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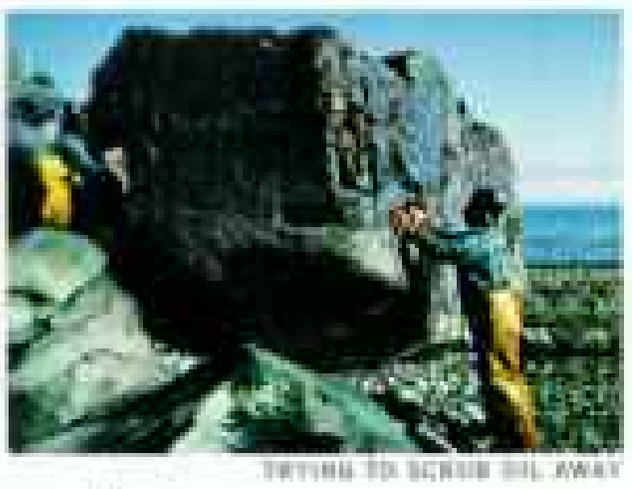


TRYING TO SCRUB OIL AWAY

Alaska's Big Spill—Can the Wilderness Heal? 5

When the supertanker Exxon Valdez ran aground last March 24, spewing 11 million gallons of crude oil into Prince William Sound, some feared that the pristine waters would never recover. Bryan Hodgson assesses the worst tanker spill in U. S. history and a six-month, billion-dollar cleanup effort. Photographs by Natalie Fobes.

SHADOWS SUPPORT PEARY'S CLAIM

New Evidence Places Peary at the Pole 44

Eighty years after Robert E. Peary reported he had reached the North Pole, his claim was still disputed. To settle the controversy, the National Geographic Society commissioned the Navigation Foundation to make a comprehensive study of the expedition's documents, photographs, and navigation techniques. Foundation president Rear Adm. Thomas D. Davies presents compelling evidence that Peary did, in fact, reach the Pole.

VOTING IN THE SUPREME SOVIET

Atlantic and Arctic Ocean Floors

The first of a new map series portrays in vivid three-dimensional paintings the latest knowledge from decades of seafloor exploration.

TOMB LID OF DMITRII, SON OF IVAN IV

The Kremlin and Its Treasures 62

Jon Thompson and photographer Cary Wolinsky win entry to once closed corridors, tracing the history of the Kremlin from a 12th-century fort to palatial center of Soviet government and ceremony. With a photographic portfolio (pages 82-92) of the dazzling art and trappings of tsarist Russia housed in the Kremlin.

NEST GATHERER LIGHTS HIS WAY

Nest Gatherers of Tiger Cave 107

In dark caves of Thailand, generations of men have risked their lives to obtain a prized commodity—edible bird's nests, essential ingredient of a traditional Chinese soup. Eric Valli and Diane Summers photograph the Thai in their precarious pursuit.

SAMPLING A ROBOT'S FARE

Dance of the Electronic Bee 134

Recently developed, a tiny robot honeybee programmed by computer communicates to living bees information about distant sources of nectar. The mechanical marvel can even deliver a sample of sugar water to prove its point. Photographs and text by Mark W. Moffett.

COVER: *Rescue efforts proved futile for a pigeon guillemot, one of perhaps 100,000 seabirds killed by the oil spill that fouled Alaska's shores and waters last spring. Photograph by Natalie Fobes.*

And work they did, for week after frustrating week, an army of 11,000 men and women pitted against the worst ever U. S. tanker spill. On May 23 about 180 workers attacked the stricken shore of Green Island with high-pressure hoses to break up the tarry residue and wash it to the water's edge for collection. Such methods, however, sometimes killed shoreline organisms. Exxon Corporation, responsible for the oil and its ill-fated tanker, will spend more than a billion dollars attempting to clean up one of the costliest industrial accidents in history. Another price: the withholding of scientific data about the spill because of pending lawsuits and damage claims.

A debate over whether to use chemical dispersants to break up the North Slope crude was rendered moot when hurricane-force winds broke up the black tide and drove it southwest. Eventually patches drifted 500 miles along the Kenai Peninsula to the Alaska Peninsula and Kodiak Island. Although volunteers struggled to save oiled seabirds, tens of thousands died. Local fishermen, galvanized by the threat to the sound's commercial salmon hatcheries, grabbed most of the available containment gear and sped to protect their livelihood.

Alaska's Big Spill

Can the Wilderness Heal?

By BRYAN HODGSON
NATIONAL GEOGRAPHIC SENIOR WRITER

Photographs by NATALIE FOBES

It had always been inviolate, an archipelago of eagles and whales. But last March 24, 11 million gallons of oil assaulted Prince William Sound when the *Exxon Valdez* struck a reef. Three weeks later the tide washes oil from one fouled island among scores (following pages). Cleaning a beach, Alaskan Sonya Knight weeps at the wildlife loss. "Cry for one animal," a co-worker advised, "but work to save the rest" (left).

IN THE BEGINNING, when the supertanker *Exxon Valdez* gutted herself on Bligh Reef and vomited 11 million gallons of crude oil into Alaska's exquisite Prince William Sound, it seemed truly like the ending of a world. Seabirds were dying by the thousands in the muck. Vast stocks of salmon and herring and halibut would perish next, naturalists feared, and with them an industry and a way of life. On the eighth day of the disaster I walked shorelines that glittered black as far as I could see. A pitiful handful of cleanup vessels confronted the largest tanker spill in United States history. What hope could there possibly be?

Five months later I walked those shores again. Incredibly I found pink salmon spawning in a stream that had been choked with oil, and I smelled fresh seaweed on a pebble beach where native bacteria had eaten much of the oil away.

Clearly the world had not ended.

Equally clearly, its rehabilitation had just begun. Throughout the sound and down the Gulf of Alaska as far as lower Cook Inlet and Kodiak Island, the damage had been staggering. Oil had drenched or spattered at least 1,200 miles of shoreline. Experts believed that as many as 100,000 birds had died, including some 150 bald eagles. At least 1,000 sea otters had perished, despite an eight-million-dollar rescue and rehabilitation program. Economic costs had been staggering as well: The state had canceled the opening of herring fisheries and restricted the salmon take, together worth more than one hundred million dollars a year.

Meanwhile the Exxon Corporation, owner of the ship and the spilled oil, had spent a billion dollars on a cleanup campaign in which some 11,000 workers had scoured beaches with everything from high-pressure hot-water jets to rakes and shovels and paper towels.

Now, as winter approached and Exxon closed down its effort, new controversies were added to older ones. Was Exxon quitting too early with the job half done, as state officials claimed? Had the cleanup actually done more harm than good? Many scientists now felt it time to let nature cleanse herself with the tides and violent storms of winter.

"Sometime in July the cleanup crossed the

ROY CORRAL/ANIMALS, ANIMALS (RIGHT)

Days after the spill, fishermen confront oily gunk a foot thick clogging a bay on Eleanor Island, about 35 miles from the wrecked tanker. Throughout the spill area, 36,000 dead seabirds, such as a grebe (right), were found—perhaps a third of those killed. Recovered animals were frozen for possible use as evidence in lawsuits; more than 150 have been filed against Exxon.

Staining the vista of the Chugach Mountains, the *Exxon Valdez* lies atop Bligh Reef two days after the grounding. Forty-two million gallons of remaining oil that would have vastly multiplied the disaster if the *Valdez* had sunk were pumped

into smaller vessels. Southbound from the trans-Alaska pipeline terminal at Valdez, the ship met disaster after 28 miles, outside normal shipping lanes, with the captain absent from the bridge.

line from being beneficial to being harmful. In effect, we created a second oil spill," I was told by Dr. Jacqueline Michel, a science adviser to the National Oceanic and Atmospheric Administration (NOAA). "Our tests showed large-scale mortality in beach organisms after some of the hot-water washes. Also, because of the flushing away of oil-coated sediments, we found up to ten times more hydrocarbons in the intertidal and subtidal zones than we did just after the initial spill."

Dr. Michel has researched the effects of oil spills for the National Science Foundation and NOAA since 1974, participating in studies of the *Amoco Cadiz* disaster, which dumped 68 million gallons of oil on the coast of France in 1978. Within three years scientists found that most of the major impacts had disappeared.

"The story is much the same in all crude-oil spills," she told me. "On exposed rocky beaches with much wave action, little oil is left after a year. On quieter beaches the oil persists from two to three years and is frequently mixed with sand and buried. Salt marshes suffer the most damage, and efforts to clean them are too destructive to do any good. In general, fish and bird populations tend to be replaced. The possible long-term effect on the tidal and intertidal ecosystems will take years to learn."

Such research was widely published before the *Exxon Valdez* ran aground in the first minutes of Good Friday, March 24, 1989. Coast Guard Vice Adm. Clyde Robbins, appointed to coordinate the responses of a welter of state, federal, and industry agencies, wishes the research had been more widely read.

"It was almost as though this spill was the first one we've ever had," he told me. "From the start we tried to establish committees to get organization into the activities. But people on the committees had never dealt with oil before. All they saw was oil, and they wanted it GONE! Everyone had a veto vote. And anyone who said 'maybe we should wait to see what nature does' was angrily questioned."

AS I TRIED to learn more about the long-term consequences of the spill, I found that many scientists were not permitted to discuss their findings. By congressional decree federal and state agencies are authorized to make a damage assessment that will result in a financial claim against the spiller sufficient to cover costs of complete restoration.

In harm's way

A vile amorphous blob, the oil inundated some shores yet left others untouched due to vagaries of wind and current. As it broke up and drifted to the Alaska Peninsula, the spill hit four national wildlife refuges, Chugach National Forest, and three national park areas,

CANNERY CREEK

Columbia Glacier

ROUTE TAKEN BY EXXON VALDEZ

Valdez Narrows

Port Valdez

Valdez

PIPELINE TERMINAL

TRANS-ALASKA PIPELINE

A fourth of the nation's domestic oil, as much as 2.1 million barrels a day, flows through the trans-Alaska pipeline from Prudhoe Bay to Valdez.

Glacier Island

Busby Island

Tatitlek

Bligh Reef

Bligh Island

PRINCE

SITE OF OIL SPILL

Naked Island

Eleanor Island

WILLIAM

Block Island

Smith Island

Goose Island

0 10 km

0 10 mi

60°30′N

SOUND

Oiled shoreline

Unaffected shoreline

Rocky shoreline

Marsh or tidal flat

Sand and/or gravel beach

Sea otter concentration

Wild bird concentration

Herring spawning area

Salmon terminal and harvest area

Salmon hatchery

NOS CARTOGRAPHIC DIVISION DESIGN: ALLEN CARROLL; RESEARCH: LINDA R. KRIETE PRODUCTION: VICKI McMALLEN-PRATT; MAP EDITORS: ANN PLATTE, JOHN T. BLOCK PAINTED BY SUSAN SANFORD, MED SCI ART CO

Green Island

Channel Island

Montague Island

Gulf of Alaska

147°W

Leaving the outbound shipping lane, the *Exxon Valdez* crossed over the inbound lane to avoid icebergs calved from Columbia Glacier. She failed to resume a normal course and struck Bligh Reef.

National park, monument, or preserve

National forest

National wildlife refuge

300 km

300 mi

North Slope

TRANS-ALASKA PIPELINE

Prudhoe Bay

A L A S K A

Bering Sea

Fairbanks

CHUGACH NATIONAL FOREST

Palmer

Anchorage

Cordova

Valdez

Mt. McKinley

Cook Inlet

KATMAI NATIONAL PARK AND PRESERVE

ALASKA PENINSULA

AIAKCHAK NAT. MONUMENT AND PRESERVE

Bristol Bay

Barren Islands

Gulf of Alaska

AREA AFFECTED BY OIL SPILL

Unimak Pass

Kodiak Island

Shelikof Strait

Shumagin Islands

New York

Washington, D.C.

Boston

Cape Cod, MASS.

SPILL AREA SUPERIMPOSED ON EAST COAST OF UNITED STATES

Outer Banks, N.C.

Atlantic Ocean

Including Katmai National Park and Preserve. More than 1,200 miles of shoreline were oiled (key). Had the spill occurred on the eastern seaboard, it would have stretched from Cape Cod to North Carolina's Outer Banks (right).

The U. S. Coast Guard tracked the oil aerially with technology such as side-looking airborne radar (SLAR), which detects oil-smoothed waters amid normal wave patterns.

Alaska's Big Spill

Titanic impact left a huge boulder impaled in the hull of the *Valdez*, inspected by salvage divers off Naked Island. Submerged pinnacles had sliced open eight cargo tanks and three seawater ballast tanks. She was towed about 20 miles to safe anchorage there 12 days following the mishap. Tankers such as the *Exxon Baton Rouge* (right, at center) had earlier taken on most of the unspilled oil.

FLIP NICKLIN (ABOVE); MICHELLE BARNES

"We've been instructed that our work is litigation sensitive, so I can't comment or speculate about our findings," I was told by Kimbal Sundberg, a habitat biologist with the Alaska Department of Fish and Game. "But I can tell you what we plan to do. We will make a three-year study of the near-shore coastal habitat, from Bligh Reef to as far as the oil was carried down the Alaska Peninsula, almost to Aniakchak. We've established 98 oil-affected sites, which we'll study from about 65-foot water depth in the subtidal zone to the so-called supratidal zone, where oil has been splashed up by waves. We'll compare these with 28 control sites unaffected by oil—although these have been hard to find.

"But how do you put a price on a barnacle? How much for a limpet? Or a mink, a river otter? We're considering intrinsic value, not just a price tag. We're all heading for court. We'll have to make our case, and Exxon will certainly dispute. This adversarial science is unfortunately necessary."

Studying beach areas is not easy, he told me. One party on the Alaska Peninsula found that a brown bear had attacked their parked helicopter, raking the door and biting through one of the floats. "The weather is dangerous too, particularly in the bays along the Shelikof Strait. The winds there can go from 5 knots to 35 or 40 knots in five or ten minutes. Above all, we don't want to kill anybody."

If science is a forbidden topic, I wondered, how can I answer questions about the fate of the fisheries that loomed so urgently early in the spill? I set out to retrace the travels of two earlier visits and to piece things together as best I might.

MY FIRST EXPERIENCE coping with the spill had been on April 1, when I sailed aboard the Alaska state ferry *Bartlett* with a volunteer force of Cordova fishermen and high school students bound for Sawmill Bay on Evans Island in Prince William Sound. There they would reinforce fragile threads of floating booms protecting the Armin F. Koernig salmon hatchery. It was one of five such facilities that provide between 50 and 60 percent of the Prince William Sound pink salmon harvest, worth as much as 35 million dollars a year. A small fishing fleet had rushed to its defense in the first days of the spill.

We arrived on a brilliant morning after sailing through heavy patches of oil in nearby Knight Island Passage. There was a strangely festive atmosphere as volunteers launched shiny new aluminum skiffs onto sparkling waters. Their cargo: sorbent materials and booms in Easter colors of yellow, pink, and white.

I boarded a skiff with fishermen Tom Kohler and Jay Whitteker and watched the bright colors disappear as we collected globs of oil floating against the boom that protected the hatchery. It was impossible to stay clean. I remarked that the oil looked like sewage.

"I wish it was," said Jay. "At least it would biodegrade faster."

Later I toured the hatchery with manager Eric Prestegard. At a shoreline pen three

million inch-long pink salmon fry swarmed toward us to be fed. "Soon we'll be releasing four to five million fry a day. We must pen them up in incubation boxes and feed them until the zooplankton bloom begins between late April and early May," he said. "Normally they spend a month or two feeding on this zooplankton before they swim to the open ocean to mature. So we have two worries—that the oil will kill the fish and that it will kill the plankton."

Now, returning in mid-September, I wondered how things had gone.

"We never did get oil inside the boom. The fry went out on schedule, and all indications are they survived just fine," assistant manager Mark Somerville told me. "We had an incredible plankton bloom, the highest we've ever seen. There was no contamination."

The progress of the salmon fry was observed for two months by a team led by Ted Cooney of the University of Alaska's Institute of Marine Science. Like most scientists I had met, Dr. Cooney was deeply chagrined by the restrictions on communicating knowledge. But he described the study design:

"Starting on May 8, with three graduate students trained in salmon and plankton studies, we took daily samples of both the fry and the plankton they were feeding on. We measured growth rate and took flesh for hydrocarbon testing. Samples were collected both in Sawmill Bay and outside the bay, where the fry lingered for about ten weeks. We have two months of data to analyze, and we will be able to compare it with a baseline study done in the late 1970s."

Boom and bust characterized most of the de-oiling effort. Workers wipe soiled boulders on Naked Island, a practice widely derided as "rock polishing." More waterborne oil often came ashore to render such efforts useless. Besides earning $16.69 an hour, some participants felt fulfilled by doing something—anything—positive for the environment. Equally determined, a pair of fishermen tow a boom with their seiners to skim a fraction of the oil coating Herring Bay, one of the sites most heavily fouled during the initial onslaught. Everywhere the oil quickly thickened, preventing efficient collection.

BEFORE MY VISIT to Sawmill Bay, I had first flown with Alaska Governor Steve Cowper to see Tatitlek, an Aleut village only six miles from Bligh Reef. Alaska natives throughout the spill zone depend on subsistence hunting and fishing and were deeply afraid that their livelihood and way of life was being poisoned.

"Right now, herring are spawning. The salmon and ducks are coming in. It's scary because we don't know what's happening," said village elder Ed Gregorieff, 65.

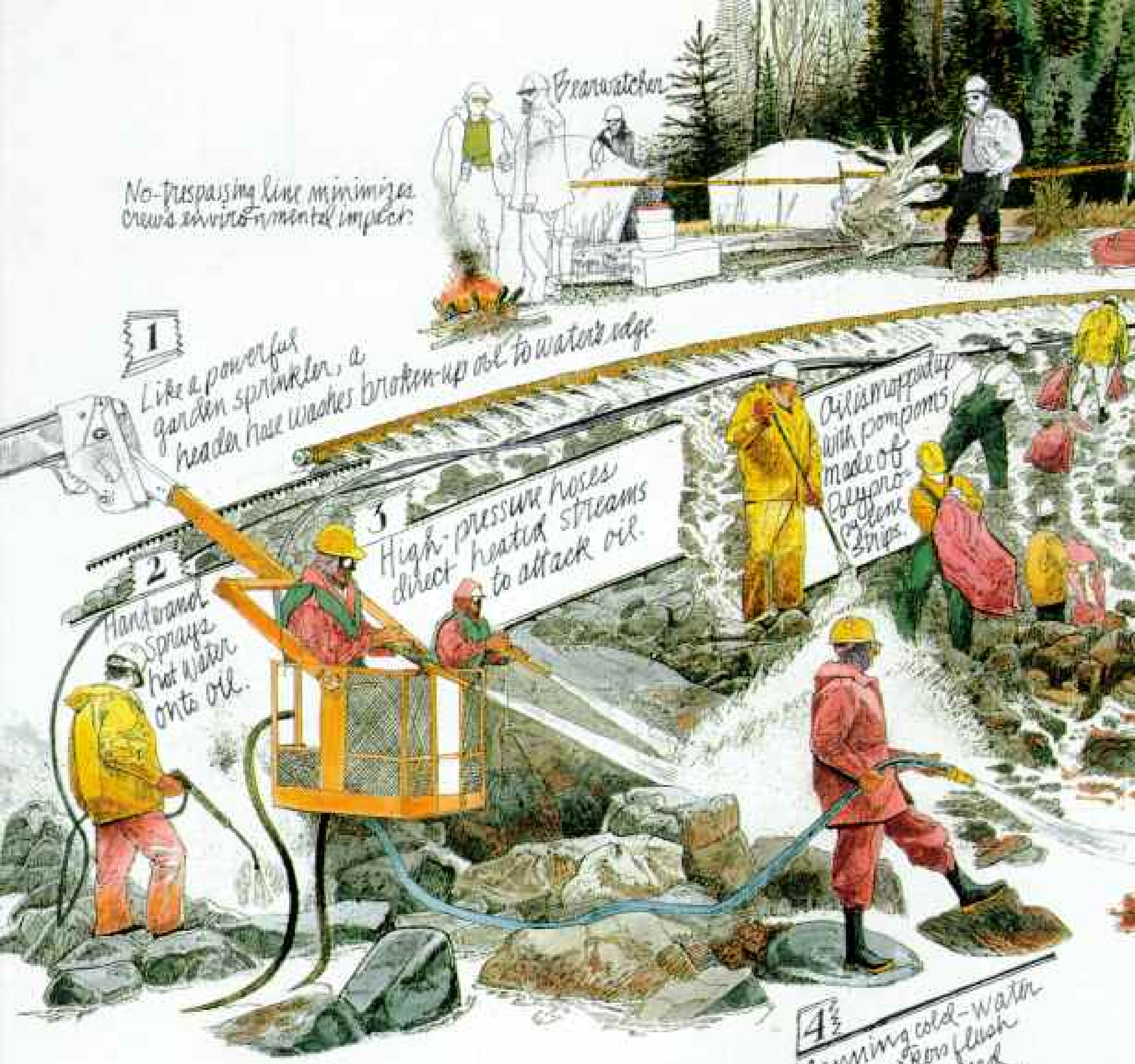
Governor Cowper replied: "If you're damaged, we need to know how much, and we'll try to get you a check. For now we're going to test mammals and birds for toxicity, so you'll know if they're safe to eat."

By mid-September the promise had produced some encouraging news.

"We have tested 5,000 fish sent in by state inspectors and by native subsistence fishers, and so far we have found no crude-oil contamination," I was told by Richard Barrett, head of the state's Division of Environmental Health laboratory at Palmer.

Barrett and his staff first inspect the fish. Anything that looks remotely like oil is picked up on an oil-absorbent pad, diluted with a chemical called hexane, and exposed to ultraviolet light. Hydrocarbons fluoresce brightly, and so far no crude oil has been found.

"Next we do what is called organoleptic testing—meaning to look, smell, and taste," Barrett told me. "We place samples of flesh in sealed jars, heat them in a microwave oven for a few seconds to volatilize any possible hydrocarbons, and then smell each sample. Next the samples are cooked completely, and we taste



Ashore, it was war

Engines roar through a Prince William Sound cove as an amphibious squad attempts to clean an oil-blackened island. Their tactics look sophisticated but basically constitute an old-fashioned frontal assault.

Seawater pumped through a perforated hose (1) on high ground creates a continuous wash to carry oil broken up below to the water. Like hand wand wielders (2), technicians in a hydraulic lift (3), often employed to reach cliffs, use high-pressure hoses with 140°F water heated on barges to blast oil from rocks—a practice that also killed shoreline organisms. Other workers use cold water to flush oil (4) toward vessels called skimmers (5) for eventual recycling. Oily waste from cleaning the mess ashore was incinerated or sent to toxic-waste dumps. Containment booms with foam flotation employ a flexible skirt below the water to keep oil from escaping. Such efforts may have removed only 20 percent of the oil coating all shorelines.

Contracted work.

Landing craft transfer workers and equipment

Truck engines power water heaters on barges.

Boom tender checks joints for oil seepage.

5

A skimmer, shown in cross section at right, uses an adsorbent conveyor belt to draw the oil on board. Rollers scrape and squeeze the oil from the belt.

PAINTING BY JACK UNRUH
CONSULTANTS: JOHN ROBINSON, NOAA HAZARDOUS MATERIALS RESPONSE BRANCH; JACQUELINE MICHEL, RPI INTERNATIONAL, INC.

each one. You can't mistake it if anything is there."

Reassuring as they were, the test results weren't enough for some natives.

"On Kodiak they thought organoleptic testing sounded too primitive. They had heard so many reports of oiled fish that they demanded highly specialized laboratory tests," I was told by Ann Hayward Walker, a NOAA scientific support coordinator, who had just returned from a three-week survey of native villages from Prince William Sound to Kodiak.

THESE TESTS quickly became a high priority for Usha Varanasi, director of NOAA's Environmental Conservation Division in Seattle. "We have taken halibut and salmon from native villages in Prince William Sound, the Kenai Peninsula, and Kodiak and tested them using high-performance liquid chromatography as well as gas chromatography/mass spectrometry," she told me.

"So far we have found no hydrocarbons in their flesh, except for a few pink salmon from Kodiak that contained some traces in the parts-per-billion range. Fish are very efficient at converting hydrocarbons they ingest into metabolites and excreting them from the liver to the gall bladder. Consequently we would expect flesh contamination to be slight.

"Shellfish are not efficient, and we have found contaminated clams and mussels from Windy Bay, Chenega, and Kodiak—sites that were severely impacted by the spill."

NOAA scientists have tested 900 halibut for the Halibut Commission, finding no contamination. To assist in damage assessment, the NOAA research ship *Fairweather* has sampled hundreds of fish and shellfish, and spawning fish have been studied to detect any reproductive dysfunction.

"We are studying a system that has never been severely impaired by pollution, so if there are any problems, they should be evident fairly quickly," Dr. Varanasi said. "For the subsistence people, we have put everything we have behind the program. I am delighted we can discuss the results of our tests."

More cautiously, Al Maki is willing to discuss his work as well. He is Exxon's science adviser, with a 20-million-dollar budget to study the spill through spring 1990.

"We've selected more than 300 people with the best credentials in the country to do an accurate, science-based assessment of the spill," Dr. Maki told me. "We now have thousands of water and sediment samples from Prince William Sound through Kodiak and the Alaska Peninsula. Our data clearly show that hydrocarbon concentrations in the water remain at relatively low background levels—levels in the low parts-per-billion range.

"To date we have seen no substantive effects on the extent of herring spawning. We've sent divers down to take samples of eggs from both exposed and unexposed areas, and we've hatched the eggs in the lab and rigorously tested the fish embryos.

"We've also examined young and juvenile herring, which spend their first two months in the intertidal and subtidal zones. Initial results showed good survival. We've taken tissue samples to test for hydrocarbons, but we are still awaiting the results.

"As for pink salmon, this spring we were concerned with the out-migrants that came down the streams at the time of the spill. What happened? We used wire cages called live cars and placed salmon fry in them at both exposed and unexposed sites. The data are convincing: We monitored the samples for two weeks, and there were no oil-related mortalities.

"Now we are measuring escapement—the number of salmon that successfully returned to their native streams to spawn. Here we developed a new technique using a video camera mounted beneath a helicopter and a computer-enhanced image that enabled us to get an actual hard count of spawning fish, not just an estimate. We have done this on more than 50 streams. And this year there was a very large spawning run.

"To follow the actual spawning, we placed eggs in more than 200 sample containers and buried them in the gravel beside the naturally deposited eggs in both oil-affected and non-affected zones. We will pull sample boxes throughout this winter to see what effects there may be."

FOR ME one of the most distressing moments of the spill came when I heard orphaned newborn seal pups utter their strangely human cries at a rehabilitation center in Valdez. They had been brought in from Herring Bay, on Knight Island, one of the most heavily oiled sections of the sound.

Although seals come under the jurisdiction

Blotting oil with a paper towel, Sophie Katelnikoff (below) spends Mother's Day doing what she can for a beach near her village of Larsen Bay on Kodiak Island. A friend wields a spoon against the oil, now transformed into a thick emulsion called mousse. Villagers feared its effects on offshore clam beds. Along the southwestern end of the spill, officials protested vigorously when impact was generally assessed as less severe than in the sound.

BRYAN HODGSON, NGS STAFF (ABOVE); KEN GRAHAM PHOTOGRAPHY

Rare good news may come from an experimental project called bioremediation, designed to promote the growth of microorganisms naturally present in the environment that break down oil. Technicians spray a nitrogen-phosphorus fertilizer mix on an oil-laden shore of Green Island in hopes of stimulating oil-eating bacteria. On a nearby island a test grid shows noticeable improvement in a treated area (right, at right) compared with an untreated plot, at left and above. By September a stretch of Green Island has recovered dramatically (above).

The technique, long employed against toxic wastes, could double the speed of natural oil removal.

Netting a sad harvest, Jerry Patton collects birds that perished on Channel Island. They were analyzed in Valdez, as were Green Island victims including a sea otter and a loon (right). Concern ran high for some 5,000 bald eagles, such as this adult with an oiled head en route to a rehabilitation center. Nearly 150 eagles are known dead. Long-term effects may plague others that scavenged contaminated carrion.

of NOAA, they also become the concern of the Alaska Department of Fish and Game when they "haul out" to give birth or molt onshore. That casts state biologists Kathy Frost and her husband, Lloyd Lowry, in the role of foster parents.

"The seals are molting now, so they have shiny new coats," Frost told me in September. "They are hauling out to sun themselves, and I hope the areas are clean enough so they can go into winter with clean coats.

"It will be at least three to six months before we can tell what effects the oil has had. We're waiting in line for lab tests. In October we'll collect a few more animals for study and hope to have comparative tissue analyses by then.

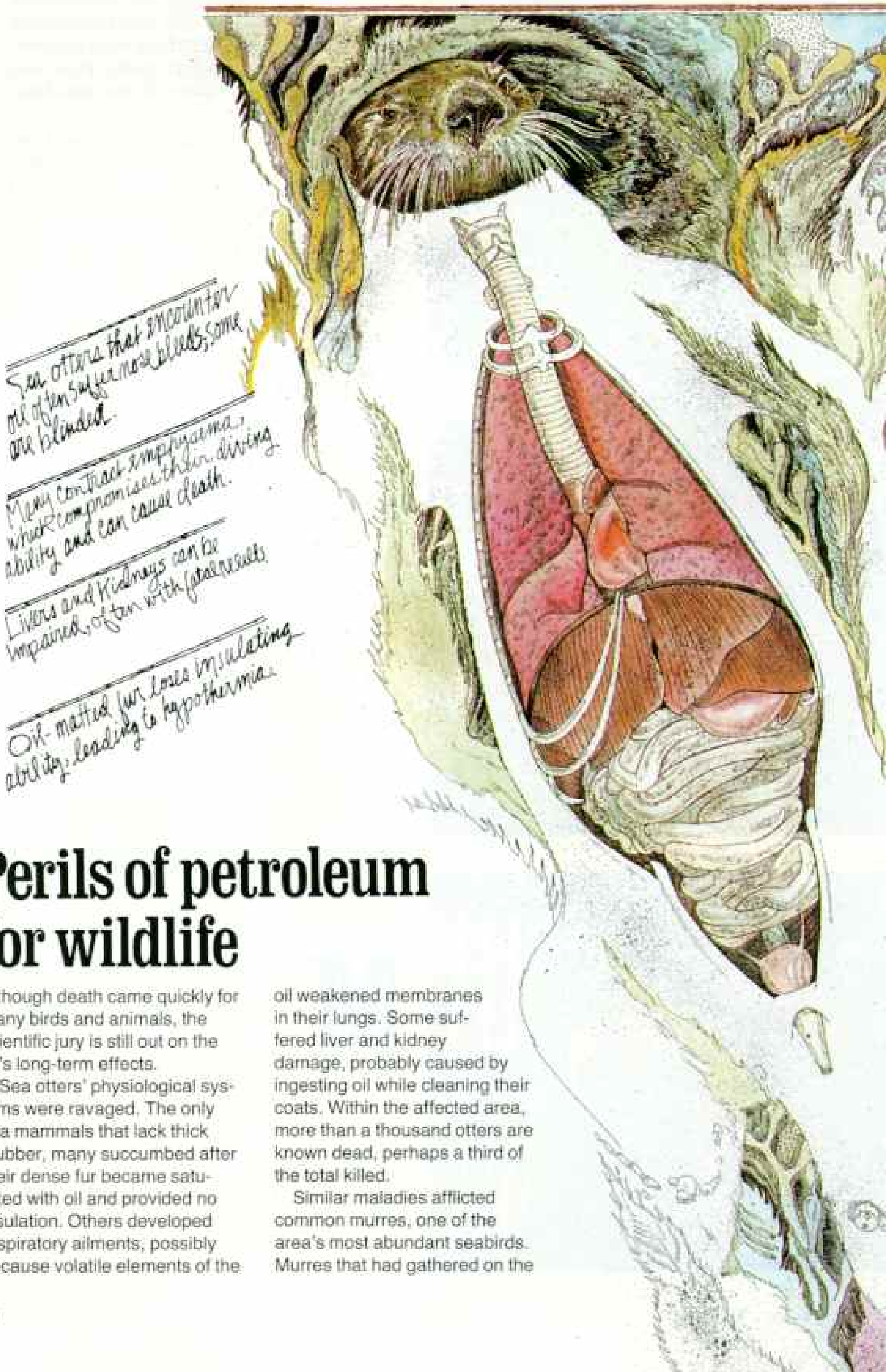
"We never saw a lot of seal deaths that could be attributed to oil. Some premature pups were picked up, but they could have been natural abortions. We found several newborn pups that may never have taken a breath. The mothers had a lot of stress, both from the oil and from human activity.

"Not many dead seals were found. The number of carcasses was fewer than 30. Seals sink when they die, and that's why they are hard to find.

"We're doing aerial surveys of 25 areas and comparing the results with similar studies done in August and September of 1984 and 1988. But there was an unexplained drop of 40 percent in the population between those years, so we will not get a good comparison. On Tugidak Island, south of Kodiak, for instance, the population dropped from 10,000 to 2,000, and nobody knows why. Starvation might be one reason. Pollack is one of our largest fisheries here—but it is also a key prey species. We can't maximize fisheries and marine mammals at the same time."

MAXIMIZING SAFETY at the expense of fishing became a priority early in the spill when state officials announced a "zero tolerance" policy that prohibited fishing in any area where oil was reported. The policy, designed to protect consumers and to preserve the untainted image of Alaska fish on world markets, had some unintended results.

"I hope the state realizes what zero tolerance means," I was told by David Kennedy, NOAA science coordinator. "In addition to Exxon oil, our laboratory has found that fisheries were closed for bilge oil, diesel oil, and



Perils of petroleum for wildlife

Although death came quickly for many birds and animals, the scientific jury is still out on the oil's long-term effects.

Sea otters' physiological systems were ravaged. The only sea mammals that lack thick blubber, many succumbed after their dense fur became saturated with oil and provided no insulation. Others developed respiratory ailments, possibly because volatile elements of the oil weakened membranes in their lungs. Some suffered liver and kidney damage, probably caused by ingesting oil while cleaning their coats. Within the affected area, more than a thousand otters are known dead, perhaps a third of the total killed.

Similar maladies afflicted common murres, one of the area's most abundant seabirds. Murres that had gathered on the

water in huge rafts prior to breeding were fouled en masse. Oiled feathers (inset) lost their insulating ability and hypothermia set in.

The oil invaded the food web when predators such as bald eagles scavenged oily seabird carcasses, carrying them to their nests and contaminating eggs or young. Of 125 eagle nests surveyed, two-thirds failed last year.

PAINTING BY JACK UNRUH
CONSULTANTS: TOM WILLIAMS, MONTEREY BAY AQUARIUM; D. MICHAEL FRY, UNIVERSITY OF CALIFORNIA, DAVIS

hydraulic fluid. There's a certain amount of oil associated with any fishery, and this policy, if enforced in the future, could continue to cause routine closures without any Exxon oil."

KODIAK, along with the Kenai and Alaska Peninsulas, received little attention in the early days of the spill. This was true even though broad patches of sheen—a coating often only thousandths of an inch thick—accompanied by evil-looking streamers of an oil-water emulsion called mousse were drifting down from Prince William Sound.

But in early May a dramatic press conference by officials of Katmai National Park and Preserve announced that 90 percent of Katmai's 260-mile coastline had been devastated.

To check those early reports, photographer Natalie Fobes and I boarded a single-engine Bell LongRanger helicopter for the 80-mile trip from Kodiak. At Hallo Bay, on a broad expanse of beach, we found Kodiak fishermen Ed Stiles and Kelsey Crago, who had been hired by Exxon to look for oil and dead birds.

"We've picked up about 3,000 birds in the last five days," said Crago. "Most of them were murres, killed around the Barren Islands northeast of here. They keep drifting in with the tide. We're collecting the bodies to keep the bears and eagles from eating them."

The bay was smeared here and there with oil and tar balls. A bear had left oily footprints on driftwood logs. "This is the prettiest place in the world—as long as you don't look down," said Stiles.

Just to the north, at Cape Chiniak, we found a party of 20 workers loading a small landing craft with hundreds of blue plastic bags filled with heavy oil. "It's ironic, but we can earn more shoveling oil than we can fishing for cod," said one of the workers, Paul John "Tiny" Smith of Albany, Oregon.

Compared with the oil-drenched shorelines of Prince William Sound, which had absorbed about 90 percent of the spill, the damage here seemed light to moderate. On Kodiak and Katmai those definitions are fighting words.

"We consider this oiling to be an ultimate insult to a national park," Jay Wells of the National Park Service told me. "It will be years before we know what damage has been done to the bear and eagle populations and to the shoreline ecosystem itself."

Next day the oil-spill rumor mill provided

For a sea otter named Lazarus, there was a resurrection.

He showed up as yet one more emergency around 11 p.m. on April 14 at the Valdez Sea Otter Rescue Center, one of four such facilities that cared for the creatures. To this makeshift hospital set up in a college dormitory, a steady stream of otters slathered in oil had been arriving for two weeks by helicopter, boat, or even in cardboard boxes delivered by good samaritans.

It had been another long day; the staff of two dozen was exhausted. Ken Hill, a veterinarian from Cordova, examines the latest victim (above), a male picked up by a rescue vessel. Delivered in a pet carrier, he was barely moving.

His breathing stops. So does his heart. "He's had it," Ken says.

Everyone hears that, and no one accepts it. An oxygen mask goes over the otter's muzzle. An intravenous tube goes into his leg. Warm saline solution is injected under his skin, and he is laid in a warm bath. Ken holds his jaws open with a bar (top right) as a syringe is connected to a tube that carries both an energy booster and an activated charcoal slurry—to counteract the oil's toxicity—into the animal's stomach.

When he was out of danger, "a cheer went up," says Terrie Williams, a physiologist working with Ken (middle right, at right) during a two-hour washing with liquid detergent to clean the fur of the patient, which the staff named Lazarus by appropriate acclamation. A far more laid back Lazarus

(left) is one of about 200 otters now returned to the sound and waters beyond, some with radio transmitters implanted to signal their locations.

Terrie, based at the University of California, San Diego, reports that about half the 156 otters brought to the Valdez center were saved. Of the otters she tested, all the survivors had toxic hydrocarbons in their bloodstream at a concentration of 200 parts per million or lower, while those that died showed higher levels.

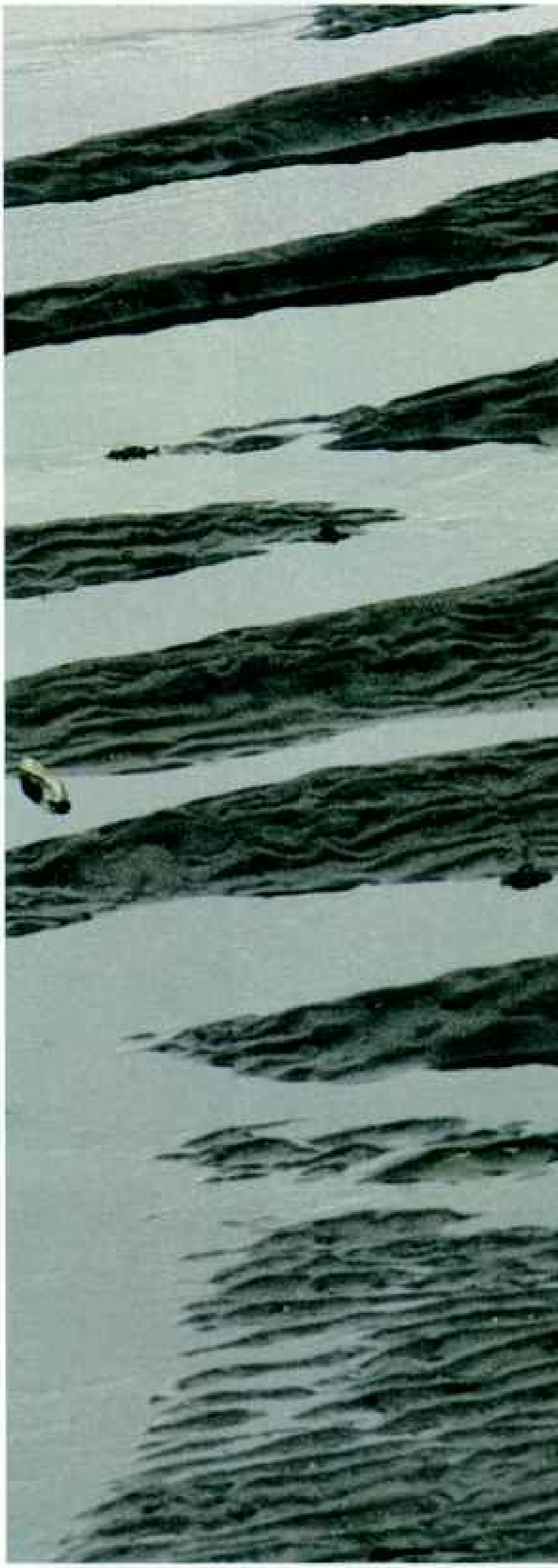
me with an unexpected bonus. Orders came from Washington to dispatch a Coast Guard and NOAA team, equipped with a sophisticated mobile laboratory, to prove or disprove alarming reports that large quantities of oil were heading for Chignik Bay and possibly Unimak Pass at the end of the Alaska Peninsula. With help from Lt. Comdr. Ken Elmer, commander of Coast Guard flight operations at Kodiak, I flew on a C-130 Hercules 360 miles southwest to a gravel landing strip at Sand Point, a fishing village in the Shumagin Islands. From there a Coast Guard H-3 amphibious helicopter made the 80-mile final leg to Cold Bay, a deactivated Strategic Air Command base that more than lived up to its name.

What followed was a magical two-day tour of remote islands and coastal bays, of deserted beaches piled high with logs splintered by ferocious storms. The peninsula is a beachcomber's paradise of random wreckage from the vast Pacific, and a naturalist's paradise as well. Foxes and wary gray wolves observed our passage, and we surprised dozens of huge brown bears as they lumbered along well-trodden shoreline "bear highways" with plump cubs in tow.

But we found no oil until the second day, when the familiar patches of silvery sheen appeared in the Shelikof Strait as we returned to Kodiak.

"We are called to 25 oil spills each year, from grounded vessels and fueling accidents," I was told later by Paul Gates, the U. S. Department of the Interior's regional environment officer and a member of the interagency regional response team established by federal law to respond to spills of oil and other hazardous materials. "Usually we take them in stride, but on this one, emotions overwhelmed everything almost from the start. Now we've issued instructions to first confirm oil sightings before reporting them—and report to federal officials, not to the press."

By contrast, emotion seemed eerily absent at a five-day hearing held in Anchorage in May by the National Transportation Safety Board



Land mammals also run afoul of the spill, with uncertain consequences. A brown bear's grimy legs and back show the oil it encountered elsewhere on this beach in Katmai National Park and Preserve. Bears, river otters, and foxes may scavenge oil-coated seabirds.

(NTSB) to investigate the causes of the *Exxon Valdez* accident.

According to witnesses the tanker's captain, Joseph Hazelwood, had boarded the ship and retired to his cabin for some two hours while a harbor pilot guided the ship in darkness through Valdez Narrows. Returning to the bridge when the pilot was dropped off, he ordered a course change to 180 degrees to avoid icebergs coming from the Columbia Glacier. He then switched the steering mechanism to automatic pilot.

At about seven minutes to midnight Hazelwood went to his cabin, leaving Third Mate Gregory Cousins and seaman Robert Kagan with instructions to steer back to the regular traffic lane when the ship came abreast of Busby Island.

Instead, according to instrument records, the giant tanker continued in a straight line for 11 minutes, veering only slightly to the right a few seconds before crashing onto Bligh Reef at four minutes past midnight.

On the witness stand Cousins testified that he had switched off the autopilot when Hazelwood left the bridge. When the ship reached Busby Island, he ordered helmsman Kagan to turn the ship ten degrees to the right. When radar showed the ship was not turning, he called for 20 degrees right rudder. About two minutes later, Cousins said, "I looked at radar, didn't like what I was seeing," and ordered hard right rudder. Then he telephoned Hazelwood and said, "I think we're in serious trouble." As he spoke, the ship ran aground.

Second Mate Lloyd LeCain, the navigation officer, who came to the bridge minutes after the disaster, testified that the ship's steering gear appeared to be in order. When the ship was on autopilot, he said, turning the wheel would have no effect on the rudder.

"The only people who know exactly what happened on that bridge that night are the captain, third mate, and Mr. Kagan, and anything else is irrelevant," LeCain said.

Hazelwood, under criminal indictment, did not attend the hearing, but his voice was heard on official Coast Guard tape recordings made on the night of the wreck.

At 27 minutes after midnight, he radioed:

"Yeah. . . . We've . . . it should be on your radar there . . . we've fetched up hard aground north of Goose Island off Bligh Reef. And, uh, . . . evidently . . . leaking some oil, and . . . we're gonna be here for a while, and . . . if you want . . . so you're notified."

Chief Mate James Kunkel told of the drama that followed. Racing to the control room, he saw that the ship was listing to starboard while eight cargo tanks gushed oil at some 200,000 gallons a minute. He told Hazelwood that the ship would capsize if it came off the reef.

"I feared for my life . . . ," Kunkel said. "It was the worst thing I'd ever been involved in. . . . I wondered if we were going to see the sunrise."

Nevertheless, Hazelwood tried to free the ship. Almost 45 minutes after the accident, he radioed to Valdez Coast Guard Comdr. Steven McCall that he was having "a little problem here with the third mate, but . . . we're working our way off the reef. . . . The vessel has been holed, and . . . we're ascertaining right now, we're trying just to get her off the reef, and . . . we'll get back to you as soon as we can."

WHEN I RETURNED to Valdez, I learned how close the *Exxon Valdez* had come to inflicting an unimaginably worse disaster by spilling her entire 53-million-gallon cargo into Prince William Sound.

"I'd never seen that much hull damage—I was sort of awestruck. One rock was broken off eight feet inside the hull," I was told by Rick Wade, owner of R&R Diving Services, who was called by the Coast Guard to make an emergency underwater survey of the ship at daybreak on Good Friday.

He showed me a videotape recording of the gaping wounds along some 600 feet of the hull, attesting to the enormous inertial force with which the 30,000-ton ship, laden with more than 170,000 tons of oil and moving at 12 knots, disembowelled itself on a series of reef pinnacles before finally grinding to a precarious halt on a narrow ledge.

The video sound track captured the agonized groaning and creaking of steel on stone, like an eerie voice of tragedy.

"The reef was being ground to gravel by the hull while I was down there. It wasn't a comfortable place to be. The ship could have come off the rocks anytime," Wade said.

John Tompkins, Exxon's salvage manager, agreed: "We had an unstable vessel," he told me. "Eight cargo tanks and three ballast tanks were holed. She would have gone

With a tender nudge, an oiled female harbor seal in Herring Bay shows she still knows her pup despite its own oil-blackened skin, creamy white underneath. Many seals killed by oil sank out of sight, making a tally impossible.

With so little known of oil's effects on marine mammals, scientists seized a chance to examine a gray whale that washed ashore on Kodiak Island. Cause of its death is still under investigation.

down eventually if she had come off the rocks that night. She still had more than 42 million gallons aboard—80 percent of her original cargo—and we wanted very much to spill no more. We had to find a way to take cargo off and get ballast water in without moving the ship. If we had done it wrong, she could have slid off the shelf. When we got the 70-knot winds, there was much anxiety and fear."

THE FIRST to start emptying the tanker were members of the U. S. Coast Guard Strike Force, an oil-spill response organization based in California and Alabama, equipped with pumps, booms, and oil-pickup gear designed to be air-dropped at the scene of a spill.

"We flew in on Good Friday with five high-volume pumps," said Lt. Comdr. Gary Reiter, commander of the Pacific Area Strike Team, which is based near San Francisco. "On Saturday we were on the tanker transferring cargo."

The team also brought along several oil-skimming units, which include a 612-foot containment boom with skimmers and a self-powered floating pump unit designed to be towed by so-called vessels of opportunity at the spill site. In Prince William Sound the opportunity fell to the Coast Guard cutter *Sedge*.

"If we'd had one of these skimming units operating in the first week, we could have collected 600 gallons a minute for days, because the oil was thin and easy to pump," said the *Sedge's* skipper, Lt. Comdr. George A. Capacci. "That's 16,000 barrels a day, theoretically—if we had had a barge to pump to. As it was, it took us more than two days to deploy the boom, because we never had practiced it. Then the oil got so thick that we couldn't

Breakdown of a spill

As soon as the oil gushed into the cold water of Prince William Sound, it began to change, affected by physical and chemical weathering processes, the initial phases shown above.

The spill spreads and starts to evaporate. Oil droplets disperse into the water column, a generic liquid core sample. Some of the oil's aromatic components dissolve, and the slick grows more viscous.

As waves stir and batter the hydrocarbon bouillabaisse, it forms a heavy water-in-oil emulsion, or mousse, almost impossible for cleanup crews to pump.

In silt-laden water, oil droplets can also join suspended particulates by adsorption and sink. "Despite fears that the sound's bottom would be paved with oil, the particulate concentration was too low. It didn't happen," says marine chemist Dr. James R. Payne.

Weeks later, at right, bacteria (red) attack the surface of the oil, and sun-stimulated oxidation dissolves more components. Eventually wind and waves shear the mousse into pancakes, which in turn break into tar balls that may wash ashore.

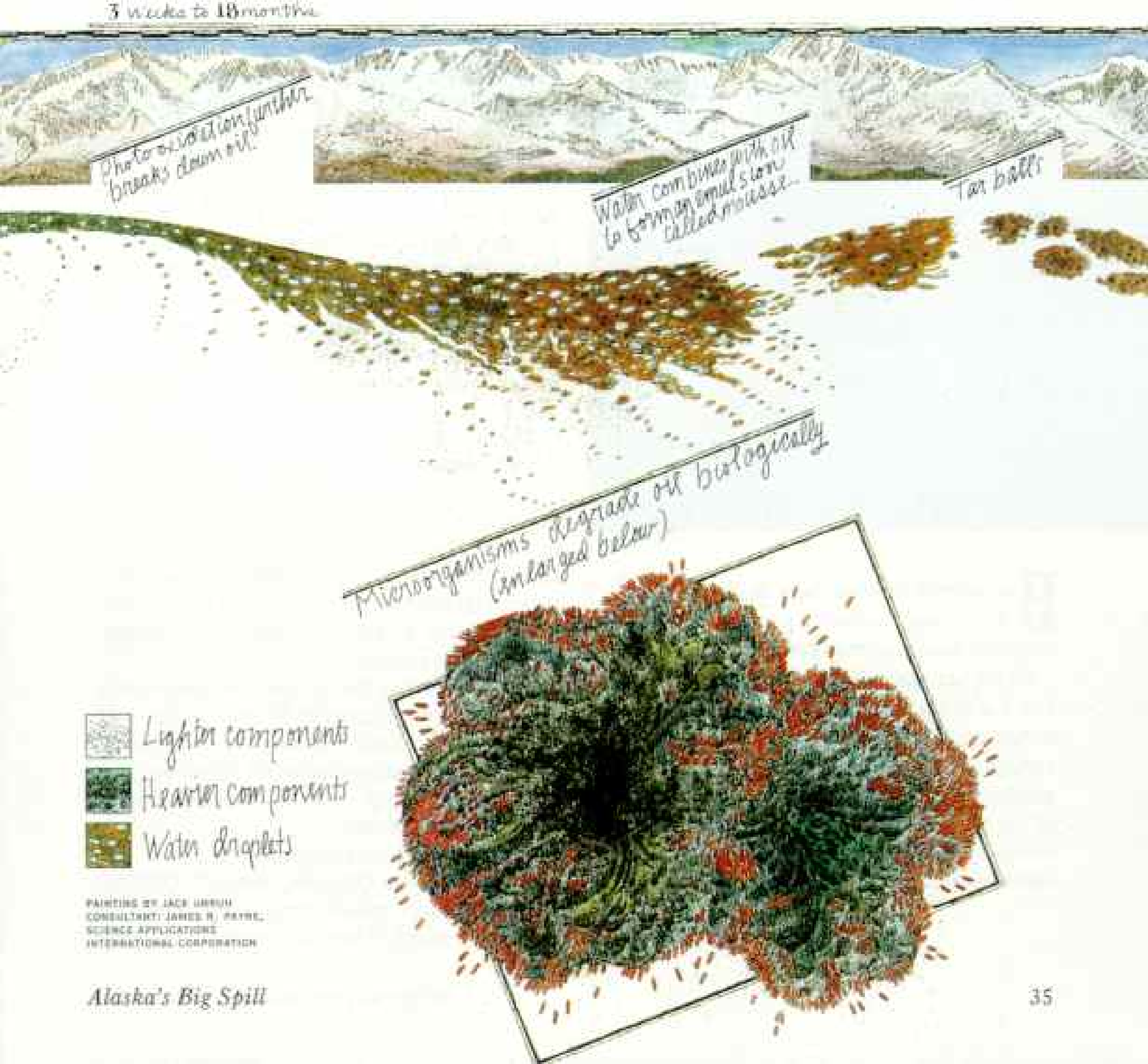
pump it any more. So the total skim for *Sedge* in seven days was about 3,500 barrels."

Such episodes were typical in the spill's first days. NTSB investigators wanted to know why the response team of the Alyeska Pipeline Service Company required 12 hours to mobilize and travel the 28-mile distance to the *Exxon Valdez*, an apparent violation of the five-hour response time specified in the official contingency plan.

There was no violation, protested Lawrence D. Shier, Alyeska's marine manager, since the plan merely described "a set of conditions that cannot really be extrapolated to a real situation." Alyeska was more specific in a written statement subsequently delivered to the board: "Equipment which Alyeska, with the approval of the State of Alaska and the federal government, had assembled for use in response to a 'most likely spill' of 1,000 to 2,000 barrels was now being employed to combat an oil spill approximately 175 times larger."

CONFUSION WAS THE NORM in Valdez in the first days. Decision making was the province of committees that included representatives of eight state and federal agencies. The strongest voices belonged to members of the Cordova District Fishermen United (CDFU), who had won injunctions against construction of the Alaska pipeline. Their battle was lost in 1973 when Congress authorized construction, but Cordovans have had little regard for the oil industry since then—an attitude reinforced by knowledge that today a large red salmon is worth more than a barrel of oil.

"The fishermen were the only ones who knew the tides and currents. And we were the only ones who had boats to do the work," I



PAINTING BY JACK UNRUH
CONSULTANT: JAMES R. PAYNE, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION

was told by Jack Lamb, a CDFU officer. "I told Exxon that the oil posed a real threat to the hatchery at Sawmill Bay, and that we wanted to take all available booms and skimmers to protect it. Exxon said OK. That was the only time there was a large concentration of equipment to save a specific place."

Lamb later won applause at a congressional inquiry after he heard that Alyeska experts had dismissed the possibility of a 200,000-barrel spill as something that might happen once in 241 years.

"There's a saying only one in 100 Alaska brown bears will bite," he said. "Trouble is, they don't come in numerical order."

WHATEVER ALYESKA'S ROLE, it was swallowed up almost immediately by the activities of the Exxon Shipping Company, whose response team arrived in Valdez within 24 hours of the accident.

"We went all the way to the Black Sea of Russia to get large booms—from Russia, from Finland, from Norway, from Denmark, from France, from the United Kingdom. In early stages we were chartering U. S. military aircraft; we needed C-141s and C5-As to move the heavy stuff," Frank Iarossi, Exxon Shipping president, told the NTSB panel. "The one clear thing we were not able to do, and I'm not sure there was a power on earth that could do it, but that was recover the 258,000 barrels that had already spilled. The only thing that could have helped was dispersants."

Just two weeks before the spill Alaska environmental officials had preauthorized emergency use of chemical dispersants, which act like a detergent to break up oil into tiny droplets that mix with water. Final authority rested with Commander McCall, as federal on-scene coordinator. Because the sea was calm, lacking energy to mix dispersants, he wanted tests made. Not until Sunday afternoon did results convince him they would be effective.

By then it was too late. Exxon had amassed 40,000 gallons of dispersant, enough to break up only a fraction of the spill, but 70-knot winds made further spraying impossible.

Later, responding to a state of Alaska civil suit for damages and costs of the spill, Exxon would countersue, charging that the state itself was responsible for some of the damage because it had argued against dispersants—a charge the state vigorously denied.

Meanwhile, the chaotic mess of floating oil became the responsibility of Jim O'Brien, Exxon's water-cleanup coordinator. A retired Coast Guard officer who commanded the Pacific Area Strike Team, he had handled more than a hundred oil spills.

By coincidence we had met only weeks before in Antarctica, where he had been called in by the National Science Foundation for a spill of more than 170,000 gallons of diesel fuel by an Argentine naval transport at Palmer Station. Volatile diesel fuel evaporates rapidly, leaving little residue.

This spill was different. He had assembled a fleet of some 60 skimmers. Most effective were 22 Marco vessels provided by the U. S. Navy. The Marco skimmers use an oil-attracting belt rather than pumps and can handle a wide range of oil thickness.

And thickness was the problem.

"The oil was changing daily," O'Brien said. "The most volatile portion evaporated in the first 20 hours. Then wave action mixed the

FLIP NICKLIN (RIGHT)

Beneath the mousse, diver Mark Dionne (facing page) avoids a mess in Montague Strait ten days after the spill.

Oil will not sink without added weight. By the time the mousse reached Katmai, some had turned to sticky muck that had accumulated enough sediment and detritus to settle in the shallows (above). "It took hours to get the stuff off my diving suit," says photographer Natalie Fobes. Mixed with fine-grained sediments, such deposits may persist for years.

FLIP NICKLIN (ABOVE)

Could multimillion-dollar fisheries disappear from the sound in a cloud of oil? First the May herring season—worth 12.3 million dollars in 1988—was canceled, but the salmon catch brought in six times as much, a bonanza symbolized by their teeming fry (above).

To protect such young salmon, scheduled for release from the Armin F. Koernig Hatchery a month after the spill, a furious campaign to set booms, dubbed the "Battle of Sawmill Bay," left volunteers limp but victorious (right). A pink salmon fry's adipose fin is clipped (bottom right), a signal that its nose contains a coded wire and

that when the adult fish returns two years hence, the head should be sent to officials who will check for toxic effects.

With the spill threatening this year's returning adults, the state announced a zero-tolerance policy for contamination. Chris Allison, a microbiologist, examines a salmon sample with tests that include sight, smell, taste, and fluorescence under ultraviolet light. Of thousands scrutinized, none failed. Although most spill-affected waters were closed, fishermen still caught 24 million salmon in sound waters that remained open, part of a near-record statewide catch of 152 million.

heavier remaining oil with water to create an emulsion, or mousse, that was about 80 percent water. By the time this mixes with kelp and other debris, it is so heavy that pumps can't raise it more than two or three feet.

"There's an important thing people must realize in planning for a spill this size: No amount of equipment will clean it all up, even if they give you a month's notice to get ready," he said. "Look at the expanse of water involved, and figure the time it takes to deploy boats and skimmers and support vessels at 12 knots. Skimmers need barges to collect their oil. Crews need food, ships need fuel, and somebody has to collect the garbage.

"And nothing works if the weather's bad."

In mid-September, weather in the Gulf of Alaska can go from sunshine to blizzards with very little warning. And so, for better or worse, the massive mechanical cleanup program wound down.

BUT AT SNUG HARBOR, on Knight Island, I find that a very subtle but very exciting cleanup program has just begun. Scientists of the Environmental Protection Agency have successfully demonstrated a process called bioremediation, in which oil-eating bacteria, native to Prince William Sound, may become the best cleanup crew of all.

Chuck Costa, EPA's site manager, shows me a long pebble beach neatly marked off into test plots by staked cords.

"We sprayed some plots with a special fertilizer called Inipol EAP22. Other plots we left alone. The fertilizer stimulated the bacteria to degrade the oil faster and began making a dramatic difference in the appearance of the rocks in only two to three weeks."

He turns some rocks over, and I see they are clean underneath. Only by digging about five inches into the shingle can I find evidence of the oil that once coated the entire beach. Sand fleas leap about my hand as I dig.

"We are still learning how deep the bacterial activity may go," Costa says. "We believe it may extend as deep as 12 inches in some areas. What the bacteria leave behind are the asphalt hydrocarbons. They are unsightly, but they aren't toxic."

One of the project's originators was Dr. Hap Pritchard, chief of EPA's Microbial Ecology and Biotechnology Branch at Gulf Breeze, Florida. When the spill occurred, he was

They have met the enemy, and it's all over them. A dog-tired crew that has done battle on Eleanor Island rides a landing craft to the U.S.S. *Juneau*, an assault ship chartered to feed and house about 400 workers. Weekly paychecks during the

cleanup averaged $1,800, yet the risks of exposure to oil for days at a time, despite protective clothing, are virtually unknown. Ironically, more has been learned of oil's toxic effects on animals than on the people who tried to save them.

working on a new EPA program to develop bacterial degradation of toxic waste.

"Stimulation of bacterial growth by nitrogen and phosphate feeding is well-known, but never on large-scale spills," Dr. Pritchard told me. "The idea of an oleophilic fertilizer—one that will cling to oiled surfaces—came from the French company Elf Aquitane. The fertilizer liquid contains oleic acid, lauryl phosphate (a shampoo-like detergent), and urea. We have tested it for toxicity to marine organisms and found it to be perfectly safe when applied properly."

Some environmentalists protested the technique, saying it could cause a plankton bloom. The state required further testing on Alaska organisms, and only six weeks after the successful demonstration was Exxon given permission to spray the fertilizer on 70 miles of beaches that had been heavily contaminated.

One of them was on Green Island, which I had visited months earlier to see the massive cleanup operation in full swing.

Now the beach was silent. There were still signs of oil but not the sticky black enamel-like coating that had been left after the first assault. I saw mussels and barnacles and seaweed growing in crevices of the rocks.

Perhaps it is true, I thought, that such catastrophes as the great Alaska oil spill are beyond man's ability to remedy. But are they within man's ability to prevent?

Congress has attempted to answer that question with stringent legislation requiring elaborate inspection and control of tanker operations and crew training. The oil industry has proposed a 250-million-dollar program to establish five coastal response centers, each equipped to deal with a spill of 8.4 million gallons. Meanwhile, debate continues on the merits of requiring tankers to have double hulls. Research into larger and more efficient oil pickup systems has been reactivated.

But nobody I talked to believed that technology alone could control giant spills, even in favorable weather and favorable locations. Sooner or later, through human error or simply through the perils of the sea, spilled oil will assault another shore. And sooner or later, the damage will have to be left to nature to repair.

But never again should nature be left so foolishly to chance. □

On January 28 an EXPLORER TV program covering the potential impact of oil development on Alaska wildlife will air on TBS SuperStation at 9 p.m. eastern time.

Like a vividly multiplying malignancy, the spill returns to Valdez in the form of thousands of bags of oily cleanup debris. Clean-burning hospital incinerators processed this batch, which required about six months. Recovered oil was recycled, and 50,000 tons of additional oil-soaked material were shipped to an Oregon toxic-waste dump.

In June oily water oozes up from contaminated sediment to fill a hole dug on a Block Island shoreline previously treated by Exxon. The company disbanded its cleanup army in mid-September pending the arrival of winter storms, which some experts believe will become natural allies by continuing to remove the oil. Meanwhile, ice and snow may keep this Alaska tragedy out of sight, but not out of mind.

New Evidence Places Peary at the Pole

EIGHTY YEARS AGO a committee of the Board of Managers of the National Geographic Society examined Comdr. Robert E. Peary's claim to have reached the North Pole on April 6, 1909, and found no reason to doubt him.

This judgment was confirmed by a committee of the U. S. House of Representatives in 1911. Nevertheless, as Rear Adm. Thomas D. Davies remarks in the following article, Peary's claim was "engulfed in controversy." This was largely due to the competing claim of Dr. Frederick Cook, who told the world he had reached the Pole a full year earlier. Over the decades Peary was given the laurel, but critics persisted in raising questions about his navigation and the distances he claimed.

CHARLES STAFFORD COLLECTION

The question still continues to grip the popular imagination. By and large, controversy is good for exploration, because it generates new effort to find the truth and stimulates young explorers to find new answers to old questions. The world needs young explorers in every field. But beyond healthy controversy lies darker and more dubious ground. The Society felt that a "docudrama" broadcast on national television six years ago reached that ground with the portrayal of an innocent Cook being victimized and deprived of his rightful claim by a malevolent Peary.

For many years the Peary polar diary had been sequestered in the National Archives, with access to it restricted. Now the Peary family agreed to release it. The Geographic commissioned Arctic explorer and author Wally Herbert to examine the diary; he concluded in the September 1988 issue that Peary had missed the Pole in part because wind-driven ice carried him west.

Saying that is one thing, but calling Peary a fraud is another. That is what the *Washington Post* reported in front-page headlines a year ago. The charge was made by Baltimore astronomer Dennis Rawlins, based on his analysis of an undated document found in the archives that he presumed to be observations Peary made at the Pole in 1909. Rawlins concluded that Peary was 105 nautical miles from the Pole and knew it.

We asked the Navigation Foundation, a Maryland-based group devoted to preserving the art of navigation, to examine the Rawlins analysis; it quickly discovered that what Rawlins took to be calculations for compass variation were in fact the serial numbers on Peary's chronometer watches!

It seemed time to try to put an end to a controversy that was clearly moving away from fruitful debate. We asked the Foundation to undertake a comprehensive study of all the evidence regarding the Peary claim and draw a warranted conclusion, let the chips fall where they may. This the Foundation has done. Its work seems to me unimpeachable. Unless something better comes along, I consider this the end of a historic controversy and the confirmation of due justice to a great explorer.

Gilbert M. Grosvenor

PRESIDENT, NATIONAL GEOGRAPHIC SOCIETY

Vanishing-point of a long-standing controversy seems at hand with the Navigation Foundation's close-range photogrammetric analysis of Robert E. Peary's photographs—one piece of evidence, among many presented, that places him at the North Pole on April 6-7, 1909, "within the limits of his instruments."

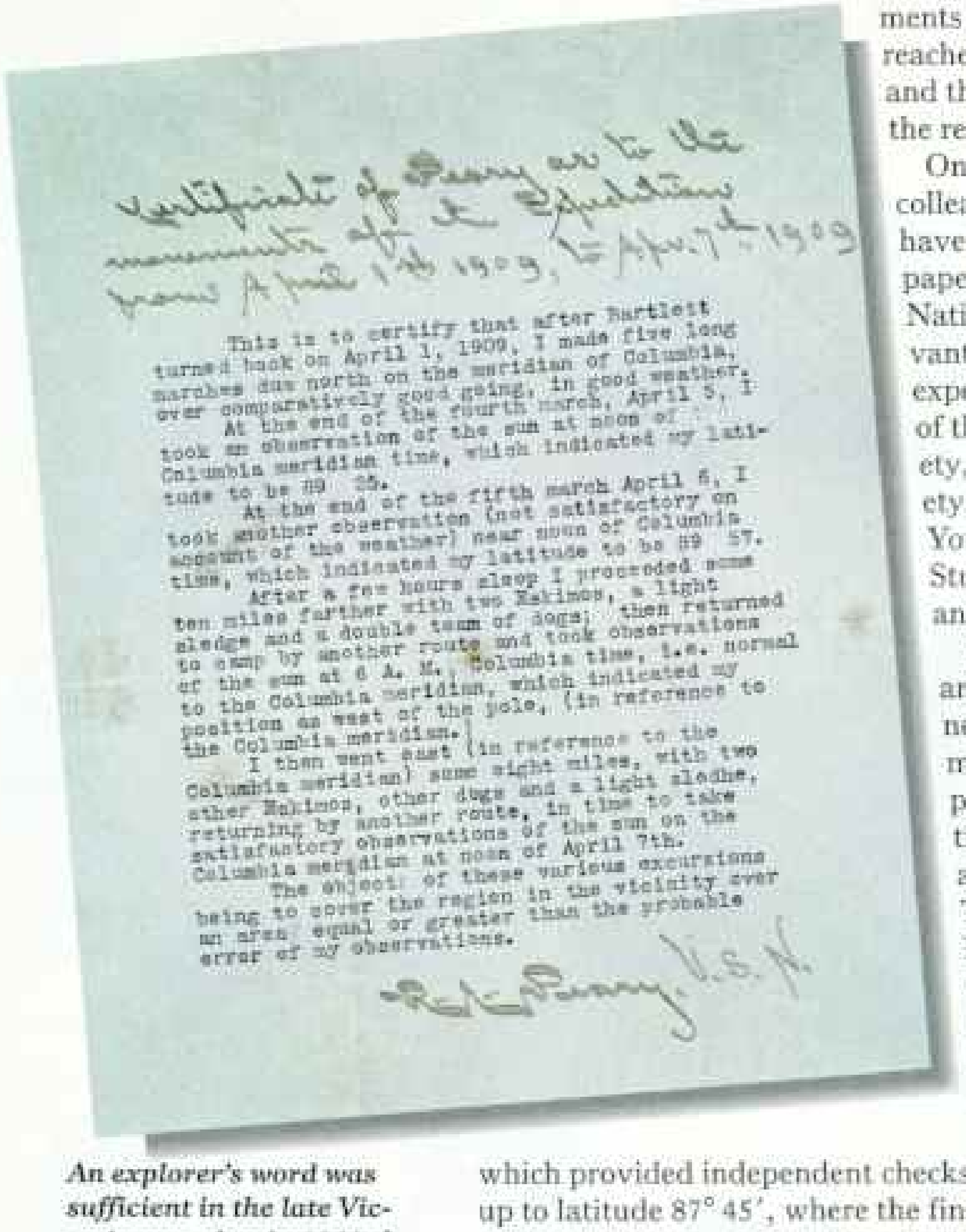
NATIONAL GEOGRAPHIC PHOTOGRAPHER VICTOR R. BOSWELL, JR.

By
THOMAS D. DAVIES
Rear Admiral, USN (Ret.)
PRESIDENT, THE NAVIGATION FOUNDATION, ROCKVILLE, MARYLAND

AFTER 12 MONTHS of what we believe to be the most exhaustive examination of documents relating to the Peary polar expedition of 1909 ever undertaken, the Navigation Foundation has concluded that then Comdr. Robert E. Peary and his companion Matthew Henson, along with the Smith Sound Eskimos Ootah, Egingwah, Seegloo, and Ooqueah, reached the near vicinity of the North Pole on April 6, 1909. Peary's observations of the sun during a 30-hour period in and around his final camp, named Camp Jesup, showed that within the probable error of his navigation instruments (about five miles), the party had reached the Pole, as Peary, Henson, and the Eskimos all maintained for the rest of their lives.

On the way to our conclusion, my colleagues at the Foundation and I have combed through 225 cubic feet of papers in the Peary collection at the National Archives and reviewed relevant papers of Peary's and other expedition members in the collections of the American Geographical Society, the National Geographic Society, the Explorers Club in New York, the Peary-MacMillan Arctic Studies Center at Bowdoin College, and many other institutions.

From his own correspondence and papers from his Arctic journeys, we determined that Peary's method of navigation was by compass corrected by noon observations of the sun—a method appropriate to polar latitudes. Then, in addition to scrutinizing Peary's North Pole observations, we also examined the observations of expedition members Professor Ross Marvin of Cornell and Newfoundlander Capt. Robert Bartlett of the *Roosevelt*, which provided independent checks on direction and distance covered up to latitude 87° 45′, where the final dash to the Pole commenced.



Duplicate of Peary's letter to the Expedition
Camp Jesup, Lat. 87° 47′, April 7th, 1909

This is to certify that after Bartlett turned back on April 1, 1909, I made five long marches due north on the meridian of Columbia, over comparatively good going, in good weather.
At the end of the fourth march, April 5, I took an observation of the sun at noon of Columbia meridian time, which indicated my latitude to be 89° 25′.
At the end of the fifth march April 6, I took another observation (not satisfactory on account of the weather) near noon of Columbia time, which indicated my latitude to be 89° 57′.
After a few hours sleep I proceeded some ten miles further with two Eskimos, a light sledge and a double team of dogs; then returned to camp by another route and took observations of the sun at 6 A. M., Columbia time, i.e. noon to the Columbia meridian, which indicated my position as west of the pole, (in reference to the Columbia meridian.)
I then went east (in reference to the Columbia meridian) some eight miles, with two other Eskimos, other dogs and a light sledge, returning by another route, in time to take satisfactory observations of the sun on the Columbia meridian at noon of April 7th.
The object of these various excursions being to cover the region in the vicinity ever an area equal or greater than the probable error of my observations.

Robt. E. Peary U.S.N.

An explorer's word was sufficient in the late Victorian era, but in 1909 the controversy between Peary and Dr. Frederick Cook over rival claims to having attained the Pole required each to submit additional evidence, including Peary's written statement (above).

NATIONAL ARCHIVES

With the cooperation of the United States Navy we compared the ocean-depth soundings recorded by the expedition with modern profiles of the Arctic Ocean floor and found that these support Peary's account of his entire trek to the Pole and, incidentally, rule out the westerly displacement of Peary's track and thus the location of Camp Jesup suggested by British author and explorer Wally Herbert in NATIONAL GEOGRAPHIC (September 1988). We also examined patterns of ice drift in the Arctic Ocean and the expedition members' accounts and concluded that the initial drift westward noted by Herbert was offset by a subsequent rapid eastward movement of the ice that he apparently overlooked.

Finally, and most convincingly, we applied modern methods of

close-range photogrammetry to a number of photographs that Peary identified as taken around Camp Jesup and determined that the position of the photographer was essentially where Peary's final celestial observations showed him to be. We also applied this technique to a photograph made by Peary on his 1906 "farthest north" expedition and, as a check on our methodology, to a photograph of the Will Steger polar expedition taken at the Pole in May 1986.

Although several institutions in Europe and the United States, including a committee of the U. S. Congress, concluded in the years following 1909 that Peary and his team had indeed reached the Pole, the subject was engulfed in controversy, continuing to this day, due to the rival and now discredited claim of Dr. Frederick Cook. The dispute engendered questions about Peary's method of navigation, based largely on a presumed need for longitude observations, and about the distances he claimed to have traveled on the final dash. We found that remarkably little new information had been introduced into the record by a succession of critical books and articles in the nearly seven decades since Peary's death. Thus we first addressed the issues of navigation and distance.

We have determined that Peary's method of navigation by dead reckoning corrected by observations, as he described it to the congressional committee, was appropriate and completely adequate for the polar region. It was, in fact, the method used by Roald Amundsen in his successful trek to the South Pole in 1911. Contrariwise, Robert F. Scott's navigator, on his doomed South Pole expedition, wasted precious time struggling with the reduction of complex conventional but nonessential longitude sights.

The peculiar condition close to either Pole that calls for a change from conventional lower latitude techniques is the greatly diminished size of each degree of longitude. At 135 miles from the North Pole, where Captain Bartlett turned back in 1909 after taking his last observation, degrees of longitude are within 2.4 nautical miles of one another, in contrast to 60 miles at the Equator; thereafter they grow even closer together, until they merge completely at the Pole. This phenomenon makes longitude sights, especially as one draws closer to the Pole, essentially useless.

Our research uncovered sufficient celestial sights made by Peary in Arctic regions in the 1890s and the early 1900s to convince us that he was a highly competent navigator and surveyor, which is not surprising given his formal training as a civil engineer and his earlier experience in surveying a proposed Nicaragua canal route, as well as that with the U. S. Coast and Geodetic Survey. His location by celestial observation of the farthest north point on the coast of Greenland, utilizing his surveyor's techniques, was checked with modern equipment by scientist Robert L. Lillestrand in 1969 and found to be more

Interest in the ancient art of navigation unites the 500 members of the nonprofit Foundation for the Promotion of the Art of Navigation. Board members Capt. Terry F. Carraway, Lt. Comdr. John M. Luykx, G. Dale Dunlap, and Foundation president Davies headed the task force that spent a year examining the North Pole claim. Shown here at the National Archives in Washington, D. C., they examined each of the papers in the 225-cubic-foot Peary collection.

NATIONAL GEOGRAPHIC PHOTOGRAPHER JOHN CORB

An EXPLORER cable TV documentary on the Peary claim will premiere on TBS SuperStation at 9 p.m. eastern time December 17, 1989.

Sounding a frigid sea, Peary's expedition carried 6,000 feet of steel piano wire wound on each of two wooden spools mounted on sledges. Ten soundings were made (facing page) between Cape Columbia and the Pole.

ROBERT E. PEARY COLLECTION

DIAGRAM BY RICHARD SCHLECHT

accurate than most existing maps. It defies all reason to suggest that Peary (whom even Herbert describes as "the most experienced polar explorer of his day") was unable to find his way due north when the need arose.

From his 1909 base at Cape Columbia, the latitude and longitude of which was known, Peary's plan as conceived and executed was to head due north until his estimated mileage, corrected by observations for latitude, indicated that he should have reached the Pole. He would then take a series of sun sights to locate the Pole from that position and make whatever final excursion was necessary to assure that he had indeed "nailed" the location and thereby attained his goal.

His method called for finding the direction of the Pole from the sun as often as feasible. By always heading straight for the Pole itself, however he had been diverted, he compensated as he went along for the effects of ice drift, changing magnetic variation, and detours to the east or west due to open water leads and unsurmountable high pressure ridges. His was a zigzag course with his heading intermittently corrected to true north, not a beeline up a given meridian.

Peary's compass always pointed to the magnetic pole and not true north. However, he was able to set his compass course by the sun, which, when visible on the trip north, lay exactly due south at "local apparent noon," the moment when the sun reaches its highest altitude above the horizon. To make an observation for apparent noon, a sextant is used to measure the angle between the sun and the horizon. Since the frozen Arctic Ocean with its ice ridges does not provide a clean horizon, an instrument called an artificial horizon—a small wooden pan covered with glass and filled with liquid mercury—is used with the sextant. The mercury acts as a perfectly level mirror, and the sextant measures the angle between the sun and its reflected image.

Marvin or Bartlett (and finally Peary) would stretch out behind the pan and train his sextant on the image of the sun in the mercury; what he saw were the two images of the sun, which would very slowly approach each other as the sun rose. He would watch, over the course of 10 to 15 minutes, for the sun to reach culmination, its highest point or "local noon," at which moment the two images would stop approaching and start to recede. The direction of the sun was then due south, and, of necessity, the observer would have been looking back along the northbound trail. Any significant deviation from that trail would be immediately apparent. The reverse direction was due north. In truth, after taking his sight, all he had to do was stand up and turn around; his shadow would point true north.

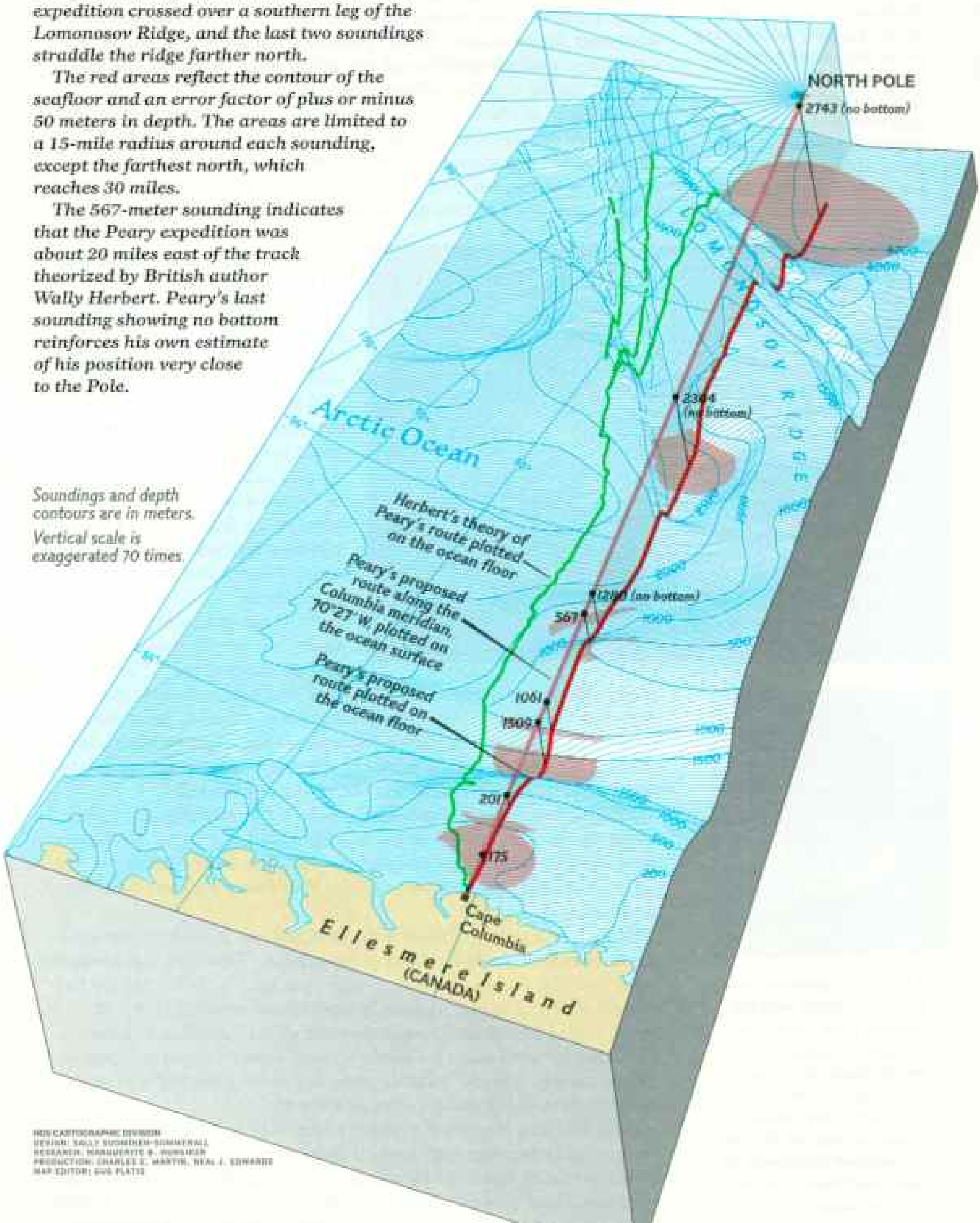
North of about 88 degrees, however, the rising and setting of the sun is too slight to provide accurate direction by this method. Thus Peary relied on dead reckoning rather than additional sights for his last five marches.

When taking a sun sight, the observer would note the time of the culmination on his watch, and it is important to note that the time indicated by the watch did not have to be the "correct" time. Much has been made of the fact that the *Roosevelt*'s chronometers were fast when Peary set his watches from them upon departing for the Pole. We have determined that the most probable error of the watches was less than one minute, but whatever the error was, it did not matter, since the time of the sun's maximum altitude determined the time of

The Foundation plotted eight of Peary's soundings on a digital terrain model. They indicate the expedition crossed over a southern leg of the Lomonosov Ridge, and the last two soundings straddle the ridge farther north.

The red areas reflect the contour of the seafloor and an error factor of plus or minus 50 meters in depth. The areas are limited to a 15-mile radius around each sounding, except the farthest north, which reaches 30 miles.

The 567-meter sounding indicates that the Peary expedition was about 20 miles east of the track theorized by British author Wally Herbert. Peary's last sounding showing no bottom reinforces his own estimate of his position very close to the Pole.



Soundings and depth contours are in meters.

Vertical scale is exaggerated 70 times.

IBRU CARTOGRAPHIC DIVISION
DESIGN: SALLY SUSMAN-SUMMERALL
RESEARCH: MARGUERITE R. HUNSICKER
PRODUCTION: CHARLES E. MARTIN, NEAL J. EDWARDS
MAP EDITOR: GUS PLATIS

local noon. Whatever his watch read when the maximum altitude was achieved was regarded as local noon on subsequent days when noon sights were not taken, but direction of the noon sun was used whenever it was visible. We are persuaded that Peary's system of navigation was adequate to get him to the near vicinity of the Pole without taking longitude observations along the way.

The question then becomes, could Peary have covered the distance to the Pole and back in the time he had to do it? His critics have scoffed at the distances he claims to have traveled on the final leg to the Pole with Henson and the Eskimos as his sole companions. It follows inexorably that they also label as "faked" the series of celestial observations that undeniably show him to be in the immediate vicinity of the Pole.

We minutely examined those sights for mistakes that a faker would be likely to make, and we could find no reason to believe that they are not genuine, as determined by the National Geographic Society's experts in 1909. Among other things, the pattern of "random scatter," the fingerprint of the field observer, is completely consistent with other sights Peary made on previous expeditions.

As to the distances in controversy, we specify them, as Peary did, as nautical miles "made good." The polar party covered about 270 miles (excluding the excursions at the Pole) round-trip from 5 a.m. April 2, when they departed from Camp Bartlett (where the captain turned back), to 30 minutes after midnight on April 10, when they returned to the same camp after spending 30 hours in the vicinity of the Pole.

Peary covered the distance to the Pole in five marches averaging about 27 miles per march, at an average speed of about 2.5 miles an hour. In 1986 Will Steger covered virtually the same distance at the same speed and expressed the opinion that Peary's claims were not unreasonable.

Peary's return trip, from 4 p.m. on April 7 to 12:30 a.m. on April 10, is more frequently the basis of skepticism. This trek was made in three forced marches of about 45 miles per march, following the party's old trail and using previously built igloos, totaling about 48 hours of sledging at an average speed of about 2.8 miles an hour, with nine hours of stops for food and rest. Peary's rapid progress on the return trip was attributable more to the duration of his extended marches than to the small increase in speed.

Both factors are understandable when one considers that every hour of delay increased the party's chance that their southward travel would be hindered by winds that would obliterate the trail or open leads that could be slow to freeze over with the onset of warmer weather, leaving them to face starvation on the ice. Few explorers have been so motivated to drive themselves and their teams to the bounds of their endurance.

Tools of the trade for an Arctic explorer in 1909 are in the Peary collection at the National Archives (below)—his chronometer-type watches, lower left; an artificial horizon (a pan filled with mercury, necessary where ice ridges block a clean horizon), upper left; a bottle of mercury for use in the horizon; and his sextant with eyepieces.

Peary's grandson, Edward Stafford, preserves his compass (above), a primary navigational instrument that he double-checked at local noon by observations of the sun (facing page).

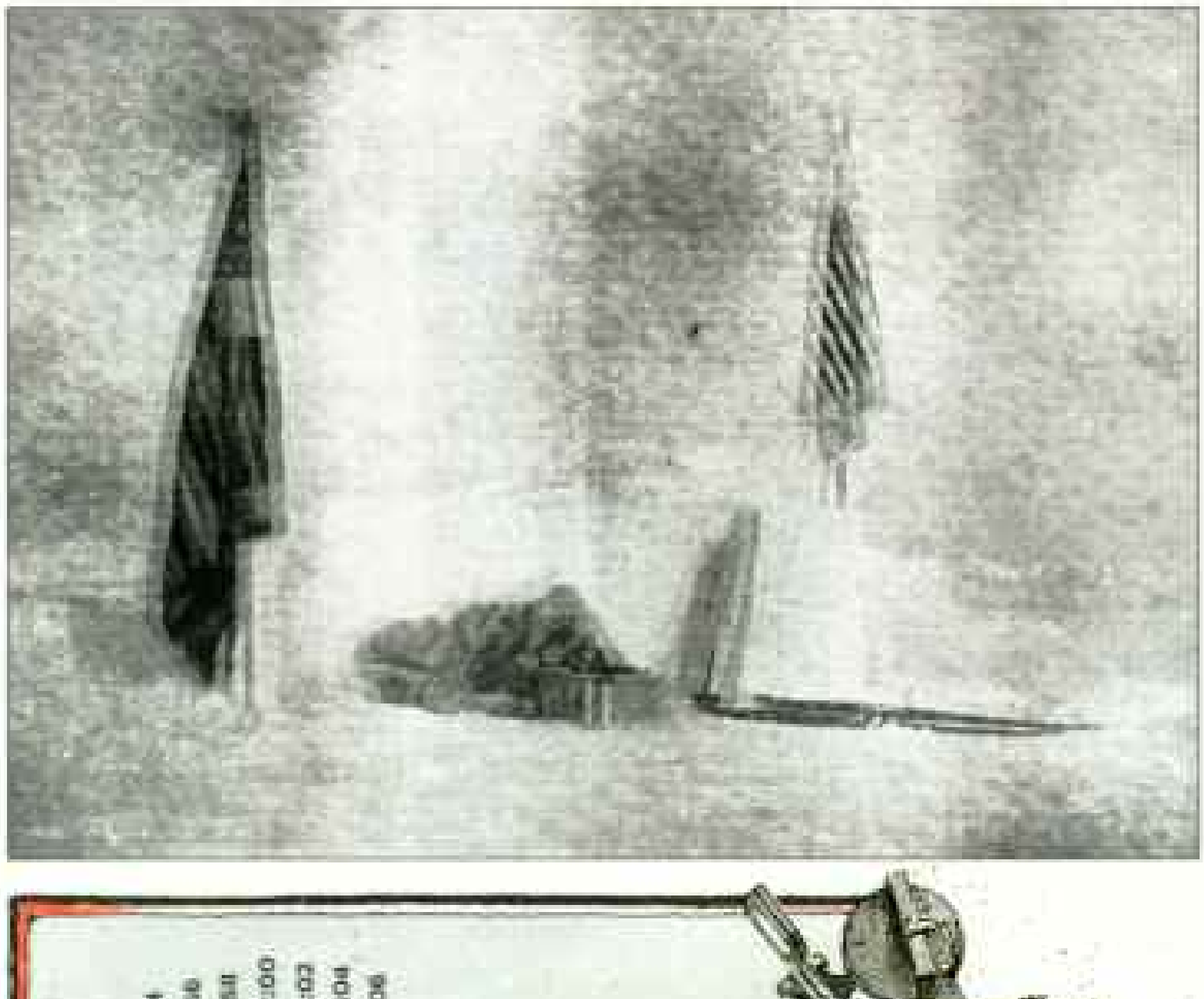
VICTOR R. BOSWELL, JR. (TOP); NATIONAL GEOGRAPHIC PHOTOGRAPHER JOSEPH H. BAILEY

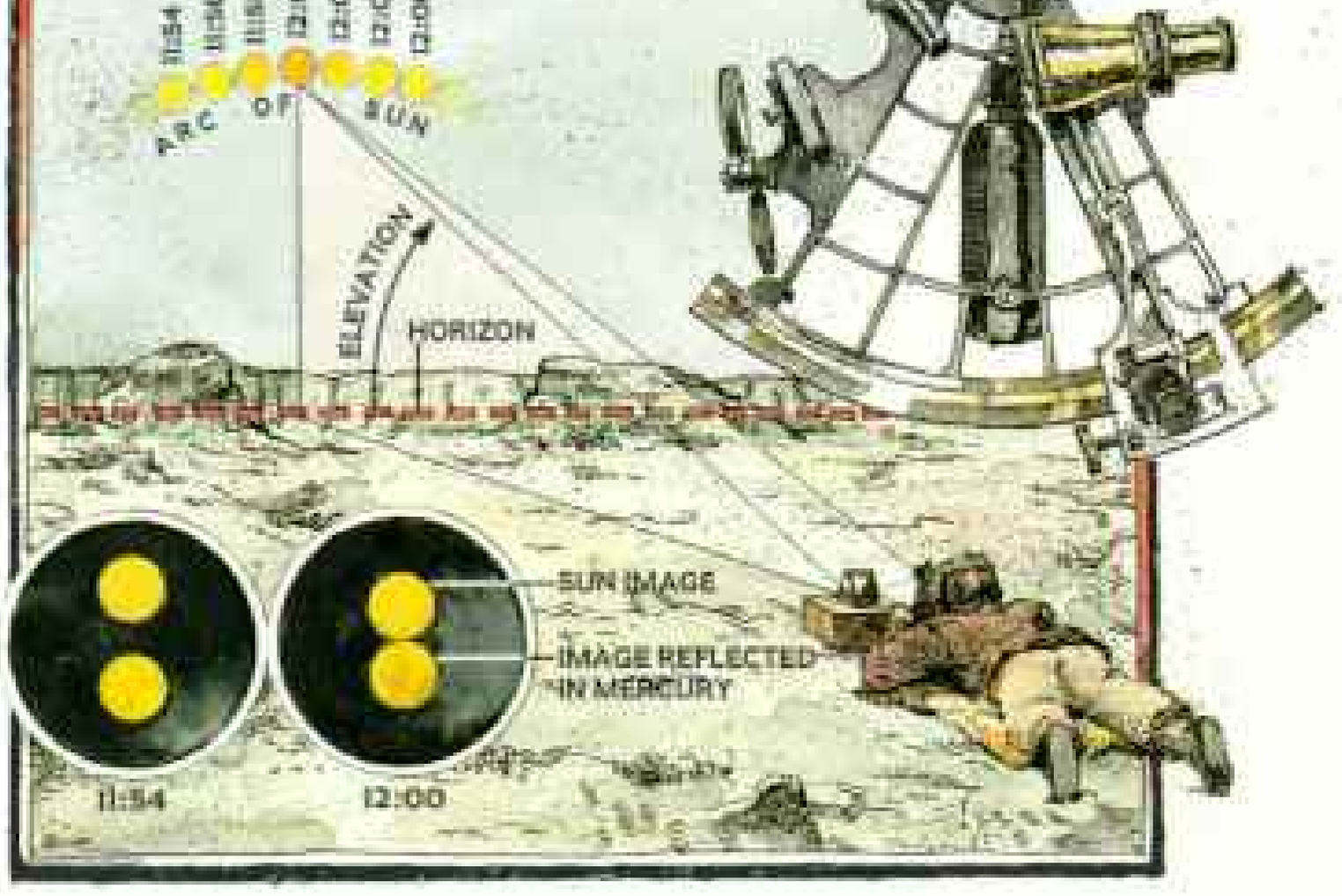
We examined the distances and speed of a number of sled travelers in the Arctic, including Peary himself on his earlier expeditions, and found that his 1909 figures are entirely credible. Dogs and sleds with far less skillful drivers than Matthew Henson and Peary's Eskimos have often maintained or exceeded these claimed speeds over much longer distances. For example, Gunnar Isachsen, captain of the *Fram* under the Norwegian explorer Otto Sverdrup—who concedes the superiority of the Smith Sound Eskimos and their dogs, which he did not have—wrote in the *Geographical Review* in January 1929: "On our sledging trips we were not content with marches under 15 miles. We often made 20 to 30 miles, and marches of over 30 miles were not rare. Several times we even made marches of over 70 miles. If we could make such long marches over ice which may be supposed to have been about the same kind as the ice on the most difficult part of Peary's journey, then even longer ones may be made on better ice such as that which Peary met on his journey to the Pole in 1909 to the north of the 'Big Lead.' It is my opinion that marches of the length of Peary's on his North Pole expedition of 1909 are possible not only for parts of his trip but for the entire journey."

In addition to Steger, many other explorers with sledging experience have found Peary's speeds credible. Two experienced sledgers, Lord Shackleton (explorer Sir Ernest Shackleton's son) and geologist-glaciologist Geoffrey Hattersley-Smith, who note that they traveled extensively by dog team in north Greenland and Ellesmere Island in the 1930s, '50s, and '60s, responded to the recent controversy with a letter to the *Times* of London.

I quote from the letter: "It was clear from our conversations with the Greenlander Odaq [Ootah], the last survivor of the polar party, that Peary found very good travel conditions on the last stretch to the North Pole. We have ourselves travelled up to 70 statute miles 'between sleeps,' admittedly on very good surfaces, so Peary's distances, allowing for deviations of route, were by no means extraordinary."

Speed in sledging is determined by a number of variables—the ability and determination of drivers, the strength of dogs, the configuration and weight of sledges, and, of course, ice conditions. Peary's





Using his artificial horizon, Peary looked through an eyepiece at a sun image and its reflection. Ten to fifteen minutes of observation would show the sun rising to its zenith, apparent noon, when it lay due south. At local noon in clear weather Peary's shadow pointed due north. In cloudy weather, he could find due north by his corrected compass reading.

ROBERT E. PEARY COLLECTION (TOP); DIAGRAM BY RICHARD SCHLECHT

ROBERT E. PEARY COLLECTION

Photographs prove Peary was close to the Pole

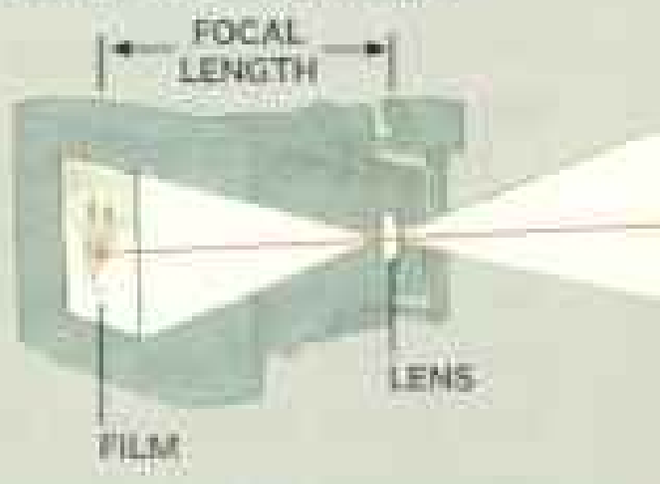
SHADOWS are clues in a technique—called photogrammetric rectification—to find the sun's elevation when photographs were taken.

The elevation can be determined by correcting for perspective. The fact that nearer things seem larger and farther things smaller, even though both may be the same size, underlies the principle of perspective. In a drawing of three men of the same height standing in a line, the nearest will appear largest and cast the longest shadow (top right).

An artist determines the proper proportion of objects in a painting by drawing lines from the outside edges of the objects—a table, a person—back to vanishing points, which define the horizon. Objects of the same size placed so their outside edges are within the converging lines are said to be "in perspective." Think of railroad tracks that vanish together on the horizon.

This only happens if the tracks are on level ground. Railroad tracks that run downhill will converge toward a vanishing point below the horizon. This is also characteristic of vanishing points defined by connecting sunlit objects with their shadows in photographs. The second diagram and Peary's photograph near Camp Jesup illustrate this principle. The vanishing point (VP), found by drawing lines (orange) from the object to the shadow it casts, is below the horizon and outside the frame of the photograph.

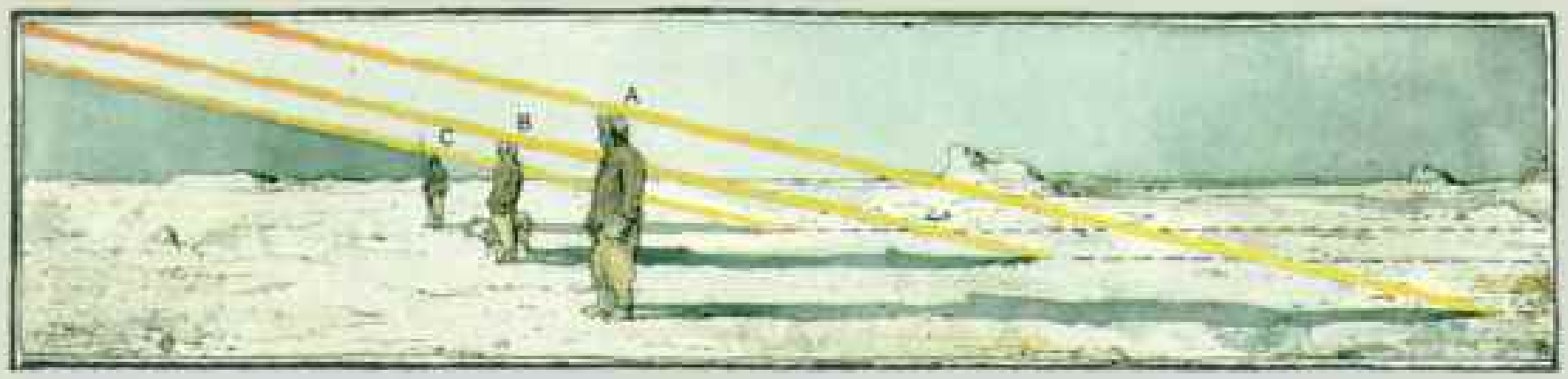
It next must be ascertained

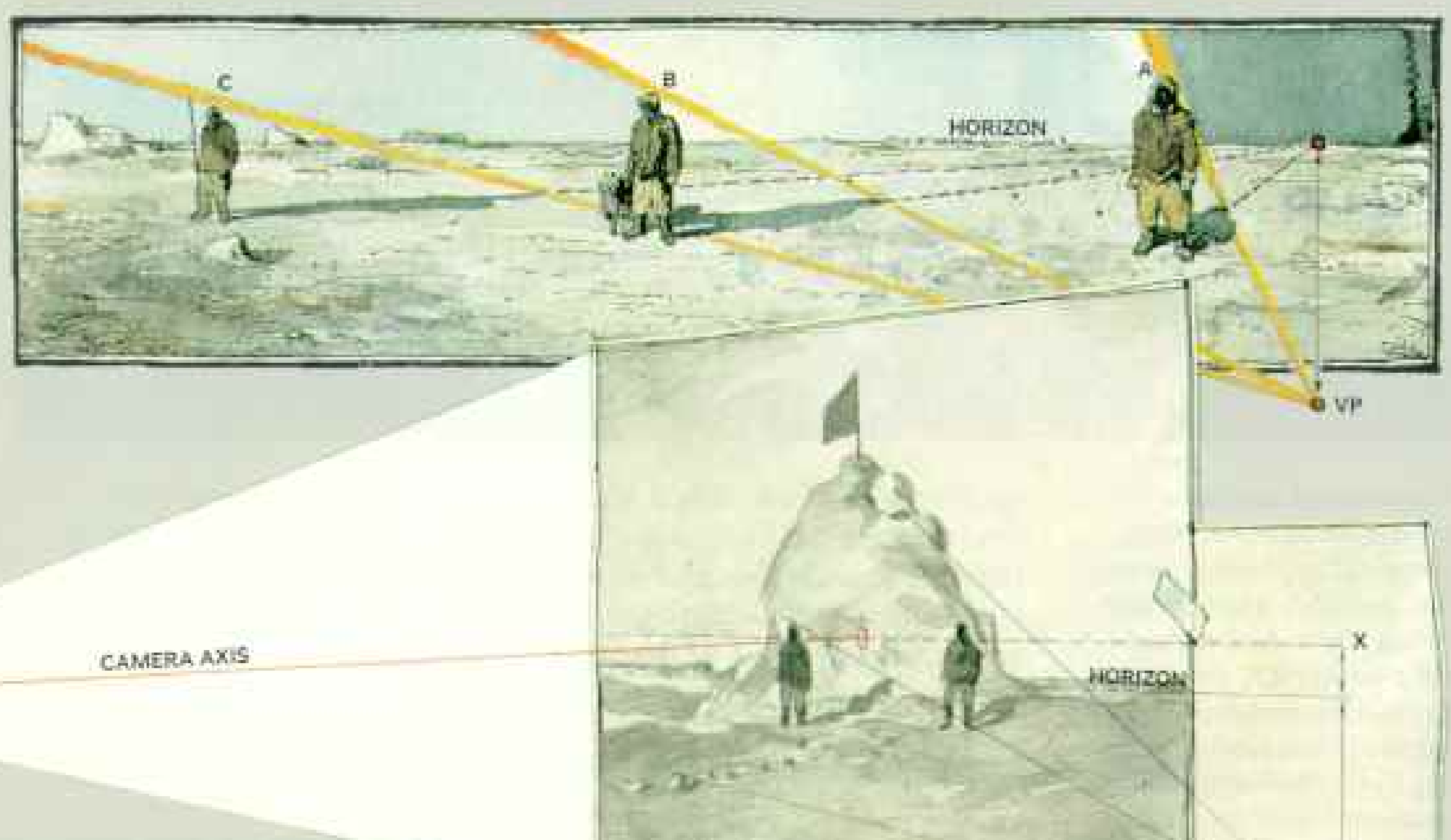


how far the camera was tilted up or down. An exact center point is found by drawing diagonals from the corners of a complete negative or contact print. A line (X) drawn through that point parallel to the actual horizon provides the basis for finding the camera tilt. Thus were the vanishing point, horizon, and camera axis determined for Peary's "pinnacle picture," which he took near Camp Jesup (left and diagrams at bottom).

Next the focal length of the lens must be known to find the angle between the sun and the camera axis, and between the sun and horizon. With the help of the Eastman Kodak Company, the Foundation determined that Peary used a Number 4 Folding Kodak with a focal length of 6.74 inches.

The rest is mathematics. Five equations determine the relationships between these angles and fix a final angle for the sun. For this photograph the angle of elevation of the sun is 6.8 degrees. The 1909 *Nautical Almanac* gives the elevation of the sun near the Pole on April 7, 1909, at 6.7 degrees. The average of five photographs indicates that Peary was close to his asserted position. The Foundation's conclusion: "The pictures were taken in the very close vicinity of the Pole."

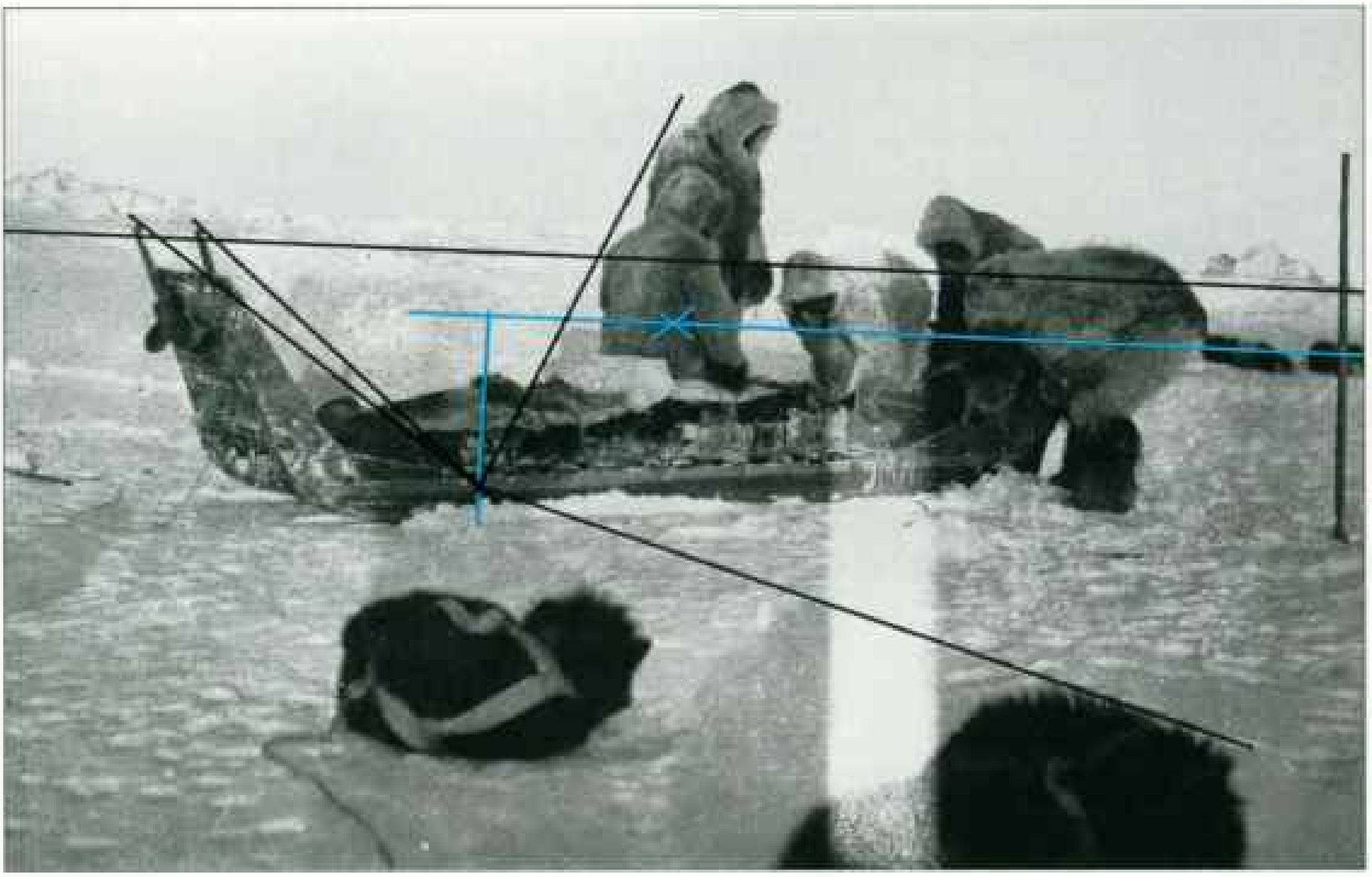




DIAGRAMS BY RICHARD SCHLECHT

Eskimo drivers were unsurpassed; Ootah's sledging skills had made him a legend in his own time among his people, and Matt Henson after long years in the Arctic had become almost his equal. The Smith Sound dogs were conceded to be superior to those of other Eskimo tribes. Peary's 40 dogs for the final dash were the pick of 133 that had started the trek and were well fed and rested in readiness for the final assault.

Other than Peary's own description we cannot know what ice conditions were at the time, but we do know that Steger reported a smoothing of the ice and the presence of a frozen north-south lead that provided an improved surface for sledge travel in the near



Peary could not have known he was recording proof of his position when he made this photograph about 18:00 hours local time on April 7, 1909, of expedition members making their last sounding near the Pole. Photogrammetric analysis based on the positions of the center target, horizon line, and vanishing point confirms that Peary was very close to his claimed position —about five miles south of Camp Jesup.

ROBERT E. PEARY COLLECTION

vicinity of the Pole. Ralph Plaisted's colleague, Col. Gerry Pitzl, navigator on their successful snowmobile assault in 1968, similarly reported that for the last two weeks before reaching the Pole travel was "practically unrestricted. . . . In many cases the lead direction was north, affording us the luxury of effortless travel."

Measurements of the ocean depth (soundings) taken by Peary on the trek from Cape Columbia to the Pole contribute significantly to the much debated question of where his track lay. These data were no help to Peary in proving his case in 1909, since a profile of the Arctic Ocean in the vicinity of the 70th meridian did not then exist. Now of course it does. The Defense Mapping Agency made available to the Foundation a number of relevant bottom depths obtained by U. S. submarines operating under the Arctic ice, and these were used to refine a recent chart of the area issued by the Office of Naval Research.

A computer-generated model based on these data show that if Peary's track was close to the 70th meridian, he would have twice crossed over a major feature of the ocean bottom, the Lomonosov

Ridge, during the trek to the Pole. Sure enough, a series of deep-shallow-deep soundings by Marvin indicates that the party passed over a southern leg of the ridge. A sounding made by Bartlett at 87° 15′ north indicates that he was over the canyon just west of the ridge, and Peary's sounding at 89° 55′ showed that he had by that point crossed the ridge again. Thus he was on or very close to the track he describes in *The North Pole*. In any event, he could not have been on the track described in NATIONAL GEOGRAPHIC by Herbert; Marvin's soundings could only have been made some 20 miles to the east of Herbert's suggested track. Moreover, Peary's own sounding of 2,743 meters without reaching bottom, made at about

five miles from his Pole camp, Camp Jesup, rules out at least one of Herbert's three suggested locations for Camp Jesup.

Herbert's conjecture as to Peary's track is based on a westward drift of the ice just north of Cape Columbia of about 20 miles in the first three days, caused by easterly winds. He asserts that from the outset of the polar assault Peary was always to the west of where he thought he was because he had failed to take this phenomenon into account. However, Herbert overlooked the fact that after returning to the land base for supplies during this period, Marvin and fellow expedition member George Borup recorded that westerly winds (also noted by Peary) were moving the ice north of the shore lead rapidly back eastward. To their surprise the outbound trail, which earlier had been driven 15 miles west of Cape Columbia, had drifted back nearly to its original position. We have thus concluded that during the entire northward trip, Peary would have experienced only a slight westward drift due to the net effect of wind. Moreover, modern data on prevailing ocean currents show that he would have experienced a slight *eastward* ice movement as he got closer to the Pole.

Triumph at the Pole in 1986 was photographed by National Geographic assistant director of photography Kent Kobersteen on May 3, as members of Will Steger's expedition raise their arms in victory. A satellite fixed their position a few hundred yards from 90° north. Photogrammetric analysis by the Foundation confirmed that position within five miles.

Another disputed claim of Peary's, that in 1906 he had traveled farther north than any other man, was confirmed as a result of the photogrammetric analysis of a photograph he made at his "farthest north." The Foundation's examination places Peary very close to the 87° 06' he claimed.

NATIONAL ARCHIVES

The net effect of ice drift that would be predicted from these two causes is negligible.

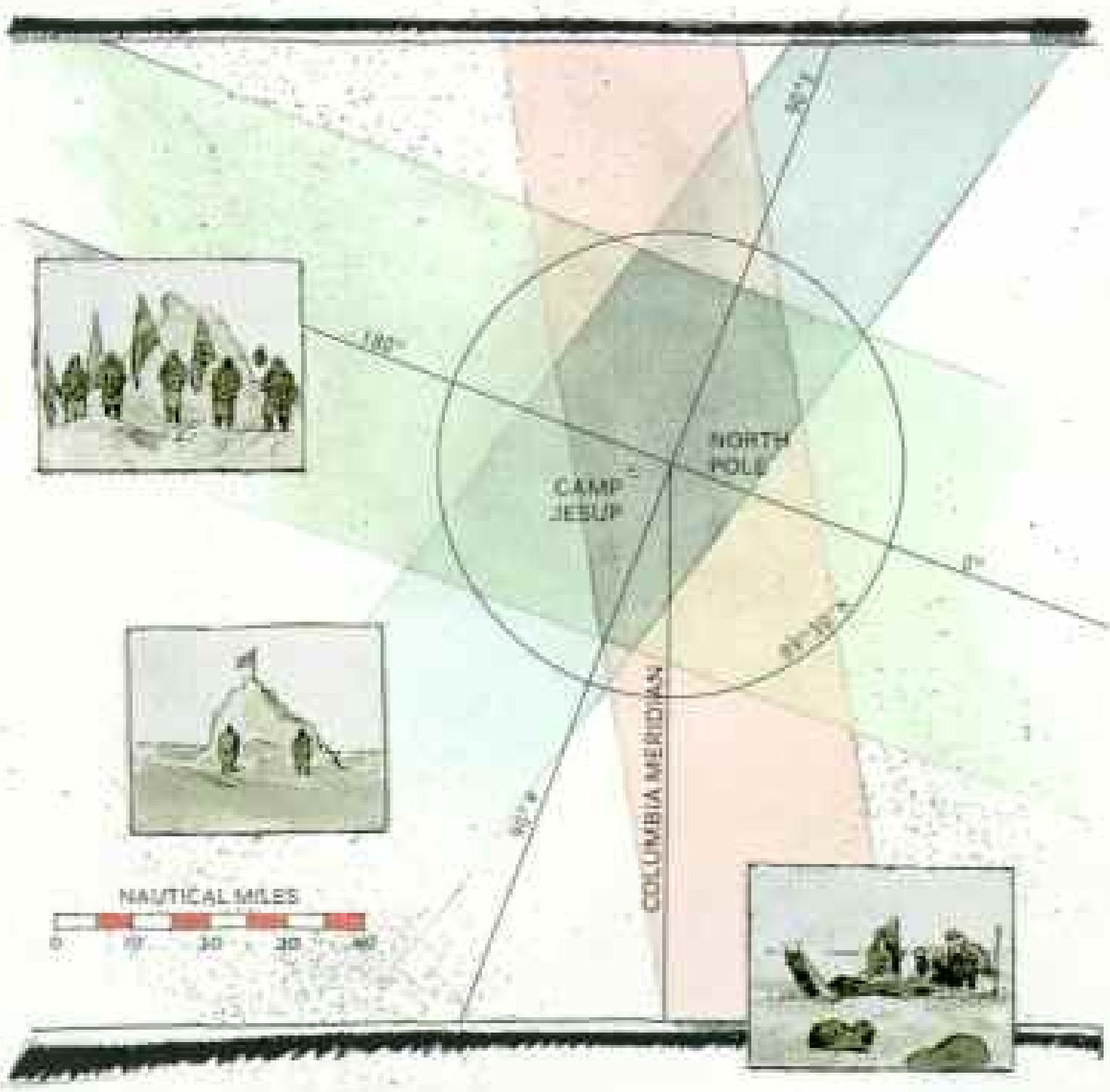
Our final and most conclusive examination was of the photographs taken by Peary near Camp Jesup. Since an inadequate attempt by merchant captain Thomas Hall in *Did Peary Reach the Pole?* (1917), there seems to have been no real analysis of Peary's photographs; accordingly our efforts represent new evidence. Techniques of photographic analysis that were pioneered during World War II developed into a fine craft during the Cold War years of satellite observation. One technique, called photogrammetric rectification, can produce the angle of the elevation of the sun from the shadows in pictures. This angle can be compared with the sun angle calculated from the *Nautical Almanac* to confirm a specific location and time.

Certain prerequisites must be met. There must be shadows that begin and end within the frame of an uncropped negative; there must be a horizon to determine the orientation of the camera; and the focal length of the camera must be known. Thus not every photograph can be so analyzed.

Establishing the focal length posed an initial problem because the only Peary camera we found was the 1906 camera at the National Geographic Society. With the help of the International Museum of Photography in Rochester, New York, however, we determined the focal length of the type of camera Peary was using in 1909.

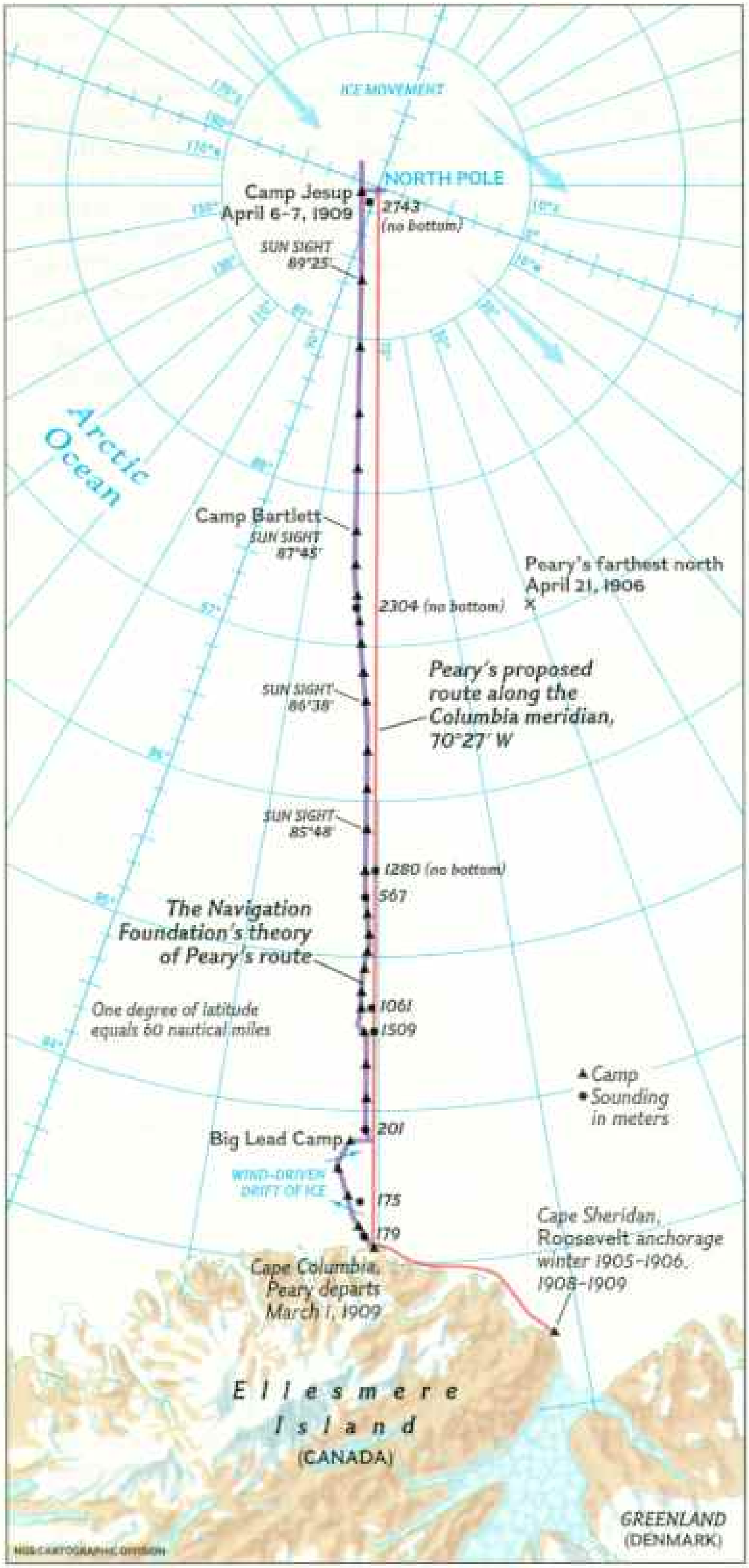
The technique is one based on simple perspective. Imaginary lines drawn through each object and the end of its shadow would be, in the real world, parallel to the sun's rays. Such lines drawn on a two-dimensional picture converge at a vanishing point (often outside the picture). This vanishing point is also the point at which a ray of sunlight through the camera would cast a shadow of the camera. Thus the vanishing point defines the angle of the sun's rays relative to the optical axis of the camera—which may be pointing up or down, as shown by the location of the horizon. The mathematical method used to fix these relationships is spherical trigonometry, much like that used in the reduction of a navigation sight. The *Nautical Almanac* gives the declination of the sun at the Pole for the date, and the time (taken from Peary's account or other sources) tells which meridian the sun is on. The altitude of the sun measured from the photograph was used to establish a rough "line of position."

We were able to analyze several pictures in the vicinity of Camp Jesup and concluded that Peary was probably within four or five miles of his reported position, and certainly no more than 15 miles away. Since we had the 1906 camera, and since the 1906 "farthest



Bands of probable position based on photogrammetric analysis bracket the Pole. The Foundation determined that some pictures were taken 15 hours apart. Since the sun's direction changed, intersecting bands of position could be plotted. The pictures had to have been taken within the shaded intersection area. Thus, the Foundation concludes, Peary was as close to the Pole as his sights showed.

DIAGRAM BY RICHARD SCHLECHT

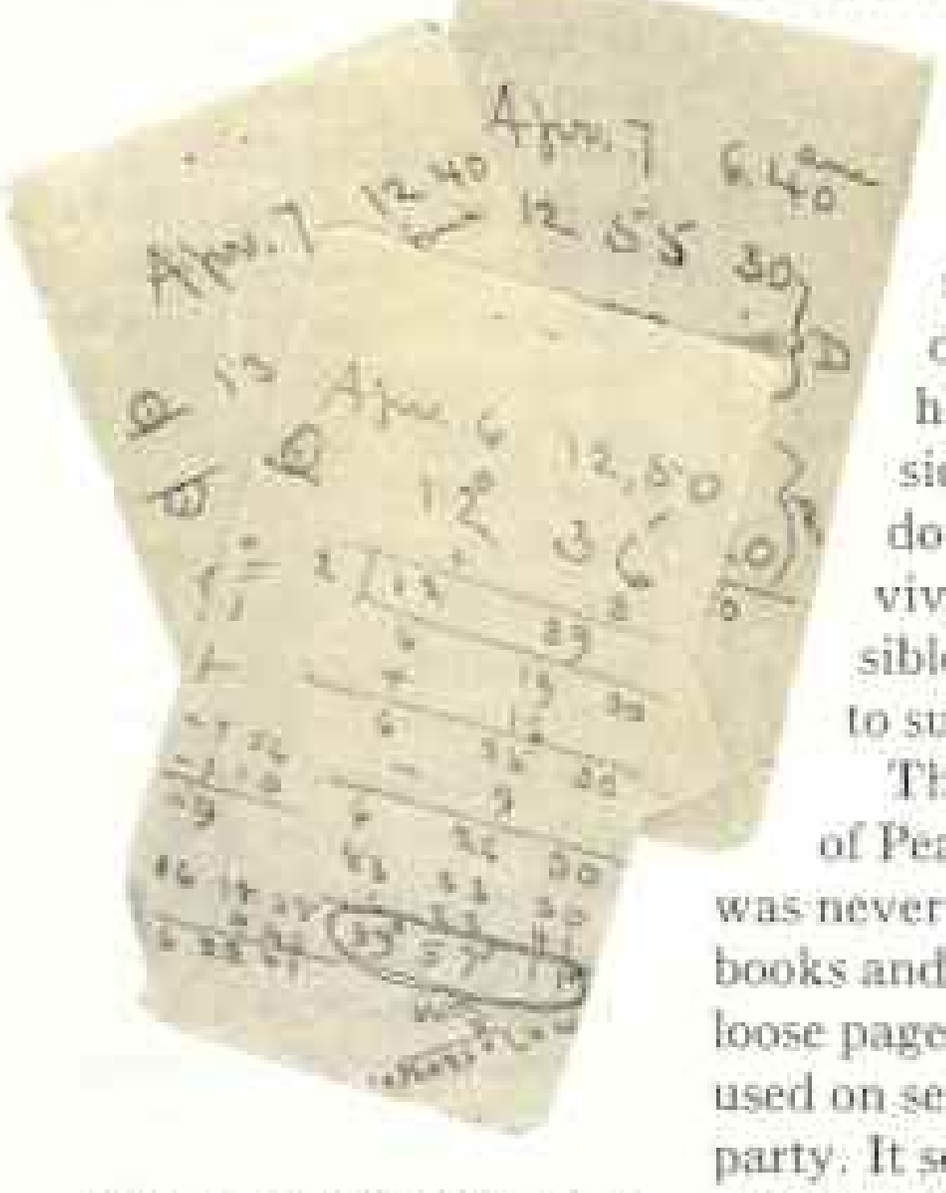


Always north until the goal was reached

Combining the evidence of ice movement, soundings, noon sightings, and photogrammetric rectification, the Foundation was able to reconstruct a route for the expedition, which places it "essentially at the Pole" on April 6 and 7, 1909. The movement of ice that carried the party west after leaving Cape Columbia reversed as Ross Marvin and George Borup returned for supplies, and put the track closer again to the 70th meridian. The locations of the soundings correspond to estimates of position made by the party. Marvin's and Bob Bartlett's noon sights give latitudes as they journeyed north. The track assumes that the party headed due north after each sun sight. The early going was slow, particularly after the party was delayed by open water from the 5th to the 11th of March, but after passing the southern dogleg of the Lomonosov Ridge, the going improved noticeably, and north of 88° the surface permitted higher speeds, as modern expeditions have confirmed.

The Foundation unanimously agreed that Peary realized his lifelong goal of attaining the North Pole. It expressed the hope that its report marks the end of a historic controversy.

The U. S. flag whips above Peary's igloo at Camp Jesup (facing page), his North Pole camp.



Peary's proof of his polar position—observations of the sun made on April 6 and 7—was provided to the National Geographic Society and later to the congressional committee considering his claim. Critics have contended the observations could have been faked, but the Foundation has compared them with many other Peary observations and considers them genuine.

NATIONAL ARCHIVES, BY JOSEPH H. BAILEY (ABOVE); ROBERT E. PEARY COLLECTION (FACING PAGE)

north" location has also been questioned, we applied the rectification technique to Peary's photograph taken at noon on April 21, 1906, on his misfortune-plagued expedition. Though many critics maintain that he faked his speed and distances to surpass the record established by the Italian Cagni, we found that he was at least as far north as the 87° 06′ latitude that he claimed, and perhaps a little farther.

With these technical proofs of Peary's account, what are we to make of the anecdotal evidence his critics use against him—the lack of a destination on the cover of his 1909 diary, the blank pages for the return trip, the unattached page on which he noted "the Pole at last!!!", his diffident attitude toward Henson at the Pole and later, and his delay in claiming success after reaching the *Roosevelt*. These are not matters that a foundation such as ours is designed to examine, belonging to historians or psychologists rather than navigators. But having delved so deeply into the Peary archives, we can hazard a few speculations of our own.

For example, Peary's answer to the congressional committee that he was too busy to fill in his diary on certain dates seems credible. He was certainly busy during the 30 hours spent at the Pole—during which he made two excursions totaling 36 miles to make certain that he had nailed down its location—and afterward, driven by the need to survive, hastening back to his base as quickly as humanly possible. Keeping a complete diary must sometimes be secondary to survival.

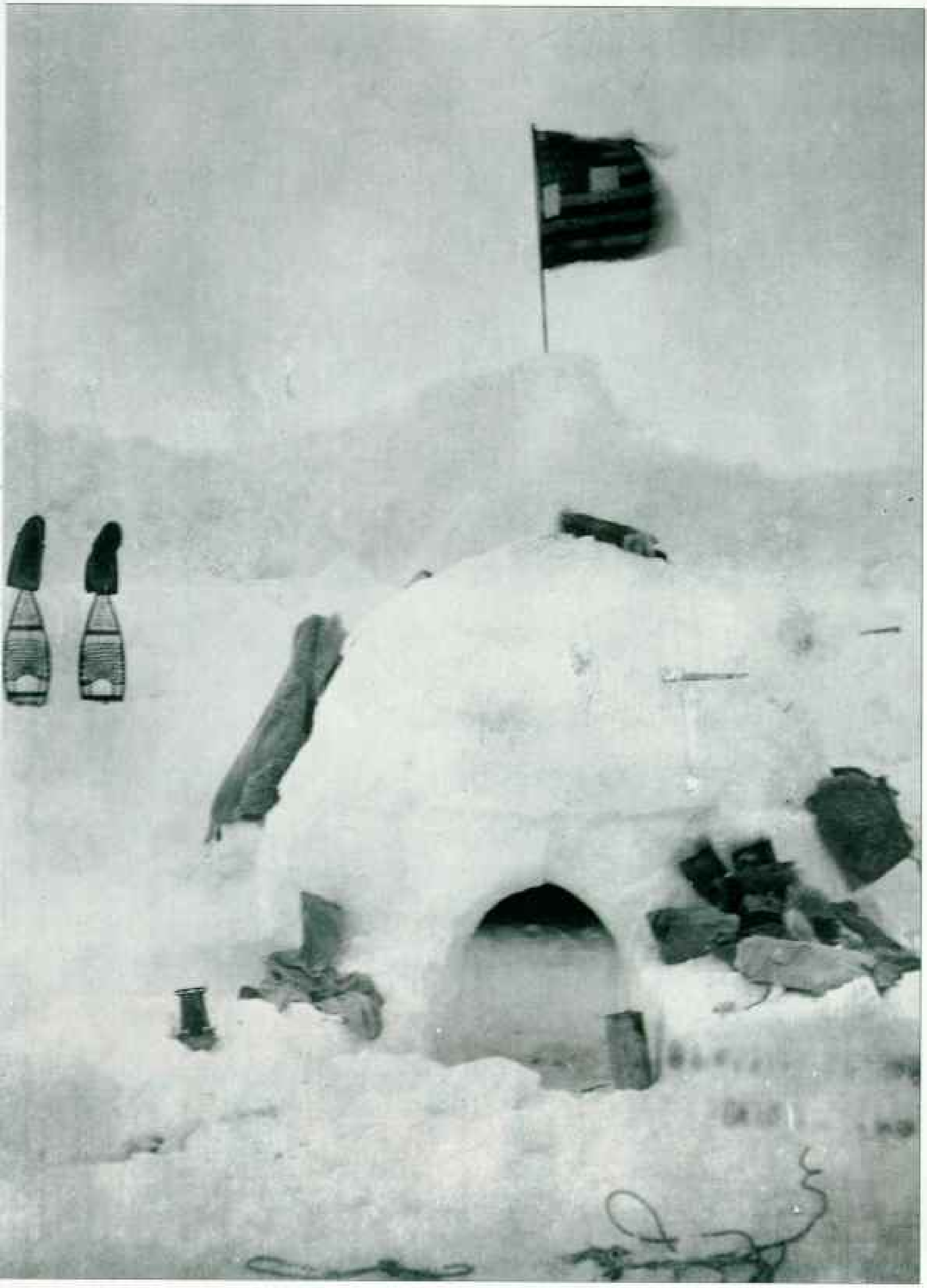
The incomplete cover is typical of virtually every journal of Peary's in the archives. We must remember that the diary was never intended for public inspection but as an aid in preparing books and articles. We surmise that Peary made the entry on the loose page from a second notebook that he carried on the trip and used on several occasions to write notes to other members of his party. It seems to us that had Peary faked the diary as his detractors suggest, he would not have invited suspicion by leaving pages empty, nor would he have scrawled his dramatic announcement on a loose insert.

Peary's coolness toward Henson may have resulted from resentment that his assistant and two Eskimos actually reached the location of Camp Jesup ahead of him and that Henson had suggested that he was "the first man to sit on top of the world." In any event, in his many conflicting accounts of his journey, Henson never once questioned that he and Peary had reached the Pole.

Contrary to what some critics have stated or implied, Peary let expedition members know upon his return to the *Roosevelt* that his assault on the Pole had met with success. True, he was afterward withdrawn and despondent, but this may have been due to his grief over the death of the dedicated young Professor Marvin on the latter's trek back to the ship with two Eskimo companions, or it just may be that the man was physically and emotionally exhausted.

In the light of all the data we have assimilated and analyzed, the board members of the Navigation Foundation have unanimously agreed that Peary realized his lifelong goal by attaining the North Pole on the last of his many expeditions.* We found no evidence to the contrary. And, on a personal note, we cannot but hope that this marks the end of a long process of vilification of a courageous American explorer. □

**The full report is available for $15 from the Navigation Foundation, Box 1126, Rockville, Maryland 20850.*



New Evidence Places Peary at the Pole

Inside the KREMLIN

By JON THOMPSON

Preparing to break ranks, the Estonian delegation to the Supreme Soviet confers in the Kremlin in 1988 before voting against new measures for suppressing popular demonstrations. Seizing upon Mikhail Gorbachev's new policy of *glasnost*, or openness, national groups from the Baltic to the Caspian are finding the voice to challenge Russian hegemony, even in that citadel of Russian power, the Kremlin itself.

Photographs by CARY WOLINSKY STOCK, BOSTON

Red stars top Kremlin towers where the Byzantine double-headed eagles of imperial Russia once rose. The Kremlin is ablaze in light to celebrate the anniversary of the 1917 Revolution. Site of grand balls under the Romanov tsars, the Grand Kremlin Palace, at center, now serves as a meeting place for the Supreme Soviet, legislature of the new, popularly elected Congress of People's Deputies.

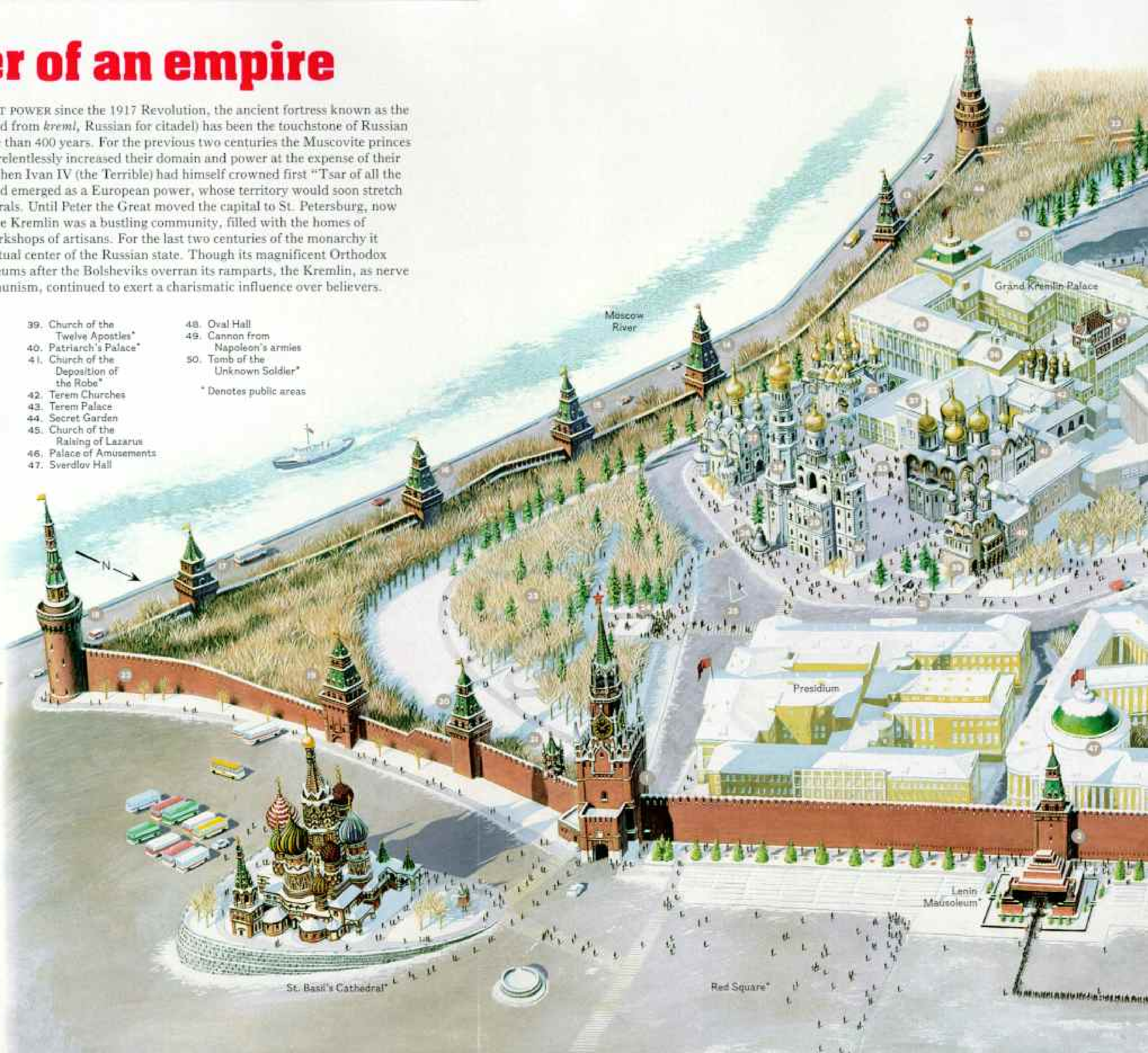
Center of an empire

SYMBOL OF SOVIET POWER since the 1917 Revolution, the ancient fortress known as the Kremlin (derived from *kreml,* Russian for citadel) has been the touchstone of Russian history for more than 400 years. For the previous two centuries the Muscovite princes who resided here had relentlessly increased their domain and power at the expense of their neighbors. By 1547, when Ivan IV (the Terrible) had himself crowned first "Tsar of all the Russias," Muscovy had emerged as a European power, whose territory would soon stretch from Ukraine to the Urals. Until Peter the Great moved the capital to St. Petersburg, now Leningrad, in 1712, the Kremlin was a bustling community, filled with the homes of aristocrats and the workshops of artisans. For the last two centuries of the monarchy it functioned as the spiritual center of the Russian state. Though its magnificent Orthodox churches became museums after the Bolsheviks overran its ramparts, the Kremlin, as nerve center for world communism, continued to exert a charismatic influence over believers.

Much remains of the ornate Kremlin complex built under Ivan III (the Great), including sections of the 7,300-foot-long brick wall and the 20 towers. Four of the churches surrounding Cathedral Square are among the oldest structures in the Kremlin, with the Assumption Cathedral dating from 1479.

1. Savior Tower
2. Senate Tower
3. St. Nicholas Tower
4. Corner Arsenal Tower
5. Middle Arsenal Tower
6. Trinity Tower
7. Trinity Bridge*
8. Kutafia Tower*
9. Commandant Tower
10. Armory Tower
11. Borovitskaia Tower
12. Water-pumping Tower
13. Annunciation Tower
14. Secret Tower
15. First Nameless Tower
16. Second Nameless Tower
17. Peter Tower
18. Beklemishev Tower
19. Sts. Constantine and Helen Tower
20. Alarm Tower
21. Little Tsar Tower
22. Kremlin wall
23. Secret Garden*
24. Statue of Lenin*
25. Ivanovskaia Square*
26. Tsar Bell*
27. Archangel Cathedral*
28. Ivan the Great Bell Tower*
29. Belfry*
30. Filaret Annex*
31. Tsar Cannon*
32. Annunciation Cathedral*
33. Cathedral Square*
34. St. George Hall
35. Meeting Hall of the Supreme Soviet
36. St. Vladimir Hall
37. Palace of Facets
38. Assumption Cathedral*
39. Church of the Twelve Apostles*
40. Patriarch's Palace*
41. Church of the Deposition of the Robe*
42. Terem Churches
43. Terem Palace
44. Secret Garden
45. Church of the Raising of Lazarus
46. Palace of Amusements
47. Sverdlov Hall
48. Oval Hall
49. Cannon from Napoleon's armies
50. Tomb of the Unknown Soldier*

* Denotes public areas



PAINTING BY T. W. RUTLEDGE
CONSULTANTS: JACK KOLLMANN, STANFORD UNIVERSITY, AND VLADIMIR KATERYAN, MOSCOW STATE SUPERVISING BOARD FOR HISTORICAL AND CULTURAL MONUMENTS

THE KREMLIN, that vast medieval citadel surmounted by golden domes, was bathed, as in a fairy tale, by the soft northern light of the Russian morning. This was my first visit, and as I approached its battlements and towers, I tingled with excitement and with a faint apprehension provoked by the history and haunted symbolism of this mysterious place.

At the Kutafia Tower gate, bored guards glumly scrutinized me and my belongings, then waved me inside like any other tourist among the thousands, Soviet and foreign, who come here. I crossed the bridge over the Alexandrovskii Gardens, where the Neglinnaia River used to be (it now runs in an underground pipe), and entered through the Troitskaia (Trinity) Tower with its massive wooden doors.

A convoy of military trucks swept past into the Arsenal, one of the largest buildings in the Kremlin complex. In spite of a screen at the entrance I could see into the courtyard, where young guards goose-stepped with a look of intense concentration on their faces, rehearsing for their stint at Lenin's tomb just outside the walls in Red Square. Farther on, circles of tourists were admiring a huge cannon that has never been fired and an enormous broken bell that has never rung, both described by the guides as the largest in the world.

Past the great bell I turned right into Cathedral Square. Around it cluster the Patriarch's Palace, the Ivan the Great Belfry and Bell Tower, Ivan the Great's Palace of Facets, and the three cathedrals (Assumption, Annunciation, and Archangel), redolent with the high drama of Russian history, that form the nucleus of the ancient Kremlin. This is where early tsars were married, crowned, and buried.

Standing among the stones that Ivan the Great had raised into great cathedrals, I imagined the wedding in 1547 of a later Ivan, the Terrible, to Anastasia Romanovna, afterward celebrated for her beauty and intelligence. A procession of bearded men in long silk caftans make their way into the packed Uspenskii (Assumption) Cathedral. Candles flicker; incense fills the air. The Metropolitan of Moscow in his costly vestments intones the service. Shouts of joy erupt from the huge crowd, and great bells ring out from the tower.

Father of the Soviet state, Vladimir Ilyich Lenin lived in the Kremlin for five years with his wife and sister. On display in his preserved apartment, pictures show Lenin as a youngster with his family and after a crippling stroke before his death in 1924.

Centuries of invasion, pillage, and siege had elapsed before such regal celebrations were possible. In January 1238 Genghis Khan's grandson, Batu Khan, advancing like a whirlwind at the head of a large Mongol army, had reached Moscow, an unimportant fortified town on a small hill where the Neglinnaia River joins the Moscow River. The rude outpost was soon taken, and its ruler, Vladimir Iurevich, son of the Grand Prince of Vladimir, was captured and killed.

The Mongol subjugation of Russia, which Russian historians call the Tatar Yoke, lasted

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JON THOMPSON, an English physician and antiquarian, has a special interest in Russian history. The most recent of photographer CARY WOLINSKY's many GEOGRAPHIC coverages was "Wool—Fabric of History," in May 1988.

two centuries. During this time Moscow underwent a phenomenal transformation to become the most powerful principality in Russia, though its houses were little more than log cabins and even its palaces and fortifications were made of wood. Moscow's wooden houses were vulnerable to devastating fires, which swept through the city every 20 years or so. Only one chapel and the crypt of another church survive from the Mongol period.

YET TRACES of the old Moscow are sometimes discovered—almost always by accident. In the early 1960s construction workers erecting the new Palace of Congresses uncovered great logs that were identified as part of a defensive rampart built 800 years before.

In May 1988, while photographer Cary Wolinsky and I were working on this article inside the Kremlin, a workman digging a hole in the floor of a basement canteen near the Kremlin's Spasskaia (Savior) Tower found some strange black objects. He thought he had discovered a collection of toys enclosed in a wooden box lined with birch bark, but the objects turned out to be a hoard of 299 pieces of 13th-century silver jewelry and other objects (page 80).

Tatyana Avdusina, curator of the archaeological collections of the Kremlin's museums, is convinced that the jewelry belonged to Batu Khan's victim, Vladimir Iurevich himself. "Only the wealthiest family could have owned such objects," she told me.

Before my astonished eyes Tatyana laid out massive bracelets decorated with fabulous human-headed creatures, large breast ornaments with angels and Christian crosses, filigree necklace-beads, heavy star-shaped pendants covered with thousands of silver granules, men's finger rings with bird designs, a jeweled gold ring with an Arabic inscription, delicate earrings, and silver money bars from Kiev, Chernigov, and Novgorod.

In 1480, during the reign of Ivan III (the Great), Grand Prince of Moscow, a Mongol army encamped across the Ugra River withdrew without attacking Moscow. Mongol rule was over, Ivan's reputation was made, and Moscow's permanence was assured. Ivan wanted impregnable fortifications incorporating all the latest advances in military technology and an impressive citadel adorned with fine buildings to put his stronghold in the top league of the world's capitals. He set about rebuilding the Kremlin on a grand scale, bringing architects, military engineers, and hydraulic experts from Italy.

The ancient triangular hilltop site (the Kremlin stands some 125 feet above the Moscow River) was slightly enlarged to its present 69 acres and enclosed by a high, castellated brick wall as thick as 20 feet, with fortified towers at the corners, barbicans over the entrance gates, and additional towers in between. According to legend, the design included a number of secret tunnels extending beyond the Kremlin walls.

This enormous undertaking took 30 years to finish. Though numerous decorative additions have been made to Ivan's

Lenin's niece, Olga Dmitrievna Ulyanova, says that "the people wanted to see Lenin as he was in life, so his wife and family agreed" to the huge tomb on Red Square. Raised on a small street in the Kremlin, she recalls childhood impressions of Stalin as a "kindly" man.

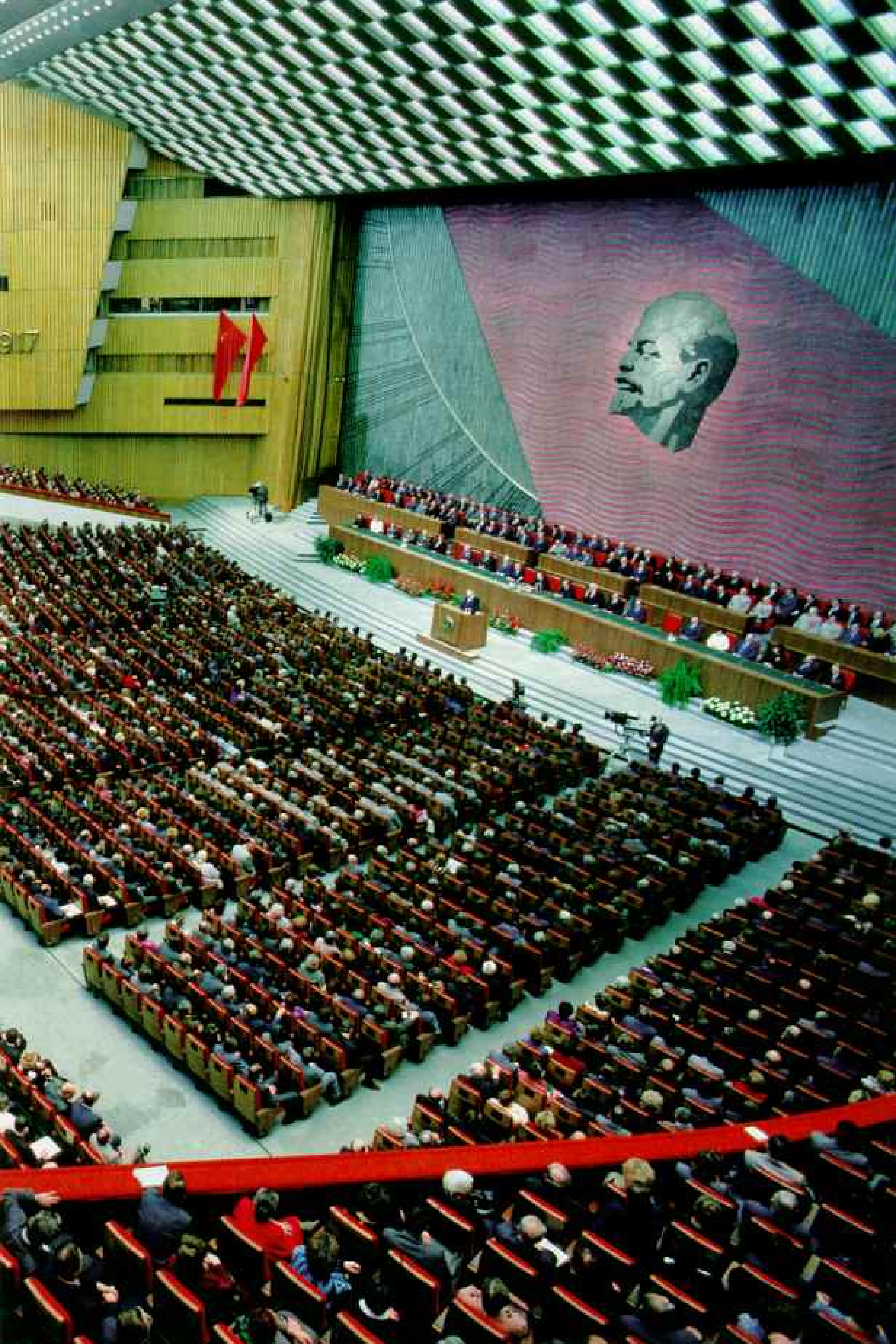
Corridors of power meet in the Council of Ministers building, where day-to-day decisions affecting the lives of 280 million Soviet citizens are made. Vsevolod Murakhovskii's numerous telephones underscored his importance as first deputy prime minister. Mementos on his desk included a button praising President Mikhail Gorbachev, whose policies eased the way for GEOGRAPHIC coverage of the normally off-limits building, where Gorbachev's office is also located.

fortifications in the past five centuries and many of the old buildings have been destroyed, much of his "Italian Kremlin" still stands.

In the days of Ivan the Great and afterward a whole medieval city existed within the Kremlin walls—workshops and barracks, great houses for noblemen, a monastery and dozens of churches, log-paved streets teeming with people. By 1520 Moscow was said to have 41,500 houses. I expected the bustle and hubbub of colorful crowds, the dust and smell of everyday life, ancient stones worn by the boots of generations of Russians and their subject peoples.

Instead, all was clinically clean, spotless and orderly and paved with new stones, the buildings freshly painted and restored to look like new, the churches lifeless museums, and the old Terem Palace with its red-and-white painted roof like something out of an elaborately contrived film set. No one I saw inside the Kremlin walls seemed to belong there: They were all sightseers, outsiders like myself.

Inside the Assumption Cathedral, with its tall pillars and its upper walls and lofty ceiling entirely covered with paintings of saints, angels, and biblical scenes, I caught two tiny, linked glimpses of eternal Russia. A cold-faced blond woman wearing the red armband of an official guardian pounced angrily on someone about to take a photograph, and as she turned away, another woman, eyes lifted to sacred images, crossed herself discreetly. *(Continued on page 78)*



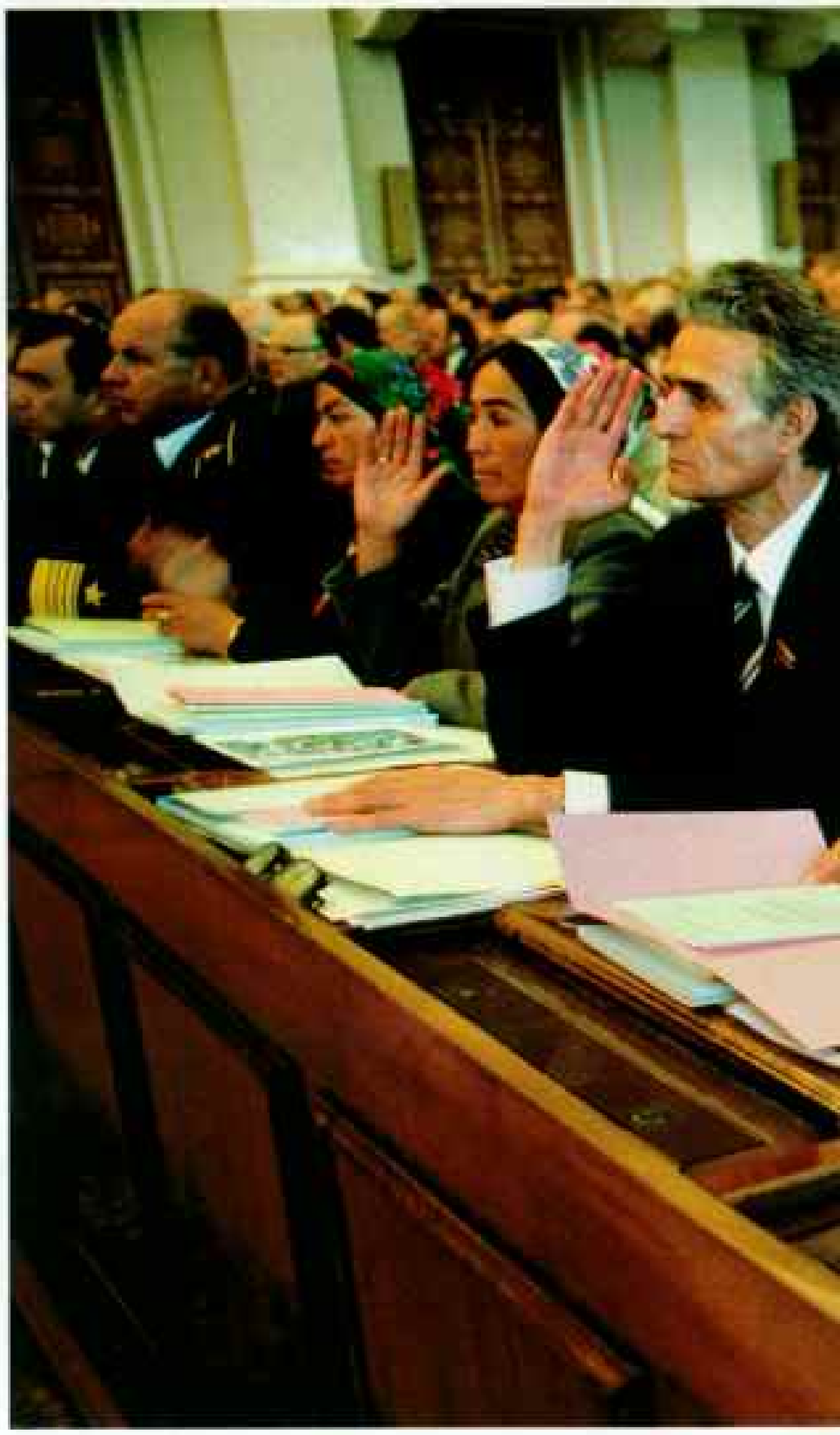
< PRECEDING PAGES

Arena for art and politics, the Palace of Congresses includes a 6,000-seat theater that accommodates huge convocations of the Communist Party as well as serving as a second stage for the Bolshoi opera and ballet companies. Backdropped by an image of Lenin, the party's Central Committee hosts a "solemn session of the working people of Moscow."

A lesson in just saying nyet was delivered to the Supreme Soviet on October 28, 1988, when Roald Sagdeev (above) and 12 other delegates became the first in recent memory to raise a hand against proposed legislation. Then director of the Space Research Institute, Sagdeev was voting against antidemonstration regulations proposed by the Communist Party. Other members of the Supreme Soviet, seen here (top right) earlier as they rubber stamped legislation with their unanimous affirmative votes, were astonished.

Later, in the halls of the Presidium building (far right), delegates discussed the implications of the revolutionary mood that was sweeping their institution. Though nominally responsible for enacting all of the nation's laws, the Soviet legislature had historically been subservient to the will of the Communist Party, to which most delegates belong.

Darling of the foreign media, maverick Boris Yeltsin (right) became a symbol of the emergent movement toward democratization when the party's attempts to strip him of power were resoundingly repudiated by Moscow voters in the 1989 general elections.



THE KREMLIN'S MUSEUMS are watched over by *babushkas*, an army of working grandmothers wearing the head scarf that has been named for them. In the Annunciation Cathedral a few steps away, the babushka on guard radiated a kindly presence. When I asked about the icons, she introduced me to Liudmila, an expert on the cathedral.

Liudmila was shy and seemed guarded in her answers, but she explained that the rows of icons served as a pictorial summary of Christian teaching and had an exact arrangement. The central image above the door to the sanctuary, for example, was always that of the Savior. This was important in former times because few people could read. Russia's greatest icon painters, including Andrei Rublev, Theophanes the Greek, and Prokhor of Gorodets had worked here, but their paintings were thought to have been destroyed in the great fire of 1547 (the year of Ivan the Terrible's wedding). There was widespread amazement and delight when cleaning the icons—part of the process of restoration that began in 1918 and is still unfinished—revealed that several thought to be later copies were in fact the originals.

I was struck by the harmony of the Annunciation's translucent gold-brown stone floors and the rich colors of the magnificent icon screen. Still, I wondered. Where was the working Kremlin, the one we in the West hear about nearly every day in the news?

Beaming with pride, a young Kremlin guard shows off his credentials in the Alexandrovskii Gardens, a popular park by the northwest wall. Members of the Kremlin security force live in the old Arsenal building, which is closed to the hundreds of thousands of tourists who visit here each year.

A Soviet Army honor guard (opposite) protects the Tomb of the Unknown Soldier, where an eternal flame commemorates Soviet troops lost in World War II.

The largest cannon in the world—with a 35-inch bore—points across rows of parked black official cars toward two huge, yellow-painted office blocks that lie beyond the no-man's-land of Ivanovskaia Square. On the right is the Presidium building, which houses the offices of the Supreme Soviet, the body that in theory governs the country—as distinguished from the Communist Party, which rules it. Next door, green domed and red flagged, stands the Council of Ministers

building, where President Mikhail Gorbachev has an office and where the Politburo meets on Thursdays. This much I knew, but would I ever get permission to go there?

Clearly I needed a plan. I decided to explore the Kremlin's public areas in the hope of finding ways of gaining access to its real, hidden life. I began with the Armory. This greatest of Kremlin museums, which houses many of Russia's most important historical treasures, is under the care of curators, nearly all of them women, with a deep knowledge of their subjects. One of these, Irina Bobrovnitskaya, guided me through the maze of Ivan the Terrible's seven wives (not all of them recognized by the Russian Orthodox Church), alternately blushing and apologizing for her halting English. She introduced me to the Measure Icon, ordered by Ivan the Terrible to celebrate the birth of his son, also called Ivan. The icon (page 86) is 18 inches long, the same length as the newborn tsarevich, whose father killed him after he grew up by striking him with an iron-pointed stick in a fit of temper. In effect this act of parricide brought the 700-year-old Riurik dynasty to an end.

There is no shortage of books and films describing Ivan the Terrible's sadistic cruelty and reign of terror. It is less well known that Ivan was a patron and connoisseur of the arts who commissioned the best-known building in Russia, the flamboyant Intercession Cathedral, better known as St. Basil's, which confronts the visitor to Red Square with the challenge: "Understand me if you can!" Ivan was an able, if ruthless, statesman, and Soviet scholars who regard central authority as something to be desired see him as the real founder of the centralized state.

I SPENT MANY HAPPY DAYS in the museum being taught by the best specialists and looked after with the greatest kindness. At eleven o'clock sharp on most mornings I would get a call from the ample and maternal Elizaveta Shakurova, head of the Armory, to go to her office for tea and delicious cakes. One day Elizaveta brought out a photograph of herself surrounded by five senior clergymen of the Russian Orthodox Church.

"This was taken in June 1988, the millennium of the coming of Christianity to Russia," she told me. "We gave back to the church some of the holy relics stored in Kremlin museums since the Assumption Cathedral was closed for worship in 1918." She smiled and offered me another cake, adding, "Of course, we only returned the ones of little monetary or artistic value. They were especially pleased to get the skull of St. John Golden Tongue, believed to give special blessing and protection to those who keep it."

My understanding of the Kremlin's history improved rapidly when I met Natalia Vyueva, curator of the Terem Palace, which lies behind and contiguous to the Grand Kremlin Palace. A born teacher with an encyclopedic knowledge of Russian history,

Natalia dug out old books for me and was the perfect guide to the Terem's maze of little corridors, stairways, buildings set at odd angles, chapels built one on top of the other, connecting passages, and curious recesses, all built at different times for different people. The chapels give an intimate glimpse of the private lives of the first three tsars of the Romanov dynasty—Mikhail Fedorovich, his son Aleksei Mikhailovich, and his grandson, the young Fedor Alekseevich—but on the whole I didn't like the Terem because it is not genuine.

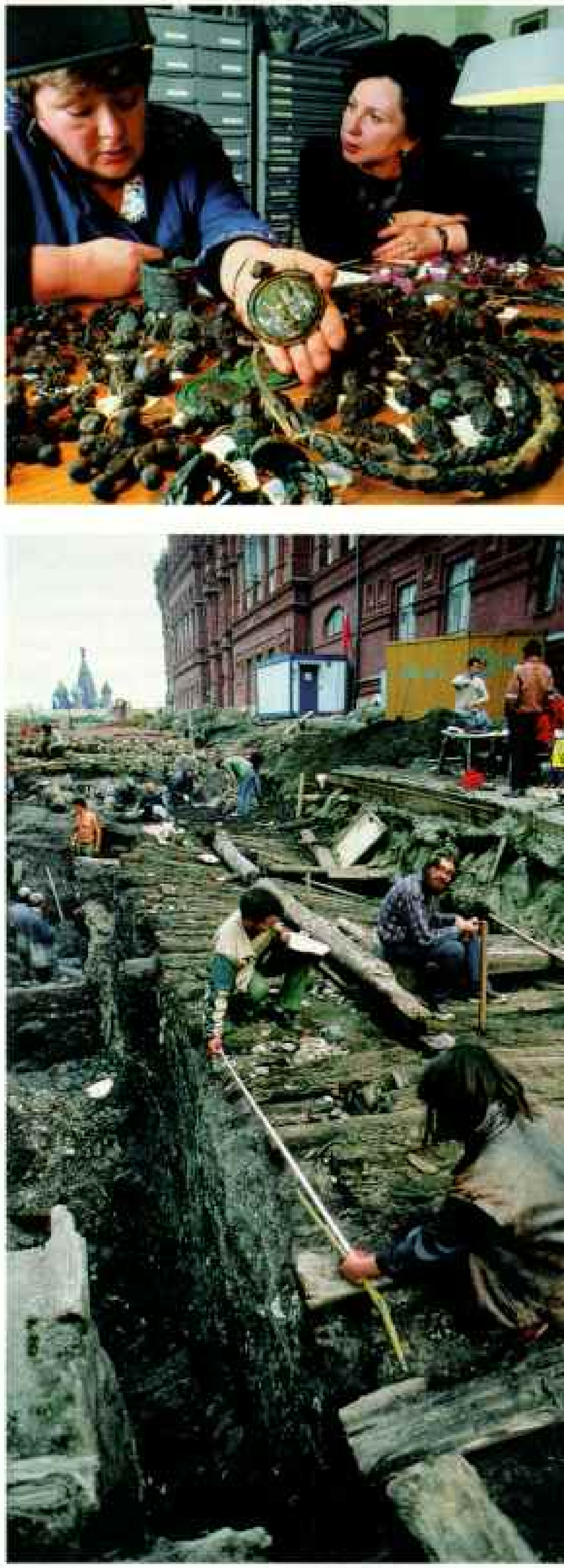
In the late 1830s, during the construction of the Grand Kremlin Palace, the Terem was redecorated in a 17th-century style that existed only in the imaginations of the decorators. The result has a cloying artificiality, the tiled stoves are not old, none of the furniture belongs, and the colored-glass windows are a theatrical fantasy.

I did like the Tsarina's Golden Chamber, however. Its wall paintings from the 16th and 17th centuries give it unquestionably the best atmosphere of any of the rooms in the old palace.

Natalia put my impression of the Terem Palace as a lifeless film set into perspective. "Peter the Great," she explained, "always loathed Moscow. In 1682, just before his tenth birthday, he was called out to face a bloodthirsty mob of musketeers. They burst into the Kremlin, seized his uncle and several family friends, and threw them onto the upturned pikes of the soldiers below. The mutineers hacked their speared bodies to pieces. As tsar, Peter built a new capital, St. Petersburg, and moved there in 1712, while construction was still in progress. He abandoned the Kremlin, and life there more or less died." It did not revive until Moscow became the capital again in 1918.

The new Bolshevik government turned the cathedrals and churches into museums and expelled the clergy but retained the old Christian nomenclature for Kremlin landmarks, so that one enters this fortress of atheism through gates named for the Savior and the Holy Trinity and continually encounters reminders of the fervent Christianity of old Russia.

The Grand Kremlin Palace was built by the tsars to impress visitors with the wealth and might of the Russian nation, and its function under the communists remains the same. I attended the official greeting of British Prime Minister Margaret Thatcher by Mikhail Gorbachev in the palace's vast St. George Hall. The two leaders entered simultaneously from opposite ends of the hall, each accompanied by a small retinue, and walked toward each other across 65 yards of crimson carpet. Mrs. Thatcher, obviously impressed, gazed upward at the massive chandeliers and downward at the elaborately inlaid wooden floor. The two leaders met in the middle and shook hands with theatrical solemnity. *(Continued on page 93)*



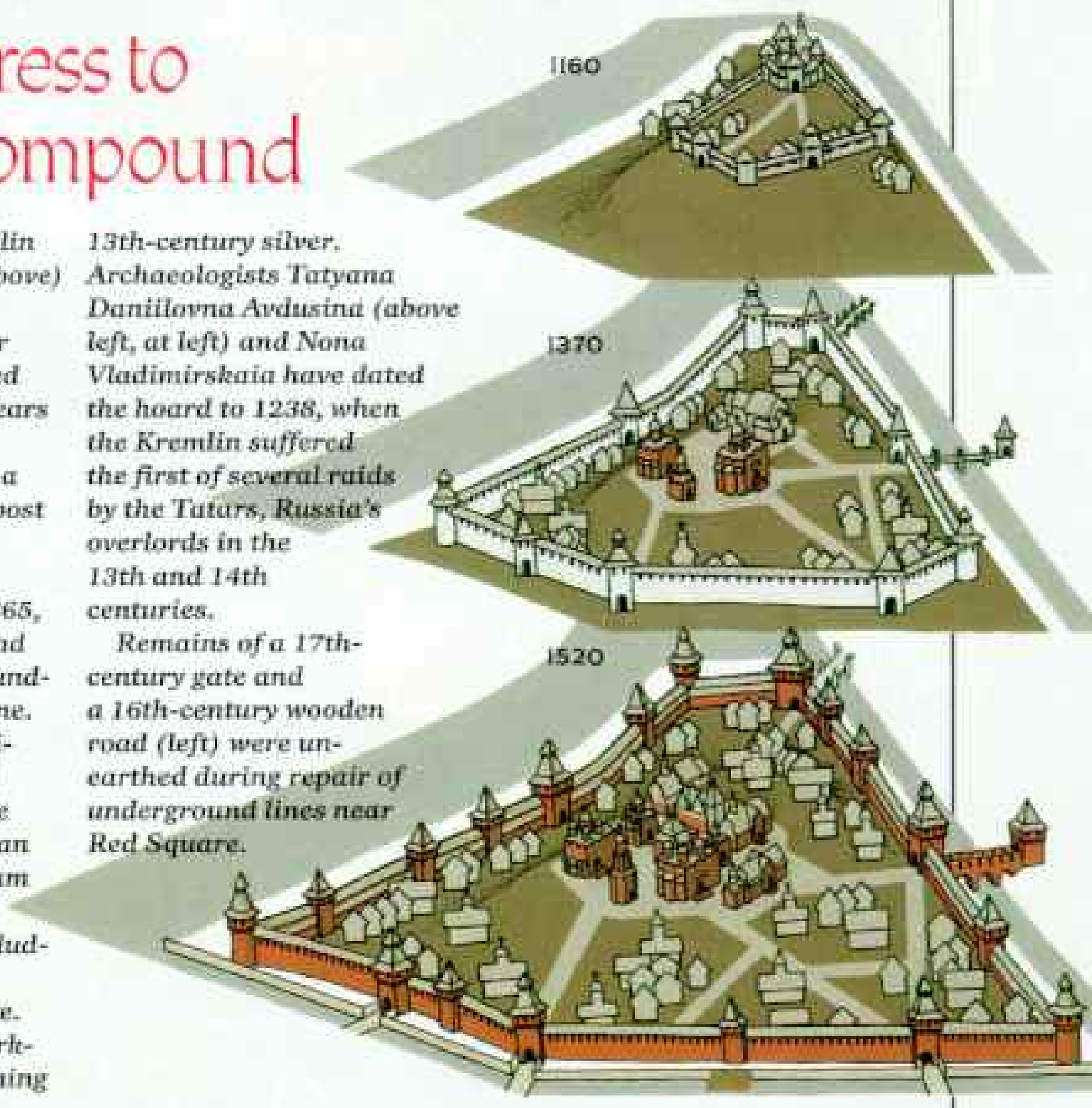
From fortress to palatial compound

A city of wood, the Kremlin of the 1330s (painting above) was just emerging as a major commercial center under Ivan I. Its recorded history had begun 180 years before, when the Grand Prince of Vladimir built a stockade around an outpost on the Moscow and Neglinnaia Rivers.

After a great fire in 1365, Grand Prince Dmitrii had the expanded city surrounded by a wall of white stone. Impressive as these fortifications were, they had fallen into decay by some 120 years later, when Ivan the Great recruited a team of Italian architects to rebuild the Kremlin, including a new brick wall enclosing the 69-acre site.

In 1988 a Kremlin workman found a box containing nearly 300 pieces of 13th-century silver. Archaeologists Tatyana Daniilovna Avdusina (above left, at left) and Nona Vladimirskaia have dated the hoard to 1238, when the Kremlin suffered the first of several raids by the Tatars, Russia's overlords in the 13th and 14th centuries.

Remains of a 17th-century gate and a 16th-century wooden road (left) were unearthed during repair of underground lines near Red Square.



PAINTING BY A. M. VASNETSOV, COURTESY MUSEUM OF THE HISTORY AND RECONSTRUCTION OF THE CITY OF MOSCOW (TOP); PAINTINGS BY T. M. BUTLEDGE; CONSULTANTS: JACK KOLLMANN AND VLADIMIR GATOVSKY

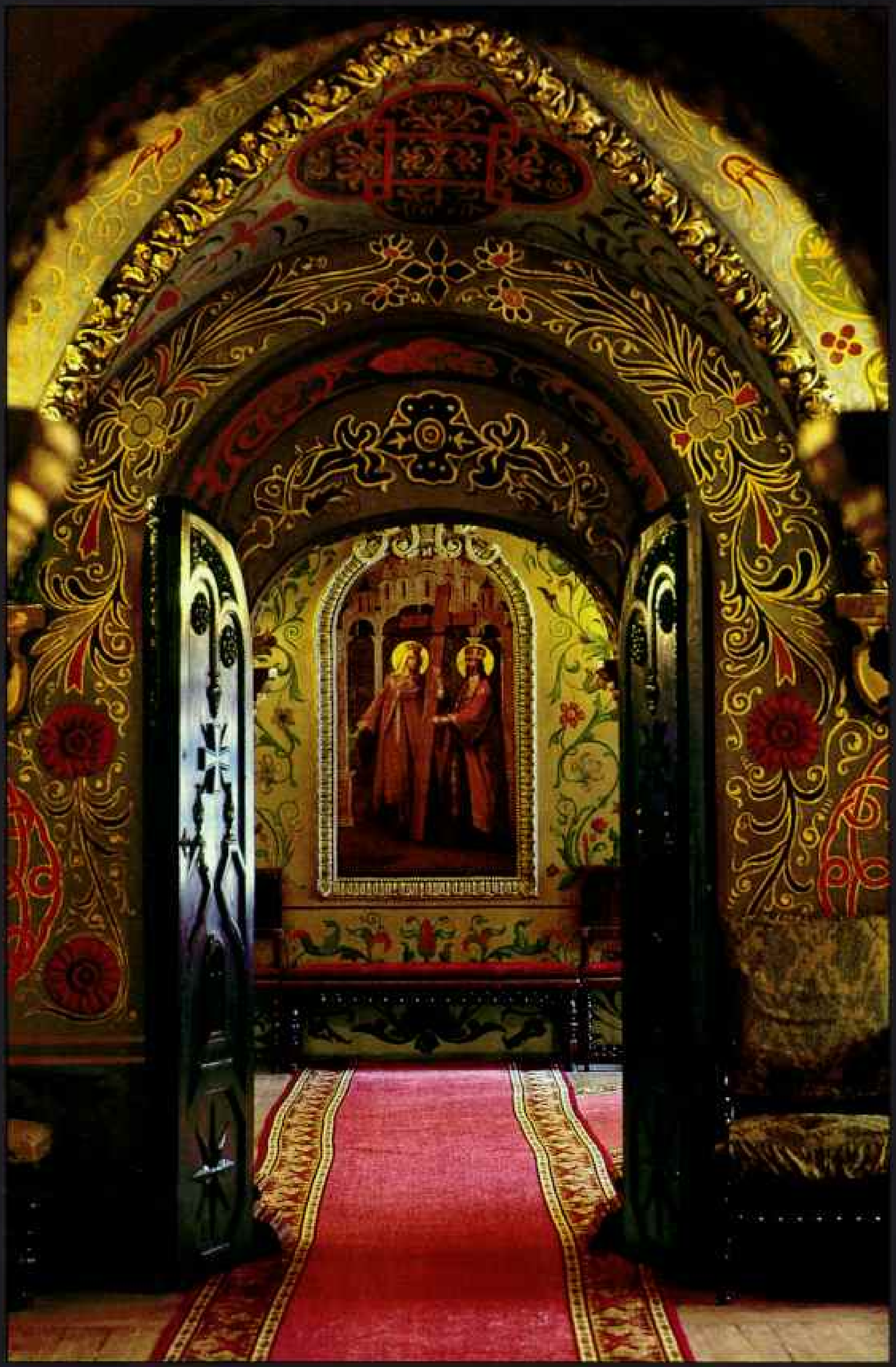
TREASURES OF THE KREMLIN

BEHIND THE WALLS of the fortress Kremlin, a dazzling collection of artwork fills the museums, palaces, and churches that make up the State Museums of the Moscow Kremlin—while the buildings themselves offer a veritable history of Russian architecture. Nearly 100,000 objects illuminate seven centuries of Russian royal life, dating from as far back as the early Muscovite princes. Gold and silver vessels of stunning beauty share space with enameled saddles, silver bridle chains, and other equestrian trappings; huge collections of antique weaponry contrast sharply with exquisite examples of Russian needlework and gem-encrusted vestments.

A gift from the last tsar, Nicholas II, to his wife, Alexandra, in 1913, a jeweled enameled egg from the House of Fabergé—one of ten in the Kremlin collection—exemplifies the luxurious tastes of the Russian aristocracy. Embellished with portraits of the Romanovs, the egg opens to display a world globe depicting Russia's spectacular growth during their 300-year dynasty.

Many of the Kremlin's buildings have undergone frequent resurrections and restorations, either from the ashes of fire or to suit the whims of imperial egos. Part of a constantly evolving palace complex begun by Ivan the Great in the 15th century, the Terem Palace—one of the Kremlin's first nonwooden residences—was enlarged in 1636 for Mikhail Romanov, first tsar of Russia's last dynasty. Though the building's structure remains intact, the heady mixture of fantasy and opulence displayed in the tsar's chambers (right) and elsewhere probably bears little resemblance to the original decor. In the mid-1800s the Terem was thoroughly renovated in a 17th-century style and incorporated into the new Grand Kremlin Palace.

After Mikhail's grandson Peter the Great moved the capital to St. Petersburg—his "window on the West"—the Kremlin's grand buildings languished for two centuries, used only as ceremonial centers and for occasional imperial visits. But Russian monarchs continued to be crowned in the most imposing of the Kremlin's three great Orthodox cathedrals, the Assumption (pages 84-5). Now museums, these churches embody one of the world's most splendid legacies of Russian Orthodox art and architecture.



"NOTHING IS BY CHANCE in a Russian cathedral," says a Kremlin curator about the Assumption Cathedral. "The columns support the ceiling, the saints support the church. That is why the saints are painted on the columns." Behind the columns a wall of priceless icons, some from the 12th century, separates the nave from the sanctuary. Last October, for the first time since 1918, authorities allowed the cathedral to be used for a Russian Orthodox service.

MEMORIAL to a puppet tsar, a golden chalice (below) was given to the Archangel Cathedral by Tsarina Irina upon the death of her husband, Fedor, in 1598. After the reign of her brother a succession of impostors known as the False Dmitriis vied for the Russian throne. The real Dmitrii, Fedor's half brother, had died mysteriously, some say by Boris Godunov's orders, in 1591. His likeness decorates a tomb cover (right) dating from 1630.

IVAN THE TERRIBLE commemorated the birth of his son Ivan with the Measure Icon, a likeness of the boy's patron saint, John of the Ladder, made the exact length of the newborn. In 1581, 27 years later, the tsar killed his son in a fit of rage. This doomed the Riurik dynasty, as another son, the feebleminded Fedor, succeeded him. Though Fedor reigned, his wife's brother, Boris Godunov, effectively ruled the land.

TESTIMONY to Muscovy's position as an emerging power, untold wonders of art and armament from kingdoms east and west flowed into the treasury of Ivan the Great. Two Persian war masks (right) date from the 16th century, their former gilding probably lost in one of the many fires that have swept the Kremlin.

Despite the fires, the cache of riches eventually outgrew Ivan's treasury building and accumulated through the centuries in the damp cellars and storerooms of the Kremlin's many palaces and cathedrals.

FROM THE FORGES of a 17th-century Kremlin workshop, a pair of decorative breastplates, too dear for battle, were probably reserved for parades. The lion's face, with a cannon barrel in its jaws, signifies an artillery unit of the tsar's army.

Art and weaponry became one in the workshops of the Armory. Here artisans imported from around the world labored to produce the elaborate trappings of war demanded by the tsars.

By the early 18th century, after most workshops had been moved to St. Petersburg, the Armory had become a storehouse for royal treasures of all manner. The present Armory building, completed in 1851, houses much of the Kremlin's collection, which dates mostly from the 13th century or later.

FRETWORK OF FANTASY FIGURES adorns a 17th-century rifle from the Kremlin workshops. One of some 300 antique guns in the Armory, the gun predates the reign of Peter the Great, who modernized his army with flintlock firearms. Crowned in 1682 at the age of ten, Peter was said to have mastered 14 crafts, including boat-building, which he learned in the Netherlands. Legend has it that an array of gold-framed ivory buttons, hand carved with military themes, were produced by Peter himself as decoration for one of his coats.

HUNGARIAN NATIONAL MUSEUM

CHURCH AND STATE were powerful allies in 1486, when Ivan the Great presented a silver tabernacle called the Great Jerusalem to the Assumption Cathedral. The niello-finished vessel is decorated with likenesses of the Twelve Apostles.

Disparate Slav principalities, which began their conversion to Christianity in 988 under Vladimir I, achieved political unity under Ivan the Great. Nine years before he ascended the throne in 1462, Constantinople had fallen to the Muslim Turks, creating a spiritual vacuum for eastern Christianity that in time would be filled by Moscow—the "Third Rome" of Russian Orthodox legend. Cementing his ties with the church, Ivan took for his wife the Byzantine princess Sofia in 1472. Unhappy with the provincial character of his court, he hired Aristotile Fioravanti and other Italian architects to refurbish the Kremlin. Besides rebuilding the Assumption Cathedral, they erected the magnificent Palace of Facets. Designed in the Italian style, it was completed in 1491, making it the oldest secular building in the Kremlin. Perhaps the most celebrated room in the Kremlin, its main chamber (right) served both as throne room and reception hall for Ivan and his successors. The room's interior has undergone several radical changes through the centuries; the present murals date from 1882.

When Gorbachev received U. S. President Ronald Reagan in the chamber in 1988, he was continuing a tradition that dates back to Ivan the Great. A 17th-century painting (above) is thought by some to depict the welcoming of a Polish delegation by the first False Dmitrii during his brief reign (1605-06).

A WORLD OF WEALTH beyond imagining unfolds in the Armory, the Kremlin's main museum. Here are the jewel-encrusted, sable-trimmed crowns of the tsars; and here are their thrones, including one embedded with more than 800 diamonds. Dating from the 16th through 18th centuries are carriages that trundled the tsars and their families through the rude streets of Moscow and St. Petersburg. One of the grandest (above, at far right) was a gift to Catherine the Great, reportedly from her lover Count Grigorii Orlov.

Russia's notorious Prussian-born monarch, Catherine came to Russia as a 15-year-old to marry Peter III. In 1762 she staged a coup and had herself crowned empress. Next to a tapestry portraying her in later years is her coronation dress, embroidered with golden eagles.

BY DEGREES I learned my way around the Kremlin and finally approached the frontier of the other world I was interested in, the one that lies behind the public facade and beyond the tourist trail. My first insight into how to get permission to enter the Kremlin's world of power and politics came by coincidence when one day I went on a tour of the Grand Kremlin Palace with a guide from the Armory. I wanted to photograph some of the rooms. Camera-carrying foreigners are always regarded with special suspicion, and this request made the guide nervous. "But the Ministry of Culture has given permission," I explained, doing my best to soothe her. The guide looked even more uncomfortable and went off to make a telephone call.

She returned saying that it was impossible to take any pictures and that it was nothing to do with the Ministry of Culture anyway. "Well then, who *does* it come under?" I asked. "The KGB," she replied. Every building within the Kremlin has a guard able to grant or refuse entry, who may be an eagle-eyed babushka, a plainclothes policeman, or a uniformed officer. But the security of the Kremlin is the responsibility of the KGB—the ubiquitous Committee for State Security.

It was now clear: To get anywhere I must deal directly with the KGB. This was an exquisitely difficult matter. Top Soviet officials concerned with sensitive questions of state security are not allowed to communicate with foreigners. I would have to negotiate with people I was not permitted to meet.

It was more than a year before I was ushered directly into the Grand Kremlin Palace, seated in one of the tsar's private apartments, and asked by a genial gentleman in civilian clothes what it was that I wanted. He was tall, slim, fiftyish, with clear blue eyes set in a long face and a large, straight nose that gave him a rather un-Russian appearance. Though he got a salute from the uniformed officers and I once thought I heard someone call him general, I never saw him in uniform. I shall call him K out of respect for the sensitivity of his position as the head of Kremlin security.

I handed K a long list of requests. He read it and exploded in laughter: "You want to climb the Savior Tower? I shall need an extra ration of milk to stomach that responsibility!" He leaned over to Cary Wolinsky. "What Russian have you learned?" he asked. In a flash of inspiration Cary remembered from lunch the word for mustard—*gorchitsa*. At every subsequent meeting, to the puzzlement of bystanders, K would call out "Gorchitsa!" instead of good morning.

K had the power to cut red tape, and cut it he did, giving Cary and me unique opportunities to observe the workings of the Kremlin. I grew very fond of him and missed him when he became ill before I left. We also formed a bond with K's assistant, Slava. At first I perceived this functionary merely as another of the gray men who come in the hundreds to work in the Kremlin, wearing the security man's uniform of gray suit and soft-soled shoes. Later I found, as one so often does with the Soviets, that the grim mask of officialdom concealed a warm and generous nature.

We first met Slava on a visit to the Trinity Tower to take photographs. He walked behind, observing our smallest actions. Access is through a closely guarded entrance that leads to the headquarters of Kremlin security, the surrealistically named Palace of Amusements, where Stalin lived in the 1920s and '30s. This building has two inner courtyards, where the cars of the top leaders are kept. As we approached the Palace of Amusements, our Russian companions were tense and nervous, as if some secret was about to be revealed.

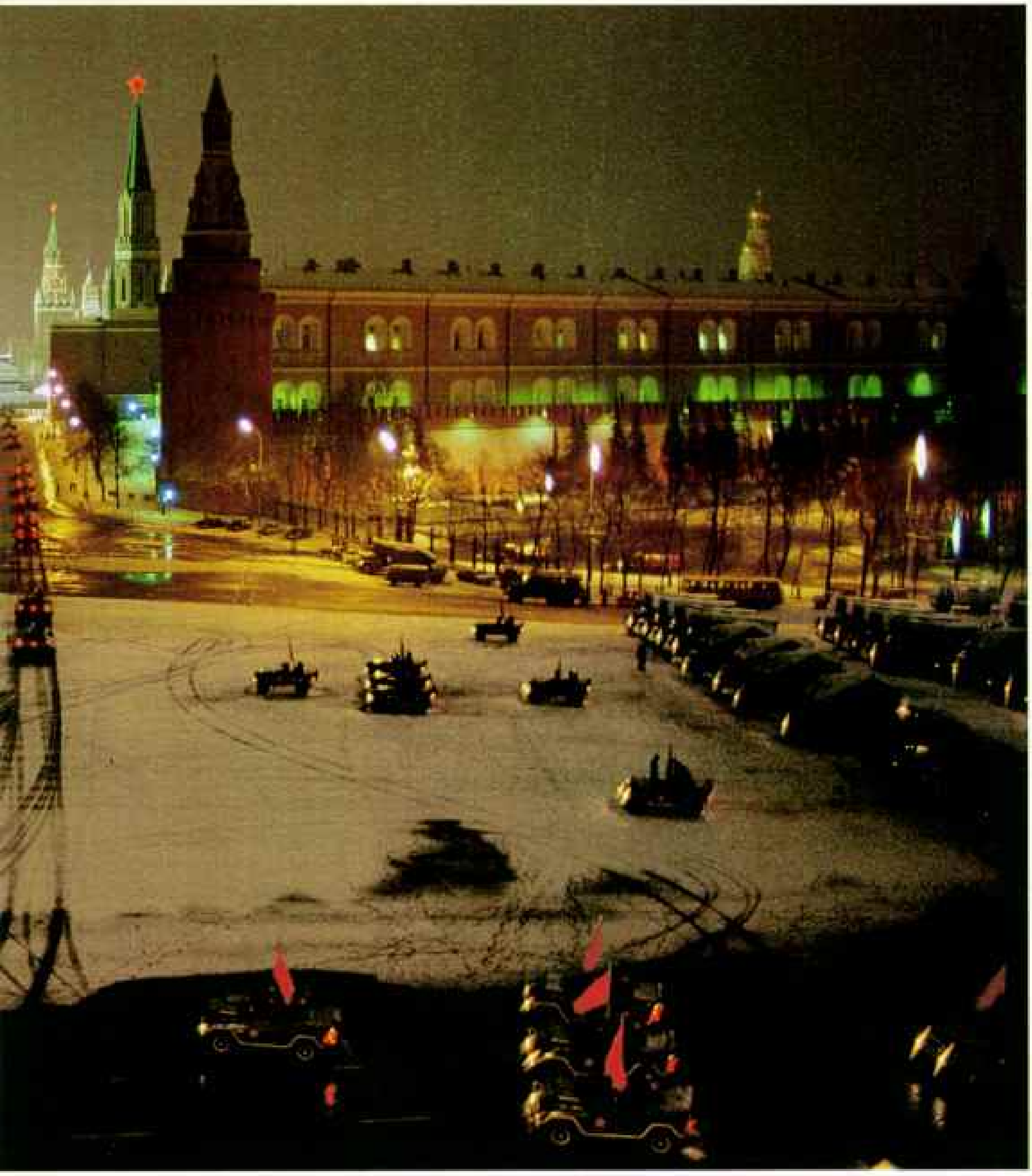
Inside Trinity Tower we were greeted by a most unexpected scene: The guard on duty was playing a trumpet at his desk. It turned out that the tower is the rehearsal studio of the Kremlin Commandant's Exemplary Band, a highly accomplished and versatile military band that plays at state visits and other official functions and is heard over Soviet radio. That day the musicians were making a multi-track recording of heavy-metal rock numbers. Later I heard them playing abstract music by a modern Soviet composer as well as the more usual marches and waltzes.

THIS DISCOVERY broke the ice, and soon other "secrets" came into our possession. We discovered, for example, that Slava was in charge of a Kremlin falconry team. Slava explained that the Kremlin has a recurring problem with flocks of hooded crows that assemble

In the still of the night, a convoy of Soviet tanks files between the State Historical Museum, at left, and the Corner Arsenal Tower en route to Red Square. Preparing for its role in the November 7 parade for the anniversary of the Bolshevik Revolution, the army rehearses in the early morning hours before Moscow's nine million people arise and reclaim their streets.

near the Oval Hall, where they set up a noisy cawing in apparent imitation of the Council of Ministers.

The crows are mischievous and high-spirited birds, much admired by the human beings who work in the inner Kremlin. When ice conditions are right, crows compete to perch on the cross of the central dome of the Annunciation Cathedral. One after another they jump off, ski down the dome on their backsides, and shoot off into space. I saw one



crow drop a chestnut down one of the big metal rainwater pipes, fly down to the ground, listen as it bounced and rattled its way to the bottom of the spout, then pick it up and repeat the performance.

"Unfortunately," said Slava, "there are too many crows. Their numbers must be controlled." The sound of gunfire inside the Kremlin would be an embarrassment, so the Kremlin Commandant's office took up falconry as a more discreet means of culling.

K himself introduced Cary and me to the falconry team in the Tainitskii (Secret) Garden, which extends from Ivanovskaia Square to the Kremlin wall by the river. The falcons' handlers, Oleg and Nikolai, both Kremlin guards, were shy and awkward until Oleg, with touching spontaneity, handed around apples picked from a nearby tree. Oleg and Nikolai had with them a fine juvenile goshawk, one of three in training. The bird was attached by jesses to a leather gauntlet worn

by the handler, equipment they had made themselves (below). The handler trains the hawk to return to him by whirling a feathered lure. The falconry operation has not been a total success: Crows know a goshawk when they see one, and they immediately fly away en masse. I never saw one caught.

Nearby, female gardeners diligently weeded and watered. In keeping with the ancient Russian tradition of impressing foreigners, they had all put on new blue denim uniforms. Indifferent to their withering stares, K picked roses and presented them to my charming assistant with a wicked twinkle in his eye.

Despite our contacts with K, Cary and I sometimes ran afoul of men and women whose job it was to be paranoid. The lower part of the Secret Garden is strictly closed to the public; no one may even approach the service road entrance near the Borovitskaia Tower. When Cary, ignoring warning signs, stepped a few yards inside the forbidden area to photograph the Armory, the nearest security man blew a shrill blast on his whistle. A passing black car bristling with antennas screeched to a halt, and one of K's men jumped out and created a tremendous furor.

From this extraordinary reaction I inferred that the Secret Garden still has its secrets. Legends abound of people leaving the Kremlin by secret tunnels—including Napoleon, retreating from fires that swept the city. When I asked people in a position to know, all said that they knew nothing about any tunnels, replying so quickly and with such consistency as to lead me to believe the opposite.

WHEN I VISITED the apartment where Vladimir Ilyich Lenin lived and worked during his five years in the Kremlin, security was extra strict—documents scrutinized on the way in and out, a soft-shoe man at almost every turn, even an escort to the toilet. The reason: President Gorbachev's office is nearby.

Once inside the Council of Ministers building, I was led along elegant creaky-floored corridors covered with government-style crimson carpeting, past offices posted with the occupants' names. It was impossible to keep track of where I was at any given moment. None of the passages meet at right angles, and to make it worse the corridor windows open on an inner courtyard shaped, ironically, rather like a pentagon. I had been in Russia long enough to wonder whether this 18th-century labyrinth was part of a master plan to disorient visitors.

My scholarly guide at Lenin's apartment-and-office suite, Liudmila Kunetskaya, disarmed me with her courtesy and frankness. "Lenin and his wife were both of the nobility," she told me, with the enthusiasm of one who loves a familiar subject. "His wife,

Nadezhda Krupskaya, was a hopeless cook . . . they had a servant . . . Lenin's sister smoked . . . Lenin himself enjoyed hunting, went to bed late and got up late . . . he and his wife slept in separate rooms . . . he had a command of seven foreign languages—French, German, English, Italian, Czech, Polish, and Swedish, plus a knowledge of Latin and Greek."

Lenin was one of many false names he used to confuse the tsar's secret police. His family name was Ulyanov. Lenin and his wife shared their apartment with his unmarried sister, Maria, and the rooms still preserve something of the family's presence. The piano scores copied out in a neat hand bear witness to their musical interests. "Vladimir Ilyich sang baritone, and the women played the piano," Liudmila told me. The oilcloth on the kitchen table, the chipped plates, cheap bentwood chairs, scattered belongings, and personal photographs give the feeling of a real, if Spartan, home. Books were Lenin's passion, and his rooms house some 8,000 volumes in several languages. His own phenomenal output of some ten million words was for the most part published posthumously.

A photograph taken by Lenin's sister shows him near the end of his life, age 53, sitting in a wheelchair after a stroke that paralyzed his right side (page 70). A lot of interest surrounds Lenin's ethnic origins, and I thought that it might be possible to discover something by examining unretouched photographs. I was intrigued to observe that Lenin, descended through his father from Mongol Kalmyk forebears, had the epicanthic fold—the extra fold of smooth skin covering the upper eyelid. This feature is not always visible in his official likenesses.

For a firsthand account of life in the Ulyanov family I turned to Lenin's niece, Olga Dmitrievna, a sprightly, bespectacled teacher of physical chemistry at Moscow University, now in her 50s. On a bitterly cold morning she took me to see the house in Cavalier's Row where she had lived with her parents until the 1950s, a short street where the Palace of Amusements and the Palace of Congresses are located. She reminisced about the wonderful time she had as a little girl in the Kremlin. She went everywhere, played in the old buildings, rode a pony in the Secret Garden, and from time to time came upon her uncle's bloody-handed successor, Joseph Stalin, walking in the grounds. "As a child I saw him as a kindly man," Olga says.

Lenin's family, told that the people wanted to see him as he was in life, agreed to the display of his corpse. His wife may have expressed their real sentiments when she wrote to *Pravda*: "Do not allow your mourning for Ilyich to take the form of external reverence for his person." Lenin was, of course, a militant atheist, so it is a great irony that he became the focus of a quasi-religious official cult. Its hallowed images, orthodox texts, and joyous festivals parody the trappings of the religion that he so vigorously suppressed.

The cult's principal relic is Lenin's corpse, exhibited in a glass case in a squat red granite building. *(Continued on page 102)*

Kremlin Commandant Gen. Gennadii Bashkin oversees the comings and goings of all within his domain—even the crows that crowd Kremlin roofs. To reduce their numbers, yet avoid the sound of gunshots coming from the Kremlin, goshawks were trained by falconry experts (opposite) on Bashkin's security staff. After a long wet day, one bird gets his wings dried in a public restroom.

Shrine to an illustrious revolutionary, and perhaps to human patience as well, Lenin's tomb has been the focus of endurance-testing lines since his embalmed body was placed here in 1924. "Some come the night before," said the photographer, "and sleep in the park. Mainly they are curiosity seekers." Last November Lenin's tomb was closed for repairs, to be reopened in mid-January 1990.

Chairs are considered a nuisance at dinner receptions in the Palace of Congresses, where guests stand to partake of an otherwise formal meal. "It's easier to move around and socialize," one explained. This occasion was hosted by President Gorbachev in honor of the Soviet Olympic team. During the reception Arvidas Sabonis (below), star of the gold-medal-winning Soviet basketball team, asked—and later received—Gorbachev's permission to play outside

the Soviet Union. Though the Portland Trail Blazers own U. S. rights to the seven-foot-three-inch Lithuanian, he signed a one-year contract to play in Spain for the 1989-90 season.

In the Kremlin there is no shortage of lavish halls for affairs of state. Especially imposing are a chain of ceremonial rooms in the Grand Kremlin Palace, each bearing the name of a saint. In 1987 a British delegation awaits Gorbachev, who had earlier received Prime Minister Margaret Thatcher in St. George Hall, an extravagantly decorated room some 65 yards in length. Later a set of cultural and economic accords between the two countries were signed in adjoining St. Vladimir Hall.

Kremlin Commandant Gen. Gennadii Bashkin, whose regiment of guards provides the sentries, told me that since 1924 more than 110 million people have visited the tomb. (Closed for repairs last November, it is scheduled to reopen this month.) In 1941, as the German army approached Moscow, Lenin's body was secretly removed and taken to Siberia for safekeeping. His posthumous condition is remarkably good, his beard still red and his skin radiant. His pickled brain—sectioned and preserved in paraffin—resides in the Institute of Neurosurgery.

It was my own impression that the endless queue to see Lenin's remains has been generated neither by devotion nor, as skeptics might suspect, by rent-a-crowd. The people I spoke to were from every corner of the U.S.S.R. Some had slept in the Alexandrovskii Gardens to get to the front of the line. And why were they there? A man from Uryupinsk summed it up: "This is my first visit to Moscow, and I want to see all the sights."

I decided to join him, and great theater it turned out to be. The line advances steadily. At the entrance a soft-shoe man rechecks for bags and cameras. "Turn left!" *Uniformed guards everywhere.* "Take off your hat, button your jacket!" *Six steps down, turn right, more steps down.* "Uncross your arms!" *Surprisingly deep underground: Yes, I remember, the old moat was excavated.* "No talking!"

Ah, there's the body, feet pointing toward Red Square; waxy face on a white pillow, black jacket with collar and tie. Soft lighting and silence. The right hand is clenched, the effect of Lenin's stroke. *Too much reflection from the skin—could it be wax?* Tiptoe around the foot of the bier with its glass walls and decorated metal superstructure. The left hand is open. "Turn right!" Up the steps and out of the darkness into the light again.

Outside, the line drifts past the graves of the famous: Chernenko, Brezhnev, Stalin, Frunze, Kalinin, and others, each with its portrait bust and posy of plastic flowers (Stalin's larger than the others), then along the Kremlin wall where the remains of other "renowned figures in the international communist movement" are interred. Stalin's corpse once lay alongside Lenin's, but Nikita Khrushchev had it moved out in 1961. Cary wanted to photograph Stalin's grave, but permission was refused. I wondered if this meant the tyrant's remains were in for another demotion—perhaps to the Novodevichii Cemetery, where Khrushchev is buried.

I WONDERED, often, what Lenin and Stalin would think of the new men of the Kremlin, and of their policies of *glasnost* (openness) and *perestroika* (restructuring). One of these, Vsevolod Murakhovskii, then first deputy prime minister of the U.S.S.R., kindly invited me to sit in his office for half a day while he went about his business. He occupied a large room, its walls, floor, doors, and furniture inlaid with woods of every color and grain to give a most elegant effect. His desk sported the inevitable collection of telephones, including, of course, the status-giving *vertushka*, an exclusive telephone system restricted to high officials (page 72). A campaign button on his pen rack bore a smiling likeness of Gorbachev and the breezy un-Russian slogan, "I like Gorbi."

Murakhovskii, sixtyish, stocky, red faced, and ferocious looking, turned out to be a person of great affability and charm. He invited his official visitors to sit with him at a long table with 20 chairs around it facing his desk. One group from Siberia wanted machinery, another spoke about a food-packaging symposium in the United States they had attended, another presented a report on hydrological problems in Central Asia.

After Murakhovskii's visitors left, we discussed some of the problems of greatest concern to him. He was clearly deeply troubled by the situation in Central Asia, where the diversion of water for irrigation has caused the level of the Aral Sea to drop by 45 feet, leaving former fishing villages 50 miles inland.

Naturally, I took every opportunity to observe President Gorbachev at close quarters. I watched him moving among the athletes at a reception for the Soviet Olympic team and noticed that he has that rare quality of giving his attention to the person he is speaking to as if no one else in the world matters. Clearly the athletes found him approachable. A Soviet reporter overheard Arvidas Sabonis, the seven-foot-three basketball player, asking if he was going to be given permission to play for the Portland Trail Blazers. "It can be discussed," Gorbachev replied diplomatically. When someone handed him an invitation card and asked for his autograph, a real scrimmage began, to the distress of the security men. Gorbachev

While parents wait patiently in the cold, an army of children descends upon the Palace of Congresses for the annual New Year's party. With three shows a day for ten days, some 250,000 children are entertained with games in the lobby (above) and staged shows in the huge theater. Grandfather Frost, a figure remarkably similar to Santa Claus, presides over all.

Too good to pass up, a steep hillside near Borovitskaia Tower has been the site of impromptu sledding for years—an officially unsanctioned pastime winked at by officials. Inside the citadel's walls, a new breed of revolutionaries are challenging the old order with glasnost, perhaps marking a new chapter in Kremlin history.

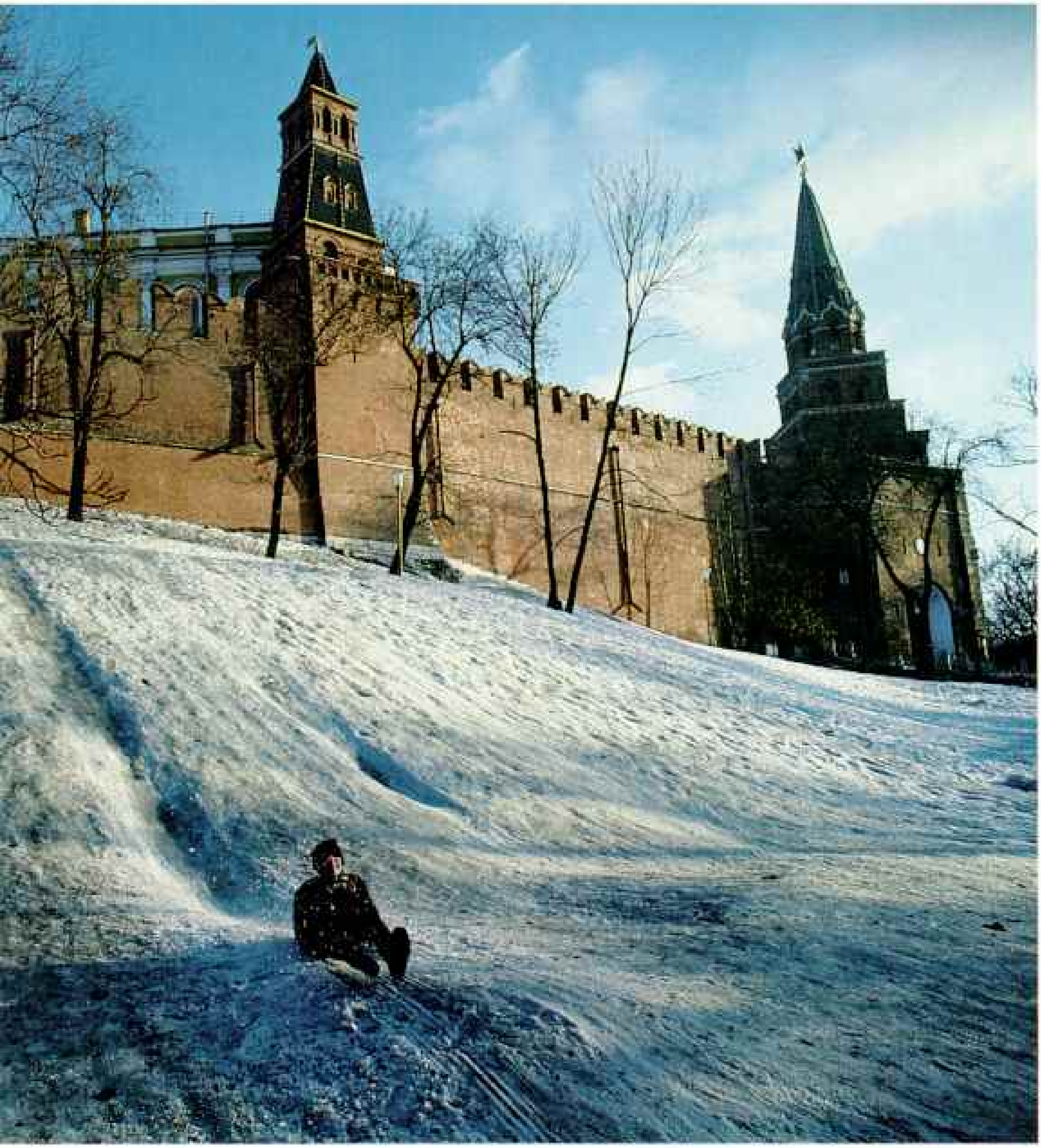
signed, smiled, and even got his wife to sign the cards for good measure.

A REVEALING OPPORTUNITY to observe the Soviet leader arose on October 28, 1988, at a meeting of the Supreme Soviet in the Grand Kremlin Palace. This was the body of 1,500 that enacted the laws and from which—as head of its Presidium, or executive committee—Gorbachev held his title of president. The deputies took their seats in a chamber equipped with rows of neat desks facing a podium reserved for the Presidium. A 16-channel sound system provides, in theory, for interpretation of the languages of the 15 republics that make up the U.S.S.R.—although, in practice, only the Russian channel is used. Deputies come from every corner of the U.S.S.R. and from all walks of life. The colorful crowd included a sprinkling of high-ranking military men wearing great slabs of medal ribbons that cynics refer to as their "icon screens." I counted 18 rows on one old warrior.

Under discussion was a bill relating to public demonstrations. Since Stalin's time no one had ever voted against any proposal put before the Supreme Soviet, the perfunctory "anyone against?" invariably being followed by a unanimous vote in favor. This time, however, 13 people actually raised their hands in opposition. An astonished silence was followed by incredulous laughter and commotion. At that very moment I was on the floor of the hall watching President Gorbachev. He was relaxed and smiling, chatting to Prime Minister Nikolai Ryzhkov as if saying, "That's what I was hoping for."

Several months later the reforms went even further, as a new Congress of People's Deputies convened in May 1989. Most of its 2,250 members, chosen in locally contested elections, belong to the Communist Party. But the new body is in turn empowered to elect the president as well as the more streamlined new Supreme Soviet—which occasionally surprises conservative party members by voting against them on defense matters, pensions, and business taxes, among other issues.

In choosing the path of reform Gorbachev in some ways resembles Peter the Great, who, against the determined opposition of conservative opinion, introduced new ideas and techniques from abroad in an attempt to drag his isolated, stagnating country from the Middle Ages into the 18th century. Gorbachev's position is even more difficult and



dangerous than Peter's. Not only does he have as potential enemies those who are jealous of their privileges and do not want to change, but he also has to contend with a rising tide of expectations for better living conditions, more consumer goods, and greater independence for the nationalities—in effect, an end to Russian domination, which predates the communist era.

On a winter's morning just before leaving Moscow, I walked to the Kremlin through the Alexandrovskii Gardens. Children were sliding down the steepest part of the Kremlin hill on improvised toboggans.

At the Borovitskaia Tower gate I noticed a militia captain of the Kremlin detail pulling some seeds out of his pocket. I recognized this man as one who had been difficult on several previous occasions. He gave a little whistle and a bird flew down and took the food from his hand. "Make yourself at home!" he said, waving me through with a big smile.

All strength to the new revolution, I thought deep within myself. □

NEST GATHERERS OF TIGER CAVE

Article and photographs by
ERIC VALLI and DIANE SUMMERS

With nothing but skill to keep him from falling, 52-year-old Sahat reaches out from a 90-foot bamboo scaffold to pluck a tiny bird's nest from a cave wall in southwestern Thailand. This prized treasure—once the home of baby swiftlets like these (above), but now abandoned—is the essential ingredient of bird's-nest soup, a Chinese delicacy.

Clinging to bundles of vines that have been lashed to a giant stalactite, Sahat, his 22-year-old son, Em, and 45-year-old companion, Ip, use torches to search for the nests in Rimau (Tiger) Cave. A cluster of nests, looking like small porcelain cups, are visible on the rock face at right, where Em reaches out with his three-pronged rada. *Flashlights slung across the climbers' backs are saved for emergencies.*

"Wherever the birds fly, we go," say the nest gatherers, who ascend hundreds of feet in the vast cavern of Rimau Cave. In their quest for the swiftlet nests, which tend to be grouped near the cave roof, they scale a complicated network of bamboo pillars and scaffolds erected by generations of climbers.

The panoramic view, at left, shows the men scaling a bamboo pylon called Lumu, or "pillar of the pierced nose." The pylon leads straight up to a nostril-like hole, through which vines are threaded to secure the bamboo to the rock face.

From there the men continue their climb up a series of stalactites on yet more vines and bamboos.

Within grasp of the precious "white gold," Sahat (top) wedges himself into the folds of a stalactite and reaches up with his rada, a special tool (above) that is thought to have magic powers. To take a nest with anything else, the men believe, would be like stealing from the spirits of the cave, and that would lead to trouble.

The swiftlet nests are translucent and rubbery, consisting largely of dried bird saliva.

FROM THE RICKETY bamboo perch nearly 300 feet above the floor of Rimau (Tiger) Cave, I peered down into a well of darkness. The twittering staccato call of thousands of swiftlets echoed in the vast cavern.

Pinpricks of moving torchlight pierced the pitch-black world below—the feeble lights by which other climbers ascended a fantastic bamboo structure in search of nests consumed by the millions in bird's-nest soup. From this cave on an island in the Andaman Sea off the southwestern coast of Thailand, and others like it along the shores of countries such as Burma (now called Myanmar), Malaysia, Vietnam, and the Philippines, generations of men have risked their lives to harvest the edible nests of these birds that fly in the dark: in this case, *Aerodramus fuciphagus* (the white-nest swiftlet) and *Aerodramus maximus* (the black-nest swiftlet).

These nests, made from a glutinous substance secreted from a pair of enlarged salivary glands situated under the birds' tongues, are blended with a rich chicken stock to produce the famous Chinese delicacy.

All around me, dimly revealed by the torchlight of my three Thai companions, stood a surrealistic bamboo structure—pylons, platforms, and bridges. Bamboos soared high above us. The ammonia stench from the thick carpet of bird and bat guano was almost overpowering. I muttered to myself, "This is madness—total, absolute madness."

Yet the climb had been exhilarating. My three agile companions—the humorist Ip, the serious elder Sahat, and his son Em—ascended effortlessly, their fluid movements like a dance. The bamboo pylon, which shuddered and creaked under my much greater weight, scarcely shook beneath them. At one point I crawled gratefully into a niche in the rock face to rest, curling my six-foot frame into a ball. Then I was climbing again over a bamboo span inclined at a 45-degree angle. In places the rock bulged over the bamboo like a paunch, forcing me to step out over the abyss.

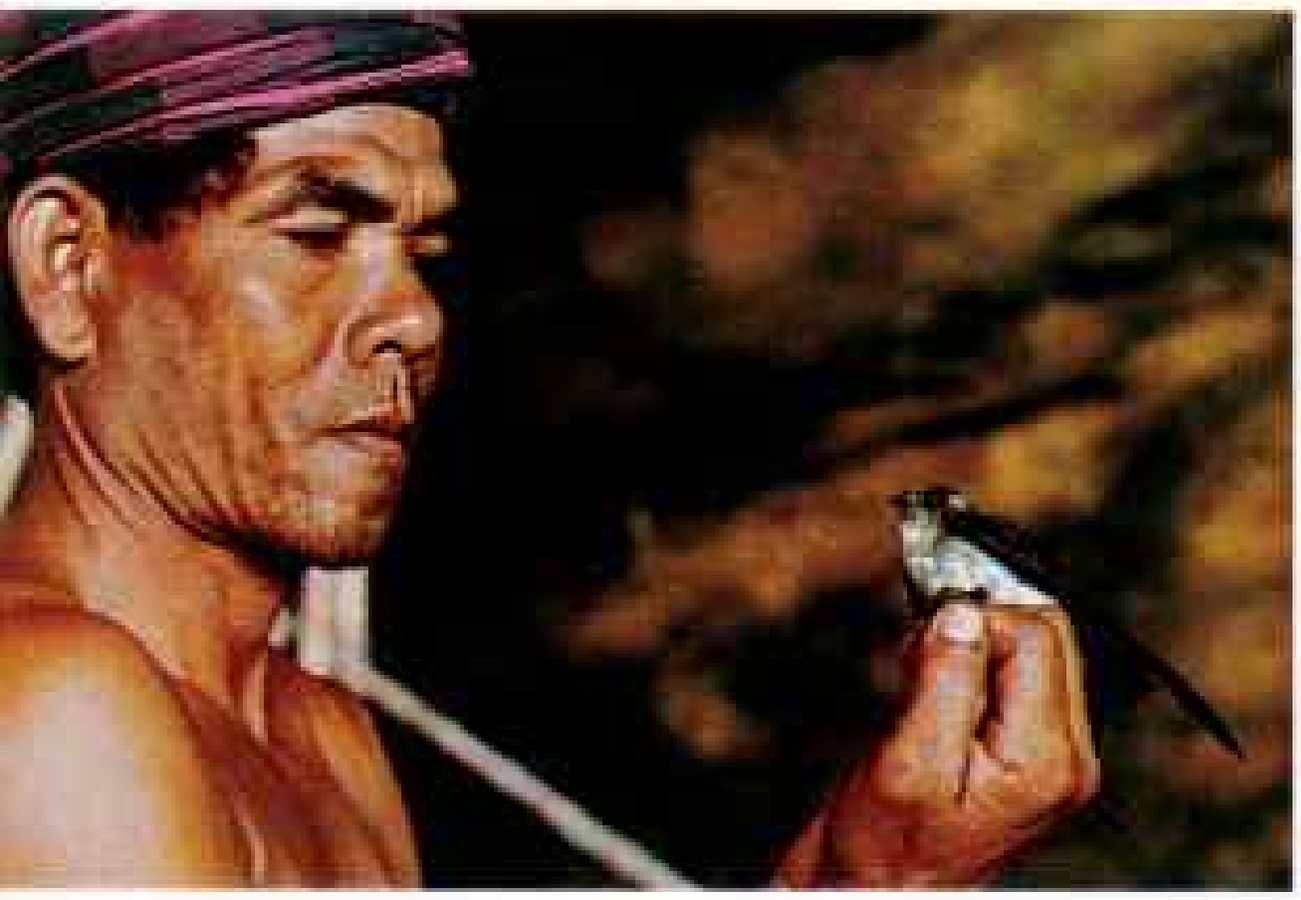
Alone, this climb would have been a nightmare. But the calm of my three companions was infectious—to them, clambering up this fragile trellis of bamboos and vines was just another day's work. Like their fathers and grandfathers, the climbers have been taking the nests since they were boys. At 52, Sahat was the eldest. There was not one gram of extra fat on his muscular frame. His gentle face was framed by a neat white beard, tapering to a point. Ip, Sahat's junior by ten years, was boyish and exuberant, and his comic impersonations of his friends—and later of me—sent everyone into fits of laughter.

Looking into the face of Em (who at 22 was the youngest of the trio) as he held his torch over my notebook, I realized that even for him the climb had not been so effortless as it seemed. Pearls of sweat glistened on his face.

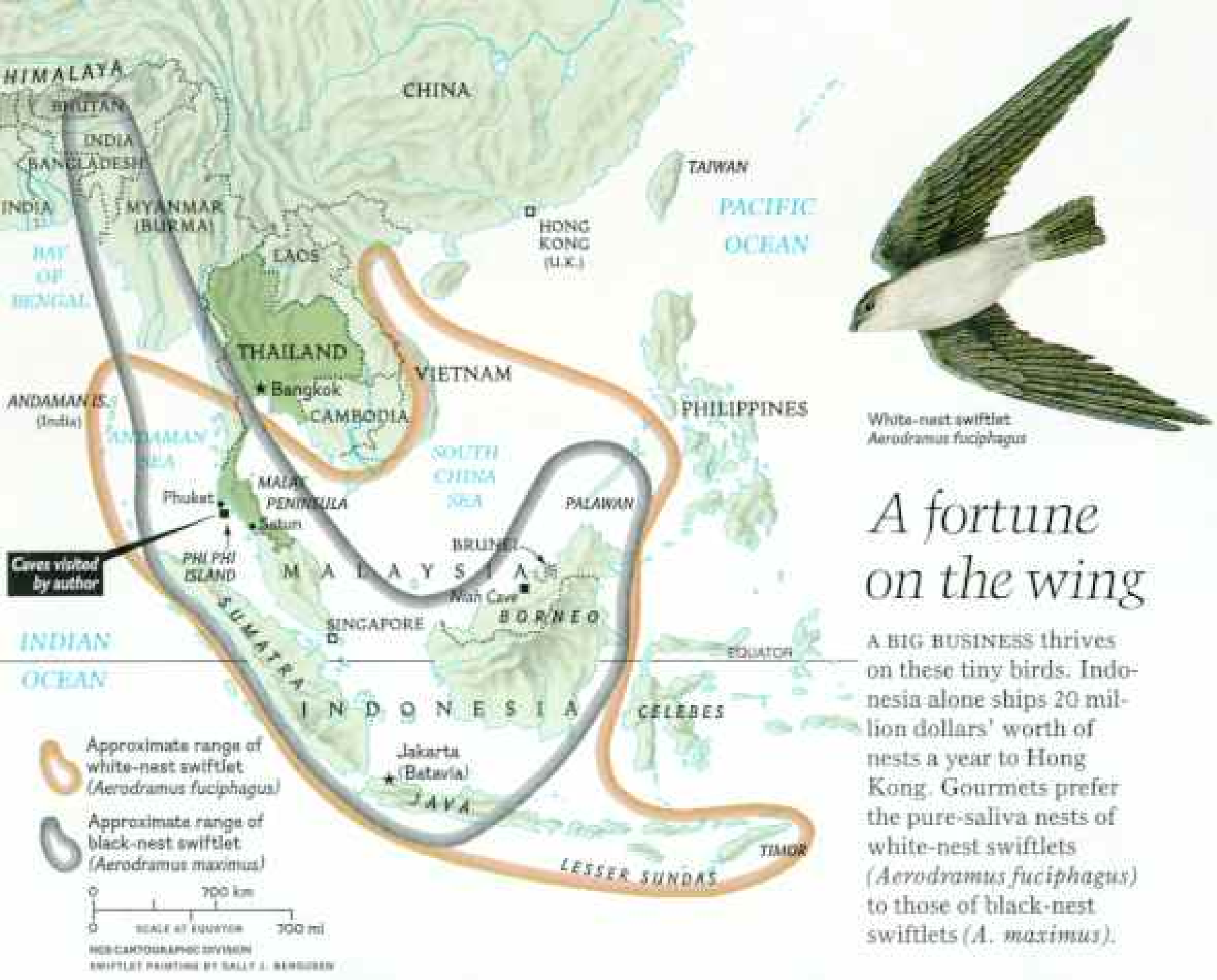
MORE WORK lay ahead. Sahat and Ip reinforced the structure that traversed the cavern with more bamboos and vines. Nimbly they crossed the void on this bridge, which was barely as wide as their feet, and disappeared between immense stalactites.

It was only when I heard "*Ma*—come!" that I took a deep breath and followed. My legs shook. The slightest error in judgment would be fatal. To keep my composure, I imagined my weight radiating through every fiber of the vines that secured the bridge. Ip's torch flashed between the stalactites. His hand took mine and led me to the safety of the rocks. This was as far as I would go.

A husband and wife team, ERIC VALLI and DIANE SUMMERS are the authors of "Honey Hunters of Nepal" (GEOGRAPHIC, November 1988).



Stunned by the impact, a black-nest swiftlet rests in Ip's hand after colliding with him in the darkness. Uttering rapid loud clicks, the birds use echolocation to find their way in the caves. But the swiftlets, easily startled by the climbers, frequently bump into them.



White-nest swiftlet
Aerodramus fuciphagus

A fortune on the wing

A BIG BUSINESS thrives on these tiny birds. Indonesia alone ships 20 million dollars' worth of nests a year to Hong Kong. Gourmets prefer the pure-saliva nests of white-nest swiftlets *(Aerodramus fuciphagus)* to those of black-nest swiftlets *(A. maximus)*. The birds rebuild them twice, usually in the same location. The third nest is left until the swiftlets raise their young. After the fledglings leave the nests, the third nest is removed, and the collectors return to their other occupations—Ip is a boat carpenter, Sahat and Em are fishermen.

Soon Sahat, Ip, and Em were doing what they had come to do—harvesting nests. The three of them are capable of gathering 150 in a typical day. The two older men slid down a vine. Their voices echoed beneath us. In the gloom I could make them out on a platform that looked even more fragile than the bamboos that brought us here. The lianas holding the scaffolding groaned, the bamboos bent.

Beside me, Em chiseled a nest away from the rock face with his *rada*, a three-pronged tool carried by each of the men. The nest was about two inches across. Its fine texture and translucency reminded me of a porcelain teacup. Em broke it into two and, after passing me half, bit into his share. I did the same, but to my great disappointment the raw delicacy was tasteless and rubbery. The nest gatherers nonetheless swear by its rejuvenating power. During the collecting season, from February to May, they climb the bamboo web at sunrise and descend only in the evening. Traveling light, without food or water, their sole source of nourishment is the nests, which they believe give them the energy of birds.

Nests are collected three times in a season.

THE HARVEST is big business. In Hong Kong nests currently sell for as much as a thousand dollars a pound, and the price continues to rise. A leading authority on the history and chemistry of bird's nests, Yun-Cheung Kong, professor of biochemistry at the Chinese University of Hong Kong, believes that swiftlets' nests have been eaten in China for 1,500 years. According to Dr. Kong, the discovery of Tang-dynasty porcelain near Niah Cave in northwestern Borneo suggests that importation of the delicacy goes back as far as A.D. 700. Early in the Ming dynasty (1368-1644) a eunuch named Cheng Ho made seven voyages through Southeast Asia in command of an imperial fleet. Among his instructions from the emperor were to note the diet and produce

A descendant of the Malay fishermen who have harvested bird's nests for generations, Ip greets a passing fishing boat from the mouth of Lo Liam Cave. Although it is not certain when the Chinese began eating nests, records show extensive trade in this region by the 1600s. A 36-foot-long mural of ships discovered on a wall of Wong Lung Cave (left) depicts mainly Malay ships from the 19th century. Such pictures, some showing earlier ships, appear in a number of other caves and may represent a record of the vessels that visited these islands.

of these foreign parts. Cheng Ho's route touched all the major bird's-nest-producing sites of today, and it is possible he brought back samples to present to the imperial court. Some authorities credit Cheng Ho with introducing foreign nests into China, but no written record of this event has been discovered. Dr. Kong believes that nests in China had been exhausted before foreign ones were imported.

By the mid-17th century edible nests were a prized commodity. In the late 1700s, 125,000 pounds (four million nests) annually passed through the Javanese port of Batavia (Jakarta). Today Hong Kong consumes more than 60 percent of all bird's nests, about a hundred tons, or 25 million dollars' worth, annually. The Chinese communities of North America rank second, accounting for about 30 tons yearly. The United States does not import raw nests because of the presence of a bacteria, clostridium. All nests destined for the North American market are washed in a sulfite solution and cleaned of impurities before export. The biggest importer of bird's nests until the communist revolution was China. Now China imports 10 percent of the Hong Kong market.

Most bird's nests are eaten at home, but bird's-nest soup can also be consumed in Hong Kong restaurants for as much as $50 for a single bowl. The standard method of preparation is to cook the nests in chicken stock. More elegant recipes include "Phoenix Swallowing the Swallow," a chicken filled with bird's nests and double-boiled in a porcelain pot to yield a clear consommé.

The men of Rimau Cave collect two kinds of bird's nests: The white nest of pure saliva built by *A. fuciphagus* and the black nest of *A. maximus*, which incorporates the birds' feathers. The black nest is thought to have less nutritional value than the white and, because of its impurities, is less expensive. The so-called red nest, regarded as a great delicacy by chefs who claim that it is tinted by the blood of the swiftlet, may actually take its color from iron oxide in the rock to which it was attached.

IN RIMAU CAVE, those who eat bird's-nest soup and their reasons for doing so seemed very far away. I was fascinated by the process of nest gathering and by the skill and daring of the men who did it.

One day, high in the cave, Em and I watched the two older men tie vines end to end, making a strand some 70 feet long. By

Nimble as a circus acrobat, a nest gatherer named Samane pulls himself hand over hand into the entrance of a sea cave. His companions have moved their boats to one side in case he loses his grip. In February and March the gatherers take

nests twice; the birds come back and rebuild. The men generally harvest the third and last nest in May after fledglings depart. Biologists have found that the swiftlet population is in decline and urge a more limited harvest.

torchlight Sahat and Ip searched among the tangle of lianas until they found a place to attach their rope. Then they climbed down and disappeared into the blackness.

I tried to imagine how the first men wove this amazing web. According to Sahat the original structure was built by a sage called Tok Ta Pa from Satun in the south. Working alone, this ancient had climbed to the top by hammering poles into small holes in the rock. Tok Ta Pa instructed his companions waiting below not to utter a word, even if they saw him almost fall, for the spirits might hear them and push him over.

The nest gatherers tell tales of men turning themselves into bridges to cross the void, of seeing in the dark without a torch, of ghosts and bad spirits chased away by the magic three-pronged rada. "But now the magic is disappearing," Sahat told me. "People like Tok Ta Pa no longer exist. These days we had better build our bamboos strong, for there are still a multitude of spirits living in the caves."

He warned me never to sit down on the knot

of lianas from which the scaffolding was secured. To me it looked like a wild tangle of hair from which disheveled strands hung down to secure the bamboos. But to Sahat it was Hua Dao, a sacred place inhabited and protected by a god. "Nor must you cut the old vines, for they were tied there by the magic of our forefathers," he cautioned.

Ip chuckled at the older man's stories. "You know how our ancestors built the scaffolding bamboos?" he asked me with a sparkle in his eyes. "They used their brains!"

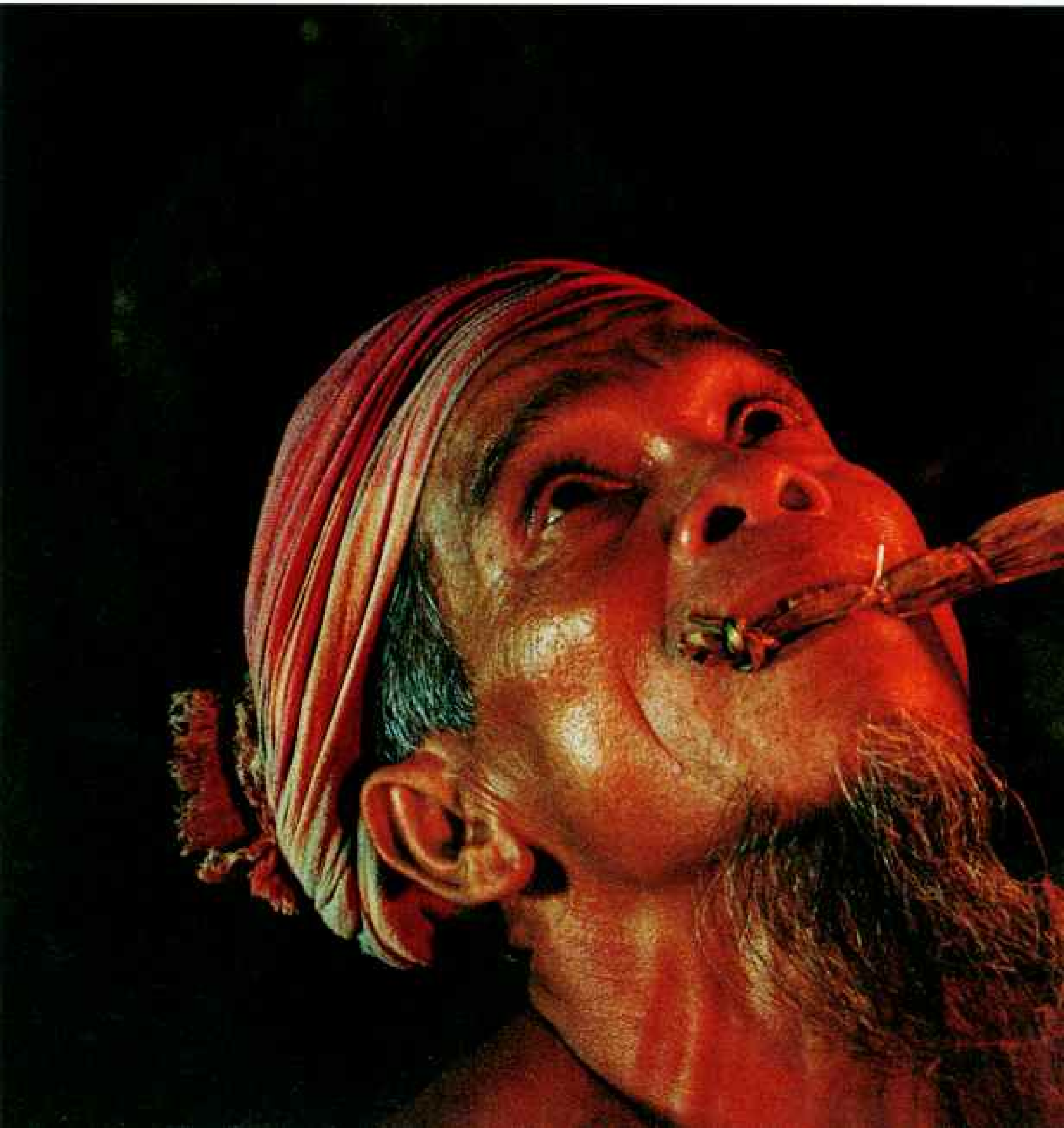
Before beginning their dangerous work, Sahat and Ip leave tobacco and coconut milk near a ribboned stalagmite named Tok Rimau, the god of the cave. "We make these offerings to please Tok Rimau," says Sahat. "Then we can collect the nests because he allows us to do so." Their work is strenuous as well as risky: Both Sahat, who pulls a root out of the way (bottom), and Ip typically climb ten hours a day. Sahat's counterpart in Khalad Cave, Ron, has a massage after a long day.

"How could they have ever got up there without the help of the gods!" Sahat snapped, offended by this blasphemy.

Whatever their beliefs, the nest gatherers take no chances. Believer and skeptic alike have a special vocabulary for use inside the cave, as if it is, indeed, the gods' domain. Words like "falling," "death," "blood," and "fear" are never spoken there. They believe that if the spirits hear such powerful words, they will cause an accident. "My friends say to me, 'You have a dangerous job, you can fall down easily,' " Sahat told me. "But that's not true; otherwise we would all be dead. My father fell three times but never died. It was not his time. Those who have committed bad deeds are the ones who die."

But as I climbed, I remembered Ip's more practical advice: "Leave your worries at the foot of the bamboo. Up there, think only of yourself and what you must do. Many have died by having thoughts of other things."

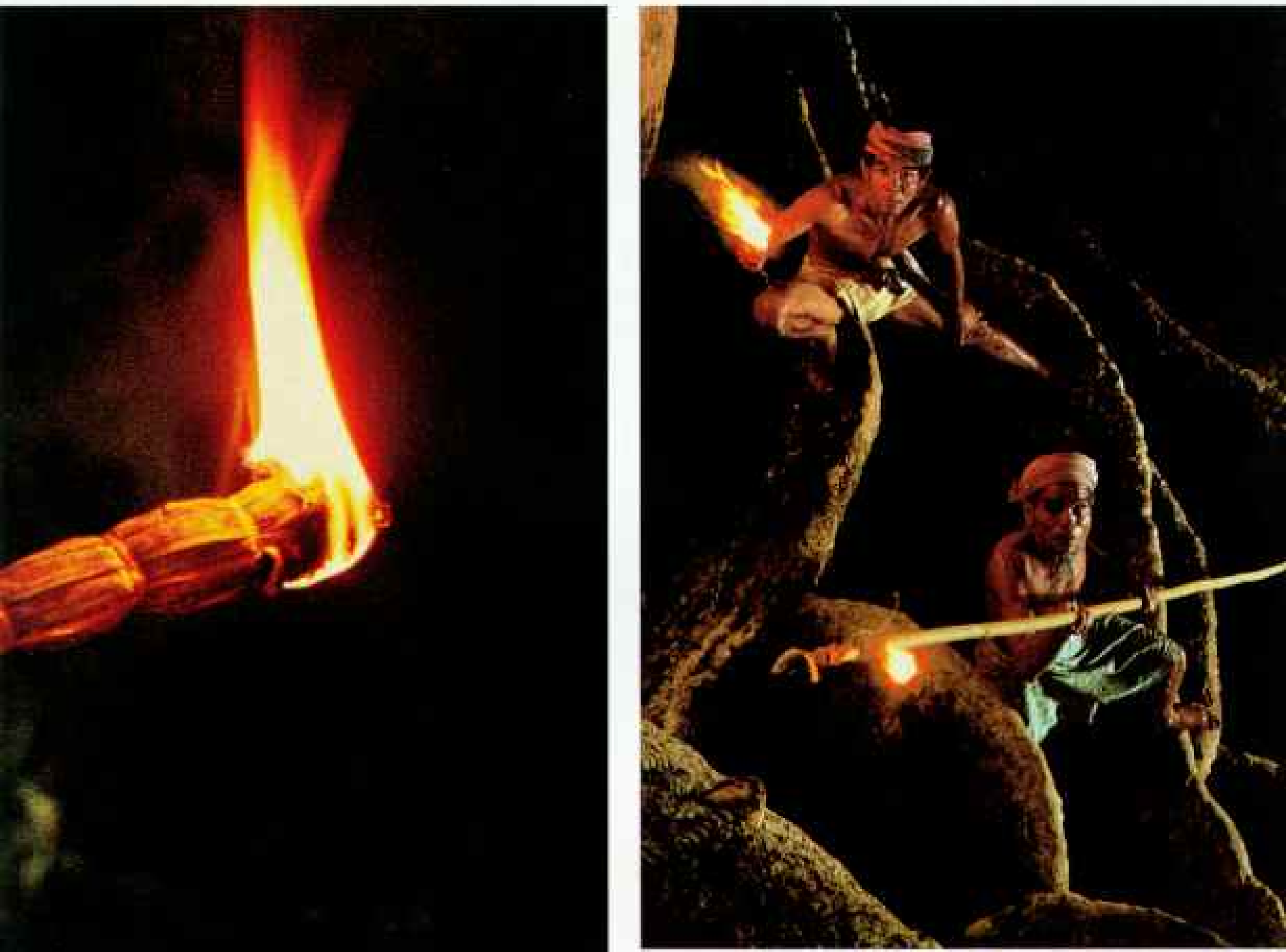
I concentrated on making my movements smooth and light. I began to forget the abyss, and I almost enjoyed this strange exercise. "What is the strength of the next bamboo?" That was the question. Some are so old they crumble to dust. Men have died trusting their weight to a rotten bamboo. "Tap the bamboo," Ip and Sahat told me. "If it answers like



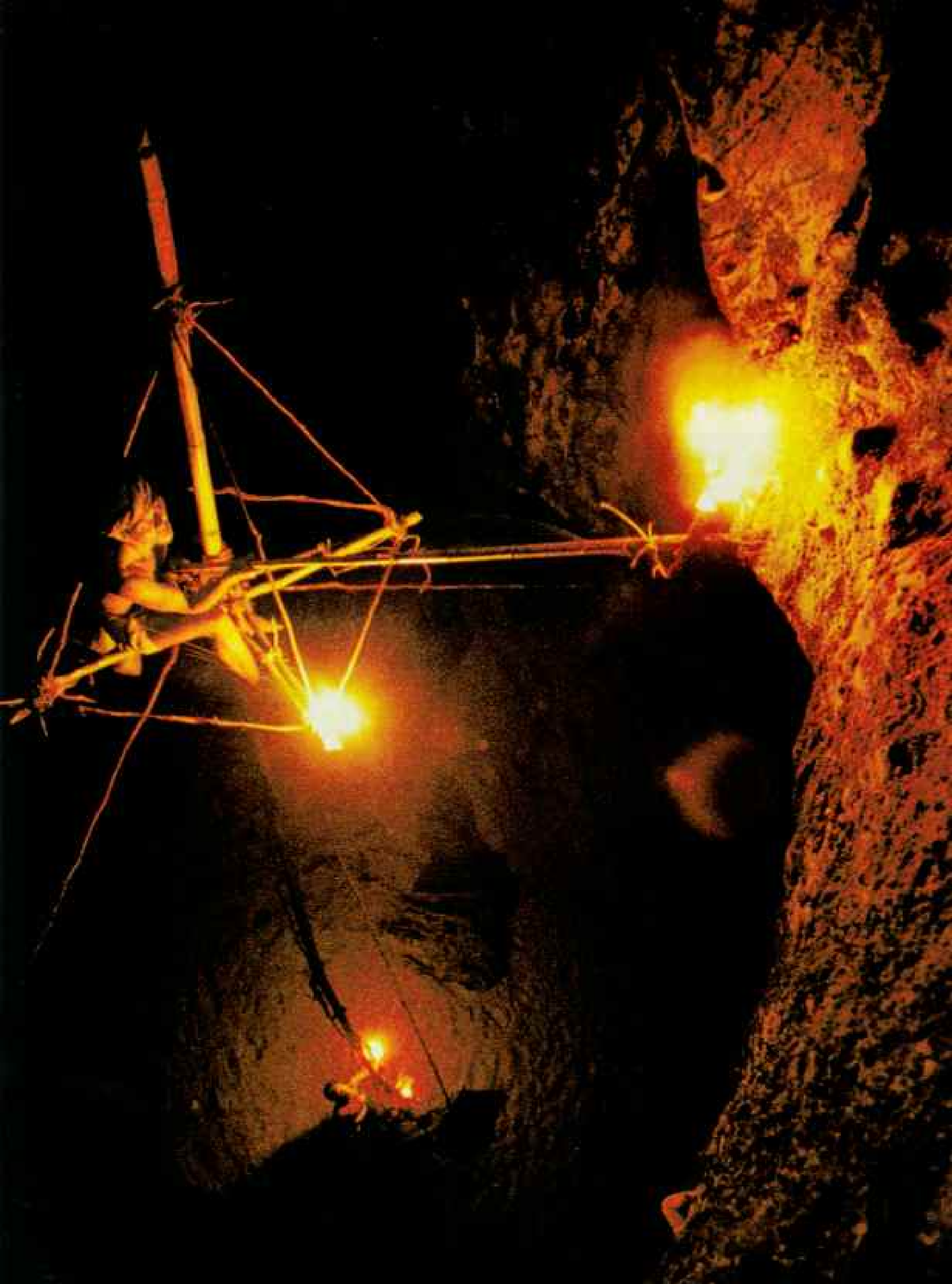
cardboard, leave it. It has lost its strength. If it sings well, give it your weight. Never take just one vine, always take three or four."

I WAS SURPRISED at how quickly I became accustomed to this frightening realm. At first I had nightmares about climbing through the labyrinth of galleries and chambers. I felt as if I were moving through the twisted bowels of some mythical underworld creature. But soon, after climbing every day with the nest gatherers, the creaking bamboos, the darkness, and the ever present void were just a part of the job.

During my first visit to the cave, I climbed as the nest gatherers did—freestyle. When I returned to complete this story, I used climbing ropes and other alpinist's gear. I was joined by Sylvain Bardoux, who had climbed with me in many difficult situations in the Himalaya, and, thanks to modern equipment, he and I were able to go where even the nest gatherers never ventured. One day we discovered a wall of white nests but did not dare pull them away with our bare hands. A gatherer always removes the nests with his rada. These tools are blessed and imbued with magic powers: Taking the nests without them was like stealing from the cave's spirits and would anger them. If a nest gatherer finds that he has



To keep his hands free, Sahat grips a torch in his teeth as he works. Such torches—made from bark soaked in resinous sap and tied with string—cast a broad light on the cave walls, more useful than the narrow beams of their flashlights. When necessary Sahat ties a torch, along with his rada, to the end of a bamboo pole (above) to reach hard-to-get nests.



left his rada behind, he must descend immediately; this is a sign from the gods that it is dangerous for him on the bamboo that day.

Ip, with his sense of humor, his skill as a climber, his knowledge of the caves and tunnels, became our indispensable companion. He took us on a tour of discovery through some of the other caves. Playing a punishing game of follow the leader, he led us with a mischievous smile from chamber to chamber, down dizzying heights on lianas and mud slides, through long tortuous tunnels. The stuffy atmosphere left us gasping for breath.

To enter the cave called Tamyai, we passed through a narrow passage. The eyes of bats gleamed in the beam of my flashlight, red ants bit my legs. It was difficult to get a grip on rocks slippery with thick black slime. Ip said that the rock was sweating. The beating of wings was the only sound in this still universe.

I forced myself to overcome claustrophobia. Being much larger than my companions (with my photographic equipment I outweighed Ip by some 70 pounds), I had to exhale and stretch my arms over my head to wriggle through. Halfway along I used my knees and feet to stop myself from sliding down the vertical shaft through the top of a chamber 650 feet high. It was not until my feet were once again securely on solid rock that I could breathe freely. No wonder the gatherers call this passage Rapo ("born a second time").

When caves are too wet for scaffolding, which tends to rot quickly, the climbers use a "walking bamboo." Guyed by vines to the cave floor, this structure (left) can be picked up and moved even while Ip clings to its top. Rotten bamboos covering the cave floor (above) testify to the hazards of the enterprise.

USUALLY the swiftlets' nests were built near the top of a vertical face close to the roof, whether in the great heights of a cavern or in a low alcove. Nests occurred in groups, numbers varying according to the area of wall surface available. If the gatherers could not reach them, they would affix their rada and torch to the end of a long bamboo pole.

Again and again I was surprised by the places where the birds nested. Sometimes the nests were as much as two miles deep in a labyrinth of tunnels. The birds were able to find their way through this maze, always returning to their roosting site.

It is this ability to navigate in the dark that has given the cave-dwelling *Aerodramus* a distinct advantage over non-echolocating swifts. Uttering a series of rapid loud clicks like the sound of a rattle, the birds are able to find their way as they fly in the darkness of the caves. They can feed in distant localities during the day, return to roost late at night, and nest in habitats such as caves and inside the roofs of buildings, far away from most of their predators. Among birds echolocation is known only in these swiftlets and in the unrelated oilbirds of tropical America.

The swiftlet's system of acoustic orientation is rudimentary—unlike the navigation apparatus of the bat, that of the swiftlet is not sensitive enough to detect insect prey—but it is adequate to perceive the contours of large solid surfaces such as cave walls. Nevertheless, the startled birds were constantly bumping into us, feathers flying as they darted off.

At twilight, outside the cave, we watched swiftlets feeding. As the sunlight faded, an

Suspended from the rock face by vines, a bamboo bridge forms a strand in a surrealistic spiderweb 200 feet above the floor of Rimau Cave. Above Sahat's head, as he waits for Ip and Em, black nests cling to the wall. The climbers pass them by

for more valuable white ones higher up. Such nests are tucked under ledges as high as 300 feet and as deep as two miles into the caves. Shortly before the authors joined the group, two climbers fell to their death from the bamboo.

explosion of birds filled the triangular patch of sky hemmed in by the canopy of trees. They gorged on flying ants and other insects. Far above, a bat hawk glided large, bold, and slow, waiting for an opportunity to swoop down on these tiny birds.

IN CAMP after ten hours on the bamboo web, the men hung their bags, swollen with nests, on a high beam. Exhausted, they sat on the mats, eyes staring vacantly, skin smeared with the dirt of the cave.

Camp was a loosely woven bamboo platform jutting out over the crashing sea, suspended by lianas to the cave roof. Each man was assigned a sleeping area of his own, shielded by a screen. Otherwise the nest gatherers lived communally.

After a long day's work those too tired to talk stretched out on their sleeping mats. Ip rolled tobacco in a banana leaf and smoked peacefully. Sahat turned toward Mecca and prayed. Someone switched on a television set perched incongruously on a rock.

One evening the calm of the camp was interrupted by the blare of a boat's horn. The boss, Mr. Apichat, was approaching on his weekly visit to weigh and collect the nests. Wearing a jaunty straw hat and freshly laundered shorts and T-shirt, Mr. Apichat looked more like a vacationer than the owner of a multimillion-dollar enterprise. But in fact he is in the bird's-nest business in a big way, holding a five-year lease on some 60 islands, for which he pays the Thai government a fee of 1.5 million dollars, and employing a hundred collectors.

Mr. Apichat's round face was wreathed in a broad smile as he distributed cakes and soft drinks to the men. They greeted one another warmly. He gave them news from home and a fresh battery for the television set he had brought them as a gift on a previous visit. He assumed a more serious air as he ordered Ip to spread the nests gathered in the last week over a bamboo mat. He inspected them closely and weighed them on a shiny chrome scale—25 kilos of top-quality white nests worth $50,000 in Hong Kong.

Afterward, Mr. Apichat joined the men for a meal. His short, stocky figure and pale skin denoting his Chinese ancestry contrasted with the slim, dark figures of his workers. He told me that he and his family were descendants of Chinese who settled in southern Thailand early in this century. The nest gatherers, like most

Home away from home during the nesting season, a bamboo platform—suspended by vines from the roof—provides living quarters for the half dozen climbers of Taluk Cave. Each man is assigned a sleeping area, shielded by a screen (and sometimes decorated by a pinup). Karia, the cook, prepares fish for dinner.

Sahat's granddaughter, Diana, visited for a while at Rimau Cave. Without their own families to cheer them, the men at Saka Cave pass the time watching a soccer match on a battery-powered TV.

To protect their valuable harvest from poachers, nest gatherers are often heavily armed. They post warning signs and have also been known to booby-trap cave entrances. These caves are a sizable investment: One businessman paid the Thai government 1.5 million dollars for a five-year lease on some 60 islands. Suspected thieves (below) at Phi Phi Island, attracted by big profits on the black market for the nests, face six months to a year in jail if convicted. Swiftlet chicks tossed onto a beach in Satun Province may be the victims of such greed.

of the people in this region, were Muslims, the descendants of Malay fishermen who began to collect the nests generations ago.

After dinner, while the men watched a boxing match on television, Mr. Apichat discussed the hazards of his business. There is the danger of climbing, of course, which he knows from exploring the caves with his workers. But the peril doesn't end there: Armed men must accompany him everywhere and escort the nests on their journey to the mainland. Shootouts with pirates on the high seas have left his guards with many scars. "Everybody around here knows the value of the nests—30,000 baht [$1,200] per kilo on the black market," Mr. Apichat explained to me. "These pirates are poor fishermen. They are armed. They shoot to kill."

Outside the cave a large sign written in Thai warned poachers of land mines buried near the entrance. This is no bluff; last year several thieves died as a result of stepping on mines.

"Unfortunately we are forced to take these precautions," said Mr. Apichat. "Sea gypsies live close to some of my islands. They don't give us the chance to harvest the nests because they steal them before we even get there."

THE NESTS may have even greater value than gourmets and pirates suspect. In Hong Kong, over tea in his laboratory, Dr. Kong spoke about the possibility of a bright medical future for the nests. They have long been used in traditional Chinese medicine to treat maladies of the lungs, as a food for rejuvenating the skin, and as a tonic for children, convalescents, and the elderly.

As part of his research into Chinese herbal and animal medicines, Dr. Kong has found that the nests contain a water-soluble glycoprotein that promotes cell division within the immune system.

"If we can manage to isolate this active ingredient and identify its target cells, it's conceivable that it might be used as an adjunct to the drug AZT to combat the immunodeficiency in AIDS," Dr. Kong speculates.

Some scientists are concerned that overharvesting is taking an excessive toll of eggs and young birds. Dr. Kong is among them. "If harvesting continues on this scale, the species may die out before we know what good their nests could do us," he says.

At the National University of Singapore the

To document the nest gatherers' skill, photographer Eric Valli (above, at right) performed derring-do of his own. Rappelling down the rock face on a nylon rope, he dangled in midair on a small plywood seat to get some of his most dramatic shots. For others, he climbed the scaffolding, though he was 70 pounds heavier with his gear than the agile men for whom the bamboo structure was built. A safety harness saved his life once and that of his assistant, Sylvain Bardoux, three times, when bamboos crumbled beneath them.

zoology department has been researching harvest-management methods. "Harvesting cycles must be adapted to breeding patterns," says Kang Nee, who conducted the study. "Until this is done, no amount of protection against poachers can compensate for the harm done by cave owners themselves."

She recommends limiting each year's harvest according to weather conditions and the birds' breeding behavior. The first nests would be collected before the birds lay their eggs. The next, built during optimum dry conditions for fledgling survival, would be left for rearing the young. Only after the young departed would these be taken. Because fledging had occurred during a favorable period, there might even be a third harvest as the parents would be able to exploit a still abundant food supply for another nest-building attempt.

Any harvest-management plan requires the cooperation of cave owners, who would have to accept a short-term reduction in profits in return for a future increase of nest yields. Leases on bird's-nest-producing islands are put up for bids every five years; some believe this encourages the desire for quick profits.

Mr. Apichat is concerned with conservation, but many harvesters are not. And that is not the only factor involved. In a nearby province men working for another employer refused to enter a cave after a climber had fallen to his death, for fear of meeting the dead nest gatherer's ghost. This gave the swiftlets time to lay their eggs, and when the gatherers did return, they spilled the eggs and young birds in order to take the nests. I saw hundreds of newly hatched swiftlets dying on the cave floor, among broken eggs, with cockroaches moving in for the feast.

On the cliffs near Rimau Cave are many rotting bamboos, testifying to the abundance of nests once gathered there. Now they are abandoned, and the swiftlets are gone. Ip spoke of the nest gatherers' determination to continue the only way of life many of them have ever known. "There are no birds left up there," Ip said, gesturing. "They went away because they were afraid of people. But we will follow them wherever they go. If we see nests, we will try to get them. If it seems impossible, we will find a way to reach them."

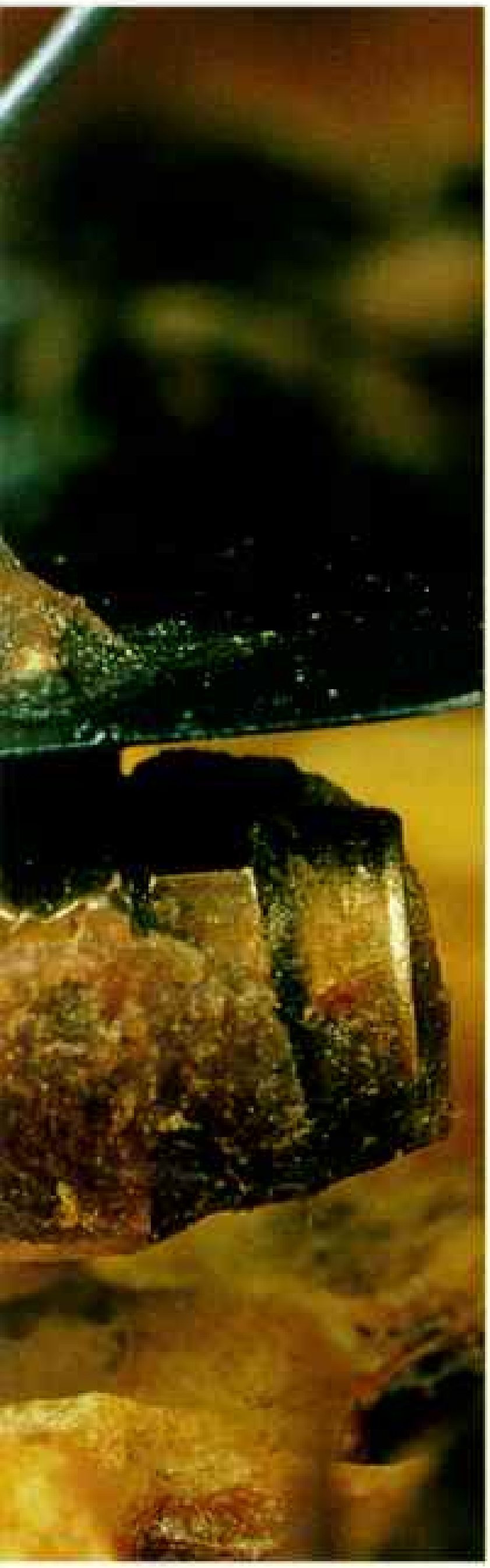
I admired Ip's determination to travel to the dark heights where the swiftlets fly, but feared for these remarkable creatures that give him his livelihood. □

A day's labor in his grasp, Sahat hands down to Ip a bag of 40 or so nests worth $800 in Hong Kong. About 60 percent of the world's supply is consumed there, where a wholesaler's helper (above) washes feathers from black nests. The smallest impurities are removed by tweezers. Traditionally recommended for convalescents, the delicate nests today are more often consumed for their sheer extravagance.

Dance of the Electronic Bee

Article and photographs by MARK W. MOFFETT

In breakthrough experiments the world's first successful robot honeybee "talks" to live bees in their own language—the dance. With this ungainly but effective mimic, scientists are unlocking secrets of animal communication.



WITHOUT FUSS or fanfare historic discoveries are being made in a shed near Würzburg, West Germany. There a team of scientists has tested a tiny mechanical honeybee that, communicating like a food-finding scout bee, directs followers to distant locations.

Among all the means by which animals communicate—from the infrasound of elephants to the visual displays of great apes—it is the dance of the "lowly" honeybee that most scientists view as genuinely unique. Honeybees, like people, can exchange information about things remote in space and time. A bee, by dancing, informs her nestmates of the location, type, and quality of food she has found. She comes intriguingly close to using true language.

This fact has been known for years. As a student I recall watching honeybees dance in an observation hive at the Milwaukee County Zoo. Armed with a book by Nobel Prize winner Karl von Frisch, who discovered that bees use dance to communicate, I deduced that my bees were telling nestmates about a spot 300 meters to the southeast. Then I surprised myself by finding an isolated bed of flowers humming with bees at that exact location.

I was thrilled by my correct reading of the dance, yet my feelings could hardly compare to those of Danish and West German scientists when, in August 1988, they first put an imitation bee on a comb in a darkened hive, directed it by computer, and realized they were "talking" to real bees.

Knowing that the bees would beg for a sample of nectar, the scientists were able to deliver. They released a drop of peppermint-scented sugar water

through a tube above the brass robot's head (left), simulating regurgitation by a real bee.

Although the robot is anatomically incorrect and rigged with rod, nectar tube, and an electromagnet covered with colored tape (above), bees don't see these in the dark. The robot had been smeared with wax and placed in the colony overnight to absorb local odor because resident bees are known to attack intruders from foreign hives.

WINGS vibrating, hindquarters waggling, a bee dancing on the side of the honeycomb (above right, marked with red paint) directs followers to nectar or pollen found on a recent journey. She dances a figure 8 that details distance and direction. A few bees stay with her for several dance circuits. As they get the message and fly out to duplicate her journey, their places are quickly taken by others.

The angle between the dance direction and the vertical is known to signal the direction from the hive to food in relation to the sun (diagram, page 139). At the center of the figure 8 the bee waggles her abdomen and quivers her wings, indicating the distance. The intensity of the dance plus the samples offered and the lingering odors on the bee's body suggest the type of food and its quality. But many details are still unclear.

I was observing the honeycomb in the darkened research shed under red light that was invisible to the bees. Though they are of the same species (*Apis mellifera*) as the North American honeybees I'm accustomed to, they are differently colored.

In the dark the follower bees apparently "hear" the message of the dancer. Her whirring wings produce strong currents of air, according to experiments conducted by Axel Michelsen, an expert on animal hearing at Odense University in Denmark. With student Per Kryger, he used tiny microphone probes with tips a few millimeters apart to record and measure these minute air-particle oscillations. When amplified, the sound reminded me of the flutter of a dove on takeoff. The air waves fade so fast that follower bees must be close to the quivering wings to sense them. The rapidly dissipating sound does not seem to disturb nearby hive inhabitants that may be following other dancers.

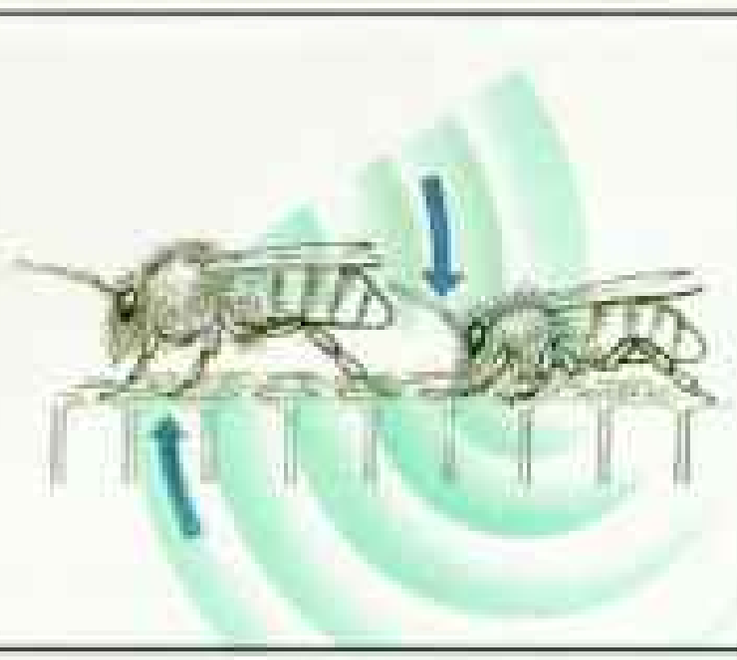
The bees seem to perceive the sound with their antennae.

Experiments by Wolfgang Kirchner of Würzburg University and William Towne of Kutztown University of Pennsylvania overturned previous opinion that bees are deaf. In addition Michelsen and Kirchner, using a laser beam to measure vibrations, showed that followers beg for samples by pressing their bodies down and transmitting a burst of vibration through the honeycomb.

Despite such scientific advances, many uncertainties remained about the significance of certain aspects of the dance as communication. The ideal solution was to build a robot that conformed with a real dancer in as many ways as possible. The robot had to dance a figure 8, give out samples, and broadcast sound in the proper way. Previous bee models duplicated other parts of the dance, but not the correct sound.

The key was the single wing, made from part of a razor blade. Inscribed with an "S" and lying across the robot's back (lower left), it reminded the team of Superman's cape. The front edge of the wing was glued to an axle rotating on two bearings that resemble beady eyes. A wire attached to the razor wing reaches an electromagnet that vibrates it to mimic the sound patterns produced by real dancers. The main rod connects to motors, all shielded by the black curtain behind computer operator Axel Michelsen (upper left).

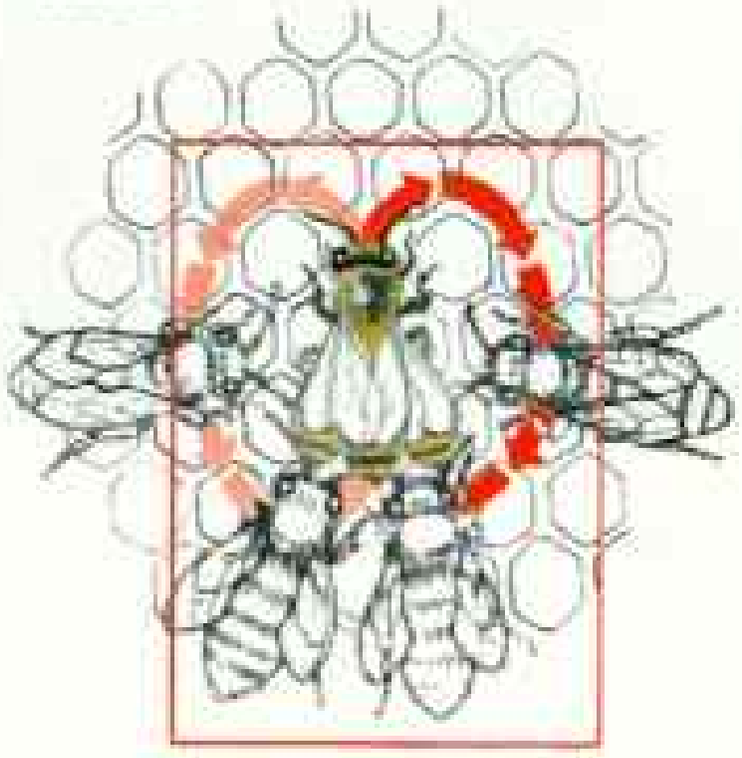
Michelsen programs the computer to describe a location to which the robot will direct its followers; the motors are then set in motion. The computer automatically adjusts the angle of the dance every ten minutes as the sun moves across the sky. Occasionally Michelsen puts a tiny microphone close to the buzzing model. A glance at an oscilloscope assures him that the robot continues to produce the correct sound. Although it cannot perceive vibration messages from followers that are seeking a food sample, the operator periodically grants a sugar-water sample.



Dancer's wings vibrate, sending rapid pulses of air that evidently are picked up by the follower's antennae.

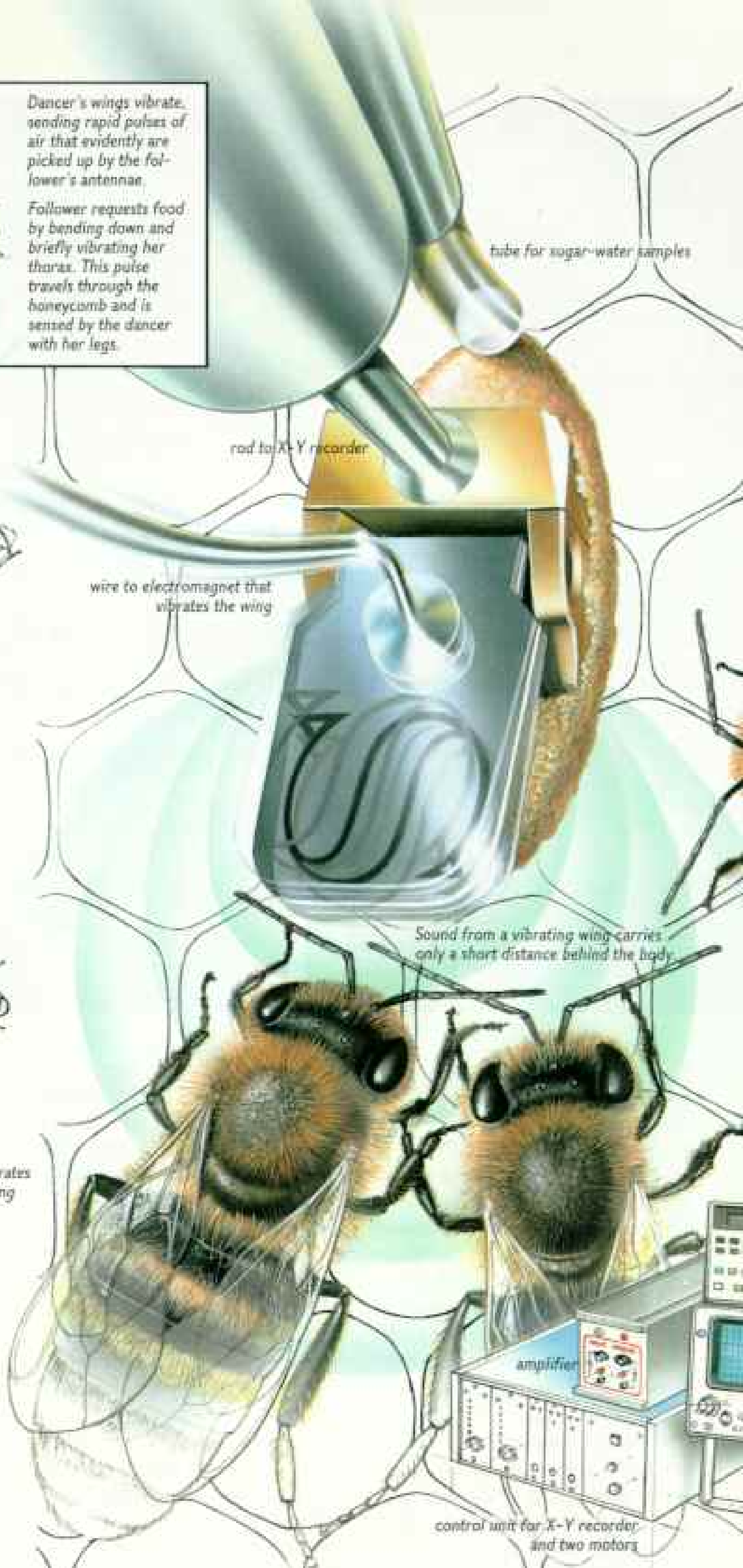
Follower requests food by bending down and briefly vibrating her thorax. This pulse travels through the honeycomb and is sensed by the dancer with her legs.

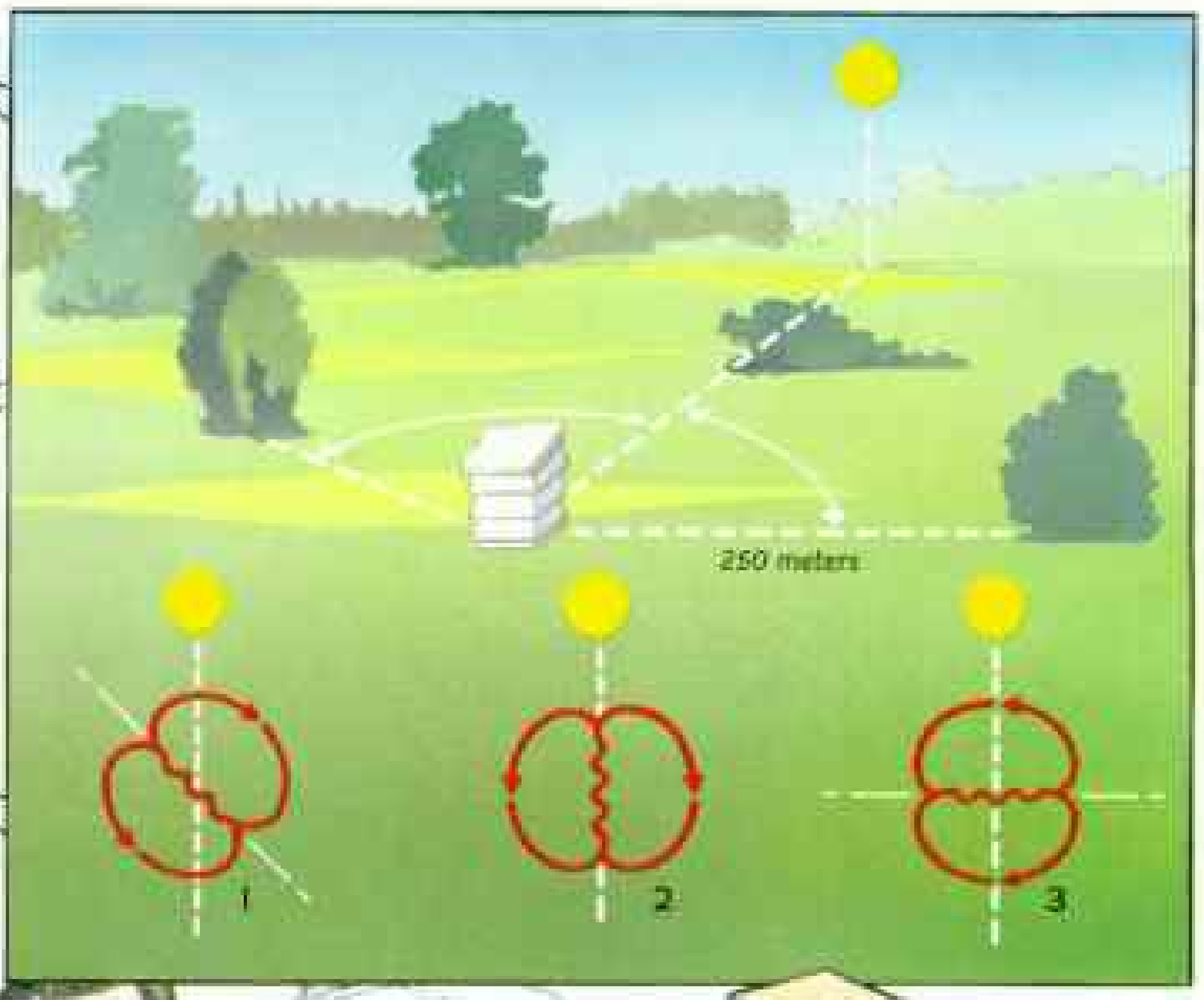
Circling into position for her waggle run, a dancing bee is surrounded by followers.



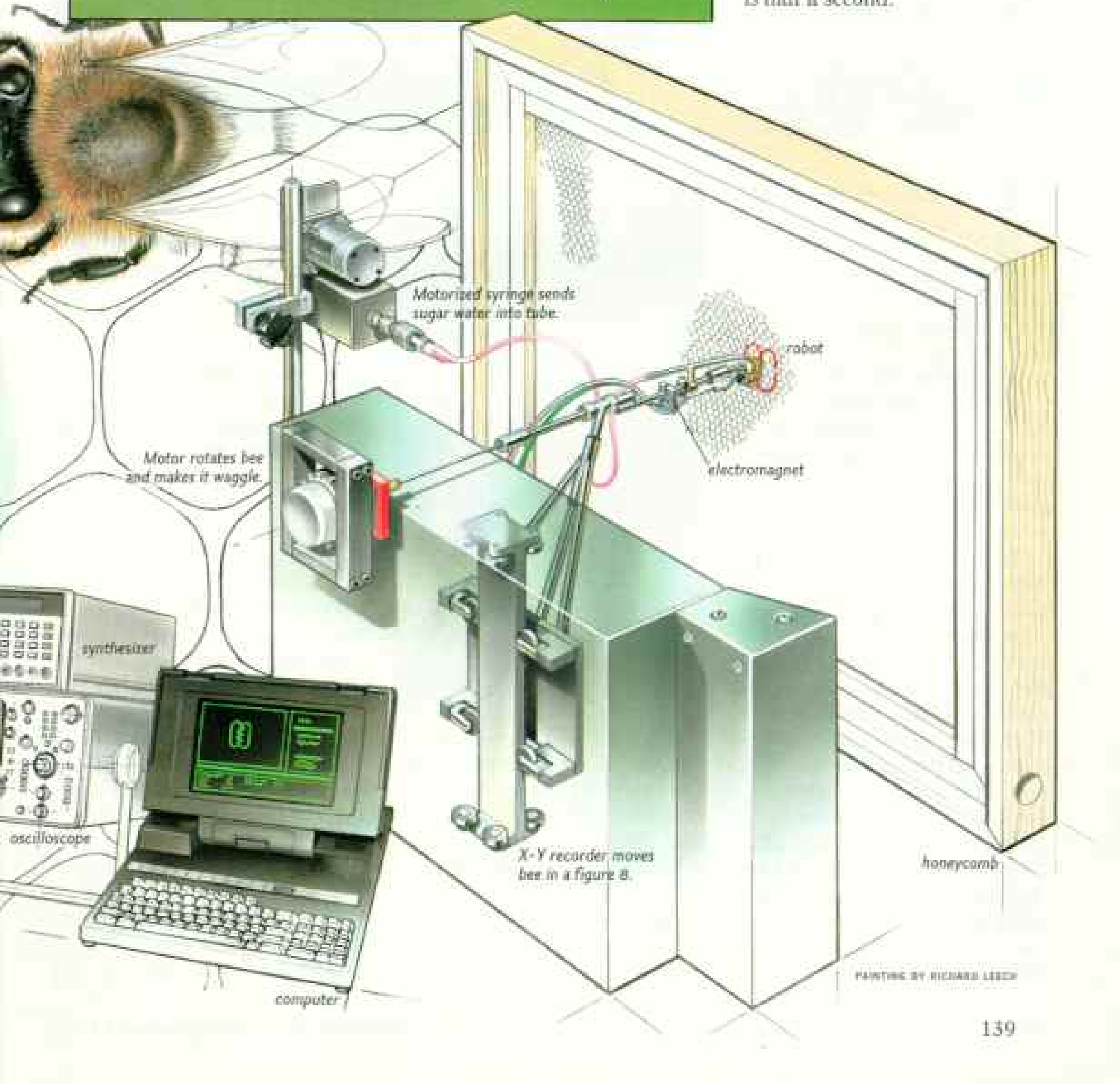
At the center of the figure 8 the dancer vibrates her wings and waggles her body while moving forward. Followers "listen" intently.

Now the dancer circles to the opposite side of the figure 8 to position herself for a repeat of her waggle run.





The angle between the "waggle run" and the vertical represents the angle between a food source and the sun. In this scene three food sources are located at equal distance from a hive. For food at a 45-degree angle to the left of the sun, the bee arranges the waggle run at the center of the figure 8 at a 45-degree angle to the left of vertical (1). For food directly in line with the sun, the dance is straight up (2); for food 90 degrees to the right, the dance is at a 90-degree angle (3). The longer lasting the waggle run, the farther the food. For a distance of 250 meters, the run is half a second.



PAINTING BY RICHARD LEECH

LIVE BEES were paying close attention to the little robot. But were they following its directions with accuracy? To find out, observers had to track food gatherers after they left the hive.

Departing bees were provided with a tiny exit hole below their comb, but some single-minded novices headed for the open shed door, here being closed by Wolfgang Kirchner.

To learn the destination of the bees, Bent Bach Andersen (above), an electronics engineer from Odense who constructed the robot bee, and other volunteers—including preeminent bee authority Martin Lindauer of Würzburg, a principal investigator—sat beside peppermint-scented bait to count arrivals during a three- to six-hour period while the robot danced. Experiments were scheduled for August, when harvested grainfields around the shed offered few natural sources of food to distract their subjects.

Bait was placed at regular intervals in a straight line as far away as 1,500 meters to test the bees' reckoning of distance or at a set distance but in various directions from the hive to test direction-finding skills.

During the experiments 200 to 300 bees arrived at a site when instructed by a live bee. The dancing robot sent from 20 to 100 bees to their goal, yet fewer than 10 bees located the site when the robot offered samples but did not dance.

We now know that both the waggle and the correct sound pattern are necessary for communication: When either is omitted, recruitment to observer stations doesn't occur.

There is certainly much more the robot can teach us. Eager to find out exactly how bees communicate, the team dreams up strange dances. What happens if the waggle run takes place on the outside of the figure 8? Or if a bee waggles at one place in the dance and buzzes in another? Or if the waggle is set for 1,500 meters and the sound for 250?

Since subtle distinctions in the dance can be programmed into the robot, bee researchers for the first time are able to do tightly controlled communications experiments. At last we have a powerful tool with which to tease apart the details of an elegant insect language. □

DREAM VALLEY

With

Matt STETSON

And

Emily HUNT

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LISA SILCOX, IMA RIVER FILMS

From short features to full-length films, the Geographic has become one of the leading producers of documentaries in the world.

"It's an exciting time for television," says Tim Kelly, vice president and director of the Society's television division. "With the rise of cable TV, broadcast syndication, home video, and international coproduction, we've seen new pathways opening up to a worldwide audience. And it's a great time to be doing this, a pivotal time in terms of world politics and global environmental concerns. Now more than ever, we have a great opportunity to carry out the Geographic's mission."

Thanks to Tim and his staff—and the support of Chevron and Turner Broadcasting, who've shown great confidence in us over the years—the Society has emerged as one of the world's leading makers of documentaries. Of the 25 most popular shows on PBS, our Specials hold 20 places—including the first 13. During the past few years, our television division has virtually exploded: Twenty-five years ago we produced four hours of programming a year; today, some 60 hours.

Many of our films are now made for EXPLORER, our two-hour magazine-style program carried each week on TBS SuperStation. Hosted by oceanographer Bob Ballard, EXPLORER can be seen in nearly 51 million homes in the United States. Ballard's own "Secrets of the *Titanic*" ranks as the single highest-rated basic cable program ever.

A growing number of EXPLORER films are being coproduced with partners such as the British Broadcasting Corporation and Central Independent Television in the United Kingdom, and the Tokyo Broadcasting System in Japan. Through such cooperation we have not only expanded our foreign audiences but also gained access to new ideas and producers.

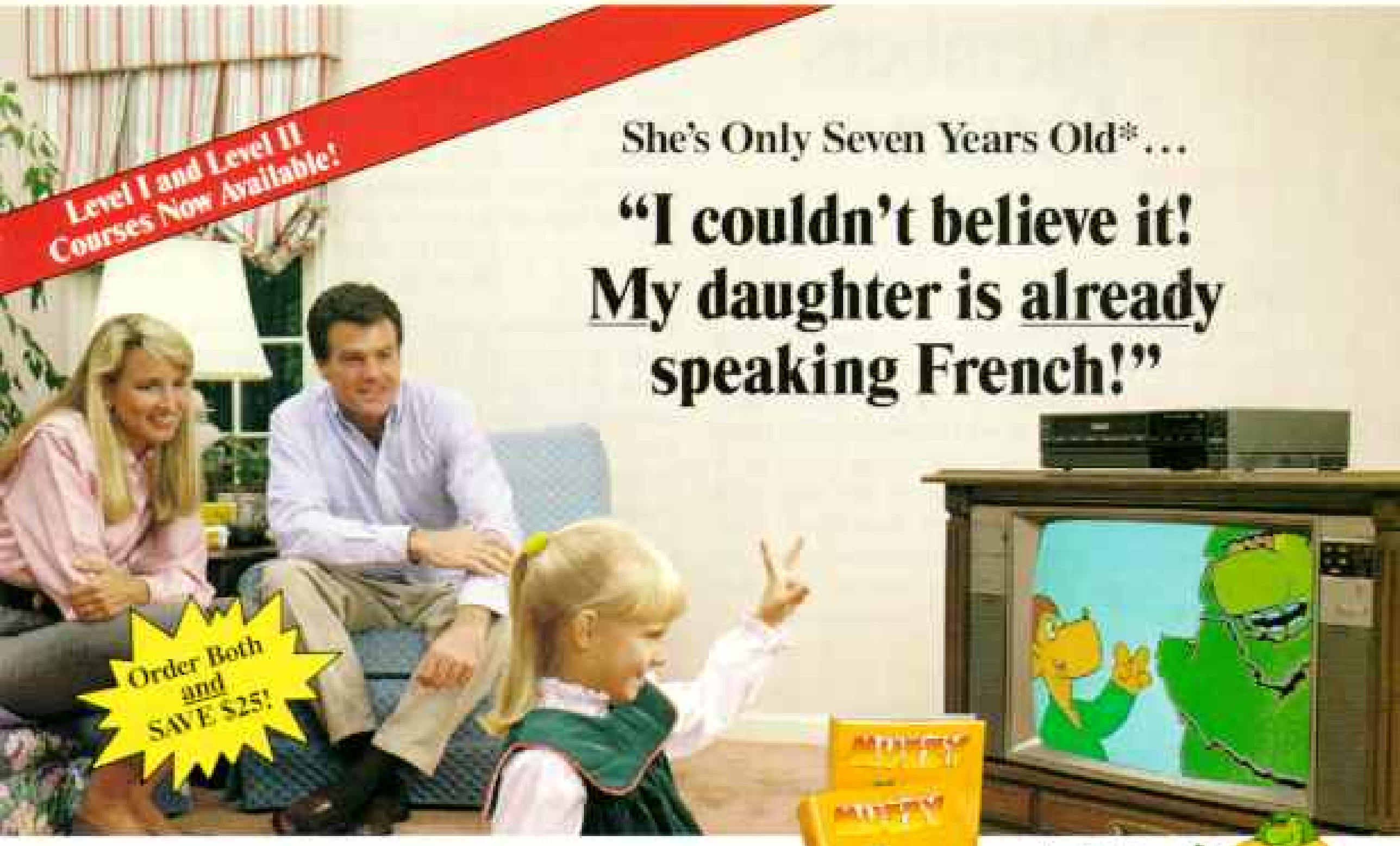
We also release at least a dozen of our best films a year on videocassettes, both here and abroad. In addition, Specials from past years can be seen on the *Best of National Geographic*, a syndicated series on broadcast television, and selected EXPLORER films can be viewed on the syndicated series *On Assignment*.

Today, more than ever, viewers can afford to be more selective in what they watch. By taking a few moments to review television listings in advance, they ought to have no trouble finding quality programs.

Our own 1990 Specials, coproduced by WQED/Pittsburgh, premiere January 10 with "Amazon, Land of the Flooded Forest," followed by "Bali, Masterpiece of the Gods" on February 7, "Journey to the Forgotten River" on March 7 (about wildlife in Botswana), and "Voices of Leningrad" on April 4—another season we can be proud of.

When we first entered into television a quarter century ago, we did so slowly and deliberately. We knew the electronic media held great promise for us, and we wanted to be ready when the right moment came along. That moment has arrived—and we're making the most of it to meet the growing demand for quality geographic information.

Gilbert M. Grosvenor



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Sweden	Age 7	Spain	Pre-School
Austria	Age 8	Canada	Pre-School

**Ages represent top schools and programs; compulsory language education usually begins several years later.

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Here is perhaps the greatest gift you will ever give your child... a second language. And at an astonishingly affordable price of just $145† per course, payable in four installments of $36.25† each. Order *Muzzy* or *Muzzy Level II* today. Or, order both and save $25! There's no risk! If you and your child are not absolutely delighted, you may return the course(s) within 30 days for a full refund. Order today from Early Advantage, 47 Richards Avenue, Norwalk, Conn. 06857.

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Members Forum

The First Crusade

I was astonished at the mild and almost admiring tenor of the article on the crusaders (September 1989). With the exception of a few weak references to the slaughter along the route and in Jerusalem, the author treats the crusaders like a mixed fellowship of pilgrims on the way to a shrine. The pleasant, often humorous tone makes light of what were fanatic attacks on civilian populations, Muslim and Jewish, and certainly not a "religious conflict" between military or political equals.

DIANE J. KRITT
Burtonsville, Maryland

The statement "They completed the only truly successful Crusade" may be correct only in a narrow sense. In the summer of 1107, 60 ships and 7,000 to 8,000 men under the command of 17-year-old King Sigurd left Norway on a westerly course. In England as a guest of Henry I, Sigurd doubled his forces and sailed on to the Holy Land. When he landed two years later, he had fought eight battles in the Mediterranean. He consolidated the Christian power in Palestine by teaming up with Baldwin of Boulogne, ruler of Jerusalem, and defeating [the city-state of] Sidon, the prime enemy. After the Crusade, Sigurd gave his fleet to Emperor Alexius of Constantinople, who furnished Sigurd and his men with horses and equipment; they rode home in triumph.

FIN HEDIN
Everett, Washington

The Arabs still consider the Crusades as an unwarranted aggression by European nations on a peaceful area—much as western Europe felt about the Mongol hordes at a later date.

ROBERT WYNNE
Mercer Island, Washington

The crusaders left an area torn by conflict, including a profound mistrust of peoples and policies of western Europe, which endures to this day. Westerners should read *The Crusades Through Arab Eyes* by Amin Maalouf, Schocken Books, 1985.

WILLIAM G. HUGGINS
Columbus, Ohio

Malawi

As a demographer, I found a couple of glitches in your beautiful story on Malawi. The crude birthrate is much higher than 3 percent; it is estimated at 51 per thousand, or 5 percent. Also, the caption on page 372 says that at age 41, Kacheche is only six years shy of the average life expectancy. In fact, a life table shows that he has at least another 25 years to live. Indeed, in many sub-Saharan countries life expectancy at birth is very low because of the heavy toll of infant mortality.

JOHN F. MAY
Rockville, Maryland

After chugging along with Paul Theroux on his train adventures in Asia (GEOGRAPHIC, June 1984 and March 1988), I was delighted to read about his return to Malawi. I too found the people incredibly friendly and optimistic in the face of harsh poverty, enough to reassess my own understanding of happiness.

BROTHER JOHN A. KERR
Bronx, New York

Considering that the Malawian government long banned journalists out of fear of unfavorable publicity about one of the most arbitrary dictatorships in Africa, Theroux's essay is indeed welcome, particularly as it highlights the many grave problems. Less welcome, however, is his seeming acceptance of the government's self-serving contention that dictatorship and repression are the only way to ensure that black Malawians remain "stable and orderly." The country's problems will be solved only when people are free to discuss them without the fear of being detained without trial.

LEROY VAIL
Associate Professor of African History, Harvard University

Mr. Theroux described Malawi's autocratic one-party rule, censorship, "a rubber stamp" parliament, as well as religious persecution in an even-handed report on a nation whose stability has been purchased in part at the cost of suppression of dissent.

As a supposed academic expert on the Third World, I found the article coincides with my more limited impressions. Most African experts either ignore Malawi or present it as a client of South Africa, ruled by a traitor to African liberation. Naturally Theroux does not venture a response to what is on the mind of every Malawian—what will happen after Banda.

CHARLES W. ARNADE
San Antonio, Florida

Shakers

Bitterness does not describe the daily life of a Shaker. Where was there any mention of a bustling museum, a library in constant use, daily worship and fellowship at Sabbathday Lake? This positive living force that flows everywhere among the secular tasks and daily prayers is the reason that to hear "Simple Gifts" sung in the

Elves: myth or reality?
Wheat: plain or exciting?

Recent evidence challenges old beliefs.

The romantic legend of tiny bakers who live in a hollow tree and use magic ovens to produce crackers and cookies of uncommon quality has long fascinated scientists and snackers alike. But documented evidence of the existence of elves has proven as difficult to find as a truly flavorful wheat cracker. Until now.

Two isolated incidents strongly suggest that elves not only exist but are solely responsible for a great little snack.

A noted elfologist vacationing in east Africa observed striking similarities between the native baobab tree *(Adansonia digitata)* and the legendary hollow tree *(Keeblerum vacuosis)*. Coincidentally, a snack lover relaxing at home observed very little similarity between Keebler® Wheatables® and the wheat crackers she was accustomed to eating.

Establishing the direct lineage

of the Keebler® Hollow Tree remains problematic. But proving that elves had more than a tiny hand in the creation of Wheatables® is a lead pipe cinch. What else but an elfin recipe could explain such zest and pizazz in wheat crackers, a category more noted for wholesomeness than excitement? What else but the thoughtfulness of elves could explain the timely appearance of this cholesterol-free snack cracker low in saturated fat? What else but the modesty of elves could account for the fact that you've probably never heard that snackers prefer Wheatables® over original Wheat Thins® by a margin of two to one?


wheat cracker

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meetinghouse is to "touch the hem of heaven." There will be no "brief eternity" as long as young people keep coming to hear. That is the real story.

NANCY MARCOTTE
Editor, The Shaker Quarterly
Poland Spring, Maine

This is a most interesting and painstakingly accurate account of this fascinating people and their vanishing way of life. Good reporting is very rare in this day of sensational and often irresponsible writing.

ROBERT F. W. MEADER
Hancock Shaker Village
Pittsfield, Massachusetts

Their future may be uncertain, but the Shaker song "Simple Gifts" lives on in the tune of the hymn "Lord of the Dance" and of the Aaron Copland ballet *Appalachian Spring*.

MARK RICHARDSON
Halifax, Nova Scotia

The site of North Union became Cleveland's Shaker Heights. There are a few remnants of the Shaker community, including a famous dam they built. The Van Sweringen brothers who developed the suburb had the derelict buildings destroyed since they did not fit into the new scheme.

RICHARD KARBERG
Cleveland, Ohio

In honoring Shaker craftsmanship, we are preserving the best about these people, instead of focusing upon their self-reproach, sexual repression, and excessive emphasis on personal perfection, which are frighteningly familiar to anyone dealing with today's dysfunctional families.

PAUL F. FOLMSBEE
Apex, North Carolina

Himalayan Sanctuary

In 1986 my husband and I trekked the Annapurna circuit described (September 1989). Having lived in Alaska (before the spill), we thought nothing could rival its majesty and beauty. We were wrong; the Annapurnas were breathtaking. We only hope the same fate doesn't befall them, mismanagement and carelessness.

SUE ELLIS
Owatonna, Minnesota

Even environmentally conscious travelers must bear a part of the responsibility for the cycle of deforestation and ensuing landslide. This was part of Sir Edmund Hillary's commitment after his Mount Everest assault helped put Nepal on the adventure tourist map. Galen Rowell should realize that even his boots leave footprints.

TOM EARLEY
Bartlesville, Oklahoma

Nepal needs a conservation idea that works. In other areas of Nepal, harmless-sounding efforts are only aggravating the situation. In November 1988, I lived in the village of Shermathang on the boundary of Langtang National Park. The government had recently forbidden residents to cut wood in the park but had given them no other means of cooking or heating. Villagers bend the rules to survive, such as sneaking wood at night. To crack down, the Nepalese Army arrived to protect the forest. The catch is that army personnel are not subject to the same stringent rules and may use as much wood as they like for cooking, heat, and building barracks. In Shermathang, 40 army men were stripping the forest much faster than the villagers, who number about 700.

SUSAN GRAMRICH
Ann Arbor, Michigan

Members Forum

Regarding J. R. McCarthy's letter (September 1989) suggesting that the screams heard by Uwe George in the tepuis (May 1989) were caused by mountain lions, please let readers know those impressive noises were likely made by howler monkeys that can generate a variety of jungle sounds (see page 434, October 1989). I have woken in La Gran Sabana from dreams of being in a tropical storm to find that the howling wind noises—of monkeys—continued. They can be tricky and nasty; I recall several waiting in hiding as I walked past and then scaring me with excellent imitations of a raging jaguar.

LIRAIN URREIZTIETA
Tucson, Arizona

Geographica

In your September issue you mention the illusionists Siegfried and Roy as having the most prominent white tiger collection outside India. We at the Hawthorn Corporation own 57 white tigers, the largest collection in the world. The one at the National Zoo and those of Siegfried and Roy are descended from males of our breeding.

JOHN F. CUNEO, JR.
Richmond, Illinois

It is misleading to imply that all of the Zuni tribe sought a national park; some members are concerned that a park on their sacred land will infringe on outdoor religious ceremonies. There is also concern for the rights of those whose grazing land will be appropriated by a park.

MRS. GLENN FREHAFER
Chula Vista, California

Letters should be addressed to **Members Forum**, *National Geographic Magazine, Box 37448, Washington, D. C. 20013, and should include sender's address and telephone number. Not all letters can be used. Those that are will often be edited and excerpted.*

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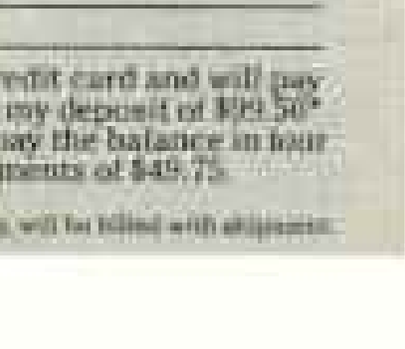

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JANUARY 1990

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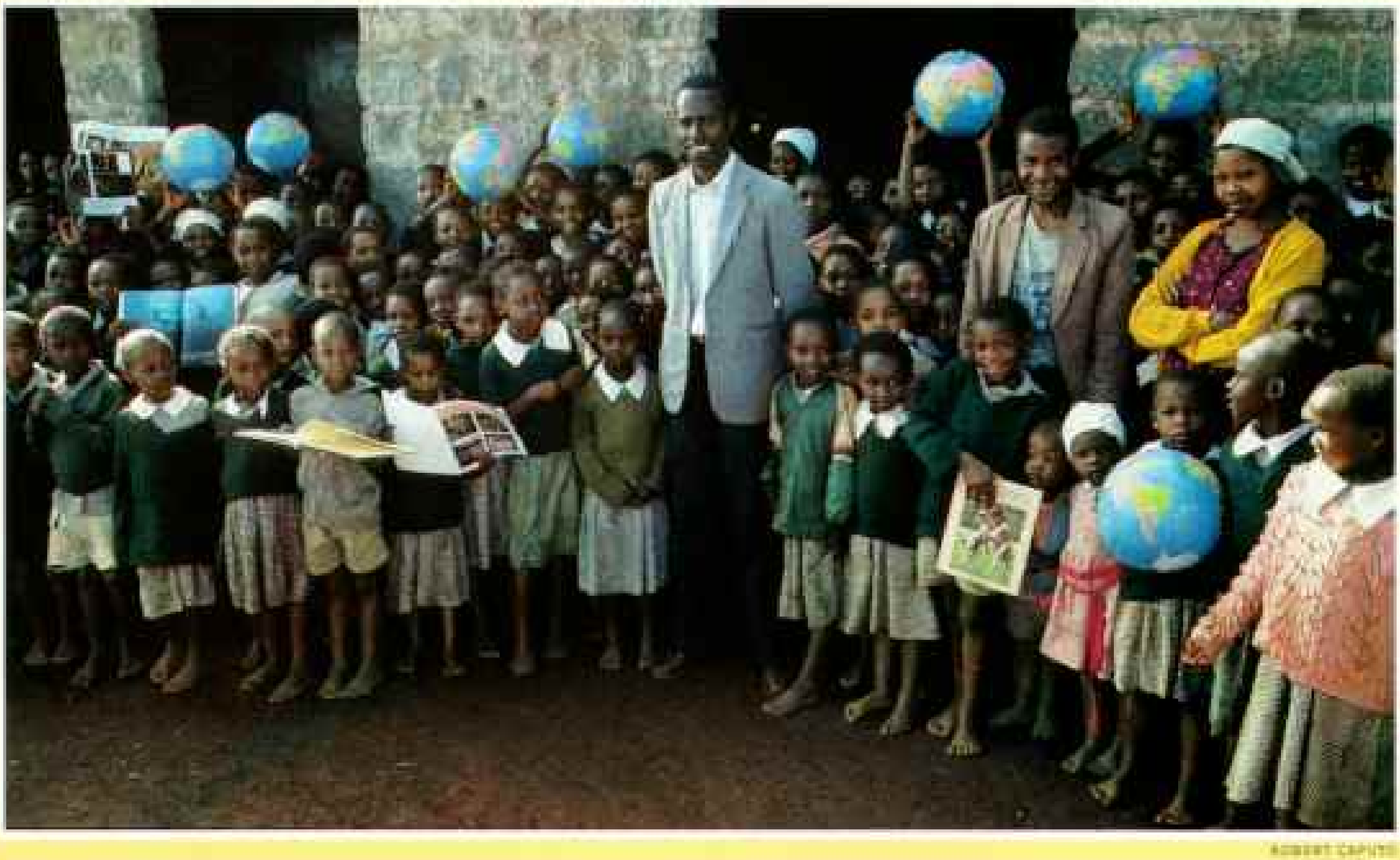


ROBERT CAPUTO

Gifts From the Heart for a Kenyan Family

In the December 1988 NATIONAL GEOGRAPHIC, Robert Caputo recounted the dream of Njoroge and Susan Munoru, who live in Kenya's Central Highlands: to see their four children through secondary school.

Many share the dream. When Caputo returned to Kenya last August, he brought the Munorus (above, at right) word that GEOGRAPHIC readers had contributed more than $1,800, which has been deposited in a Nairobi bank, to pay school fees for the Munoru children. The family was overwhelmed.

"Those are good people, to help us," Njoroge Munoru said. "God bless them very much. Because of those good people, our lives have changed. Now we can use the little money we make to feed our children better and make a better home to live in."

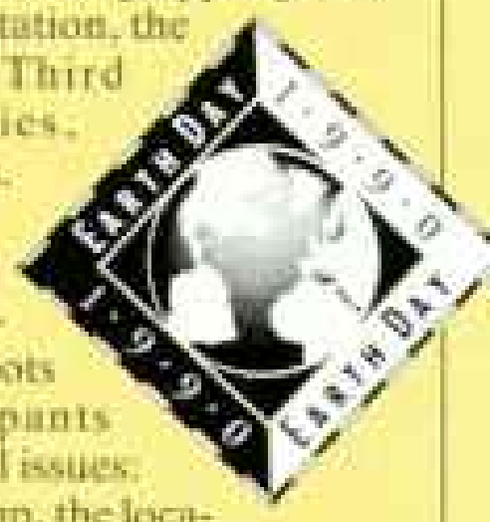
The donations represent more than ten years' wages for Munoru, who augments the meager earnings from his coffee farm by working as a stonemason—when work is available. The bank account will pay tuition and other school fees, which average $75 a year per pupil, for several years.

The local four-room, four-grade school has dirt floors, no windows or doors, and no electricity. Caputo gave the headmaster, Samuel Boro Githii, at center, a portion of the donations to install windows. He also gave the school a selection of National Geographic Society children's books, globes, and maps. "With maps like these, our children can know every place on earth," Githii said.

Earth Day 1990: Going Global

On April 22, 1970, the first Earth Day, 20 million participants showed how much Americans cared about environmental issues. This April 22 organizers of Earth Day 1990 hope to show that this interest has expanded into concern for the future of the whole planet. That same concern impelled NATIONAL GEOGRAPHIC to devote the December 1988 issue to the question of whether "this fragile earth" can be saved.

Denis Hayes, coordinator of the first Earth Day and chairman of the coalition organizing this year's activities, says that the past 20 years have shown that environmental issues are interrelated—on a worldwide scale. For example, he says, dealing with global warming means grappling with acid rain, deforestation, the ozone layer, Third World economies, and similar issues.



Hayes says that this year's activities will begin with grass-roots efforts. Participants will focus on local issues, a toxic-waste dump, the location of a power plant, "whatever it is that's of fundamental importance to a community." But, he adds, "we want them to tie in to the global issues as well. We want people to learn that they can understand and influence the environment. If they insulate their houses or use energy-efficient appliances and cars, they can help reduce atmospheric pollution and global warming without major changes in their life-styles."

Every Earth Day 1990 participant will be asked to plant a tree and care for it, as a symbol of the role trees play in removing carbon dioxide from the atmosphere, controlling erosion, serving as windbreaks, providing firewood, retarding desertification, and offering shade.

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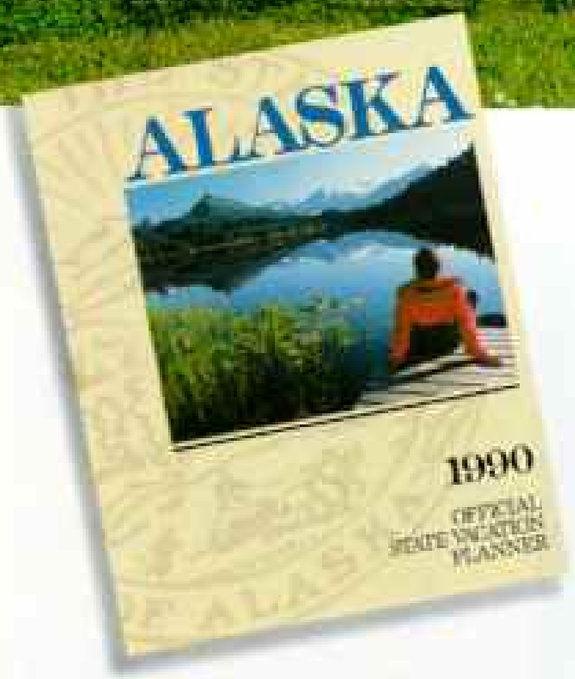

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Saving Rare Films of Arctic Explorers

Each man joined Robert E. Peary on his efforts to reach the North Pole. Each went on to long careers exploring the Arctic himself. Each received the highest honor of the National Geographic Society, its Hubbard Medal.

ADMS. PHOTO

Capt. Robert A. Bartlett (above) and Comdr. Donald B. MacMillan also made significant films recording life in Arctic regions. The Library of Congress and the Peary-MacMillan Arctic Museum and Arctic Studies Center at Bowdoin College in Brunswick, Maine, will together preserve and catalog those films.

The museum holds 90,000 feet of images recorded on Bartlett's expeditions from the 1920s to the 1940s. The Library of Congress will transfer the deteriorating, highly flammable nitrate film to safety-film stock, and the museum then will make video copies for scholarly and educational uses. The museum will help inventory the library's collection of film shot during MacMillan's journeys.

Bartlett first went north with Peary in 1898, and he commanded Peary's supply ship *Roosevelt* in 1908-9. He was awarded the Hubbard Medal in 1909, the same year that Peary was given the Society's Special Medal of Honor for discovery of the North Pole. Bartlett went on to explore the Arctic on his schooner, the *Effie M. Morrissey*, until his death in 1946.

MacMillan joined Peary on his final polar expedition in 1909 and made 29 subsequent trips to the Arctic, the last in 1954. He was awarded the Hubbard Medal in 1953.

The films of both explorers show the many changes in the cultures of native peoples in Greenland and elsewhere in the far north, according to Susan Kaplan, director of the Arctic Museum.

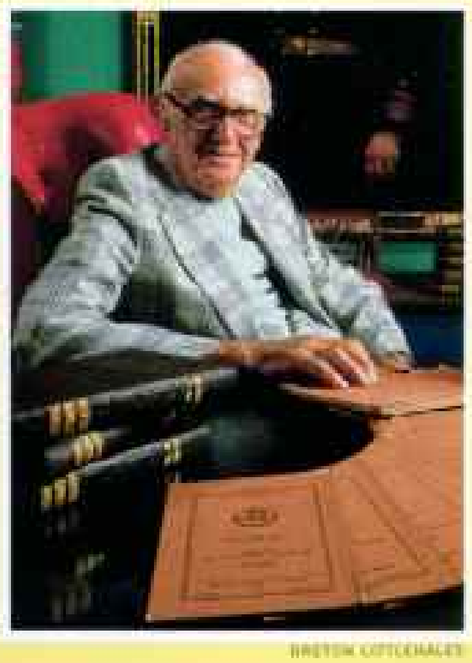
Evoking the Past via Covered Bridges

Few items in America's landscape evoke the nation's past more than a covered bridge. Brenda Krekeler, a geographer, became fascinated by covered bridges in her native Ohio and traveled to 14 states to track down hundreds of them. Her book, *Covered Bridges Today*, records the decline in their numbers. In the 1800s the United States had about 12,000 covered bridges, Krekeler says. Today there are about 800, and the number is dropping through neglect, damage caused by floods, even arson.

Covering bridges protects them from the elements; exposed wooden bridges deteriorate in a few years. Newer construction materials and methods have made them obsolete.

There are some 220 covered bridges in Pennsylvania, more than in any other state. Parke County, Indiana, which hosts an annual covered-bridge festival, has 33. The longest covered bridge in the U.S.—460 feet—spans the Connecticut River, connecting Cornish Township, New Hampshire, and Windsor, Vermont. An 1887 bridge near Cilleyville, New Hampshire, tilts because its builder angered his assistants, who then cut some timbers short. Another New Hampshire bridge, at Ashuelot (below left), is an American Gothic masterpiece. And a Lancaster County, Pennsylvania, bridge was carried away in a 1972 flood. It floated around another covered bridge and came to rest on a road. It was dismantled and returned to its original location, and Amish carpenters rebuilt it.

SHAWN HENRY



BRETON CITY-COUNTY

A Collector's Death, a Collector's Tribute

Dr. Edwin C. Buxbaum, author of *Collector's Guide to the National Geographic Magazine*, died last summer in a Wilmington, Delaware, hospital at the age of 86. But before his death Dr. Buxbaum (above) received a touching letter from a Hungarian collector of the magazine who read about him in the March 1989 President's Page.

"Your excellent book is a treasured piece of my small library," József Fuzesi wrote to Dr. Buxbaum. "It isn't too sweeping to say that it can be regarded as the collectors' bible."

Fuzesi said that for him the magazine has had "a double educational value":

"When I started to collect GEOGRAPHICS, I couldn't read the articles; I was fascinated only by the beautiful pictures. My keen interest in the contents of the articles prompted me to learn English, and when I could read everything, new vistas opened up for me on the whole world."

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Antarctic Whales: Down in the Count

Population figures for whales that feed in the Antarctic may be far lower than experts had thought, according to a study presented at the International Whaling Commission's 1989 meeting. One U. S. researcher calls the study's admittedly preliminary figures "alarmingly low."

Two South African mathematicians based their estimates for populations of several species of whales on sightings made on IWC cruises over a six-year period. Those were incidental sightings, made while scientists were trying to count minke whales below 60 degrees south latitude.

The numbers for blue whales are the most startling. Sightings indicate that as few as 500 animals may feed in the region surveyed, just 0.2 percent of those thought to have existed before whaling began. The IWC has banned commercial whaling until after a review to begin this year (GEOGRAPHIC, December 1988).

The chief U. S. representative to the IWC, William E. Evans, cautions that data based on minke whale surveys may not accurately reflect the population of other species. Still, he says, "we have to take the data seriously. We may have overestimated the recovery of fin, sei, blue, and sperm whales from commercial whaling."

Steven L. Swartz, a marine mammal biologist, calls the estimates believable and says that some southern whale populations may be "so severely depleted that they may never recover to their original size."

Inuit Family Reunion, Thanks to Glasnost

Soviet *glasnost* has opened the way for a family reunion on the roof of the world. A delegation of Eskimos from Siberia met last July for the first time with their Alaskan, Canadian, and Greenlandic counterparts at the General Assembly of the Inuit Circumpolar Conference (ICC). The meeting in the Greenland town of Sisimiut realized a long-standing dream: bringing together the world's Inuit peoples (GEOGRAPHIC, February 1983).

In 1987 Soviet leader Mikhail Gorbachev called for a comprehensive international plan to protect the Arctic environment and to develop cultural links among the region's indigenous peoples. (The same policy shift led to a 1988 meeting between Alaskan and Siberian Eskimos, described in the October 1988 GEOGRAPHIC in "Air Bridge to Siberia," by Wilbur E. Garrett and Steve Raymer.)

Since 1977 the ICC has sought to be a unified voice for the 115,000 Inuit scattered over four nations along the Arctic's treeless shorelines. The ICC has consultative status in the United Nations Economic and Social Council.

Only 1,600 to 2,000 Eskimos remain in the Soviet Union, where they are one of 26 northern ethnic groups. "A lot of their concerns are similar to ours," says ICC President Mary Simon, from Kuujjuaq in northern Quebec. "They include the environment, living conditions in the Arctic, preserving one's culture." One of the key issues, she says, remains protection of their homeland's fragile environment against careless exploitation.

PETER TURNLEY (TOP) AND ANTHONY HOWE, BOTH BLACK STAR

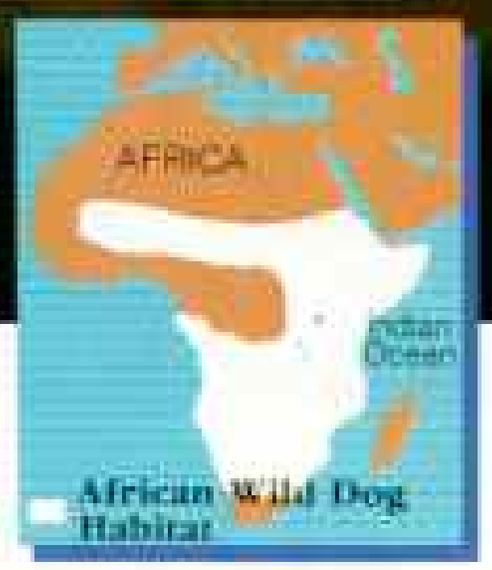
Danger Still Stalks a Cameroon Lake

Lake Nyos, from which a cloud of carbon dioxide spewed in 1986, killing 1,700 villagers and 3,000 cattle (top) in the African nation of Cameroon (GEOGRAPHIC, September 1987), could produce a new disaster.

American scientists who studied the lake found its bottom waters warming and its chemistry changing. George Kling of the Woods Hole Marine Biological Laboratory says that this indicates Lake Nyos (above) is fed by a soda spring. Since other such springs in the area are high in carbon dioxide, that may be how carbon dioxide gets into the lake. The lake is markedly stratified, and the upper layer acts as a lid holding the gas-laden bottom water in place. But any force—an earthquake, a rockslide, strong winds—that roils the lake could have the effect of shaking a soda bottle, bringing the gas to the surface, where its release would again threaten life.

Kling says there has been no major increase in the lake's carbon dioxide, but enough remains since the 1986 tragedy that the lake still is very dangerous. And there is another threat: A natural dam holding back the lake's top layer is eroding at an alarming rate. Not only would its collapse trigger the release of carbon dioxide, but, Kling says, there could be "a tremendous flood" endangering villagers as far away as Nigeria, 65 miles distant.

African Wild Dog **Genus:** *Lycaon* **Species:** *pictus* **Adult size:** Head and body length, 75-100cm; tail 30-40cm; shoulder height, 75cm **Adult weight:** 20-27kg
Habitat: Semidesert, savannah and dense woodland from the Sahara to South Africa
Surviving number: Estimated at less than 7,000 Photographed by Jonathan Scott



Wildlife as Canon sees it

Drama unfolds on the dusty Serengeti Plains as an African wild dog presses a herd of wildebeest to a thundering stampede. Six to eight adult pack members follow close behind this lead dog, and in a cooperative effort they will chase and seize the prey. The ability to quickly select a vulnerable animal, usually from the young or weak, determines the success of the hunt. While in search of prey a pack may wander up to 30 miles within its home range in a single day. These "wolves of Africa" were once abundant throughout most of the continent. Today, only scattered and isolated populations remain, the result of disease, relentless persecution by humans and continuous encroachment on their gradually dwindling habitat.

To save endangered species, it is vital to protect their habitats. Understanding the fragile balance of our world's ecosystems holds the promise for the future. Photography, both as a scientific research tool and as a means of recording the world around us, can help promote a greater awareness and understanding of the African wild dog and how it lives within its natural environment.

And understanding is perhaps the single most important factor in saving the African wild dog and all of wildlife.

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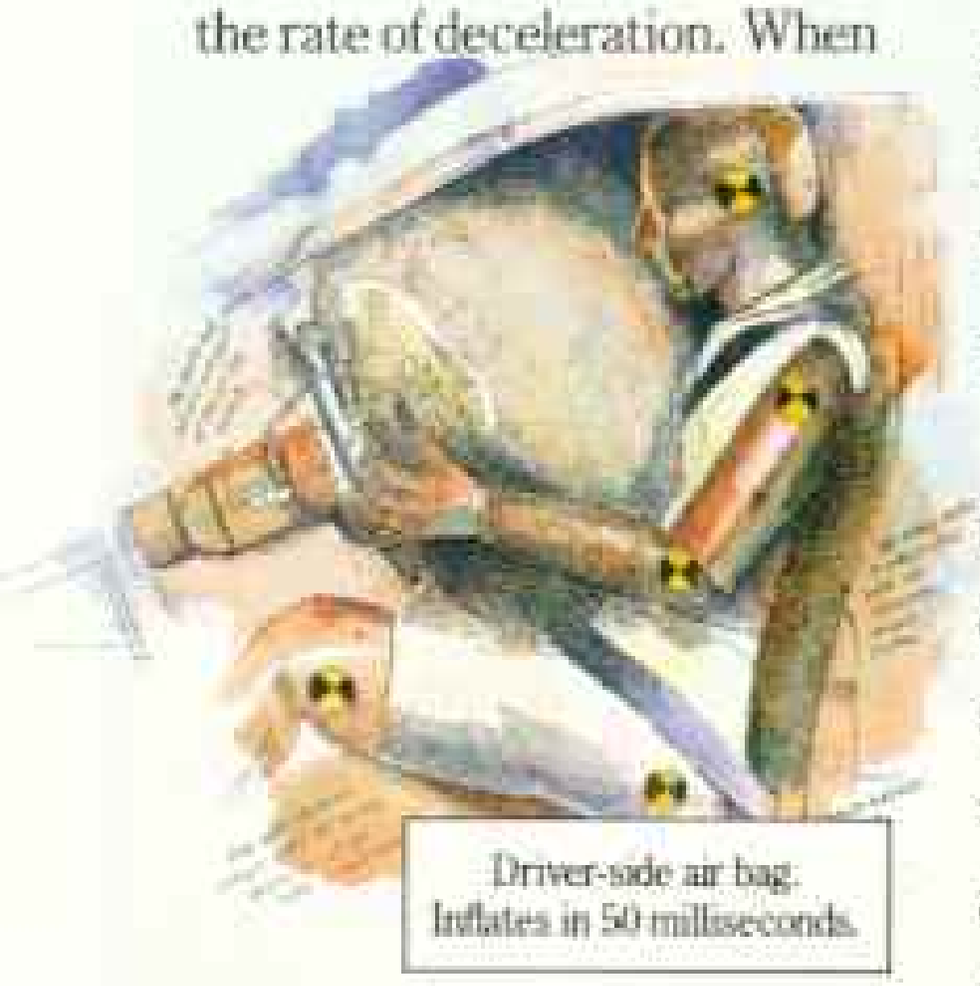
Fifth Avenue also offers a four-wheel anti-lock disc brake system. An electronic control unit senses the speed of each wheel and determines the rate of deceleration. When



Driver-side air bag. Inflates in 50 milliseconds.

that rate is too rapid, the system correctly reduces the amount of hydraulic pressure applied to each brake, helping to prevent lockup and skidding on slippery roads.

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ROLLS ROYCE CORNICHE	3 YEARS UNLIMITED	3 YEARS UNLIMITED	NONE	3 YEARS UNLIMITED	3 YEARS UNLIMITED
MERCEDES BENZ 560 SEL	4 YEARS 50,000 MILES	4 YEARS 50,000 MILES	NONE	4 YEARS 50,000 MILES	4 YEARS 50,000 MILES
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STRAT COOKING TIPS

1. If you're concerned about fat, check the "Skinniest Six" below. 2. Great marinades come disguised as vinaigrette, yogurt or red wine. 3. Leftover steak is the ultimate cold cut.

MEANWHILE BACK AT THE STOVE

You can cook a steak even if you haven't got a weekend or a grill. Just sear both sides in a hot iron skillet. You get the speed. You get the ease. And most important, you get the steak.

FAST FORWARD ROAST BEEF

You don't have to drive 300 miles to grandma's house just to have roast beef. Ask any microwave cookbook. About 20 minutes a pound is all it takes. Regular ovens can do it in about 30 minutes a pound. And leaner roasts cook faster. Which leaves you with plenty of time to call grandma after dinner.

THE GREATNESS OF SMALLNESS

The sirloin that touched both ends of the plate has been fajita'd and it's been tossed. It's been stir-fried and it's been skewered. Because small amounts of beef are hugely interesting.

Figures are for 3-ounce servings, cooked and trimmed. © 1991 Beef Industry Council and Beef Board.*

ROUND TIP
6.4 gms total fat*
(2.3 gms sat. fat)
161 calories

TOP LOIN
7.6 gms total fat*
(3.0 gms sat. fat)
172 calories

TOP ROUND
5.3 gms total fat*
(1.8 gms sat. fat)
161 calories

Beef.

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EYE OF ROUND
5.5 gms total fat*
(2.1 gms sat. fat)
153 calories

TENDERLOIN
7.9 gms total fat*
(3.1 gms sat. fat)
179 calories

SIRLOIN
7.4 gms total fat*
(3.0 gms sat. fat)
177 calories

NATIONAL GEOGRAPHIC MAGAZINE

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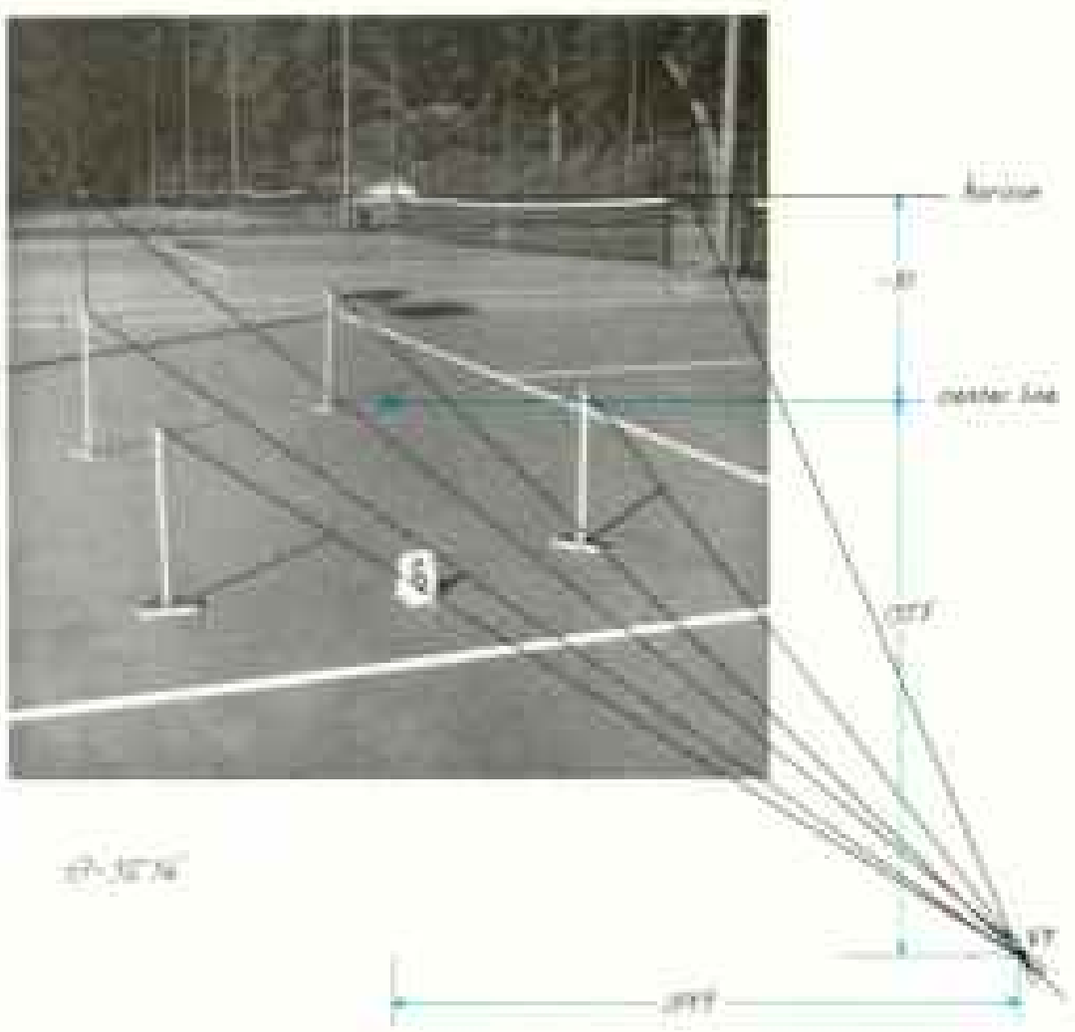
SUN ANGLE, ANYONE?

The game being played on the tennis court in Janesville, Wisconsin (below), is actually an experiment that helps confirm that Robert E. Peary reached the North Pole on April 6, 1909. William G. Hyzer, an expert photogrammetrist, set up a horizon artificially by using poles topped with Ping-Pong balls; he then applied the process of photogrammetric rectification (pages 52-3) to the white sticks and the shadows they cast to



determine the angle of the sun above the horizon. Photogrammetric analysis of the tennis court picture gave a sun angle of 32° 56'. This was only one-tenth of a degree from the actual angle of the sun. With several pictures taken at the same place at different known times, this process can give a position within a few miles.

Hyzer had earlier confirmed the Navigation Foundation's analysis of Peary's photographs that showed him to be where he always claimed—at the Pole, or as close to it as his instruments could measure. As the Foundation concluded in its report, celestial sights can be faked, but natural shadows in photographs cannot be falsified.

It is fitting that such convincing evidence of Peary's veracity derives from photographs, which have always been an important part of the GEOGRAPHIC's contribution to education. Simple, ever changing shadows on a turning earth, captured in a photographic moment, have helped finally resolve an 80-year-old controversy.

It is game, set, and match to Peary.

Melbert B. Cary Jr.

EDITOR

Maybe it's time to conduct some oat bran research of your own.

If you've read about any of the recent medical studies on oat bran, you're aware that oat bran can be important to your good health, as part of a low-fat, low-cholesterol diet. But what these reports won't mention is that *Kellogg's® Common Sense™* Oat Bran cereal contains more oat bran than any leading ready-to-eat cereal. Nor do these reports mention just how good *Common Sense™* Oat Bran tastes. For that information, we suggest you buy a box and do a little research of your own.

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Before hurricane Hugo, this was the largest single employer in this small community.
Now, no one's working here.
We're all working together to help them put their lives back together again—better than ever.
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Government assistance and insurance will help only so much. But they still need more. They need you.
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The Governor's Office
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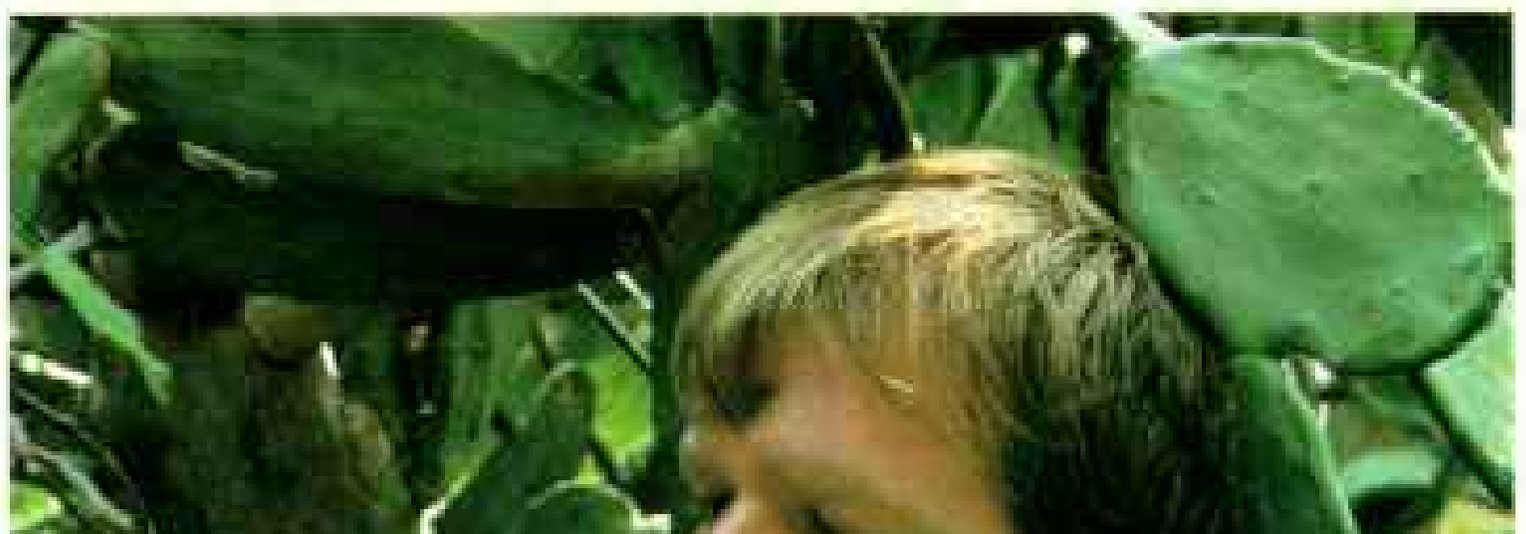
On Assignment

IT CAME NATURALLY to world-roving zoologist MARK W. MOFFETT, given his longtime interest in how animal societies are organized. When he was studying jumping spiders in Sri Lanka, Mark sought out the dwarf honeybee, *Apis florea*, smallest of the honeybee species. He knew it



PHOTOGRAPHS BY ROBERT JACKSON (ABOVE) AND MARK W. MOFFETT

behaved quite differently from the more familiar species, *Apis mellifera*, he had been observing for the robot bee article in this issue.

Unlike those bees, which nest in cavities, dwarf bees of Asia construct nests on branches amid dense foliage to avoid detection. To guard the nest—full of inviting honey that draws ants and other predators—hundreds of bees blanket their home with their bodies, up to several layers thick (above). The living curtain also helps control the temperature of the nest. This unusually small colony hovers nearby as Mark inspects their nest (top right).

While all honeybees dance to communicate the location of food, dwarf bees perform in the open atop their nests (right)—a view never before published in such detail. The dancer orients straight at the flower target, lifting her abdomen like a flag so followers

can see it. Her dance is silent, and followers apparently get the message just by watching. For species that dance in dark cavities, some experts believe wing sounds evolved to provide a "voice."

Curiosity has always characterized Mark, who recalls, "I was a permanent problem to my parents. From about age three I just wanted to sit in the backyard and watch ants." At 17 he began traveling in Central and South America with expeditions to investigate lizards, snakes, beetles, and butterflies. After graduating from Beloit College in Wisconsin, Mark earned his Ph.D. in biology at Harvard, based on 28 months of travel in Asia—studying ants.

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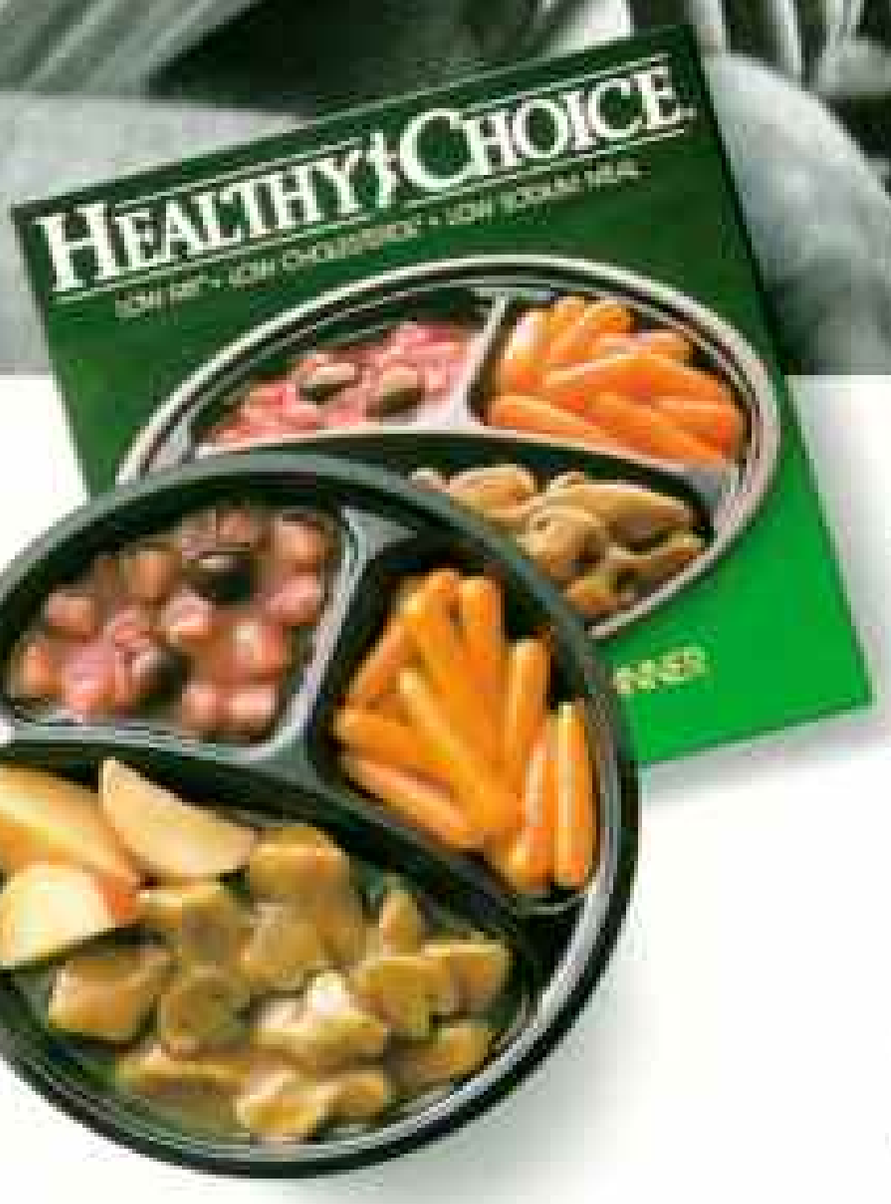

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