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NATIONAL GEOGRAPHIC

ONLY IN SORCERY, such as Merlin the wizard spun, are a man's eyes as keen as an owl's, his reach as high as a mountaintop, his speed faster than the wind. Yet recently I had a reminder of how modern technology has made such wizardry come true. The American Association for the Advancement of Science (taking for its theme "Science and Technology: New Tools, New Dimensions") invited NATIONAL GEOGRAPHIC to present a program to its annual meeting, held this February in Washington, D.C. While preparing for that program, I realized the full extent of the GEOGRAPHIC's debt to scientists and the images of science—and how those images have so drastically reshaped our knowledge.

Over the years we have done our best to translate the often arcane discoveries of modern science into readily understandable text and illustrations. We find that scientists are pleased with this process of making their work known and meaningful to millions of interested laymen.

The pictures that appear in our pages, made from visible light and radio, infrared, ultraviolet, X rays, and gamma rays, have enabled us in the comfort of our own homes actually to see the swirl of galaxies as they travel in space, to gaze on a living cell, to map the minerals of the moon, to see nature as a butterfly sees it, to peer at places in the dark oceans where continental plates diverge, to follow the whirling tracks of particles so small they can still not be seen.

We have looked closely at the hominid bones found in the soils of Africa by Richard E. Leakey and Donald C. Johanson, and at the stunning artworks surrounding a Chinese noblewoman and an Egyptian pharaoh who seem to have drifted from another world.

What have we learned from science's kaleidoscope of images? We have a far better idea of our place in the universe, and of the basic mechanisms that create species on this planet. We know a good deal more about the history of the earth, through its ceaseless changes over eons.

But still, at the end, this gallery of shapes and colors leaves one not only with a sense of wonder but also with an increasing sense of mystery. How will the pictures of A.D. 2000 be taken, and what will they be of?

Gilbert M. Grosvenor

NATIONAL GEOGRAPHIC

THE NATIONAL GEOGRAPHIC MAGAZINE VOL. 153, NO. 3

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COVER: *Insignia of wealth in an austere land, a turquoise-covered peyrak crowns a young woman in mountain-girt Ladakh. Photograph by Thomas J. Abercrombie.*

"It's an explosion,
a renaissance,
a changed country . . ."

Spain

By PETER T. WHITE
FOREIGN EDITORIAL STAFF

Photographs by
DAVID ALAN HARVEY

A first step: Tenderly, a penitent encourages his son as the youngster prepares for his initial procession with a religious brotherhood during Holy Week in Valladolid. Yet as such traditional Easter pageants marched across Spain last year, the minds of its citizens were fixed on a revolutionary event just weeks away—free elections, the first in four decades.

As the dictatorship of Generalissimo Francisco Franco fades in the wake of his death in 1975, a long-polarized nation once again strives for democracy with stability, as it often has during the past 165 years. The hurdles are formidable—bitter memories of a brutal civil war, demands from outlying regions for autonomy, an uncertain economy—but from many voices in the passionate debate, cautious optimism echoes.

HOLY WEEK IN SPAIN. In dozens of towns and villages, hundreds of images of Christ and the Virgin will be carried in procession—attended by tens of thousands of colorfully cloaked and hooded figures, gazed at by millions. It's a collective spectacle unparalleled in Europe.

I have come to witness that, and to bask in the soft spring of this land of wine and olives, of glorious castles and beaches. Remarkable, that a country of 35 million inhabitants can attract an equal number of foreign visitors a year; that an area not quite as large as France has as much scenic variety as the 48 contiguous United States. And that alongside *castellano*—meaning the Castilian, or Spanish, language—three other languages still are spoken on Spain's geographical and cultural periphery. I hope to sample all that too, but right away I can see that I'm in for even more.

Fateful changes are shaking the Spanish State. Francisco Franco, who for decades ruled as "leader by the grace of God," died not long ago, and the National Movement, the sole political organization he permitted, has just been abolished. Free parliamentary elections are to be held within three months, in June 1977—the first in 41 years.

Already 125 parties have been legalized, graffiti are sprouting, demonstrations multiply. In the capital of Madrid, a colonel's lady asks me what the world is coming to, women marching for legalization of divorce? A student is glad he no longer needs a certificate of good conduct to get a driver's license. "It's an explosion, a renaissance, a changed country," an editor tells me, "*estupendo*, astonishing."

Ages mix in Almansa. Fairgoers soar near a Moorish castle; a cross

testifies to the reconquest that ended Islamic rule in 1492.

Spain's swift transition from one-man rule toward democracy seems to astonish everyone. Will this change go all the way? And will it produce stability, with relatively few losing their lives and none their property? That would be without parallel in Spanish history, if not in the history of the world.

ON PALM SUNDAY in Toledo, the cardinal primate of Spain declares that faith is still the greatest need. He says the greatest danger is the Devil.

Monday in the provincial capital of Valladolid, a young man in green cloak and white gloves adjusts his two-foot-high black hood, emblems of the brotherhood of Our Lady of the True Cross. It dates from 1498. Why is he here? "Because I feel it."

Valladolid is noted for its museum of polychrome saints: fine carvings amazingly painted, ultra-lifelike. Look into St. Paul's mouth, you'll see discolored teeth and a textured tongue; crystal over his eyes makes them shine. Teenagers pause before a martyred Christ by Gregorio Fernández. A girl gasps, "*¡Pobre!* Poor fellow!" Spaniards feel familiar with their God. It's from the heart —like the fervor of the Counter-Reformation that burst from 16th-century Spain.

At dusk on Holy Tuesday in the provincial capital of Cuenca, trumpets and drums precede floats slowly swaying uphill, carrying saints and flowers and candles. The weight of the floats is distributed among dozens of hooded carriers—about a hundred pounds per man; each pays for the privilege. The brotherhoods' cloaks are violet or white, their hoods green or garnet or gold. Onlookers crowd streets, windows, and balconies, quietly. Some following the floats wear unpointed hoods; one, apparently a woman, carries a baby in a red snowsuit. She walks barefoot on the cobblestones.

These are all cities of the Meseta, the mostly arid tablelands of central Spain. At its center sprawls Madrid (map, pages 302-303), with four million inhabitants; one million are away on Holy Week vacations.

From Cuenca I drive toward the Mediterranean—southeast to Benidorm, the beach favored by many from Madrid (page 304). After Villanueva de la Jara, famous for mushrooms, and Tarazona de la Mancha, prolific in wine and sheep cheese ("best when aged in olive oil"), I descend to Albacete, famous for cutlery. Here begin the extra-fertile lands called *huertas*, intensely irrigated for fruit.

Glory by the chestful *glitters at a Madrid ceremony. Between the gloves of a vice admiral shines the Cross of Naval Merit, First Class. Spain's armed forces, traditionally guarantors of stability, view any redistribution of power with wary eyes.*

Small towns cluster beneath big castles—Chinchilla, Villena, Sax. Villena also boasts big factories for shoes. Many go to America.

Benidorm, twenty years ago a fishing hamlet with one policeman on a donkey, has 150 big hotels and 40,000 apartments. Its Holy Wednesday procession features a school band with majorettes in miniskirts. The brotherhood dates only from 1969 and its Christ moves on rubber tires. This is the Costa Blanca, the White Coast. From here popular beaches stretch north to the French border; up there it's the Costa Brava, the Wild Coast.

Among a hundred discotheques in Benidorm I choose "Europe's largest," a flying saucer in concrete. "Room for 2,700," adds the manager, "mostly foreigners." A bus disgorges a planeload that left London three hours ago. In boutiques I see signs in German, French, English, as well as in Spanish: *Leder*, *Cuir*, Leather, *Cuero*. Often Spanish is last, but nobody seems to mind. The money the foreigners bring is a major prop for the economy.

The pageantry of Holy Week unrolling

Costa Verde

Bay of Biscay

Cabo de San Adrián

Costa de la Muerte

La Coruña

Avilés

Gijón

Santander

Oviedo

Sella River

Asturias

Los Beyos Gorge

Picos de Europa

Bilbao

Basque Provinces

Camariñas

Cabo Finisterre

Santiago de Compostela

Lugo

Cordillera Cantábrica

Galicia

Sierra del Caurel

León

Vitoria

Ebro

Pontevedra

Vigo

Orense

Miño

Sil

Carrión

San Vicente de la Sonsierra

Burgos

Atlantic Ocean

Leon

Old Castile

Palencia

Duero

Zamora

Valladolid

Aranda de Duero

Montejo de la Vega de la Serrezuela

Douro

Tormes

Salamanca

Segovia

Peñalara 2,430 7,972

Avila

Guadalajara

MADRID

Alcalá de Henares

Pico de Almanzor 2,592 8,504

Torrejón de Ardoz

Plasencia

Cuenca

PORTUGAL

Toledo

New Castile

Cáceres

Extremadura

Tajo (Tejo)

Badajoz

Guadiana

Ciudad Real

La Mancha

LISBON

Sierra Morena

Córdoba (Cordova)

Jaén

Andalusia

Guadalquivir

Sevilla (Seville)

Huelva

Granada

Sierra Nevada

Mulhacén 3,478 11,411

Capileira

Almería

Málaga

Jerez de la Frontera

Cádiz

Marbella

Costa del Sol

Costa de la Luz

Atlantic Ocean

GIBRALTAR (U.K.)

Mediterranean

Strait of Gibraltar

Monte Hacho 195 640

Ceuta (SPAIN)

Isla de Alborán (SPAIN)

Tangier

MOROCCO

Melilla (SPAIN)

Elevations in meters (black) feet (red)

KILOMETERS 0 100

STATUTE MILES 0 100

MAP DESIGNED BY JOHN W. LOTHERS
DRAWN BY ELIE SABBAN
COMPILED BY GUS PLATIS
NATIONAL GEOGRAPHIC ART DIVISION

FRANCE

Navarre

Pyrenees

Pamplona

Monte Perdido 3,355

Pica de Aneto 3,404

ANDORRA

Huesca

Gállego

Cinca

Segre

Gerona

Catalonia

Costa Brava

Zaragoza (Saragossa)

Lérida

Barcelona

Hospitalet

Ebro

Tarragona

Aragon

Costa Dorada

Balearic Sea

Teruel

Castellón de la Plana

Costa del Azahar

Turia

Valencia

Valencia

Júcar

Albacete

Almansa

Chinchilla de Monte Aragón

Villena

Sax

Benidorm

Alicante

Segura

Murcia

Murcia

Costa Blanca

Cartagena

Sea

Menorca (Minorca)

Balearic Islands

Torrella +1,445

Palma

Manacor

Mallorca (Majorca)

Ibiza (Iviza)

San Antonio Abad

Ibiza

Formentera

Spain

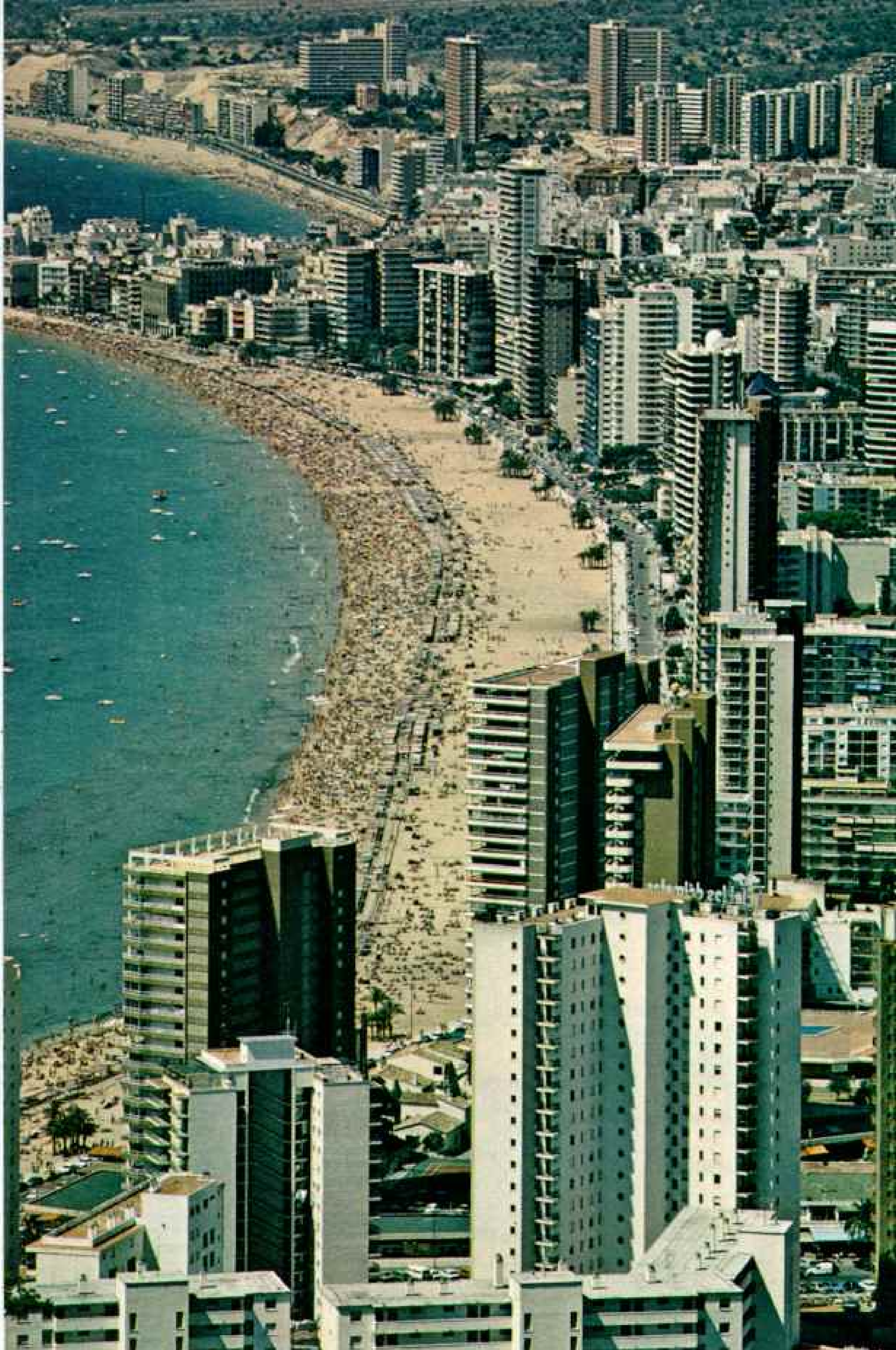
HISTORY DIVIDES the Spanish State into many regions, each fiercely individualistic. Ancient kingdoms and regions kept their privileges even under the 16th-century Habsburg monarchs. Then came the Bourbons in 1700; from the plateau of Castile authority reached to the outlands. Today Spain's regions still resent control by Madrid. Demands for autonomy ring loudest in three non-Castilian tongues: Catalan in Catalonia, Valencia, and the Balearic Islands; Euskara among Basques, who spill over into Navarre; and Gallego in Galicia. The languages were suppressed by Francisco Franco, who came to power in 1939 after a three-year civil war that saw his conservative Nationalists, backed by Hitler and Mussolini, defeat a liberal Republican government aided by Stalin.

In an emotional ceremony last October, a form of Catalonian self-rule abolished 38 years ago was restored. In the Basque Provinces continuing violence leads some to fear the birth of a Spanish Ulster.

Languages of Iberia

AREA: 194,897 square miles, including the Canary Islands and several North African enclaves. Spanish Sahara was ceded to Morocco and Mauritania in 1976. **POPULATION:** 35,400,000. **RELIGION:** Roman Catholic. **ECONOMY:** Olives, grapes, wheat, citrus fruits, wine making, shipbuilding, cork, minerals, fishing, tourism. An industrialization drive began about 1960 but peaked in 1974; unemployment rate, about 8 percent. **CITIES:** Madrid, capital (pop. 4,472,963); Barcelona (pop. 4,443,124); Valencia (pop. 1,923,942). **CLIMATE:** Wet, cool north; cold winters and hot, dry summers in central plateau; mild along the Mediterranean coast.

ALGERIA



across Spain now takes me, by chartered plane, to the far northeastern interior. Flying over almost constantly mountainous terrain, I glimpse landmarks of great preoccupations past and present. Lonely castles attest to waves of Christian reconquest from Islam, pushing south. This crusade—begun early in the eighth century, and lasting, off and on, for more than 750 years—removed Moorish rule from Spain for good.

Towns appear huddled, as if for defense; the rivers look puny. But man-made lakes are plentiful, some small, some huge. Modern Spain has built the most extensive system of dams and irrigation conduits in Europe.

IN SAN VICENTE DE LA SONSIERRA (population 1,200) two penitents redden their bare backs with rhythmic strokes from bundles of rope. It's a traditional act of faith. They lurch along streets lined with camera-pointing visitors, in an atmosphere of carnival. That ought to disappear, the priest tells me. But many villagers do not agree—it's good business, after all.

I fly on, south, over more sierras and reservoirs, across the rivers Duero, Tajo, and Guadiana, to land along the silty Guadalquivir in time for the last of the five Holy Saturday processions held in Seville.

The image of Our Lady of Solitude, with a brand-new gold crown, moves amid five-foot candles and scores of penitents carrying heavy crosses. Intermittently she stops, while a girl or an old man sings a *saeta*, an impassioned solo in praise of her.

Dead-tired in my rented car, a little Spanish-made Seat (pronounced SAY-ot), I unwittingly go the wrong way on a one-way street. I am stopped by an impassioned traffic cop of Seville: "This is an international sign, it's the same in Peking as in Seville! *Even Our Lord Jesus Christ riding a donkey in Jerusalem would respect a sign like this!*"

Alas, the Spaniard is a man of many words. My young friend Juanga, who accompanies me as an interpreter, warned me from the start: "In Spain you cannot be brief, it isn't polite, you must embroider. After all, we are human beings, individuals, not machines. . . ." Thank God tomorrow is Resurrection Sunday, and this poor penitent can sleep.

But no, a lot of Seats are out early, honking. From their windows thrust clenched fists and red flags with yellow hammers and sickles. The Communist Party suddenly is legal again, after 38 years. It's time for a backward glimpse into the passionate politics of Spain.

Two hours from bustling Seville, in the 3,000-year-old harbor city of Cádiz, I stand in the Church of St. Philip Neri, where men now put Christ back on the cross for another year.

El boom *rocks Benidorm.* Turistas *by the jetload from London, Paris, and Frankfurt join holidaying Spaniards seeking "perfect Mediterranean blues" of sea and sky. A fishing village twenty years ago, Benidorm now calls itself the capital of the Costa Blanca; it boasts 150 major hotels. A Pied Piper (right) touts one of the city's hundred discotheques. At the height of the tourist flood in 1973 about 35 million rained into Spain—one for every Spaniard—and spent an equivalent of three billion dollars.*

From this elegant marble floor, 165 years ago, a *Cortes*, or parliament, proclaimed a liberal constitution, calling for freedom and democracy for Spain.

It never really took effect and was formally suppressed two years later. Nine times since then has democracy been resurrected and buried again—often violently, with an aftermath of firing squads, imprisonment, and exile. Ever since the Cortes of Cádiz there has been a hardening of a long-existing division into two Spains: one liberal and innovative, the other conservative and traditionalist; each idealistically hostile to the other, uninclined to compromise.

A poet has written: "Little Spaniard coming into the world, may God keep you, one of the two Spains will turn your heart to ice."

IT'S A JOY to drive eastward in Andalusia, past vineyards growing grapes for sherry and meadows raising fighting bulls, through hill towns where every house is getting its spring whitewashing.

I give a lift to a young man in blue jeans. He's a soldier, and on weekends he hitchhikes from far away with his little bundle of clothes and red-handled bullfighter's sword. He hopes for a chance to learn on one of the farms—lucky bullfighters become millionaires.

I stop in cafés for politely embroidered conversation. How gracious everyone is to a stranger! One convivial evening a wasp-waisted girl from Seville picks up a guitar and sings: "I spoke with God. I told Him I love you. He told me to forget you. I answered Him, impossible." It's a fandango, she says, "Few words but strong feelings, from the heart."

So one disputes with God? "Yes, love comes first." She's engaged, she tells me later, but doesn't know when she'll marry. "We have love but not enough money. One must think of the future."

Next morning, on a narrow hill road where men are blasting to make it wider, I come around a bend and halt before an evocative panorama. Far on my right, a great square rock—Gibraltar. "We call it *la espinita*, the little thorn," says Juanga. "The British took it from us in 1704." Straight ahead is the Mediterranean. Far in the haze is Africa.

The last chunk of Spanish Empire, the Spanish Sahara, was given up in 1976, but a few enclaves remain on the Moroccan coast. That African peak above the haze is Monte Hacho, Juanga says. From there, in the summer of 1936, General Franco watched the embarkation of his Moorish troops—a crucial opening move in Spain's most recent civil war; after three years it ended in triumph for traditionalist Spain. Franco ruled as generalissimo and leader until he died at 82 in November 1975.

"To us that's not just a piece of our history, like what Hannibal did here or Napoleon there. This civil war is very close to us, and that is one of our big problems. We have not overcome those feelings."

Many have told me so, from both sides. Teenagers too. They know what happened to grandfather and to Uncle José. . . .

Of hundreds of thousands killed, most were victims of massacre behind the lines: landlords, officers, priests—"Fascists." Socialists, Communists, anarchists—"Reds."

Mass executions continued for years after the end of the war. Many of those picturesque castles were full of political prisoners. Now newspapers and magazines rehash the civil war almost daily.

Could it happen again? "That is the terrible question," a middle-aged publisher said to me in Madrid. "Spain hasn't stood still in the past forty years, but there still are two radically different conceptions about what the country should be."

We sat talking in a café favored by people of the left. He added that any moment young men of the extreme right might barge in and order everyone to stand and sing hymns of the Franco days. Should someone refuse, they'll beat him.

HAPPILY, tourists needn't worry about any of that. Down along the whitewashed Costa del Sol, or Sun Coast, in Puerto Banús near Marbella, visitors from southern California and Florida say it's just like home—the yachts, the sky, the pizzeria. A New Yorker says, look how clean, no garbage! A real-estate salesman exults over 330 sunny days a year, great golf, exclusivity. One bedroom with sea view, $45,000—villas up to $1,000,000; but hurry, prices are rising.

In Málaga I pause to admire the carnations for sale on the main boulevard—pink, yellow, orange—before turning my car toward the Sierra Nevada, where there's skiing half the

year just a two-hour drive from the subtropical Mediterranean.

At Capileira, at 5,000 feet the second highest village in Spain, a van with a loudspeaker proclaims: "I am the chick seller; I also have American turkeys, the biggest turkeys in the world. . . ." Capileira ladies buy briskly.

I learn that people here may be poorly dressed but have a lot of money in the bank. All from wheat and beans on these steep slopes? No, they also have 20,000 sheep. And there's a real-estate office: A Norwegian came in 1972; now 170 Scandinavians and Germans own land here; hotels are planned and ski lifts. A discotheque opens this summer.

On the other side of the Sierra Nevada, in Granada, the director of the Alhambra, that romantic Moorish fortress with pleasure gardens and pools, is happy about the big new parking lot. I rest in the shade, amid birds and splashing fountains—it's a Muslim idea of paradise. And all these good-looking damsels walking by. . . .

I hear music as crowds push into an amphitheater on the Alhambra grounds. Young troubadours in 16th-century-style knee breeches play guitars and mandolins and sing, romantically, satirically, exuberantly. Those damsels applaud madly.

It's a get-together of extremely eligible bachelors, the *tunas*, or university singing societies, from Murcia, Valencia, and Asturias, from Extremadura and the Canary Islands, from most of the many regions of Spain. To join, a student must be musical and give priority to having fun. Then won't one's studies take a little longer? *Claro*, but parents usually understand.

That night the Alhambra is gloriously lit. A *tuno* and a girl slowly walk away, his black cloak enveloping both.

NEXT MORNING I stand in the Royal Chapel before a gilded wrought-iron screen and the tomb of Ferdinand of Aragon and Isabella of Castile, the royal couple called the Catholic Monarchs.

They took Granada in 1492 and thus completed the reconquest from the Moors. They also gave decisive impetus to the long process of elevating a central power—in effect the crown of Castile—above the other kingdoms and regions on the peninsula. (The single exception is Portugal.) Castilian increasingly became the dominant language and Madrid, in due course, the center of the first modern bureaucracy. To this day domination from Madrid meets widespread resentment.

Outside the chapel I see a slogan sprayed on a wall: Andalusia wants autonomy! Similar feelings churn in every corner of Spain, prompted by pronounced cultural differences.

It's not only that Catalonia, Galicia, and the Basque region still nurture different languages. "Cross another mountain," I've been told, "and you're in another country."

Indeed, a leading newspaper talks of 15 Spains, a nation of nations, a people of peoples. Long-smoldering problems of regionalism are heating up.

BACK IN MADRID a sociologist explains. Under the 16th- and 17th-century Habsburg monarchs, former kingdoms kept their laws and privileges. The notion of one big centrally run Spanish state was brought from France by the 18th-century Bourbon kings and glorified by 19th-century ideologues and 20th-century generals. To his dying day, Franco—himself a Galician, but imbued with the spirit of centralism—extolled the grand enterprise of building one Spain, united and great. Quite a few Spaniards remain faithful to this ideal.

"And so for 200 years centralism has sought to suppress the individuality of the regions. But the ways of the Catalans or Galicians or Andalusians or Basques are still quite different from those of Castile. . . ."

I hear a lot about Castilian attributes. Castilians love to talk about them.

A restaurateur in Segovia noted for especially tender suckling pigs—he roasts about ten thousand a year, plus mountains of baby lamb—says Castilian food is hard to digest. "But we are a hard people, conditioned by our hard climate, very cold and very hot."

A Madrid executive descended from 16 generations of dukes tells me: "We have some virtues and some big faults. We are very idealistic, and so we tend to go to extremes. But we also are very individualistic—we all want to be first, and when we can't be, we criticize fiercely. We are loyal to family and friends. We have *orgullo*." That means pride, also stubbornness, sometimes arrogance. "And we are very hard with our enemies. Dialogue is difficult."

I ask a journalist to characterize some non-Castilians.

"Catalans," he says, "are sentimental, pragmatic, good traders. Open to discussion and compromise." Basques: "A very close society, inflexible, good at sports. Hard workers. They feel they're an ancient super-race." Andalusians? "Exuberant, clever with words, philosophical. Good at getting the most with the least strain." And what of Gallegos, the people of Galicia? "Nostalgia-prone, soft-spoken, don't like to commit themselves. Good politicians."

He says these are all stereotypes, of course, but there's truth in them. "If you want to meet some really curious people, go southeast. . . ." No, I'm off to the Bay of Biscay, to the land of those inflexible Basques.

IN BILBAO after midnight, in the drizzle the Basques call *sirimiri*, teenagers dance in the street to the tunes of a *txistu*, a little Basque flute. Playing it in public could have led to arrest only a few months ago, they say. Never has it been played as much as now.

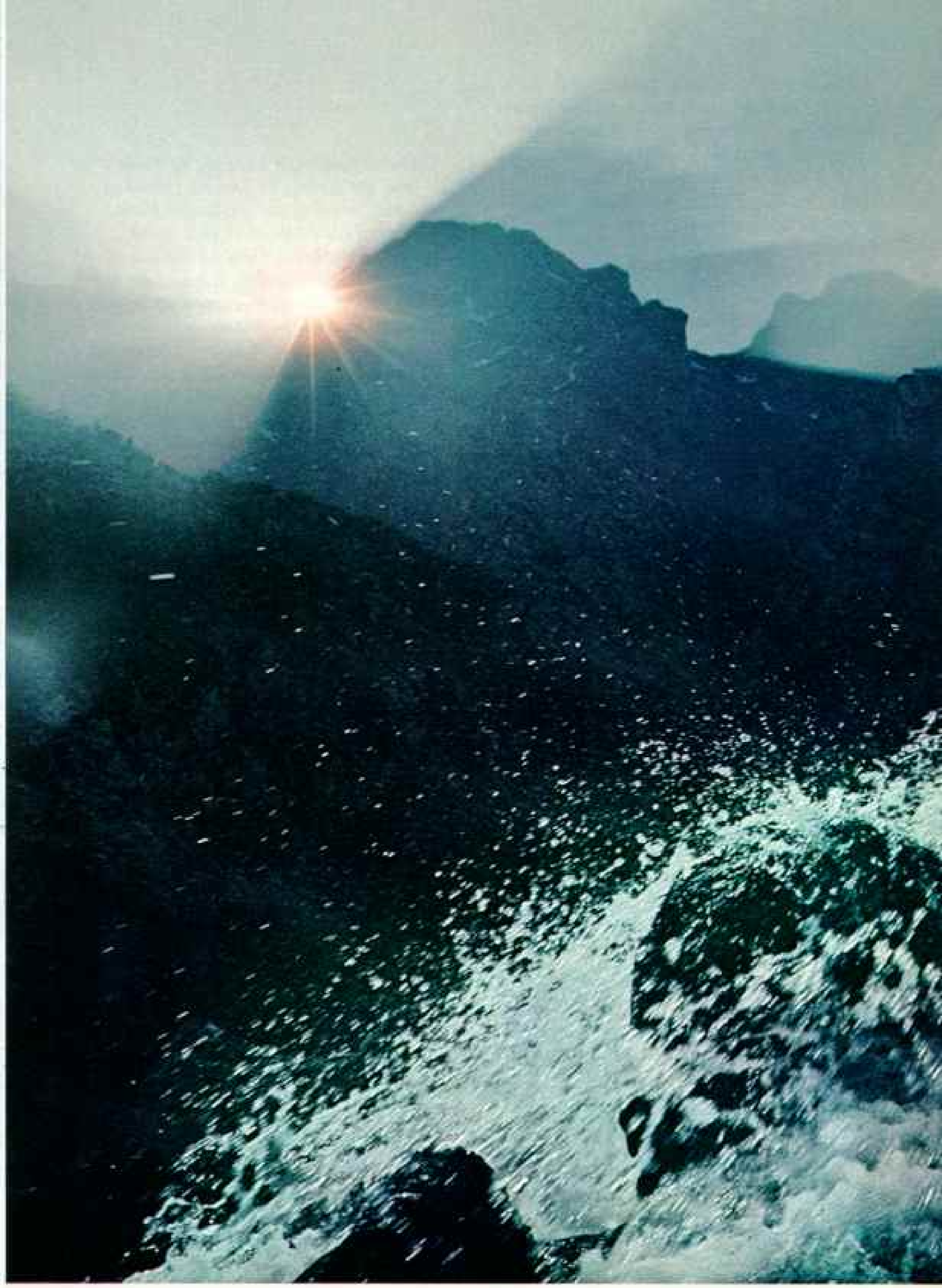
A young artist tells me that for years the Basque language was suppressed too. Many city people in their 20's and 30's can't speak it, but they're learning, and their parents are pleased. "Among kids, if you don't speak *euskara* you're out."

I take the superhighway east—past high-tension lines and factories, along rain-washed hillsides with sturdy cattle and farmhouses built of stone from the Cantabrian cordillera—to San Sebastián, the pearl of the Cantabrian coast, a traditional summer resort.

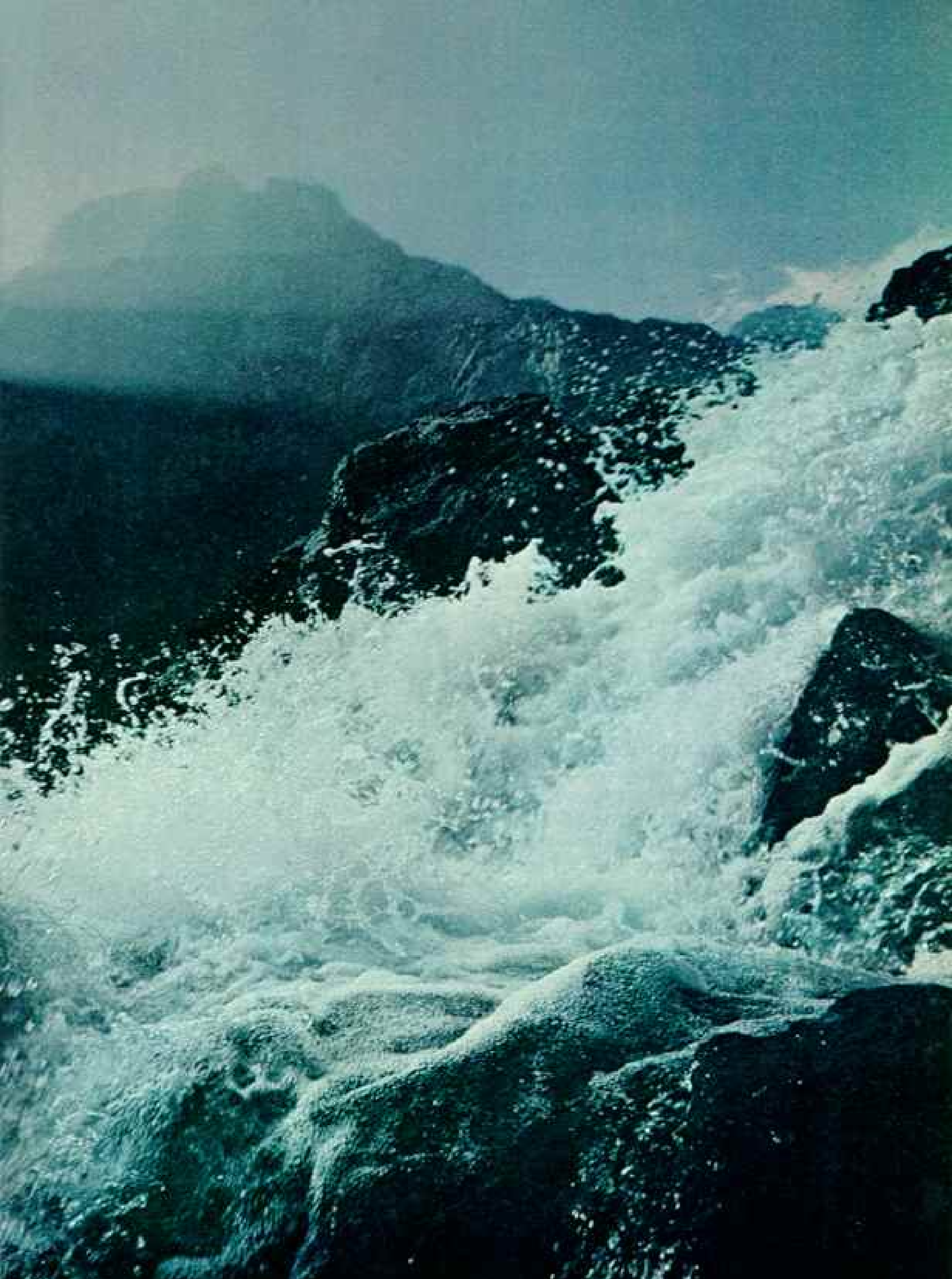
Waves crash against pine-topped rocks guarding curved beaches. A statue honors Juan Sebastián Elcano, the first navigator to sail around the globe. He went with Magellan in 1519 and pressed on after Magellan was killed in the Philippines. Many Basques served as navigators for Spain's traffic with the New World.

San Sebastián is a hotbed of fastidious eating, most intensively pursued by gastronomic societies in the old quarter (page 315). Early in the evening members go to dozens of clubhouses and cook for themselves or for a table of men. "We also sing a lot," says the secretary of the Gaztelubide Society. "We come from different circumstances, but when we pass the door we are equal." Women may enter on special evenings twice a year.

Burdened with beauty, *a farmer and his donkey in Zamora Province haul flowering* nabiza, *turnip plants, to feed his cattle or to be pressed for vegetable oil. Only 40 percent of Spain's soil is arable, much of it nurturing olive groves, vineyards, and orchards. An impressive irrigation system helps, but it helps a dwindling labor force. A million fewer Spaniards worked in farming in 1972 than in 1962. Many a son heads for a city factory rather than retrace his father's uphill struggle.*



With primeval thunder, a torrent leaps from a rocky cleft in the



Picos de Europa in northern Spain's Cantabrian Mountains.

Around a gas stove I see men intently stirring, smelling, tasting. The secretary concocts a sauce to go with cod and asparagus. "Onion. Wine. Parsley. Garlic. Very light! The main thing is to know when to take it off the fire."

Outside there's riot in the narrow streets. Young demonstrators shout for autonomy! For amnesty for political prisoners! Against police repression! Some clutch broken bricks to use as missiles.

Crack! I duck into a doorway, along with a boy and two girls. Those are rubber bullets—fired by riot squads of the paramilitary Policía Armada, the gray-clad police commanded from Madrid, on duty in all fifty provincial capitals. Those fat black rubber balls can kill.

Tear-gas canisters also fly by; one smolders on the pavement outside our doorway. The smoke feels like a knife stuck into my nose. From an upstairs window, water splashes down to douse the canister. A girl says the police will be here at any moment, truncheons flailing.

I'm glad to be back in the clubhouse. An old member bemoans the younger generation. "All they know is to fight the police. But nationalist feeling is strong in all age groups."

A FOCUS of this feeling is the little town of Guernica, enshrining the stump of an oak beneath which monarchs of Castile swore to respect the ancient laws of the Basques; among these were that none shall be imprisoned without trial, or threatened with torture. Those laws were suppressed in 1876. But a seedling of that oak has produced another tree, now tall and green in the mist of spring.

Forty years ago this day, German airmen flying for Franco devastated the town. Red-white-green Basque flags, newly permitted, are fastened across balconies; I see flags with a bit of black cloth or a black beret affixed to the middle, marks of mourning. A picture exhibit presents hundreds of schoolchildren's

Rage rears untamed *as stallions battle for supremacy during a roundup of wild ponies in Galicia. Wranglers test their machismo by throwing the horses bare-handed. Manes are then trimmed and the hair is sold to make fine paintbrushes.*


Selmer
CARUSO

visions of that bloody day. One—just one, signed Yolanda—shows a dove with an olive branch. At a crowded Mass the priest calls this a day not of death but of life renewed.

Leaving the Basque country, I pass the town of Tolosa. ETA, a far-left organization of Basque ultranationalists, held up a bank here two days ago and killed a sergeant of the Guardia Civil. That's also paramilitary police—centrally controlled, uniformed in green with black patent-leather hats, patrolling the smaller towns and rural areas.

The army general heading the Guardia Civil has come from Madrid for the sergeant's funeral. "He died for law and order," the general tells me. "We must fight the terrorist forces that menace all Western civilization."

Sad faces peer from an apartment house for Guardia Civil families. Across the balconies, white bed sheets are fastened; in the middle of each is a bit of black cloth.

FOR CHEERING UP, I can imagine no more exhilarating place than Barcelona, the metropolis of the Catalans—especially the Ramblas, the long chain of boulevards with a broad walkway in the middle. Kiosks for newspapers and books, stalls with flowers, fruit, nuts, and birds—all under plane trees rustling with Mediterranean breezes while thousands stroll, just stand around, or lounge at café tables, drinking, talking, dreaming. . . .

Barcelona's exhibitions also sparkle. I see frescoed saints and carved madonnas from Romanesque and Gothic churches all the way to the Pyrenees—a legacy of medieval glory. Seaborne Catalans once conquered Sicily, Sardinia, and Naples.

An entire museum is devoted to the most influential painter of this century, Pablo Picasso, who came from Málaga and went to Paris but spent his youth here. The annual auto show unveils new models of the world-renowned motorcycles made in Barcelona by Bultaco (following pages).

I wander through the Spanish Village, an artificial little town with an arcaded main square, typically Castilian, set among specimens of regional architecture. It's left over from the International Exposition of 1929; craftsmen ply traditional trades—glassblowing, pottery. Tourists love it. If only Spanish unity could be built as readily.

¡Exquisito! ***"The Nose" knows.*** *José Ignacio Domecq lives up to his nickname as he tests sherry in Jerez de la Frontera* ***(facing page)****. Jerez means "sherry," and that often means Domecq, a top producer of brandy as well. In San Sebastián a Basque gourmet* ***(below)*** *savors a seafood dish in one of the city's many all-male gastronomic societies.*

Barcelona throbs with Catalan consciousness. Censorship is off and publishing thrives, in Catalan. A professor of philology describes it as a bridge language between French and Castilian, closer to Latin than either, with a great literature and numerous dialects. In the Balearic Islands it's *mallorquí*. Would he say something in pure *català*? "Certainly. *¡Volem l'Estatut!* We Want Autonomy!" One sees that slogan all over.

To most of the Catalans I meet that doesn't mean independence. "My heart is in Catalonia," a manufacturer says, "but my head is in Spain."

A businessman adds, "We simply want to be recognized as a people. When the Castilians hear this, they call it separatist, but all that most of us really want is some control over our own affairs."

He'd gladly settle for a federal system, with no more local power than each state enjoys in the U. S. "Why shouldn't we have something to say about our roads and our schools? Or what industry we want here? Why can't they understand that?"

Off the Ramblas I squeeze into a jammed exhibit of posters from the turbulent past. Catalan Republic, 1931! Catalan self-government, the Generalitat, 1932! From the year 1939 there's a big calm face of Franco. Some of the slogans are just like today's.

DRIVING SOUTH, I pass crowded industrial suburbs and fashionable beaches, a refinery and a cement plant with its own little harbor. Much cement goes to the U. S. Then it's more beaches of the sunny Costa Dorada, the Gilded Coast.

At the delta of the river Ebro, silt has built up a marshy promontory. Marsh birds and mosquitoes seem to love it.

Now it's the Costa del Azahar, the Coast of the Orange Blossoms, with clusters of glassy apartment towers. Then a refinery again, construction cranes, dense traffic—I have arrived in Valencia.

But I still haven't left the Catalan language area. The professor called Valencian a Catalan dialect. Valencians say it's a language

***Grandfather's toy**—a rugged, powerful Bultaco motorcycle—delights a grandson, as Francisco Bultó takes a spin through his vineyards (**right**). Many off-the-road bikers swear by the machines his company builds. The bikes are hand-assembled in Barcelona (**below**), an industrial magnet that draws workers by the thousands from other regions, especially Andalusia.*

of their own. They had a form of self-government too, until the early 1700's.

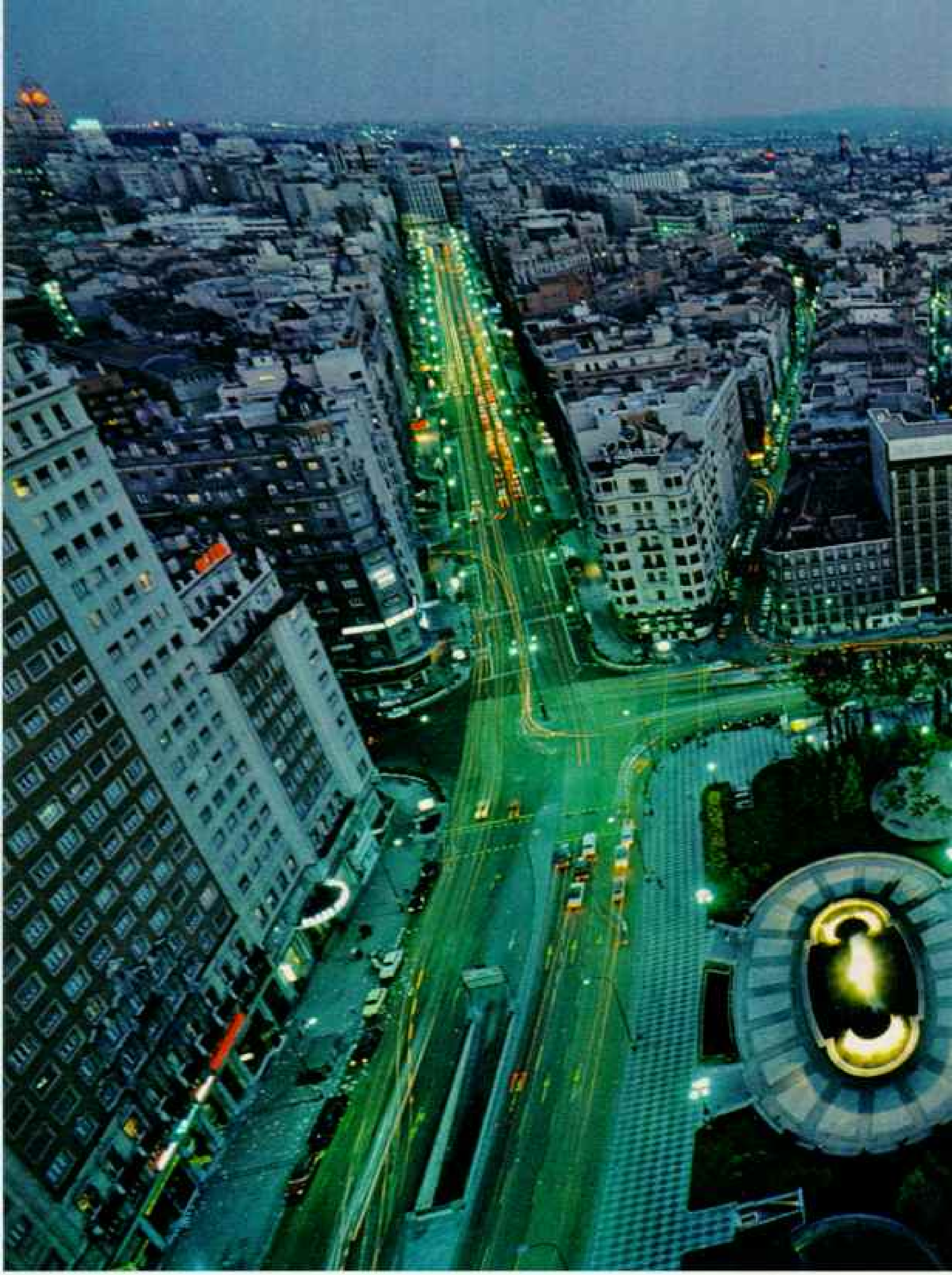
On a seaside terrace I eat *paella valenciana*, bits of meat, seafood, and chicken mixed into saffron rice—best when it's "relaxed," not sticky, each kernel distinct. I meet university students distributing leaflets—they're on strike. Why should Madrid dictate their courses? Is that democracy?

I GO to the brand-new Ford plant just south of Valencia—built for 400 million dollars to turn out a thousand cars a day, the new Ford Fiesta. Nobody there but the Guardia Civil. It's a lockout. Workers say 530 cars a day should be enough.

Back in Madrid, employees of the national airline demand a raise of 118 percent. They're offered 25 percent. Inflation in Spain is running at 30 percent a year.

"Our economy is in serious trouble," a shipping magnate tells me. "Some of the biggest industries are nearly bankrupt." A banker says investors are holding back because of political uncertainty.

Yet for a long time the economy was booming. True, if measured on a per capita basis—gross national product divided by the number of people—this country is still relatively poor, ranking near the bottom in Europe with Ireland, Greece, and Italy. But in more glamorous indexes, Spain had done herself proud: between 1960 and 1973, one of the highest economic growth rates in Western Europe—by



"There was Madrid, and I carry it like a photograph in the inside-pocket of my mind," wrote novelist Elliot Paul. A monument to Miguel de Cervantes rises from

the central Plaza de España, while the night comes alive on the Gran Vía at left. The Royal Palace, upper right, is used by King Juan Carlos to meet official visitors.

1970, fifth place in industrial output. In world shipbuilding, fourth!

Now, amid worldwide economic slowdown, there's less demand for Spanish ships. Spanish workers who used to send home much foreign currency from Germany, France, and Switzerland are drifting back. . . .

THE LATE BOOM in Spain is linked to sizable changes on the central plateau, as I can see as I drive northeast from the middle of Madrid. On Castellana Avenue aristocrats' mansions have given way to office blocks. After the last Metro station it's Univac and Coca-Cola, ITT and a kitchen-appliance factory; the Pegaso truck plant; and the air base at Torrejón de Ardoz, built to accommodate the United States Air Force. U. S. aid, military and economic, helped start the boom. I pass more factories amid open fields. Then the town of Alcalá de Henares, Cervantes' birthplace, steadily adding high-rise apartment buildings. And more industrial plants all the way to Guadalajara. That's

still no more than an hour from Madrid.

Beyond that bustling core, much of the Castilian countryside—some 100,000 square kilometers in the center of the Iberian Peninsula, always sparsely settled—has to a considerable extent been emptied of people. This is an area bigger than Hungary. It has been called the Iberian demographic desert.

"The young move away," a farmer tells me 240 kilometers on, where steep, eroded, reddish slopes recall the arid American West. Irrigation lets him grow fruit and potatoes, but hoeing is hard work. "They'd much rather go and work in factories." Most of the jobs are around Madrid or Barcelona or Bilbao.

Many a village stands nearly empty, with only an old couple or two in permanent residence. Such a place is Peroblasco, on a hill along a little river. A painter has bought a house here, but he is away. At dusk a shepherd brings his flock down from a nearby mountain. And because it's Saturday, three cars arrive from Madrid, with four young couples. One of the men, a geologist, has bought a

The possibility of death *hurtles past a matador—a spectacle that thrills aficionados by the millions. The national passion is boosted by favorites like Alvaro Domecq (above), who prepares himself spiritually for the ring. He fights on superbly trained horses, a style known in Julius Caesar's time.*

house here too, and is bringing friends for the weekend. He says quite a few Madrid people do the same, it's not expensive.

The big exodus has been a boon to wildlife, I am told, but not for *el buitre leonado*, the "lion-colored" or griffon vulture. It used to be a rare village day when some mule or sheep didn't drop dead, and people were glad to see vultures then. They still are. But with so much less carrion around, the vulture population dwindled. And so the Bird-of-prey Refuge of Montejo has been established, with vultures as primary beneficiaries.

They eat all they can at a feeding ground high on a cliff, glide off to their nests, and regurgitate for their babies. A refuge guard says a meat-packer sends carcasses that do not come up to standard but are free of disease. Two years ago there were 250 vultures in residence. Now there are 350.

We talk of silent villages I've seen nearby, of tile roofs fallen in and adobe washing away. His village is different, he says. Thanks to a dam finished in 1962, it has good irrigation and sugar beets, and very little emigration. So it's a good life in Montejo de la Vega de la Serrezuela? *¡Hombre!* Yes!

He shows me his house. His oldest son, who works in the Michelin tire plant at Aranda de Duero and also helps in the fields, has rebuilt the inside. All is modern.

He takes me to his cave. He dug it with his brothers on winter nights in the lean years after the civil war. Here their wine matures after pressing in the cooperative.

He says they come often, in winter every evening. Why watch TV and be bored? It's much better here, talking and drinking with friends, playing cards. "We taste many good moments here." Especially on Sundays, with chops or cutlets on charcoal.

AT THE ROYAL PALACE in Madrid, plumed guards present arms, cavalry sabers flash—foreign ambassadors hand their credentials to Juan Carlos I, King of Spain. He plays a key role in the Spanish political drama (pages 328-9).

He speaks of a new stage in Spanish history—of respecting social, economic, and individual rights, regional characteristics, and the popular will. He says all should participate in the decision-making process. He also is determined to uphold traditional values and the unity of Spain. He is walking a tightrope.

How popular is Juan Carlos? Many tell me that nobody is a monarchist in Spain today, but without him there could be no peaceful transition to democracy—the right and left would be fighting by now. Even Santiago Carrillo, the secretary-general of the Communist Party, approves of his moderating role.

Yet quite a few don't like it at all. I hear bitter talk in a bar favored by right-wingers.

"This king is ruining all the work of the *Caudillo*"—of the Leader, meaning Franco.

"He's selling us out."

The speakers feel doubly betrayed. Juan Carlos—a grandson of the Bourbon Alfonso XIII, who left in 1931—is king today because Franco appointed him. Adolfo Suárez, the prime minister picked by the king, used to be secretary-general of the National Movement. Now Suárez says on TV that he is for democracy, that he approved legalizing Communists because they're Spanish too. . . .

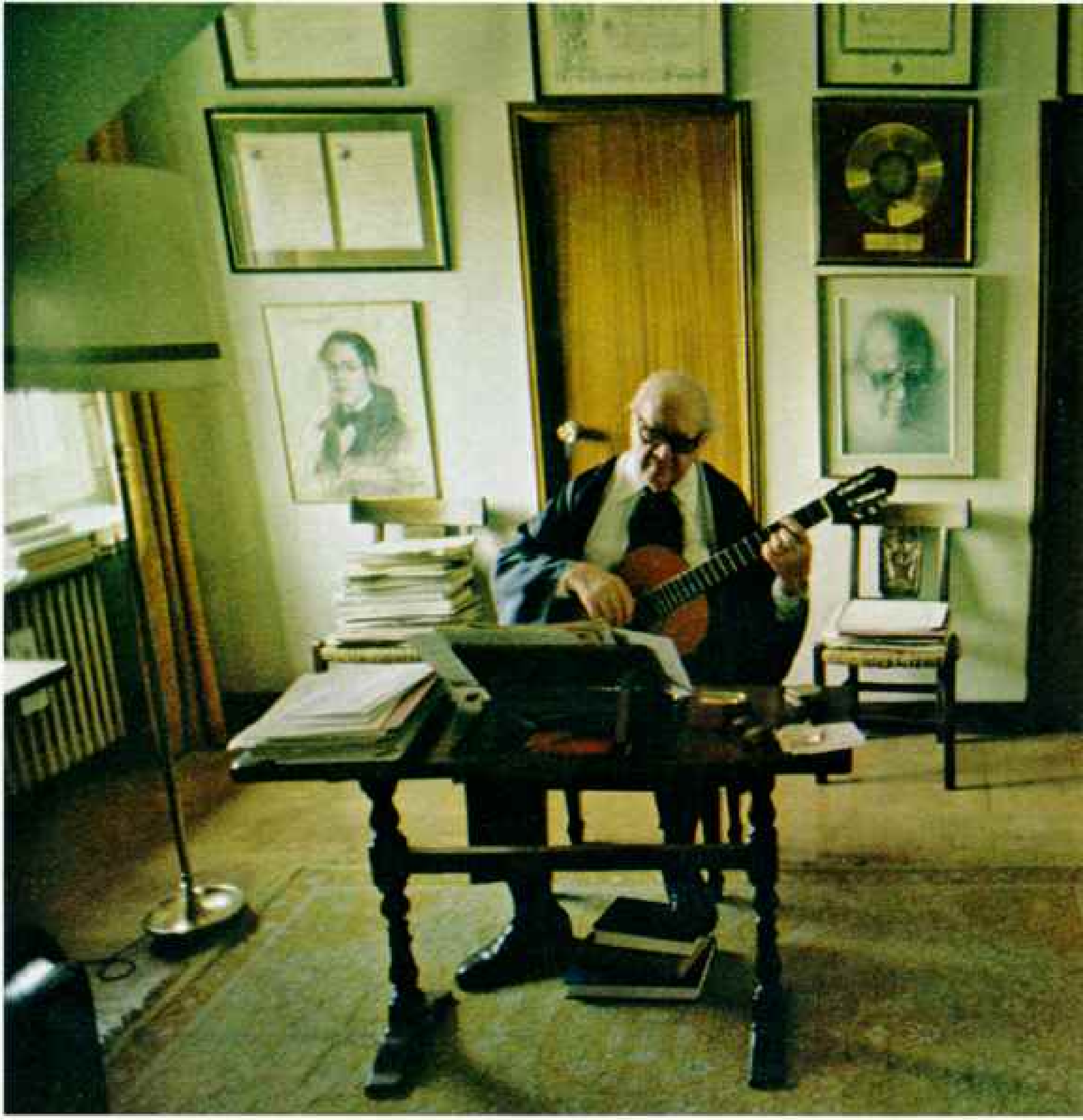
Nostalgia for Franco wells up at meetings of the Fuerza Nueva party (pages 324-5), in speeches by its leader, Blas Piñar. He calls Marxism satanic and democracy dirty; he doesn't care about elections: "What matters is loyalty to July 18th!" That's the day Franco's proclamation ignited the 1936 uprising.

Pardo Palace, where Franco lived and worked, has been opened to the public. I see pictures he painted, photographs of him with trophy stags and trout, the altar in his bedroom where he kept a reliquary with a hand of St. Teresa of Avila. A middle-aged lady visitor commiserates with a guide.

"For forty years we have been living well," she says, "but I fear for the future. These young people. . . ." He says he can't open his mouth at home or his sons land on him very hard. She says, "We need a strong hand and a lot of work, and the first that moves out of line, crush him with a club."

I AM OFF on a final trip to the Iberian periphery, starting with the moist northern region of Asturias and its Picos de Europa—jagged peaks that rival the grandeur of the Rockies, a climbers' paradise (pages 310-11).

The snow is gone, the valleys are muddy. People wear wooden clogs. They pour very hard cider, great! But can one get to love goat cheese with live worms in it? A village lady noted for her *cabrales* tells me that in July,



and in August, flies lay eggs on it as it is made, so there will be worms. But now in early June there are as yet no flies. Alas, the early cheese gets no worms, and so I'll never know.

I follow the river Sella rushing north to the Atlantic through the gorge of Los Beyos. Limestone rises sky-high, stark and straight. After a gorgeous day of fishing for salmon, what's more welcome than this sign at the little bridge? *Bar y Camas*—Bar and Beds.

Turning westward along the shore, I pass a huge steelmaking complex at Avilés and follow the curvy roads of the Costa Verde, the Green Coast. It is steep and rocky, reminiscent of Maine and Oregon. And then I'm in the peninsula's northwestern corner, on the Costa de la Muerte, the Coast of Death.

*"**I found the guitar** almost at a standstill . . . and raised it to the loftiest levels of the music world," wrote Andrés Segovia. In his Madrid apartment he fingers the instrument that few classical musicians took seriously until he began to make it sing the strains of Bach and Spanish composers such as Manuel de Falla.*

The nation's musical gifts to the world also include pianist Alicia de Larrocha, soprano Victoria de los Angeles, and the late cellist Pablo Casals. In 1939 Casals left his homeland to protest the Franco regime. He returned only once.

"Franco! Franco! Franco. . . !" His memory lives at a rally of the ultra-conservative Fuerza Nueva party; the National Movement, the only political organization Franco permitted, has been abolished. Last June Spanish voters rejected the legacy of el Caudillo*—the Leader; Fuerza Nueva won less than one percent of the vote. The big winners: a centrist coalition led by Prime Minister Adolfo Suárez, with 35 percent, and the Socialist Workers Party, with 29 percent.*

Freedom of expression explodes with displays that would have horrified

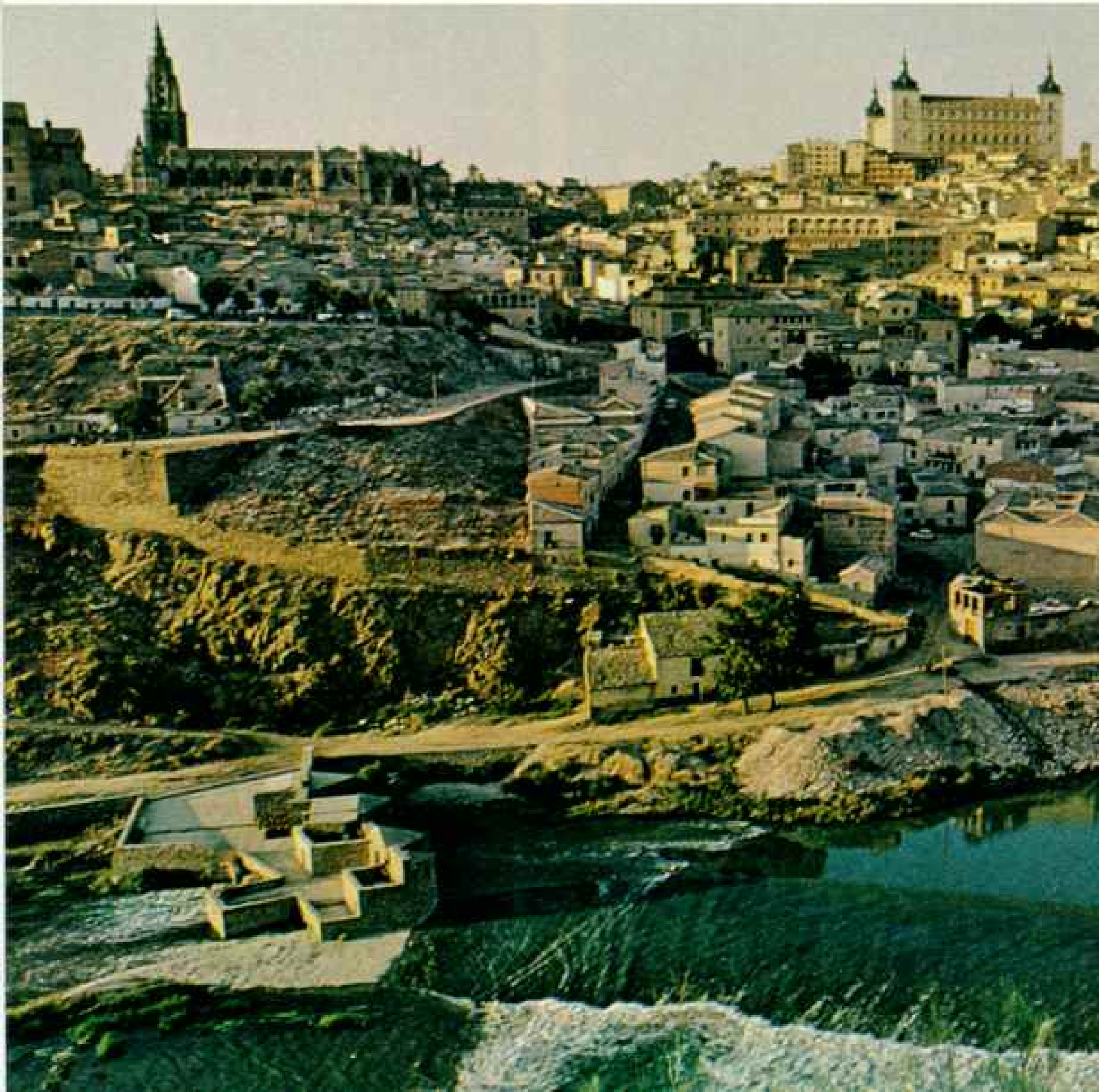
*Franco. Graffiti bloom in Madrid (**left**), while cosmetic Communism and the striped flag of Catalonia color a Barcelona beach party (**right**). A testament to Franco's oppression surfaced a month after the elections, when Protasio Montalvo (**above, right**) came out of hiding. In this small basement apartment Montalvo, former Socialist mayor of the town of Cercedilla, spent nearly every day of his life after the Nationalists triumphed in 1939. His family kept his secret. "I am surprised that I can still talk normally," he says today, "because for 38 years I whispered."*

Tourist brochures don't call it that, but the fishermen know the name well. Many boats have sunk here, from the Cape of St. Adrian to Cape Finisterre. A lighthouse keeper says it's the fog and the wind, the huge waves and the rocks just under the surface. Sunbathers cluster on gentle beaches farther south.

I note a construction boomlet at Camariñas; the men have been away, making good money on oil rigs in the North Sea. But on the whole, Galicia still is one of the poorest regions, with a traditionally high emigration rate. Inland, at Santiago de Compostela, the old pilgrimage center and university town, I ask about the spray-painting on the wall. *Galicia Ceibe?* That's *galego* for Free Galicia.

In deepest Galicia, in the valleys of the Sierra del Caurel, I meet sturdy characters of another time. A woman walks on a mountain path, twisting fibers onto a spindle as she goes. The result, eventually, will be wonderful socks. A man who puts me up for the night walks nine hours every other day, up and down steep mountainsides, delivering mail to scattered hamlets; he just made himself a new wooden plow.

In the morning another man is out looking for a sheep named Morita. He worries that a wolf might have gotten her. Not long ago a wolf grabbed one of his sheep, but he held on at the other end until the wolf let go. "All he got was a mouthful of wool."



FOR FUN and romantic reflection, the highpoint of my final excursion is the arid, underpopulated region on the Meseta bordering on Portugal: Extremadura, the "land beyond the river Duero." Hence came great explorers and conquistadors, Cortés and Pizarro, Balboa and Orellana, Pedro de Alvarado and Hernando de Soto. And now it's fiesta in Plasencia!

The shops are closed for days, nobody works, one drinks a lot and sleeps little. There's *King Kong* at the movies, there's a "sexi show." Tomorrow—Alvaro Domecq (page 321), the bullfighter on horseback!

And then, Cáceres by night. I pound the cobblestones and wonder. That tower with

***Castilian roots run deep** in Toledo, the Spanish hub until Philip II established Madrid as the capital in 1561. A few years later El Greco fell in love with Toledo and immortalized it on canvas. The Infantry Academy crowns the river Tajo's bank, at right, while the famed Alcázar rises at center. There, in 1936, a Nationalist colonel withstood a two-month siege by Republicans, who shot his captured son after the colonel refused to surrender.*

A soldier at nine, Don Felipe, Prince of Asturias, the king's son and heir apparent, joins the army in a ceremony (right) in Madrid. Proud onlookers include King Juan Carlos and Queen Sofia, and Prime Minister Suárez, smiling broadly over the prince's left shoulder. The king, Franco's handpicked successor, had his legitimacy confirmed when his father, Don Juan de Borbón, renounced his own right to the throne. King, prince, and the family dog, Mika, share a quiet moment (above). Juan Carlos, a stabilizing force in a time of change, told photographer Harvey: "I truly want democracy, but some Spaniards just don't understand how democracy works. They want to push too far, too fast."

its highest battlements intact, a rarity hereabouts. The Catholic Monarchs lopped off castle tops to let the nobles know who would be master. . . . Over there broods the mansion built by Juan Cano Moctezuma. His father, a comrade-in-arms of Cortés, had married an Aztec princess, a daughter of the doomed ruler of Mexico. . . .

There is magic in old Cáceres in the moonlight. One feels a presence of that hard, proud breed—of Castilian idealism and will to rule—that enabled Spain to assemble an empire more vast than that of ancient Rome or modern Britain. It lasted 300 years.

Cathedrals built with Castilian zeal still dot the New World, and many a man in Mexico City or Buenos Aires, no matter what his accent, will tell you proudly that he speaks castellano.

ON SUNDAY before the election, a thousand meetings erupt across Spain. Cars with loudspeakers, millions of posters and leaflets, all proclaim urgent messages.

The far right says, "Fewer parties and more work!" From the more moderate right: "Want to keep your country house? Vote Alianza Popular!" Prime Minister Suárez heads a 12-party coalition calling itself Unión de Centro Democrático; it's for democracy.

PSOE, the Socialist Workers Party, says Socialism Is Freedom! The Communists say Communism Is Democracy! Anarchists put up a big black A. They say don't vote.

On election day in Madrid, I see an old woman befuddled by her 12 ballot papers with 366 names. She's heard Suárez isn't bad. A young woman tells her: "No, Socialists are best." Old woman: "Well, you're young, you must know. Who is a good Socialist?"

The prime minister's coalition gets 35 percent of the vote and 165 deputies; the Socialists of PSOE are not far behind. Communists get 20 seats, the right only 16. The king addresses the new Cortes that is to write a new constitution, the tenth since 1808. The old Communist firebrand Dolores Ibarruri—called La Pasionaria, the passion flower, just returned from exile and promptly elected from Asturias—sits with men who with Franco fought Reds as the incarnation of evil.

"Democracy has begun," declares the king. "Now we must try to consolidate it. We must endeavor to eliminate forever the historical causes of our confrontations. Tolerance is by no means in contradiction with strength of conviction. . . ."

There is widespread relief that the election went so quietly. Now if only the workers would stop demanding big raises, if only the wealthy would start paying taxes. . . .

Municipal elections will be next—no longer will local officials be appointed by the Ministry of the Interior. The left is expected to make sizable gains. Then could it be 1936 all over again?

Meanwhile demonstrations are still met with tear gas and rubber bullets. Demonstrators die, policemen are assassinated. I remember two men talking one ugly day. This chaos must be stopped, said one. The other said, "But it's the police who make the riots."

And then they got to the heart of the matter.

"Look, if you are forbidden to cross the street, and you cross it, you can't complain if I beat you."

"Hombre, if I am sure I have the right to cross, and you beat me because I do, then I'll beat you. . . ."

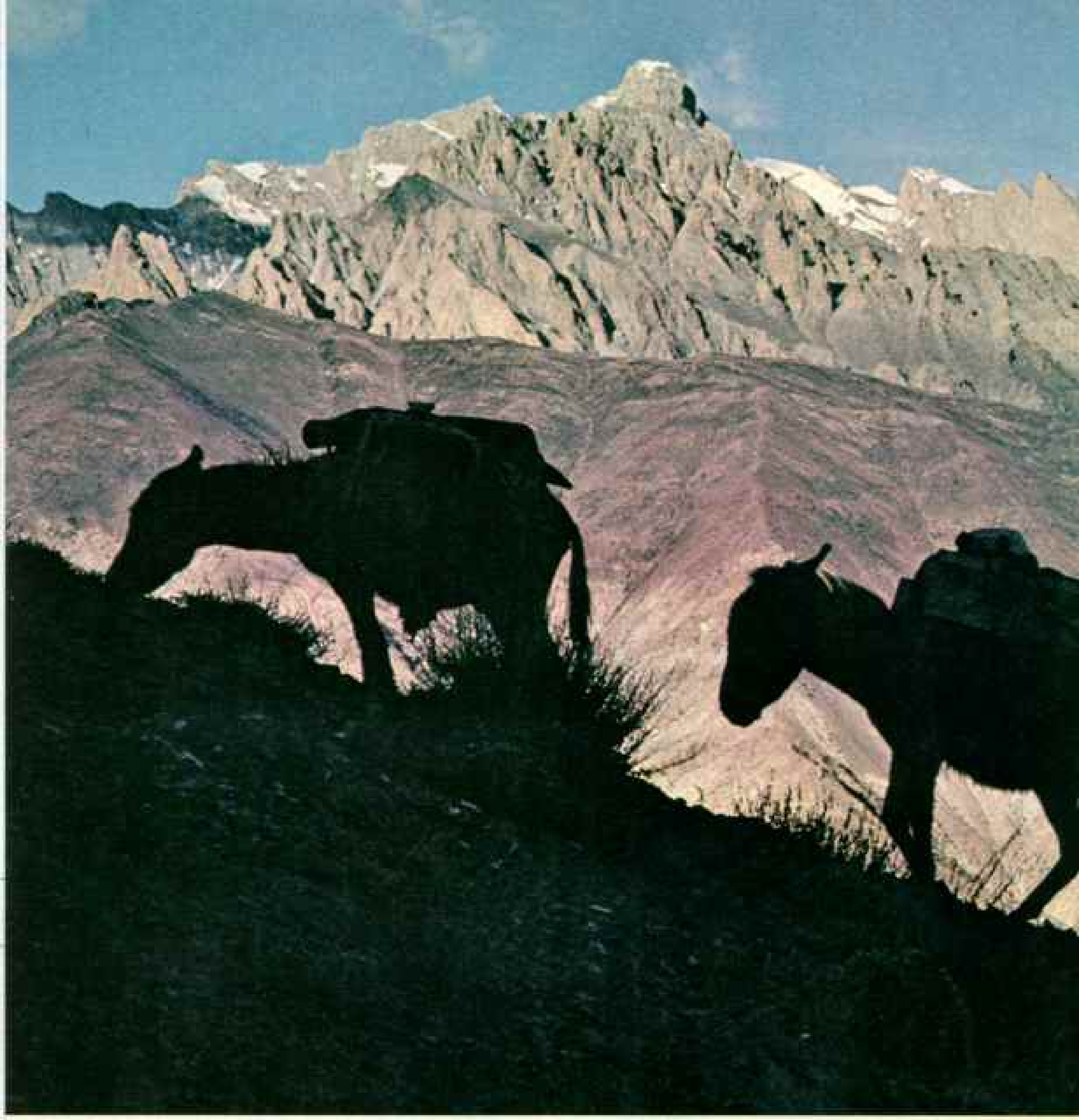
Certain generals are said to be itching to step in—to restore order, to uphold unity. The government proposes to retire officers over 55. Would they go quietly?

A wise old industrialist tells me Spain is like a volcano. "It can be very beautiful and calm, but when it erupts, everything is possible. Serenity can be lost very easily."

Will this volcano hold its temper? That's still the big question—and the hope—in Spain. □

***Two Spains** relax side by side as Basques gather on a dock in Bermeo. Older women clad in traditional black stare out to sea, while a young couple caress their firstborn son. What kind of future will he inherit?*

Don Quixote, Cervantes' dauntless warrior, recounted an adventure in which an enchanted knight had long languished under a sorcerer's spell. "Patience," the knight said, "and shuffle the cards."



Ladakh–The Last

Amid the rumpled mountain fastness of India's most remote district, the author's party labors across a 4,600-meter pass (15,000 feet). Here, in the forbidding terrain of the Himalayas, a robust people embellish their frugal lives with rich endowments of faith.

SINCE QUITTING the yak-herders' camp at daybreak, our small caravan had plodded up the faint track along treacherous slopes of scree, across splashing glacial streams, and finally over the last jagged ramparts to Achirik Pass. Although a minor watershed by Ladakhi standards, it registered 4,800 meters on my

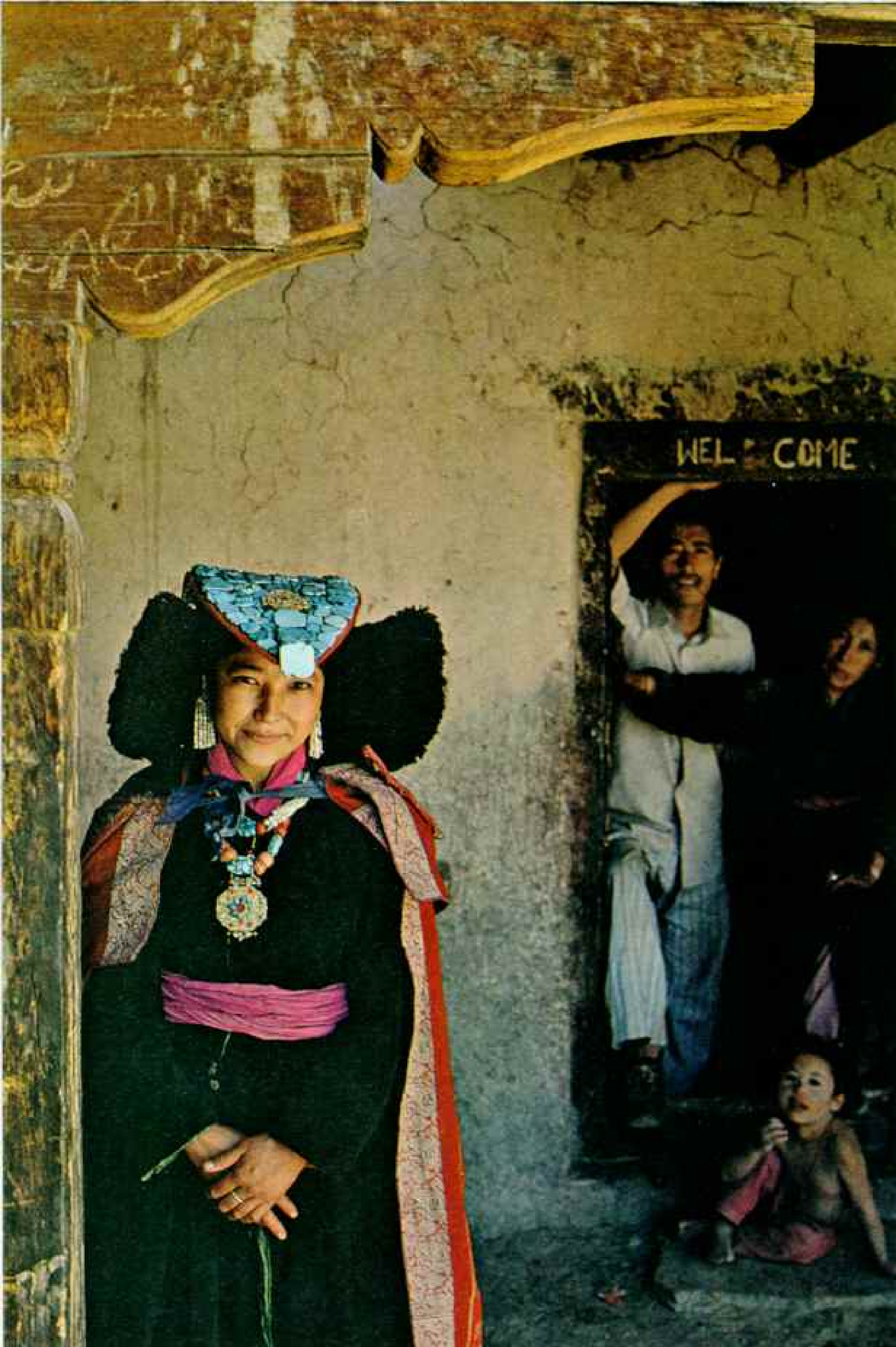
Shangri-la

ARTICLE AND PHOTOGRAPHS BY
THOMAS J. ABERCROMBIE
FOREIGN EDITORIAL STAFF

pocket altimeter—a few footsteps higher than snowy Mont Blanc, the Alps' highest peak.

We halted in the whipping wind, struck breathless by the thin, cold air—and the panorama! Far below, the cold gray Indus—raging from even loftier sources in nearby Tibet—coiled through the heartland of Ladakh, a dun-colored moonscape encircled by glistening peaks. In narrow valleys watered by melting glaciers shone occasional patches of green, oases in a vast Himalayan desert.

Though less exhausting than the climb, the long descent proved more hazardous. On a slippery ridge the donkey loaded with my cameras stumbled toward oblivion. Teamster Tsering Stobdan, digging in his heels,


WEL COME

managed to drag it to a halt. Farther down I had my own brush with disaster.

"Rock falling!"

It was Nawang Tongspon, my Ladakhi friend and interpreter, on the trail above me. I saw the dark speck, an accidentally dislodged stone, growing larger and bounding right for me. Suddenly, striking an outcrop, it exploded into a fusillade. Leaping to dodge the deadly fragments, I missed the narrow path and found myself slipping toward the cliff's edge. Clawing at the sharp rocks, I wrenched myself to a stop just in time.

I nursed my bruises at the hospitable hearth in Sonam Paljor Ezangs' kitchen at Achirik village (pages 340-41), our first prolonged halt on a ten-day trek through central Ladakh. We sipped cupfuls of *solja*, tea heavily flavored with salt and yak butter, while Sonam pressed me for news from the outside world. His children, who hid at first sight of the strangers, peered shyly from outside the circle of firelight. I supposed from the general astonishment in the village—some three days' march from Ladakh's capital, Leh—that few outsiders reach these remote precincts.

"Indeed, you are the first," Sonam said, "and we are honored." His wife nodded and refilled our wooden cups.

"Oh, I have visited Leh," Sonam continued, "and seen foreigners there, in the bazaar. Soldiers especially—from faraway India. But not to speak to, of course."

I explained that we hailed from an even more distant land: America.

"Amer-ka? Amer-ka?" Our host savored the word. "But tell me, just where is that?"

Geography and Politics Isolate Region

Given the rigors of Himalayan travel, it is small wonder that for centuries Ladakh's lost valleys lay outside the world's mainstream, that much of its hinterland remains uncharted. Some 200,000 people—about half Muslim, half Buddhist—dwell in this mountain-girt region (map, below). An independent monarchy off and on for more than a thousand years, it served as a caravan crossroads for merchants from neighboring Tibet, Kashmir, and Chinese Turkistan.

In 1947 the Ladakhis, absorbed by India, escaped the cultural purges that befell their

Her wealth arrayed for all to see, a young government worker from the capital city of Leh displays a headdress of rough-cut turquoise stones. At one time an autonomous kingdom of 117,000 square kilometers (45,000 square miles), Ladakh was divided between India and Pakistan in the late 1940's. The Ladakh district of India was split once again when the Chinese-Indian War of 1962 ended with the desolate region of Aksai Chin firmly in Chinese hands.

Tattered missives to the gods, prayer flags flutter high above Leh, Ladakh's largest city (**left**). Once a crossroads for central Asia's great caravans, the 3,500-meter-high city thrived in the last century as a mart for Tibet's wool trade with British India. The caravans are now gone, and Tibet is inaccessible, but commerce continues as the city of 15,000 bustles with Indian garrisons here on border patrol.

The nine-story palace in the background, abandoned sixty years ago, was built in the 16th century by Ladakh's royal dynasty. Though the family's power declined with the emergence of a democratic India, Queen Diskit Wangmo (**above**, seated) has recently assumed the role of Ladakh's political leader. Here she listens to a keynote speaker during her successful run for a seat in India's parliament.

Tibetan cousins under Chinese Communist occupation. But India's border conflict with Pakistan and China in the three decades since has cut off Ladakh from its other neighbors. Not until 1974 did India open the district to foreign visitors.

Recently I spent two months toting my cameras along the jeep roads and foot trails of this little-known land. I found it peopled by hardy mountain stock, proud, spirited, steeped in ancient traditions, not yet encumbered by modern gadgetry such as matches, gunpowder, or (except for mechanized prayer devices) the wheel.

Wherever I ventured, I found that the ancient laws and stunning pageantry of Tibetan Buddhism still order and enrich the austere lives of most Ladakhis. In small, self-sufficient, mountain-bound villages such as Achirik, one best savors that subtle spectacle of man in perfect balance with nature —and with the supernatural as well.

Next morning I walked with Sonam through rippling fields of barley blushed with stands of wild roses. He was a small wiry man with almond eyes and a bronze face battered by sun and frost. Behind his shaven forescalp long locks curled down to his collar, a hairstyle set by a ninth-century Tibetan king, Langdarma, and still in vogue. From the red sash at his waist dangled a charm box, iron tweezers for removing thorns, and a small pouch stuffed with flint and tinder.

Sacred Spring Defies Winter

The same icy brook that greened Sonam's small terraces turned the crude gristmill that ground the family's *tsampa*, or parched barley meal, mainstay of every villager's diet. The family's *dzomo*, a crossbreed between the yak and domestic lowland cattle, added butter, curd, and dried cheese to the fare.

We each shouldered a sack of meal and started back. Not far from his house we paused at a small chorten, one of thousands of religious monuments that dot the Ladakhi landscape, marking graves and holy sites. Typically, this one was built of mud brick, shaped like a giant chess pawn and topped by a tall, ringed spire. From beneath it flowed a crystal spring.

"It is a sacred spring," Sonam said as we drank our fill. "Even in winter when others freeze, this one always gives us water."

A few yards below, the stream spun a paddle wheel that turned a copper cylinder.

"Inside are scrolls of Buddhist prayers," Sonam explained. "Each turn is a prayer spoken." Often throughout the day Sonam twirled a smaller prayer cylinder in his hand to while away time between chores.

Soon after *(Continued on page 342)*

LYNN ABERCROMBIE (RIGHT)

Nourished by glaciers, lush parcels of ripening grain in the Indus Valley (**left**) offer startling contrast to Ladakh's overwhelmingly stark landscape. With only 7½ centimeters (3 inches) of precipitation a year and a brief growing season, farmers must rely on glacial melt to irrigate their terraced plots. Near Tikse a youngster (**right**) harvests mustard plants.

LYNN ABERCROMBIE

Their hands seldom idle, Ladakhis of both sexes avail themselves of every spare minute—whether standing or sitting—to spin sheep's wool on twirling distaffs (**above**). Nearly every home has a loom for turning out bolts of homespun for the family wardrobe. Long, heavy sashed robes and brocaded stovepipe hats comprise the traditional costume for men and women alike.

Family life centers around the spacious kitchen—especially during the long and bitter winters, when its glowing yak-dung fire offers the only warmth in the house. In the tiny hamlet of Achirik, family and friends of Sonam Paljor Ezangs gather on carpets around his open hearth (**top, right**) to honor the author's visit with generous servings of *solja*, or Ladakhi tea. Prepared with salt and butter, this savory drink tastes more like soup to Western palates. The staple of Ladakh is *tsampa*, parched barley meal. Using an age-old process still widespread throughout central Asia, Sonam funnels the grain through a millstone (**right**) that is turned by waterpower from a nearby stream.

Despite government moves to further economic development by encouraging cottage industries, most villages concentrate on maintaining self-sufficiency. Achirik's two households manage to feed themselves on a small holding of irrigated bottomland.

darkness chilled the valley, Sonam rattled open the iron lock to the small chapel off the courtyard of his house and carried butter-lamp offerings to the gilt statues of Buddha and his disciples. Dusty brocade concealed one statue completely.

"That is the powerful Yamantaka," Sonam said in hushed tones. "He protects our house from evil spirits. Eight arms, the head of a ferocious bull, spouting flames, he is too horrible to behold—and too dangerous. One gaze could drive a person mad." Women of the household were not allowed near.

"Once each year, in winter, my son and I unveil this wrathful deity," he added, "but only after two days of purification rites and prayers."

God of Mercy Has Eleven Heads

Wrapped in my down bag in the courtyard, I drifted off to sleep on the soft syllables of Sonam's vespers. *"Om Mani Padme Hum,"* he repeated over and over: "Hail to the Jewel in the Lotus."

Spiritual life in this remote corner of Ladakh centers around the *gompa,* or lamasery, at Sumdah, perched at 4,000 meters, a half-day's march from Sonam's village. The resident lama was absent, meditating elsewhere, but his aged father, the sacristan, kindly opened the sanctuary.

A thousand Buddhas gazed down upon me from one wall; other frescoes unfolded the drama of the "Great Teacher's" life. Above the main altar, pierced by a narrow beam of sunlight, loomed a giant with eleven heads: Avalokitesvara, the Buddhist god of mercy.

Following pilgrim custom, I laid a white prayer scarf on the life-size bust of Rinchen Zangpo, sainted legendary founder of the lamasery. "Master, the Precious Jewel," as Ladakhis reverently call him, came from Tibet nearly a millennium ago.

"Using his miraculous powers, the Master built this gompa in one evening," the old sacristan told me. "Then he flew through the sky to the other side of the mountain and completed two more before morning."

That would make Sumdah Ladakh's oldest standing lamasery—if only by a few hours.

The village of Sumdah, population 37, is undoubtedly older. I stayed a few days there, at the foot of the shrine, in the home of Sonam Wangyal, the cooper (page 352). In summer he spends most days adz in hand, cutting and fitting poplar staves into tall buckets, the kind used throughout Ladakh for churning butter or brewing *chang*—barley beer.

Wangyal was seldom alone. Despite the noisy dog chained to his gate, many passersby stopped to rest from their heavy loads and gossip with the smiling carpenter. They sheltered from the midday sun under Sumdah's lone shade tree, growing at 4,000 meters.

"Normally trees will not survive here," Wangyal told me. "The climate is too severe. We nursed this one since it was a sprig." He fetches his lumber by donkey from down in the valley.

Drought-struck Farmers Pray for Sun

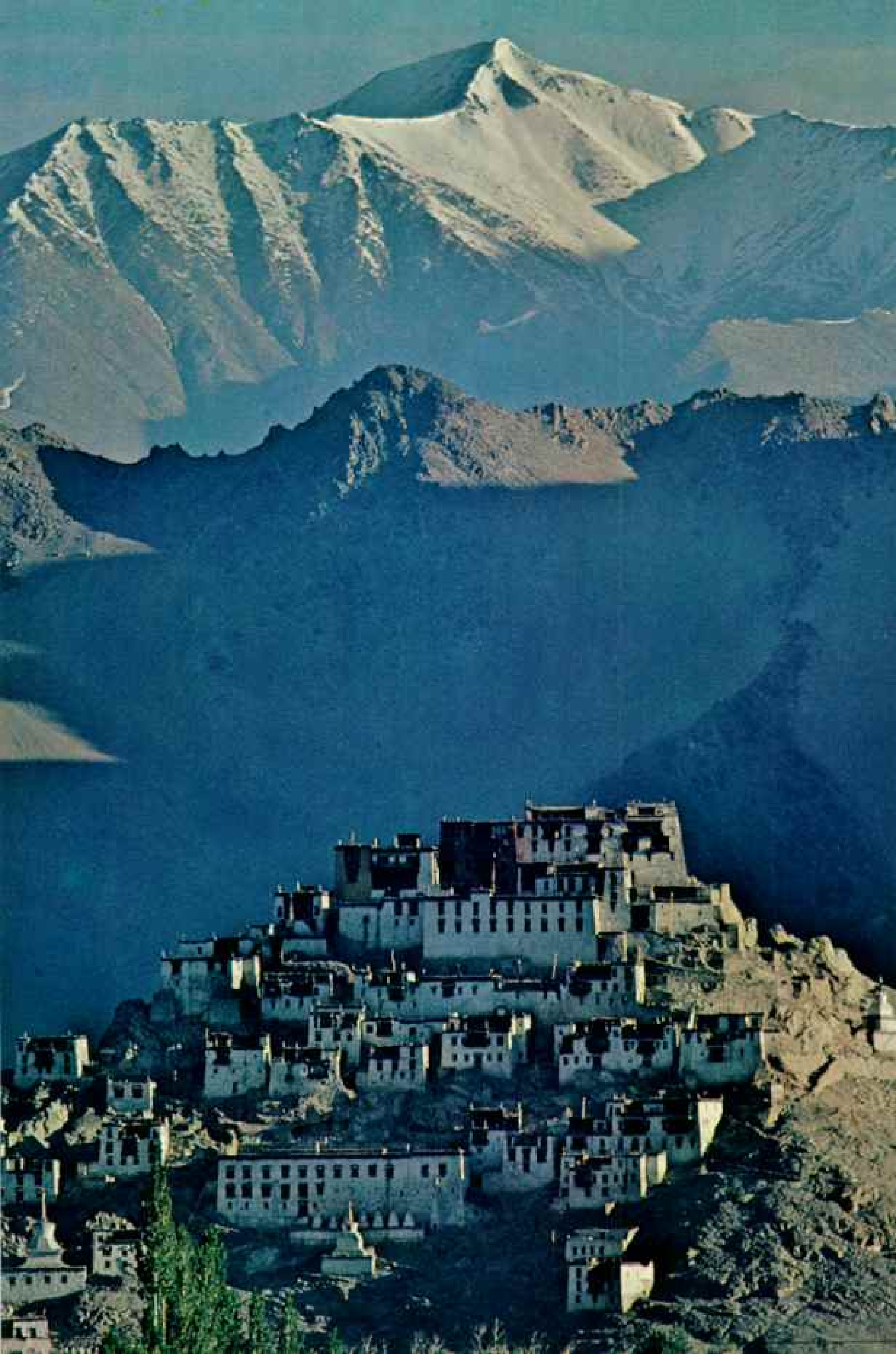
To survive here, at the top of the world, villagers husband every resource. They count little on rainfall, averaging seven and a half centimeters (three inches) a year—no more than the Sahara—and most falls as snow. For parched fields, farmers pray not for rain but for sunshine to melt the nearby glaciers.

With long-handled wooden spades the women ration precious water to the carefully groomed terraces. Every weed goes into a basket; the more succulent are boiled as greens, the rest stored for fodder. Wood is too precious to burn, even in minus-30°C winter months. Dried dung fuels most houses. Donkeys, sheep, and cattle, stabled in the lower floors, add their body heat.

Wangyal's cousin joined our party on the trek back to Leh. The three finished buckets lashed to his small donkey would fetch a total of about 120 rupees ($14) in the bazaar in Leh, little enough for more than a week's labor and transport.

Poor in resources, Ladakh relied on rugged caravanners who met there to exchange the riches of other *(Continued on page 346)*

Stairstepping toward heaven, the lamasery of Tikse climbs a high knoll in the Indus River Valley, east of Leh. Rich in art treasures, numerous *gompas*—Tibetan for "solitary places"—have long been the cornerstones of Ladakhi culture, as they were in Tibet before the Chinese Communist purges in the 1950's.



Smile of enlightenment on a gilded Buddha, bathed in soft light from votive butter lamps, holds a young novice in thrall at Shey Gompa (**left**). Erected 345 years ago by craftsmen from Nepal, Ladakh's largest bronze statue reflects the great trans-Himalayan culture exchange that enriched its past.

Printed in Tibet from woodcuts more than a century ago, a manuscript from the vast library at Lamayuru Gompa (**above**) chronicles the lives of Buddhist saints. When not in use by the monastery's monks, these bark-paper pages are pressed between lacquered slats and bound in silk brocade.

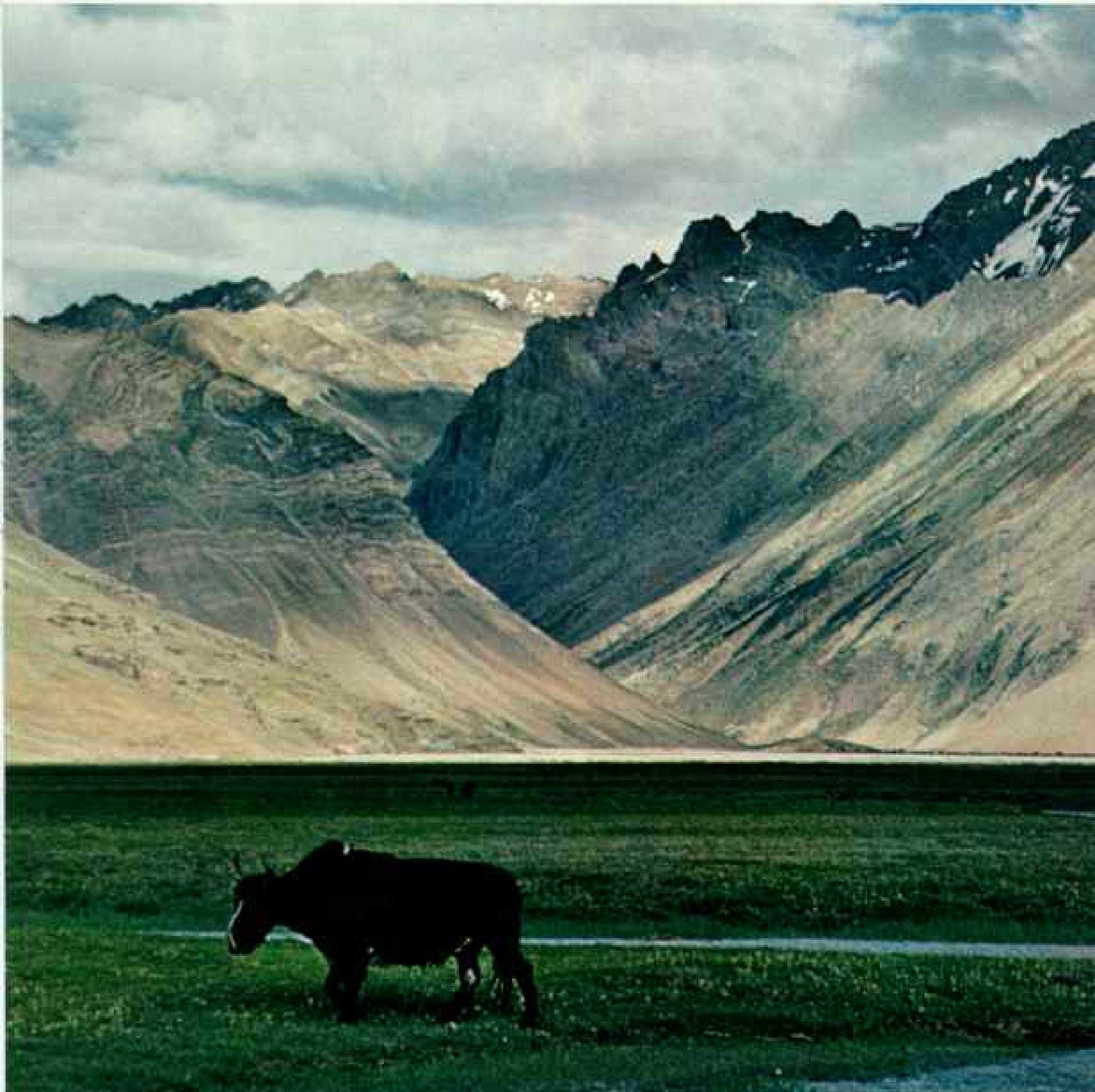
lands. From the lush plains of Kashmir, from distant Lhasa, up over the icy Karakoram Range from Chinese Turkistan, the great Asian trade routes converged on Leh.

In the town's buzzing marketplace merchants of Yarkand and Kashgar bartered gold, tea, silk, musk, and medicines in return for cotton, pearls, spices, indigo, and brocades.

"It took 34 days, the march from my home in Yarkand down to Leh," said Hajji Tokta Neyaz, one of the last to cross the 5,575-meter (18,290-foot) Karakoram Pass from China. The old Chinese Muslim, trapped in Ladakh when the Communists closed the border in 1949, now runs a small inn at Kargil, Ladakh's second largest city.

"It was a backbreaking trail, long and high," he went on. "We had to slit the noses of some of the mules and ponies so they could suck enough air into their lungs.

Cattle of the Himalayas, yaks ford a branch of the glacier-fed Suru River.



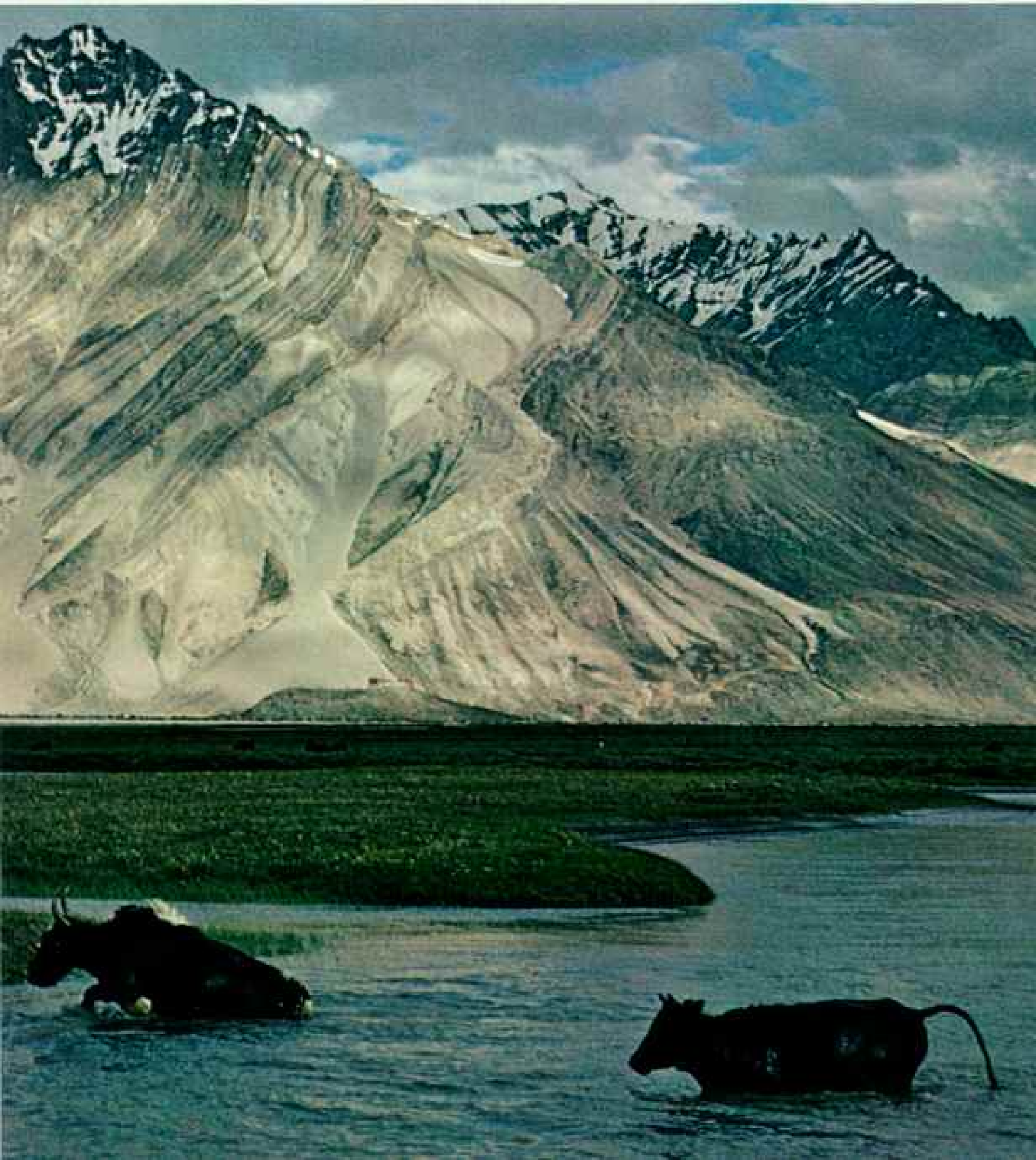
"But there was no danger of getting lost. Bleached bones of animals and men regularly marked the trail.

"It is only by the grace of God my own are not strewn there with them," Hajji Tokta said. "In a bad fall near the pass I broke my hip. Luckily, a companion stayed behind with me. It was a month until I could be moved. We nearly starved.

"While I was recuperating in Leh, China closed the border, cutting me off from my wife, my family." His eyes glossed. "My children were small then. They would be in their 40's now, if they are still alive."

Cut off by war and politics from its former world, Ladakh turned south toward Kashmir and greater India. Now, as I edged through the cosmopolitan midsummer throng in Leh's bazaar, the atmosphere seemed to be "business as usual."

Ringdom Gompa tops a hillock at the base of the towering Zaskar Range. 347



Ladakhi housewives in long-tailed bonnets hawked radishes and turnip greens, and rough-cut nomads, down from Rupshu near the Tibetan border, mingled with Indian soldiers. Knots of French and German tourists bused up from the Kashmir Valley inspected Himalayan handicrafts.

"Joolay!" shouts one curbside entrepreneur, "Hello!" The old man's smile is as hard to resist as his wares: small altars emblazoned with lions, dragons, temple bells, and trumpets; a lama's ceremonial bowl fashioned from a human skull; silver charms to ward off disease and biting dogs; a three-edged ritual dagger to vanquish the triple evils of ignorance, passion, and aggression.

Honking their way through the pandemonium come Kashmiri trucks piled with produce, crates of squawking chickens, rough lumber from the lowlands. Local jeep-taxis are emblazoned with mottoes of the new age: "Discipline Makes a Nation Great," and "The Nation Is on the Move."

Soldiers Patrol World's Highest Road

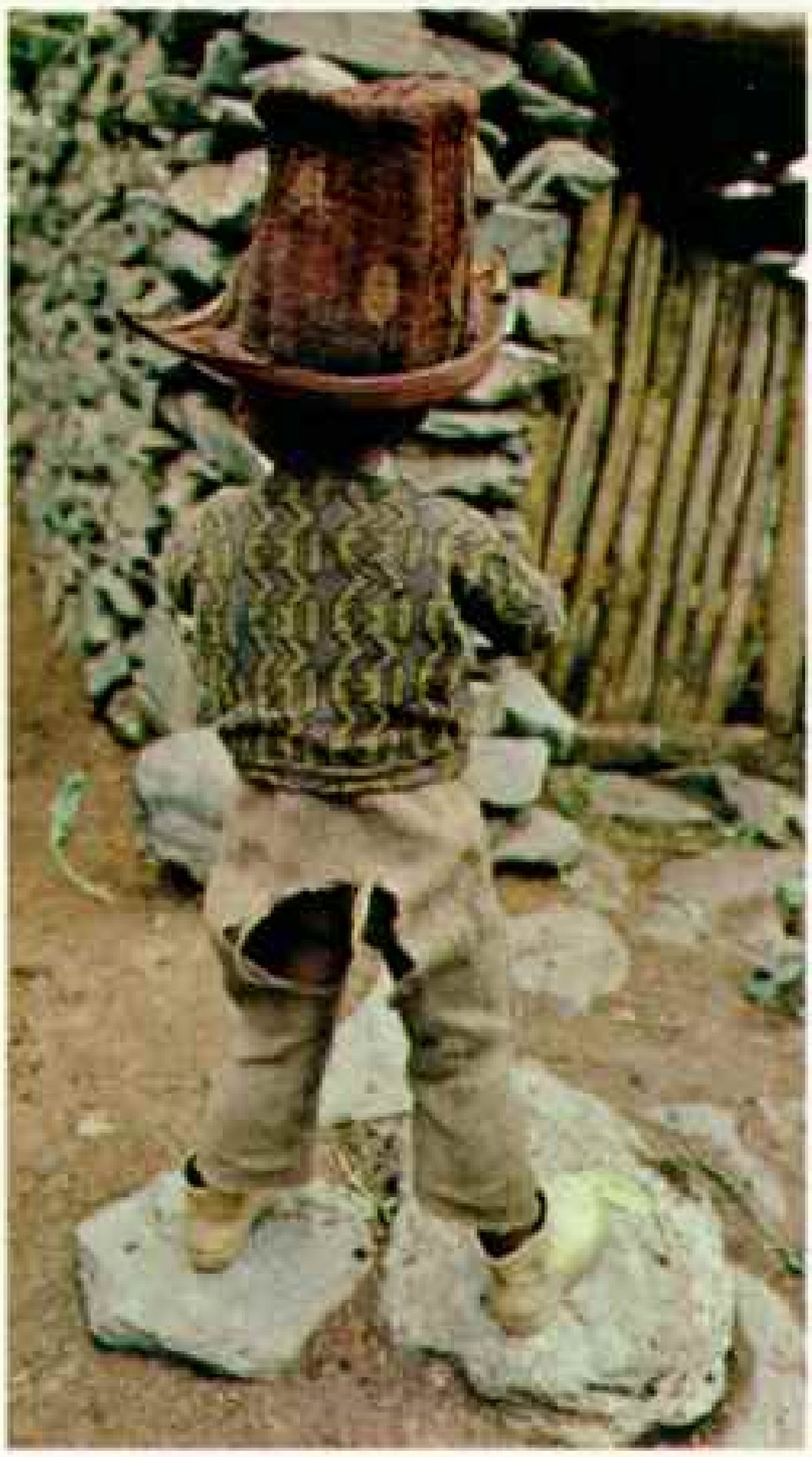
The nation, of course, is India. Ladakh has been part of India—officially a district in Jammu and Kashmir State—since that country gained independence from Great Britain in 1947. It was paid little heed by the central government until the Chinese invaded in 1962. China annexed some 28,500 square kilometers of northeastern Ladakh, the desolate high plains of the Aksai Chin. The Indian Army rushed to complete a 434-kilometer motor road from Srinagar to Leh, cutting the 16-day journey to two. Some 40,000 troops now garrison Ladakh's frontiers.

In Leh I talked with the commander of India's forces in Ladakh, Maj. Gen. R. Trevor Morlin, a tall, dark, rugged soldier whose accent was as much Cambridge as its native Calcutta.

"We keep the trucks rolling, several hundred a day, during the short summer season," he said. "Khardung La, at 5,600 meters the highest motor road in the world, is open just three months a year. In many of our high frontier outposts winter temperatures drop to 40° below zero.

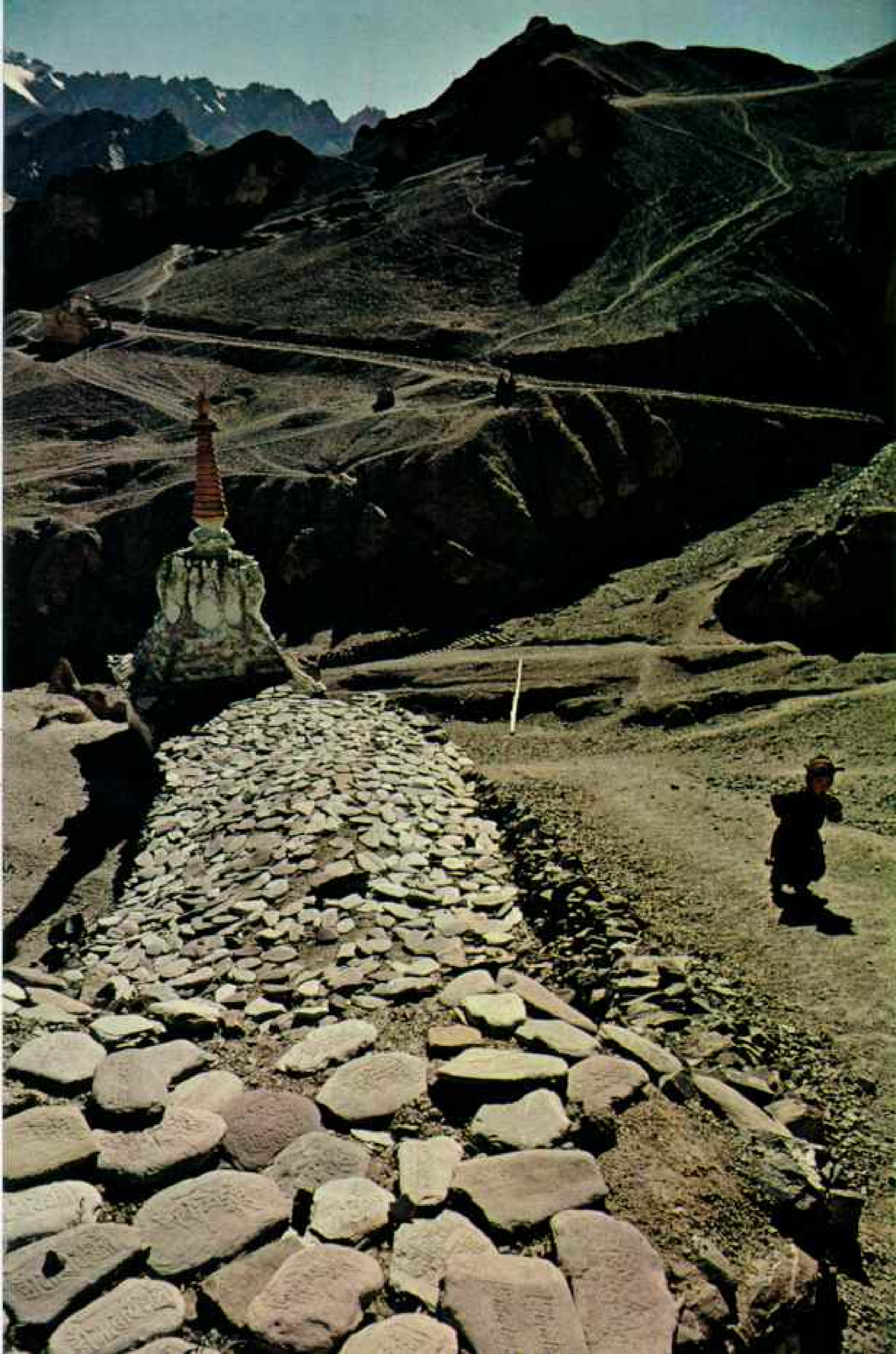
"Even down here in the valleys—Leh is at 3,500 meters—a soldier's efficiency is well below what it is at sea level," General Morlin continued. "Of course, we have recruited many young Ladakhis. Tough chaps they are and damn fine soldiers. Our regular troops we put through a ten-day acclimatization course here before sending them north to the highest outposts."

Mama's hat adds a touch of dignity to a youngster in Sumdah (**below**) who wears "bottomless" pants—a Ladakhi answer to the diaper problem. The woolen cap on a younger child (**facing page**) guards against cold winds, while the amulets and needles that decorate it ward off evil spirits.



The army's main mission is to patrol Ladakh's remote borders, but as the region's largest employer it has also become a major factor in the local economy. Many Ladakhis are earning their first paychecks as laborers on new army roads and cantonments.

As a district in the republic of India,



Pleas from the pious, flat prayer stones (**left**), or *mani*, pave long embankments that mark the approaches to Ladakhi villages and monasteries. Most are inscribed with the simple Buddhist prayer for which they were named: *"Om Mani Padme Hum,"* or "Hail to the Jewel in the Lotus." Following tradition, a young Buddhist passing this mani wall keeps it to his right; those descending use a path

on the other side. Like beacons along the way, reliquary shrines called chortens commemorate deceased lamas and wealthy supplicants. Miniature chortens and votive tablets molded from funeral ashes and clay (**above**) represent more humble tributes.

To purge demons from a sorrow-plagued home, a lama from Ridzong Gompa performs a rite of exorcism (**upper right**) by luring the offending spirits into offerings of food. After praying over each contaminated dish, he casts it into a ceremonial fire. Their own houses in trouble, largely because of declining recruitment of youth, Ladakhi monasteries must rely increasingly on the kindness of tourists to sustain themselves. Rupees, dollars, and pounds sterling fill an offering dish by an altar at Lamayuru Gompa (**right**).

Beer barrel turns playpen for a son of Sumdah's village cooper, Sonam Wangyal. To make each cask of hand-hewn poplar staves takes two days of painstaking labor. *Chang*, a beer brewed from barleycorns, will fill them later. All his workshop tools (**top**) were made by a local blacksmith.

Ladakh is also getting its first lessons in democracy. During my visit I found the tiny capital in the throes of "election fever." Portraits of candidates papered the marketplace; jeeps, bristling with loudspeakers, patrolled the streets, shouting promises for a better tomorrow in Urdu, Ladakhi, and English. I was surprised to see, heading the Congress Party's ticket for Ladakh's seat in the parliament in New Delhi, the name of Her Highness Gyalmo Diskit Wangmo, the queen of Ladakh (page 337).

Ladakhi Queen Elected to Parliament

Ladakh has always been a monarchy. The royal family traces its lineage back to the legendary king, Nya Tri Tsanpo, who ruled in the third century B.C. Still, after the rise of Tibetan Buddhism a thousand years ago, royal authority was usually at the pleasure of the powerful lamas who had created, in effect, a loose-knit theocracy.

During the past 150 years, which brought increased Muslim influence, British rule, and finally accession to India, royal fortunes further declined. When her husband, King Kunzang Namgyal, died in 1974, the queen inherited an honorary office. Not content with being a mere symbol, she decked out her jeep with bright bunting and bounced over the countryside in a month-long, village-to-village campaign—and won. She granted me an audience the day before she left to take up her duties in New Delhi.

"My most important mission will be to plead Ladakh's case with my colleagues in the federal parliament," said the soft-spoken queen. She wore the simple blue wraparound robe of the women of Leh. A white silk kerchief was her only crown. Tiny, winsome, at 42 she could still pass easily for a teenager.

"We are now 200,000 strong, occupying some 70,000 square kilometers," Queen Wangmo continued. "This makes Ladakh, by area, the largest district in India; in terms of population, the smallest. And we lie far from the capital. We want to exploit our mineral resources, develop hydroelectric potential, improve agriculture—but we will need help and funds from the central government."

Despite the changes that are brewing in Leh, Ladakh's scattered lamaseries remain a major influence in the land. The Lamaistic religion, an ancient Buddhist creed, is the

warp around which Ladakhis still weave the fabric of their life.

Few families are without at least one son in the monkhood. The religion's wrathful deities police a Ladakhi's conscience; its benign spirits comfort him. Much of what education he has comes from the lamas, who also bless his birth, consecrate his wedding, interpret his future, cure his ills, and—when the trials of this present incarnation cease—cremate his remains. His social life is tuned to the lively festivals held at the lamaseries.

These hilltop retreats also offer weary travelers shelter for the night. I stopped at Lamayuru Gompa, the first lamasery I encountered in Ladakh and the most beautiful. Perched on a ledge like a fairy-tale fortress above its tiny village, Lamayuru could be the centerpiece in a Chinese watercolor. I coaxed the jeep up a narrow path cut into the mountainside and through the gate into the whitewashed courtyard.

Monks Read "Bible" Aloud—108,000 Pages

Around the tall chortens and up the narrow street flickered the red and yellow robes of the lamas. One sinewy holy man, with head shaved and polished and hands pressed together in the Buddhist greeting, introduced himself as Lama Thuphstan Spalzangs, the *choschamba*, or bailiff, of the lamasery.

"As you see, you have caught us during a busy time," Lama Spalzangs said as he sent for salt-butter tea. "Most of the year there are but two dozen monks here in Lamayuru. The others are abroad in the villages. But now about 200 are gathered here. Tomorrow begins the annual reading of the Kahgyur, our scriptures."

It is a formidable task, for 108 volumes—each about a thousand pages—make up the Ladakhi "Bible." Even with scores of lamas participating, the recitation takes three weeks.

In the *dukhang*, or assembly hall, Lama Spalzangs drew one of the sacred tomes from the monastery's renowned library to show me. Reverently he folded back the silk brocade wrapping and removed the thick stack of long bark-paper pages.

"This volume was printed from woodblocks in Tibet more than a hundred years ago," he said. "It is one of thirteen that deal with monastic discipline and conduct."

I asked my host how long he had belonged to the order. "All my life," he answered. He meant it literally.

"I was born in Ledo, a village along the Indus not far from here, 37 years ago. By certain mystic signs my parents knew immediately that I was destined for the religious life. A lama was called in and confirmed the omens. When I was 6, I left to become a novice here at the monastery."

Demons Exorcised in Ancient Ritual

Much of a lama's time is spent outside the monastery, ministering to the villagers. I watched them conducting rites during my stay with the Rinchen Lonpo family in the farming village of Alchi (page 351). For the Lonpos, I learned, it had been an ill-starred year. During the bitter winter one of their sons had died of illness; another had been killed in a highway accident. Clearly, evil spirits plagued their house. Three holy men were called in to exorcise the demons.

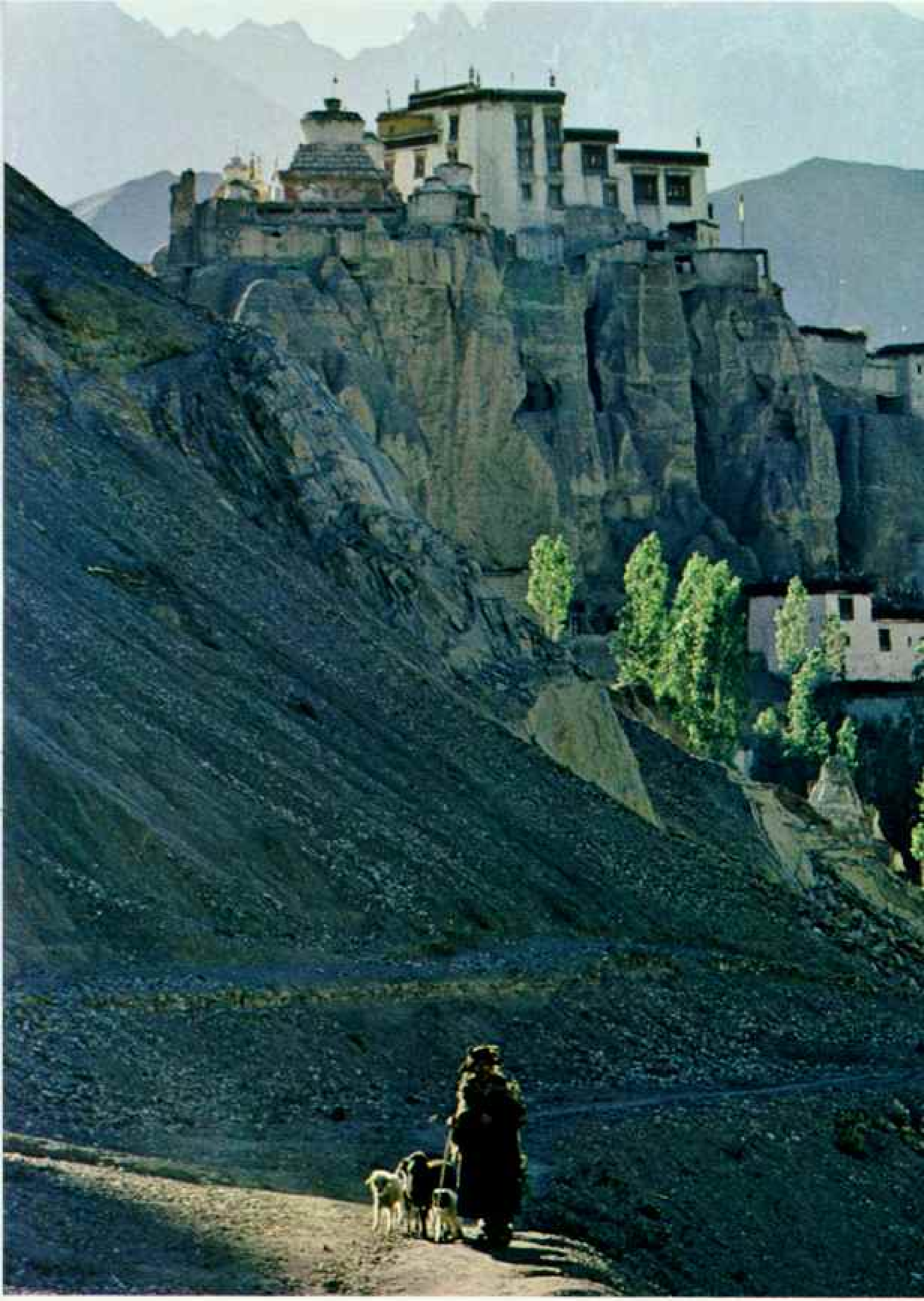
As the monks began their incantations in the family's rooftop chapel, masons arrived with loads of mud bricks. In the center of the Lonpo courtyard, facing east, they built a low square altar. While the women of the house boiled kettles of water for tea and warmed casseroles of food for the lamas, old Rinchen Lonpo and his son, Sonam, filled copper plates with barley, tea, rice, salt, butter, and mustard seeds—to feed the gods. From my duffel I added a two-kilogram bag of sugar.

Early next day the ranking lama outlined a mandala, or sacred circle, on the altar and sketched in mystic symbols with a stream of white sand paid out between thumb and forefinger. Then, lighting a fire of kindling and yak dung on top of the design, he began to chant. A second lama, seated at a low table, rang a bell and waved a ceremonial thunderbolt of brass.

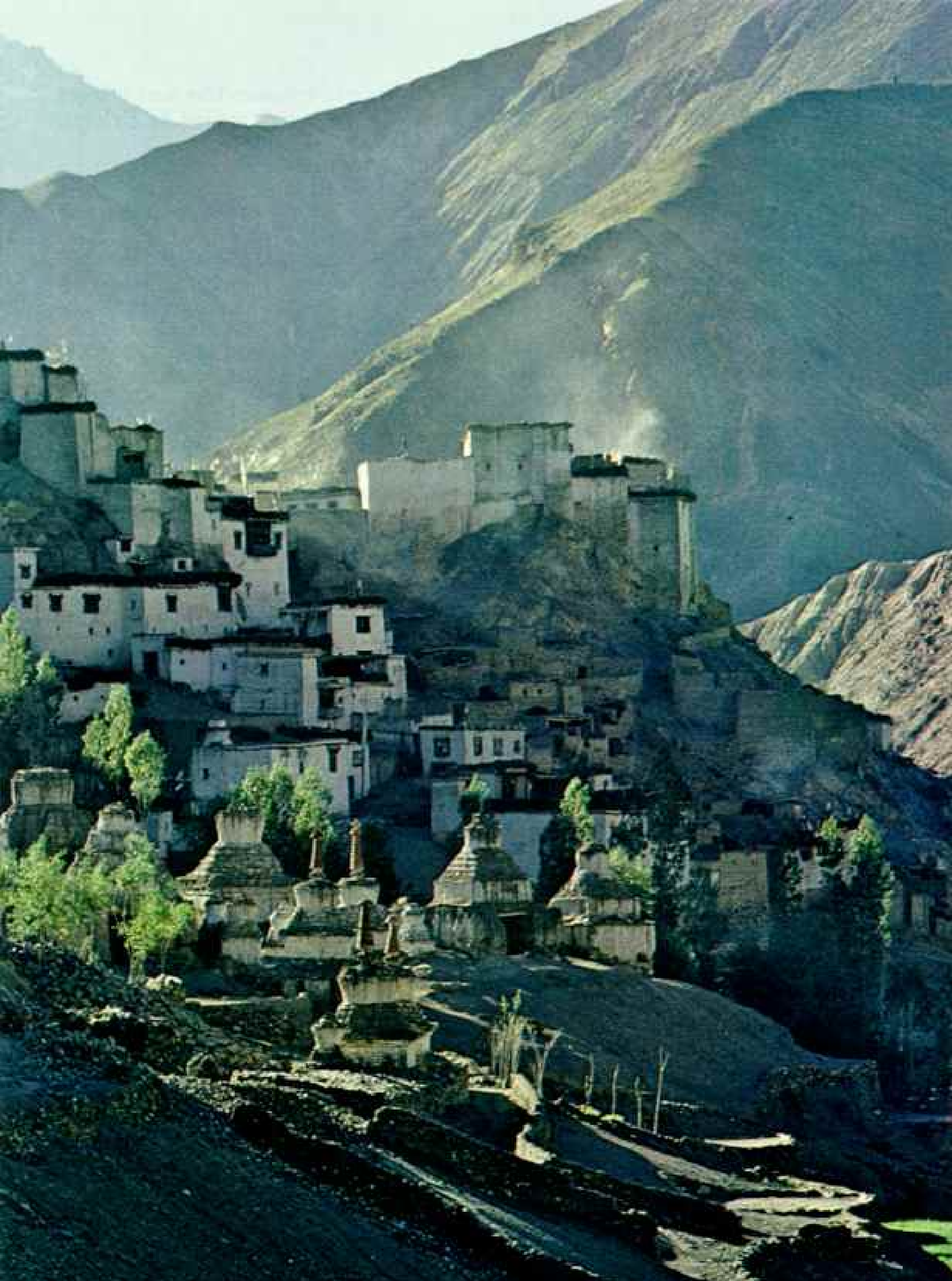
"They are calling the evil spirits into the offerings," Mr. Lonpo whispered as we watched from a doorway. A third lama, the youngest, donned a white mask and began carrying the plates to his superior, who committed the sacrifices to the crackling pyre. The acrid, evil-laden smoke was whisked away on the cool morning breeze.

Most large festivals are observed in winter, when fields are frozen and villagers have time on their hands. But the most spectacular of all, at Himis *(Continued on page 358)*

Wrathful deities from Ladakh's pagan past—mimed by grotesquely masked celebrants—whirl in ritual dance (**right**), while behind a black papier-mâché mask a lama awaits his cue (**above**). Every June villagers from miles around gather at Himis Gompa for Ladakh's largest festival—the birthday celebration of Padma Sambhava, founder of Tibetan Buddhism, or Lamaism. In the eighth century, some 1,200 years after the death of Buddha, the Indian missionary journeyed far and wide across the Himalayas, where he was said to have tamed a thousand local demons and recruited them as guardians of the faith. Thus it was that some of the world's most rugged people were converted to the gentle ways of Buddhism.



As if grown from the rock, Lamayuru Gompa rises above its village at



first light, while a woman leads her sheep to the high slopes of Fotu Pass.

(Continued from page 353) Gompa, 40 kilometers southeast of Leh, takes place in June to honor Padma Sambhava, eighth-century founder of Lamaism.

As lamas act out an ancient mystic drama, people from outlying regions throng to the event. Many camp for several days in the poplar groves that skirt the monastery, Ladakh's richest and most powerful.

Sidewalk Dentist Pries His Trade

I followed the wide path that zigzags up to the main gate, where merchants had stretched canvas tents. Some did a brisk business in pilgrim wares—prayer beads, incense, magic amulets. Others hawked sweaters, socks, mirrors, padlocks, rice, balloons, whistles, and candied mulberries. Larger tents offered hot meals, tea, and barley beer.

I watched a sidewalk dentist, a Sikh from southern India—his cloth spread with rows of plastic teeth, shiny pliers, and a framed diploma—as he hammered and pried the jaw of his stoic patient, then wired a new bridge in place. Nearby, an itinerant puppet master delighted youngsters with Punch-and-Judy antics from an ancient Hindu epic.

The monastery's wide courtyard rapidly filled with a cosmopolitan, squeezing-room-only crowd of village rustics, elegant ladies sparkling in turquoise and silver, monks twirling prayer wheels, and European tourists just off the bus with cameras at the ready. Uniformed police brandishing willow switches kept a small square clear for the dancers.

The throng parted briefly to let pass His Holiness Drukpa Doongsay Rimpoche, a living Buddha in bright red robes. The aging teacher blessed outstretched hands as two young lamas helped him across the cloister to mount the throne of honor.

Blasts on a pair of trumpets, carved from human thighbones, opened the festivities. Then long brass horns, shrill oboes, crashing cymbals, tiny bells, and booming yak-skin drums filled the air with music from another world. Dancers in black robes of Chinese silk burst into the courtyard, waving wands festooned with streamers. They were followed by a second troupe, masked by gleaming brass visors (pages 354-5).

"The first dance purifies the precincts," a lama explained to me. "The second consecrates them for the arrival of the spirit of Padma Sambhava."

The great saint arrived, garbed in the robes of a Buddha and encircled by three-eyed demon-kings. Another troupe, clad as Mongol warriors, danced in welcome. A quartet of skeletons decked out with jesters' bells wielded snakes and intestines, reminders of the transitory nature of the flesh.

Later, monks laid out a small human effigy made of barley dough on a low earthen altar. "The image embodies the forces of evil," my informant told me. Perhaps, as some say, it recalled cannibalistic rituals of Ladakh's pre-Buddhist days.

Finally the most fearsome specter of all entered, a giant named Shawa with a black face, a muzzle spiked with fangs, and a long menacing horn—another incarnation of Padma Sambhava—to hack the effigy with a long curved sword. The skeletons returned to kick the remains into the cheering crowd.

Spirits of Change Confront Ladakh

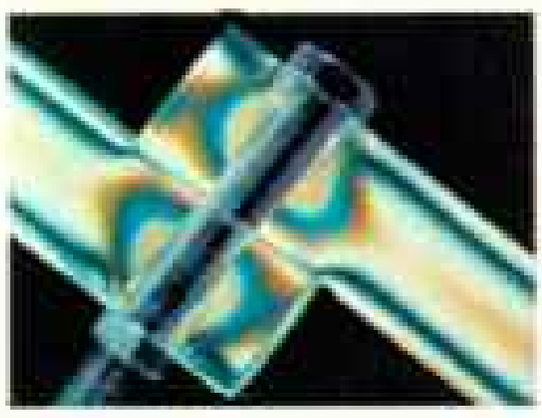
On the way down from the monastery, tangled traffic jolted me back to the 20th century and to the petty trials of this present incarnation. These foreigners' machines, the army, a new radio station, profits from tourists—all are transforming the face of Ladakh. How long, I wondered, can the fierce guardian deities fend off the spirits of change?

As my jeep rumbled across the narrow bridge over the Indus, I watched the setting sun ignite the rows of high peaks that rim this last Shangri-la. Source of all life, dwelling place of the gods, the eternal Himalayas shelter and nourish these pious folk.

In this majestic setting I felt somehow reassured. Whatever the future contrives, the Ladakhis—firmly planted in the soil of this world, on close terms with the provosts of the next—will take it in stride. □

Spinning prayers with each step, two elderly pilgrims pick their way down from Himis Gompa. The devout believe that each revolution of the scripture-filled copper wheels sends supplications heavenward. In this high, remote land of endless prayer, faith seems to direct each step of the way.

Eyes of Science



By RICK GORE

Photographs by JAMES P. BLAIR

BOTH NATIONAL GEOGRAPHIC STAFF

Lighting new vistas for scientific research, photography and other imaging techniques probe nearly everywhere in the physical universe—from man, to the cosmos, to within the atom itself.

A mummylike image of a man (**facing page**), displayed on a TV screen in a Texas laboratory, maps the contours of his body.

In the most detailed view of a star other than the sun (**foldout, opposite**), a computer and a camera combine to chart subtle temperature differences—from hot orange to cooler blue—on Betelgeuse, 500 light-years away in the constellation Orion. The feat is comparable to photographing a grain of sand a mile distant.

Color vignettes (**above,** clockwise from top) show a cube drawn by a computer, a color-coded X ray of a human head, and curving lines of stress, visible only in polarized light, in plastic bars joined by a bolt.

(FROM TOP LEFT) ARGONNE NATIONAL LABORATORY; HOWARD SOCHUREK, AND POLAROID CORPORATION; (FOLDOUT) KITT PEAK NATIONAL OBSERVATORY

THIS WINTER, whenever it has stormed in Muskegon, Michigan, airborne meteorologists have been chasing snowflakes with a high-speed camera. They hope to learn how snow grows from invisible specks into complex crystals.

Meanwhile, in California, energy researchers are focusing incredibly fast "streak cameras" on targets of nuclear fuel too tiny to see. They want to photograph what happens when the targets are hit with a laser pulse that lasts a fraction of a billionth of a second and carries for that moment much more wattage than all the power plants in the U. S. The cameras record these attempts to achieve nuclear fusion, the same reaction that keeps the sun burning. If harnessed, fusion could answer our energy needs in the next century.

Off Mexico's Baja peninsula, oceanographers are cruising in a submarine nearly two miles deep along the East Pacific Rise. At those frigid, lightless depths they hope to photograph a chain of young volcanoes and, perhaps, hot springs like those that cameras discovered last year off the Galapagos Islands.* Such springs support an astonishing array of creatures that thrive on a food chain alien to most life on earth.

In Cleveland, pediatricians John Kennell and Marshall Klaus have been filming mothers and infants starting moments after birth. The pictures reveal that in the first hour a baby is alert, with its eyes open. The mother gazes intently at its face. Such early eye-to-eye contact, the doctors believe, helps bond mother and child for life.

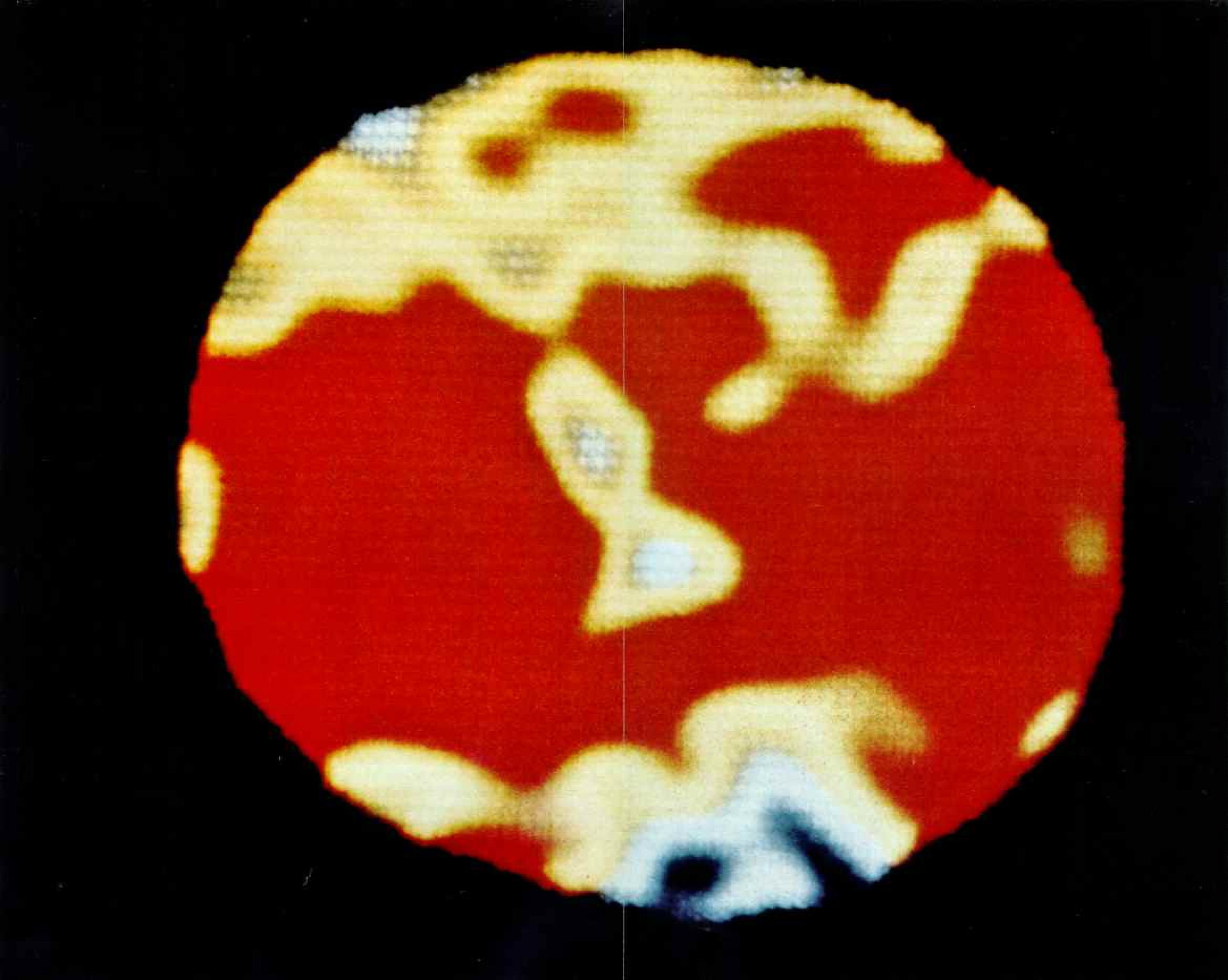
In his University of Chicago laboratory, Dr. Riccardo Levi-Setti is practicing micro-portraiture on the fossils of a very rare trilobite from Bohemia, revealing that the eyes—perhaps nature's first—of this long-extinct arthropod were optically quite sophisticated.

And during this past Martian winter, the Viking 2 lander sent back pictures that let scientists identify white frost 150 million miles away around the red rocks of Mars.

Different scientists, different fields, different tasks. What they have in common is their chief tool—a camera.

Indeed, since Frenchman Louis Daguerre found in the 1830's that he could make a silver

*See "Oases of Life in the Cold Abyss," by John B. Corliss and Robert D. Ballard, in the October 1977 NATIONAL GEOGRAPHIC.



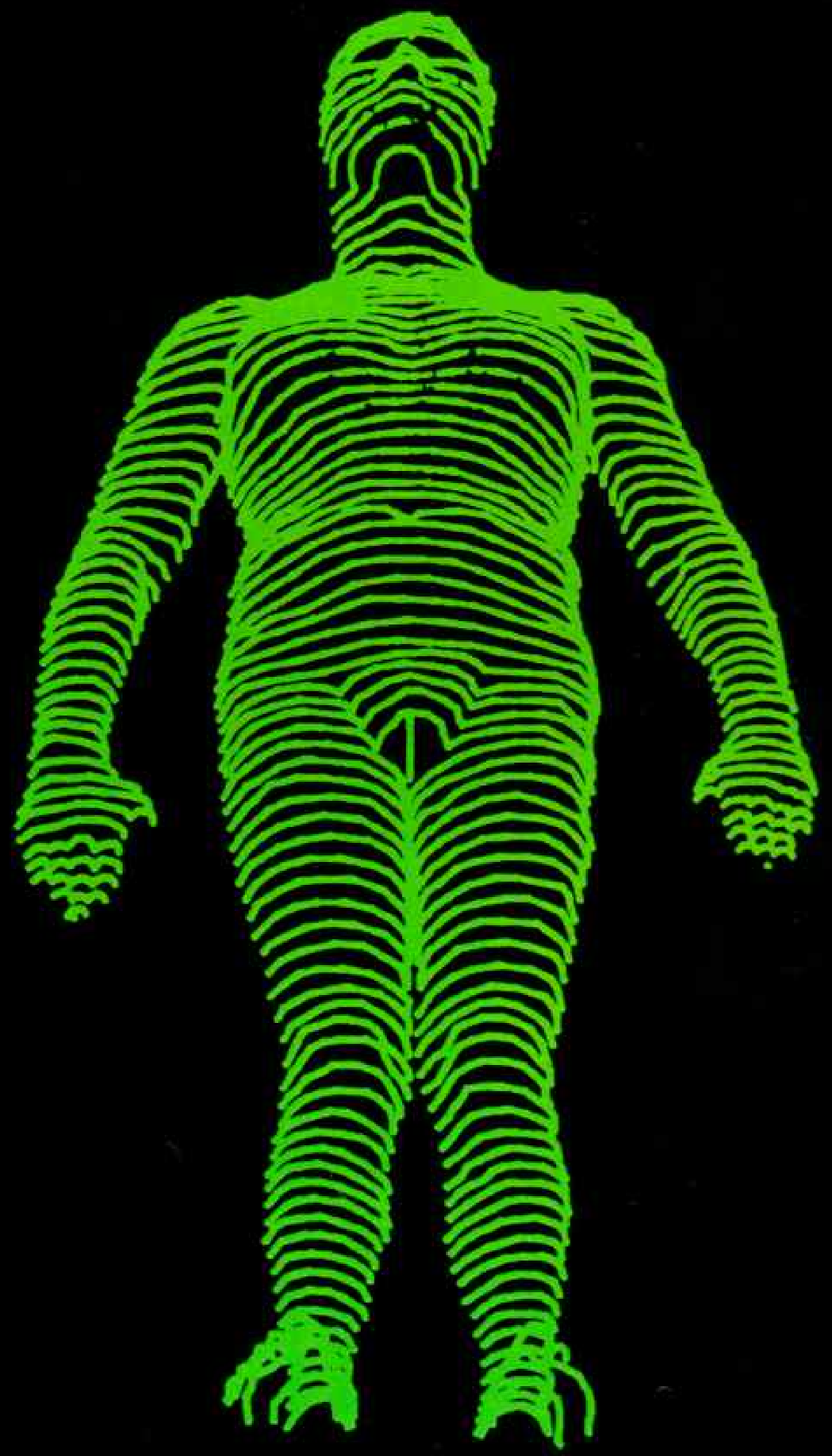


plate light-sensitive by exposing it to iodine fumes, cameras and scientists have grown inseparable. In 1840 a so-called daguerreotype of the moon was made. Almost simultaneously the first photographic negatives appeared. Scientists soon coupled these with embryonic flash devices and stop-action techniques to study such subjects as the stride of an athlete, the gait of a horse, and the beat of an insect's wings. They put their crude flashes under the ocean and flew their cameras on kites and balloons.

By 1895, when Wilhelm Konrad Roentgen discovered X rays, it was clear that visible light was just part of a great spectrum of electromagnetic energy. Visible light, radio waves, infrared, ultraviolet, X rays, and gamma rays can all now be captured in images. Pictures can even be taken with sound.

With the possible exception of computers, the camera and newer imaging devices are the most important scientific tools of this past century. The reason is simple: Cameras extend our vision immeasurably, showing us what is too fast or too slow, too bright or too dim for our eyes to behold. Cameras go where we cannot and document what our memories might soon distort or disregard, or what time and progress will destroy.

SOME MONTHS AGO I set out to explore the value of those imaging tools to science. I visited scores of laboratories.

Astronomers at the Kitt Peak National Observatory showed me the first detailed pictures of the face of a star other than our sun, the supergiant Betelgeuse (pages 361-2).

Electron microscopist Mark Ellisman told me how he can freeze and split apart the four-ten-millionths-of-an-inch-thick membranes enwrapping our brain cells and photograph craters and vesicles within (page 373).

Pictures taken in ultraviolet gave me the eyes of a butterfly and let me see the intricate wing markings, invisible to man, that help a male and female insect recognize each other.

In Lancaster, Pennsylvania, RCA engineers showed me tiny light-sensing electronic chips, known as CCD's, that they say may someday take the film out of photography and give us home movies we can view immediately.

I saw a small "fly's eye" lens, with 10,000 microlenses built into it. Using this fly's eye, Venezuelan experimenter Dr. Humberto

Taking the measure of a man

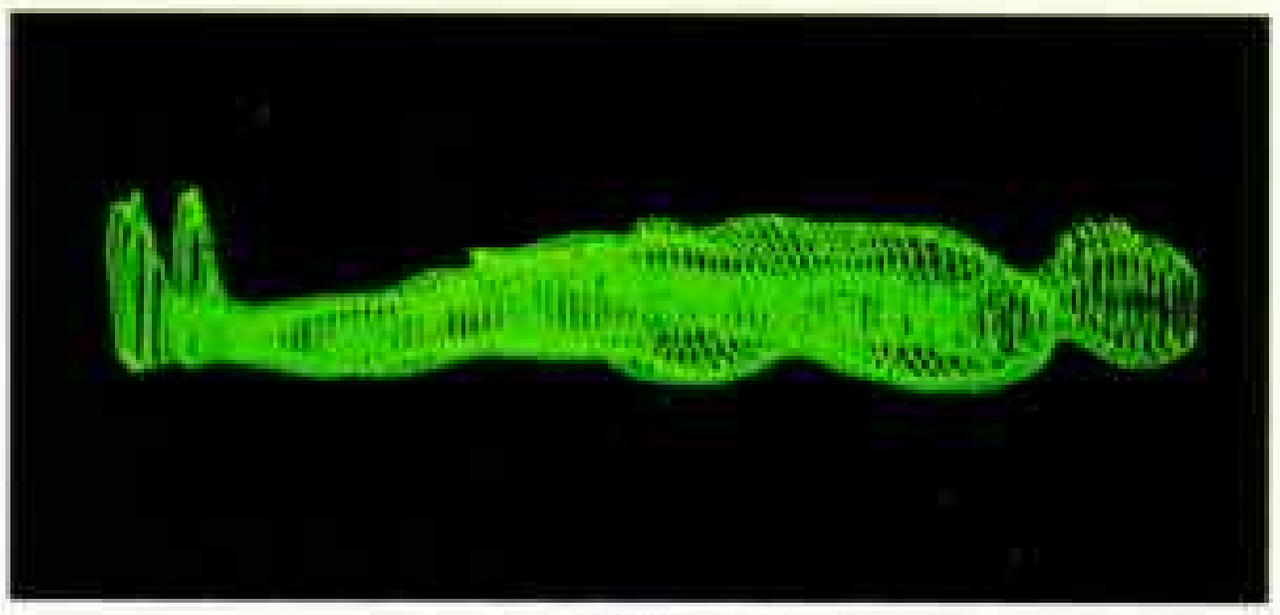
MAPS OF HUMAN TERRAIN result from the new science of biostereometrics—the three-dimensional measurement of living things using techniques similar to aerial mapping. At the Texas Institute for Rehabilitation and Research in Houston, an electronic flash casts a speckled pattern over author Rick Gore (**above**). Professor Jaime Cuzzi mans a stereo camera; another simultaneously photographs Gore from the rear.

The stereo photographs, viewed in pairs, appear as three-dimensional images of the body fore and aft. Utilizing

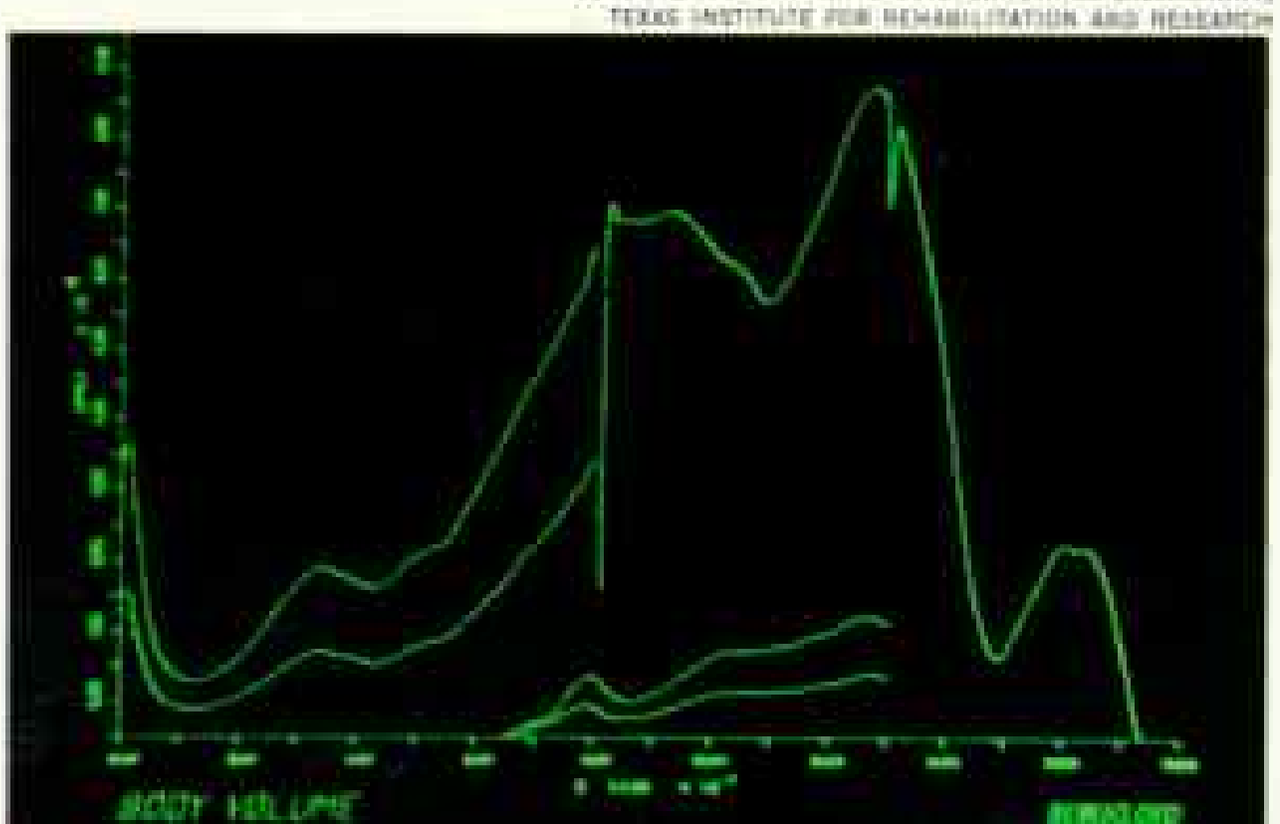
the artificial texture created by the speckled pattern, a machine plots the coordinates of more than 5,000 points on the body as data for a computer.

Assembling the data for presentation on a TV screen, the computer images the body frontally (**overleaf**), in profile (**right, upper**), and as a graph showing the distribution of body volume (**right, lower**). The computer can also zero in to image the head, an arm, or a leg—from any angle.

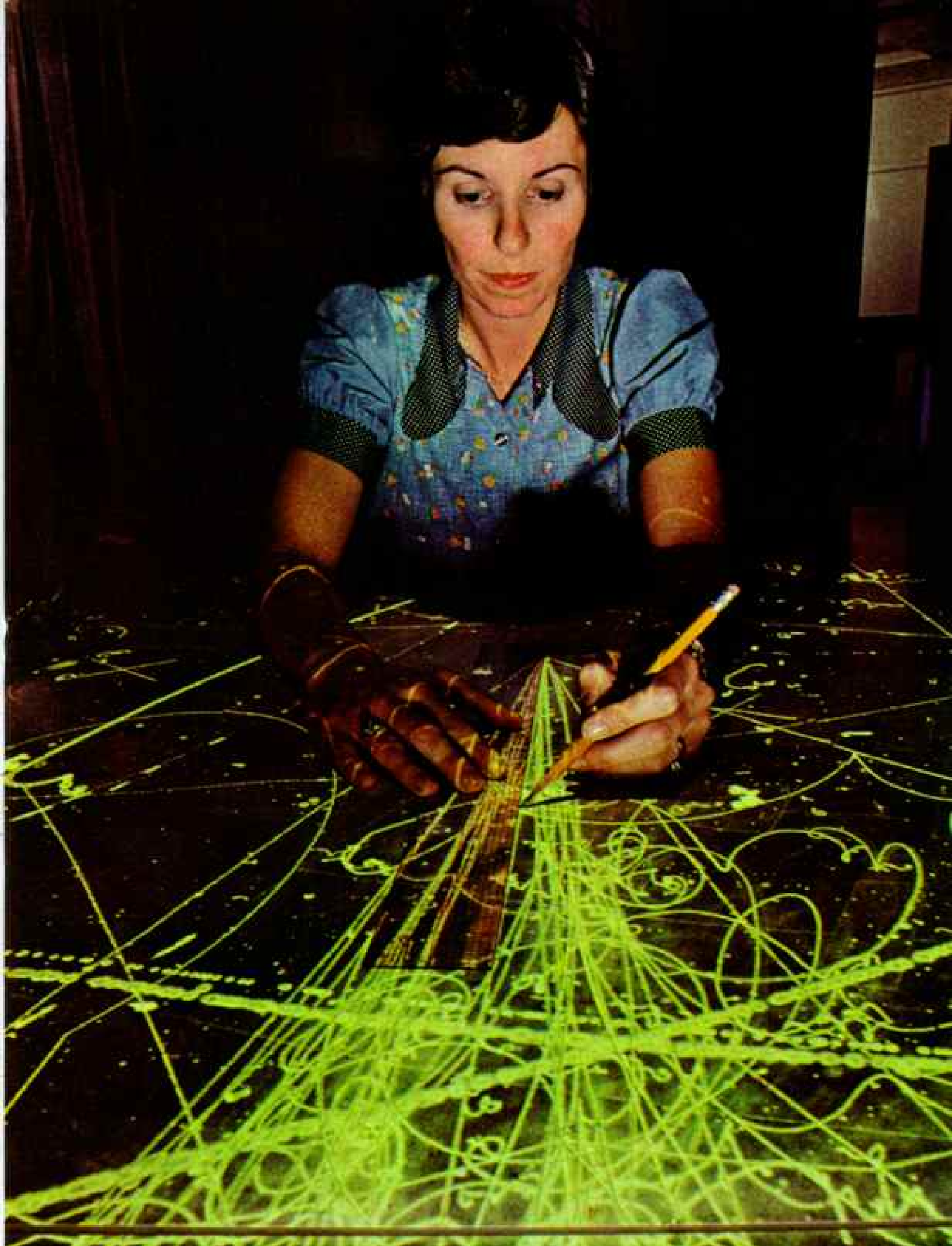
Apollo 16 and Skylab astronauts were measured before and after their flights to determine changes in body volume. More down-to-earth applications include custom-made artificial limbs, early detection of spinal deformation in children, better treatment of cleft palates, and better military helmets.



COMPUTER IMAGING BY BIOSTEREOMETRICS LABORATORY, TEXAS INSTITUTE FOR REHABILITATION AND RESEARCH



The Wondrous Eyes of Science



Fernández-Morán can photographically reduce a 20-volume encyclopedia onto a space the size of a typewritten page.

So many people are using the camera in so many ways that I cannot produce an inventory. What I do offer is an album of snapshots and vignettes. These give glimpses of the technological frontiers we have reached and the scientific questions we are asking in this last quarter of the 20th century.

SITTING AT A COMPUTER near Sioux Falls, South Dakota, I listed the most remote places I had been. A tiny, isolated village in central Alaska, a hellish swamp on Australia's north coast. An Indian river crossing at the foot of the Himalayas. A Sudanese town far up the White Nile.

It had taken me days of planning and travel on past assignments to reach each place. Yet thanks to two picture-taking satellites named Landsat 1 and 2, I could now revisit all four spots in less than ten minutes.*

65° 42′ N., 156° 25′ W. The coordinates for Huslia, Alaska, went into the mammoth computer at the Earth Resources Observation Systems (EROS) Data Center. Within seconds a high-speed printer produced 80 choices of pictures the Landsats had taken of Huslia over the past five years.

I selected one. A microfilm cassette was plugged into the viewer—and there was Huslia with nearby mountains and drainage patterns in beautiful focus.

4° 51′ N., 31° 37′ E. There was Juba in Sudan. What Victorian geographers would have given to see the Nile's course so clearly!

The two Landsats, from their 570-mile-high orbits, have captured 95 percent of the earth's land surface under good viewing conditions (pages 370-71). The images are stored at Sioux Falls' EROS Data Center, where anyone can order copies.

Those most interested are oil and mining companies. Their scientists can pick out from these bird's-eye views geologic formations that indicate possible mineral deposits.

Landsat images are also used to census crops over large areas, to monitor spring runoff of mountain snows, to detail defoliation by gypsy moths in Pennsylvania, and to assess quickly the extent of damage from catastrophic floods. Foreign countries, likewise, are using Landsat to help inventory their natural resources.

The world is not as well mapped as we might believe. Landsat pictures have revealed, for instance, new lakes in Iran and uncharted islands in Brazilian rivers.

Satellite-borne cameras and other sensing devices give scientists the big picture, showing them patterns in weather systems, the earth's crust, or ocean currents that are often too extensive to detect from the ground.

FOR EXAMPLE, Dr. Robert E. Stevenson at the Scripps Institution of Oceanography showed me a Skylab photograph of a spectacular stream of swirls in the northwest Caribbean. "Our concept of the oceans has changed radically since 1973 when we spotted these subsurface eddies," the U.S. Navy researcher said. "No one had ever actually seen them. Now we know they can be hundreds of miles in size and persist for months.

"Some are only a few hundred feet deep. Others go all the way to the bottom. We used to think such turbulence was random. Now we know it forms in an orderly fashion. Maybe it's equivalent to storms in the atmosphere."

The oceans may turn out to be as complex as the atmosphere. Fronts have been found moving through the ocean depths. Great internal waves have been detected sweeping across the continental shelves.

While we have only recently put cameras into space to look back at our own planet, we have long been *(Continued on page 372)*

*See "Landsat Looks at Hometown Earth" by Barry C. Bishop, NATIONAL GEOGRAPHIC, July 1976.

Scenes from a microworld

THE EYE CAN'T SEE protons, electrons, and other subatomic particles, but a camera records their frothy wakes in a chamber of liquefied neon and hydrogen at the Fermi National Accelerator Laboratory in Batavia, Illinois. Technician Karen Carew points to a straight line, possibly the track of a pion dislodged from its spot in a neon atom's nucleus by a neutrino traveling at the speed of light.

Portraits of things great and small

LIKE A HORSE with blinders, man sees only a narrow band of the electromagnetic spectrum that spans the radiant energy common to all things. Today photography and other imaging techniques are removing the blinders.

Radio telescopes detect long-wavelength RADIO WAVES from distant galaxies; computers image the data. A satellite records MICROWAVE emissions to chart Antarctic ice.

INFRARED sensors can measure temperature differences to picture the heat radiating from a man's face or escaping from a house in winter.

Peering into the VISIBLE-LIGHT portion of the spectrum, photography defines what is too fast or too slow, too small or too far for the naked eye to see.

Scanning electron microscopy

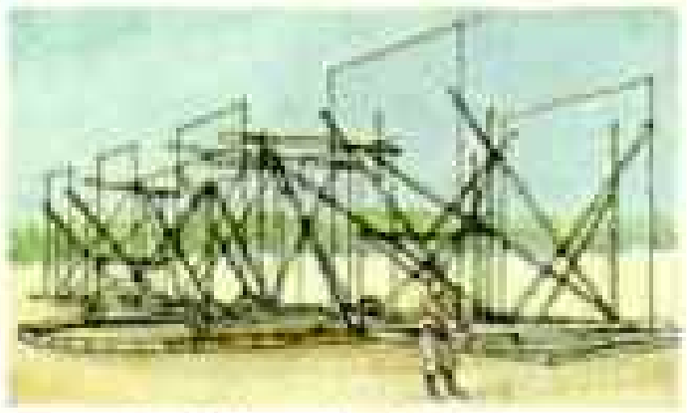
The scanning electron microscope uses an ELECTRON BEAM (**left**) instead of light rays to make a greatly magnified view of the head of a fruit fly.

Retouched areas of a painting are revealed by ULTRAVIOLET light. Above earth's atmosphere, Skylab's ultraviolet detectors record a violent solar eruption.

X RAYS penetrate human tissue to reveal fractures, and even to pinpoint tuberculosis scars in the lungs of a woman long dead. The short-wavelength rays spot defects in castings and welds. X-ray emissions from space outline the remains of a star that exploded 20,000 years ago.

Detected by Apollo spacecraft, GAMMA-RAY emissions help to map the moon's chemistry. Emanating from radioactive materials, the rays penetrate dense gold to detail the interior metalwork of a pharaoh's funeral mask.

RADIO/MICROWAVES

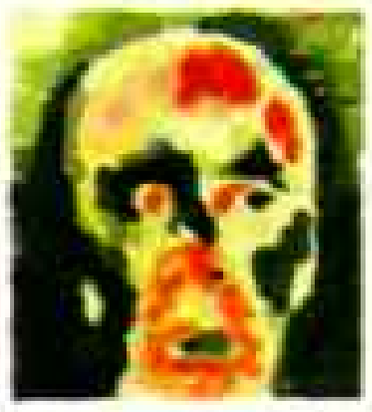


1932: Karl Jansky discovers radio waves from space

Studying earth's seasonal changes

INFRARED

1800: William Herschel recognizes infrared rays

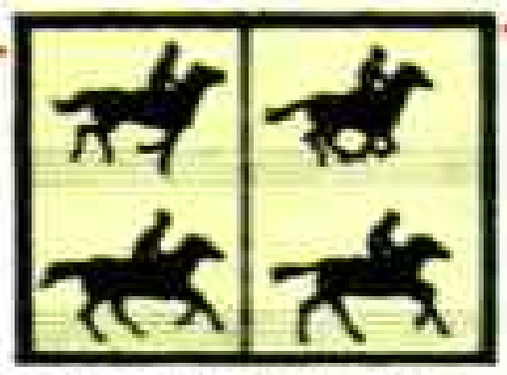


Thermograms

Undersea mapping

VISIBLE LIGHT

1826: Joseph Niépce and the world's first photographic image



Eadweard Muybridge's stop action

Harold Edgerton's strobe flash

Earth observation

ULTRAVIOLET

1801: Johann Ritter discovers ultraviolet rays

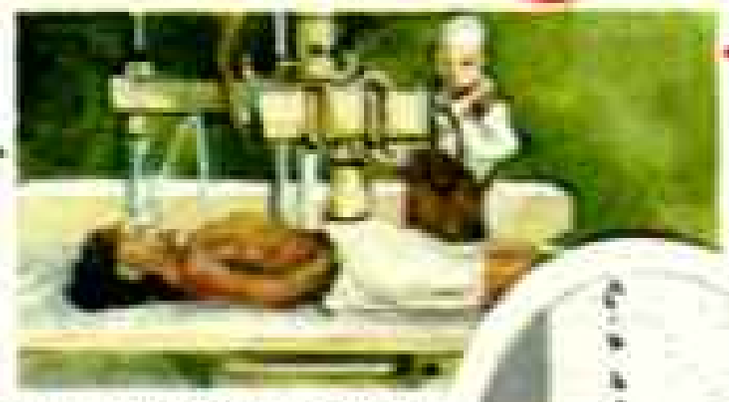
Art research

Revealing hidden markings

X RAYS

1895: Wilhelm Roentgen discovers X rays

Medical diagnosis



Examining 2,100-year-old Chinese noblewoman

Checking welds

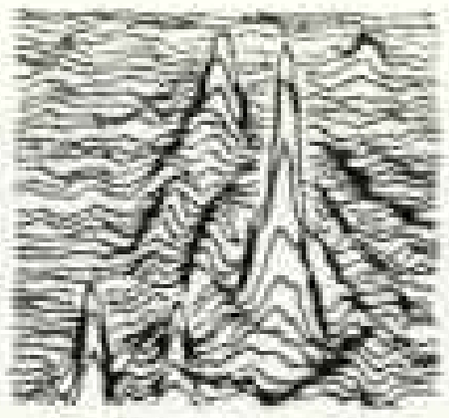
GAMMA RAYS

1900: Paul Villard detects gamma rays

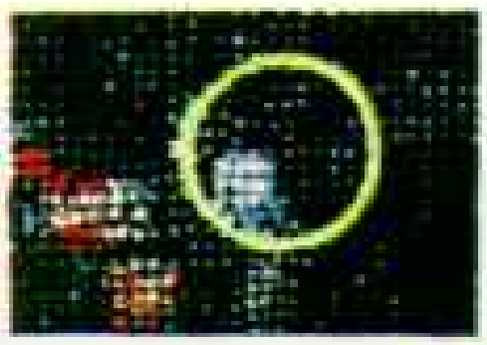
Determining the moon's chemical composition

Winter in Antarctica

Mapping the Milky Way

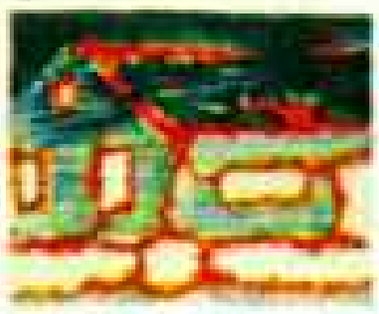


Radio waves from other galaxies



Studying the sun's corona

Monitoring crops

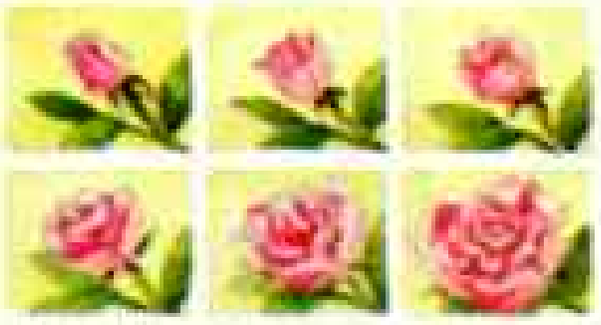


Recording heat loss

Seeing deeper into the Sun

Animal behavior

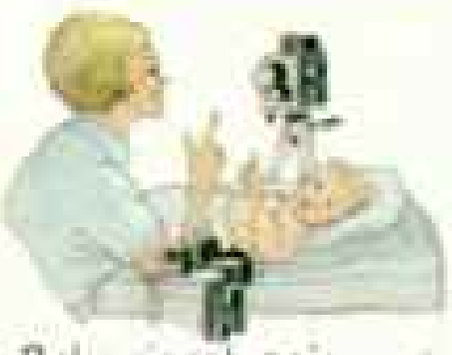
High-speed movies



Time-lapse photography

Keeping track of sunspots

Anthropology



Behavioral sciences

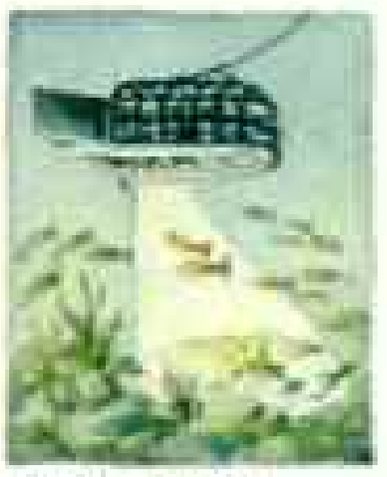
Photomacrography

Photomicrography

Instant photography

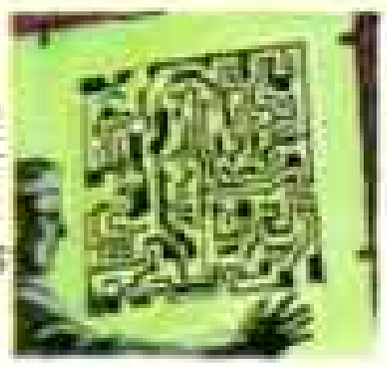
Polarized light

Revealing obscure archeological sites



Deep-towed underwater camera

Charting solar eruptions

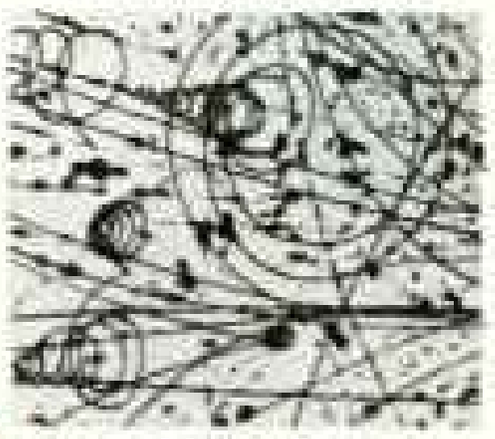


Reduction of electronic circuits

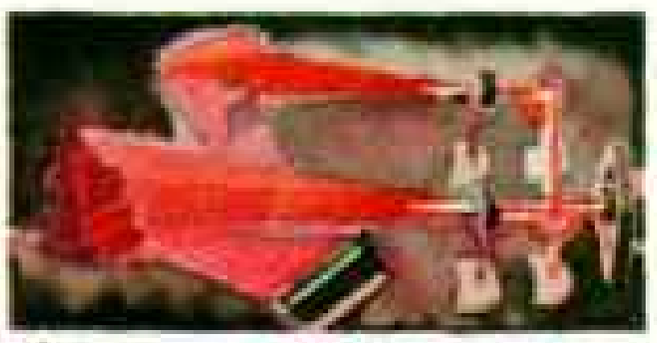
Vladimir Zworykin: father of television

Silicon-chip image detector... gives eyes to Mars' roving robot

Mineral analysis

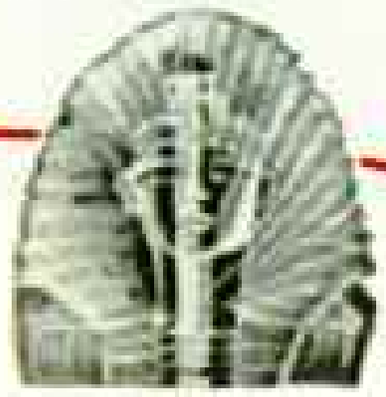


Identifying subatomic particles



Holography

Locating the sun's magnetic fields



Internal-structure analysis

Mapping remnants of an exploded star

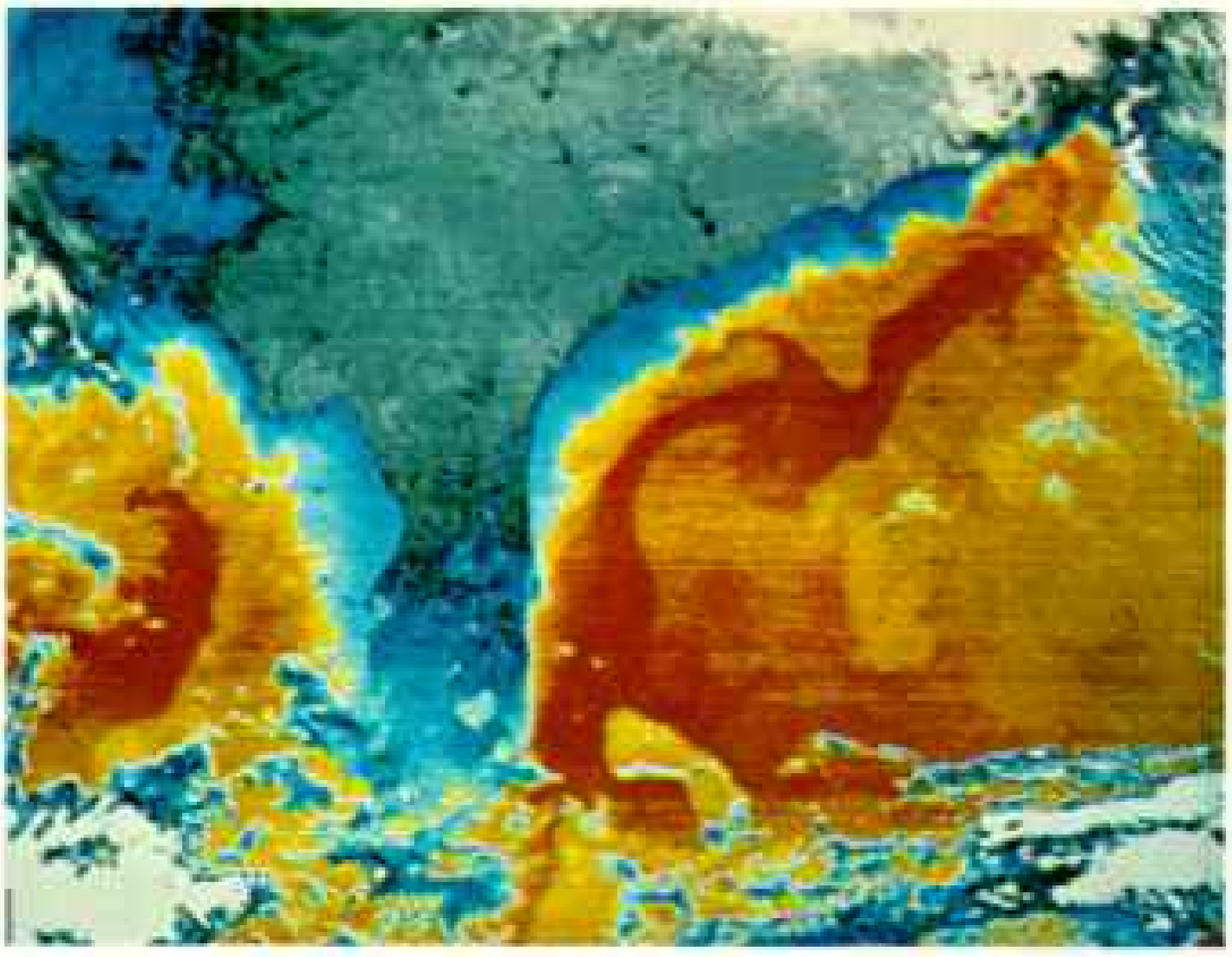
Shadowgraph of shock waves

Picture library for planet earth

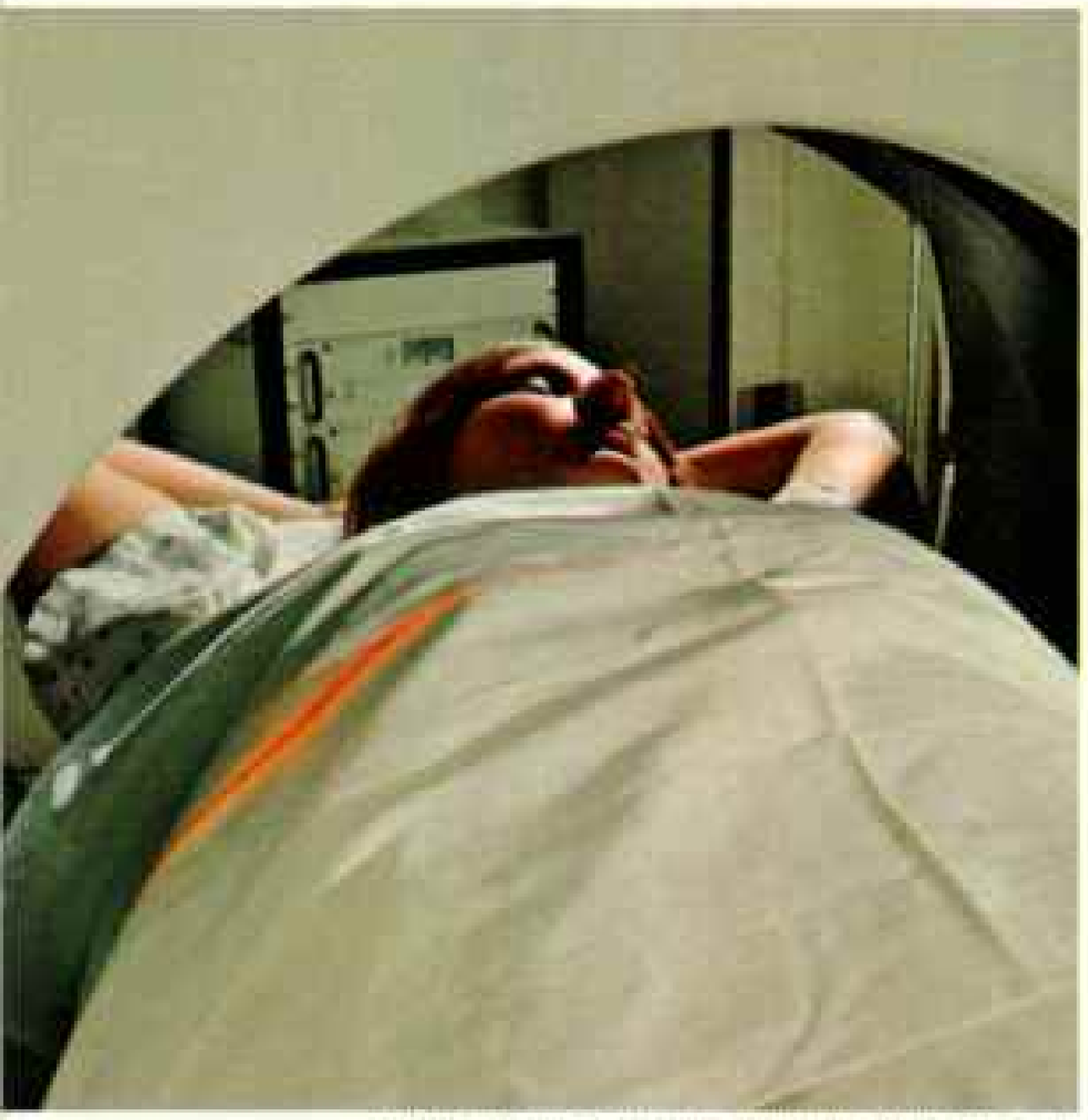
MORE THAN A MILLION IMAGES of the globe, recorded by Landsat satellites, are stockpiled for scientific and commercial use at the U. S. Geological Survey's Earth Resources Observation Systems (EROS) Data Center at Sioux Falls, South Dakota.

Enhanced by a new technique involving a computer-driven laser beam, a Landsat image of southern Florida (**right**) shows the Everglades and the "Gold Coast" with unprecedented clarity. Translating taped data into video images (**above**), EROS principal-systems analyst Fred Waltz looks for terrain patterns on Cape Cod.

The Gulf Stream and the Gulf of Mexico's Loop Current appear orange (**below**) in a color-coded infrared image from a National Oceanic and Atmospheric Administration (NOAA) satellite.



NATIONAL ENVIRONMENTAL SATELLITE SERVICE, NOAA (BOTTOM LEFT); AND NASA AND U. S. GEOLOGICAL SURVEY EROS DATA CENTER (ABOVE)



THOMAS P. WEAREY, CLEVELAND CLINIC FOUNDATION (BELOW) AND MARK H. ELLISMAN, UNIVERSITY OF CALIFORNIA AT SAN DIEGO (FACING PAGE)

Slices of life

TAKING A NEW LOOK inside the body, a computed-tomography scanner records thousands of low-dosage X rays (**top**) for a detailed picture of internal organs; a red laser beam shows the area scanned. A cross section produced by a computer (**above**) shows the spine, lower center, and the adjacent aorta. This image revealed a pancreatic cyst to the right of the spine and aorta.

Nerve-cell membrane takes on a lunar look (**facing page**) under the eye of an electron microscope. The four-ten-millionths-of-an-inch-thick membrane is split with an ultra-thin razor to reveal millions of tiny vesicles containing chemicals that may control mood and behavior.

(Continued from page 367) photographing the universe.

"The telescope is really a camera—with a long-focus lens," Kitt Peak astronomer Helmut Abt told me. "It was natural to put a photographic plate at the end of a telescope."

"Almost no one actually looks through telescopes today," said Dr. Abt's colleague Bill Schoening. "We are getting really deep into the sky, and most of the objects we are interested in are far too dim to see—the eye can't integrate this light. But the photographic plate can sit there for hours, registering photon after photon until an image builds up.

"This photograph, for instance, took hours to make. Only one of the thousands of stars it shows would be visible to the naked eye."

LOOKING AT ALL THOSE STARS I had never seen before, I could discriminate perhaps twenty different levels of brightness. But new techniques let astronomers take the starlight on the plate and break it down into hundreds of shades of brightness. Another powerful tool is an instrument that separates the incoming light from stars into spectral bands from long-wavelength red down to short-wavelength blue.

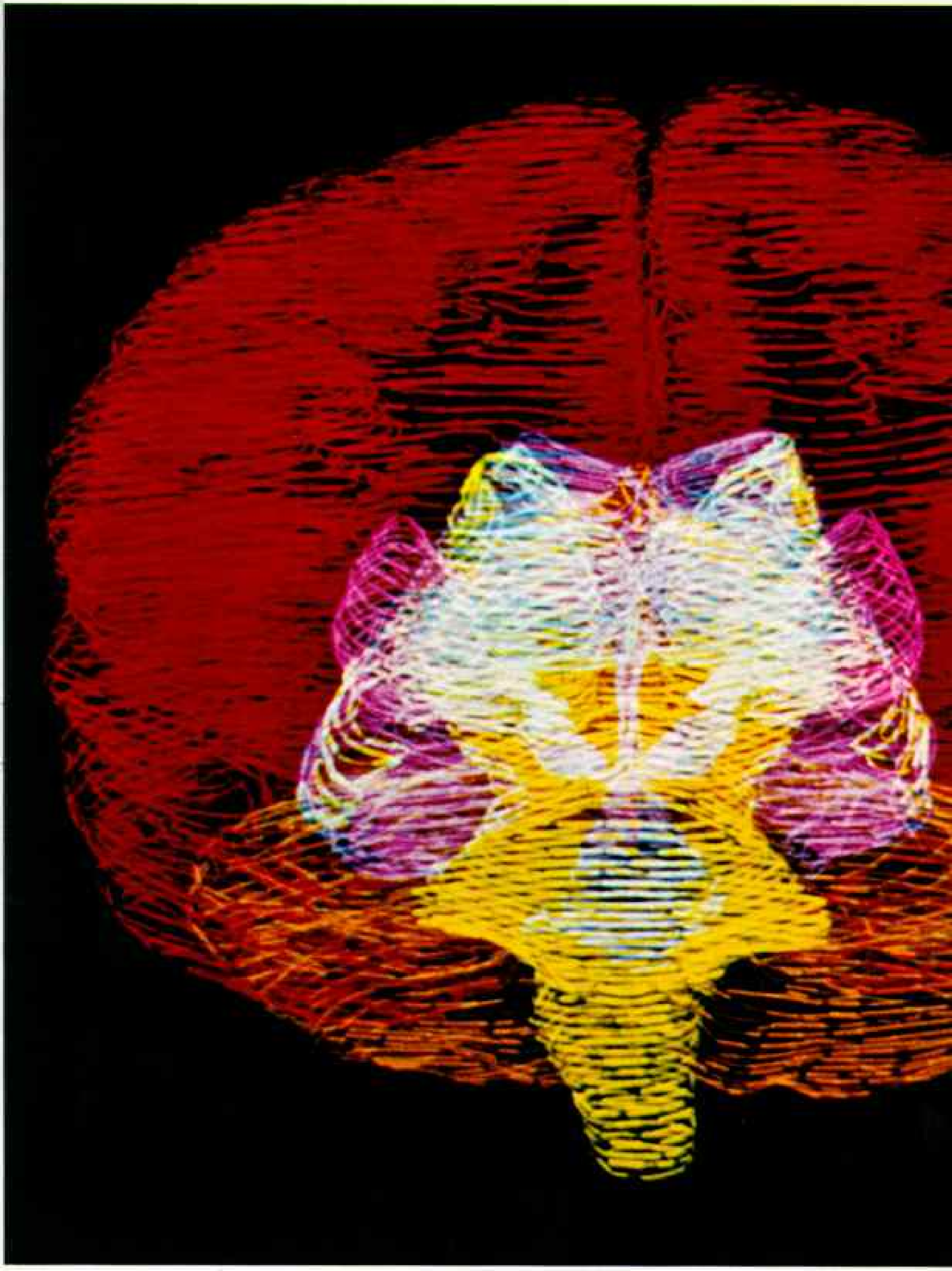
"When you spread out the light from a star and photograph its spectrum, you see gaps," explained Dr. Abt. "Each element, such as hydrogen or iron, has a set of gaps—wavelengths that it absorbs rather than radiates. So if those wavelengths are missing from the spectrum, you know that that element is present in the star you are observing."

Astronomers can coax more than a star's composition out of its spectral patterns. They can take its temperature and determine its atmospheric pressure. Motion causes the spectral bands to shift, so by measuring that shift, astronomers can tell if a star is moving toward the earth or away, and approximately how fast it is rotating.

Using light-intensifying tubes, Kitt Peak scientists have analyzed the composition of the gas and the distribution of the minute dust particles in an unnamed nebula 17,400 trillion miles—nearly 3,000 light-years—away.

Astronomers also image radiation other than visible light—radio waves from distant galaxies and ultraviolet light from the sun, for example.

Photography also *(Continued on page 376)*

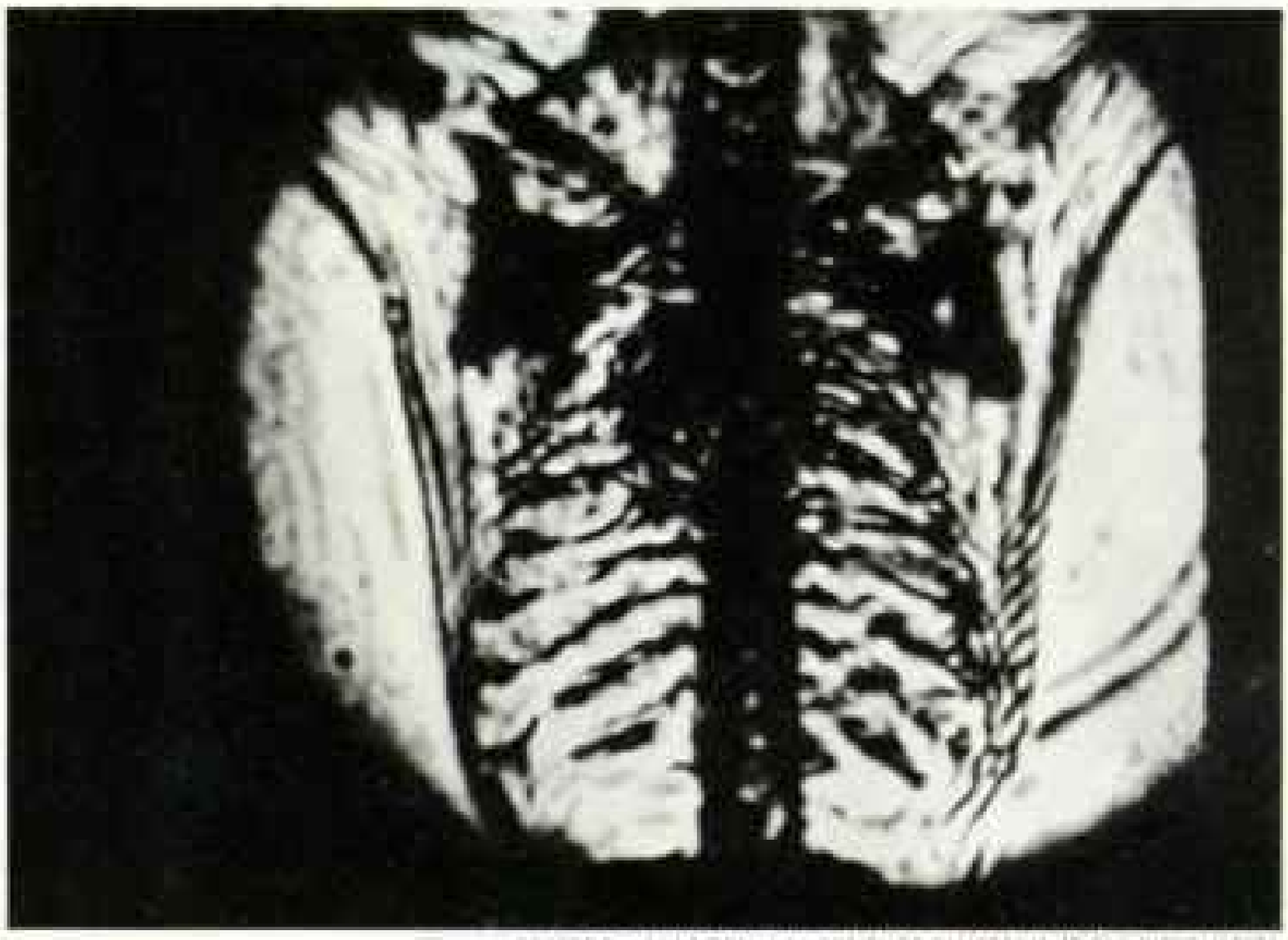


Exploring man's inner space

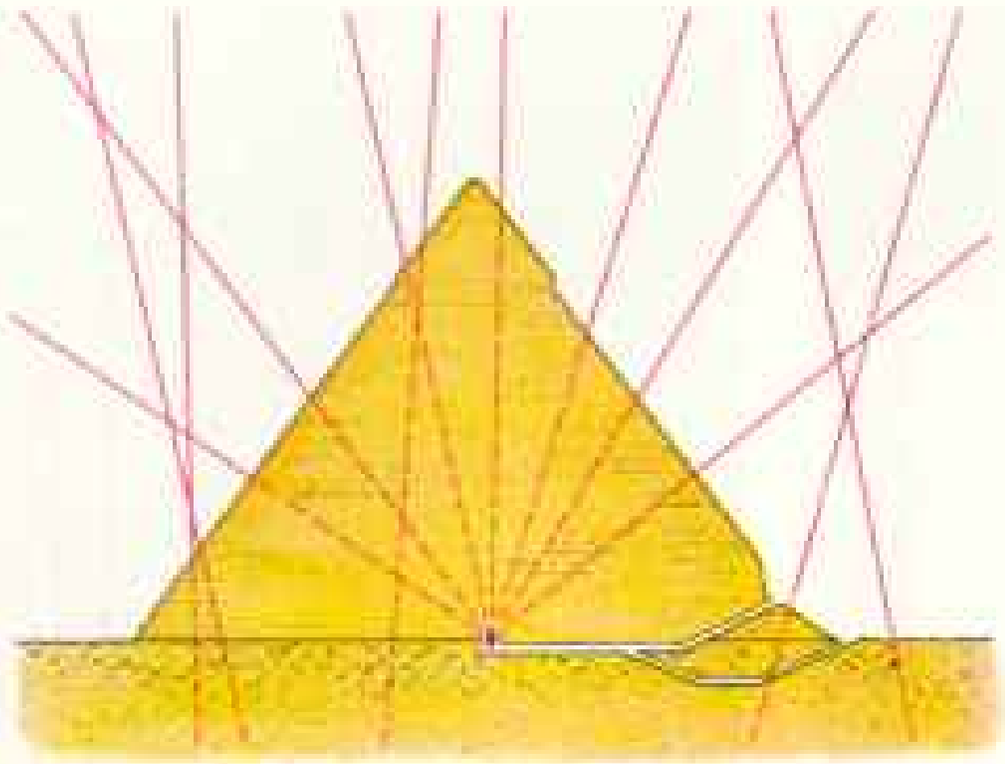
IN A BRAIN drawn by a computer, the twin hemispheres of the cortex are colored red, the brain stem, yellow (**left**). Thousands of photographs of brain cross sections are electronically processed by a computer, which then presents the information as a three-dimensional video image for color coding. The technique allows scientists to make comparisons of brain size and structure.

Gamma-ray imaging, developed at the Argonne National Laboratory in northern Illinois, may permit early diagnosis of lung disease. After a patient takes a whiff of krypton gas, healthy lungs (**above, left**) seem to glow as the gas decays, emitting gamma rays that show as light specks on a TV screen. Since the gas cannot penetrate the emphysema-clogged lungs of a heavy smoker (**above, right**), the extent of the disease is revealed.

Ultrahigh-frequency sound waves, distorted as they pass through a human fetus, are used to image the chest cavity (**below**). The acoustic holographic technique by Holosonics, Inc., at Richland, Washington, promises to help doctors pinpoint tumor locations and other disease conditions.



ROBERT B. LIVINGSTON, UNIVERSITY OF CALIFORNIA AT SAN DIEGO (LEFT); ARGONNE NATIONAL LABORATORY (TOP); HOLOSONICS, INC. (ABOVE)

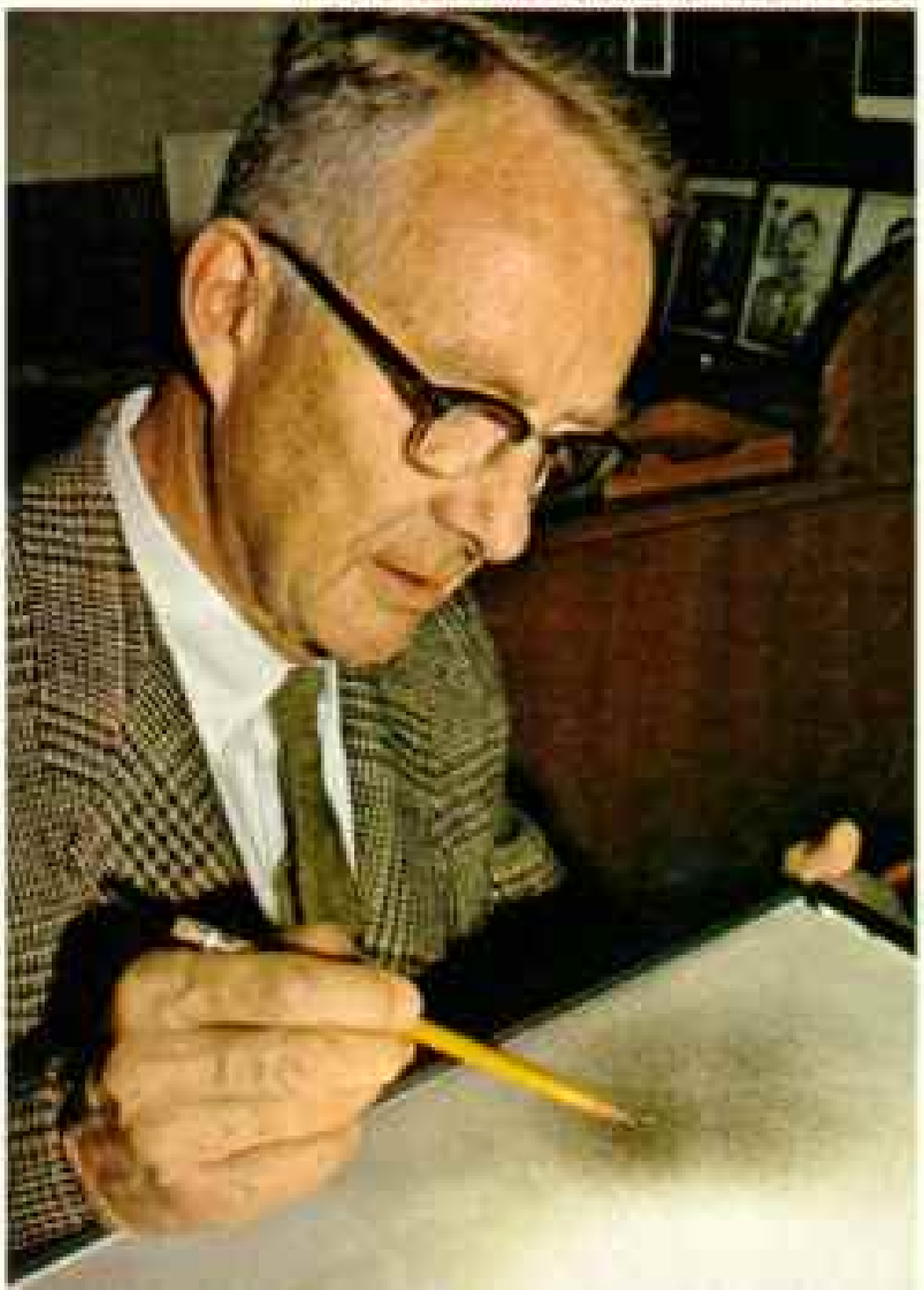


Cosmic rays reveal a pyramid's interior

DEEP PROBE of a pyramid aided in the search for a possibly rich burial chamber in the monument built by Pharaoh Chephren some 45 centuries ago. Utilizing cosmic rays that constantly bombard the earth, scientists set up detectors in an empty chamber beneath the pyramid (**above**). Rays passing through an open chamber would register with greater intensity.

Analyzed by computer, the measurements yielded a shaded image (**below**), showing the structure's four ridges and high peak. Those passing through the side nearest the detectors left the dark cluster indicated by the project originator, Dr. Luis W. Alvarez. As it turned out, the test showed that the upper part of the pyramid is solid.

NATIONAL GEOGRAPHIC PHOTOGRAPHER ROBERT F. SISSON



helps scientists explore the past on this planet. Archeologists, for example, are inveterate picture takers. Excavating a ruin usually destroys it, but the camera can document each stone before it is turned, or record how a piece of pottery is positioned in a tomb.

Sometimes archeologists take to the air to photograph the countryside, seeking evidence of ancient ruins in patterns invisible from the ground.

Aerial photography is a mainstay of other sciences as well. When a major tornado strikes in the Midwest, University of Chicago meteorologist T. Theodore Fujita hurries to photograph the havoc from above. Whenever possible he focuses on cornfields; twisters leave signatures in the swirling patterns of toppled cornstalks.

"People used to think that a tornado is one big funnel—one great wind. That's not true," says Dr. Fujita. "Our pictures show not a simple swath but lots of small vortexes dancing around within. The big wind is usually much weaker than people imagine. It's these little winds that probably do the great damage. They may explain why a tornado seems to jump and skip."

CARTOGRAPHERS, TOO, find aerial cameras invaluable. From a plane they make a series of overlapping pictures. Later, through an optical device, they combine two successive views into one stereo image. They then translate the picture into a topographic map of the terrain they have photographed.

Recently a Houston biomedical team led by Dr. R.E. Herron has been applying these same mapping techniques to the human body. I asked Dr. Herron to make a map of me.

A few minutes later I stood naked, except for a G-string and a skullcap, in front of special cameras in a darkened room at the Texas Institute for Rehabilitation and Research. A stereo camera and a strobe light with a speckled filter were aimed at my front side. A similar setup was trained from behind. The strobes popped, projecting a speckled pattern across my skin, while the cameras recorded my terrain (pages 364-5).

"We have now, in effect, an optical replica of your body," Dr. Herron told me as I dressed.

Several hours later his colleagues Dr. Dan Sheffer and Jaime Cuzzi put the developed

National Geographic, March 1978

plates in a machine called a stereo plotter. I looked through the eyepiece and saw myself staring back—green, speckled, and in 3-D.

I saw also a tiny floating white dot, which I could raise or lower with a dial until it landed on the surface of my image. The speckled pattern made it easy to align the dot with any of the contours of my body. Once I had positioned the dot on one point of my skin, I pressed a foot pedal, and in seconds a computer card came out of a nearby console. It contained three numbers: coordinates for that point on my body.

OVERNIGHT a technician scanned both sides of my image. The next morning Dr. Sheffer patted two thick stacks of computer cards. "You've been reduced to this—5,158 points," he said, leaving to feed the data on the cards into a computer.

Jaime Cuzzi asked the computer to produce 19110.01—my new code name—on a screen. I watched a little green dot slowly draw my head, then my trunk, arms, and legs. Not only could this replica be rotated or turned in any direction, it could also be dissected and any piece looked at in detail. Graphs could be plotted to show how much surface area I have and how my volume is distributed.

The Apollo 16 and Skylab astronauts were stereogrammed like this before and immediately after their missions, so that space doctors could determine how weightlessness had affected body volumes and densities.

Among his numerous projects Dr. Herron is studying a group of children from ages 9 through puberty to determine precisely how and where their body geometry changes as they grow. He has measured distinct changes in the shape and volume of women's breasts during their menstrual cycles. He believes that the geometry of our bodies, including organs and even the cells within, can be indicators of healthy versus abnormal conditions.

Though such biostereometrics is mainly a research tool today, it is also being used to design safer seats in vehicles, artificial limbs that conform precisely to the physiques of the handicapped, improved sports equipment, and protective clothing. Perhaps one day we will all have a set of computer cards that describe us and tell a computer just how to tailor our clothes.

Other new imaging techniques can give doctors a window on our internal condition. The most revolutionary is a big doughnut-shaped X-ray machine called a computed-tomography, or CT, scanner. Taking thousands of low-dosage X-ray measurements, it creates detailed cross-sectional pictures of a patient's brain or torso.

"With conventional X rays we can see four things: bone, air, fat, and everything else. But we just can't discriminate between the various soft tissues. We'd be lucky to find the liver," explained Dr. Thomas F. Meaney of the Cleveland Clinic Foundation.

"With the CT scanner we don't just see the liver; if there's anything wrong in the liver that creates a difference of even 1 or 2 percent in the tissue's X-ray absorption rate, we can find it. We can see inflammations and distinguish both benign and malignant tumors. We can determine the extent of many cancers. Thus in many instances we can eliminate exploratory surgery."

The CT scanner's clearest advantages are in diagnosing brain disorders. Previously, when doctors did a standard X ray of the skull, all they could see was bone. CT lets them look into the brain. They can find a tumor when it's tiny—before it's too late.

THE VALUE of a CT brain scan was driven home poignantly at the medical center of the University of California at Los Angeles.

The infant looked far too fragile to be put in such a big, cold machine. He was two months premature, and his head was enlarging. The doctors said that he might have hydrocephalus, in which case too much cerebrospinal fluid was building up in the cavities inside the brain. Or perhaps his brain was bleeding. Hydrocephalus can usually be treated by tapping the excess fluid surgically. Bleeding would almost surely mean death or severe brain damage.

"Without the CT scanner," explained radiologist Dr. Gabriel Wilson, "we could, one, send a radiopaque material through the umbilicus to the blood vessels in the brain. Or we could do a pneumoencephalogram—displace the brain fluid with air through the spinal canal. We don't like to subject a tiny baby to either procedure."

Instead, the CT scanner did the work painlessly in 20 seconds. Within only minutes the doctors had a picture in hand: It was

hydrocephalus. There was hope for the child.

Another technique, involving slender, light-transmitting glass fibers, can now give physicians a firsthand look at internal trouble spots such as ulcers, polyps, and blocked windpipes. Bundles of the fibers, snaked down the esophagus or into the intestines, carry images to an external eyepiece.

I put the snake end of one of these fiber-optic scopes in my pants pocket and looked in the other end. Quite an odd sensation to cruise amid my keys, several quarters, and half a roll of Certs while looking straight ahead through the eyepiece.

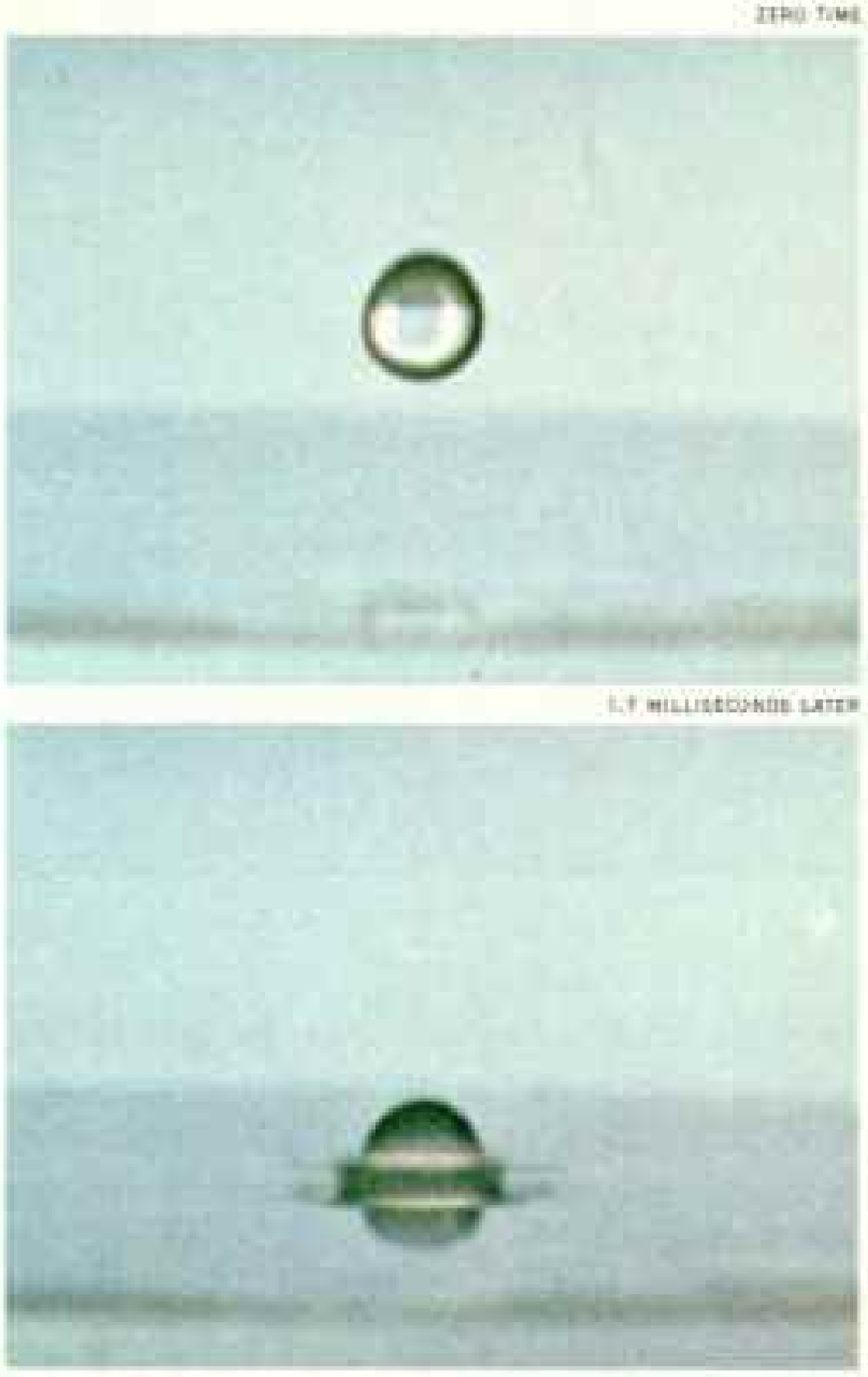
"We have telescopes less than two millimeters thick," said surgeon Stephen Gans in Los Angeles. "They are being put into the ventricles of the brain, used for looking at fetuses in utero, and inserted into the kidney and bile ducts. We may soon even be able to put one into the eyeball."

OUR MOST INTIMATE inner spaces are those within the cells of our bodies. But even these invisible chambers are being explored and photographed today with powerful electron microscopes.*

"This picture was the first electron micrograph ever taken of a cell," Dr. Keith Porter reminisced, pointing to a photograph of a chick embryo cell above his desk at the University of Colorado. "I remember that night in 1944. It took us until 3 a.m. Back then the electron microscope was little more than an unwieldy toy. But that picture changed the course of our lives."

Such pictures also changed the course of

*See Kenneth F. Weaver's "Electronic Voyage Through an Invisible World," GEOGRAPHIC, February 1977.



DANIEL J. ANCHARSKEY, THOMAS DISNER, AND JAMES P. BLAIR (FACING PAGE); AND GEORGE A. LAMBERT, ARGONNE NATIONAL LABORATORY (ABOVE)

Too quick for the eye

BOILING MAD, a bombardier beetle (**left**) blasts offending tweezers with a searing spray normally reserved for attacking ants. Employing catalytic chemistry, the beetle heats its caustic juice to boiling within two abdominal "explosion chambers." A microphone picks up a barely audible pop that signals the spray and triggers an electronic flash that freezes the three-hundredths-of-a-second reaction on film.

If liquid coolant accidentally contacted molten fuel in a nuclear breeder reactor, would a vapor explosion result? No, concluded Argonne National Laboratory scientists—the contact temperature is not that great. Experiments included dropping relatively cool pentane into hot silicon oil (**top**), substituting these for reactor materials. As movies taken at 2,000 frames a second show, explosive boiling (**middle**) and fragmentation (**bottom**) occurred when the 30°C pentane contacted 240°C silicon oil.

THOMAS FISHER, CORNELL UNIVERSITY

biology. They revealed that the protoplasm within cells is not as innocent as egg white, as some biologists believed. Rather it is a community of many particles, each with its own role to play in the cell's behavior.*

Recently, using an extremely high-energy electron microscope, Dr. Porter and his colleagues at the University of Colorado have taken stereo pictures of whole cells at resolutions not previously achieved. Before, an electron microscope's beam could only penetrate thin slices of cells.

I put on polarized glasses to look at one of these 3-D pictures. Suddenly it seemed I was on the cell membrane, peering right into its sea of particles. A cluster of round pigments was exploding toward me from a scale of a reef-dwelling squirrelfish. When threatened the squirrelfish can change its color from pink to red within six seconds. This micrograph had frozen a moment of that blush.

Biologist Mark Ellisman pointed to a latticework of extremely fine fibers that seemed to interlace and guide these exploding pods of pigment. These fibers are only five millionths of a millimeter wide. No one knew that this ultrafine lattice existed. Yet all those particles that we had thought were free-floating apparently sit in this fibrillar matrix like flies in a spiderweb. Is this webbing the cell's choreographer, moving the particles about, structuring—and perhaps even masterminding—the life of a cell?

"The cell now appears to be a very fine, liquid-filled sponge," Dr. Porter told me. "It is, I fear, distinctly more complicated than we had ever imagined."

The electron microscope is giving us a new view not only of the cell, but also of the atom. Nearly eight years ago Dr. Albert V. Crewe of the University of Chicago made the first electron micrograph of a single atom. He has recently taken movies of the same atoms, uranium. To his surprise he found that they "move about like bees in a swarm."

"Conventional theory says that atoms in solid state are rigid and only vibrate," explained Dr. Crewe. "Well, it ain't so—at least in one case. What that means for the theory we can't say. It's like with Galileo. You build a better telescope, and you start to see things."

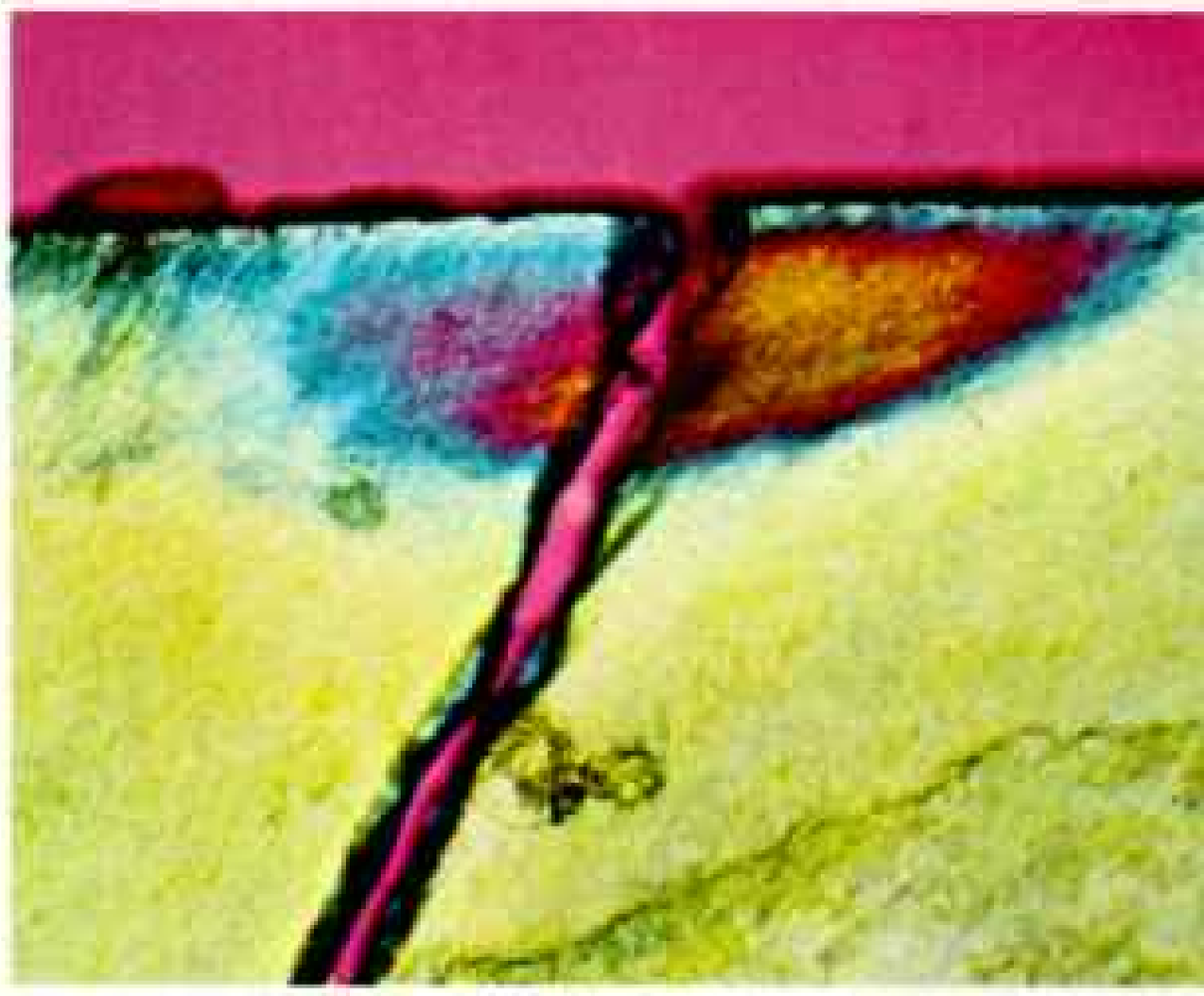
NOT FAR AWAY at Fermilab in Batavia, Illinois, physicists are finding all sorts of strange things within the atom, things such as "kaons," "pions," and "muons." What they would really like to see is a "quark," particularly one with "charm."

Such jargon baffles all but a tiny elite of physicists who are struggling to understand the fundamental laws of matter.

Quarks and charm, along with "color" and "flavor" and "truth" and "beauty," are names applied in whimsy to important new subatomic particles and their properties.

A few decades ago we thought an atom was merely a nucleus, composed of protons and neutrons, and orbited by varying numbers of

*The author described "The Awesome Worlds Within a Cell" in the September 1976 GEOGRAPHIC.



Ultraviolet bulls's-eye targets the nectar area of a primrose willow (**left**) for visiting bumblebees, which see light in both visible and ultraviolet wavelengths. As seen by the human eye, the flower appears a monotone yellow (**far left**).

The camera records the ultraviolet image through a quartz lens that transmits ultraviolet light. A filter screens out rays of visible light.

Cross section of a diseased tooth broken in half (**right**) shows the healing properties of a new mineralizing fluid that may someday appear in toothpaste. Photographed through a microscope in polarized light, the untreated section of the lesion glows orange. Bluish tinge to the left of the fracture indicates the remineralizing of enamel.

LEON M. SILVERSTONE, UNIVERSITY OF IOWA

electrons. Now we have counted hundreds of other particles.

Physicists are hoping that the theory of quarks will help explain this dizzying number of particles. A quark, most now believe, is the fundamental building block of the nucleus. Quarks have a special property, dubbed color, that enables them to bind strongly with other quarks to become new particles. Flavor is the sum of a quark's other properties, among them electrical charge and, in some cases, charm. Charm is the property that lends greater mass and a shorter life to certain quarks.

A quark, if found by itself instead of bound to other quarks (an impossibility, in the view of some scientists), could help physicists better understand the forces that hold the universe together. Today we can list four basic forces: gravity, electromagnetism, and two nuclear forces, one strong (color) and one weak (flavor). Could these all be expressions of the same universal force? Scientists believe they are on the track of the ultimate truth.

The camera lets scientists see some of those tracks. Special techniques are needed to detect particles that exist for only a fraction of a billionth of a second before decaying.

Physicists first generate certain of the longer-lived particles, such as neutrinos, in huge accelerators and fire them into chambers filled with liquefied gas, such as hydrogen-neon. The gas is kept exquisitely near its boiling point—about 250 frigid degrees below zero Celsius. At controlled pressures even the slight perturbation of a particle passing through at nearly the speed of light will trigger a track of boiling bubbles. That track can be photographed and scrutinized. If one particle collides with another, sprays of tracks fly off in a chaos of lines, curves, and curlicues from the point of impact.

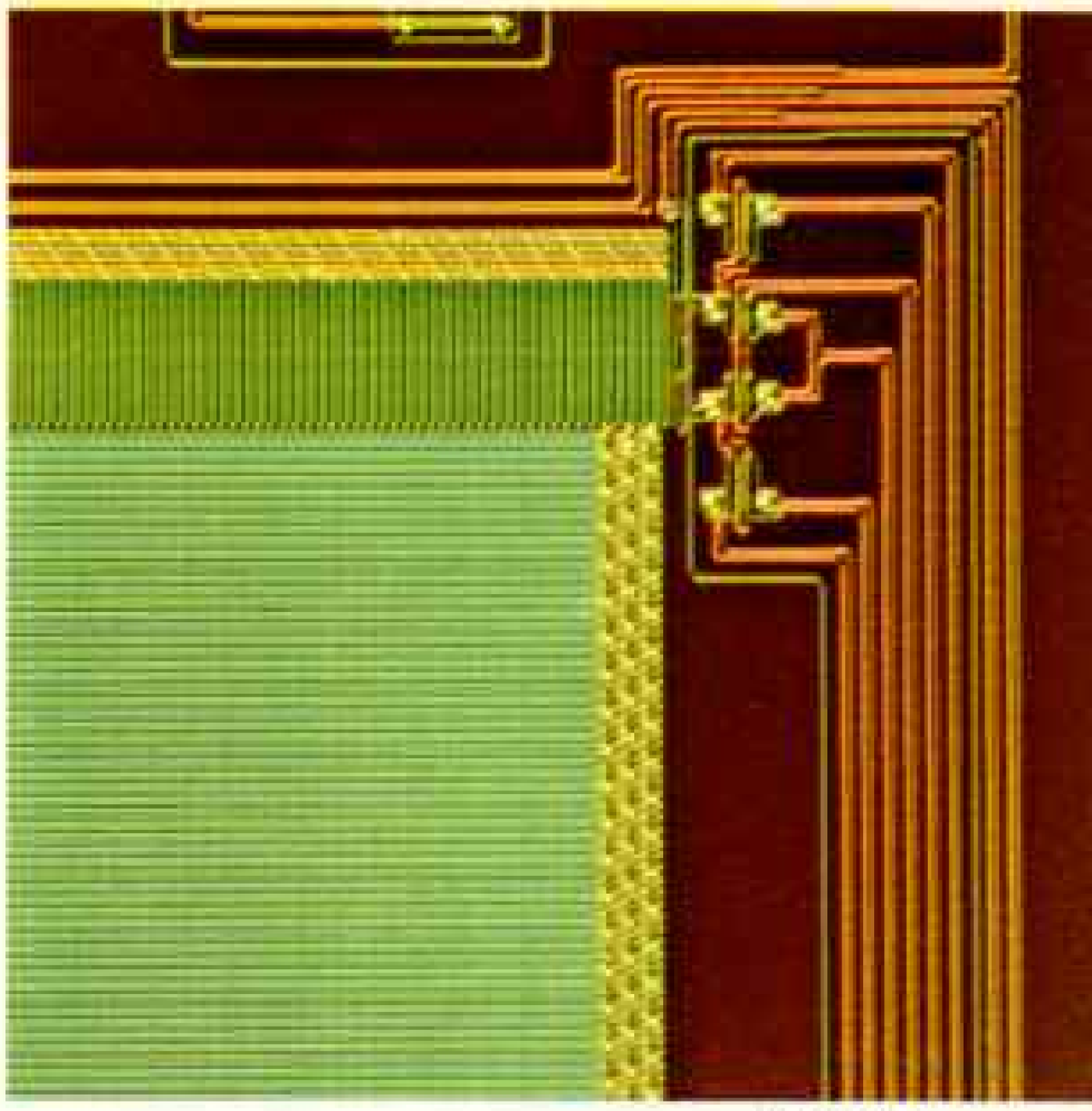
"YOU CAN SEE four distinct neutrino events in this picture," said Dr. George T. Mulholland, who directs bubble-chamber operations at Fermilab's Neutrino Laboratory. It looked like a map Leonardo might have drawn of the cosmos. "The neutrino penetrates deep into the proton. The proton, we believe, is built from tightly bound quarks. When a neutrino collides with a proton, we can learn a lot about charm indirectly in the debris created.

"The neutrino is a very elusive particle, however. It has no electric charge or rest mass, and it travels at the speed of light. The neutrinos generated here could go through a thousand earths and not interact with another particle. So the odds of getting an interaction in the bubble chamber are very low. We aim a billion neutrinos into the chamber for each picture, and are happy to see just one event."

As inscrutable as the behavior within atoms seems, the behavior concocted in the human mind can be even more mysterious. The camera has become a candid tool of those scientists who explore why we do what we do.

Behavioral scientists are filming gestures, fleeting facial expressions, and body language, hoping nonverbal communication will open

Minicameras from microcircuits



ELECTRONIC EYES—163,840 of them—are packed into a postage-stamp-size, light-sensitive silicon chip held by RCA technician Fred Ingle (**left**).

Called charge-coupled devices, or CCD's, the chips will someday replace bulky tubes in present cameras that utilize beams of electrons. RCA's color-TV minicamera looking over Ingle's shoulder, ten times smaller than today's cameras, uses only three CCD's. It televises a chip against a computer picture of the circuitry of a CCD.

Enlarged 75 times, the light-sensitive elements on one corner of a CCD show as horizontal green lines (**right**), the supporting circuitry as heavier red lines. The tiny chips may supplant film in conventional cameras.

SALLY CRAIG

new windows into the human psyche. Psychological counselors now use photographs brought in by a patient as vehicles to help him focus on his feelings. And ever since Margaret Mead and George Bateson photographed the nonverbal communication among Balinese in 1936-38, anthropologists have been using the camera to record primitive cultures before they disappear.

All human behavior, of course, originates in the brain. Neuroscientist Dr. Robert Livingston is charting the parameters of the mind with a camera. He has produced spectacular films that show for the first time in three dimensions and vivid colors how the brain's many components are organized.

His technique is to slice a brain into some 10,000 cross sections and photograph each. Then a technician carefully traces selected photographs with an electronic pen, which transfers the images into a computer. When enough cross sections are processed, the computer can create models of that brain.

"We can see through the brain, look into it from any angle. We can pull parts of it out for a closer look," Dr. Livingston told me at the University of California at San Diego. "We've been surprised to find that each brain is different," the neuroscientist added. "Different geometries might imply different capabilities. So one thing we hope to do is to collect pedigree brains from, say, gymnasts, musicians, and mathematicians and compare them."

Dr. Livingston also wants to watch how degenerative conditions such as Parkinson's disease change brain structure. Another project is measuring the size and shape of the brains of modern man and the great apes, as well as the fossil skulls of early man. He is also gathering brains from human embryos of various ages, hoping to visualize how our brains emerge and grow.

HOW THOSE BRAINS develop after birth becomes the domain of the psychologist, and here, too, cameras have become key tools. Recently, evidence has been building that babies are a lot smarter a lot earlier than scientists had realized.

In Seattle 19-day-old Kevin Plachy sat in an infant seat, staring up at developmental psychologist Dr. Andrew N. Meltzoff. Video cameras were trained on the faces of both. Slowly, Dr. Meltzoff began sticking out his tongue. Kevin was intrigued. For about a minute he seemed absorbed in thought. Then he began repeatedly to stick out his own tongue, at first haltingly, then more masterfully.

Some psychologists would say that such gestures are simply automatic reflexes—babies are not supposed to be able to mimic until they are at least eight months of age. But Dr. Meltzoff believes his cameras document intentional mimicry.

"There's so much we are discovering about babies," he said. "Video cameras are crucial. They don't miss anything, and we can analyze gestures frame by frame. Ten years ago we thought infants couldn't see well enough to mimic. Now we know that they can at least focus on simple objects from birth. They can clearly recognize faces by three weeks. The world is normally whizzing by too fast, with too many distractions, for a baby to express its competence. But in our controlled environment, we see that a baby is actively processing —organizing and making sense of the world it sees right from birth. The human being is an intrinsic problem solver."

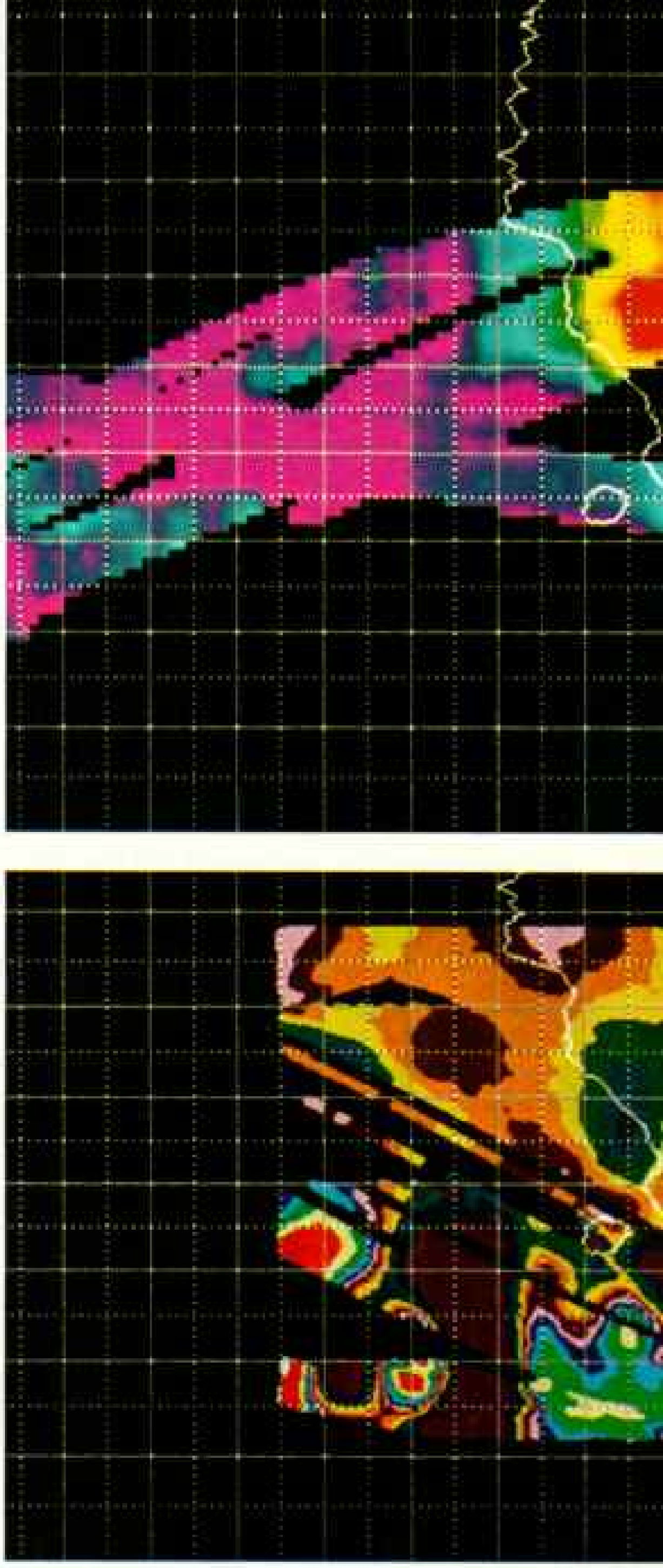
FOR YEARS, TOO, animal behavior, ranging from the courtship of orangutans to the dance of the honeybee, has filled countless frames of film.

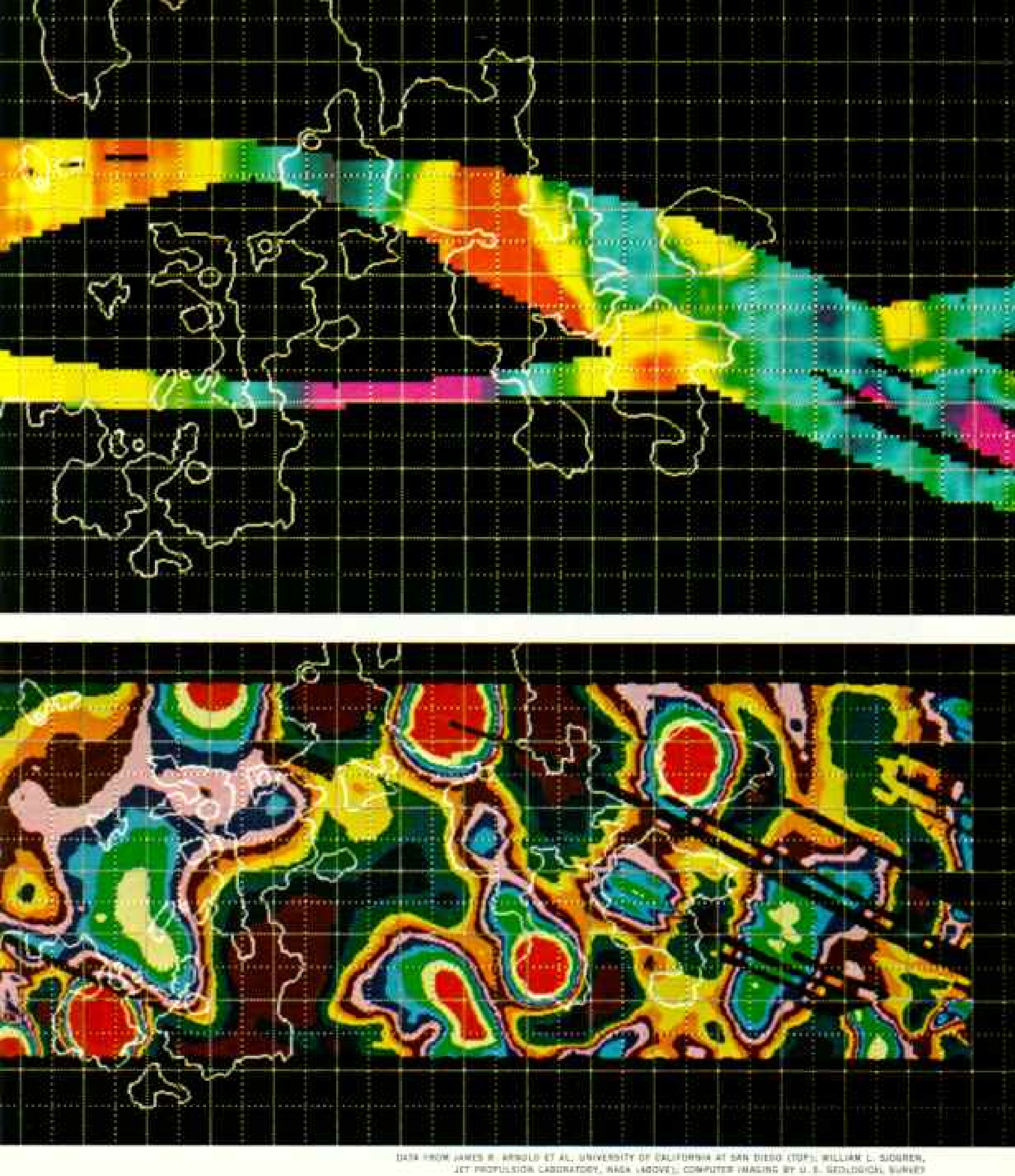
Some animals that we consider lowly have mastered astounding tricks. Take the bombardier beetle, for instance. When an ant attacks its legs, the beetle retaliates devilishly. A split second after it is bitten, it squirts a boiling hot irritant over the ant.

How does the beetle heat this irritant to 100°C so quickly? Why doesn't the hot fluid hurt the beetle itself? How does it aim its fire so precisely? At Cornell University Dr. Thomas Eisner and Dr. Daniel Aneshansley have been studying those problems through high-speed photography.

When I arrived at the laboratory, a beautifully marked beetle dangled from a wire beneath a microphone, flailing its legs. "The microphone lets the beetle take its own picture," said Dr. Aneshansley. He tweaked one of the beetle's legs with tweezers. Faster than my eyes could follow, the insect rotated its rear and with a scarcely audible pop flashed a squirt of acrid-smelling liquid at the tweezers. The microphone picked up the pop and triggered a strobe-lighted camera system that is fast enough to capture a portion of the 10-to-30-millisecond act of spraying (page 378).

Such photography has helped Dr. Eisner learn the beetle's secrets. In "explosion chambers" within its abdomen, the beetle mixes precursors of its irritant with a catalyst. As the precursors are transformed into the irritant, intense heat is released. Steam builds up until the explosion *(Continued on page 389)*





DATA FROM JAMES R. ARNOLD ET AL, UNIVERSITY OF CALIFORNIA AT SAN DIEGO (TOP); WILLIAM L. SJOGREN, JET PROPULSION LABORATORY, NASA (ABOVE); COMPUTER IMAGING BY U. S. GEOLOGICAL SURVEY

Mapping the moon

COMPUTER turns cartographer to transform mountains of numerical data from lunar missions into visual images—actually specialized maps of the moon.

Yellow and orange hues (**top**) indicate high concentrations of iron in lunar basins outlined in white, while curving swaths correspond to the orbits of Apollo command modules, whose instruments detected differences in gamma-ray emissions and beamed the data earthward. U. S. Geological Survey computers color-coded the data.

Smorgasbord of colors (**above** and **left**) charts variations in the moon's gravitational pull. Bright red zones indicate areas of high gravity, caused by concentrations of dense materials.

JET PROPULSION LABORATORY, NASA (BELOW AND RIGHT)

Eyes for a robot

PREPARING TO INVADE MARS, an experimental roving robot (**above**) locates and picks up a rock at the Jet Propulsion Laboratory. In this time exposure, streaks from flashlights mounted on the robot's head track its path. The rover "sees" with silicon eyes—two novel cameras that sense light with new solid-state wafers similar to CCD's. Thousands of tiny sensing elements on each wafer record a scene, such as a Martian rock field (**left, upper**). The data feeds directly into the rover's computer. The computer numbers each rock and translates the image into a map (**left, below**) that its circuits can use to help the robot navigate or collect objects. Two rovers may be launched in the late 1980's to wander across the boulder-strewn surface of Mars.

The stunning sunrise at right was photographed by an earlier visitor to the red planet: the Viking 2 orbiter. As dawn breaks, a cloud of water ice plumes off the great volcano Ascreaus Mons. Massive canyons, Valles Marineris, scar the equatorial zone, while far to the south, frost carpets the giant Argyre basin.

Born to be a mime

ANDREW N. MELTZOFF AND M. KEITH MOORE, "SCIENCE," VOLUME 198, 1977 (BELOW)

INSTANT IMITATORS, babies mimic gestures a lot sooner than scientists thought, reports Dr. Andrew N. Meltzoff of the University of Washington's Child Development and Mental Retardation Center.

Observed by a TV camera, Dr. Meltzoff sticks out his tongue (**above**) at a 20-day-old girl. Another camera monitors the child. When Dr. Meltzoff removed the pacifier, the infant stuck out her tongue. So did others in the study (**left**), and also repeated mouth-opening and lip-pursing gestures.

Videotapes helped ensure objectivity. Observers unaware of Dr. Meltzoff's gestures watched one screen to record the infants' responses. Others viewed a playback of Meltzoff to check him for undue prompting.

(Continued from page 384) chambers erupt.

Still-higher-speed pictures show that the beetle's spray comes in a series of pulses about one and a half milliseconds apart. Apparently the pulsing keeps the explosion chamber from overheating. Cool precursor enters before each pulse. "It's like a machine gun in which every bullet is cold and cools the muzzle," said Dr. Eisner.

PROBING with television cameras, Dr. Eisner has uncovered other secrets of the insect world. TV cameras can sense ultraviolet, or blacklight, wavelengths that many insects can see, but we cannot. Therefore, when equipped with a UV-transmitting lens, a portable video unit can record nature from a honeybee or butterfly's point of view.

Spectacular patterns suddenly emerge on the petals of marsh marigolds and black-eyed Susans. Presumably these markings guide pollinators to the nectar. Flowers that are pollinated by birds and bats rather than by insects lack the markings.

TV cameras sense all types of light much more efficiently than film. For every hundred photons of light passing through a lens, only a few strike the light-sensitive silver grains on standard film. The rods and cones on the human retina will capture about ten. The phosphorescent screen of a TV camera will register about ninety.

Moreover, devices developed for night surveillance during the Viet Nam War can intensify very dim light. I stood in front of one of these in an RCA lab that was too dark for note taking. Nevertheless my image on a TV monitor was bright and sharp.

For future space shuttle experiments RCA is thinking of coupling one of these intensification units with a revolutionary invention called a charge-coupled device, or CCD.

CCD's are silicon chips no bigger than postage stamps. They are the first generation of solid-state elements—as opposed to electron tubes—that can broadcast high-resolution TV pictures. Like the tiny circuits in very small computers, they can work wonders.

RCA is about to market a CCD color-TV camera about the size of a portable tape recorder. Its three little CCD chips replace bulky vidicon tubes. Each CCD contains 163,840 silicon sensors, or "pixels." These pixels convert photons coming through the camera lens into thousands of discrete electrical charges, which are read row by row and converted into the TV image. The pixel data can be broadcast live or tape-recorded.

Instant-replay home movie cameras with erase and edit features are in the offing. So are CCD still cameras, when more refined CCD's are developed. Then we could store dozens of snapshots in a small electronic memory and replay them like a slide show on home TV screens. With photocopy attachments we could make prints of our favorites.

"We like to think we are someday going to significantly challenge film photography with electronics," said RCA engineer Harold Krall.

Solid-state imagers may revolutionize science as well. The orderly array of pixels on a CCD is much like the network of rods and cones on our retinas. Such devices can be the eyes of the computer.

ALREADY at the Jet Propulsion Laboratory in Pasadena similar silicon devices are giving eyes to an experimental Mars robot rover, whose descendants may roam across the red planet in the late 1980's, collecting samples and conducting experiments.

When I visited JPL, the Volkswagen-size rover was being rewired and was paralyzed, but I watched a videotape made earlier as it maneuvered about the JPL campus picking up rocks. It is basically a computer sitting on a dolly-like platform. It has a long extendable arm with a metal claw. Its head is a black stalk with camera sockets and a laser turret that moves back and forth surveying its path.

"Once we give it a task, it carries it out all by itself," said scientist Don Williams.

"The robot is being trained to recognize trouble—like a cliff or a canyon. It is able to find a path through a boulder field, or else say, 'I give up. I can't get out of this maze. Help me, earth.' It has a mind of its own."

The Mars rover lives in JAIL, which is short for JPL's Artificial Intelligence Laboratory. JAIL is a good place to end this survey. For JAIL is where the camera is evolving into something more than a tool. Photography is going solid-state and cybernetic. It will soon be almost impossible to divorce the camera from the computer, and our children may find that in the last quarter of the 20th century we gave eyes to an intelligence more awesome than artificial. □

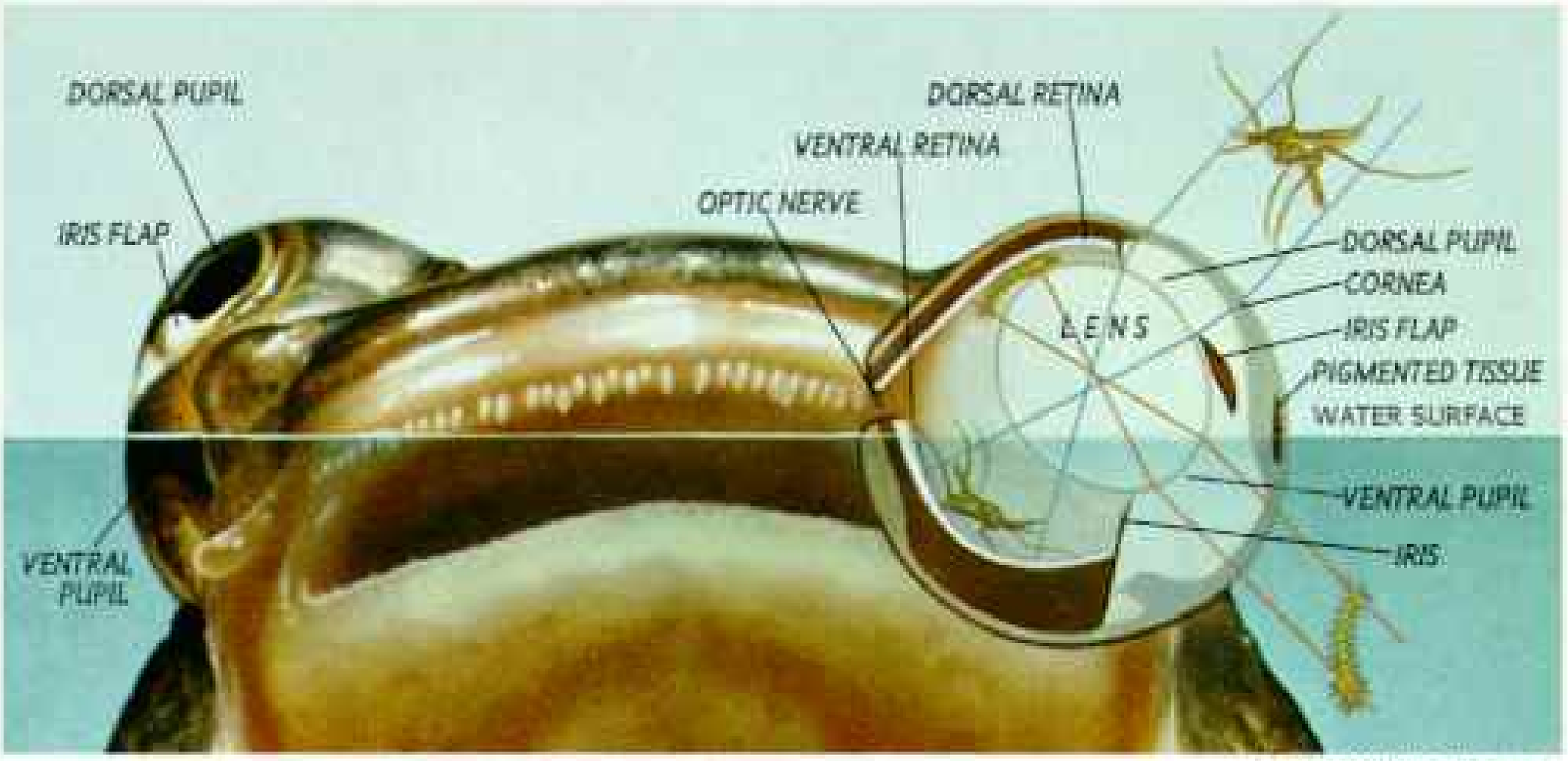
The Four-eyed Fish Sees All

PICTURE STORY BY
PAUL A. ZAHL, Ph.D.

DUNK YOUR HEAD into a pool of water, open your eyes, and of course everything's a blur. Using simple logic, it's not hard to imagine that a fish taken out of its element will similarly be reduced to hazy vision. In rivers and estuaries from southern Mexico to northern South America, however, there exists a fish that confounds this apparently elementary lesson in fish and human optics. Its name is *Anableps*, but it is commonly known as the four-eyed fish. Not only does it peer clearly through water, but it also focuses on objects in the air—all at the same time.

The four-eyed fish actually has only two eyes, but they are divided into upper and lower halves, each half with its own focal length, endowing *Anableps* with simultaneous dual vision. As it glides along just under the surface, the pupils above water survey the aerial realm, while the submerged pupils scan the aquatic world, enabling the fish to feed on, or flee from, creatures that fly and those that swim. Large optic-nerve bundles running from the eyes to the central nervous system are visible under a light at night (**right**).

GENUS ANABLEPS, 23 TO 30 CM (9 TO 12 IN.)



NATIONAL GEOGRAPHIC ART DIVISION

BUILT-IN BIFOCALS provide the key to *Anableps's* remarkable dual vision. A speckled band of pigmented tissue and two iris flaps visible just above it divide each eye at the waterline, in effect creating two pupils (**below**), one for above water and one for below. Viewed from above, the iris flaps resemble projecting fingers inside the bulging eye (**right**).

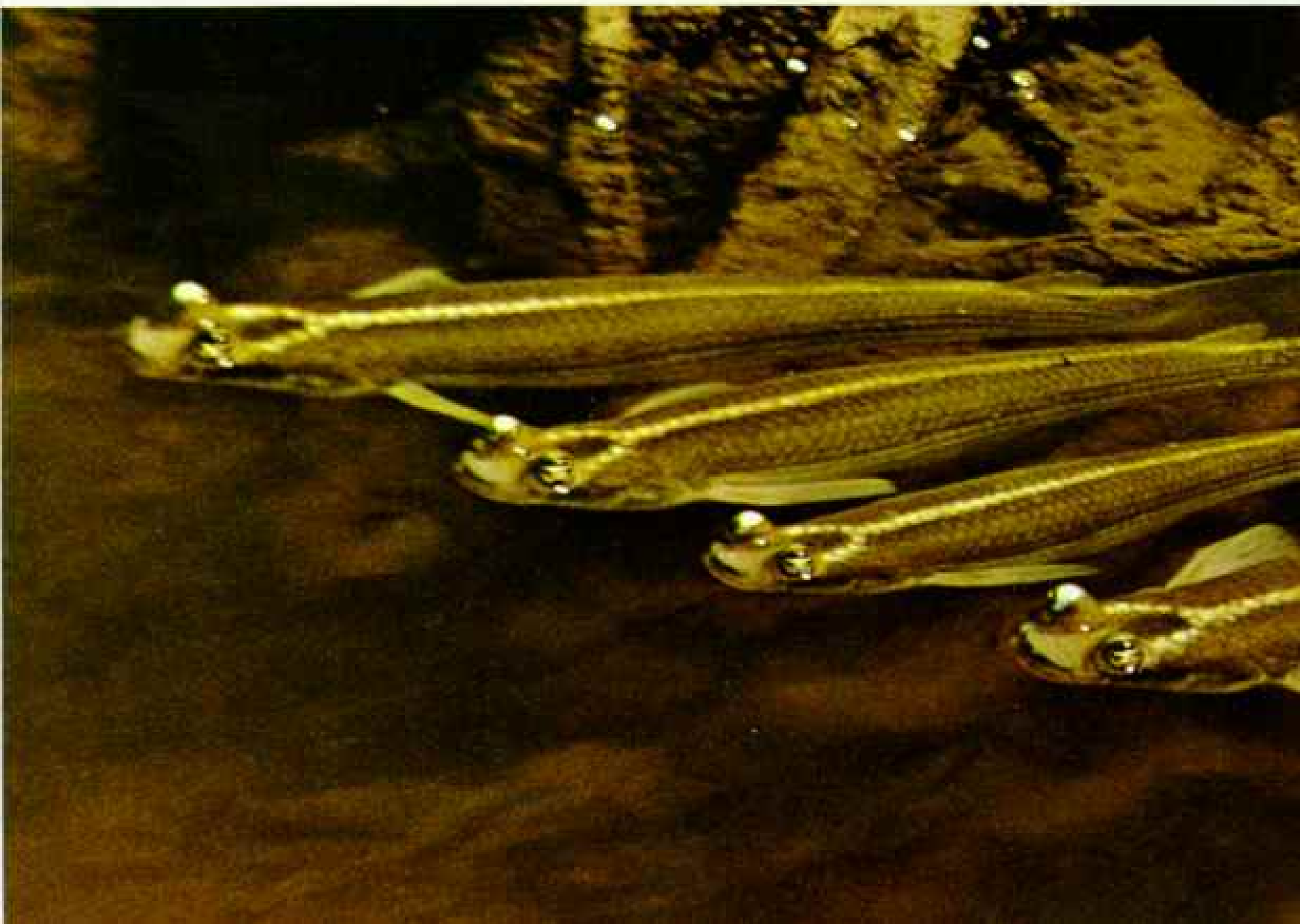
Because the refractive natures of water and the surface of the eye, or cornea, are almost identical, light reflected from underwater objects passes straight through the cornea, to be bent and focused sharply on the retina by the lens, which has a higher refractive index. Air, on the other hand, has a lower refractive index than the cornea so that the light is bent twice—once by the cornea and again by the lens (diagram, **above**).

Anableps, using its unique egg-shaped lens, sees both images clearly. The part of the lens aligned with the lower pupil is rounded like a typical fish lens, so that an image of a swimming insect larva will be focused on the retina. The less rounded upper part, more like the human lens, compensates for double refraction when objects in the air are viewed. A mosquito can thus be clearly seen.

The four-eyed fish will lunge into the air to ambush flying insects or dip beneath the surface to catch swimming creatures. More commonly, however, it cruises the shallow water near a shoreline and captures crustaceans, algae, and insects that are trapped in the surface film.

Scientists have determined that *Anableps* relies mostly on its aerial vision, which can detect smaller objects at greater distances than the aquatic sight system. But the fish often dives to feed or escape predators. When on the surface, *Anableps* repeatedly bobs its head to moisten its "upper eyes."

EYES BY THE HUNDREDS poke out of the water like periscopes as a school of *Anableps* lies in wait for low tide near the mouth of the Suriname River (**top**) in Surinam. When the water goes out, the fish may fling themselves onto the shoreline, where they gulp mouthfuls of nutrient-rich mud. Should the fish spy a low-flying egret or kingfisher—major predators—they quickly wiggle back into the brackish water and bound



away on the surface, sculling with their tails (**above**). Fishermen also pose a threat, but keen-eyed *Anableps* usually spots the stalkers and races away as the net is being tossed.

On Marajó Island at the mouth of the Amazon River, a goggle-eyed patrol of foot-long *Anableps* (**below**) pauses in shallow water for food to be carried past by an accommodating tide. □

TEXT BY THOMAS O'NEILL

Easygoing, hardworking Arkansas

By BOYD GIBBONS
NATIONAL GEOGRAPHIC STAFF

Photographs by MATT BRADLEY

TOM BLACKMON, smiling, microphone in hand, leans out the window of his white Ford camper. He looks into the faces of Arkansas farmers, his auction customers.

"All right, a good stock trailer. I got a thousand on the money . . . eleven and a half, now seventy-five, now twelve. . . ."

This is the Back Gate auction, on the banks of the Arkansas River in flat southeast Arkansas. The farmers have come here from the orchards on Crowleys Ridge, the oil fields around Smackover, the pine hills around Pine Bluff, from places like Bald Knob, Rocky Mound, Greasy Corner. There are a few cowboys here in pointed boots and high-crowned hats from the forested Ouachitas (WASH-ih-tahs) and Ozarks to the west and northwest.

There are bidders here from 28 states, but mostly these are soybean, rice, and cotton farmers of the Delta, the eastern third of the state—biscuit-and-redeye-gravy country. Their visored caps advertise John Deere, CAT Diesel Power, Gristo Feeds, Red Barn Fertilizers, Log Hog.

The month is March, windy and cold, and the river is muddy and wide. To escape the spitting rain, I squat beneath a flatbed trailer and watch Tom Blackmon work (pages 398-9). At 37 Tom is a master of the craft of auctioneering—rhythm, momentum, psychology, humor, and knowing the value of what he sells. He learned from his father, Eddie, who struts among the bidders as a ringman, touching an elbow, patting a shoulder, signaling bids with a "hup" and an upward jerk of his arm. Tom has been auctioneering all winter, and his voice is a musical rasp—a tenor Johnny Cash. He protects his throat by gargling with 3 percent Mercurochrome and by "rattling" with the tip of his tongue, cantering phrases like "who will bid" into something that sounds like "hoodalabidda."

"All right, that's a real good combine . . . hoodalabidda ten thousand? Nine, nine, nine, and now ten, now ten five. . . ." Tom sells the combine, and the camper creeps down the row of machinery to a disc. A bumper sticker on Tom's camper reads: IF YOU COMPLAIN ABOUT FARMERS, DON'T TALK WITH YOUR MOUTH FULL.

In the next two days Tom will sell more than two thousand pieces of used farm machinery. More than a thousand bidders have

Tickled to be here, twins Amanda and Meghan Williams traded beach for mountain when their parents left jobs in Florida to start a new life in the Arkansas Ozarks. "It was exciting," Mrs. Williams said of the move. "We found a vibrancy in the people, and nothing but good feelings and genuine concern"—an oft told tale in a state that takes life as it comes.

Facing the fickleness of weather and prices is an old story to farmers like Bert Pouncey (**right**), whose soybeans were threatened by drought last year. Humor helps (**below**), but resourcefulness and self-reliance lie at the heart of the state's prodigious agricultural output. Already-well-used machinery sold by auctioneer Tom Blackmon (**lower right**) will most likely be tinkered with, cussed at, and kept running for years to come.

registered in his trailer. Blackmon's Back Gate auction is the largest sale of its kind in the country. The sellers simply park their machinery along the river and leave without any receipt. "We walk away from sales like this with well over a million dollars of their money," Tom says, "and they never worry." Arkansas trust.

Agriculture is big business in Arkansas. Almost 40 percent of the state is farmland, soybeans are the leading crop, and more rice and broiler chickens are produced than in any other state. Arkansans also raise everything from cotton, hay, wheat, corn, oats, grain sorghum, spinach, snap beans, pecans, apples, peaches, grapes, strawberries, cucumbers, tomatoes, and watermelons that outweigh the farmers, to cattle, horses, hogs, turkeys, quail, chukar partridge, pheasant, crickets, fish, and worms. Turn on the television in Little Rock —fertilizer commercials.

Tom and Bonnie Blackmon live in a mansion full of antiques on leafy Edgehill Road in Little Rock. "We go to New York to the theater every year," Tom says. "People up there always expect us to be barefooted."

Weary of this stereotype, Arkansans remind visitors that wealthy people live here, that they have the Arkansas Symphony Orchestra, the Arkansas Arts Center, a repertory theater, the National Center for Toxicological Research, the *Arkansas Gazette*, modern shopping malls—that they do wear shoes.

After seven weeks and 4,000 miles of driving around the state, I also learned this about Arkansans: They are resourceful and enterprising, waste little, can make and repair just about anything, and they hustle imaginatively for income. They have to, because wealth here, while not invisible, is not prevalent. Many Arkansans barter and trade, often at auctions.

I asked Eddie how he felt about Arkansas. "This is a lot better state than 49 other states think it is," he said. "And I live in Texas."

Prairie Teaches a Hard Lesson

Pioneers pushing westward into Arkansas Territory in the early 1800's often got lost in the forests and swamps of the Delta (as De Soto had more than two and a half centuries earlier), so many paddled up the rivers—the White, the Red, the Ouachita, the St. Francis, the Arkansas. Those leaving Arkansas Post, the first white settlement (near Back Gate), came out of the forest onto a treeless prairie, an irregular oval of flatness about ninety miles long and forty wide. The Grand Prairie.

Those who stayed and tried to break the soil were more often broken by it. Poke a stick into the prairie. You might just as well try to push a pencil through macadam. Beneath its shallow loam is a blue hardpan clay. Arkansas cement.

About the turn of this century the Grand Prairie was discovered to be a natural paddy. The Rock Island Railroad advertised this fact (and its land for sale) throughout Iowa and Illinois, and German-American farmers came here to grow rice. From a distance Stuttgart, Arkansas, looks like the Dallas skyline (pages 418-9). Up close it is a small town of huge

Farmers' artwork appears each spring on the flat face of the Grand Prairie

in eastern Arkansas, when rice growers raise levees before flooding their fields.

grain elevators—the aorta of rice and soybean production. Arkansas rice goes into Campbell Soup, Quaker Puffed Rice, the Soviet Union, the Middle East, and the craws of a million ducks that invade the prairie each fall along with thousands of hunters.

Catfish swim on the prairie. So do goldfish. From farm ponds Arkansas produces more baitfish than any other state, and is second only to Mississippi in raising catfish.

On their farm near Carlisle (about 60 acres of rice, 400 of catfish) Ray and Dot Schroeder sink ten-gallon milk cans in their Grand Prairie ponds. The female catfish lays her eggs in a can, and before she can eat the eggs, the male bats her out and guards them with slow sweeps of his tail.

Last year Ray was voted "Catfish Farmer of the Year" by the Catfish Farmers of America, but his catfish were unimpressed. When Ray slides his hand into the milk cans to get eggs for Dot's hatchery, the males try to bite him. Big ones have knocked him flat with their powerful tails.

Catfish are to Arkansas, and much of the South, what salmon are to the Pacific Northwest. In Dumas, in Little Rock, in roadhouses all over the state—as well as in the Schroeders' kitchen—I became pleasantly addicted to crisp green onions, hush puppies, and fried fresh catfish, rolled in cornmeal and dropped in cast-iron pots of peanut oil hot enough to light a kitchen match.

A Highway for Barges

The Arkansas River rises in Colorado and enters Arkansas at Fort Smith. It meanders between the folded Ouachita Mountains and the Ozark Plateau to Little Rock, then on to Pine Bluff between pine hills and prairie, across the Delta to bed finally at the Mississippi (map, right).

With a series of locks and dams (twelve in Arkansas) and the spending of 1.2 billion dollars, the U. S. Army Corps of Engineers has made the Arkansas navigable up to Tulsa, Oklahoma. Tugs and barges freight in steel and raw materials and take out grain and coal. Originally it was hoped that a million tons would be moving on the river by the time the project reached Tulsa, but almost three times that tonnage was recorded in the first year of operation (1969) and last year more than eight *(Continued on page 407)*

MISSOURI
Bull Shoals Lake
Norfork Lake
Mountain Home
OZARK PLATEAU
Buffalo
OZARK N F
BUFFALO NATIONAL RIVER
Mountain View
Fox
Rushing
White
Little Black
Black
Newport
Garvert Ferry Lake
Little Red
Searcy
Bald Knob
Subject of controversial channelization project
Cache
ARKANSAS
CROWLEYS
RIDGE
St. Francis
Paragould
Blytheville
Jonesboro
Mississippi
West Memphis
Memphis
Greasy Corner
TENNESSEE
MISSISSIPPI
Forrest City
Morrilton
Menifee
Conway
Pleasant Valley
Lake Conway
Lake Maumelle
North Little Rock
LITTLE ROCK
Carlisle
RICE
GRAND PRAIRIE
Stuttgart
Humphrey
White
Helena
ST. FRANCIS NATIONAL FOREST
WHITE RIVER NAT. WILDLIFE REFUGE
Benton
Pine Bluff
Arkansas
DeWitt
ARKANSAS POST NAT. MEMORIAL
Back Gate
Dumas
HILLS
DELTA
Saline
Warren
Monticello
Camden
Ouachita
Smackover
Bayou Bartholomew
Lake Village
Hamburg
FELSENTHAL NAT. WILDLIFE REFUGE
Crossett
El Dorado
Wilmot
Mississippi
Elevations in meters (black) feet (red)
KILOMETERS
STATUTE MILES

Arkansas

A WINNING COMBINATION of rich river-fed lowlands and mountain hollows underscores Arkansas' nickname: "Land of Opportunity." The rugged Ozarks draw tourists and sportsmen seeking a taste of hill country. Cotton, rice, and soybeans quilt the Delta, and vast tracts of pine in the southwest feed the mills of the robust forest-products industry. In the Arkansas River Valley stands Little Rock, capital city and growing industrial heart of the state.

AREA: 53,104 sq. mi.; rank, 27th. 55% forested. **POPULATION** (1976 estimate): 2,109,000. **ECONOMY:** Lumber and wood products; food processing; oil and natural gas; leads U. S. in bauxite; farming—poultry, leads in broilers; soybeans; leads in rice. **MAJOR CITIES:** Little Rock, 139,700; Fort Smith, 68,000; North Little Rock, 62,000.

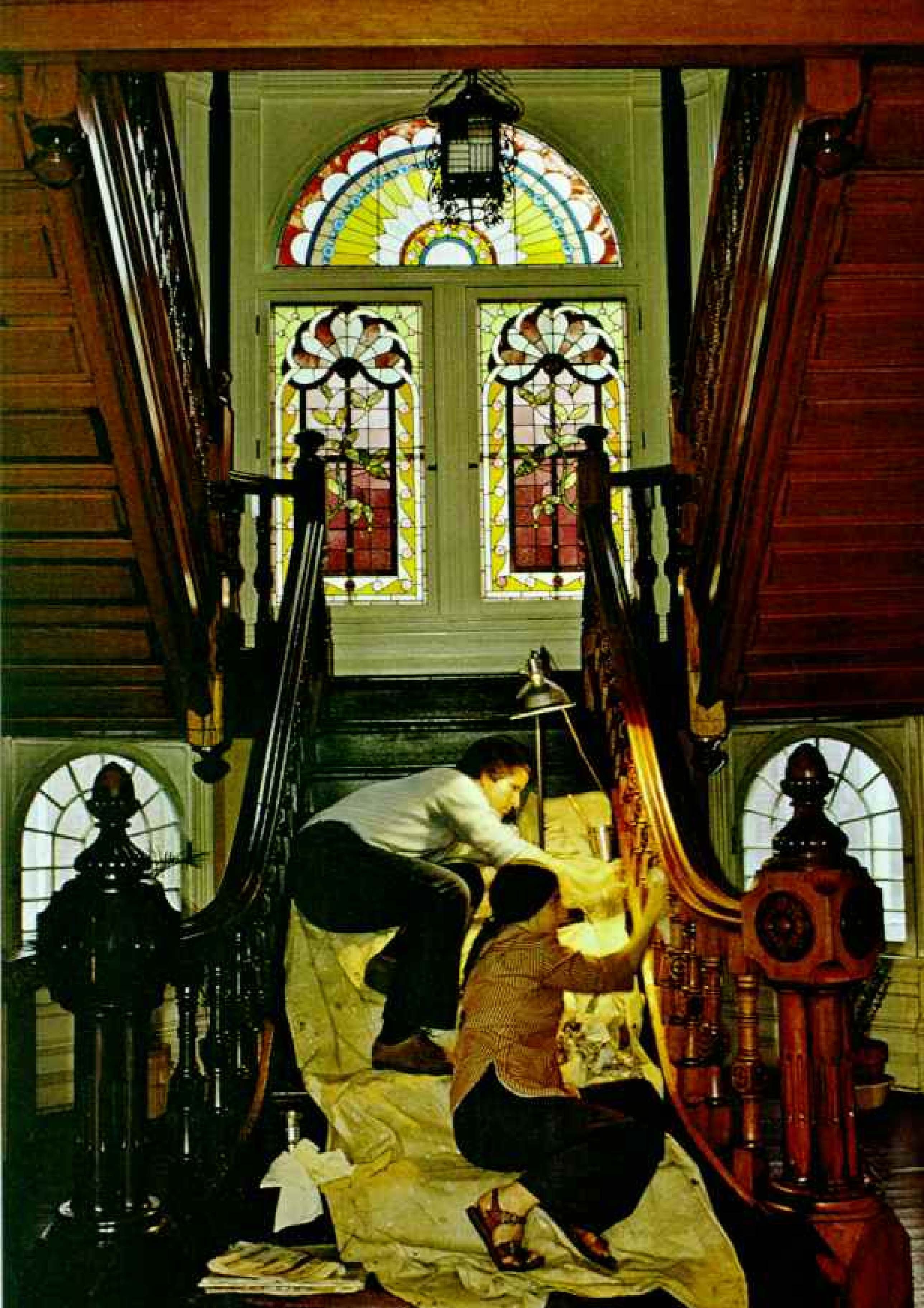

4

A capital way of life: Little Rock sports new prosperity with a certain élan. Businessmen gather at noon to practice on a rooftop putting green (**left**) of the downtown Worthen Bank building. Mountain musicians pluck and saw in the lobby of the nearby First National Bank during its Ozark Crafts of Christmas program (**right**).

The city's economy languished after racial strife in the late 1950's. But stability and intensive civic efforts have since drawn dozens of new industries, including a Falcon Jet plant (**lower right**) where airframes flown in from France are customized to suit buyers' tastes.

Cultural horizons have also broadened. The Arkansas Arts Center not only offers city residents a chance to participate in drama,

dance, and fine arts, but also reaches out to smaller communities through touring troupes, a wandering artmobile, and teacher training programs. The center's Children's Theater, which travels both statewide and nationally, stages productions from Pinocchio (**above**) to Shakespeare. The troupe performed in Washington, D. C.'s Kennedy Center during the inauguration of President Carter.



(Continued from page 402)

million tons.

For years virtually all bauxite (for aluminum) mined in the United States has come out of the ground near Benton, a light-industry town near Little Rock. The river project has made it possible to supplement the Arkansas ore with higher-grade South American and African ore, barged upriver.

True Grit and a Casting Rod

At Benton I encountered Tom Blackmon selling bass boats.

"OK, a 1975 Glastron bass boat in need of engine work, but it's still a good boat. Does the engine run?" The manager nodded. "It runs . . . twenty-eight hundred now, twenty-eight-twenty, now thirty, twenty-eight-fifty, trailer and all. . . ."

All across Arkansas you see pickups trailering expensive bass boats—sleek, low fiberglass silhouettes, less like watercraft than jet interceptors. In Arkansas, as throughout the South, bass fishing approaches a scientific, gadgeted mania: hydraulic pedestal seats, electric trolling motors and anchors, engines up to 200 horsepower, depth finders, temperature gauges, aerated live-fish wells, and casting decks covered in poly-turf.

Not everybody here bass fishes, but I met few who do not. To describe an afternoon fishing with Arkansans as relaxing is to be far wide of the truth, for in pursuit of the black bass they are grim and determined. And at tournaments they are fanatics—as I found out at one sponsored by the Arkansas Bass Association on Lake Ouachita, in the rocky hills near Hot Springs.

Before dawn, the dark harbor was growling with 350 fishermen and 175 bass boats. On the check-in barge, a man aimed a light into boat wells to be sure no one was going into today's tournament with yesterday's fish. The boats pitched and rolled, big engines rumbling, reminiscent of a naval invasion. The harbor twinkled with red and green running lights and, like small coal fires, the flickering orange blips of depth finders.

Lining up the first flight, Joe Wilson and George Schweer, officials of the tournament, weaved among the boats. A metallic red Mon-Ark, a blue and white Roughneck XL, an apricot Ranger with Apache stripe.

Jim Owens backed his white Bass Cat away from the pier as David Pryor, standing,

Homesteader spirit draws settlers to country and town. Herbert Kimbrough and family (**above**) left Little Rock for a 20-acre farm, where months of cutting and clearing created pastures for horses and room to ride. His wife, Kay, a social worker, still commutes daily to the city. But Kim says, "I was raised in the city, worked in the city, but this is where I belong."

Charles and Becky Witsell (**facing page**) took another road, buying and renovating a house built in 1889 in Little Rock's "Quapaw Quarter," the city's oldest sector. Growing numbers are investing their futures in the inner city.

threaded line through the rod guides. David Pryor is the governor of Arkansas, a man who prefers fishing at a more civilized hour and comfortable pace.

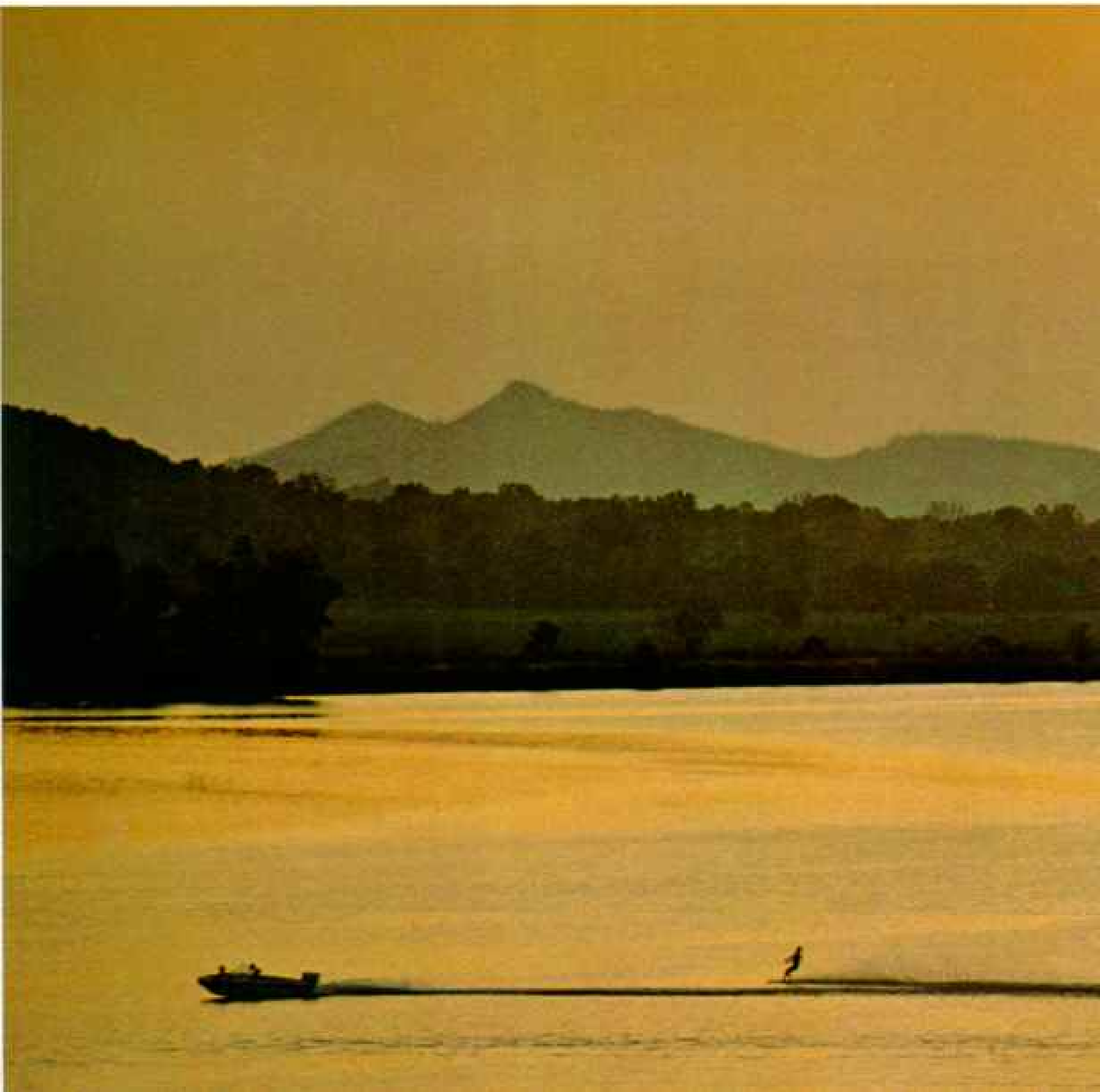
The fishermen, tensing, reversed their caps like baseball catchers. Some wore crash helmets, plexiglass visors, goggles.

"Let me have your attention!" Joe shouted into his mike. "Kill all your big engines!" In the momentary silence, Joe said a brief prayer, then the harbor thundered to life.

"Ease out, now!" Joe shouted. "No rooster tails! *Ease out!*" A few eased out, but the boats were soon at flank speed, rooster tails spuming, and the harbor was a raging sea.

Cotton Cordell was not there, but his livelihood was: plastic worms, "crank baits" (Big O, Super Shad, Gay Blade), pistol-grip graphite rods. Carl Richey Cordell, Jr., is an Arkansas success story. As a boy, Cotton lacked money to buy lures, so he made his own. Cordell Tackle, Inc., in Hot Springs, is now among the largest manufacturers of fishing lures in the United States. The lead jigs are shaped in jewelry molds. The Plastisol worms come in delicious hues of raspberry, strawberry, and grape. Fishermen keep demanding exotic colors, so Cotton produces them: Hot

Water-skier's signature streaks the Arkansas River, a once treacherous channel



Head Neon, Firebelly, Chameleon Green.

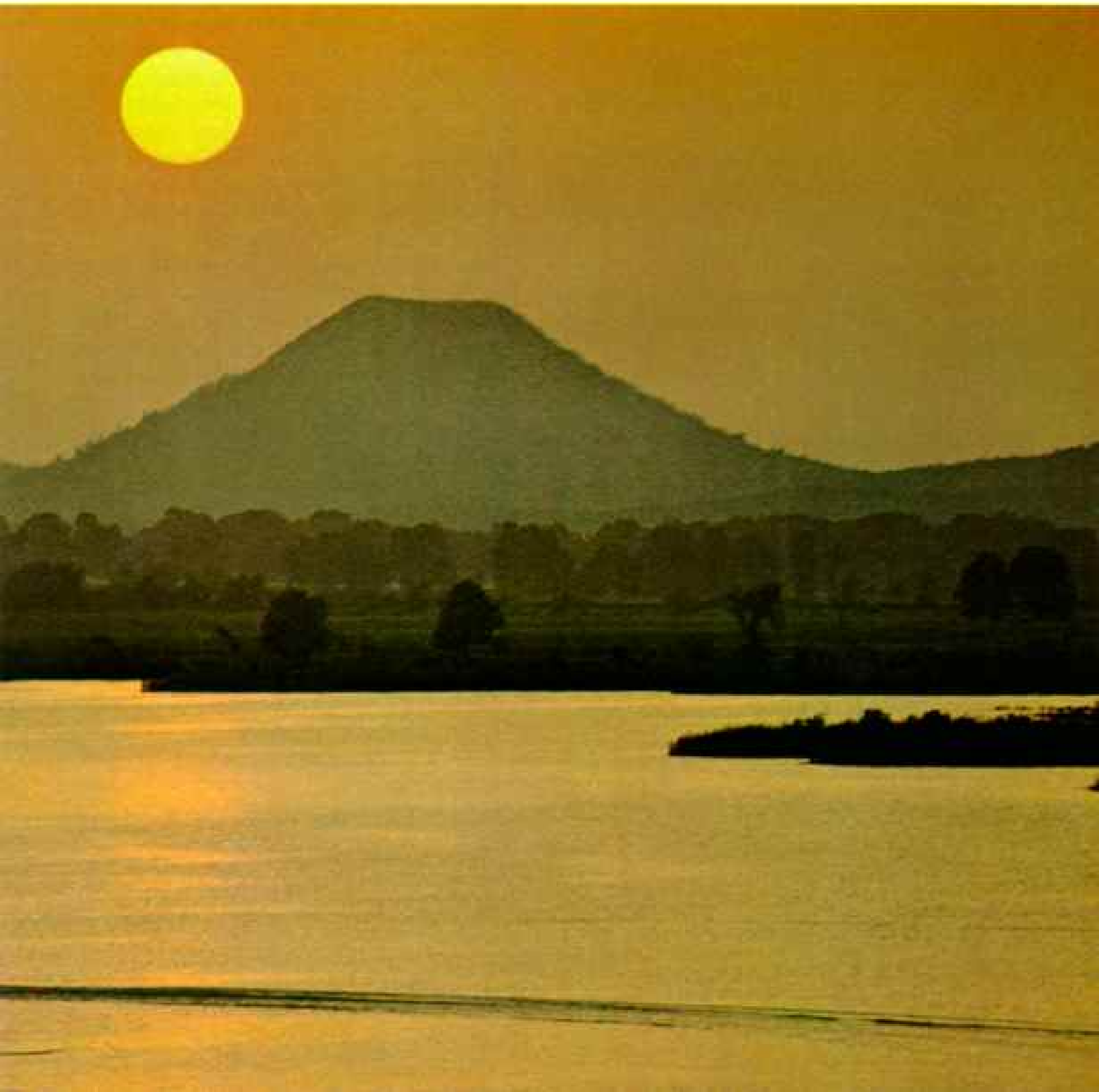
I once asked Cotton how many colors I needed to catch bass. "About three," he said, smiling. "Light, dark, and yella. That's all you need. But people want *this*." And he held up a nine-inch plastic worm, soft brown body and hot-pink nose, which in the light glowed iridescent purple. "See? It's gotta be 'purty.' "

Too Busy for Trivial Things Like Eating

That evening the governor was exhausted. "I'll tell you," he said, "I was fishing with a serious fisherman. My hand got so tired casting and cranking, I was afraid I was going to throw that rod in the water. I offered Jim a candy bar. 'Unh-unh,' he said. 'I don't eat when I fish.' "

At the boat auction in Benton, Herbert Kimbrough bought chicken wire, coops, jars, tools, and plow handles. Kim, who grew up in Little Rock ("I'm just a curb-and-gutter man"), quit his floor-covering business to go back to the land, to a 20-acre farm near Menifee (page 407).

The day I drove out to see him, Kim was standing in his yard, an immense black man with arms like the limbs of an oak, in bib overalls, T-shirt, and work boots, his hair a



trellis of small cornrows. He has a gentle, melodious drawl.

"Come on in. Would you like a beer? I was just fixin' to take a break. All I do around here is piddlin'. I'm tryin' to do what interests me."

We had a beer and walked across the field to his woods. Each morning Kim clears out brush and water moccasins, so his children, someday, can ride their horses through the oak and hickory. Kim's horses come when he whistles, a trick his grandfather taught him. Sundance, Kim's pit bullterrier, was in the woods. He studied my leg with the interest of a shark. I studied the woods for an exit.

One Man's Dream

Kim prefers clearing brush to kneeling on floors. "I love that cutting wood. I can relate to that. That's real. Grandfather had him about 15 to 20 hogs behind the barns. I'm gonna have the same thing."

Kim owns some pullets and plans to get a milk cow, a goat, fish for the pond, and a used tractor. Near the house is an orchard and garden. For shade in the horse pasture, Kim has planted a few pine seedlings. He stores his hay in a '49 Chevy resting on blocks, his tools and saddles in his "Furniture and Floors, Inc." panel truck. The basketball backboard reads: "Zoned Industrial . . . Call John L. Burnett . . . 376-3811."

"When I have this place fixed up the way I want it, I'll start doing floors again to make some money. I got a long ways to go, but I come a long way."

Kim, who is 33, remembers a Little Rock of trolleys and busy sidewalks when he was "coming up" near the Rock Island Railroad tracks in the city's south end. Kim swam in a stock pond and swept out grain cars, selling the sweepings to a woman for her chickens and ducks. Blackbirds swarmed to the tracks for grain, and Kim flattened them under "falls," old doors propped up on triggered sticks. "We'd pick 'em and cook 'em up with peas all around. Birds, when you was coming up, was a real treat."

For years Little Rock swelled with whites and sharecropper blacks moving from the small towns and mechanized farms in search of jobs. In the 1950's whites began drifting to the suburbs—then flooded to them after the confrontation between Governor Orval Faubus and federal troops over integration of Central High School. Most downtown businesses have followed. Now, even at rush hour, downtown sidewalks are nearly empty, as workers slip down elevators to parking lots and drive home to the suburbs.

One day Kim drove me around Little Rock. We passed Central High School.

"In 1957 this street here was mobs," Kim told me. "You know what I mean? Broom handles, boat oars. When it got dark, you'd

Duck call's raucous quacking answers duck talk in the sky (**right**). More than a million ducks, primarily mallards, wing through the state each fall along the Mississippi flyway, feeding in rice fields and flooded timber. Wild turkeys and deer, once almost wiped out, have been nurtured back to healthy numbers through effective game laws and restocking programs. Stocking for profit is big business on the Grand Prairie where catfish are raised as a crop on aquafarms. Here a thrashing herd is rounded up by seine (**left**).

Spotlighting the need for renewal, Pine Bluff residents stage a May Day festival to draw attention to their downtown district. Square dancers twirl in front of the county courthouse, gutted two years before by a fire. The building dates from before the Civil War, and is now being rebuilt.

The little town of Wilmot, in the Delta, searched ten years for a doctor to man its clinic. Then Dr. Thieu Bui (**left**) arrived in May of 1975 at Fort Chaffee, processing center for the resettlement of 50,800 Vietnamese and Cambodian refugees. A former army surgeon, Dr. Bui now has a thriving family practice in Wilmot.

better do like the chickens—get near your roostin' place.

"This used to be an all-white area. Now it's all black."

We bumped through the industrial east end, where Kim and his wife, Kay, once lived. Kay is a social worker (master's degree) in Little Rock, commuting 78 miles daily. During the week their children live with Kim's parents in Little Rock and are bused across town to schools in white areas.

We passed War Memorial Stadium, where the Arkansas Razorbacks play football when they are in town; the University of Arkansas is in Fayetteville, in the Ozarks. If Arkansans have a unifying passion, it is their football team, the Razorbacks. Throughout the state, on bumper stickers, billboards, filling stations, laundries, you see pictures of a violent, charging red hog. Razorback Realty, Razorback Shooting Supplies, Razorback X-Ray Co. "Soooeeee!" Razorback country.

Truth in a State's Nickname

We drove through Sugar Hill, University Park—well-to-do black neighborhoods—and then into Pleasant Valley, Little Rock's Beverly Hills. Kim stopped the car.

"You see, black folks look at this and try to make it. They can't touch this out here. They want to feel like they're close, though. But they find themselves just work, work, work, grinding that nose down. They think they can kill that work. They're wrong. You can't kill work. I've seen work kill men. See that yardman? He's gettin' to it."

Years ago Kim's father couldn't wait to get out from behind the plow and mule and head for the city. Kim is going in the opposite direction, and gladly leaving the city behind. Kay has reservations about what they may be giving up, but they pull together.

"Whatever a man wants to do, whatever makes him happy, he can find it in Arkansas," Kim said. "Arkansas people will stop what they're doing and talk with you. They're friendly. You can have car trouble on the interstate at midnight, knock on a door, and people will help you. They'll do that in Arkansas. Arkansas *is* the 'land of opportunity.' It's been that for me."

Arkansas has been that for Junior Cook, too. He pulls drum, buffalo, carp, catfish, and alligator gar out of the Arkansas River in trammel nets and sells them at his market in Pine Bluff.

Sport fishermen refer to gar and carp as "trash fish," and most commercial fishermen in Arkansas throw back everything but the catfish and buffalo. Junior keeps everything but the turtles.

"Y'know, a gar don't eat no dead bait," he says. "He don't eat no chicken liver like a catfish. We get $1.30 a pound for catfish and 60 cents a pound for gar. Gar's not bad eating."

Junior is a pleasant, almost whimsical man, and his anger is slow to rise—except when he sees poachers using the magnetos of crank telephones to shock fish to the surface. When poachers put wires in the river and "telephone" fish, Junior goes to his house trailer and telephones the law.

Junior is 53 and is content in his native Arkansas. "I been around quite a bit," he says, "different countries while I was in the Army. I do like to go to other places and see other things. But this is where my old den tree is. They say an old coon likes to come back and dip in his den tree. Arkansas has been good to me. I believe I can find enough to do here, and then some."

Competing With Television's Lure

Jim Hatch came to Arkansas because here he could make a difference. Jim is from Illinois, by way of Juilliard. He plays bass with the Arkansas Symphony and, like the other string players, teaches strings to schoolchildren who until recently played only band instruments. Jim is impressed with their musicianship. He finds the attitude toward art more genuine here than in New York City. Jim is tall, slender, 31, and adroit with children.

"OK, tonight when you're watching 'Charlie's Angels,' I want you to cross the strings like this. . . ."

"I don't watch 'Charlie's Angels.'"

"OK, 'The Waltons,' whatever. . . . Who watched Rostropovich last night?"

"Who's that? I watched 'Charlie's Angels.'"

For years opportunity was what Arkansas had little of, squeezed out by drought, the Depression, the overlogging of the Ozarks. By World War II, Arkansans were streaming out of the hills and the Delta, heading for the aircraft plants in California.

In his youth Orval Faubus followed the

strawberry harvest to Michigan, thinned apples and cleared slash in Washington, hoboed in Chicago.

"I slept in that fine park on Michigan Avenue," he told me, "and a policeman would come through every day at 4 p.m. and blow his whistle to move us out of sight so the hoi polloi could walk by on their way to the World's Fair. The next time I stayed in Chicago, I was governor, and I could afford to stay in a suite."

Bringing Jobs to Arkansas

The irony was not lost on migrating Arkansans—Faubus among them—that their reputation as industrious workers got them jobs not in Arkansas but outside it.

In 1955, with the state almost drained economically, Governor Faubus appointed the late Winthrop Rockefeller to the newly formed Arkansas Industrial Development Commission. What Rockefeller may not have known about industrial development, he more than made up for in his influence with the industrialists. As chairman of AIDC, he helped organize (and sometimes fund) an aggressive sales campaign to attract industry to Arkansas. AIDC compiled encyclopedic facts about the state and, particularly, the towns where plants might best locate. The communities looked around at their assets, vacuumed, set the table, and switched on the porch light. Forrest City got a hoist-manufacturing plant. Baldwin started building pianos in Conway, and soon neighboring states were looking over the fence with envy.

In the years since AIDC was established, Arkansas has reversed its declining population (now more than two million). Companies have invested four billion dollars in building and expanding 3,500 plants here. A fourth of all Arkansas workers now hold manufacturing jobs. Lumber, paper, furniture, electric motors, buses, food processing, aircraft components. Of this country's 500 largest companies listed by *Fortune* magazine, 120 have plants in Arkansas.

Delmar Middleton is not in the *Fortune* 500. Nor—were there one—would he be in a *Fortune* 500,000. Unlike International Paper, Weyerhaeuser, Georgia Pacific, and the other large companies that own almost four million acres in Arkansas and dominate its timber industry, Delmar operates a small mill, a 440 Corley, on a few acres in the Ozarks. He uses a 54-inch circular saw to cut oak, hickory, and gum into railroad ties, lumber for grocery pallets, and bark slabs for charcoal.

More than half of Arkansas is commercial forest, and a fourth of all Arkansans in manufacturing are employed by the forest-products industry. Peckerwood mills—as those like Delmar's are called in this region—are remnants of the past, when timbering was done mostly by small entrepreneurs scattered about in the woods. The days of the whipsaw, the sash saw, the gang saw are gone. So are most of the *(Continued on page 420)*

Before the bugle calls at Hot Springs' Oaklawn Jockey Club, high-strung Thoroughbred Gas-a-Gas takes a reassuring nibble of his calm companion, Herman (**facing page**). Lucky pieces abound at the track. One visitor from New Mexico believes in wearing luck on every finger (**above**). Tourists often take a bath—even when the track is closed—in water piped from thermal springs in the Ouachita Mountains. In 1832 Congress created the Hot Springs Reservation, now a national park.

Agribusiness: Arkansas style

FLOOD OF FUTURE PICKLES tumbles into a gigantic vat at the Atkins Pickle Company during the busy summer harvest (**left**). Cucumbers roll in from both Texas and Mississippi, as well as from farms in Arkansas. The state's central location near expanding markets in the South and Southwest has helped the food-processing industry achieve amazing growth since World War II. Tyson Foods, Inc., one of the state's leading poultry producers, contracts with farmers all over the Ozarks, who deliver almost two million broilers a week. In its Springdale egg plant, nearly half a million table eggs a day are candled to assure quality (**right**).

Tree farming plays a growing role in the forest-products industry, Arkansas' leading manufacturing employer. Low-grade hardwood logs stockpiled at the Potlatch Corporation's yard in Warren (**above**) were harvested primarily from stands of mixed hardwoods and pines, and will be used for manufacturing paperboard. To foster fast-growing pines, some foresters use herbicides to control hardwoods, a technique that has raised protests and legal challenges from environmentalists.

Towers that rice built, grain elevators rise above Stuttgart, in an area

where German-American farmers pioneered rice cultivation in the early 1900's.

(Continued from page 415) Delta hardwoods (now soybean fields) and more than a million acres of Ozark forest (now cattle pastures). So too, practically, are the likes of Delmar Middleton.

"It ain't much," he says, "but it's a git by."

Half the furniture manufactured in the state is made around Fort Smith, as are cups by Dixie, appliances by Whirlpool, peanuts by Planters, and baby food by Gerber. Herman Udouj (YOU-dodge) started Riverside Furniture in 1946 with a bottle of glue and some orders for baby furniture. He's now chairman of the board of the largest furniture company in Arkansas, where nostalgia is put into "nostalgia furniture" with whacks of a chain. The Udoujes own 200 Thoroughbreds, which they race at Oaklawn (Hot Springs) and other tracks around the country. The bronze front doors of their elegant home in Fianna Hills, a Udouj development overlooking Fort Smith, weigh half a ton.

Unlike the Deep South of the Delta, Fort Smith is a town of the West—once the end of the rope (Hanging Judge Isaac Parker's) for outlaws who terrorized western Arkansas and the adjoining Indian Territory. "It's a solid town," says Herman. "Between them, a husband and wife at our plant earn maybe $17,000, have a little farm, raise their own vegetables and meat, but they'll have two cars and a good bass boat. It just doesn't take as much to live here."

Ozark patriarch, Orvil "Strawberry" Henson (**facing page**) has cut broomcorn in Kansas and picked apples in Washington. Now 66, he's home to stay with his second wife and the youngest of his 16 children (**above**). He resents newcomers who clear the forest for development. But of those who come to find a simpler way of life, he believes "that's real worthwhile. Those people won't hurt the land."

Craftsmanship for Sale

Not the least of the state's attractions for industry is the attitude toward work. "The work ethic," Governor Pryor says, "is extremely strong here. In Arkansas workmanship means something."

Arkansans make everything from turkey calls to violins. At his home in Russellville, Jimmy Lile makes knives: dropped-point hunters and skinners, Arkansas toothpicks, Bowies, folding knives that close with the click of a Rolls-Royce door. Chairman of the Knifemakers League of Masters, Jimmy shapes handles out of wood, India stag antler, ivory from elephant tusks (which he keeps in a bank vault). He grinds the blades out of D-2 high-carbon, high-chrome tool steel, and heat-treats them in a Thermolyne furnace. He sharpens the cutting edges on Washita and hard Arkansas oilstones, mined by one of the state's oldest industries from the uplifts of novaculite in the Ouachitas, a stone so abrasive that it quickly wears out splitting mauls, quarrymen's boots, and the cleats on huge crawler backhoes. Diamond saws are used to cut this stone. (Diamonds come from Arkansas, too, from a state park near Murfreesboro. Find one, and it's yours.)

In 1946 Paul Klipsch found space in a shed in Hope to make loudspeakers. Klipsch now has 90 employees and lots of space. His Klipschorns, the woofers of which are built

of nine-ply birch from the U.S.S.R., are considered by many to be the finest loudspeakers in the world. Made in Arkansas.

Millions of chickens are made in the Ozarks. Hatched after World War II, the chicken industry now employs thousands of Arkansans, particularly in the Ozarks, where hills of hardwood are being killed off with herbicides, cleared, and fertilized with chicken litter to grow grass for cattle.

Last year Tyson Foods, Inc., of Springdale grossed about 225 million dollars. Each morning red Tyson buses take some 300,000 chicks from their hatcheries to contract farmers all over the Ozarks, who raise them to broiler size.

Chickens by the Fistful

When the sun goes down, Jimmy Graham goes into chicken houses and snatches thousands off their feet. He heads one of Tyson's 15 catching crews. Jimmy is slight of build, but he has the grip of a blacksmith. Tonight I watch him catch chickens at a farm near Tontitown, an Italian settlement where grapes are grown. A front-end loader ferries empty coops from flatbed trailers to the chicken house and returns, red-lighted and grunting, with coops full of confused chickens.

The chicken house—the length of a football field—is bathed in dim blue light, enough for the catchers to see, but not enough light to arouse the chickens, which squeeze together in a warm, sleepy sea of white. The air is full of dust, feathers, ammonia, and the muted "puks" and "yeeoks" of 19,000 contented chickens. Like umpires dusting the plate, Jimmy and his catchers bend at the waist, grab chickens by the legs, invert them, and rapidly stuff the legs between their thumbs and fingers. Lugging nine birds from his left fist and three from his right, Jimmy stuffs them into a coop and grabs more. "Used to be, twenty thousand chickens was a hell of a night," he says. "Now twenty thousand is nothing—now it's about 35,000." Don't arm wrestle with a chicken catcher.

The Ozarks have traditionally been hills of hard times and ticks, of row cropping and timbering for barrel staves, then emptiness when the trees went down and the soil played out. Ozark people still look upon their hills as "a good place to live, but a tough place to make a living."

In the fall Arthur Gunter picks apples in Missouri, and in the winter he traps coon, bobcat, and coyote in the Ozarks. On his farm near Pelsor he has some cows and hogs, and he plows with a mule. He cooks and refrigerates with butane, heats with a wood stove, and lights his house with Coleman lanterns. Arthur, who is 54, grew up not knowing how to hunt for turkey and deer, and neither did his father. In these devastated hills there weren't any.

Now deer, turkeys, and some bears are returning to the Ozarks. One morning recently Arthur hunted for a turkey, shot it, found some wild ginseng, picked 80 dollars' worth, went home, and plucked the bird. When I walked into his yard, he was stretched out on the seat of his pickup, shoes off, doors wide open, listening to the ball game on the radio.

A New Life in the Hills

Tourists come to the Ozarks to see the Passion Play at Eureka Springs, the Ozark Folk Center at Mountain View, or to nose around the hills trying to photograph people like Arthur Gunter. Many want to return—permanently—and increasing numbers are doing just that. Land in much of the Ozarks can be bought for a few hundred dollars an acre, and state and local taxes are the lowest per capita of any state in the U.S. Between 1970 and 1975, about 39,000 more people moved into the Ozarks than moved out. They come out of snowbanks and traffic in Chicago to live in retirement communities and to fish. Many are homesick natives returning from California. Some are dropouts from the '60's, back-to-the-landers who build lofted cabins of battened green oak with heavy doors like safes, live off the land (and their own kind of grass), and learn why so many natives gave up and left: More self goes into

Like frozen fireworks, stone pillars born of time and water stand revealed by floodlights in Blanchard Springs Caverns, near Mountain View. The same forces cut the surface of the once uniform highland plateau to create the undulating ridges and valleys of today's Ozark mountains.

Gaggle of gigglers face the judges in the "Little Miss

Pink Tomato" beauty contest, held each spring in Warren.

these rocky hills than subsistence comes out.

When Lewis Grabbe and his wife came to the Ozarks, near Rushing, eight years ago, Lewis knew nothing about masonry. But stone by stone, year by year, he has been building a house to leave to his children and grandchildren. Lewis Grabbe is 55 years old, scarred, and muscular. His big fists are gnarled from fights in the Navy (boatswain's mate) and lifting stone in the Ozarks.

Lewis removes by hand only enough trees to let in the sunlight needed to grow pasture; his 42 acres look like a London park. In a grove of oak, persimmon, and hickory is a compartmented bathtub he built of stone: a dry well at one end, where he stands and scrubs; a fireplace at the other to heat water. He exudes a spiritual joy about hard labor.

"They're hauling stone out of Stone County like you wouldn't believe," he says. "Some people will say, 'That stone's in my way.' But I look at it as something that's been here for eons. I wanted to build my own house from materials off the land. I face my house east, 'cause that's where all our learning comes from. I want to put my house square with the world. Maybe I'm a little odd, but I appreciate what God's done for me."

Search for a New Beginning

Some miles away Cindy Berman stands at the entrance to her first Ozark home, looking across a canyon to the green hills beyond. The Ozarks, like the Ouachitas to the south, are intimate hills, not awesome mountains, and one must spend time here to fully absorb their beauty. Cindy's single piece of furniture, where I sit, is a cot of lashed-together pine branches—the first functional product of her hands. This dwelling, like Lewis Grabbe's, is of Ozark stone, but no human hand shaped it. Cindy Berman came to Arkansas from Long Island three years ago with only a knapsack and an issue of *Mother Earth News*. In this cliff is where she lived for the first nine months. In a limestone cave.

Of those like Cindy who try to live off the Ozarks, probably far more leave than persevere. (A master's degree and a tree house, many natives say.) Most of them find loneliness, fear, and hunger. But Cindy also found herself, and that's what she moved here for.

Shedding Some Academic Blinders

Cindy is 26, tall, has thick eyelashes, brown hair, a full mouth, long, strong arms and legs, and an enthusiasm for life that would astound Norman Vincent Peale.

"When I came down here, I just wanted to sit by this creek and be by myself. In a covert way I thought I was better than these people. Boy, oh boy, was I wrong. The smartest people are the self-educated ones. Now I see that plain old life experience is the real education. I'm a whole lot more humble than I ever was."

Cindy now lives in a cabin she built of pine from her hillside. She got her door and windows from a dump. Her wood stove cost $35. Her table is a telephone-cable spool on end. She carries her water in buckets from the creek far below. Cindy studied to be a teacher, but she has had difficulty finding work in the Ozarks, and what she has found, like catching chickens, has not held her interest.

She barters for things, for labor, for food. She grows vegetables and spices, and sundries apples, tomatoes, and watermelons, which shrink to a leatherlike candy. Cindy exists on about $500 a year.

She no longer invites friends down from New York, and enjoys going there even less. Her city friends belittle her way of life and try to talk her out of it: "You're a schoolteacher—you ought to be teaching."

"Even some of the natives can't understand why I enjoy chopping wood with an ax," she says. "They'd buy a chain saw. What I enjoy as a simple, beautiful life, they see as poverty.

"I've just gained faith in my ability to do anything I want. I grew up believing you learn everything from a book. Now I learn by doing, or watching someone else do it."

Cindy put her finger on Arkansas. "Things around here have different values than dollars and cents. These people really know how to make do." □

"**The gods do not deduct** from man's allotted span the hours spent in fishing." If the proverb were true, a good many Arkansans might well live forever. One of every four has a fishing license. And somewhere along Arkansas' 9,700 miles of streams and 580,000 acres of lakes, there's a spot for each to find fish and solitude.

The Thousand-Mile Glide

By KARL STRIEDIECK

Photographs by OTIS IMBODEN

NATIONAL GEOGRAPHIC PHOTOGRAPHER

Snug as a foot in a shoe, the author straps into his sailplane on Bald Eagle Mountain, Pennsylvania, assisted by his wife, Suzanne (**below**). Last year he rode winds along ridges from Pennsylvania to Tennessee and back—a world record. Hugging Bald Eagle's flank (**overleaf**) during a trial run, he takes his own picture with a wing-mounted camera.

THE NOISE of thrashing branches outside my home on Bald Eagle Mountain woke me, and I rolled over in the darkness to check the clock beside my bed: three-thirty. In robe and slippers I went outside, wondering if this could be the thousand-mile day.

Overhead in the moonlight, clouds were scudding by, driven by a northwest wind. And it was cold for early May in Pennsylvania—33° Fahrenheit. A day or so earlier, this chill air mass had been in Canada.

All the signs said "Go." I telephoned my official ground observer, Bob McLaughlin, to lure him from his warm bed, then began the preflight chores. Ballast tanks in the wings of my sailplane had to be filled with 250 pounds of water, and the barograph checked to be sure it would make its inked tracing of the altitude during the record attempt. I had finished and was bolting down a hurried breakfast when Bob arrived. Together we rolled the big fiberglass bird out to the runway behind my house.

Almost a year earlier there had been another thousand-mile day. I had flown my sailplane down the Appalachian ridges into Tennessee and back. But because of a technical mistake on my part in photographing the most distant point reached, that flight—the longest ever made in a motorless aircraft—did not become an official world record. Today, I promised myself, I'd remedy that mistake by making the flight again (map, pages 434-5).

To some, the flight of a sailplane—or glider—must defy logic. How can a heavier-than-air machine possibly stay aloft for hours without an engine?

A sailplane's "engine" is really the sun. Solar energy is absorbed unequally on this multisurfaced earth, and that imbalance generates currents in the ocean of air. Vertical currents—bubbles of heated air—rise in what are called thermals. Horizontal currents, of course, are called winds. When they blow against the side of a slope, they are deflected upward.

A sailplane can ride the rising air, circling in thermals or soaring on the upthrusting wind close to a hill—much as a surfer rides a wave. If the air rises faster than the normal sinking speed of the sailplane, the pilot can gain altitude.

The winds were whistling up the Appalachian slopes on this blustery day, and I would be flying down through the strong updrafts at high speed. But I must not dive too steeply, for the stresses caused by flying too fast in the roiling air could peel the wings from my sailplane.

Turbulence Jolts Glider After Takeoff

The first light of dawn was turning the mountains to gray when I was towed aloft by a jeep. I released the tow cable, swept into the surging lift of the mountainside, and banked around until my goal was behind me. The flight would officially begin 37 miles northeast at Lock Haven airport, where witnesses waited to document my passing.

As I raced along the ridge toward Lock Haven, the air was so turbulent that once the g-meter on my instrument panel registered five and a half. A savage gust had shoved my glider upward so violently that I'd been pressed into the seat with the force of five and a half times my weight.

Fifteen minutes after takeoff I soared through the imaginary window of air over Lock Haven—the starting gate—and banked again, southward toward the goal. It would be a long day, and each minute of it I'd be racing the clock to get back to this airport before sunset.

Staring at the ridges that stretched ahead to the horizon, I thought of the boyhood hours I had spent sitting on those slopes, watching the birds soar by. Many a hawk and eagle hitch free rides on the updrafts during migratory flights along this flyway.

Later—a decade ago—I flew their route myself, but six miles high, as an Air National Guard jet pilot. From that vantage point I could trace the mountain chain for hundreds of miles, from my home state of Pennsylvania clear down into Tennessee.

Who could resist trying to travel that route like a bird? In 1966 I acquired a wife, a glider, and a rustic mountaintop farm near State College, Pennsylvania.

Since then, Suzanne has become a soaring pilot, for we share the yen to be a bird. And I've lost count of the times she has towed me aloft with our jeep, confident that I'd come soaring home in time for dinner. Five of those flights have set world distance records.

There is a wonderful predictability to ridge running—a reliability flatland soaring pilots must envy. To fly cross-country, they

must find a thermal, circle in it to gain altitude, then hunt for another one more or less in the direction they want to go, and circle again. A beautiful sight, that aerial ballet, and great sport. But certainly not the most effective way to get from point A to point B.

Still, thermaling is a gentler sport than ridge running. The long wings of my sailplane were flapping up and down, the tips describing ten-foot arcs in the turbulence. On an earlier flight I had carried drinking water in a baby bottle—but still the bumps were violent enough to spurt water through the nipple onto my plastic canopy.

Tail Wind Out, Head Wind Home

Because the winds were hitting the slope from a northerly angle, I'd have a tail wind helping me on my way to Tennessee. It was a mixed blessing, though—I'd have to buck a head wind on the return journey. And there were a few gaps in the mountains to jump, and no ridge at all for the final 25 miles to the turn point. I'd have to use thermals to get across those flat spots.

But for now, it was ridge running at air speeds upwards of 150 miles an hour—often just above the treetops. I sped southwest, past my home landing strip, toward the first hurdle at Altoona, Pennsylvania.

Could I glide across this four-mile gap, or must I waste precious minutes hunting for thermals? Always on a flight like this a pilot is faced with two choices—go fast or play safe. I was at 3,200 feet, and a comfortable 600 feet above the treetops; plus, I had that tailwind. I pushed straight across.

A few miles farther on I gingerly approached Claysburg. I'd almost been blown out of the sky there on a previous flight, when a dynamite blast went off in a limestone quarry below.

Today, though, I could see workers in the quarry. They'd be heading for shelter if a blast were imminent. Or so I reasoned. But to play safe, I decided to skirt the mine.

The gap at Bedford—this one was eight miles wide. From 3,400 feet I slid across it, gradually sinking, and regained my altitude on the slope at the southern end. I paused near Cumberland, Maryland, to thermal even higher. Ahead lay a 35-mile stretch of ridge too low to generate strong lift. It was a nervous 35 miles, with few emergency landing fields below. But by working thermals and weak ridge lift, I managed to stay aloft.

Air racing over a ridge sometimes forms

Like a boy with a kite, a jeep tows Striedieck into the air at his farm on Bald Eagle Mountain for a practice flight (**left**). Official observer Bob McLaughlin and Striedieck (**above**) inspect an altitude-recording barograph.

what is called a mountain, or lee, wave: Smooth sheets of air race up, then farther downwind, arc down and up again. Riding the second upswing of a wave like that is soaring at its best.

Near Hopeville, West Virginia, I found a wave and boomed along, grateful for the smooth ride. In the turbulence, I had felt like the ball in a whistle. Altitude was no problem now. At times, my altimeter read 10,000 feet. But even this smooth ride had its drawback. I was above the clouds and couldn't see the ridge. Half an hour later it was down to turbulent ridge running again.

Lebanon, Virginia, just 18 miles from Tennessee, found me circling once more. But these circles were not rising ones; I was checking my drift to determine the force and direction of the wind. I had a decision to make. From here on the mountains tapered off, generating less and less lift. Unless winds were favorable, I would have to turn back.

Farther south, a forced landing could mean more than just the loss of a record; it could mean the loss of my glider. It is a sad fact that, year by year, the pastures along my route—potential landing fields—are being fragmented. At the same time, sailplanes are getting larger and more expensive.

Well, worrisome decisions are part of the price of being a bird. I weighed the odds. The winds were not strong, but at least they blew from the right direction. I pressed on.

It was a harrowing 130 miles to the turn

KARL STRIEDIECK

Proof he was there. On May 9, 1977, Striedieck dips his left wing to make the required photograph (**above**) that confirms his turn point, a railroad bridge near Oak Ridge, Tennessee; it shows as a curved dark line at right center. During a previous flight he took the picture from the wrong angle, and the record was denied him.

Undaunted, he does it again (map, **right**), riding lifting ridge winds and columns of rising warm air called thermals.

point. Often, I had to circle in thermals to supplement the weak lift from the ridges.

Then, finally, there *were* no more ridges. Flying slowly, at the sailplane's most efficient glide angle, I faltered ahead, working every rising thermal I could find.

Ballast Jettisoned as Ground Looms

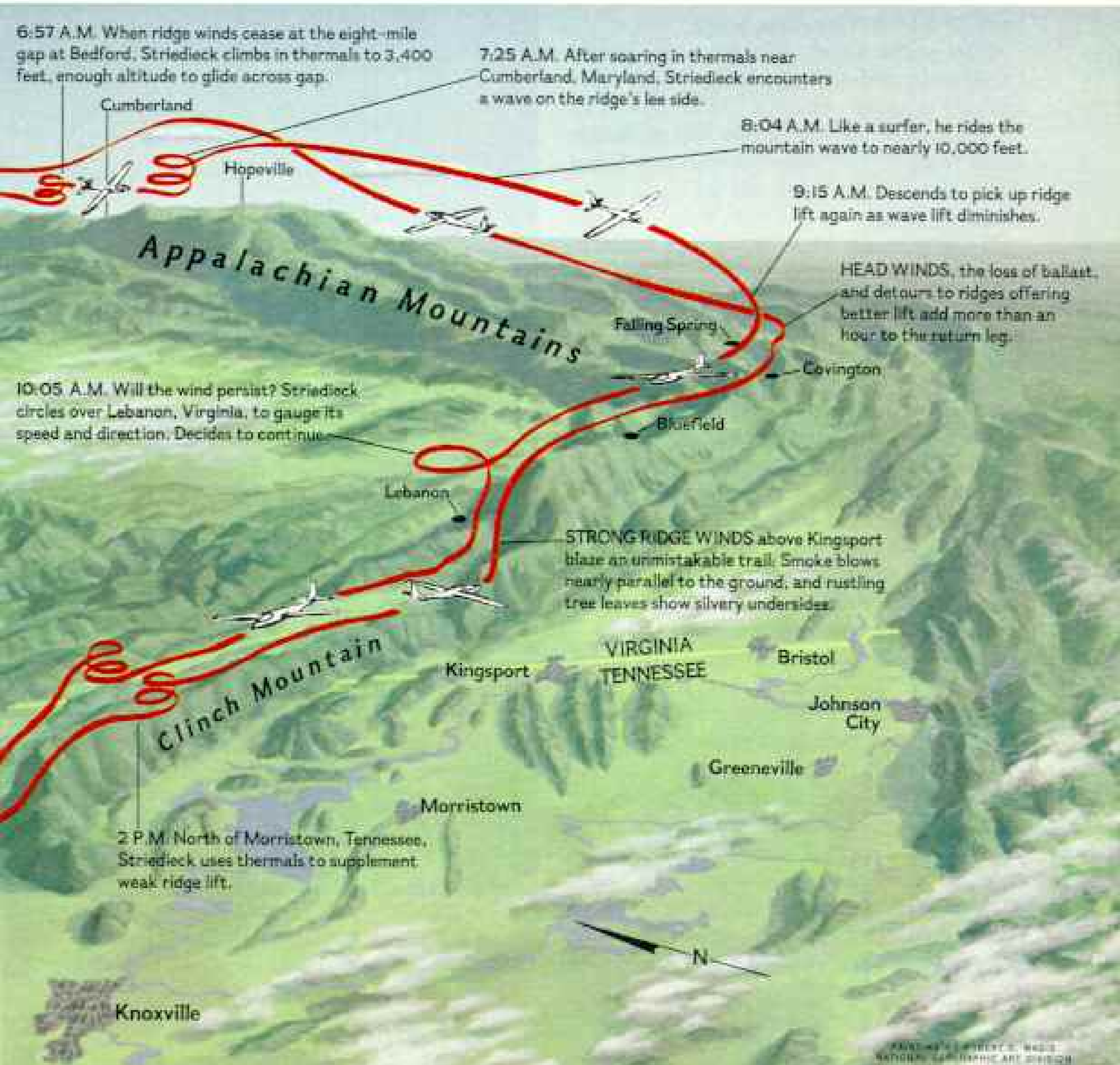
I was losing the battle. The Tennessee countryside now lay only 500 feet below, and I jettisoned my water ballast. That 250 pounds had increased the glider's speed; now it was a liability.

But Murphy's law—what can go wrong *will* go wrong—came into play. Though it was warm in my cockpit, because of the canopy's greenhouse effect, the outside temperature was cold. A drain tube on my ballast tanks had iced up, and some water found its way through a tank vent into my cockpit.

Dolefully, I watched it flow in above my right shoulder, soaking my side on its way to the bottom of the fuselage. And it was more than just uncomfortable, it was a matter of real concern. Would it freeze the mechanism that extended my single landing wheel? If so, when I touched down I might discover the breaking strength of a fiberglass sailplane.

No point in worrying about it now; slowly I flew on. With most of the water gone, my fight for altitude succeeded. At 12:30 p.m. I reached the turn point.

On my first thousand-mile day, my official photograph of the turn point—the railroad



bridge over Bullrun Creek near Oak Ridge, Tennessee—was taken just three degrees outside the required "90-degree quadrant."

This time I made *sure* I was in the right place when I snapped the shutter. To play safe, I photographed the point with a second camera mounted under the canopy before I headed north again.

Murphy's Law Works in Reverse

There are happy times when Murphy's law works the other way—what can go right *will* go right. On my way back over the flat countryside, the thermals were there when I needed them. Near Kingsport, Tennessee, I picked up good ridge lift. Below me, the smoke from house chimneys was blowing almost parallel to the ground, for the wind was increasing. Soon I was flying northeast at 115 miles an hour, and I left Tennessee behind.

Trees on the Appalachian slopes are mostly hardwoods, and a good wind—say, 20 miles an hour or more—traces a visible sign of its passage, blowing the green leaves upside down to show their silvery undersides. Often I saw those light "wind streaks" as I raced along the ridge.

Halfway across Virginia my luck began to go sour again. Strong downdrafts—appropriately at Falling Spring—brought me down to 500 feet. But ridge lift saved the flight and let me climb the mountain once more.

I found a wave again, nearing the Pennsylvania border; its silken lift pushed my airspeed to 140 miles an hour. But clouds closed in below me, and I was forced to dive beneath them to keep track of the mountain slopes. Otherwise I might blindly veer too far off course, above the clouds.

The clock was my enemy now. Lock Haven was still a hundred miles ahead, and sunset was less than an hour away.

Could I make it straight across the eight-mile gap at Bedford? Probably not. I invested a precious 25 extra minutes in a detour to a downwind ridge and back again on the far side of the gap.

Then, like a sea gull heading for its nest, my big fiberglass bird raced the setting sun toward the airport. I radioed ahead for an observer to witness my landing.

There was the tinkle of shattering ice when I pushed the landing gear lever, but the wheel extended normally. At 8:10 p.m.—after more

Clawing for altitude, Striedieck climbs in a thermal over Hopeville, West Virginia,

on a tune-up flight. Down on the ridges he must locate a thermal quickly if the wind dies, or else set his sailplane down in a farmer's field—if he can find one fast enough.

Trailing water, Striedieck dumps wing ballast (**above**) before a landing on Bald Eagle Mountain. The added weight increased the glider's speed and bolstered its slender wings—66 feet across—against punishing turbulence.

For certification as a world record, a photograph (**below**) records particulars of the flight; times shown do not reflect actual takeoff and landing. The picture must appear after the turn-point photograph, on the same roll of film.

KARL STRIEDIECK

than 14 hours aloft—that wheel touched the runway again. Stiffly, I clambered out of the narrow cockpit into the cold and windy twilight. I stood shivering; my clothes were still sodden from that water ballast I'd tried to dump 500 miles away in Tennessee.

But inside me there was a warm sense of accomplishment. I had made the two longest glider flights in history—and *this* thousand miler surely would go into the record books.

Ahead lay a monumental paperwork task of documenting the record, but tomorrow would be time enough to think of that.

Next Stop Miami Beach?

Waiting for a ride home from the airport, I stared silently at the dark sky.

Suppose another day like this turned up, and at the far end of the ridge I found a "cloud street"—long lines of cumulus clouds—stretching toward Florida. I had seen similar cloud patterns on weather-satellite photographs, and I could find good lift beneath those clouds. Oak Ridge by noon, and then a cloud-street dash southward. . . .

Wouldn't it be something—truly something—to take off from my Pennsylvania mountain and land somewhere in Florida? □

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BOTH BY JACK BALCER

Biblical Elam

IN CIVILIZATION'S CRUCIBLE bordering the Tigris and Euphrates, two cities of the Elamites—a people mentioned in Genesis—once rivaled the fame of Babylon and Ur. Susa was found as long ago as 1850. Now a National Geographic-aided dig in southern Iran, led by archeologists Robert Dyson, Jr., and William Sumner, is unearthing what may be 3,000-year-old Anshan (**above**). Troves of cuneiform tablets and clay sealings (**right**) may cast new light on the Elamite language. Support such Society research; nominate a new member below.

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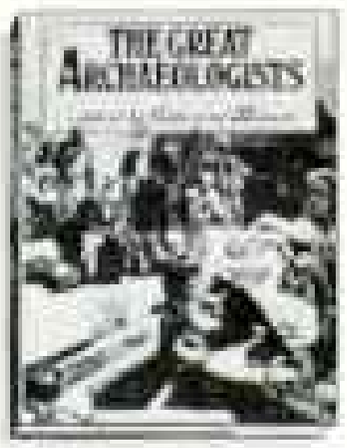

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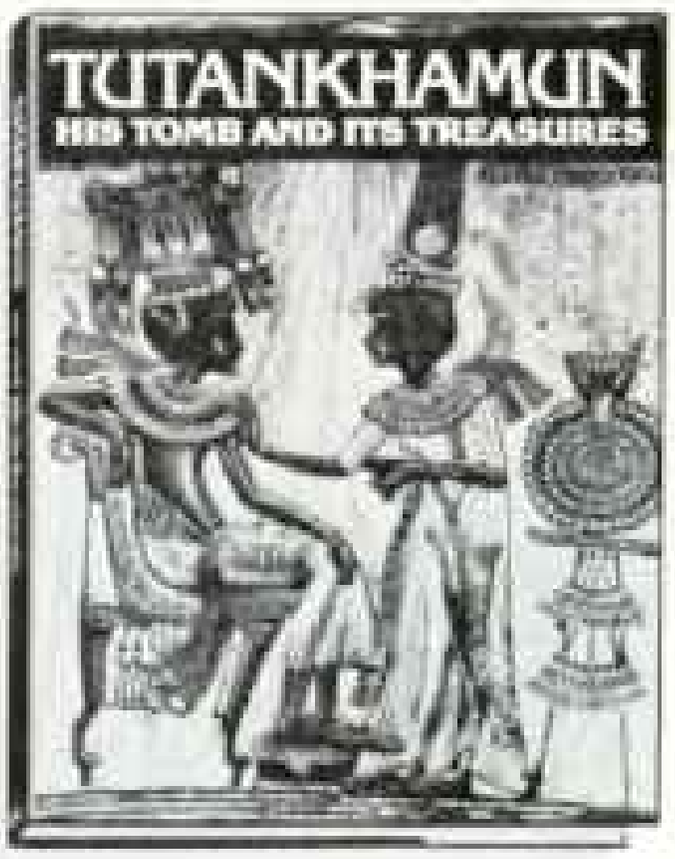

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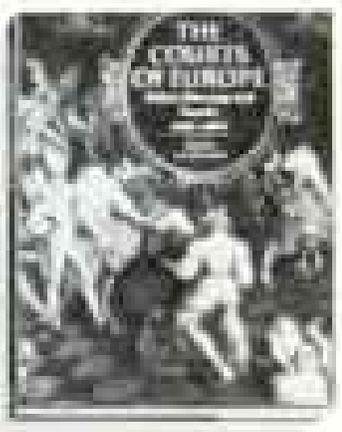

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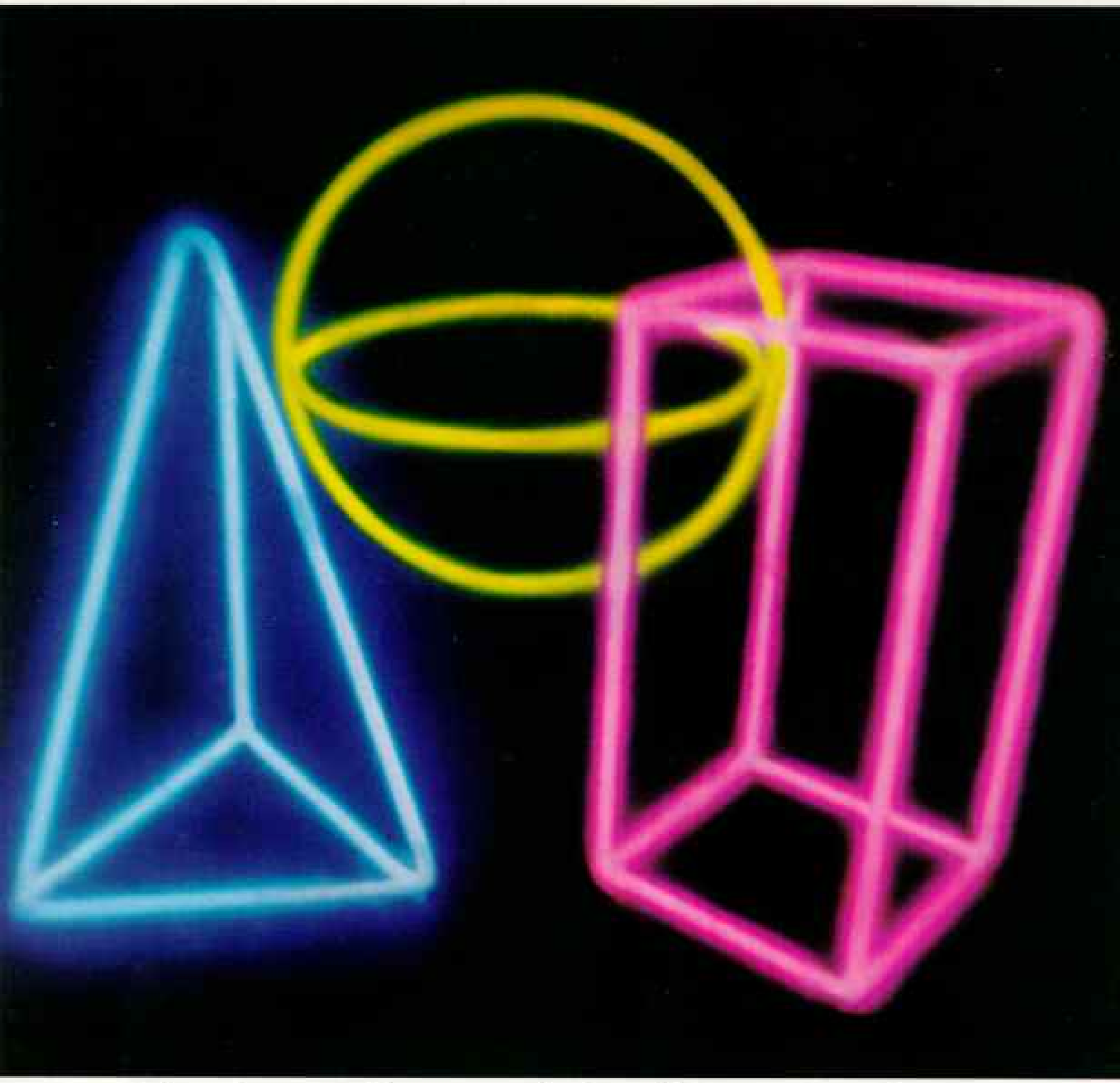

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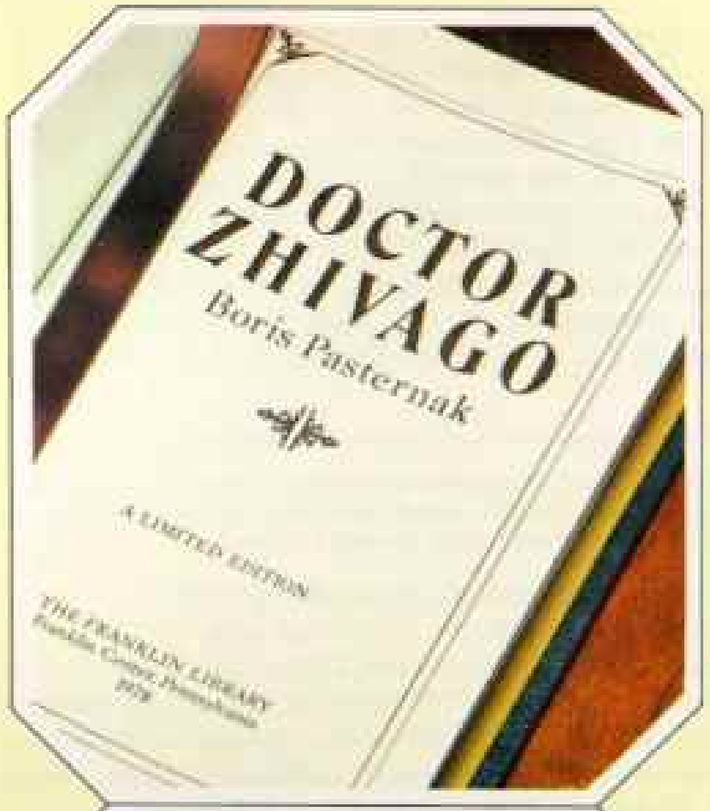

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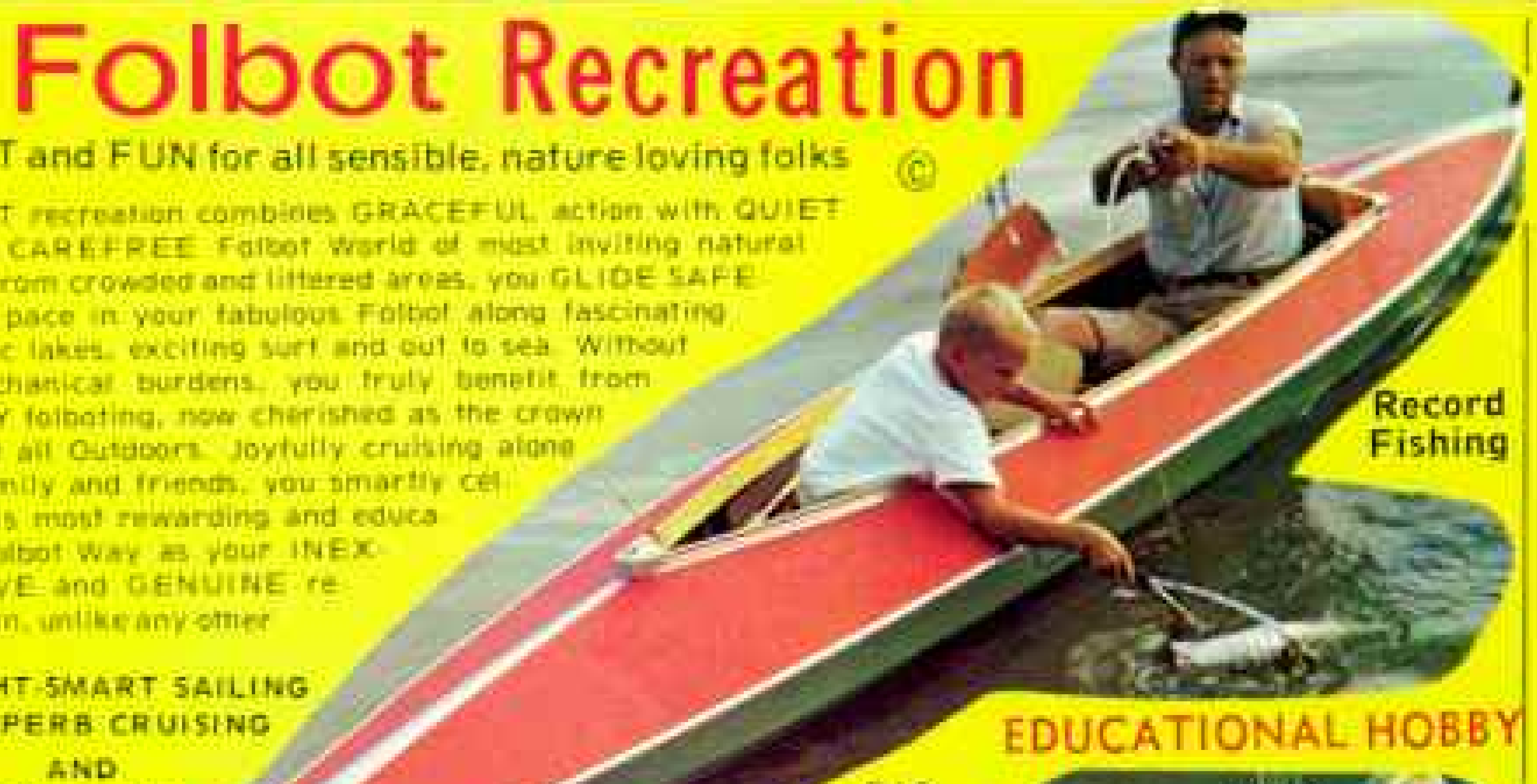

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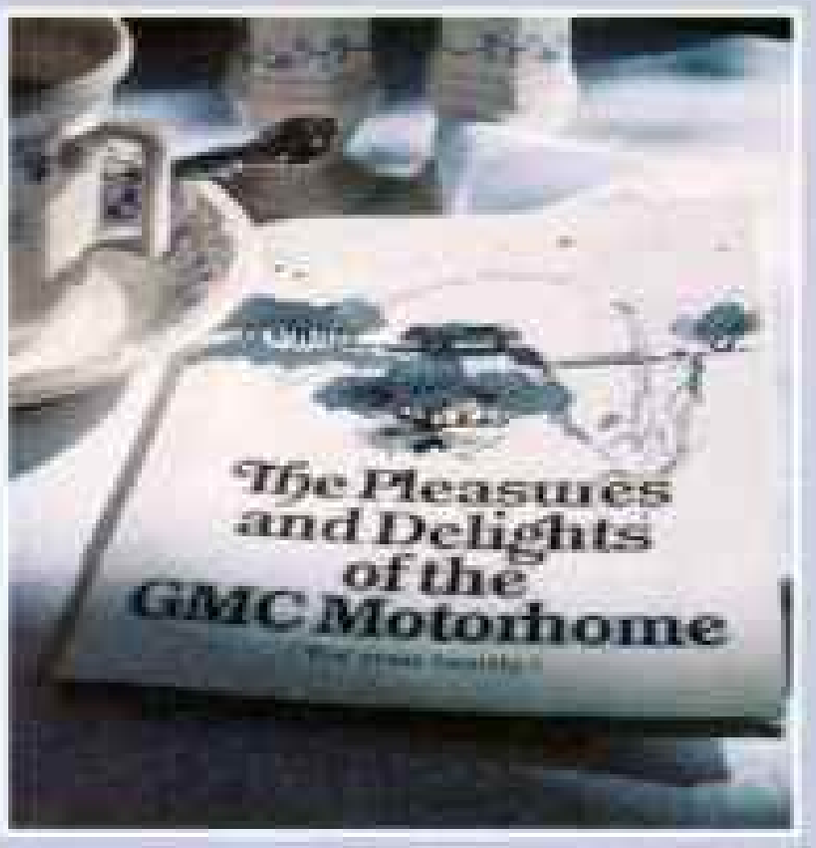

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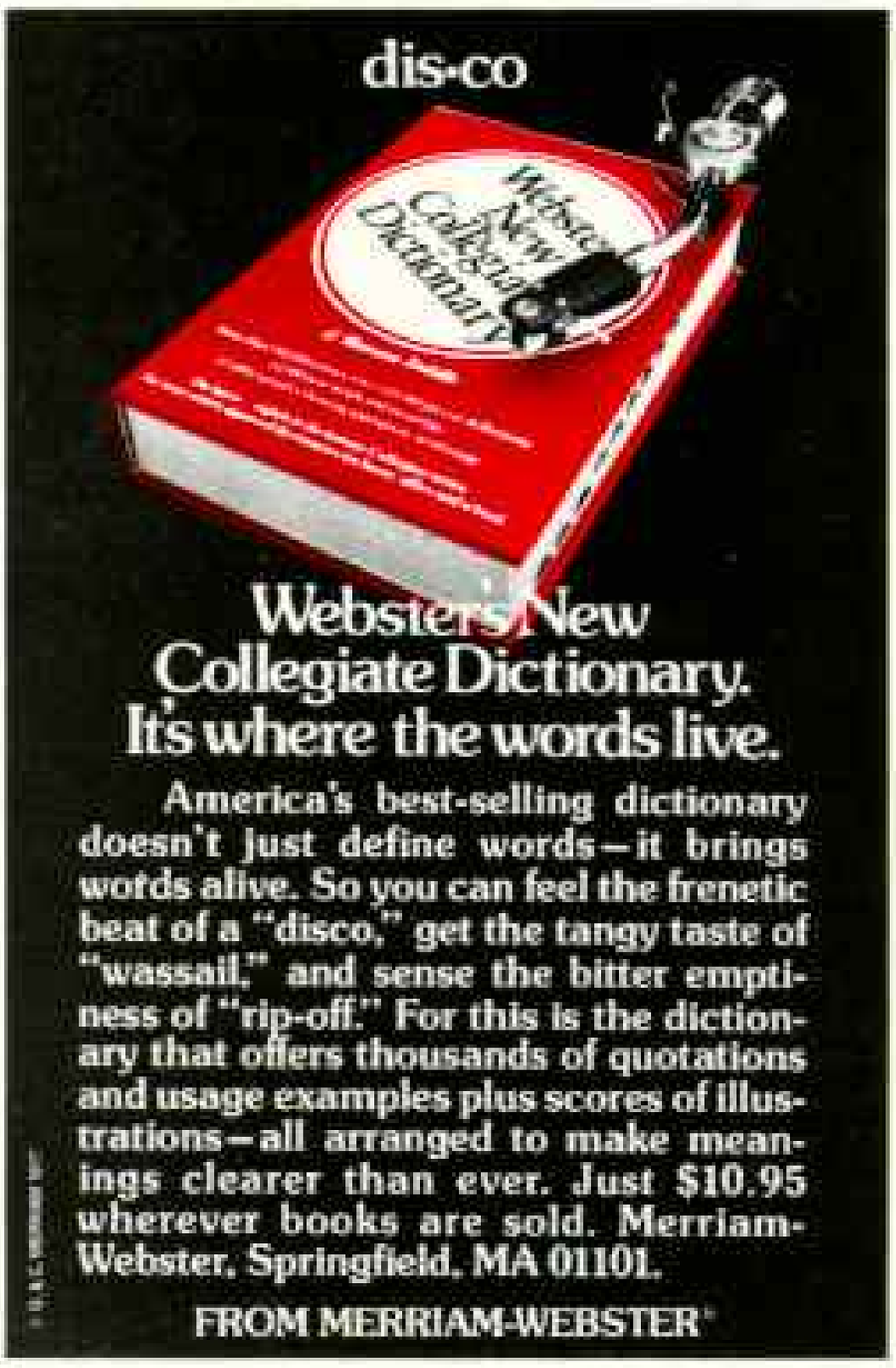

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