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COVER: Candles of memory light a cemetery on the Mexican island of Janitzio during the Day of the Dead ceremony (pages 146-7).

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Scientist meets a Florida "mermaid"

JOTTING NOTES on a waterproof pad, zoologist D. S. Hartman hovers above a browsing manatee, or sea cow. At home in salt or fresh water, the little-known mammals graze grassy bottoms of estuaries and rivers on both sides of the tropical Atlantic, surfacing every few minutes to breathe. Tales of these strange "fish" that suckle their young, brought to Europe by New World explorers, contributed to the myth of the mermaid.

Clear, tepid springs feeding Florida's Crystal River provide an ideal laboratory for Mr. Hartman's observations, the first

intensive study of manatees in their natural habitat. He snorkels for hours at a time among as many as 50 of the gentle half-ton behemoths. Aided by a grant from the National Geographic Society, he plans to tag manatees with ultrasonic transmitters, hoping to solve the mystery of their uncharted seasonal migrations.

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By 1978, cars will be less of a smog

Some people think of the twenties as the golden age of motoring. They have a point.

We drove on wiggly roads instead of turnpikes. Fifty miles an hour was heady stuff. Cars were reasonably reliable but still slightly adventurous. And there weren't many of them. Who cared if they smoked a bit? The blue vapors floated up to the blue sky and disappeared. Or seemed to.

By the fifties, things were different. There were twice as many cars. And a new word had entered our vocabulary. Smog. The car's contribution to this phenomenon had become a

problem to be taken very seriously. Rightly so.

By 1978, there will be six times as many cars on American roads as there were in the late twenties. Will the exhaust problem be six times worse? The answer from Jersey's affiliate, Esso Research, is a resounding no. Here are a few incontrovertible facts.

Air pollution from cars reached its zenith last year. We have now passed the turning point. Despite the car population explosion, total exhaust emissions will go down this year—further down in 1969—and further and further down in all successive years.



problem than they were in 1928.

By the early eighties, the unburned gasoline exuded by each car will be less than half an ounce a day. Little more than you need to fill a cigarette lighter.

Credit for this encouraging news must go equally to oil industry scientists, automotive engineers and intelligent lawmakers. But Jersey can justly claim a major role.

Esso Research scientists have worked with car experts to design fuels and lubricants that help cut unburned gasoline vapors and carbon monoxide to a minimum.

They have built a simple device that can reduce evaporation from your gas tank and carburetor by 95 per cent.

And they are now studying catalysts and

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Ten years from now, we may well look back on the 1960's as the not-so-golden age of smog.

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August, 1968

NATIONAL GEOGRAPHIC

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AS WE DROVE SOUTH into Mexico, my wife Lucy read aloud to the family from a history of Spanish exploration in the New World. One passage dealt with the legend of El Dorado—The Gilded Man—an Indian chief said to have been so wondrously rich that his subjects coated him, rather than crowned him, with gold.

For his coronation, Lucy read, the chief “was anointed with oil and sprinkled with gold dust, then . . . pushed on a raft out upon the sacred lake . . . he dived into the water and washed off the gleaming metal.”

Our son Kenny, who is 14 and frugal, was appalled at the vision of such waste. His brother Mike, a year older, was skeptical.

“Some old-time Spanish promoters made the story up,” he said, “to get people to come to America.” Mike had a point, for the legend of El Dorado inspired one of the greatest gold rushes and eras of discovery in history.

From their Mexican bases, 16th-century conquistadors set out across unknown lands in search of treasure. El Dorado eluded them, but they found something far more precious—lands of infinite promise, encompassing much of what today is northern Mexico and the western United States. Seventeen towns, cities, and mountains in the two nations bear the name El Dorado in tribute to the epic explorations.

Now, four centuries later, Mexico awaits another invasion inspired by gold—the gold of Olympic medals. This October athletes

See no evil, speak no evil: Two little Mexicans playing beside a road near the village of Bahuichivo try—unsuccessfully—to cloak their curiosity. This autumn, with visitors streaming south to the Olympic Games in Mexico City, these stay-at-home sightseers will find much to fill their eyes.

South to Mexico City

Article and photographs by

W. E. GARRETT

Assistant Editor



PHOTOGRAPH BY NATIONAL GEOGRAPHIC SOCIETY



"Salga, salga, salga – Come out, come out, come out," a fisherman chanter implores a departed soul during the Day of the Dead ceremony. *"Let the Holy Rosary break the chains that bind you,"* he prays as women and children, bundled against the November chill, keep a vigil



PHOTOGRAPH © NATIONAL GEOGRAPHIC SOCIETY

in the cemetery on Janitzio Island in Lake Pátzcuaro. In the early hours of All Souls' Day, devout Tarascan Indians strew family graves with marigold petals and light candles for departed relatives. Offerings of fruit and pastry are to nourish the spirits should they arrive hungry.



Mexican Journey

Driving south through Mexico, as thousands of Olympic visitors will do this fall, the Garrett family followed a route of their own choosing, seeking out-of-the-way sights as well as familiar landmarks. On their trip from the United States border to the Mexican capital they motored more than 2,000 miles through 12 of Mexico's 29 states and the Federal District. Countless times they crossed trails blazed by the 16th-century conquistadors, whose epic journeys first opened the world's eye to the beauty of this mountainous land and the grandeur of its Indian empires.



ESTABLISHED © W. H. P.

from around the world will gather in Mexico City for the XIX Olympiad. Many visitors, lured to the Mexican capital as much by the country as by the event, will retrace the historic *caminos reales*, or royal highways, on their way to the games.

For Mike and Kenny, school ruled out attendance at the Olympics, so we decided instead on our own summertime invasion of Mexico. We followed no one trail, but crossed many. Our route took us more than 2,000 miles in six weeks—from El Paso, Texas, through northwestern Mexico to Mexico City (map, opposite). To allow for side trips into remote and sometimes difficult areas, we rented a camper—virtually a home on wheels, complete with bunks, kitchenette, and independent water and power supplies (above). With this freedom to explore the byways, we hoped to study the character as well as the look of a great land.

As we passed through El Paso, it seemed that half the United States had decided to join us. An endless rush-hour flow of automobiles and trucks eased with us over one of the bridges that cross the Rio Grande into Ciudad Juárez. Mexican border guards waved the traffic on with rarely a pause.

"If they stopped every car just long enough to say '*buenos días*,' Mike remarked, "they'd have the world's worst traffic jam!"

One of Lucy's pamphlets supported Mike's notion. "Juárez is Mexico's busiest port of

Mules command the right of way on a plantation trail near San Blas. A banana harvester stares in surprise at the Garretts' camper-bus, a vehicle that proved ideal for exploring little-traveled lanes of Mexico's hinterland.

Christmas shopping in July, the author's teen-age sons, Mike and redheaded Kenny, buy copies of Toltec vases and figurines made by these young vendors in Tula.





Good neighbors cheer a neighborly swap. Presidents Lyndon B. Johnson and Gustavo Diaz Ordaz ride through the confetti-filled streets of Ciudad Juárez on October 28, 1967. The festivities marked the end of a boundary dispute that arose in 1864, when the Rio Grande flooded and shifted its course. The



PHOTOGRAPH BY W. E. GIBBETT © N.G.S.

settlement included changing the river's path again and trading sections of Juárez and neighboring El Paso, Texas.

entry, and El Paso ranks first among United States gateways," she noted. "People crossed the border here more than 60,000,000 times last year."

Border commerce, in fact, has made Ciudad Juárez Mexico's fourth largest population center—after Mexico City, Guadalajara, and Monterrey. It has also made it, in partnership with El Paso, one of the world's largest bilingual urban areas. English is compulsory in Ciudad Juárez's schools, as is Spanish for students in El Paso. A few still speak "Tex-Mex," a lingo that is both but neither.

Four-footed Intruders Monopolize Roads

We drove through El Chamizal—The Thicket—a 630-acre parcel of land, parts of which were claimed for a century by both the U. S. and Mexico. In agreeing to Mexico's ownership, the two countries also rerouted four miles of the Rio Grande in a new concrete channel and traded 193-acre chunks of El Paso and Juárez.*

Juárez was hard at work replacing its former border-town carnival atmosphere with a sedate \$11,000,000 civic-renewal project. Already completed are a magnificent new hotel, handsome shops, a museum of art and history, and an irresistible crafts center. The latter could have bankrupted our safari where it began. Lucy wanted to buy some of everything in it. Kenny, eager to move on, saved the day by insisting prices would be better to the south.

Late that afternoon we camped in the Samalayuca Desert, a vast expanse of drifting dunes south of Ciudad Juárez (page 173). Travelers often meet blasting sandstorms here, but not a gust stirred as we struggled to the top of a high dune for a view of the sunset.

The failing light tinted the bleached landscape a pale rose, then a deep red, as creeping shadows shaped and reshaped the forms. Then, in an instant, the sun slipped from sight, shrouding the dunes in a gray afterglow. We returned to the warmth of the camper.

Others, too, sought warmth nearby. As the chill of the upland night sharpened, burros and cattle drifted out of the unfenced rangeland onto the highway, lured by the heat stored in the pavement. We did not challenge their right to the darkened roadway.

Lucy's continuing history lesson took on added significance that night as she read from Cabeza de Vaca's account of his travels. In 1536, almost a century before the *Mayflower* pilgrims left England, three white men and a Negro slave, the first foreigners to visit this area, had passed near our campsite.

Cabeza de Vaca led the group—castaways from a wreck off the Texas coast. They endured eight hellish years, most of the time as slaves of the Indians, the rest escaping across Texas and northern Mexico to a Spanish outpost near the Pacific (map, page 148).

Next day we detoured from the main highway to visit Casas Grandes—Great Houses (following pages)

*For a detailed map of the exchanged areas, see "New Portrait of North America" in the April, 1964, NATIONAL GEOGRAPHIC.





Silent sun-washed plazas of Casas Grandes once resounded to the voices of thousands who dwelt in multi-storied adobe apartment houses. Urban center of an Indian civilization that flourished between A.D. 1050 and 1340, the city covered 260 acres. An ingenious system of underground conduits supplied water to the inhabitants. Archeologists began excavating 40 acres in 1958; erosion has since badly damaged these ruins 125 miles southwest of Ciudad Juárez.



rotalamerik © n o a

Adobe cage, photographed from the inside, imprisoned a macaw 800 years ago. People of Casas Grandes raised the birds for their feathers, which they used in ceremonies of the Plumed Serpent cult. Kenny Garrett holds the cage's door plug.

Urique Canyon bares its beauty to horsemen venturing into the rugged Tarahumara Range. From this mighty gorge and its neighboring canyons huge amounts of copper and other minerals were mined in the 17th century.

More than a mile below this temperate, cactus-studded height, the Urique River winds through tropic lowlands where orchids, oranges, mangoes, and avocados thrive. Parrots, pumas, and jaguars inhabit the slopes. Here, too, live some 50,000 Tarahumara Indians, among the most primitive people in North America (pages 156-9).

"*Un gran hombre*," Señora Luz Corral de Villa describes her late husband Francisco—better known as Pancho—Villa. Photograph above her portrays the daring rebel leader of the early 1900's. Señora Villa maintains a museum in the former home and headquarters of the revolutionary general in the city of Chihuahua.



—a spectacular 260-acre ruin. Here, long before Columbus, lived a people, relatives of our Southwestern Indians, who built a flourishing culture in a hostile desert land.

Climbing the ceremonial pyramids and exploring the ruined adobe apartments aroused our imaginations. We envisioned priests regally approaching their altars, housewives molding pottery in the shade of their homes. But we could only guess at their true nature, for these people left no written records—only what archeologists can read in these ruins.

"We have no idea what they called themselves," Dr. Charles C. Di Peso told us, "so we use the term Casas Grandians."

Under Dr. Di Peso's direction, a joint United



PHOTOGRAPH BY NATIONAL GEOGRAPHIC SOCIETY

States-Mexican team spent three years excavating 40 acres of the city from its sarcophagus of sand and exploring its mysteries, and seven more years analyzing their findings. Dr. Di Peso interrupted work on his reports to share some of the conclusions with us.

"They had temples, ball courts, multistoried apartment houses, a city water system, sewers, and steam baths. They even tamed the arid foothills of the Sierra Madre to serve them"

Dr. Di Peso explained that the Casas Grandians developed hydraulic engineering to an astonishing degree. Their labyrinth of terraces and *trincheras*, or check dams, laced some 11,000 square miles around Casas Grandes, drawing life for crops and gardens from nearly

parched wasteland. Many of the dams, estimated to be more than 900 years old, still control water, preventing erosion (map, page 148).

"People often ask us why we dig up the past," Dr. Di Peso continued. "Casas Grandes offers us a perfect study of what can happen to a prosperous urban culture. In many ways its case parallels what is happening in our cities now, with their riots and unrest.

"The Casas Grandians enslaved neighboring tribes and developed a caste system. Their builders, artisans, and engineers became highly specialized and concerned only with their own problems. The laborers were forced from a rural way of life into an unfamiliar urban pattern, which may have led to a breakdown

of the internal social and religious structure.

"Toward the end, these urbanites let their apartments fall into ruin and took refuge wherever they could—in the temples and the public colonnades—and in these places they built cooking fires and flimsy partitions. The sewers were allowed to clog up and were used by some of the people as burial places.

"From there, of course, it was only a short step to disaster. About the year 1340, during either an internal riot or an attack by outside enemies, the once-powerful city was burned and abandoned. Temple ornaments were purposely broken and scattered. Hundreds of bodies were left in the ruins."

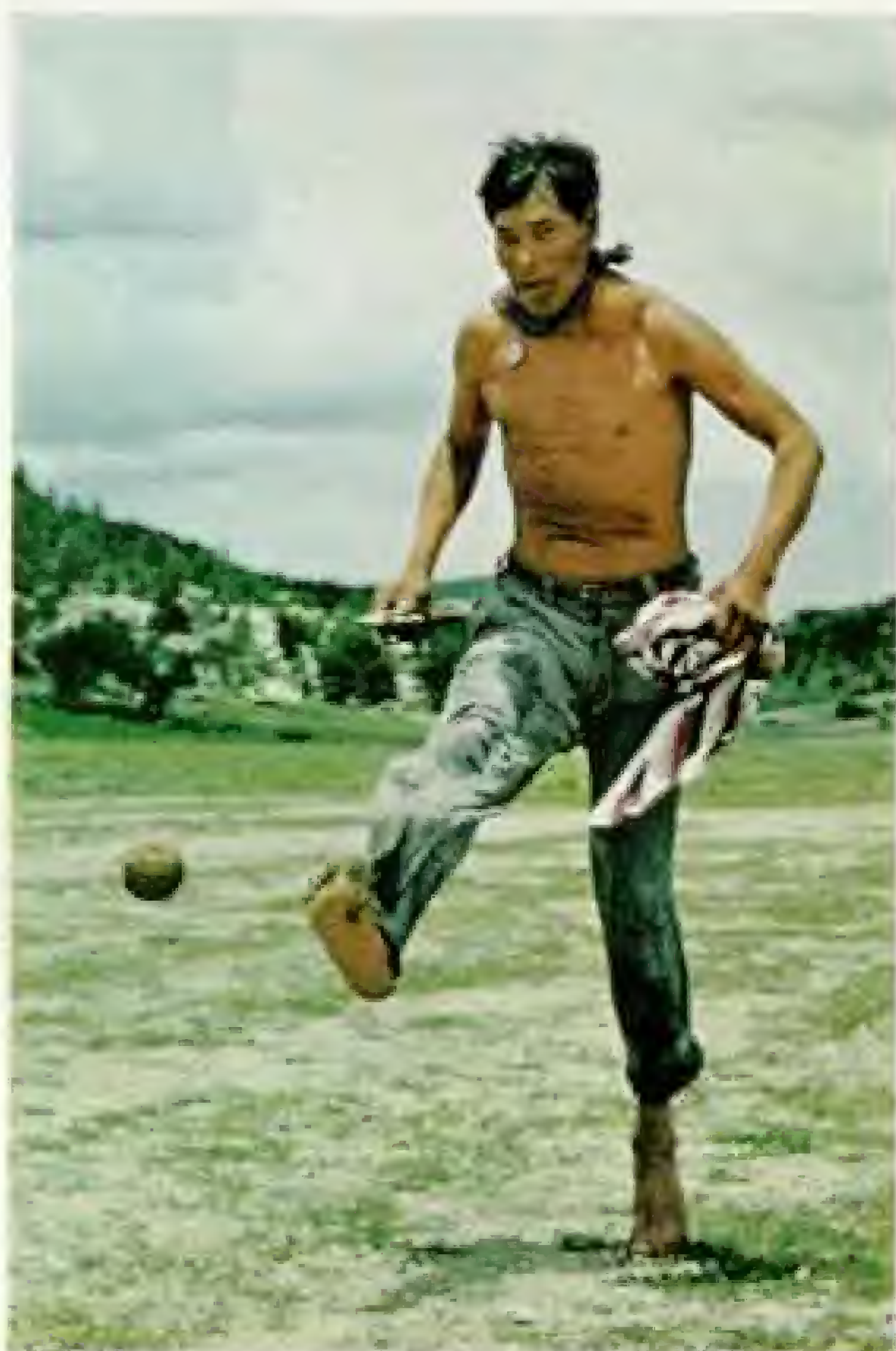
Robin Hood—or Ruthless Bandit?

Some 180 miles south of Casas Grandes stands another monument to the past, this one a more recent memorial. It consists of a huge house in the city of Chihuahua, the capital and mining center of Chihuahua State, and it belongs to Señora Luz Corral de Villa.

Controversy still clings to the name of Gen. Francisco Villa, better known both to Americans and Mexicans as Pancho Villa. To many in the years preceding 1923, Villa was no more than a colorful bandit in an age when Mexico was plagued by bandits. To admirers, however, the great Pancho was a sort of backlands Robin Hood, a patriot bent only on ridding his beloved Mexico of tyranny and corruption. Whatever his aim, Pancho Villa's career came to a sudden close in 1923, when his automobile was ambushed by unidentified gunmen in Hidalgo del Parral, a mining town in northern Mexico.

Today the front part of the general's former home and headquarters houses a private museum run by his widow, the redoubtable Señora Villa herself (page 154). As we examined the bullet-riddled 1919 Dodge in which Villa met his death, we were suddenly engulfed by a wave of children scampering out of the museum and out of reach of the very vocal señora. "They make as much noise as an atom bomb. I'd like to put them in a rocket and send them to the moon." She emphasized the trip with a swoosh of her hand, then smiled. "But it matters nothing—their grandfathers fought beside the general. They are welcome to live with their families in his house as long as they wish."

Gesturing toward the battered car, Señora Villa remarked: "I don't know who fired the shots, but my husband was killed the same day of the week—a Friday—as Christ, Lincoln, and Kennedy, and for the same ideals."



ROBERTSON © A.P.S.

Their name means "flying feet". Possessed of fantastic stamina, Tarahumara Indians compete in barefoot races that often continue for 48 hours. As they run, they kick wooden balls which are as large as oranges when the race begins but wear down to half that size. Two Tarahumaras ran in the 1928 Olympic marathon in Amsterdam but, despite their prowess at home, lost the 26 $\frac{1}{2}$ -mile race.

It was obvious that to his widow the bandit-hero is all hero.

In Chihuahua we made plans to journey to Los Mochis near the Gulf of California. Even today the trip is impossible by car, for the great mountain spine known as the Sierra Madre Occidental and the Tarahumara Range, with its giant canyons (preceding pages), block access. The latter plunge deeper and four times longer than the Grand Canyon.

Until 1961, the only way across was by mule. Then the Chihuahua al Pacifico railroad, pushing track 420 miles through 89 tunnels and over 31 bridges, finished its line from the city of Chihuahua to the Gulf of California. It was the first road of any kind across Mexico's rugged Sierra Madre between the United States border and Durango, 674 miles to the south (map, page 148).

To visit this spectacular country we would ride the railroad's self-propelled car, called the *autovia*, which makes the up-and-down trip to Los Mochis in 13 hours (pages 160-61).

Somewhat apprehensively, we entrusted our camper to Señor F. J. Sáenz Coloma, traffic manager at Chihuahua, to be loaded on a flatcar. I asked him to load it backward, since I had heard that rock slides occasionally broke windshields. He laughed at the idea.

"Don't worry. We spent so much money on this railroad that we can't afford accidents. In the slide area we run scout cars ahead of the trains as a safety measure."

We boarded the *autovia* early in the morning and rolled across the foothill country, enjoying the constantly shifting scene. Stewards served breakfast just west of Chihuahua. Through the windows, among the gathering hills, we could see white-faced cattle grazing the steep slopes.

Silver Brought No Wealth to Creel

Mike and Kenny soon discovered the State Geologist of Chihuahua, Señor Carlos García Gutiérrez, aboard our car. He explained that, like them, the Sierra Madre range ahead of us was quite young, having been formed by volcanic action only 11 to 40 million years ago, but also it is very rich.

"Chihuahua," he told them, "leads Mexico in the mining of lead, zinc, and iron." He caught Kenny's glance. "But those are uninteresting metals, yes? We are also first in silver and second in copper and gold!"

We had a glimpse of Mexico's once-vast silver empire when we left the train at Creel for a few days.

In years past, silver ore carved from the Sierra Madre came to Creel by mule on its way to Mexico City. Obviously, Creel had profited little from it. Old log cabins and a few rough-planked houses and stores line the unpaved street. Though a few prospectors still drift through, Creel today makes its sparse living off timber from the Sierra Madre.

When the Spanish arrived in the 16th century, they found many different Indian tribes in this high country. Today only the Tarahumaras remain in any number. The invaders brought something far more deadly than pikes or guns. Old World diseases such as smallpox scythed down whole peoples. Often, epidemics raced ahead of the conquistadors, so that the victims never met their destroyers. In the 150 years that followed, the native population of central Mexico plummeted from an estimated 11 million to only 3 million souls.

Still in the high Sierra, which protected them from the white man's epidemics, live the cave-dwelling Tarahumaras, among the most primitive Indians left in North America. A friend in Chihuahua had radioed ahead, asking a Jesuit missionary working with the Tarahumaras to meet us. The young padre, the Reverend Luis G. Verplancken, a native of Guadalajara, showed us through the clinic he established in 1965 for Tarahumara children. Surveys had shown that 80 percent of the youngsters died before they were five, either from malnutrition or from untreated diseases.

Our first look at the Tarahumaras appalled us. In the clinic, infants lay quiet, or cried almost soundlessly, their skin stretched tight over thin bones. A nurse placed one child they called "El Viejito"—the little old man—on the scales. He was 18 months old and weighed only 11 pounds.



AMERICAN © N.S.L.

Zest for running spurs Tarahumara women as well as men. Instead of kicking a ball, they fling linked straw hoops. As they dash forward, they scoop them up with a stick and toss them ahead.





Cave-dwelling Tarahumaras live on the high mesas of the Sierra Madre range. This Indian mother grinds corn in a stone metate, while father carves a wooden ball for his son. To make the violin that rests against the gate, he split pine into thin boards, smoothed them, and glued them with *iki*, a substance extracted from lily bulbs. He plays the instrument with a bow strung with horse hairs.

Missionary nun broadcasts Spanish and health lessons to isolated Tarahumara children from the mission school at Sisoguichie. Indian boys and girls are trained as teachers by the mission and taught to operate battery-powered receivers. Returning home, they tune in on the daily sessions to teach other youngsters.



EDUCATION CENTER AND COMMUNION BY W. C. BARRETT © N.S.A.

A mere 14 pounds at two years of age, a Tarahumara boy cries in fright at the Jesuit clinic in Creel. Eighty percent of the Tarahumaras die before five of malnutrition or disease. Uncertain and reserved in social contact with outsiders, the Tarahumaras live in the shadow of famine, despite efforts by Mexico's National Institute of Indian Affairs to improve their lot. They can coax only meager crops from the rocky soil. Though they herd cattle, sheep, and goats and use the manure as fertilizer, they never milk the cows, and usually kill animals only for religious feasts.





"We save most of those we can get to the clinic," Father Verplancken told us. "They arrive looking fat, but it's all fluid and no flesh. Even when they get enough corn, they lack protein—there is very little game left in the mountains. The Indians catch and eat mice, when they can find them.

"As for germs," he added, "the Tarahumaras don't believe in what they can't see. Some parents visit the children, see how well off they are with us, and simply never return for them.

"We can't change the parents, but we are trying to reach the children. There are probably 50,000 Tarahumaras scattered through the mountains, but they don't live in large communities and they have no central leadership. Over a 26,000-square-mile area we have a total of 3,650 students in 63 schools. All but 10 of these are radio schools, where we teach the children via short-wave sets provided by the mission."

Indians Race On Through the Night

Father Verplancken invited us to join him on a tour through part of his parish. Just outside Creel, we came on a Tarahumara foot race.

Four men and four women ran continuously from one end of a mile-long field to the other. Each barefoot man kicked what resembled a wooden baseball ahead of him, and each woman tossed a pair of linked straw hoops in like manner, scooping them up with a short stick on the run, and flinging them ahead (pages 156-7).

As I ran alongside one of the women taking pictures, she playfully—I think—swung her stick at me between scoops. From the rocky cliffs, almost a quarter of a mile away, drifted the sound of laughter. Using curiosity as an excuse to stop running, I spotted dozens of Indians watching from the craggy bleachers.

Father Verplancken explained that

Burrowing into the heart of the lofty Sierra Madre, a diesel-electric *antovia* of the Chihuahua al Pacifico railroad dives through 89 tunnels and across 31 bridges in the 420 spectacular miles from the city of Chihuahua to the Gulf of California. Here at El Divisadero, a regular lookout stop, passengers leave their car for an eye-filling vista.

Lifeblood of the land, water gushes through irrigation canals veining the west coast near Los Mochis. A network of dams, which when completed will be much like the Tennessee Valley Authority's system, traps runoff from the Sierra Madre and transforms this semidesert to fertile farmland. Sugar cane, rice, wheat, corn, tomatoes, and flowers thrive in a climate that permits year-round cultivation.



Symbol of prosperity, the handsome new headquarters of the farmers' association in Los Mochis reflects the wealth that irrigation dams have brought to the region. A sleepy village turned boom town, Los Mochis means "place of the land turtles," but officials happily joke that perhaps the city should be renamed Liebre, Spanish for "hare." Some business leaders predict that within ten years Los Mochis will be the largest city on Mexico's west coast.





MIDDLEBURY CLIPPINGS, AND DETACHMENTS © A.S.S.



The heavier the load, the higher the pay: The thought may make their burdens seem lighter to a Yaqui Indian family carrying cotton from the fields to a weighing station near Los Mochis. Hand-picked cotton brings a higher price than machine-picked, so the labor merits exceptionally good pay by Mexican standards. During the fall harvesting season a family of four can earn 300 pesos a day—the equivalent of \$24—plus free lodging, food, and medical care.

this particular race was merely an exhibition. The contestants had been running for only eight hours, to entertain the local Indians.

The real race—a grueling, cross-country affair for men only—took place between Creel and an opposing village 14 miles away. The main contest, involving seven round trips, had been under way for some 21 hours—and it was less than half over!

The runners, Father Verplancken added, sometimes wear rattles to help them stay awake. At night, guides light the trails with pine torches, to keep the balls in sight and to enforce the rules—an important consideration, since the Tarahumaras bet their goats, chickens, and blankets on the outcome.

With Father Verplancken we visited a cave occupied the year round by one of the Tarahumara families.

"Most of them are semi-nomadic," he explained, "migrating down into the warm caves of the canyons in winter and returning to the

plateau in summer to tend their cornfields."

Our host was a man named Sebastián, whose cave served as living quarters for his family and for a small herd of goats. A stone wall with a pine-log gate across the cave front assured privacy from uninvited animals (pages 158-9). The vaulted opening admitted light and fresh air. Inside it is never too hot, never too cold.

Sebastián's pretty teen-age daughter, María Pilar, obviously had enough schooling to be embarrassed at living in a cave, and she shyly refused to let me photograph her. I sympathized, and yet I've seen worse living conditions in the slums of our own cities.

Pride Defers to Modern Medicine

Reports of a sick baby led us from Sebastián's cave to the rocky fields below. There we found a Tarahumara farmer scratching a furrow for corn with a primitive wooden plow and a team of oxen. Father Verplancken

EDUCATIONAL © NATURAL HISTORICAL SOCIETY



Flowers for chickens: Gold gives way to green as pickers harvest marigold blossoms in a field near Los Mochis. The petals contain a high concentration of a yellow compound called xanthophyll. Dried, powdered, and mixed with chicken feed, the flowers impart a yellow glow to the fowls' fat and to egg yolks—an appearance pleasing to housewives. But the concentrate adds no nutritive value.

Close-up shows how workers snap off the heads. The popping sound of breaking stems fills the fields like a chorus of toy crickets. Copying cotton pickers, the harvesters drag long cloth sacks between their legs. As they move up the rows, they pull off only the larger blooms, leaving smaller ones to mature for one of five later pickings.

asked directions, and the farmer indicated a small cabin beyond the rise of a hill.

We found the baby's mother inside the sparsely furnished cabin, but she was too frightened to answer Father Verplancken's questions. The sick child lay hidden in her *rebozo*, or shawl. Presently, at the padre's suggestion, we left.

A few paces away from the cabin, the mother caught up with us. I understood none of the conversation that followed, but slowly the mother pulled back the soiled cloth to expose a week-old boy, his eyes closed and crusted, his body spotted with running sores. She reluctantly offered him to Father Verplancken. After a week in the clinic the sores had healed and the brown eyes had opened.

During that week we flew to the waterfall at Basaseachic, which drops straight down for more than a thousand feet. We rode horses up narrow, cliff-hanging trails to the pine-forested rim of Urique Canyon (pages 154-5).

From there we gazed down at a tropical village on the Urique River, more than a mile below, where oranges, bananas, and mangoes were growing.

Finally, we bade Father Verplancken good-bye and boarded the *autovia* once more. In a few hours we dropped from the high Sierra Madre to the coastal plain along the Gulf of California.

Here a series of dams gathers and then doles out mountain water for irrigation. From the train we saw canals funneling the water to fields that stretch along the coast (page 162). When the project is completed, we learned, two million acres will produce crops the year round in the once-barren plain.

At the hub of this booming farm country lies Los Mochis. Founded in 1903 by a United States businessman, Benjamin Johnston, to serve his sugar refinery, it changed little in its first half century. Now a paved coastal highway, irrigation, and the long-awaited Chihuahua al Pacifico railroad have brought new life to the town.

True to Señor Sáenz Colomo's promise, our camper was waiting in Los Mochis, unscathed by its flatcar ride. Also on hand to welcome us was Señor Gilberto Limón, a local representative of Mexico's Department of Tourism.

As we piled into the camper, I noticed a flock of new taxis hauling passengers from the crowded station. Each carried six to seven fares, depending on the driver's ambition and the size of his passengers.

"Our town has the same problem," Señor Limón said, smiling. "It is like a little boy who has grown very fast—its pants are too tight!

"For example, we already have four airlines serving the city, but we have no airport—we must use the strip belonging to the sugar mill. Most farmers spray with airplanes—it's much faster and it doesn't waste valuable land for tractor lanes. Crop-dusting planes even sow the rice crop."







In communion with the sea, the Pacific port of Mazatlán attracts big-game anglers with its abundant sailfish and marlin. Boats of Mexico's largest shrimp fleet dock in the harbor. Twice a week the luxury ferry *La Paz* sails from here to the town of La Paz in Baja California.

"Sweet-ride shores," surfers call the beaches at Mazatlán. California sportsmen motor a thousand miles with boards strapped atop their cars to challenge these hurtling breakers.

ESTABLISHED BY W. E. LAMBERT © 1954



As we drove into Los Mochis, Señor Limón continued the verbal tour.

"Almost everything of importance that you see—paved roads, banks, a hospital, hotels—has sprung up in the past six years."

He suddenly grinned. "A few weeks ago a woman tourist interrupted me, complaining that she didn't want to see these things, she wanted to see the 'real' Mexico. I suppose she meant some Mexican sleeping under a big sombrero; but I could have assured her that there is little sleeping during planting or harvest times. And, with two to three crops a year, that's most of the time."

Roberto Vargas Ochoa, a local farmer, offered to take me to his fields the next morning. *Mañana* turned out to mean 2:30 a.m. Señor Vargas picked me up in a new Chevrolet equipped with a two-way radio to keep him in touch with operations over 1,000 acres. The car also boasted air conditioning, a modern Mexican substitute for a shady sombrero. At dawn we stopped amid cotton fields that were being picked clean by some of his 1,500 workers. Señor Vargas stripped a fluffy white boll from one of the plants.

"Mexico's cotton is world-known for its high quality," he said. "Hand-picked crops rate higher than the machine-picked ones, for they contain less trash. But labor is getting scarce—five years from now, half of our picking will have to be done by machines. Each can do the work of 100 men."

Crops Travel, but *Braceros* Stay Home

Besides the vast fields of cotton, sugar cane, rice, tomatoes, and wheat, we were astonished—and dazzled—by the sight of millions of marigolds in luxuriant bloom over 120 acres of irrigated land (pages 164-5). The crop, some 12 tons of blossoms per acre, is dried and ground into powder. Added to chicken feed, marigold meal enriches the color, though not the nutritional value, of egg yolks and chicken fat.

On Roberto's desk back in Los Mochis, I noticed several National Geographic Society books about the United States.

"We're closely tied to the States here," Roberto said. "Many of our people go to Phoenix, Arizona, for medical treatment. And my children go to camp in West Virginia."

Like the lady tourist, I wondered if this could be the real Mexico, whose best-known export a few years ago was migrant labor. Last year only 6,000 such *braceros* crossed the border northward to work. Instead, Los Mochis farmers sent most of their crops,



including 390,000 tons of choice vegetables, to the United States.

There is ample evidence of prosperity in and around Los Mochis. We passed farm boys on their way to town on Mexican-made motorcycles instead of on burros. One boy, not yet mechanized, enlivened his burro ride with a transistor radio. Record stores featured albums by the Beatles and the Mamas and the Papas. Señoritas in miniskirts must now be included in the list of local tourist attractions.

Roberto had suggested I visit the local farmers' cooperative. In the glass-and-walnut-

paneled board room of their strikingly modern building (pages 162-3), the president, Manuel Flores Rodriguez, a local tomato grower, reeled off from memory enough statistics to choke a textbook on economics.

"From farming, this valley grossed 80 million pesos last year. Our standard of living is among the highest in Mexico. A family of four—father, mother, and two children—can make 300 pesos a day, 24 dollars, just picking cotton, with all lodging, food, and medicine free. Secretaries are paid as much in our offices as in Mexico City."



Famed tropic resort of Puerto Vallarta fringes Banderas Bay. Today 45 weekly flights pour tourists into the once-somnolent town that suddenly found itself in the news when *The Night of the Iguana* was filmed nearby in 1963. Ripening fruit hangs from the stem of a papaya, foreground.

Daring diver times his plunge with an incoming comber as he plummets from a cliff in Mazatlán. When the surf surges in, 12 feet of water lies below; outgoing seas leave half that depth.



EDWARD RIFE (LEFT) AND SPENCER BRUCE © N.Y.S.

Señor Flores told me about a new deep-water port planned for the nearby coastal village of Topolobampo. Already Japan rates as the area's principal cotton market. "Within ten years this will be the largest city on Mexico's west coast," he predicted.

So much, I thought, for the woman tourist and her search for the "real" Mexico!

But not many miles to the south, we began to see that the boom economy of Los Mochis is something of an exception. Half of Mexico's people, in fact, still exist at a bare subsistence level, and a fourth can neither read nor write.

But the picture, happily, is changing. Everywhere Mexicans called my attention to their schools and repeated an impressive statistic: Almost five times as much money now goes to education as to defense. As a result, a new school opens somewhere in Mexico every day.

Most Mexicans still farm the land for a living, but only 11 percent of the country is arable and only 5 percent produces yearly crops. Still, the average Mexican takes pride in his land and works it despite all handicaps. Typical of such indomitable spirit were two farmers we met south of Los Mochis. They



Gliding through a shadowed tunnel, a dugout canoe brims with bananas. Following a course that must constantly be cleared by machete, the craft travels from a remote planta-



© 2000 National Geographic Society

tion to a road where trucks can pick up the fruit and carry it to market. Iguanas hide amid the branches and oysters encrust the roots of this dense mangrove jungle near San Blas.

were recent *ejidatarios*—recipients of free land under Mexico's half-century-old program of agrarian reform.

They welcomed me to their newly fenced field bordering the coastal highway. One man walked behind a mule-drawn plow, struggling to turn the sun-baked earth. His partner followed, dropping seed corn into the shallow furrow. As well as my poor Spanish permitted, we talked of bad land, good mules, and high hopes.

Presently, I explained my purpose and requested permission to photograph them in the new field. They looked at each other and answered modestly: The field, yes, but themselves, no. The older man explained:

"My cousin here did not shave today. Our

clothes are old." He looked down at his knees. "And my pants are torn. The *norteamericanos* would look at the pictures and see that we are poor Mexicans."

It was a question of dignity. I understood, and wished them much luck.

Fortunately, nature supplied western Mexico with one priceless geographical asset—superb tropical beaches. Increasingly, by air, land, and even by sea, tourists with vacation money flock to enjoy them. A few visitors without visible means of support come too—hippies attracted by marijuana and comparatively low-cost living. But Mexico, having enough poor of its own, encourages them to make a quick departure through the nearest exit with a polite "*adiós*."

Waves of lava engulf Parangaricutiro village; only the church, once the pride of its people, rises above the flood. When Parícutin spurted its molten rock from a nearby cornfield in 1943, scientists from many nations flocked here for the rare opportunity to study a volcano from-



Tourism has increased threefold in the past decade. It brings in nearly a billion dollars a year—almost half the total earnings in foreign exchange—making it Mexico's biggest industry. The Olympic Year should draw more than two million visitors.

All Roads Lead to Mazatlán

If Acapulco, still far south of us, is the king of Mexican resorts, Mazatlán is surely the crown prince. Long Pacific rollers and miles of broad beach permit surfing and swimming (pages 166-7), but the tropical atmosphere encourages relaxation, too.

Ocean bathing in Mexico sometimes brings its own surprises. National law decrees that all beaches are public—and the public includes

commercial fishermen. One morning as I enjoyed the surf, a huge haul of mackerel was netted and dragged ashore in front of Mazatlán's Hotel Playa where, moments before, dozens of guests had been sunning. If there were complaints, I didn't hear them over the whir and click of cameras.

After four weeks of hard traveling, we decided, as thousands of visitors do each year, to make Mazatlán our home for a while. Our camper found plenty of company. Mazatlán berths up to 600 trailers at a time, mostly within a block of the beaches.

Not all of Mazatlán's immigrants hail from north of the border. At the elegant beachside Balboa Club we dined with an attractive Mexican couple, Sergio Prunedá and his wife

its birth. Nine years later the cone had grown to today's 1,500 feet. Plants slowly take hold again amid the lava.

Waves of sand: The ever-moving Samalayuca Desert, 75 miles south of Ciudad Juárez, reshapes its dunes at the whim of westerly winds.

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PHOTOGRAPHY BY G. A. B.



Toy. Sergio, an architect and one of the designers of the club, moved from Mexico City in 1953. Now he is not only Mazatlán's leading architect but also the town's most unabashed promoter.

"Bill," he said, "as an architect I could work anywhere. Toy and I simply chose Mexico's most beautiful town."

Sergio insisted on managing our tour of Mazatlán.

"I'll even show you our slums," he promised. "We're not proud of them, but people come here so fast we can't build enough housing. We've been the largest port on the west coast for years, and now we've become a crossroads of transport within the nation."

Sergio's claim was not an exaggeration. We had arrived from the north and would leave toward the south. A new car ferry now shuttles twice a week across the Gulf of California, connecting Mazatlán with La Paz, on the isolated tip of Baja California. To the east a highway crosses Mexico's Sierra Madre, providing a spectacular mountain drive from Mazatlán to Durango and giving the latter—along with all of north-central Mexico—easy access to a western port.

A light 515 feet above the sea directs shipping around the finger of land on which Mazatlán stands. Inside the city's protected harbor we saw Mexico's largest shrimp fleet, whose 275 boats netted a 14,000,000-pound catch last year.

True to his word, Sergio showed us Mazatlán's slums—although at first we didn't recognize them as such. Wide dirt streets and small houses open to sun and sea breezes gave the low-rent area a look of contentment, if not affluence. Our tour ended back at Sergio's home, a three-story architectural delight that grows out of a wooded cliff and looks down on a secluded pool scooped from the boulder-strewn beach.

The next day, Sergio captivated Mike and Kenny with the suggestion that we test Mazatlán's claim to the title "Marlin Capital of the World." Actually the huge, iridescent creatures that vaulted into the air with our bait and tailwalked across the water proved to be sailfish, not marlin, although the latter abound in west coast waters. We freed the fish, which averaged more than a hundred pounds each, to fight another day.

Pigskin Bombs Take Place of Leaflets

Sergio left us to tour Mazatlán's open market on our own. Normally, unlike Lucy, I display tremendous sales resistance, but I become a compulsive buyer in a Mexican marketplace. Even food vendors find me an easy mark. I couldn't resist a dozen clams on the half shell for only 24 cents. These "*patas de mulas*" tasted a bit like Chesapeake Bay cherrystone clams, though the blood-red juice disturbed me. But Mazatlán thinks of everything: In a nearby stall, I found a man who offered



Pátzcuaro spreads a feast on market day. Each Friday morning Plaza Grande becomes a great open-air showcase for produce of the region's Tarascan Indians. Here a seller assures the author's wife that his fruits and vegetables come fresh from farms on the shores of nearby Lake Pátzcuaro.

"I will trade you three sticks of firewood for 36 *cuerepos*," a woman proposes as a final offer to a fish vendor at Pátzcuaro. A moment's deliberation—then the merchant scoops up three dozen of the minnow-size fish, and both Tarascans nod their satisfaction.



old-time herb remedies for queasy stomachs.

As a relatively young town (founded in 1802), Mazatlán finds itself short of colorful history—with one exception. It was the first city in the New World, and the second in the world, to be bombed from the air.

On Sergio's tour we had met Camilo G. Medrano, a part owner of Mazatlán's largest shrimp plant. He introduced his mother, last survivor of those wounded in the 1914 bombing attack. Her memory of the event, not surprisingly, is very clear.

"Government troops were under siege in Mazatlán. Somehow the revolutionary forces acquired two airplanes and used them to drop propaganda leaflets. Of course, as kids we

loved to see the planes and to grab leaflets before the soldiers could collect them.

"Then someone read about the Italians dropping bombs on Tripoli. Since the revolutionary forces had no bombs, they made two by stuffing explosives and scrap in wet pigskins and letting them dry. At about 8 a.m. May 6, 1914, we heard planes and ran into the street."

Only later did Señora Medrano learn what took place next. The pilot of the first two-seater intended to bomb the fort, but his plane lurched and the bombardier lost his grip on the pigskin he was holding over the side. The bomb plummeted into the unsuspecting crowd in the street. It killed 4 and



Elegance of clean-flowing lines distinguishes a water pitcher produced in Santa Clara, a Michoacán town noted for copper crafts.

Boy at the bellows fans flames in a Santa Clara foundry. An artisan thrusts a sheet of copper into the fire to soften it for hammering. The region's copper supply was long ago depleted; now Tarascan Indians buy scrap to shape vases, dishes, and candlesticks.



wounded 15, including Señora Medrano, then only 13 years old.

Turning south, we joined the trickle of summer tourists who drive through verdant jungle to reach San Blas and its uncrowded beaches. In colonial times Spanish galleons from Manila, loaded with Oriental treasure, occasionally called here. The little port launched explorations that reached up the Pacific coast as far north as Alaska.

Sand Entombs a Once-proud Port

The early padres, too, sailed from this coast to California, and the town's cannon foundry later supplied them with mission bells. But over the centuries tide and current combined

to destroy the port. Sand slowly filled the harbor, choking it until nothing larger than a canoe could enter. Now, on the hill above town, a deserted church looks over the little harbor that once sheltered privateers and pirates. Today's only invaders are squadrons of fanatical mosquitoes.

East of San Blas we rode a cargo canoe through a spring-fed jungle stream used to bring bananas from plantations to the highway. As we twisted through the channel, the mangrove jungle closed overhead, weaving a cooling tunnel around us (pages 170-71).

Orchids hung from the branches. A four-foot-long green iguana, fearful to behold but dangerous only to vegetation, lay motionless

ENTRANCE BELOW AND WOODENRAMP BY W. G. GARRETT © R.A.S.



as we passed, confident of his camouflage. We docked beside the waterway's spring source, enjoyed a cooling swim, and lunched on *tacos de frijoles*—tortillas stuffed with beans—at a small restaurant.

Steep hills covered with a jungle of brush and banana plants rose around us. Kenny and I scrambled along behind one banana worker and his burros as he cut fruit on the steep slopes. We didn't keep up for long; it was like mountain climbing in a steam bath. But the banana harvester seemed impervious to the heat. Two quick machete chops, and a 20-foot

banana plant toppled. Another swing freed the stalk. Next year, we knew from talking with the banana boatmen, another plant with its single blossom would grow from the root like Jack's beanstalk.

Our boatman stopped beside a pineapple field on the return trip. We snacked on two of the fresh-picked fruits. At the docks the foreman hung a ripe stalk of bananas in our camper for us to pick from as we drove south.

A great many Americans have seen the Puerto Vallarta area without ever having set foot there. It was the location for the filming

of Tennessee Williams's drama, *The Night of the Iguana*. Before its movie fame the village lay picturesque and isolated (pages 168-9).

Precipitous cobbled streets still meander upward to shops and homes overlooking Banderas Bay, one of Mexico's largest and deepest. Women still kneel over laundry along the banks of the Rio Cuale, or wade to deeper water to play and bathe. A few burros—"Mexican jeeps," Mike calls them—still pack loads along the beach and past the shops.

But the town is no longer isolated. Now forty-five tourist-packed flights arrive each week at Puerto Vallarta's international airport, and a new 100-mile-long highway connects it to the rest of Mexico by paved road for the first time.

One resident, Eduardo Marroqui Serrano, told us of his experiences ten years before when he built the first modern tourist hotel.

"We had no electricity and no construction equipment," Eduardo said, "so we built, you might say, by burro-power. Boys loaded the animals with sand at the beach. They plodded several blocks by themselves—burros are bright and easy to train, you know—and climbed up ramps to whatever floor of the hotel we were working



REINHOLD/© NATIONAL GEOGRAPHIC SOCIETY

Off the hip bounces a 12-pound rubber ball that flies toward the goal line at Villa Unión, near Mazatlan. In *kulama*, a version of an old Aztec game, the player can strike the ball only with his hip, which he protects with a leather binding. "I tried the game once," reports the author, "and wore a bruise for a week."

on. There was a day-long shuttle of burros.

"One night the owner of the burros complained that one of his animals had been stolen. We finally found it in one of the unfinished rooms, still waiting to be unloaded!"

Through the words of Bart McDowell, a NATIONAL GEOGRAPHIC colleague, we felt we already knew Guadalajara intimately, and we planned only a brief visit. We stayed long enough to confirm our impression of the charm of Mexico's second-largest city.* Lucy and the boys spent the first day dickering in its mammoth market for those "better prices to the south" that Kenny had promised. Even without dickering, we found bargains by the score in the State of Jalisco's Institute of Arts and Crafts. The director, Jorge Ramirez M. Sotomayor, explained the institute's purpose.

"We help the craftsmen with money and materials," he told us, "and then sell their work for them at a fair price. We encourage self-expression; we never push an artist in a particular direction, but we try to help him avoid mistakes."

A group of primitive-impressionist string pictures particularly appealed to Lucy. They are designs made with bright strands of yarn pressed onto a board coated with soft wax.

"*Tablas huicholas*, we call them," Señor Sotomayor said. "The Huichol Indians still live independently in the mountains north of Guadalajara. The Spanish never conquered them. They use the *tablas* in their religious rites, but often they come into town and sell the pictures to tourists.

"They hold ceremonies in which they chew 'buttons' from peyote cactus, which contain a hallucinatory drug, in order to make contact with their gods. Messages come to them, they tell us, through visions in which nature is transformed. After

the ceremony, they try to re-create the visions in their *tablas*. One man told me he becomes so sensitive under peyote that he can hear the sunlight moving across the cornfields!"

Before entering Guadalajara, we had passed through a vast flow of congealed black lava. Near the village of Angahuán, 105 miles southeast of the city, we were reminded again of Mexico's continuing geological growth.

Twenty-five years ago, on February 20, 1943, a farmer was startled at his plowing by

*See "The Most Mexican City: Guadalajara," by Bart McDowell, NATIONAL GEOGRAPHIC, March, 1967.



STYLING: NATIONAL GEOGRAPHIC SOCIETY

Sliding down a stony street in hilly Taxco, youngsters ride "butterboards," so called for their polished, slippery bottoms. Nestled in the mountains of the Central Plateau, Taxco calls itself Mexico's Silver City because of the abundance of the metal in times gone by, and now because of the exquisite pieces fashioned by its modern craftsmen.

a rumbling explosion in the middle of his field.* Soon the farmer owned a volcano instead of a farm. Within six days the cone measured 525 feet in height. The earth continued to disgorge lava, eventually burying two villages and nine square miles of fields (pages 172-3). Parícutin, Mexico's most publicized volcano, was born.

Today the peak is said by scientists to be dormant, but Mexicans in the region are not so sure. "I have counted more than 60 live fumaroles inside the crater," a guide told us. "Parícutin is not asleep; it is only waiting."

Like the ash from Parícutin's eruption, we drifted east toward Mexico City, stopping

briefly in the lakeside village of Pátzcuaro. Watching Lucy shop for fresh supplies in the open-air market (page 174), I reflected once again on the social significance of marketing.

It is never a question of whether the seller will come down from his first price; he will. The buyer's status depends on the wit and humor with which he brings this about. Once, in the Pátzcuaro market, I carelessly agreed to the announced price. The vendor, thunderstruck, refused to sell. Finally, in desperation, he did my haggling for me and presented me with what he considered a fair bargain.

*See "Parícutin, the Cornfield That Grew a Volcano," by James A. Green, *GEOGRAPHIC*, February, 1944.



We visited Janitzio, the island home of many Lake Pátzcuaro fishermen who supply Pátzcuaro's market. As our boat drew near the island, we encountered a form of business that is growing all through tourist-conscious Mexico. A fisherman on shore dashed to his canoe, paddled furiously toward us on a collision course, then abruptly stopped and began unconcernedly fishing with a graceful dip net.

Fishermen Earn Pesos for Poses

As he well knew, the hand nets of Janitzio—called butterfly nets—are a trademark of the island, featured in every travel book and brochure. They now serve largely to net pesos

from tourists, who pay for the privilege of shooting their own postcard views. For serious fishing, nets almost a thousand feet in length and handled by five-to-seven-man crews have proved far more productive than the smaller, more photogenic models.

On an earlier visit to Janitzio, I had watched a moving ceremony marking the Day of the Dead. Shortly after midnight, on November 2, the island women bring to their family burial plots an assortment of gifts: food, candles, marigolds, and wooden frames decorated with flowers, fruit, and small skulls molded of sugar. They spread mats on the ground and set up the decorations—one candle for each



Fisherman who seeks no fish poles across a lake in the crater of a dormant volcano near Yuriria. With a treadle, he raises a framed net at the bow and scoops up aquatic insects peppering the water. He dries and sells the catch for bird and fish food.

The fishermen stick bundles of rushes in the shallow lake as breeding places for the bugs, called water boatmen.

Taco the parrot, purchased by the Garretts in Mazatlán, enjoys a meal of dried water boatmen.



PHOTOGRAPH BY JEFFREY AND KATHARINE © 1982



REYNOLDS © NATIONAL GEOGRAPHIC SOCIETY



Homage to the Virgin

LIGHTS BLAZE through the early morning hours of August 15 in the town of Huamantla. Before dawn on the Feast of the Assumption of the Virgin, a statue of Our Lady will ride in a two-mile procession. Men labor feverishly to decorate the streets over which the image will pass. Residents of each block compete for the best design as they sift sawdust of different hues through stencils to create floral patterns.

Finally the lane lies ready. As the figure of the Virgin moves out of the chapel and through the still-dark streets, candlelight flickers on the faces of the devout (opposite). Then dawn breaks, and after a Mass, the statue is returned to the chapel to await next year's feast.

The artistic talent of Huamantla's men has earned them an invitation to pattern the Zócalo, the three-acre central plaza of Mexico City, for the gala opening of the Olympic Games in October.





¡Aja, toro! ¡Aja!—Charge, bull! Charge! Amateur matadors challenge a bull let loose in the streets of Huamantla, where reverence reigned only hours before. On the morning of the Feast of the Assumption of the Virgin, half a dozen beasts thunder down



PHOTOGRAPH BY W. T. GARNETT © N.S.A.

the processional route, horns slashing the air. Come afternoon and they will face more skillful adversaries in the ring, the climax of the fiesta in Huamantla.

remembered relative, and a censer of burning copal. They arrange the food and sprinkle marigold petals over the entire setting. Then the women and children sit in contemplation or chant prayers throughout the chill night. Thousands of flickering candles cast a pall of smoke and mystery over all.

Until the cold finally drives the tourists back to their warm hotels, blinding flashes from the many cameras, it seems to me, would discourage any spirits who might choose to return for the annual visitation. Bearing this in mind, I photographed the ceremony using only the light of the candles (pages 146-7 and cover).

Over a breakfast of whitefish at a cantina by the lakeside, an island priest talked of the local burial customs.

"Our cemetery doesn't look like a cemetery simply because the people can't afford headstones. But they know their plots. Since space is limited, when a member of a family dies all previous remains are removed from the grave and the new body is placed at the bottom. The earlier remains are then put back on top. There may be twenty to thirty occupants in each grave."

Ingenuity Turns Bugs to Profit

Near Pátzcuaro, in a crater lake at Yuriria, we discovered fishermen who catch no fish. The men poled across the still waters while levering a rectangular-framed net in and out of the water with their feet (pages 180-81). They were sifting the surface of the lake for insects they call mosquitoes, but which are actually water boatmen (*Corixidae*). Mexican ingenuity has turned the insects to a good purpose: the lake is a virtual bug farm. Its harvest, dried and sent to Mexico City, brings \$1.80 a pound from pet fanciers who feed it to their fish, turtles, and birds.

Twenty-eight miles northeast of Mexico City we stopped to marvel, as men have done for ages past, at the Pyramids of Teotihuacán (following pages). Laid out by skillful architects more than a millennium before the rise of the Aztecs, the pyramids

overshadow the ruins of a city believed to have been larger than imperial Rome.

The vastness of these monuments gives one a deep sense of humility. From the Pyramid of the Sun we walked half a mile up the Street of the Dead to a smaller counterpart, the Pyramid of the Moon. Five hundred years after Christ, this street served as the main ceremonial artery of a city of 4,000 buildings and perhaps 100,000 inhabitants. Teotihuacán lingered as a minor Aztec religious center until the Spaniards arrived, then became completely overgrown. Scholars knew of its existence, but formal excavation did not begin until the end of the 19th century.

Mexico City: Mosaic of the Past

Markers on highways all over Mexico announce the distance in kilometers to the capital city. In six weeks we had checked them off, beginning with 2,040 at Ciudad Juárez, to zero and our goal, Mexico City. Nowhere is a capital more symbolic of its nation, or more important culturally, politically, and economically to an entire people.

On entering the city, we figuratively threw away Lucy's research library, for no book on Mexico City, however artfully written, can keep up to date. A seventh of Mexico's people—more than 6,500,000—live here, and the percentage grows each year as the flight from farms to metropolis continues.* In a country two-thirds mountainous, Mexico City lies in a valley that is itself 7,500 feet high. Many spas might well envy its climate, but not its air. On all but the clearest days, smog obscures the nearby snow-covered peaks.

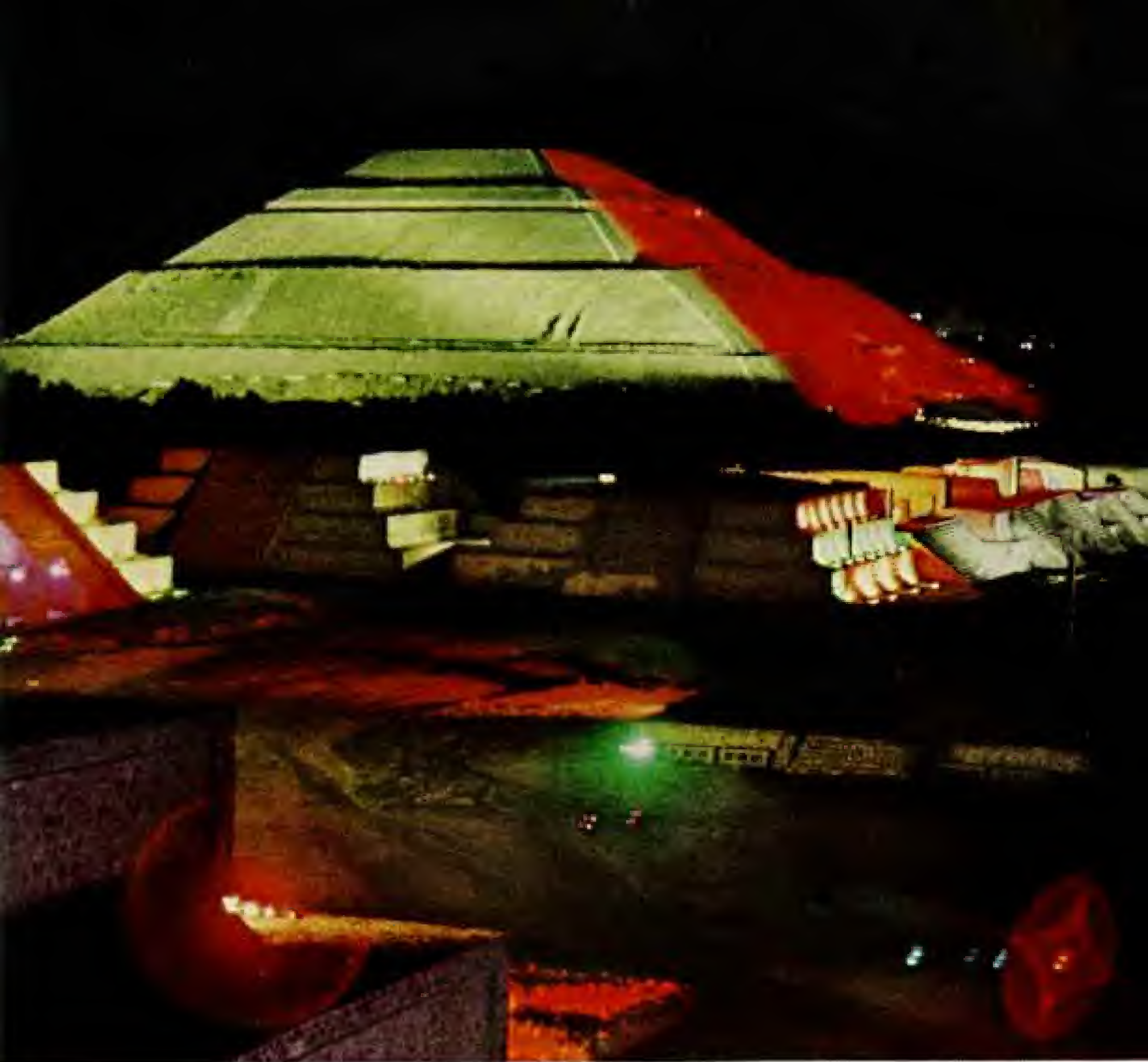
The crusty bread of Mexico City, unrivaled in the Western Hemisphere, and the wide Paseo de la Reforma, patterned after Paris's

*See, in the *GEOGRAPHIC*, "Mexico in Motion," by Bart McDowell, October, 1961; and "Mexico's Booming Capital," by Mason Sutherland, December, 1951.

City of the Gods: Teotihuacán bathes in color during a spectacle of Sound and Light, an after-dark program of illumination and historical narration. The Pyramid of the Sun, here viewed from the Pyramid of the Moon, rises as high as a 19-story skyscraper. Some archeologists think its construction kept 10,000 laborers busy for 20 years.

Built some 2,000 years ago by a highly skilled people, the ceremonial and urban center 28 miles northeast of Mexico City spreads over eight square miles—a vast aggregation of shrines, temples, priestly palaces, pyramids, and apartments divided by the Street of the Dead (diagram, right).





ESTACIONES © M.S.S.



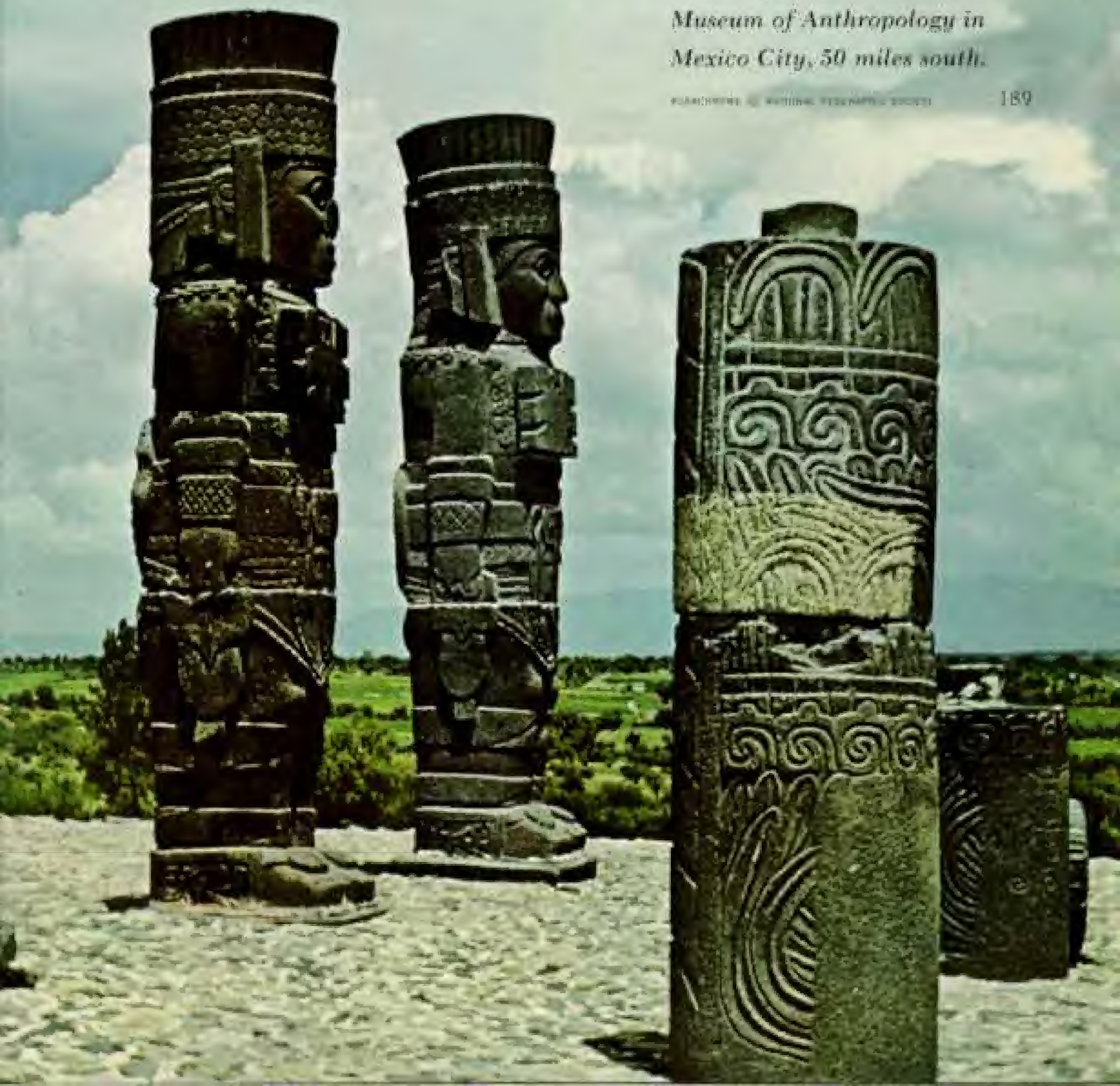
Archeological zone of TEOTIHUACÁN



FEARSOME WARRIORS of a bygone age stare with empty eyes over the ruins of once-mighty Tula, capital of the Toltecs. The four 15-foot-high statues, together with pillars, supported the roof of a temple atop the Pyramid of Quetzalcoatl, the supreme deity of the Toltecs. Dart throwers in the right hands resemble guns in holsters; left hands hold the darts. Replica at far right replaces an original now displayed at the National Museum of Anthropology in Mexico City, 50 miles south.

ILLUSTRATION BY NATIONAL GEOGRAPHIC SOCIETY

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Like a bride who wears both old and new, Mexico City blends yesteryear with today and tomorrow. Designers of the Plaza of Three Cultures, a new commercial complex, reconstructed the Aztec pyramids that once dominated a marketplace here. Santo Domingo Church, built during the Spanish colonial period, adjoins a school that was one of the first to serve Indians. Gleaming tower at right houses the Foreign Ministry. Luxury apartments rise at left on land where shabby tenements formerly stood.

Skeletal vestiges of the past come to light at Olympic Village, which will house hundreds of athletes. Here on the site of ancient Cuicuilco, archeologists uncovered 10 ceremonial structures and 180 graves. This plot contains a pottery bowl and the skeleton of a woman 25 to 30 years old, buried an estimated 2,600 years ago. Dr. Roberto Jiménez Ovando, an anthropologist, records the findings.



Champs Elysées, recall the days of French rule under Maximilian. Spain shared the best years of its own history with Mexico and left its architecture, language, and blood lines. A current influx from the United States brings scores of businesses and a colony of 30,000 United States citizens.

The city's imminent invasion by athletes from around the world will focus on Olympic Village, built over the site of Cuicuilco—where the Mexico City area's oldest ceremonial center once flourished. A volcano, Nitle, erupted about 2,000 years ago, entombing the sacred place and, in a sense, embalming it.

While we visited the site of Cuicuilco, a workman brushed and troweled dirt from the tomb of a young woman who lived there 2,600 years ago. Beside him, huge cranes



DESIGN AND CONSTRUCTION COURTESY BY W. J. CASSETT INC.

hoisted the finishing touches to a 10-story apartment house scheduled to help welcome Olympic athletes. Construction work (opposite) has exposed much of the ceremonial complex that was Cuicuilco. Four reconstructed pyramids now grace the entrance to Olympic Village.

As Olympic Village went up, a subway went down, down into the old lake bed on which Mexico City rests. Although most of the lake has been drained, mud still underlies the city. Thus, since the Aztecs dumped the first fill into Lake Texcoco 600 years ago, Mexico City has been sinking.

The nation's most revered shrine, the Basilica of the Virgin of Guadalupe, slowly settles, tilting toward the west and falling apart under the stress. The Palace of Fine

Arts lists several degrees. A steel pipe near the National Palace stands 18 feet above ground level. Originally, it served as the casing of a well.

Through this marshy subsurface Mexico City tunnels its first subway, and protects it with an outer casing of concrete. Even so, joking residents say that it will require submarines, not trains. One archeologist predicted facetiously that a few years from now the city may settle below the subway, leaving Mexico with its first elevated railroad.

Actually, archeologists delight in the subway construction, for it provides them with a million dollars' worth of excavation. All Mexico could be declared an archeological preserve. In almost every field you may pick up obsidian flakes and bits of pottery, and

digging in downtown Mexico City amounts to rummaging through the Aztec past.

In the company of Professor Raúl Martín Arana, leader of the archeological team overseeing the excavation, we visited one of the subway sites. Here and elsewhere, hundreds of men using picks, jackhammers, bulldozers, and diesel shovels are chewing a network of great trenches through the city.

In an unusual display of cooperation between builder and archeologist, Professor Arana has authority to halt work at any time to send his people, mostly students, into the trenches with trowels to save a broken clay figurine or some other artifact discarded by an Aztec householder. Over the roaring and shoveling, Professor Arana pointed to the site of the first important discovery.

"In front of this Church of Monserrat we found a statue of the Aztec goddess Coatlicue," he said. "A bulldozer damaged her slightly before anyone saw her, but now she is on

display in the National Museum as the 'treasure of the month.'

"Probably the Spanish priests had thrown her as fill into the foundation when they were building their church. Perhaps they wished to keep the Indians from worshiping the idol.

"We're saving and cataloguing about half a ton of material a day now, yet that's only 5 percent of what we find. But, when we reach the Zócalo...!"

The Zócalo, I knew, was the place where the Aztec Emperor Montezuma had his lavish ceremonial plaza in the early 16th century. El Dorado himself couldn't stir more excitement among the archeologists than does the Zócalo and the treasure they expect to find there. Here the Spanish conquistadors built on top of Montezuma's plaza with disdain for the culture they were burying. In a few years, commuters may be stepping out of their underground trains into an Aztec treasure vault, or into an altar room where priests held rites in the city they called Tenochtitlán, a metropolis greater than any in Spain at the time.

City Subway Pierces Past and Future

Thus, in building their new subway, the residents of Mexico City have found themselves tunneling into their past as well as into their future. In the muck that hampers and frustrates their builders, the people find solid cultural foundations. The land that spawned some of the greatest cities of earlier cultures—Casas Grandes, Teotihuacán, and Tenochtitlán—now vibrates anew with activity.

Spurred on by their reputation as gracious hosts, Mexicans rush to complete new hotels, stadiums, streets, and highways for the Olympiad. To revive the original cultural aspects of the Olympics, Mexicans plan some 1,500 events, including art exhibits, dramas, and concerts, for 1968. By the time of the games, historical monuments will have been cleaned, new trees and flowers planted, and large commercial billboard advertisements removed throughout the city.

The New World today gilds no El Dorado, but Mexicans nonetheless expect their Olympic visitors to return home feeling—as the first Spanish did—that they couldn't believe their eyes.

THE END




PHOTOGRAPHY: GABRIEL AND ROSAMONTE © S. S. S.

Last of a triumvirate of renowned Mexican muralists, 71-year-old David Alfaro Siqueiros shares the glory of Diego Rivera and José Clemente Orozco. Perched on a 40-foot scaffold (opposite), he works on his latest and largest creation, the three-dimensional "March of Humanity." Shaped from steel and painted with vivid acrylic colors, the 32,000-square-foot mural will adorn the interior of an auditorium in a new hotel for Olympic visitors.







The Incredible Salmon

By CLARENCE P. IDYLL, Ph.D.

Chairman, Division of Fishery Sciences, Institute of Marine Sciences, University of Miami

*Illustrations by National Geographic
Photographer ROBERT F. SISSON*

I REMEMBER WITH AWE the fantastic spectacle. Hordes of sockeye salmon on their autumn spawning run glutted the river I was wading. I was looking for tagged fish—a biologist making studies on the Adams River in the vast Fraser River system of British Columbia.

Big males, their bodies a vivid scarlet and their heads green, rushed from Shuswap Lake over the shallow bar at the entrance to the Adams. They shot upstream with a frenzy of spray, tails thrashing and backs half out of the water.

Farther along, in deeper stretches of the river, fish hung in nearly motionless schools, some awaiting the final maturation changes that precede spawning, others waiting for part of the riverbed to clear of fish so they could take their turn at nest building. Salmon can crowd the Adams in almost unbelievable numbers (page 100).

Yet salmon runs are smaller than they were in the past. This is something to be deeply regretted, and to be combated with as much vigor as can be mustered, for this noble fish counts as one of the sea's most valuable resources. It provides man with food, sport, and profit, and its life story is both dramatic and mysterious.

Since antiquity man has watched with fascination as salmon battled upriver to spawn, their silvery coats transforming into nuptial dress, sometimes of startling hue. He has spied on preparation of the saucer-shaped nests in the beds of swift streams, and

Life's mission fulfilled: Sockeye salmon in flaming dress glide together in courtship ritual over their spawning nest, or redd, in this unusual photograph made with an underwater camera. Driven by one of the strongest instincts in nature, the salmon found their way across the trackless Pacific, eluded fishermen, battled upriver, and leaped waterfalls and man-made obstructions. Finally reaching their native waters, with life draining from them, the sockeyes will assure a new generation, then die.

PHOTOGRAPH BY NATIONAL GEOGRAPHIC SOCIETY



learned that, for most salmon, spawning is their final act before death.

He has watched the emergence of tiny fish in spring-time, and later seen them make their way downstream to the sea, to be swallowed by the ocean's immensity. He has wondered where they go and what they do in the years of their sea existence. And especially he has scratched his head in deep puzzlement over how they find their way back through the trackless ocean to the same river, the same tributary—the same riffle, perhaps—where they began life years before.

Fishing Bears Warned by Intruder's Whistle

The best vantage point I have ever had for watching the start of the salmon's life cycle was in the Brooks River, one of the major spawning streams supporting the great Bristol Bay sockeye runs of Alaska (map, page 208). I went there in late summer, 1966, to catch up on the latest developments in salmon research.

A metal observation tower built by the United States Bureau of Commercial Fisheries stood in the middle of the stream so that observers could perch 20 feet up and spy on the spawning fish.

Nearing journey's end, sockeyes thrash in the seine of Canadian fisheries scientists in Shuswap Lake, British Columbia; researchers tag them (left) for the final swim to spawning grounds along the lower Adams River. The taggers record size and sex of each fish, an epitaph noted again within a few days when the dead fish line the riverbanks. Tallying the number that spawn helps conservationists estimate the future population and set limits against overfishing. More than a million salmon may make the run up the Fraser River system to the Adams, most of them arriving in a single week. The fish cover the 300 miles upstream in 18 days, traveling about 17 miles a day.



PHOTOGRAPHER: U.S. NATIONAL GEOGRAPHIC SOCIETY

Dr. Wilbur Hartman of the Brooks Lake Research Laboratory guided the bureau's Dr. George Harry and me to the tower through a forest of white spruce. As we walked, I noticed that Will whistled frequently, and his talk was louder than usual.

"Why the racket?" I asked.

"Bears," said Will succinctly. Alaska bears, he explained, love salmon and are commonly encountered among the spawners.* They can be aggressive and, when startled, they sometimes attack people. It is better to advertise your coming and give the bear a chance to slip off into the woods than to surprise him.

We had come to the Brooks River to look at sockeye salmon. There are four other kinds of salmon on the Pacific coast of North America—chinook, coho, pink, and chum (paintings, pages 214-15). Asia has a sixth species as well, the masu, which resembles the coho in appearance. Japanese call it *sakura masu*—"cherry trout." The original member of the tribe is the Atlantic salmon (page 216). Millen-

niums ago some of the ancestors of this strain are thought to have migrated across the Arctic Ocean; through the ages their descendants evolved into the present Pacific species.

To Americans and Europeans alike the Atlantic salmon is one of the most highly prized of fishes; explorers of the Pacific Northwest were delighted to find waterfall vaulters that looked so familiar. Yet the Atlantic salmon is actually closer biologically to the sea trout of Europe, and to the rainbow and cutthroat trout of our Pacific streams, than it is to the Pacific salmon that bear its name.

Like the trout, Atlantic salmon can spawn more than once. Perhaps eight or ten females in a hundred, and a smaller proportion of males, live to reproduce a second time. A tiny fraction of the females may spawn a third or even a fourth time, males apparently never more than twice. Pacific salmon all die after a single spawning, and that answers the

*See "When Giant Bears Go Fishing," by Cecil E. Rhode, NATIONAL GEOGRAPHIC, August, 1954.

question I am asked most often about the salmon's life story. Somehow people find especially poignant the thought that the reward for the intense physical struggle of the spawning journey is certain death.

The tower in Brooks River rang metallically as Will and George and I climbed to our perch. Beneath us salmon spread almost uniformly over the stream bed. Everywhere fish dashed about, protecting their territories, digging nests, spawning. River edges and shallow bars became the graveyards of spawned-out fish, their duty to the race done, their lives ended.

I watched salmon below me turn suddenly on their sides and slap the gravel bottom with powerful tails. Sand, pebbles, and larger stones were dislodged and carried downstream by the river's swift current. The result was a hollow—a nest, or redd, in which the female would lay eggs (page 200).

"There's a good battle!" George exclaimed, as a sudden flurry drew our attention to a nest at the base of the tower. Protecting his territory, the male dashed at an intruder, snapping with the hooked snout and fierce teeth that had transformed his jaws during the spawning journey (right). For a moment the two fish rolled over and over together, then dashed from the nest a few feet before breaking off the encounter. Another pair of males tangled briefly, then sidled crossways downstream in a ritualized bluff—as if daring each other to start the fracas anew.

Camera Captures a Rare Sight

Despite interruptions for such jousting, the redd is built and spawning occurs. Unless an observer knows what to look for, though, he may miss the actual spawning act. Even many veteran field biologists have never seen it; thus NATIONAL GEOGRAPHIC photographer Robert F. Sisson's pictures represent a remarkable achievement (pages 201-202).

The female salmon settles to the bottom of the nest, and the male takes a position beside and a little to the rear of her. Suddenly both fish begin to vibrate rapidly, and thrust themselves forward in the redd. When eggs and milt are released simultaneously, about 98 percent of the female's eggs are fertilized and settle to the bottom.

After the spawning act, the female moves upstream and digs another egg pit, where the pair spawns again. Meanwhile, gravel carried downstream covers the first group of eggs. A

female may spawn in five or more egg pits—occasionally with different males.

The river's unremitting current smooths the gravel bottom. New waves of salmon move in to dig and spawn and die.

The eggs lie for many weeks under as much as 16 inches of gravel. Eventually the dark spots that are eyes shine through the transparent shells. Late in this "eyed-egg" stage the unborn little fish can be seen wriggling around, preparing to burst forth.

Some time in the winter the eggs hatch. The alevin, as fisheries men call the hatchling that emerges, is an ungainly creature, with a massive orange-colored yolk sac attached to its underside. The sac supplies food for the little fish while it waits in the gravel, developing (page 203). Then on a dark night it

EXTRUDING (BELOW) AND FOODING (R) R.L.S.



Hooked jaws of a male sockeye can be as fearsome as they look; males may seize rival suitors by the tail and shake with bulldog ferocity during fights at mating time. Males develop misshapen jaws on the spawning run from the ocean, while females swell with eggs. Stomachs shrink as both sexes shun food, living on stored fat.

Traffic jam of the home ward-bound builds up in the lower Adams River. Late arrivals must actually wait turns for breeding space. Studies of the 305-acre spawning ground reveal that in a recent bumper year it produced a sockeye catch retailing for \$30,000,000.





Slapping her tail against the bottom, a sockeye kicks up a cloud of sand as she digs the first egg pit in her redd. The salmon may spend several days and nights digging and resting, rarely helped by her waiting mate. After depositing a portion of her eggs in a spawning ritual with the male, she moves slightly upstream to spawn again. Gravel from the second egg pit washes down to cover the first. By the time she has dropped all 3,000 or more eggs, her tail is worn and frayed, and death is near.

Rivals fight it out: A sockeye on her redd tips at another female before the gaze of her mate, who keeps his distance. After their initial curiosity wore off, the salmon ignored the remote-controlled camera, protected in a waterproof glass tank set on the bottom of the shallow creek.



wiggles forth, an inch-long fry beginning life in the open world.

And a cruel world it is. Flooding, drought, and temperature changes in the water can be deadly. The young salmon are prey to sculpin, trout, yearlings of their own species, birds, even the aquatic, immature stages of dragonflies. The attrition is terrible—out of some 3,000 eggs from a female sockeye, only 30 to 100 salmon will reach fingerling size.

The young of pink and chum salmon move directly to sea. Other species remain in lakes or rivers for a year or two, sometimes growing as long as five or six inches before traveling

downstream. Once in the ocean, they are hard to trace, but intensive tagging experiments are lifting the veil. Salmon swarm over much of the northern Pacific Ocean (map, page 208). During the earliest stages, while still in the estuaries, they swim in enormous schools—salmon counters in 1964 watched hordes of little pink salmon passing shore points in southeastern Alaska at an estimated rate of 750,000 a day for two full months.

As the fish grow older, recoveries of tagged fish indicate, they separate from their fellows and migrate as individuals, moving in great ellipses through the vast reaches of the North





(SPAWNING) LOWER LEFT, AND BROADCASTED BY ROBERT F. SISSON (C) 1952.

Moment of spawning: Milky, sperm-laden milt floods an egg pit in this remarkable view from beneath a mating pair of pink salmon. Eggs emerge from the female's red vent. Just above, a jet of milt obscures the vent of the male. The heads of both fish lie outside the photograph at lower right. Older unfertilized eggs drift at left.

Working with biologist William R. Heard, photographer Sisson devised a spawning tank with camera window (right) at Lovers Cove Creek, Alaska.





EDUCHEMING © NATIONAL GEOGRAPHIC SOCIETY

Instant of fertilization. Milt systematically swirls counter-clockwise over the surface of a sockeye egg and finds the single micropyle, or entry dimple, at the center of the silhouetted curve of the egg. The first sperm to enter triggers fertilization. Then, as new life begins, the micropyle closes. Sperm cells survive less than a minute in the cold salmon streams; but manage to fertilize almost all the eggs. Nature balances the high mortality of the young with the thousands of eggs laid by each female. Circular fat globules within the egg feed the developing embryo. After two months of effort, photographer Sisson hit on an edge-lighting technique to produce this first portrayal of the moment of fertilization, magnified 90 times.

Big-eyed orphans, these Atlantic salmon (top right) began hatching at 19 weeks with eyes already developed. In close-ups 10 times life-size, a hatchling (lower left) thrashes its tail out of the egg and soon begins wriggling in the gravel (far right). Attached yolk sac feeds it until it can find food for itself. With spring, the fry works up through the gravel blanket that sheltered it during winter, and begins life in the river. These salmon were spawned in Newfoundland and hatched in an improvised tank at the National Geographic Society's Washington, D. C., headquarters.

Pacific. Pink salmon travel a single loop of 3,000 to 4,000 miles during their 12 to 14 months at sea. Some Bristol Bay sockeyes make an annual circuit of more than 2,000 miles for three years in a row. Chinooks are known to sweep along the Aleutian chain past the easternmost longitude of Asia, and live at sea for three or four years.

Atlantic salmon make some extraordinary migrations, too (map, page 209). One individual tagged at Loch na Croic in Scotland was recaptured in Eqaluk Fjord, Greenland, 1,865 nautical miles away. A fish from the Annapolis River in Nova Scotia was caught off Ramah, northern Labrador, after a journey of almost 1,700 nautical miles.

During the last months of their lives salmon head for home rivers on an amazingly precise schedule. So exact is the timing of Alaska's Bristol Bay sockeye run, for example, that all the fish, numbering as many as 50 million, arrive in the estuary within three weeks in late June and early July—despite the fact that individuals approach it from at least half the directions of the compass, and from a distance of 1,200 miles or more. They gather with such uncanny accuracy that the peak of the run, occurring about July 5, never varied by more than eight days in the ten years covered by a recent scientific survey.

Consider the problem the salmon faces in getting home. When its reproductive urge tells



REPRODUCED BY VICTOR E. BIRRELL, JR., NATIONAL GEOGRAPHIC SOCIETY © 1973

it to head back for spawning, it can follow no trails worn into the ocean by long lines of ancestral fish. There are only shifting currents, slight differences in saltness, and subtle variations in the temperature of the water, none of which seem patterned enough to be useful in steering a migration course.

At the mouth of its home stream, the fish may have to breast mile upon mile of murky estuary where it is unable to see even a few feet. Upstream it passes tributaries great and small, with enticing coolness and the promise of clean gravel for spawning. Somehow the choice between this fork and that one is made correctly in nearly every case (pages 218-19).

I discussed this miracle of migration one

day with photographer Sisson and Drs. Ross M. Horrall and Aivars B. Stasko (page 208). Ross and Aivars are associates of Dr. Arthur D. Hasler of the University of Wisconsin, who has advanced the hypothesis that in the ocean the salmon can set a course by the position of the sun.

Homing Seems to Involve Several Senses

"If this is so," Ross said, "it achieves what the human navigator does, but without benefit of sextant and chronometer. Experiments with fingerling salmon and bluegill in an outdoor tank at Dr. Hasler's laboratory have shown that they can in fact maintain a compass direction when the only cue is the sun's location.





"Of course," he added, "we can't be sure adult salmon possess the same ability."

Salmon also migrate at night, often through storm-churned seas. And in June, when Bristol Bay sockeyes are setting courses for home, daytime skies above the outer bay are overcast more than half the time.

"Another theory," I interposed, "involves electromagnetic clues in the sea. The idea was suggested by a research team at the University of Washington. Ocean currents generate small but measurable electrical voltages as salt water moves through earth's magnetic field. These voltages might serve as a guide to the direction of the ocean currents. Certain eels can detect such weak electrical fields, and salmon may do the same."

Ross summed up: "The fish probably uses several senses to guide its ocean migration. The job is just too difficult to be accomplished by any single mechanism."

Transmitter Traces Sockeye's Course

Ross and Aiyars had come to Washington's San Juan Islands to fill in pieces of the salmon puzzle by tracking individual fish that had been caught and fitted with ultrasonic transmitters, then released.

Through sheerest coincidence, I found myself in the middle of this experiment, a project sponsored by the National Science Foundation and the Office of Naval Research. I was visiting a cannery at Anacortes, Washington, where I had worked when I was with the International Pacific Salmon Fisheries Commission. In the cannery's wet-floored packing room I watched orange-red salmon eggs being brined and packed into wooden boxes to produce *sujiko*—salmon caviar—for the Japanese market.

My wife Marion chose to remain outside where the footing was dry. As she stood there, a worker dashed up with what appeared to be an elongated, old-fashioned radio tube. "Look what my wife found when she was cleaning a salmon!" he exclaimed.

Marion isn't a scientist's wife for nothing. "I'm sure my husband would be interested in seeing that," she said. "Could I show it to him?"

Thus I acquired what I suspected to be one of Ross Horrall's ultrasonic devices. The next day in Friday Harbor I showed him the instrument.

"Tremendous!" he exclaimed. "It's one of ours all right. Those things cost \$80, and we're lucky if we get them back. We've released four fish, and this is the first one recovered."

Fisheye view of hatchery life at Bonneville Dam on the Columbia River is revealed by a Fisheye lens. Here a swirl of four-inch-long coho fingerlings frames an aproned worker, spectators, and the photographer, top center, who trips the shutter by remote control. New fortified foods have resulted in hatchery stock of increasing vigor.

Later Bob and I watched Drs. Horrall and Stasko slip a duplicate cylinder— $7/8$ of an inch thick and $3\frac{1}{4}$ inches long—down a sockeye's gullet (page 208). The fish, released, remained inactive for an hour or so while we hunched over our receiving equipment in a skiff. Then, about noon, the steady note being picked up through the directional hydrophone in the water turned into a "wowing" sound.

"That happens when the fish swims," said Ross, springing to life. "Muscle movement varies the pressure against the transmitter, modifying the sound waves."

Aivars started the outboard motor and we began our pursuit. The transmitter in the salmon had a range of about a mile, and we followed the fish as it approached East Sound, which cuts Orcas Island nearly in two. The shore there curves north—as if pointing the shortest route to the salmon's Fraser River spawning ground. Yet it forms a cul-de-sac, and if the sockeye had entered, it would have had to turn around and come out again.

Without hesitation the salmon ignored the false promise of East Sound and headed for Peavine Pass, the route that would lead most directly toward the Fraser River. Bob and I left then, but Ross and Aivars trailed the fish for nine hours. They learned that it tended to take the direct route rather than follow shoreline indentations—another bit added to the knowledge of salmon migrations at sea.

Its Nose Knows Its Old Home

If the mechanism of ocean migration is still mysterious, scientists are on surer ground when it comes to explaining how the salmon gets from river mouth to spawning site. It follows its nose. As Dr. Hasler at the University of Wisconsin puts it: "The fish smells its way home from the coastline of the sea, tracking a familiar scent like a foxhound."

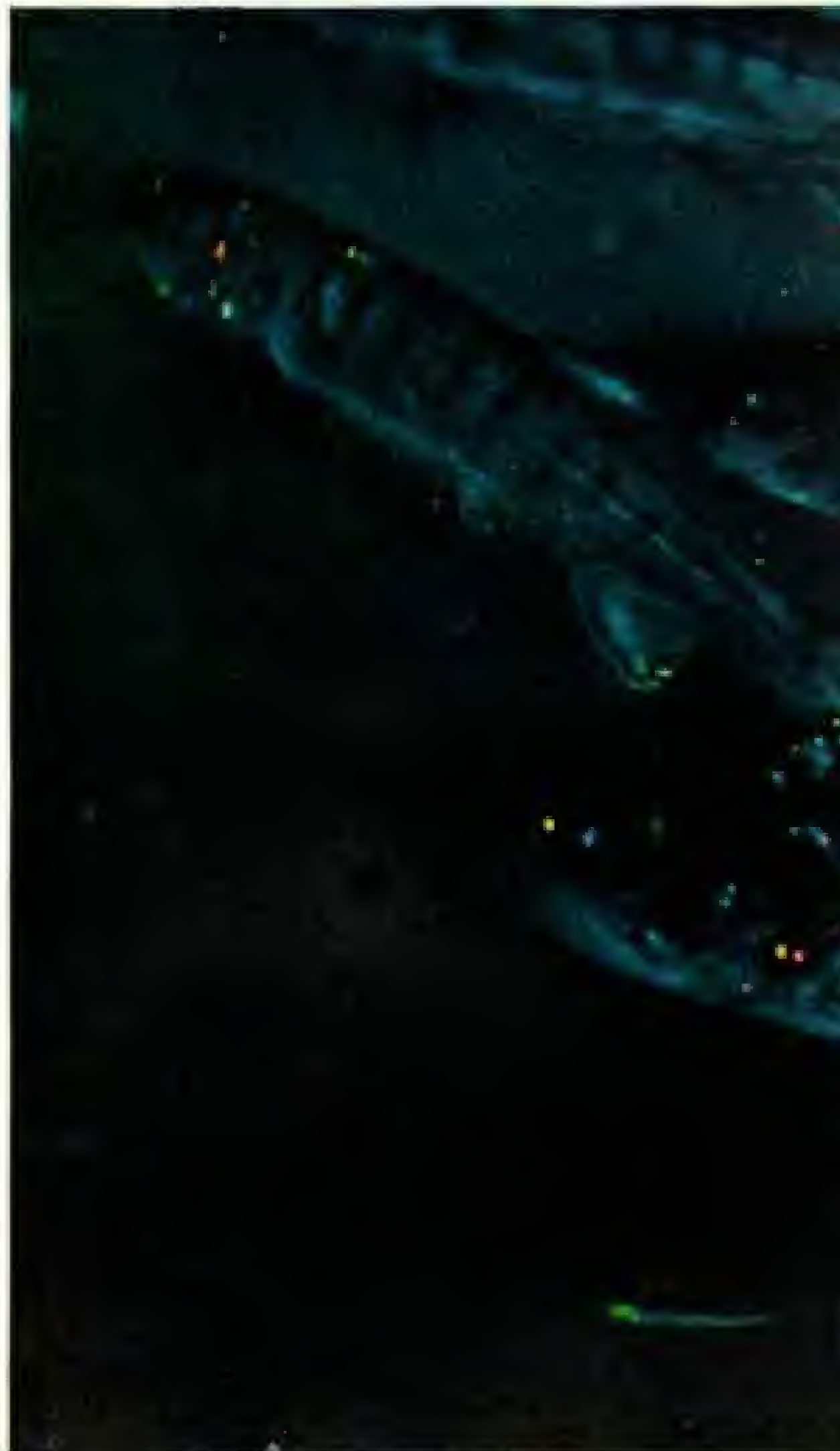
That scent may be produced by dissolved organic material from plants in the tributary and may vary from one tributary to another only in the slightest degree. Downstream it is rapidly reduced to extremely low concentrations. To detect such faint traces, a fish must have fantastic ability to pick up odors and to tell them apart.

The salmon has such a sense. It can perceive dilutions of one part in a billion. If a quart of water in which a human hand or the paw of a bear has been dipped for a minute is poured into a stream, it can cause migrating salmon to stop climbing a fish ladder a hundred yards away. Other fish have similar acuity. Laboratory experiments show that the



Head in a tagging hood, a pink salmon fry is wired for sound. A tiny stub of hair-thin wire slips through a hollow needle, right, into the insensitive cartilage of the head of a fry held in a biologist's fingers. The magnetized wire, which the fish wears for life, later triggers the "beep" of a sensing device checking fish at a cannery or as they swim upriver for spawning. Retrieved and examined, the color-coded wire tells when and where the fish began its travels.

Tattooed seafarers, coho sprayed with fluorescent pigment shimmer under ultraviolet light. Such spots, which last several months, help biologists trace paths of migration.



eel can detect alcohol in water in proportions equal to a teaspoonful in Lake Superior.

Dr. Hasler's theory suggests that salmon become "imprinted" with the particular complex smell of their home water during their residence as eggs, fry, or fingerlings. This experience, he believes, is powerful enough to cause the fish to "remember" the odor from one to seven years later when it is swimming upstream as an adult. Similar imprinting at the river's mouth, where fingerlings play for a time before going to sea, may provide a second remembered odor.

To test his theory, Dr. Hasler's team collected coho salmon that had climbed separate branches of Issaquah Creek near Seattle, Washington. The fish were taken downstream and released just below the creek's fork—some with their nostrils plugged by cotton soaked in petroleum jelly. Most of the fish with sense of smell unimpaired found their way back to the original collecting point. But the ones with nose plugs were unable to choose their own stream with certainty.

For some salmon, the trip upriver is short. Pinks and chums usually spawn close to the sea, sometimes right in the intertidal zone. Other species travel hundreds of miles inland; some chinooks battle upstream for months, journeying as far as 2,000 miles from the coast.

Salmon Shun Food on Homeward Trip

The inland migration is a herculean ordeal. The salmon arrive at the river mouth in prime condition, their flesh often tinged red from carotenoids of the shrimp-like crustaceans on which they have fed at sea, and oil-laden from a diet of herring and other fatty fishes.

But once headed upstream, they stop eating altogether. The jaws of the male begin to hook grotesquely, eventually he cannot close his mouth. The stomachs of both sexes shrivel. Through their long struggles against current and waterfall, the fish live on body-stored fat alone, becoming mere carriers for the sex products they will deposit before they die.

Commercial fishermen lie in wait for the returning salmon hordes. Gill-netters take





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Minnow-size transmitter adds an electronic voice to a sockeye's stomach. Returned to the water, the fish appeared to adjust to the device in about an hour. Then it swam off toward the Fraser River to spawn, all the while signaling its location to listening scientists following by boat.

Sound of the salmon: Dr. Ross M. Horrall, University of Wisconsin zoologist, turns a directional hydrophone mounted under the boat and homes in on the sockeye's signal. Canvas-covered receiver in front of the author, Dr. Clarence P. Idyll, right, picked up a fluctuating sound as the fish began to swim. With the sextant, Dr. Aivars B. Stasko, a Canadian zoologist, helped map the sockeye's homeward run through the San Juan Islands. Instead of following the irregular coast, the fish chose a more direct route. Scientists theorize that fish navigate at sea by a combination of senses, including taking bearings from the sun and reading the weak electrical voltages generated by ocean currents.





them in murky waters where the entangling meshes can't be seen. Purse-seiners encircle them in clear waters with a fence-like net that draws together at the bottom, sometimes trapping in a single haul tons of fish worth thousands of dollars. Trolling, a scattering of traps, and the ancient Indian gear called a reef net reap additional harvests.

Roughly a billion pounds of Pacific salmon a year are now taken by commercial fishermen. Japan lands the most, followed by the United States, the U.S.S.R., and Canada. The biggest catch is of pinks, then chums, sockeyes, cohos, chinooks, and masus. Atlantic salmon landings are much smaller—24 million pounds on a yearly average. Canada and Denmark (including Greenland) lead this production, with European countries as far south as Spain adding small amounts.

Commercial salmon fishing is a tough and dangerous trade. I was reminded of this when I went with biologists George Harry and Theodore Merrell of the Bureau of Commercial Fisheries to visit Alaskan communities whose economies depend on the salmon.

Our plane landed on the pewter surface of Bucareli Bay, and we took shelter from the light rain in a small cafe in the village of Craig. The voice at the next table was grim.

"Just disappeared in the fog, he did. Walked forward to the galley for a cup of coffee, and we never saw him again. Coast Guard's look-

in', but like as not they'll never find him."

The tragedy had shaken the village.

"More than a dozen salmon fishermen are lost overboard nearly every year in Alaska," Ted said. "Those that survive earn their pay in cold, wet, hard work."

Fisheries' Yield Slowly Dwindles

Not as many salmon are caught now as in the past. A combination of factors—overfishing, dams, and destruction of spawning grounds—has reduced the yield taken by United States and Canadian fishermen along the Pacific coast from a peak of more than 900,000,000 pounds in 1936 to last year's 335,000,000, a record low. Alaska now produces about five times as much salmon as all the other U. S. Pacific States combined, but its recent yearly totals have averaged only about 60 percent of the catches for the peak 1930's.

The history of the Atlantic salmon is melancholy, too. In North America the species once ranged from the Hudson River north and east. Its flesh was a staple food—so plentiful that some indentured servants in the 1700's demanded contracts specifying that they would not be forced to eat salmon more than three times a week. Yet today no commercial salmon fishing exists in the entire eastern United States, and few rivers outside Canada can claim more than a meager population. Many streams in Europe where

Like the rings of a tree trunk, markings on a salmon scale—removed by forceps (upper) and projected onto a screen—record the story of an Alaskan sockeye's life. Fisheries biologist Dr. Charles DiCostanzo deciphers age by locating areas where the rings, which form at the rate of several a year, crowd together, reflecting the slow growth of winter months: here he points to the fifth winter of a fish that has lived six years. When the fish swam to sea, rings became heavier and coarser than those developed in fresh water. By tabulating the ages of returning salmon, biologists can calculate how many fish from a particular year's spawning reach their headwaters to breed. The red disk pinned through the shingled scales (right) is a device to help track migrating salmon.



salmon once were plentiful now are completely empty of them.

As avidly as the salmon is fished for profit, it is even more passionately pursued by the sportsman. The wealthy pay \$1,000 and more for a week's exclusive fishing rights to a handful of pools on such famed Atlantic salmon rivers as Scotland's Tay, England's Wye, Nova Scotia's Margaree, New Brunswick's Miramichi and Restigouche, and Newfoundland's Humber.

By contrast, during salmon derbies in the Pacific Northwest, thousands of people crowd the water in pursuit of chinook and coho. For the anglers who catch the biggest fish there are prizes ranging from lapel buttons to automobiles. On my way to Vancouver Island by ferry last summer, I passed through one of these tournament rites—marked by a horde of boats containing an estimated 11,400 people.

Do Chinook Leap to Banish "Lice"?

Anglers catch hundreds of thousands of salmon every year—and have a glorious time doing it. To be touched with that glory, I set out from Comox, British Columbia, before dawn one cool August morning in search of the wily tyee—a chinook of heroic size. With my brother-in-law Eric Haffenden as my companion, I headed for the Campbell River, where a combination of good fishing during spawning runs and good promotion has made the Tyee Club renowned.

The slight shivering I experienced as we rowed against the diminishing tide was only partly the consequence of the chilly air. The main cause was excitement. Chinooks are the giants of the salmon species, averaging 20 pounds; a tyee is, by definition, a chinook of 30 pounds or more. The Tyee Club consists of the fortunates who have landed these monsters, and Eric and I aspired to membership.

We watched the tips of our trolling rods to make sure they maintained the peculiar little dance that indicated proper performance of the lure. Salmon strike at flies, spoons, spinners, and live herring bait. Every angler has a favorite lure he loyally sticks to—for half an hour of unsuccessful fishing, that is.



Then he makes a change. And then another.

In the dissolving darkness we could see salmon leaping against the morning sky, and Eric asked an age-old question: "Why do salmon jump?"

"To shake the lice," said Dick Knowles, our guide.

I doubt that this is so, but I cannot offer a better reason. The "lice" of salmon are parasitic copepods—distant cousins of the shrimp and lobster—which cling to gills and other parts of the fish. Many fishermen believe the parasites so annoy the salmon that it tries to shake them by leaping.

Another question from Eric: "If salmon have stopped feeding by the time they get this far on their spawning migration, why do they strike at lures or bait?"

"I've heard a lot of answers to that," said Dick. "but I really don't know. Maybe it's just general annoyance at something in their path,

or perhaps they never lose the habit of striking at small fish."

I could contribute no better explanation, nor do I think any scientist can at present.

Thrill of Victory—but No Bottom

Though the sun was high by now, neither Eric nor I had had a strike. Dick spoke up: "When the fish start to hit, they often hit everywhere for about ten minutes. Of course, it's not the same ten minutes every day."

Suddenly my own "ten minutes" arrived. There was a jerk on my rod, and it bent alarmingly. The reel began to sing. I was tied to a big salmon! For 15 minutes I played the fish inexpertly but adequately. It broke the surface enough to excite me feverishly; I could see it was bigger than any fish I had ever caught. Eventually it tired and was brought alongside, to be lifted into the boat with a dip net.

"I'm afraid it may be a disappointing 29

CATCHING (BELOW) AND HOLDING © NATIONAL GEOGRAPHIC SOCIETY







pounds," said Dick. He was high; my fish weighed an even 25, so I missed the Tyee Club button.

To me the fish looked huge, so it seemed incredible that only the week before a tyee three times as large—77 pounds—had been caught in the same waters. The biggest chinook ever taken on sport tackle was a giant of 92 pounds hooked in the Skeena River of British Columbia. And a monster of 126½ pounds turned up in a trap near Petersburg, Alaska. I saw it there, mounted in a store window.

Few other species of fish are as important to both sportsmen and commercial fishermen as the salmon. Yet man has pummeled it with heavy blows: over-fishing, dams, and pollution.

Last summer I went in a small boat up the Willamette River from Portland to Oregon City, Oregon.

(Continued on page 216)

One that got away. A big sockeye, still wearing the silvery blue-green of sea life, ignores a young fisherman's fly to leap falls near the mouth of the Brooks River. Fish caught at the beginning of their spawning run taste best; with breeding changes, the flesh becomes almost tasteless.

One that didn't. Black bear wins a meal as a chum salmon loses the fight to reach its Olsen Creek spawning ground in southern Alaska. Photographer Sisson reports that apparently a few bears were purposely fishing for succulent egg-filled females—and having near-perfect success.



Life portraits of a famous family: Pacific salmon

Paintings by National Geographic Artist WALTER A. WEBER



Oncorhynchus nerka

Sockeye salmon, left, in flamboyant spawning attire migrate up Alaska's rivers under the name of red salmon. Perhaps 30,000,000 fight their way upstream in two spawning areas alone: the Fraser River system in British Columbia and the Bristol Bay watershed in Alaska. After a year or two in fresh water, young sockeye migrate to the ocean. They make two or three annual circuits of the North Pacific before returning inland to spawn. In the Pacific Northwest, fishermen at the mouth of the Columbia River know sockeye as bluebacks, so called because of their sea colors. Averaging five to seven pounds, sockeye produce deep-red meat that brings a premium price.

Coho, or silver salmon, right, average 6 to 12 pounds. Their readiness to take artificial lures has long delighted sports fishermen from northern California to Alaska. Even commercial fishermen land half their annual catch by trolling with spoon and herring bait. Last year sportsmen caught nearly a third of a million scrappy coho off the mouth of the Columbia River alone. Females like this one may dig their redds anywhere from just above the intertidal zone to several hundred miles inland, spawning at the age of three or four years. Coho glisten with a slightly spotted blue back, turning reddish during the spawning run.

Next to chinook, coho are the least abundant of all Pacific coast salmon. But the coho population may greatly increase if a dramatic 1966 project in the Great Lakes area continues its initial success. Fingerlings from west coast hatcheries were planted in Michigan rivers. They migrated to Lake Michigan, but did not try to swim to the salt-water Atlantic through the St. Lawrence Seaway. Instead, the landlocked coho spent 17 months in the lake, ravenously feeding on alewives. When they returned to their rivers to spawn, they averaged a whopping 12 pounds.

This promising addition to the lake's traditional but depleted supply of game fish has infected midwestern fishermen with what sportswriters call "coho madness." The species' impressive start in Lake Michigan has prompted plans to introduce it into other of the Great Lakes. Hatchery operators in Oregon and Washington also claim success in increasing west coast coho runs through the development of a drug-fortified food pellet.



Oncorhynchus kisutch © W.A.

Humpback, or pink salmon, right, undergo one of the most striking changes of all salmon before breeding, when a bulge of cartilage forms behind the male's head. Unlike other salmon, humpies always return to spawn at the same age—their second year. In Washington and southern British Columbia, pink salmon runs occur in the odd years. So far, attempts encouraged by commercial fishermen to establish runs in even years have failed.

Pinks often spawn in late summer, usually not far upstream. The short-lived pinks grow fastest of all salmon and average three to five pounds at maturity. They sometimes take flies and other fishing lures, but lack the fight of game fish.

Named for their paler meat, pinks are a bonanza for commercial fishermen in both North America and Asia. The number of pinks caught each year exceeds that of any other salmon.



Oncorhynchus gorbuscha



Oncorhynchus keta

Chum salmon, left, especially the males, spawn in a motley of reds and dusky purples, with distinct vertical bars, winning them the nickname of calico salmon. Another name, dog salmon, may stem from early belief that the meat was good only for dogs. Commercially, chum salmon makes the poorest canned product.

Chum frequently spawn in intertidal zones. Fingerlings swim directly to the estuary, where they may feed for some time before continuing into the open ocean. Mature at about four years, chum average 13 pounds. Some of them spawn in midwinter, later in the year than other salmon.

Chinook, or king salmon, shown in spawning red and steely sea colors at right, win a royal salute for flavor, fighting spirit, and size. Lewis and Clark staved off starvation by eating upriver chinook as their party trekked toward the Pacific 160 years ago. When they found salmon in streams draining to the west, the explorers were convinced they had crossed the Continental Divide.

Many Canadians know chinook as spring salmon, for their early spawning runs in some rivers. A female produces about 5,000 eggs. The young linger from a week to a year in fresh water, then swim to sea for three or four years of voracious eating and rapid growth. Mature fish average about 20 pounds.

To sportsmen, the giant chinook caught off Vancouver Island are tyees. The largest chinook ever taken on rod and reel weighed 92 pounds. The biggest on record, trapped in Alaska, 126½ pounds. Pacific coast sport fishermen catch approximately half a million yearly.



Oncorhynchus tshawytscha © W. S. S.



Salmo salar © 1983

Atlantic salmon receives hearty praise as the "greatest game fish in the world" from its fans along coasts of both Europe and North America. Despite dams and river pollution, Atlantic salmon still breed in streams in Maine, Canada, Greenland, and Iceland, and from northern Russia to Portugal. But they long ago disappeared from the waters surging by Manhattan Island, where Henry Hudson found them "in great store" in 1609.

Believed to be the ancestral stock of the Pacific species, Atlantic salmon mate at three or four years, but do not always die thereafter, as do their cousins. They change from a deep steely blue (left) to a bronze-purple or greenish color during the spawning run. Eight to 10 percent of the females spawn a second year, and a few survive to make four-round trips. Adults average about 15 pounds, but record catches include an 83-pounder taken in Norway and an 84 $\frac{1}{4}$ -pound prize in Ireland.

(Continued from page 213)

The water was a thin soup of suspended wood fibers. Ugly masses of sludge floated on the surface, and gushers of purple, bright red, and yellow waste poured from paper mills on the banks.

"This pollution sometimes reduces the oxygen content of the water to two milligrams per liter," Bob Rulifson of the Federal Water Pollution Control Administration told me. "That's equivalent to what a man would experience at 19,000 feet without an oxygen mask."

Dams Offer a Perilous Choice

Dams wreak further havoc on the salmon's habitat. In New England, dams built during the 1800's to power new factories blocked Atlantic salmon migrations and figured decisively in the fish's precipitous decline. Dams in the Pacific Northwest have also done great damage.

Man-made fish ladders, usually a series of stairstepping pools, help adult salmon bypass dams. But the young going downstream have difficulty finding the high-level entrances, and they face two unpleasant choices: a plunge over spillways that can make matchsticks out of driftwood, or a dive into hydroelectric turbines where, according to a recent study, one out of every ten fish is killed.

Dams inundate the spawning grounds, too. About 70 percent of the nesting and nursery areas for spring runs of chinook on the Columbia River disappeared when gigantic Grand Coulee Dam was built. Ten other dams on the main stream, and several on the Snake River, have greatly damaged this waterway, once the main producer of chinook salmon.

The activities of foreign boats, added to heavy fishing by our own citizens, make salmon conservation more difficult. Just the phrase "Japanese high-seas fishing" produces angry reaction in fishermen's groups in Alaska, while the mention of salmon netting by Danish boats in Greenland coastal waters stirs ire among the fishermen in villages of Canada's Maritime Provinces. I got strong comment on the subject from

a grizzled seiner captain at an Alaskan dock.

"Dern foreign boats," he said vehemently. "They take *our* fish—they were hatched in our rivers, weren't they? And they don't pay no attention to what we're trying to do to make sure enough fish get upstream to spawn future catches. Many salmon that die in their gill nets drop off, just wasted. They net far out in the ocean before the fish've grown as big as they could. Dern foreign fishermen!"

Atlantic salmon taken in Greenland waters come from streams in countries on both sides of the North Atlantic. Greenland catches have leaped a hundredfold within the past decade, to the distress of Canadian, American, and European fishermen.

Both the Japanese and Greenland fisheries are perfectly legal—yet, as the seiner captain pointed out, they are wasteful and pose major conservation problems.

Research: Key to Salmon's Future

Faced with grim facts about slipping salmon numbers, man has attempted to stem the decline. Hatcheries first were thought to be the answer, since the greatest mortality occurs in the earliest stages of life. But while artificial culture of fertilized eggs is easy, results from stocking streams with fingerlings have been disappointing. Salmon raised in hatchery trays and ponds seemed less able to fend for themselves than those spawned in the wild.

Now such new hatchery techniques as better diets for young fish show promise. Fishery scientists say hatchery culture may be working well for chinook and coho.

More Columbia River coho are being caught than ever before—new records each year for the past six. Dick Pressey, biologist in charge of hatchery operations on the Columbia for the Bureau of Commercial Fisheries, put it this way:

"Columbia River sport fishing is fabulous. In 1961 the coho catch off the mouth of the river was less than 100,000. Last year fishermen landed more than 300,000. Marked fish from hatcheries were well represented in the catch, and so we think hatcheries are responsible to a large degree."

Only time will permit a final assessment. And time, too, will permit an appraisal of an interesting newer tool in fish culture. This is the spawning channel—a specially constructed area of stream bed, carpeted with the best kinds of gravel and washed with controlled amounts of clean water. Such channels are now in vogue for producing larger runs of sockeye, pink, and chum.



SPAWNING BY ROBERT T. SISSON (E) S.A.S.

Hooked beauty, an Atlantic salmon stretches a fly line in Newfoundland's Humber River; photographer Sisson obtained this shot with a waterproof camera submerged on a pole. Although no longer feeding, spawning salmon rise to lures, perhaps out of habit. Avid anglers pay \$1,000 and more for a week's fishing rights in some of Europe's and North America's salmon rivers.

"The enthusiasm for spawning channels seems to have replaced some of the old passion for hatcheries," Dr. Ferris Neave, a noted salmon biologist, told me at his laboratory in Nanaimo, Vancouver Island. "There is no question that they can produce—up to downstream migrant size—a far higher percentage of salmon than natural conditions can. But these installations are new, and it will take years to evaluate their full effect on adult runs."

Biologists are convinced that long-term cycles in ocean conditions—notably temperature—also affect salmon abundance for good





MONOCHROME LABORATORY AND RETOUCHING © N.A.S.

Following their noses, pink salmon sniff out the unique scent of home. To demonstrate this ability, Alaska fisheries men netted salmon on spawning grounds, carried them a mile downstream along Olsen Creek, then released them in the water with balloons tied to them. Here the salmon head back upstream, making the correct turns—those with red balloons swim up the right fork, yellow balloons to the left. Fish with nostrils plugged, unable to recognize their native creeks, often took the wrong turn.

Battered and dying; a male chum salmon ignores John Helle in Olsen Creek. The biologist finds wetsuit and mask ideal for studying the last sad chapter of the salmon's odyssey.

or evil. Such variations may lie beyond the control of man. But other factors are within his power to influence. The basic tenet of modern salmon conservation is that the salmon population of each stream must be treated as a separate unit, and for each a sufficient number of adults must be allowed to escape the fishery and spawn in a clean, undamaged environment. Where this has been done, gratifying surges of fish have appeared—in numbers sometimes exceeding record runs of the past.

There is little danger that salmon will become extinct. One of the great lessons of salmon conservation is that the fish have a tremendous capacity to increase in number, if given the chance. But unless we use more wisdom than in the past, and learn to control such adverse pressures as pollution, dams, and overfishing, there is no doubt that more and more streams will lose their runs of a handsome and delicious fish—one of mankind's major natural resources.

THE END

The Age of



Sail Lives On at Mystic

By ALAN VILLIERS

Photographs by WESTON KEMP

Aloft in the square-rigger *Joseph Conrad*, youngsters relive the rugged days of old.

RECAPTURED BY NATIONAL GEOGRAPHIC SOCIETY 221





FROM THE FRONT VIEW

Heeling to a Pacific breeze, the *Joseph Conrad* heaves out of Sydney, Australia, in 1935, when the author—then the owner—sailed her around the world. Built in 1882 to train Danish seamen, the *Conrad* passed into private hands before becoming a U.S. school ship in World War II. In 1947 an act of Congress transferred her to the Marine Historical Association, which created Mystic Seaport, Connecticut, as a last port of call for America's sailing past.

century New England. Along its cobbled streets they have set buildings that would have been typical of such a town: a tavern, a small church, sturdy homes, a lighthouse, a sail loft, rigging loft, shipsmith's shop, and—not typical but well-suited—a research library of maritime history (painting, pages 226-7).

But mainly they have assembled an astonishing fleet of unique old vessels. On the grass, silent and stalwart at their last berths, stand shallow-hulled skimming dishes which once set enormous spreads of sail; deep-hulled old-timers with the capacious, sea-kindly hulls of another age, bluff and solid; log canoes, kayaks, out-

riggers brought from the South Sea islands.

Afloat are more. On my last visit, I recognized a Chesapeake Bay bug-eye, rakish and low; a Danish galeas; a Grand Banks dory fisherman formerly out of Gloucester. Picking a swift way through a fleet of sailing dinghies came a beautiful schooner yacht, the *Brilliant*. I remembered her wonderful run of 15 days, 23 hours from Block Island across the North Atlantic to Bishop Rock in the Scilly Islands. Later she was owned by California sportsman Briggs S. Cunningham. He gave her to Mystic, and now, as she slipped effortlessly along, she carried a crew of youngsters chattering happily in the sunshine.

Fair Mariners Climb *Conrad's* Rigging

All this I hoisted in with a quick glance, but my eyes kept returning to the *Conrad*, where years before I had stood many a watch in Cape Horn gale and Pacific calm. Though her seagoing days were over, she still looked the

I RUBBED MY EYES and looked again. There was something very familiar about those tall masts with their graceful spars. There was no mistake about it. They were the masts of full-rigged ships, reaching for the sky beyond the houses by the old Boston Post Road where it passes through Mystic, Connecticut.

I had sailed one of those full-riggers around the world. There she was, the stout and shape-ly old school ship *Joseph Conrad*. I quickened my pace down the short lane to the waterfront. Massive anchors stood on cable-encircled lawns. Old guns, long retired from the sea, reared their elderly muzzles toward the New England sky, as if still ready to belch smoke, fire, and cannon balls if needed.

That was the first time I saw Mystic Seaport. I have been there many times since, and watched its steady growth. Here history-minded citizens have re-created, with charm and careful accuracy, a seaport town of 19th-

Seafarer for half a century, Captain Villiers stands a familiar watch—at the helm of the *Joseph Conrad* in her Mystic berth. The Australia-born mariner and writer has rounded the Horn in square-rigged grain ships and sailed in Arab dhows; in 1957 he relived the Pilgrims' crossing in *Mayflower II*. His salt-sprayed adventures have engrossed a generation of NATIONAL GEOGRAPHIC readers and enliven the pages of the Society's book *Men, Ships, and the Sea*.

handsome, faithful little ship she had always been to me.*

I heard shouting—an odd falsetto note. Youthful figures tumbled up the *Conrad's* companionway. Girls! Teen-age young women in blue uniforms, dozens of them. The prettiest, slightly older than the rest, was obviously an officer.

I gave her "Good morning," disguising—I hoped—my surprise at seeing her there. She was the mate, she told me, Mate Beverley Hallman, originally from Arkansas. She first came to Mystic for a training course when she was 16. Now a Vassar graduate, she'd accepted an appointment as an instructor, and she loved it.

"That first experience included a four-day cruise on the *Brilliant* with nine other girls," she said. "During that blustery September weekend, the schooner showed her record-breaking speed on a sail to Block Island. We were no sissies as we scraped knuckles furling sail and working lines. I returned with 'Mystic fever,' not easy to cure. I can't help but keep coming back."

Mate Beverley told me that she gave lectures, helped the girls learn the ropes, led them in singing sea chanteys, and taught dinghy sailing. She talked to them about the maritime greatness of the United States and the meaning of the New England sea traditions.

"It's all part of our heritage," she explained. "So much of what is finest in America dates from the days of sailing ships. That's why we have these courses: to teach interested teenagers real, living history with real ships. The *Conrad* is an ideal background for absorbing information about ships and the sea. The kids



FORNACRE/PHOTO BY NATIONAL GEOGRAPHIC PHOTOGRAPHER JIMMY BRETT © N.G.S.

sail in our fleet of dinghies and in the *Brilliant*. We have courses in spring, summer, and fall. Boys come, too, but we get more girls."

Marion Dickerman, for many years Education Director at Mystic, confirmed this. She told me that in an ordinary year some 100 boys attend the courses, and more than 500 girls.

Daring Voyage Leads to America

The Danish galeas *Gundel*, like other ships at Mystic, has a colorful history. In 1948 the apple-bowed little ketch, though only a 65-foot coastal vessel, battled the Atlantic to bring 29 Latvian refugees to the United States from their temporary home in Sweden.

"It's not only the ships, but the whole atmosphere here that I find so absorbing," said Beverley. "These are real ships, not monuments. I'm only sorry that some of them can no longer go to sea."

*Alan Villiers described his adventures sailing the *Joseph Conrad* in the February, 1957, GEOGRAPHIC.



Looking at the *Conrad's* 86-year-old hull, with its gold-scrolled black bows poised before the re-created port, I wondered what Mate Beverley would have thought if she'd been aboard in 1934, when I saved the *Conrad* from a Copenhagen scrap dealer and sailed her to New York. I had a few seasoned hands and a boy crew. It was winter, and a wild Atlantic storm soon put her to the test.

In the middle of a black and blowing night, the gale suddenly whipped around on me. The *Conrad* began to slip backward, gathering sternway as her few set sails were forced against her masts.

I can see the old ship now, pausing, trying to catch her breath: I square the main and mizzen yards. I put the helm amidships (so the sea will not knock her rudder off). At the order, boys rush to brail in the spanker, which is making her unmanageable.

The situation wasn't unique, of course. It was called "being caught aback." But you had to do the right thing—everybody had to do the right thing—at once, or else.

Agonizingly the *Conrad* slowed her sternward rush. She stopped, the sails on the foremast swinging her head

Window-shopping for history, visitors stroll along cobbled Seaport Street, whose venerable shops face the Mystic River. As a setting for its vessel-lined wharves, the Marine Historical Association scoured the east coast for old maritime buildings and moved them to the Seaport, creating an authentic coastal village of a century ago. Horse-drawn wagon holds barrels for ship's provisions.

Quart of cure delights a half-pint patient. Francis Kahl tends the Bringhurst Apothecary and Doctor's Office on Village Street. The shop's inventory, acquired in part from a 19th-century Delaware pharmacy, includes leech jars, bleeder knives, and a turnkey for extracting teeth.



Retrieved from [http://www.18th-century.com](#)

Magnet for children despite efforts to keep them away, an immense anchor dominates a Seaport green. Lost off Long Island, New York, during the Revolution, the mass of iron and wood belonged to a British man-of-war.



Mystic Seaport

FOR CENTURIES the men of Mystic built ships—schooners, whalers, clippers—and sailed them to earth's far corners. Then steam overtook the windships, and one by one they died. Alarmed, three citizens formed the Marine Historical Association in 1929, and out of it grew the living maritime museum called Mystic Seaport. To its site came gifts of small craft and schooners, anchors and heirlooms. Today more than 400,000 persons a year come to rediscover a glorious era.



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Mutiny in the fo'c'sle! In a gleeful melee, girls wage a towel fight in quarters where student sailors bunked during the *Joseph Conrad's* days at sea. Living aboard the permanently moored square-rigger, these girls participate in the Seaport's-Mariner Training Program, which familiarizes some 600 young people a year with America's maritime heritage. Lining the rail (right), deckhands greet callers in a dinghy beneath the ship's figurehead, a likeness of seaman-author Joseph Conrad.



around to bring the wind behind the canvas on the main and mizzen. I held my breath and looked aloft. The mizzen tops'l was beginning to fill. A few seconds more and the sail bellied out. I tried the helm. She steered! She was safe. Good little ship, not bound for the depths this time.

Remembering the wind's roar and the spray on my face, I was grateful that the *Conrad* is being preserved at Mystic. I hope she may last at least another hundred years.

"We've had young people coming to the *Conrad* at Mystic since 1949," said Miss Dickerman. "We've had groups from 15 states and Canada in the past two years. They can master

the rudiments of piloting, learn practical seamanship, sail small boats, and get to know something about the weather.

"During the summer the Seaport runs a course in American maritime history at university level, too. The six-week graduate course, under the direction of Dr. Robert G. Albion, now Gardiner Professor Emeritus of Oceanic History at Harvard, has been going since 1955. The University of Connecticut grants credit for it."

Mystic Seaport abounds in such courses and institutions, just as it does in ships.

Some of these "institutions" are human, notably the late Carl C. Cutler, famed sailing-



PHOTOGRAPHS © NATIONAL GEOGRAPHIC SOCIETY

ship historian and seaman, ex-lawyer, dyed-in-the-wool New Englander. His forebears lived in Hingham, Massachusetts, in the 1600's. Carl himself sailed before the mast to the *Antipodes* in the bark *Alice* and wandered the Tasman Sea and New Zealand coast in schooners before returning to study law at Columbia University.

Priceless Bits of History Vanish

I was lucky enough to have known Carl Cutler for years before he died, early in 1966. He was the man most responsible for the vision of Mystic Seaport, and I heard its story from him at firsthand.

"Back in the late 1920's," he said, "I found children playing with builders' models of famous American ships, the actual hand-carved half-hulls that were used for working out the lines of full-size ships. Adults were cutting them up for firewood. Even customs officials were throwing out priceless American shipping records.

"I thought this destruction was a pity. There seemed to be no convenient place where old families could preserve their treasures. So I got together with Kirt Stillman and Ed Bradley"—Dr. Charles Kirtland Stillman and Edward E. Bradley, leading citizens—"and we decided to do something about it.



Wooden widows of ships long lost flank Willard Shepard at the Ship Carver's Shop on Village Street. He chisels a spread-winged eagle like those that adorned the transoms of many a sailing ship.



REPRODUCTION BY WALTER SCOTT © 1934

The robed "Lost Lady," above, her seagoing past a mystery, came from a London antique shop. Seaport figureheads include Greek gods, Scottish Highlanders, and St. George in wooden armor.



"Kirt was a descendant of one of Mystic's greatest shipbuilding families. Ed was a prominent industrialist, a man of ability and vision who had been at sea in sailing ships himself. They knew what I was talking about.

"So on Christmas Day, 1929, we set up the Marine Historical Association. With that small local body, we started our living museum. The idea caught on."

Morgan Brings Mystic's Big Break

Dr. Stillman and Mr. Bradley died before much could actually be achieved. But with Carl Cutler and members of the Mallory family, Mystic shipbuilders and shipowners, they laid the foundations for Mystic Seaport, and laid them well. Still, if it had remained nothing but a restored waterside building or two, a repository for old documents and relics, the museum would hardly have achieved world-wide notice.

Its great moment came with the chance to acquire the *Charles W. Morgan*, a real Yankee whaler and one of the best. She was a veteran of 37 successful voyages between 1841 and 1921, ranging across the whole Pacific, Atlantic, and Indian Oceans and the Arctic as well, an "Old Ironsides" of America's world-wandering whaling fleets. But in 1941 she lay damaged, neglected, and beginning to rot at South Dartmouth, outside her home port of New Bedford, Massachusetts.

The hurricane of 1938 had damaged the *Morgan*, stout ship though she was. Appeals for restoration funds brought little response. New Bedford already had the model of the whale ship *Lagoda*—the world's largest model ship—in a hurricane-proof building. So the *Morgan* was offered to Mystic, as she lay.

Carl Cutler went to New Bedford. To inexperienced eyes, the *Morgan* appeared hopeless. Embedded in sand, her stern cocked high in the air by the gale, she looked a shambles, with broken yards lying just as they had fallen, her decks rotten and full of holes. But a seaman could see that she was still salvable. There was no fundamental structural damage to the hull.

"Rigging and decks can be renewed," said Carl, "a whole ship cannot. We'd have to

straighten her, move the fallen spars, and fix her decks before we could touch her. What would it cost? Nobody knew. We had to tow her to Mystic, too. We were struggling along without funds. 'Forget it,' said many. 'Wait and see.' We were on the brink of World War II. 'It's the wrong time.' But it's always the wrong time to do anything bold, I thought. We *must* save that ship."

And they did. The president of the association at the time was another enterprising New Englander, Philip R. Mallory. His great-grandfather, Charles Mallory, had come to Mystic in 1816 as a young sailmaker from nearby New London. He stayed to build ships, own ships, and manage a great shipping line.

"Go ahead," said Philip Mallory, very quietly.

So Curator Cutler got bids to tow the *Morgan* down. The lowest was \$7,500. The association did not have as much as \$750.

"I'll stick my neck out," said Philip Mallory. "I'll put up the \$7,500."

From the day the old whale ship arrived, Mystic never looked back. A fund-raising campaign in New Bedford brought \$8,000 for new spars and rigging; Carl Cutler did much of the *Morgan's* re-rigging himself, aided by a group of volunteer high-school boys.

Even "Kind Neptune" Lent a Hand

Slowly those lofty spars rose until they stood high above the Boston Post Road. The long years of World War II came at last to an end. People noticed the *Morgan*. Strangers, instead of driving past, saw her shapely black bows and her graceful masts beckoning from behind the houses of Mystic, and they came in. Indeed, it was difficult not to.

"She looks beautifully on the water," wrote Charles Morgan, her owner, when she was launched 127 years ago. And she still does, though she's no longer in the water, but safe beside it in a dry berth (opposite).

It seems incredible that this wooden ship, only 105.5 feet long, 27.7 feet wide, and 17.6 feet deep, had ever made the long voyages that she did. Imagine, 37 voyages under 30 different captains, around and around the world over a span of 80 years!

Flagship of Mystic Seaport's growing fleet, the whaler *Charles W. Morgan* wears sails and bunting for the Fourth of July. Built in 1841, she sailed for eight decades and in every ocean, on voyages that sometimes spanned four years; her false gunports frightened off South Pacific cannibals. When the association acquired her in 1941, the gallant ship lay rotting and neglected. Today, proudly restored, she forms the focus of Seaport exhibits.

"May kind Neptune protect us with pleasant gales and may we be successful in catching Sperm Whales," read the log of the *Morgan* on September 6, 1841, and things seemed to have worked out just that way.

Her first voyage, lasting three years and four months, took her around the Horn to the whaling grounds of the Pacific Ocean. Her crew did battle with whales wherever they saw them—off in those puny rowboats on their fabulous "Nantucket sleigh rides," foaming over the deep behind some frantic sperm to fight it out by hand.

The old *Morgan* was whaling at sea until 1921. She is the last known wooden whaler in the world. No barnacled Moby Dick now blows for her; the Mystic River is quiet, and not for whales. But those dead days come starkly alive for visitors as they view the harpoons and flensing knives, the tryworks—with its brick hearth and iron boiling pots—

for rendering the oil, and the wooden gaming chair in which the captain's wife could be hoisted over the side into a whaleboat to gossip, or gam, with another wife when ships crossed wakes.

Mystic Becomes a Maritime Magnet

Soon after the *Morgan* appeared at Mystic, visitors began taking an interest in the growth of the museum, and eventually the admission fees helped. Some visitors, approving what they saw, made gifts or joined the Historical Association, whose membership now exceeds 12,000. Local stalwarts like Mrs. Mary Greenman Davis and the late Mrs. Mary Stillman Harkness—descendants of old Mystic families—gave buildings, land, money, relics. People streamed to little Mystic, first in the summers, then in spring and fall as well, and soon all the year around.

Other old ships and small craft were given





LEFT: HENRIE LEBOEUF AND HODGKINS OF WESTON CORP. © W.L.L.

Sinews of a sailing ship; manila yarns feed from bobbins into a collector plate at the ropewalk. In a shed stretching 250 feet behind Seaport Curator Edmund Lynch, left, and Assistant Registrar Philip Budlong, machines once twisted strands for rigging.



Beside his leaping flame, shipsmith Herbert Norton shapes a harpoon. The smithy, built in the whaling port of New Bedford, Massachusetts, in 1846, made fittings for the *Morgan* a century ago. Today the great hearth heats much of the ironware used in restoring Seaport ships and shops.

or willed. Still others were discovered in odd inlets and creeks, brought to Mystic, and restored. Congress, by a special act, gave the *Joseph Conrad*. I had sold her in 1936 to Huntington Hartford, and he had given her to the U. S. Government for use by the Maritime Commission as a school ship during World War II.

The New England fishing schooners—the famous two-masted Grand Bankers of Kipling's *Captains Courageous*—had almost vanished before Mystic Seaport was thought of. A few old-timers survived as humble freighters off Newfoundland or in the West Indies. Reduced in rig and heavily engined, they were almost unrecognizable.

The *L. A. Duntton*—once a swift Gloucesterman—was found at Grand Bank, Newfoundland. "Progress" had caught up with her. Her topmasts had been lopped off, her 75-foot main boom cut down, an engine thrust into her after-quarters, and her fish room made into a cargo hold. She did well as a freighter, but in time she was too small even for that. Too small—and too old.

In October, 1963, an association trustee bought her for Mystic, and she was restored to original condition.





REPRODUCED ABOVE AND SUBSEQUENT © T.H.A.

Sailors a century apart meet in the Stillman Building, once a Mystic River textile mill and now the Seaport's main museum. Nearest figurehead, representing Civil War Adm. David G. Farragut, once graced the bow of the clipper ship *Great Admiral*. With its ships' carvings, the museum displays a rich collection of other relics and curios: old journals and logbooks, charts, ships in bottles, tea chests, prints and paintings, scrimshaw (left), and models of celebrated sailing ships.

Man against leviathan serves as a subject for scrimshaw, here carved on a sperm whale's tooth and shown almost actual size. Relieving the monotony of years-long odysseys, American whalers turned their rough hands to creating this delicate folk art.

It was a good job. Now she stands proudly at her wharf, one of the last representatives of a long line of stout fishing ships that once worked the Grand Banks.

Along with the ships came buildings—now more than 60—that array of sheds and lofts essential to shipbuilding and ship maintenance. These include the old Mallory sail loft, a ropewalk, and a spar-storage shed. And, of course, a rigging loft well stocked with marlinespikes, fids, dead-eyes, tackles, and small and huge snatch blocks.

But the people came first. Mystic has never had a single great benefactor, as Virginia's beautifully restored Williamsburg had in John D. Rockefeller, Jr.

"Mystic Seaport always had faith in itself," said Waldo C. M. Johnston, Director of the Seaport. "And it knows how to help itself, too. We have a staff of more than 150 now and an annual budget of more than a million dollars, but local volunteers are still very important."

Mrs. Brower Hewitt, honorary president of the Seaport's 300-member Volunteer Corps, explained: "We have all sorts. Retired couples and housewives, babysitters and grandmothers—a whole cross-section of community life—donate more than 8,000 hours of their time every year. They do every kind of thing—filing, researching, telling visitors about our ships and exhibits—and we lean upon them heavily. We have more than 400,000 visitors a year, and they all want to know something. We couldn't get along without our volunteers."

Morgan's Chronometer Still Marks the Hours

I walked around the 37-acre Seaport—slowly, because there was so much to take in. Along the main street, paved with cobbles of long ago (pages 224-5), rose a strange medley of sound—caulking hammers, coopers' irons, the clang of metal on shipsmiths' anvils, the rumble of whale-oil barrels. I heard the lusty shouts of workmen hauling a heavy cutting-in tackle on a handcart.

All these scenes and sounds seemed to blend so naturally that they were not strange at all, though the traffic on Connecticut Route 27 thundered by within yards. I realized only slowly that I was part of a re-created waterfront scene of a hundred years ago.

I looked into the little red one-room schoolhouse, ready for students. In the 19th-century bank I noted the fat old handwritten ledgers and the stovepipe hats waiting there for the long-gone clerks. Behind it the 50-seat Fishtown Chapel raised its Gothic steeple, surmounted by a black-rooster weather vane. Moved to the Seaport after standing for 70 years on the New London Road just outside Mystic, it is a graceful white church furnished with its original pulpit and 12 gray spindle-backed benches.

Nearby, I listened to the period timepieces in the Pugsley Clock Shop, where the *Morgan's* chronometer still ticks off the hours, and sniffed the aromas of Brazil coffee and Celebes spices wafting from the open door of the Geo. H. Stone General Store. The traditional cracker barrel and apple basket stand there still. Across the street, I dropped in at Schaefer's Spouter Tavern.

"These places are all real," Carl Cutler had told me.

"A few stood here; the rest people gave to us when they saw what we were doing, and we moved them.

"Mystic Seaport has continued saving ships, buildings, relics, logbooks—*tradition*. You know what sort of course a ship is doing by looking back along her wake. Well, here is part of America's wake. You can look back here and learn."

"At Mystic we are not merely preserving heirlooms from a bygone era," Philip Mallory explained. "The Seaport is dedicated to perpetuating those values stemming from courage, hard work, imagination, and—perhaps this above all—self-reliance. Ships and the sea taught these things, the very origins of our freedom."

And, indeed, Mystic Seaport bustled with life. Children scampered down the main street, boarded the ships, streamed through buildings filled with models, paintings, and figureheads of long-gone ships (pages 230-31). Others picnicked while their elders listened in Seaport Planetarium as Frederic W. Keator, a retired Yale professor, expounded on the mysteries of an orderly universe—mysteries that mariners helped to solve.

I looked in at the G. W. Blunt White Library, repository of thousands of treasured manuscripts, books, and records, where the strong, adventurous face of the late Blunt White himself smiled from a portrait. I had known Blunt and Marian, his wife. I'd stayed with them in their colonial home at Mystic, and I knew his famous racing yacht *White Mist*, though I had never sailed with him.

Beef Boiled in a Canvas Bag

In the hush of the library, sagas of the sea came trooping into my mind as I wandered through the stacks, where the Marine Historical Association keeps shelf on shelf of ledger-like journals and logbooks, many of them more than a century old. I read part of the diary of Albert Burrows, a Mystic-born seaman who at 14 had shipped as a cabin boy aboard the whaler *Romulus* in 1851. In one place, he described a typical ship's fare:

"For dinner each day boiled salt beef and

pork assisted each day as follows: Sunday 'duff' flour water and grease with a few dried apples for the crew and raisins for the cabin thrown in and boiled with the beef in a canvas bag. Monday—bean soup. Tuesday—boiled rice. Wednesday—pea soup. Thursday—'duff' again. Friday . . . no extras. Saturday—salt codfish.

"When there were potatoes or other vegetables on board we had them occasionally besides vinegar once a week and flapjacks every 1,000 barrels of oil. We had flapjacks accordingly three times in the course of the voyage of three years."

Sailor's Spartan Life Impresses Boy

I left the library and followed a crowd of visitors up the gangway to the *Morgan*. We scrambled down a companionway to the crowded little fore-castle, where the whalemen of a century ago had lived and eaten, slept in their cramped bunks, strained to read or carve by the light of a single smoking whale-oil lamp. The guide spoke of the years men spent in that dark hold—a thousand men, all told, on the *Morgan's* voyages—with this their only home for hundreds of days and nights. And he repeated one small boy's reaction to the hold's cramped gloom.

"Why," he blurted, "my daddy wouldn't let me sleep in a place like this *one* night."

It struck me suddenly that the old *Morgan* had brought the past to life for the boy, and that in his brief moment of understanding—doubtless repeated countless times in the minds of countless other boys—the idea of Mystic Seaport had borne priceless fruit.

Mystic Seaport preserves the stirring spirit of those men who braved long voyages and of the modern mariners to whom their proud heritage has passed. It retells their stories in old sea-stained logbooks, on much-used charts, in relics, and in real ships. All these priceless mementos might have disappeared with the old seaport but for Mystic Seaport's "founding fathers," who chose instead to restore it and make it a living shrine to the great American past and an inspiration for a greater future.

THE END

In an eventide ballet, spidery silhouettes scramble up the *Conrad's* rigging. Enlisting in Mystic's Mariner program as apprentices, young people earn promotion to ordinary and able seaman, and perhaps to the highest rating, mariner. During their stays—three days at a time in spring and fall, up to 10 in summer—they learn to row surfboats, tie and splice ropes, read charts, and obey the "Rules of the Road." Most find they acquire not only an understanding of the seaman's life but a new sense of self-reliance.



WHILE THE AUTHOR was gathering material for this article last summer, a Basque cab driver in Biarritz, France, remarked to him with obvious pride: "You know we have a Basque governor in the United States now."

"Yes," Mr. Laxalt replied, "he is my brother Paul."

As Robert Laxalt has related so memorably in his book, *Sweet Promised Land*, their father, Dominique, came from the misty Pyrenees of France to the high Sierras of Nevada as a shepherd 62 years ago. He and his wife, also a French Basque, have given six children to their adopted land. Paul, the eldest, was elected Governor of Nevada in 1966. Robert, a writer of both nonfiction and novels, lives in Reno, where he directs the University of Nevada Press. On assignment for the *NATIONAL GEOGRAPHIC* he has written "Basque Shepherders, Lonely Sentinels of the American West," in the June, 1966, issue, and now this poignant account of a visit to the land of his forefathers. —THE EDITOR

Land of the Ancient Basques

By ROBERT LAXALT

Photographs by WILLIAM ALBERT ALLARD

THE SOUND OF THE DISTANT HORN came fluting up the brackened slopes. In the half light of the rude tree hut, the Basque hunter held up his hand for silence. The sound of the horn came again, and this time the note of warning in it was unmistakable.

"So now it begins," he said. "You had better go down."

Three of us were cramped into the Tower of Death, a tiny tree hut perched in the topmost branches of a giant oak. The floor we stood on was piled with whittled wooden projectiles shaped like small paddles. Far beneath us—in this high mountain pass of the Pyrenees—was an old stone cabin with a sagging roof whose slates were green with lichen. And beyond the cabin, strung on poles that towered 50 feet into the air, hung a sweep of nets so fine as to be almost invisible.

This was the *palombière* of Lecumberry, in the French region of Basse Navarre. The *palombière* (freely, "place of doves") is one of a dozen located in the high passes of the Pyrenees on the border between France and Spain. Here, for many hundreds of years, the Basques have netted the wild dove in its autumn migration from the Scandinavian countries to the warmer climes of Spain and Africa.

As my Basque cousin Bertrand and I descended the dizzying ladder from the tree hut to the ground, the peaceful scene below was transformed into one of furious activity. Villagers in black berets were scrambling out of the cabin; some to dive into camouflaged mounds that held the levers to trip the great nets, others to conceal themselves behind a wooden barricade.

Through the eye slit in the barricade I saw the flight of doves—dark specks in a broken arc—coming swiftly into the funnel of the pass. When

Pride of race and realm marks the faces of a Basque family: Jean Mainhaguet, his wife Gratianne, and son Pierre in Ibarrolle, France. An ancient people whose origins are lost in time, Basques inhabit the western Pyrenees and nearby coasts of France and Spain. Despite the pressures of other cultures over the centuries, Basque villagers still cling to their ways and to their unique language.



they were so near that I could hear the drumming of their wings, the white wooden projectiles lanced out of the Tower of Death like falcons whirling down in attack. They are thrown by hand to frighten the doves.

The flight reared up like a single thing, and then, to protect itself, dived close to the ground and came the rest of the way to the nets in a blur of swiftness. When it struck the nets, there was a soundless explosion of feathers. Birds hung in awkward disarray in the webbed strands as though they had been pasted against a canvas of sky. Then the levers were jerked, and the nets came tumbling down. The air was rent with a spine-chilling sound that once had been a Basque war cry, and the villagers descended upon their catch (pages 244-5).

They picked their way carefully

over the delicate strands of the fallen nets to extricate the doves. Some would be cooked and eaten immediately, but most of the hundreds caught would be penned to provide fare through the winter months ahead. And for everyone captured, thousands would pass the Pyrenees in safety.

Afterward, my cousin Bertrand and I went down the mountain, walking under a crimson-and-gold canopy of beech and chestnut trees in full color of autumn.

"Did you find it cruel?" he asked.

I shook my head. "No, I found it old and tragic and . . ." I hesitated, "and in a way I can't explain, beautiful."

"Good!" said Bertrand. "Then you have not lost your Basque heritage by being born in America."

Only then did he explain to me the aspects of religion and poetry that

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ON THE HEIGHTS OF ESKUAL HERRIA, as the Basques call their land, a couple starts homeward after gathering bracken as bedding for their animals. The farmer whittled the wooden teeth for his rakes. Mules and oxen haul his loads. The dog watches quietly and loyally over his master's sheep. © 1962 by [unreadable]

accompanied the hunt. He told me of the Mass of thanksgiving offered in the village churches at the end of the hunting season. Then, in that unself-conscious way of people who are raised with song, he sang the tribute the Basques had always offered to the beauty and pain of the dove.

*Urtzo churia, urtzo churia
Errani zaddak othoiegina
Nundat buruz houndonen...*

White dove, white dove,
Tell me if you please,
Where were you traveling,
Your route so straight, your heart at ease.

From my country
I departed with the thought of
seeing Spain.
I flew as far as the Pyrenees,
There lost my pleasure
And found pain.

The wild-dove hunt of the mountain Basques symbolized to me the





essence of this ancient race whose origins and language are obscured in mystery. Though the age-old isolation of the Basques is breaking down, I had seen a primitive tradition that had managed to survive the centuries.* In that misted mountain pass I sensed a warrior ancestry that still lived.

We had broken now out of the mist, and the scene that unfolded below us was like that of a hundred valleys throughout the seven provinces we call *Eskual Herria*, the Land of the Basques (map, page 246). In the slanting rays of the late sun, the white waters of the *Laubiar* coursed along the valley floor. On the green mountains, distant houses of whitewashed stone were bordered on one side by vineyards and on the other by tiny figures of grazing sheep.

In a little village at the base of our mountain, white buildings with red-tiled roofs clustered around the steeple of a church. A man with a black beret and a wooden staff on his shoulder was walking ahead of two plodding oxen and a cart with great wooden wheels. The scents of greenery and moist earth rose up around me, and then unexpectedly the church bell in the village tolled the

Caught in mid-flight, wings still fluttering, doves struggle in the nets of a *palombière*, or "place of doves," at Béhoreléguy, France. Each autumn for uncounted years the Basques have awaited the migration of wood pigeons, also called ring doves (*Columba palumbus*), from Scandinavia to Spain and Africa. In mountain passes the people hang their gossamer webs and drive the birds to capture. The right to net the birds belongs to households in the region and passes down from generation to generation. Birds not cooked immediately for a feast are kept in cotes for winter provisions or are sold to restaurants.

*See "Pigeon Netting—Sport of Basques," photographs by Irene Burden-Scougall, NATIONAL GEOGRAPHIC, September, 1949.



STACARDEP JRVVIVY AND KIMMURDRE © N.S.S.

Plucking the harvest, a Basque extricates a dove. Housewives simmer the plump-breasted birds for three days in red wine, garlic, vinegar, and spices to make *salmis de palombe*.



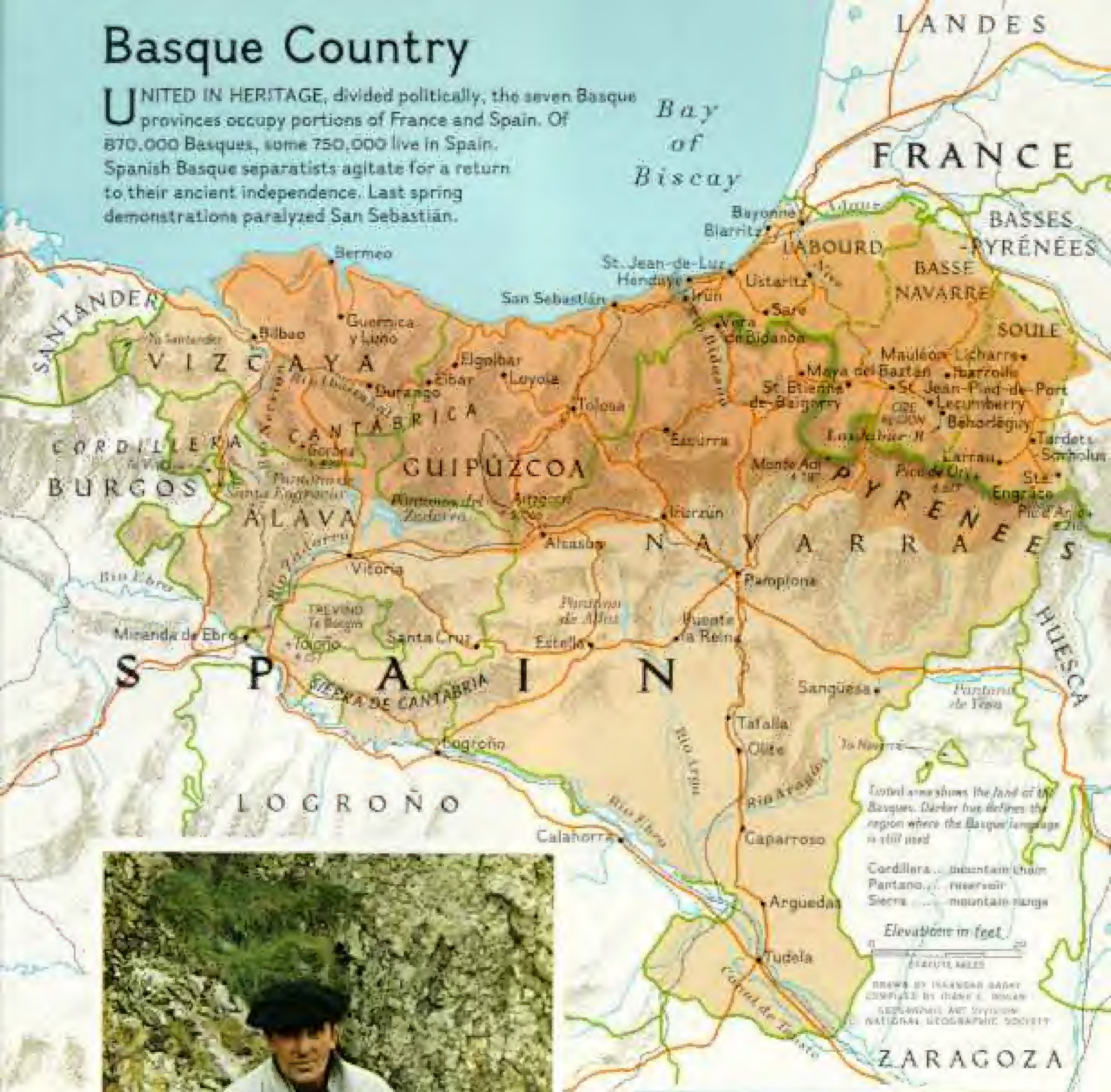
From the Tower of Death a riddle sings into the air, simulating a falcon, the nemesis of doves. To escape, the birds dive earthward into the nets of the Basques.

Doves tangle by the score in the strands hung in the mountain pass. For each one captured, thousands evade the snare and continue their southward journey.

Wild battle cries of the Basques, which once struck fear into the hearts of foes, ring out as the nets collapse to trap the doves. The men then collect their catch.

Basque Country

UNITED IN HERITAGE, divided politically, the seven Basque provinces occupy portions of France and Spain. Of 870,000 Basques, some 750,000 live in Spain. Spanish Basque separatists agitate for a return to their ancient independence. Last spring demonstrations paralyzed San Sebastián.



ENTOURNAGE DE JONATHAN S. BLAIN



Trekking the land of his parents' birth, the author rests during a mountain hike. He carries a *makhila*, the walking stick of the shepherds. Mr. Laxalt and his family lived in the French Basque country for two one-year periods, strengthening ties of blood and friendship.

hour, and the melancholy sound nearly brought tears to my eyes.

This was the Cize region in Basse Navarre, where I and my wife and children were to spend most of our two long sojourns in the Basque country. In the neighboring valley was the village where my mother had been born, and beyond the high range in the distance the rugged mountains where my father had been born. This was the country of my people's beginnings.

Isolation—Key to Basque Identity

In the baffling search for the origins of the Basques, theories range from the fantastic—that the Basques are the survivors of Atlantis, the fabled continent that sank into the sea; and the possible—that they are the only vestige left of Cro-Magnon man; to the probable—that they are descended from the mysterious Iberians who once peopled Spain.

Their language is unrelated to that of either their French or their Spanish neighbors. At various times philologists have found curious links between Basque and such far-flung languages as Finnish, Gaelic, Welsh, Georgian, Eskimo, and Japanese. To date none of these searches has borne solid fruit.

One thing is certain, however. In addition to their language, a self-imposed isolation has been the secret of the preservation of the Basques. Their history is replete with violent resistance to invading peoples: Romans, Visigoths, Franks, and others, seeking to settle in *Eskual Herria*.

It is not a country by political fact or boundary, but rather by racial identity. The Basques inhabited the mountains and seacoasts of a corner of the Bay of Biscay long before recorded history began. Their uniqueness has been demonstrated by anthropologists through studies of blood groups. The Basques have the lowest frequency in Europe of blood group B, a high frequency of blood group O, and the highest known incidence in the world of the Rh-negative blood type.

Originally, as a closely knit society of clans, they probably peopled a much larger area than the tiny portion of southwest France and the neighboring region of Spain in which nearly 900,000 Basques live today.* Later the clans withdrew into a smaller confine and grouped themselves into adjoining republics governed by elected rulers. Though these republics were completely democratic and independent of each other, they were united by language and

blood. From this unity came the rallying cry "*Zazpiak Bat*—The Seven Are One" that has been handed down through the centuries.

Eventually, the republics succumbed to the weight of great nations and were divided between France and Spain. Basque rights of self-government were slowly surrendered to French and Spanish national policies.

Today, four of the seven provinces—Guipúzcoa, Vizcaya, Álava, and Navarra—are Spanish. The remaining three—Labourd, Basse Navarre, and Soule—are part of the French Department of Basses-Pyrénées. All seven are still peopled largely by Basques.

It is because of this division that the great Basques of history have been identified as citizens of Spain or France. Few people know today that Basque blood ran in the veins of Juan Sebastián de Elcano, who was one of Magellan's officers and who, after Magellan was killed in the Philippines, became captain of the first ship to circumnavigate the globe. Another Basque, St. Ignatius of Loyola, founded the Society of Jesus. Simón Bolívar was only one of many political leaders of Basque descent who shaped the destinies of Latin America. And the Basques gave Maurice Ravel and Pio Baroja to the worlds of music and letters.

Farm Hides in a Mountain Fastness

Until modern times it was almost unheard of for a Basque not to marry within the blood. In the conservative mountain villages a boy risked disinheritance if he married a girl even from another Basque village.

I remember our first encounter with this tradition in the high mountain province of Soule, where my father was born.

My wife Joyce and I went to visit one branch of my father's family, at the home of my cousin Josep. Leaving our car where the road ended in the valley below, we mounted on foot up grassy slopes so steep that I could stand upright and reach my hand out to touch the hillside. We crossed hedgerows by climbing over wooden stiles, and passed through thick forests on trails cut deep by the hoofs of oxen and sheep.

The house with its old stone walls and slate roof lay in a remote mountain pocket. Wooden shoes scarred by long wear were set neatly outside the door, which was so low that we had to stoop to enter. There was gloom inside,

*See "Life in the Land of the Basques," by John E. H. Nolan, NATIONAL GEOGRAPHIC, February, 1934.



Homes handed down from generation to generation nestle amid fields of hay and corn in the Spanish village of Ezcurrea. Nearby stands the spired church and adjacent handball court—"one to serve the



PHOTOGRAPH BY WILLIAM ALBERT ALLARD © N.Y.S.

spirit, the other the body." Basques jealously guard the sanctity of their homes. "Only the family shares the table," reports the author. "My cousin, for example, has never eaten at his best friend's house."



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made warm by a roaring fire, and the light glinted off brass candlesticks and utensils above the hearth. From the great ax-hewn beams hung hams wrapped in immaculately white cloth, and strings of drying peppers.

In anticipation of our coming, the women of the house had begun preparing the meal the day before over the open fireplace. Nearly everything came from the farm itself—pâté, soup thick with vegetables, boiled chicken with a spicy tomato sauce, and the Basque delicacy that was the main course, milk-fed lamb called *achuria*. The wine and coffee that

Vines respond to tender care with a bountiful crop. Most Basques carry their grapes to communal wineries, but some bottle their own wine. Basques also make *Izarra*, a liqueur flavored with flowers of the Pyrenees.

Swish of a razor-sharp scythe fells bracken on a damp hillside. "On a crisp fall night," recalls the author, "rings of fire, carefully tended, creep across the slopes as the men burn the fern to keep it from encroaching on grasslands."

went with the meal Josep had carried up in a pack on his back.

Yet in this humble home the long table was covered with a starched linen tablecloth and napkins and set with old china that must have been family treasures.

It was a splendid feast, punctuated by much laughter and singing. Josep as *etcheke jainn*, or master of the house, sat at the head of the table. He wore his beret through dinner in the Basque way, and his wife's old father, Chemarc, had on the short pleated cloak that is called a *chamarra*. Josep's wife did not sit at table with us but busied herself serving. This did not mean a lowering of station, because in Basque life women are held in highest respect. And woe to the man who dares criticize her cooking or the keeping of her house.

Mixed Background Baffles Cousin Josep

While we were at table I noticed that Josep was completely mystified by Joyce. It had nothing to do with her fair coloring, because Josep himself was blue-eyed and blond, as are so many Basques in the remote mountain valleys. Obviously it had to do with her obliquely tilted eyes and high cheekbones.

It was not until the end of the long dinner that Josep summoned enough courage to say in French, which is the language of courtesy when there is anyone present who does not speak Basque, "Since you are married to my cousin and you are now a cousin to me, would it be indiscreet to ask your race?"

Joyce listed her origins—Norwegian, Swedish, English, Irish, and Welsh. As she mentioned each one, Josep's jaw dropped lower. "But it's not possible!" he exclaimed.

I assured him it was true, that a true American breed was emerging from the blending of nationalities. But to this day I am not quite sure whether he believed either one of us. He had lived too long in these isolated mountains where Basques had always married Basques.

In our time in the Basque country we came





Director of smiles, a photographer readies relatives and friends for a wedding portrait in St. Jean-Pied-de-Port, France. After the church service, the bride and groom traditionally walk to the cemetery where they will one day lie side by side—an acknowledgment of the lifelong bonds of

to know many parts of it. We knew the life of the seacoast and the thundering fury of Atlantic tempests on the Bay of Biscay (pages 262-3). We tasted the springtime melancholy of San Sebastián, with its shaded boulevards, and the gracious hospitality of fine Basque houses in Bilbao.

There we saw the clash of transition from old to new that is affecting so many parts of Spain. An industrial boom has rocked this port capital of the Basque Province of Vizcaya to its foundations.

As we approached the town, the sound of roaring trucks and blaring horns mingled incongruously with the clip-clop of a little burro laden with baskets of provisions for some outlying farm. A man with a scythe on his shoul-

der stood outlined against a backdrop of towering smokestacks. A gray haze of cinders settled slowly over a field where men in berets and women in black head-scarves worked the ground with crude hoes.

Yet Bilbao is fighting to preserve its old grace and Basque pride of city.

We toured the thriving shipyards with Don Castor Uriarte, a venerable architect whose family is one of the oldest of the province. I asked him about the overcrowding and slum problems that go with any great influx of factory workers. He replied firmly:

"The *vizcainos* have always taken care of their own. There were neither slums nor poverty in Vizcaya before, and there will not be any in the future."



ENTRETIENNE © NATIONAL GEOGRAPHIC SOCIETY

marriage. Wedding festivities, once held in the home, today take place in a local restaurant. Revelry lasts for hours, with a wedding supper and midnight snack interspersed with singing and dancing. The guests then escort the newlyweds to their home, dancing hand in hand through the streets.

In most of Eskual Herria, the old ways continue. At St. Jean-de-Luz in France, we saw the departure of the fishing fleet in November, when Basque sailors follow the tuna from the Bay of Biscay to the coast of Africa on a six-month voyage (pages 268-9).

It was a time of excitement and great emotion, as it must have been in the days when the first Basque whalers set out to sea in open boats, and later, when Basque explorers and privateers sallied forth in search of adventure and booty.

For the fishing fleet, the day of departure was signaled with booming cannon. The quay was crowded with families of the fishermen—old widowed grandmothers in black dresses and scarves, tearful mothers holding up their

babies to see, and girls in trim modern dress waving goodbye to their sweethearts.

On the brightly colored fishing boats, ruddy Basque sailors in blue turtleneck sweaters and yellow oilskin pants divided their time between their work and shouting hoarse farewells to their loved ones.

The water was so rough that it seemed impossible the fleet could get out past the breakwaters. But word had come that the open sea was less stormy, and the men had decided to make a dash for it. With pennants flying bravely, the boats went in little groups of four, pitching and plunging in the heavy seas.

By the time the last of them had darted out beyond the breakwaters, dusk had fallen and the boats were marked by dancing pinpoints

of light. An old sailor whose voyaging days were over stood on the quay until the last light blinked out on the horizon, and then turned away and went sadly home.

To know the heart of the Basque country, one must live, as we did, in its mountain villages. There, many of the houses have names instead of numbers. We have lived in houses named Esker Ona, meaning "thanks with all good heart," Mati Baña, meaning "Marie lives here," and Goizean Goiz, or "early in the morning."

They are old, solid houses of stone with worn and polished wooden floors and few conveniences. Through the long winters, open fireplaces and tiny gas heaters provide the only heat, and we learned to dress warmly in heavy sweaters.

Our home for a time was St. Jean-Pied-de-Port, once the capital of Basse Navarre. Because it stands at the foot of a pass through

the Pyrenees, this village has heard the measured tread of Roman legions, of the armies of Charlemagne and Napoleon, and the weary footsteps of pilgrims on their way to the shrine of Santiago de Compostela in Spain.

An old stone fortress dominates the village. At the foot of La Citadelle, encompassed by ramparts, lies the old fortified town of sagging stone houses with age-blackened tiles and a maze of cobblestone streets. But now the village has grown far beyond the ramparts, and bright new houses rise beside the old.

My family's adaptation to Basque life was almost painless. My wife's immersion into the slow pace of the village was complete; she learned the daily shopping routine of buying bread at the bakery, lamb and beef at one butcher shop, and ham and bacon at another. And through it all there were the village women's discreetly probing questions and tidbits of village happenings in fair exchange for information given.

Hard Work Helps Break the Ice

Our children, after meeting with reserve and distance at first, were accepted wholeheartedly by their friends and playmates. My son Bruce's bent for sports helped him in this matter of acceptance by the Basques, who are by nature passionately attached to the physical. Then 15, he learned to play handball, soccer, and Rugby well, and in turn taught his comrades some feints in basketball, which was new to the Basque country.

My daughters Monique and Kristin, 12 and 10, made lasting friends in their own way, and complicated family names like Barnetche, Jaureguiberri, and Garicoitz became familiar household words. They explored the secrets of the forests, collected wild flowers by the bushel, joined the raids on cherry orchards, and learned to make pets out of crickets.

As for me, my time apart from writing and research trips went into helping my cousins with the haying and planting. At first they were politely surprised that an *Amerikanoa*

Spray of sparks fans from a cutter's torch in a shipyard at Bilbao, Spain. Behind him a crane lowers a prefabricated bow section into place. The city, founded in 1300, became a shipbuilding center, using lumber from nearby forests now depleted. Iron mines in the region provide raw material for today's vessels.

Rouged by a fiery furnace, a sampler in a Bilbao steel plant gauges the readiness of the molten metal by its color.



EXPERIENCE OFFSHORE, AND RECALIBERS TO S.L.A.





Signposts of burgeoning Bilbao, smoking chimneys mark industrial plants along the Nervión River, the city's road to the sea. New low-cost housing rises in foreground. Portuguese and Spaniards from nearby areas, seeking employment in the shipyards and



WOODCROFT BY WILLIAM ROBERT BURNS © 1911.

metal-working plants, flock to the predominantly Basque city, capital of the Province of Vizcaya. With the influx of such peoples, the Basque culture of Bilbao fades. Many men and women marry non-Basques, a practice unheard of in the isolation of rural towns



ARTIST: J. GARCIA / GALLERIA

Basque banker, industrialist, and public servant, the Baron of Güell and his wife live on the outskirts of Bilbao. A portrait of an 18th-century Spanish king, Ferdinand VI, hangs above their fireplace. The ancient Basques had no nobility; those with titles today either earned them with government service or married into them. The baroness, a non-Basque, inherited the title from her father.

was capable of physical work. No matter how much I tried to explain that hard work was what had made the United States, the legend of riches and soft living persisted. Then, curiously, after they became used to my presence in the fields, their attitude changed to one of disappointment unless I could work as hard as they. It was a revealing lesson.

There were other lessons. One time, when my cousin Bertrand and I drove up to a tavern, I automatically locked the car. Bertrand regarded me with pain and said, "To lock a car in my village is as much as to say you regard my neighbors as thieves." I learned that in the Basque country to steal is unthinkable. Houses and cars left open are safe as churches.

Basque Shirkers Risk Social Ostracism

I also discovered that an insult is never forgiven. Though the Basques delight in sharp repartee, great care is taken that it does not cross the line into insult. On one occasion another cousin, whose name is Sauveur, and I approached a group of Basque men talking in the street. He introduced me to all but one man. I asked him later why he had made the exception. He shrugged and said, "He insulted me once. I haven't spoken to him in ten years."

But perhaps the strongest facet of Basque character is obligation to duty. To fail one's duty is to invite total exclusion. A scholar friend of mine, Jean Mirande, once told me: "The Basques do not have much use for those who won't do their duty. They censure them with silence or forget they exist. On the surface these may seem hard terms for living, but you must remember that this is a people who could not have survived as a race without the most rigid rules of group conduct."

It is a paradox that with these strict rules goes a passionate love of individual freedom. The Basques are regarded as one of the proudest and most independent peoples on earth. The geographer Strabo recorded their courage and ferocity in Roman times. Warriors would unhesitatingly kill themselves rather than face capture; sons would even kill their fathers to spare them the shame of being prisoners, he wrote.

Basque traditions are nowhere more alive than in the home of Julio Caro Baroja, nephew of the master Basque novelist Pio Baroja. The younger Baroja is probably the foremost living Basque historian and ethnologist. By the grace of a rare invitation, my wife and I went to see him in the ancestral Baroja-

Alzate home in Vera de Bidasoa in Spain.

In this sun-baked village of the Province of Navarra, the house of the Barojas looms like a fortress of massive gray stone. Its great portals are flanked on one side by the coat of arms of the village, and on the other by the Alzate family crest.

The house is a shrine to the memory of the turbulent Pio Baroja, who in his lifetime wrote nearly a hundred novels. The younger Baroja told us it was here that aspiring young writers like Ernest Hemingway and John Dos Passos came to visit the master.

Today Julio Caro Baroja, a solitary man, carries on the literary tradition in his own scholarly field. He could not choose a better setting for his work. His home is a veritable museum of Basque history. Its spacious rooms are filled with furniture of ancient vintage, oil paintings of sea captains, soldiers, and statesmen of the Baroja-Alzate family, miniatures and ivories gathered by them from far corners of the world, and thousands of old manuscripts. A former stable on the lower floor contains old carriages and crude scythes, swords, shields, and blunderbusses of times past.

Joyce and I sat with Baroja at one end of a long wooden dining-room table, already familiar as the setting of family gatherings in his uncle's books. As a courtesy I had brought him one of my own books and a copy of the June, 1966, NATIONAL GEOGRAPHIC in which I had written an article on Basque sheepherders in the American West.

Mountain Villages Keep Language Alive

He was especially interested in whether Basque descendants in the United States were preserving their language. When I told him it was being lost, he shrugged philosophically. "I fear the mark of death is on our ancient race. But what else can one expect? In the long process, it is inevitable that all races and civilizations must be assimilated."

Yet despite what we both knew was true, I could not help feeling the fact of loss more keenly in that moment than ever before.

Sadly, the most ancient of European languages seems destined to die. With the advent of heavy tourism on the seacoasts and the inroads of business in the major cities, more and more Basques must use Spanish or French.

In the mountain villages, however, the language remains secure for the present. From dawn until dark of the weekly market day, the streets and taverns and open stalls where

Confetti-covered couple finds a moment of quiet on a festive night in St. Jean-de-Luz, France. On saints' days and on most Saturday evenings the village erupts in gaiety. Often a *toro del fuego*—bull of fire—will be carried through the streets. Stuffed with fireworks, the papier-mâché effigy explodes in a crescendo of brilliant lights, to the delight of both children and grownups.



EXACTLY AS BY WILLIAM ALBERT HALLARD © HALL

Dreams of glory call a would-be bullfighter to practice with cape and sword near the Plaza de Toros in San Sebastián. The bull ring, one of the largest in Spain, reverberates with shouts every Sunday afternoon during the summer season. In mid-August the nation's greatest matadors vie for the favor of the crowd during the city's "Great Week." But the most noted festival in Spanish Basque country occurs in Pamplona, where during the *Fiesta de San Fermin* men and boys test their courage by running with the bulls that charge through city streets on their way to the ring.





Clouds lower over San Sebastián on the Bay of Biscay. A lone couple watches waves smash against the sea wall on a blustery fall day. In summer, crowds through the hotel-lined promenade of this resort town, the unofficial summer capital of Spain.

wandering merchants display their wares are filled with the soft sounds of Basque.

Since our village of St. Jean-Pied-de-Port is a central one, *paysans* from the surrounding mountains and valleys and visitors from nearby villages have gathered there for as long as anyone can remember.

In the past they came on foot, in carriages, and on mule and horseback. Today it is rare indeed that one sees a shawled woman sitting cross-legged on a packsaddle with her faithful umbrella in one hand and a market basket in the other. Buses, cars, and jeeps now bring the visitors to market day.

The livestock bargaining begins at first light of dawn, amid a tumult of bawling calves and squealing pigs and bleating lambs. The livestock buyers move from one farmer to

another, haranguing them with all the old tricks of the trade.

"I have my family to think of, too. How do you expect me to make a living when you ask a price like that?"

"This calf is more suited to making a suitcase than good veal."

"The market is down. Prices are down. Don't you read the newspapers?"

But the *paysans* have long been accustomed to the haranguing of buyers. The tirade flows off their shoulders like water. With the quietness of mountain people, they simply shake their heads if the price is not right. When the offer comes to their liking, they either nod or extend their open palms for the three hand slaps that signify a sale.

After the market is done, the men retire to little restaurants for a long lunch, visiting with their friends and singing the old songs.

In the afternoon, it is the women's turn. With market baskets in hand, they wander from one merchant's stall to another down the winding central street of the village, making



EXHIBITIONER © NATIONAL GEOGRAPHIC SOCIETY

a purchase of sugar or coffee here and an article of clothing there (page 271). Always there is the pleasurable business of surprises for the children at home—little sacks of candy or a bag of peanuts.

Later, the day gives itself over to the courting. Young men and women pause shyly to visit and stroll with each other. If the weather is good, there will be a street dance in the evening for the young, while mothers sit and watch from the sidewalk cafes, and the men go to the inside handball court to watch and bet on their favorite *pilotari* in this time-honored game that is believed to have originated with the Basques. Out of this sport was born the game of jai alai, which is still dominated by Basque athletes in Europe and the Americas.

In all, market day in the Basque country is business and pleasure and song entwined leisurely one with another.

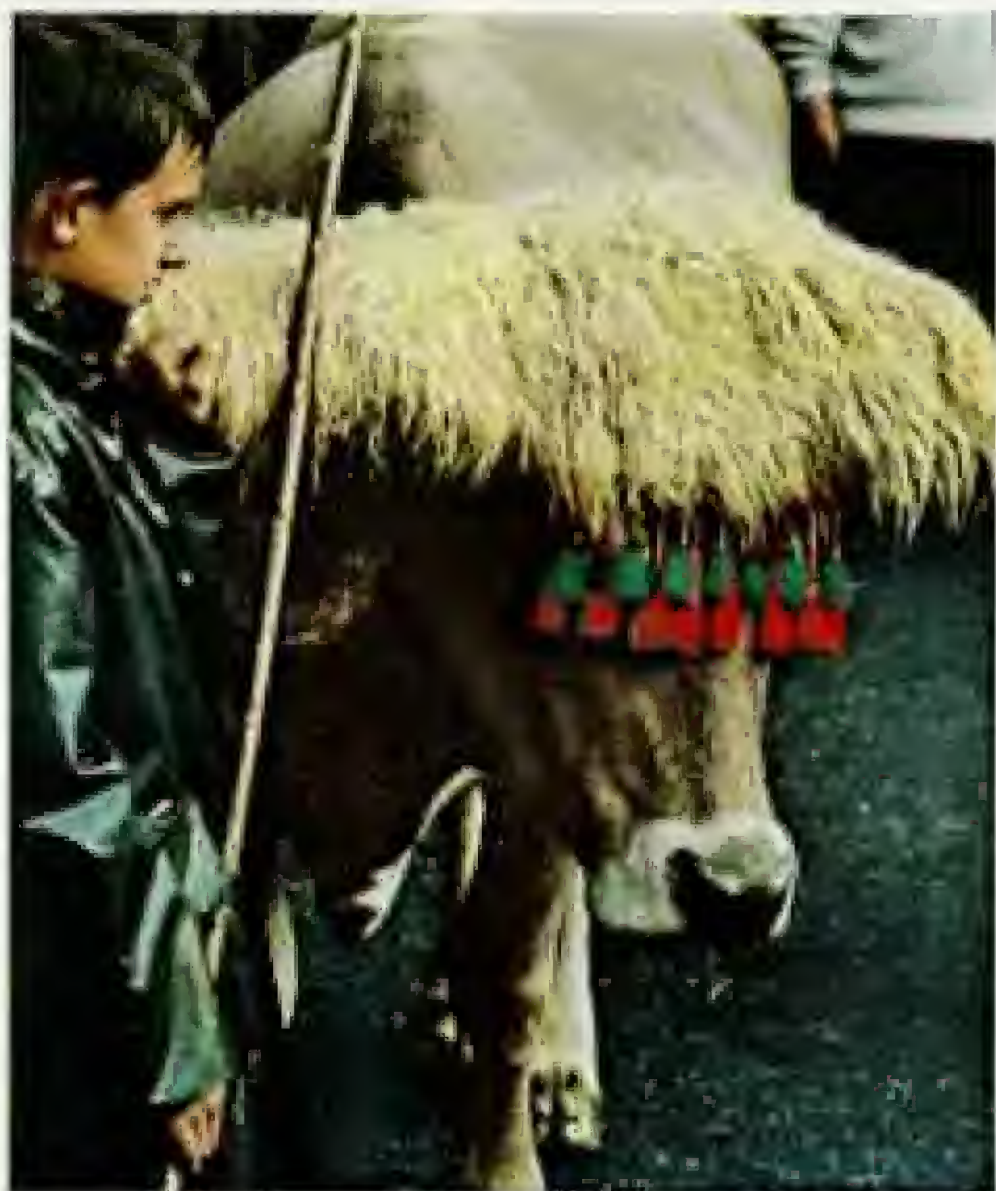
The Basques have a score of songs for every occasion—the gay tunes of festival time, the melancholy songs of farewell, the angelus

Eagle eye and lightning reflex send a jai alai ball hurtling toward a wall in Guernica, Spain. The sport grew from the Basque villagers' handball game called *pilota*. Each player wears an elongated wicker scoop with which he catches and returns the ball.

after Mass, when men's deep voices pour down from the galleries with the almost irreverent gusto of a sea chantey.

To me, it was a source of constant surprise and delight to be exploring some mountain and to hear in the distance the clear tenor of a young shepherd singing an air without words at the top of his lungs. Or to hear a group of youngsters singing as they walked homeward down a country lane. Or to pause to listen to my youngest daughter and her little playmates amusing themselves on our front step by singing together.

This tradition of perpetual song is sometimes puzzling to the visitor. Once we went to the Spanish Province of Navarra with my cousins to participate in the feast of San Fermín at Pamplona, an old town whose name in



Sheepskin chapeau adorns an ox at a cattle show in Sare, France. The covering keeps flies from the animal's eyes. Other Basques like to drape their oxen with embroidered burlap that sometimes covers the entire back. "Soon the great beasts will disappear," the author says sadly, "to be replaced by tractors."

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Resounding crash of horns echoes in the streets of San Sebastián as shepherds pit their rams in a bout of brute power. After each sally, men and boys anxiously eye the contenders for signs of weakening; the match ends when one ram refuses to fight. Wagers fly back and forth in the best Basque tradition. Any contest of skill or strength brings out their gaming spirit.



Mirrors on bearskins capture glimpses of Iholdy, France, during the Feast of Corpus Christi. Uniforms of these paraders derive from those of Napoleon's infantry engineers, but the origin of the mirrors remains a mystery.

Tension mounts as a dancer brushes a glass of wine in the Dance of the Zamalzain, the oldest Basque dance. Two groups perform: These in gay costume represent good; others in tatters, evil. Each dancer executes intricate steps around the wine glass. At the climax, the leader of the good leaps onto the glass, then springs away—hoping he won't topple the tumbler. Then the leader of the evil dancers takes his turn. If he spills the wine, good luck will reign for the coming year.



DANCERS OF ZAMALZAIN. (LEFT) AND WILLIAM ALBERT BLAND © N.S.S.

Basque is Iruña. It is a remarkable time, when Basques from all the provinces throw off their reserve for a week of boisterous singing and dancing through the town, and test their courage by baiting bulls in the narrow streets.

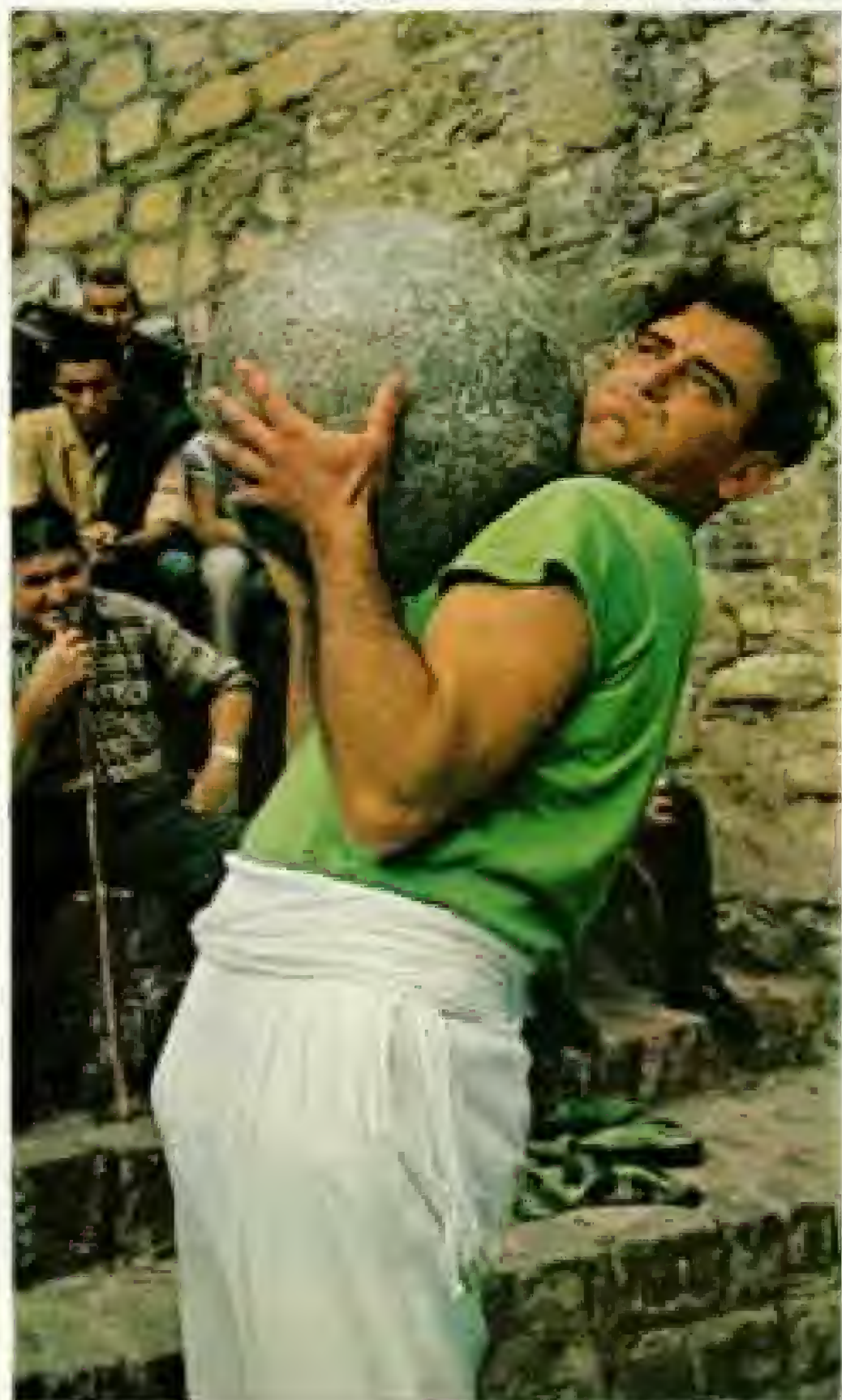
In the restaurant where we had lunch there was a group of ten young Australian men at a table next to us. The festive Basques were singing songs to them, but the Australians suspected they were being made fun of. They looked baffled and a little angry.

Finally I went to their table. "They are not insulting you," I said. "They're welcoming you in song. Why not return the courtesy?"

They did, bursting out with "Waltzing Matilda." The Basques listened in fascination and then gave them rousing approval. The lunch became a lusty exchange of Basque and Australian songs. And when we chanced upon the Australians the next day, they had managed to find a guitar and were singing to a rapt audience in the crowded street.

Straining every muscle, Teodoro Irazusta hefts a 347-pound stone ball to his shoulder in a weight-lifting contest at San Sebastián. Another popular Basque sport: grueling wood-chopping competitions.

RECORDED BY WILLIAM ALBERT HILARY © 1988



The Basque song reaches its highest stage with the troubadour, or *bertsolari*. To be a *bertsolari*, one must have an agile mind as well as a good voice. The troubadours are not only singers but on-the-spot improvisers of verse who compete with each other in song.

In these encounters the *bertsolari* will argue any given subject—the good life of the sailor as compared to the mountaineer, the bachelor's life against that of the married man, the Basque who has stayed in his homeland and the Basque who has gone abroad.

I watched two of my favorites, Xalbador and Mattin, dispute in song at a village feast in St. Étienne-de-Baïgorry in France. Xalbador is a lean-faced Basque who affects in contest the pose of someone slightly tipsy. His beret is pushed back on his head, so that his lank hair falls over his forehead. His forte is an attitude of droll cynicism toward life.

Mattin is his opposite in every way. Short and round, he reminded me of Friar Tuck. But behind his jolly grin is a rapier mind.

It was an incredible performance. For nearly an hour they exchanged quatrains with dizzying speed. At the end it was impossible to know who had won out. But one thing was certain. The villagers who listened to them would have many delicate turns of phrase in the nuance-rich Basque language to relish for weeks afterward.

Good and Evil Joust on a Wine Glass

After Basque singing, one remembers Basque dancing. One spring day we joined a throng of people in the central square of the village of Tardets, my father's birthplace, in the mountain province of Soule.

Early that morning dancers had begun wending their way down from where green meadows met the snow line, dancing in each village along the descent. Their route would end in Tardets.

They were performing the Dance of the Zamalzain, the oldest Basque folk dance and one of the most ancient in Europe. Once it must have been a pagan fertility dance to celebrate the coming of spring. It is a dance of good against evil, beauty against ugliness, and man's eternal battle to conquer his circumstances.

We were standing with my cousin, Petye. "As you will see," he said, "the Zamalzain is a very difficult dance. In order to do it properly, one must begin when he is ten years old."

As we spoke, the crowd parted and the dancers came into the square to the accompaniment of music from the *tchirula*, a shrill Basque flute played with one hand while the



ENTHUSIASM BY MICHAEL ALBERT BLAND © RIGGS

For a Basque born to dance, even practice can be a joy. Dressed in traditional costume, the Goizaldi troupe rehearses the *jota* in a San Sebastián square. "The Basques borrowed the dance from Spain's Aragon region," Mr. Laxalt says, "and with their love of the difficult have made it more intricate."



High and dry at low tide, boats undergo repairs in the harbor of St. Jean-de-Luz, France. Soon the water will rush in, halting the work. Tides in the Bay of Biscay, among the highest in the world, may rise and fall 40 feet. In November the fleet departs to net tuna, following the run from the bay to the African



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coast. Early seafarers, Basques scoured the sea for whales in the Middle Ages. Later explorers prized the mariners as crews. When warring European powers made privateering a profitable trade, Basques quickly sought letters of marque and haunted the Atlantic and Caribbean in search of booty.



other beats out a heartbeat rhythm on a drum called an *atabal*.

There were two troupes of dancers. One was resplendent with dazzling costumes, and the other was dressed in shapeless rags and hideous face masks.

Petye explained: "One troupe represents good and beauty and the other evil and ugliness. But in this dance, good does not always conquer evil. The beautiful dancers must make the good win out. Keep your eye on the goblet of wine in front of the dancers."

In turn, one of the beautiful dancers and one of the grotesque dancers approached the wine glass. The beautiful dancer stood erect with his upper body held rigid and only his legs in motion.

In time to the shrill music, his sandaled feet skimmed above and around the wine glass so closely that it trembled (page 265). When he backed away, the grotesque dancer went through the same routine, but in contrast to the other his motions were purposely disjoint-

ed. Still, he did not upset the goblet either.

The laughing good humor and the applause of the onlookers faded into silent apprehension as the dance reached its climax. This was when the Zamalzain, the leader of the beautiful dancers—whose waist was encircled by a wooden framework representing a tiny horse caparisoned with velvet and lace—danced toward the wine glass. His lightning feet performed their movements around the glass, and then suddenly he leaped onto it and as quickly soared into the air and away. The glass rocked violently but it did not spill.

Then the king of evil approached the glass. His slovenly dancing mocked the perfection of the leader of the beautiful dancers. His sandals landed firmly on the edges of the glass, but when he leaped away the glass fell over and the red wine spilled.

There was a huge sigh of relief from the villagers, and then wild shouts of approval. Beauty had triumphed over ugliness. Good had conquered evil.



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Wares spread to the discerning eye, women of St. Jean-Pied-de-Port settle down to trade news of friends and family. The men, who haggled over the prices of their animals during the morning market, leave the arena to their wives and retire to the bar for song and wine.



“Lean, almost fleshless faces” —thus the author describes these tillers of the ancestral soil. Proud guardians of their households, Basques nurture the land as a trust from their forebears and as a promise to their heirs. Contrary to the Napoleonic law that divides property among all children, Basque estates pass to the eldest—male or female. Younger sons either marry into a property, become priests or artisans, or emigrate to the Americas. Those who leave home are always free to return.



JOURNEYING BEYOND THE CLOUDS, shepherd and sheep head for high springtime pastures in the Pyrenees. In autumn, when snow threatens, they come down again to the warmth of village stables. In these mountains, sheep are a mainstay of the economy. Dye marks denote ownership.

EXTRACTS BY JONATHAN K. BLAIR © N.C.S.

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As we walked up the lane toward my cousin's farm, I exclaimed, "I can't recall when I've been so nervous as waiting for the outcome of this dance; of all things."

"Well, it's more than a dance," said Petye. "It's an omen. What happened today portends good for the year." He grinned self-consciously. "I know that in these times one is not supposed to put much stock in such things. But still, one cannot escape feeling better inside when the omens are good."

The several days before and after the first of May are days of excitement in the mountain villages. This is the time when shepherds move their sheep from the valley floors to the high mountain meadows, where they will remain until autumn.

From dawn to dusk roads and lanes are filled with small flocks of 50 to 100 sheep (preceding pages). In the Cize region, the sheep are of a strain known in Basque as *manek*—a pure breed perhaps brought here by the Romans. They are delicate animals with gracefully curving horns, finely shaped heads, and long fleeces of curling wool.

Each flock has its own distinctive markings—splashes of dye on shoulders and rumps. Proud of their animals, the shepherds from nearby farms make it a point to take them through the main village street of St. Jean-Pied-de-Port. The flocks move to the sound of tinkling bells.

Shepherds in berets follow with polished *makilak*, or walking staffs, in hand, leading mules and donkeys loaded down with provisions and bedrolls. At their heels are the little shepherd dogs of the Pyrenees.

Hollows Shelter Basque Shepherds' Huts

Jean Pierre, a Basque shepherd with bronzed skin and black curly hair, allowed us to go with him on his trek to the high mountains. In exchange for this courtesy, my cousin Sauveur had obtained a jeep to carry Jean Pierre's provisions and three young pigs. Still, I sensed a certain reluctance in Jean Pierre's attitude toward me.

The berry-choked lane rose sharply from the outskirts of the village. We passed little farmhouses with shutters thrown open to the good day, and answered friendly waves of farmwomen in black aprons.

We moved through deep forests of beech and chestnut and moss-covered oaks, forded cascades of water flowing down the green hillsides, and inched our way past chasms that dropped sharply to the valley below.

When we had climbed above the timber line, we seemed in a world apart. There were great sweeps of treeless mountains covered with a soft and yielding mantle of new spring grass. Brilliant patches of wild flowers grew on the slopes facing the sun, and in the sheltered hollows stood the old stone huts called *etcholak*, in which the shepherds had lived from time out of memory. An immensity of silence was broken only by the music of the bells.

As we crossed the grassy sweeps, the shaggy wild ponies of the Pyrenees watched us warily. These were the *pottokak*, believed to be descended from a prehistoric horse.

Farther along we topped a ridge and surprised a flock of vultures tearing at a lamb they had managed to kill. They were immense creatures with brown bodies and black heads. At sight of us they hopped awkwardly along the ground in



Surcease from loneliness: Two shepherds meet at the hut of Jean Pierre Bidande. With expertise, the visitor shoots a stream of wine into his mouth from a *chabakoa*, or wineskin. The fire, built on an earthen hearth, warms a stew; smoke escapes through vents in the ceiling. Like their sheep, Basque shepherds bed down on mattresses of bracken.



APPROXIMATE BY WILLIAM ALBERT ALLEN © N.Y.S.

a frantic effort to escape. But as soon as they were airborne, their ungainliness vanished and they soared majestically away.

We left the jeep where the track ended, unloaded the pigs, and shouldered the provisions. Because of Jean Pierre's attitude of distance, I took the heaviest load—grain for the pigs—on my shoulders. There was an instant thawing in our relationship.

A climb brought us to a tiny hut with walls built of stones of all sizes, the cracks chinked with clay. There was an open fire pit in the middle of the floor (above). Jean Pierre would

live here for the next six months on a fare that changed but little from day to day: coffee with milk in the early morning, pork and eggs at midmorning, and at night a stew of pork or lamb and whatever vegetables he was able to raise in his little garden. Sometimes, too, there might be trout, which he would have caught with his bare hands from among the rocks of the high streams. Fresh supplies would be brought to Jean Pierre once a week.

Outside the hut there was an oval corral built of piled stones. Joined to it was another corral, long and very narrow like a chute.

Basque grandmother, diligent in her faith, prays in the village church at Ste. Engrâce, France. The Basques resisted Christianity for centuries, but once they adopted it, about the 11th century, their fervor became second to none. From the village of Loyola, Spain, came St. Ignatius, the Basque who founded the Society of Jesus.



FETTERBERRY © R.S.S.

Promise of sunshine after the rain (opposite) generates glad hearts and light feet as children skip home to Béborléguay. As reserved as their parents, young Basques display their cheerful spirit only with their playmates. "We could not entice them into our house," said the author, "but they would often join our children in the front yard to sing the afternoon away."

"In the life of the shepherd," Jean Pierre explained, "he must milk his sheep twice a day—at dawn before they are let go to graze, and at night when they are brought back to the corral."

In the early mornings the sheep are herded from the oval corral into the chute for milking. The shepherd moves from one end of the narrow confine to the other, milking each ewe in turn. Every few days he carries the milk in great containers to where a jeep can transport it to the cheese makers in the valley below. From there, the cheeses eventually go to the caves at Roquefort.

"In times before," Jean Pierre said, "the shepherds made all the cheese in their *etcholak*. But now we're getting modern, too, you see."

He ducked into the hut and emerged with something in his hands. It was a cheese mold with a wooden hoop and drawstrings. I recognized all of it immediately—the strings to draw the hoop tighter so as to squeeze the excess liquid from the forming cheese, and the grooves in the wooden mold to save the tasty liquid for drinking.

"But though most of the milk goes down now to the valley," Jean Pierre said, "I still save enough to make the old shepherd's cheese. For my taste, it is still the best."

I could not help smiling as I handled the wooden mold, and Jean Pierre regarded me with resentment. "Do you find this amusing?"

"Not at all," I said. "You see, my father was a shepherd in these mountains before he went to America. He slept in a hut like this, and he lived as you live. He has told me so often about these molds, but I had never seen one."

Jean Pierre looked at me incredulously. "Forgive me," he said. "I should have understood that you know more than a little about the life of a shepherd."

And so he became a friend. Though I had learned another lesson from the Basque country, he had learned one too—that the roots of the Basques of America came out of the same soil as his. It was a fair exchange.

The Lasting Summons of an Ancient Land

But only after I had left the Basque country did I fully realize how very familiar it had all seemed to me. Every experience and every emotion had carried with it that curious familiarity.

It had to do with the land as well as the people. It had to do with wintry Pyrenean days when gray skies pressed down on bare forests and blue smoke wreathed upward from a hundred village chimneys to fuse with the gray.

It had to do with April days when the forests reappeared as magically as if a giant hand had planted them overnight in a hundred shades of green, and the air was redolent with perfume. And it had to do with summer days when the valleys were brilliant with color, and life had recaptured the earth and their hearts, and the Basques were gay.

It had to do with *Eskual Herria*, and when thousands of years have gone into one's blood, this was a thing that could not be washed away in one generation.

THE END



CRYSTALS

Magical Servants of the Space Age

By KENNETH F. WEAVER, Assistant Editor

Illustrations by National Geographic

Photographer JAMES P. BLAIR

WHHEELING THROUGH SPACE, a satellite spreads a pair of purple-blue wings. Sunlight strikes the glistening surfaces; converted to electricity, it powers the spacecraft's instruments and transmitter.

Deep in a concrete silo in a western prairie, an ICBM tipped with a nuclear warhead stands guard as its "brain," somewhat larger than a shoe box, continuously monitors the readiness of the missile.

In a Cincinnati hospital, a doctor destroys a skin cancer with the brilliant red pulse of a ruby laser.

And in the radio station in your home town, a quartz wafer the size of a nickel, vibrating hundreds of thousands of times each second, assures that you always get that station at the same place on your dial.

All these situations, which seem totally unrelated, share one important element. All depend on crystals: the solar cells of the spacecraft, the computer circuits of the missile, the ruby rod of the laser, and the quartz oscillator at the broadcasting station.

They are all part of the magic world of crystals, a strange world I have explored in recent months in visits to laboratories and industrial plants around the country. I have learned that such crystals—usually man-made, usually costly, and often nearly as small as the Biblical mustard seed—lie at the very heart of modern technology.

As Harry Gail, a Westinghouse spokesman, puts it: "Take away these specialized crystals, and communications would go back to horse-and-buggy days. The high-speed computer and virtually the entire space program would be impossible."

Crystals in nature, of course, are anything but rare: salt

Like an alchemist of old, technician Charles L. Andrew lifts crystals of synthetic quartz from an autoclave, a device similar to a pressure cooker, at Western Electric's Merrimack Valley Works in North Andover, Massachusetts. Dissolved quartz flowing across quartz "seeds" has built up the six-inch-long slabs. Often better than nature's best, such synthetic crystals play a surprising role in the life of electronics-age man.

PHOTOGRAPH BY JAMES P. BLAIR © N.G.S.



What is a crystal?

FROM THE ROCK of earth's crust to the lacy snowflake, most solid matter is crystalline. This means that its atoms, for reasons not entirely understood by scientists, arrange themselves in orderly three-dimensional patterns called lattices. Alum and table salt, right, reflect this inner order in their outer shape. Most crystalline matter, however, is a conglomeration of small crystals, and its external appearance belies the inner order. Because of their atomic structure, some crystals exert strange forces on light and electricity or possess great strength—properties that man finds increasingly useful.



ORDERLY ATOMS of table salt crystallize in the shape of a cube, a corner of which appears above. The chloride atoms, shown in orange, interlock with the sodium atoms (black) along alignments called planes.



QUARTZ CRYSTALS VIBRATE when electricity is applied. Thin plates of the mineral, vibrating at precise rates, keep radio transmitters on proper frequencies. Such crystals, tuned to different frequencies, separate simultaneous calls on the same telephone channel. Twisting or squeezing quartz produces an electric current.



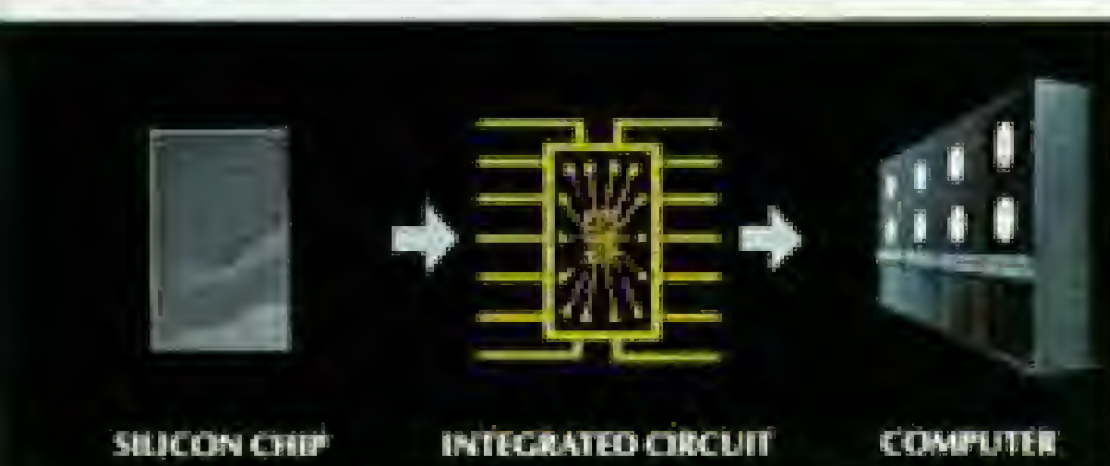
LIGHT GENERATES ELECTRICITY with the aid of crystals, a boon to camera fans and space scientists. When sunlight strikes the crystalline selenium in a light meter or the silicon-solar cells on a satellite, electrons in the crystals become activated, providing the current that powers the meter and satellite.



DELICATE "WHISKERS," each a single crystal of sapphire, possess amazing strength and heat resistance. Combined with metals, they form materials that may one day meet the structural demands of superlength suspension bridges and heat-plagued hypersonic aircraft.



LASER'S INTENSE LIGHT shoots from ruby crystals. Here a flashtube (coiled around a ruby rod) releases a powerful burst of light—a flash that excites electrons in the ruby. These generate a compact laser beam. Lasers can destroy cancerous tissue or drill the holes in diamonds for making thin wires.



BETTER "BRAINS" FOR MISSILES, such as this Minuteman II, depend on crystals used in miniaturized electronic circuits. Cranking resistors, transistors, and other devices on tiny crystal chips, scientists vastly reduce size and increase "brain-power" of aerospace computers. (page 291)

and sugar, for example. Diamonds and rubies. Ice and the delicate, fanciful snowflake. The rocks and minerals of the earth's crust, and most metals and ceramics—all these show crystalline structure inside when broken or etched.

In fact, glass and plastics are about the only nonorganic solid substances of everyday life that normally are noncrystalline.

What is it that sets crystals apart? Look at a few grains of table salt under a simple magnifying glass, and you will begin to see the answer. Each unbroken grain appears as a cube, with sharp edges and corners and flat faces (opposite and next page). Other kinds of single crystals reveal more complex shapes, but all naturally possess the same flat planes.

Home-grown Crystal Resembles a Gem

This orderliness on the outside reveals a significant orderliness inside as well. The secret of every crystal is that its atoms respond to their inner electrostatic forces by arranging themselves in a highly regular order to achieve stability. Except where a flaw interrupts it, this geometric pattern, called a lattice, repeats itself endlessly as the crystal grows.

With a bit of patience, you can actually observe the growing process. While I was working on this article, my secretary, Miss Heather Burridge, experimented with crystals of ordinary potash alum. She dissolved the chemical in warm water, let it cool to form seed crystals, and then suspended one tiny seed in the saturated solution.

Two days later the seed crystal had obviously grown. It showed the unmistakable octahedral shape of an alum crystal—two pyramids with their bases together.

The weeks went by, the solution slowly evaporated, and the crystal became larger and larger. As I write, it glistens on my desk—more than half an inch across, and as beautifully faceted as a diamond (above).*

As a single alum crystal grows, its double-pyramid structure stays the same. It obeys the laws of the crystal world in repeating its atomic patterns over and over.

It is because of this regularity that carefully controlled amounts of impurities may be added to many crystals to give them seemingly magical properties that man can use to his advantage. And nowhere have crystals become more important than in electronics.

"We do not believe in miracles; we rely on them."

I saw this sign on the wall at Texas Instruments Incorporated, in Dallas, Texas, where



BOONCHONG ET AL. © 1960

How to grow a crystal: Heather Burridge, the author's secretary, made this single eight-sided crystal of alum by dissolving one part of alum by weight in five parts of warm water. This produced a heavily saturated solution which, after cooling, yielded an initial seed of alum. Suspended in the remaining solution, the seed gradually grew into this gleaming octahedron.

chips of silicon crystal by the millions are turned into integrated circuits, the newest and most glamorous product of the electronics industry. A miracle they are indeed; integrated circuits squeeze scores of electronic components into a shimmering flake so thin it can slip through the eye of a needle or vanish in a puff of air (page 291).

To appreciate the miracle, you need to recall a bit of electronics history. If you ever looked inside an old-style radio or television set, you know that much of the space was filled with bulky, fragile glass tubes used to control or amplify the flow of electricity. They required a great deal of electric power and gave off annoying amounts of heat. Frequently they went bad and had to be replaced.

*For those who would like to repeat the experiment, see *Crystals and Crystal Growing*, by Alan Holden and Phyllis Singer, Anchor Books, Doubleday & Company, Inc., Garden City, New York, 1960, \$1.45.



PHOTOGRAPHS BY VICTOR R. BOSWELL, JR., NATIONAL GEOGRAPHIC PHOTOGRAPHER AND JAMES P. WEAVER © 1984



Gems of the pantry shelf, crystals of table salt, each a single translucent cube, sparkle against a red background. Salt refineries dissolve rock salt, then, by evaporation, regrow the crystals for purity and uniformity. An added chemical coating helps prevent the grains from melting and clogging saltcellars on humid days.

◀ Like shattered glass, sugar crystals, magnified 60 times, glint in polarized light. To show the growth pattern of this highly complex natural crystal, NATIONAL GEOGRAPHIC photographer Victor R. Boswell, Jr., dissolved sugar in water and smeared the solution on a microscope slide. As evaporation began, the first seed crystals solidified into the core at upper left. Racing to capture sugar still in solution, the crystals grew outward, overrunning and sealing off bubbles of liquid, appearing here as dark flecks. Each crystal lies at a slightly different angle to the light, bending the rays to produce a variety of colors.

Bristly crystals of beryllium oxide (below) split a laser's beam, entering at left, the light emerges divided into rays. The crystals' refractive strength permits research into uses for the laser's intense light. Such clusters of branching crystals are called dendrites, from the Greek *dendron*—tree.



▶ Building blocks of matter lie like stones of a ruined city in this slice of silicon, magnified 250 times. Engineers at Texas Instruments Incorporated, in Dallas, etched highly polished silicon with vaporized hydrochloric acid. Because crystal atoms unite more strongly along some planes than on others, the vapor ate into the sample at varying speeds. As indicated by the large configuration at right center, the acid cut deeply on the plane that here appears horizontal and even more drastically along the vertical planes. Blunted corners reveal a third plane of growth that was little affected. A phase-contrast microscope makes the silver-gray silicon appear bright orange.

Silicon, which makes up 28 percent of the earth's crust, stands second only to oxygen in abundance among the elements, and forms the basic stuff of most soil and rock. This sample, grown under rigid controls for use in complex electronic devices, is 99.99999 percent pure.



Squad of synthetic sapphires glows in invisible ultraviolet light. Each has been impregnated with different metallic atoms such as manganese, cobalt, or chromium, causing the sapphires to fluoresce with varied colors under "black light." Lapidaries can distinguish synthetic gems from natural only under magnification or by chemical analysis; synthetic sapphires and rubies now abound in jewelry shops.



Resembling taffy pulled from a pot, a silicon ingot grows by the "crystal-pulling" process at Texas Instruments Incorporated. A rod lowers a silicon crystal seed into a crucible of liquid silicon at 2,600° F., slightly above its melting point. The cooler seed causes the melt to freeze, or crystallize, at the point of contact. Withdrawn as crystallization takes place, the crystal grows six inches an hour. Slow rotation, preventing growth along natural crystalline planes, gives it a cylindrical contour. Such crystals form a base for integrated circuits (pages 286-7).



Within recent years, vacuum tubes have become obsolete for many purposes. In applications that do not require much power, they have been replaced by the transistor, invented two decades ago at Bell Telephone Laboratories. The transistor, made from germanium or silicon—substances known as semiconductors—performs the functions of the vacuum tube with a speck of crystal smaller than the letter "o" on this page.

Transistors can be encased in metal cans roughly the size of a garden pea and soldered into a wired circuit. Markedly smaller and lighter than vacuum tubes, they require far less power and give off relatively little heat. And they have proved to be vastly more reliable and long-lived.



STYLING: JANE BROWN; STYLING: JANE BROWN; AIR FORCE CORPUS CHRISTI RESEARCH LABORATORIES; PHOTOGRAPH BY JAMES P. GALT © R.S.S.

And so with transistors—devices of a type that engineers call “solid-state”—came the age of electronic miniaturization. Transistors became important foundation stones of military aviation, missilery, and space exploration, where it is vital to save space and weight.

In the civilian world, the transistor brought about the explosive growth of computers, which have invaded every area of life. The device became a household word with the tiny hand-held radio. It led to a billion-dollar-a-year semiconductor industry, producing transistors and related electronic items.

But it was not the transistor that drew me to Texas Instruments. It was the next generation of electronic marvels, the integrated circuit, pioneered just a decade ago at TI.

This new microminiature device packs an *entire electronic circuit* of transistors and related components, such as diodes and resistors, into a single speck of silicon, with further savings of space, weight, and cost. It is relatively unaffected by moisture, aging, or vibration. It will make possible all kinds of things we could never do before. It may revolutionize your life.

Factory Air Made Incredibly Clean

The complicated process of making an integrated circuit at TI takes 60 days. I followed the entire sequence in a day, with Larry LeVieux as my guide.

I put on a Dacron cap and gown to walk
(Continued on page 288)



Slices of silicon ingot house the circuits



Plastic mask, when vastly reduced, will plot "wiring"



Furnace heat diffuses circuit elements into wafers



Simplified diagram shows a transistor in cross-section

The miraculous "IC"

TAKE A TINY CHIP of synthetic crystal, cram it with scores of minute electronic devices, and you have the integrated circuit, or IC, a little giant that has revolutionized electronics technology. Successor to the bulky vacuum tube and the transistor, the IC goes through an ingenious manufacturing process, described below. The end product is an engineer's delight: rugged, long-lasting, low in cost, fantastically speedy. Magnified 12 times (right), the IC with its gold leads and parallel prongs for soldering also reveals unsuspected beauty.

SLICING OFF A WAFER 12/1000 of an inch thick, IC technicians polish it even thinner. Silicon provides a good material for the circuits because its electrical properties can be precisely altered by adding controlled amounts of impurities, called dopants. A wafer will eventually carry a grid of hundreds of IC's, not yet cut apart in the sample at top.

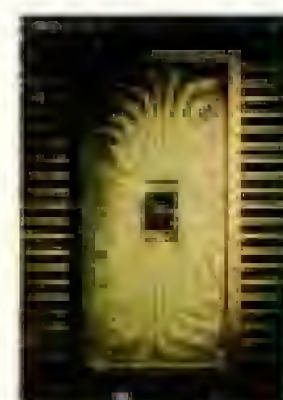
TO PATTERN THE COMPONENTS and wiring for each chip, a computer-controlled machine cuts a series of large plastic stencils, called masks. Here an engineer inspects a mask at Texas Instruments, the firm that pioneered in IC's a decade ago. A mask is reduced photographically at least 500 times to exact chip size, then reproduced over and over on a glass plate so there is one for each chip in the wafer. Complex photographic and chemical steps transfer the images to the wafer surface. Now, guided by the masks' openings, or "windows," technicians can implant the circuit elements.

LIKE BAKED COOKIES, wafers emerge from a furnace at North American Rockwell Autonetics in Anaheim, California. Temperatures up to 2,500° F. diffuse impurities into the wafers.

To illustrate this miniaturized manufacturing, a **GEOGRAPHIC** artist drew two cross-sections of an IC transistor, lower left. To form its negative collector, technicians cover the chip with a mask. Then they slide the wafer into a furnace containing a dopant of vaporized phosphorus. Bombarding the wafer through the mask's window, the phosphorus atoms penetrate and form a negative pocket—the collector area. A similar baking with a different mask and a different dopant—vaporized boron—creates a positive base area. A third such process creates the emitter area.

To interconnect these areas and link them with the rest of the circuit, the wafer is coated with a conducting material such as aluminum. Then, with circuit routes plotted by a mask, the unwanted conducting material is etched away, leaving a microscopic raised web—the IC "wiring."

FINAL PRODUCT: The black IC chip and its mounting are smaller than a postage stamp, right. Enlarged (opposite), the chip shows its aluminum "wiring." This IC has already been surpassed by others still smaller (page 289).



ILLUSTRATIONS BY JAMES H. BLAIR © 1965





Peering through high-powered microscopes, technicians align masks precisely atop wafers in the photo-processing of integrated circuits at Texas Instruments. Caps and smocks help control dust in this "clean room"; some scientists foresee a day when such work may be done in laboratories orbiting in the nearly dust-free vacuum of space.

(Continued from page 285)

through "clean rooms" (above), where ordinary factory air, containing more than two million particles of dust and pollen per cubic foot, is filtered and cleaned until as few as a dozen particles per cubic foot remain.

In glowing furnaces, where crucibles reach temperatures of 2,600° F., I saw silvery gray, sausagelike ingots of silicon—each a huge single crystal—produced by a process known as "crystal pulling" (page 284). I watched diamond saws cut these ingots into wafers the size of a silver dollar, which were ground and polished to mirror smoothness and about the thinness of the cover of this magazine.

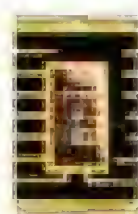
"As many as 1,000 integrated circuits, every one identical, will go into each of these wafers," Larry told me.

Finally, I saw trays of the crystalline wafers put into furnaces where carefully controlled, infinitesimal amounts of impurities were deliberately diffused through intricate masks into the very surface of the silicon.

The diffused impurities alter the electrical properties of silicon, which is called a semiconductor because its electrical characteristics lie between those of a conductor and an insulator. Exquisitely tiny areas of the silicon, treated with impurities, become conductors. Boron, for example, makes positive areas



ILLUSTRATION BY JAMES F. HARRIS © R.C.T.



Gold nerves serve a microbrain. Enlarged here, a hand-guided "pen" strings gold wire as fine as a baby's hair from an IC chip, center, to its frame. Heat and a gentle push of the pen fuse the gossamer strands to contact points. The IC—shown actual size at left—has only 1/8 the area but does twice the work of the older IC on page 287.

with a deficiency of electrons, and phosphorus makes negative zones with a surplus of electrons (page 286).

Joined by a spider web of vapor-deposited aluminum that takes the place of soldered wires, these negative and positive pockets become a circuit that can control or amplify electrical currents as easily as—and hundreds of times more reliably than—the earlier generations of single transistors or vacuum tubes.

Since the silicon wafer is brittle, it can be diced into hundreds of chips by scoring with a diamond point, just as a glass cutter scratches glass. When the scored wafer is put on a rubber block and rolled with a Lilliputian rolling

pin, the individual, identical chips break apart and can be picked up with a vacuum pencil. All that remains is to seal each crystal chip in metal or plastic, with fine gold wires providing connections to the outside world.

"You'll notice that only women are working on these chips," Larry told me. "They have to watch constantly through powerful binocular microscopes, and they use delicate tools and jewelers' techniques. Men usually can't stand such finicky concentration.

"Take this woman, for example. She bonds gold wires to the chip. The wire is far finer than your hair. She makes 14 connections around the edge of a chip that is only 1/16 of

an inch on a side, then fastens each wire to one of the 14 little gold posts that surround the chip (preceding page). She is so fast that she can finish 400 units a day."

My muscles ached with tension just watching such dainty operations.

IC's Tested by Whirling and Heating

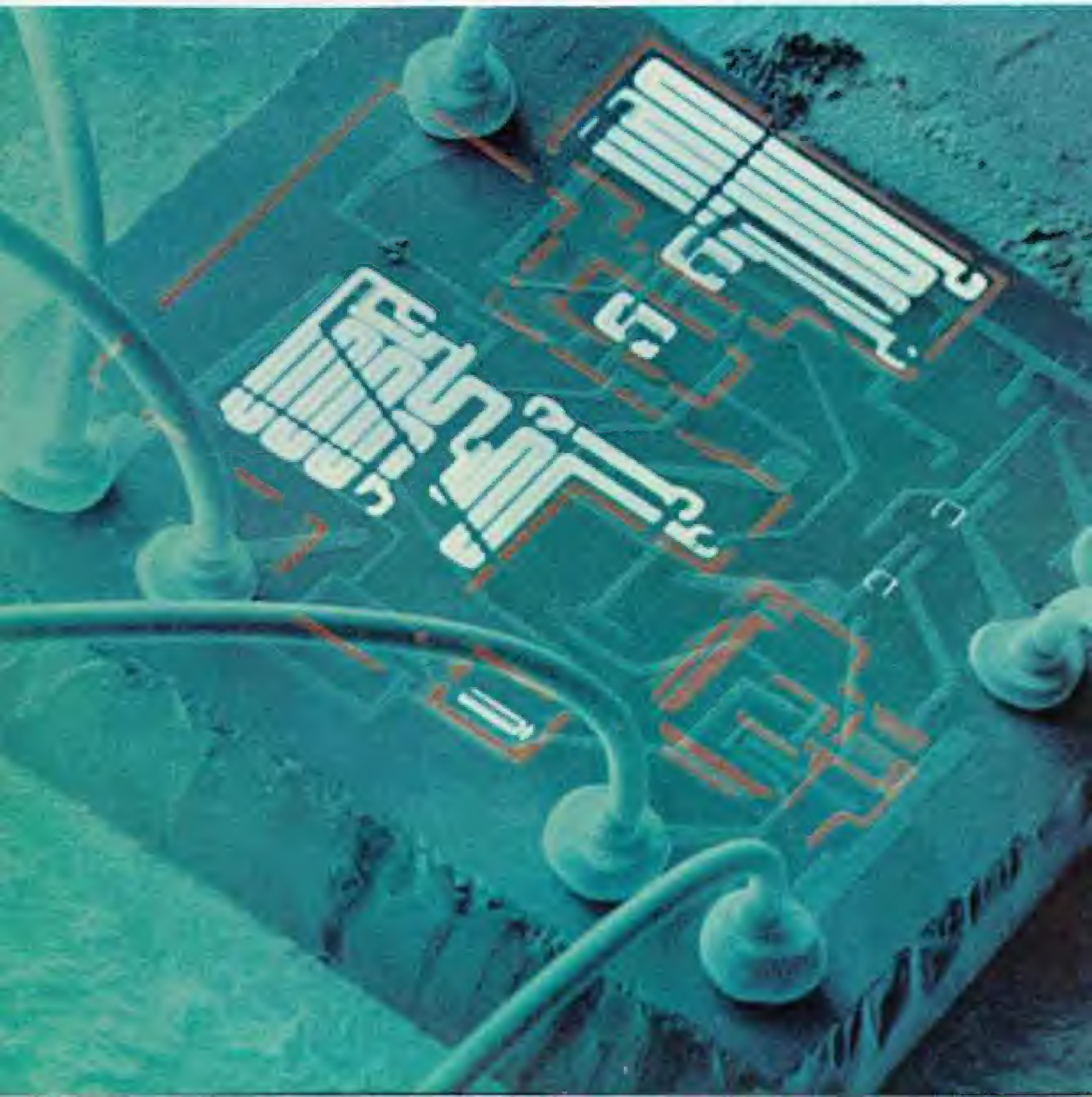
"These IC's will go into the onboard computer that will guide the Minuteman II, the new version of our chief nuclear missile," Larry explained. "They will have to withstand heavy acceleration force if the missile is launched. So we test the circuits in a centrifuge where they build up to as much g-force as a well-hit golf ball.

"We also subject them to heat in ovens and give them scores of electronic tests. By the

time we send IC's on to our customers, they should be good for hundreds of thousands of hours of trouble-free service."

At North American Rockwell's Autonetics division in Anaheim, California, I saw some of Texas Instruments' integrated circuits being assembled into computers that will guide the Minuteman II missiles to their targets. Each computer, roughly half again the size of a shoe box, is a compartment filled with nearly 3,000 IC's that weighs 36.5 pounds (opposite). It is only half as heavy and half as large as its transistorized predecessor and operates on half the power, yet it costs 40 percent less, and has twice the capability. So the warhead can go farther with greater accuracy and fool enemy radar more successfully.

Similar "black boxes" filled with IC's are



going into the nerve centers of the Apollo spacecraft and the new Air Force fighter-bomber—the F-111A—and they helped Surveyor take pictures on the moon.

In all these applications, streamlined size and weight are obviously important.

"But for consumer goods and services," as Dr. Jack Morton, Vice President of the Bell Telephone Laboratories, points out, "our objective is not just to make things tiny. Rather, we use miniaturization to get performance and economy we could not get otherwise.

"If we cut transistors apart, fasten on leads, encase them, and then put



EXTRACTING (LEFT) AND FIDUCIARY BY JAMES P. GLENN © A.S.E.

One circuit board replaces many, here arrayed around it, after IC's miniaturized the computer aboard the Minuteman II, the Nation's chief strategic missile. The missile's light, bread-box-size brain, only half as large as the transistorized computer carried by Minuteman I, helps increase range and payload. Minuteman gave the major impetus for developing the integrated circuit.

Mighty midget, a chip that houses 44 electronic components slips through the eye of an ordinary sewing needle. Such IC compactness pays off not only in space saved but in reduced time required for electricity to pass from component to component—a vital factor in computers that must do hundreds of millions of computations in a second.



EXTRACTING BY JAMES P. GLENN © A.S.E.

Miniature circuitry (left) shows its anatomy in this extraordinary X-raylike view of a chip, magnified 250 times in a scanning electron microscope at the Westinghouse Research Laboratories in Pittsburgh, Pennsylvania. On a surface only 4/100 of an inch across, two mazelike resistors and several rectangular transistors seem to glow white in reaction to the microscope's electron stream. Light blue indicates the aluminum surface "wiring" that connects components; red lines are isolating walls.

them together again in circuits, it's like breaking Humpty Dumpty apart and then patching him up. It wastes money and increases the number of failure points.

"These days it costs at least a dime every time an assembly-line operator even picks up a transistor. If the same operator can work on 100 transistors at a time in one IC, look how the unit costs go down."

Because of their tremendous advantages, nearly a quarter of a billion dollars worth of integrated circuits were manufactured last year, chiefly for use in computers. Production is skyrocketing, and by 1970 most elec-

tronic items you buy will probably contain at least some IC's.

For your automobile, IC's that will easily last the life of the car are going into ignition systems. A few 1968 Pontiac and Ford models have pioneered in the use of IC's in their voltage regulators.

"Talking Pill" Aids Medical Research

The remarkable properties of crystals, in both transistors and integrated circuits, have given a tremendous boost to the new science of micro-electronics. Among its many uses, some of the most startling will be in the field



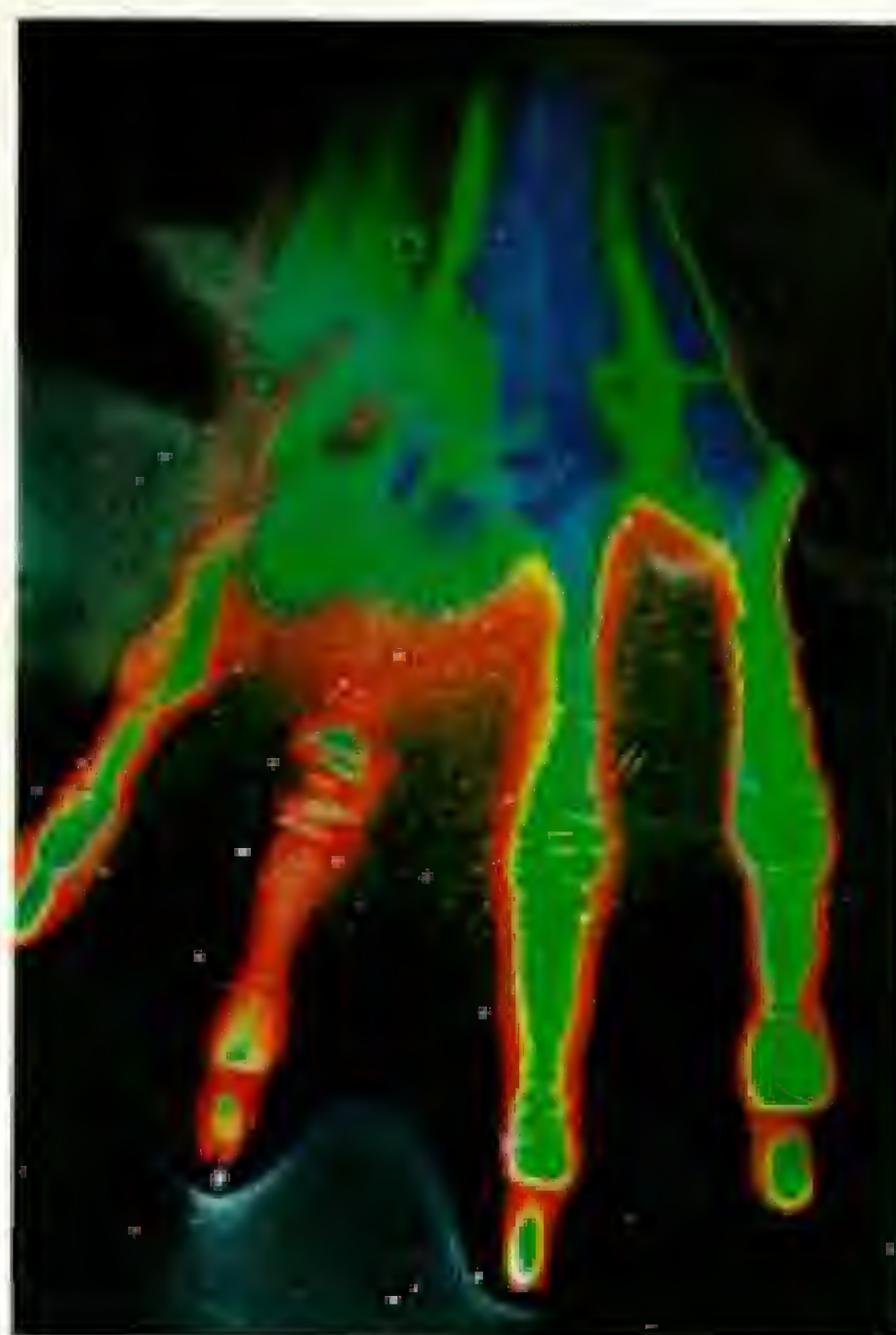
of medicine. Micro-electronics offers the doctor a whole kit of new tools.

There is already a capsule containing a sensor and an ultraminiature radio transmitter which you can swallow; it broadcasts the activity of your digestive tract to the listening doctor.

For the heart patient, a device smaller than a pack of cigarettes can be carried in a pocket to pick up and transmit heart rate and electrocardiograms. If the patient thinks he is having a heart flare-up, he can dial his physician, hold the mouthpiece close to the device, and the data will be transmitted by telephone.

And something really far out in medical electronics is promised by the experiments of Dr. Lawrence Pinneo of the Stanford Research Institute in Menlo Park, California. Working with monkeys, Dr. Pinneo implants very small electrodes in various areas of the brain, then stimulates selected areas by broadcasting to a tiny receiver embedded in the skull and attached to the electrodes.

Dr. Pinneo has learned how to make animals laugh, eat, walk, or sleep by remote control, and he can influence emotions. In time this work may help people who are paralyzed because of brain damage, as from a



Fingers glow like ghostly talons in an experiment with "liquid crystals" at the Westinghouse Laboratories. A technician squeezed an ice cube to cool the blood flowing to his fingers, then pressed the back of his hand against a plastic film coated with liquid crystals. Temperature differences show up as varying colors. Cool areas appear red. Intermediate temperatures register green; the warm back of the hand, blue.

Taking a face's temperature, Dr. Oleg Selawry, right, paints his subject with carbon black, then daubs on liquid crystals. Warmer regions register green and blue. Such tests may help outline cancerous areas, usually warmer than benign tumors. Demonstrating the process at St. Jude's Hospital in Memphis, Tennessee, Dr. Selawry confirms temperatures with a thermocouple.

stroke. A doctor may be able to reactivate the paralyzed limbs by electronic commands. Physicians may also be able to control emotions of deeply disturbed individuals.

Transistors are better than vacuum tubes, and IC's surpass transistors, why not, then, multiply the advantages by combining many different circuits on one silicon slice?

A number of electronics firms are racing to do just that. They call it "large-scale integration." Using new techniques to crowd components closer and closer, one firm says it can already put nearly a million on a two-inch slice—although it has not yet solved the problem of making all of them usable. The medieval theologians who debated how many angels could dance on the point of a pin had nothing on today's electronics engineers.

Computers May Do Household Chores

When these supercircuits and "computers on a slice" come out of a laboratory some years hence, the stuff of dreams will become reality. The computer, adaptable to an infinite number of tasks, will become remarkably cheap by today's standards. According to predictions given me by industry leaders, including Dr. Simon Ramo, Vice Chairman of the Board of TRW, Inc., at Redondo Beach, California, here's what it will do for you:

- In your car a computer no bigger than a teacup will control your ignition system and all the instruments on your dash. More important, it will continuously monitor radar signals that measure the distance to the next car. If the distance becomes too small or the rate of approach becomes too great for safety, an alarm will sound.
- In your home, a rented terminal linked to a master computer will virtually run your household. It will control the environment—heating, cooling, humidity. It will control all your appliances and radio, hi-fi, and television sets. If you are delayed on a shopping trip, you will be able to phone in and direct the computer to turn on the stove and start dinner. It will figure your income tax and at any moment tell you your balance in the bank.
- If you wish, you will even be able to have books in your city library reproduced on a screen in your home, page by page. The books, of course, will have been recorded on magnetic tape at the library. And your newspaper may one day roll out of a machine in your home, printing news fed into the computer, for a fee, at the newspaper office.

- At the department store, the clerk will take your personal identification card, put it into a slot connected by computer to the local banks, and the amount of the purchase will be transferred from your balance to the store's account. If your balance won't cover the purchase, the computer will say so. Checks will become obsolete for most purposes.

All this can become possible through large-scale integration.

Crystals Convert Light to Power

The marvels we have looked at so far all involve the special properties of semiconductor crystals—chiefly silicon.

Many other kinds of crystals offer their own unique capabilities. Ruby crystals, for example, can be made into lasers, which amplify light and produce enormously bright and powerful beams.*

Some crystals convert light into electricity. Crystalline selenium does this in a photographer's light meter (page 280). The amount of light hitting the selenium determines the strength of current it creates, and thus controls how far the pointer moves across the dial.

Many spacecraft wear thousands of thin purple-blue rectangles of silicon. These are solar cells; they provide the spacecraft with electricity converted from sunlight at rates as high as 10 watts per square foot of surface.

Piezoelectric crystals, such as quartz or Rochelle salt, give off electricity when twisted or pressed, or vibrate rapidly when an alternating current is applied. (The name comes from a Greek root meaning to press or squeeze and is pronounced pee-AY-zoh.)

At the Bell Telephone Laboratories in Murray Hill, New Jersey, I saw a simple but revealing demonstration of how such crystals work. In an exhibit case, a wafer of quartz is connected to an electric meter. A mechanical hammer periodically strikes the crystal. At each blow, the needle on the meter jumps, showing that a current is passing through.

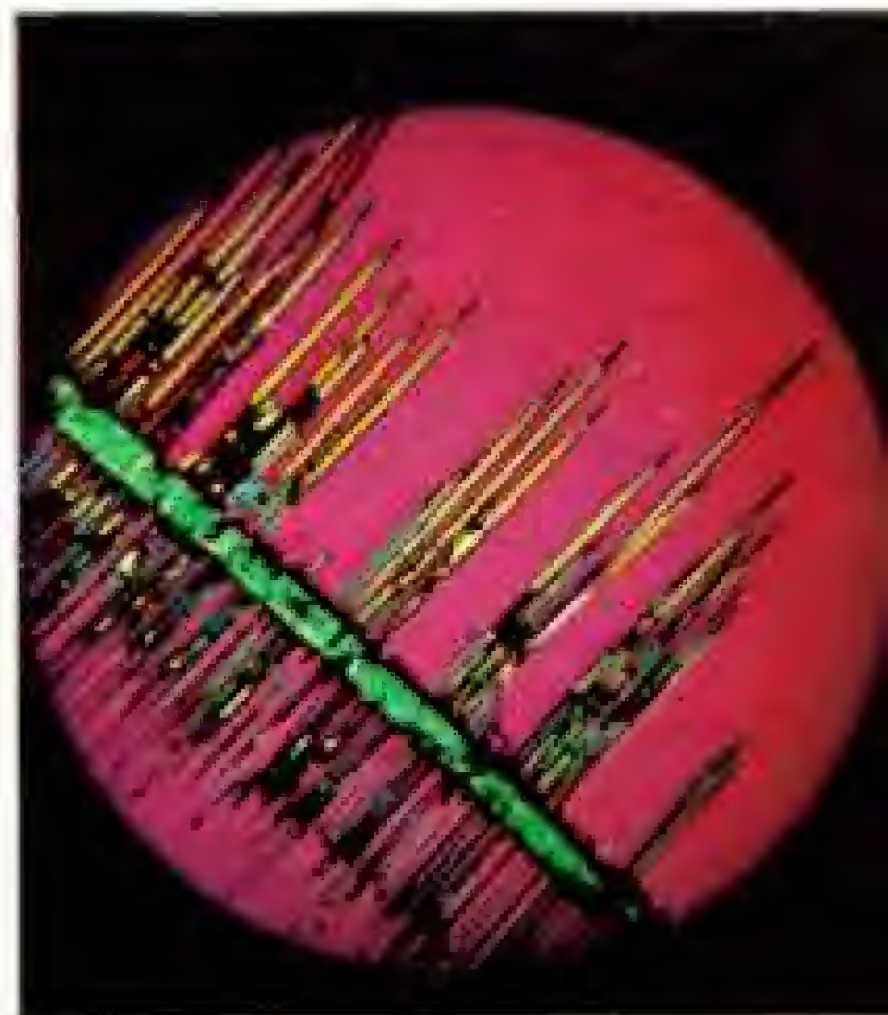
Piezoelectric crystals are used by the millions for all sorts of useful tasks. In many phonograph pickups they respond to the vibrations of the stylus in the record grooves by giving off a weak current, whose variations are amplified and sent on to the loud-speaker. They work similarly in microphones. In submarine sonar systems, they detect sounds. And in radio stations thin quartz wafers vibrating

*See "The Laser's Bright Magic," by Thomas Mely, NATIONAL GEOGRAPHIC, December, 1966.



Space Age loom: Quartz threads feed into a matrix of 22,000 vertical steel rods at Avco Corporation in Lowell, Massachusetts. Made from crystalline quartz that has become partly amorphous, the filaments are light but stronger than steel. Here technicians handweave the strands among the rods, creating a structural block, seen as white. Withdrawing the rods, they will thread filaments through the rod holes, reinforcing the block three-dimensionally. Then they will impregnate it with epoxy or other resins. Already tested for high-stress gears, the material also holds promise for use in such tortured hardware as spacecraft heat shields.

ILLUSTRATIONS BY JAMES P. HALL (LEFT), AND BOB BRILL © N.S.A.



Minuscule sinews of science, whiskers of aluminum oxide, or sapphire, grow in a ceramic tray (left). Enlarged eight times, they resemble a city's night skyline (above). A billion weigh only a pound. Such whiskers can reinforce metal, plastic, and glass, a use pioneered by Dr. Willard H. Sutton of General Electric.

at carefully determined rates control the broadcast frequencies.

In 1963 an IBM physicist, J. B. Gunn, discovered that a speck of gallium arsenide, a man-made crystal, gives off microwave radiations when a current passes through it. These vibrations pulse at the rate of one to ten billion a second, overlapping the radar range.

A Radar Set for the Blind

Industry has been quick to see the possibilities of "Gunn devices" made from these crystals. Within a few years we will probably see on the market radar sets light enough and cheap enough for blind people to carry, or for everyday use in automobiles and small boats.

In General Electric's Space Sciences Laboratories near Philadelphia, Dr. Willard H. Sutton showed me the finest crystals I have ever seen. They were sapphire "whiskers," about half an inch long, but so fine that a billion would weigh only a pound. In a mass they looked like cotton candy, but they were amazingly stiff to the touch (preceding page).

Delicate as they may seem, fine whiskers such as these, or thin filaments of such substances as boron, can be mixed with metals or plastics to produce incredibly tough, heat-resistant, new Space Age materials. Some, lighter than aluminum yet stiffer and stronger than steel, theoretically make possible skyscrapers five times as high as the Empire State Building, or suspension bridges twice as long as today's longest.

Military men wax enthusiastic about the advantages for nose cones, rocket nozzles, and parts of supersonic jet planes. And before long your dentist may fill your cavities with crystal-reinforced compounds.

Of all the improbable mysteries I ran across in preparing this article, the strangest concerned the "liquid crystals" Fred Davis showed me in the Westinghouse Research Laboratories at Pittsburgh. Derivatives of cholesterol, these organic materials flow like viscous liquids, yet have the inner structural orderliness of solid crystals. They respond with high sensitivity to temperature changes.

Mr. Davis spread liquid crystals on a thin sheet of black plastic. Colorless at first, the liquid quickly took on color as he warmed it with an electric light bulb. Reds, greens, and blues chased each other across the surface in fleeting patterns, faster than the neon lights of Las Vegas. Cooler areas showed red, hotter areas blue (pages 292-3).

Doctors are experimenting with such liquid crystals as a possible aid in cancer diagnosis. Most cancers show up as hot spots because more blood circulates in the tumor area. Benign tumors are usually cooler.

As I review today's magic world of crystals, I think of the ancient Greeks who invented the word. They would be even more astounded than you and I are by the dazzling, colorful, useful array of substances that bear the name. After all, to the Greeks *krystallos* meant just one thing—"clear ice"! THE END

Announcing a new series of technical research reports

SINCE ITS FOUNDING in 1888, the National Geographic Society has made grants in support of 449 research and exploration projects. These have resulted in hundreds of technical monographs as well as many memorable articles in this magazine.

Now the Society is creating a new publication, *Research Reports*, to summarize the findings of these diverse projects and to cite resulting articles and scientific papers. The summaries will usually be written in technical language by the scientists who did the research.



The first volume in the new series contains abstracts of 29 projects authorized by the Society in 1963. Typical of the wide range of National Geographic Society-sponsored research and exploration projects, this volume alone includes archeology on land and beneath the sea, astronomy, Australian meteorites, Arctic exploration, ecology and dynamics of coral-reef creatures, radiotracking of grizzly bears in Wyoming, evidence of echolocation by small mammals in Madagascar, studies of monkeys in east Africa, of free-ranging chimpanzees in Tanzania, of birds in New Guinea, and of the Lua population of Thailand.

Subsequent volumes, uniformly bound, will be issued periodically, eventually embracing research projects from 1890 to date.

Copies of the first volume, a 251-page cloth-bound book, may be obtained for \$5, postage paid, by writing to Dept. 517, National Geographic Society, Washington, D. C. 20036. Request later billing if desired.



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Androscoggin— the river they rescued from drowning

New Hampshire's Thirteen Mile Woods is wild, beautiful river country famous for salmon, trout, canoe trips, hunting and scenic driving. But it came close to drowning in one vast puddle. A hydroelectric dam was planned for the Androscoggin River. Opponents were few.

Government Engineers were ready to do the job, if the idea won approval. Then a National Wildlife Federation's affiliate — The Federated Sportsman's Clubs of New Hampshire — spoke. They had objections, a lady secretary named Rachael Terrill to voice them, and other clubs in agreement. They warned that the swift, clear waters would turn sluggish, trout and salmon would die off, and game-filled forest land would become mudflats. Still, few listened.

Suddenly, in 1966, those who loved their river found they had scarcely any time left. But they made seconds count. Paul Bofinger, of the Society for the Protection of New Hampshire Forests, organized a local committee. They got help from the Audubon Society, Society of American Foresters, League of Women Voters, newspaper editor Bud Warren, Tom Christensen's radio station, reporter Linnea Staples, and many others. They spread the facts all over New Hampshire, winning support from the paper and land holding companies that own much of the property.

Then the utility company entered the picture. From a study of its own, it declared the dam uneconomical and detrimental to natural resources. So Governor King asked the conservationists, under Bofinger's leadership, to plan for the valley's permanent protection. The river was safe.

Sinclair believes that everyone has a stake in preserving our natural environment. We publish these true stories of private citizens — such as those near the Androscoggin Valley — in the hope that other Americans in their own communities will be inspired to action. Visit New Hampshire — you'll enjoy what the people there saved for you. Let us help you plan the trip... or any pleasure trip in the USA. Write Sinclair Tour Bureau, 500 Fifth Avenue, New York, N.Y. 10020. Dept. G.



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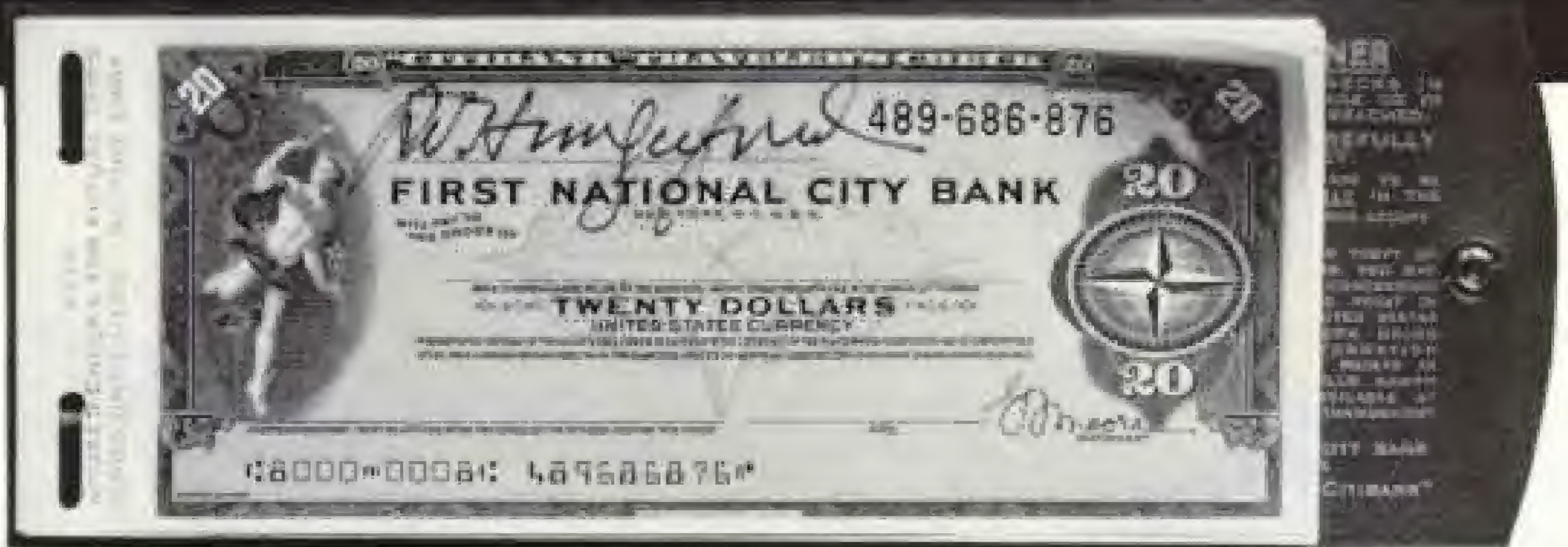
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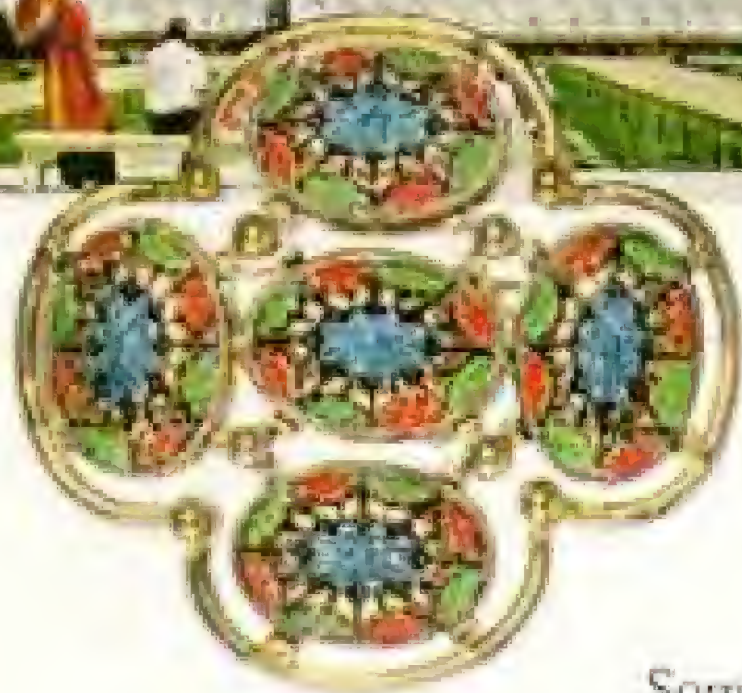
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Jewelry shown actual size



Sometimes a nation's traditions suggest an idea. In Spain, colorful pageantry is a tradition. Striking adornment is another, as symbolized here in Sarah's distinctive "Senorita" earrings.



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