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THE PERSIAN GULF
AFTER THE STORM 2

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COVER: Resembling creatures from another world, environmentalists in protective suits examine the tar-encrusted ground amid raging oil fires in Kuwait. Photograph by Steve McCurry.

AFTER THE STORM

Sandwiched between blackened sand and sky, camels search for untainted shrubs and water in the burning oil fields of southern Kuwait. Their desperate foraging reflects the environmental plight of a region ravaged by the gulf war.

By THOMAS Y. CANBY SENIOR ASSISTANT EDITOR

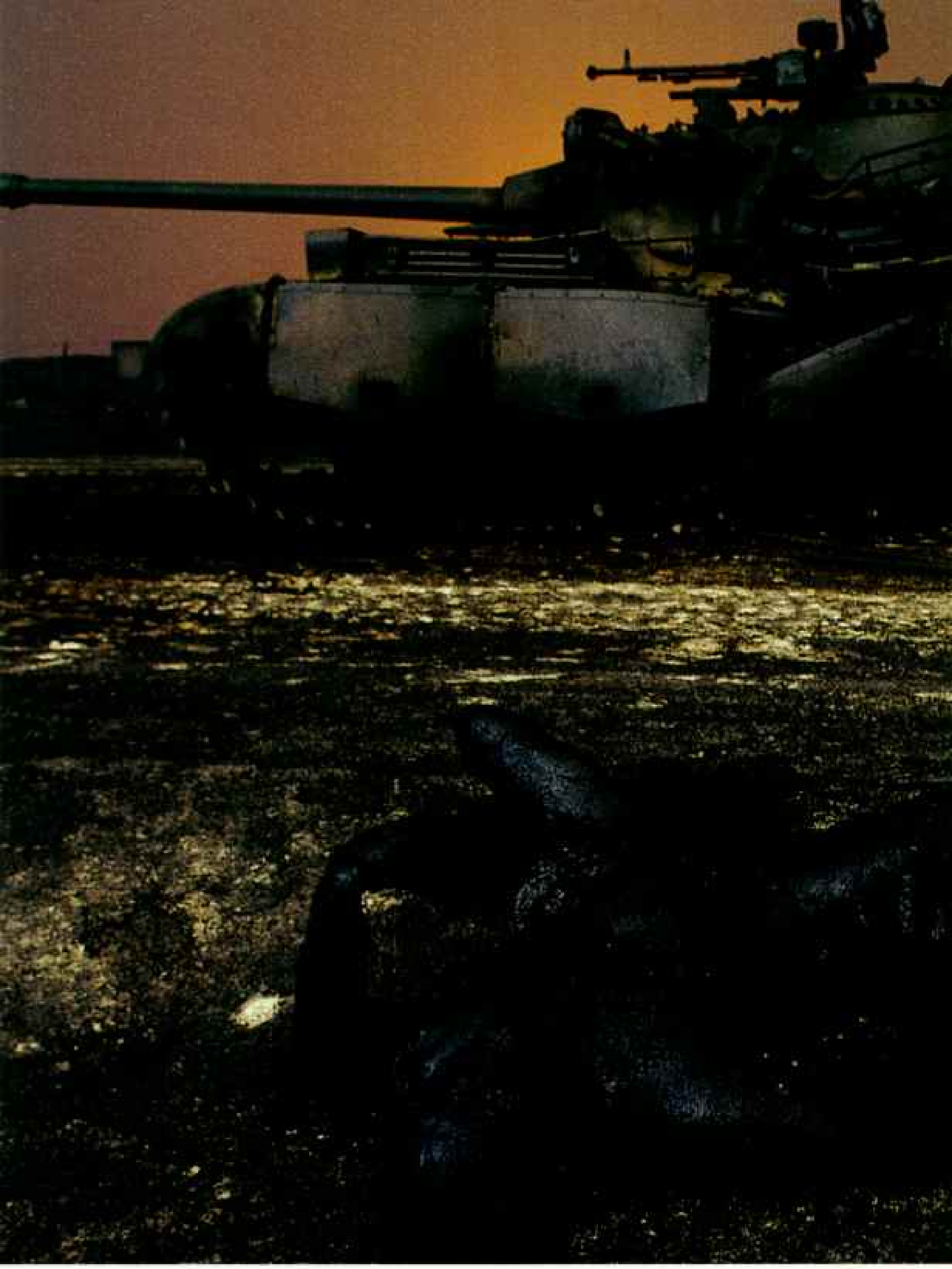
Photographs by STEVE McCURRY MAGNUM

Mourning a loved one killed during the Iraqi occupation, these Shiite Muslim women return each Thursday to weep and pour bottles of scented water on the grave in Kuwait City. This

section of the walled cemetery, near the now destroyed Entertainment City amusement park, has been set aside for civilian victims of the war.

A swim in a lake of pure oil at Ahmadi dooms this cormorant to join tens of thousands of birds killed by slicks and oil pools from gushing sabotaged wells. Some oil lakes measure more

than a mile long and a yard deep. What to do about them is undecided. Reprocessing the oil for later use is possible but difficult, and it is not a high priority.



No retreat sounds for an oil-covered corpse and a Soviet-built tank wasting in a Kuwaiti oil field. Nearly forgotten in the euphoria of victory and the shock of environmental ruin were

some 100,000 killed in the fighting. In Iraq, where water pipelines and treatment plants were bombed, more lives are threatened by contaminated water supplies.

SKIRTING ABANDONED BUNKERS and mindful of hidden Iraqi mines, we have driven deep into the inferno of Kuwait's Ahmadi oil field. Fires of dynamited wellheads, roaring like jet engines, rage on every side.

We stop for photographer Steve McCurry to shoot pictures, and I take a count. Sixty-eight fountains of fire hurl smoke into the black canopy overhead. Throughout this shattered land more than 500 flaming wells spew poisons aloft, each systematically ignited by Iraqi invaders three weeks before.

In this dark and surrealistic landscape a drizzle of soot and oil flashes in our headlights and stains our protective gauze masks. The smoke cloud blocks the midmorning sun, and the fouled desert air is chill.

Some of the fires leap 200 feet in the air. Twisting and writhing in the wind, they resemble flaming tornadoes tethered to their wellheads. The hottest we give wide berth, lest the searing heat touch off our gas tank.

We explore an abandoned farm laid out among the wells. Grasses and trees glisten black, oily to the touch. A faltering specter parts the twilight—a horse. Once it was a fine white Arabian mare. Now it is a gaunt ghost, pitiably stained and matted with oil. It nuzzles our headlamps oddly, as if craving light, then reaches for our offering of apples and water. We know it soon will die in this befouled land.

A few miles to the south, where the Persian Gulf washes the sands of the Arabian Peninsula, another environmental atrocity assaults the region. Here probably the largest oil spill ever known, covering some 600 square miles of sea surface, blackens 300 miles of coastline and much of the wildlife it nurtured. Blasting pipelines and storage facilities and emptying loaded tankers, the Iraqis deliberately spilled as much as six million barrels of crude—Iraqi as well as Kuwaiti (map, pages 14-15).

Evacuating invaders met a dead end on a highway leading out of Kuwait City (facing page) when their convoy of commandeered vehicles was bombed and rocketed by allied aircraft. The hulks were later shoved off to the shoulders for eventual removal. Where no roads existed, thousands of vehicles loosened the desert's thin protective crust during the war; experts worry that intensified sandstorms may result.

Like the air and sea, the land has felt war's ravages. Thousands of military vehicles, churning the desert surface in Saudi Arabia, Kuwait, and Iraq, have violently altered the soil structure. A result, says Farouk El-Baz, director of the Center for Remote Sensing at Boston University, may be a worsening of sandstorms whipped up by the *shamal*, the notorious northwesterlies. Paradoxically, where the Kuwaiti smoke cloud hangs over the desert, falling oil and soot congeal with the sand to form a brittle crust.

I visited the gulf soon after the guns had stilled, when concern was beginning to focus on the war's environmental impact. I came away appalled by the magnitude of the disaster and the wantonness of the Iraqis who perpetrated it. I learned too that only intensive medical and scientific monitoring can ultimately assess its true cost.

The oil fires in Kuwait, and the monstrous plume they exhaled, riveted the world's attention. Each day relentless flames devoured about five million barrels of oil, generating more than half a million tons of aerial pollutants, including sulfur dioxide, the key component of acid rain. Billowing two miles high, the sooty pall rode the winds to smudge far beyond Kuwait: Black rains fell in Saudi Arabia and Iran; black snow greeted skiers in Kashmir more than 1,500 miles eastward.

Human health is already being affected, in

A lucky war veteran takes a late afternoon stroll at the Kuwait zoo. One of the few animals spared by Iraqis, this hippo—suffering from a skin infection from a stagnant pool—wandered from his pen and found grass to eat. One neighbor, a hardy elephant, still has a bullet lodged in its shoulder. An injured bear died after red tape prevented its being flown to Saudi Arabia for surgery. Iraqis also slaughtered horses grazing near oil fields (below).

ways and degrees perhaps never to be known with certainty. Respiratory ailments appear to be increasing markedly. And researchers worry about carcinogens in the great cloud.

Nor was there prospect of quick relief. Three Texas fire-fighting crews and one from Canada were struggling to fly in equipment and contend with land mines and bureaucracy when I roved the country in mid-March. Two months later a hundred wells had been brought under control, but these were the easiest ones. Growing lakes of oil and submerged mines may delay the task for several years.

Hammad Butti, an employee of the Kuwait Oil Company in Al Ahmadi, south of Kuwait City, had watched helplessly as the Iraqis blew up the wells. "Saddam Hussein sent down oil men from Iraq, and they studied our operation. If you didn't cooperate, they would kill you. A month before the disaster they kicked us out of the control room, where I worked.

"On Sunday, February 17, they began to fire the wells. They put dynamite in each, put a sandbag on each charge to direct the blast downward, and detonated it with an electric charge. Every 10 or 15 minutes they fired another well—boom! Soon the sky was full of fire and smoke."

Mr. Butti took me to see the control room, which had regulated the flow of oil from the field to offshore tankers. "My chair was in that corner." The room and its computerized controls had been blown to smithereens.

We went to his home, half a duplex of company housing, within earshot of the howling well fires. The pall of smoke hung low overhead, spreading darkness and cold. A film of grimy oil coated every surface, including the skin and clothes of his 17 children. They gathered around us, as did his two wives, Fatima and Saada.

"How do you get them clean?" I asked. "Scrubbing," Fatima said, kneading worn hands. "Still we are never clean."

HALF A BLOCK AWAY lived Nizar Kawash and his wife and four children. Mr. Kawash, a professional nurse, was in charge of the emergency room at the oil-company hospital.

"We're treating many more bronchial and asthma cases," he told me. "A lot of coughing and upper-throat infections." I encountered many Kuwaitis who felt intense anxiety about carcinogens and other unknowns that might lurk in the hovering smoke.

"It's hard on the children," said Mr. Kawash. "When they play outside, they turn black, like little car mechanics. We can't let them go anywhere, for fear of mines and live cluster bombs." From the living room we could hear an allied demolition team detonating unexploded bombs that had been dropped on nearby Iraqi emplacements.

Most of the neighbors had fled, first from the Iraqis, then from the cloud. The family lived on food they had stored and sparse supplies obtainable with ration cards. They gathered water from cisterns of abandoned homes.

Mrs. Kawash showed me their flock of 37 chickens. Once alabaster leghorns wore a grimy gray. "They stopped laying when the smoke came. The roosters even stopped crowing." Ahmed, nine, emerged from the henhouse beaming, a welcome first egg in hand.

I paused at the vegetable garden. The plants were dead from the coating of oil and lack of irrigation water. "The eggs and vegetables meant so much," said Mrs. Kawash, faltering. Then she blurted, "I hate to have to ask for food. Yesterday I cried all day."

What would they do? "The bombs didn't drive me out and neither will the smoke," said

Mr. Kawash. "How can I leave the hospital when I'm most needed? I hope my wife will leave temporarily, with the children. . . ."

THIRTY MILES SOUTH of Kuwait City, I visited a once innovative agricultural experiment station. Here I saw in microcosm the smoke's effects on farming elsewhere under the plume.

Iraqi soldiers had bivouacked at the station, and it lay in shambles; even the photocopiers had been booby-trapped. Dazed agricultural scientists were just starting to pull things together again.

"The Iraqis used the business office for a command and control center," said Jamal Mohammed, an irrigation engineer. "Kuwaiti resistance fighters sent word to the allies, and you can see the result." He gestured toward rubble surrounding a crater—a testimonial to the pinpoint accuracy of allied bombing.

We entered the greenhouse area; Arab agriculture relies heavily on these shelters from heat and cold. "Greenhouse cultivation requires 80 percent illumination for growth," said a technician. "The smoke will interfere, as will falling soot. Only strong chemicals can remove the soot from the glass."

Daunting setbacks faced the acting director of animal health. "We had a herd of 550 dairy cattle," said Khalil Al Dosari. "The Iraqis ate all but 79, and these are in bad condition. We had experimental sheep and goats, bred to produce triple births; the Iraqis ate the breeding stock." He showed me the slaughter spot, blood soaked and swarming with flies.

Mr. Al Dosari foresaw smoke-related problems throughout the region. "Chemicals from the fires will enter the milk of sheep and dairy cattle through respiration and feed and by soiling of their udders. Wool will require chemical cleaning before it can be used. Reduced sunshine and falling soot may cause deficiencies in essential vitamins D and E."

I visited a prime agricultural region, centered on the town of Al Wafrah. Before the war immigrant workers in this irrigated oasis had raised an abundance of vegetables and fruits, chickens and eggs. We saw no living crop, no working farmer. Cucumbers grown for export to Paris withered in the greenhouses. Chicken houses reeked of dead fowl. The thousands of workers had returned to the Philippines, Bangladesh, Sri Lanka, Pakistan, and India, affecting national economies that had benefitted from wages they sent home.

PERSIAN GULF

TIDE OF DESTRUCTION

One of the world's most polluted bodies of water, the Persian Gulf pays heavily for its role as the Middle East's oil highway. A quarter of a million barrels of oil pollute it each year, yet the gulf takes more than five years to flush contaminated water through the narrow Strait of Hormuz. Oil aside, gulf water is in places one and a half times more saline than the oceans. Still, numerous life-forms thrive on the shallow western side, where it is possible to stand chest deep in water two miles out. These shallows are ideal habitat for algae, the bottom link in a food chain that has made the western gulf a prime fishery for millennia. The shallows are also the final resting place for the gulf war oil spills, given prevailing winds and currents.

More than 500 burning oil wells released an enormous cloud of smoke. The plume threatened Iranian crops with acid rain and was carried at least as far east as India.

IRAQ

IRAN

KUWAIT

SAUDI ARABIA

BAHRAIN

Basra

to Baghdad

Abadan

Shatt al Arab

Safwan

RAUDHATAIN

SABRIYAH

Bubiyan Island

AL FAW TERMINAL

MINA AL BAKR

Fayilakah I.

Kuwait

Al Jahrah

Awhah I.

January 19, 1991
SEA ISLAND TERMINAL
January 20

Kubbar I.

AHMADI
MAGWA

MINAGISH

Al Ahmadi

MINA AL AHMADI

UMM GUDAIR

BURGAN

Al Wafrah

WAFRA

Qaruh I.

Bandar-e Bushehr

Al Khafji

January 28

Ras al Mishab

Safaniya

February 1

Harqus I.

Farsi I.

Ras at Tanaqib

February 5

Karan I.

Al Arabiyah I.

February 7

Manifah

Kuraya I.

Ras az Zawr

February 9

Jana I.

Abu Ali I.

Al Jurayd I.

February 14

Gurmah I.

Al Jubayl

Ras Tannurah

Al Qatif

Ad Dammam

Dhahran

Al Khubar

Al Manamah

March 23

Al Uqayr

Dukhan

Dates show the spread of oil to its farthest extent as of late March. The main spill occurred at the terminal at Sea Island.

Species at risk

- Shrimp nursery
- Pearl oyster bed
- Dugong critical habitat
- Turtle nest site
- Osprey nest site
- Heron and waterfowl feeding area
- Flamingo feeding area
- Cormorant and tern breeding area

Plovers and other shorebirds are found the entire length of the gulf coast.

Marine habitats

- Mangrove
- Sea grass
- Coral reef
- Desalination plant
- Extent of oil spill
- Oil pipeline and terminal
- Site of leaking tankers
- Oil field with well fires
- Current
- Bathymetry in meters

Prevailing winds (late January and February 1991)

Secondary winds (late January and February 1991)

N

0 75 km

0 75 mi

CONSULTANTS: JOHN H. ROBINSON, NOAA/HAZARDOUS MATERIALS RESPONSE BRANCH
JACQUELINE MICHEL, RESEARCH PLANNING, INC., COLUMBIA, SOUTH CAROLINA
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NGS CARTOGRAPHIC DIVISION

INTERTIDAL ZONE
Each tide brings more oil into shallows, while winds and currents push slicks farther along the shore.

PREVAILING WIND

HIGH TIDE

LOW TIDE

SUBTIDAL ZONE
Sand-laden oil sinks to bottom, covering burrows of worms, fish, and shellfish. Globules later float upward, becoming tar balls.

CORAL REEF
Submerged beneath deadly surface oil, reefs and limestone mounds may escape undamaged.

Vital to gulf life are intertidal mats of blue-green algae, home to tiny organisms on which fish and animals feed. Shallow-water sea grass beds are habitat of juvenile shrimp and some 500 other species of small creatures, as well as venomous sea snakes. Fishermen fear oil damage to breeding grounds of commercially valuable finfish, particularly mackerel and grouper.

Zagros Mountains

IRAN

Bandar-e Abbas

Qeshm I.

Strait of Hormuz

The gulf's counterclockwise current and prevailing northwesterly winds guided oil south along the Saudi coast, sparing the coast of Iran.

QATAR

Al Khawr

Halul I.

Doha

Umm Said

Ras al Khaymah

Ash Shariqah

Dubayy

OMAN

Gulf of Oman

Zirku I.

Abu Dhabi

Ar Ruways

UNITED ARAB EMIRATES

OMAN

BOUNDARY UNDEFINED

26°

24°

33°

54°

56°

At the Kuwait zoo, a handful of animals had survived the occupation, and these were suffering from neglect; some bore wounds inflicted by Iraqis who shot caged beasts for food or pleasure. Others had disappeared—believed abducted to Iraq—while a fortunate few had been adopted by Kuwaitis, to be returned when the storm of war had passed.

KUWAITIS KNEW their environment was in dire trouble, but they had lost the means to measure the damage. Before the war this wealthy nation had supported one of the premier scientific centers of the Middle East, the Kuwait Institute for Scientific Research. Now KISR was a shell, plundered and partly destroyed. Before fleeing, the Iraqis left their familiar final insult by defecating on the floors.

I located a more modest lab, hidden in a seedy commercial section. There, in the semidarkness of a city without electricity and living under the smoke, I spoke with technician Sabah Abdul-Wahab. "The Iraqis left three air samplers. We placed them on roofs of hospitals, which have emergency generators."

She showed me the first air analysis since the fires began. As expected, it revealed a sharp increase in sulfur dioxide. To my surprise, however, by stringent U. S. health standards the level still was safe. Sampling a broad range of smoke pollutants, a team of U. S. experts tentatively concluded that the situation "does not appear to be life threatening."

The mounting stench outside the International Hotel signaled another environmental problem: Trash was piling up, and the shattered national infrastructure could not cope.

To the rescue came an unlikely convoy: 30 dump trucks and loaders of Waste Management, Inc., of Chicago, toiling northward from Saudi Arabia behind George Villasana, a company vice president. "We came without a contract—we'll do the job, then see about money," said Mr. Villasana. Dependence on foreigners, I learned, characterized pre-war Kuwait, and now their absence contributed much to the country's seeming paralysis.

Among the flaming oil wells of Kuwait, I saw dynamited wellheads that had not caught fire. Geysers of gray-brown crude spurted 50 and 60 feet in the air. Around them grew small lakes of oil, and these caused great concern: What if they found their way down to the gulf?

The gulf needs no more oil.

Nobody knows, or ever will know, the exact amount Saddam Hussein released. "Our best estimate is between four and six million barrels," said Capt. Robert E. Luchun of the U. S. Coast Guard, senior American spill adviser in Saudi Arabia. "It's as if a fleet of monster tankers ran aground."

Why the uncertainty? "In reality the spill was a series of releases," Captain Luchun said. "Iraqi artillery ruptured oil tanks during the battle for Al Khafji, and oil flowed into the gulf. The Iraqis released oil at the Sea Island loading area, off Kuwait—the largest spill. To top it off, they brought in loaded tankers—seven, we think—and dumped their cargoes."

Nightmarish as the present spill is, if four brave Kuwaitis had not tricked the Iraqis, it could have been three times as large.

"We worked by night because the Iraqis had spies," recalled Khalid al-Othman, a refinery superintendent with the Kuwait Oil Company at Mina Al Ahmadi. "A 48-inch pipe carried oil from storage tanks down to Sea Island. Those tanks held 8.5 million barrels that the Iraqis intended to release into the gulf. We secretly closed a valve the Iraqis didn't know about and, to fool them, changed the valve indicator to 'open.' When they dynamited Sea Island to release the main spill, our valve held back those millions of barrels in the storage tanks."

THE DELUGE of oil that was released struck a vital ecosystem. Gulf waters teem with life. "The gulf is shallow—only 110 feet deep on average," explained John McCain of the Research Institute of King Fahd University of Petroleum and Minerals. "As a result, unique physical and biological processes promote vigorous growth of sea grasses and algae at the bottom, along with plankton in the water. For thousands of years this productivity has supported fisheries of shrimp and finfish like mackerel, mullet, snapper, and prized hamour, or grouper."

On the Saudi side—the coastline hit by the oil—this shallowness translates into gentle beaches with wide intertidal zones. These make the gulf an important region for migrating and wintering wading birds, including plovers and sandpipers. Seaward, vast marine meadows support larvae and fry.

Off the Saudi coast a chain of islands claims critical importance to wildlife. Two species of cormorants frequent them—the great

Fire fighters from the Kuwait Oil Company spray foam to smother a two-week-old blaze at a sabotaged oil-tank farm—one of the few early victories over fires set during Iraq's "scorched earth" retreat. Most burning oil facilities were surrounded by mines that had to be cleared before fire-fighting crews could even approach them.

cormorant and the endemic Socotra. Green turtles and endangered hawksbill turtles crawl ashore to plant their eggs. Most islands are ringed with fragile corals.

In this system, oil is a familiar presence. The gulf is both the source and the highway for much of the world's crude. Officials estimate that a quarter of a million barrels a year routinely spill—much more was lost during the eight-year Iran-Iraq war—and most gulf nations possess limited cleanup capabilities. I drove beaches that were paved for miles with old "tar mat," previously spilled oil and sand weathered into a thick asphalt crust.

Yet no precedent existed for the enormous slick that crept from Kuwait.

"We first saw it on January 19," said Ala Al-Rabeh of the Research Institute, whose computer model helped forecast the movements of the slick. "Luckily, for two weeks the winds were unseasonably soft and often blew from the southeast. This held the slick at bay and gave valuable time to prepare."

Quick action—though limited in scope—came from Saudi Aramco, the immense national oil company. Vital facilities line the threatened coast: tanker terminals, refineries, power and desalination plants. The company laid down 25 miles of boom, mobilized a fleet of 21 oil-recovery vessels, and activated its arsenal of cleanup devices.

A second agency oversees imperiled coastal facilities. This is the Royal Commission for Jubayl and Yanbu, whose head, Prince Abdullah ibn Faisal ibn Turki, presides over an empire of refineries and petrochemical plants. It too moved decisively to deploy booms and remove encroaching oil.

The rest of the coast—the undeveloped domain that falls by default to gulf wildlife—came under the jurisdiction of MEPA, the Meteorological and Environmental Protection Administration. But the agency was ill prepared and enmeshed in bureaucratic rivalries. It found itself overwhelmed by the colossal spill—a *(Continued on page 24)*

SATELLITE IMAGERY FROM EROS DATA CENTER, USGS; MOSAIC ASSEMBLED BY NGS PRE-PRESS GRAPHICS DEPARTMENT

"Strategically it was senseless. The only casualty was the environment."

ABDULLAH TOUKAN, SCIENCE ADVISER TO KING HUSSEIN OF JORDAN

A swarm of tornado-like plumes from the Burgan oil field blacken the afternoon sky (previous pages). Kuwait's oil-and-soot clouds rose as high as 22,000 feet, releasing tons of pollutants daily.

The scope of the fires is startlingly clear in a photomosaic of four Landsat satellite images. Kuwait City—jutting into the gulf near the center of the image—is wedged between smears from burning oil wells to the north and south. Taken from 440 miles up on two passes in late February, the images were digitally "stitched" together by computer for this nearly seamless overview covering an area of 10,000 square miles. Glowing in a pattern below Kuwait City are blazes in the Burgan oil field, the world's second largest, after the Ghawar field in Saudi Arabia.

Dousing the fires is complicated by the pressure of Kuwait's oil deposits, as much as 15,000 pounds per square inch. Most of the wells will continue to gush until capped; some sunk in the 1940s still flow from natural pressure.

Aliens on a fiery plain, environmentalists Rick Thorpe and Michael Bailey of Earthtrust examine a field where the ground has been encrusted with oil (right). Hazards have gone underground on the Kuwait City beach (top) as French soldiers remove mines planted to foil a sea assault that never came. At the edge of a nearby minefield, Muslims pray facing Mecca.

disaster that would have overtaxed the response capabilities of Western nations.

Meanwhile the international community reacted. The United States Coast Guard dispatched two radar-surveillance aircraft specially equipped to monitor slicks. The National Oceanic and Atmospheric Administration (NOAA) sent a spill-trajectory analyst, and the Fish and Wildlife Service designated a spill-response biologist. All were veterans of Alaska's *Exxon Valdez* spill.

Advisers and support also came from Europe, Australia, and Japan. Compared with emergency responses familiar to the international group, however, the gulf cleanup effort appeared minuscule and irresolute.

Winds shifted, and the slick moved southward, washing over the Saudi coast. "With every tide the oil floated in and out of embayments, and it left little untouched," observed Othman Llewellyn of the Saudi National Commission for Wildlife Conservation and Development, a key agency assisting MEPA.

TO GAUGE the enormity of the disaster, I flew in a Saudi helicopter with Aziz Alomari, MEPA's daily reconnaissance scout. Near the Kuwait border the beaches were white; winds and tides had spared them. Farther south the scene invited disbelief.

Offshore, an immense film of oil called sheen polished the sea and mirrored the somber smoke cloud from the Kuwaiti oil fires. "Some of the oil is new—probably from leaks at Sea Island off Kuwait," said Mr. Alomari. Floating in the sheen were chocolate mats known as mousse—older oil that had combined with the water to form an emulsion.

Just south of Al Khafji the slick first came

aground. Oil blackened the broad tidal zone, often half a mile wide. My imagination saw a malevolent giant wielding a Magic Marker to outline the crenellated coast.

Farther south we rounded a cape into Al Musallamiyah Bay. Its sculptured shores were hideously stained, as if charred by fire. Here the intertidal zone was a black band a mile wide; pools of oil waited for the next tide to smear it on more wildlife habitat.

To seaward the oil thinned out. "About 40 to 50 percent evaporates as volatiles," said Mr. Alomari. "A lot has gone ashore, and some has sunk—weighted down by sand from shore or sand blown onto the sea by the winds. And, of course, there's the recovery effort."

From the air this effort appeared puny—a few crews sent out by Aramco, the Royal Commission, and MEPA manning skimmers and vacuum trucks and dumping the recovered oil into inland disposal pits for salvage later. But their cumulative effect was impressive: 20,000 to 30,000 barrels a day.

In Ad Dafi Bay the oil piled the thickest. I smelled it from the copter. We circled over Gurmah Island, with its treasured stand of dwarf black mangroves. Countless doomed trees lined tidal channels that once pulsed with life and now ran black with oil.

Below us I picked out Abu Ali Island, with its connecting causeway. It thrust like a bent arm far out in the gulf. Abu Ali's north shore wore the ugly rime of oil. But along the southern shore the water sparkled clear. The island was serving as a natural boom, holding back the black tide from industrial Al Jubayl, from Tarut Bay and its fleet of fishing dhows, from the great industrial port of Ad Dammam.

That evening at MEPA headquarters in Dhahran I attended the daily meeting of the

A tangle of oily tidal creeks, viewed from a few hundred feet up, curl across the sand at low tide on the Saudi coast (facing page). One slick, shown red in an enhanced satellite image (bottom), choked coastal habitats on Abu Ali Island.

Working under wartime conditions, the Saudi government set up a lone bird-cleaning center, where several hundred birds were saved. Its beak taped to save volunteers' fingers, an oil-covered cormorant gets the toothbrush treatment during a lifesaving bath.

EOSAT

spill-response team, a group ably led by Nizar Tawfiq. By now I had come to know and admire the concerned individuals who gathered about this long table. Senior meteorologist Walid Bakir Agha predicted the next day's winds and where they might move the oil. Aziz Alomari described the fresh slick near Ras at Tanaqib seen from our helicopter.

Ominous news came from Jay Rodstein, the NOAA spill-trajectory analyst: Oil was nearing the north coast of Bahrain.

Abdul Rahman Al-Shahri gave the Aramco update: 320 men in the field had recovered 16,549 barrels of oil that day. A Dutch contractor hired by MEPA gave a similarly encouraging report, as did an American firm recovering oil for the Royal Commission.

At the edge of the circle of oil fighters sat an anxious and dwindling group: private contractors, many of them American. With news of the spill, hundreds of oil-cleanup companies had seen a need and an opportunity and had offered their services. A handful of representatives sat uneasily night after night, incurring costs, awaiting action by MEPA.

The agency seemed unable to make the decisions needed to protect Saudi wetlands and the wildlife and fisheries they supported. Almost daily foreign teams visited the coast to survey the damage and prescribe cleanup procedures, but little action followed.

I JOINED A GROUP pointing toward stricken Al Musallamiyah Bay, favored habitat for migrant wading birds. "There's too much oil-impacted beach to clean all of it," said John Oestergaard, a Danish expert representing the International Maritime Organization. The IMO was coordinating international assistance on the spill and has since set up a multimillion-dollar cleanup fund. "We'll try to save two or three sections that are manageable and important for wildlife."

Approaching the bay, we encountered a target range used by troops preparing for the ground war. Vehicle tracks churned the sand amid a litter of spent missile launchers. This patch of desert would take years to heal.

At water's edge, oil-coated crabs lay everywhere. "It's a relief that they've died," said Tony Preen, an Australian biologist whom the Saudis had asked for assistance. "A few days ago they were still struggling."

We trod a strange, oil-soaked surface, wrinkled like a rug. "Algal mat," said Mr. Preen.

It is late morning, but under the oil cloud the only bright points are flaming wells—and tire tracks left by photographer Steve McCurry's car. The oily, soot-covered top layer of sand adhered to the tires, uncovering the white desert surface underneath.

"Important habitat but dying under the oil."

"We can make use of the tide and natural drainage channels to remove oil without disturbing the surface," said John McMurtrie, managing director of Alba International of Scotland. Mr. Oestergaard had recognized Alba as one of the companies having the technology for cleaning fragile beaches.

Four camels wandered by, cropping marsh grass. I watched one place its mouth around an oiled tuft, hesitate, then pass on.

Dead fish scattered the beach; dead cormorants, dead grebes; feathered shapes too encrusted to identify. "Terrible. And so unnecessary," said Mr. McMurtrie, alluding to the ease with which many baylets could have been protectively boomed.

Similar frustration gnawed Tony Preen: "Every coastal installation has been protected with multiple lines of booms. Yet we haven't been able to deploy a single meter of boom to protect natural habitats."

IN THIS DREARY ATMOSPHERE of environmental defeat, one small victory shone through. It went to the gulf's imperiled turtles. Egg-laying season was approaching, and there was worry about the turtles' nesting grounds. The islands were badly oiled and so littered with debris that the amphibians would scarcely be able to lumber ashore and dig pits. Volunteers were needed, and helicopters—impossible to come by. Disaster loomed.

Word reached the British Royal Air Force, and it offered Chinook copters. Royal Marines and their U. S. counterparts provided strong hands. In three days they tidied four island maternity wards. "The day we finished, an early arriving hawksbill waded onto an island to nest," said a pleased John Grainger of the Saudi wildlife commission.

Gurmah Island, with its many mangroves, was another major concern. Don Kane, a spill-response specialist with U. S. Fish and Wildlife, had worked with three other volunteers to lay 1,100 feet of protective boom across tidal channels carrying oil among the trees. We boated to Gurmah to check on them.

Wearing high boots, we crossed immense algal mats to the mangroves. The tallest came to my chin. "Not giants," said Mr. Kane, "but for Saudi Arabia this is important habitat." Clumps of small stalks resembling asparagus grew in channels among the trees. "Those are pneumatophores," he said, "roots that allow the mangroves to respire." Many were black with oil, and adjacent trees wore yellowing leaves; most would die.

We came upon booms the foursome had laid. One had sunk beneath the surface, and oil slithered past. Mr. Kane waded into oily water above the tops of his boots and secured the boom to a sturdy mangrove.

Other booms floated nicely. As planned, oil piled up on their seaward sides, while the protected channels carried clear water past healthy trees. "When the island heals, those will seed a new forest," said Mr. Kane.

Good things also were happening at the

bird rehabilitation center in Al Jubayl.

"We've received about 1,200 birds so far," said director Yousef Al-Wutaid. "Several hundred have been processed and released in the wild. We'll free 50 more tomorrow."

Assistant director Peter Symens pointed out recent arrivals: a begrimed gray heron, a great cormorant, a haughty Caspian tern, ruffled and indignant. "The tern was a real tar ball when he came in. He's got a powerful beak." Mr. Symens flexed a finger in recollection.

"We rehydrate new arrivals with a mix of water, sugar, and salt. Oil halts their metabolism, and the rehydrant kick-starts it again. Then we wash the birds in household detergent." I watched a Socotra cormorant slowly shed its stain in the hands of two volunteers, a U. S. Marine and a Royal Highlands Fusilier. The infantrymen would spend two hours gently cleaning between feathers.

Hundreds of birds milled in recovery rooms, waiting to regain their natural water repellence. From there they would graduate to a holding pool, last stop before release. Ninety-seven preened around the pool that day, lolling like bathing beauties.

Not all the patients survived. "At first we lost most of the great cormorants," said Mr. Symens. "They were sensitive to stress. Then we tried Inderal, a drug that depresses the heart rate. We haven't lost one since.

"The grebes are still a problem. Oily sand sticks to their feathers, and they tend to swallow it, forming a lethal stone in their gizzard. There's nothing we can do for them."

Run by the wildlife commission in an unused cafeteria, the center became a magnet for volunteers. Many were military personnel. "A nearby British field hospital was staffed with 900 nurses, expecting heavy casualties

from the ground war," he said. "They had only nine patients. The nurses pitched in, and male volunteers quickly followed.

"In terms of birds killed, the number we treat is small. But the center has served to raise public awareness. Many of our volunteers are Saudis, from as far as Riyadh and Jiddah."

How many birds has the slick claimed? "From body counts along the beaches, we estimate at least 20,000," said Mr. Symens. "Fewer birds are being brought into the center now, and we're hoping the worst is over."

BACK IN DHAHRAN there was little sign of action. Mid-March brought Ramadan, the Islamic month of daytime fasting, and the tempo of work slowed. Fewer contractors appeared at the MEPA meetings; many had gone home.

A small Texas company persevered. Alpha Environmental had come from Austin to cleanse Saudi wetlands with its oil-eating microbes and a special biocatalyst to stimulate them. The Research Institute of King Fahd University set up experiments to test the technology and its aftereffects. Alpha Vice President Franz Hiebert scoured Dhahran for 18 aquarium tanks. Soon assorted combinations of bugs, catalyst, seawater, and floating oil were percolating in an institute lab.

At press time, Alpha was optimistic that it would soon win a test of its technology on a Saudi beach.

Bad news came from NOAA: Radar told of oil reaching Bahrain, where abundant sea grass supports large populations of dugongs, mammalian cousins of manatees.

Heat was now a problem and would get worse. "By June it may be 130°F in the shade," warned Lt. Comdr. Kenneth Keane

of the Coast Guard. "Workers will become nauseated by gases from the oil if they're not wearing respirators. And respirators are cumbersome. The window for action is closing."

Similar concerns had set wheels turning in the offices of Dr. Tawfiq and others high in the Saudi government. In late March, just before I left the kingdom, word came that MEPA had named Crowley Maritime Corporation, a major U. S. spill-response firm, as principal contractor for coping with the oil. At long last a means existed for assigning subcontractors to clean despoiled beaches.

During the two months of seeming inaction that followed the spill, the international team often drew comparisons with other spills, such as *Exxon Valdez* in Alaska. That event, so much smaller in scale, evoked a response 20 times as vigorous. Ten thousand workers at a time, volunteer and official, had labored

One down, hundreds to go: Texan Brian Krause of "Red" Adair's legendary oil-fire-fighting team aims a "stinger" to help plug a gushing well. "Drilling mud" will be pumped down the pipe to permanently stem the flow. In many cases it will prove cheaper to drill new wells than to repair old ones. As foreign firms move in, the military is shipping out—but not before every returning vehicle is scrubbed clean from tip to tread. Department of Agriculture inspectors have trained crews to rid equipment of hitchhiking pests.

to help clean that state's fouled beaches.

I raised the obvious question: How strong is the environmental ethic in Saudi Arabia?

"Recall that we were at war when the spill occurred," said Abdallah E. Dabbagh, director of the Research Institute. "Saudi resources were strained to the limit, and still are." It was true. The kingdom had not only waged a war but also generated electricity and water to support three-quarters of a million foreign troops. It was stretched financially, and wartime conditions had prevented obedience to the first rule in an oil spill: Stop the flow at its source.

What about the lack of public involvement? "The people were confident the agencies would take care of it," said Dr. Tawfiq. "If the government had asked them to help clean up, they would have." He reminded me of the Saudi volunteers at the Al Jubayl bird center.

"Both MEPA and the wildlife commission reflect Saudi Arabia's growing concern for nature," said Australian biologist Tony Chiffings. "The movement originated in part when the princes of the royal family, who are ardent falconers, became concerned about a decline of houbara bustards, their main game bird, as well as other wildlife. Prince Saud Al-Faisal

learned that the bustards could be bred in captivity. This planted the idea of a captive-breeding program for bustards and other species, such as oryx and gazelles. The commission grew from this seed."

I crossed the causeway from Saudi Arabia to Bahrain and walked a final beach. Tar balls freckled the sand. "They represent only a fraction of the oil from earlier spills," said NOAA's Gary Ott. "Relative to what struck farther north, they won't cause much harm."

Spoils of war, a stripped car is claimed by a shepherd boy at Al Ahmadi. Farmers' fear of mines may give overgrazed land time to renew, small benefit from a war that fouled sea, land, and air.

HOW MUCH HARM will be caused by the fires and the oil slick? Opinions vary. Unlike the fires, the slick falls within human experience, in kind if not degree. Some experts expect its effects to be less dire than first feared. This stems in part from the gulf's history of adaptation to spills.

"It's a catastrophe, no question," said Othman Llewellyn of the wildlife commission. "But when we went out soon after the spill occurred, we saw sites that had been hit hard in past years and recovered."

Yusef Fadlallah of the Research Institute foresees a possible decline in gulf fisheries. "Juvenile fish and shrimp will die because of the destruction of nursery habitat; other sea life along the shore will be killed directly."

Dr. Dabbagh of the institute agrees. "By invading the shallows, the oil struck the gulf's primary energy source—its kitchen, you might say. This will be felt for generations."

There is concern too about the oil surrounding wells that were dynamited but not fired. Seeping oil could taint Kuwait's groundwater.

A different threat faces the desert surface. Geologist Farouk El-Baz fears that disruption of nature's "desert shield," the armor of pebbles over naturally compacted sand, will lead to formation of shifting dunes that could block roads and airports and engulf farms. Plant geneticist Bikram Gill of Kansas State University sees a danger to ancestral grasses that may hold genes important to cereals like wheat.

What will be the effects of the fires and the spills in terms of human health?

"My major worry is toxic metals," said Mohammad Sadiq of the Research Institute. "They are released by the slick, by combustion of oil, and by the explosives detonated in the war—the charges and metal jackets. Seawater samples from the northern gulf showed levels of metals ten times higher than normal.

"Some of the airborne metals will settle on the ground, especially in the vicinity of Kuwait, contaminating both soil and vegetation. Sheep, goats, and camels grazing on contaminated land will accumulate the metals, which may enter the food chain. Many are carcinogens, or cause brain damage and cardiovascular disorders."

The preliminary atmospheric study by the team of U. S. experts gives grounds for optimism. Samplings revealed no significant amounts of carbon monoxide or the two dread combustion products, hydrogen sulfide and polycyclic aromatic hydrocarbons.

Tests downwind of the fires, made by the British Meteorological Office, found a high concentration of particulates. Fine particulates are emerging as a major culprit of lung-related diseases. Those who live in Kuwait City may be at special risk should temperature inversions—common in summer—trap and concentrate the oil-fire smoke. Fortunately the fires lack the energy to pump contaminants directly into the stratosphere, so they may not cause the climatic change some had predicted.

The fires' unprecedented size gives them high scientific value. This has prompted a major research initiative by the National Science Foundation, the University of Washington and several other universities, the National Center for Atmospheric Research, and the National Geographic Society.

"Not only do the fires possess the potential to affect regional weather," William Cooper of NCAR told the Society's Committee for Research and Exploration, "they also offer an opportunity to test aspects of the nuclear winter hypothesis, which predicts severe cooling from smoke clouds reflecting sunlight. They can illuminate the effects of pollution on clouds themselves, an uncertainty in our understanding of climate change."

As the fire fighters extinguish the wells, skies gradually will clear over Kuwait and lands downwind, and the worst of the nightmare will fade. In shallows along the Saudi coast, plants and animals will recolonize, but here too the healing may never be complete. Both will remind us that in war the environment is an inevitable casualty.

IN THE EYE OF DESERT STORM

By STEVE McCURRY MAGNUM

On the second night of the ground war, I realized that darkness would never fall.

To the south of my position with the 42nd Field Artillery Brigade near the border of Iraq and Kuwait, the sky glowed deep red. Kuwait's oil was going up in flames.

From the first moments of Desert Storm, I was amazed by the sheer scale of the campaign. As the sky brightened on the first morning of the invasion, I stared at my own column of tanks, trucks, and other support vehicles stretching as far as I could see front and back, with identical lines on either side from horizon to horizon.

But if there was a war to fight, it wasn't here. We made progress as fast as we could. Once in a while we stopped, and soldiers dashed around carrying powder explosives (upper right). Then with a roar our big guns launched a rain of fire ahead of our advancing columns to soften up the enemy. During four days of advance, the unit, attached to the Army's VII Corps, fired an ear-numbing 5,440 artillery rounds and 1,286 rockets.

The invasion route took us north, deep into Iraq. Then we turned sharply southeast and headed toward Kuwait.

Operation Desert Storm met an actual desert storm in its second and third days—relentless winds kicked up a howling, sandblaster-like onslaught that cut visibility to just a few yards. Three of my cameras literally bit the dust, hopelessly jammed.

But the winds could also have been a lifesaver. Blowing directly toward Iraq's arsenal of chemical and nerve-gas rocket launchers, they may have rendered those weapons useless.

Day three brought grim evidence of the fighting ahead. Corpses of Iraqi soldiers lay by burning hulks of armored vehicles and abandoned positions. And attesting to the effectiveness of Desert Storm's lightning rear attack from the north, Iraqi guns still pointed south.

My driver, a soldier named Scott, decided to switch columns and headed across the terrain toward an adjacent stream of traffic.

Not a good idea. We found ourselves gingerly trying to maneuver through a bumper crop of unexploded "bomblets" from allied cluster bombs. I stayed in the backseat of the jeep, figuring if the front end blew up, I'd have an extra two feet of space. I also sat on my flak jacket.

It was on day four that we reached Kuwait—and finally caught up with the war. As we neared the border, Apache helicopters and Bradley Fighting Vehicles were just ahead firing into Iraqi bunkers and vehicles. An Iraqi truck full of munitions exploded like some ghastly Fourth of July display.

"Put on your Kevlar!" yelled Scott, motioning to his helmet. But I was more comfortable in my L.A. Dodgers baseball cap.

We had a good vantage point for the raging battle—too good in fact. Our jeep mounted a berm near the border and got stuck on top of it, with an entire

column lined up behind us.

We tried manhandling it over (below). Then another vehicle tried to pull us clear. But our stubborn mule of a jeep wouldn't budge. It finally took a good strong shove from a truck to put us over the top.

On we pushed into Kuwait, and we didn't stop until about 11 p.m. When we woke up at 4 a.m., the war was over.

Our unit was ordered to stay put. To get into Kuwait City, I had to retrace our steps back into Saudi Arabia, hitchhiking with two Army couriers who took me for a very scary late-night ride through the mine-strewn desert with no map and no radio, only a compass.

At last I reached Kuwait City. It was 11 a.m., yet the darkness caused by the burning oil wells was like a moonless night. The photos I brought back show the black, hellish landscape—yet they cannot convey the fine mist of oil particles that hangs in the air, nor the deafening roar of the wildly burning wells.

Nor can they show the unexploded bombs and mines that dot the Kuwaiti landscape. I'll never forget the chilling moment when I got out of the car to stretch my legs under a jet black Kuwaiti oil cloud and caught a glimpse of an allied "lawn dart" mine behind the vehicle with our tire tracks running right over it!

Desert Storm may have been a rout, but the real battle may well be Desert Cleanup. □

"THE BEST IDEA AMERICA EVER HAD"

By PAUL C. PRITCHARD
Photographs by CARY WOLINSKY STOCK, BOSTON

"TO CONSERVE THE SCENERY and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same . . . unimpaired for the enjoyment of future generations." With a stroke of his pen, President Woodrow Wilson thus signed the National Park Service Act 75 years ago this month.

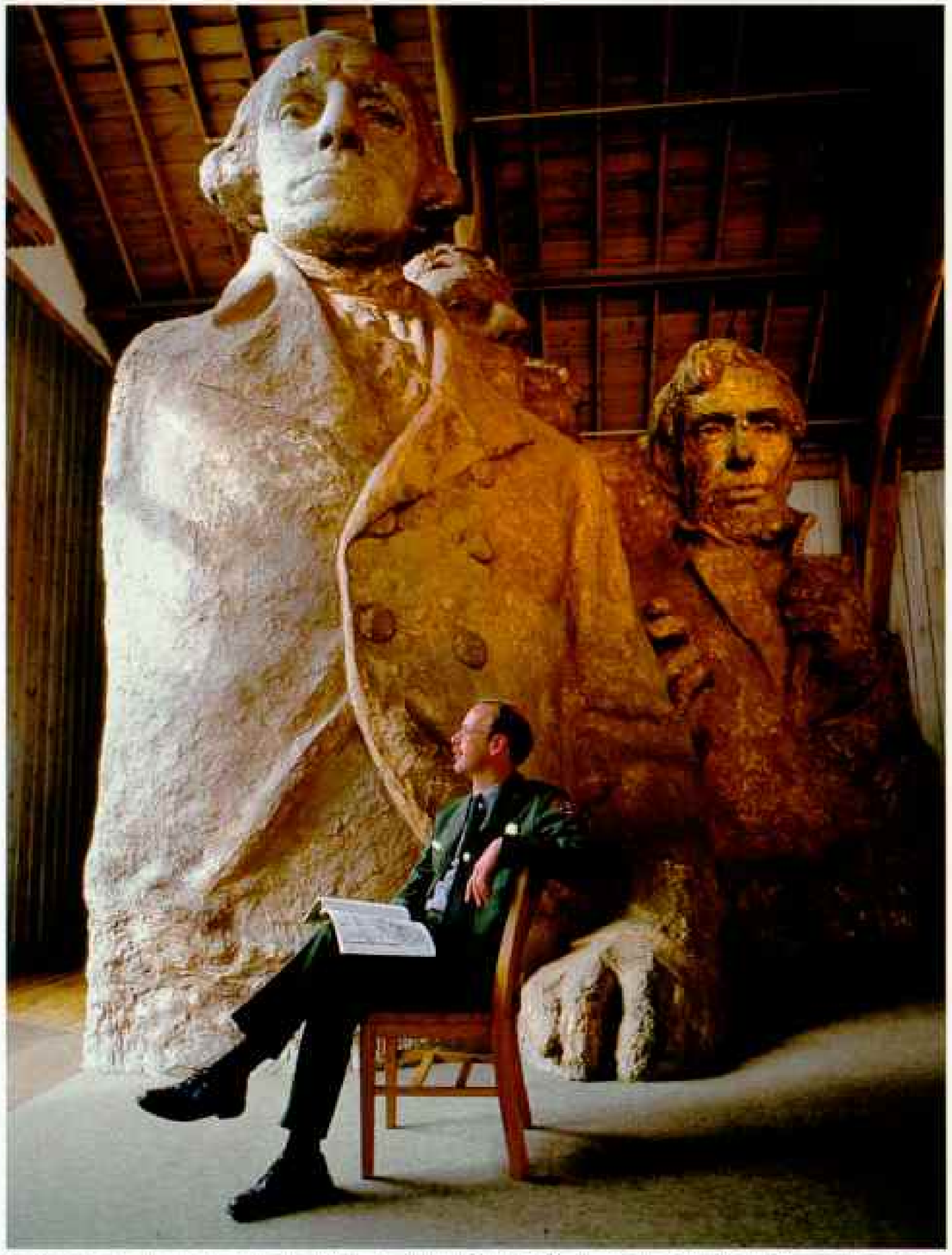
Thirty-six national parks were brought under a single federal agency by this law. Former British ambassador to the U. S. James Bryce called them "the best idea America ever had." In the words of J. Horace McFarland, one of the visionaries who helped establish our National Park Service in 1916, "It is the one thing we have that has not been imported." Other nations had preserved gardens and open spaces—but mainly for the privileged classes. Not so for the U. S. parks, which would be preserved for all.

The National Park System has grown to 357 sites covering 80 million acres, including national parks and monuments, wild and scenic rivers, seashores, historic sites, scenic trails, and battlefields. In addition to natural wonders, such as Yellowstone and Grand Canyon, the Park Service preserves pieces of our history and culture—British cannon surrendered at Yorktown, the derringer that killed Abraham Lincoln, Carl Sandburg's typewriter, even a type of short-legged Hereford cattle bred by President Lyndon B. Johnson.

The service is acutely aware that its lands are among the last natural refuges for America's plant and animal diversity. More and more, it is being called upon to provide scarce habitat for thousands of species and to use the parks as laboratories for research in a world of dwindling wild places. The service's 12,000 employees include those investigating why rare saguaro cactuses are dying in the Southwest, seeking how to protect a shrinking population of sea turtles in the U. S. Virgin Islands, exploring how to get clean water to Florida's Everglades in the right volume, and managing a bison herd in Yellowstone that wanders outside the park.

(Continued on page 42)

Rainwater caught by a sandstone canyon reflects the almost perfect symmetry of flanking cliffs in Capitol Reef National Park, Utah. Dedicated National Park Service personnel protect and interpret such striking landscapes as well as significant monuments to U. S. history and culture for fellow Americans and visitors from around the world. MARC MUENCH



BENEATH MODELED PRESIDENTS, SUPERINTENDENT DAN WENK HOLDS PLANS FOR RENOVATIONS AT MOUNT RUSHMORE, SOUTH DAKOTA.

THE NATIONAL PARK SERVICE 75 ANNIVERSARY

MELTWATER IN A GLACIER CAVE CASCADES PAST A CRYSTALLINE ICE PYRAMID IN ALASKA'S GLACIER BAY NATIONAL PARK. FRED HIRSCHMANN

LEHMAN CAVES IN GREAT BASIN NATIONAL PARK, NEVADA, WEAR A FILIGREE OF LIMESTONE DEPOSITS. JIM BRANDENBURG

"It is a better world with some buffalo left in it, a richer world with some gorgeous canyons

VISITORS EDGE CLOSE AS GOUTS OF LAVA FROM KILAUEA HIT THE OCEAN, STEAM, AND SPATTER IN HAWAII VOLCANOES NATIONAL PARK.

VINE MAPLES DRIP WITH HANGING MOSS, WATERED BY 140 INCHES OF RAIN YEARLY IN OLYMPIC NATIONAL PARK, WASHINGTON. PAT O'HARA

unmarred by signboards, hot-dog stands, super highways, or high-tension lines. . . .” Historian Wallace Stegner, 1955

These concerns reflect a growing sensitivity and sophistication in our understanding of the natural world. In Yellowstone, for example, where bleachers were once erected at the garbage dumps so tourists could watch grizzly bears feeding, the dumps have been closed, the bleachers have been razed, and thousands of dollars have been spent to install bear-proof garbage cans. The bears have returned to their normal diet, and they are healthier.

As our understanding of nature has changed, so has the role of national parks. Most Americans probably still think of picture postcard vistas. But, in fact, most parks today focus on history or culture, and they often are within easy reach of cities and suburbs. And many of today's parks reflect our nation's evolving values and demographic mix.

In San Antonio, Texas, the Park Service is working with the Roman Catholic Church to preserve old missions, representing the heritage of Spanish colonial days. In California, Asian Americans have asked for a national park at Manzanar recognizing the internment during World War II of American citizens of Japanese descent. In Massachusetts, restored 19th-century textile mills at the Lowell National Historical Park sit in a city of 103,000, the site of America's first planned industrial town.

Our park system has been called the "largest university in the world." The prime purpose of the system, says Yale University historian Robin Winks, "is to educate people, with the 357 park units as branch campuses." But this great university faces a number of challenges stemming from overcrowding, understaffing, and budget constraints. In the 1970s our parklands were doubled with the creation of many urban parks and the addition of more than 40 million acres of Alaska lands. But there has been no comparable increase in staff—this during a time when more people than ever, more than 250 million a year, are visiting parks. The number of visitors is expected to grow, with estimates that the parks' popularity will push the annual visitation figure to half a billion by the year 2010.

Today there are parks, such as Great Smoky Mountains and Shenandoah, where millions of feet walk over the same ground during the course of a year. Visitors seeking solitude are often disappointed to find that some parks are beset by the same crowding and noise that afflict cities.

Even the chief of the Park Service is not immune. "On my first visit to Yosemite two years ago," recalls National Park Service Director James M. Ridenour, "it was so noisy outside I had trouble sleeping. It's quieter in my home not far from the nation's capital than it was in the park that night. We hope that we don't get to the point where we'll have to close parks down, but at Yosemite and some other parks we may have to put up a chain across the road and say, 'Sorry, nobody gets in until somebody comes out.' "

While the flood of visitors rises, the federal budget for parks has failed to keep pace, leading to the deterioration of many parks, which suffer under a backlog of maintenance, renovation, and repair that could cost more than two billion dollars. To neglect these projects threatens not only the preservation of our heritage but also public safety.

Not long ago a building at the Martin Luther King, Jr., National Historic Site in Atlanta collapsed. In Philadelphia the roof of Independence Hall leaked for a number of years. At Grand Canyon an abandoned uranium dig emits low-level radiation only a few steps from a visitors path.

Under this stress, park rangers could become an endangered species, victims of too little pay and too much work. Surveys within the Park Service indicate that while many dedicated individuals continue to perform outstanding feats of public service, the general level of morale is at an all-time low. It's understandable. Many rangers who joined the service to be close to nature must increasingly deal with the problems of drug enforcement, vandalism, and pollution. Rangers' average starting salary is only $15,000. Lacking adequate housing, some have been forced to sleep in their cars; others subsist on food stamps. "The rangers of the National Park Service can't live on sunsets," says Representative Bruce Vento of Minnesota, chairman of the House Subcommittee on National Parks and Public Lands. "We're eroding the professional nature of the job."

A ready source of income for the parks could come from concessionaires — private businesses

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PAUL C. PRITCHARD is president of the National Parks and Conservation Association, a nonprofit citizens organization dedicated to defending, promoting, and improving our country's National Park System. Photographer CARY WOLINSKY covered the Kremlin and its treasures for the January 1990 issue.

Patte & Mike Danisiewicz

Saguaro National Monument

Shoulder to shoulder with a saguaro cactus, ranger Mike Danisiewicz and his wife, Patte, a Park Service biological technician, examine the 25-footer to assess the effects of pollution on native plants. In the following pages meet some of the Park Service's 12,000 employees—all in their way as much a natural resource as any rock arch or geyser.

licensed to sell food and hotel space in parks. They operate as monopolies and make more than 500 million dollars a year but return only a small portion of that profit to the federal government. The money disappears into a general fund for use in other programs. But even if Congress mandated that a larger portion of concessionaires' annual earnings be returned directly to the Park Service, this alone would barely reduce the financial strain.

Another approach for stretching federal park dollars has already begun, with the Park Service joining with state and local governments to create jointly operated parks, such as the Lyndon B. Johnson National Historical Park in Texas and the Lowell National Historical Park.

The federal government relies on partnerships with private land conservancies. In the old days the government might have acquired wild lands and unique habitats. These days private conservation groups buy lands and manage them as preserves or hold them in trust until they can be transferred to the Park Service. Concerned citizens have also established the National Park Trust, which is raising money to buy the two million acres of private lands within our national parks. The idea is to hold these lands safe from development. Businesses also contribute to the trust, gaining goodwill in the process.

Such partnerships will carry the Park Service into its next 75 years, according to James Ridenour. "Without the active involvement of state and local governments and the private sector, we could not begin to preserve—let alone manage—the land needed to meet the outdoor recreation and open-space needs of our population. The natural resources of the parks are under increased stress . . . the present and future health of the system depends, to a great extent, on the level of public support we can achieve."

This anniversary has rekindled concern for the well-being of the National Park Service. Americans care deeply about their natural and cultural heritage, and they admire the dedicated individuals who keep our parks open. Without such people, some of whom you will meet in these pages, there could be no national parks.

PORTFOLIO TEXT BY
CATHY NEWMAN
NATIONAL GEOGRAPHIC SENIOR STAFF

Sonny Bass

Everglades National Park

With 80 pounds of tranquilized Florida panther draped around his neck, Park Service wildlife research biologist Oron "Sonny" Bass heads to a mobile medical unit with Melody Roelke, a veterinarian for the state of Florida. There the big cat's blood, feces, semen, and saliva will be sampled, and its radio-tracking collar will be refitted.

The Florida Panther Recovery Project is a joint effort between state and federal agencies to study and save the 30 to 50 panthers that live in the wild.

The Everglades and adjoining areas are the last stronghold of the panther, nearly eliminated by hunting and diminished habitat. That panthers need room is indisputable. Bass has tracked one panther over a 600-square-mile area.

"They're tough," says Bass, who has also studied eagles, manatees, and the Cape Sable seaside sparrow in his 15 years with the service. "They use everything they've got to survive."

Sometimes that is not enough.

The imperiled Everglades, utterly dependent on free-flowing water, must compete for the resource with agriculture and the growth of Miami. The habitats of park plant life and of wildlife like the panther hang in the balance.

Jeff Judd

Hawaii Volcanoes National Park

Jeff Judd is a law-enforcement officer, but at Hawaii Volcanoes everybody ends up doing first aid. Despite signs warning about heat exhaustion, poisonous fumes, and the razor-like edges of lava underfoot, visitors get into trouble hiking in to see the spectacular flow streaming down Kilauea. They wear sandals on the sharp, slick flow or, disregarding hazard signs, trek out on the lava outcrop that hangs tenuously over the Pacific and can break at any time without warning.

"You can't stop them. We treat injuries all day," says Judd, descended from a personal physician to Hawaiian kings, here bandaging an injured hand.

Visitor protection is a constant headache, and sometimes heartache, at all parks. Rangers can tell an unending litany of horror stories about visitor negligence. Some end in death.

At a western national recreation area some years ago, a man took his young son fishing but brought only one life vest along. When the boat capsized, he put the vest on his son and pushed him toward shore. "I love you," he said.

JERRY YARBROUGH

WHITE SANDS NATIONAL MONUMENT

For chief ranger Jerry Yarbrough keeping what he calls "the sandbox" clean can be as simple as stooping to retrieve a carelessly tossed beer can or as complex as helping the Army haul out a thousand-pound piece of scrap from an aircraft by truck (right).

The cool, white dunes of the park near Alamogordo, New Mexico, are pure gypsum, and they are surrounded by the White Sands Missile Range. About a hundred times a year the park shuts down for an hour or two while the Army conducts tests.

Yarbrough goes on a helicopter spotting mission looking for debris (upper right). Each year the Army retrieves several tons of scrap.

For many, being a ranger is a calling, more religion than job. But it has its cost. Salaries are low, hours long, and moves frequent and abrupt. Yarbrough has uprooted his family six times since joining in 1971.

Still, he'd never dream of doing anything else. Satisfactions range from the profound—saving a life—to the pleasantly small—receiving a mailed package filled with the fine, white sand.

"From someone who took a bit of dune home with them, then thought better of it," Yarbrough explains.

Mary Meagher

Yellowstone National Park

That's not just a bison in the spotting scope research biologist Mary Meagher holds—it's a last vestige of frontier.

Yellowstone holds some of the few free-roaming bison left in the country. They are doing well, perhaps too well. After the park opened to winter use in the 1960s, snowmobiles opened roads that made it easy for bison to forage. The herd increased to perhaps 3,000. Pressed for space, bison leave the park and are shot; some ranchers fear strays may infect their cattle with brucellosis.

The bison overpopulation confirms Meagher's belief that "too many people in a park cannot help but impact nature." Intricate business: balancing bison and people. She sides with bison. "We need wild bison as reference points. Scientifically and spiritually."

Bobby Mattos

Hawaii Volcanoes National Park

It takes the nose-in-the-wind instincts of a hunter like Bobby Mattos to find a feral pig (right). Pigs were introduced to the Big Island to provide meat for early settlers. The most destructive pests in the park, their appetite for plants threatens the last relics of native tropical forest.

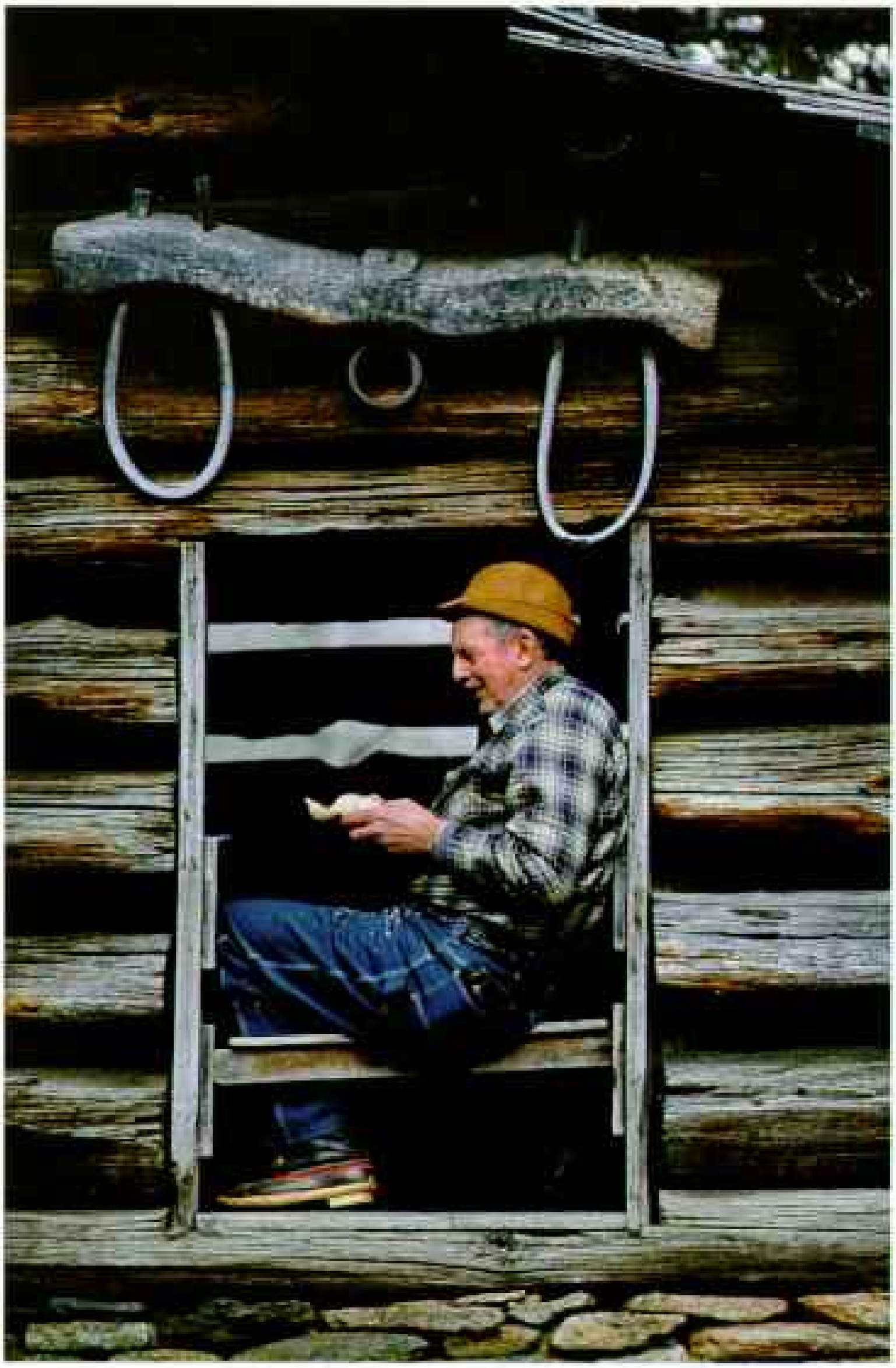
In 1981 the pig wars began. Forest was fenced off section by section, and the pigs were hunted in an effort to reclaim the park for native vegetation.

Dogs track the pigs but can lose their way in the thick jungle or slip into

DAVID BOYNTON

30-foot-deep cracks obscured by vegetation on the lava terrain. So they are fitted out with radio collars (as was photographer Cary Wolinsky, a precaution against losing him).

So far 20,000 acres have been recovered, though some 2,500 pigs remain at large. When he's not hunting, Mattos pulls up exotics—introduced plants that overrun the indigenous flora. And bit by bit, natives like the *'ohi'a-lehua* trees and *hapu'u* tree ferns spring up and flourish as a corner of native Hawaiian rain forest is reclaimed.



Festus Bourne

Blue Ridge Parkway

"Carving a duck is simple," says Phipps "Festus" Bourne, as he whittles a block of white pine. "You just get it in your head what it looks like—and cut off everything that doesn't look like it."

Festus has been a seasonal ranger at the Blue Ridge Parkway for 20 years. The parkway, a 470-mile ribbon of two-lane road, wanders along in its own sweet time from Rockfish Gap, Virginia, to Cherokee, North Carolina. Festus can be found at Mabry Mill—a working gristmill and blacksmith shop off the parkway, 40 miles up the road from where Virginia cozies up to North Carolina. It's been said the mill doesn't live in the past. Thanks to Festus it takes you there.

He can craft a dulcimer, a door hinge, a roof shingle, or a belly-shaking story. Ask him to tell his yarn about mule eggs. Or the tale about the time he carved a wooden foot for a man with a wooden leg.

They all end with a grin as broad and bright as the view from Groundhog Mountain on a summer day.

Ailema Benally

Hubbell Trading Post National Historic Site

In a room of rugs woven by Navajo hands, cultural interpreter Ailema Benally explains how Navajo like her mother and grandmother traded their handiwork for groceries at the Hubbell Trading Post.

For Ailema there is a deeper resonance to the post, still in operation today in Arizona. Here she came to understand her identity as a Navajo.

"As a child, I played with Barbie dolls and joined the Girl Scouts. Navajo culture was left out of my life. Working at the trading post has opened a different set of values to me," she says.

Fourteen years ago she suffered an automobile accident and the loss of a job and boyfriend in one week. A relative suggested she see a medicine man. He discovered a curse had been placed on her; through ceremony it was broken.

"John Lorenzo Hubbell, who founded the post in 1876, could look beyond his own world and see the Navajo not as savage but as having a different, rich culture. I hope visitors can take some of this home in their hearts."

Mike Williams

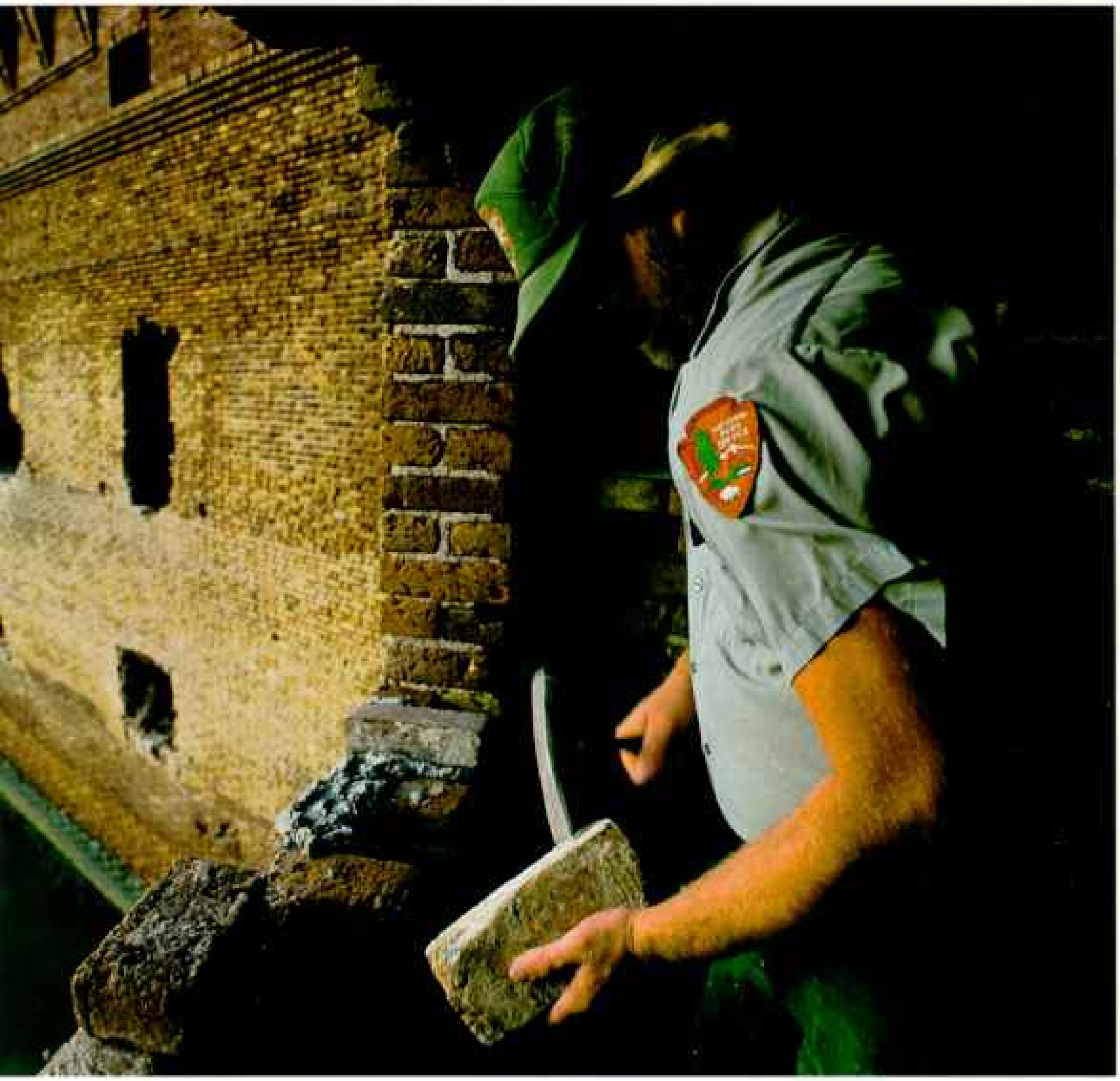
Boston National Historical Park

Bringing a unicorn down to earth is a first step in a ten-million-dollar renovation of Boston's Old State House, built in 1713, and nearby Faneuil Hall. Supervised by engineer Mike Williams, here with his hand on a leg, the project is one of many overseen by the Denver Service Center, the planning, design, and construction division of the Park Service. The unicorn will be regilded and its bracing strengthened.

The buildings are owned by Boston but are part of a park administered by the Park Service in a cooperative arrangement among federal, city, and private organizations.

In his behind-the-scenes job Williams has designed an oil-spill prevention plan for Glacier Bay and a sewage treatment plant for Yosemite.

"I could make more money in the private sector. But I'd never get to work on buildings like this."



Stephen Siggins

Fort Jefferson National Monument

Call it a mason's dream—or maybe nightmare. Fort Jefferson National Monument has 16 million bricks. "At the very least," says mason Stephen Siggins, here working on one. Siggins belongs to a team of Park Service masons who travel the Southeast.

Started in 1846 but never finished, the fort, which sits on a slip of an island 70 miles west of Key West, was designed to protect shipping lanes in the Straits of Florida. A federal prison during the Civil War, it later held some of the men convicted of complicity in the assassination of President Abraham Lincoln.

It was made a national monument in 1935; restoration began two years ago. The fort was large enough to garrison 1,500 men. Today ten park personnel are based there.

Patching up the eight-foot-thick walls of this masonry marvel is a challenge, says Siggins. And not without its small surprises. Recently a mason found an old half-smoked cigar behind some bricks. "Like the boss came along suddenly and a workman put it out."

Leon Alsworth

Lake Clark National Park

He flies a mosquito of a plane. "You wear it like a shoe," says photographer Cary Wolinsky of the two-seater.

The plane, here on ice at Alaska's Lake Kontrashibuna, is indispensable. "There are no roads in the park," says Leon Alsworth, pilot and ranger.

Weather permitting, he's in the air tracking radio-collared caribou, looking for poachers, or, when need be, flying search-and-rescue missions. He can land on a patch of ice or snow the size of a football field.

It's real seat-of-the-pants flying, says his supervisor. In a crunch, Leon's the man you want at the controls.

But then he soloed in a plane before he got his driver's license.

He lost his father and brother in airplane crashes but doesn't dwell on that. "Flying is my job," he says simply, as if that says it all. And it does.

Ralph Tingey

Northwest Alaska Parks

Cold nose, warm heart: An exercise run on the sea ice near Kotzebue ends with a face licking for Ralph Tingey, superintendent of a three-park region near the Arctic Circle. Tingey breeds huskies, which compete in races like the Iditarod. The sport gives him a bond with the area's 5,000 or so native people, and managing their subsistence hunting is one of his major responsibilities.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Clark Moore

Martin Luther King, Jr., National Historic Site

When the bell signals the end of day at Our Lady of Lourdes Catholic School, Chasidy Moore skips across the street to park headquarters, where her dad, Clark, is chief ranger.

The park, a 23-acre area of Atlanta where Martin Luther King, Jr., grew up, is a living, breathing neighborhood as well as a historic site. Children play tag on the playground down the street from the Ebenezer Baptist Church, where the civil-rights leader preached. Elderly folks sit on their front porches and take note of tourists who enter the house at 501 Auburn Avenue, King's birthplace.

The house is a simple two-story wood structure. In the dining room, Moore will tell you, Daddy King made each child recite Bible verses and discuss world events when the family gathered for meals.

A father himself, Moore finds a lesson: "As the child grows, so grows the man."

King's grave is just down the street. "Free at last," the letters on the tomb say. "Free at last. Thank God almighty. I'm free at last."

Calvin Bahe

Canyon De Chelly National Monument

He decided to teach his sons to box. Then their friends got interested, and now Calvin Bahe, here training his son Johnny, runs a boxing club. His 15 kids come from as far away as Kayenta, Arizona, a 120-mile drive. Along with advice on left hooks, Cal, a Park Service law officer, and his wife, Judy, a social worker, counsel the kids on drug and alcohol problems.

"Boxing gives them self-esteem," Cal says. This year one star pupil made it to national competitions, the first Navajo to do so. The Bahes are proud of their champ, and of the kids' personal victories as well. One teen lost his father and in grief turned to drugs. "He worked it out with us," says Judy.

Canyon de Chelly, where prehistoric Indians built dwellings in sandstone cliffs, is on Navajo tribal land, but the Park Service administers the monument. Cal must uphold the law but be sensitive to his Navajo community.

As visitors to parks increase, so does crime. Last year the Park Service recorded 1,683 arrests for serious crimes.

Parklands'

FROM sea to shining sea and beyond, the National Park System celebrates an inventory of 357 sites covering 80 million acres. The system includes North America's tallest mountain (Mount McKinley, or Denali, in Alaska), the world's largest known cave system (Mammoth Cave in Kentucky), and such American icons as Independence Hall and the Statue of Liberty. Categories listed at right barely

growing pains

reflect the park system's diversity, ranging from volcanoes, canyons, and seashores to forts, battlefields, and homesteads.

In 1960 the Park Service managed 187 sites covering 26 million acres. Since then parklands have trebled in area, partly because the public has pressed to protect unique features of the United States. In 1978 President Jimmy Carter added more than 40 million acres of Alaska wilderness.

In the past three decades the number of visitors has more than trebled as well: from 80 million to 257 million. Today two-thirds of Americans have visited at least one site. But budgets have not kept pace with public use and land acquisitions, thereby forcing hard choices in the allocation of funds for site maintenance, equipment repairs, and staffing.

A COMEBACK FOR NUCLEAR POWER?

OUR ELECTRIC FUTURE

By PETER MILLER ASSISTANT EDITOR

Photographs by
ROGER H. RESSMEYER STARLIGHT

Though it appears limitless as it flows into San Jose, California, our nation's electricity supply could soon come up short. Are new nuclear power plants the answer?

IT WAS JUST BEFORE MIDNIGHT when Larry Taylor got the phone call. He hadn't gone to bed yet. The 50-year-old executive of Florida Power & Light Company was pacing in his living room. As director of power supply for one of the nation's largest utilities, he was responsible for keeping the electricity flowing to nearly six million people. On this night, December 23, 1989, he had plenty to lose sleep over.

For the past week a mass of frigid air had been racing south across the United States. Record low temperatures had been registered in 25 states: minus 45°F in Havre, Montana; minus 26° in Topeka, Kansas. By Friday morning the cold front had reached northern Florida. By Saturday afternoon it was snowing at Cape Canaveral.

Taylor knew this meant big trouble. Even if everything worked perfectly, FPL's system would creak under the strain as customers up and down the peninsula pushed up their thermostats—75 percent of all Florida houses depend on electric heat.

And there had already been problems. Two generators had to be shut down when their natural gas supplies were diverted to more desperate parts of the country. Other plants were struggling with frozen control lines and clogged filters. And there was no way to buy more power from other utilities.

It's going to be close, Taylor worried.

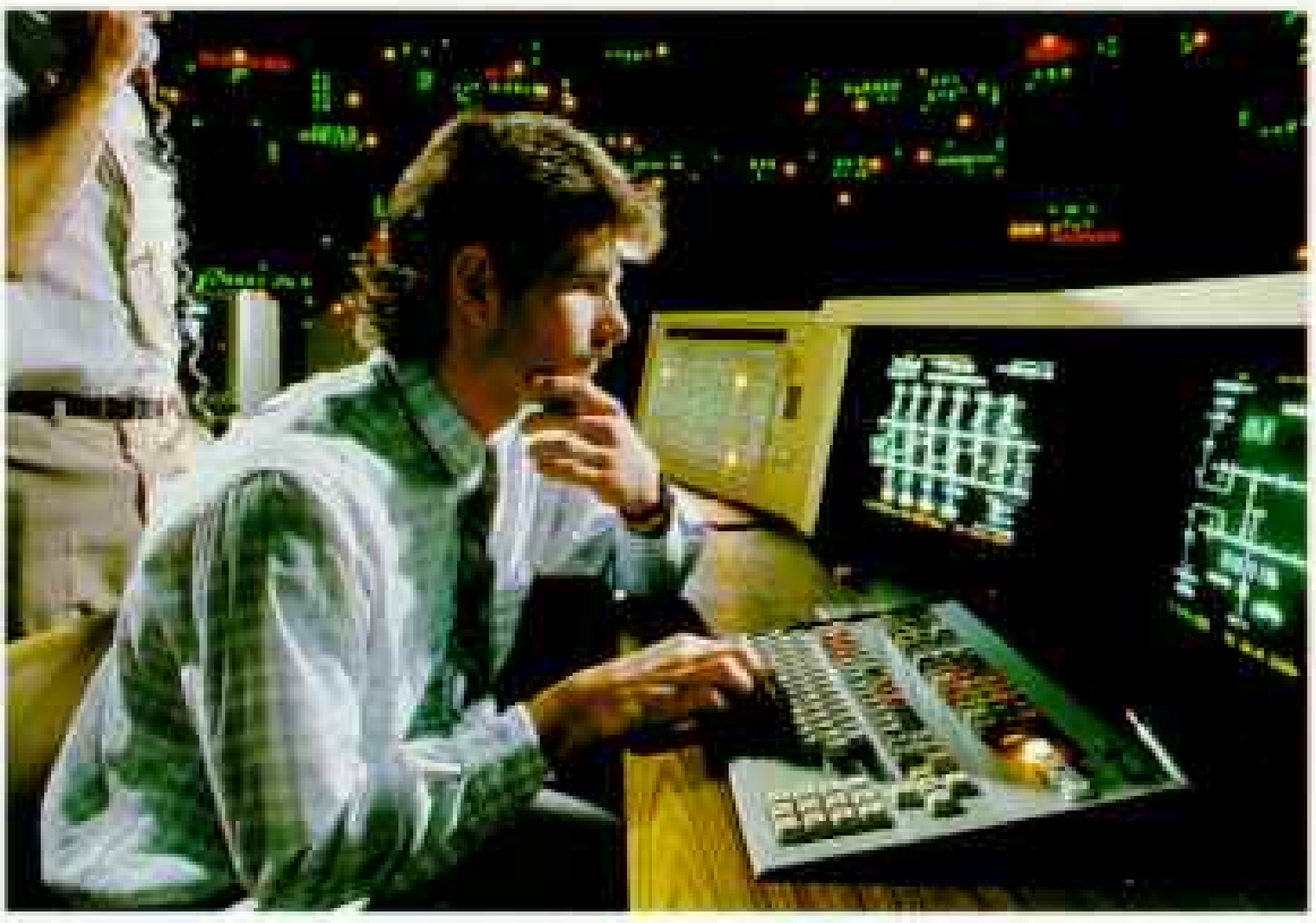
For hours FPL had appealed to customers to turn off holiday lights, lower thermostats, and delay Christmas cooking. But there was still a question in Taylor's mind whether the system could meet the challenge. Arriving home late from his office, he thought it just might—until the phone rang.

It was the control center in Miami: One of the nuclear reactors at the Turkey Point plant 30 miles south of the city had just blown a fuse. This posed no immediate safety threat, but it knocked 700 megawatts of power off the grid—enough to serve 160,000 houses.

That's it, he thought. Ball game.

Florida was about to experience the kind of emergency that analysts have been warning about for years—and not only for that state. After two decades of reliable power, the mid-Atlantic states and the Southeast, particularly Florida, are being threatened by blackouts, especially during heat waves and cold spells. If adequate steps aren't taken in parts of the Midwest and California, residents of those areas too may soon find themselves in the dark.

The lights started going out in south Florida around 6 a.m. the day before Christmas. As consumption rose—nearly doubling the peak hit the previous Friday—the public's thirst for electricity outpaced FPL's ability to produce it. To keep the entire system from failing, managers began "rolling blackouts," cutting power to hundreds of neighborhoods for periods as long as 30 minutes.



POWER BROKER

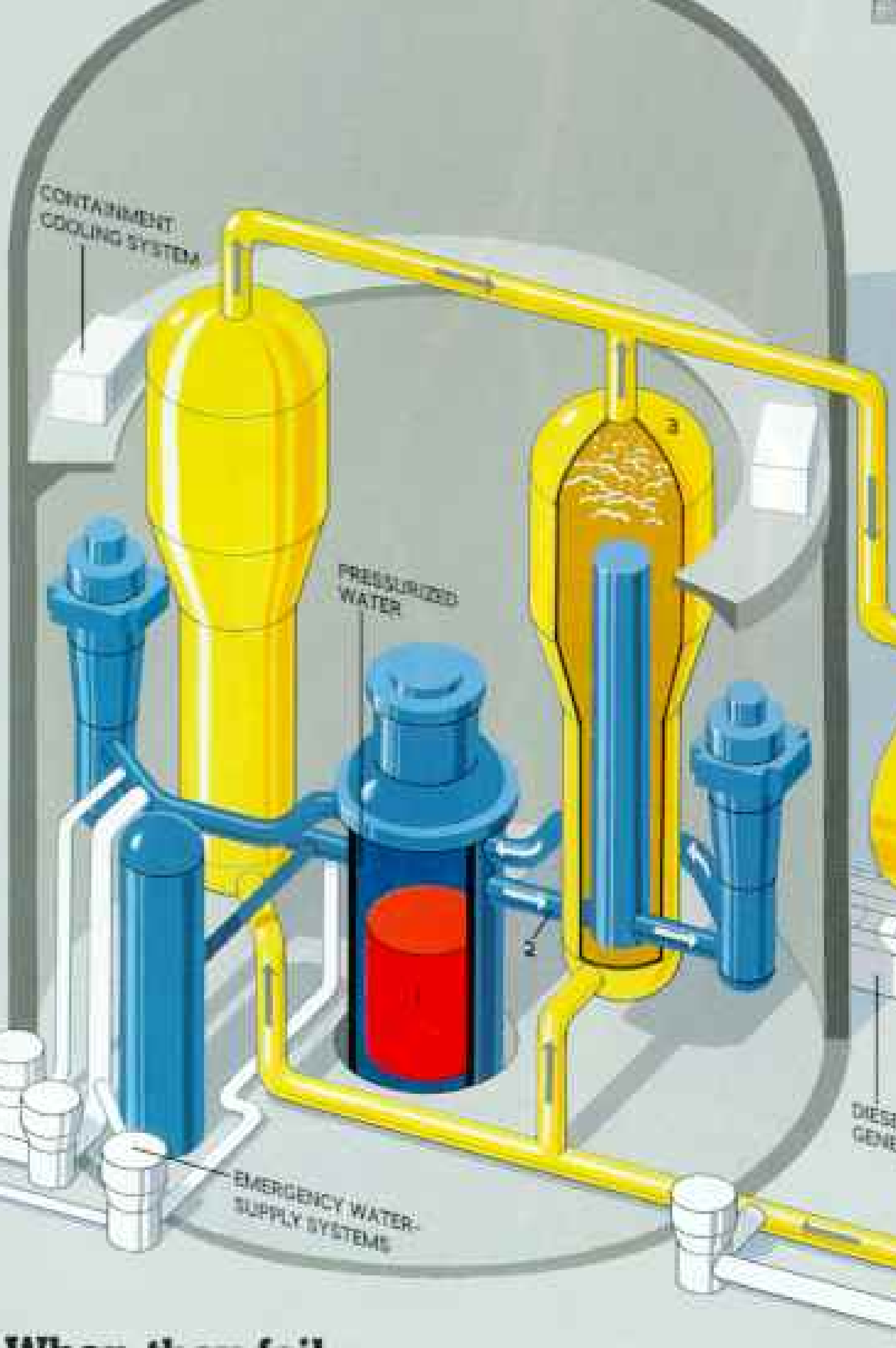
Poised at the energy control center for the city of Los Angeles, Don Sievertson monitors a network of power lines and substations in the San Fernando Valley. Balancing supply and demand throughout the entire city, load dispatchers also buy, sell, and trade power with other electric utilities in the region.

A potential hazard to high voltage lines, lightning is simulated by 1.3-million-volt surges at a research center in Lenox, Massachusetts (opposite). To protect the public from power shortages of all kinds—not only those caused by weather—planners are studying new ways to generate and distribute electricity.

REACTOR DESIGNS: NEW AND IMPROVED?

SINCE THE 1979 MELTDOWN at Three Mile Island in Pennsylvania (right), emergency shutdowns at the nation's 113 reactors have been reduced by three-fourths. Yet some analysts say the chances of a severe accident within the next 20 years remain as high as 25 percent. To improve the odds, designers have gone back to the drawing boards.

BETTMANN ARCHIVE



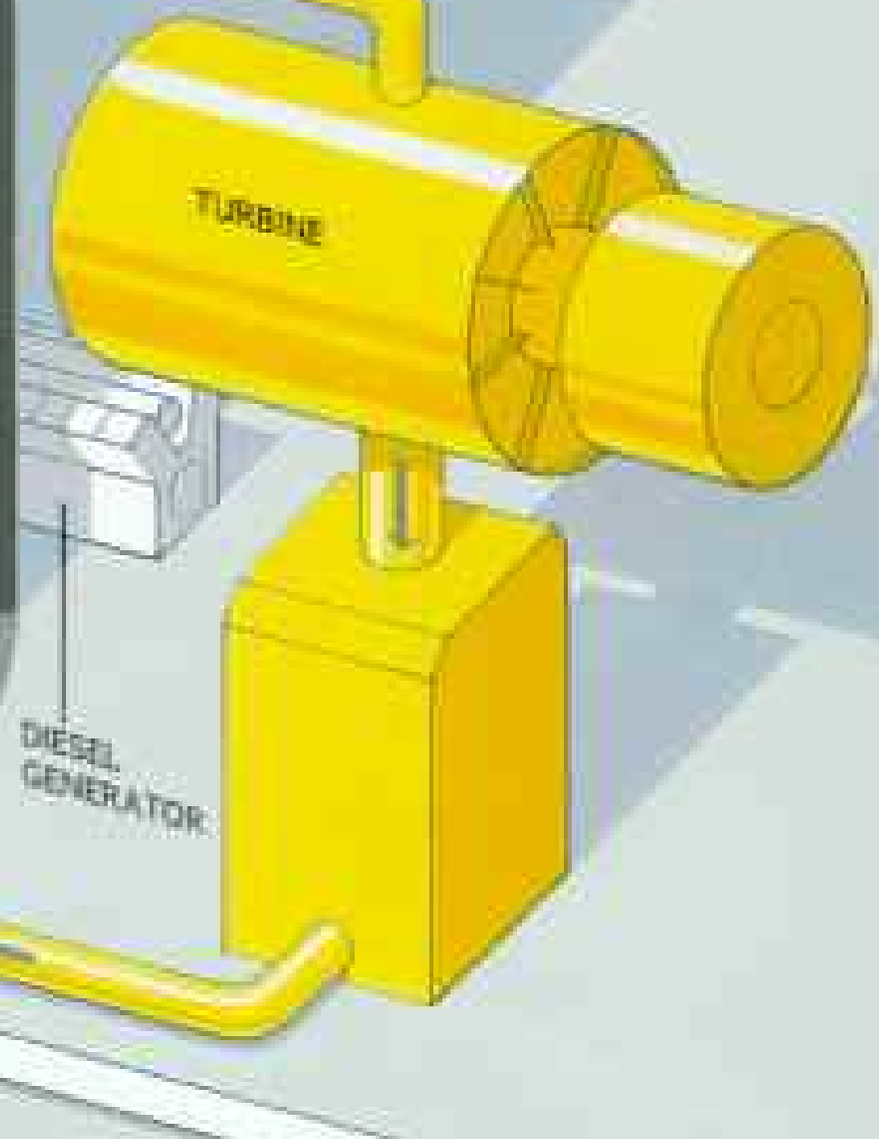
How nuclear reactors work

All commercial units create electricity by boiling water. A typical reactor (left) produces 1,000 megawatts (MW) of power through the following steps:

1 **Reactor core** creates heat through the splitting of uranium atoms.

2 **Pressurized water** in the primary (coolant) loop carries heat to the steam generator.

3 **Steam generator** vaporizes water in a secondary (power-generating) loop to drive the turbine.



When they fail

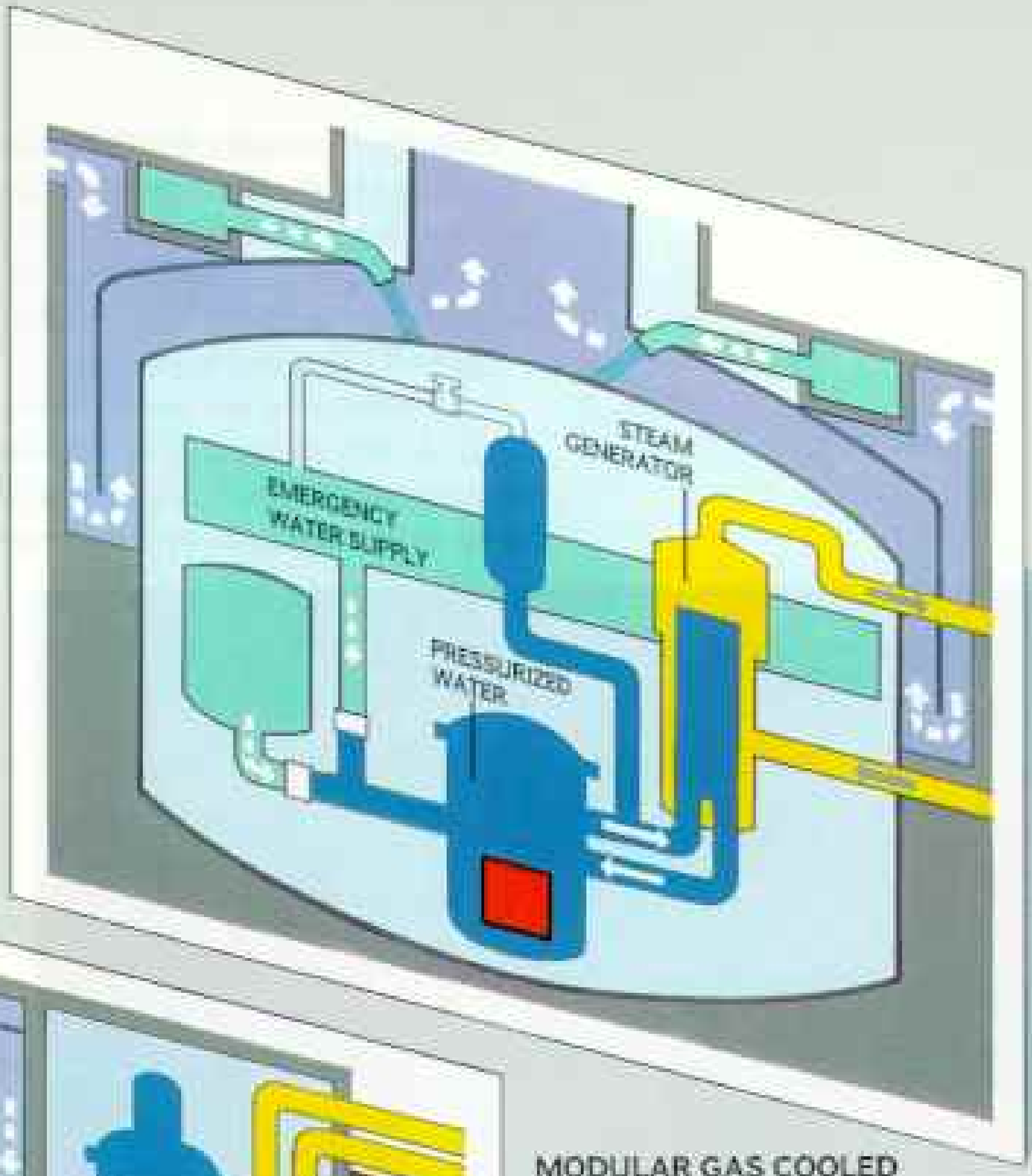
Though most water-cooled reactors have operated safely during the past three decades, some components have proved troublesome. Among them: steam-generator tubes prone to crack, valves that fail to open or close, and backup electric sources vulnerable to interruption. When emergencies arise, reactor safety depends entirely upon backup mechanical and electric devices—themselves vulnerable to breakdown. By contrast, proposed reactors would use gravity, natural air flow—convection—and evaporation to give operators more time to respond. In addition, the reactors would operate at reduced power, sacrificing output for added safety.

The goals: simpler, safer, less costly

PASSIVE WATER COOLED

Replacing active safety systems with more reliable passive ones, the AP600 (right) would position tanks of water above the reactor core to flood it by gravity during an emergency. Sprinklers would cool the outside of the steel containment vessel. Prefabricated modules could speed construction.

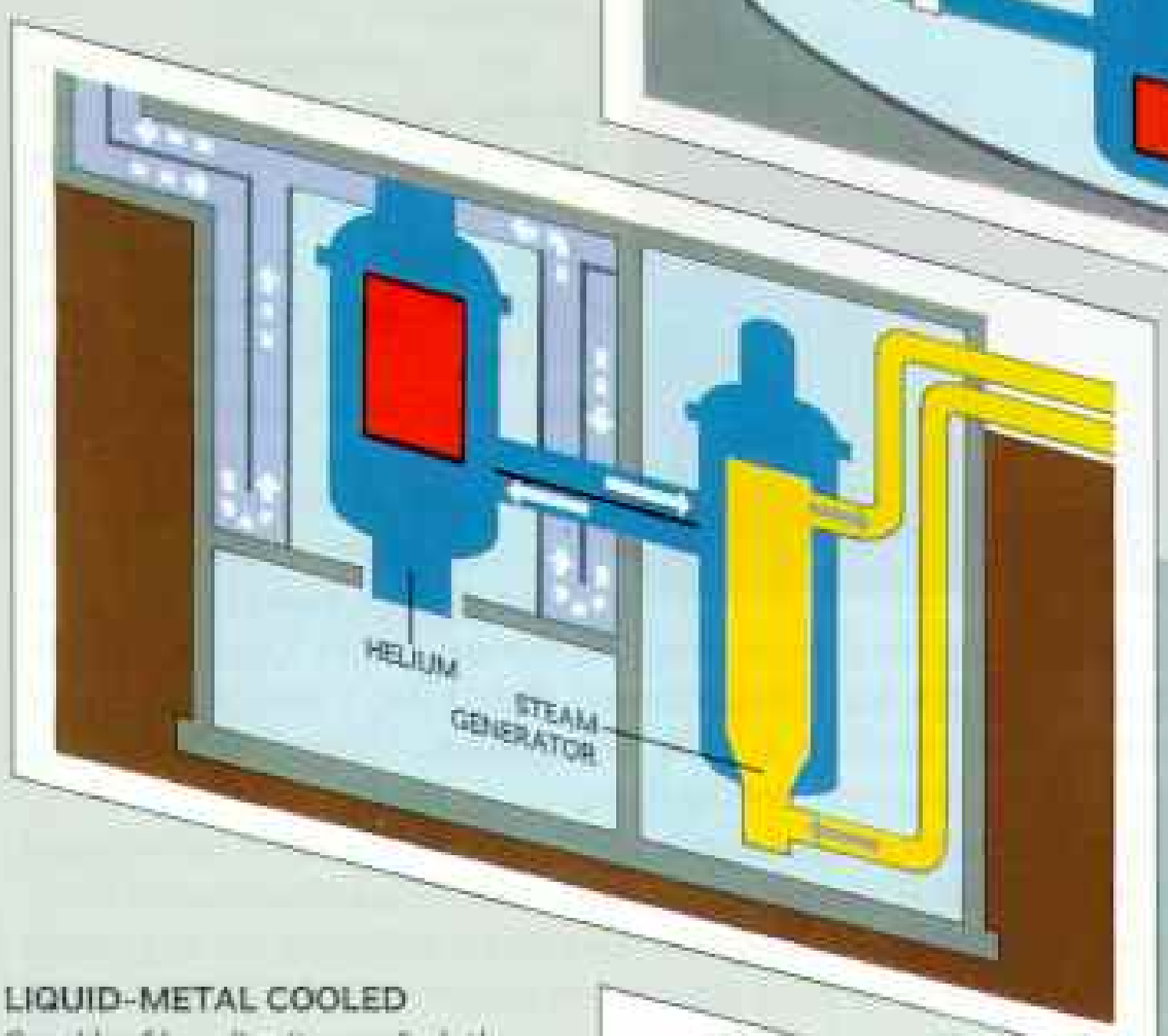
DESIGN: Westinghouse
FUEL: uranium dioxide
COOLANT: pressurized water
OPERATING TEMP: 600°F
GENERATING CAPACITY: 600 MW



MODULAR GAS COOLED

The MHTGR (Modular High Temperature Gas-Cooled Reactor) would run on coated uranium pellets in a system that is virtually meltdown proof. Using helium as a coolant, it could operate at high temperatures, making it more efficient. And it could supply, as a by-product, the high-temperature steam needed for industrial processes like coal gasification. Four modular reactors would be grouped together at each plant.

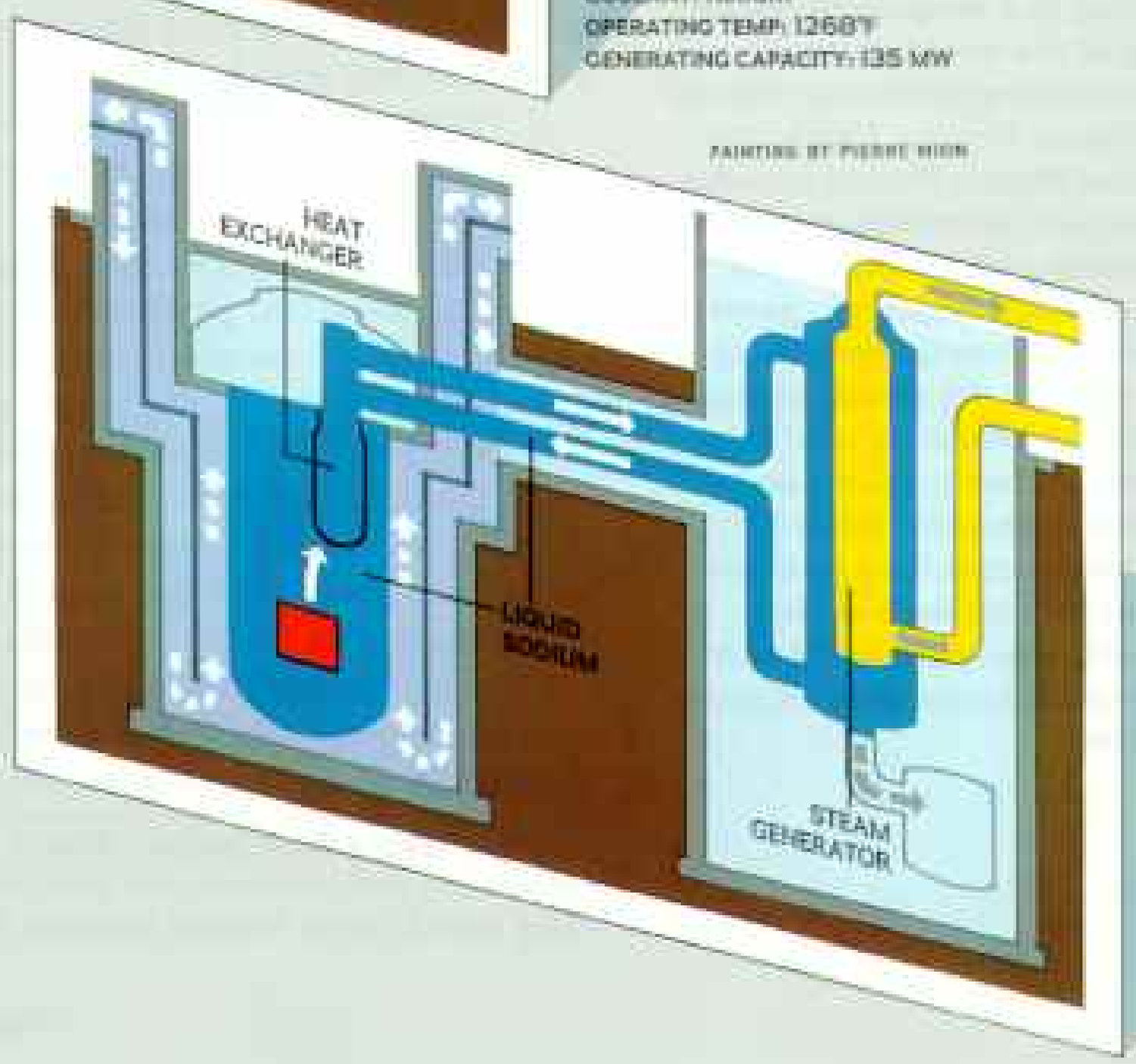
DESIGN: General Atomics
FUEL: coated uranium pellets
COOLANT: helium
OPERATING TEMP: 1268°F
GENERATING CAPACITY: 135 MW



LIQUID-METAL COOLED

Capable of breeding its own fuel, the PRISM (Power Reactor Innovative Small Module) could help uranium supplies last centuries longer. Its core would be submerged in liquid sodium—a metal that can absorb large amounts of heat but must be protected from contact with air or water. Nine reactors would be grouped together at a single power plant.

DESIGN: General Electric
FUEL: uranium/plutonium/zirconium
COOLANT: liquid sodium
OPERATING TEMP: 905°F
GENERATING CAPACITY: 155 MW



PAINTING BY PIERRE HION

- REACTOR CORE
- COOLANT LOOP
- POWER-GENERATING LOOP
- MECHANICAL BACKUP SYSTEMS
- AIR DUCTS TO CARRY AWAY HEAT
- EARTH
- MECHANICAL CIRCULATION
- NATURAL CIRCULATION

Even high-priority facilities such as hospitals and police and fire departments were eventually cut off. Officials in West Palm Beach told residents to boil drinking water after the water-treatment plant lost power. Families found themselves opening Christmas presents by flashlight and warming holiday food by candles.

Larry Taylor was miserable: "I felt like I let everybody down."

A blackout like the one in Florida reminds us how deeply we in the U. S. rely on electricity. It's easy to forget what keeps the light shining on the porch, the water steaming in the shower, the beer frosty in the refrigerator, what brings the television to life, runs the machines in the factory, the elevators in the office tower.

And our dependence is growing. During the past two decades our use of electricity has increased 92 percent.

Yet construction of new power plants has leveled off. Big facilities begun in the 1970s, including many nuclear ones, created a surplus of electricity that has lasted until now. But many of these projects cost far more than expected, and state regulators prevented utilities from passing along cost overruns to consumers.

As a result, most utilities simply dropped out of the construction business, says Eugene Gorzelnik of the North American Electric Reliability Council, a private research firm serving electric companies. "There was just no incentive for them to take the risks."

To make matters worse, many older plants are about to be forced into retirement. The average age of coal-burning plants in the U. S. is more than 25 years, and new laws on air pollution are beginning to bite—as many as 20 of the dirtiest polluters in the Midwest and Southeast may soon be shut down.

If current estimates are correct and electricity consumption increases by about 2.5 percent a year, we could be headed for real problems. At that rate the nation could require within the next 20 years an additional 270,000 megawatts—the equivalent of 270 large coal or nuclear power plants.

The threat of shortages may be delayed if the economy slips deeper into recession. Or, more positively, the threat may ease thanks to changes in the utility industry itself. Driven by state regulators to hold down costs, many power companies have been turning to conservation programs to reduce demand and to private generating firms to fill the gaps with new capacity—both unconventional approaches in a traditionally conservative industry.

As policymakers confront these issues, America's long-buffeted nuclear industry sees a chance for a comeback. Its solution: a new generation of reactors—ones the designers say would be safer

NUCLEAR RECYCLING CENTER
Too hot to handle, used radioactive fuel sets water aglow in a 30-minute time exposure (facing page). The fuel rods are cooling in a temporary storage pool at the world's largest reprocessing plant near Cap de la Hague, France. Unlike the United States, France recycles used fuel, chemically separating uranium and plutonium for reuse. The process is expensive and controversial because of fears about the spread of plutonium, which can be used for bombs. Waste products are sealed in glass for burial. A technician monitors radiation at the 65-foot-deep wells (above) where the wastes are stored until a permanent site is selected.

Award-winning photographer ROGER H. RESSMEYER has covered space exploration and astronomy for the GEOGRAPHIC. He lives in Sag Harbor, Long Island, about 30 miles from the Shoreham nuclear power plant.

and less expensive than earlier models, environmentally friendlier than coal plants, yet powerful enough to satisfy electricity demand.

The nation's 113 nuclear reactors already generate 20 percent of our electricity. The new reactors being promoted are designed to be more tolerant of human error, giving operators hours instead of minutes to react to emergencies. They would be simpler to put together, reducing construction time and costs. And, like current reactors, they would produce neither the pollutants that cause acid rain nor the carbon dioxide that adds to global warming—all of which are given off by fossil fuels such as coal, oil, and natural gas.

Yet nobody appears to want these nuclear machines—neither the utility executives who would buy them, nor the investors who would finance them, nor the state regulators who would approve the purchases, nor many of the citizens who would live near them and tap into the power they would produce. Even if a power company was to place an order for one, it might never get the chance to build it, given the financial and political obstacles.

In short, though the nation needs more electricity, neither fossil fuels nor nuclear energy—our two main sources—appear desirable ways to generate it any more. How did we get into such a fix?

FRENCH PRIDE
Like peas in a nuclear pod, four 1,300-megawatt reactors face the Normandy coast at Paluel. Using standardized designs, the French build such plants in less time and for less money than comparable U. S. stations, most of which are custom-built. France's 55 nuclear reactors provide 75 percent of that nation's electricity.

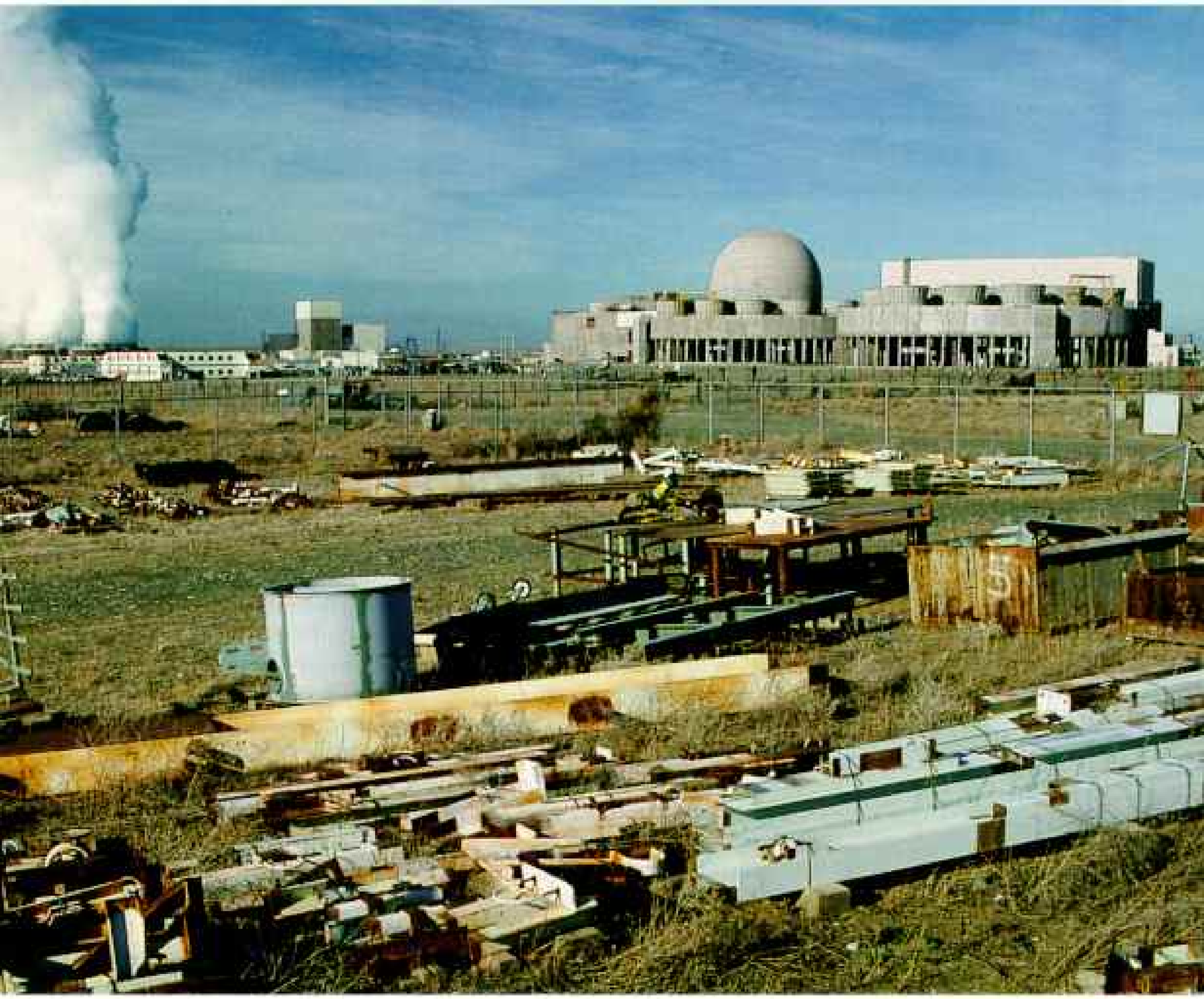
FIFTY-FIVE MILES east of New York City on the north shore of Long Island stands a silent nuclear power station with robin's-egg blue walls that holds clues to the nuclear side of this question.

The Long Island Lighting Company (LILCO) began building the Shoreham plant in April 1973 to supply rapidly growing Long Island. Delayed by protests from nearby communities as well as by federally mandated design changes, the plant escalated in cost from 300 million to 5.5 billion dollars before it was completed in December 1984.

Yet it has never produced a single watt of commercial power.

Instead Shoreham became the focus of a debate between state and national officials over which level of government should control the location of nuclear power stations. Maintaining that the nearby towns could not be safely evacuated during an emergency, Suffolk County officials and New York Governor Mario M. Cuomo invoked states' rights to keep the plant from opening, while U.S. Secretary of Energy James D. Watkins, citing national energy needs, fought to prevent Shoreham from being dismantled.

Caught in the middle, LILCO shareholders cut their losses. In



AMERICAN FLOP
Scattered across a "lay down" yard at Hanford, Washington, parts for an unfinished nuclear plant grow more obsolete by the day. Of five reactors started in the 1970s by the Washington Public Power Supply System, only one has been completed. The utility ultimately defaulted on 2.25 billion dollars in bonds. Such financial disasters helped put an end to nuclear construction in the United States.

June 1989 they agreed to sell Shoreham to the state for one dollar in return for a decade of higher rates to help recover their costs. The message was clear: Nuclear projects would continue to be bad money risks as long as opponents could get them delayed or even canceled.

The record of financial disasters is dismal. More than a dozen nuclear projects have nearly ruined the utilities that have dared to undertake them—whether through political problems or mismanagement. In one of the worst cases, the Washington Public Power Supply System, a consortium of 115 public utilities in the Pacific Northwest, defaulted on 2.25 billion dollars of municipal bonds in 1983 when it tried to build five reactors at the same time. Only one was finished.

During the past 20 years, tens of billions of dollars have been wasted in this country on nuclear projects that were never completed—or, like Shoreham, completed but never used—a figure that still terrifies investors. "If a utility was to announce plans to build a new nuclear plant under today's regulations," says energy banker Anthony V. Leness of Merrill Lynch & Co., "most investors would rush to sell their holdings in that company."

As damaging as it's been, however, the threat of huge financial losses is only one of the demons frightening away potential supporters of nuclear power. The accident at Three Mile Island in 1979 cast another shadow over the whole industry. Through operator error at the power plant near Harrisburg, Pennsylvania, cooling water dipped below safe levels in one reactor and triggered a meltdown. Because the steel vessel encasing the melted uranium did not allow the radioactive fuel to escape, there were no injuries. But the meltdown called into question the safety of every reactor in the U. S.

Earlier incidents came back to public attention: a partial meltdown at an experimental reactor near Detroit in 1966; a fire at an Alabama plant that destroyed essential power cables in 1975; a close call in California in 1978 when a worker dropped a light bulb on a control panel, short-circuiting part of the electrical system.

With each disclosure the public's anxiety increased. (The rupture of a coolant tube in a Japanese reactor in February—activating the emergency cooling system—may weaken support for that country's plans to build 40 reactors during the next 20 years.)

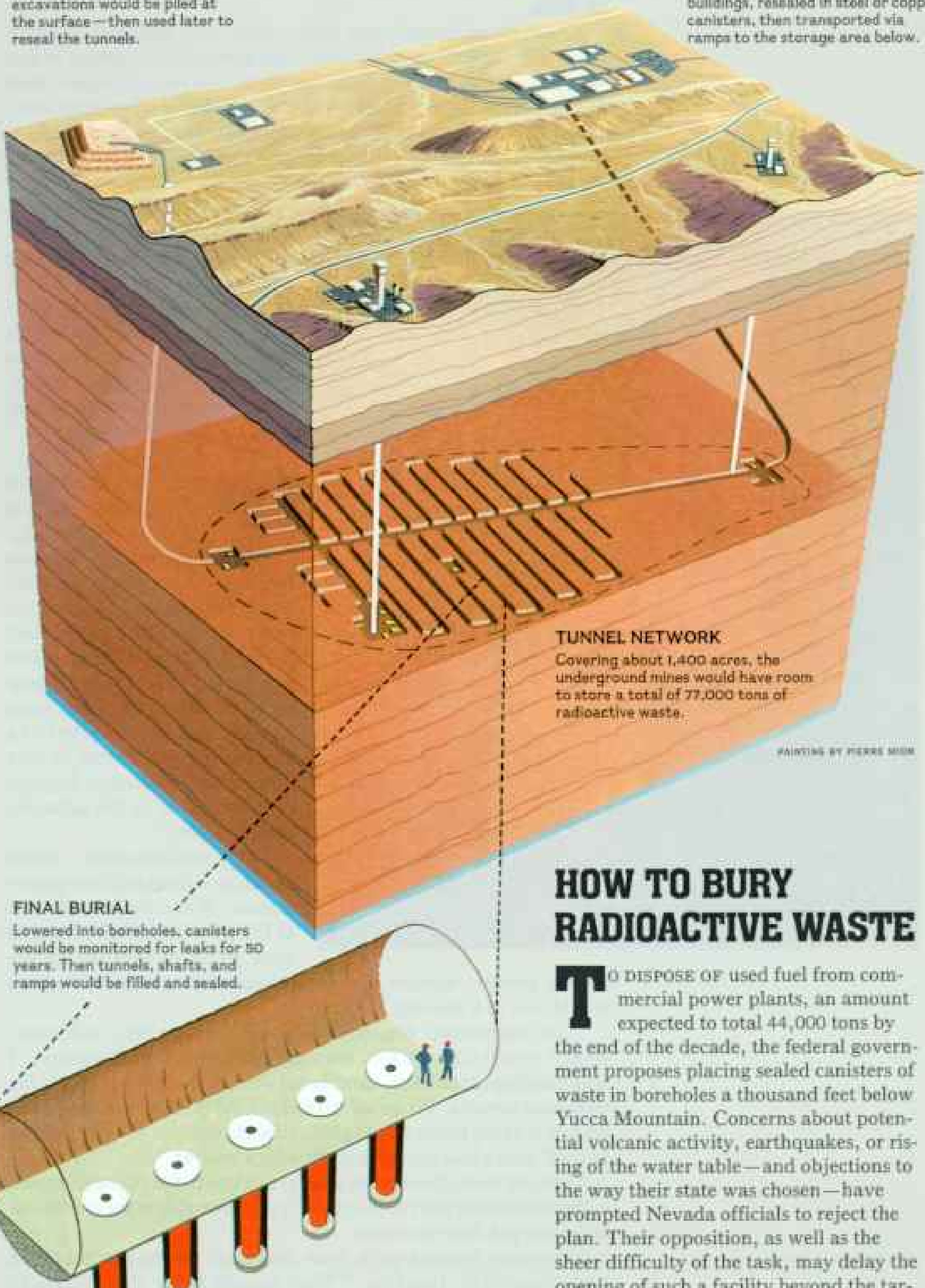
Then there's the specter of nuclear waste. The quantity of radioactive spent fuel temporarily stored at commercial power plants around the country has tripled during the past decade. Despite the fact that the U. S. Department of Energy (DOE) has spent more than two billion dollars trying to establish a permanent repository, little progress has been made.

It could take as long as 20 years, says DOE, before a repository can be opened to permanently store this nuclear waste. By then 70

SAFE FOR ETERNITY?
That's the question being raised about Yucca Mountain, Nevada, a desert area a hundred miles northwest of Las Vegas. The U. S. Department of Energy is studying the site for a permanent nuclear waste dump, where deadly materials could be safely stored for at least 10,000 years—practically forever in human terms—by which time radioactivity would have dropped to acceptable levels. Some scientists doubt we can plan that far ahead.

TUFF PILE
Formed of compacted volcanic ash and dust, tuff from excavations would be piled at the surface—then used later to reseal the tunnels.

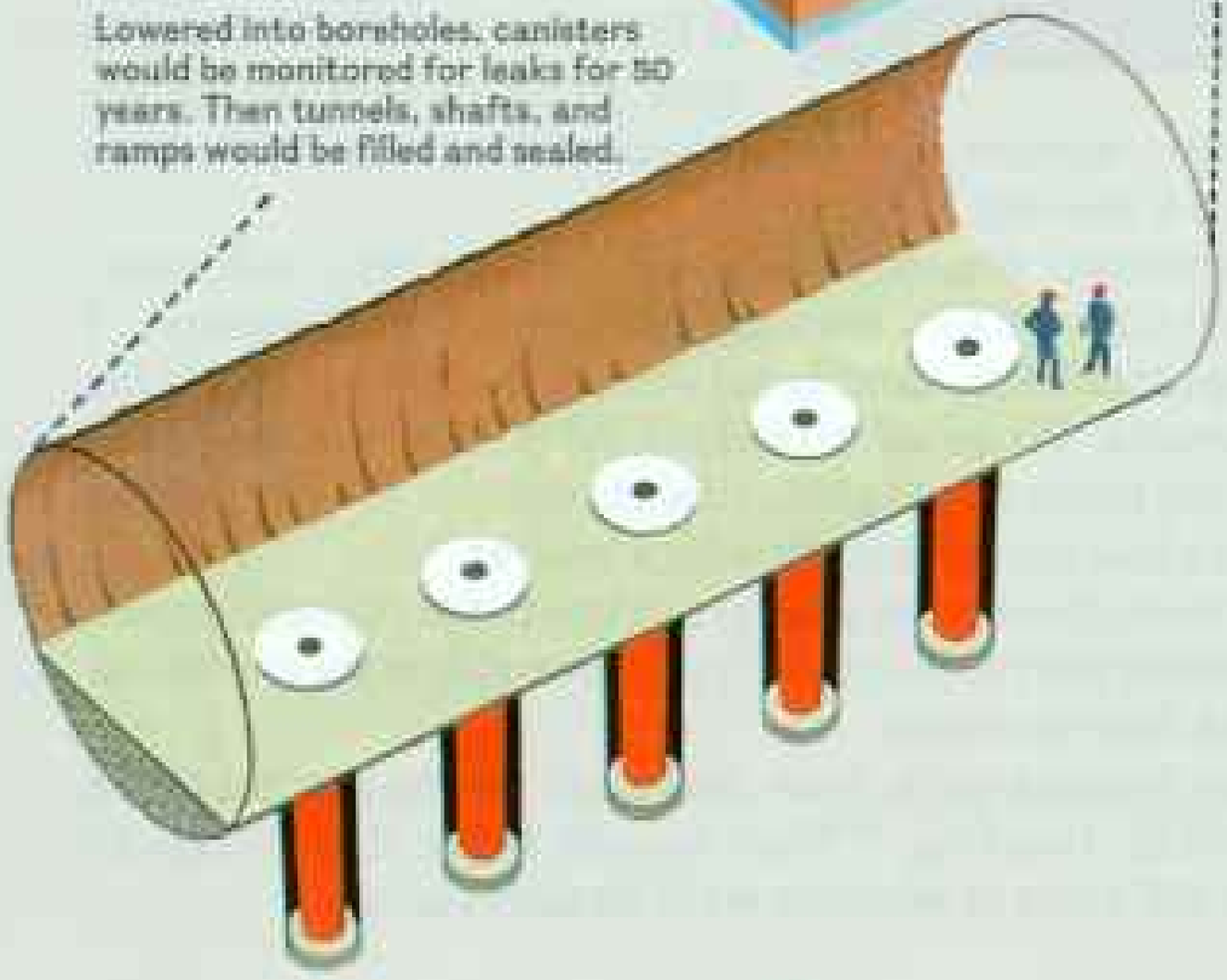
SURFACE FACILITY
Delivered by rail or truck, nuclear waste would be unloaded at two buildings, resealed in steel or copper canisters, then transported via ramps to the storage area below.



TUNNEL NETWORK
Covering about 1,400 acres, the underground mines would have room to store a total of 77,000 tons of radioactive waste.

PAINTING BY PIERRE MION

FINAL BURIAL
Lowered into boreholes, canisters would be monitored for leaks for 50 years. Then tunnels, shafts, and ramps would be filled and sealed.



HOW TO BURY RADIOACTIVE WASTE

To dispose of used fuel from commercial power plants, an amount expected to total 44,000 tons by the end of the decade, the federal government proposes placing sealed canisters of waste in boreholes a thousand feet below Yucca Mountain. Concerns about potential volcanic activity, earthquakes, or rising of the water table—and objections to the way their state was chosen—have prompted Nevada officials to reject the plan. Their opposition, as well as the sheer difficulty of the task, may delay the opening of such a facility beyond the target date of 2010.

percent of the nuclear power plants in the United States will have more spent fuel than they can handle with current on-site storage facilities.

The main obstacles, once again, have been political. Though DOE is investigating an arid site a hundred miles northwest of Las Vegas, Nevada, for deep burial of nuclear waste, Governor Bob Miller and the state legislature have blocked key studies in the area, called Yucca Mountain. They cite possible volcanic activity, earthquakes, or rising water table as dangers. And they object to the way the project has been forced upon their state.

Financial risks, safety concerns, and nuclear waste—these are the issues holding back nuclear power. Until each is addressed, there is little chance for a comeback in this country—a fact that has been foremost in the minds of reactor manufacturers as they've put together their new designs.

THERE WAS an element of theater in the experiment that day in 1986 at Argonne National Laboratory outside Idaho Falls. About 60 scientists from around the world had been invited to witness a live simulation of a severe nuclear accident. Rows of chairs were lined up on the turbine deck of a research power reactor, where video monitors showed displays of instruments in the adjacent control room.

The demonstration would simulate a blackout at a power station. While the reactor was at full power, the lab scientists were going to shut off all the coolant pumps—a move that at most conventional nuclear plants would lead to a disaster.

"The countdown was done like a NASA launch—ten, nine, eight," recalls Charles Till, associate director of the laboratory. "I was standing at the back, looking out over all these heads and at the television screens. When we turned off the pumps, the first thing we saw was the temperature going straight up! Not a pretty sight to anyone who's had anything to do with a reactor."

Then the room shook with a *bang!* as a steam valve popped open in the nonnuclear part of the plant. It posed no risk to the crowd but definitely got their attention.

"Everyone jumped up in their chairs and swung around to the back," says Till, laughing. "They wanted to see if the Argonne people were still there or whether we'd already run out."

As the temperature of the core increased, the reactor's unique metal fuel—an alloy of uranium, plutonium, and zirconium—expanded, letting enough neutrons escape to slow down the chain reaction. Within ten minutes, reactor power had dropped from 100 percent to almost nothing and temperature had returned to normal, without operator intervention.

The device that performed so well was EBR II, a research breeder reactor in operation since 1964. It had been modified by Argonne scientists to test its inherent shutdown capability. Such safety features as well as simplified designs are to be incorporated into the new generation of reactors. Among the new candidates:

AP600: Westinghouse's Advanced Passive 600-megawatt reactor would be a simplified version of the pressurized water reactor, the type most widely used around the world. Compared with a conventional plant the same size, designers say, the AP600 would require half as much concrete, 80 percent less electric cable, 60 percent fewer valves and pipes, 50 percent fewer large pumps and heat exchangers, and 35 percent less ducting.

Although its core would be larger than that of a conventional reactor, the AP600 would operate at a lower temperature, making it more forgiving of human errors—"like driving a car at 40 miles per hour instead of 60," says program director Howard J. Bruschi.

MHTGR: Designed by General Atomics of San Diego, the Modular High Temperature Gas-Cooled Reactor would circulate helium coolant rather than water through a core composed of billions of kernels of uranium, each coated with protective layers of carbon and silicon carbide and bonded in fuel rods. Because these pellets can withstand temperatures higher than any the MHTGR can generate, they could not release radioactive material, even if all the helium leaked from the system.

That makes it a true "walk-away" reactor, says Linden Blue, General Atomics' vice chairman. "You can have the worst kind of accident, go home and have lunch, take a nap, and come back and deal with it. Not to worry. No need to panic."

PRISM: Further into the future, General Electric's Power Reactor Innovative Small Module would use liquid sodium, a more efficient carrier of heat than water or helium, to cool its alloy fuel. As a breeder, PRISM would also make more fuel than it consumes. And it might be capable of recycling nuclear wastes as fuel, reducing the time that the most long-lived wastes would have to be stored—from hundreds of thousands of years to only hundreds.

Other innovative designs are the PIUS (Process Inherent Ultimate Safety) reactor by ABB Atom, CANDU 3 (Canadian Deuterium Uranium) by AECL, and the SBWR (Simplified Boiling Water Reactor) by General Electric—all of which aim for greater simplicity. "We looked at every component with a view of taking it out," says GE's Daniel R. Wilkins.

The safety features of these machines have earned cautious consideration from environmentalists.

"If we're going to save the planet, we're going to have to phase out fossil fuels," says Jan Beyea of the Audubon Society. "And though we are optimistic about the technology for solar power, the world is too important to put all our eggs in that basket. So we think it makes sense to put resources into testing these so-called idiot-proof reactors."

TINY BUT POWERFUL
Each one precisely crafted, fuel pellets for the MHTGR—dwarfed by a penny—contain a thousand times more energy by weight than coal. Manufactured by General Atomics in San Diego, the pellets start as droplets of uranium (facing page), which are then solidified and coated with layers of carbon and silicon carbide to give them a protective shell. This permits them to withstand temperatures as high as 3600° F, giving the MHTGR a greater margin of safety than conventional reactors.

NO MATTER how many improvements new reactors incorporate, of course, they will still be challenged by those who oppose nuclear technology on principle. Nuclear power, after all, is more than a technical issue. It's a question of social policy. And that means that the fate of new reactors relies at least as much on public opinion, economics, and national security as it does on engineering details.

Nuclear power is also an international issue, as the U.S.S.R.'s Chernobyl disaster demonstrated in April 1986.* A power surge caused by a sequence of operator errors at the badly designed Ukrainian plant melted the uranium in one reactor. Blasting out of its casing, the fuel vaporized the cooling water in a monstrous steam explosion. Radiation killed 31 men at the site, and hundreds of people suffered radiation sickness. Clouds of radioactive dust drifted over Europe and northern Asia. Estimates of future deaths from the accident range from a few thousand to tens of thousands.

*See "Chernobyl—One Year After," by Mike Edwards, in the May 1987 NATIONAL GEOGRAPHIC.

An 18-mile radius around the site remains officially uninhabitable.

Today 429 nuclear reactors create electricity in 25 countries. The International Atomic Energy Agency, based in Vienna, Austria, promotes nuclear power around the world and attempts to prevent diversion of fuel for use in weapons.

Countries approach nuclear technology in various ways, depending on their political systems and priorities. France and Sweden, in particular, took opposite paths during the past decade.

On a bright day last September, two dozen delegates from the French Parliament gathered in a meeting room at the Westin Hotel in Washington, D. C., for a briefing by U. S. energy experts. At the podium was Harold Finger, then president of the U. S. Council for Energy Awareness, a group that represents the nuclear industry.

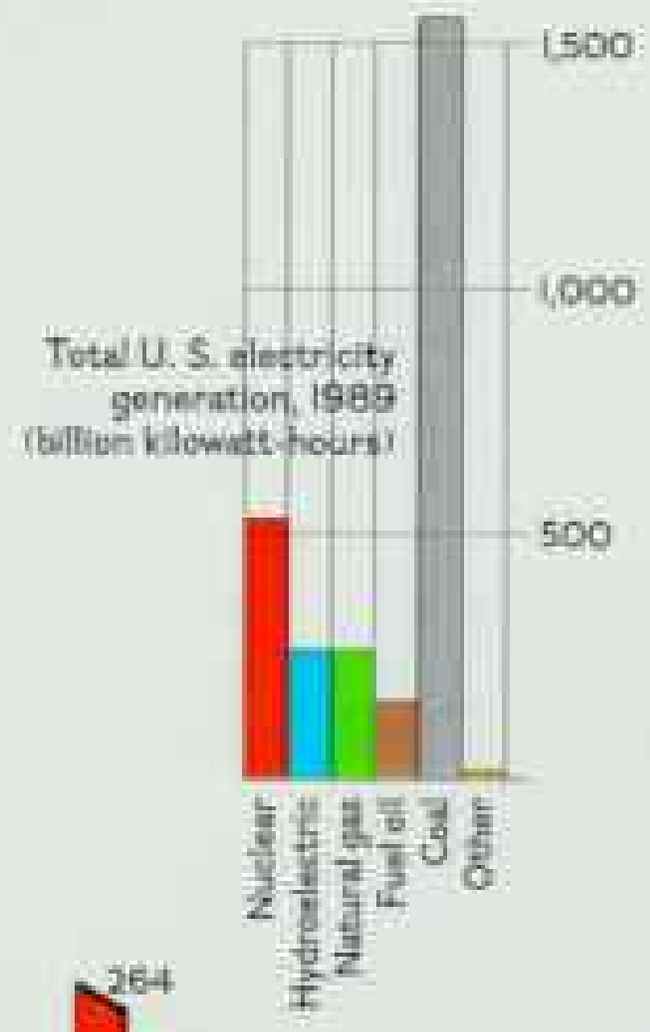
"In France you've done everything in your nuclear program that we said we wanted to do in the beginning here in the U. S.," he told them. "I envy the totality and the logic of your system."

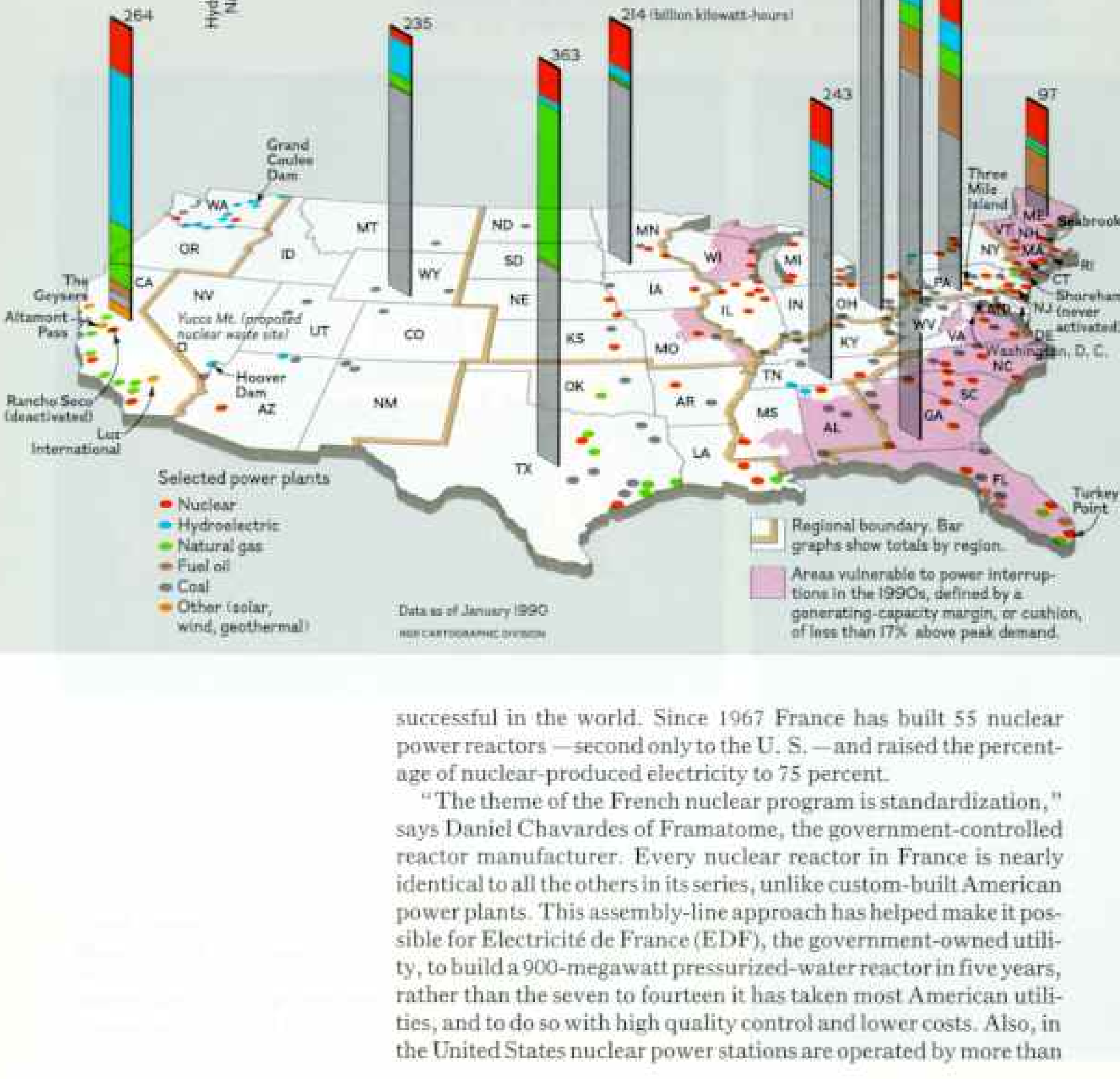
Finger's words reflected the feelings of many of his American colleagues, who consider the French nuclear system the most

ON THE CUTTING EDGE
Adjusting the beam of a copper-vapor laser, Mark Martinez (left) at the Lawrence Livermore laboratory in California demonstrates a new process for separating out uranium isotopes for nuclear fuel. A leader in this technology, the U. S. hopes to regain its place in the enriched-uranium market. Technicians at Argonne National Laboratory in Idaho (above) renovate a "hot room," where a new method of recycling metal fuel will be tested. Simpler and potentially less expensive than using uranium in conventional ceramic form, metal-based fuel systems could make it economical to operate breeder reactors, which create more fuel than they consume.

U.S. POWER: A MIXED BAG

RICH IN RESOURCES, the U. S. generates electricity in many ways: Hydropower is a major factor on the West Coast, fuel oil in the Northeast, natural gas in some Gulf states and in California, nuclear in the East, and coal nearly everywhere. Even so, some regions (pink) may suffer shortages of electricity in extreme weather. Planners hope "negawatts," power saved by conservation, will help delay a crunch.





successful in the world. Since 1967 France has built 55 nuclear power reactors —second only to the U. S. —and raised the percentage of nuclear-produced electricity to 75 percent.

"The theme of the French nuclear program is standardization," says Daniel Chavardes of Framatome, the government-controlled reactor manufacturer. Every nuclear reactor in France is nearly identical to all the others in its series, unlike custom-built American power plants. This assembly-line approach has helped make it possible for Electricité de France (EDF), the government-owned utility, to build a 900-megawatt pressurized-water reactor in five years, rather than the seven to fourteen it has taken most American utilities, and to do so with high quality control and lower costs. Also, in the United States nuclear power stations are operated by more than

50 completely separate utilities, some more skillful than others.

Just as important, the French utility has generally been able to site its nuclear stations without the kind of public opposition that U. S. power companies have dreaded. Some say that this is due to the traditional reluctance of the French people to question central authority and to their support for a nuclear military policy. Others point to EDF's information campaigns and programs of economic development.

Take the village of Cattenom, a community of 2,700 on the bank of the Moselle River in northeastern France. The town is located in a steelmaking region hit hard by the recession of the mid-1970s. In 1979 EDF began construction here of four 1,300-megawatt pressurized-water reactors—one of the largest nuclear complexes in France.

Since the power plant was started, EDF has built more than 900 houses in nearby communities, 53 of them in Cattenom. The utility has invested 47 million francs (eight million dollars) in local roads and pays more than a fifth of the town's annual budget in taxes.

Cattenom's schools, community center, athletic stadium, town hall, and tennis club were all financed through loans backed by EDF taxes, says Mayor Alphonse Bohler. And the workers at the plant help keep the town's businessmen prosperous. You couldn't find a bigger fan of nuclear power than the mayor, who is as proud of Cattenom's cooling towers as he is of the portrait of Charles de Gaulle that hangs on the wall above his desk.

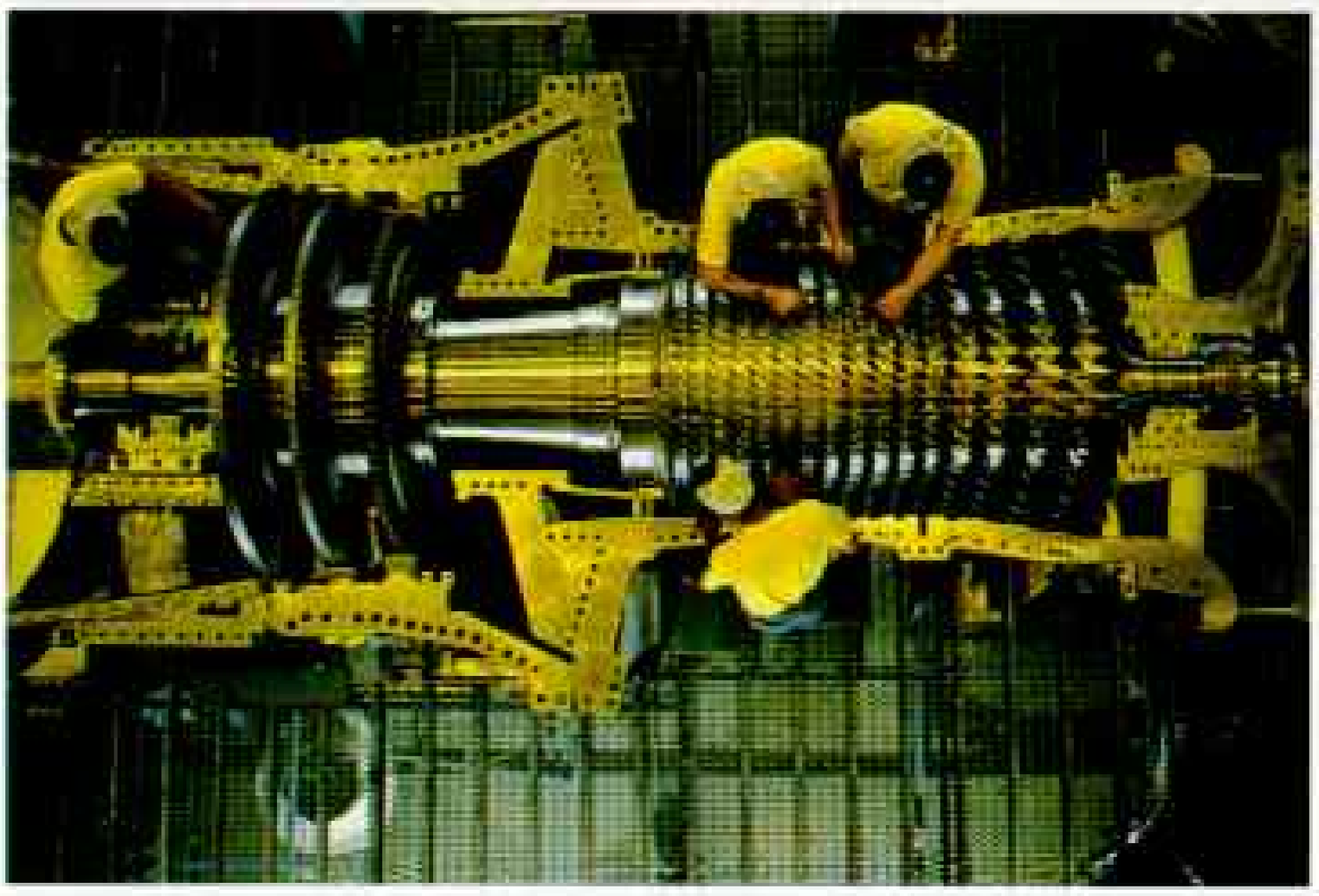
NORTHERN GIANT
Nearly 700 miles north of the U. S. border, six hydroelectric generators being installed at Hydro-Quebec's La Grande 2A complex could supply 7 percent of New England's power by 1992. Buying electricity from Canada allows U. S. utility companies to delay construction of new plants.

"We were living in the Middle Ages when I was first elected," says Bohler, who has held office since 1959. "Now we have four doctors, two dentists, a pharmacist, and a lawyer."

To introduce the plant to the public, EDF welcomes busloads of visitors every day to Cattenom—some 18,000 a year. Opposition to the station has come mainly from residents of nearby Germany and Luxembourg. Following the accident at Chernobyl, thousands of protesters gathered at the German border ten miles away. But in Cattenom and surrounding communities there has never been a serious campaign against the plant.

"Sure, there were people against the plant at the start," says Nathalie Louis, dabbing a solution onto a customer's hair curlers at Salon Bernard. "Now those same people are working there."

The program still has its critics. Some complain about the huge



QUICK FIX

Because they can be installed quickly and are relatively clean burning, natural gas turbines (above) are a frequent choice among power companies feeling the pinch of higher demand. But gas-run plants have something in common with fuel-oil-driven plants such as the four 375-megawatt units at Northport, Long Island (top): worries about the price and availability of fuel supplies.

debt (230 billion francs, or 39.5 billion dollars) that EDF accumulated during its rapid nuclear buildup and the fact that the country has more reactors than it needs. Others object to the limited role allowed the public. "France is the ultimate example of how to develop nuclear power without debate," says Christian Batallie, a member of parliament from Nord-Pas de Calais.

"The French way of doing things is very different," says Daniel Chavardes. "We are very receptive to logic and rationality, while Americans are more emotional and shortsighted, though very pragmatic. In France we accepted nuclear energy as a logical means of achieving energy independence. After all, we are the nation of the philosopher René Descartes."

SUCH IMPORTANT DECISIONS should not be left to a technical elite, however. That was the conclusion reached by the people of Sweden in March 1980 when they voted in a national referendum to end their nation's use of nuclear power. They did so despite the fact that Sweden's 12 reactors are considered among the best run in the world.

Following the vote, the Swedish Parliament passed a law forbidding further nuclear development and setting a deadline of 2010 for shutting down the nation's 12 nuclear reactors. (A subsequent attempt to begin the shutdown in 1995 failed.)

The Swedish referendum was among the first in a wave of setbacks for nuclear power in Europe outside of France. Reactor construction was halted in Spain in 1984, and a virtual moratorium began soon after that in the Netherlands, West Germany, Yugoslavia, and the United Kingdom. Last year Italy's Parliament closed that nation's two remaining plants; four reactors in what used to be East Germany were shut down for safety reasons; and Swiss voters chose to ban new nuclear projects until the end of the decade.

Chernobyl had a lot to do with this. Swedes in particular were shaken by the catastrophe. Not since Soviet weapons tests of the 1960s had they suffered such levels of radioactive fallout.

Mats Eriksson first heard the rumors from neighbors around a bonfire in the village of Trödje. The dairy farmer had taken his son, Jan, and daughters, Karin and Marie, to celebrate the festival Valborgmässoafton—the Eve of the First of May.

DIRTY BUT NECESSARY

Eight hundred feet down, West Virginia coal miners use an automated longwall shearer to cut a 28-inch swath of coal from a seam. Coal-fired power plants produce more than half the nation's electricity, but they also emit pollutants that cause acid rain and release carbon dioxide, which adds to global warming. New, clean coal technologies remain mostly in the demonstration stage.

FICKLE WIND *Even in California's windy Altamont Pass the breeze sometimes stops. That's why the state's 15,000 wind turbines (including one that sparkles with season's greetings) deliver only 25 percent of the power they could*

theoretically generate. Fortunately the turbines, which are independently owned, work most efficiently and economically in summer, when the Pacific Gas & Electric Company needs the power most.

It had been raining there for several days, a soft steady rain.

"You know, someone said the rain's dangerous," a man told him. Another said: "The reactor down at Forsmark is leaking."

Eriksson didn't take the stories seriously until he heard a report on the radio that the Swedish power plant at Forsmark had not been the site of an accident but rather was the first place outside the Soviet Union to detect the disaster at Chernobyl.

Most Swedes had no need to worry. As the radioactive clouds swept across Scandinavia, the average resident received a smaller dose than he or she would have from a chest X ray. But in northern Sweden and along the east coast, reindeer, moose, fish, mushrooms, and berries—favorite foods—were tainted by cesium 137.*

Among those affected was Mats Eriksson. Because it had rained on his village, fallout there was heavier than in most parts of the country. He didn't realize how heavy until he took part in a health survey: "They told me I had so much cesium in my body that if I were one of my own livestock, I'd be unfit for sale."

More than any other recent issue, nuclear power has troubled the

*See "Living with Radiation," by Charles E. Cobb, Jr., in the April 1989 NATIONAL GEOGRAPHIC.

PUTTING TRASH TO WORK

Burning a 2,000-ton mountain of trash every day (right), the city of Bridgeport, Connecticut, generates 10 percent of its electricity from what citizens throw away. At the city's advanced incinerator (above), environmental technician Patti Barbour checks one of three furnaces whose smokestack filters help reduce pollutants. About 130 waste-to-energy power plants dot the country.

Besides trash, wastes from forests and farms also contribute to the nation's power supply. Maine generates about 20 percent of its electricity by burning wood chips, while the island of Hawaii gets as much as a third of its power from burning sugarcane residues. Even so, renewable biomass sources total less than one percent of the nation's generating capacity.

Swedes. While the French have a taste for strong, centralized authority, Swedes prefer consensus. Their economy—free-market capitalism mixed with a socialist-style welfare state—relies on cooperation among organized labor, industry, and government.

Despite this instinct for consensus, neither the members of the Social Democratic Party nor any other political group has managed to put together an acceptable plan to accomplish the nuclear phase-out. Thus the issue returns year after year, splitting apart otherwise healthy coalitions, drawing attention away from other important issues, and generally haunting politicians.

"I can't think of another problem that has caused such difficulty for the political system," says Bo Andersson of the Swedish Trade Union Confederation. "It's very un-Swedish."

Swedes depend on nuclear power for half their electricity (the rest coming mainly from hydropower), and they have no easy way to replace it. Building new dams is out because the country's four largest unharnessed rivers are protected by environmental laws. And parliament has set goals for carbon dioxide emissions that limit new fossil fuel plants as well.

No nuclear. No new hydro. Restricted fossil fuel. What's left?

FARMING THE SUN
Lights from a maintenance truck thread through the world's largest solar-thermal complex, Luz International, in California's Mojave Desert. Working at night, the 20-person crew takes a week and a half to wash the company's 1.5 million mirrors, which produce 95 percent of U. S. solar electricity. The mirrors focus the sun's rays on tubes filled with synthetic oil. The oil boils water in a heat exchanger, which sends steam to a turbine.

Photovoltaic cells, by contrast, convert sunlight directly into electricity. Their relatively high cost has limited use so far to devices such as irrigation pumps, billboard lights, pocket calculators, and remote residential systems. But new materials may make them more affordable and widen their application.

"There is no solution on the supply side alone," says Thomas Johansson of Lund University. "We must reduce consumption."

At Iggesund Paperboard in the village of Iggesund, 185 miles north of Stockholm, the effects of greater efficiency are easy to see. Adjacent to the old pulp mill, where pounding pumps drown out all voices and condensed steam trickles down brick walls, a sleek new mill painted in pastels uses a variable-rate pumping system to cut electricity by one-third. Such improvements, if adopted throughout the economy, could largely compensate for the loss of Sweden's nuclear power, says Johansson.

Others are not as optimistic. According to a study by Vattenfall, the country's largest utility, it may cost as much as 200 billion kronor (32.5 billion dollars) to replace Sweden's nuclear plants with currently acceptable systems—natural gas, biomass, wind-powered generators. And if electricity prices escalate as a result, some 50,000 jobs may be lost in energy-intensive industries such as

mining, steel, and paper. Considering such a possibility, many doubt the phaseout is even feasible.

Here in the United States there appears no chance for a nuclear phaseout such as Sweden's—barring another major nuclear accident. Since 1982, referenda to ban nuclear power in states such as Maine, Massachusetts, and Oregon have failed, suggesting that most Americans are not disenchanted enough with the technology to want to throw it away.

"We're at the bottom right now, but we're going to see a rebirth in this decade," says Bertram Wolfe of General Electric, expressing the confidence of nuclear-industry leaders.

Antinuclear groups, nevertheless, say there are good reasons to watch Sweden as it prepares for a future without nuclear power.

"It's going to happen here too by default," says Ken Bossong, director of the antinuclear Critical Mass Energy Project. "There haven't been any orders for nuclear plants in the U. S. since 1978,

and the plants that exist now are slowly aging and will eventually get shut down. So whether it's formal policy or an informal policy, a phaseout is already happening." Just look at California, says Bossong, where Sacramento voters in 1989 turned off the Rancho Seco reactor because it continually needed expensive repairs. With about a fourth of their power coming from hydroelectric dams, geothermal springs, solar collectors, wind farms, and biomass generators, Californians get more electricity from renewables than they do from nuclear.

What's good for California isn't necessarily good for everybody else. Few places enjoy the right geography to exploit solar, wind, and geothermal energy as productively as California. In 33 states coal remains the primary fuel for electricity. Six states depend mainly on nuclear power, five on fuel oil, four on hydro, and two on natural gas.

"There's no silver bullet in energy," says Assistant Energy Secretary J. Michael Davis. "Different parts of the country require different solutions."

During the past five years the trend clearly has been toward advanced natural gas turbines, which are less expensive to build but use more expensive fuel than do coal plants. In the next decade, however, many analysts see a shift to clean coal technologies such as fluidized bed combustors, which suspend coal particles in jets of air as they burn, and gasified coal turbines.

Also ahead: new tactics for energy conservation. Under a plan approved last August, California utilities that encourage customers to use more efficient appliances, machinery, and lighting get to share the financial savings. Customers may save a billion dollars on electricity, while the utilities earn as much as 15 cents profit for every dollar of power they *don't* sell.

BRIGHT IDEA
The power it takes to light a single 70-watt incandescent bulb will illuminate four equally bright compact fluorescent bulbs, as George Preston of Philips Lighting demonstrates. Though compact fluorescent bulbs can cost $15 or more apiece, they last ten times longer. One Massachusetts utility boosted conservation by letting customers pay for bulbs by the month. Such technology, if fully exploited by both businesses and homeowners, could help reduce U. S. consumption of electricity by as much as 44 percent by the year 2000.

LOOKING OUT HIS OFFICE WINDOW at the palm trees and marsh grass of Juno Beach, Florida, C. O. Woody considered what the best solution might be for the 35 counties depending on Florida Power & Light. As senior vice president, Woody helps map the strategy that will guide FPL and its customers through the difficult years ahead.

"I grew up here. This job is my life. When I fly in at night and see all the lights burning, it gives me a great feeling," he said. "It's awful to think what happens when they go out."

The area served by FPL is one of the fastest growing in the nation. To keep up with a population that increases 3 to 4 percent a year (about ten new customers an hour), the utility plans to add two power plants and upgrade two others by the end of the decade.

What kind of plants have they chosen?

"We looked at everything conceivable, around 50 possibilities," said the executive. "But when you consider the realities and the

costs, you get them all down to a reasonable few pretty quick."

A nuclear plant wasn't one of them.

"We seriously considered one a few years ago when we first heard about the standardized 600-megawatt concept," he explained. "The vendor gave us some dollar and kilowatt numbers, and we ran them through all our alternative analyses. But when we considered the uncertainties of the investment and the negative perceptions that still abound in the public, not to mention the waste issue, we just had to back away."

Between now and the end of the decade, FPL is placing its bets on advanced gas turbines, because they are quicker to build, require less capital, can be added in small increments, and are viewed more favorably by state regulators, who tend to disapprove of risky, long-term investments.

"We focus on the short-term in this country," complains Energy Secretary James Watkins. "You make a quick deal today and everybody praises you, and they don't look out there in the future."

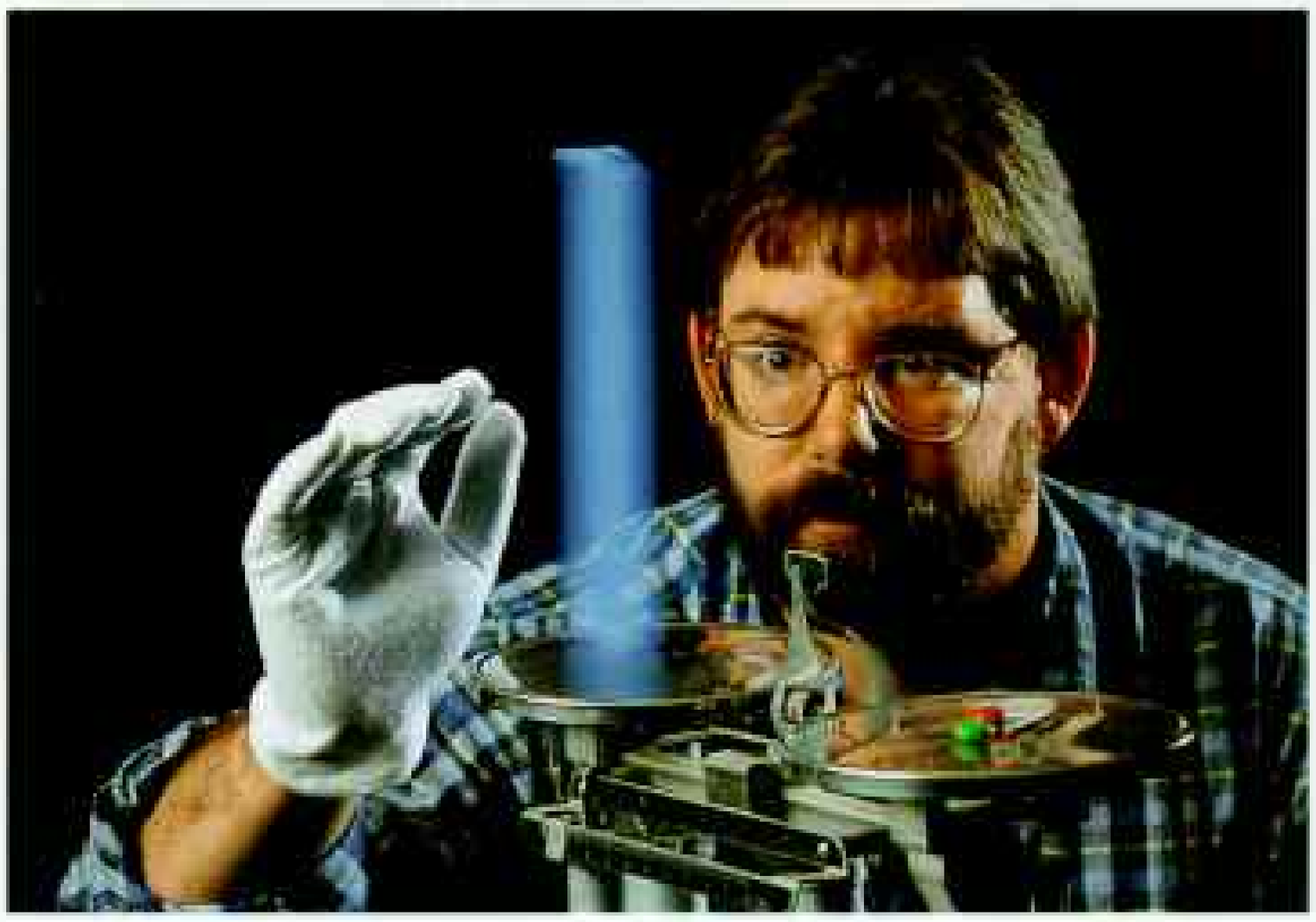
In the future: That's where next-generation reactors remain for now. Though a few might be started before the end of the 1990s—perhaps by the federally owned Tennessee Valley Authority or by a consortium of several utilities and a reactor manufacturer—the idea of a nuclear revival remains wishful thinking by its promoters. Neither the American public nor the political system appears to be ready for it.

"Our federal democratic system makes a nuclear revival a difficult challenge," says I. C. Bupp, managing director of Cambridge Energy Research Associates, a private consulting firm. "There may be circumstances under which it could be manageable, but it won't happen overnight."

Last February President Bush proposed a national energy strategy favoring new nuclear plants. But it is not clear that his plan will be welcomed by Congress and other sectors of the nation. For now we are counting on gas turbines, conservation programs, and purchases of electricity from Canada to keep us out of trouble. We want to move away from the dirtiest of fuels and find renewable sources of energy—but we do not yet agree on the path.

If this pushing and shoving between our needs and desires seems inefficient compared with policy-making in France, that may be a fair characterization. If it seems unnecessarily contentious compared with the consensus process in Sweden, that too may be true. But we probably can't do anything about it, says William McCollam, Jr., president emeritus of the Edison Electric Institute. "It's the price we pay for our system of democracy."

Meanwhile the nuclear industry presses on with advanced designs, waiting for the moment when public opinion and the marketplace may give it another chance.



LIGHT IDEA

Weighing less than two M&M's, a piece of aerogel developed at Lawrence Livermore National Laboratory is one of the best insulators ever tested, says chemist Tom Tillotson. The glass-like substance, 99.8 percent air, works six times better than fiberglass insulation.

To reduce demand, many utilities promote conservation—even helping pay for home insulation and more efficient appliances. Power companies paying people to use less: one sign of a changing electric future.

FUSION: STILL TOMORROW'S DREAM

TANTALIZING US with the promise of endless energy tapped from ordinary water, fusion power remains decades away from commercial application.

At Princeton University researchers are refitting a doughnut-shaped machine called a tokamak (right) in an attempt to achieve the elusive break-even point at which energy released by fusion equals that required to produce it. Using powerful magnets to confine a superhot ring of gas, the tokamak heats the nuclei of hydrogen isotopes extracted from water until they fuse together, releasing energy. A commercial reactor could harness that energy to drive a conventional steam turbine.

Scientists at the University of Rochester take a different tack, blasting a small pellet of hydrogen fuel with 24 beams from a two-trillion-watt laser (above). In the implosion that results, deuterium and tritium nuclei fuse and release energy.

Neither method has yet demonstrated that a self-sustaining fusion reaction is practical. If they ever do so, our worries about electricity may become a thing of the past. □

CUBA at a Crossroads

By PETER T. WHITE
ASSISTANT EDITOR

Photographs by JOSÉ AZEL
CONTACT PRESS IMAGES

Nearly 30 years after the Cuban missile crisis sent the world to the last tick before nuclear war, Cuba remains stubborn, socialist—and as alone as an old Soviet rocket under guard near Havana.

Capitalist cash and socialist sweat build the 22-story luxury Hotel Cohiba in Havana's Vedado section, planned by Spanish investors and the Cuban government for a 1992 opening.

MIDNIGHT IN Santiago de Cuba, carnival is in the air. Trumpeters, drummers, costumed revelers by the score, all strut, skip, and dance past brightly lit decorations in the main plaza of the second largest city on the island of Cuba. I see matadors, butterflies, devils, Beauty and the Beast! And what a beauty, just look at—

Suddenly, darkness. I can't see a thing. This is typical of Cuba nowadays, something impressive is marred by unwelcome circumstance, in little things and in big ones too.

I've been getting used to petty annoyances, such as checking into the leading hotel in a provincial capital, after a hot, sticky day, and there's no hot water. That's so common you're supposed to get 10 percent off your bill. No running water at all? Twenty percent off. Even in Havana itself, in the elegant Tocororo restaurant, the air-conditioning might go off in the middle of lunch; one night I went to see the movie at Cine Caribe—but no, the whole district was blacked out.

As to things that really matter, one soon hears, on the one hand, of dramatic achievements in the social sphere, and that's all the more remarkable since Cuba is what Comandante en Jefe Fidel Castro himself calls a Third World country. From the comandante on down, officials never tire of pointing out that now, 32 years after "the triumph of the revolution," there are proportionately more doctors—some 40,000!—and universities—35—for Cuba's ten and a half million people than

anywhere else in Latin America. Nobody has to go hungry, no child unvaccinated.

On the other hand, one soon discovers that here is an economy so pinched, so beset by shortages, that people think themselves lucky if they can find a jar of mayonnaise to buy, or a plastic comb, or a tin of shoe polish. The day you find a dozen of any of these in a shop, bingo, you'll grab them all.

After 20 minutes the carnival lights are on again, more bands and beauties pass, onlookers spout uninhibited comments. "These men are terrible," says the young lady who is my translator, smiling. Don't women mind? Oh no, she says, in Cuba the women love to hear that they've been noticed—"You mustn't be too thin, of course, especially in the back." In such a case the men might say *está infumable*—"she's unsmokable." It means not enjoyable, like a cigarette smoked down too far.

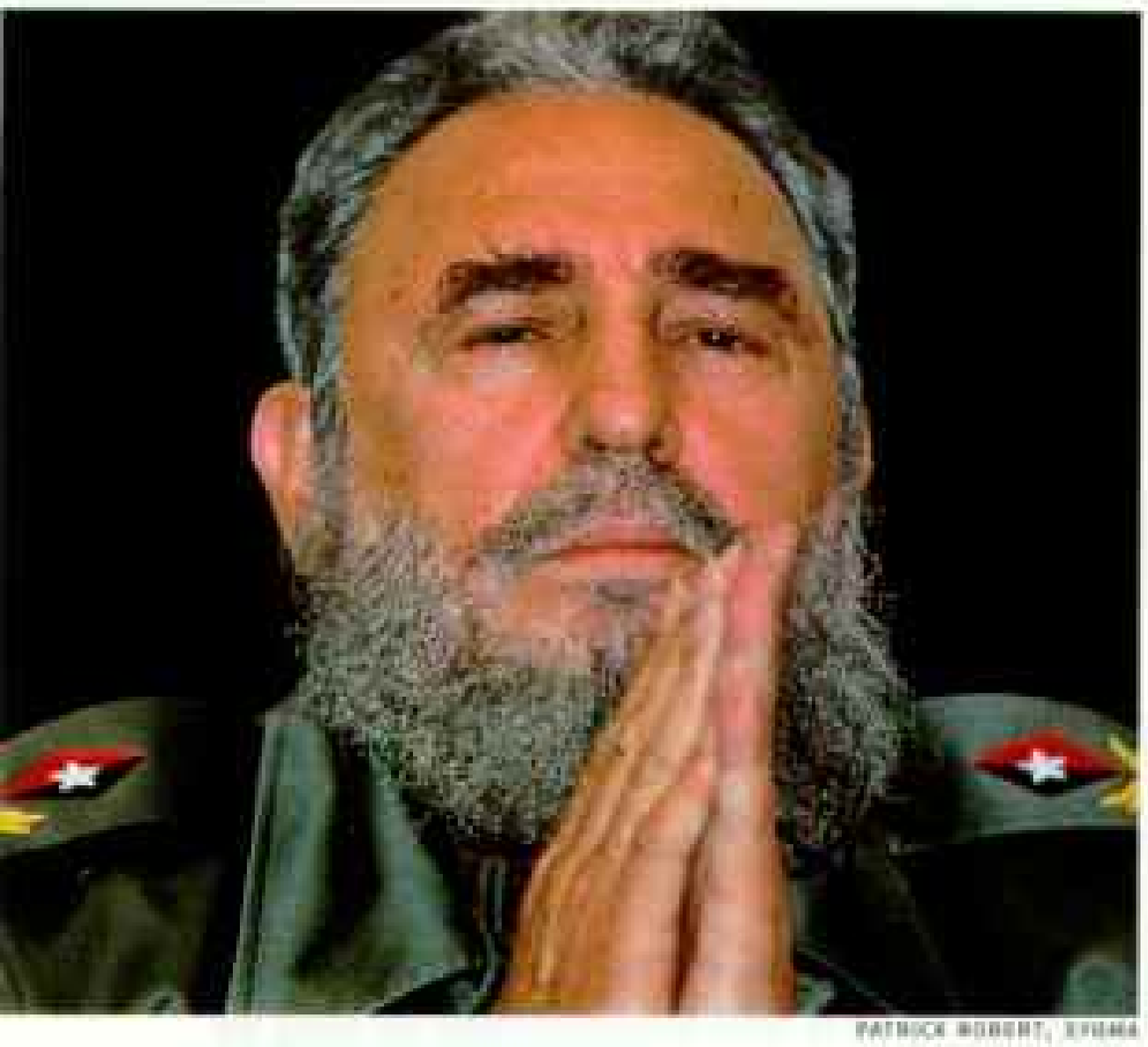
I have come for a firsthand look at what these vivacious Cubans have achieved and how they cope with their ever more pressing everyday problems. For nearly three decades communist Cuba has depended primarily on trade with the Soviet Union and its longtime East European allies. Now, Castro says, such commerce with countries of the "former socialist community" has virtually ceased; some Soviet deliveries, notably oil, have been drastically cut. "We are working under very tense conditions, very tense. . . ."

But unlike Soviet leaders, Castro forswears any deviation from his brand of socialism. "We have swept away the capitalist system," he says, "and it will never return as long as there is a communist, a patriot, a revolutionary in Cuba." And so, while even China and Albania have been inching away from communist orthodoxy, the government of Cuba remains one of the last in the world to profess Marxism-Leninism. How long can it go on like that? Castro ends his speeches defiantly: "Socialism or death! We shall win."

TRAVELING WITH ME is not only a translator, delegated by Cuba's Council of Ministers, but also an official of MINREX, the Ministry of Foreign Affairs, whose help is essential. If I want to visit a sugar mill or any place off the tourist circuit, the MINREX man will contact a local functionary of the Cuban Communist Party who then assures the person in charge of the place I want to see that it's all right. That's the system. But from time to time, as will be readily detectable, I do meet Cubans when I am not, so to speak, chaperoned, as I move around to assemble, bit by bit, my mosaic of this beautiful country under pressure.

A typical landscape: great expanses of green with tall palms, singly or in little groups;

Slow, fast, and then faster, sacred batá *drum rhythms seize a dancer in Santiago de Cuba seeking communion with the Afro-Cuban divinity Babalú Ayé. The government accepts such rites merging Christian and African beliefs. Long spurned, conventional Christians slowly grow in number; today the Communist Party considers having them as members.*



PATRICK ROBERT, SYGMA

The trademark beard is flecked with gray. At 64, Fidel Castro has outlasted seven U. S. presidents, firm in his vision of Cuba's destiny. "Socialism will be the society of the future," he said last year, even as his Soviet-bloc allies crumbled. Thirty-five years ago only about a dozen guerrillas stood by Castro's side in eastern Cuba's rugged Sierra Maestra (right) to struggle for President Fulgencio Batista's overthrow. Growing hatred of the Batista regime fueled widespread support. Not until 1961, two years after Castro came to power, did he declare himself a Marxist-Leninist. At once admired and abhorred, Castro concedes that Cuba must change but not at the cost of socialism and the single-party system—or his own 32-year rule.

In the 32nd year of the revolution

REPUBLIC OF CUBA

AREA: 110,861 sq km (42,804 sq mi). **POPULATION:** 10,620,000 (60% born since the revolution). **CAPITAL:** Havana, pop. 2,090,000. **RELIGION:** Roman Catholic, Afro-Cuban traditional. **LANGUAGE:** Spanish. **LITERACY:** 94%. **LIFE EXPECTANCY:** 75 years. **INFANT MORTALITY:** 10.7 per 1,000. **ECONOMY:** Industry: food processing, oil refining, nickel mining, textiles, chemicals, biotechnology, tourism. Exports: Sugar, nickel, citrus, fish, tobacco. Imports: Oil, machinery, manufactured goods, food products, chemical products, raw materials. **TRADING PARTNERS:** U.S.S.R., Spain, Mexico, Japan, China.

CUBA

DISEASE DEVASTATED Taíno, Ciboney, and Guanahatabey Indians who had thrived in Cuba until the arrival of conquistadores in the 1500s. Four centuries of Spanish colonial rule ended in 1898. Following three years of U. S. military occupation, Cuba became a republic. American influence remained strong until the 1959 triumph of the Cuban revolution. As relations with the U. S. soured, Cuba drew closer to the Soviet Union. In April 1961 Cuban forces repelled a U. S.-sponsored attack by exiles at the Bay of Pigs. After the U. S.-Soviet missile crisis of 1962 military confrontation ceased, though an embargo aimed at isolating Cuba continues as U. S. policy.

endless fields of sugarcane; buzzards circling on high. In the foreground, perhaps, a rider with a big straw hat on a small horse, herding cattle. In the distance the smokestack of a sugar mill, usually built before the revolution. Or a couple of longish four-story buildings next to a water tower; that's a boarding school, postrevolution, for teenagers who work three hours a day in the surrounding orange groves and go home on weekends.

And those ubiquitous palms! *Roystonea regia*, the royal palm, makes even botanists wax lyrical: majestic, stately, its smooth stone gray trunk curiously bulged like a strange marble column reaching into the sky, long leaves drooping sinuously. Birds love its black fruit and carry the seeds all over the country—the royal palm will thrive anywhere. It's a staple of passionate Cuban poetry, part of every Cuban's picture of the beloved homeland.

I HAD COME IN TIME for the great sugarcane harvest. It goes on from November through May or June, when the heat gets into the 90s. You're out there from dawn till dusk with a short extra-wide machete, blunt on top. You grab an eight-foot stalk with your left hand, slash it close to the ground where most of the sweetness is, cut off the top, strip the dry leaves from the stalk, and grab the next one. Little egrets follow, eating freshly exposed bugs.

There used to be 350,000 *macheteros*. Now there are 60,000. Most cutting is mechanized, but that isn't easy either. The harvesters rumble and sputter till late at night, with lights.

At the mills—154 of them, says the Ministry of the Sugar Industry—huge steel rollers squeeze out the sugary juice to be boiled, clarified, evaporated, and separated into molasses and sugar crystals. Molasses makes rum, yeast, and cattle feed; the fiber left after squeezing, called bagasse, will fuel boilers or make paper and wallboard.

At Cienfuegos, on the south coast, inside a warehouse as big as a dirigible hangar, I see piles of tens of thousands of 50-kilogram bags containing snow-white refined sugar. They're going to Arab countries, for dollars, which Cuba desperately needs. But more than half of Cuban sugar—raw, beige colored—is shipped in bulk to the U.S.S.R., from Matanzas or Guayabal or half a dozen other ports. Soviet ships also load up with citrus fruit and nickel after bringing tractors, trucks, canned meat, wheat, and various consumer goods, weapons, and most of Cuba's fuel oil and gasoline. Such has been Cuba's economic lifeline. Now that's being steadily constricted.

One symbol of scarcity is *la cola*. The word means a queue, a line, standing and waiting. Getting to work in Havana, by bus, and home again, may take hours; the old Hungarian buses keep breaking down. You plan a

Tiny boats are giant hats for fishermen lugging inner tubes along Havana's famed seawall, or Malecón. Off the shore, a pair drifts against a skyline barely altered since the revolution. Frustrated by Cuba's economic and political limitations, hundreds with no other means to leave have boarded inner tubes for the U. S.

birthday party with a dozen guests, and you want to serve pork? Your ration book won't get you enough, so you'll stand in line today, hour after hour, and tomorrow too, at a special Havana market where unrationed meat *may* be available at higher prices.

Waiting for the bus, you see the same faces again and again. A man tells me he got to know a woman in the bus cola and after six months he divorced his wife, she divorced her husband, "and then I married her."

FIDEL CASTRO says the export of medicines, along with tourism, is Cuba's best hope for hard currency—and in the Havana suburb of Playa, at the Center for Genetic Engineering and Biotechnology, a young researcher tells of recent successes. A cream to speed the healing of burns. AIDS test kits, cheap. A new meningitis vaccine earning millions of dollars from Brazil.

As for tourists, both Cuban and foreign, their main goal is the beach at Varadero, reached by a two-hour drive along the north coast. The big hotels here are for foreign tourists from October through spring, for Cubans in summer. Some new hotels have been put up with money from abroad—Castro declares it's all right to let foreign capitalists earn a return on such investments, as long as Cubans can learn from them how to run tourist hotels properly. The Sol Palmeras just opened—408 rooms, much marble, huge pool. At the Los Cactus, opened two years ago, the pool hasn't had water for a week, says a lady from Montreal. "They give you a different reason every day." She adds the food is terrible, the beach wonderful, the water warm—and the prices are ridiculously low.

The beach is wonderful indeed. Austrians, Spaniards, a French couple are baking in the sun. But no American tourists, because the U. S. placed a trade embargo on Cuba. That began after revolutionaries nationalized American property in 1960 without compensation—the phone and electric companies, dozens of sugar mills, thousands of acres of land. And so U. S. citizens may visit Cuba but not spend any money there. Journalists, like me, are exempted.

A discordant voice: On the terrace of a hotel full of Canadians, a middle-aged Cuban who plays in the band tells guests that life here is hell. "On the surface all is nice and relaxed," he says, "underneath it's tightly controlled. People who have to talk to tourists are carefully selected." As he talks, he smiles in case

Central Havana residents take the air on their crumbling balconies, while in the colonial city of Trinidad a woman cleans up in an old house partitioned for privacy. Shortage of building materials makes for overcrowded housing.

he's being watched. "See that woman near the pool? She's incredibly afraid she might be accused of fraternizing. She's not a party member, but they need tourist guides." He's had trouble because he doesn't like the band he's assigned to; they don't play to his taste. He's said so, and that's bad. No, he doesn't want to leave Cuba; he loves his country. "I'll sit it out here, but every morning I wonder if I'll lose my job today."

EARLY MORNING TV, Channel 6, Havana. First aerobics (a man and a woman), next a vintage Disney cartoon (Mickey and Donald). Then drawings by first graders, each with the little artist's name and school. And now here's Brig. Gen. Urbelino Betancourt, deputy chief of the general staff of FAR, the Revolutionary Armed Forces, explaining with map and pointer why Cuba has just had to mobilize. He says it's in case of a massive air strike or "an invasion by the enemy," meaning the United States. Poised against Cuba are B-52s, aircraft carriers, the 82nd Airborne!

The U. S. is in fact conducting annual maneuvers in the Atlantic and the Caribbean. Fidel Castro says those *Yanquis* must be up to something; it's better to mobilize a hundred times than to be surprised once. "If they come, they'll experience another Vietnam."

And so for a week, missile batteries sprout next to Havana apartment houses, MIG-29s spread sonic booms. Recalled reservists and

the MTT, the Territorial Troops Militia, exercise with tanks and bazookas. The newspapers are full of it. And then, overnight, it's all gone. This happens regularly, says a foreign resident—"a bit of drama to keep the revolutionary spirit alive."

As food shortages grow, workers at Havana harbor unload Vietnamese rice. Ration books in hand, shoppers in Santiago de Cuba line up daily for bread. Mostly empty cases line Havana's Fin de Siglo department store, pre-Castro purveyor to the bourgeoisie. Declining imports (especially of fuel), factory closings, and a moratorium on new construction signal Cuba's toughest economic straits in three decades. No longer able to prop up the island's economy, the Soviet Union is cutting back subsidies and moving toward hard-currency trade. Cuba now counts on tourism and biotechnology to bring in new revenue.

LA BAHÍA DE COCHINOS, the Bay of Pigs, lies on the southern coast; here a U. S.-supported force of 1,297 Cuban exiles landed in April 1961, aiming to destroy Castro's regime. They were mopped up in three days. Eventually 1,091 prisoners were allowed to go free in exchange for food and medical supplies. Now a museum displays weapons and maps in memory of this invasion.

I push inland, into the Zapata Swamp. Here

Sleep invades a day-care center in Havana's Miramar section, and at another in San Antonio de los Baños miniature portraits stuck onto stars match washcloth to child. The government runs such facilities throughout the island; parents are charged by ability to pay. Mothers-to-be who flock from the surrounding countryside for prenatal care at a state-run home file down a street in Bayamo. Such free preventive care has helped make Cuba's infant-mortality rate the lowest in Latin America.

shimmers Laguna del Tesoro, "treasure lake," a six-square-mile lagoon lined with reeds where foreign sportfishermen have caught record-size largemouth bass. Two young men in a boat are working their way through the shallow water, pulling in a half-mile-long gill net—dislodging tarpon, tilapia, a three-foot *manjuari* with what looks to me like the head of a crocodile and the body and tail of a fish. They've been at it all night and will return after lunch to set out the net again.

From my boat I ask about their fishing cooperative. You work 20 days a month, they say, then it's 10 days off. This month they'll work an extra five days, voluntarily, to fulfill the monthly plan, four tons per man. Volunteers will get an *estimulo*, a reward. A *trabajador destacado*, an outstanding worker, is chosen each month, and the best of the year is named a *vanguardia*. And that's how one gets good things in Cuba.

Here's how the system was explained to me. There are moral rewards—medals and diplomas. And there are material rewards, given at the workplace, perhaps the right to buy a Soviet-made fan or refrigerator at a good price, or a week at Varadero beach.

To get such rewards, you amass merit points—let's say for voluntary work on weekends in a construction brigade, helping build an apartment house. Your merits will be posted, and at the end of the year your fellow workers vote. Who'll get the vacation at the beach? They may vote it to you, but you might choose to wait for something really big—an apartment or a car; that'll take years, of course. It's like this in all the offices, factories, and agricultural cooperatives in Cuba. This year Castro has called for 120 hours of voluntary work from everyone.

Even day-care centers work on a reward basis. The minister of education told me there are hundreds of these for children 45 days to six years old. "It costs us three times as much per child as primary school." I can see why when I

visit a center at Cienfuegos: a staff of 48 for 198 kids, a new three-story building with kitchen and laundry. The children change into play-clothes that are washed daily. On staggered schedules, they have showers, playtime, lunch, nap, snack. I see a row of toothbrushes, each with a symbol: umbrella, banana, duck. A one-year-old is brushing his four teeth. Even if a kid has only one tooth, that one must be brushed after eating. "We try to teach the right attitudes," says the *directora*. At what age comes reading? Not here, she says, it isn't good to push the ABC's on little children.

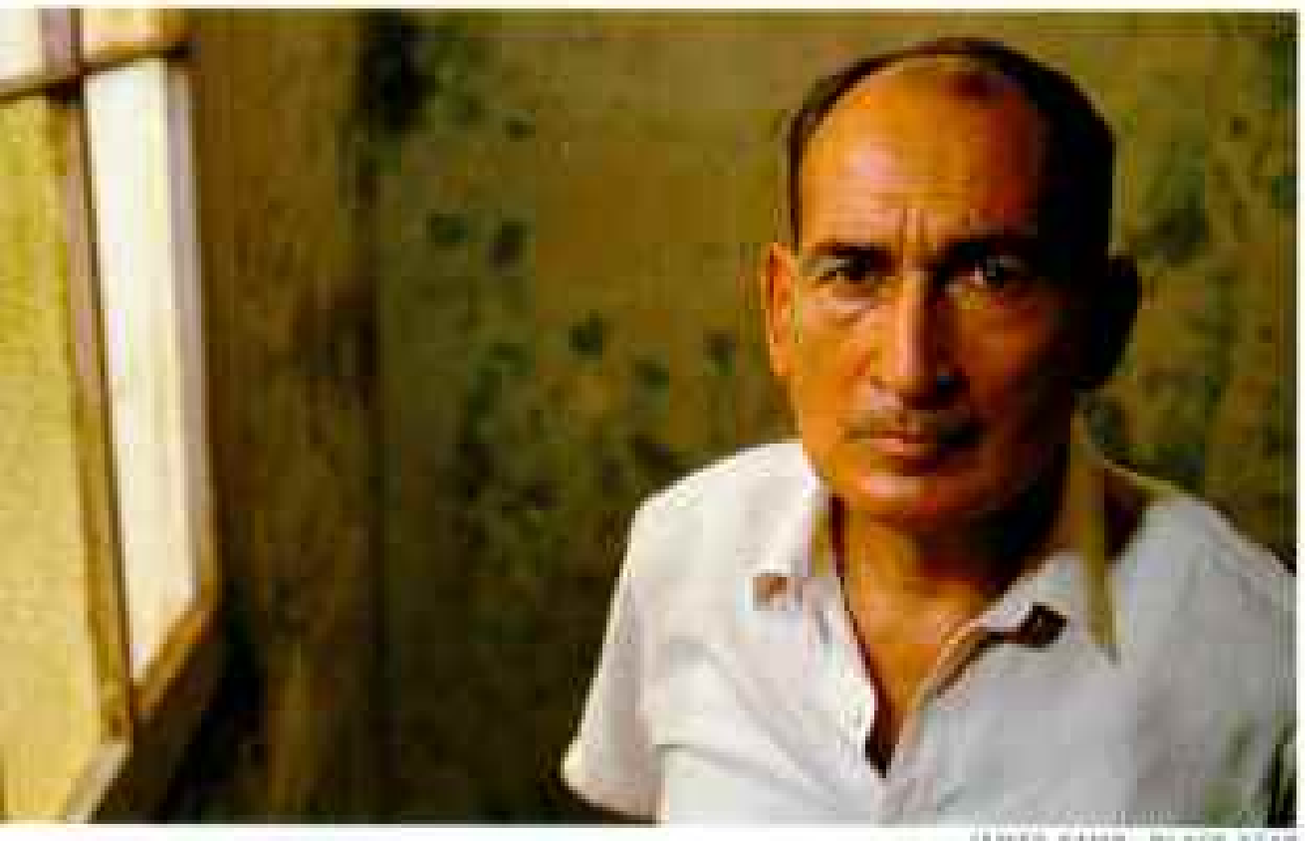
The fees are modest, but there aren't nearly enough places for all the youngsters in this age group. So how does a mother get her child in? I'm told there will be inquiries. At her workplace—is she a good worker? In her neighborhood—is she a good revolutionary? Isn't there a grandmother who could take care of the child?

The president of her CDR will know.

THOSE CDRs, the Committees for the Defense of the Revolution, what are they really? They take retired people on excursions, collect blood for hospitals and paper for recycling; they urge people to clean up their block, discourage children from playing hooky, and organize graduation parties. But the primary objective is revolutionary vigilance, says the national CDR coordinator, Gen. Sixto Batista. A senior official at the national headquarters adds: "The CDR is the tool of the Communist Party to take its policies to the people, to their community, into their houses." Everyone 14 or older is urged to belong. Every block has at least one CDR. In the mountains a CDR may cover ten scattered houses. Members patrol at night to guard against any kind of delinquency.

There are 15,000 CDRs in Havana, the official tells me; the countrywide total is 101,000—"altogether 7.3 million members, or 89 percent of the adult population." I make a quick calculation; what about the other 11 percent, or 896,000?

"They are enemies of the revolution."



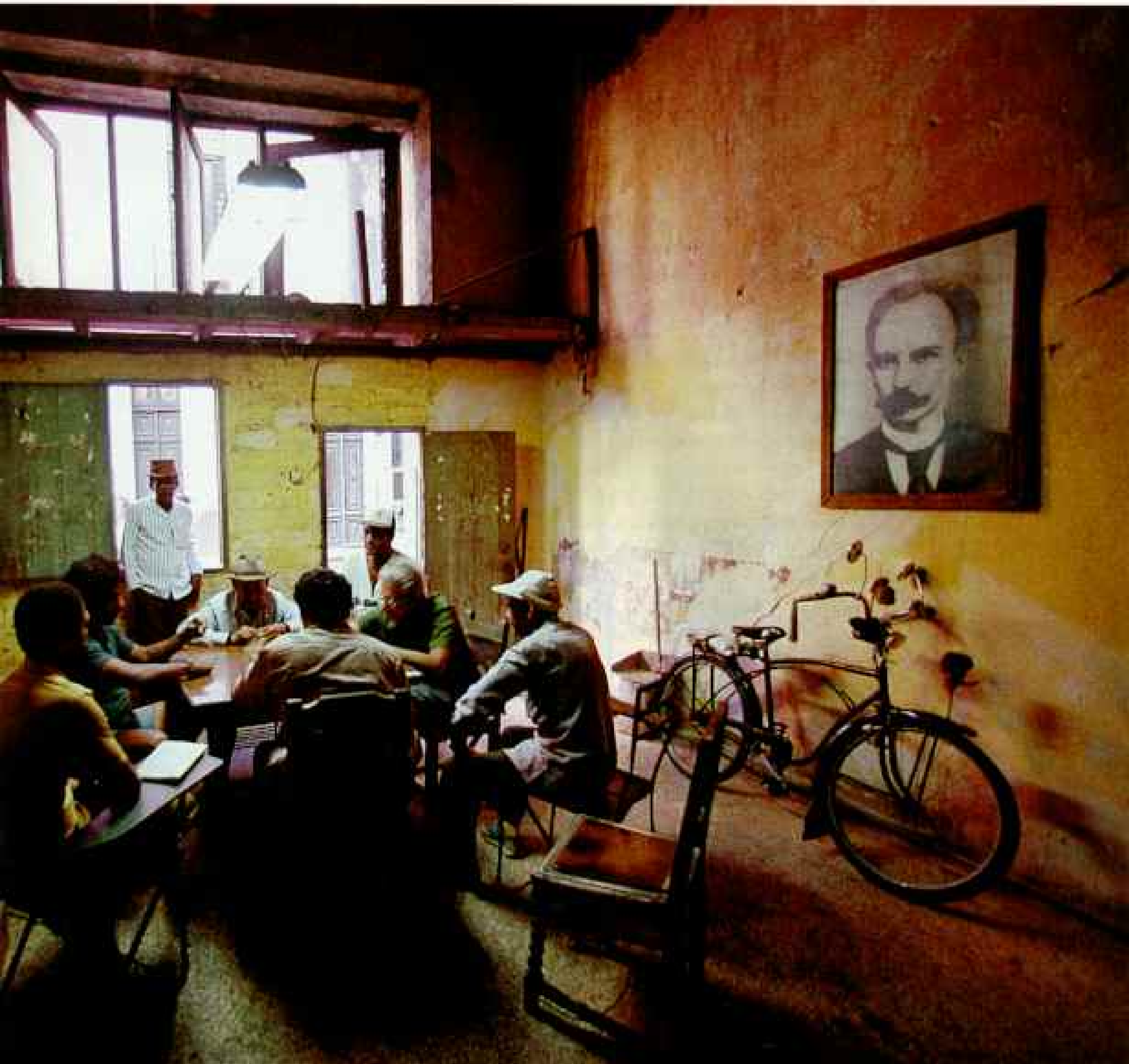
JAMES KAMP, BLACK STAR

Political watchdogs and civic activists, members of a Committee for the Defense of the Revolution break for dominoes in their central Havana meeting room. Cubans who openly denounce the system face ostracism, mob harassment, or jail. Gustavo Arcos (above), an early Castro ally turned critic, last year heard a crowd outside his Havana apartment jeering "Worm!" and "Counterrevolutionary!"

Most Cubans benefited from the revolution, he says, but some were hurt by it: the rich, the bourgeoisie, the landowners. More than a million have left, thousands have not. "Those are the ones we really watch, the class enemies who want to harm our revolution. They hate us and feel terrorized by us."

Given the scarcity of things, there are unofficial systems at work in Cuba too. For example, if you want construction material, you're supposed to receive it as a reward, a man explains, but he has another way. "I'm fixing up my house and need wire to tie the reinforcing rods. My brother is a truck driver taking shipments from Havana to my town, and the loader certifies that he put on a hundred spools. But he really loaded 102—my brother paid him something. When my brother gets here, he'll unload a hundred spools and give me those extra two. That's how we all get construction materials here; we pay people off."

HOW ABOUT that vaunted health system? The idea is for every Cuban to have his own doctor close by, to be visited for a checkup twice a year and seen as often as necessary, free of charge. Half the population is looked after by 11,900 family doctors, recent graduates all—about one for every 150 families or 500 people. I stop at some of the ubiquitous three-story doctors' houses. They're white, square, with the doctor's quarters on top and the nurse's quarters and consulting room downstairs. Often it's the same diagnosis—hypertension or diabetes or asthma. People are urged to



stop smoking, but a lot are hard to convince.

A health ministry man tells me that the family-doctor program, begun in 1984, is scheduled to cover everybody by the year 2000. People not yet covered go to clinics. All women get Pap smears and, if pregnant, extensive prenatal care. No, all this is not cost-effective—"it's a manifestation of political will." So far, he adds, eight million Cubans have been screened for SIDA—that's AIDS in Spanish. Anyone confirmed HIV positive is isolated in a *sidatorio*—an AIDS sanitarium.

CUBA'S WESTERN TIP is richly blessed with natural endowments. Along the road in Pinar del Río Province I see a weathered sign in English: The Mecca of Tobacco. Indeed, two municipalities—San Luis and San Juan y Martínez—grow the makings of the world's finest cigars. That's thanks to a very special microclimate of moist nights and cool mornings and to acres of cheesecloth stretched over the growing tobacco plants against insects and too much sun.

No less important is the care taken to compose those little masterpieces, using leaves from different parts of the plant: From up high comes strength; from the middle, aroma; from low down, burnability. Cuban cigars bring millions of dollars from Spain and France, Britain and Switzerland. Quite a few, I hear, come surreptitiously into the U. S.

In the Viñales area limestone masses as high as a thousand feet rise steeply from the plain, as if dropped there by some giant. Some have enormous holes in them—hundreds of feet wide, formed by erosion—and some of these holes are reachable by traipsing through natural tunnels. Guided by a farmer, I reach such a hole, called the Valley of the Nightingales, an idyllic spot, green, full of birdsong in the afternoon sun. Before the slaves, brought to Cuba in the early 1500s, were freed at last in the 1880s, runaways built villages in such holes.

This farmer has been given traps to capture *jutías*, ratlike rodents that can grow up to two feet and weigh 20 pounds. He is to mate them and raise as many as he can. For fur? No, for food. It's one of the new measures in keeping with the "special period in time of peace," meaning hard times just short of war.

You can meet hard times in a category 1 Havana restaurant too, for different reasons. I ask for coffee. *No coffee.* Why not? *The lady who makes it is pregnant.* I point to an idle waiter; can't he make coffee? *Yes, but that's her job, and she's pregnant. Also, the coffee powder is missing.* How so? *Well, it's locked up.* Really? *Well, actually every morning someone delivers coffee, but it can only be given to the lady who's responsible, and she's. . . .* Yes, I know. May I speak to the administrator? *He's not here—toothache.* May I speak to his deputy? *Well, I am, but only to a*

Dancers strut past foreign vacationers at the resort of Varadero to drum up interest in the evening show. Squeezed by foreign debts and a U. S. economic embargo that includes a ban on tourist spending, Cuba looks to tourism from other countries for hard currency. Last year 320,000 visitors brought in 216 million dollars.

certain limit, which I can't exceed. We're trying to find another woman; she should have been here by now. Why isn't she? *Only the administrator for personnel would know. Perhaps there aren't enough workers.* But Fidel said if Havana had 100,000 fewer workers things would work better. *Ah yes, that's right.*

Alas, Fidel also just said that Cubans are the most hospitable, friendly, attentive people in the world, but put one into a waiter's uniform and he becomes a terrible thing.

FOR A WHILE before the revolution Havana had a reputation as a place of intrigue and tawdry romance. There's still a whiff of that in the lobby of the Havana Libre hotel, the former Havana Hilton. It teems with foreigners who aren't strictly tourists: Admirers of Fidel Castro and representatives of leftist-oriented rebel movements from around the globe, more or less skeptical journalists, and people coming to Cuba's incessant festivals and congresses—guitar players, filmmakers, anesthesiologists. Many are invited by the government, expenses paid. They're watched by secret-police agents from the "ministry," meaning MININT, the Ministry of the Interior. Part of the mix too are some of Havana's prettiest women—university students from nearby classrooms dropping in to use the telephone and the bathroom. And *jineteras*. The word comes from *jineta*, or horsewoman; nowadays it means women looking for hard-currency men.

In town too are a few American sportsmen participating in the 40th annual Ernest

Medals on veterans of the Angola war light up a May Day celebration in Havana's Plaza de la Revolución. Dolls lend a girlish touch to the barracks of an all-woman artillery unit outside Havana. Women volunteers were part of a force of 300,000 Cuban soldiers who fought in Angola from 1975 to 1988.

Hemingway International Marlin Fishing Tournament. Their six cabin cruisers made it in 3½ hours from Key West to the Marina Hemingway outside Havana. "No problem with U. S. law," says one skipper, "we're fully hosted." He means the Cuban tourist authorities are paying their expenses.

From time to time, far from Havana, I encounter evidence of Cuban traditions reaching back to earlier times. Thus between the Escambray Mountains and the Caribbean coast dozes the Spanish colonial city of Trinidad, reflecting its heritage of 16th-century conquistadores, 17th-century corsairs, and 18th-century sugar barons. Its architecture is neoclassic and baroque, with a Moorish flavor. Cobblestone streets; facades of pastel pink, blue, and yellow; fancy wrought-iron grilles and mahogany balustrades—all sparkle after restoration.

In the former mansion of a slave trader, full of antique furniture and knickknackery, a photographer fusses over a girl in a long blue dress and wide-brimmed blue hat. She's a *quinceañera*—she has reached her 15th birthday, a milestone. For this day Cuban parents may save for years, to do right by their girl with the nicest outfit they can rent, with plenty of rum for plenty of guests. This girl is chubby, to say the least—but in her lacy gown, with that serene smile, she looks to me every bit as graceful as the Meissen figurines behind her.

In the town of El Cobre in southeastern Cuba, surrounded by mountains, rises the sanctuary of Our Lady of Charity, the patroness of Cuba. There are two Masses daily, three on Sundays. In a chapel, I see hundreds of propitiatory offerings—badges of soldiers and policemen, a plaque from Soviet technicians at the big textile mill in Santiago. And a little golden figure presented by El Comandante's mother—asking favor and protection, perhaps, for her son Fidel and his brother Raúl. Five years younger than Fidel, Raúl has been at his brother's side since their earliest days of political agitation at the University of Havana; today he is minister of defense, Fidel's deputy and possible successor.

ON A SUNDAY MORNING in Santiago de Cuba, next to the old Moncada barracks where Fidel Castro fired the opening shot of his revolution, first graders race go-carts with deafening noise. A dozen nine-year-old boys and girls in made-to-measure army uniforms display a torn-down gasoline engine; they're from the Fuel and Lubricants Club of Tania the Guerrilla Primary School. Their teacher explains they don't have rifles yet, but they're learning about the history and importance of oil. "We want our children to know our weapons," an army major tells me while high school girls

Trading battlefields for pineapple fields, soldiers in Ciego de Avila Province play cautious catch with prickly piñas shaped like grenades. Lack of fuel is forcing reliance on manual and animal labor.

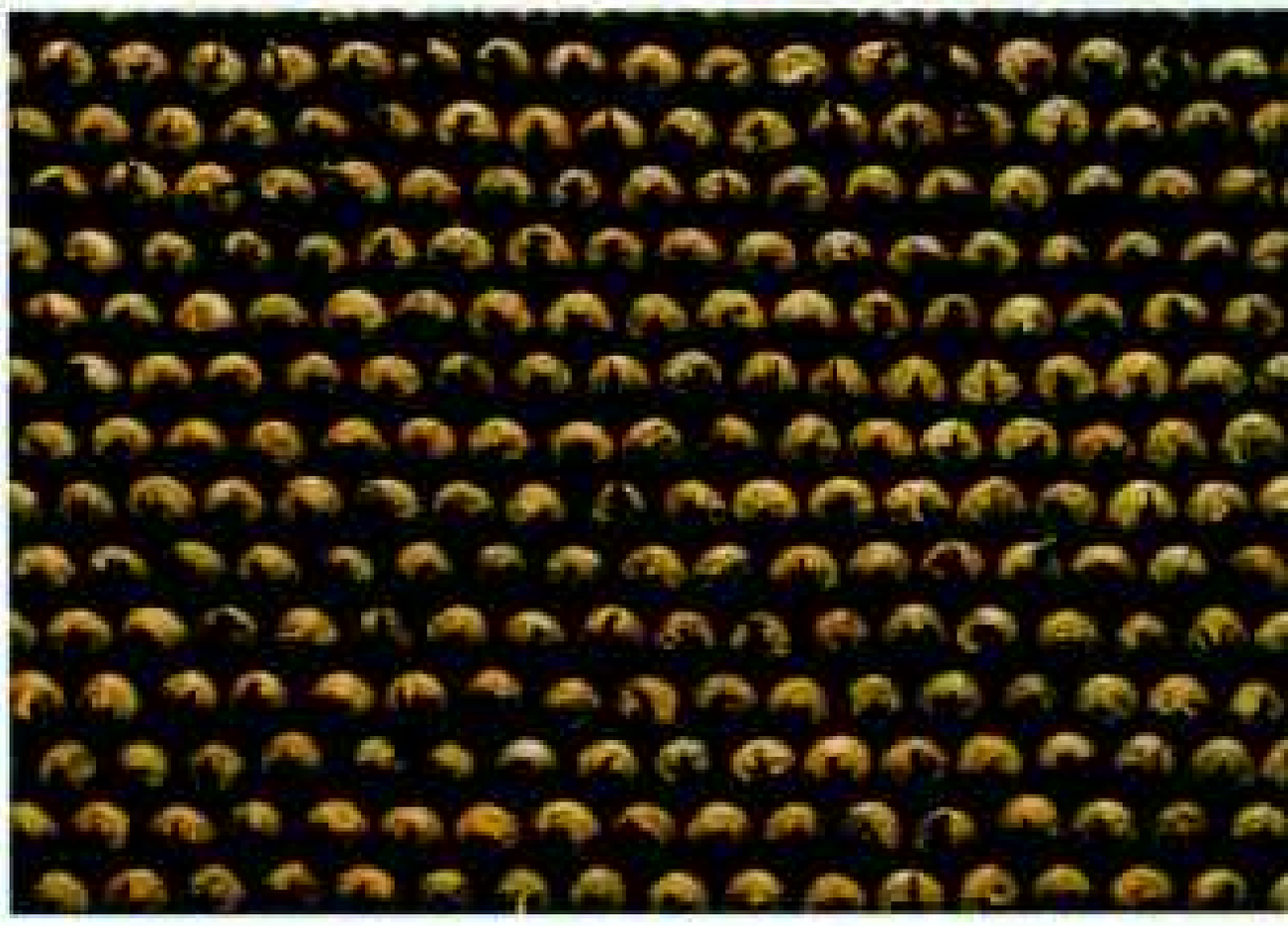
shove a blank shell into a 57-mm antitank gun. "North American tanks spotted—destroy them!" *Boom.*

It was in 1953 that Fidel and 110 revolutionaries attacked the Moncada barracks; most of the attackers were killed immediately or soon after. Castro was captured, tried, imprisoned, and eventually released. He went to Mexico, to plan his next strike.

Driving west along the coast from Santiago, I find rocky bays and deserted beaches, the ruins of a Spanish fort, and more evocations of history—of 1898, the year American troops landed to help wrest Cuba from the Spaniards. I see a gun turret sticking out of the water, a remnant of a Spanish warship run aground. To my right rises the Sierra Maestra; from the town of Chivirico a mule train is setting out—up there grows coffee. I stop at the village of La Plata.

Fidel Castro landed not far away, in 1956, coming from Mexico with 81 men crammed into a 43-foot boat that ran aground near shore. The bedraggled rebels, having lost most of their weapons, scrambled into the mountains, harassed by government soldiers and planes. But the mountain farmers supported them, and the country was ripe for change.

Castro was down to 26 men when he surprised the government post at La Plata and captured nine rifles and a submachine gun. It was his first military victory. Within 24 months he rode in triumph through Havana.



CASTRO, CLOSE UP. It's the 26th of July, the anniversary of the Moncada assault—Commander in Chief Fidel Castro, First Secretary of the Communist Party of Cuba and President of the Councils of State and of Ministers, is about to speak in Havana's Revolutionary Square. Balloons rise, leaflets float down, tens of thousands cheer the massive figure in olive green fatigues.

He puts on his glasses. A little wave of his outstretched left hand and there is silence. He begins slowly, clearly, with expansive gestures to right, to left; by turns he is outgoing, sarcastic, impassioned—his craggy face and silvery beard reminiscent now of Santa Claus, now of Michelangelo's Moses. His theme is

Lunch pail in hand, a sugarcane cutter strides past stalks in Guantánamo Province. Cuba's lifeblood since colonial days, sugar remains 70 percent of the country's exports by value, but economic reforms in the Soviet Union threaten Cuba's subsidized market there.

A worker hand-rolls a cigar (top), and rows of finished Cohiba cigars (above) await export to foreign fanciers who will pay some of the world's highest prices. "In the . . . spiraling smoke of a cigar, there was always something revolutionary, a kind of protest against oppression," said Fernando Ortiz, late chronicler of Cuban culture.

struggle, struggle, resist and resist. "The imperialists think we won't be able to resist—how little they understand our people. . . . We are millions of men and women, armed to the teeth, willing to win or die!"

The speech lasted three hours; in the middle, as millions watched on TV, the transmission ceased for five minutes. Power failure?

Even now some "imperialists" remain camped on the island. Near Cuba's eastern tip, I drive from the city of Guantánamo, capital of the province of that name, southeastward in the early morning sun past brand-new orange plantations and old sugar fields. After an hour I'm at the gate of the U. S. Navy base on Guantánamo Bay.

Some two dozen Cubans still go in and out daily, to work on the base, which is otherwise cut off. Since 1903 the U. S. has held an indefinite lease; the annual rent is now $4,085. It's promptly paid by check, but the Cubans won't cash it. Some 7,000 Americans live in there—sailors, marines, dependents—amid all the comforts of a small midwestern town, with drinking water from a desalination plant, and food for the supermarkets coming twice a month by barge from Jacksonville, Florida.

EVERY THURSDAY AFTERNOON a radio announcer in Havana says: "And now here's Dr. Monika Krause from the National Center for Sex Education!" She answers letters and takes questions on the phone, before an audience probably

only slightly smaller than Fidel Castro's.

Dr. Krause, who came from East Germany a generation ago, tells me she's appalled by the widespread ignorance of Cubans in sexual matters and especially by a new survey among teenagers. The girls insisted male promiscuity is a natural attribute. The boys said it's necessary, or they'll get sick.

That's the tradition, she says, in all social levels, nationwide, and it's deplorable. "When a boy is 15 or 16, his father wants to hear of his sexual exploits, as proof of his manliness. If the boy says he's been going with a girl for three months, the father will say, 'What, only one, you have to have more, you must practice a lot.' " And the boy's mother will agree. At the same time, boys are expected to watch over their sisters; they must be pure. "But when the girls get away from the family, what happens? In those boarding schools, where hundreds of thousands of teenagers pick citrus three hours a day? At night, when the teachers think they're in bed, they're really out there in the orchards."

Also part of the tradition, she says, is that a woman must please her man no matter what—even now when more than half of Cuban professionals are women, when most women go to work. "What happens? A woman is in militia

Lights and television bring the modern world to a Taíno Indian legacy, a bohío *made of wood and royal palm fronds, outside the town of Baracoa.*

training on Sunday, her husband too. They come home sweaty, dirty, and tired, and she brings him a towel and soap and clean underwear—'There, darling, now take your shower.' Then he has a nap while she cooks. They all eat, and then she does the dishes while he and the kids watch TV. And then she washes the dirty uniforms."

ON MY LAST OUTING I'm in the heart of the Sierra Maestra to meet the family doctor of the village called El Mulato. It's cool up here—now misty, now sunny, and misty again. Then a burst of rain. Around me is cloud forest, with pines and palms festooned with plants that draw their nutrients from the air and the rain. Cuba's highest mountain, 6,476-foot Turquino, only ten miles away, is hidden most of the day.

This young doctor (above)—his parents named him Vladimir—is very revolutionary, proud of the new road and the two-room school. He has 363 people to look after—"three pregnant women, ten kids under one"—in 12 little groups of houses, three here, nine there. Some are seven mountainous miles away. He makes visits by mule or on foot.

We visit a farmer after an hour's walk on a slippery up-and-down path. He has pigs, goats, and coffee trees; around him live his two daughters and sons-in-law with nine grandchildren. Last year, the farmer says, he got legally married. Thanks to Dr. Vladimir! The

doctor has been organizing mass weddings, with a cake and white gown for each bride; until he came two years ago, people here couldn't afford to get married, so they simply lived together. Soon Dr. Vladimir will marry his 64th couple—on Fidel's 64th birthday!

I'd flown up to El Mulato in a Soviet-built helicopter that a short time ago was a troop carrier and gunship in Angola. Now it's painted white and carries tourists around. The pilot, a major trained in the U.S.S.R., saw combat in Ethiopia and then in Angola, where Cuban soldiers had long been helping the government fight off insurgents and their supporters from South Africa. Over the years some 300,000 Cubans served in Angola. Now the last ones are coming home; also the bodies

The family doctor makes house calls in El Mulato, a remote hamlet high in the Sierra Maestra—and he doesn't charge a peso. Dr. Vladimir Díaz treats Fredesbinda Pérez for a breathing ailment inside the hilltop hut she shares with her husband, Ramón. Although health care is free, recent trade disruptions have caused shortages of some medicines.

Last year modern medicine saved the life of Javier Márquez, five, who traveled from Santiago to Havana for open-heart surgery; he recovered with the help of breathing exercises—and the support of his mother.

of the fallen—hundreds of them—for ceremonial burial. One veteran tells me that having seen the misery most Angolans must endure, he thinks Cubans are well-off. Another says the Angolans are ungrateful; it was all a big mistake.

WHAT CAN I CONCLUDE, after eight weeks of seeking *el sabor de Cuba*, as the phrase goes—the flavor of Cuba? That Castro is tough. All his life he has stayed supremely confident in the face of seemingly hopeless odds; it appears inconceivable that he would permit fundamental reforms. And that while Cubans are displeased with the workings of his system, they are adjusted to it, manage to get something out of it, and are fearful of drastic change.

I recall two emphatic voices. A woman in her 20s: "Everybody talks about scarcities, but my father always tells me we shouldn't complain about stupid little things. He says 'I was cleaning shoes on the street when I was seven, but all four of you children have a university education. If the exiles came back, the people with money, we'd suffer a lot—they'd take everything back, they'd make the beaches private again.'" And a man in his 30s: "If somebody tells us that to get the things we want we'd have to overthrow the revolution, no thanks! The exiles would cut the budget for education, for health—would they care about poor children or old people?"

Telephone repairman Humberto Pérez peers beneath a flag veiling a Havana skyline hazy as Cuba's future. "Will it be an independent, industrious Latin American nation?" revolutionary José Martí asked nearly a century ago. "This and nothing else is Cuba's task."

Every day brings astonishing news from Cuba. A Soviet Politburo member visits, but there is no communiqué. Castro frets that Cuban-Soviet commercial relations are up in the air—"at this moment we know nothing!" At long last a new agreement is signed: The U.S.S.R. will still take all that Cuban sugar but send a lot less oil.

And so Castro speaks of ever more drastic retrenchment. Massive Soviet-supported construction projects—the nickel plant at Camarioca and the nuclear power plant and the big oil refinery at Cienfuegos—may never be completed. Plowing is to be done with oxen. Fewer buses? More bicycles! One hundred eighty more items will be rationed; electricity, already much curtailed, will be cut further.

The Communist Party bureaucracy is to be reduced too. There's talk of "rectification of errors"—but it's nothing like the Soviet Union's *perestroika*. Cuba needs Marxism-Leninism more than ever, Castro says. He vows: "If I'm told 98 percent of the people no longer believe in the revolution, I'll continue to fight. If I'm told I'm the only one who believes in it, I'll continue."

WHAT WILL HAPPEN? An item from Havana radio gives me pause: Temporary lack of beef and poultry in the capital make the population worry that soon there won't be any meat at all and have led to protests and disturbances in front of butcher shops. A food ministry bureaucrat says these shortages are due only to vehicle breakdowns and delays in slaughterhouses—people should do all their complaining by phone to his office.

Is this how something big could start? Say there's rioting, nervous police start shooting, troops are sent to subdue the rioters but turn on their officers instead. Could it be that by the time this article appears in print Fidel Castro will be gone—pushed out, perhaps, by army officers seeking to avert chaos? And then, will there be an outpouring of relief, after 32 years of progressive disillusion with the revolution?

Maybe. More likely is that Cuba will just go muddling along. But no matter what, there'll still be impassioned poetry and drumming and dancing, and the consolations of the *orichas*—those powerful divinities of *santería*, the Cuban composite of Roman Catholicism and African belief. There'll still be rodeos in the countryside and glorious beaches with *tangas* and *tanguitas*—tiny bathing suits and tinier ones still. No lack of Soviet fuel will stop teenagers from falling in and out of love, and in again. And before long it'll be time for another carnival.

And so, for the foreseeable future, there'll be no shortage of things to look forward to on this beautiful island of palms and buzzards and sugarcane. □

L'ENFANT SILHOUETTE IN A COLLAGE BY SARAH SCHARF, CIRCA 1789, COURTESY U. S. DEPARTMENT OF STATE

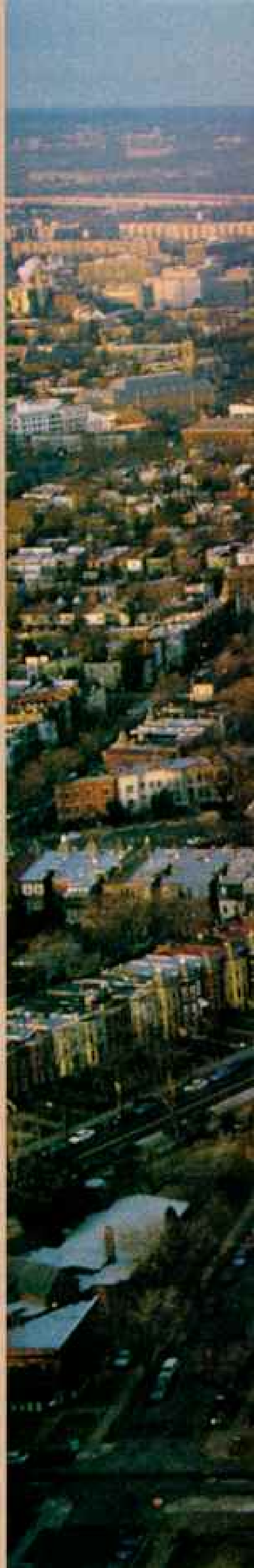
L'Enfant's Washington

By ALICE J. HALL
ASSISTANT EDITOR

Photographs by SISSE BRIMBERG

L'ENFANT MAP, 25 BY 61 INCHES, LIBRARY OF CONGRESS

Two hundred years ago this August, architect Pierre Charles L'Enfant presented President George Washington with his bold design for the new federal city, the only map of Washington in L'Enfant's hand to survive (above). Built from his plan, the city (right) spreads west from Lincoln Park past the Capitol.



"A plan wholy new," L'Enfant's design encompassed 6,100 acres of rolling Maryland countryside. He sited public squares on high ground and connected them with wide diagonal avenues. On a hill he called "a pedestal waiting for a monument," he placed the Capitol, with a clear view of the President's house and a promenade to the Potomac.

This new computer-enhanced reproduction of L'Enfant's map reveals Thomas Jefferson's notes to the engraver, such as a corrected spelling of "Potomac."

PLAN
of the CITY, intended for the
Permanent SEAT of the
Government of the
UNITED STATES
Projected agreeable to the direction
of the PRESIDENT of the UNITED STATES
conformable to the ACT of CONGRESS
of the 16th of July, MDCCXC.
establishing the Permanent Seat
on the bank of the Potowmack

Plan of the city of Washington
in the territory of Columbia
ceded by the states of Virginia
and Maryland to the U. S. of America
and laid out by order of the said
government for the permanent seat of the
general government

OBSERVATIONS explanatory of the PLAN.

I.
II.
III.

Breadth of the Streets.

REFERENCES.

A. THE
B.
C.
D.
E.

N.B.

SCALE OF POLES.

GEORGE TOWN.

POTOWMAC RIVER.

PART OF VIRGINIA, WITHIN THE FEDERAL DISTRICT.

EASTERN BRANCH.

PART OF MARYLAND, WITHIN THE FEDERAL DISTRICT.

Lat. Congress House 38. 53. N.
Long. 0. 0.

References.

F.
G.
H.
I.
K.
L.
M.

N.1.

PRODUCED BY THE U. S. GEOLOGICAL SURVEY FOR THE LIBRARY OF CONGRESS

DAYBREAK comes with thick mist and drizzle. President George Washington, tall and distinguished at 59 years, and 36-year-old Maj. Pierre Charles L'Enfant leave their lodgings in the port of Georgetown on the Potomac River and mount horses. The younger man, an architect-engineer, is also tall and courtly but has a beaked nose and a manner some consider arrogant. They ride east across swollen Rock Creek, past corn-stubble fields and timber, to inspect uneven Maryland countryside that will become the nation's capital. The land, an English visitor later observes, "waves in gentle curvatures, never rising into a hill, never sinking into a valley . . . surrounded by a complete amphitheater of hills."

On this historic Tuesday, March 29, 1791, Washington is attracted to a ridge with a view south to his beloved Potomac: Here will rise a house for the President. The mounted party rides another mile to Jenkins Hill; L'Enfant calls it "a pedestal waiting for a monument." That monument will be the U. S. Capitol.

Washington finds the weather so bad that he derives "no great satisfaction from the review." But for the visionary L'Enfant lengthy conversations with the President encourage him to plunge ahead on a "grand pland of the whol city."

That grand plan would be revised several times by L'Enfant, under Washington's watchful eye. But the only draft in the designer's hand to survive is a large pencil-drawn map, one of the great treasures of the Library of Congress. Age-worn and obscured by varnish, its lines are hard to read. So, for the map's 200th birthday this August, the National Geographic Society helped sponsor a clear reproduction (left). Thanks to computer digitization by experts at the U. S. Geological Survey, the original legibility has been restored. Now everyone can compare L'Enfant's ideas with the city as it exists today.

The reproduction of L'Enfant's plan is a cornerstone of a four-year joint program with the Library of Congress, funded in part by a $348,250 Society grant, to improve access to and preservation of the library's unique collection of 2,000 maps and atlases on the evolution of Washington, D. C.

How did that master politician and general George Washington and the brilliant, artistic L'Enfant come to partnership in the creation of the federal capital? By a circuitous route that involved L'Enfant's rise to national eminence and ultimately, through his own character faults, his fall from grace.

The two men had met at Valley Forge after L'Enfant arrived in 1777 as a brash 22-year-old volunteer, one of scores of Frenchmen who joined the Revolution's cause. He had turned his back on a sure future in Paris, where his father was a prominent painter employed by Louis XVI. A fledgling artist, young L'Enfant sketched the American general, who wrote of him as "Monsr. Lanfang."

L'Enfant became an aide to Baron von Steuben, Prussian drillmaster of the ragtag U. S. forces. Later the young Frenchman saw action in Savannah, was wounded, and spent nearly two years as a prisoner of the British.

After the war L'Enfant designed buildings

AQUATINT BY T. CARTWRIGHT AFTER GEORGE BECK, LIBRARY OF CONGRESS

PAINTING BY EDWARD SAVAGE, ANDREW MELLON COLLECTION, NATIONAL GALLERY OF ART

Dream fulfilled, Washington picked the Potomac site for the capital. This 1796 painting shows him with wife Martha, grandchildren, valet William Lee, and a L'Enfant map. When the government took up residence in 1800, the view downriver from heights above Georgetown (top) showed more countryside than city.

in New York City. He became a figure in society, not handsome but a favorite with the ladies. His 1789 renovation of City Hall to serve as Federal Hall for Congress and as Washington's Inaugural site added to his stature.

L'Enfant had higher ambitions. Petitioning Congress in 1784, he had suggested an army corps of engineers, which would, among other duties, build a federal capital. In September 1789 he offered himself to the President as designer of such a capital; it should reflect "the greatness of the empire." The words could have been Washington's own, and 18 months later the job was L'Enfant's. There was no design competition, no budget, and no contract.

And why was the capital sited on an obscure patch of Maryland? The location of a federal town had been the subject of vitriolic debate in Congress for a decade, since it promised great political and commercial advantage. At least 40 sites had been considered: places like Kingston, New York; Germantown, Pennsylvania; even Marietta on the undeveloped Ohio frontier. Debates often split between Northerners and Southerners.

Not even the signers of the Constitution could agree, but they did give Congress "exclusive Legislation . . . over such District (not exceeding ten Miles square)."

In July 1790 Congress finally agreed on a location somewhere on the Potomac, the river Washington had promoted for years as the water route to the West. The act gave the President authority to pick the exact site and to get the capital built. The vote came only ten days after a historic compromise. Secretary of the Treasury Alexander Hamilton agreed to urge northern states to vote for a Potomac capital if

Set in granite, the title from L'Enfant's map decorates Freedom Plaza (left), where stone paving illustrates the alignment of the President's house, the Capitol, and the Mall. Where the Mall crosses the view south from the President's house, L'Enfant proposed an equestrian statue of Washington; the monument, completed in 1885, is instead an obelisk (below), placed slightly off the intended axis.

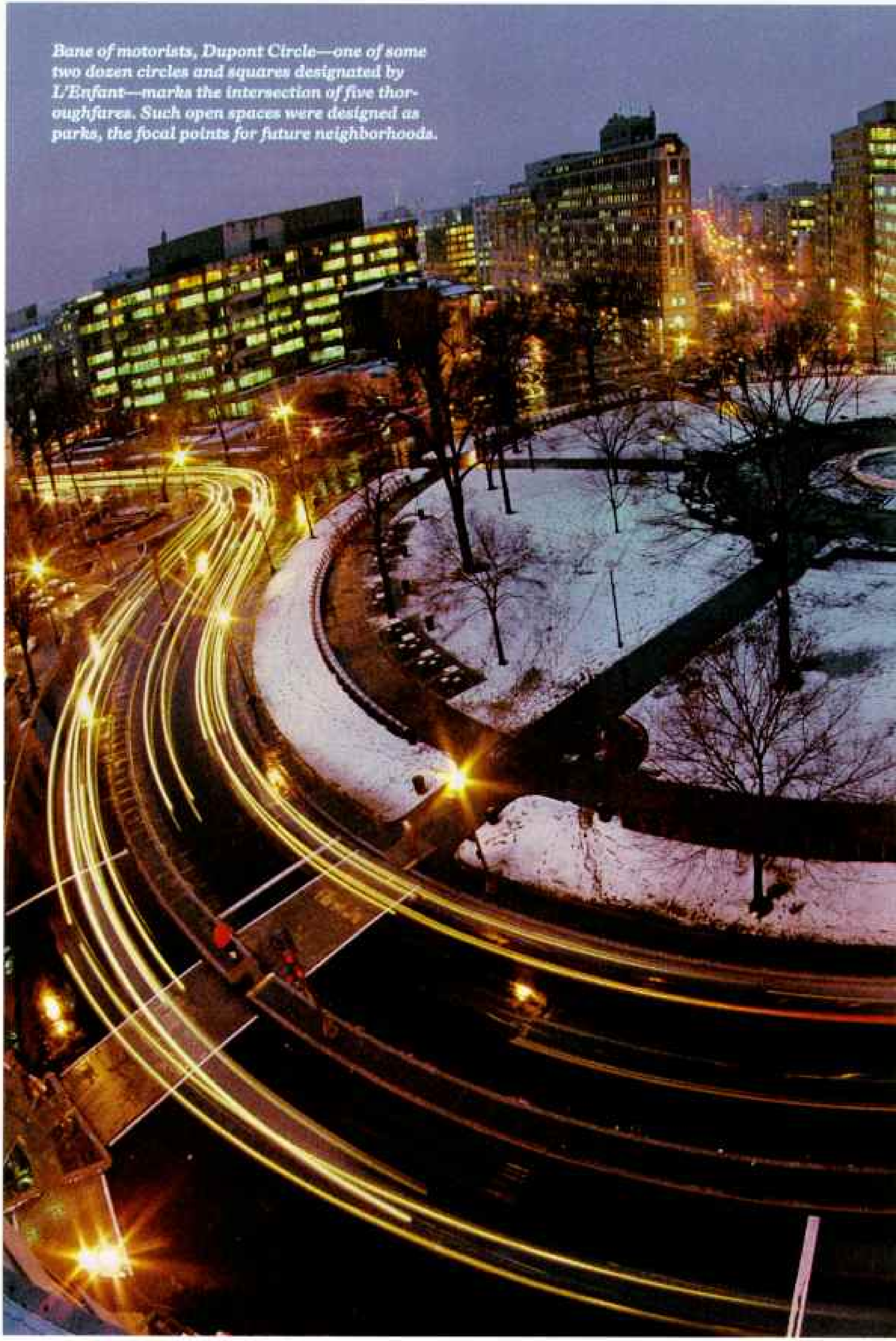
Virginia Congressman James Madison would influence Southerners to swallow their aversion to centralized power and vote for federal assumption of the states' war debts.

WITH CONSPICUOUS SPEED the President places the ten-mile square astride the Potomac at the head of navigation. (The Virginia side was ceded back to that state in 1846, reducing the district by a third.) He calls on surveyor Andrew Ellicott to lay out the district's bounds and L'Enfant to design a city within; to supervise the project, he picks three friends as commissioners: Daniel Carroll, Thomas Johnson, and Dr. David Stuart. The haste results from fears that Philadelphia, where Congress is to meet until 1800, will lobby to keep the government there permanently.

So in the dead of winter 1791 Ellicott begins his survey, assisted by astronomer Benjamin Banneker, a 59-year-old black Maryland farmer, son of a freed slave. Sighting on stars, they find the district's latitude and longitude and determine its boundary. L'Enfant sketches from horseback, sometimes impeded by "a fall of snow and stormy wind." The area from Georgetown to the Potomac's Eastern Branch covers some 6,100 acres, five times the size of Philadelphia. Two town sites have already been plotted by local speculators, Carrollsburg on the east and Hamburg on the west. Will the new capital encompass one or the other? Fortunes ride on the answer.

After Washington rides with L'Enfant that foggy March Tuesday, he reaches a surprising decision: The new capital will spread across the entire 6,100 acres. Skillfully the President

Bane of motorists, Dupont Circle—one of some two dozen circles and squares designated by L'Enfant—marks the intersection of five thoroughfares. Such open spaces were designed as parks, the focal points for future neighborhoods.



then persuades the landowners to "make a common cause of it" and cede their lands with modest recompense. L'Enfant is given an exceedingly broad canvas.

For the next three months the artist is hard at work. From Thomas Jefferson, who serves as Washington's intermediary, he borrows maps of Paris, Amsterdam, Karlsruhe, Turin, and other European cities.

In late June L'Enfant travels to Mount Vernon to show "an Incompleat drawing only correct as to the Situation and distances of objects." But here, in fact, is the basic plan, for the President's eyes only. Washington is well pleased. The scheme will be little altered during the vicissitudes that befall L'Enfant in the next eight months; for the next two centuries it will be a bible to capital planners.

As L'Enfant's memorandum explains, he "first determined some principal points to which I wished making the rest subordinate." These heights will receive the Capitol, the President's house, and Lincoln Park, proposed location of a zero-mile marker.

He next "made the distribution regular with Streets at right angle north-south & East-West." He then opens diagonal avenues from the principal points to "connect each part of the City with more efficacy by . . . making the real distance less." Each square would be within view of the next, permitting a "resiprocity of sight."

A tree-lined promenade spreading west from the Capitol to the river will be lined with elegant buildings. This is today's Mall, site of Smithsonian Institution museums. L'Enfant was probably remembering the chateau at Marly near Versailles, where a Louis XIV palace overlooked a mall embellished with basins and lined with guesthouses for nobility. In America L'Enfant's promenade will be a "place of general resort." Washington publicly places his stamp of approval on L'Enfant's vision when he rides the area with the designer and Ellicott on June 28.

Summer passes in a frenzy of activity. L'Enfant conducts surveys "to determine the acute angles & intersect lines with exactness." His men maneuver around the capital's first tourists—"daily visitor both natives and foreigner" viewing the future site of the Capitol.

How to pay for the city remains a problem. The sale of lots will raise money, Washington and Jefferson believe. L'Enfant has doubts. In late August he brings to the President the manuscript map that we now commemorate, reminding him it contains the ideas "which met your approval at the first begining of the business." Then he enters the political fray over financing. Eventually 15,000 lots will be available, L'Enfant reports, and could bring in an immense sum "if cautiously managed." Don't sell yet, he advises, but borrow a sum on the credit of the property itself. Washington is adamant to sell, to keep the project moving, to keep Philadelphia at bay.

The next meeting of the commissioners, attended by Jefferson and Madison but not L'Enfant, produces major decisions: The sale of lots is set for October; the city is named Washington to honor the first President; the district is to be the Territory of Columbia. Streets running north-south are to be numbered, those going east-west will be lettered. Jefferson likely contributes this scheme, introduced at Richmond in 1780 when he was governor of Virginia. L'Enfant is asked to have 10,000 copies of the map printed.

Even more tasks are loaded on the designer. Draw plans for major buildings, hire workers, lease a quarry for building stone, finish the survey of avenues. And as a personal favor, Washington's secretary Tobias Lear asks, would L'Enfant please purchase some lots for him and for Massachusetts friends.

L'Enfant does this favor. But few other buyers attend, and only about $2,000 is raised that day. L'Enfant does not display his map,

In L'Enfant's plan the Capitol (above) and the President's house were clearly visible highlights of Pennsylvania Avenue. Later, President Andrew Jackson placed the U. S. Treasury building beside the presidential mansion; a wing added in 1860 (facing page) blocks the view of, and from, the White House beyond.

Difficult to the point of insubordination, L'Enfant was dismissed in 1792, died in obscurity in 1825, and was buried in Maryland. In 1909 he was reinterred with full honors in Arlington National Cemetery, where his monument overlooks the city he planned for posterity.

and the President reprimands him, "None who knew what they were about would be induced to buy . . . 'A Pig in a Poke.'"

The next squabble is laid at the President's doorstep. Daniel Carroll, nephew of the commissioner of the same name, proceeds to build a home knowing it protrudes into a square on a planned diagonal (New Jersey Avenue). To set an example, L'Enfant demolishes the offending walls, ignoring orders from the commissioners "to desist." He even chides them, "You will see the propriety of your not Interfering with the process of execution."

Incredulous, Washington writes L'Enfant: "Having the beauty, & harmony of your Plan only in view, you pursue it as if every person, and thing was obliged to yield to it." Jefferson, furious, advises: "To render him useful, his temper must be subdued."

L'Enfant's personality—stubborn, egotistic—brings him closer to downfall. When he should be overseeing the engraving of his map, he is preparing a huge budget for 1792. Finally Hamilton, Jefferson, and Washington concur on dismissal, saying "your services must be at an end." The next day Washington adds, "Every mode has been tried to accommodate your wishes . . . except changing the Commissioners. . . . weeks have been lost . . . in obtaining a Plan for engraving . . . further delay in this business is inadmissible."

The job of getting the map engraved is turned over to Ellicott, who makes minor modifications; the plan remains L'Enfant's. The President asks that the map carry L'Enfant's name, but the final prints bear only Ellicott's, for reasons unknown. In future years the Frenchman, denied just credit and compensation, picks up a few commissions, but he overspends and still spurns compromise. No longer a celebrity, he passes into ignominy.

"L'Enfant is a tragic hero," says architectural historian Pamela Scott, "a man of genius with overriding character faults that meant he was never able to achieve his potential. He could never bow to authority. He may have been right, as about the sale of lots, but it didn't matter. He had no political sense."

Yet his plan survives. Map historian Richard Stephenson, who oversees the L'Enfant map at the Library of Congress, sums up: "What I find most amazing is that when our country was nearly broke and so small in population—four million, according to the 1790 census—our leaders had the vision to create a city plan that still works today." □

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New Crown Victoria

Have you driven a Ford...lately? Ford

Report from the President

Washington, D. C., Reaches Its 200th Birthday

Most American cities grew haphazardly from waterside settlements with little overall planning; some turned into high-rise jungles of asphalt and concrete. But our nation's capital became one of the most attractive low-rise cities in the country, if not in the world. As a native Washingtonian, I am astonished by the city's faithfulness to its original design, a plan long out of public view.

I attribute my city's good fortune to the vision of Pierre L'Enfant, who conceived the plan for the capital just 200 years ago, and to his successors. L'Enfant selected the commanding hilltop site for the Capitol; other buildings since have stayed well below its height. He laid out our broad diagonal avenues long before the great radial boulevards of Paris were built.

Today the only surviving map of Washington in L'Enfant's hand, a national treasure entrusted to the Library of Congress, is almost unreadable (page 122). To make it accessible, a computer-generated reproduction was initiated by the Library of Congress with the support

BOTH BY JOSE AZEL

of the National Geographic Society, the United States Geological Survey, and the National Park Service.*

Many months ago the cracked and faded map was taken to the USGS headquarters in Reston, Virginia, to be photographed. Photographs shot at different light levels to accentuate various details were digitized on computer tapes. Then cartographers led by William Schinkel called up each line and letter and carefully outlined them (left). Dirt specks on the original were a problem, says Schinkel. "Trying to distinguish them from penciled dots was a challenge." Here he checks the shadings along the Potomac shore (above).

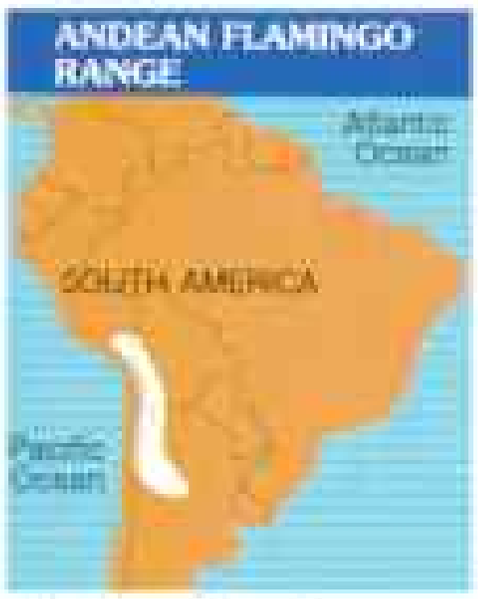
Thousands of man-hours produced a copy of the L'Enfant map that highlights the designer's explanatory notes and even makes legible previously unreadable notes by Thomas Jefferson (pages 125-6).

This project also enhances the reputation of L'Enfant, a man whose contributions have been dimmed by time. I find him fascinating: a transplanted Frenchman who fought for us in the Revolution, a favorite of the ladies who never married, the protégé of a powerful President. Yet he possessed all-too-human flaws: He could not work easily with committees; he had an exaggerated view of his worth. Once, after completing a renovation in New York, he refused as inadequate a payment of ten undeveloped acres on Manhattan's East Side. What a curious irony that the land today is worth more than 300 million dollars.

Gilbert M. Grosvenor

*THE COMPUTER-GENERATED REPRODUCTION OF L'ENFANT'S PLAN, A SEPARATE FACSIMILE OF THE ORIGINAL, AND A DESCRIPTIVE PAMPHLET ARE AVAILABLE AS A SET FOR $35 FROM THE PUBLISHING OFFICE, LIBRARY OF CONGRESS, WASHINGTON, D. C. 20540.

WILDLIFE AS CANON SEES IT



Andean Flamingo
Genus: *Phoenicoparrus*
Species: *andinus*
Adult size:
Length, 115 cm;
stands approx. 130 cm
Adult weight: 3 kg
Habitat: Salt lakes and marshes of the central Andes, South America
Surviving number:
Estimated at 50,000
Photographed by
Günter Ziesler

Andean flamingos gathering on a cold morning harmonize with their surroundings into an idyllic scene of subtle pastel hues. Feeding on microscopic algae and invertebrates, these elegant waders are closely linked to the dynamics of their aquatic ecosystems. Egg-collecting and habitat loss from stream diversion, especially in Chile, endanger the rare Andean flamingo. To save endangered species, it is essential to protect their habitats and understand the vital role of each species within the earth's ecosystems. Color images, with their unique ability to reach people, can help promote a greater awareness and understanding of the Andean flamingo and our entire wildlife heritage.

You're driving by that
like you do every day,
asks you what they
answer that you're not
occurs to you that you

It also occurs to you that you don't have the foggiest idea how to go about finding out.

Well, we can't say we blame you. Over the years, our industry hasn't exactly been noted for open doors, much less open dialogue.

chemical plant, just when one of your kids make in there and you really sure and it probably should be.

But recently, the member companies of the Chemical Manufacturers Association have taken some crucial steps towards changing that. Through an effort called Responsible Care.®

Many of us, for example, are now regularly holding community meetings. Which give the people who live near our plants an opportunity to tell the people who run them about their fears and concerns. And to ask questions of the people who actually run the plant, day in and day out.

Others are offering tours to anyone interested in a firsthand look at the way we make, handle and dispose of chemicals. Because, ultimately, the best way to answer your questions about what goes on behind the walls of our plants is to show you what goes on behind the walls of our plants.

We're opening the lines of communication in other ways. In some cases, quite literally. Call **1-800-624-4321*** and we'll tell you how you can find out what your local chemical company is making. We'll also send you our **Responsible Care® Brochure**, which details other ways we're working to keep you informed.

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*8 a.m. to 7 p.m. EDT

The Chemical Manufacturers Association.

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Forum

Ramses

"Ramses the Great" (April 1991) was very informative and brilliantly illustrative. But to term a king "great" mainly on his prowess as a builder is a contradiction in terms. The primary duty of a monarch, by any standard of civilization, is the betterment of his people. To exploit slaves to create stupendous structures for personal glorification is hardly a sign of greatness. Kings like Ramses II were arguably retarders of societal reform and are not ancestors humankind should be proud of.

VIVEK MEHRA
North Dartmouth, Massachusetts

Many books gloss over Akhenaten's physical peculiarities as a transformation of Egyptian art. When the Tutankhamun exhibit came to the United States, I observed that several of the Tut statues showed womanly breasts. My subsequent research suggests that in the last four hereditary pharaohs of Dynasty XVIII, enlargement of the breasts (gynecomastia) was actually representational and indicative of a familial abnormality, not an artistic convention (*Journal of the American Medical Association*, July 11, 1980, pages 160-64).

DR. BERNADINE Z. PAULSHOCK
Medical Center of Delaware
Newark, Delaware

In speculating about the parting of the Red Sea during the Israelite Exodus from Egypt, you suggest that nothing beyond a chance shifting of the winds was responsible for the rout of Pharaoh's pursuing army. This is jarring to those of the Jewish and Christian faiths to whom the event represents a miracle of God. My suggestion: Stick to geography and leave the exegesis of the Scriptures to the theologians.

TIM ROYAPPA
Boston, Massachusetts

Last October my wife and I fulfilled a lifelong dream to visit Egypt, and I have become obsessed with the country. As Florence Nightingale wrote during her journey up the Nile in 1849-50, "One wonders that people come back from Egypt and live lives as they did before." The companion article on the Sphinx proved that we are still learning new things about the enigmatic Ramses II.

MARC DERRY HASBROUCK
Lawrenceville, Georgia

Baseball

David Lamb captures America and our hearts with "A Season in the Minors." His summer journey through the minor-league parks is a vacation dream come true. His words and William Albert Allard's pictures express the feelings baseball evokes from true fans of the great American pastime.

PAUL M. REALINI
Pacifica, California

I was surprised and disappointed that you would spend so much space on baseball, a subject well covered elsewhere and in greater detail. Against the importance of saving the Sphinx and our food supply, it is really minor-league stuff.

BOB FORMAN
Monmouth, Illinois

As a veteran baseball wife starting my 21st season, I have spent 18 of those years with my husband through his days as a minor-league player, manager, and coach. Through the good and the bad, there's no other life like it. Now my husband is in the big leagues, but we and our sons will never allow ourselves to forget the minor leagues or the wonderful people we met and played with.

MRS. LEO MAZZONE
Rawlings, Maryland

Leo Mazzone now coaches for the Atlanta Braves.

The city I live in is currently bidding for a Triple-A baseball team. The issue has been buried in bureaucratic bumbling and the flip-flopping of support from one day to the next from city councillors. If only they would read David Lamb's article instead of arguing over stadium costs and public support, they might gain some feeling for what the game is all about. To paraphrase the movie *Field of Dreams:* "If you build it, they will come."

PAT VAUGHN-SCOLLON
Ottawa, Ontario

I think I am falling in love with America and with that game called baseball, even though I've never been to America or within cooee of anything to do with baseball. Until the day comes when I can see both, I'll continue to read with wonder what could be the most informative magazine in the world.

CAMERON KEATING
Sandy Bay, Tasmania

Genetic Erosion

Robert Rhodes's "The World's Food Supply at Risk" was sobering, but a parallel problem with the genetic erosion of our livestock is no less compelling. Indigenous breeds have been improved or replaced by single-purpose strains that require sophisticated management, high levels of nutrition, ample clean water, and antibiotics, vitamins, and other growth enhancers. There is no animal

gene bank in North America similar to the plant gene bank, and there are no wild relatives to provide genetic infusions. Fortunately, nonprofit groups such as ours are banding together to help form an umbrella agency, Rare Breeds International, to share strategies to safeguard livestock.

DONALD E. BIXBY
American Minor Breeds Conservancy
Pittsboro, North Carolina

Even backyard gardeners can help reverse the alarming loss of plants. If they sought out older heirloom vegetables, which replicate themselves from seed, the fading art of seed saving would be in the hands of ordinary people, and a broad range of valuable genes would be in wide circulation.

TERI DUNN
Horticulture *Magazine*
Boston, Massachusetts

The Heritage Seed Program in Canada searches out and preserves heirloom, rare, and endangered plants. For example, our members rescued from Nova Scotia the Old Dutch pole bean, which people used to string up and dry in their attics for soups and stews.

HEATHER APPLE
Heritage Seed Program
Uxbridge, Ontario

A Swiss organization, Pro Specie Rara, collects old seeds and takes care of old, near-extinct breeds of animals. People can order seeds to plant, and farmers can breed animals adapted to their region.

ERICA GROB
Hedingen, Switzerland

Feeding the world's hungry is not a technological problem of production. Existing agricultural production is more than sufficient, even in many famine-plagued countries, to provide everyone on earth with an adequate diet. People are prevented from feeding their families because of political and economic inequities. Either they lack the cash to buy food, or the most productive land is used to grow export crops.

GRACE GERSHUNY
Organic Farmer *Magazine*
Montpelier, Vermont

Today one out of every ten persons is fed by the increased harvests that the miracle strains of rice have made possible. By the year 2020 some 4.3 billion people, more than half the estimated world population, will depend on rice for most of their food. Global rice production must rise from today's 470 million tons to 760 million tons annually just to maintain current levels of nutrition, which are already inadequate.

THOMAS R. HARGROVE
International Rice Research Institute
Manila, Philippines

Could the proud founder of the University of Virginia actually have misused *its/it's* as cited on page 83 in "add an useful plant to it's culture"?

DAVID A. SHORT
Bloomfield, Iowa

This usage—taken from the original Jefferson document of 1800—was common in his day.

Extremadura

The photographs are very good in "Cradle of Conquerors," but too few. How can readers form an idea of the magnificence of the scenery without a panorama of the snow-covered Sierra de Gredos, whose meltwater in some villages courses through channels diverted to every front door, or a picture of Trujillo with streets little changed since the time of Pizarro? What can readers learn of the formative presence of Arabs and Jews in this part of Spain, the latter exemplified in Hervás with its narrow passageways in the Jewish Quarter?

MARY VARELA
Madrid, Spain

Falcon Rescue

As unfortunate as the effects of DDT on birds may be, it is important to put its use in proper perspective. Since 1942 DDT—by killing disease-ridden mosquitoes, ticks, and fleas—has saved millions of lives in India, Pakistan, Sri Lanka, and other countries and probably thousands of American troops who would have contracted malaria, typhus, or bubonic plague during World War II. A potentially catastrophic typhus epidemic in Naples in 1944 was checked by DDT, a feat without parallel in medical history. In addition, DDT, which is relatively nontoxic to humans, acts as an anticarcinogen. Thus the small amounts of this substance in our fat may actually have a protective effect against carcinogens. DDD, a related pesticide once used in California to control biting flies and mosquitoes, is sometimes even used as a drug, mitotane, to treat adrenal cancer.

GORDON W. GRIBBLE
Professor of Chemistry
Dartmouth College
Hanover, New Hampshire

Although your map shows no breeding pairs in the Vancouver Island area, we have been observing peregrine falcons along the cliffs of Gabriola Island on our wildlife cruises for years, and almost on a daily basis this spring.

DAVID LITTLEJOHN
Nanaimo, British Columbia

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photo courtesy of COMSTOCK, INC./Michael Stuckey

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BEV DOOLITTLE

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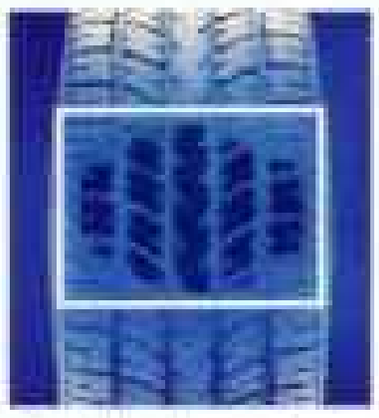

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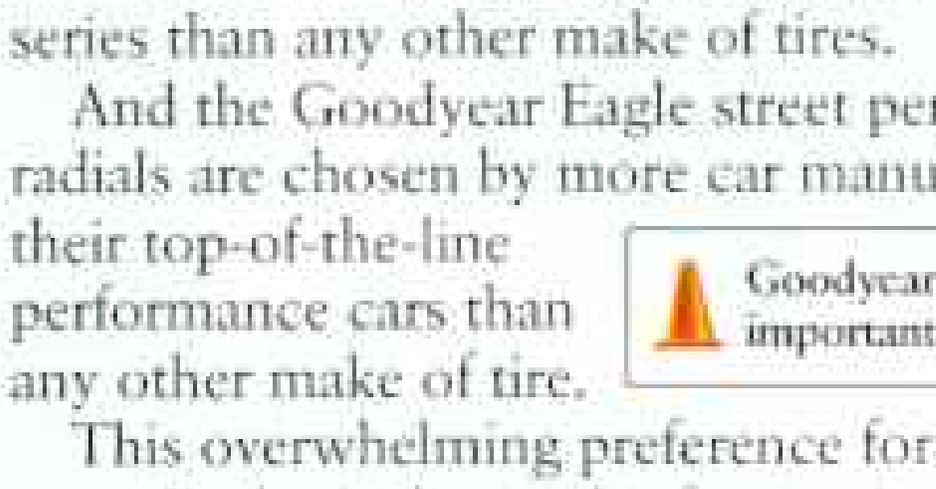

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GOODYEAR

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Geographica

Census Finds a New Major California City

In California these days, big cities are born in less than a decade.

Moreno Valley in southern California's Riverside County had a mere 28,120 people in 1980. More than 90,000 new residents later—an increase of 322 percent—it has 500 miles of streets, supports two school systems, and has joined the ranks of what the U. S. Census Bureau calls "major cities"—those with populations topping 100,000.

The 1990 census emphasizes California's position as the fastest growing state. Six of the ten major U. S. cities with the most rapid growth are within its borders: Rancho Cucamonga, Escondido, Oceanside, Bakersfield, Fresno, and Chula Vista expanded by more than 60 percent.

The losing cities in the population sweepstakes are mostly in the Midwest and East. Detroit's population dropped by 14.6 percent, Chicago's by 7.4, Baltimore's by 6.4, and Philadelphia's by 6.1. And five cities lost their places on the major-city roster: Columbia, South Carolina; Davenport, Iowa; Pueblo, Colorado; Roanoke, Virginia; and Youngstown, Ohio.

DAVID L. BRILL

Helping Mexican Indians and Rain Forest Too

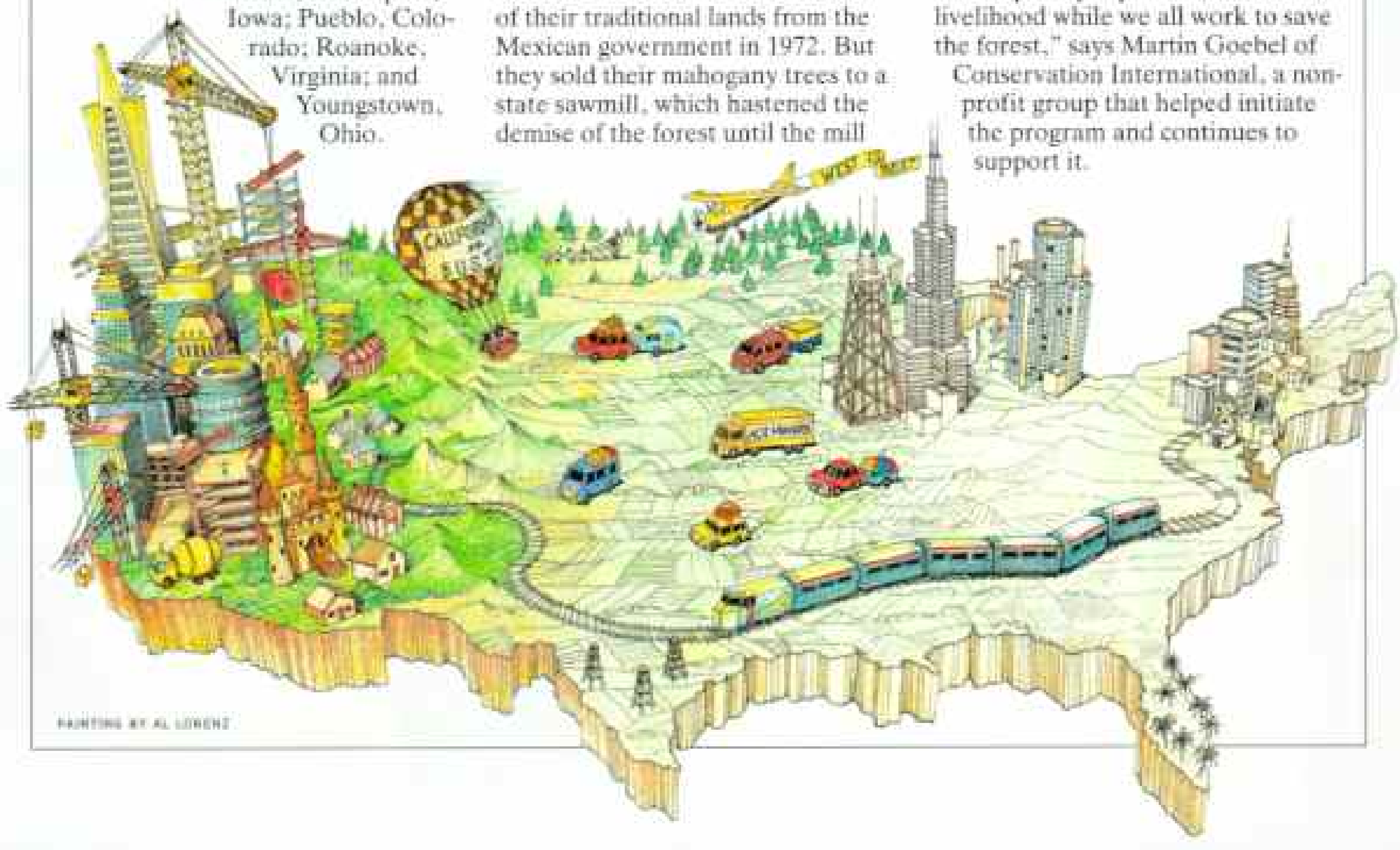
The Lacandona, Mexico's largest remaining tropical rain forest, lies on the Guatemala border. It holds about 400 Lacandon Indians, whose territory has shrunk as land-starved settlers have poured in (NATIONAL GEOGRAPHIC, October 1985).

The Indians won exclusive use of their traditional lands from the Mexican government in 1972. But they sold their mahogany trees to a state sawmill, which hastened the demise of the forest until the mill closed in 1989.

In the past 30 years the population in the area has swelled from 10,000 to 150,000. The incoming farmers have diminished the fertility of the soil by relying on slash-and-burn practices. Now their cornfields and cattle pastures are pushing into the 815,000-acre Montes Azules Biosphere Reserve, a nationally protected area in the heart of the Lacandona.

To preserve this isolated region, Mexico has approved the funneling of almost a million dollars to a research station to promote less destructive—and more productive—agricultural methods as well as better ways to protect the forest's diverse plant and animal life.

"It's a beachhead from which we can help the people sustain their livelihood while we all work to save the forest," says Martin Goebel of Conservation International, a nonprofit group that helped initiate the program and continues to support it.



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Geographica

An Antarctic Forest Grows New Theories

It was one autumn's leaf fall, a moment in time in the Transantarctic Mountains. But the discovery of layers of southern beech leaves two to three million years old 300 miles from the South Pole threatens a long-held notion: that Antarctica's ice cap has been in place for about 15 million years.

The leaves (below) were uncovered last December by the same scientists who five years earlier found fossilized beech wood in the same area near the Beardmore Glacier (GEOGRAPHIC, January 1987). Expedition leader Peter-Noel Webb of Ohio State University says the leaves bolster his research group's theory that temperatures in Antarctica were much warmer much later than has been thought.

Exactly when the continent's summer temperatures came to average 10°F below zero—as they do now—is still unknown. But Webb's colleague David M. Harwood of the University of Nebraska notes that it would have to be at least 50 degrees warmer for beeches to grow.

Tree ring studies will help reveal seasonal climate changes, Webb and Harwood add.

Found: A "Missing" Hawaiian Volcano

Geologists have definitively located the missing twin of Kohala volcano west of the island of Hawaii. The underwater mountain is called Mahukona.

The absence of Kohala's twin had been puzzling, because it represented a gap in one of two parallel chains of volcanoes that run along the southern Hawaiian Islands. A likely candidate was identified in the early 1980s when bathymetric surveys revealed an undersea mountain about 30 miles west of Kohala.

Now Michael Garcia of the University of Hawaii and Mark Kurz of Woods Hole Oceanographic Institution have used a submersible to dive on Mahukona, named for the nearest port. Rocks recovered from its summit—3,500 feet beneath the ocean surface—are indeed lavas that bear the geochemical signature common to all other volcanoes in the Hawaiian Islands.

Mahukona last erupted about half a million years ago, Garcia says. On land, it would be impressive, measuring about 12,500 feet from base to summit. But Mauna Kea—Hawaii's highest peak—extends 31,600 feet from base to summit, 13,800 feet of it above the sea.

NGS CARTOGRAPHIC DIVISION

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PETER-NOEL WEBB (LEFT); WILLIAM K. STEIGER

Chesapeake Skipjack Fleet Nears Extinction

Once there were 1,500 working skipjacks (above), graceful sailing sloops with clipper bows and huge triangular leg-of-mutton mainsails, dredging for the fat, juicy oysters that lined the Chesapeake Bay (GEOGRAPHIC, October 1980). But a century-long decline in the oyster harvest—from 11 million bushels in 1880 to about 400,000 for the past several years—has brought a drop in the number of skipjacks too. Only about 20 still work the bay; a handful sail as recreational craft.

The major causes of the oyster decline are two parasites, called MSX and dermo, that are harmless to humans but kill oysters. Now when Russell Dize takes out his 90-year-old skipjack *Kathryn*, he reckons that 35 bushels of oysters is "a so-so catch," and 60 bushels "a good day." The legal limit is 150.

To avoid overharvesting and to help keep the fleet in business, watermen like Dize are required to go oystering four days out of six the old-fashioned way: dredging only under sail.

"Seeing a skipjack is like watching an Errol Flynn movie," says Tobi Ross of the Maryland Department of Natural Resources. "There's so much romance and pride." But, she adds, "my gut feeling is they're almost history."

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KEN REGAN, GOT PICTURES

Recycling Chips Away at Mountains of Plastic

A sea of plastic, 14.4 million tons of it thrown out in the U. S. each year, represents a potential gold mine in the garbage dump. Manufacturers will pay $200 a ton for discarded plastic to turn it into everything from carpeting to tennis-ball felt.

Yet most of this lucrative market goes begging. The recycling rate for plastic is only 1.1 percent, compared with 12 percent for all other recyclable materials. The problems: Its bulk makes plastic expensive to collect and transport to recycling centers, and there it must be painstakingly hand-sorted.

Rhode Island is overcoming such drawbacks. At the state's 5.5-million-dollar Materials Recycling Facility (MRF) plastic containers cap a mound of steel, aluminum, and glass also awaiting processing (above). The MRF concentrates on two widely used types of plastic, chopping milk or water jugs into flakes sold to make highway drainage pipes and flattening plastic soda bottles that eventually become polyester fiber used in sleeping bags and other goods. The plant processes about 1,900 tons of plastic a year and sells it for $140 to $220 a ton. That helps the facility to nearly break even on its operating costs: $35 a ton for recycling all materials.

THOMAS EISNER AND DANIEL ARETZ/BARLEY, CORNELL UNIVERSITY

Beetle's Blast Works Like Hitler's Buzz Bomb

Anything unwise enough to disturb a bombardier beetle gets doused with a boiling chemical jet from its backside. Chemical ecologist Thomas Eisner of Cornell University, who collects the beetles by hand, knows the feeling well. "It's not enough to make you scream," he says, "but you do wonder what the heck is going on."

Recently Eisner and his colleagues found a most unlikely parallel between the insect's chemical engineering and the World War II German V-1 flying bomb. Aided by the late Harold Edgerton and his famed high-speed cameras, the researchers recorded both the sound and the visual fury of the beetle's blasts—audible pops and puffs of smoke. They discovered that some species emit sprays in violent pulses—500 a second. Within their abdomens two chambers store chemical reactants. When the beetle fires, the chemicals mix to form benzoquinones that are repellent to predatory ants, spiders, birds, frogs, and mice.

A pulsed jet from an intermittent chemical reaction also powered the V-1, but the beetle's engineering outlasted Hitler's. "And a good thing too," adds Eisner.

National Geographic, August 1991

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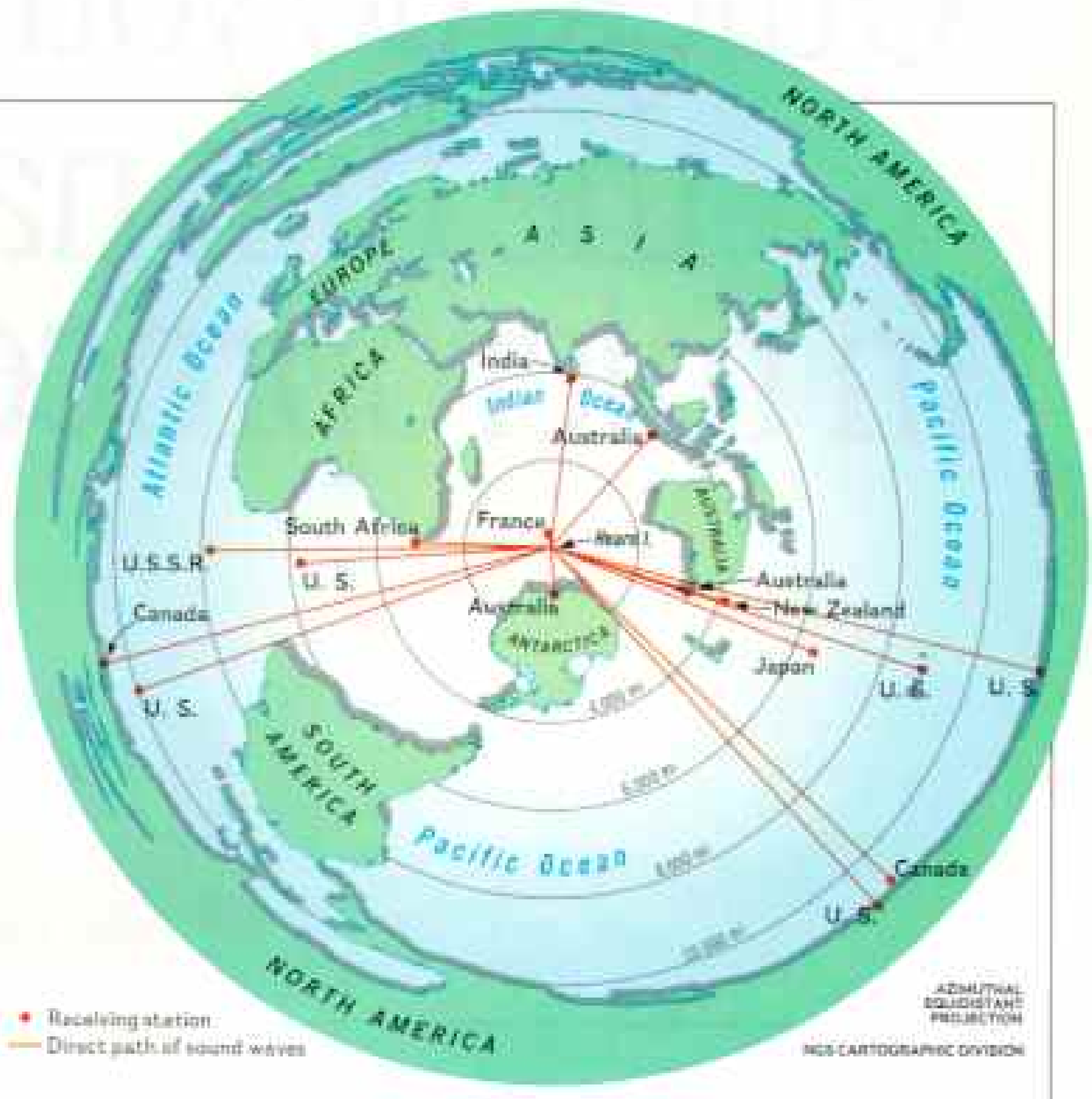
Undersea Sound Waves to Test Global Warming

Is the earth heating up? Debate simmers over the effects of an atmospheric buildup of greenhouse gases. Air, land-surface, and sea-surface temperatures fluctuate greatly. But such variations are far smaller in the deep ocean, where scientists seek to measure possible warming with powerful sound signals heard halfway round the world.

Led by Walter H. Munk of the Scripps Institution of Oceanography, an international team uses a basic principle: As water warms, sound travels faster through it. The team hopes to transmit sound through the oceans periodically for perhaps a decade and chart changes in the travel time. The time will decrease if the deep seas heat up, confirming global warming.

In a first test last January near aptly named Heard Island, signals sent from 600 feet deep were received by a network of international listening posts (right). Some sound waves made an 11,000-mile, 3.5-hour trip. Amid concern that marine mammals could be harmed by the foghorn-like tone, a monitoring ship found no complaints from nearby whales.



Sky-dancing Woodcock Needs Habitat Help

Aldo Leopold sat enthralled, dawn and dusk, at the courtship display of the male American woodcock. Such spring sky dances, as he called them, are now far fewer for these shy, rotund birds, which have declined in the past 25 years by a fifth in the Midwest and more than a third in the East.

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"Up and up he goes, the spirals steeper and smaller, the twittering louder and louder. . . . Then, without warning, he tumbles. . . . levels off and returns." In the 1940s naturalist

Urban development is partly to blame for the bird's plight; in addition, many remaining forests have become too mature for the woodcock. But woodland owners can help bring back the woodcocks' stage. "They need a mix of habitats," says Ron Burkert of the Ruffed Grouse Society. His group has joined with the U. S. Forest and Fish and Wildlife Services to clear-cut small strips through old forests. They encourage private landowners to do the same—ideally near moist soil rich in earthworms, on which woodcocks gorge—creating a patchwork of clearings, brush, and young woods for nesting.

Amber Time Capsule Doubles Mushrooms' Age

So delicate are mushrooms that they dissolve in a blink of time. Their origin, it was thought, dated back some 20 million years. But in 1989 a golden window opened to George O. Poinar, Jr., a paleobiologist at the University of California at Berkeley. He examined a lovely piece of Dominican Republic amber encasing a mite (below, at top). But within the amber lay a greater treasure—a rarely preserved ancient mushroom estimated to be 40 million years old, proving that these fungi are twice as venerable as once believed.

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BRIEF SUMMARY

INDICATIONS AND USAGE

This drug product has been conditionally approved by the FDA for the prevention of angina pectoris due to coronary artery disease. Tolerance to the anti-anginal effects of nitrates (measured by exercise stress testing) has been shown to be a major factor limiting efficacy when transdermal nitrates are used continuously for longer than 12 hours each day. The development of tolerance can be altered (prevented or attenuated) by use of a noncontinuous (intermittent) dosing schedule with a nitrate-free interval of 10 - 12 hours. Controlled clinical trial data suggest that the intermittent use of nitrates is associated with decreased exercise tolerance, in comparison to placebo, during the last part of the nitrate-free interval; the clinical relevance of this observation is unknown, but the possibility of increased frequency or severity of angina during the nitrate-free interval should be considered. Further investigations of the tolerance phenomenon and best regimen are ongoing. A final evaluation of the effectiveness of the product will be announced by the FDA.

CONTRAINDICATIONS: Allergic reactions to organic nitrates are extremely rare, but they do occur. Nitroglycerin is contraindicated in patients who are allergic to it. Allergy to the adhesives used in nitroglycerin patches has also been reported, and it similarly constitutes a contraindication to the use of this product. **WARNINGS:** The benefits of transdermal nitroglycerin in patients with acute myocardial infarction or congestive heart failure have not been established. If one elects to use nitroglycerin in these conditions, careful clinical or hemodynamic monitoring must be used to avoid the hazards of hypotension and tachycardia. A cardioverter/defibrillator should not be discharged through a paddle electrode that overlies a MINITRAN patch. The arcing that may be seen in this situation is harmless in itself, but it may be associated with local current concentration that can cause damage to the paddles and burns to the patient. **PRECAUTIONS: General:** Severe hypotension, particularly with upright posture, may occur with even small doses of nitroglycerin. This drug should therefore be used with caution in patients who may be volume depleted or who, for whatever reason, are already hypotensive. Hypotension induced by nitroglycerin may be accompanied by paradoxical bradycardia and increased angina pectoris. Nitrate therapy may aggravate the angina caused by hypertrophic cardiomyopathy. As tolerance to other forms of nitroglycerin develops, the effect of sublingual nitroglycerin on exercise tolerance, although still observable, is somewhat blunted. In industrial workers who have had long-term exposure to unknown (presumably high) doses of organic nitrates, tolerance clearly occurs. Chest pain, acute myocardial infarction, and even sudden death have occurred during temporary withdrawal of nitrates from these workers, demonstrating the existence of true physical dependence. Several clinical trials in patients with angina pectoris have evaluated nitroglycerin regimens which incorporated a 10 - 12 hour nitrate-free interval. In some of these trials, an increase in the frequency of anginal attacks during the nitrate-free interval was observed in a small number of patients. In one trial, patients demonstrated decreased exercise tolerance at the end of the nitrate-free interval. Hemodynamic rebound has been observed only rarely; on the other hand, few studies were so designed that rebound, if it had occurred, would have been detected. The importance of these observations to the routine clinical use of transdermal nitroglycerin is unknown. **Information for Patients:** Daily headaches sometimes accompany treatment with nitroglycerin. In patients who get these headaches, the headache may be a marker of the activity of the drug. Patients should resist the temptation to avoid headaches by altering the schedule of their treatment with nitroglycerin, since loss of headache may be associated with simultaneous loss of anti-anginal efficacy. Treatment with nitroglycerin may be associated with lightheadedness on standing, especially just after rising from a recumbent or seated position. This effect may be more frequent in patients who have also consumed alcohol. After normal use, there is enough residual nitroglycerin in discarded patches that they are a potential hazard to children and pets. A patient leaflet is supplied with the systems. **Drug Interactions:** The vasodilating effects of nitroglycerin may be additive with those of other vasodilators. Alcohol, in particular, has been found to exhibit additive effects of this variety. **Carcinogenesis, Mutagenesis, and Impairment of Fertility:** No long-term animal studies have examined the carcinogenic or mutagenic potential of nitroglycerin. Nitroglycerin's effect upon reproductive capacity is similarly unknown. **Pregnancy Category C:** Animal reproduction studies have not been conducted on nitroglycerin. It is also not known whether nitroglycerin can cause fetal harm when administered to a pregnant woman or whether it can affect reproductive capacity. Nitroglycerin should be given to a pregnant woman only if clearly needed. **Nursing Mothers:** It is not known whether nitroglycerin is excreted in human milk. Because many drugs are excreted in human milk, caution should be exercised when nitroglycerin is administered to a nursing woman. **Pediatric Use:** Safety and effectiveness in children have not been established. **ADVERSE REACTIONS:** Adverse reactions to nitroglycerin are generally dose-related, and almost all of these reactions are the result of nitroglycerin's activity as a vasodilator. Headache, which may be severe, is the most commonly reported side effect. Headache may be recurrent with each daily dose, especially at higher doses. Transient episodes of lightheadedness, occasionally related to blood pressure changes, may also occur. Hypotension occurs infrequently, but in some patients it may be severe enough to warrant discontinuation of therapy. Syncope, crescendo angina, and rebound hypertension have been reported, but are uncommon. Extremely rarely, ordinary doses of organic nitrates have caused methemoglobinemia in normal-seeming patients. Methemoglobinemia is so infrequent at these doses that further discussion of its diagnosis and treatment is deferred (see **Overdosage**). Application-site irritation may occur, but is rarely severe. In two placebo-controlled trials of intermittent therapy with nitroglycerin patches at 0.2 to 0.8 mg/hr, the most frequent adverse reactions among 307 subjects were as follows:

	placebo	patch		placebo	patch
headache	18%	63%	hypotension and/or syncope	0%	4%
lightheadedness	4%	6%	increased angina	2%	2%

OVERDOSAGE: Hemodynamic Effects: The ill effects of nitroglycerin overdose are generally the results of nitroglycerin's capacity to induce vasodilatation, venous pooling, reduced cardiac output, and hypotension. These hemodynamic changes may have protean manifestations, including increased intracranial pressure, with any or all of persistent throbbing headache, confusion, and moderate fever; vertigo; palpitations; visual disturbances; nausea and vomiting (possibly with colic and even bloody diarrhea); syncope (especially in the upright posture); air hunger and dyspnea, later followed by reduced ventilatory effort; diaphoresis, with the skin either flushed or cold and clammy; heart block and bradycardia; paralysis; coma; seizures; and death. Laboratory determinations of serum levels of nitroglycerin and its metabolites are not widely available, and such determinations have, in any event, no established role in the management of nitroglycerin overdose. No data are available to suggest physiological maneuvers (e.g., maneuvers to change the pH of the urine) that might accelerate elimination of nitroglycerin and its active metabolites. Similarly, it is not known which — if any — of these substances can usefully be removed from the body by hemodialysis. No specific antagonist to the vasodilator effects of nitroglycerin is known, and no intervention has been subject to controlled study as a therapy of nitroglycerin overdose. Because the hypotension associated with nitroglycerin overdose is the result of venodilatation and arterial hypovolemia, prudent therapy in this situation should be directed toward increase in central fluid volume. Passive elevation of the patient's legs may be sufficient, but intravenous infusion of normal saline or similar fluid may also be necessary. The use of epinephrine or other arterial vasoconstrictors in this setting is likely to do more harm than good. In patients with renal disease or congestive heart failure, therapy resulting in central volume expansion is not without hazard. Treatment of nitroglycerin overdose in these patients may be subtle and difficult, and invasive monitoring may be required. **Methemoglobinemia:** Nitrate ions liberated during metabolism of nitroglycerin can oxidize hemoglobin into methemoglobin. Even in patients totally without cytochrome b_5 reductase activity, however, and even assuming that nitrate moieties of nitroglycerin are quantitatively applied to oxidation of hemoglobin, about 1 mg/kg of nitroglycerin should be required before any of these patients manifests clinically significant (≥ 10%) methemoglobinemia. In patients with normal reductase function, significant production of methemoglobin should require even larger doses of nitroglycerin. In one study in which 36 patients received 2 - 4 weeks of continuous nitroglycerin therapy at 3.1 to 4.4 mg/hr, the average methemoglobin level measured was 0.2%; this was comparable to that observed in parallel patients who received placebo. Notwithstanding these observations, there are case reports of significant methemoglobinemia in association with moderate overdoses of organic nitrates. None of the affected patients had been thought to be unusually susceptible. Methemoglobin levels are available from most clinical laboratories. The diagnosis should be suspected in patients who exhibit signs of impaired oxygen delivery despite adequate cardiac output and adequate arterial pO_2. Classically, methemoglobinemic blood is described as chocolate brown, without color change on exposure to air. When methemoglobinemia is diagnosed, the treatment of choice is methylene blue, 1 - 2 mg/kg intravenously. **DOSAGE AND ADMINISTRATION:** The suggested starting dose is between 0.2 mg/hr* and 0.4 mg/hr*. Doses between 0.4 mg/hr* and 0.8 mg/hr* have shown continued effectiveness for 10 - 12 hours daily for at least one month (the longest period studied) of intermittent administration. Although the minimum nitrate-free interval has not been defined, data show that a nitrate-free interval of 10 - 12 hours is sufficient. Thus, an appropriate dosing schedule for nitroglycerin patches would include a daily patch-on period of 12 - 14 hours and a daily patch-off period of 10 - 12 hours. Although some well-controlled clinical trials using exercise tolerance testing have shown maintenance of effectiveness when patches are worn continuously, the large majority of such controlled trials have shown the development of tolerance (i.e., complete loss of effect) within the first 24 hours after therapy was initiated. Dose adjustment, even to levels much higher than generally used, did not restore efficacy.

HOW SUPPLIED

MINITRAN System Rated Release In Vivo	System Size	Total Nitroglycerin in System	NDC Number
0.1 mg/hr*	3.3 cm²	9 mg	NDC 0089-0301-03
0.2 mg/hr*	6.7 cm²	18 mg	NDC 0089-0302-03
0.4 mg/hr*	13.3 cm²	36 mg	NDC 0089-0303-03
0.6 mg/hr*	20.0 cm²	54 mg	NDC 0089-0304-03

MINITRAN Transdermal Delivery System, 0.1 mg/hr, 0.2 mg/hr, 0.4 mg/hr, 0.6 mg/hr, is available in cartons of 30 patches. **CAUTION:** Federal law prohibits dispensing without prescription.

*Release rates were formerly described in terms of drug delivered per 24 hours. In these terms, the supplied MINITRAN systems would be rated at 2.5 mg/24 hours (0.1 mg/hr), 5 mg/24 hours (0.2 mg/hr), 10 mg/24 hours (0.4 mg/hr), and 15 mg/24 hours (0.6 mg/hr).

NTR-4 BS

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*The current published average wholesale price for Minitran is less than that of Transderm-Nitro and Nitro-Dur. Retail pricing may vary from community to community and may affect cost savings to the patient. Transderm-Nitro is a registered trademark of Ciba Pharmaceutical Company; Nitro-Dur, of Key Pharmaceuticals, Inc.

†*Clinical Therapeutics*, Vol. 11, No. 1, 1989, pp 15-31.

Please see adjacent page for summary of prescribing information.

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On Assignment

STEVE MCCURRY, MAGNUM

"Disaster is my beat," says Senior Assistant Editor TOM CANBY of his three decades at the National Geographic Society. "I've covered famines and earthquakes, floods and droughts, but this was my first time in a war zone. And once is enough."

Last March Tom traveled through Kuwait and Saudi Arabia to report on the war's environmental toll for this issue. Within earshot of gunfire from Iraq's civil conflict, he came across remnants of a retreating Iraqi convoy, destroyed from the air. Blackened vehicles were draped with the charred corpses of Iraqi soldiers, their flesh gnawed by dogs. Clothes and appliances looted from Kuwaiti homes were strewed among mess kits, antipersonnel mines, and the faded photograph of what appeared to be a man's wife and daughters.

"The destruction the Iraqis wrought on Kuwait—the murder and torture, the burning and dynamiting, the spilling of oil—was so barbaric as to defy understanding," Tom says. As the GEOGRAPHIC's science editor he was appalled that Iraqi scientists had, under orders, methodically looted instruments from laboratories, watched by their Kuwaiti counterparts with whom they once had collaborated.

Smoke from Kuwait's 500-plus flaming wellheads produced darkness at noon, and Tom's surgical mask, supplied by the Society's Medical Division, soon became stained with falling soot and oil droplets. "And my shoes picked up an ever thickening coating of oil and sand; soon I was standing half an inch taller. The oil was incredibly gummy; before I came home, I happily abandoned those shoes in my hotel room."

Tom recalls hair-raising drives along oil-slick roads where, a month later, two British journalists died when their vehicle slipped into a pool of burning oil.

While investigating the Iraqi-engineered oil spill, Tom managed to get a scoop for the magazine. He chanced on four daring Kuwaitis who had outsmarted Iraqis bent on opening oil pipes into the gulf. Secretly closing an outlet valve but setting its indicator to "open," the oil workers prevented 8.5 million barrels from entering the gulf and perhaps delivering a lethal blow to the wounded ecosystem.

In the course of his Geographic career—which began when he won a competition to write books for the Society—Tom has scuba dived to a submerged archaeological site in a Florida sinkhole, toured the sewers of the Vatican to report on the world of rats, penetrated the secrecy of the Soviet space program, and shared the anguish of villagers faced with famine in Bangladesh and the Sahel. His work has been recognized with awards from the Aviation/Space Writers Association, AAAS-Westinghouse, and Western Writers of America.

Despite his passion for travel, for Tom there's no place like home. He still lives in the little Maryland community of Sandy Spring where he was born.

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