rock, vast Chesler Park lured early cattlemen and bears a rancher's name. Spires called the Needles, some towering almost 500 feet, surround the 2,000-acre cow pasture (following pages).



Professor of Geology at Texas Tech University in Lubbock, Dr. Mattox has been studying Upheaval and similar salt structures since 1958. With him, his son Richard, and state parks board member Ed Claus of Moab, Toppy Edwards and I drove 40 miles west of town, then hiked up an ovenlike canyon and into the tortured heart of the dome, a sunken geological garble that made us feel we had somehow stepped onto the moon (pages 88-9).

Dr. Mattox's hand swept the surrounding walls of red cliffs towering 1,000 feet above us. "See the curves in their strata? That means warping under tremendous pressures. There's not enough shattering to support the meteor theory."

The warping thrust came from below, from a huge column of salt pushing upward into an area of weakness, bulging the surface into a mountain that cracked open and eroded into a crater of concentric stone strata, their jagged edges twisted upward. Hence the three-dimensional bull's-eye effect.

The central monument in this big hole is a lofty stone stiletto that stands within two degrees of the vertical.

"That's a piece of the White Rim, a sandstone formation that's generally about 1,800 feet lower than it is here," Dr. Mattox said. "And it usually lies horizontal."

Aquatic Life Thrives in the Desert

In another part of this rock country, I found Steve Romney, a doctoral candidate at the University of Utah, taking samples of the water in potholes for a census of the life they support. I peered into the pothole that held Steve's attention, and gradually was made aware of community upon community of life:

Beetles to the extent of 12 genera and 15 species, including some fast-moving ones called whirligigs that zipped in dizzying circles; a couple of species of mosquito larvae; three forms of waterbugs; and fairy shrimp, tadpole shrimp (page 89), water fleas, Mayflies, several species of gnat larvae. . . .

"Almost every time we check our potholes, we discover a new form," Steve said. "I think we'll find that the food chains here are like those in the sea, with algae as the basis. If you doom the algae, you doom everything. In a small pothole, a bar of soap might do it, or a cigarette butt. The balance is delicate."

Some of the pools are permanent, Steve said, fed by springs, but others fill only when it rains; yet even the temporary pools teem with life. Most forms survive in the egg stage, for months and maybe years. But others—the little gnat larvae and pupae—simply dry out in a brown, dusty crust on the dry rock until new rains refill the pothole. Then that brown crust begins to part and wriggle, a process that might be labeled "instant life."

Peril Lies in Petaled Beauty

If you come to Canyonlands in May, you will seldom be beyond sight and smell of flowers—pale and delicate evening primrose, sweet and yellow hollygrape, fields of globe mallow that stretch away into an orange blur on the horizon. But at least one bloom that caught my eye, a fetching cluster of purple, carried a sinister connotation.

"Locoweed is addictive to livestock, and unless they can be stopped from eating it, it is fatal." Dr. Stanley L. Welsh, Professor of Botany and Range Science at Brigham Young University, told me. "The popular name derives from the Spanish word for 'crazy,' to describe its victims; horses will struggle to find it on their dying legs."

Some locoweed is of the genus *Astragalus*, which has species by the score. Stan has found 20 that are "micro-endemics"—limited to small areas of southeast Utah. As we walked above Millard Canyon one day, he spied one species that prompted a story.

"In the 1880's, a botanist named Marcus Jones rode over Utah on a bicycle, studying plants. He found so many new *Astragalus* species that he ran out of names. Finally, in desperation, he named this one *desperatus*."

One of the most minute forms of terrestrial life here offers tantalizing mysteries. A crumbly dark crust on the desert soil hardly looks alive at all, but it contains half a dozen to a dozen kinds of algae, fungi, lichens, and other minute plants called cryptogams.

"They obviously benefit mutually," Dr. Kimball T. Harper, Associate Professor of Biology at the University of Utah, told me. "But we're just beginning to understand how."

For example, some lichens contain algae that tap the air for nitrogen, that essential part of the life-sustaining proteins and a boon to the nitrogen-poor desert soil. Other algae secrete a sticky sheath that helps cement the crust—and retards erosion.

For my long-time friend Bill Taylor, park naturalist who spearheaded an environmental-education program in the area, this cryptogamic soil exemplifies the fragility of the apparently rugged land.

"One passage by a herd of cattle, or by

human beings, can turn the crust into powder," he said, "leaving it vulnerable to the first windstorm or downpour. After this is explained to visiting school children, they begin tiptoeing whenever they come near it. If we can teach children to tiptoe now, maybe they will tiptoe for the rest of their lives."

The same water power that gouged the Green and Colorado Rivers' deep canyons also sweeps boats along at marvelous velocities, but in an easy and restful way where the brown surface flows velvet smooth.

But many river miles lack the velvet. Just three miles below the confluence, where the Colorado's canyon forms a bowl called Spanish Bottom, a big sign advises: "Warning. Dangerous Rapids. No boating beyond this point without a permit from the Superintendent of Canyonlands National Park."

Here Cataract Canyon begins. Beds of hard limestone and dolomite squeeze the muddy river into a churning sluice that races all the way to Lake Powell. The water boils over dams formed of boulders fallen from sky-high cliffs, of hair-trigger-balanced talus piles, of debris jetted in from side canyons by the incredible force of once-in-a-century superstorms. The result is 20 miles of fluid, frothing stairs that offer as breathtaking a ride as a man could want, especially in a 17-foot-long skittering bubble of a raft (below).

"I hope you enjoy getting wet," Dee Holladay greeted me as I piled my gear on the bank by his raft. I noted that Ron Smith, skipper of our four-raft expedition, wore a waterproof wrist watch and loaded a waterproof camera. Co-skipper Bill Belknap sealed his wallet in plastic. Toppy Edwards's camera cases vanished into a special waterproof hold. We seemed to be rigging for a dive.

Serenity Marks a Raft Trip's Start

But I was reassured as we pushed off from Potash, 12 miles below Moab, into a serene stretch of tamarisk-fringed river and drifted lazily around gooseneck bends.

Granary of a vanished people awaits a harvest that never comes. Marc Smith lifts the flagstone lid of a seven-centuries-old rock-and-adobe bin built by the Anasazi; the author and Loie Belknap Evans peer in. Rafts on the Colorado River, far below, will carry them through the rapids of Cataract Canyon.

Yawning crater of Upheaval Dome, encircled by a rampart of rock, suggested a meteor impact to some geologists. But others found the explanation in the earth far below. Vast salt

Out of the sere desert springs a bright bounty. Mutually beneficial colonies of algae, fungi, mosses, and lichens form a rough dark crust that enriches and preserves the soil supporting these ground-hugging daisies. Some lichens sustain algae that draw nitrogen from the air and deposit the much-needed element in the desert soil. Other algae secrete a substance that helps hold the soil together.

deposits, the residue of ancient seas, pushed upward through weakened rock, forcing the overburden into a dome that cracked and eroded, leaving the craterlike depression.

Tadpole shrimp lives in a water-filled pothole where ground temperatures often exceeding 140° F. dry out the stone cavities and bake them for months or perhaps years. In egg form or as dehydrated larvae or pupae, tiny aquatic creatures survive broiling heat—and winter's freezing cold—then wriggle into vigorous activity when new rains descend. One small pothole may shelter scores of species.

A fat beaver's plopping dive from bankside reminded me of the era of the mountain men who led the way into this land. Near the Green River in Hell Roaring Canyon, I had seen the autograph of one such trapper, pecked into the rock, "D. Julien 1836." I remembered my talk in the town of Green River, Utah, with his modern-day counterpart, "Beaver Bill" Howland, who first went trapping at the age of 15, some sixty years ago, and learned to love the river's freedom and the frontiersman's extravagance of speech: "You think this water is muddy? I've seen it so thick you could track a coyote across it!"

Learning to Like the Taste of Grit

The water under our rafts looked thick enough to hold tracks, and I was surprised to see Dee scoop up a cupful and drink it appreciatively. I was even more surprised to find I liked the taste, grit and all.

"A river man's gizzard gradually fills with sand," Ron told me, "and when he dies, he wills it to another river man, so none of the sand will go to waste."

The merits of this arrangement eluded me, but I forgot it in the discovery that our river experts were preoccupied by another aspect of the river—the amount of water.

Volume is measured in cubic feet per second, and spring snowmelt in the mountains had swollen the flow.

"Some forecasts say it will hit 40,000 cu-secs," said Dee.

"What does that mean?" asked a hesitant member of our party, Marilyn Mitchell. She had been invited by her friend, Loie Belknap Evans, Bill's daughter.

"Above 20,000 we lose all control," Ron told her solemnly. Of course he was kidding —or was he?

With all this conditioning for panic, it was anticlimax to learn that the river's rise was far short of predictions, and that the skill of our raft crews made the difficult look easy and the hazardous seem safe.

Still, it was unsettling to reach Mile-long Rapid and read the inscription, now partly submerged on a rock, left in 1891 by James S. Best's prospecting expedition: "Hell to pay. No. 1 [boat] is sunk and down."

Mile-long's mile of heaving white water is prelude to three other mighty cataracts known collectively as the Big Drop. Many a boatman has gotten a rude dunking here. In an effort to express the demoniac wrath of the Big Drop's final rapid, somebody named it Satan's Gut.

Above each rapid there comes an instant when the swiftening current grips the boat irrevocably, and a roar that lately seemed distant and academic now overwhelms your ear—like being in the birthplace of thunder. You try to see the shape of the peril ahead, but as yet the face of the rapid is unknown, hidden by a speeding shoulder of water that expands ever closer.

Then the tossing rooster tails of spray, the geysers, the long smooth slides that end in splattering explosions, rise into view as your raft lips over the edge. Here and there brown swirls jet downward into huge sucking vortexes, holes in the river, that would have no trouble swallowing a boat.

Your raft lurches ever faster, rams into tossing, jolting walls, buckles, whirls, takes water, but stays afloat. The horrendous holes dart harmlessly by. "Grab those buckets and bail!" shouts your boatman. You retract your fingernails from your palms, thus freeing your hands from the safety ropes, and bail furiously. Already you hear the next rapid's roar.

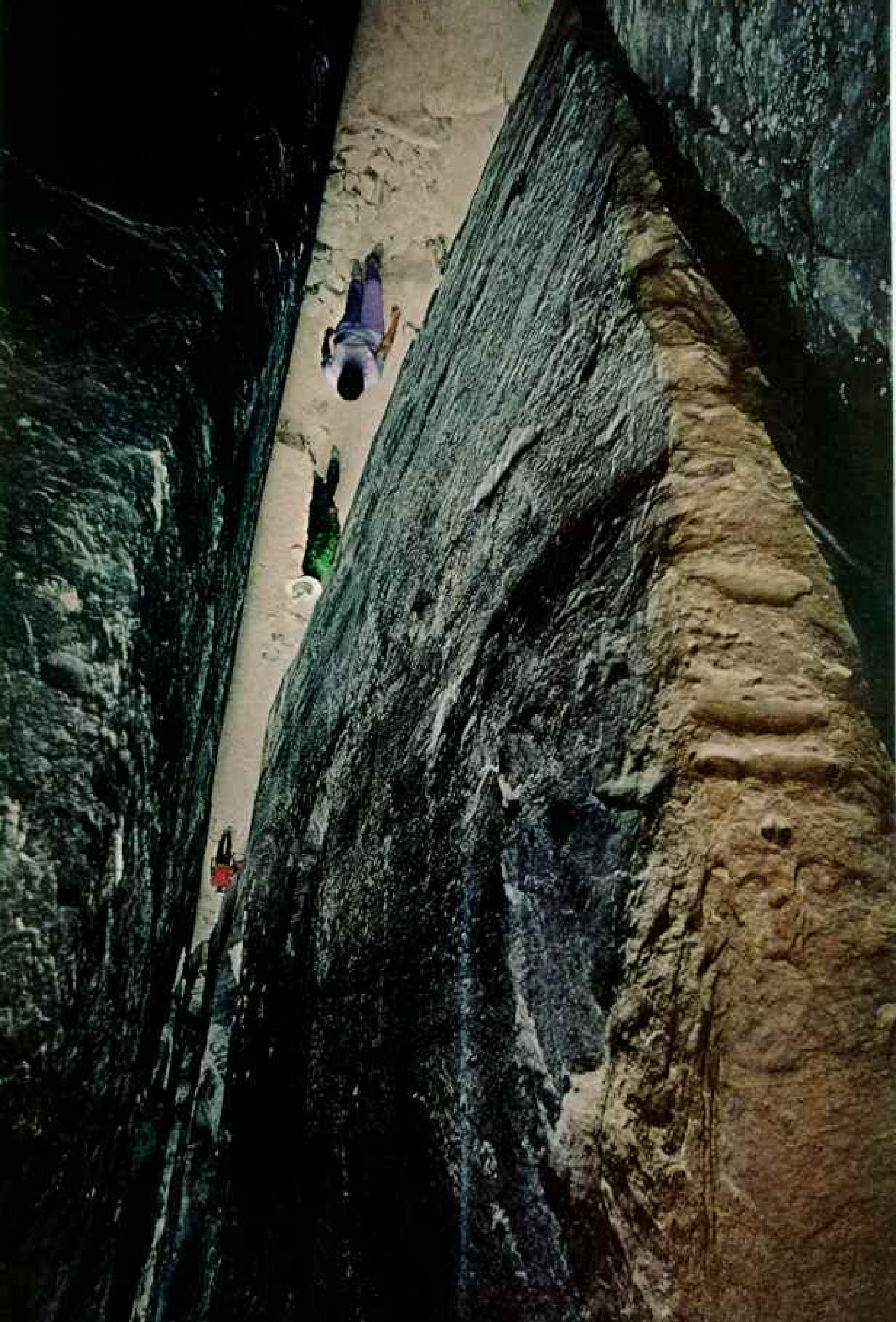
Stealthy Caller Evokes Good Will

At last a turn in the canyon shot us from the final rapid into the gathering stillness of Lake Powell, and I suddenly had a mental picture of formerly sunlit white water now locked in blue silence far below, as in a tomb. And I resented the man-made lake.

During our final night's camp beneath a star-paved sliver of sky in Dark Canyon, we had a stealthy visitor. Next morning we saw the 2½-inch paw prints in damp sand of a cougar that had slipped down from the heights for water. He came within 30 feet of our dying campfire, and the realization of his seeming brashness gave us a kind of joy. To find a wild creature still uncowed by man's long history as a destroyer seemed a hopeful sign as we try to learn better ways.

"I hope he enjoyed his drink," said Ron. □

Passage through solid rock, a rupture called the Joint Trail leads from Chesler Park to Chesler Canyon, half a mile away. Subterranean water, dissolving salt deposits far below, undermines the surface and helps create such fissures and fantasies in stone.



BERMUDA

Balmy, British, and Beautiful

By PETER BENCHLEY

PHOTOGRAPHS BY

EMORY KRISTOF

NATIONAL GEOGRAPHIC PHOTOGRAPHER

PATRONS OF THE GLOBE THEATER in London back in 1612 probably wondered what William Shakespeare was talking about when he referred to the "still-vex'd Bermoothes" in his comedy *The Tempest*. What were these Bermoothes, anyway? And what continued to vex them?

Then, as now, the Bermoothes were a small archipelago in the Atlantic, known today collectively as Bermuda, lying about 650 miles southeast of Cape Hatteras (inset map, page 96). Then, as now, what vexed them was their constant friend, provider, ravager, and whimsical enemy—the sea.

I was to discover as I got to know the archipelago, and especially as I dived on Bermuda's reefs, that the sea has taken a stunning toll of ships and men since well before Shakespeare mentioned the islands.

At a depth of 40 feet, the sunlight turned the water hazy blue. As Teddy Tucker, Bermuda's most renowned salvage diver, pantomimed instructions to me, he seemed a half-naked blue ghost performing some mystic ritual. He plunged his hand deep into the sand beside a rotted timber, and his eyes told me to do likewise. I did, and suddenly felt a different texture—soft and flaky. I withdrew a fistful of what appeared to be brown leaves. Teddy pantomimed a man smoking. What I was holding, I realized, was tobacco—unseen and untouched by anyone since it sank off the west end of Bermuda, with the ship that carried it, almost 400 years ago.

"She was taking tobacco to Europe," Teddy explained when we were back aboard his 43-foot salvage boat, *Brigadier*. "There was a mass of the stuff. It's

Coral gems on a gold-plated sea, the islands of Bermuda have a vast expanse of the western Atlantic all to themselves, yet lie only two hours by jet from New York. Winds, wafting the Gulf Stream's warmth, bestow a benign climate on this vacationists' lodestone, Britain's oldest remaining colony. On routine patrol, a plane from the United States Naval Air Station on Bermuda gets a sun-spangled view of the entire island chain.

Finders and keepers: Treasure hunting amid Bermuda's ship-snaring reefs has been a lifetime passion for underwater sleuth Teddy Tucker. He plucked the 2¾-inch emerald-studded gold cross (**left**) —worth more than $100,000—from under two feet of sand near the wrecked 16th-century Spanish ship *San Pedro* (map, page 97). The government exercised its right to purchase such treasure and now exhibits the jewel in its museum at The Flatts Village.

Finders can usually keep lesser but still-valuable items. A member of Teddy's team (**below**) recovers a glazed stoneware bowl and sherds of an olive-oil jar from a wreck site. One of a late-16th-century Spanish vessel's three anchors (**right**) rides a winch line to the surface.

an important piece of evidence. But that's all I seem to be able to get from this wreck—a bit of evidence here, a bit there, leading to no solid answer."

A 46-year-old bear of a man, Teddy Tucker has been pursuing sunken treasure for almost half his life (pages 116-17). In the 1950's, after years of following clues, he surfaced from two sunken ships with a Spanish treasure worth $180,000, including gold bars and a magnificent gold cross inlaid with emeralds (above). Since then he has discovered and scoured dozens of wrecks, but few seemed to have the promise of the one we were diving on. This 16th-century vessel had apparently never been disturbed. It should have yielded, if not a treasure, at least a ship's purse.

After more than two years of painstaking excavation, Teddy still hadn't been able to solve her mystery. "She can't have been salvaged already," he said. "Otherwise, we wouldn't have found her guns. They're the first things to go."

The day before, Teddy had found a silver coin—so badly oxidized that it seemed nothing more than a black stone until he cracked it open and revealed the faint imprint of a design. Today he had found a crushed silver chalice. "It was probably used to celebrate Mass," he said, "which means she was a Catholic ship, most likely Spanish or Portuguese. But we already knew that."

"How?" I asked.

"She held her liquids in olive-oil jars rather than in barrels, the way the English did. Besides, she had been to Spanish ports. Tobacco meant she had probably been in Cuba. Her deck cargo was lignum vitae."

I asked about the guns, which were English, dated 1577.

"That doesn't mean anything," he said. "The English exported guns all over. Many of the guns in the Spanish Armada were cast in England.

"I discussed the marine growths on her bottom with R. Tucker Abbott, a biologist at the Delaware Museum of Natural History. He tells me that the ship must have been anchored in the Azores, or maybe the Canary Islands, for at least eight months before coming to Bermuda. But beyond that, I'm not sure of too much about her. She's a tight one with her secrets."

Teddy sounded resigned. He knows that the sea conceals far more than it reveals.

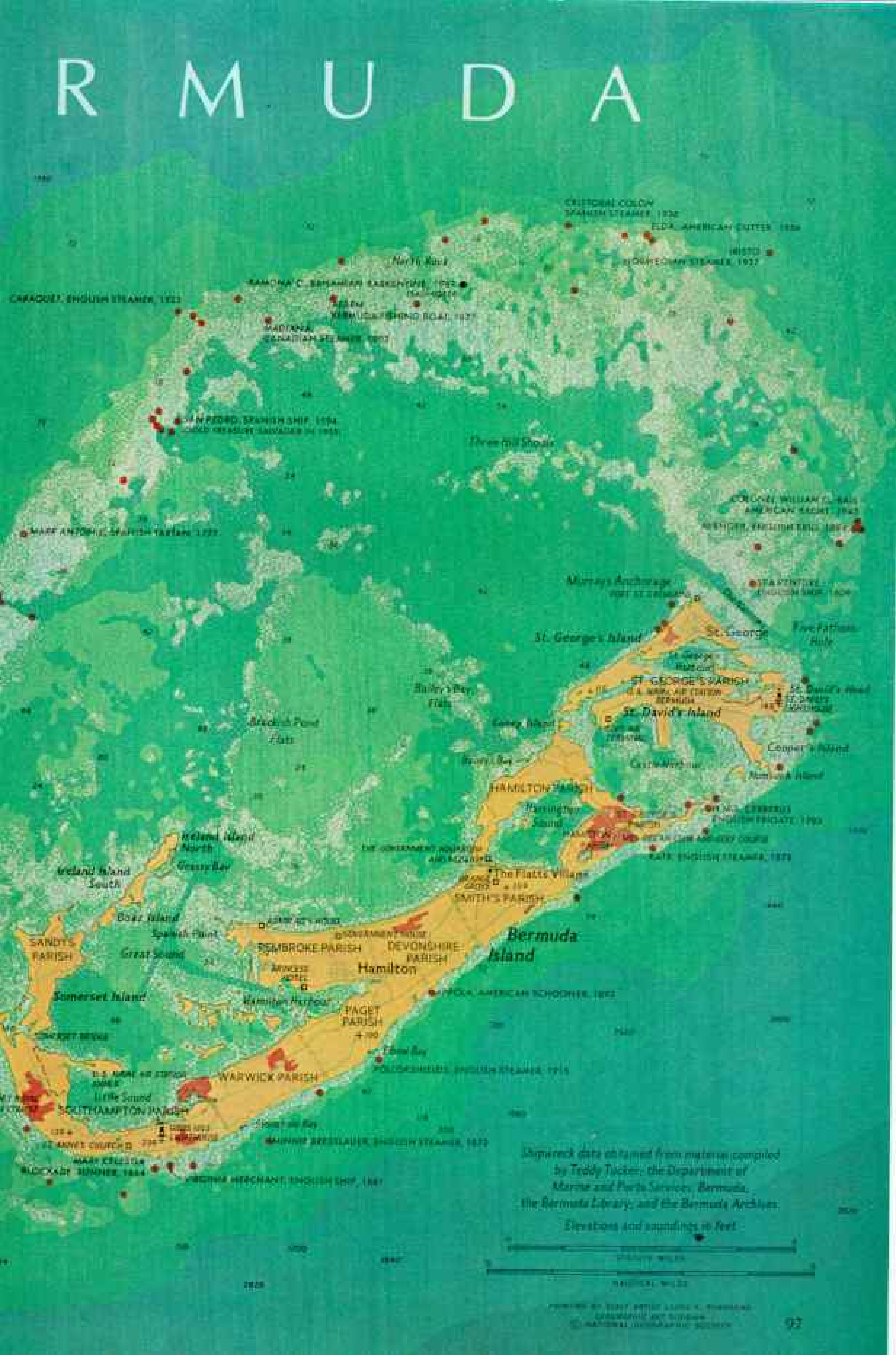
Islands' History Haunted by Shipwrecks

The Bermudians' affair with the sea has been going on for nearly four centuries. It has been a stormy relationship. The first men to set foot on Bermuda were shipwrecked sailors, though no one is sure when that happened. Officially the islands were discovered sometime before 1515 by the Spaniard Juan de Bermúdez, whose name they bear. The English were the first to settle (again, by shipwreck) in 1609; by then one castaway had taken the extraordinary trouble to carve initials resembling FT, a cross, and the date 1543 in a rock on the south shore.

Bermudians have had to make their living from the vexing sea, but the reefs that ring the islands have made them pay dearly. Divers have found the graves of some 120 ships that had mortal encounters with Bermuda coral (right). And modern navigational aids have failed to render the reefs benign. A three-masted barkentine, the *Ramona C.*, came to grief less than four years ago.

Today, however, most of those who inhabit and visit the lovely islands are content to partake of the sea's delights rather than to challenge its power. The more than 375,000

Navigator's nightmare: The bones of some 120 ships have been located amid the reefs that guard Bermuda; perhaps as many more await discovery. Englishmen who struggled ashore in 1609 from the wrecked Virginia-bound vessel *Sea Venture* became unwilling founders of the colony.


R M U D A
CRISTOBAL COLON
SPANISH STEAMER, 1936
North Rock
CARAQUET, ENGLISH STEAMER, 1923
MADIANA
CANADIAN STEAMER, 1903
SAN PEDRO, SPANISH SHIP, 1594
Three Hill Shoals
Murrays Anchorage
St. George's Island
St. George
Five Fathom Hole
ST. GEORGE'S PARISH
St. David's Island
St. David's Head
Cooper's Island
Castle Harbour
Nonsuch Island
Coney Island
Bailey's Bay
Flats
Brackish Pond
Flats
HAMILTON PARISH
Harrington Sound
KATE, ENGLISH STEAMER, 1878
The Flatts Village
SMITH'S PARISH
Bermuda
Island
Ireland Island
North
Grassy Bay
Ireland Island
South
Boaz Island
Spanish Point
SANDYS
PARISH
Great Sound
PEMBROKE PARISH
DEVONSHIRE
PARISH
Hamilton
Somerset Island
Hamilton Harbour
PAGET
PARISH
WARWICK PARISH
Little Sound
SOUTHAMPTON PARISH
Shipwreck data obtained from material compiled
by Teddy Tucker, the Department of
Marine and Ports Services, Bermuda,
the Bermuda Library, and the Bermuda Archives.
Elevations and soundings in feet

tourists who journey to Bermuda every year pour about $73,000,000 into its economy—more than three-fourths of the total revenue.

As a result, the 52,000 residents enjoy an enviably high standard of living. And visitors find a cornucopia of pleasures that, even 60 years ago, led the ailing Mark Twain to write to a friend, "You go to heaven if you want to —I'd druther stay here."

Few Island Days Unblessed by Sun

Because it is bathed by winds off the Gulf Stream, Bermuda enjoys uncharacteristically mild winters, considering its northern latitude. The coldest temperature ever recorded was in the high 30's, and never has there been a year with fewer than 340 days with at least some sunshine. So the jet-age visitor from, say, New York, finds himself transported in less than two hours into a bona fide subtropical paradise. Oleander, hibiscus, bougainvillea, poinciana, poinsettia, and palm and casuarina trees grow profusely. Bananas, grapefruit, oranges, lemons, and sea grapes hang beside the narrow roads.

Bermuda is technically a conglomerate of at least 150 small islands. The main ones, linked by bridges, form a curved chain about 22 miles long and three miles at the widest point. The total area is only 20.59 square miles. A visitor on a rented motorbike can see nearly all of Britain's oldest remaining colony in a couple of days.

One morning, for instance, I set out during Bermuda's rush hour, joining dozens of executives motorbiking to work in Hamilton, the capital city. They were uniformly dressed in short-sleeved shirts and (what else?) Bermuda shorts. I spent the morning shopping in Hamilton for British woolens, Irish linen, and both French and local perfumes.

Then I toured the eastern parishes (Bermuda has nine parishes in all). In The Flatts Village I stopped at the Government Aquarium and Museum, which houses the Tucker treasure. At Bermuda's northeastern end I

Posing for a whimsical snapshot, a bride and groom take over the traffic policeman's "bird cage" in Hamilton, Bermuda's capital. Stores along Front Street, "Showcase of the British Empire," tantalize tourists with goods from around the world.

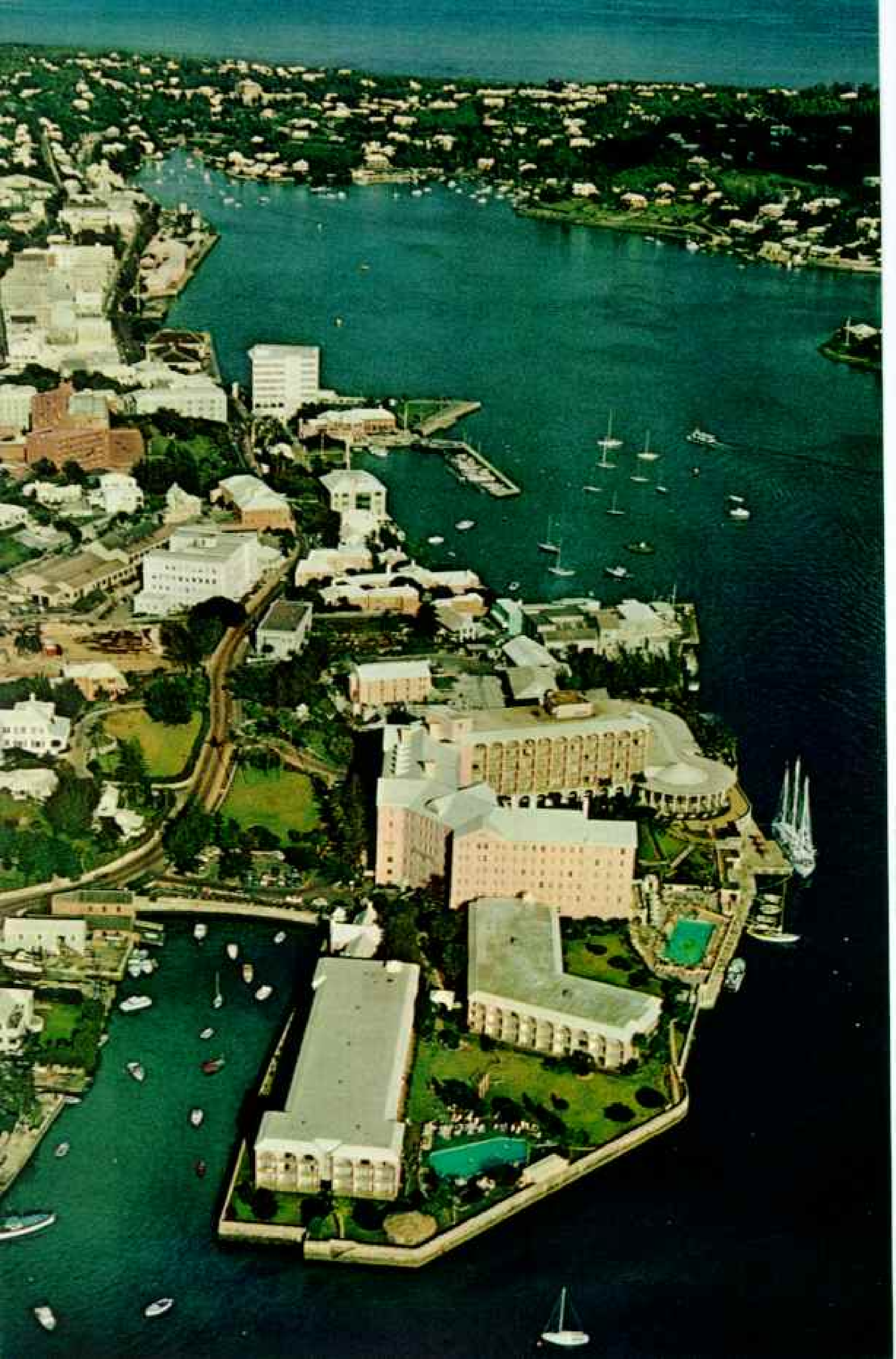
Pedestrians step smartly as noisy flocks of small cars and motorbikes beep and buzz along city streets and outlying roads. Banned until 1946, motor vehicles have ousted all but a lingering few of the fringe-topped horse-and-buggy rigs once characteristic of Bermuda.

Laws restrict the number, size, and horsepower of automobiles. To stay within size limits, some have recessed bumpers and door handles. Short-term visitors may not rent cars, but can hire motorbikes for excursions—20 miles per hour maximum speed—among the bridge-linked islands.

(ektachrome (above) and kodachrome © n.g.s.

Luxury is a bargain in such Bermuda emporiums as Trimingham's, where knitwear attracts a shopper. Prices on many imported items—Scottish cashmere, Irish linen, French perfumes—range well below those in the U. S. But everyday goods from the States—toothpaste, frozen foods, magazines—tend to run higher.

Thickly clustered waterfront and elegant suburbs surround Hamilton Harbour. Land commands fantastic prices on tiny Bermuda, where some 52,000 residents are hosts to more than 375,000 visitors a year. Stately complex of the Princess Hotel rises at right; the Royal Bermuda Yacht Club juts into the waters beyond.



Her dinner brought to gaff, a vacationing sportswoman thrills to the rewards of game fishing. Her prize: a blackfin tuna. Bonefish, pompano, barracuda, marlin, and bonito also lure anglers to Bermuda waters.

visited the quaint little town of St. George, where the first colonists settled and built St. Peter's, one of the first Anglican churches in the Western Hemisphere.

The next day I traveled westward from Hamilton through the parishes of Paget, Warwick, Southampton, and Sandys, stopping at the Gibbs Hill Lighthouse and Somerset Bridge. The latter, known as "the world's smallest drawbridge," opens a panel only wide enough to pass a sailboat's mast.

Tiger Shark Yields a Toothy Souvenir

Having sated their curiosity with this much sightseeing, most visitors are content simply to play tennis or golf, to dive on the reefs, or just to lie on one of the pink beaches along the south shore. For, to quote Mark Twain again, "Bermuda is the right country for a jaded man to 'loaf' in. There are no harassments; the deep peace and quiet of the country sink into one's body and bones and give his conscience a rest." These allurements can also be the food of love. Bermuda for years has been a mecca for honeymooners.

But for those like Teddy Tucker, who are still wedded to the sea, Bermuda's waters offer excitement aplenty. One blustery September day we went out beyond the reefs to do some fishing. We anchored in 40 fathoms of water, and Teddy began to chum, throwing handfuls of tiny fry overboard to attract larger fish. For a while, the fish came quickly: three big barracudas, some bonitos, a stunning rainbow runner, and several groupers, the latter hauled 240 feet from the bottom on monofilament handlines. Then, mysteriously, the groupers stopped biting.

"There must be a shark down there," said Teddy. He rigged a thick nylon line, baited a shark hook with two bonito heads, and secured it to the *Brigadier*'s handrail. Not five minutes after the bait hit the bottom, the line tightened with a musical *thrum*.

"Grab hold and start pulling!" Teddy shouted. "But watch your feet don't get tangled. If he runs, he'll take all that line and your leg with it."

We hauled and brought up a thrashing, snapping, eight-foot, 400-pound tiger shark. We lashed ropes to his head and tail and secured him to a gunwale. "Let's take him back," Teddy said. "Somebody's always looking for a souvenir shark jaw."

As we started for shore, he added: "It was one just about as big as this that decided to take a bite out of me when I was diving on a

wreck one day. I didn't have any warning at all. This thing just came at me and made a pass, turned around and came again, straight for me.* I put out my hand—just in reflex—and grabbed his nose, and he kept coming, pushing me backward and most of me sliding underneath him.

"I didn't know what to do. Again in reflex, I put up my other hand and happened to jab a finger in his eye, real sharp. The beast stopped and backed off a ways, then shook his head and, zoom! Off he went. By the time he was ready to try again, I was long gone."

A shudder scampered up his back and arms. "I hate even to think about it."

When we got back to the dock, Teddy said, "You'll stop and have a bite of fish with us?"

"I'd love to," I said. "What are you cooking, the grouper?"

"Heck, no, the barracuda."

"But I thought barracuda was poisonous."

Teddy laughed. "I'll tell you what: I'll cook it, we'll all eat it, and if one of us dies, why, that'll be a warning to the others."

While Teddy deep-fried the barracuda, his wife Edna set a table overlooking the water. The fish was delicious, and none of us became a warning to the others.

Sounds Gave Islands an Early Name

Before I left that evening, Edna said, "You know, if you really want to get a sense of what Bermuda was like long ago, you ought to talk to Sister Jean. I'll call her for you."

Sister Jean de Chantal Kennedy, a Roman Catholic nun from Cambridge, Massachusetts, has lived in Bermuda for more than 20 years and has become an authority on the islands' history. I asked her why 16th-century mariners called Bermuda the "isle of devils."

"Part of the reason was the noises," she said. "Breeding sea birds made horrid night sounds. Then there were the howling winds, the dangerous reefs, and, I suppose, the wild hogs. They came from Spanish ships, early on."

"Then it wasn't because the early mariners thought demons haunted the place?" I asked.

"There were no demons," Sister Jean said. "But there was plenty of rascality just the same. Even some of the governors were rascals. Dan Tucker, who came here from Virginia in 1616, cudgeled forty men before breakfast one morning."

Bermudians still commemorate his meanness, though few realize they are singing an American frontier ballad written two centuries after Governor Tucker's day:

Old Dan Tucker was a dirty old man,
He washed his face in a frying pan,
He combed his hair
with the leg of a chair. . . .

Folk history may be too hard on Dan Tucker, many times the great-uncle of the present Bermuda Tucker clan, for when he arrived he found the island populated by sots and idlers. Part of the trouble was that Bermuda had been heavily oversold to English immigrants. It was supposed to be blessed with pearl-yielding oysters, ambergris, and a soil that would grow first-rate tobacco. In fact, only one substantial piece of ambergris was found, the oysters were not pearl-ridden, and much of the tobacco was rank and unpalatable.

Bermuda Salts Sailed Cedar Ships

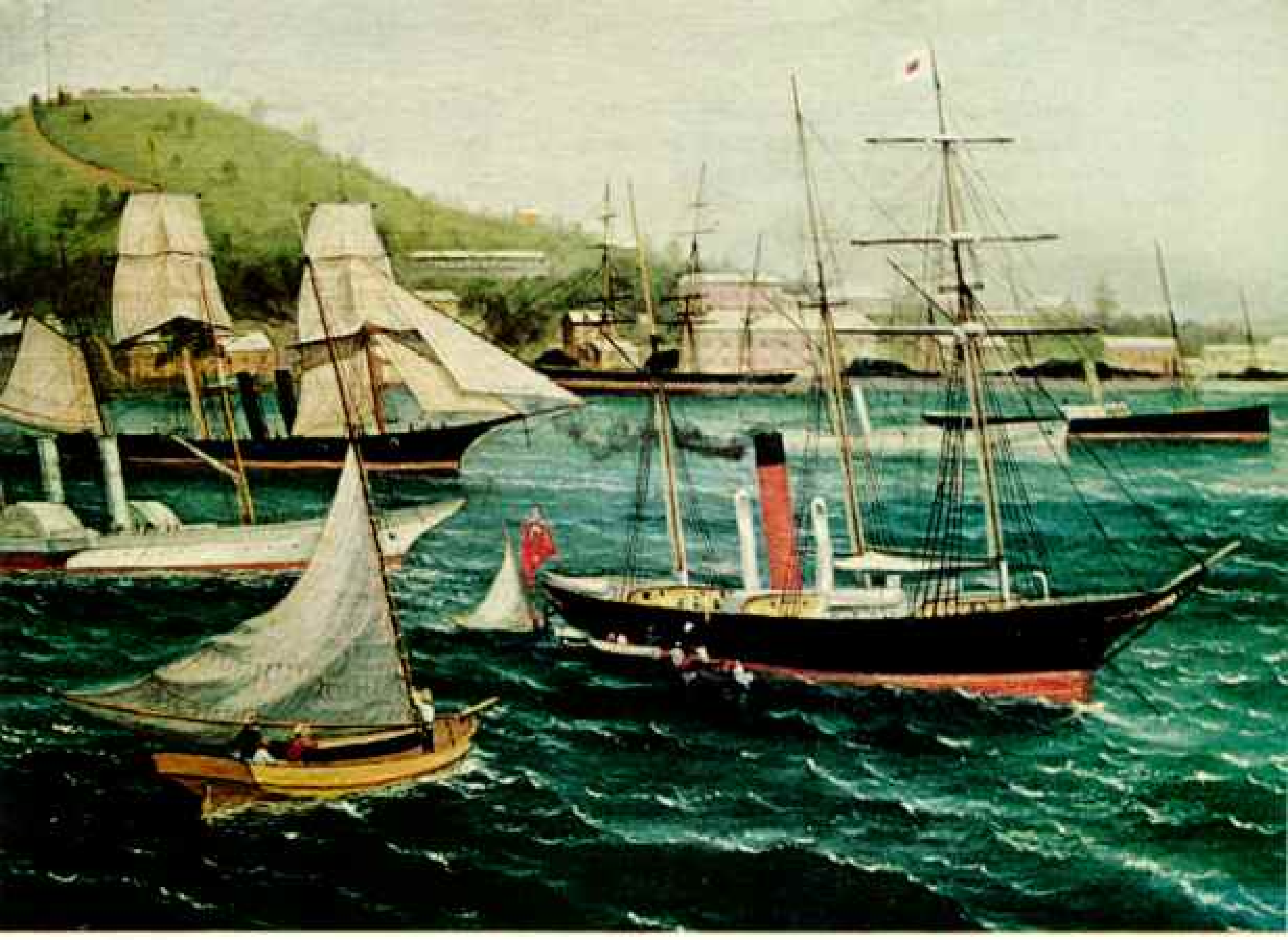
Eventually, Bermudians discovered that the islands did have one natural bounty that would provide a handsome living: cedar, tough and close-grained, which could be fashioned into fast sailing vessels. By the end of the 17th century, Bermuda had embarked on maritime commerce that would endure for a century and a half and would give Bermuda sloops and Bermuda sailors a prominent place among the world's seafaring powers.

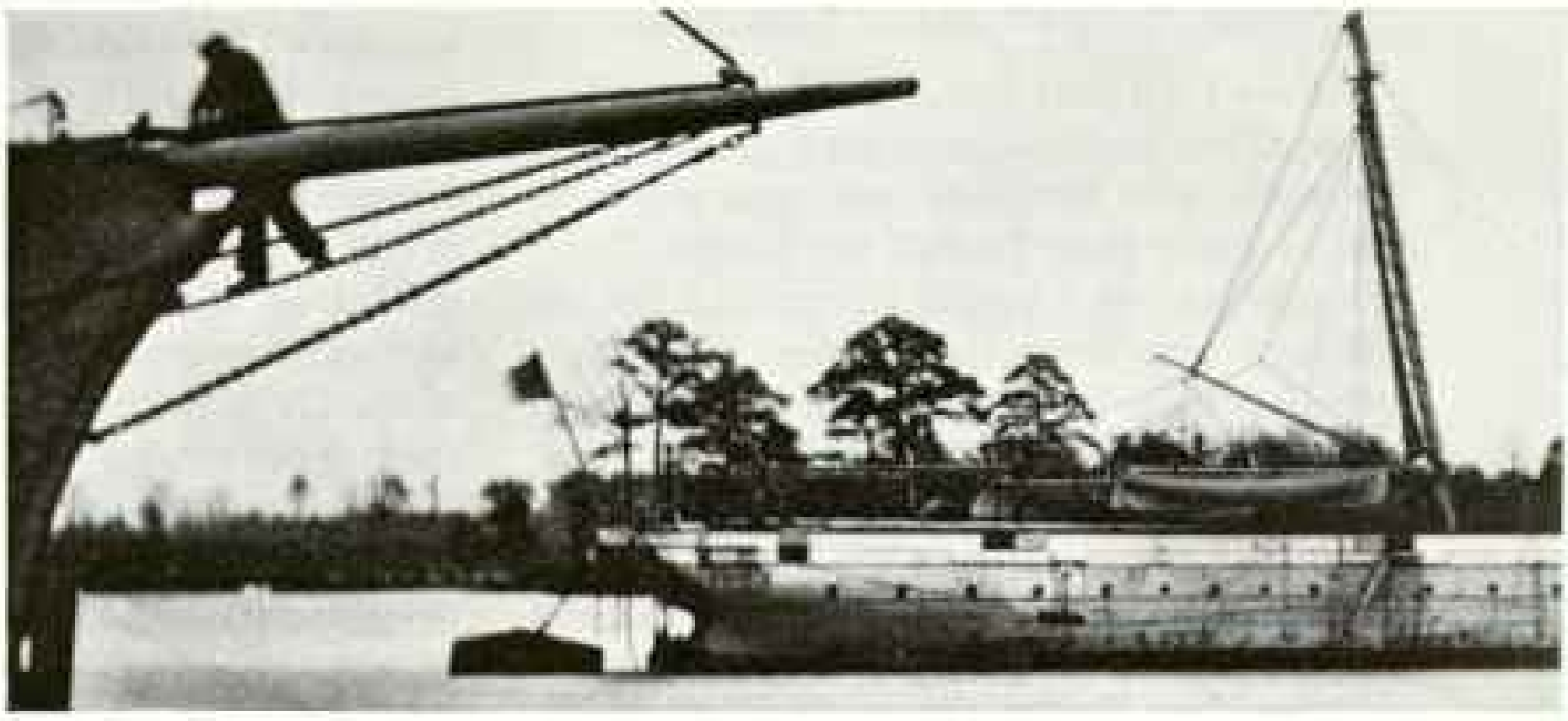
They voyaged south to the Turks Islands, where they gathered salt, which they traded to the American colonies for food. Some also loaded up with West Indian rum and sugar and sold them in other ports. By the middle of the 18th century, Bermudians summed up their dependence on the sea in a brief phrase: "salt, cedar, and sailors."

During the American Revolution, Britain's colonies were shut off from trading with the Americans. Since that meant certain strangulation for Bermuda, a few of its leading citizens appealed unofficially to the rebels for help. The Americans said they would be happy to continue to trade with Bermuda—but only for Bermuda's hefty stores of gunpowder. Consequently, one sultry August night a band of islanders made off with virtually all Bermuda's powder and rowed it out to two American ships waiting beyond the reefs.

Since the islands lay smack in the middle of the trade lanes, Bermuda's daring mariners also turned to privateering. Armed with letters of marque, which allowed them to prey on the King's enemies, they prowled the ocean in search of spoils.

*Nathaniel T. Kenney wrote of "Sharks: Wolves of the Sea" in NATIONAL GEOGRAPHIC for February 1968.

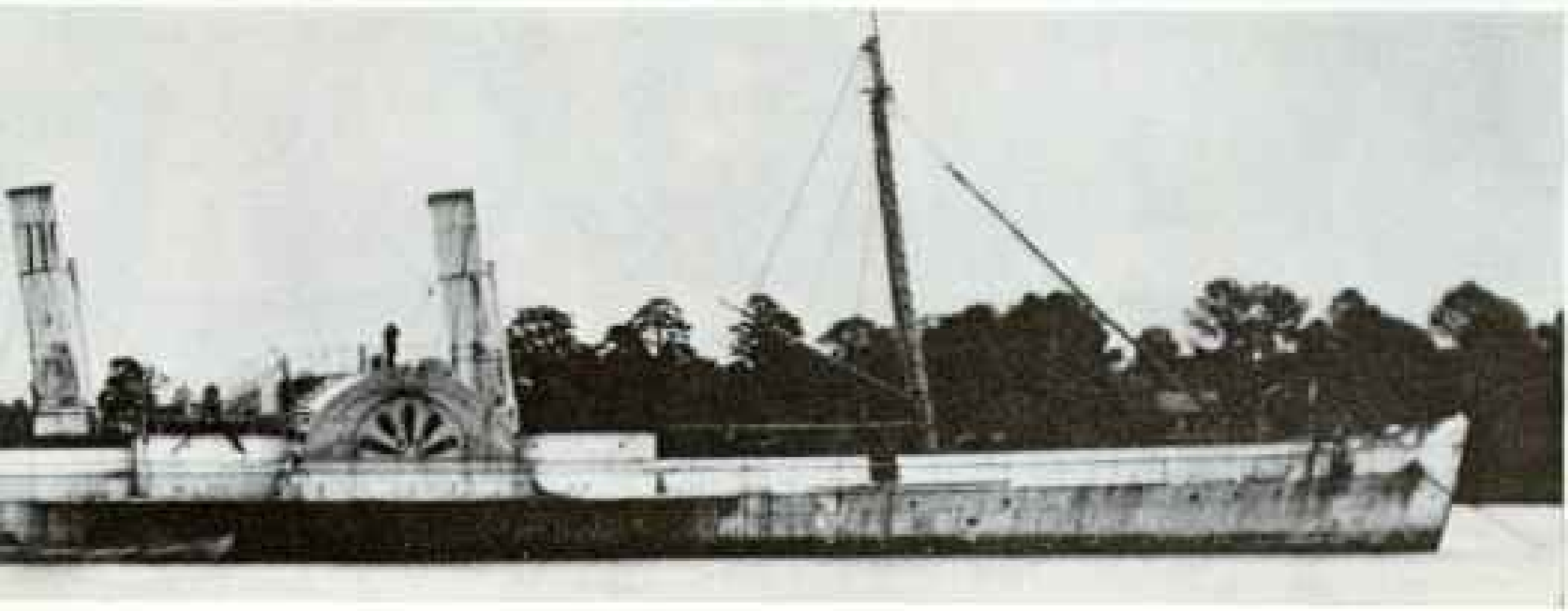




Blockade-runners' rendezvous. Bermuda's St. George's Harbour bustles with activity during the United States Civil War (**top**). "Neutral" Bermudians—in fact, sympathetic to the South—became middlemen in the maritime traffic between Britain and the Confederacy. In the early years of the war, paddle-wheelers like the *R.E. Lee* (**middle**) slipped through the North's naval blockade as though it were a sieve. In Bermuda they exchanged cargoes of cotton for arms and equipment from British ships.

Hulk of another paddle-wheeler, *Mary Celestia* (**right**), rusts 60 feet down off Bermuda's south coast. In 1864 she ripped a bilge on a reef and sank with her Dixie-bound cargo of munitions and bacon.

ALEXANDER MACOMB CRAIGHEAD COLLECTION, WEST POINT MUSEUM (ABOVE); BRADY COLLECTION, LIBRARY OF CONGRESS (CENTER); SATACHROME © N.G.S.



A story persists about one renowned privateer, Capt. Darrell Harvey, who departed in 1799 aboard a 120-ton bark with a crew of 125—about fifteen times the necessary manpower. A few months later he returned to Bermuda with 18 other ships, all captured and manned by his supernumerary crew.

Whenever privateering fell off, Bermudians found another way to capture ships—from land. By rearranging beacons, the natives ingeniously confused passing mariners and lured ships to their doom on the reefs. Wreckers waited for ships to hit, then darted out to salvage them.

Bermudians like to tell a tale about a stormy Sunday morning when a church service was under way at St. Anne's. A man rushed in and began whispering to some of the male members of the congregation, who were seen to reach for their hats.

"John Smith, what are you saying to these people?" demanded the minister.

"Parson," said Smith, "there's a ship on the southwest breakers."

The parson quickly shed piety in favor of profit. "The congregation will remain seated until I take off my surplice," he said. "Then, boys, we'll all start fair."

PHOTOGRAPHED BY BRUCE DALE (C) N.G.S.

Equestrian winner Shep Hallberg—one of more than 6,000 Americans living in Bermuda—poses proudly with her steed Whisper Jet after taking a second place in horsemanship at the 1970 Bermuda Agricultural Exhibition. The colony has no college-level schools, so she and many Bermudian classmates will attend universities in the U. S., Canada, or England.

It was during these boom years of wrecking and privateering that some of Bermuda's most majestic houses were built. The preferred material was local limestone, which is soft enough to be cut with a wood saw.

One of the most stately homes is Orange Grove, built in the middle of the 17th century. It has been in the family of the present owner, William Zuill, for almost 200 years.

"Just tell the driver 'Orange Grove, Smith's Parish,'" Mrs. Zuill said on the phone as she invited me out for tea one day. "They all know it."

When I arrived at Orange Grove, Mrs. Zuill, a delightful petite lady in her 70's, suggested I take a look around the house, which I did with pleasure, marveling at the sturdiness of the old cedar-beamed ceilings and the 20-inch thickness of the interior walls.

"They were built to last," Mrs. Zuill said. "And because we've never been conquered or fought over, really, they have been allowed to last."

Later Mrs. Zuill insisted, "You must stay and have cassava pie with us. You haven't lived in Bermuda until you've tasted it."

Cassava pie is a local delicacy and, some say, an acquired taste. It is a huge casserole-type pie made from starchy cassava root, pork, beef, chicken, beef stock, and eggs. I was quite taken with it—but largely, as Mrs. Zuill was quick to note, because of the generous infusion of spices.

"Without the spices," she said, "you think it's paste."

Naturalist Struggles to Save Island Life

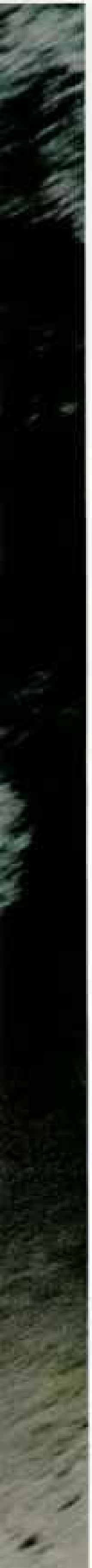
Though it thrives in Bermuda, cassava is not a native plant; it was brought from the West Indies. And unfortunately, the islands' indigenous flora and fauna have not weathered the years as successfully. David Wingate, a young botanist-zoologist, intends to do something about it. The burly, bearded Wingate, head of the conservation division of Bermuda's Department of Agriculture and Fisheries, is trying to restore to a 15-acre island called Nonsuch, at the entrance to Castle Harbour, the plants and wildlife that existed on Bermuda at the time the first settlers arrived.

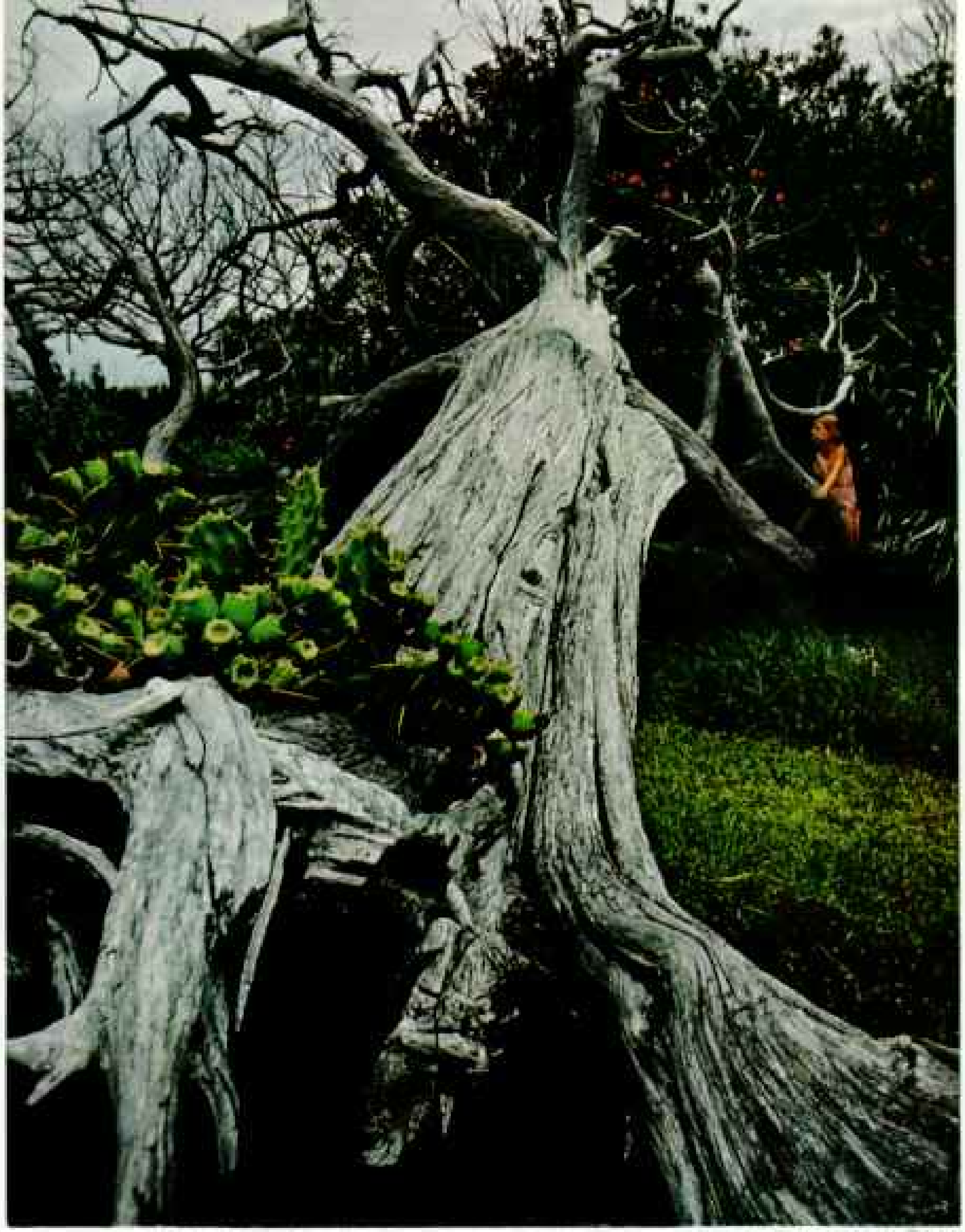
"Nonsuch used to be a paradise," Mr. Wingate said. "But then, about 1947, the juniper scale epidemic struck the islands' cedars and spread like a forest fire. Only 4 percent of the trees survived [page 109]. So when I moved to Nonsuch to live in 1962, there was nothing but the ghost of an old cedar forest, with crab grass underneath. Since then I've planted more than 4,000 trees—many different types, among them blight-resistant strains of cedar."

Old records suggest that Bermuda had 160 species of plants in the 16th century, and Mr. Wingate hopes to restore most of them. His work with fauna will be easier. "Bermuda had no native land mammals," he explained. "They had no way of getting here."

Mr. Wingate has become the official guardian of the cahow, or Bermuda petrel, which lives in rock crevices on some of the Castle Harbour islands. It had been generally assumed, until 1951, that the species was extinct.

(Continued on page 112)





KODACHROMES BY HOWIE GRAMLEY (LEFT), AND EMORY KRISTOF (ABOVE); KODACOLOR (LOWER) BY STEPHEN BARNBROOK © N.G.S.

Stricken patriarch, a cedar killed by the scale insects that swept Bermuda in the 1940's supports a growth of prickly pear. Boats made from the tough wood coursed the sea for centuries, winning enduring fame for Bermuda shipbuilders. Today the lordly cedars have nearly disappeared.

Facing extinction, the cahow, or Bermuda petrel (**right**), once flourished on the islands. Feeding at sea for months at a time, the birds would return to dig nesting burrows. Hogs released by early Spanish voyagers rooted the gentle creatures from their burrows. Later, famine-plagued islanders slaughtered all but a few. The birds survived only on offshore islets, where they had to contend for nesting sites with other enemies, including aggressive white-tailed tropicbirds (**left**). Today only 24 breeding pairs of petrels remain. Even these may be doomed by DDT residues—picked up not in Bermuda but from contamination accumulating in the ocean food chain.

Fanfare of trumpets from the Bermuda Regimental Band (**left**) inaugurates the Port Royal Golf Course in Southampton Parish. With the sea itself for a water hazard (**below left**), the 8th hole —a challenging par three—tests vacationing golf buffs and visiting pros. Beyond the clifftop green, the two tones of ocean water mark shoals near shore and greater depths to seaward.

Northernmost coral isles in the world, the Bermudas sprawl atop a seamount that climbs from the ocean floor 16,000 feet below. Barely breaking the surface in many places, the low-profiled islands nowhere rise more than 260 feet above sea level.

Eons of wind, rain, and surf have ground Bermuda coral into talc-soft beach sand and whittled starkly beautiful shapes out of limestone outcroppings along the shores. Stonehole Bay on the south shore of Warwick Parish takes its name from an erosion-carved fissure (**below**), here framing a bikini-clad swimmer.

"In 1500," he said, "there were probably more than a million cahows on Bermuda. Then the hogs came. The ground-burrowing cahows, which evolved in the absence of mammals, had no defenses against these new predators, and were all but eliminated by them before man ever settled here. By 1600 there were maybe 100,000 birds confined to smaller islands not accessible to the hogs.

"During a famine in 1614, 150 people were sent from St. George's to live on Cooper's Island and eat the cahows, the only meat available. The birds were so tame they would come and land right on your arms, and you could pick the fattest one. Even today, you're just another stone in their environment. They'll walk over you to get to their nests, or use your head as a take-off point."

Sea-borne Menace Threatens a Species

If an expedition, which included the then-teen-aged Mr. Wingate, had not rediscovered the cahow in 1951, the bird would have become extinct. Scientists found only 18 pairs, and they were threatened by white-tailed tropicbirds, which take over the cahows' burrows and kill their chicks. By putting special baffles over the entrances to the burrows, Mr. Wingate was able to keep the larger tropicbirds out, and more chicks survived.

Today, there are still only 24 breeding pairs, ranking the cahow among the world's rarest birds (page 109). They have not been able to breed fast enough to ensure survival.

"We're convinced it's because of pesticide residue," Mr. Wingate says. "DDT interferes with enzymes that govern formation of eggshells and makes them thin and vulnerable. DDT has been found in cahow embryos in a proportion of 6.4 parts per million—a level we know to be dangerous from research with ospreys and other birds." *

Cahows feed far out to sea, and the tiny islets where they breed have never been exposed to DDT. The conclusion seems obvious, says Mr. Wingate: The ocean food chain itself is contaminated.

Another relic of Bermuda's past, whose numbers are even smaller than the cahow's, is hardly in danger of extinction. For more than a century Bermudians have been staging lively races for boats unique to the islands: the famous fitted dinghies. There are fewer than half a dozen left. Just over 14 feet long, with a beam of 5 feet 3 inches, the boats can carry more than a thousand square feet of sail on masts as tall as 40 feet.

One Sunday Francis Patterson, the controller of a large Hamilton firm and skipper of the dinghy *Contest II*, invited me to watch a race. Making ready in St. George's Harbour, Francis explained some of the intricacies of dinghy racing. "Each boat has four suits of sails, to cope with different wind conditions. There's a crew of six: a skipper, a mainsheetman, a jibsheetman, two backstaymen, a bailer, and, if necessary, a seventh man for ballast. The bailer is critical; with all that weight in the boat, you've only got about two inches of freeboard.

"If the wind changes and there's a need to lighten up, the skipper just tells someone to jump overboard. Especially near the end of a close race, bodies fly over the stern like scraps of wood—pushing with their feet to give an extra bit of impetus to the boat.

"You must think our rules are very liberal. They are. In the old days they were even more so. If a boat got too close to you, you might grab a knife and cut its shrouds. And in a collision, it was standard practice for someone to jump into the other boat and give it a few good whacks with an ax. The boat that got away whole was the winner."

Angular Features Mark Unusual Ancestry

After the race, during which several crewmen—amid shouts and bellows—catapulted themselves backward into the sparkling harbor, I got caught up in the crowd of fans on the wharf. Among them I spotted a band of men whose faces stood out from everyone else's. Their copper-toned, angular features reminded me of American Indians. They were, I was to discover, natives of St. David's Island, and, indeed, they numbered among their ancestors full-blooded Mahicans who had been sent from New York to Bermuda as slaves in the 17th century.

Today these Mahicans' descendants, like all St. David's islanders, are a fiercely independent lot. "You don't call them Bermudians," Craig Curtis, a Hamilton real estate broker, cautioned as we crossed a bridge from St. George's Island to St. David's one sunny Saturday. "They think of themselves as St. David's islanders, and they'd just as soon this bridge fell down and was never replaced."

Craig and I were on our way to a cricket

*The plight of the osprey was described by Roger Tory Peterson in NATIONAL GEOGRAPHIC for July 1969. See also "Pollution, Threat to Man's Only Home," by Gordon Young, GEOGRAPHIC, December 1970.

match between St. David's and Bailey's Bay, and the game had started when we arrived. The hillsides were packed with spectators.

It was a peculiarly un-British cricket match. The cheering was boisterous. Umpires were roundly hooted. When someone made a notable play, a fan who had been betting on his team would dash out onto the field and stuff a few coins into the player's pocket—like tipping the croupier at a roulette table.

Off to one side of the playing field was a large tent. We strolled over and found it jammed with shouting, shoving humanity.

"It's called the stock exchange," said Craig, "but it's really a casino. Take a look."

Inside, hundreds of men and women were packed around dozens of small tables—shooting craps, playing euchre, or trying their luck with a dice game called "crown and anchor." The croupiers lured the players with singsong chants; one big bare-chested croupier cried out, "Easy come, easy go! Give me all your money and I give you all mine. Easy come, easy go!"

"People save all year for this," said Craig. He pointed to an old man on his left. "They say he has lost $4,000. Another man they're talking about won $7,000 this morning."

Fast Rowing Paid Off for Pilot Crews

After the cricket match, we went to talk with Grover Lamb (right), who, by virtue of age, experience, and authoritative demeanor, is venerated as unofficial mayor of St. David's. No sooner was I through the door of his tiny house than he handed me a plate of sweet-potato pudding and "hash shark"—boiled spiced shark meat.

Mr. Lamb for years plied the St. David's islanders' primary trade of piloting. As coxswain of a pilot boat he helped bring ships through the perilous reefs.

Pilot crews were highly competitive. They stationed themselves atop the hills, searching the horizon for the telltale masts of incoming ships. When one was spied, each crew would rush to its gig and row out to meet the ship. The first gig to arrive alongside won the right to put its man aboard to pilot the ship into the harbor. The pilot received a third of the total fee, with the rest going to the crew and for boat maintenance. This would amount to $3 or $4 a job for each oarsman. The crew that rowed fast enough to be first to reach two or three ships a week earned $6 to $12 a man—a handsome living.

The piloting trade, Mr. Lamb told me, was

KODACHROME © N.G.S.

Veteran of the coral labyrinths, octogenarian Grover Lamb of St. David's Island earned his living for decades rowing out to vessels approaching the deadly mazes of Bermuda's reefs. When an incoming vessel was sighted, he recalls, rival crews rowed furiously to meet it. First to reach the ship won the right to put a pilot aboard. The free-wheeling tactics came to an end in 1929, when the government assumed responsibility for guiding ships.

By the seat of their pants, doughty sailors hike mightily to keep their wind-jostled Soling-class craft upright during Bermuda's International Race Week, held each spring.

Another sailing event, unique to Bermuda, features the islands' famed fitted dinghies, top-heavy 14-foot-long boats with masts towering 40 feet high. To lighten ship for added speed, crew members sometimes leap overboard.

Premier nautical event on the islands is the renowned Newport-to-Bermuda race, a blue-water classic staged in early summer every other year. Result board (**right**) proclaims the unhappy fate of six entrants that failed to finish in 1970.

149					
150	CONGERE	E			DISMASTED
151	GRUNDOON	C			DISMASTED
152	ADELE	C			DISMASTED
153	STILL WATER	F			DISMASTED
154	NEPENTHE	B			DISMASTED
155	WARRIOR	A			DISMASTED
156					

KODACHROMED BY BRUCE DALE (TOP) AND EMORY KRISTOF (C) N.G.S.

"**The sea's been a generous lady** to me," acknowledges Bermuda treasure diver Teddy Tucker. "But," he cautions, "most divers find her as stingy as a miserly aunt."

Teddy has devoted thousands of hours to musty archives and reef-fringed waters to discover his patroness's well-hidden secrets. But the hardest work begins after he has discovered the whereabouts of a wreck.

He labored more than two years excavating a late-16th-century vessel (**below**), sunk with a cargo of tobacco and hardwood. When discovered on the western reef, she rested beneath some six feet of sand. Rocks atop her rotted ribs served as ballast. As yet she has yielded no treasure.

After an exhausting five-hour stretch on the bottom, 40 feet down, Teddy wins a moist greeting (**right**) from his pet schnauzer Mitzi.

EXTACHROME (LOWER) AND KODACHROME © N.G.S.

not only dangerous, but also backbreaking, for once a crew had put its man aboard the ship, all the rest of the crew had to row back to shore. "We once rowed out 87 miles to wait for a ship," he said. "We left Monday morning and got back Friday night. When we got on board, they gave us a bucket of mangoes and some salt pork. Then we had to row back again, all but the pilot."

The government put many St. David's islanders out of business in 1920, when it ended the era of free-enterprise piloting and took over the responsibility for guiding ships through the reefs. But by then the glory days were gone anyway.

Piloting was at its height during the U. S. Civil War—and so was blockade-running. Theoretically Bermuda, like Britain, was neutral. But in fact Bermudians—to Britain's advantage—were a little more "neutral" toward the Confederacy. Britain needed the South's cotton, for which it willingly exchanged war matériel, and since the Southern ports were closed to foreign trade by the Federal blockade, Bermuda was chosen as a logical and convenient trading center (pages 104-5).

Bermudians were delighted. Blockade-running utilized their seafaring talents and was highly profitable. Captains were paid $5,000 for each round trip to Wilmington, North Carolina.

Century-old Hulks Still Strew the Reefs

The shallows around Bermuda bear mute testimony, however, that blockade-running was not all fun and profit. The carcasses of several blockade-runners still lie amid the sand and coral.

"See that patch of yellow-looking water ahead?" said Teddy Tucker, as he tossed the *Brigadier*'s anchor overboard and made fast the line. "That's one of the *Nola*'s boilers. She went down in 1863."

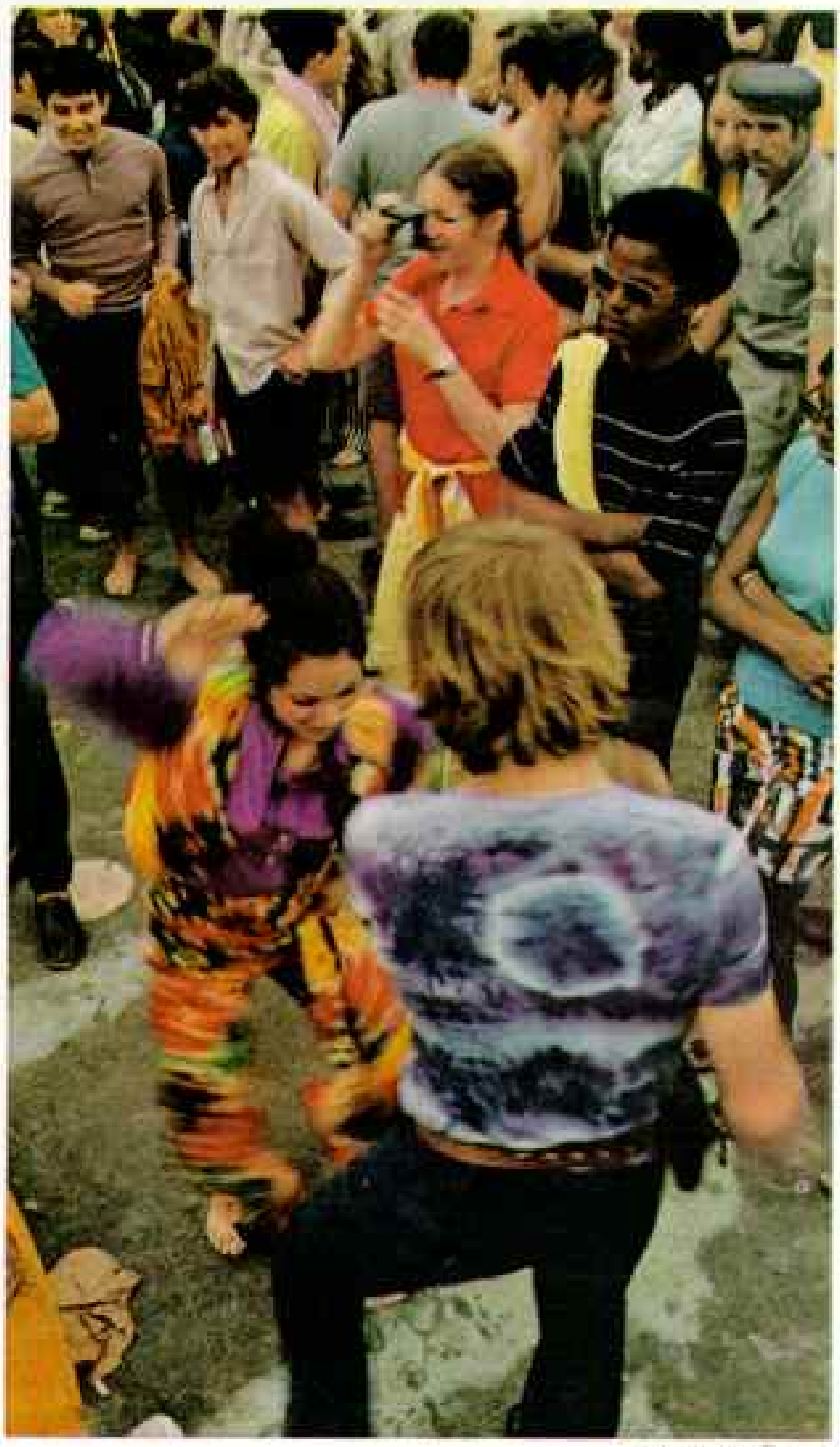
We put on scuba tanks and hopped off the stern platform. Below, the *Nola*'s massive boiler loomed from the bottom like some infernal sore. Fish swam in and out of its gaping belly. Off to the side, in rusty symmetry, lay her two paddle wheels.

Later we dived just off Bermuda's south coast, where the *Mary Celestia* lies in a sand hole—a patch of clear sand amid the coral—60 feet down.

"She was heading for the South with munitions and bacon," said Teddy. "She hit a rock and fell into the hole."

Against the white sand the dark hull of the *Mary Celestia* looked starkly neat, as if a marine mortician had arranged her for burial (page 105). We swam the length of her, and then as we began our ascent, Teddy suddenly turned back and grabbed what seemed to me nothing more than a long piece of coral.

"Lead," he said when we were back aboard the *Brigadier*. "This'll always come in handy."



Rites of spring: Bermuda's government-sponsored and supervised College Weeks, from mid-March to mid-April, lure thousands of vacationing U. S. collegians. Motorized armies of fun-seekers mount cycles and roar en masse to planned activities ranging from dances and beach bashes to deepwater cruises and weekly beauty contests.

Marooned in a sea of cycles (**above left**), a puzzled co-ed tries to recall exactly where she parked her "wheels." Strains of calypso and rock spark impromptu street dances (**above**). At Elbow Bay (**left**), a volleyball game builds appetites for lunch —provided by the government. On one memorable Monday in 1970, students devoured 5,000 hamburgers and 5,000 hot dogs in just two hours.

"How did you know it was lead?" I asked.

"By the way the coral grows. It's experience, that's all. I can look at a piece of junk on the bottom and tell by the coral whether it's copper or brass or iron or silver. Most people never know what they're looking at."

But there is more than just experience to Teddy's success. A good salvage diver must have a working knowledge of shipbuilding, history, ceramics, metallurgy, sociology, weapons, and numismatics.

"Most people just think about gold and silver when they think about salvage diving," Teddy said. "They ignore ceramics and glass and pottery—what I call nonintrinsic stuff, the stuff that doesn't have an actual value per ounce. But there's a lot of money in it. Take Rhenish ware, for instance: An undamaged decorated 16th-century Rhenish jug can bring about $3,500. Just plain glass—an old medicine bottle or flask, say—may bring $60 to $1,000 from a collector. I guess over the last 24 years I've found $400,000 worth of nonintrinsic stuff."

There is value to even the most mundane substance. One day we stopped above the wreck of the *Blanche H. King*, a four-masted schooner with a cargo of coal. We dived until we had filled four burlap bags with Teddy's fuel supply for the winter.

Traffic Pales Beside Newer Problems

That a mere four bags of coal meant an adequate winter's fuel supply on Bermuda was a bit of intelligence that began to sift north about a hundred years ago. By the 1900's, Bermuda had been discovered to such a degree that some escapees from U. S. winters were concerned that the islands would be overrun with riffraff. A frequent visitor named Woodrow Wilson was among the signers of a petition asking the Bermuda legislature not to legalize the newfangled automobile.

The plea was heeded for almost 40 years, but, in 1946, cars—of strictly limited size and power—were permitted to invade the islands. Within two decades, more than 10,000 were zipping around Bermuda's 150 miles of narrow, twisting roads.

As far as the casual visitor can tell, traffic is perhaps the only serious problem that plagues the islands. But Bermudians know it is minor compared to the profound difficulties of race relations and overpopulation.

I spent an afternoon with Sir Henry Tucker, who is Government Leader in a parliament that first met in 1620. Sir Henry was elected to office in 1968, the year in which a minor scuffle in Hamilton erupted into a race riot.

Black Bermudians complained of discrimination in education, housing, and jobs. They cited the almost complete absence of blacks in the executive echelons of the hotel business. They claimed that they were denied fair representation in the government.

Sir Henry said, "Only a fool would be complacent, but we think we have made strides in education and job opportunities. We have a growing black middle class. The only answer is a sensible partnership between reasonable people of both races."

Islands May Grow by 2,000 Acres

To solve the population problem, however, the government will need more than good will. Bermuda has sponsored birth-control clinics for more than 35 years, but still the population has grown so fast that land commands astronomical prices. A house with a good ocean view sells for $150,000 or more, and if a lucky buyer were able to find an empty half acre, he might have to pay as much as $50,000 for it.

"There are only 13,000 acres in all Bermuda," said Sir Henry, "so we shall have to reclaim more land from the sea. Our advisers say we can reclaim another 2,000 acres.

"Despite stringent zoning laws," he added, "we're reaching a point where modified high-rise apartments will be necessary. That will mean all the accompanying problems of high building costs, sewage disposal, and inadequate water supplies. You see, we're just a village in size, but we're dealing with all the problems, in microcosm, of a major country."

Where will it all lead? For centuries the Bermudians have refused to let that kind of worry spoil their enjoyment of life. Their official motto speaks for them: "*Quo Fata Ferunt*—Whither the fates will carry us." □

Partner in Bermuda's future sports a safety helmet while riding the pillion seat of her mother's motorbike. Bermuda's blacks, comprising 62 percent of the population, look forward to an era when they will share more equitably in the islands' political and economic life. A major racial disturbance in 1968 and minor flare-ups since have focused the public conscience on the grievances of blacks. Bringing them into full participation at all levels remains an urgent social goal.

Ama, Sea Nymphs of

THEY ARE ALL DRIPPING and newly risen from the sea. One wrings her skirt while a townswoman bargains with her for a shellfish; another suckles her small son as she combs her lustrous black hair; two watch a shoal of small fish playing in the water. Thus Utamaro, one of Japan's greatest portrayers of women, in a famous triptych (below) gave immortality to the *ama*, Japan's diving women of the sea.

More than any other nation in the world, Japan, crowded on mountainous islands with little arable land, looks to the sea for sustenance. From earliest times artists and poets have celebrated the ama, most curious of Japan's fisherfolk.

The ama dive for food—shellfish and edible seaweeds—never for pearls. Some of the things they have been doing for 2,000 years (a venerated Japanese work tells of ama diving before the time of Christ) appear to go against the most basic rules of modern diving. Ama plunge without breathing apparatus of any kind to depths as great as 75 feet many times a day. Now they have begun to attract the attention of scientists as well as of poets and painters.

Until the past few years, almost nothing was known of what happens within the body of a human who repeatedly dives deep, in cold water, while holding his lungs full of surface air. As an overcrowded planet begins to turn to the sea for more food, and even more living space, we need the answers to many such questions about man in the sea.

For years the submerged world has held me in thrall, and in late summer I went to Japan to plunge with the ama.

Japan

Article and photographs by LUIS MARDEN
CHIEF, FOREIGN EDITORIAL STAFF

There are ama all round Japan's coasts, except in the far north, but most live along the east and west shores of Honshu (map, page 128). The best known are the ama of Hekura Jima, in the Sea of Japan off the Noto Peninsula. During the winter these ama live in the city of Wajima, on the mainland.

Wind and Tide Brought Ama to Wajima

When I reached Wajima in late August and walked through the quarter where the ama live, I saw few people, only some children rolling hoops and a few old men repairing nets. Almost to a woman, the ama had migrated to Hekura, 30 miles offshore.

Of the 115 ama registered with the fisheries cooperative of Wajima, 85 go to Hekura every season. They migrate early in June and remain until the end of September. Lately, however, an increasing number have elected to stay on Hekura the year round.

At Sumiyoshi Shrine, a Shinto holy place in Wajima that dates back more than 800 years, I talked with a priest, Osamu Asai, who has charge of nearly 3,000 old manuscripts chronicling the history of Wajima and its ama. While I sipped green tea, Asai-san unfolded the yellowed papers.

"The first ama came to Wajima by accident," said the priest. "They had existed in our southernmost island, Kyushu, from most ancient times. In Eiroku 12 [1569], several boats carrying ama from Kanegasaki, near Fukuoka, were blown to sea by a typhoon; there the strong Tsushima Current swept them north to these shores.

"They landed at Akasumi village, and when they had recovered, they dived for food

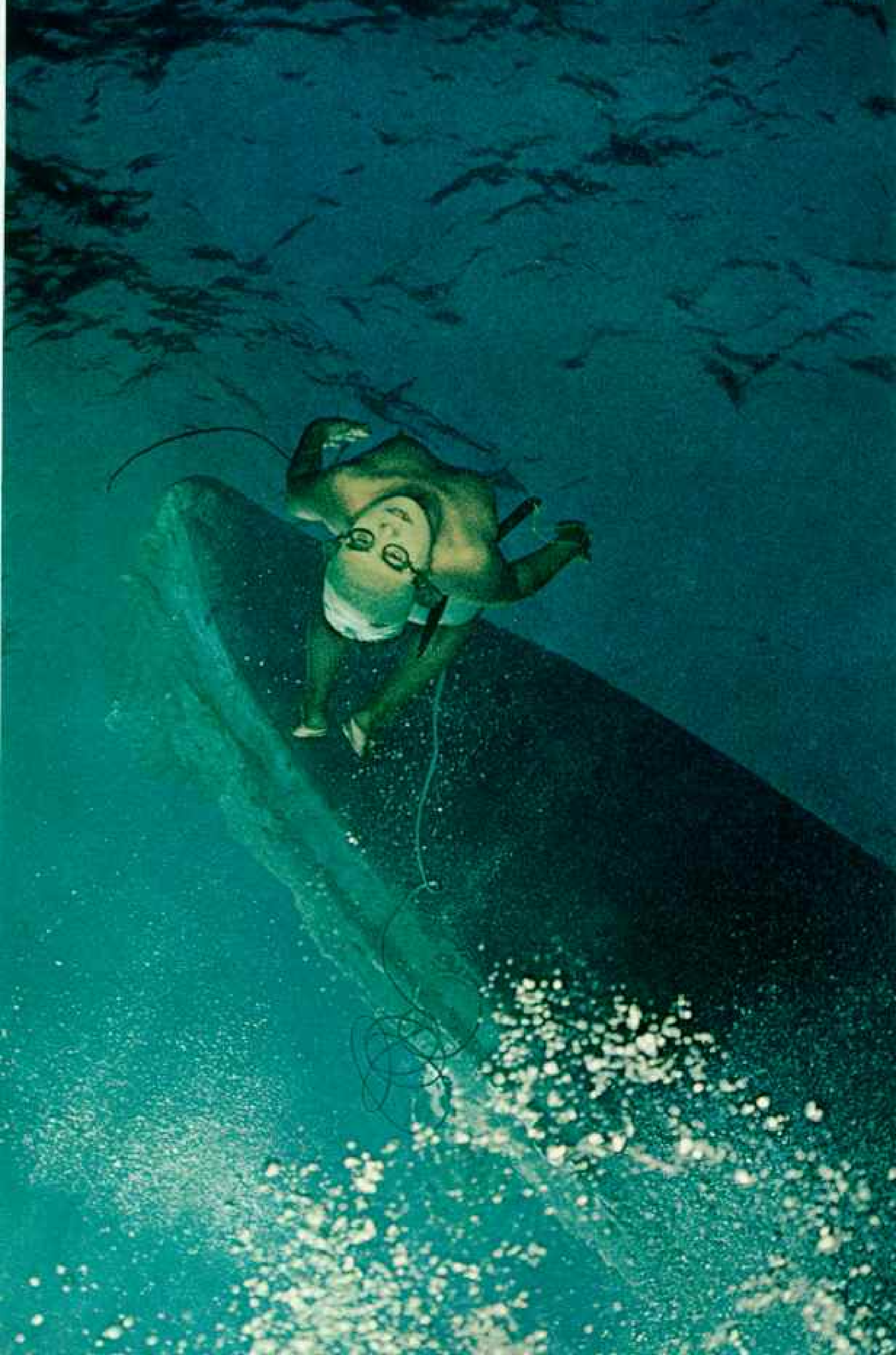
MUSEUM OF FINE ARTS, BOSTON

Three-part block print by the 18th-century master Kitagawa Utamaro salutes the *ama*, diving fisherwomen of Japan.

Plummeting into the sea, an ama dives 60 feet to abalone beds off Hekura Jima (following pages). A lifeline leads to a boatman-tender on the surface. White cream guards her face against salt and sun; goggles help her to see underwater. Years of experience assure her safety.

In scattered settlements along the Japanese coastline, the ama divide themselves between deep divers called *funado*, "ship people," and *kachido*, "walking people," who fish only in the shallows. To conserve the sea's dwindling resources, local officials prohibit the use of breathing aids, thus perpetuating the ancient way of life.

KODACHROME © N.G.S.



and found many shellfish. The ama remained until they had repaired their boats and could sail for home. They began to come yearly, and eventually founded a colony at Wajima.

"By then this whole region had fallen under the sway of the *daimyo* Maeda, and they petitioned this feudal lord for permission to stay. He consented on condition that they bring him regular tribute of *awabi*, abalone. From 12 families of 400 years ago, the colony has grown to today's 1,129 souls."

I sailed shortly after dawn one morning for Hekura Jima in a motor vessel of 83 tons. The sea was calm, and the boat made the passage in less than three hours.

The island, nowhere more than 41 feet above sea level, is a low stone shield, a mile and a quarter by a half mile. The ama live in nine hamlets scattered round the foreshore under the white finger of a lighthouse.

Elite Among Ama Work From Boats

The ama of Hekura, like those of the rest of Japan, belong to two classes: The *kachido*, "walking people," dive in shallow water, usually from the shore, and toss their catch into a floating wooden tub; the *funado*, "ship people," older and more experienced, dive in deeper water from an anchored boat.

Next morning I set out for the diving grounds in one of the 50 ama boats. Most carried one ama and a crewman—a husband, father, brother, or other close relative who steered the boat and tended the diver while she was on bottom.

A friend in Kyoto once said to me, "In Japan we envy the ama's husband above all men." When I pointed out that with all the pulling and hauling, the husband often finished the day more tired than the wife, he said, "Ah, but we refer to the kachido's husband. He just sits at home."

Actually, when an ama's husband is not tending the diver, he is apt to be out all night, fishing. The Japanese have an appetite for work.

I rode with Nakamichi-san and his two diver-daughters, Hideko, age 16, and Toshiko, 18. Except for a few older women, the ama of Hekura no longer dive semi-naked, and the girls wore black leotards. Most others wore all-enveloping suits of black neoprene, the diver's wetsuit.

While the girls spread a layer of white cream on their faces for protection from sun and salt, I examined their diving goggles, which had separate eyecups of white metal

Time is the adversary as an ama searches for abalones, meaty single-shelled mollusks that clamp on rocks amid swaying kelp forests. The iron helps her break the animals' suction. Stones

tied to her waist counteract natural buoyancy. As pressure increases, rubber bulbs above her ears force air into the goggles, thus preventing the eyecups from being squeezed into her eye sockets. This 40-year-old ama stays down a minute, then tugs on her lifeline, and her boatman hauls her up. By avoiding over-exertion, she may make 100 plunges a day and gather perhaps 30 pounds of abalone.

shaped to fit snugly into the eye sockets. Until about a hundred years ago, the ama dived without goggles. Shellfish were plentiful, and they groped for them in shallow water. As the shellfish diminished, the ama had to dive deeper, and they needed to see.

The early eyecup goggles had one defect. As the diver plunged deeper, increasing water pressure drove the edges of the eyecups deep into the eye sockets, forcing the eyeballs out of their orbits like squeezed grapes.

About sixty years ago some unknown genius invented a beautifully simple device to overcome this. A small pear-shaped rubber bulb projects from the side of each eyecup. As the ama descends, mounting water pressure forces air from the bulb into the eyecup, relieving pressure on the eye socket.

To prevent fogging, the girls rubbed their goggles with the crushed leaf of mugwort *(Artemisia vulgaris)*. Its juices formed a protective film on the glass.

Finally the girls tied a string of egg-shaped weights round their waists and slipped over the side. Hideko took a deep breath, expelled some of it, and dived. Nakamichi-san passed her lifeline over his right forefinger. "I feel her moving, like a big fish," he said.

Breaching ama gasps for breath as her

A strong tug. Swiftly he pulled the line in, hand over hand, until Hideko's head broke water, blowing like a surfacing seal in a corolla of cascading water. As Hideko handed up four *sazae (Turbo cornutus*, a species of marine snail), Toshiko exhaled a valedictory sigh and slipped beneath the surface.

Iron for Weight and Thumps for Luck

The ama of Hekura dive in two periods: from ten in the morning until noon, when they go ashore to eat lunch and warm themselves round a fire on the beach; and an afternoon period from two to four o'clock. In the afternoon I searched for abalone *(Haliotis)* in deeper water with Masako. This 40-year-old woman was, like most ama, short and stocky, with well-developed legs and a deep chest.

The boat carried a safety line 150 feet long, and a shorter descending line attached to a 35-pound piece of iron. The diver's husband passed the weighted rope over a large pulley and hung the weight just below the surface. The ama, naked except for tight-fitting shorts, picked up a flattened iron bar with an upturned end, thumped three times on the gunwale—"to bring luck"—and thrust it into the back of her belt.

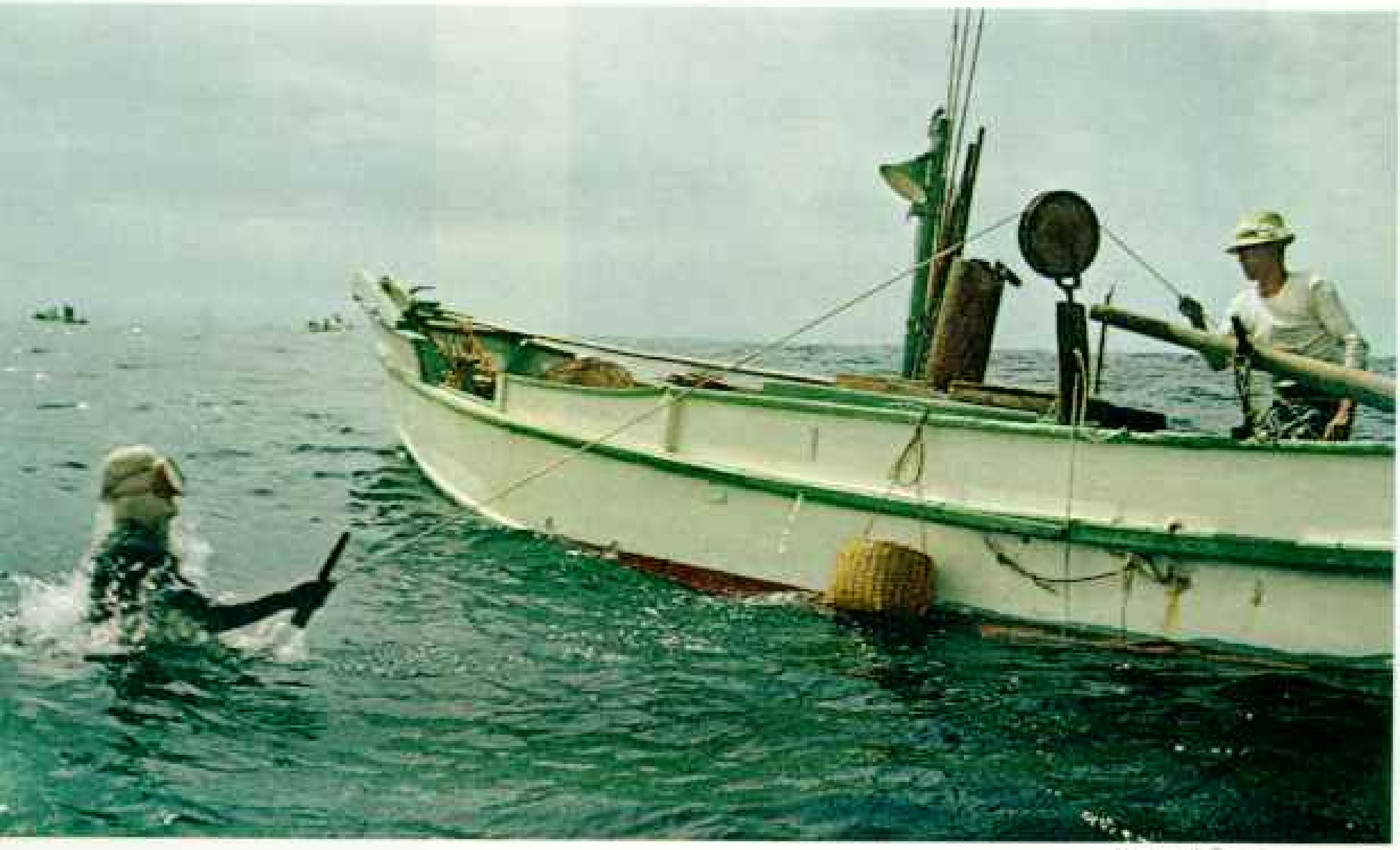
She dropped over the side and, holding to the descending line, began to hyperventilate —that is, to breathe slowly and deeply. She expelled her breath through pursed lips in a plaintive whistle, like the distant crying of curlews on a wind-swept shore. Japanese poets call this *iso nageki*, the elegy of the sea.

I too had entered the water, but I wanted to remain on the bottom to take photographs, so I took my air with me in a tank strapped on my back. Sixty feet down, I waited for ama-san. She plummeted toward me in an explosion of light, holding the descending line just above the plunging weight.

The sea was limpid, and we swam over a moving plain of mustard-yellow kelp, seaweed with a name as sinuous as its undulant ribbons—*Laminaria*. The ama stood on her head, half buried in the waving seaweed, looking for the domed shell of an awabi. I kicked my way down into the submerged forest beside her. The ama pointed; near her left hand I saw a convex reddish form.

The abalone, unlike the clam or oyster, has only one shell. With the firm foot muscle that fills the shell the creature adheres to rock. The ama inserted the beveled end of her iron under one edge of the shell, and with a quick

boatman pulls her in. The diver works with a fleet harvesting the sea off Kuzaki (map, opposite).



Awaiting the season's start, ama of Kuzaki warm themselves beside an early-morning fire. Clad in cotton suits, these kachido divers work in only 10 to 30 feet and deposit their catch in floating wooden tubs. Man in the background joined this group to earn extra cash.

Ordinarily only women dive, because their thicker layer of subcutaneous fat makes them less susceptible to cold water. Compared to other Japanese women, the 7,000 ama are slightly taller, heavier, and more likely to suffer ear disorders. Few of their daughters train for diving; more attractive city jobs beckon.

Conservation-minded local fisheries associations set strict rules about season, methods, and even attire. Last year Kuzaki limited the abalone season in this overharvested area to only one hour a day.

FIGURINE IN HAYWOOD RUSSELL COLLECTION, 1949; KODACHROME © W.G.S.

Ivory miniature once served as a toggle for the purse of an 18th-century Japanese. The ama figurine clutches an oversize clam and an abalone pry-ing iron. Japanese art and literature have portrayed women divers for 2,000 years.

In an age-old rite, an elder of Kuzaki transforms a seafood prize into an offering for the Grand Shrine of Ise, sanctuary of the sun goddess and Japan's major Shinto temple. After the circular abalone muscle has been cut into one continuous strip like an apple peel (**right**), it dries in the sun. Then the strips are divided and tied with rice straw in small bundles.

The ama harvest some four million pounds of abalone a year. In city markets, it sells for as much as $4 a pound. Toys are often shaped from the iridescent shells.

upward jerk broke the suction. She dropped the shell into her net bag and gave the lifeline a tug. Pulled by her husband, she shot toward the surface like a jetting squid.

Our ama made nearly fifty dives that afternoon; she remained on the bottom almost exactly sixty seconds each time. Halfway through she climbed into the boat and put on a short cotton jacket to get warm.

When I surfaced, I asked her the classic question: Why do women, rather than men, dive in Japan?

She smiled shyly and replied with some diffidence; Japanese women hesitate to question male superiority: "Because I can stay in the water for three or four hours. Men cannot stand more than an hour."

True; women have a thicker layer of subcutaneous fat than men. I am sorry, ladies, but that is the way the physiologists put it.

Our ama had taken nearly thirty pounds of awabi. That night—and for nearly a week afterward—we dined on awabi and sazae, raw, steamed, and sun-dried.

Village Bedecked With Drying Squid

To visit the Tsushima divers, least known of the ama of Japan, I reversed the migration route of four centuries ago, traveling south from Honshu to Kyushu to reach the city of Fukuoka.

The Tsushima Islands lie 80 miles out to sea, across a strait of turbulent currents. Beyond, only 40 miles of water separate them from South Korea. I sailed there in 4½ hours in the 800-ton *Taishu Maru*.

Magari, the ama town, shelters behind a breakwater in a small half-moon bay. When I entered the village at the edge of the sea, I found what seemed to be the squid capital of the world. All around hung thousands of drying squid (*Todarodes pacificus*), swinging and rustling in the breeze. White, cream, pale brown, they danced in the wind, looking like shrunken, endlessly repeated Wellsian Martians with their bunched tentacles and staring eyeholes. They swayed, waved, flapped, swung, and swished. Out on the breakwater the squid sighed mournfully, like a flock of sorrowing doves, as a fresh breeze swept through them from the open sea.

Forty ama work out of Magari; the youngest is 35, the oldest 86. I went out one morning with two of them, Eiko Okano and Yukie Umeno, both 35 years old, to dive in a cove about an hour up the coast. We dropped anchor near a rounded rock islet.

Umeno-san showed me her mask, an intermediate type between the separate eyepieces of Hekura and the modern one-piece face mask. Umeno-san's goggles were one-piece but kidney-shaped, and left the nose uncovered. At one side hung a single compensating bag made of catskin. From the bag a tube led into the mask, and another hung down near her mouth. Before entering the water, Umeno-san inflated the catskin by blowing into the tube, then closed it off.

Magari ama dive without a descending line and without a safety line. Together we jackknifed at the surface and swam down to the sea floor fifty feet below, parting the tangled fronds of seaweed in the subaqueous jungle, peering and groping for awabi. Nearby a single small iridescent squid regarded us balefully from an enormous eye.

At noon we ran our boat ashore and jumped out on a rock to have lunch. The ama quickly gathered driftwood and dead pine branches and made a blazing fire. They laid abalone, sazae, and a dozen sea urchins in the embers, where they began to steam and bubble.

In a quarter of an hour we scraped the charred spines from the urchins, broke open the spherical shells, and picked out with chopsticks the orange gonads, sexual organs that looked like highly colored caviar. This and the steamed awabi, sazae, and rice, with superb Japanese beer, made a seaside meal to be remembered.

Ama Influenced Japanese History

The ama of western Honshu all appear to have come originally from Kyushu, but the divers of the east coast of Japan are indigenous. Their history is as old as Japan's itself.

The humble diving women, tradition relates, were at the founding of the Ise Shrine, holiest spot in all Japan; they saved the life of a boy emperor, Antoku, by smuggling him to Tsushima and safety from warring samurai; and they were directly responsible for the first sorties of the Japanese people across the Pacific to trade with the Western World.

Only a few years after Cortés wrested the Aztec Empire from Montezuma, the restless Spaniards cast their eyes westward across the sea they named Pacific, and sailed from Acapulco in search of new worlds to conquer.

After colonizing the Philippines in 1565,

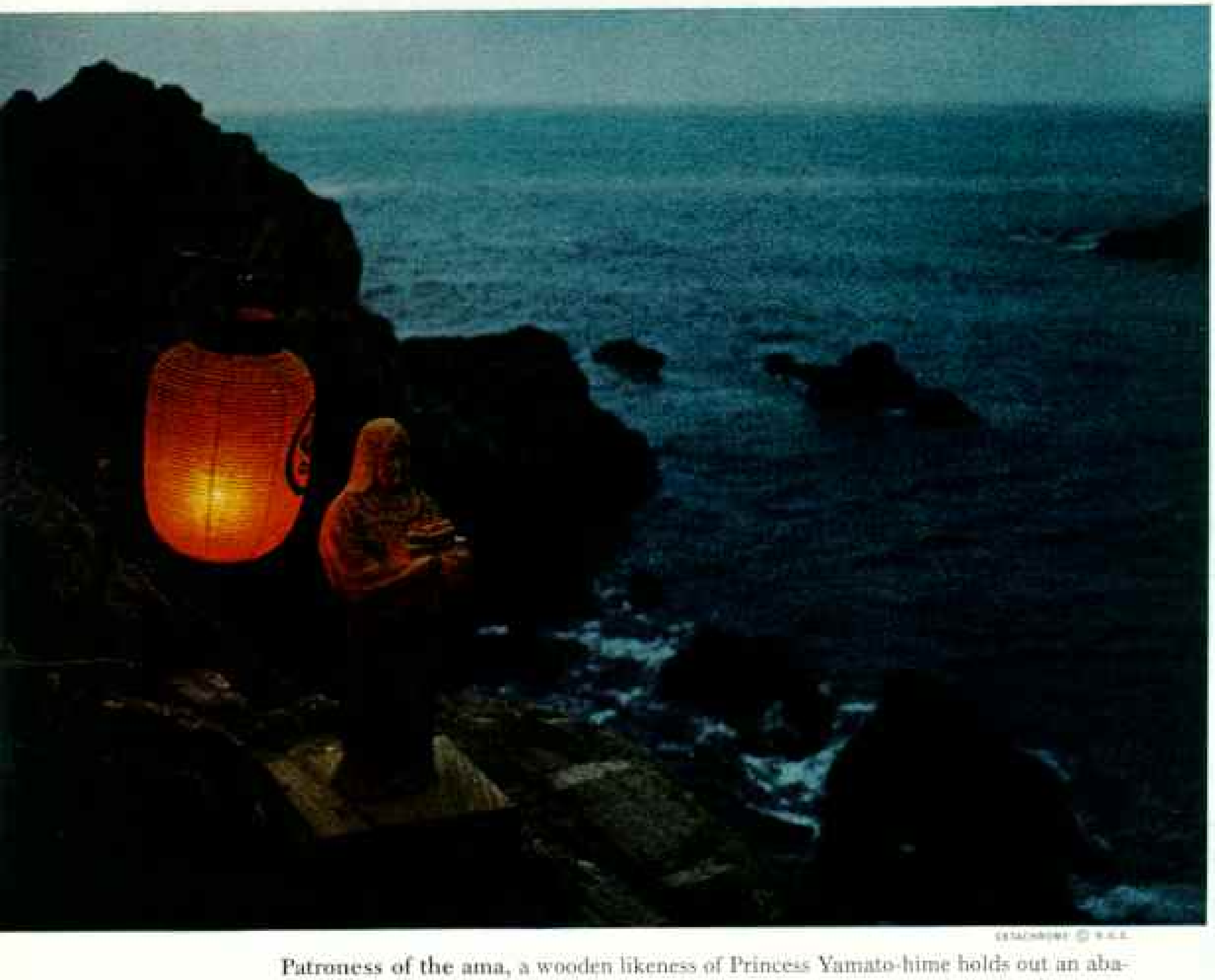
the Spaniards sent galleons to the islands each year, continuing almost without a break until 1815. The clumsy ships sailed easily westward with the trades, but found it impossible to beat back against the wind on the homeward journey. The captains learned to sail in a great arc to pick up the favoring currents and winds north and east of Japan.

In 1609 Don Rodrigo de Vivero, governor general of His Majesty's colonies in the Philippines, sailed for home in the galleon *San Francisco*. The great ship rode the mainstream of the Kuroshio, the Black Current. A typhoon sweeping up from the South China Sea overwhelmed the *San Francisco*, casting her onto the Boso Peninsula's rocky shore near Onjuku, a town that was, and still is, home to a group of ama. To that fact Don Rodrigo and 317 of his men owed their lives.

When we drove to Onjuku, we found that although the wreck of the *gaijin*—foreigners—had happened more than 300 years ago, the event was still remembered. On a hill behind the town rose the white shaft of an obelisk. The monument was erected in 1928; cut into the marble plaque on its base was a message in Spanish: "In memory . . . of the continuous and firm friendship between Japan and Mexico. The People of Mexico."

On another face a letter from the last king of Spain conveyed his "expression of gratitude." It was signed "Alfonso."

The ama saved the lives of the governor and his men, who had been cast up almost dead, the fisheries chief told me. They held the half-frozen mariners in their arms and



Patroness of the ama, a wooden likeness of Princess Yamato-hime holds out an abalone as an offering to the sea near Kuzaki. Ancient manuscripts testify that here, in 3 B.C., this daughter of an emperor chanced upon diving women after establishing Ise Shrine. Finding the ama's abalone delicious, she ordered that it be presented regularly to the shrine, thus giving special honor in the Shinto religion to the sea maids of Japan.

revived them with their own body warmth.

"When Don Rodrigo had recovered," the chief read from another plaque, "he called on the shogun to thank him for the kindness of the Japanese people. Don Rodrigo spent a year in Japan, then sailed for Mexico in a ship built by an Englishman. He took with him 23 Japanese merchants. This was the first time a Japanese mission crossed the Pacific to open trade with Europeans."

Factory Jobs Tempt Women of the Sea

That afternoon I sat in the headquarters of the fisheries cooperative drinking tea with a robust ama of 48. Two gold teeth flashed when she smiled.

"I started to dive when I was 16," Hatsue said, "and I've done it ever since. Our season is short, from the middle of May until about the 10th of September; the rest of the time I pack sardines in the cannery. Most of us don't live beyond 60; I suppose it's the cold water and the hard breathing.

"Many of our daughters don't stay in the village. They go to Tokyo to work for the big companies like Sony and Matsushita, so they can have weekends off and buy the things they see on television. Some people say ama won't last another generation. I don't know; we still have 20 young girls in our village, so we can keep going for a while."

Although the ama lose some of their daughters to industry, they are still far from a relict population. By recent count, there are as many as 7,000 women divers in Japan.

The largest concentration of ama in Japan lives on the Shima Peninsula, south of Nagoya. Most of these live in and around Wagu.

The ama of Wagu dive from an island close inshore called O-shima. I dived with them in the wash and suck of the tide among the rocks, close to the rusting wreck of a coaster that ran aground the year before.

At lunchtime, one ama told me, "Last year two of those ships with crates on decks"—she meant container ships—"collided, and one broke apart and sank. Her cargo leaked out; it was sulphuric acid. It must have rolled along the sea bottom; one girl got burned."

Nowhere are the ama woven more closely into the fabric of Japanese history than at Kuzaki, a small hamlet of weathered wooden houses huddled on a rockbound promontory not far from Wagu. In Kuzaki I examined ancient manuscripts that Ohta-san, the fisheries head, kept in his safe. The oldest, dated A.D. 1111, contained a request from Ise Shrine, the St. Peter's of Japan, for *noshi awabi*, strips of dried abalone.

"In *Nihon Shoki*, an ancient work telling us of the Yamato clan, founders of our line of emperors," said Ohta-san, "we read that in the year 5 B.C. the sun goddess, Amaterasu-Omikami, ordered the Princess Yamato-hime, daughter of the eleventh emperor, to found her house of worship at Ise. Her words were: 'The province of Ise . . . is a secluded and pleasant land. In this land I wish to dwell.'

"In 3 B.C., Yamato-hime went down to the sea and came to this place. Here she saw women diving into the sea. They offered her awabi, and the princess found it delicious. She commanded them to make regular offerings of awabi to Ise Shrine.

"Our people have held to that ever since."

Next day, September 14, the last day of the season, I watched 260 ama make a concerted assault on the awabi off Yoroizaki headland, the precise spot where Yamato-hime first saw the ama nearly 2,000 years ago.

I stood at the foot of a white lighthouse where the cliff dropped nearly sheer some 60 feet to the water. A horn signaled the start; round the point raced a flotilla of nearly a hundred boats. At the same time from the rocks below a multitude of white-clad women waded into the sea.

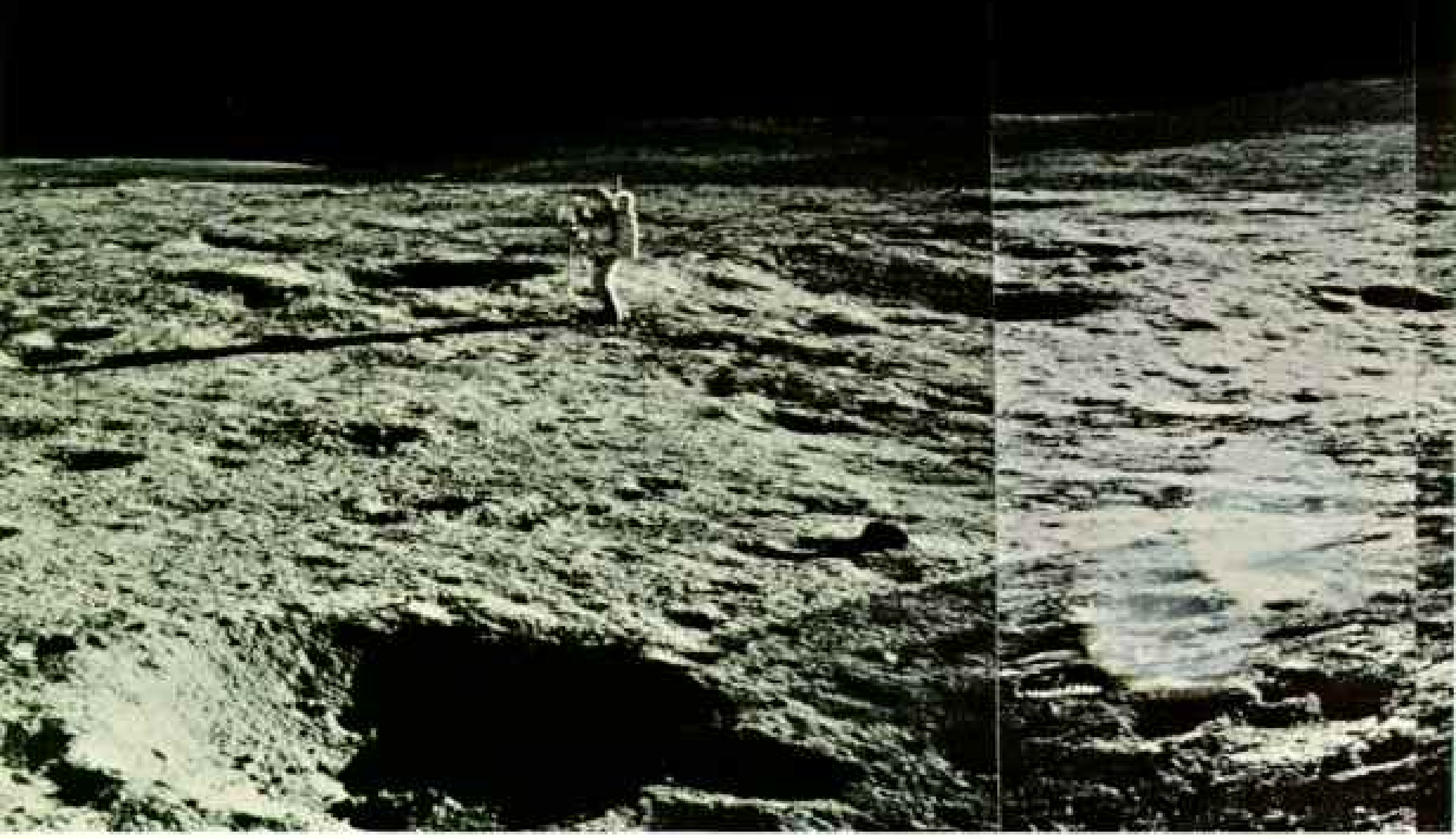
Within moments the dark sea was stippled with white, the heads of the swimming ama, and over the swash of the surf rose a sighing, plaintive chorus, the elegy of the ama's exhalations. The thin piping sounded against the whispering of the sea, repeated endlessly until it seemed that the sea itself was weeping.

Fifty minutes later, a flag fluttered from the chief's boat, and within five minutes the sea was empty.

Goddess Guards Her Diving Daughters

At dusk I returned to the headland. Above me the light turned slowly and flashed its warning over the darkening sea. The wind was dying, and I could hear only the subdued growl of the surf. At the edge I looked down. On a ledge ten yards below stood a wooden figure of Yamato-hime, holding an abalone in her upturned palms and looking out to sea. Beside her, the flickering flame of a paper lantern painted a warm orange smudge on the smoky blue of the darkened sea.

From the headland where she first looked down on them, Yamato-hime still keeps watch over her daughters, the sea nymphs of Japan. □



The Climb Up Cone Crater

By ALICE J. HALL

NATIONAL GEOGRAPHIC STAFF

"AS TOUGH as trying to find your way around the Sahara Desert," recalls Alan B. Shepard, Jr., of the unprecedented trek that took him and fellow astronaut Edgar D. Mitchell of Apollo 14 almost to the lip of Cone Crater—man's longest lunar walk to date. They touched down last February 5 at 4:18 a.m., EST, for the most scientifically challenging mission thus far. America's third team on the moon, they sought clues to the origin and evolution of earth's closest neighbor, and of the solar system itself.

The essence of wilderness surrounds the lunar module at its landing site near Fra Mauro Crater. "We are in a depression here," the astronauts' words flash to earth. "A stark place . . . pockmarked by craters . . . the sky is

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completely black." Surface color varies between "mouse brown and mouse gray." The unrelenting morning sun glares above the gold foil of the 23-foot-tall LM *Antares*. But enthusiasm triumphs. "I think they put champagne . . . in the LM water," quips an exuberant Mitchell.

While Stuart A. Roosa orbits in the command module *Kitty Hawk* and photographs future landing sites, the ground team tackles the desolation. On their first walk, lasting almost five hours, the men range about 1,000 feet from *Antares* to gather rock samples and set out research gear. Solar-wind collector (**upper photograph, right**) traps atomic particles bombarding the moon. An umbrella-shaped antenna transmits to earth the crew's observations, as well as images from the TV camera, aimed by Mitchell at left.

Nearly a mile beyond the antenna, the whaleback ridge of Cone Crater, goal of the second walk, beckons (map, page 142). The large crater at extreme right, dubbed "Old Nameless," appears as close, but actually lies twice as far away. For this 136° composite photograph, Shepard shot a series of stills with his chest-mounted camera.

Checklist on Shepard's wrist (**right**) schedules some 200 tasks, including unloading equipment from a rickshaw-like cart. Mitchell, beyond, sets up a complex instrument unit he carried from the LM. For months its nuclear-powered sensors will radio data on seismic activity and the lunar environment.

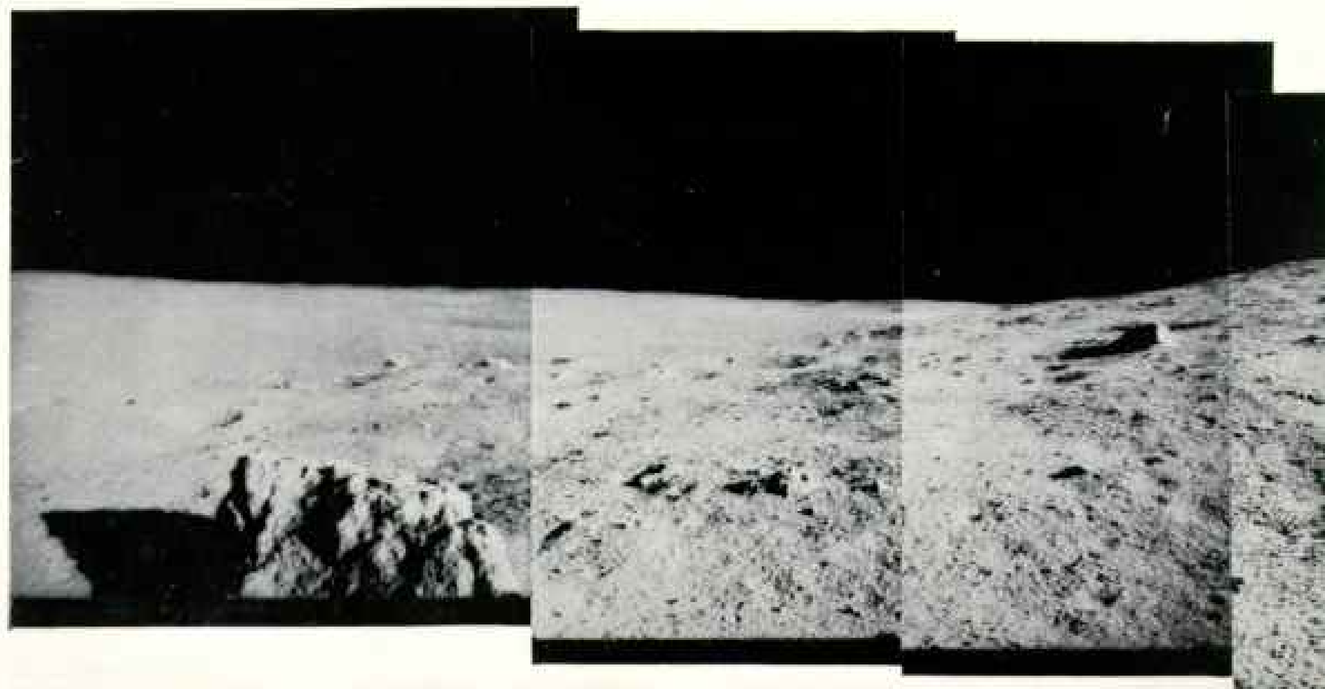
EXTRAVEHICULAR BY ALAN B. SHEPARD, JR., (TOP) AND FROM MOVIE CAMERA (LOWER), NASA

EKTACHROME (BELOW) AND 70MM COMPOSITED BY EDGAR D. MITCHELL, NASA

"LIKE RAINDROPS . . . have splattered the surface." Thus Mitchell describes the fragmented soil texture of the uplands as seen by the astronauts on their Cone Crater trek. The round trip of about two miles took 4 hours and 20 minutes.

Of the North Boulder Field (**above**), 80 yards from *Antares*, Mitchell says, "There's not a level portion out here." The boulder at left was later named "Turtle Rock" for the reptile-shaped formation atop it. From such on-the-scene descriptions, rock samples, and photographs, scientists now work to piece together a chapter of lunar geology.

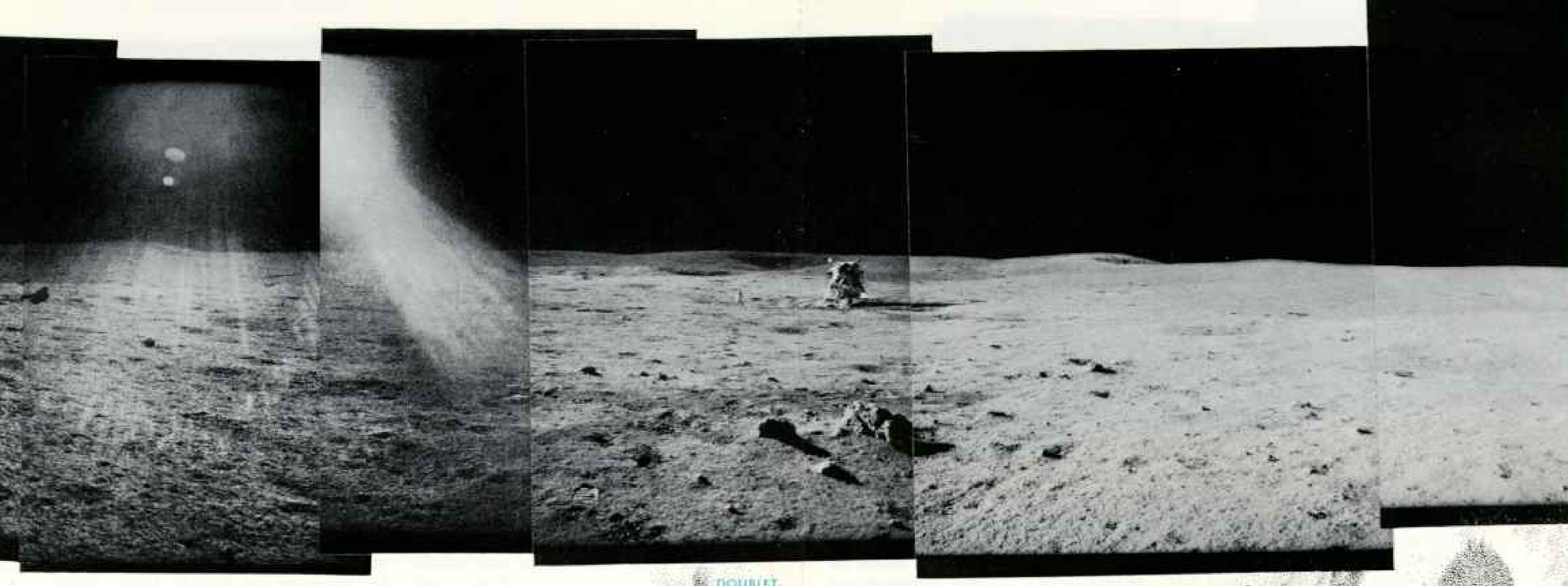
New "road" on the moon (**left**), as crude as any pioneer's ruts, traces the astronauts' route as they pull the cart. Its tracks, up to 3/4 of an inch deep, reminded them of marks made by "driving a tractor through a plowed field." Loaded with tools, rock samples, and camera, the cart would have weighed 149 pounds on earth, but came to only 25 on the moon. When tools began to bounce off, one man walked behind to pick them up.

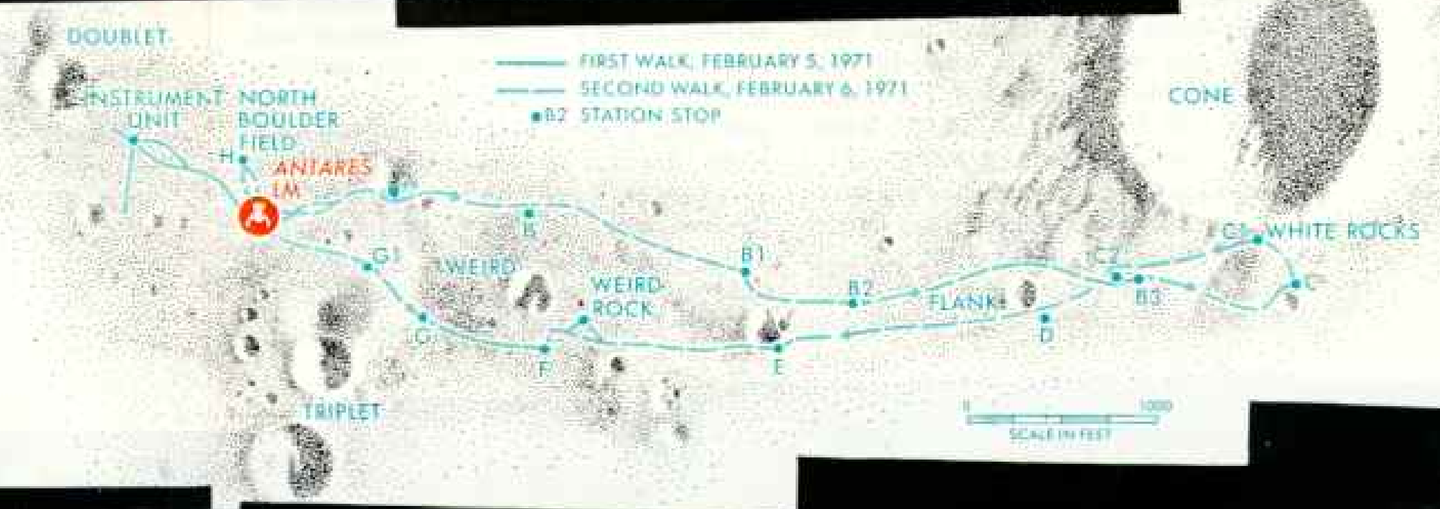


Approaching Cone Crater (**below**), Shepard pulls the cart up what looks like the last ridge. "The grade is getting steeper . . . the soil here is getting firmer," Mitchell reports near Station B2 (**map, right**). The maps the explorers carry, based on photographs taken by Lunar Orbiter 3, show features as small as six feet. But the surface keeps presenting obstacles: craters to skirt, another rise after this, then another. The men believe they are covering ground fast with their lunar lope—alternate hops and steps.

Elusive goal, Cone Crater lured the trailblazers nearly a mile from the LM. Eons ago a colossal impact 700 miles away blasted out the Imbrium basin and spread a blanket of debris over this area. Later, a meteorite gouged out stadium-size Cone, unearthing the old lunar material. On the way to the crater, the astronauts gathered rocks of a type not studied before. A huge boulder named Weird Rock helped guide them back to the LM.

GEOGRAPHIC ART DIVISION © N.G.S.





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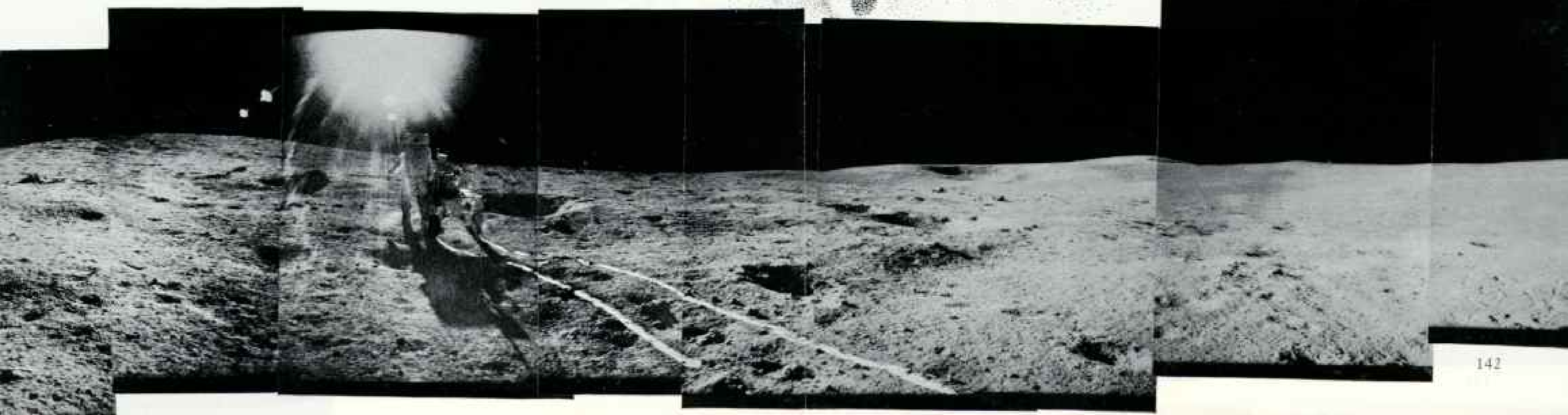
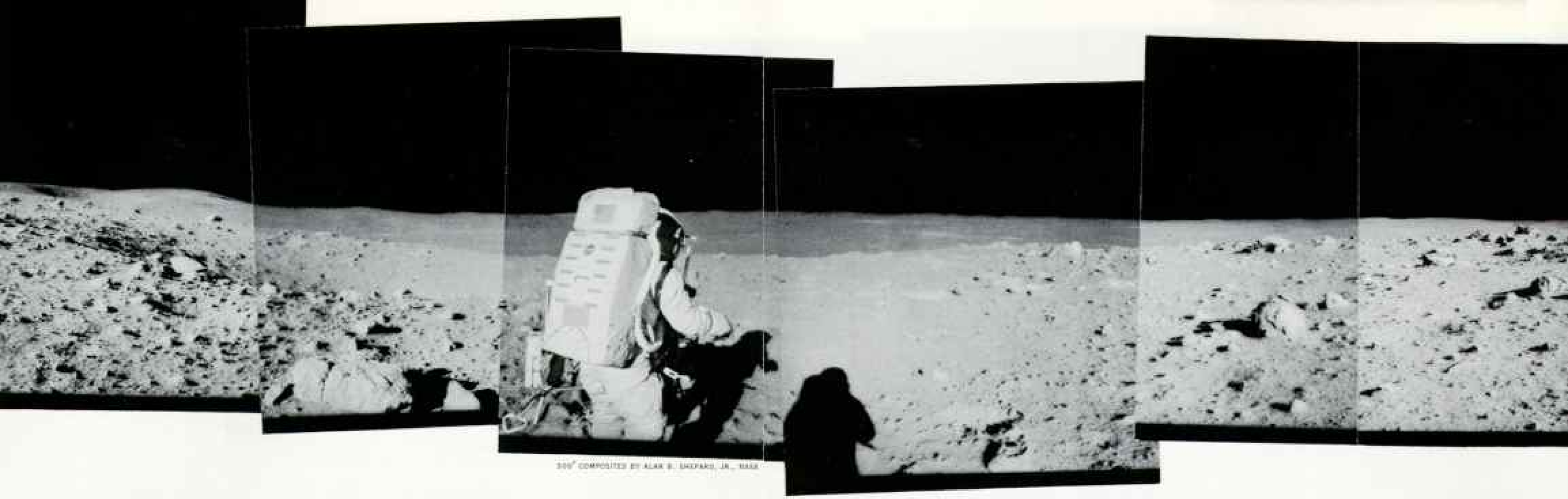




500" COMPOSITED BY ALAN B. SHEPARD, JR., NASA

"THE RIM . . . we haven't found that yet," the astronauts lament at Station C (**above**). But the number of large boulders increases. The men take more rock samples and measure the magnetic field with a portable magnetometer. They catch sight of Old Nameless at far left. Then, about 75 yards off, "almost white" rocks, on the ridge at center, draw the explorers on. "It's farther than it looks," says Mitchell, and Shepard sardonically replies, "That's the order of the day." Soon they stand "right in the midst of a whole pile of very large boulders" (**right**), evidence that the edge is near. But where?

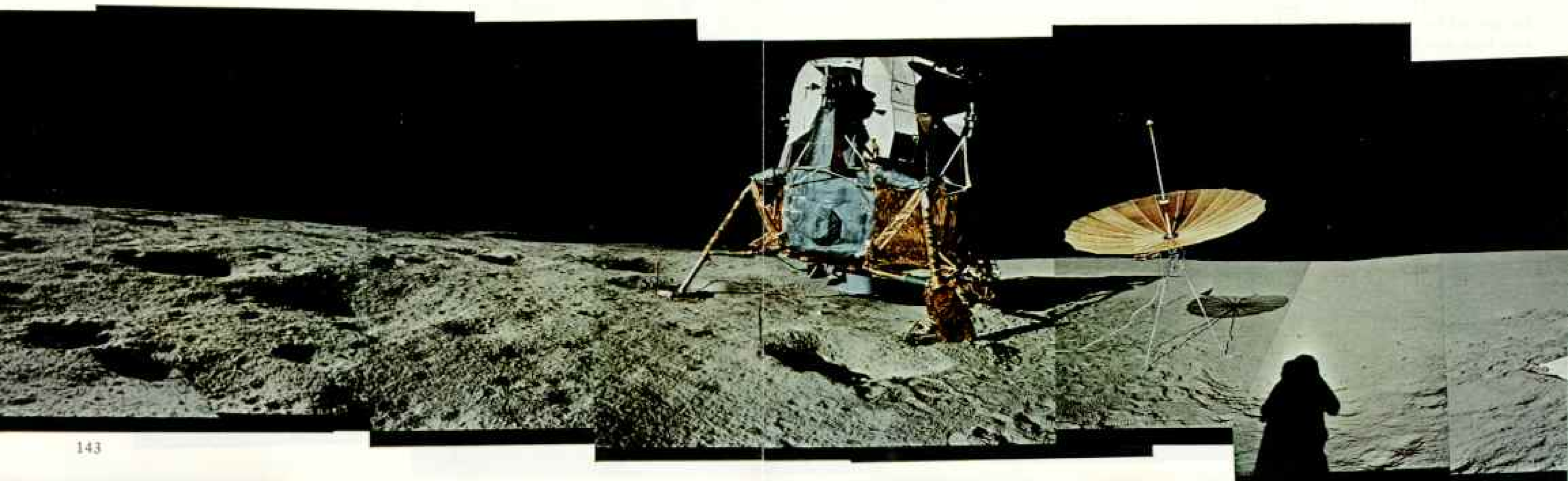
With only eight hours until lift-off, the astronauts pick up loose fragments and chip off a piece of the white rock, and then turn back. Days later, after studying maps and photographs in Houston, they conclude that here at Station C1 (map, page 142) they came within 75 feet of their destination, which lay just beyond the white rocks. Geologists, however, believe that samples taken here are most likely identical with those at the crater's edge.

The downhill leg of the journey goes fast; the highly visible lunar module guides the astronauts home. They stop for more samples amid "country so rolling and undulating, with rises and dips everywhere, that you can be going by a fairly good-size crater and not even recognize it."

The slope at home base (**below**) gives a jaunty appearance to *Antares;* one of its grasshopper legs came to rest only inches from a yard-wide crater.

After working as pilot, geophysicist, and geologist, Shepard played tourist. Attaching the head of a six iron to a tool's 24-inch-long extension handle, he hit a golf ball—for "miles and miles and miles," he said in jest. Actually, his improvised club drove the ball less than a hundred yards.

Leaving behind the umbrella antenna, its white cover, and other equipment not needed on the return to earth, Shepard and Mitchell crowd themselves and 94 pounds of lunar material into the ascent stage of *Antares.* After 33½ hours on the moon, they lift off to rejoin Roosa in *Kitty Hawk* for the three-day, 246,200-mile trip home.



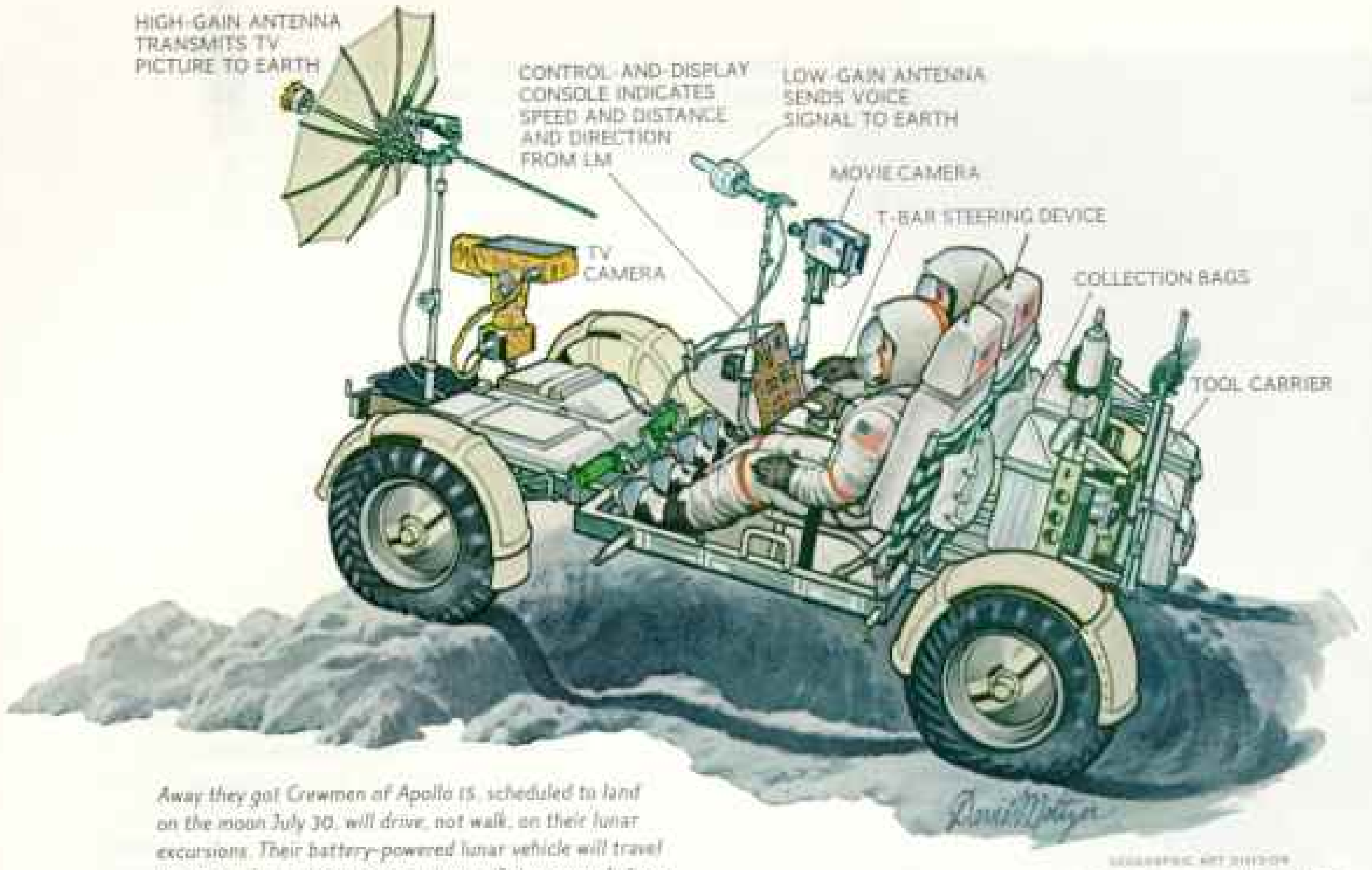
ALAN B. SHEPARD, JR., NASA

Spawn of Cone Crater: White rock that once rested under the lunar surface was broken by the impact of a meteorite and flung to the crater's rim. Most geologists believe that this material originated during the cataclysm that formed the Imbrium basin. Its energy, equal to millions of H-bombs, welded various types of minerals, dust, and rock fragments into an aggregate called breccia. The rounded surface of the boulders appears eroded, probably by the constant bombardment of micro-meteorites and stresses set up by 500° F. shifts in the moon's temperature.

After Mitchell photographed this boulder to show its setting, he hammered off a piece and dropped it in the cuplike sample container.

Hard-won souvenirs from space: At the Lunar Receiving Laboratory in Houston, Mitchell unveils two of the largest lunar rocks yet collected. Gloves protect the material from contamination as it is transferred to airtight cans for storage and later study. Here with Roosa, center, during their two-week quarantine at the lab, Mitchell and Shepard discuss with scientists the features and original location of these football-size rocks. NASA will not quarantine future Apollo crews since returning astronauts and moon rocks have carried no harmful agents or living organisms.

[illegible] (above) by A. Patnesky, Edgar D. Mitchell, NASA



Away they go! Crewmen of Apollo 15, scheduled to land on the moon July 30, will drive, not walk, on their lunar excursions. Their battery-powered lunar vehicle will travel at eight miles an hour on tires woven of zinc-coated piano wire; chevron treads of titanium, riveted to the wire mesh, will keep the wheels from sinking in deep dust.

BORROWING FROM THE PAST, building for the future, Apollo 14—in the words of Alan Shepard—"has shown we have reached maturity in the manned space program." Earlier missions, 11 and 12, emphasized the technology of landings. Like voyagers in the wake of Columbus, Apollo 14's crew systematically explored the new realm. In the final missions, 15, 16, and 17, men will venture into even more varied terrain.

The site selected for Apollo 15 holds many complexities. Plans call for the LM to land on a plain beside the lofty Apennine Mountains, where the astronauts hope to collect samples from the foot of the range itself. They may also investigate Hadley Rille, a feature of uncertain origin that appears on photographs as a dry river bed would on earth.

Apollo 15's LM will be able to stay on the moon 67 hours, twice as long as *Antares* did. Improved suits will allow greater mobility as the spacemen go about their chores.

As with earlier lunar samples, most of the rocks from Apollo 15 will be kept together in NASA's custody, but fragments will be distributed for extensive study among a thousand scientists the world over in a major program of international cooperation. □

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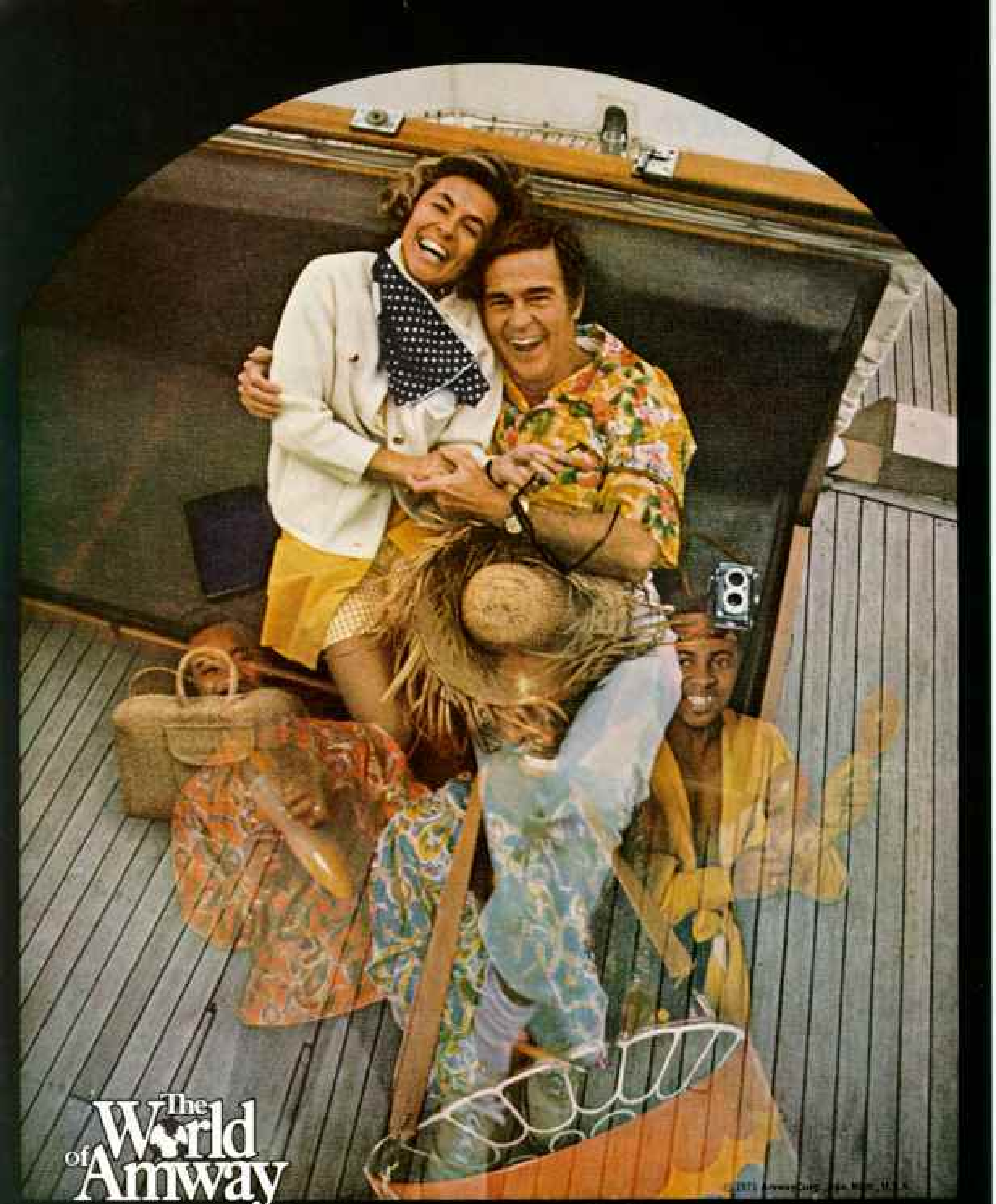

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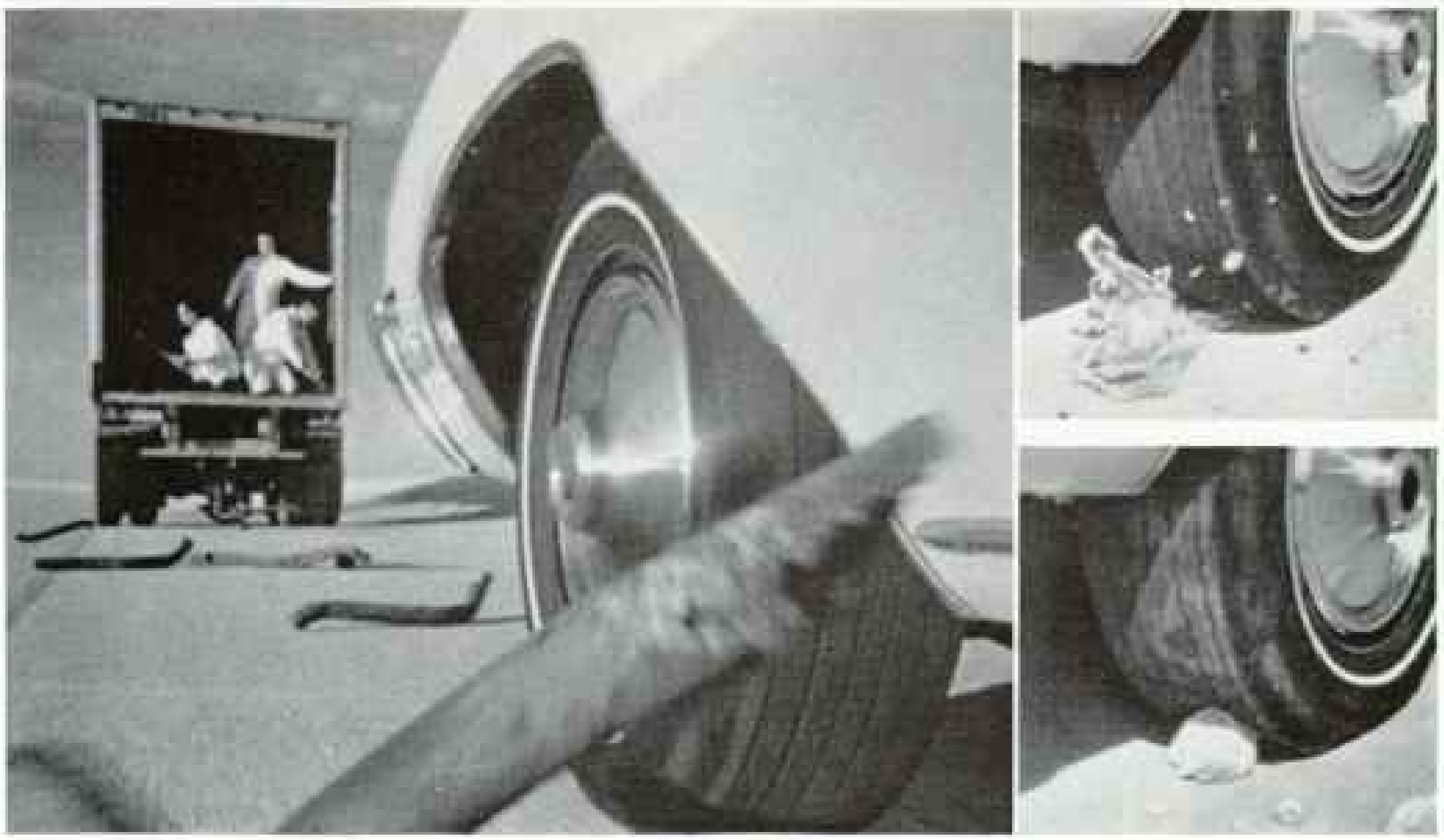

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