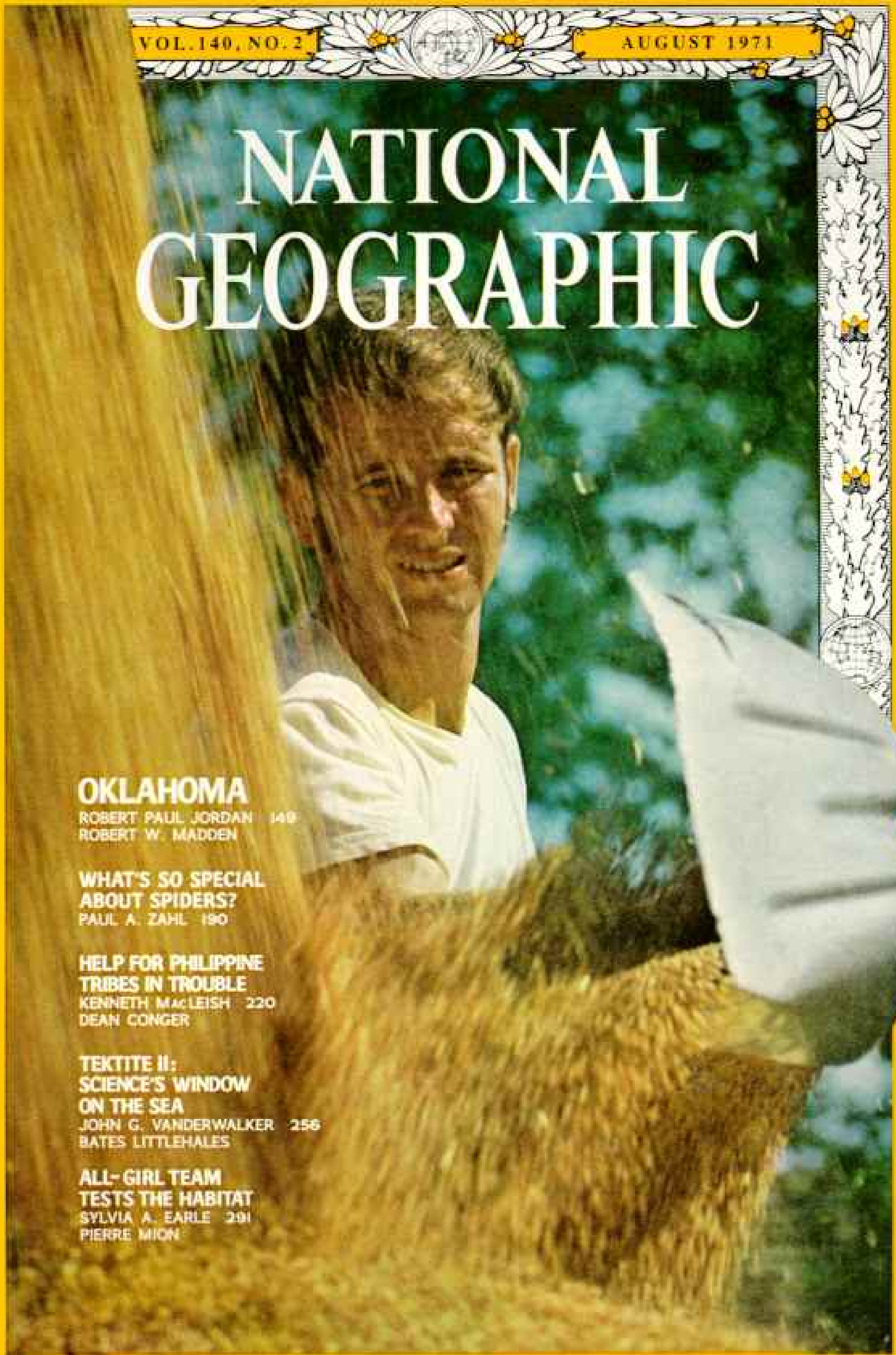
VOL. 140, NO. 2 AUGUST 1971

NATIONAL GEOGRAPHIC



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

NATIONAL GEOGRAPHIC SOCIETY

WASHINGTON, D. C.

Organized "for the increase and diffusion of geographic knowledge"

GILBERT HOVEY GROSVENOR
Editor, 1899-1954; President, 1920-1954
Chairman of the Board, 1954-1966

THE NATIONAL GEOGRAPHIC SOCIETY is chartered in Washington, D.C., in accordance with the laws of the United States, as a nonprofit scientific and educational organization for increasing and diffusing geographic knowledge and promoting research and exploration. Since 1890 the Society has supported 683 explorations and research projects, adding immeasurably to man's knowledge of earth, sea, and sky. It diffuses this knowledge through its monthly journal, NATIONAL GEOGRAPHIC; more than 27 million maps distributed each year; its books, globes, atlases, and filmstrips; 30 School Bulletins a year in color; information services to press, radio, and television; technical reports; exhibits from around the world in Explorers Hall; and a nationwide series of programs on television.

Articles and photographs of travel, natural history, and expeditions to far places are desired. For material used, generous remuneration is made.

MELVIN M. PAYNE, President
ROBERT E. DOYLE, Vice President and Secretary
LEONARD CARMICHAEL, Vice President for Research and Exploration
GILBERT M. GROSVENOR, Vice President
THOMAS M. BEERS, Vice President and Associate Secretary
HILLEARY F. HOSKINSON, Treasurer
OWEN R. ANDERSON, WILLIAM T. BELL,
LEONARD J. GRANT, W. EDWARD ROSCHER,
C. VERNON SANDERS, Associate Secretaries

BOARD OF TRUSTEES

MELVILLE BELL GROSVENOR
Chairman of the Board and Editor-in-Chief

THOMAS W. McKNEW, *Advisory Chairman of the Board*

LEONARD CARMICHAEL, Former Secretary, Smithsonian Institution
LLOYD H. ELLIOTT, President, George Washington University
CRAWFORD H. GREENEWALT, Chairman, Finance Committee, E. I. du Pont de Nemours & Company
GILBERT M. GROSVENOR, Editor, National Geographic
ARTHUR B. HANSON, General Counsel, National Geographic Society
CARYL P. HASKINS, President, Carnegie Institution of Washington
EMORY S. LAND, Vice Admiral, U.S. Navy (Ret.), Former President, Air Transport Association
CURTIS E. LeMAY, Former Chief of Staff, U.S. Air Force
H. RANDOLPH MADDOX, Former Vice President, American Telephone & Telegraph Company
WM. McCHESNEY MARTIN, JR., Former Chairman, Board of Governors, Federal Reserve System
BENJAMIN M. McKELWAY, Editorial Chairman, *Washington Star*
MELVIN M. PAYNE, President, National Geographic Society
LAURANCE S. ROCKEFELLER, President, Rockefeller Brothers Fund
ROBERT C. SEAMANS, JR., Secretary of the Air Force
JUAN T. TRIPPE, Honorary Chairman of the Board, Pan American World Airways
FREDERICK G. VOSBURGH, Former Editor, National Geographic
JAMES H. WAKELIN, JR., Assistant Secretary of Commerce for Science and Technology
EARL WARREN, Former Chief Justice of the United States
JAMES E. WEBB, Former Administrator, National Aeronautics and Space Administration
ALEXANDER WETMORE, Research Associate, Smithsonian Institution
LLOYD B. WILSON (Emeritus), Honorary Board Chairman, Chesapeake & Potomac Telephone Company
CONRAD L. WIRTH, Former Director, National Park Service
LOUIS B. WRIGHT, Former Director, Folger Shakespeare Library

COMMITTEE FOR RESEARCH AND EXPLORATION

LEONARD CARMICHAEL, *Chairman*
ALEXANDER WETMORE and MELVIN M. PAYNE, *Vice Chairmen*

GILBERT M. GROSVENOR, MELVILLE BELL GROSVENOR, CARYL P. HASKINS, EMORY S. LAND, THOMAS W. McKNEW, T. DALE STEWART, Physical Anthropologist Emeritus, Smithsonian Institution, MATTHEW W. STIRLING, Research Associate, Smithsonian Institution, JAMES H. WAKELIN, JR., FRANK C. WHITMORE, JR., Research Geologist, U.S. Geological Survey, CONRAD L. WIRTH, FREDERICK G. VOSBURGH, and PAUL A. ZAHL. BARRY C. BISHOP, *Secretary on leave*; EDWIN W. SNIDER, *Secretary*

Assistant Secretaries of the Society:
EVERETT C. BROWN, FRANK S. DELK, JOHN GOEDEL, JOSEPH B. HOGAN, RAYMOND T. McELLIGOTT, JR., EDWIN W. SNIDER
Assistant Treasurer: WARD S. PHELPS

Leonard J. Grant, Editorial Assistant to the President; Edwin W. Snider, Richard E. Pearson, Administrative Assistants to the President; Judith N. Dixon, Administrative Assistant to the Chairman and Editor-in-Chief; Lenore W. Kessler, Administrative Assistant to the Advisory Chairman of the Board

SECRETARY'S STAFF: *Administrative:* Earl Corliss, Jr., *Accounting:* Jay H. Givans, George F. Fogle, Alfred J. Hayre, William G. McGhee, Martha Allen Baggett. *Statistics:* Thomas M. Kent. *Payroll and Retirement:* Howard R. Hudson (Supervisor), Mary L. Whitmore, Dorothy L. Dameron (Assistants). *Procurement:* J. P. M. Johnston, Robert G. Corey, Sheila H. Immel. *Membership Research:* Charles T. Kneeland. *Membership Fulfillment:* Geneva S. Robinson, Paul B. Tyler, Peter F. Woods. *Computer Center:* Lewis P. Lowe. *Promotion:* E. M. Pusey, Jr., Robert J. Warfel. *Printing:* Joe M. Barlett, Frank S. Oliverio. *Production Control:* James P. Kelly. *Personnel:* James B. Mahon, Adrian L. Loftin, Jr., Glenn G. Pepperman, Nellie E. Sinclair. *Medical:* Thomas L. Hartman, M.D. *Translation:* Zbigniew Jan Lutyk.

COVER: Torrent of Oklahoma wheat engulfs a shoveler at Dacoma (pages 168-9). ACQUACHROME BY ROBERT W. MADDEN © N.G.S.

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

NATIONAL GEOGRAPHIC MAGAZINE

MELVILLE BELL GROSVENOR Editor-in-Chief and Board Chairman
MELVIN M. PAYNE President of the Society
GILBERT M. GROSVENOR Editor
FRANC SHOR, JOHN SCOFIELD Associate Editors

Senior Assistant Editors
Allan C. Fisher, Jr., Kenneth MacLeish, Robert L. Conly

Assistant Editors: Jules B. Billard, Andrew H. Brown, James Cerruti, W. E. Garrett, Edward J. Linehan, Carolyn Bennett Patterson, Howell Walker, Kenneth F. Weaver

Senior Editorial Staff: Rowe Findley, William Graves, Jay Johnston, Stuart E. Jones, Robert P. Jordan, Joseph Judge, Nathaniel T. Kenney, Samuel W. Matthews, Bart McDowell; Senior Scientist: Paul A. Zahl

Foreign Editorial Staff: Luis Marden (Chief), Thomas J. Abercrombie, Howard La Fay, Volkmar Wentzel, Peter T. White

Editorial Staff: Harvey Arden, Thomas Y. Canby, Louis de la Haba, Mike W. Edwards, William S. Ellis, Noel Grove, Alice J. Hall, Werner Janney, Jerry Kline, John L. McIntosh, Elizabeth A. Moize, Ethel A. Starbird, Gordon Young

Editorial Layout: Howard E. Paine (Chief); Charles C. Uhl, John M. Lavery

Geographic Art: William N. Palmstrom (Chief). *Artists:* Peter V. Bianchi, Lisa Biganzoli, William H. Bond, John W. Lothers, Robert C. Magis, Robert W. Nicholson, Ned M. Seidler. *Cartographic Artists:* Victor J. Kelley, Snezana Stefanoff. *Research:* Walter Q. Crowe (Supervisor), Virginia L. Baza, George W. Beatty, John D. Garst, Jean B. McConville, Dorothy A. Nicholson, Isaac Ortiz (Production), Marie L. Barnes (Administrative Assistant)

Editorial Research: Margaret G. Bledsoe (Chief); Ann K. Wendt (Associate Chief), Alice M. Bowsher, Margaret L. Dugdale, Jan Holderness, Lavenia Luder, Frances H. Parker

Geographic Research: George Crossette (Chief); Newton V. Blakeslee (Assistant Chief), Leon J. Canova, Bette Joan Goss, Lesley B. Lane, John A. Weeks

Photocopying: John E. McConnell (Chief); Lawrence F. Ludwig (Assistant Chief)

Library: Virginia Cutler Hills (Librarian); Margery K. Barkdull (Assistant Librarian), Melba Barnes, Louise A. Robinson, Esther Ann Manian (Librarian Emerita)

Editorial Administration: Joyce W. McKean, Assistant to the Editor; Harriet Carey, Virginia H. Finnegan, Winifred M. Myers, Shirley Neff, Betty T. Sanborne, Inez D. Wilkinson (Editorial Assistants); Dorothy M. Corson (Indexes); Rosalie K. Milford, Lorine Wendling (Files); Evelyn Fox, Dolores Kennedy (Transportation); Carolyn F. Clewell (Correspondence); Jeanne S. Duiker (Archives)

ILLUSTRATIONS STAFF: *Illustrations Editor:* Herbert S. Wilburn, Jr. *Associate Illustrations Editor:* Thomas R. Smith. *Art Editor:* Andrew Poggenpohl. *Assistant Illustrations Editors:* Mary S. Griswold, O. Louis Mazzatenta, Charlene Murphy, Robert S. Patton. *Layout and Production:* H. Edward Kim (Chief). *Picture Editors:* David L. Arnold, Michael E. Long, Elie S. Rogers, W. Allan Royce, Jon Schneeberger, C. William Snead. *Research:* Paula C. Simmons, Barbara A. Shattuck (Asst.). *Librarian:* L. Fern Dame

Engraving and Printing: Dee J. Ansiello (Chief); Raymond B. Benzinger, John R. Metcalfe, William W. Smith, James R. Whitney

PHOTOGRAPHIC STAFF: *Director of Photography:* Robert E. Gilka. *Assistant Director:* Dean Conger. *Film Review:* Albert Moldvay (Chief); Guy W. Starling (Assistant Chief). *Photographic Equipment:* John E. Fletcher (Chief), Donald McBain. *Pictorial Research:* Walter Meayers Edwards (Chief). *Photographers:* James L. Amos, James P. Blair, Bruce Dale, Dick Durrance II, Otis Imboden, Emory Kristof, Bates Littlehales, George F. Mobley, Robert S. Oakes, Winfield Parks, Joseph J. Scherschel, Robert F. Sisson, James L. Stanfield. Lilian Davidson (Administration). *Photographic Laboratories:* Carl M. Shrader (Chief); Milton A. Ford (Associate Chief); Herbert Altemus, Jr., David H. Chisman, Claude E. Petrone, Donald E. Stemper

RELATED EDUCATIONAL SERVICES OF THE SOCIETY

Cartography—Maps, atlases, and globes: Chief Cartographer: Wellman Chamberlin. *Associate Chief:* William T. Peele. *Assistant Chief:* David W. Cook. *Base Compilation:* Charles L. Stern (Supervisor), Charles F. Case, James W. Killion. *Name Compilation:* Donald A. Jaeger (Supervisor), Charles W. Gotthardt, Jr., Manfred G. Kogutowicz, David L. Moore. *Map Drawings:* Douglas A. Strobel (Supervisor), Robert W. Northrop, Tibor G. Toth, Thomas A. Wall. *Map Editing:* Ted Dachtera (Supervisor), Russel G. Fritz, Thomas A. Walsh. *Layout and Design:* John F. Dorr. *Revisions:* Richard J. Darley. *Archeology:* George E. Stuart. *Printing Control:* Richard K. Rogers. *Administrative Assistant:* Catherine M. Hart.

Books: Merle Severy (Chief); Seymour L. Fishbein (Assistant Chief), Thomas B. Allen, Ross Bennett, Charles O. Hyman, Anne Dirkes Kobor, John J. Putman, David F. Robinson, Verla Lee Smith

Special Publications: Robert L. Breeden (Chief); Donald J. Crump (Asst. Chief), Josephine B. Bolt, David R. Bridge, Linda Bridge, Margery G. Dunn, Johanna G. Farren, Ronald Fisher, Mary Ann Harrell, Bryan Hodgson, Geraldine Linder, Robert Messer, Cynthia Ramsay, Philip B. Silcott, Joseph A. Taney

School Service: Ralph Gray (Chief and Editor of National Geographic School Bulletin); Arthur P. Miller, Jr. (Assistant Chief and Associate Editor of School Bulletin), Joseph B. Goodwin, Ellen Joan Hurst, Paul F. Mintz, Charles H. Sloan, Janis Knudsen Wheat. *Educational Filmstrips:* David S. Boyer (Chief); Margaret McKelway Johnson

News Service: Windsor P. Booth (Chief); Paul Sampson (Assistant Chief), Donald J. Frederick, William J. O'Neill, Robert C. Radcliffe; Isabel Clarke

Television: Robert C. Doyle (Chief), David Cooper, Carl W. Harmon, Jr., Sidney Platt, Patricia F. Northrop (Administrative Assistant)

Lectures: Joanne M. Hess (Chief); Robert G. Fleegal, Mary W. McKinney, Gerald L. Wiley

Explorers Hall: T. Keilor Bentley (Curator-Director)

EUROPEAN OFFICES: W. Edward Roscher (Associate Secretary and Director), Jennifer Moseley (Assistant), 4 Curzon Place, Mayfair, London, W1Y 8EN, England; Jacques Ostier, 6 rue des Petits-Pères, 75-Paris 2e, France

ADVERTISING: *Director:* William A. Boeger, Jr. *National Advertising Manager:* William Turgeon, 630 Fifth Ave., New York, N.Y. 10020. *Regional managers—Eastern:* George W. Kellner, New York. *Midwestern:* Robert R. Henn, Chicago. *Western:* Thomas Martz, San Francisco. *Los Angeles:* Jack Wallace. *Automotive:* John F. Grant, New York. *Travel:* Gerald A. Van Splinter, New York. *International Director:* James L. Till, New York. *European Director:* Richard V. Macy, 23 rue Jean-Mermoz, Paris 8e, France.

Missed your summer vacation? Just 90 minutes away, it's still Summer in November.

Our location gives you more latitude for vacationing.

It protects you against the loss of vital summer time, with a warm sun that keeps rising when the leaves at home are falling.

And while you play golf, tennis and swim late, you have a fine opportunity to do something else early: Christmas shopping.

Here in the great shops along Front Street, you'll find a pleasure equal to the array of magnificent wares: the genuine courtesy of our shopkeepers.

Catch your vacation where it's still Summer in Fall. And hospitality is always in season.

In Bermuda, 90 minutes near.

Bermuda

For a change, come to where things haven't changed.

CALL YOUR TRAVEL AGENT, OR WRITE BERMUDA, 610 FIFTH AVE., NEW YORK, N. Y. 10020—6 NORTH MICHIGAN AVE., CHICAGO, ILL. 60602

Our summer's end is just the beginning. A warm and beautiful beginning.

To our second summer.

The setting's the same but the scenery changes. Gloriously.

Driving becomes one magnificent view after another.

Your pace is a little quieter. A little more relaxed.

The countryside, flaming with color seems somehow more peaceful and serene.

It's a time of country fairs and festivals. Of auctions and bargain-hunter's delights. A harvest-time, with fresh-picked fruit at country roadside stands.

A time when Nature's favourite children are photographers.

A time of fresh, crisp, clean air. Of warm days and cool nights.

A time for the fisherman to find a stream to himself.

And for the golfer, perhaps the favourite time of all the year.

For you, autumn in Nova Scotia may be a returning to summer delights and finding them twice delightful.

We have information to tell you how to get here, where to stay, and all the things you can do while you're with us.

Just write to:
Nova Scotia Travel Bureau,
5670 Spring Garden Road,
P.O. Box 130, Halifax, N.S.
607 Boylston Street,
Boston, Mass. 02116
630 Fifth Ave., Suite 3115,
New York, N.Y. 10020

NOVA SCOTIA

Canada's ocean playground

BOOMERANGS BY MAI THAN (LEFT) AND DEAN CONGER © N.G.S.

Geographic staff men lead adventurous lives

DEAN CONGER (left, exercising in a Philippine hamlet) photographed the splashdown of the first American astronaut. He has taken his cameras to the steppes of Mongolia and through the snows of Siberia. Kenneth MacLeish (above, holding the hands of T'boli girls) has reported on places as diverse as Singapore and the Scottish Highlands. The two have crisscrossed Java and followed the trail of Abraham from Iraq to Egypt; partway through that assignment, Syrian police arrested them as spies. When the GEOGRAPHIC's Editor decided to go after a dramatic and then-untold story—the Philippine Government's program to aid its embattled hill peoples—he chose this seasoned team. Their words and photographs (pages 220-55) underline once again the Society's tradition of bringing you the *human* side of geography.

If your child can't go to school,
maybe the school can come to her.

A child who gets ill, or has an accident, can miss weeks or months of school. Which may mean having to repeat the whole year.

Now there's a special telephone system to help children keep up with their studies, while they recover from their setbacks.

The system is called Tele-Class. And it's working in lots of places.

In Oakland, California, for example, all the child needs is a telephone, a headset, the right textbooks, and a specially trained teacher like Mrs. Molly Steele.

Mrs. Steele used to teach regular elementary school. But now she has a class of ten children. Some ill at home, some in the hospital.

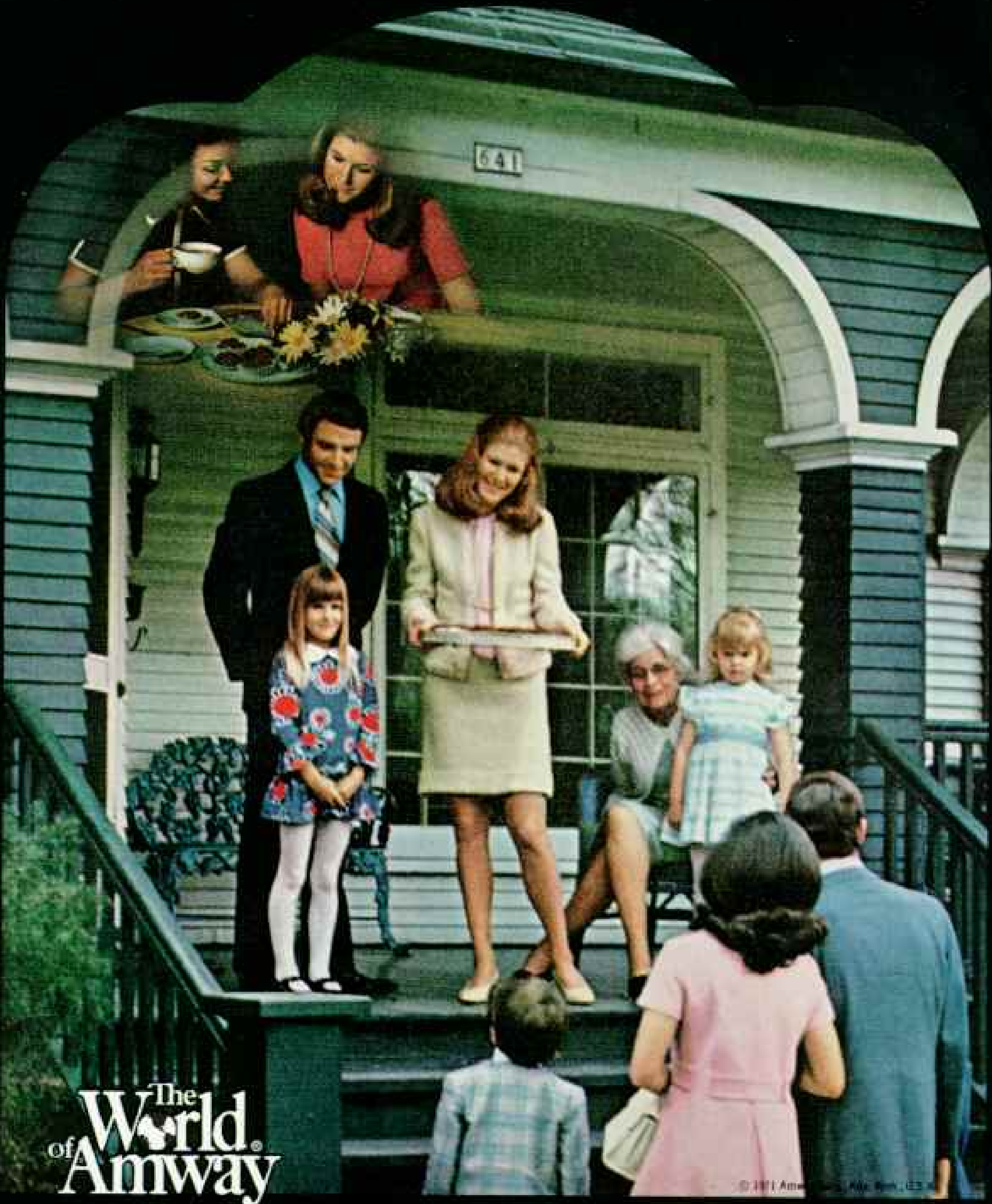
Every day she inserts a card into a special telephone and dials her students. Once they are all on the line, class begins.

Not only can Mrs. Steele talk to the children, but they can talk among themselves. So they get a classroom atmosphere complete with discussions and question-and-answer sessions.

They also get 20 hours a week of education they would have missed before.

The American Telephone and Telegraph Company and your local Bell Company are continually looking for new ways to make the telephone serve you.

One way is to help a child who can't go to school, go to school.



A friendly world. A world of people helping each other. Of Amway Distributors serving friends and neighbors in their homes. Bringing them over 150 superb Amway products for home care and personal grooming. Demonstrating these products. Explaining how to use them...most efficiently, most economically. A world of people sharing "home care know-how" with friends...a world of people sharing a business opportunity as well. Independent Distributors of Amway products who help others to start family businesses of their own... show them how to become Amway Distributors...how to join more than 150,000 other independent business people who are part of the free enterprise world of Amway.

Amway

Amway Corp., Ada, Michigan 49301 | Amway of Canada Ltd., London, Ontario, Canada.

NATIONAL GEOGRAPHIC

August 1971

WHERE PIONEERS TROD AND BLACK GOLD FLOWS, OKLAHOMA CITY BUILDS SKYWARD—A GLOWING SYMBOL OF

Oklahoma, the Adventurous One

By ROBERT PAUL JORDAN

SENIOR EDITORIAL STAFF

Photographs by ROBERT W. MADDEN

IN OKLAHOMA CITY recently, I asked a man of special vision to describe the view we shared from the thirty-first floor of a downtown skyscraper. With quiet, measured words, George H. Shirk, president of the Oklahoma Historical Society and former mayor, resurrected a shimmering ghost.

"This was just a dusty depot on the sun-scorched prairie," he said, his eyes lost in a time before his own. "A stop for Santa Fe trains. No trees. The entire water supply came from a single well, about where Broadway and Main Street meet today."

Then his reverie took speed, suddenly embroiled in one of history's great mob scenes.

"On a spring day only 82 years ago, Uncle Sam held the first land opening. All about us, between noon and nightfall, erupted a tent city of 5,000 thirsty, aggressive humans. Soldiers guarded the well, rifles ready."

Now I enjoy meeting most ghosts, but Mr. Shirk's eluded me. I could see only a moiling metropolis straggling to the sky's rim. Beneath me, where the city had been born, I stared at something else. Destruction. Devastation. Steel headache balls smashing the ribs of the dismal, worn-out business district.

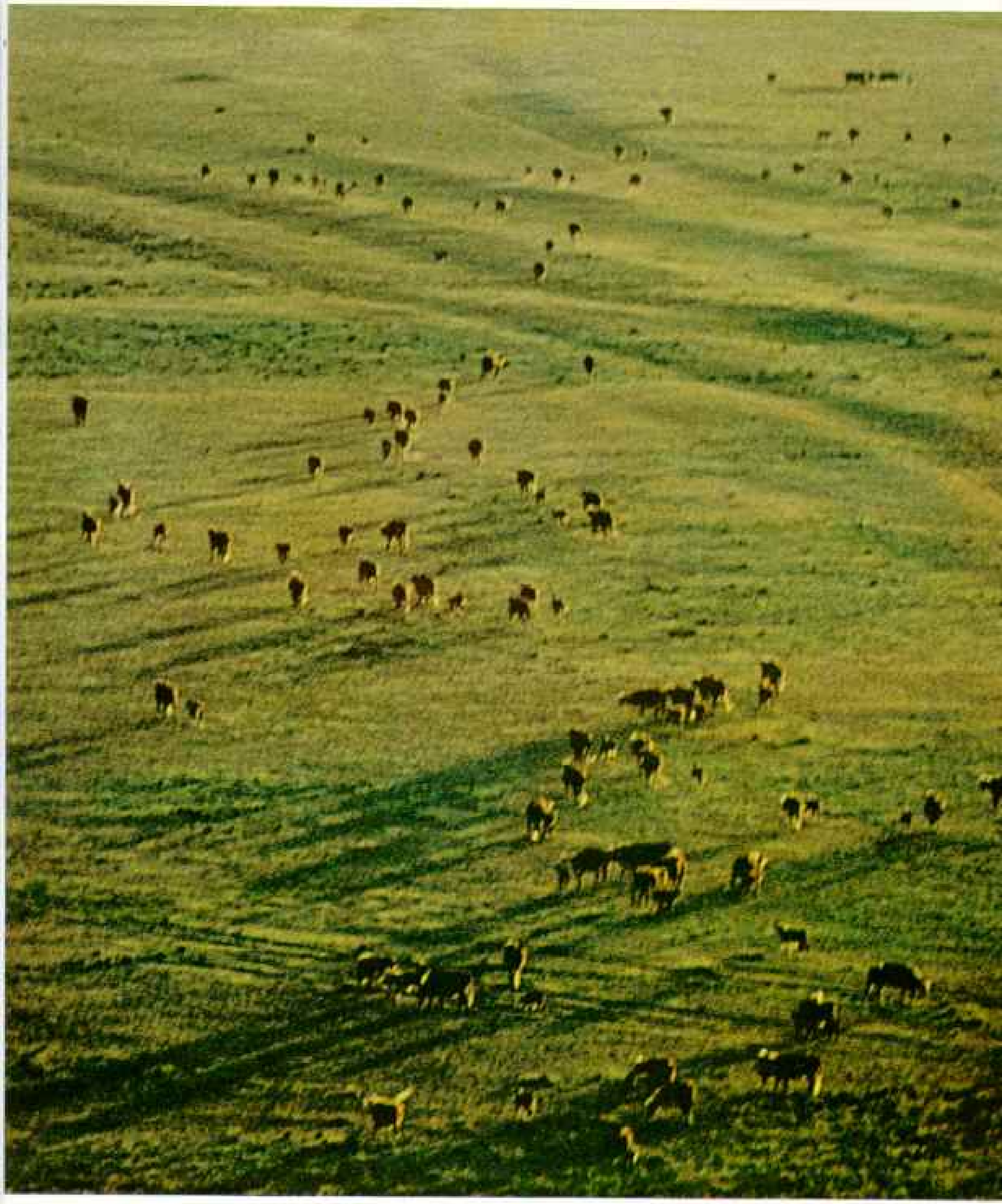
I could see, too, another dramatic birth, an emerging downtown section as modern and sparkling as man can devise. Hundreds of acres of wide streets, plazas, malls, fountains, convention center, astonishingly unconventional theater building, immense medical enclave, new homes and apartments, and the soaring thousand-eyed spires of our day.

That, I thought, is Oklahoma City for you, past and present. "The City of Tomorrow," her boosters modestly proclaim.

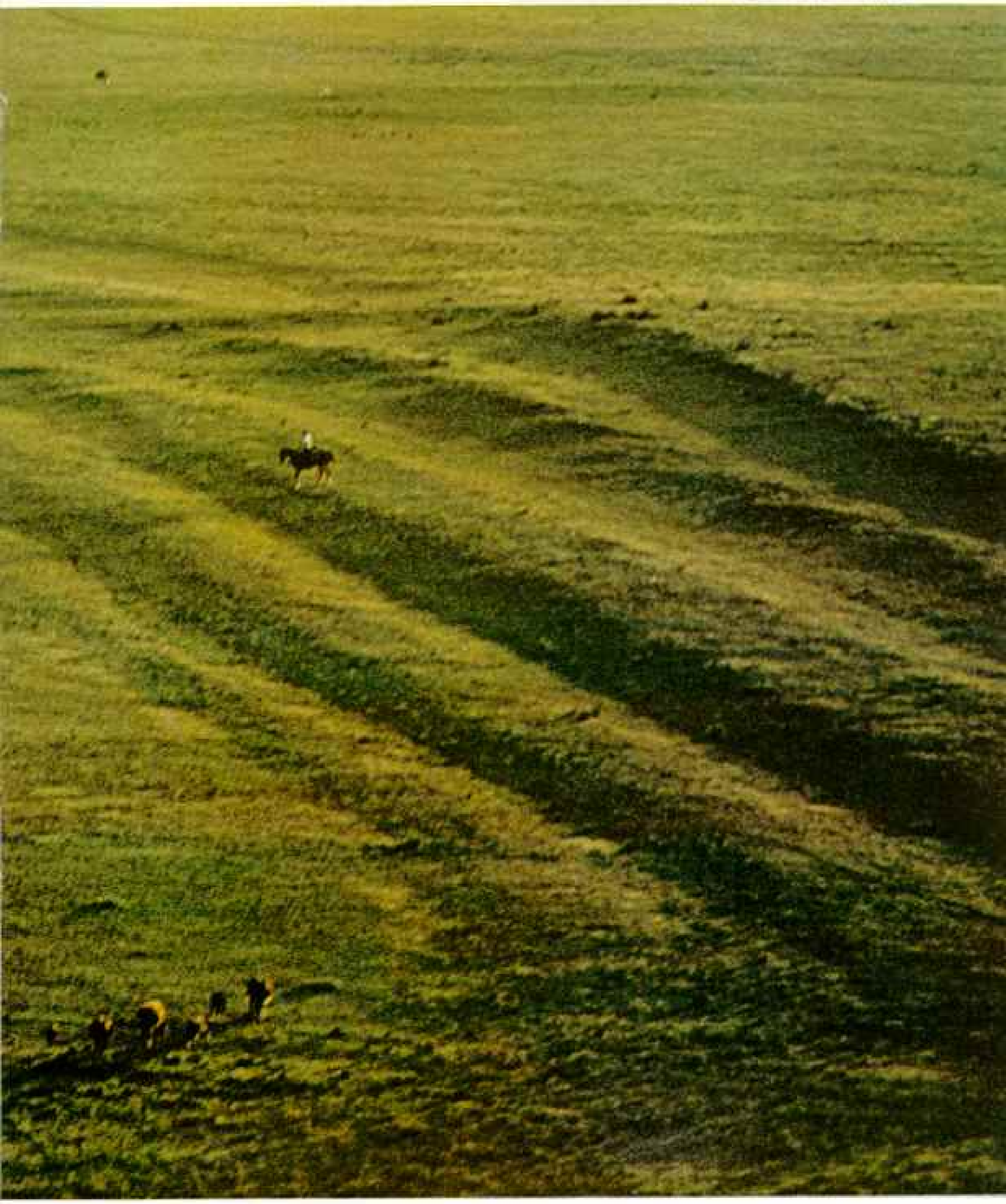
All Oklahoma, I now submit, is like that: Tomorrow Country. I say it after months of roving this young and exuberant state (map, pages 154–5), watching today's frontiersmen striking out for new horizons.

Not long ago the world and I sailed up to

History leaves its signature amid grazing cattle on the Oklahoma Panhandle. Ruts still mark the Santa Fe Trail's Cimarron Cutoff.



where in the mid-19th century dust-dogged wagon trains lumbered between Independence, Missouri, and the Southwest. Today, at accelerating pace, Oklahomans transform their stubborn land into an agricultural and industrial giant.



Tulsa's back door. It began for me in no certain place on a still, star-crackling night. Muskogee, newly and proudly the state's first seaport, lay hours behind us.

From the towboat wheelhouse we squinted at the narrow, forbidding stream, welcoming each Coast Guard buoy as it bobbed up in our searchlights. How incongruous it seemed, bringing the oceans deep into landlocked Oklahoma by pushing a barge up the winding Verdigris River.

Intent at his lonely work, Capt. Bill Kurts, Jr., flicked steering levers and throttled back our twin engines. Gingerly we eased over a rock shelf hundreds of yards long. Two miles an hour . . . one . . . only inches from scraping bottom. "Slow boat to Tulsa," a deckhand grumbled wryly.

Then we got across and glided into normal nine-foot depths. I relaxed and the skipper grinned, coffee in hand. "First time you steer a strange river," he drawled, "you sort of feel your way along."

Strange river for him. And another bizarre beginning for this absolutely one-of-a-kind Oklahoma. Next day, cutting a bracing winter breeze, we pushed the first commercial cargo into the Tulsa Port of Catoosa, opening the last port of the 1.2-billion-dollar Arkansas-Verdigris River Valleys project (pages 156-7). Now other tows would put in to Tulsa, eight-barge flotillas bearing steel, say, from Chicago, or slipping up the Mississippi from New Orleans with containerized goods from Europe, Asia, and Latin America.

Sam Frevert, the port's enthusiastic executive director, could see the bounty of that far horizon. "In ten years," he boomed, "we'll be handling more freight than St. Louis, Memphis, or Pittsburgh does today." On June 5 of this year, President Richard M. Nixon formally dedicated the McClellan-Kerr Arkansas River Navigation System.

Relic of a pioneering past, this 50-year-old stone house stands near Kenton, on the 160-acre spread of Elzy Tanner. On homesteads often bare of wood and rock, many settlers made do with crude turf "soddies."

Foretaste of the future, a 200-foot flame-tipped tower rises above Oral Roberts University at Tulsa. Glassed observation deck houses a campus radio station and a battery of "dial-for-counseling" telephones. Beyond looms the graceful Learning Resources Center, academic hub of the liberal arts college founded by the famed Oklahoma evangelist.

Bugle Signaled a State's Beginning

Yet in retrospect, a seagoing Oklahoma seems a mild triumph compared to the fantastic way the state got started in the first place. The United States of America arrived on April 22, 1889, with a much bigger bang than the world and I made aboard our towboat. Here and there you can still find an old-timer to relive that day for you.

"We milled about, waiting," recalled a peppery graybeard in his nineties, memory yesterday-bright. "People from all over the country, even women with babies. At noon a soldier standing on high ground dropped a signal flag and blew a bugle, and we tore across the line to stake our claims."

Run they did, then and many times more (page 154), hundreds of thousands of settlers whooping into the wilderness for free 160-acre homesteads and town lots, charging on blooded horses and spavined nags, buckboards and careening prairie schooners. A few rode bicycles, and some hung to the cowcatchers of snorting locomotives.

Oh, a number of wily opportunists couldn't wait, and sneaked into this new Canaan sooner than they should have. So to this day people call it the Sooner State.

Besides Oklahoma City, instant towns sprang up at Guthrie, with its railroad and federal land office, and at Kingfisher, another land office, earlier a stage stop on the Chisholm Trail when cowpokes pushed herds

(Continued on page 158)

Oklahoma!

AS THE HOT SUN CLIMBS on September 16, 1893, more than 100,000 impatient homesteaders flank the Cherokee Outlet—almost 6⅓ million acres of Indian land bought by the United States Government. The starting signal will sound at noon, but some cross the line ahead of time. Thus did Oklahomans earn their nickname—Sooners.

Guns crack, and the wild Run of '93 officially begins. In buckboards, buggies, wagons, and carts, on bicycles, horseback, and afoot, the settlers charge in a storm of dust (**below**). Chaos reigns. Wagons overturn, spilling women and children; men tumble from their mounts; screams and curses fill the air. By evening 40,000 homesteads of 160 acres each are claimed, and visionaries are laying out towns.

So went the fourth and largest of the runs that opened Indian lands to settlers. Appalled by the injuries and violence, the Federal Government eventually turned to

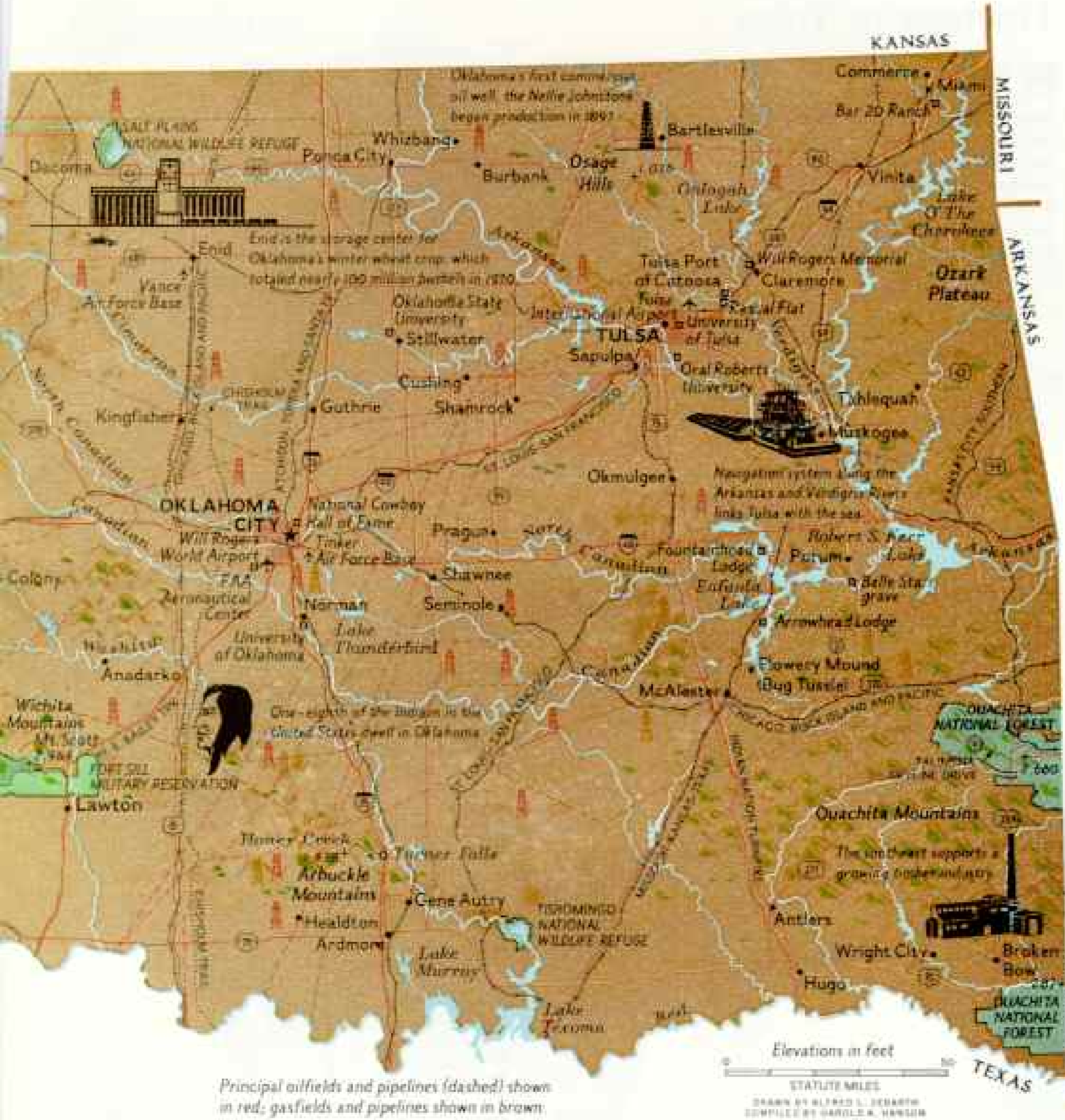
COURTESY OKLAHOMA HISTORICAL SOCIETY

allocating homesteads by auction or lottery.

Today, agriculture, oil, and industry underpin the state's economy. In renewal-minded Oklahoma City and bustling Tulsa, aviation and aerospace employ thousands. Trees cloak eastern mountains; timber gains as an income earner.

The image of Dust Bowl days fades as seaports on the prairie open at Muskogee and near Tulsa. Planners envision yet another canal system, conveying the east's excess water to thirsty western plains.

Oologah Lake, in the northeast, drowns the birthplace of Will Rogers—but his words about it still ring true: "Everyone has deep in their heart the old town or community where they first went barefooted, got their first licking, traded the first pocket knife, grew up and finally went away thinking they were too big for that Burg. But that's where your old heart is."



Principal oilfields and pipelines (dashed) shown in red; gasfields and pipelines shown in brown.

AREA: 69,919 sq. mi., ranks 18th. **POPULATION** (1970): 2,559,253, ranks 27th. **MAJOR CITIES:** Oklahoma City, pop. 366,500 (metropolitan region 625,000); capital, Tulsa, pop. 331,600 (metropolitan region 490,000), oil, aeronautics, diversified manufacturing; Lawton, pop. 74,500, serves adjoining U. S. Army's Fort Sill. **ADMISSION:** 1907 as 46th state.

Towboat to Tulsa

BARGES LASHED *to her bow, a towboat enters the first of a staircase of 17 locks, 10 miles from the Mississippi and 500 upriver from New Orleans. The channel winds another 426 miles through Arkansas and Oklahoma to give Tulsa a link with the seaports of the world. Total development cost: 1.2 billion dollars—*

The Tulsa Port of Catoosa marks upper end of the waterway.

TULSA
MUSKOGEE
FORT SMITH
OZARK
RUSSELLVILLE
MORRILTON
LITTLE ROCK
PINE BLUFF
GILLETT

the largest civil-works project ever undertaken by the U.S. Army Corps of Engineers. The waterway shortcuts looping oxbows (opposite) *like these on the Verdigris River. In this aerial view of a 40-mile portion of the channel, infrared film makes green fields appear red.*

PAINTING BY STAFF ARTIST ROBERT C. WAGIS
AND PHOTOGRAPH (OPPOSITE) © N.G.S.

DETECHROME © N.G.S.

Esthetic? No. Lucrative? Yes. Startling to tourists but fondly regarded by Sooners, an oil well throbs in front of the State Capitol. Eighteen wells rise on the capitol grounds. They have pumped more than $8,000,000 into state coffers.

Since the first profitable oil well flowed in 1897, Oklahoma drillers have found oil or gas in all but 5 of the state's 77 counties. Worried producers, pressing the search for new deposits, foresee near exhaustion of today's known reserves in perhaps a decade.

north from Texas to railheads in Kansas.

For the next 18 years, manifesting a Nation's destiny, homesteaders took land that had belonged to the Indians. In the runs, by allotment, and by lottery, Indian Territory and Oklahoma Territory were carved up, barbed-wired, and domesticated.

What was it like? In Guthrie, the sprightly former Cravens sisters, all widows, can tell you. Listen to Mrs. Lovenna Barnes, Mrs. Blanche Staggs, and Mrs. May Poteet:

"The family slept in the covered wagon that summer, until father built the sod house; carried water from the spring, until the well was drilled. We kept ourselves in the storm cellar every now and then—we could see the twisters following the Cimarron River. Mother planted corn and beans and punkins and cucumbers. She could just pick up her gun and go out across the plains and come in with rabbits, quails, or whatever it might be, because she was a dead shot.

"When we caught cold, she rubbed our chests with skunk grease and poured hot onion tea down us. Anybody who came along and wanted to preach, preached, and we all went to hear him. The first Methodist church they had down here, they had in a tent. They got lumber from the lumberyard and beer kegs from the saloon and made the seats. . . ."

Unusual Hazard Startles a Golfer

So it went, and in 1907 statehood arrived. Oklahoma—from the Choctaw words *okla*, "people," and *homma*, "red"—was on her way. She's been moving ahead ever since, wearing cowboy hat and boots, sleeves rolled up, motivated by the pioneering spirit.

In 64 years the land of red people has grown into an agricultural and industrial empire. Between countless "Howdies" and "You come backs," I watched this dynamic evolution continuing.

Farmers and cattlemen produce a billion dollars a year in crops and livestock; some ranchers ride the range in airplanes. The forty-sixth state ranks fourth in the U. S. in petroleum output, third in natural gas.

Thousands of Sooners work in aviation and aerospace. Computer networks—for airline reservations, rental cars, gasoline credit cards—increasingly center in Tulsa and Oklahoma City. Loggers farm thick forests in the southeast, replanting after they harvest.

When these vigorous people put work aside, they swim, boat, water-ski, and fish in a new marine wonderland—along with a

growing army of tourists. Like me, they vacation at attractive state-operated lodges such as Fountainhead, many to play golf. Few, however, will execute the slice as nobly as I did—but then, seldom does a deer dart across the fairway just as one swings.

I joined Oklahomans at rodeos and powwows, attended church, symphony, opera, and theater with them, admired swank rooftop clubs, dined in the hinterlands on buffalo steak (chewy) and squaw bread (crisp). Tulsa's Thomas Gilcrease Institute of American History and Art and the National Cowboy Hall of Fame in Oklahoma City thrilled me with their unparalleled displays of how the West was won. Sooners, it struck me, function about like the rest of us. So I asked an expert to explain what sets them apart.

I called on newly elected Governor David Hall one pleasant afternoon last January at the State Capitol in Oklahoma City (opposite). It was his first day in office. A tall, handsome man of 40, silver-haired and graced with a warm, gleaming smile, he seated me at a coffee table and came right to the point.

"We are blessed with pure air, four seasons, and plenty of space," said the governor. "We like to work. We live by three things. First, our independence. Oklahomans do not feel fettered. Second, a belief that the basic things in life are most important. Family life plays a greater role here than in many states I have visited. Third, a larger involvement in church-oriented activities."

I asked what he considered the state's biggest problem.

"Education," Governor Hall replied, leaning forward, hands on knees. "That's our first priority. We rank 45th among the states in per-pupil expenditures. We've got to spend more money on our schools. I am convinced that education is the greatest problem-solver of the 20th century."

Tragic Marches Brought Many Tribes

But I wonder if education can solve the problem of the Indian. Often, sadly, the first American is last here, as elsewhere.

Red men roamed the future Oklahoma long before written history. The Louisiana Purchase in 1803 signaled the beginning of Uncle Sam's resettlement policy. In the 1830's Indians began to arrive in force—victims of white expansion in the East.

Among the first to be removed to Oklahoma were the Five Civilized Tribes—Cherokee, Chickasaw, Choctaw, Creek, and Seminole. Soldiers herded them to the rolling, wooded eastern part of the territory in dreadful marches that killed thousands.

Soon the cultured Cherokees were printing a bilingual newspaper. Well-to-do tribesmen built porticoed brick academies for their children. Many married whites. Some hacked plantations from the forest and grew corn and cotton with slave labor.

Later the Army rounded up the Plains Indians, nomadic hunters of buffalo, scalp-takers: Comanches, Kiowas, Cheyennes, Arapahos, and others. They raised their tepees and lodges on the territory's western reaches.

Some Red Men Walk Between Worlds

Today nearly 100,000 Indians, of at least 65 tribes, dwell in Oklahoma. I doubt that any place blends the blood and civilization of redskin and paleface as does Oklahoma. You meet Indians in every walk of life: professional men, businessmen, scholars, politicians' wives, painters, sculptors, ballerinas. Rich ones, bankbooks fat with mineral royalties; many more poor ones, some cursed with alcoholism. Christians, some praying and singing in their native tongues.

And red men so close to the hallowed land and mystic fires of their forefathers that they cannot hear the white man's drum, nor do they wish to. They drift between two worlds.

In a small, personal way I glimpsed this dilemma on a night of half-moon and scudding clouds, in a fallow field rimmed with woods in Seminole County—two hours' drive and a century distant from Oklahoma City.

"You have traveled far to see one of our customs," said my Creek-Seminole host Johnson Scott. "Before the stomp dance can begin, the sacred fire must be lit. Will you let us honor you? Will you start it?"

Facing east in homage to the sleeping sun, giver of life, I set a match to a pile of leaves and twigs, and, when it took, added branches. It must not die out. It did not, and just so did these proud people adopt me into their tribe.

Round and round the fire they danced for hours—men, women, and children, rattles on their legs, happiness on their faces, hand in hand, singing, chanting, bowing to the blazing altar, livelier and livelier. After a time, Johnson Scott kindly led me aside, a weary paleface with smoke in my eyes.

"The fire symbolizes life," said the slim, erect Indian, a boyish 34, artist by profession, wearing eagle feathers in his hat. "The fire keeps you like a wild horse, frisky and free.

SOONER STATE SHOWPLACE: *An imaginative Oklahoma architect, Bruce Goff, designed this Bartlesville house. Walls of anthracite coal, inlaid with chunks of blue-green glass, support its sloping ceilings. Cellophane strips, ever in motion, dangle above the sunken six-sided sofa. Here owner Joe D. Price and his Kyoto-born wife Etsuko catch up with the news. The suspended screen reflects Mr. Price's passion for Japanese art.*

KODACHROME © N.G.S. 161

This is our spirit. This is our beauty. This is our home."

The sound of oil pumps suddenly intruded. I recalled that we stood on the Greater Seminole field, once the Nation's biggest.

"Where is the Indian today?" I asked him.

"Nowhere," he slowly replied, face in shadow. "But we've got something others don't have. Others have worries. We are free. We care only for our families, our kinfolk, and our land. We try to be a friend to all. . . ."

My friend Johnson Scott gave me a gift, as a token. It hangs in my study, his brooding painting of a solitary eagle feather. On it, these words are written: "I was borned alone —I buddy up with nobody."

Cherokee Chief Leads a Giant Company

Not long after I became an adopted Indian, I pointed my car into the gentle green hills of the northeast, into Bartlesville, skyscraper city with one of the state's highest per-family incomes—$10,234 in 1970.

Soundlessly an elevator whisked me to the 18th-floor executive suite of one of the foremost U. S. oil companies, Phillips Petroleum: a quiet place, opulent, impersonal. There I met W. W. Keeler, chairman of the board, and also principal chief of the Cherokee Nation (right).

"As an Indian," said this man of Cherokee extraction, "I realize that the more we are pushed, the less we are willing to go." He smiled. "I think the Irish are similar."

My wife, I replied, would agree.

The plain-suited, plain-spoken executive glanced out the wide windows of his office to the Osage Hills on the west. He said, "The Indian often has little sense of time. Youngsters are chronically late for school, and many drop out, most in the eighth, ninth, or tenth grade. The Indian isn't competitive by nature, or acquisitive. He is creative, artistic, and intuitive. He is the original conservationist. He has a lot to give, and he wants to express himself. We've got to stop saying 'they' and start saying 'we.'"

All kinds of approaches are under way to improve opportunities for Indians, one learns. The challenge, after a century and a half of exploitation, remains formidable.

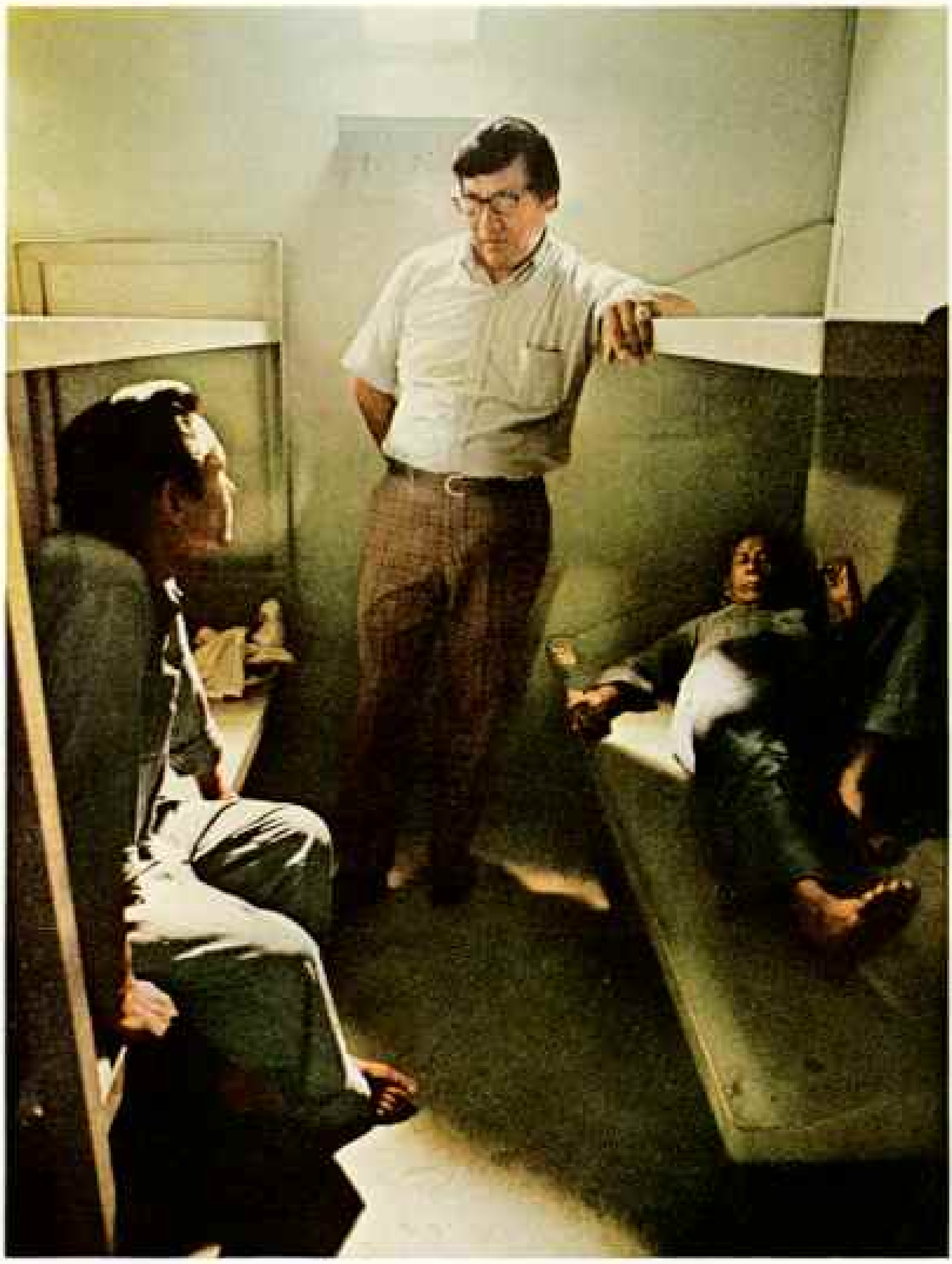
Challenge, I thought as I left, really

EXTACHROME AND KODACHROME (BELOW) © K.R.K.

Chief with two hats: As chairman of the board of Phillips Petroleum, W. W. Keeler supervises an industrial empire. Part Indian, he also sits as principal chief of the Cherokee Nation, largest of Oklahoma's tribes.

In Phillips's Bartlesville skyscraper, Mr. Keeler displays a model of a fractionating plant. In his role as Indian leader, he helped sponsor re-creation of an 18th-century Cherokee village near Tahlequah. There, each summer, the Cherokee National Historical Society presents *Trail of Tears*, which dramatizes the history of the Cherokees following their expulsion from the East in 1838-39.

Petroleum built Tulsa, and for more than half a century she proudly called herself "Oil Capital of the World." But with the depletion of many Oklahoma fields, city fathers lured other industries, especially aviation and aerospace. Today American Airlines is Tulsa's largest employer. Skyscrapers loom above the low-lying Federal Building, foreground, and new civic complex.



How can I help?: Two Cheyennes in the Clinton town jail get counsel from Lawrence H. Hart, center, who has dedicated his life to aiding fellow Indians. The Cheyenne chief and onetime Marine Corps pilot acts as director of the Committee of Concern, a group that strives to remedy the Indians' plight: a 45 percent dropout rate among schoolchildren, widespread alcoholism, and, often, a disregard for time that hinders jobholding.

For braves gone to war, Cheyenne women of Clinton gather in prayer. Intensely proud of their sons' patriotism, the War Mothers organize farewell and homecoming ceremonies. They wear vivid cloaks to ensure that others in the community do not forget those in uniform.

Nearly 100,000 Indians live in Oklahoma, an eighth of all those in the United States.

ENLARGEMENT (OPPOSITE) AND BOOKPLATE © N.G.S.

Warrior's welcome: Gerald Yellow Eagle returns from duty in Viet Nam, and the Cheyennes honor him with a dance in the hamlet of Colony (**above**). Here he stamps to the beat of drums with his parents, left, and grandfather. When the ceremony ends, ritual requires that he distribute his shawls among those who prayed for his return.

amounts to a synonym for Oklahoma. Strolling about Bartlesville, I remembered that the challenge of black gold arose here when the state's first commercial oil well, the Nellie Johnstone, came in on an April day in 1897. Tulsa's Glenn Pool arrived in 1905.

Field after field followed: Cushing, Healdton, the Burbank field in the Osage Nation in 1920—and Osage Indians became the richest people in the country, per capita, for a time. Still the strikes came—the spectacular Seminole field in 1926, the mighty Oklahoma City pool in 1928.

Oil built Oklahoma. Today, 80,000 oil wells and 8,000 natural-gas wells flow in 72 of the 77 counties. A dozen refineries hum around the clock; pipelines carry their products throughout the Midwest. I looked long at a well drilled in 1941 on a slant beneath the State Capitol (page 158). Sooners love it—and 17 others on the capitol grounds, about half of them still producing.

Unfortunately, oil and gas wells eventually play out, depleted. New reserves must be found. In Tulsa, I talked with Marion Cracraft, the gracious, respected oil and finance editor of that city's *Tribune*.

"A few years ago," he told me, "some 150 rigs were drilling in Oklahoma. There are 80-odd now. The plain fact is that the financial return on oil and gas as it comes out of the earth isn't attractive enough. Oilmen aren't going to put money down a hole if—should they hit—they can't make a profit."

Try for the Deepest Hole Yet Drilled

In the face of all this, I found a young oilman who must rank among the most optimistic of all time.

On the western plains near Elk City, I arched my neck at drilling rigs that soared as high as seventeen stories overhead. They looked like launch pads.

"That's exactly right," calmly asserted Robert A. Hefner III, 36, managing partner of the Glover Hefner Kennedy Oil Company. "Only these launches go downward—some of them toward record depths. We expect to discover gas between 24,000 and 28,000 feet. We're shooting for man's deepest penetration of the earth."

A 25,600-foot Louisiana well holds the depth record; it proved dry. Bob Hefner's firm participates in five ultradeep wells, two already producing, in the Elk City area. One, being drilled by Lone Star Producing Company, aims for 28,000 feet.

The average Oklahoma gas well comes in at 8,000 feet and costs $125,000. "How much money are you sinking down these shafts?" I asked Bob, glad not to be answering.

He winced slightly. "To go more than five miles deep requires drilling night and day, seven days a week, for as long as 500 days," he replied. "Each well costs three to five million dollars."

Where does the money go? More than 2,000 tons of steel pipe, worth a million dollars at least, must be threaded together. To seal the casing, roughnecks—as drill-rig workmen are called—pump a minimum of 20,000 sacks of cement down the hole. Equipment at the wellhead can cost $125,000. An analog computer records the drilling operations.

Future May Hinge on the Price of Gas

One has to wonder what makes a wildcatter risk everything he has on each turn of a drill bit, and I did, aloud.

Bob swung an arm around, sweeping the flat land. "This is a frontier, like the North Slope of Alaska," he said. "And it's just as unexplored. At least two billion dollars ought to be spent here in the next ten to twenty years to develop these reserves.

"Our country has to provide itself with more energy. That energy waits beneath our feet. But the price of natural gas must be raised to stimulate exploration. If a well is going to cost five million bucks, you have to produce a lot of gas to earn enough to drill another hole."

He smiled, another Oklahoman with a vision. "We're betting on the future," he said softly. "You start out with a dream, and you just keep on until it comes true or it doesn't. It's like goin' to the moon. There's a lot of reliability, but anything can happen."

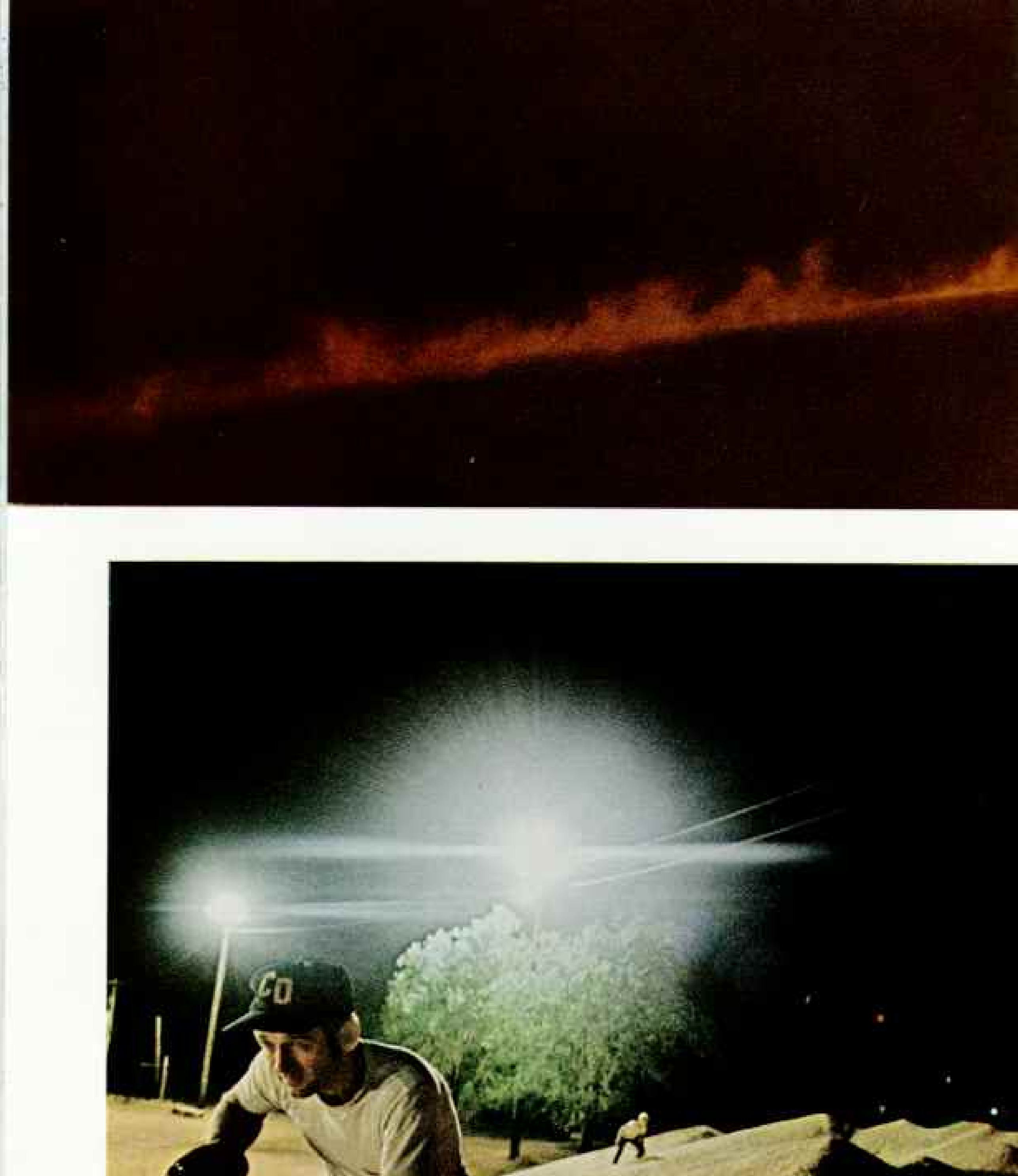
Elk City, population 7,300, senses what may happen as surely as it certifies each dusty red sunset and savors the sweet song of the rising wind. Oklahoma's biggest gas strike in decades may lie captive deep in the earth. The key turns, a diamond bit on its tip. People talk of 6,000 new jobs in the area.

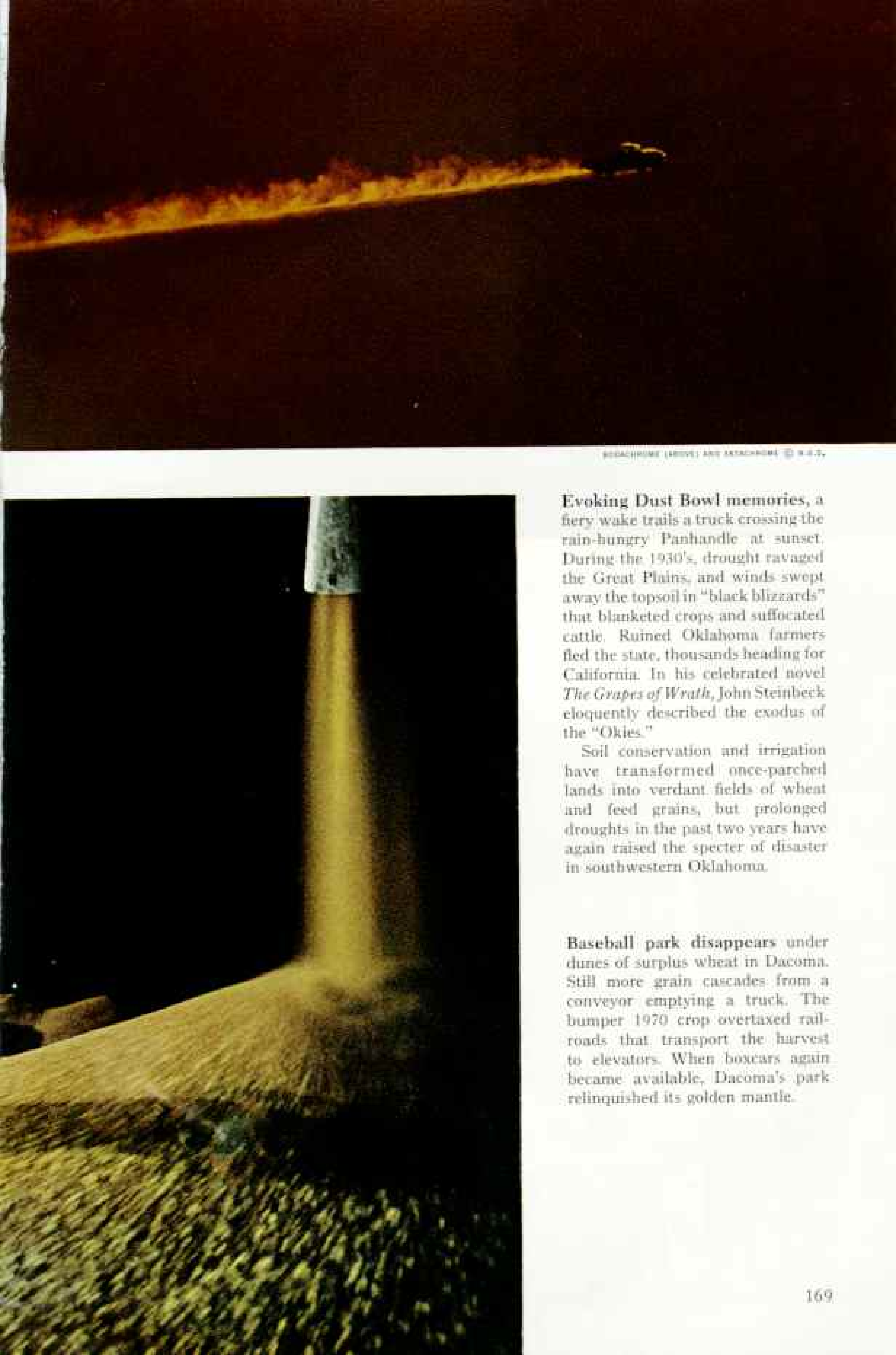
All over Oklahoma I listened to talk about gas and oil, crops, work, the day's events. One subject always overrode the rest: weather.

In the state capital last September I waited

(Continued on page 171)

Steeling herself for the decision, a pie-baking contestant at the September state fair in Oklahoma City waits out the final moments before judges announce the winner. Each year Oklahomans hold two major state fairs—the second at Tulsa in October.





KODACHROME (ABOVE) AND EKTACHROME © N.G.S.

Evoking Dust Bowl memories, a fiery wake trails a truck crossing the rain-hungry Panhandle at sunset. During the 1930's, drought ravaged the Great Plains, and winds swept away the topsoil in "black blizzards" that blanketed crops and suffocated cattle. Ruined Oklahoma farmers fled the state, thousands heading for California. In his celebrated novel *The Grapes of Wrath,* John Steinbeck eloquently described the exodus of the "Okies."

Soil conservation and irrigation have transformed once-parched lands into verdant fields of wheat and feed grains, but prolonged droughts in the past two years have again raised the specter of disaster in southwestern Oklahoma.

Baseball park disappears under dunes of surplus wheat in Dacoma. Still more grain cascades from a conveyor emptying a truck. The bumper 1970 crop overtaxed railroads that transport the harvest to elevators. When boxcars again became available, Dacoma's park relinquished its golden mantle.


OIL
MGP
MGP

ANSCHUTZ © N.G.S.

a day and a night for the rain to stop, and woke to stare from my hotel room at a metropolis in flood. Nearly eight inches had fallen.

Early in October, in east-central Oklahoma, a tornado twisted through Shawnee and other communities (left, lower). It took the lives of four persons and injured scores. Three days later, a freak storm buried much of the Panhandle under seven inches of snow. And on December 2, the thermometer climbed to 75° in Oklahoma City.

These represent extreme extremes, of course. But why such awesome variety? Oklahoma happens to be the place where—particularly in fall and spring—warm, moist air from the Gulf of Mexico collides with cold, dry arctic air.

A State's Vision: Water Flowing Uphill

Sooners can't do much about that. On the other hand, what they are doing about their water is monumental. With dams on most of her rivers, Oklahoma has become a land of lakes; 48 reservoirs have been authorized, and 24 completed. One of the first, Lake O' The Cherokees, built by the state thirty years ago, extends 66 channel miles and has 1,300 miles of shoreline. Federal agencies constructed virtually all the other dams and impoundments. The largest, Eufaula, covers more than twice the area of Lake O' The Cherokees.

Now, planning engineers forecast a four-billion-dollar outlay in the next two or three decades to bring east Oklahoma's surplus water to the west. Federal and local engineers propose to build 69 additional multipurpose reservoirs —to provide water for cities and industries, hydroelectric power, flood control, irrigation, and recreation.

Oklahoma tilts upward from 287 feet above sea level in the southeast to 4,973 feet in the Panhandle. Annual rainfall ranges from 54 or more inches in the east to a scant 16 inches in the northwest. Water thus must be conveyed uphill for hundreds of miles across the state by a series of pumping stations and canals.

"Within 15 years," declares Forrest Nelson, executive director of the Oklahoma Water Resources Board, "Oklahoma City must have more water. Parts of the west need more right now. We are studying plans for an open-ditch canal system, concrete lined, to carry water from the southeast to Oklahoma City, and out to the southwest. Most of the system will probably be 9 feet deep and 26 feet wide. We'll bridge it over rivers and tunnel it under highways."

This positive, "can do" attitude also manifests itself in

Weather on a rampage—and business as usual. Cleaving an angry sky, a lightning bolt flashes beyond Lake Thunderbird, near Norman (**above**). During a tornado that twisted through Shawnee, the top of a building landed beside a gas station that lost its roof.

Lying in a transitional zone between the humid south and colder northern climes, Oklahoma often becomes a battleground of huge air masses. The result: squall lines of gully-washing rains and violent winds.

education and research. At Oklahoma State University in Stillwater, I glimpsed it on a worldwide basis. President Robert B. Kamm spoke with quiet pride of OSU's efforts to assist emerging countries.

"College of Agriculture faculty members worked for 16 years in Ethiopia," he said. "We've served in Brazil. OSU experts in many fields are presently in Colombia, Guatemala, Thailand, Pakistan, and other lands."

I came upon some different international implications at the University of Oklahoma School of Medicine in Oklahoma City. Dr. Allan J. Stanley and Dr. Laurence G. Gumbreck held up rats and stroked them as if they were kittens. Dr. Stanley said, "We believe animals like these eventually can control the world's rat population."

Physiologists Stanley and Gumbreck have crossbred two strains of rats to create a large colony of sterile but highly aggressive male offspring, identifiable by their white markings. Ultimately, the scientists told me, an unlimited number can be raised. Introduced to wild females, they will displace the wild males; eradication will follow in time.

"This is a breakthrough that could yield undreamed-of results," said Dr. Stanley. "It represents a new approach to our environment—genetic control of adverse species."

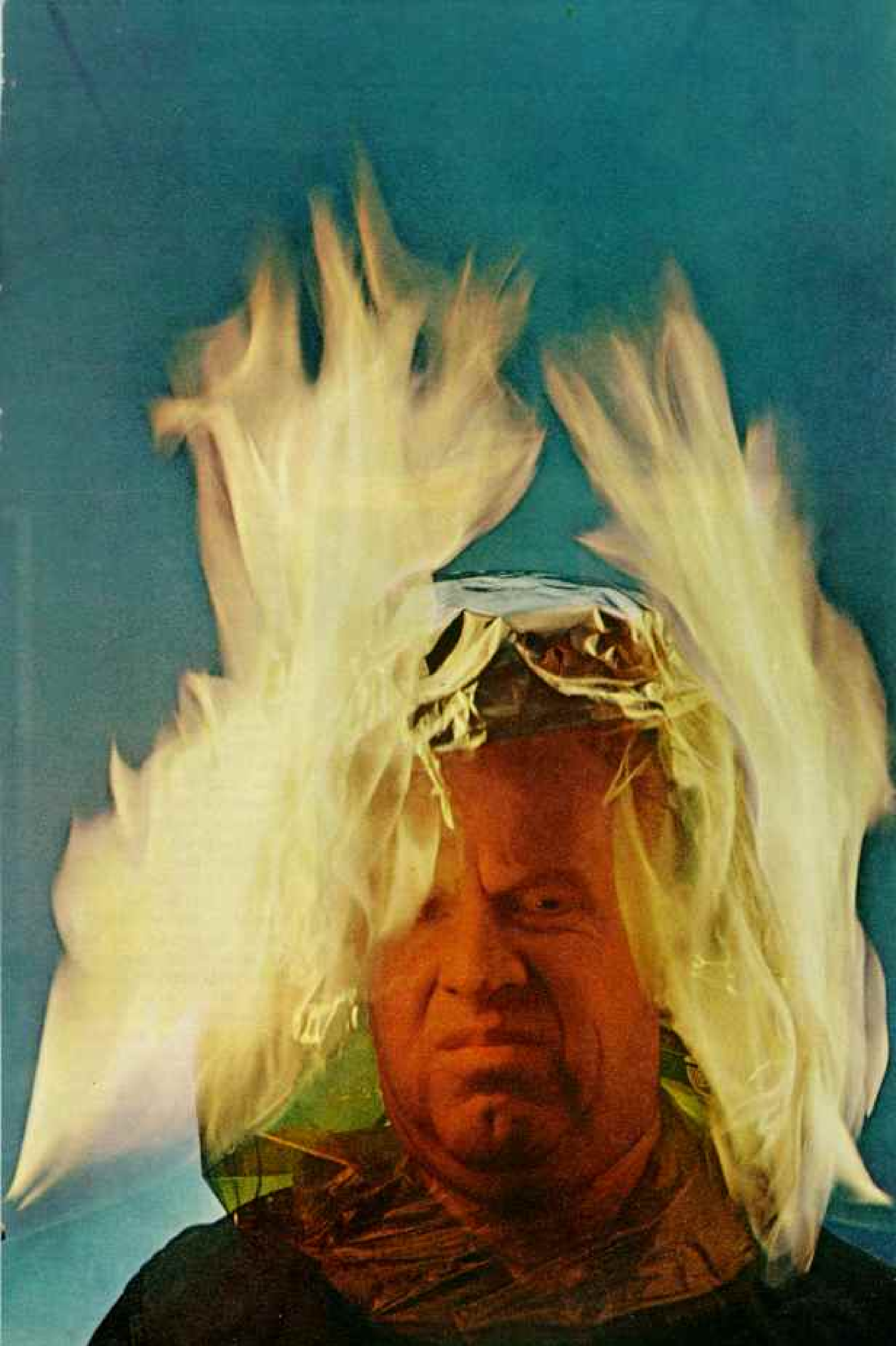
I never thought the day would come when I could give a rat an appreciative pat.

Tulsa Washes Down by Night

Oklahoma's boosters like to boast of her accomplishments in gaudy phrases—"from tepees to towers," and "from arrows to atoms." Her cities mirror the manner of her men.

Fair Tulsa, cosmopolis on the sandy Arkansas River, by day builds gleaming skyscrapers and high-speed expressways, and lives from aviation and aerospace as well as oil (pages 162-3). American Airlines, the city's largest employer, keeps some 5,000 persons busy at its maintenance and engineering center. By night, progressive Tulsa washes down

Seeking the best way to escape from a submerged plane, a test crew clambers out of an aircraft fuselage at the Federal Aviation Administration's Aeronautical Center in Oklahoma City. Dimly visible beneath the raft, a scuba-equipped lifeguard keeps watch. Enveloped in flame (**right**), FAA scientist Ernest B. McFadden tests his own invention —a plastic hood that protects the wearer from breathing flames and toxic fumes, allowing him time to get out of a burning plane.



Heat warns of danger in the diagnostic work of Dr. Jo-Anne Haberman at the University of Oklahoma Medical Center. Using an infrared scanner, which records skin temperatures in varying colors, Dr. Haberman makes a thermogram, or heat picture, of a woman suspected of having cancer. Cancerous growths show up as hot spots. This detection technique proves 90 percent accurate.

On a human hand (**below**) a thermogram captures the dramatic loss of heat caused when a subject smokes only half a cigarette. Showing as a warm orange before the experiment, the hand registers greens and blues when smoking starts. Dark blue at the fingertips represents a temperature drop of seven degrees. This tells Dr. Haberman that the nicotine has constricted the blood vessels, curtailing the flow of blood.

Throughout Oklahoma, medicine has made giant strides. At the Central State Hospital in Norman, chief mental institution in Oklahoma, the average stay now totals 28 days, compared to eight years only two decades ago. State mental-health teams and tribesmen collaborate in bringing psychiatric help to Choctaws. And medicine even rides the range: Cowboys seek out sick cattle and give them injections on the spot.

her sidewalks—to help back her claim as "America's Most Beautiful City."

Oklahoma City, amiable giant, sometimes unkindly called the world's biggest cow town, ambles over 636 square miles. Oil wells stalk across the city. At Tinker Air Force Base, more than 25,000 persons work in a vast aircraft-maintenance and supply setup. A few miles to the west, the Federal Aviation Administration's Aeronautical Center keeps tab on every aspect of civil aviation (pages 172-3). There I saw Charles A. Lindbergh's application of April 26, 1927, for an airplane license; his *Spirit of St. Louis*, it stated, was to be used in a "Transatlantic Flight." And there dedicated aeromedical researchers seek to help today's pilots—men of exactly the same model as Orville and Wilbur Wright or Lindbergh—adapt to aircraft that fly faster and higher all the time.

Oklahoma's capital is the largest U. S. city ever to elect a woman mayor—Mrs. Patience Latting. It also can claim a more mundane achievement. Back in 1935 the first parking meter was installed here; a nickel bought an hour's time. At Will Rogers World Airport, I paid grudging tribute to progress—a quarter to let my car rest for 30 minutes.

"Don't Like Meters. Or Taxes."

The parking meter's victory is not yet complete. To my surprise, I saw that Oklahoma's third largest city, Lawton, eschews them on its streets—a kindness to recall as one woos sleep amid night-firing Army artillery practice at neighboring Fort Sill.

And at tidy, hard-working Prague, population 1,800, about 50 miles east of Oklahoma City, I learned that parking meters and city taxes alike are as welcome as the measles. I dropped in on Mayor L. B. Drury, owner of Drury's Variety Store, and asked why.

"Don't like meters," he said, sitting back in a swivel chair. "Or taxes. We don't need them. This is a real thrifty town. Our treasury's got a surplus of about $334,000. We pay off a bond issue by adding $1.50 each month to everybody's water bill."

Prague was settled by a few Czechs in the Run of 1891. Others followed. Today farmers bring peanuts, alfalfa, and wheat to market here; cattle, dairying, and oil wells bolster the economy. Prague's two banks each boast assets of more than $10,000,000—largest in Oklahoma on a per capita basis. And the community owns its water and power lines.

I strolled Main Street's two business blocks, munching delectable kolaches—fruit-filled sweet rolls—from the Prague Bakery. In the pool hall, old men played dominoes and cards. I drove along quiet back streets, past trim white frame dwellings with neat yards shaded by elms, junipers, oaks, and maples. New one-story houses dotted "Mortgage Hill." In a large park on the west side of town, people gathered pecans.

"Life is good here," said Frank Seféik, a friendly, soft-spoken native son, vice president of the Prague National Bank. "We're very conservative. Everybody goes to church. A few of us still speak Czech, but a lot of old ways are gone. We have a very active Lions Club and Chamber of Commerce."

Glory Dims as Wells Go Dry

It was time to move on. I cruised north along State Highway 99, and turned off to Shamrock, a town with no future, a desiccated present, and a tumultuous past.

During Shamrock's heyday, in World War I, with black gold flowing from hundreds of wells, 10,000 people lived in the area. Tipperary Road, three-quarters of a mile long, was appropriately lined with green-fronted businesses. The town had two banks, two newspaper plants, three movie houses, five lumberyards, and enough saloons to slake the thirst of a roistering oil camp. Three doctors and two dentists helped ease her pains.

Perhaps 200 people live in Shamrock today, and some remember. One of them told me, "Why, the pipeline from this field ran all the way to Houston. They shipped the oil to Europe to fight the Kaiser. You should have been here when the war ended. Everybody was shootin' it up."

Only a few months before he died, I walked along Tipperary Road with tall Eric E. Ferren, Shamrock's mayor for 32 years and a Creek County deputy sheriff. Most houses had rotted away; foundations were overgrown with brush. The old fire bell, a rusty sentinel, hung over the firehouse entrance; the rest of the firehouse had vanished.

Strong sunlight washed a few pallid, sagging buildings, their paint long since flaked away. We stopped before a concrete blockhouse with a man-size hole hacked in one wall.

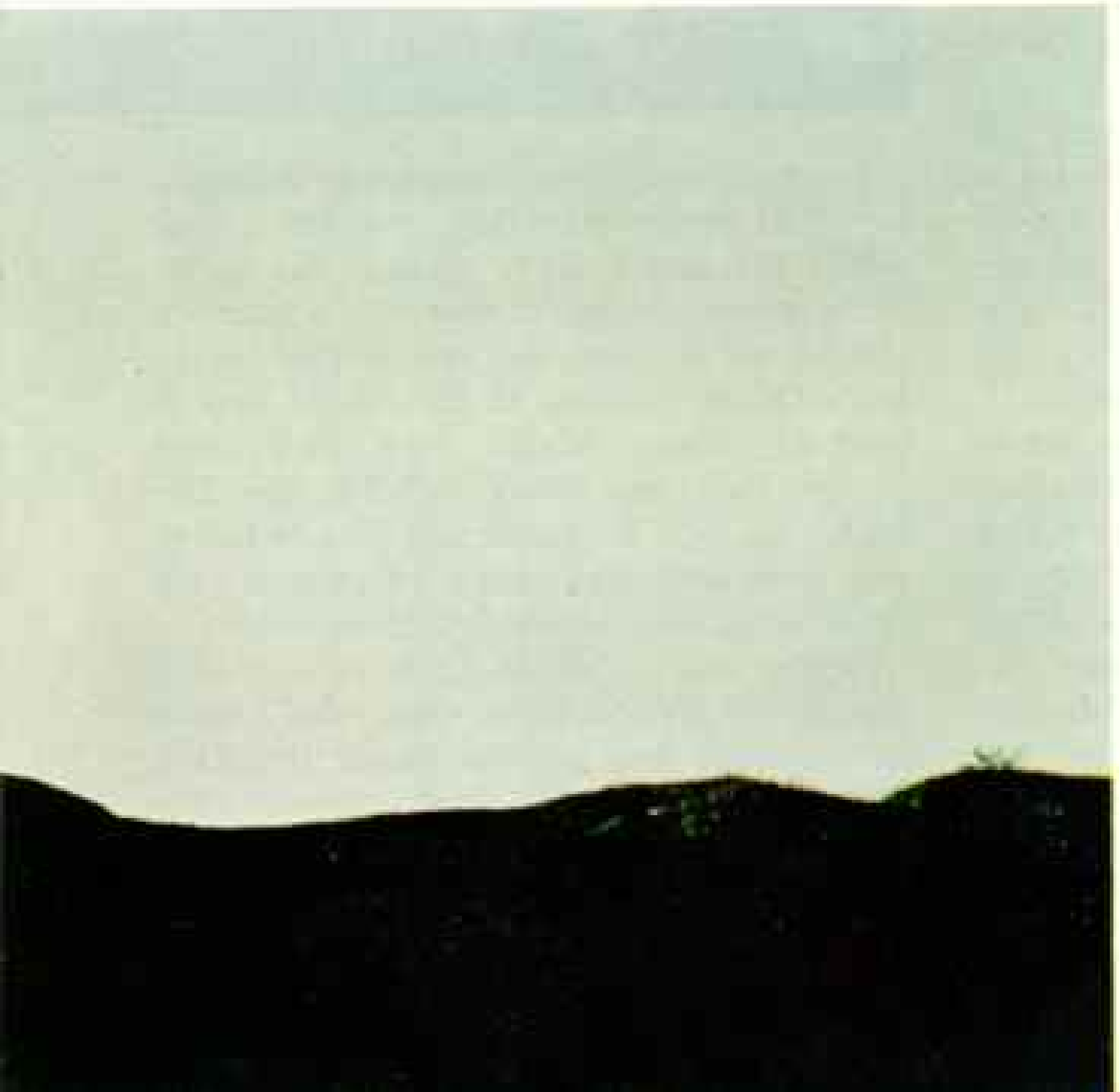
"The First State Bank stood here," Deputy Ferren said, unconsciously easing his holster.

"**Ride 'em, Buck!**" Young fans cheer their favorite at the annual Will Rogers Memorial Rodeo in Vinita. Tail outstretched, a calf flees in a roping contest (**below**).

Rogers, a rodeo enthusiast and star performer in his youth, went to school in Vinita. After he died in a plane crash in 1935, citizens organized this rodeo in his honor. The Will Rogers Memorial in Claremore, his burial place, displays the saddles, cowboy trappings, and personal effects of Oklahoma's beloved humorist.

To feed the appetite of Oklahomans for rough-and-tumble sport, the capital annually plays host to the national rodeo finals. Sooner Jim Shoulders holds 16 world championships, more than anyone else in rodeo history. Oklahoma City also houses the National Cowboy Hall of Fame, sponsored by 17 Western states.

EXPLANATIONS ARE BOOMERANGS (BELOW) © N.G.S.



Rider in the sky, a youth on a motorbike bounces over a rise in Oklahoma City. Mounds of earth for an unfinished interstate highway offer a challenge to bikers in a city with no steep hills.

Be it motorbike scramble or team play, Oklahomans revel in sports. The University of Oklahoma football team, the Sooners, achieved the longest winning streak in modern collegiate annals—no defeats in 47 games. Professional sports bear the brand of such Sooner sons as football's Jim Thorpe and baseball's Mickey Mantle and Johnny Bench.

"That's the vault. It's the only thing left. Why the hole? Bank robbers made it."

By 1920 Shamrock's oil boom had burst, and the roughnecks headed for a strike at Whizbang, over in Osage County. Whizbang soon fizzled out.

A gentle melancholy tugs at one in ghost towns, like the haunting peace of ancient battlefields. Let Oklahoma's motto—*Labor Omnia Vincit*—serve as their benediction: "Labor Conquers All Things."

I drove away, glad to be transient, wanting to watch today's Sooners at today's work. In Sapulpa, at Frankoma Pottery, I discovered more than a hundred craftsmen handily turning out nearly 30,000 pieces a week.

White-haired, jovial John Frank escorted me through his pottery, as proud of it as a man should be whose business succeeds on the fifth try. "Any piece of pottery is merely the right mud in the right shape," Mr. Frank declared. "Its value lies in what it's worth to live with, for this is the true value of art."

Last year 120,000 passersby turned off Interstate 44 to tour the plant. John Frank sometimes puzzles over the influx.

"I guess they just want to come," he muses. "My daughter Joniece and I design every piece; my wife Grace Lee runs the showroom. We *are* Frankoma. People come because they like what we create. It's our greatest compliment."

Ardmore Caters to Western Craze

All over Oklahoma I saw this story repeated. In the south, at Ardmore, I caught up with the Western-clothing boom.

"It's the only kind of apparel that is America's own," said shirt-sleeved John C. Simpler, general manager of Corral Sportswear. "My father and mother formed this business in 1953, and it's been growing ever since. People are identifying with the West, with the old, solid, traditional values. Demand for leatherwear is fantastic. We've been operating nine hours a day, six days a week, for months."

A family man in his mid-thirties whose hobby is flying, John Simpler often visits New York City on business. He said, "Some youngsters there have never seen open country." A frown. "They've never seen a cow or ridden a horse. I'm always glad to get home." His face brightened. "You can't beat Oklahoma."

As we walked to my car, a small boy galloping a large pony suddenly bore down on us, and we leaped from the sidewalk. "See what I mean?" demanded my host happily.

You can bump into enterprising businessmen and horses elsewhere, too. On a cool cloudy morning I drove through the undulating green country of the east, a hunter's and fisherman's paradise, and onto the northeast's Ozark Plateau. In Commerce, where baseball's Mickey Mantle grew up, I found George Newman busily building the fine boats that bear his name, and I knew better why Oklahoma highways are thronged with cars towing sleek inboards and outboards.

"We're making about 1,500 runabouts a year now," Mr. Newman said, "and I can't see anything but growth ahead. Boating's great for families, especially fathers. No traffic lanes. No traffic lights. No traffic jams. They can unwind and relax."

BEECHCRAFT © N.G.S.

A short drive away I pulled up at the Bar 20 Ranch. "Be glad to show you what a trained cow pony can do," said Max Blue. Spurs jingling, he took me to the corral.

There I sat with his charming Quapaw Indian wife, Jean Ann, and her sister, Geneva Ramsey, and watched a cowboy cut a cow from a milling herd. Then the rider gave his mount free rein. No matter which way the cow turned to rejoin the herd, the pony anticipated her. Stop. Start. Hesitate. Run this way. That way. Try here. There. A duel to the finish. At last the cow quit, motionless, head down. Without guidance, the pony had won.

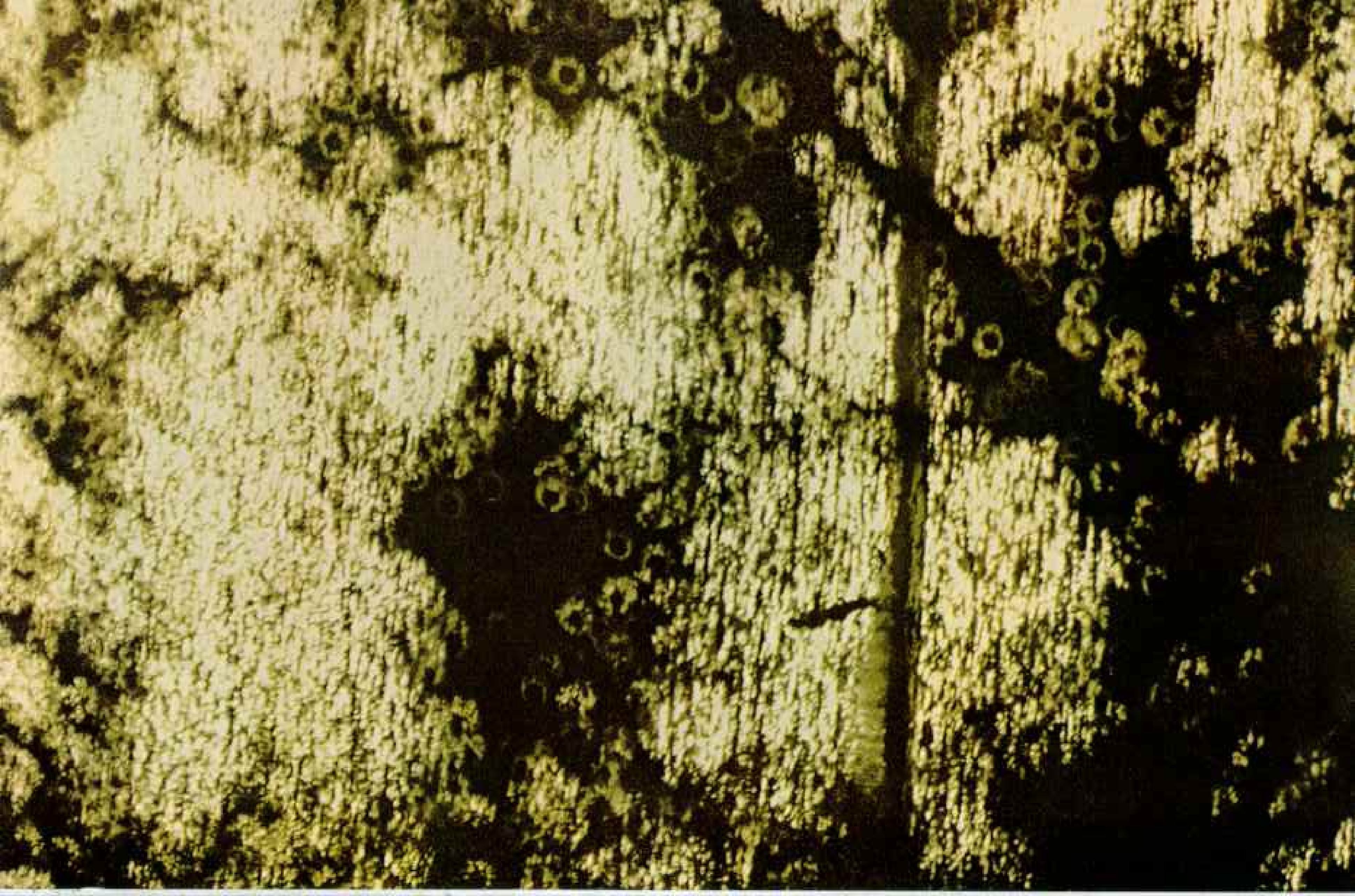
(Continued on page 184)

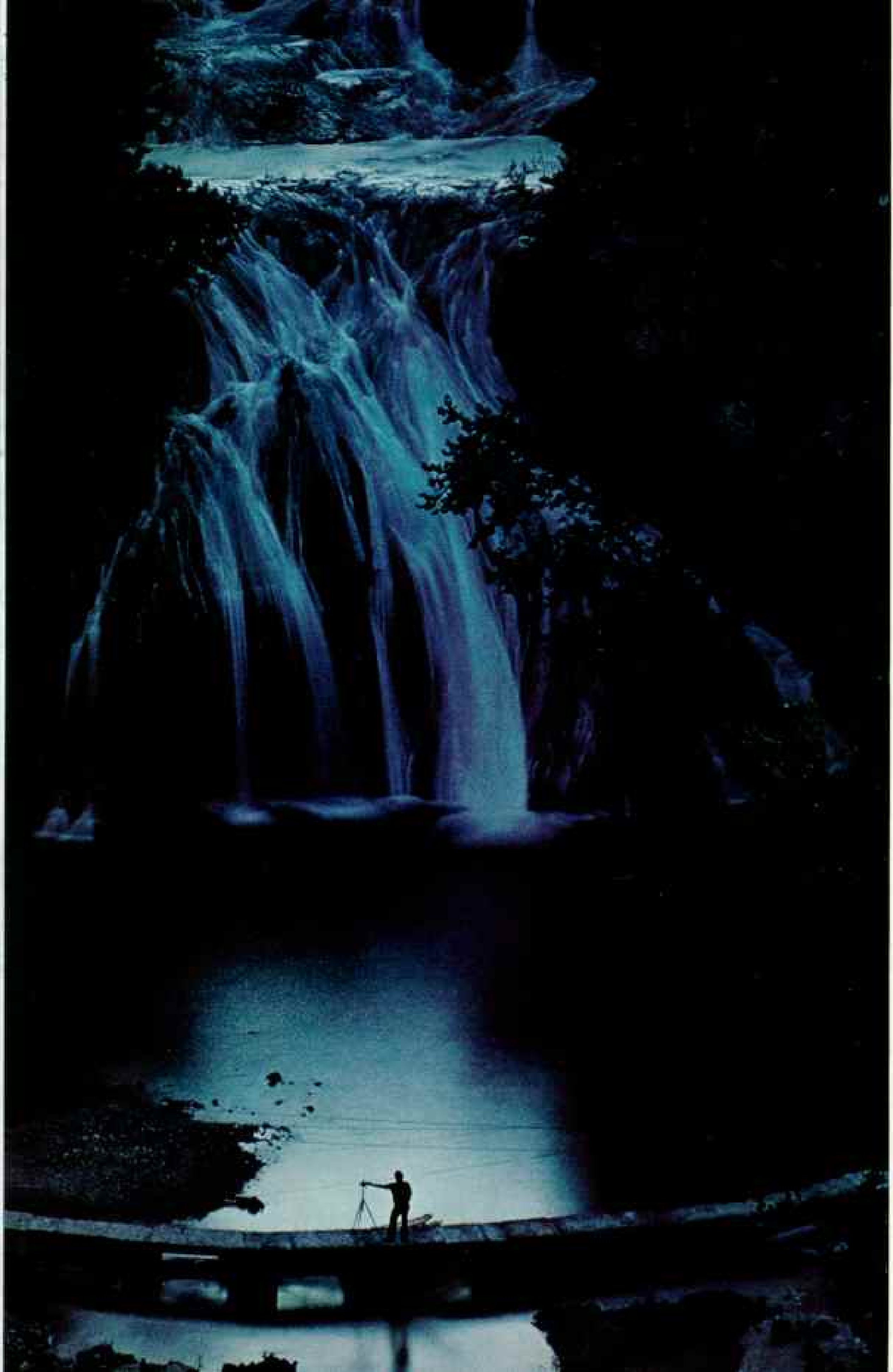
Poetry of a pirouette reveals itself to a panoramic camera as Melissa Hicks of the Tulsa Civic Ballet rehearses for *Rhapsody*. The company stages three major productions each year.

Oklahomans boast that five of their stellar ballerinas are Indians: Maria and Marjorie Tallchief, Osages; Rosella Hightower, Choctaw; Moscelyne Larkin, Shawnee-Peoria; and Yvonne Chouteau, Cherokee.

Leafy lace patterns Lake O' The Cherokees and a skier skimming across it (following pages). Also known as Grand Lake, the huge reservoir and 23 other man-made lakes cover nearly half a million acres, providing water for homes, irrigation, and recreation. "If we ever tip over," quip the Sooners, "Texas will be flooded."

SUNSCREENS © N.G.S.





In twilight's luminous blue, the waters of Honey Creek slip over Turner Falls in the Arbuckle Mountains. A once-lofty range now worn down to less than 1,500 feet, the Arbuckles expose strata of limestone, sandstone, granite, and shale that in other areas lie deep beneath the earth. Thus geologists can easily study types of rocks encountered in drilling for oil.

Soaring pylon, a chimney in disguise, dominates the lobby of Arrowhead Lodge. Crowning a promontory overlooking Eufaula Lake, the fieldstone resort cost $5,000,000. The state operates this and six other handsome lakeside lodges.

Max and Jean Ann breed and train registered quarter horses and run about 500 cows. They hope for an annual calf crop of about 90 percent; most calves, said Max ruefully, seem to be delivered in freezing weather at midnight, with snow on the ground. After the calves are weaned and have grown to some 450 pounds, they are sold. Eventually they arrive at a feedlot, fatten, and go to market.

The Blues raise quarter horses for love and calves for profit. I asked if they had any trouble with rustlers. Max jumped as if he'd heard a rattlesnake.

"There's rustlin' goin' on, you bet! We're short four head right now in that pasture across the road. One feller, he even used his private plane to spot bunches of cows. If no people were in sight, he'd radio his waiting trucks. They finally caught him."

"Shed Not for Her the Bitter Tear"

Oklahoma tallies a long and bloody account with badmen. Back in territorial times, dozens of U. S. deputy marshals were gunned down here by desperadoes.

I have seen their lairs. Just a six-gun shot from the Tulsa Port of Catoosa, outlaws skulked in a pecan grove called Rascal Flat. Atop a rocky robbers' roost in the Panhandle, bandits kept vigil over the Santa Fe Trail's Cimarron Cutoff, and galloped out to prey on passing wagon trains. Yes, and the vengeful Daltons rode through the land of the red man, and the train- and bank-robbing Doolin gang, the vicious Buck gang, the Starrs.

I know where pistol-packing Belle Starr rests in eerie loneliness, though her epitaph adjures one not to weep. She died with her boots on, this formidable horse thief and consort of renegades, friend of the James brothers; someone shot her in the back. They buried her on her own land, not far from Porum in eastern Oklahoma.

The grave lies past a plum thicket, beyond an alfalfa patch, through a grassy field fringed with sycamores, to a forgotten and scrub-tangled knoll above the Canadian River. I could find no trace of the old log cabin, though it had stood within feet of her tomb. Ah, Belle, I thought, lying amid weeds and wild flowers, do you know? Do you know the words they buried you with?

Shed not for her the bitter tear.
Nor give the heart to vain regret.
'Tis but the casket that lies here,
The gem that filled it sparkles yet.

Bluegrass ballads drift across the hills of "Little Dixie" in southeastern Oklahoma. Each August, devotees of old-time country music converge at Hugo for a festival where small groups entertain around the clock for several days.

Hugo lies in a humid, wooded region whose climate, topography, and philosophy of life contrast sharply with those of the western plains. Choctaws settled in the section after being exiled from their Mississippi homes around 1830.

Prairie piper, a young flutist contributes her impromptu bit to Oklahoma's first big rock festival, which took place last autumn near Stillwater. Authorities had previously banned rock shows, but relented for Stillwater's open-air concert, which proceeded without incident.

I returned to the dirt road where my car waited, and plunged with a will back into the real world. I spent the night in Oklahoma City, and next day pressed west.

Back in the 1930's, when dust bid the sun and drought strangled the Great Plains, a people in flight moved along Route 66, California-bound. The western half of the state remembers Dust Bowl days vividly. To some Sooners, even the tag "Okie" causes pain.

These days, Interstate 40 bisects Oklahoma, unfurling over some of old 66's roadbed, and, by and large, better times have come. I say this, and qualify it immediately. Farmers and ranchers still scan the heavens for rain. In 1970 a prolonged dry spell in the south led to the state's smallest cotton crop of this century. This year severe drought ruined southwest Oklahoma's wheat crop and shriveled pastures, bringing cattle to near starvation. When I drove past Lake Altus, this large irrigation source had shrunk to a fourth its normal size.

Yet soil-conservation practices and irrigation have paid off handsomely. The fertile red-earth fields that flow upward from the state capital to the western High Plains yield mountains of wheat and grain sorghums. Cattle cluster thickly on the ranges. In northern

Oklahoma, Enid's towering grain elevators seemed to me from afar like a castellated alabaster kingdom.

To the northwest, near the town of Freedom, I did walk deep into such a realm: Alabaster Caverns State Park, its high-domed tunnels and rooms agleam with white gypsum, sparkling selenite crystals, and many shades of softly glowing alabaster.

Bats make their home here by the untold thousands, I saw. So could a finite number of people. Far down in the cavern a small sign caught my eye: "Fallout Shelter. Capacity 3,080." What inexorable formula produced that precise figure, I wondered.

Sod House Starts a Cattle Empire

People become scarcer the farther one climbs northwest. In the three-county Panhandle, 34 miles wide and 167 miles long, dwell fewer than 27,000 Oklahomans, nearly half of them in the county seats of Beaver, Guymon, and Boise City (map, page 154).

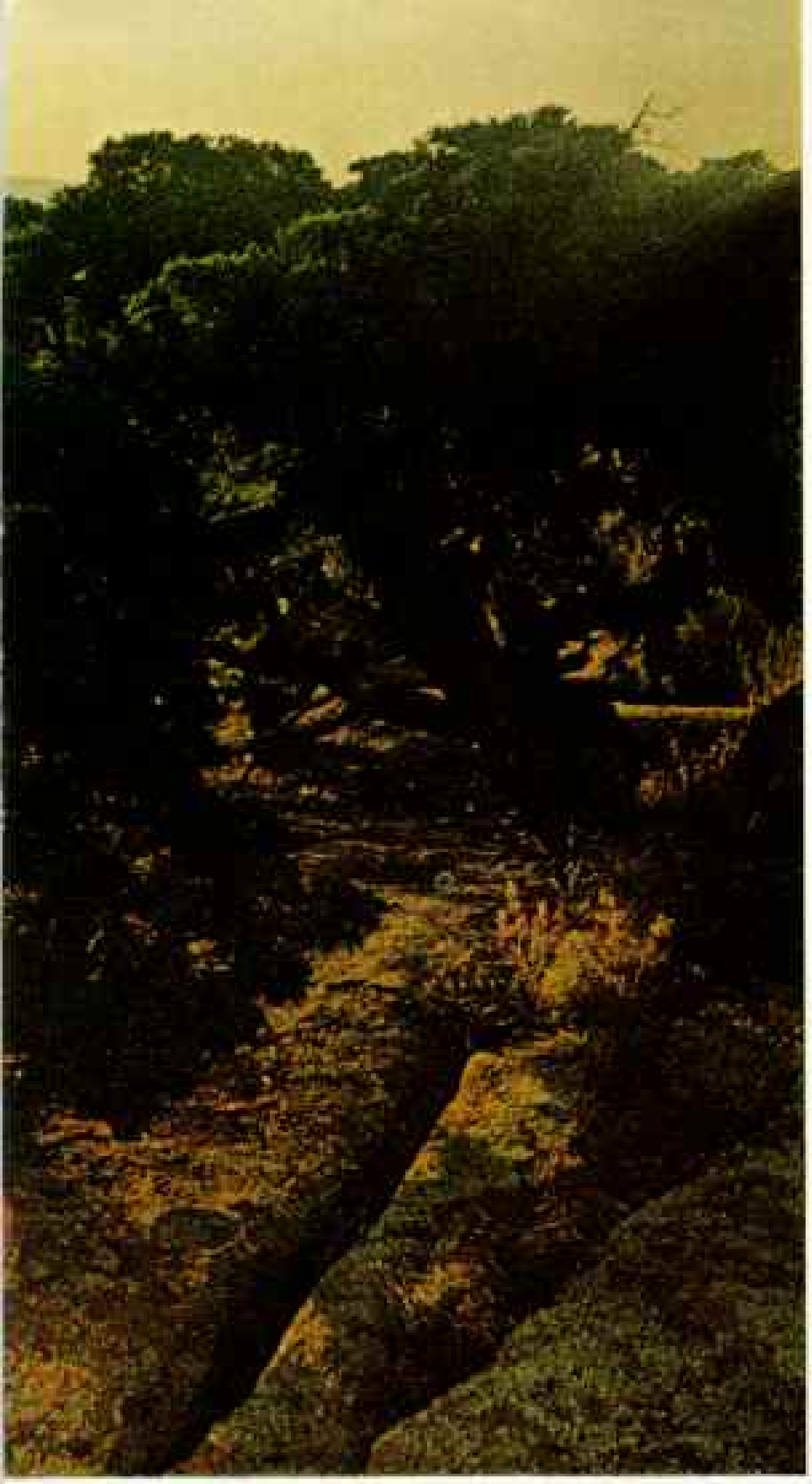
No Sooners are more sturdily independent than these. In the Panhandle, one's word usually suffices; a handshake often supplants written contracts. Before 1890, when it became part of Oklahoma Territory, this was "No Man's Land" to its scattered settlers, and "Public Land Strip" on maps. The six-shooter governed. An attempt to launch the Cimarron Territory failed.

Many homesteaders gave up. Those who hung on left us a little "how to" poem:

Picking up bones to keep from starving,
Picking up chips to keep from freezing,
Picking up courage to keep from leaving,
Way out West, in No Man's Land.

They hauled buffalo and cattle bones to the railroad at Liberal, Kansas, and got $5 a load. They burned buffalo and cow chips for warmth—the price of life when blue northers swooped down out of Canada. For courage, they took after a blue-eyed, black-haired Tennessean named James K. Hitch.

Jim Hitch built a sod house 12 miles southeast of the future Guymon in 1884—one man against an infinitude of yucca and soapweed and buffalo grass. He dug the first well, put up the first drift fence, housed the first preacher, erected the first windmill, planted the first alfalfa, and helped establish Guymon. His son, Henry C. Hitch, added to his holdings by buying up small ranches until, before he died in 1967 at 83, he could stand on the site of his father's soddy and see his own land



AQUACHROME (TOP) AND KANCHROME BY N. G. S.

to the limits of his vision. He could see, as well, great changes.

A fourth-generation Hitch piloted me over that 30,000-acre empire—tall, slim, 28-year-old Paul. His father, H. C. "Ladd" Hitch, Jr., and he operate huge feedlots in one of America's most productive beef-raising centers. They grow much of their own feed on 9,000 irrigated acres. All this marks a development of less than twenty years.

"A fifth of the beef this country eats comes from within a 200-mile radius of us," the flying cattleman yelled. He dipped the Cessna's wing at a sprawling lot where 20,000 head of cattle were confined—each gaining about three pounds a day. Beside this richly brown patch of earth nestled watered fields and native-grass pastures, a pastiche of dark and light greens.

Cattle Fatten From Bunyan-size Bin

Paul Hitch leveled off, and soon we landed on a grass strip beside ranch headquarters. "Out here," he said, "the word is 'water.' No water, no feed. No feed, no feedlot."

In a good year, 16 inches of rain will fall, enough to sustain one cow every 20 acres. Last year, less than 13 inches wet parts of the Panhandle. But deep irrigation wells, tapping the extensive aquifer beneath this region, produce astonishing results. Winter wheat thrives and corn grows as high, if one may be pardoned, as an elephant's eye.

To turn crops into sirloin, the Hitches and other feedlot operators serve cattle regulated diets of chopped ensilage and ground grain, plus protein supplements. Paul showed me a year's supply of grain. It filled a bin half as wide as a football field and half again as long, to a height of 12½ feet. Larger bins exist.

"What we do," my host summed up, "is simple, though not easy. We buy little cattle

To commune with spirits, Indian braves once scaled Mount Scott in the Wichita range. Today a paved road leads to the 2,464-foot summit, giving visitors (**above**) a breath-stopping view of the 59,000-acre Wichita Mountains Wildlife Refuge. Within its boundaries graze some 800 buffaloes, grown from a herd of 15 in 1907. The number must be limited to prevent overgrazing. After an annual roundup (**lower**), some animals are sold at public auction or donated to zoos. The Wichita refuge also protects elk, white-tailed deer, and Texas longhorns.

and sell big cattle. Without irrigation we'd still be alive, but not very prosperous."

For farmers and bankers, irrigation can be a chancy proposition. "When you see an irrigation well here," Fred Huffine, Texas County extension agent, told me, "you're seeing a $30,000 investment. We have 877 wells now in this county, against a capacity of perhaps 2,000. To finance his well, a farmer needs a sizable net return immediately. The banker has to look very closely."

Change Arrives in Little Dixie

From the parched mesa and canyon country of the Panhandle's northwest tip to the bayous of the sultry southeast, a crow flies 530 miles. I sped across Oklahoma easily in two days, and reached a dramatically different world called Little Dixie. McAlester serves as its unofficial capital. Carl Albert, Speaker of the U. S. House of Representatives, went to school in a nearby hamlet called Bug Tussle, whose name is now Flowery Mound.

Valuable reserves of coal wait in this region. But mostly Little Dixie belongs to nature. I parked high on the Talimena Skyline Drive and drank in the brooding beauty of the Ouachita Mountains, with their dark valleys and clear swift streams. On the Red River lowlands, looking into Texas and Arkansas, I saw cypress knees poking from swamps, sycamores garlanded with mistletoe, and hawks sailing high overhead.

Everywhere I found trees. Forests cover a fourth of Oklahoma. They dominate here: shortleaf and loblolly pine, post oak, red oak, white oak, hickory, sweet gum, black gum, cedar, holly. Off one-lane dirt roads I caught the pungent perfume of woodsmoke; pecker-wood mills were burning scraps. In Wright City a sawmill belched steam; nearby a huge container-board plant was going up.

I wandered back into the hills, where isolated families scratch a living from little

[Copyright] © N.G.S.

Island of calm in a bustling land: Sooners enjoy a domino game at the general store in Gene Autry, a village named for the Western singer-actor who once owned a ranch nearby. When the community's 200-odd residents celebrated the renaming in 1941, the event drew 35,000 people—including the governor and Autry himself.

plots, run a few cattle, and poach an occasional deer. Along the creeks, dilapidated houses perched on concrete blocks. Towns were sunning amidst the clatter of pickup trucks, and people nodded to me on the sidewalks. I dined on fried chicken, gravy, and hot biscuits, and dropped off some dry cleaning at a place that advertised "To know us is to love us."

Timber Cutters Look to the Future

Some of all this—how much, no one knows—soon must change. In Broken Bow, headquarters for the Weyerhaeuser Company's Oklahoma timberlands, I learned why.

A giant among the Nation's timber firms, Weyerhaeuser had recently purchased 1.8 million acres of forest in southeast Oklahoma and adjacent Arkansas for more than $300,000,000. New mills and equipment were costing $200,000,000 more. Some 1,200 new jobs would be created, and several hundred more would result indirectly. Prosperity was coming to the depressed southeast.

"Within 30 years," said Joseph C. Brown, Jr., Weyerhaeuser vice president for the area, "the demand for wood products is going to double. We have to help meet that need. We figure on being here forever, which means that we're planting as we harvest. Timber, like corn, is a crop. It is renewable."

Weyerhaeuser means to be a good neighbor, Mr. Brown told me. People can roam the forests and streams for hunting, fishing, and camping. There are no fences. They can browse cattle in some areas and cut marked trees for firewood, at no cost.

Woods Manager Dale C. Campbell took me to a pine-seed orchard and jabbed a finger at row after row of two-year-old pines standing two feet high.

"Ever see 10,000 trees like that before?" he asked. "They are pine-root stock. From them we'll take seeds, which we'll plant in a nursery for a year. As we log each 300-acre setting, we plant the seedlings 700 to the acre, spaced six or seven feet apart with nine feet between rows.

"I look at it this way. I'm nearly 50 years old. I'll be too old to harvest the trees I set in the ground today. But someone will 30 years from now. What I do affects the next generation very directly."

I thought about that early next morning, riding a logging train's jouncing caboose miles into the forest. Strong sunlight filtered through the endless woods; serene brooks sparkled and disappeared. Here indeed stood a slice of the country's future—lumber, window sashes, plywood, utility poles, fence posts, fiberboard, container board.

I headed back to town in a car driven by 37-year-old Bob Hyndman, Weyerhaeuser's Oklahoma raw-materials manager and a devoted amateur archeologist. While he one-handedly rolled a cigarette at 50 miles an hour, I made nervous conversation.

"Long before the Choctaws came here over their 'Trail of Tears,'" he replied, "Indians lived in these woods. See that clearing? I *know* they camped there. Give me a few minutes, and I bet I can find an arrowhead."

"Take your time," I replied grandly, a skeptic from suburbia.

Bob walked briskly about, bending down, tossing stones aside. "There!" he declared. I studied the ground and saw nothing.

"Got to know what you're looking for," he said, handing me a stone object the same color as the earth, a perfect point.

He walked on, and soon knelt again.

"Here's a pretty good spearpoint," he said, "but it's broken in half."

When he reads this, Bob will learn that he was right about the arrowpoint. Indians chipped it out of chert about 1,000 years ago, according to archeologists at the Smithsonian Institution in Washington, D. C. But he may be surprised about the broken spearhead. I regret having only its top half, but I prize it immensely all the same. The Smithsonian judges that it could be 4,000 years old.

New Word for the OK State

I returned to Broken Bow, checked out of my motel, and drove west through rolling, wooded country to Antlers. There I picked up the Indian Nation Turnpike and headed north, aiming for Oklahoma City and an airplane ride home to the crowded East.

After an hour or so I pulled into a rest area, wanting to stretch. I walked along the right-of-way. A covey of quail rose from the brush at my approach, wings whirring. Back at my car, I glanced idly at the license plate. OKLAHOMA IS OK, it assured me. All of the license plates say it. OKLAHOMA IS OK.

No, I said, it is not. Not at all. Oklahoma is tremendous. Put *that* on your license plates. □

What's So Special About Spiders?

By PAUL A. ZAHL, Ph.D.

NATIONAL GEOGRAPHIC SENIOR SCIENTIST

SPIDERS DO NOT INTIMIDATE Dr. Willis J. Gertsch. When I visited him in his studio-laboratory at the foot of the Chiricahua Mountains in southeastern Arizona, he dumped a live tarantula from a glass jar onto the top of his desk. The gray-brown, eight-legged shaggy thing—nearly the size of my fist—was clearly the stuff of which bad dreams are made.

"During a lifetime with spiders," reflected the scientist, his bare fingers guiding and restraining the restless creature, "I've been bitten by tarantulas of a dozen different species. And as you see, I'm still here and in moderately good health."

The big furry spider prowled inquisitively across the back of his hand. "Regardless of old Hollywood horror films," Dr. Gertsch continued, "a tarantula bite is hardly worse than a bee or wasp sting, unless you happen to have a particular allergy. As a matter of fact, some ants, bees, and wasps are far more dangerous. But it's the spiders that always make the headlines."

Dr. Gertsch had a point. Spiders are among the most feared and maligned of nature's smaller creatures—and among the most fascinating. An incredible number of species inhabit the world, but only a dozen or so can be dangerous to man. And, on the other face of the coin, nearly all do their part in keeping incalculable hordes of harmful insects in check.

Wind Wafts Spiders Far Out to Sea

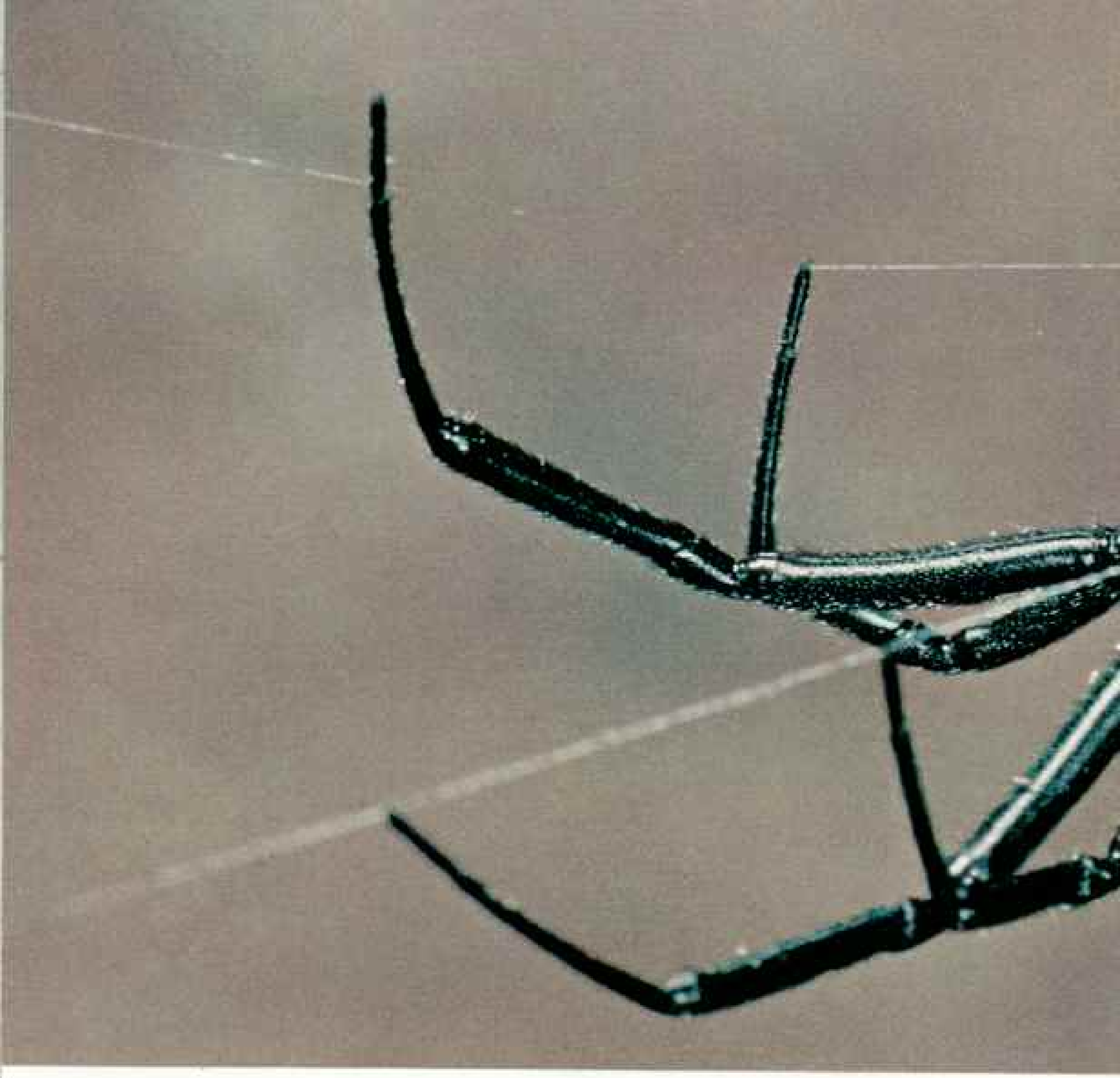
One finds spiders almost everywhere—four miles up in the Himalayas, in below-sea-level deserts, in tropical treetops, and burrowed into the earth. Mariners have even sighted them far at sea, drifting on the wind, suspended from threadlike "parachutes."

The average life of a spider spans only a year, yet a tarantula may live as long as three decades, and take eight to ten years to mature. Most spiders lead solitary lives, but a few are social, with many individuals sharing a common web. Some species are as small as pinheads, others the size of dinner plates. Though many people think of spiders as insects, they are more closely related to ticks, scorpions, and, remotely, to horseshoe crabs.

But chief among the marvels of the spider is its mastery of spinning. I have watched

Spurred by hunger and guided by instinct, a garden spider wraps a grasshopper in a shroud of silk. The efficient predator has killed the insect with a bite and now will dine on its juices. Spiders have changed little from their ancestors of hundreds of millions of years ago; they differ from insects in that they possess eight legs instead of six, and have neither compound eyes nor antennae. Essential to the balance of nature, the world's spiders—averaging at least 50,000 per acre in green areas—annually destroy a hundred times their number in insects. Scientists have named more than 30,000 species and estimate that four times that many remain unclassified.

ARGIOPE AURANTIA, 5 TIMES LIFE SIZE, TROPICAL AND TEMPERATE REGIONS; BY JAMES HEALEY © N.G.S.



human lacemakers work a spider-web motif into handkerchiefs, napkins, and tablecloths, but the result is clumsy compared to nature's often exquisite products.

Oddly enough, though, Greek mythology attributes the spider's skill to human origins. An artful weaver named Arachne impudently challenged the goddess Athena to a contest. Later, shamed and mortified by her own conceit, Arachne hanged herself. The goddess, in a moment of compassion, brought Arachne back to life, transformed her into a spider, and made her noose into a web.

"Live," Athena commanded, ". . . and that you may preserve the memory of this lesson, continue to hang, both you and your descendants, to all future times." And so the name of that superb classical spinstress has been perpetuated by scientists: Arachnologists like Dr. Gertsch study the class Arachnida and the order Araneida—spiders as a group.

Dr. Gertsch amiably coaxed his eight-legged friend back into its jar. Then the scientist, retired after many years as curator of spiders at the American Museum of Natural History in New York City, gave me a quick refresher course on arachnid evolution.

"Spiders' bodies and habits have become adapted to harvesting insect food supplies in a multitude of habitats. Most hunting spiders prowl on the ground, relying mainly on strength. Keen-sighted wolf spiders and jumpers use sheer speed in overtaking prey. Aerial

(Continued on page 198)

"Murderous biting robber": The translation of the black widow's scientific name, *Latrodectus mactans*, attests to the infamy of the little weaver (**above**). This most dangerous of spiders usually bears a red hourglass marking on its underside (**left**). One of about a dozen species that need be feared by man, it occurs commonly throughout most of the United States.

The black widow's venom—more potent drop for drop than a rattlesnake's—causes intense pain. Deaths, however, occur from only four or five of the more than 1,000 bites reported in the U. S. each year.

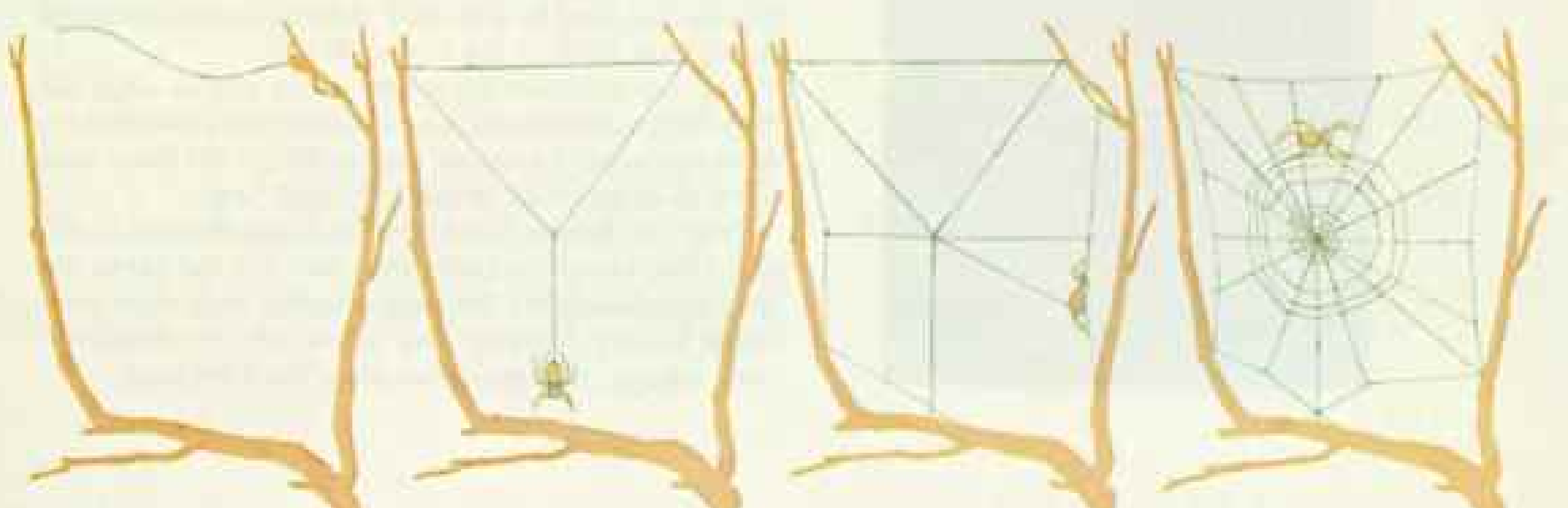
Only the female black widow causes human fatalities. Contrary to the belief that gave her the name, she does not always kill the much smaller male after mating. If hungry, however, the widow, like the females of most spiders, will resort to eating her own kind.

Nature's master spinner

SPECIALIZED TOOLS *of survival set spiders apart from all other creatures in the animal kingdom. Silk and the way spiders use it head the list of adaptations that have helped them weather eons of environmental change. A black-and-yellow argiope—a common garden spider—serves to illustrate:*

Pocked with tiny openings, the six spinnerets at the rear of the abdomen (**inset A, above**) *control and shape the silk, a liquid protein that solidifies when drawn from the body. With its silk glands, the spider can produce either dry or sticky fibers as thin as one-millionth of an inch.*

The mouth lies concealed beneath two hairy lobes at the base of leglike feelers called pedipalps (**inset B**). *After killing or paralyzing prey with venom, the spider crushes its victim between lobes and jaws.*



As the body juices are sucked up, lobe hairs filter out solid particles.

*Curved claws and thick barbed hairs at the tip of each leg (**inset C**) permit orb-web spiders to race across silken lines. They avoid entanglement in their own snares by walking only on the dry radial strands and shunning the sticky spiral threads.*

The spider tugs thread from the spinnerets by snagging it with the saw-tooth hairs and gripping with the bent median claw. The faster silk is drawn from the body, the stronger it becomes.

*An orb weaver uses the wind to set the bridge line of its home (**far left**). Dropping from the center of a second strand stretched across the gap, it anchors a vertical thread and quickly secures more radial lines. Then, starting from the hub, it puts down a temporary dry-thread spiral. That done, it reverses direction and lays down a new one of sticky insect-trapping silk, while rolling up the first spiral.*

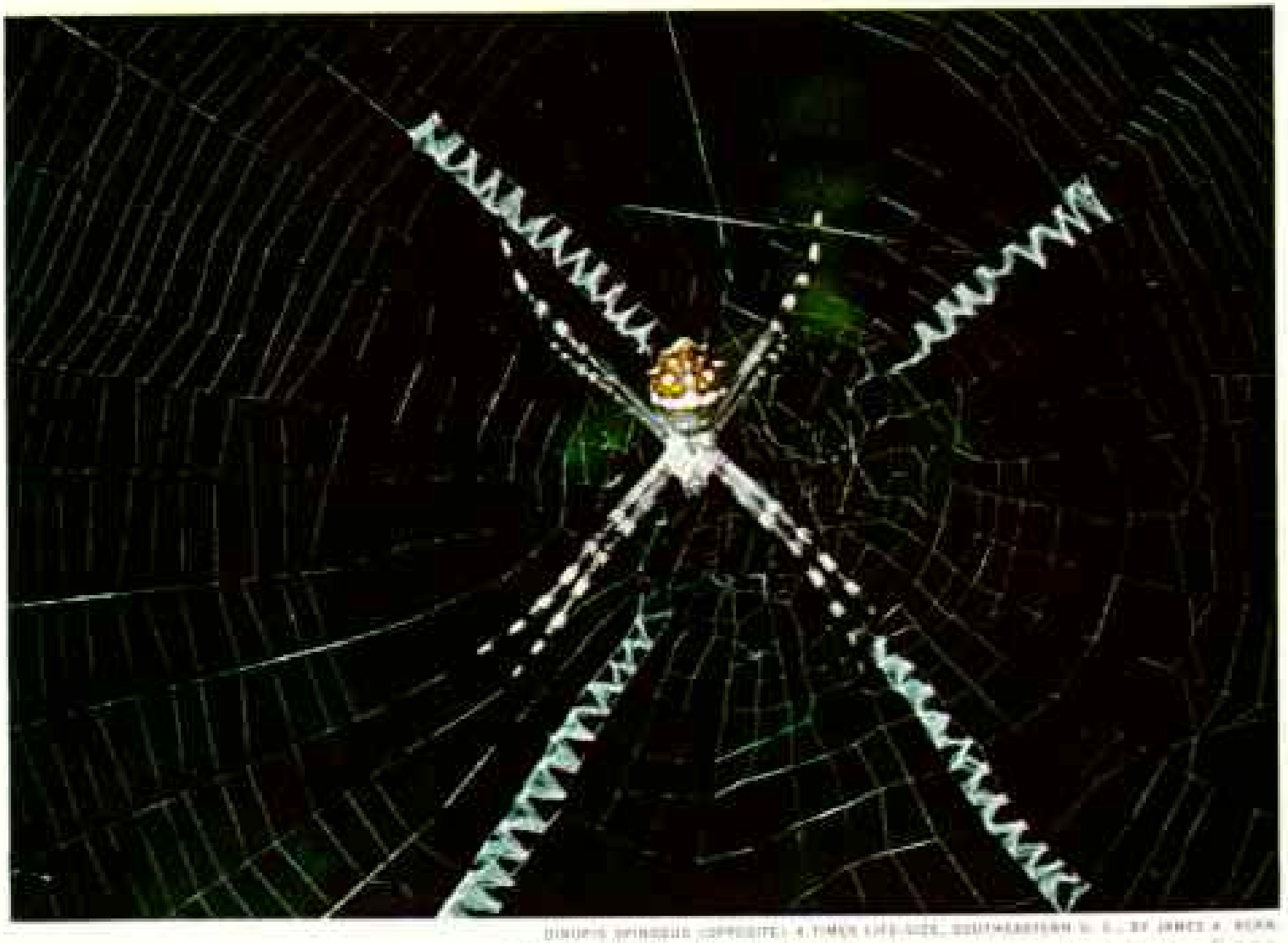
Often lovely, always functional, the silken traps fashioned by spiders give them a clear advantage over their insect prey.

Unlike her cousins who patiently wait in their webs for dinner to arrive, the ogre-faced spider (**left**), lassos her victims with a sticky net of parallel threads. Controlling it by lines held with her front legs, the nocturnal lurker spreads and flings the snare whenever an unsuspecting insect approaches her hiding place. The grotesque face that prompted the spider's name is not visible in this photograph.

Interior decorator of the spider world, silver argiope (**below**) rests head downward at the hub of her nearly three-foot-wide home. Weaver of one of nature's most perfect webs, she adorns the middle section of her geometric masterpiece with crossed zigzag bands; their function remains a mystery.

Beaded by morning dew, an orb web (**right**) rivals the beauty of the finest strands of pearls.

BY LARRY A. WEIT



DINOPIS SPINOSUS (OPPOSITE); 4 TIMES LIFE SIZE, SOUTHEASTERN U. S.; BY JAMES A. RYAN
ARGIOPE ARGENTATA (ABOVE); 2/3 LIFE SIZE, NEW WORLD TROPICS; JOHN A. J. COOKE © N.G.S.

Goliath among spiders, an American tarantula calmly submits to a close-up inspection by Arizona collector Lorin Honetschlager and his daughter Julie.

New World tarantulas—unrelated to Europe's *Lycosa tarentula*—retain features of the most primitive spiders: four lungs, jaws that move vertically instead of horizontally, and minimal use of silk. Some have legs spanning nearly ten inches, making them the world's largest spiders. Despite their formidable appearance, American tarantulas pose no danger to man.

spiders have devised three-dimensional webs within which they hang upside down (page 219), mazes of lines to entrap crawling insects, and sheets and aerial tangles to intercept jumping insects. And the orb weavers spin round geometrical webs that efficiently entangle flying or jumping insects."

Dr. Gertsch's own favorites are the more primitive spiders: American tarantulas, trapdoor spiders, purse-web spiders, and the most primitive of all, the liphistiids, little changed since Carboniferous times, some 340,000,000 years ago.

Walking Factories Produce Varied Silks

In my own exploration of the spider world, I found myself endlessly fascinated by the orb weavers. The raw material of their gossamer creations—a complex protein substance—is manufactured by five or six special glands in the spider's abdomen, each producing its own variety of silk. Acting separately or in combination, these glands supply dry or sticky threads for lines, cables, and attachment disks for webs; egg sacs; anchor lines; and swathing bands to bind prey.

The precise form of the filaments is determined by spinnerets—clusters of tiny nozzled jets from which the spider draws the silk with its hindmost pair of legs. The resulting strands of spider silk are incredibly elastic and tough—some can stretch more than 20 percent and are stronger than steel wire of the same diameter!

For all its beauty and dewy sparkle, the spider web is a diabolical achievement. To be sure, heavy insects like beetles and wasps, blundering into the snare, are apt to rip right through. But for lighter prey, the sticky, almost invisible network means death.

When delicate touch receptors pick up the slightest impact of an insect on the web, the spider skims across it to paralyze the victim with a single bite and binds it with silk (page 191). The hapless insect will either be eaten summarily—the body sucked dry of its nutritious fluids, the remains discarded—or left hanging in its mummylike wrapping for a future meal. In his classic work *The Life of the Spider*, J. Henri Fabre puts words into the mouth of a simple garden spider, "We must eat to have silk," the spider exclaims, "we must have silk to eat. . . ."

Instinct alone controls the weaving. But alter ever so slightly the spider's internal chemistry, and the web will show it. I saw this demonstrated one morning in the laboratories of North Carolina's Department of Mental Health, which experiments with spiders in one phase of a search for diagnostic clues to various mental illnesses (pages 200-201).

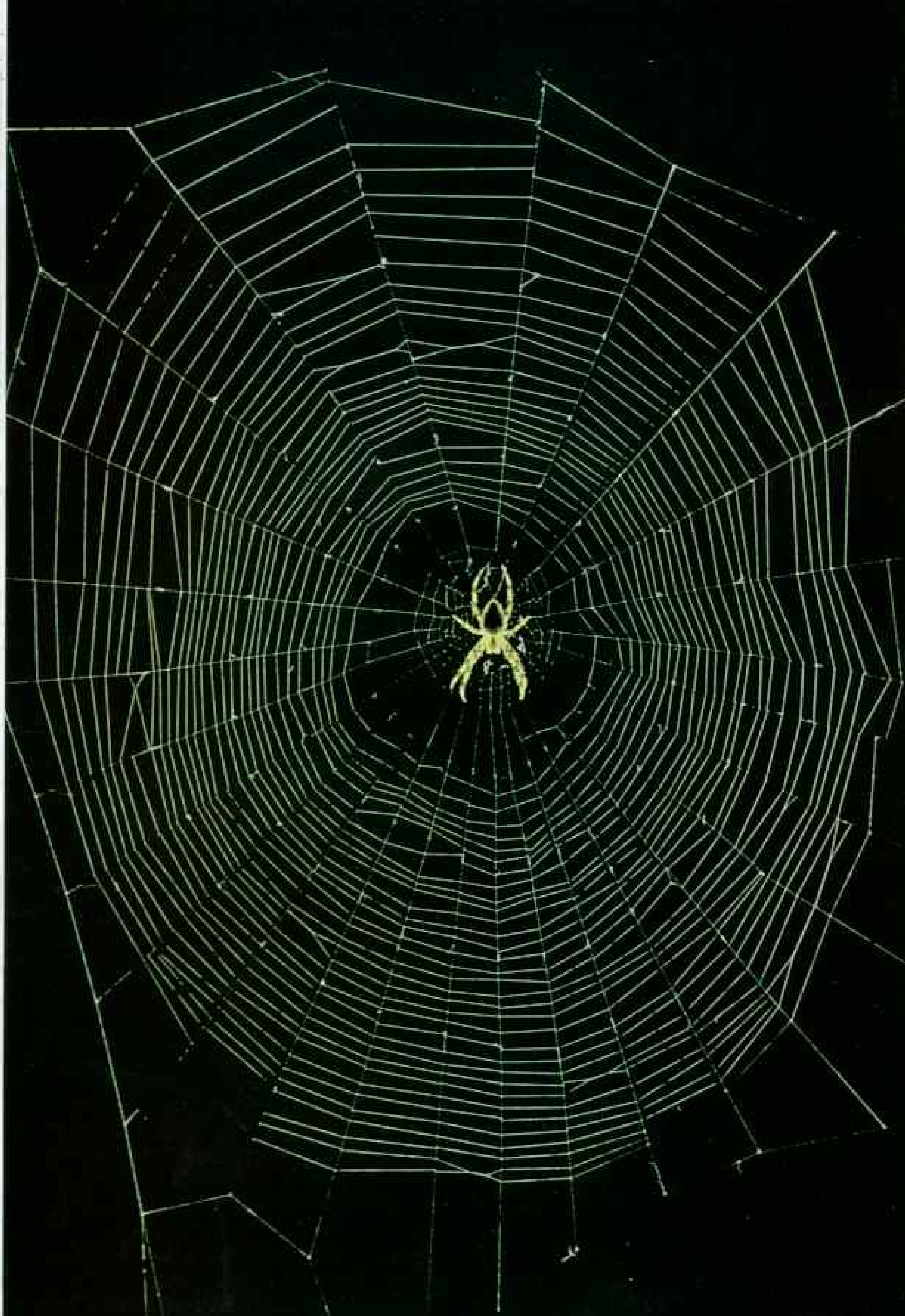
Within an aluminum frame an orb weaver was performing a sequence of rapid runs, ascents, and descents. Tattered remnants of an earlier web stuck to one edge of the frame.

"Every morning we make her spin a new web," said Mrs. Mabel Scarboro, a research assistant. "In the wild, a web seldom lasts more than a day or so; it's ripped by wind, or insects, or even the movement of the spider itself. Even though we feed this one, her instinct tells her to keep her web in good repair or she'll starve."

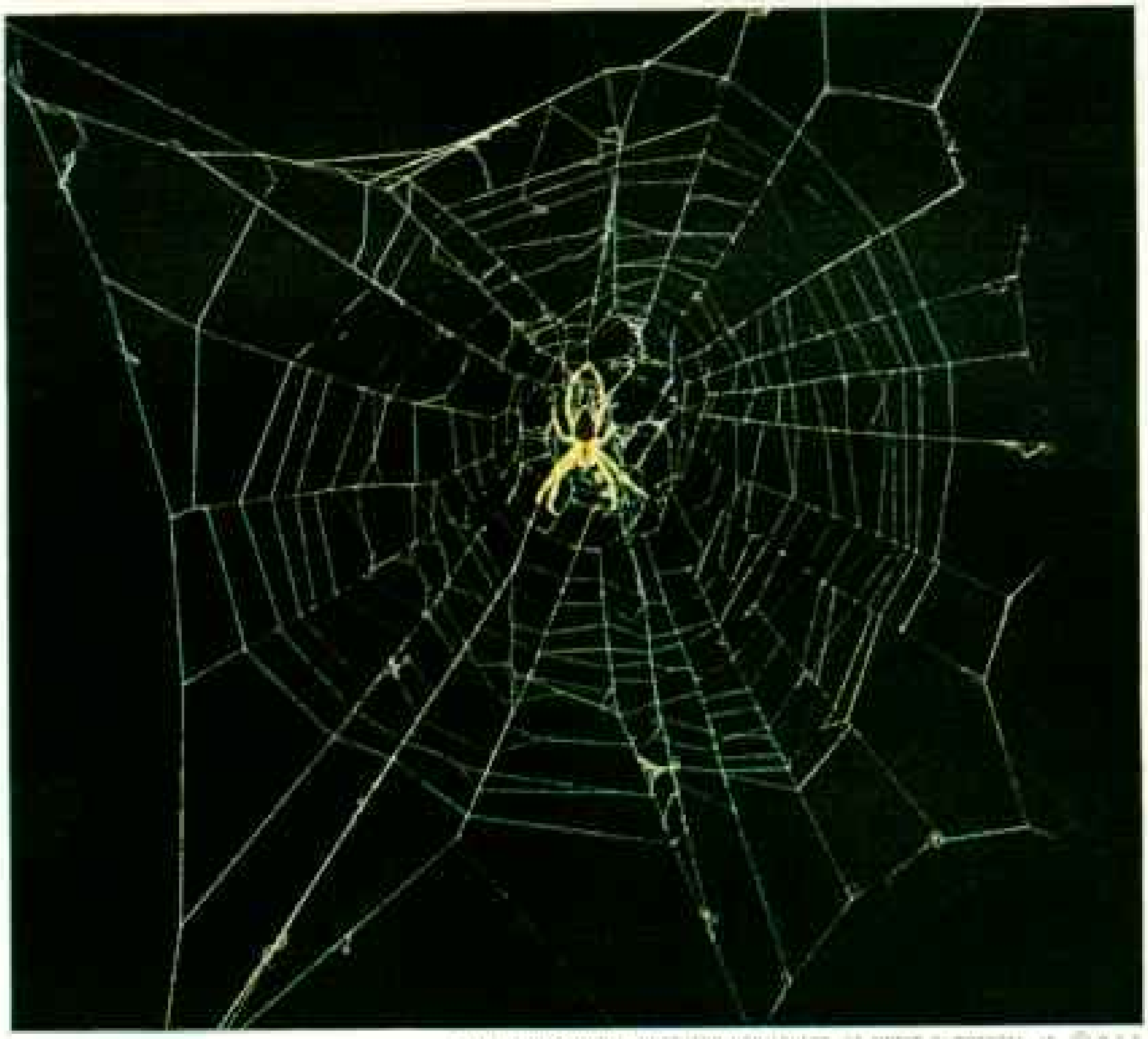
In half an hour a completed web filled the frame. It was a circular marvel of straight lines, angles, and more than 800 individual

Cautious but eager to perform his mission in life—mating—a male tarantula warily approaches the attack-ready female at extreme right. Leglike palpi carry sperm, transferred from a pore on his underside.

He advances with spurred forelegs poised. The female rears on her back legs, raising awesome fangs to deliver a death-dealing bite. But before she can strike, the male's forelegs shoot up, catching the fangs with his spurs. Thus protected, he forces her upward, exposing a furrow on her abdomen in which he deposits the sperm from his palpi (**below**).



Drug trips for science: Web weavers perform in the laboratory of the North Carolina Department of Mental Health at Raleigh. Research Director Dr. Peter N. Witt and his associates permit a spider to construct her normal orb web (**left**). Then they apply a drop of "speed"—the stimulant dexedrine sulphate—to the creature's mouth (**right**). Allowed to build another web (**center**), she spins an erratic, irregular copy. Taking information from photographs of normal and dexedrine-influenced webs (**bottom**),



ARANEUS DIADEMATUS, MUNCHIAN HOMOPHILE, BY EDITH H. RUSSELL, JR. © N.A.S.

Dr. Witt and his assistant, Mrs. Mabel Scarboro, feed the data into a computer that compares 600 selected points.

Such research reveals that each drug tested produces consistent, characteristic changes in a spider's web-weaving activity. Amphetamines and barbiturates cause irregular webs; tranquilizers and marijuana, small webs; and LSD, more symmetrical webs—apparently because the drugged spider is less distracted by outside influences.

By observing the effects of drugs on spiders, scientists hope to learn more about human biochemistry.

attachments, all engineered with mathematical precision.

Another spider of the same species was busy spinning in a duplicate frame alongside. Earlier, this spider had demonstrated its ability to weave a regular, symmetrical web. But now it had been fed a droplet of sugar water containing "speed"—dexedrine sulphate.

Mrs. Scarboro sprayed the two webs with quick-drying white paint to make the threads stand out clearly. Then I saw the strange angles and illogical backtrackings in the weaving of the drugged spider. Laboratory measurements would record angles, affixment points, number of spokes, and other data for computer analysis.

Experimenters have found that different drugs—caffeine, mescaline, and LSD, for example—produce characteristic variations in a spider's web.

Some human mental illnesses seem to be accompanied by biochemical changes in the blood or tissue fluids. Could such fluids, administered to a spider, measurably influence its weaving patterns? If so, spiders might perhaps be able to tell us—through the varying patterns of their webs—the particular illness affecting a patient, or even his progress under psychiatric treatment. This is only one potential of the experiments, which are still in exploratory stages.

Spider Responds to Strange Vibrations

Researchers are on more certain ground in the field of normal spider behavior. Dr. Peter N. Witt, distinguished research pharmacologist and director of spider investigations at the North Carolina laboratory, repeated an experiment for me.

He tapped a tuning fork and touched it gently to a web tended by an *Argiope*. Instantly she rushed across the strands and furiously assaulted the quivering metal. With her legs she pulled a silken stream from her spinnerets, and in seconds the cold prongs were bound tight.

"A slave to innate behavior patterns," said Dr. Witt. "Spiders can't alter their reactions, can't discern or evaluate subtle changes in external influences. The vibration of a tuning fork or a thrashing insect—it's all the same to them."

Perhaps even more instinct-bound than the orb-web spiders are two enemies I encountered while spider hunting with young Nicholas Eltz, who was then helping scientists at the American Museum of Natural History's Southwestern Research Station near Portal, Arizona. Nicky's terrariums already held a dozen tarantulas.

Battle's Outcome Rarely Varies

The sun had set and the desert was losing its daytime heat as I drove slowly down a twisting roadway across rolling terrain covered with sage and cactus. Nicky perched on the hood, a flashlight in one hand and a wide-mouthed jar in the other. He had explained why at dusk in summer tarantulas leave their holes to forage or to find mates. "After dark it's cooler, and they're also safe from pompilid wasps."

Abruptly Nicky signaled me to stop. He jumped off the hood, ran ahead, and suddenly dropped to his knees on the macadam. In the headlight glare I saw him scoop up something with his collecting jar. A moment later he was back with his prize—a tarantula with a body thicker than my thumb, a leg spread of five inches, and two formidable black fangs. We bagged six more specimens within an hour, then returned to the research station.

Earlier that day we had netted a metallic-blue, topaz-winged pompilid wasp and released it in a glass terrarium partly filled with desert sand. Now we dumped one of our newly captured tarantulas in with the wasp.

"First they'll wrestle," Nicky predicted, "but the outcome is usually the same."

I watched the unequal struggle, the keen-eyed wasp circling like a gladiator and sizing up the near-sighted spider, which could assume only a threatening attitude until touched. The wasp quickly broke through the spider's guard. With a lightning-swift jab, she sank her stinger into the tarantula between its third and fourth leg sockets.

(Continued on page 208)

If it moves, it's probably food. The fishing spider, here feeding on a freshly caught minnow, devours insects, tadpoles, and even other spiders with equal gusto. Like all spiders, he must inject the victim with digestive enzymes before he dines, turning soft tissues into a soup that he can draw into his body. Venom for killing prey occurs in all but two small groups of spiders.

Nimble crab spider haunts a plant laden with delicate blossoms (**right**). Named for its ability to scurry sideways and backwards, the little hunter can turn white, pink, or yellow to blend with vegetation.

In a mini-jungle of stalks and stems, a green lynx spider snatches up a victim. It trails a dragline—a safety thread anchored at intervals—that most spiders put down as they move about.

PEUCETIA VIRIDANS, 2 1/4 TIMES LIFE-SIZE. SOUTHERN U. S. TO CENTRAL AMERICA. BY JAMES AND RICHARD KERN

MISUMENOPS OBLONGUS, 2 1/2 TIMES LIFE-SIZE. EASTERN U. S.; BY F. TURNER HOPKINS

EUSTICUS CRISTATUS, 3 TIMES LIFE-SIZE. EUROPE; BY JOHN A. L. COOKE © N.G.S.

Ready-for-dinner stance: A hungry crab spider waits motionless for a flying insect to approach. When a victim draws near enough, the legs snap shut and the predator delivers a killing bite. Equipped with particularly potent toxin, these spiders readily attack wasps and bumblebees much larger than themselves.

In fashionable "wet-look" garb, Australia's red-and-black *Nycodamus* prances over the loose ground cover on which he makes his home. "The loveliness of many spiders remains unappreciated," author Zahl says, "simply because of their small size and the centuries of unwarranted prejudice against them."

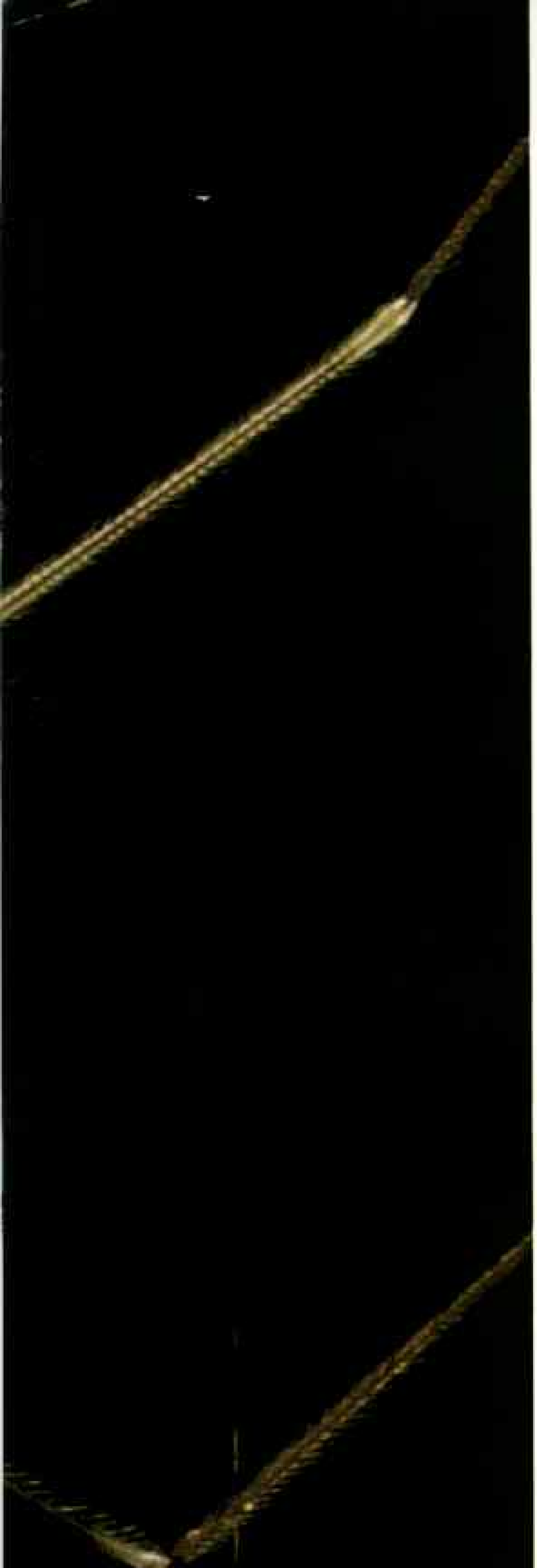
NIGERIANUS NICODAMUS, LIFE-SIZE, BY EDWARD S. ROSS

PHILIPPUS ARGENTENSIS, A 1/2 TIMES LIFE-SIZE, SOUTHWESTERN U. S., BY JAMES H. CARMICHAEL, JR. © N.G.S.

TAENIOPA SPECIOSA, A TIMES LIFE-SIZE, SOUTHWEST U. S., BY JAMES H. CARMICHAEL, JR.

Some lurk, others chase, but a jumping spider pounces on its victim—in this case another spider—from a distance as great as forty times its body length. Like most spiders, it will even kill and eat its own offspring. No other spiders match the varied coloration of the jumpers.

Glowering visage belies the mild personality of the jumping spider. Apparently emboldened by the ability to perceive sharp images as far away as 10 to 12 inches—a record for spiders—these hunters often will sit calmly on a person's finger, raptly following his movements. Nearly all spiders have eight eyes differing in size and position, but only those species that pursue their prey possess keen vision. Others rely almost exclusively on the sense of touch.



In dank, dark places nearly everywhere in the world long-legged cellar spiders may be found. This one (**left**) carries an egg cluster in her jaws. More familial than most species, cellar spiders share their webs with mates; the female can sometimes be seen holding recently hatched young. These basement dwellers violently vibrate their webs when alarmed, but when mortal danger threatens they flee the snare to seek cover in dark corners. They share the nickname "daddy longlegs" with spiders' close relatives, the harvestmen (page 211).

PHOLCUS PHALANGIOIDES, 3 TIMES LIFE-SIZE, WORLDWIDE, BY PAUL A. ZAHL © N.G.S.

GENUS MISUMENOPS, 3 TIMES LIFE-SIZE, NORTHERN HEMISPHERE, BY PAUL A. ZAHL © N.G.S.

No female guards her progeny-to-be more fiercely than the crab spider (**above**). Crouched defiantly on her egg sac, she treats every intruder as an enemy. This one even stood her ground when author Zahl slit the cocoon with scissors to expose the eggs. Usually, however, the crab spider dies of old age before her babies emerge.

PEUCETIA VIRIDANS, TWICE LIFE-SIZE, BY JAMES AND RICHARD KLEIN

Motherly solicitude often persists among spiders after the young emerge from their sturdy egg cases.

Freed from their barbed-wire-anchored sac (**above**), green lynx spiderlings will remain with the female in the silken maze until able to fend for themselves.

Wolf-spider young stay even closer to home. The parent carries them on her back for a week or more (**right**), brushing them away from her eyes as she goes. During that time the spiderlings never feed. If a little one tumbles off, it quickly scrambles back up via the nearest leg.

Most spiders produce about a hundred eggs at a time, the extremes range from one to as many as a thousand.

For a full ten seconds the wasp held her deadly thrust, apparently discharging a full dose of tranquilizer. Then she withdrew her needle-sharp weapon, stepped back, and waited. The tranquilizer worked rapidly.

The motionless spider was ten times the size of the wasp, but the wasp seized one of the tarantula's legs in her jaws and tugged the gray-black hulk across the sand to a hole she had dug earlier. She backed down the hole, pulling her burden in after her.

I already knew the last act of this drama. Positioning the victim on its back underground, the wasp would lay a single egg on the anesthetized spider's abdomen, then return to the surface and plug the hole with sand or pebbles. The tarantula is thus literally buried alive for weeks. When the wasp's egg hatches into a squirming larva, the spider serves as a food supply. This small, savage

ritual helps control the tarantula population—a necessity even with a creature so seldom harmful to man.

Even the notorious black widow, *Latrodectus*, of world-girdling range, accounts for surprisingly few human fatalities. Of 1,000 cases of black-widow bite reported in the United States each year, only four or five are fatal. Black-widow venom—for which an antivenin was developed 25 years ago—can produce such symptoms as chills, nausea, pain, hypertension, breathing difficulties, and muscle cramps.

Trash Heaps Are Home to Deadly Widows

In the company of Lorin Honetschlager, an animal collector who some years earlier had helped me find scorpions,* I learned at first-hand much of what I know of black widows. Last summer, sitting in the kitchen of his suburban home near Phoenix, Arizona, Lorin laughed when I told him I thought *Latrodectus* was a scarce spider. "Widows?" he laughed. "Put on your hat, man. In three minutes I'll show you hundreds."

We walked down the street to the backyard of an abandoned house where a trash heap had accumulated. Amid waste paper, tin cans, and rotting lumber, we found a tangle of untidily strung webs. Each had a central tube-shaped netting harboring a shiny black eight-legger with a pea-size abdomen marked underneath with the scarlet figure of an hour-glass (pages 192-3).

Alleged fiend of the spider world and undoubtedly armed with a powerful poison, *Latrodectus* will bite, Lorin insisted, only when excessively provoked—that is, when

*See in NATIONAL GEOGRAPHIC, "Scorpions: Living Fossils of the Sands," by Paul A. Zahl, March 1968.

Prickly "face" scowls from the back of a humped orb weaver. Many spiders display such elaborate markings. "Eyes" and "nostrils" in this bird's-eye view actually indicate the attachment points of internal muscles. The spider's legs conceal the real face.

GEORGE ANDREI, © 1978 TIME LIFE BOOKS, NORTHERN HEMISPHERE;
BY PAUL A. ZAHL © N.G.S.

Hidden in full view, a drab ogre-faced spider avoids enemies by simulating vegetation (**right**). It maintains the twiglike position—long legs stretched out fore and aft—while it sleeps away the day. At night it awakens to hunt for food.

JOSEPH DOMANSKI, © 1978 TIME LIFE BOOKS, SOUTHEASTERN U.S.;
BY JAMES AND RICHARD KERN

Life-saving mimicry protects this jumping spider from predators that find ants distasteful. Most ant-imitating spiders even copy the movements of their models, often waving front legs like antennae. When disturbed, however, they abandon pretense and flee.

SYNEMOSYNA FORMICA, 3 TIMES LIFE SIZE, EASTERN U. S.
BY JAMES H. CARMICHAEL, JR.

MISUMENA DIADEMA, 4 TIMES LIFE SIZE, EUROPE, BY JOHN A. L. COOKE © N.G.S.

SHAPETIGA SOCIALIS, 3 ½ TIMES LIFE SIZE, EUROPE, BY JOHN A. L. COOKE

Spiders' look-alike kin, the harvestman—or daddy longlegs—has only two eyes, usually mounted atop a short, round body. Able to regenerate legs, it readily sheds them when in danger of capture; this one has lost two.

Blotched costume conceals a cryptic bark spider as it stalks down a lichen-covered tree. Where polluted air has blackened tree trunks, darker spiders have evolved.

ARANEUS TRIFOLIUM, TWICE LIFE-SIZE. NORTH AMERICA, BY JANICE HEALEY

ALLOMOPHEROS BIFURCATUS, 2 1/2 TIMES LIFE-SIZE. JAMAICA, BY JOHN A. L. COOKE

BEPHILA CLAVIPES, 1 1/2 TIMES LIFE-SIZE. NEW WORLD TROPICS, BY RICHARD C. KERN © N.G.S.

Lurking lady of the meadows (**top left**), this shamrock spider normally stays hidden in a retreat of folded leaves positioned near her 2¾-foot-wide orb web. A taut trapline links hideout and snare. When an insect strikes, the trapline transmits the vibrations of its struggle from the web to the spider, who rushes in for the kill.

Pear-shaped and berry-bright, this Jamaican orb weaver (**above**) displays apparel befitting its tropical habitat.

GASTERACANTHA CANCRIFORMIS, 3 1/2 TIMES LIFE-SIZE. TROPICAL AND SUBTROPICAL AMERICAS, BY JOHN A. L. COOKE

World's strongest natural fibers form the web of the golden silk spider (**above**). Spider silk, once widely used for cross hairs in optical instruments, is finer, lighter, and tougher than silkworm thread. But the creatures' cannibalistic nature precludes raising them to produce silk for textiles.

Birds get the point: Spiny-backed spider, here upside down, wears pronged armor that discourages attackers.

uncomfortably confined, or unmercifully squeezed, or when its web is violently disturbed. With long chrome tweezers we picked off a dozen of the dreaded ladies, a few soft silken egg cases shaped like little marbles, and several males of the species. The latter are much smaller and pose no threat to man.

Back in the laboratory I had improvised in my Phoenix quarters, the unexpected happened. As I was transferring the black widows to a terrarium, one suddenly ran out of her jar, scurried across my right wrist and up my arm to the elbow, where she stopped to survey this new world of human skin. Despite Lorin's earlier assurances, I felt far from comfortable.

Trying not to move my right arm, I slowly reached with my left for an open jar on a nearby shelf. I eased it close to the lady who could, if she chose, bite me at any moment. Maneuvering ever so carefully, I gently coaxed the venomous creature back into the security of the jar.

In contrast to her tolerance toward me, she set upon and immediately killed the flies, moths, and other insects I dropped into her terrarium. The action seemed just as blindly purposeful as the orb-web spider's attack on the vibrating tuning fork. The widow then expertly twirled her victims into silken shrouds and hung them aside—neatly packaging provisions for the future.

Gleaming Eyes Betray Prowling Wolves

Next night Lorin and I drove out onto the desert east of Phoenix to the habitat of *Lycosa carolinensis*, a wolf spider. A member of the hunting group, this creature lives belowground in a hole rimmed with sand, bits of bark, twigs, leaf fragments, and grass.

Making no use whatever of the web-snare principle, and surfacing mainly at night, fast-moving wolf spiders streak across the ground in pursuit of prey. We found them easily, for in the beam of a flashlight their eyes glowed like the headlights of tiny automobiles, and when caught in the glare they tended to freeze in their tracks.

One species of European wolf spider, *Lycosa tarentula*, probably named after the Italian city of Taranto, inspired a popular folk dance. It was once thought that the effect of this spider's bite (actually not serious) could be shaken off by dancing wildly, hence the spirited *tarantella*. Despite the similarity in name, *Lycosa tarentula* bears no close relationship to the American tarantula.

Another variety of hunter, the funnel-web spider (family Agelenidae), spins a novel trap. At the entrance to almost any cranny she weaves a kind of tarpaulin with a central funnel-like opening where she sits in wait.

In the backyard of my home in Washington, D. C., stands a wall of unmortared stone. Here in the crevices spiders of this family live and thrive all spring, summer, and autumn. I never molest them, for their toll of harmful garden insects must be enormous. Many a summer evening after dark I have placed a chair a few feet from the wall and, with flashlight in hand, sat there for a session of spider watching.

Playing Catch With a Hungry Spider

One night I came with food—live insects netted earlier in the day. The beam of my flashlight found the mouth of a funnel where, just inside, alert and tense, sat a grayish spider with conspicuous eyes. When I made a sudden move forward with the flashlight, the creature vanished, but only for a second or two. I waited until I was sure she was accustomed to the light, then tossed a fly onto the web platform three or four inches from the funnel mouth. Instantly the spider streaked from ambush, made the catch, and disappeared back into the funnel.

Many hunting spiders have large, efficient eyes. Those with the keenest sight are the jumping spiders (family Salticidae). Although usually quite small and harmless to man, these richly colored spiders leap upon insects with the savagery of leopards. A species of jumper has been found 22,000 feet up on Mount Everest; others dwell in lowland gardens and wild woods.

Several of the hunters mimic ants in appearance and habit (page 211); some can buzz like bees; others squirt out a viscous substance to entangle their prey.

One of the strangest of the hunters, the fishing spider *(Dolomedes)*, is at home in two environments. Not only can the fishing spider run across water, but it may remain submerged for as long as an hour, holding onto bottom debris in quiet streams and ponds.*

*This remarkable feat by some spiders and aquatic insects was described in "Teeming Life of a Pond," by William H. Ames, NATIONAL GEOGRAPHIC, August 1970.

BY CARL PERUTZ

Misstep 35,000,000 years ago mired this jumping spider in resin, which hardened into amber. The oldest fossil spider predates him by more than 315,000,000 years.

Nemesis of smaller creatures, the wolf spider (**left**) rarely threatens humans; if handled carefully, the hunter can make an interesting pet.

For spider collectors who want nonliving specimens, nature provides plentiful and perfect facsimiles such as this featherlight exoskeleton (**below**) abandoned by the animal when it molted. Spiders must discard their skins to grow, and they do so at least once even before emerging from their egg sacs. Most molt four to twelve times in all, reaching sexual maturity with the final shedding. Few spiders live more than two years, and the males, who die soon after mating, rarely survive even one.

WOLF: LYCOSA (OPPOSITE); 10 TIMES LIFE-SIZE; BY ALDO MARCHIORO;
HETEROPTICA VERATRIMA (ABOVE); 5 TIMES LIFE-SIZE, TROPICAL REGIONS; PAUL A. ZAHL © N.G.S.

Peekaboo predator scouts for food from the entrance of her underground home (**above**). If an insect passes near enough, the trap-door spider will lunge at it, usually keeping the door propped open with her back legs to ensure a safe retreat.

Using comblike rakes on the jaws, the builder of a trap-door nest such as the one being probed by Kathy Wilson Rottschafer (**below**) digs a hole five to eight inches deep, then caps it with a hinged, beveled door carefully camouflaged on top. Tiny punctures on the inside of the door (**below**) reveal how the spider uses her fangs to hold it tightly shut against intruders.

After waterproofing the walls with a coating of saliva and earth, the spider lines the interior of her snug lair with soft silk (**opposite**).

BY PAUL A. ZAHL (ABOVE) AND RICHARD C. KOHN © N.G.S.

UMMIDIA NIDULANS, 6 TIMES LIFE-SIZE, JAMAICA; BY JOHN A. L. COOKE © N.G.S.

BOTHRIOCYRTUM CALIFORNICUM, LIFE-SIZE, SOUTHERN CALIFORNIA; BY PAUL A. ZAHL

A bubble of air held under the body enables it to pop to the surface at will. Insects are its usual prey, but some species capture small fish and tadpoles (page 203).

Even more remarkable, the water spider *Argyroneta*—a native of Europe and Asia—builds a diving bell underwater. The spider first spins a submerged web platform, then carries down small air bubbles from the surface to fill it like a tiny balloon. She spends virtually her entire life in or near the bell, adding new air whenever needed. *Argyroneta* even lays her eggs within the bubble, and hatchlings stay there until ready to set out on their own.

Camouflage Hides a Hunter's Lair

Trap-door spiders are unique by virtue of their ingenious dwellings. One spring I found myself in the hilly country east of San Diego, an area well known as a haunt of the California trap-door *Bothriocyrtum californicum*. Here my field collaborator was Kathy Wilson Rottschafer, a student of biology at San Diego State College, and a trap-door specialist in the making.

"When they're closed, the traps are so perfectly camouflaged that we've probably stepped on dozens already without knowing it," apologized Kathy. We were searching a little arroyo strewn with yellow spring flowers. Here and there lay patches of bare earth where one could examine the surface square inch by square inch.

For ten minutes I scrutinized the ground, looking for something I had previously seen only in photos. Then I heard a cry of triumph from Kathy. She pointed to a hair-thin arc barely visible on the surface of the soil.

"May I have your pocketknife, please?" she asked. With a surgeon's dexterity she eased the blade under the edge of the inch-wide door and pried gently. There was no give.

"A spider's in there, all right," she said, "braced just under the door, holding it shut. Surprising how strong they are."

She thumped the ground gently and the spider let go. With the blade she lifted the trapdoor—a thick cap of tightly compacted silk and dry soil. Its beveled edges might have been fashioned on a lathe (left).

The young arachnologist beamed. "There you are. And six or eight inches down at the bottom of the shaft is the lady of the house."

With sharp rakes on each of its two jaws, the spider had excavated a neat vertical shaft just wide enough for her body; she had coated

its walls with saliva-moistened earth, and covered them with a sheet of tightly spun silk. Finally she had woven the hinged and camouflaged trapdoor—her shield against a hostile world.

She was now safe from most of her enemies but still vulnerable to the pompilid wasp—nemesis of all members of the tarantula group.

When such a wasp locates a trapdoor, it chews through the cap or simply rushes in if the spider lifts the door too high. Once inside, the wasp engages the spider in the same unequal contest I had observed against the tarantula in Arizona. Then the insect departs through the now-unguarded door.

The trap-door spider designs her abode not only for safety, but also as a shelter from sun, rain, and cold. It is her courtship parlor too, her nuptial chamber, and a nursery for her young. Seldom if ever does she leave its confines, and even then ventures out only a few inches to capture crawling insects.

Indians Believed in Spider Power

Greek mythology gave us Arachne. Other myths deify the spider. "To the American Indians," writes Dr. Gertsch, "the spider is a creature of mystery and power. . . ." To the Dakotas "the orb web is a symbol of the heavens . . . from the spirals of the orb emanate the mystery and power of the Great Spirit." And the lines connect sky and earth on which an ". . . Algonkin maiden, fallen from grace as wife of the Morning Star, is sent back to earth." To certain Southwest Indians, the original creator was a spider; to others, weaving was introduced by a spider woman.

Quaint myths. But where do spiders fit into nature's plan, and into the world which man has superimposed on nature?

To begin with, the arachnid line goes back 400 million years to the first land-dwelling invertebrates. Ages of adaptation followed, during which spiders infiltrated almost every climate and every ecological niche.

Housewives are aware that any closet or dark corner, even on the thirtieth floor of a New York apartment building, if left unswept or undusted for just a few weeks, will inevitably develop cobwebs. How they get there strains one's imagination.

Gossamer Webs Capture Morning's Glory

Not only are spiders found almost everywhere; they exist in incalculable numbers. Sampling techniques have revealed some 64,000 spiders in one acre of meadow in a Middle Atlantic state and a quarter of a million in an acre of tropical forest. The worldwide count would be beyond comprehension.

The spider's marvelously inventive modes are fueled by strictly carnivorous habits which, although deadly in the insect world, are man's distinct blessing. Man must live on what he grows, and thanks in part to his eight-legged friends, destructive insects are held in check. It seems ironic that such a benefactor should typify ugliness and connote menace—should have, as the nursery rhyme has it, "frightened Miss Muffet away."

Early one September morning on a New England hillside, I came upon a patch of mountain laurel in which scores of orb webs were strung. Their silken fibers, moist with dew, caught the rays of the rising sun, and the glitter was dazzling (page 197).

Perhaps a similar enchanting encounter in 1715 inspired 12-year-old Jonathan Edwards, the future Puritan theologian and scholar, to pen what I think of as the best tribute to man's plentiful eight-legged friends. (Edwards could not have known that a century later scientists would decide that spiders are not insects.)

". . . every thing belonging to this insect," wrote Edwards, "is admirable. . . ." □

Bridging a gap in one of the anchor lines of her three-sided web, a triangle spider patiently waits for dinner. When an insect lands in her snare, she pulls the anchor line taut, then suddenly releases it, making the web vibrate and further entangling the victim. Then the venomless hunter swathes her prey in silk and sucks the juices from its body.

FRONTINELLA COMMUNIS, HALF LIFE-SIZE, EASTERN AND CENTRAL CANADA AND U. S., BY LARRY J. WEST © N.W.F.

Tangled silk snare of the bowl and doily spider also foils enemies approaching from both above and below.

Up, up, and away! A young crab spider releases a strand of breeze-catching silk and waits for a gust to carry her aloft. Called ballooning, nature's way of distributing spiderlings has helped scatter the creatures worldwide.

MISUMENOPS BILUNULUS, 9 TIMES LIFE-SIZE, SOUTHEASTERN U. S., BY RICHARD C. KERN

Help for Philippine Tribes in Trouble

By KENNETH MacLEISH
SENIOR ASSISTANT EDITOR

Photographs by DEAN CONGER
NATIONAL GEOGRAPHIC PHOTOGRAPHER

THE WOUNDED WOMAN had been hiding in the hills for 14 days. Submachine-gun bullets had struck her face, her leg, and her foot. Other bullets had killed her husband. The brass voices of gongs passed the word from ridge to ridge, speaking discreetly, for everyone in the mountains of Mindanao understands the language of the gongs.

Details reached us by runner. The hill people had heard that Manuel Elizalde, Jr., head of Panamin—the Presidential Arm for National Minorities—was in the district. Secretary Elizalde, who holds cabinet rank in the Philippine Government, is the official most deeply concerned with the plight of his nation's ethnic groups. A man walked two days through the forest to put the matter before him.

The Secretary listened, then summarized the situation:

"As the man tells it, this is a classic case of land grabbing, resistance, and revenge. Someone from the dominant society—the civilized Filipino world—tried to take a tribesman's holdings. He objected; now he's dead, and

Victim of the violence that stalks Mindanao's uplands, a woman rides piggyback to a rescue helicopter. She was shot by unknown assailants sent by Filipino settlers, miners, or lumbermen bent on seizing tribal lands. Concerned government officials strive to protect the pagan hill people from ruthless exploitation; at the same time they try to develop an appreciation of these simple peoples among their Christian countrymen.

his wife is badly hurt. Did he die because he fought back, or was he murdered? We don't know. But murder is common in Mindanao. The Manila press calls this island the 'Wild Wild South.'

"We have our frontiersmen, as did your Wild Wild West, and they're a rough, tough lot. But we mustn't forget why they're here. After World War II the government urged settlers to go to undeveloped Mindanao and start civilizing it. The nation was—and is—suffering a population explosion, and no one cared much about how land was acquired.

"The settlers took what they could get, and the tribesmen moved back to the hills. Now mining and lumber interests want the hills too. But the tribesmen have nowhere left to go. So in desperation they protest. They sometimes even stand and fight instead of quietly vanishing before the advance of what we call civilization."

The Secretary rubbed his stubbly chin and shoved his dirty white cap back from his forehead. "You know, we hear a lot about conservation these days. Conservation of animals, even of plants. But what about conservation of human beings and human cultures?"

Compassion Drives a Complex Man

Young (34), wealthy, Harvard-educated Manuel Elizalde might reasonably have been expected to join ranks with the rich and powerful. To the amazement of his peer group, excepting President Ferdinand E. Marcos and a few other men who cannot forget that the pagan tribesmen of the Philippines are their blood brothers, Elizalde cares more about the hard-pressed national minorities than about his family fortune or his life. He is a visionary idealist and a romantic. But he is also quick-witted, tough-minded, and given to sudden decisions.

"The runner says the woman's wounds have begun to smell," Elizalde said. "Let's bring her out."

The young American helicopter pilot glanced at the small cumulus of morning floating over jungle-covered peaks. "O.K.," he said. "But right now. By midafternoon those puffs will be thunderheads. Even if I could get in up there I'd never get out. What am I supposed to land on anyway?"

A thousand flying hours in Viet Nam had given Denis Rinehart a skill verging on artistry. His question conveyed no anxiety.

"The messenger will show you the place. He says the tribesmen have cleared a little space for you an hour by foot from where the woman is hidden."

"Little!" said Denis sadly. "Ha!"

"I want some guns up there," Elizalde told me. "No knowing who's around. I'll send two security men with automatic weapons. You take this." He handed me a compact H-K submachine gun. "Besides your .45."

Trumpet Heralds a Mission of Mercy

Denis made two trips to deliver the lot of us, cranking down the hole in the jungle like a swift descending a chimney. The whine of the chopper's jet engine summoned a few hill people out of the green wilderness. No outsiders were near, they said. They would come with us. The runner pointed the way, and our party set off with National Geographic photographer Dean Conger in the lead, at six feet two a giant of a man among these small, lithe mountainfolk.

Distant gongs sounded a soft reassurance, then were still. We walked in silence.

A long climb brought us to the summit of a ridge where a thatched house rested on the closest approximation to level land this crumpled country could offer. We paused while our guides spoke to the men of the place, who brought out a bamboo trumpet and sent a signal wailing away toward the higher ridges beyond.

"That is a secret message," said the runner. "It tells those who guard the woman that we come to take her out. Now they will not attack us."

Hampered by a leg badly swollen from a spider bite, I stayed behind as the group went

Flown to safety, the tribeswoman receives treatment for festering bullet wounds in her face, leg, and foot. The jungle clinic was set up by Panamin—the Presidential Arm for National Minorities. Its head, Manuel Elizalde, Jr., left, keeps a bedside vigil. The 34-year-old scion of a wealthy Filipino family, a Harvard graduate, holds cabinet rank in the government of Philippine President Ferdinand E. Marcos. Secretary Elizalde's appointment underlines the Marcos administration's concern for the island nation's oft-mistreated minorities.

on. Through gestures and pantomime I indicated to the residents of the ridge that their garden patch would be a good place for the helicopter to come if they would chop down the taller vegetation that fringed it. Smiling, they drew their fighting knives and cut wherever I pointed, destroying without protest their own most precious plants—banana, papaya, bamboo, hemp, even a few stalks of sugarcane.

I stripped off my undershirt and threw it down to mark the least lumpy section of our instant helipad, then hobbled back down the trail to signal Denis. In two minutes he came towering up out of the jungle below, caught my wave and eased onto the ridge while the tribesmen whooped and cheered. A few minutes later our advance party returned, the woman clinging to a young man's bent back (pages 220-21).

She was a pathetic little person, emaciated and clearly near death. Her face was disfigured by an infected wound, her ruined foot swollen and bleeding.

"It's good we do not have to carry her farther," said the runner. Careful hands lifted

EXTACHROME © N.G.S.

her into the chopper. Dean and two men joined her, and Denis lifted off. I waited on the ridge, watching a storm's rain curtain enshroud a peak some five miles away.

"It will be close," said one of the security men, shifting his submachine gun.

It was. The first chill drops of the line squall rattled on the leaves around us as Denis came skimming back through a pass and flared to a fast stop. We tumbled in, and he dived into the valley as gusts shook us.

I met the woman again in a clinic miles away (page 223). She lay quietly on the mattressless wooden cot. The runner who had brought us to her sat at her side and stroked her sunken cheek. Tears lined his own. Panamin Dr. Saturnino Rebong worked on her foot, his forceps tracing the bullet hole that pierced it.

"How is it?" I asked.

"It may have to come off."

"The eye?"

"Blinded."

"She does not cry or flinch. Does she feel pain?"

"She feels," he said grimly.

Lust for Land Pits Racial Brothers

I found Secretary Elizalde watching solemnly from a corner of the clinic.

"You can see that these tribesmen are only primitive savages," he said quietly. "You can see that they have no human emotions. So say some of my fellow civilized Filipinos. Well, we'll teach them their error. That is Panamin's task: not to educate the minorities, but to educate the dominant society. It will take a while. In the meantime, this is what happens. Just this morning we've received radio reports of more shooting, more deaths. Some west coast tribes report several hundred killed during the past few weeks."

Where, exactly, did all this happen? Who, precisely, were the tribesmen? Who the aggressors? Answers must be withheld pending legal actions now under way. But these are not very important questions. What is important is that this incident *did* happen, that similar incidents happen frequently in the Philippines' Wild Wild South, and—most important of all—that something is being done to halt this hideous fratricide. Fratricide, because the civilized concessionaire and the forest bowman are racially indistinguishable. Both are Malays or, better, Southern Mongoloids.

The land lust that induces today's violence

"Wild Wild South," as Filipinos call strife-torn Mindanao, resembles the American West of a century ago. The lust for wealth and the pressures of an exploding population spur expansion into tribal lands. But unlike the conflict between white and red men, here brother fights brother; most Filipinos stem from the same Malay stock. Much of Panamin's initial help has gone to the hard-pressed Higaonon, Mansaka, T'boli, and Ubo peoples.

Tropical tree house of lashed saplings shelters some fifty members of the Higaonon tribe deep in virgin rain forest. Wobbly catwalk, passing under a high-rise dormitory, leads to a central communal room. Traditionally, such breezy, swaying quarters were built as defenses against spear-wielding attackers from other tribes.

Dressed in banana leaf, a pig heads for a feast in a Higaonon *barrio*, or village. The Panamin-planned settlement provides a safe base from which tribesmen can farm nearby lands. Ultimately it will include a school, clinic, and homes for 500 Higaonons.

is a relatively recent development. For four centuries the rich lowlands seized by the Spaniards in the northern and central Philippines sufficed for them and the Hispanicized, Christianized native population. These regions were taken from their tribal owners with no more concern for territorial rights than was shown by the white conquerors of Indian-occupied inland America.

In Luzon, the great northern island which is the heart of modern Filipino culture, the wild mountain tribes in time adjusted to the new world close around them without entirely giving up their special identity. Their leaders became priests, businessmen, officials of the national government. Thus their lands became secure.

In Mindanao, too, one segment of the population has become almost as advanced technologically, and as sophisticated culturally, as the people of the Christian north. These are the Moslem Maranaos and Maguindanaos, who adopted Islam in the 14th century. Powerful fighters, living in highly organized communities, they were and are able to defend their basic rights, if not always to find acceptance for their ideology.

Pagan Ways Survived in Isolation

In the mountains of inland Mindanao the pagan tribes remained dominant. Spain never occupied their territories. Nor did the United States, which held the Philippines from the end of the Spanish American War in 1898 until the nation became independent in 1946.* The old ways of life continued. So, when the growing national need for cropland, lumber, and minerals sent more and more Filipino frontiersmen southward, the tragic confrontation of civilized adventurers and primitive residents occurred in Mindanao as it has elsewhere in Asia and in Europe, Africa, and both Americas. The drama is being played out in its classic and brutal form, but with one difference: Civilization is older now, and, conceivably, minutely wiser. It breeds not only exploiters but also dedicated, courageous men to whom the conservation of the natural world includes the conservation of natural man.

Panamin is the expression of the Philippines' new national conscience. Elizalde and his colleagues, working under a franchise given by a concerned President, are taking the first steps to establish the rights of the

*See "The Philippines, Freedom's Pacific Frontier" by Robert de Roos, GEOGRAPHIC, September 1960.

Hero among the Higaonons. Manpatilan enjoys a freedom he almost lost forever. Accused of murdering several lumbermen after they raped and shot members of his family, Manpatilan hid for two years until President Marcos gave him amnesty. Here, during a tree-house feast, the *datu*, or chief, exhorts a gathering of his people to maintain their self-respect. He noted proudly that the author and the photographer had come halfway around the world to visit the Higaonon people.

tribesmen they classify as national minorities.

Appropriately, Dean and I first met Secretary Elizalde in a jungle so primeval, among a people so unadulterated, that we might have traveled to them by time machine rather than by helicopter. In the course of a single brain-spraining day we had been transported by a series of aircraft from the luxury of a modern Manila hotel southward over seas and islands to Mindanao and, finally, across the incredible canopy of mottled green that marks virgin rain forest, the climax condition of earthly vegetation. Deep in that vivid wilderness we were set down in a secret spot to which civilization had never come. There, on the Maasam River (map, page 225), a branch of the Higaonon tribe—the "Mountain People"—follow a way of life older than Western civilization.

Villages Few Where Land Was Free

A dozen men stood waiting for us, Higaonon leaders, dressed in the costume of the tribal elite: black trousers and blouses decorated with appliqué patterns of red and white. Each shook our hands gravely. Only when they had finished did Elizalde present himself. The helicopter roared away and we headed upstream.

"We'll be staying in the home of a local subchief a couple of miles from here," the Secretary said. "You'll see how people have lived in Mindanao's forests since the first Malay migrants reached the Philippines.

"For one thing, there are still few villages here. These are not village people. They're as much hunters and gatherers as farmers. They spear and trap wild pigs and deer and monkeys, and collect roots and honey and edible leaves and insects. To grow their domestic crops—corn, upland rice, sweet potatoes, taro—they slash and burn small clearings, farm them until the rains have leached away the good of the soil (usually in three or four years), and move on.

"Land has always been free for the taking. The forest seemed endless, and within the tribal territory no one owned any particular piece. Now the newcomers who want these mountains claim that the tribes have no rights to any land at all because they have no fixed residence.

"So the Higaonon and other tribes have begun, with our help, to build *barrios*—permanent settlements—where their forests adjoin the Christian-owned lands. These people welcome new ideas. They want progress; but they want progress with pride."

He splashed along for a moment, then noted casually, "You'll pick up leeches here. Be sure to let the people of the house show you how to get them off later with red-hot embers. Don't pull them off; their heads will stick in your skin and cause infection.

"I was saying the Mountain People want progress with pride. But we haven't yet convinced the civilized world that our minorities have the right even to exist."

He spoke quietly, but the phrase hit hard.

We waded in silence up the lovely watercourse where cool, clear water swirled over smooth stones. Butterflies glittered over the tumbling ripples. Dark tree trunks rose naked and unbranching to a hundred feet or more, and vines hung from the lofty canopy. The filtered light that reached us was an emerald radiance.

"This is the most perfect forest I've ever seen," I told him. "I hope it can stay this way."

"It will. The President has told the loggers to stop right where they are. And that's four days' walk from here."

Notched Log Leads to Tree-house Haven

A side trail no outsider would have spotted led straight up the near-vertical right bank. A five-hundred-foot climb through the forest brought us to the base of a steep-sided scalped ridge, accessible by logs felled across small ravines. The house cluster perched on the ridgetop, high above the ground and supported by severed trees and piles (page 224).

The place was built not only for pleasant living but for defense. Its floor of saplings was high enough to protect those who slept on it from the spear thrusts of an enemy underneath; the access paths across the logs would present attackers to defending spearmen and bowmen like ducks in a shooting gallery.

We climbed a notched log that led into the

Content with timeless fashion, this Mansaka maiden wears a silver breastplate—an ornament that identifies the women of her tribe. Largely brought under Panamin protection, her people show a heartening selectivity toward modern ways: While adopting productive new crops and efficient tools, they maintain their own cherished arts and costumes, gods and traditions.

EKTACHROME © N.G.S.

structure. Smiling women motioned us to a slightly raised platform at the far end.

An old lady knelt before us and prepared betel-nut chews of powdered lime, betel leaf, and pieces of the nut itself. I have yet to isolate the charm of betel-nut chewing, but it is a social amenity not to be denied, and it is not unpleasant. The mouth fills with scarlet saliva, but the floor of spaced split saplings provides a means of getting rid of it. This floor was stained a not unattractive pink from hundreds of near misses.

Black Teeth Distinguish Man From Beast

I sat back, chewed, spat, and smiled redly. My hosts did the same, revealing the filed and blackened teeth which, in their aesthetic, differentiate man and beast. Though it was not mealtime, mounds of fragrant rice were brought on clean wild-banana leaves, along with bits of grilled chicken. Of salt, the most precious comestible in the deep forest, there was none. I resolved never to go visiting again without a sack or two for my hosts.

Rice grains fell from my inept fingers, but continued through the flimsy flooring to delight the half-wild pigs and chickens below. Water was passed in green segments of bamboo. As I glanced about this shaded breezy shelter I found, to my delight, that if I looked straight at anyone of any sex or age, I got back a smile.

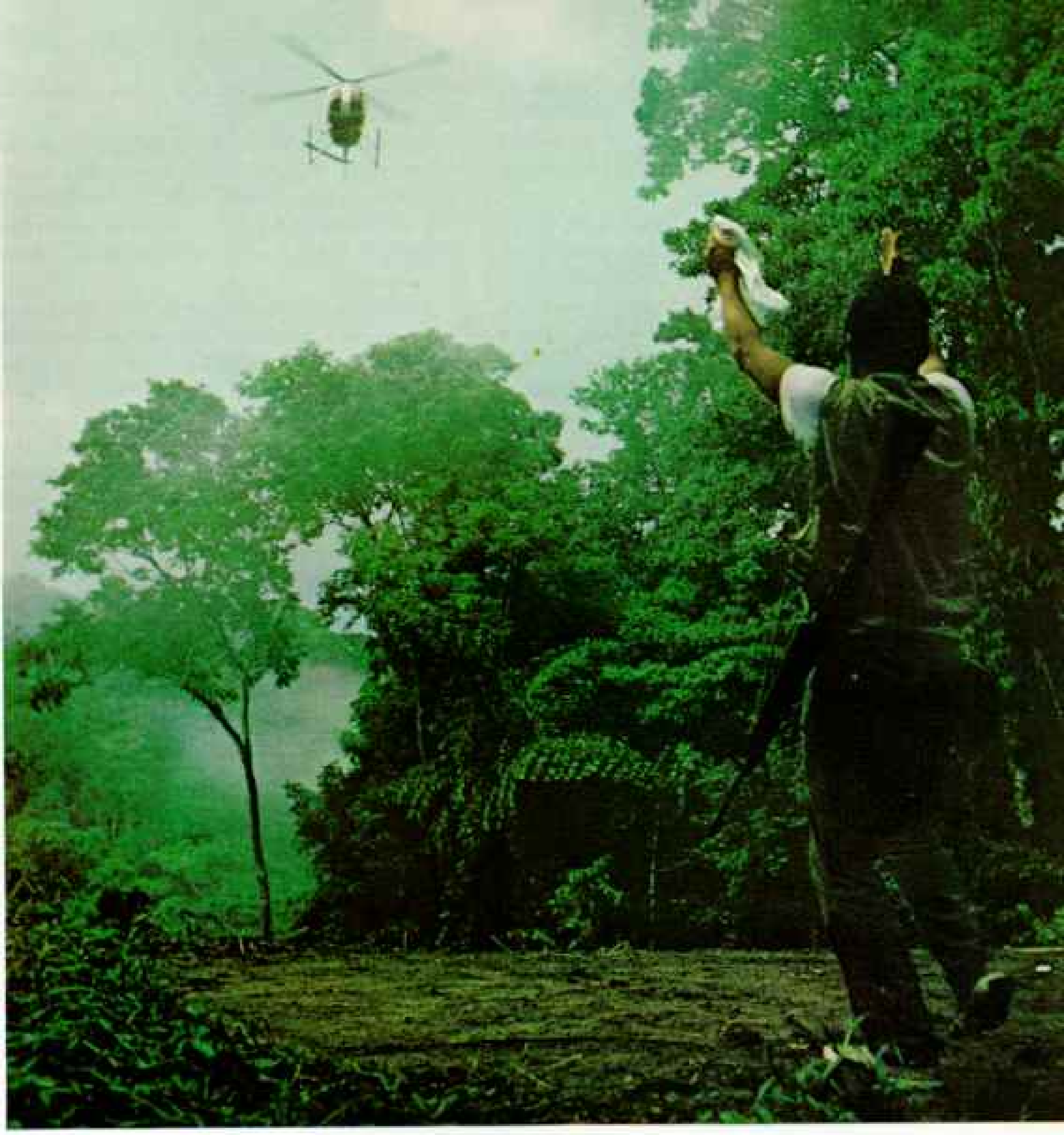
"I've told them you come here because you care about them," said the Secretary. "They don't understand that, but they're pleased."

I had felt at once the charm of this curious tree dwelling, so high and safe and sheltering, filled with the magic of a child's secret hiding place in some enchanted wood. But now I began to take stock of its ingenious design.

A single thatch-roofed platform served as the main chamber. Woven walls kept people in without rising to the roof to cut off the flow of air. Low platforms at one end and along both sides were marked off by dividers into family areas—the word "room" would not apply, for no screen or hanging separated one section from another. Near the middle of the structure a square box of earth served as a fireplace. Here women tended pots of boiling rice, and small yellow dogs, huddled in the ashes, waited for some scrap to fall.

Cradles on springs of wood bounced babies to sleep, but otherwise there was no furniture. On the walls and across the rafters (set, unhappily, at throat level for the likes of Dean and me) were digging sticks, spears, poles, baskets, looms, and containers of corn and rice. Boar's jaws hung near the fire as expressions of gratitude for many a feast, and a sacred offering vessel swung nearby, containing sacrifices to the spirits who control the courage of hunting dogs.

Wildly wobbling causeways of the slenderest saplings connected this tropic equivalent of a baronial hall with several tiny houses, perhaps six by eight feet, in which related families dwelled. The smallest of these swayed visibly on limber supports well above the roofs of the other dwellings. The entire complex was an interconnected structure, and even a small motion in any part of it could be felt everywhere else. The flop of a rooster's wings, I discovered at four o'clock the next morning, set the whole place to vibrating. And what held all this together? Not a screw,



The indispensable chopper: Waving a handkerchief (**above**), an aide guides a Panamin helicopter to an instant helipad, cleared for the occasion atop a remote ridge. Only a copter can cope with the rugged roadless region.

Happily afoot after her frightening first flight, a T'boli girl (**left**) beams as Secretary Elizalde helps a companion from the aircraft.

Datu Ma Falen, in the window seat, and a turbaned Ubo chief (**right**) get an unaccustomed view of their jungle. Rings hang in rows from their pierced ears. Elizalde often travels with chiefs to allay tribal suspicion of outsiders.

not a nail, not a twist of wire, but elegantly made wrappings and bindings of split rattan. Feather-light and flexible, the tree house could resist all but the most violent storms or earthquakes.

As the afternoon wore on, household chores were tackled with no apparent system, yet the work got done. Groups of girls, sometimes aided by a boy or two, stood around the communal rice mortar and pounded the brown grains to break away their husks. Women winnowed the dusty mass in flat baskets, separating chaff from kernels. A young mother turned the corn grinder, consisting of two millstones, one on top of the other; I had seen the same device in the ruins of Capernaum in Galilee, where Jesus taught. A baby played in the fresh meal.

Between tasks the tree-house people watched us with as much fascination as we watched them. Many of them, we learned, had never seen a foreigner, or even a Filipino. Some had never even seen a powered vehicle or a road.

Though I could not understand the words being spoken around me, I sensed that there was something remarkable about the relationships between the speakers. Suddenly I knew what it was; no sound or sign of antagonism soured the serene atmosphere of the tree house. Here fifty or sixty related people functioned as a family, and a fond one at that.

Babies born into such a community grow up knowing who they are.

Darkness fell with a suddenness possible only in a country of tall peaks, high trees, and low latitude. We ate again, this time the flesh of a pig speared in our honor. The ranking men of the household joined us while the rest watched. A torch of leaf-bound pitch lay on the palm-wood floor, tended by an occasional casual toe.

There was comfort in the closeness of others as night closed upon the lovely lethal jungle, where cobras now stalked roving rats and pythons thick as a man's thigh lay in wait for pigs and deer. These and leeches, venomous insects, and poisonous plants would threaten any human who walked the leaf-scented darkness in which soul-devouring evil spirits hovered hungrily near traps set by men to kill other men.

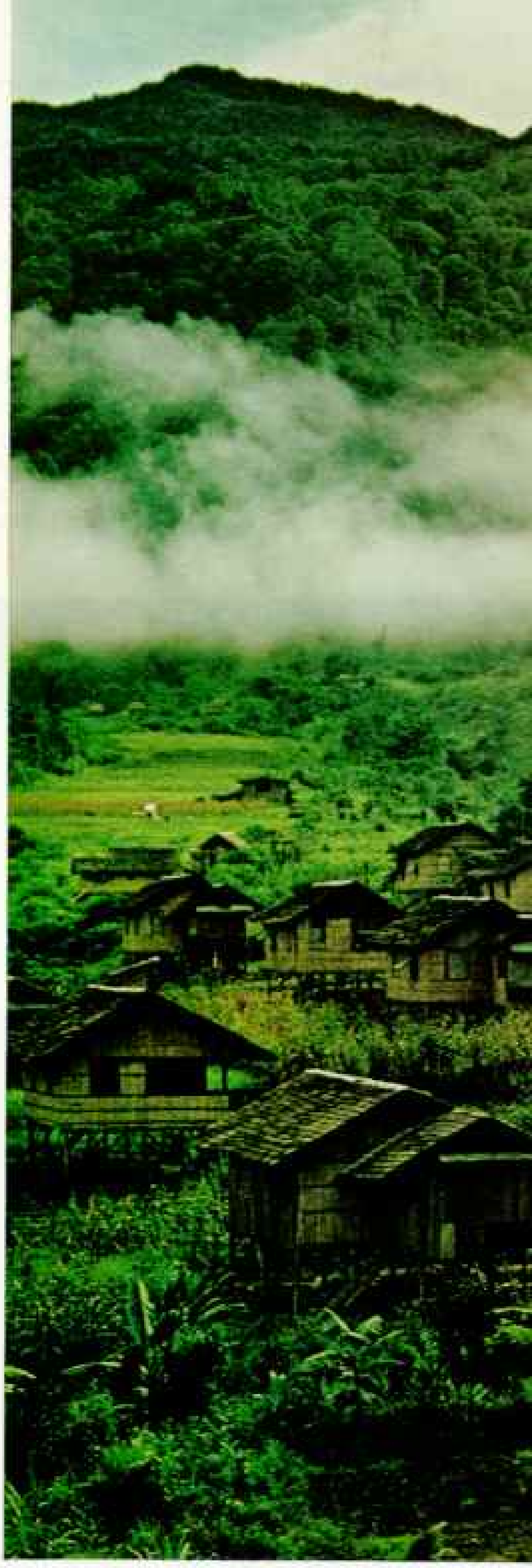
Later the old men sat in a circle, making a place for Elizalde and his interpreter.

Oratory is an art form among the Higaonons. Their serious arguments are sometimes conducted in strictly metered verse. The greatest *datu* (chief) of the region, Manpatilan (page 227), made an address whose eloquence was obvious even to me, if its meaning was not. Datu Manpatilan, I knew, had hidden for two years in the forest, accused of killing several lumbermen after they had raped and murdered his granddaughter and

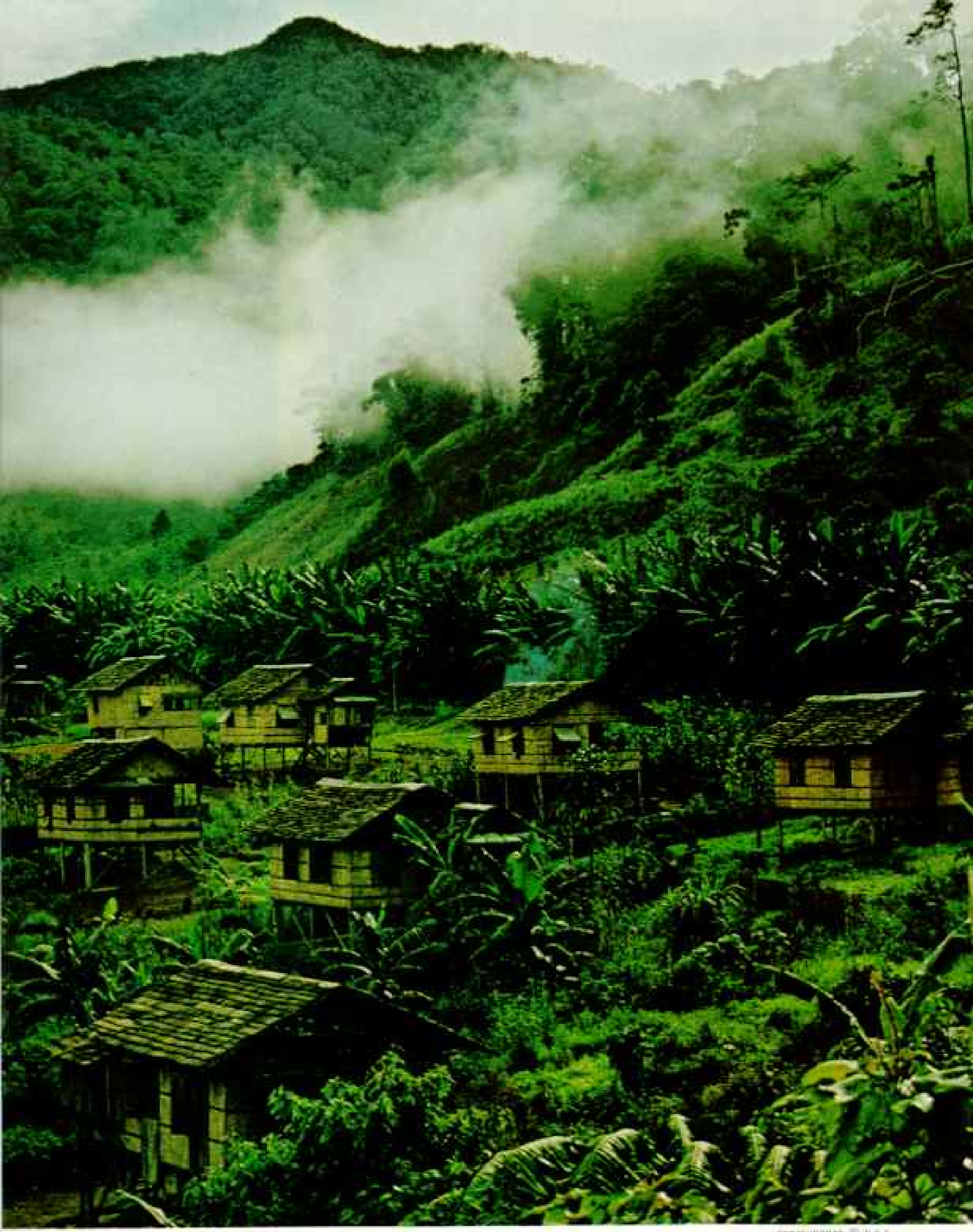
KODACHROME © N.G.S.

Life's rhythm flows unbroken in a neat Mansaka house. A woman cleans raw cotton, left, while another spins the fibers into thread. A girl in a hammock searches for lice in a youngster's hair. Skilled weavers and dyers, the Mansakas painstakingly make their own colorful skirts, but often buy cloth for their blouses from traders.

Like most of Mindanao's tribes, the Mansakas both forage and farm. In the forest they find edible roots and fruits, and hunt monkeys, birds, and wild pigs. Slashing and burning jungle clearings, they raise rice, corn, taro, and sweet potatoes. After a few years, grass and weeds encroach upon the land, and it becomes sterile as rains leach away nutrients. Then the family moves on to burn and clear again elsewhere.



Feast-day finery of their own design adorns a Mansaka trio whose barrio turned out to greet a Panamin mission. The agency gives them beads to string in traditional patterns, then markets the elaborate necklaces in faraway Manila.



Guiding hand of Panamin leaves its mark in neatly spaced huts of a Mansaka barrio. The two-year-old village already contains a school, clinic, co-op store, and beadworking shop. By drawing the forest people together, the barrio strengthens their will to resist encroachment. Panamin never compels settlement, insisting that the tribes be allowed to adopt civilization at their own pace.

Fiery dawn highlights the funeral of a T'boli. As a last act, tribesmen burn the dead man's hut so it cannot shelter his soul. Otherwise, they believe, malevolent spirits would gather there to devour it.

niece, shot his son, and killed another youth. Through Elizalde's good offices Manpatilan had agreed to surrender to President Marcos. Elizalde flew him to Manila, where the President heard his story and gave him amnesty.

Even in the strange and overwhelming world of the presidential palace at Malacañang the jungle-bred chieftain displayed wit and diplomacy. After being shown the magnificent mansion he said:

"Datu President, when I first saw your house, with its many great rooms, I told myself that if I had such a house I would have a wife in every one of those rooms. But now that I have met your lovely wife, I understand why you have only one."

Now the old man was free, and able once again to deal authoritatively with tribal problems. Orange torchlight glinted in the dark eyes fixed respectfully upon him.

Then Elizalde spoke, quietly and without flourish. "I have an old book that tells how the Spaniards came to the Philippines more than four hundred years ago. They came to Luzon in the north, and soon conquered the lowland tribes there. Then they came southward to the middle islands, the Visayas, and again conquered the people. They had no

In night-long rites, T'bolis trot the dead man around and around his hut. Gallery of relatives pays tribute with music and song. As a gesture of respect, the body has been allowed to repose in the log coffin for 15 days. Rituals interspersed with both gaiety and laments go on until dawn. Then mourners carry the coffin to a bamboo grove and lash it high in the stalks, where it will stay until it falls apart.

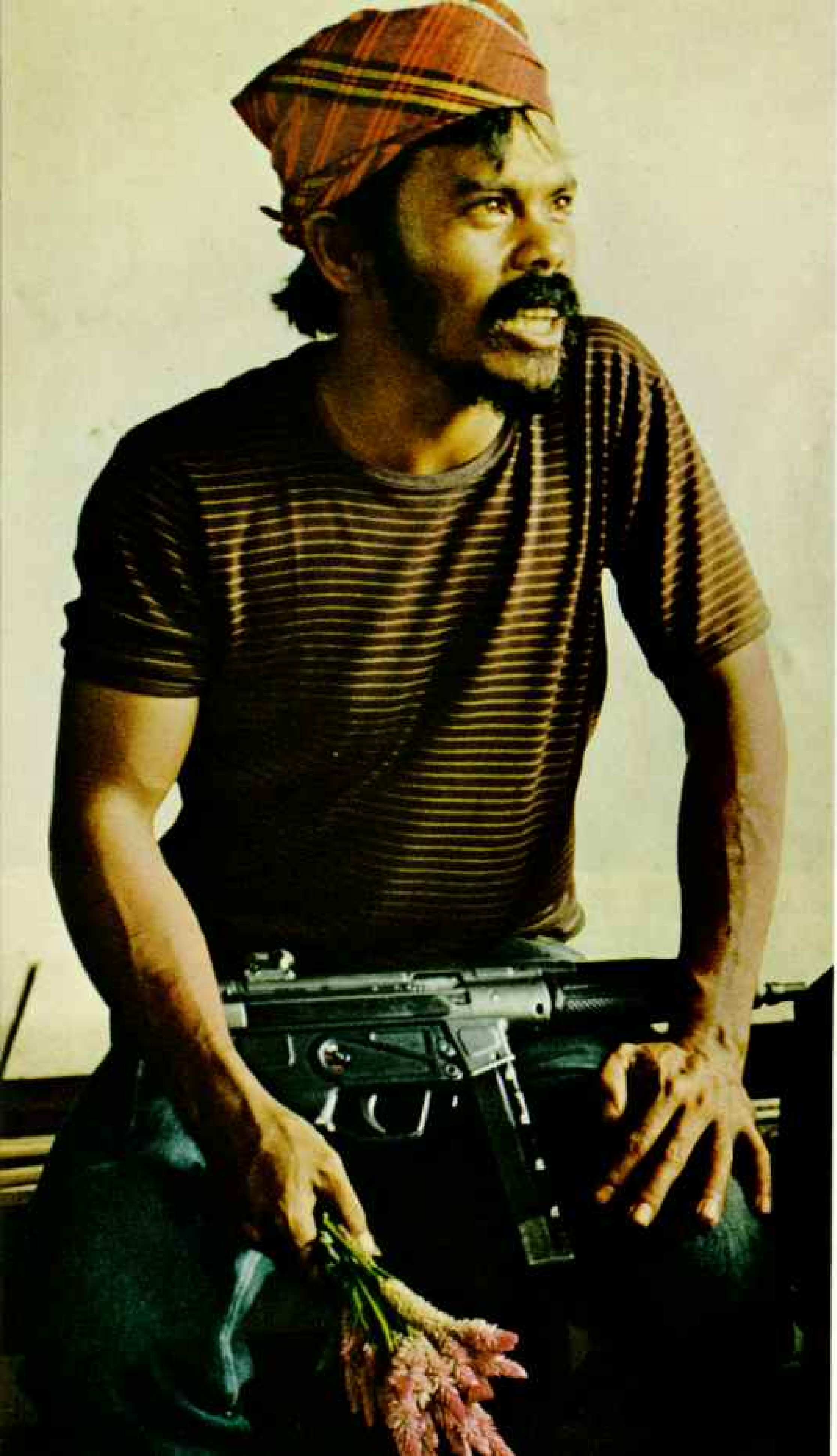
admiration for these tribes. At last they reached Mindanao and found there a great people, wearing beads and bells and bracelets." He glanced around at the bells, beads, and bracelets of his audience. "They could not conquer them. Instead, they praised them.

"Do you know who these people were? I will tell you: They were your ancestors. Spain never conquered you, nor the United States, nor Japan. Remember your old greatness. Never lose your pride as a people. If you do, then nothing can be done for you.

"Live in peace with the Filipinos; you are really Filipinos too. But do not accept abuse. Demand respect. You'll get it if you respect yourselves. But if you throw away your customs simply to imitate those of the Christians, you'll be shadows, not men. Who respects a shadow? You'll be beggars in your own lands."

"Taho! Taho!" muttered the old men. "Hear! Hear!"

Midnight was near. Families retired to their own sections and platforms. We spread our bedding on the floor. As we stretched out to sleep, an elderly woman, emaciated by tuberculosis, came close to play for us on a little one-string violin. Every voice hushed as the Mountain People lay listening to



music older than all the wonders of the West.

We flew out of the forest via the new Higaonon barrio site at Salug, near the loggers' road. Panamin Project Director Antonio Perpetua described the community-to-be.

"We will build a center here to offer medical care, education, agricultural advice. The President has given the Higaonons 44,500 acres, which will provide 2,000 families with about 22 acres each. It's a start. When the people have shown what they can do, we hope to get land for the rest of the tribe. Many will prefer their *kaingins*—their forest clearings—to village life. But the barrio will serve all."

The kind of central settlement now a-building in the Higaonon lands has existed for two years among the Mansakas, 125 miles away in eastern Mindanao (pages 234-5). These handsome, courteous people have held proudly to their way of life, but have borrowed what has seemed to them worth borrowing from the dominant society. Their women are resplendent in beads, bells, and silver breastplates, over beautifully woven cloths of their own making (page 229). Their conical hats are deftly decorated. They are expert with every native instrument—the violin, the flute, the two-string lute, the five-string bamboo guitar, the bamboo jew's harp, the gong, and the drum.

Ginger Adds Flavor to Sugarcane Beer

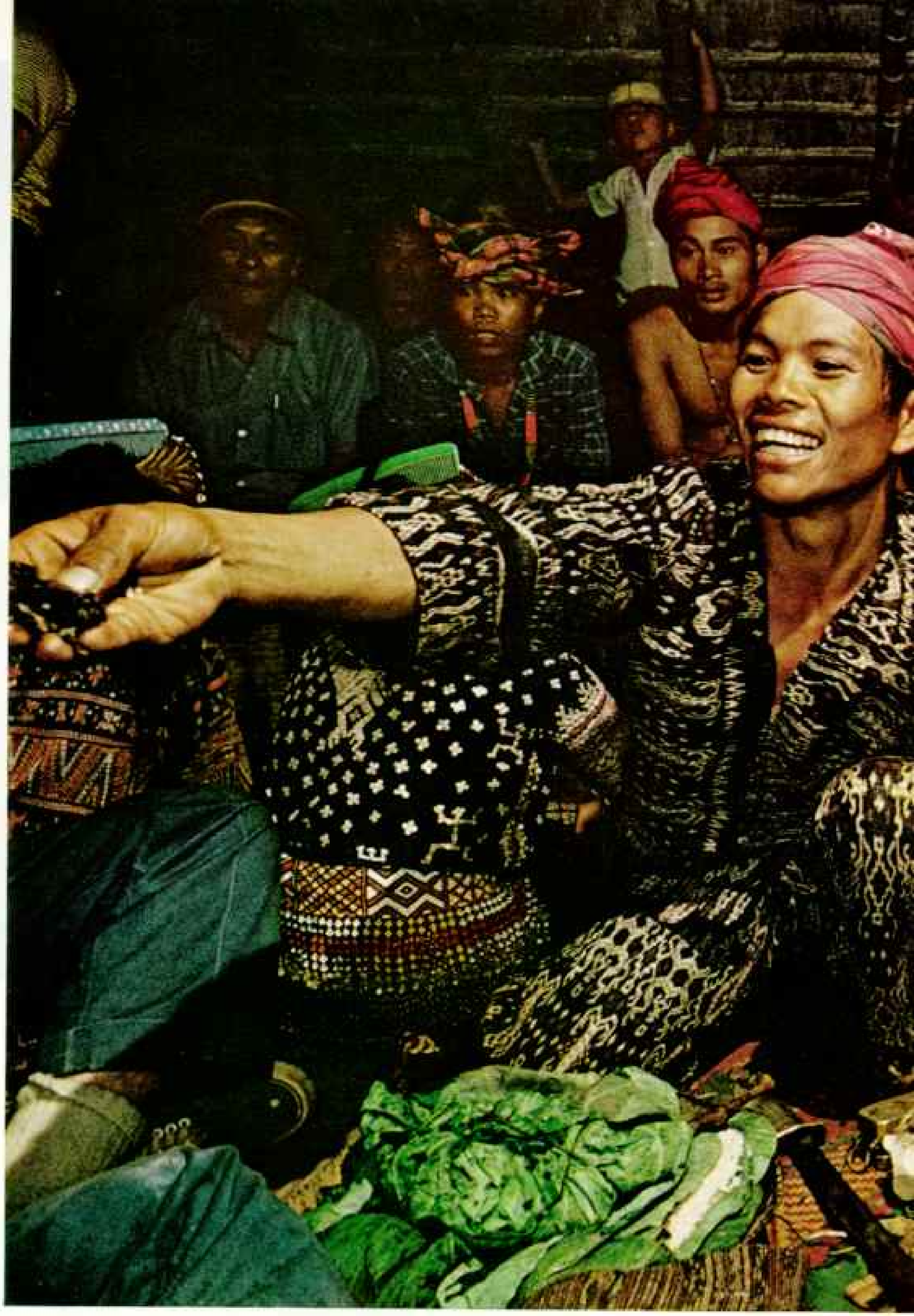
We arrived to find a great feast laid on for us beside the small river that waters the Mansaka lands. Rice boiled in green segments of bamboo. Wild pig browned over blinking embers. Chicken sizzled over coals or boiled in suspended pots. Crayfish taken from the stream were toasted for us on twigs. Later, sugarcane beer seasoned with ginger was passed in bamboo cups topped with wood shavings to keep insects out.

We visited an immaculate stilt house, roofed with shingles hand-fashioned with long-bladed knives. The owner approached me, kissed me, and touched my beard. Then he said, through a lovely young woman who had learned English at a missionary school: "I have never seen such an individual as you, with your red face and white beard, and I will dance and sing and do anything to entertain such a curious person as you."

He did. Later, in another house, a woodcarver gave me one of the Mansaka household gods, made only for the homes of the tribesmen. He said simply, "Now, on your way, take our god so he will guide you back to your place."

Proving their manly courage, T'boli youths place lighted pieces of wood on their arms, then try to sit impassively as the embers burn toward the skin. As heat sears his flesh, a lad ducks to hide his pain (**lower**). When a man dies, burn scars supposedly light his soul's way to heaven.

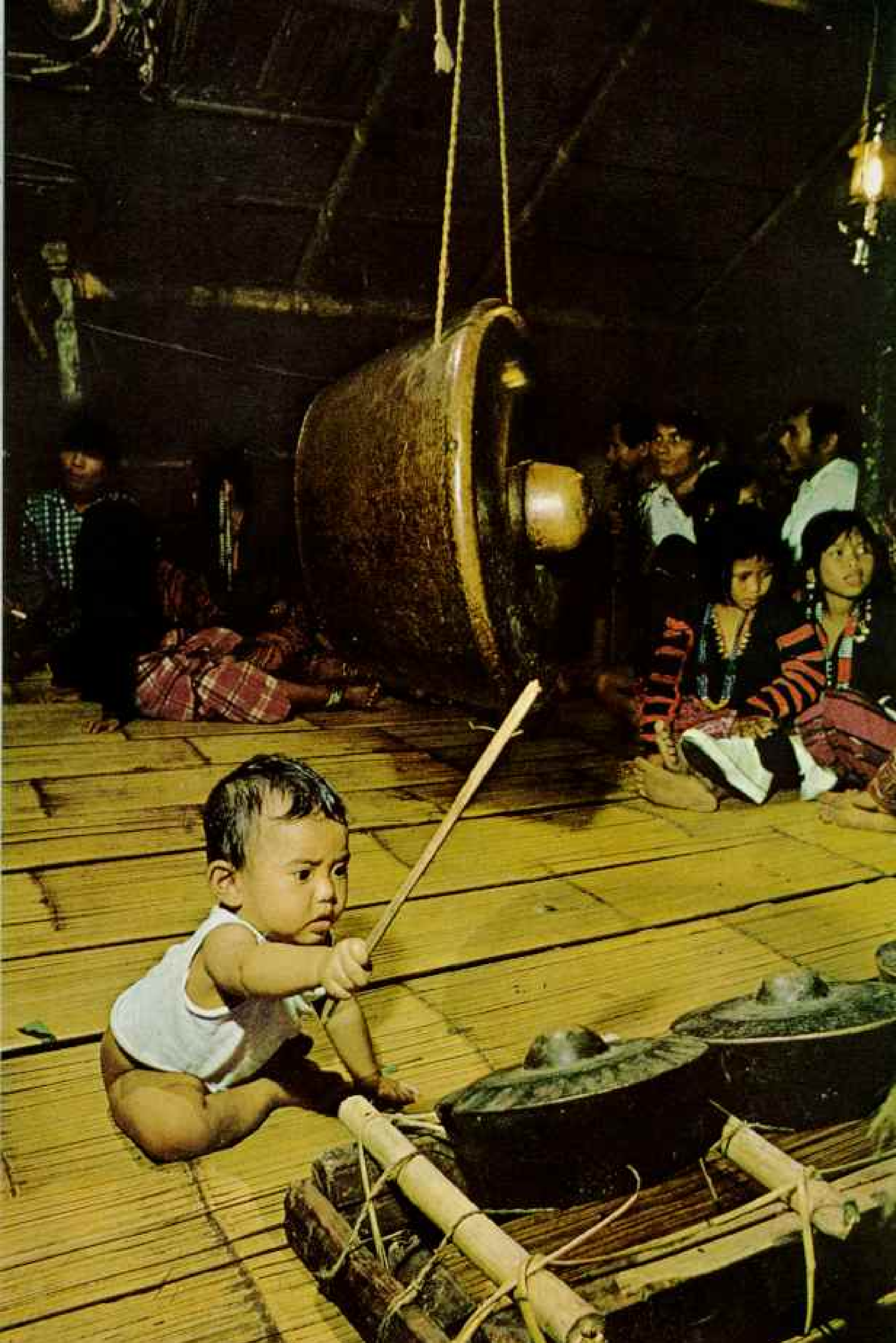
Tenderness and toughness merge in T'boli leader Mai Tuan (**opposite**). Fluent in English and five tribal languages, he gives vital assistance to Panamin Agency officials and their tribal aides must arm themselves against the ever-present possibility of ambush by gunmen hired by encroaching settlers and prospectors.



On nature's throw-away plates, T'boli women serve rice at a wedding banquet, one of many social occasions at which the Geographic team was welcomed. The host, resplendent in a suit of woven abaca fiber, offers handfuls of chicken, pork,

KODACHROME © N.G.S.

fish, and rat. As music reverberated and dancers swayed, the bride and groom sat solemnly to one side, all but ignored. T'boli men normally take several wives, but few of their many children survive the jungle's cruel toll.



We saw a clinic, a school, an all but empty co-op store, a beadworking shop, and 137 neat thatched houses.

"This is a good, well-functioning barrio," said Elizalde. "But it is a special case. The territory these people occupy is small, and I was able to persuade the loggers who work part of it that they would be better off if they stopped abusing the people.

"Our great success story—*the* great success story—is that of the T'bolis and their neighbors, the Ubos. The success is theirs. We only advised. Tomorrow we will go to the T'boli barrio. The people are expecting us. It should be quite a reception."

Learn to Read—Then Cast a Vote

Skimming the treetops, the helicopter whisked us across the south end of Mindanao and into an open valley back of the western mountains (page 231). A great crowd had gathered, not only of T'bolis in from the hills but of other tribesmen come to confer with the Secretary and see his foreign companions.

It was indeed quite a reception. As we climbed out of the copter, a good two thousand beaming, cheering people bore down on us, kissed our hands and faces, embraced us, or simply reached out to touch us as if to exchange small charges of magic. Whooping and hollering, they swept us along to a big open-sided building. ("They built everything here themselves," said Elizalde. "All we provided were a few ideas and some materials.")

For more than an hour big gongs and small ones joined with the rattling of drums and the tinkle and clash of the dancing girls' brass bells, earrings, bracelets, and anklets. Then we went on to see the rest of the barrio center.

At a small clinic, the most modern of drugs rested on homemade shelves and patients on homemade cots.

"Panamin began its work here and elsewhere in the Philippines by simply offering medical services," said one of the staff doctors. "We treated 70,000 people in our first year. Many here have respiratory diseases and malaria, also deficiency diseases; the diet of rice and a little meat is not well balanced. Infant mortality is high. Still, we save lives. We make progress."

In a simple schoolhouse two Christian ladies taught grades one and two in English, the most widespread language of the Philippines. "In time we will have T'boli teachers, so the children can learn in their own language," said Elizalde. "But they will still be taught English, and Tagalog, the national language. Then they must be allowed to vote. As illiterates, they are not."

"The barrio gives the T'bolis an anchor," said Project Director Juan Artajo. "They may be scattered through the hills but they know this place is theirs and that they are safe here. They may come for medicine or schooling, or for advice. Our lawyers counsel them here, and tell them of rights they didn't know they had. President Marcos has given them 13,000 acres, and surely more will be returned to them, for they have nowhere to go."

"And they won't move," added Elizalde. "Give a people a center, and they stand fast."

"We Listen, We Give Confidence. . . ."

At the project staff house, the Secretary and four Panamin lawyers met with leaders of local groups to discuss their problems. He talked to them through the brilliant young T'boli leader Mai Tuan, who speaks English and five tribal languages (page 238).

All afternoon delegations from the hill tribes came to sit quietly on the floor and ask advice or complain of wrongs: shooting, land theft, arson, rape. The attorneys asked questions and made notes.

"All this is essential," said Elizalde. "We listen, we give confidence, and sometimes we manage to right a few wrongs. But when the last of the troubled voices has spoken, to say 'we are being cruelly treated, and we do not know why,' I need to get back to the true tribal life deep in the forest. I need to stay for a while in a place like our Higaonon tree house to remind myself of what this struggle is all about.

"I think we'll copter up over that northwestern ridge to visit my friend Datu Ma Falen, a great chief of the Ubos. I'll send a runner to tell him we're coming."

The helicopter flew over ridges where thatched huts stood alone near small clearings. Forest grew thick in the valleys, but the highlands, stripped of their jungle cover, were mantled with pale cogon grass on which

Would-be soloist at a T'boli gathering makes his debut on a battery of gongs; orchestras of these music-loving tribesmen also include flutes, guitars, jew's harps, drums, and one-string violins. Slipping easily into adult activity, children grow up in the warmth and security of acceptance by large family groups.

eddying winds made fluid patterns. Datu Ma Falen's encampment—you couldn't call it a village—consisted of some eighty shelters set at random in an area of fifty acres or so (pages 250-51). It was called Datal Tabayong —Home in the Clouds—but despite its idyllic name the purpose of the grouping was defensive. There were enough Ubos there to put up strong resistance to any attackers. The inhabitants were comparatively safe.

Protest Leads to Unprovoked Attack

Ma Falen had good reason to worry about security. Some months before, a group of armed men had come to this hill (there were only four houses on it then) and machine-gunned his home. His 15-year-old daughter was killed, along with his 5-year-old niece. A woman was badly injured.

Why? Ma Falen did not know. Nothing in the philosophy of his people could account for the cold-blooded killing of innocents.

"Ma Falen had hosted a meeting of datus at which a message to President Marcos was prepared specifying abuse by settlers and other newcomers and asking for his help," Elizalde told me. "I delivered it. Soon afterward local authorities brought trumped-up charges against Ma Falen. The police attacked without warning. Two constables were killed.

"I persuaded Ma Falen to surrender to an emissary of President Marcos, who came by helicopter to take him to Manila."

Later, in Manila, the President told me of his conversation with Ma Falen.

"Why did you kill the constables?" he had asked. "Datu President," said Datu Ma Falen, "you are a brave man, a great fighter. If armed men had come and murdered your daughter and others of your household, I think you would have killed more than I."

The President did not disagree. "I felt that Ma Falen had been done a grave injustice," he told me. "He fought back, as befits a

In a savage pas de deux, stallions fight before an audience of Ubos. To provoke combatants for this favorite tribal spectacle, men introduce a stallion to a mare in heat, then bring out a second male to arouse the jealousy of the first. Holding the enraged animals on long leashes, handlers pit them in an encounter that resounds with the thump of hoofs against ribs until one of the horses backs off, usually uninjured.

The duel took place at the encampment of the powerful Ubo chief Ma Falen during a visit by Elizalde (**below**).

Skewered chicken tempts Elizalde and Ye Ellin, eldest of Datu Ma Falen's four wives. Treasured bracelets and rings line her arms and fingers, and anklets bespangle her legs. The pair dine at a feast laid out by the chief to honor his Panamin visitors—a spontaneous salute repeated wherever the Secretary travels.

Leader of the Ubos' efforts to hold their lands, Ma Falen has tasted the bitterness of the struggle: A few days after he joined in a protest to the Philippine President, a band of heavily armed men machine-gunned his house, killing his 15-year-old daughter and another child, and seriously wounding a woman.

warrior." The Ubo chief came back to his forest a free man.

After a warm reception by Ma Falen and a wild one by cheering tribesmen on the hilltop, Elizalde and I walked to where rank weeds marked the site of the datu's machine-gunned house. It had been burned, as are all houses in which death occurs. Bits of Ming plates, ancestral treasures of the family, lay where they had fallen on the hard ground.

"The murdered daughter is buried there," he pointed to a little enclosure of bamboo stakes. "Another child, a pretty little girl, came afterward to pick up the shiny cartridge casings. Then she remembered what they were. They found her sitting on the ground with her lap full of brass shells, crying."

I could think of nothing to say, and had no voice for speaking.

Stallion Fights Highlight a Welcome

We went slowly up the slope, reluctant to join the boisterous crowd at the summit. Drums and gongs were already sounding, playing an accompaniment for two women as they made a dance of their rice pounding. Little boys threw tops. All the women wore their best embroidered blouses and as much brass and beadwork jewelry as they possessed. Some had reddened their lips and accented their eyebrows with blue-black stain.

Men wore the superb brass-handled swords for which the Ubo smiths are famed, and many carried spears, unstrung bows of black palm, and poisoned arrows covered by reed sheaths. Long hair and breechcloths marked some of these as people just in from the depths of the forest.

In Ma Falen's new house we found about as many people as could sit on its floor—say, about 75 in a space roughly 15 by 35 feet. Visiting datus and their families were paying their respects to Ma Falen and his four wives. The eldest, Ye Ellin, sat cross-legged on her part of the sleeping platform, very pregnant, beaming, and cute as a button. She was gussied up in her finest finery, with two coiled brass rings on every finger and another set on her toes, along with the usual anklets, bracelets, necklaces, and earrings (page 245). She embraced Elizalde fondly and kissed me politely on the cheek.

"She is a great lady with the innocence of a child," said Elizalde. "If she is hurt or unhappy, she cries. If she is pleased, she laughs. She does not show anger or hatred."

We chewed betel and ate a little food, as is customary. Then the sound of whoops and cheers brought us outside to watch the graceful and largely bloodless violence of stallion fights, the favorite spectacle of the Ubo and T'boli people (pages 244-5).

Later, wandering at will through the loosely clustered houses, I watched women weave cloth and baskets, make pottery, fashion exquisite links of horsehair for ear ornaments. Near one house men carved lutes out of solid logs. Near another, an emaciated metalworker made marvelous castings—bells, sword hilts, hollow bracelets—in molds formed by wrapping clay around intricately carved wax models (page 249). Later the wax melted as the clay was fire hardened, leaving negative impressions to shape the molten metal as it was poured in.

Swords Have One Soul, People Two

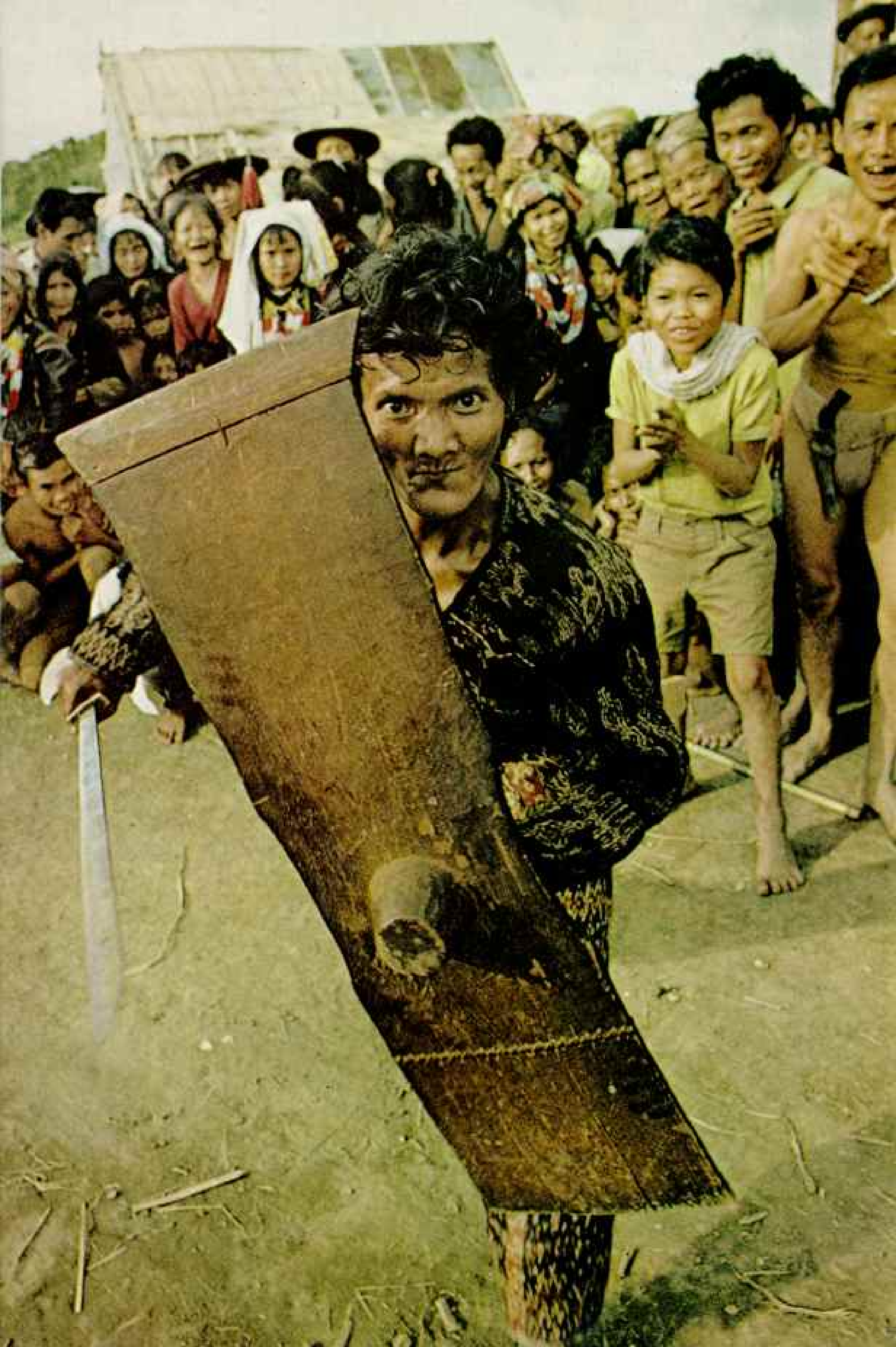
I learned a curious and wonderful thing about these people and their artifacts: Once an object is completed, it has a soul (people and large animals have two). For that reason it hurts them to sell what they have made.

In a clearing a man and his wife planted taro shoots, he making the hole with a digging stick, she inserting the bit of root. Around them high stumps stood stark and black in a clearing, while logs fell apart under the onslaught of termites and decay.

Hunters, having proven their skill in an archery contest on the hill, took bows and spears and went into the forest after game. I knew better than to follow them. If their dogs found game and gave chase, they would run where I could hardly walk. I would be left alone. And I had no wish to follow any mountain trail without a guide. On a recent excursion to a nearby cave, where the T'bolis had used wicker rackets to down dozens of delicious little bats (batminton?), Mai Tuan had shown me traps designed for every animal from mouse to man.

(Continued on page 253)

Curiosity overcoming her shyness, a Ubo girl intently examines the photographer, whose beard, fair skin, and six-foot-two frame evoked amazement among the small, lithe tribesmen. Densely woven bib of beads fastens to the youngster's earrings.



From a crude forge, a work of art. With craftsmanship nurtured for generations, Ubos fashion ornate brass sword hilts, each wrought in the finest detail (**left**). As an artisan adds embers to his fire (**below**), a woman works moplike pistons inside twin bamboo cylinders. These force air through pipes to fan the fire and melt the tough alloy in a crucible buried under the coals.

To mold their famed hilts, Ubos employ the ancient lost-wax process. Carving a facsimile in beeswax, they cover it with clay, which takes on the intricate pattern. Then they heat the clay and pour out the wax, leaving a cavity to receive the molten brass.

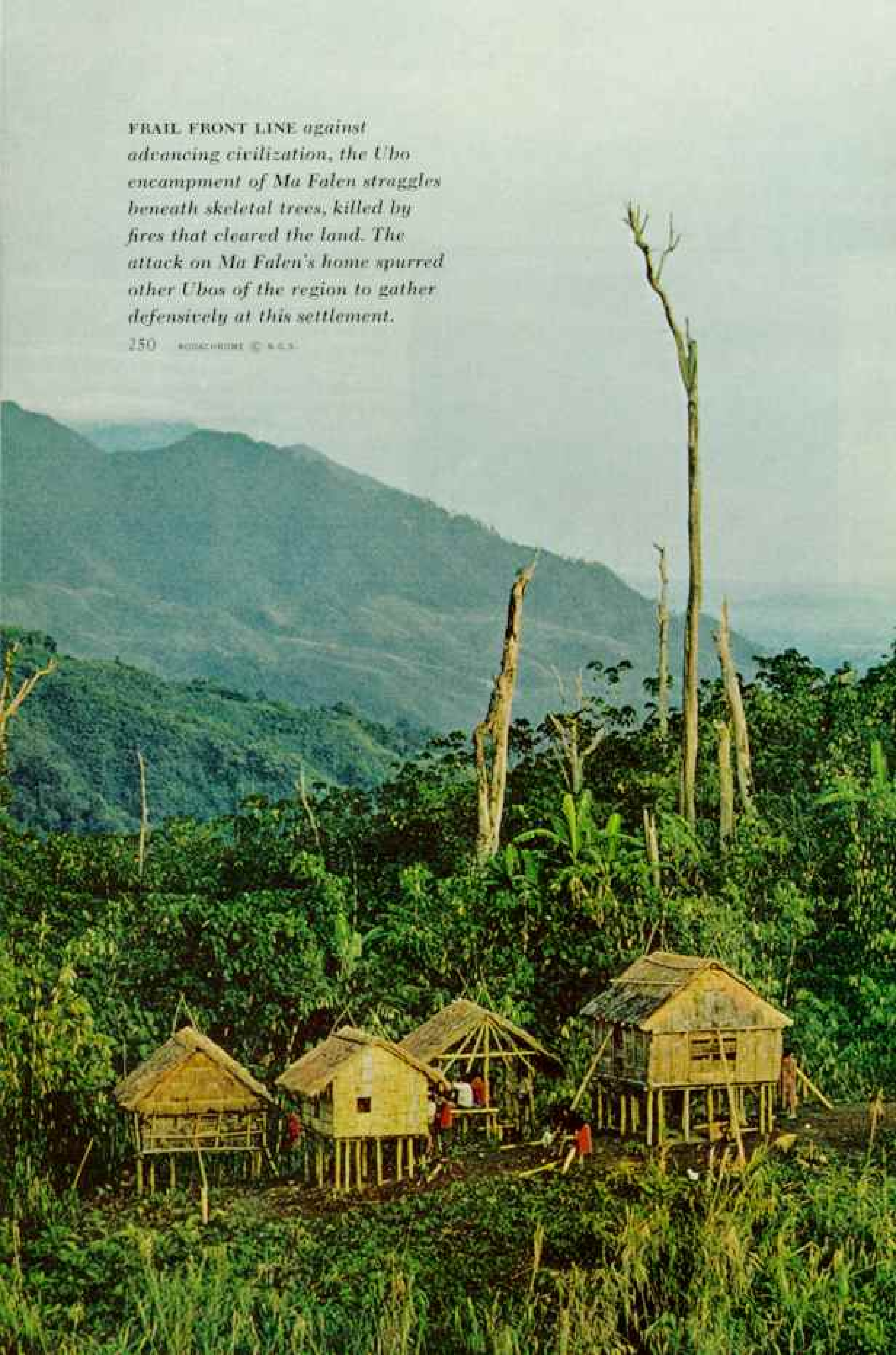
Frugally melting down their old hilts when they make new ones, the tribesmen often augment their brass supply with empty World War II shell casings.

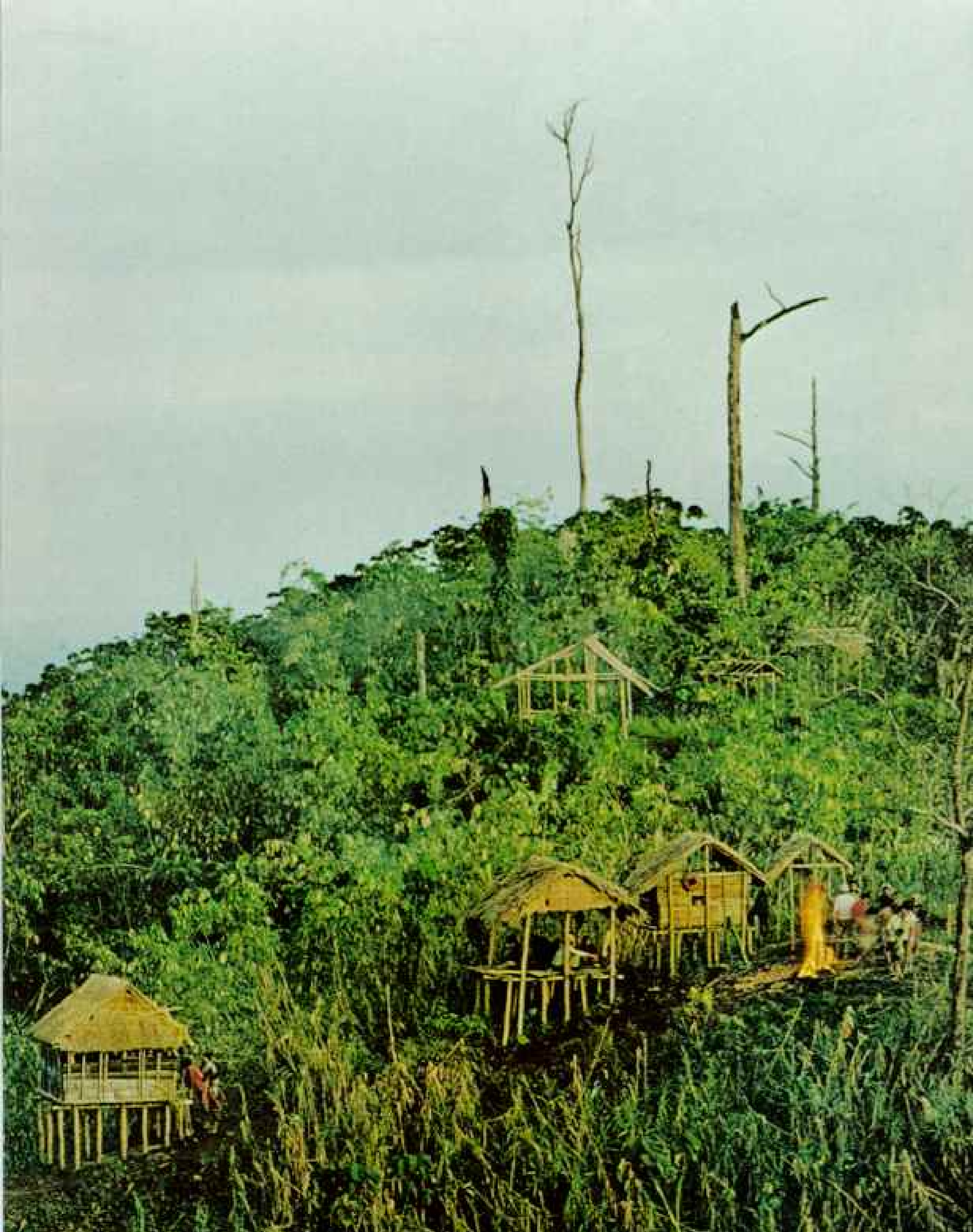
Eyes outflashing his sword, a Ubo man burlesques a war dance. Delighted audience yells cadenced approval during the festivities that accompanied Secretary Elizalde's stay with Datu Ma Falen.

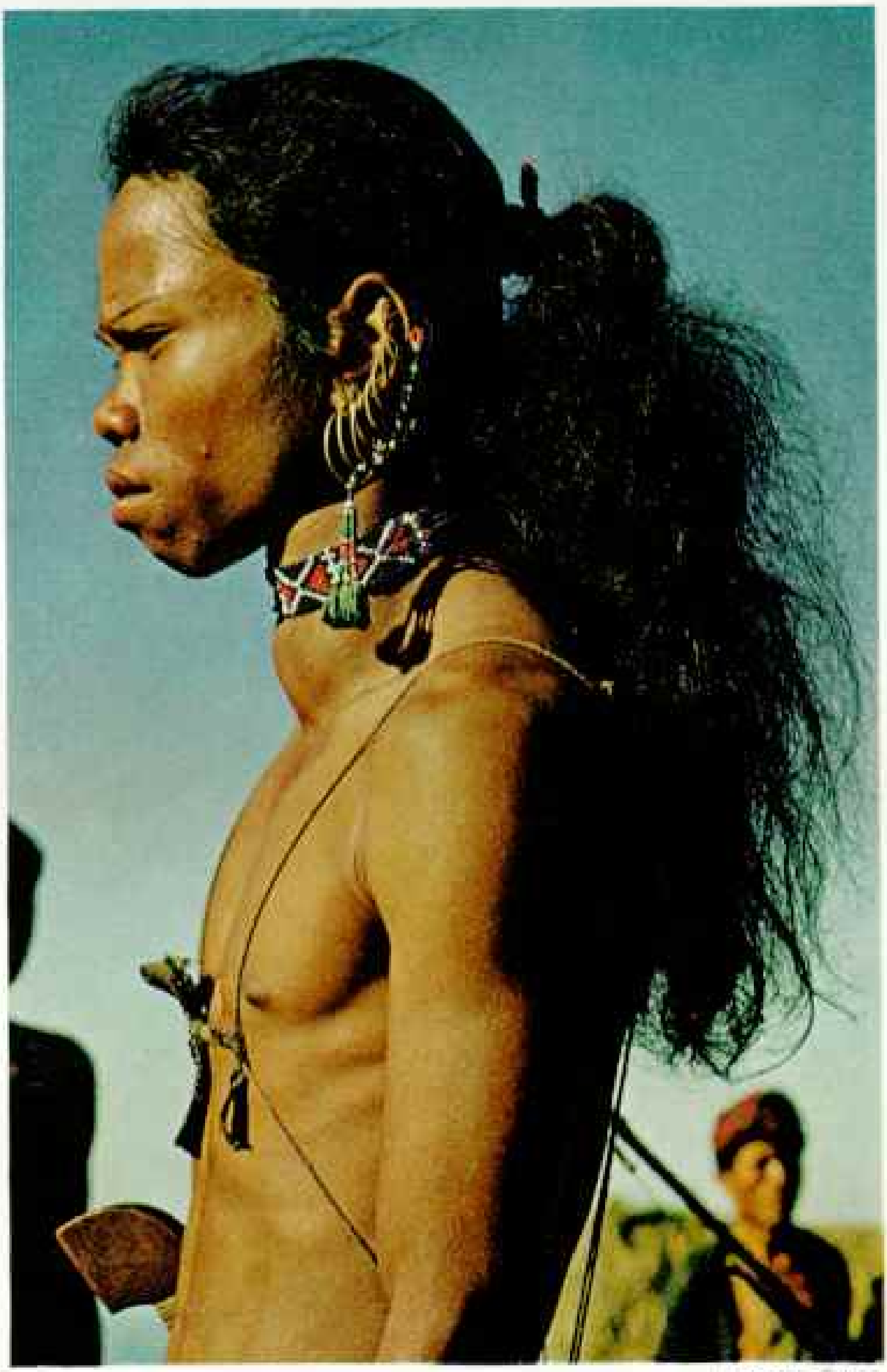
A Ubo smith fashioned the dancer's sword from steel that may once have been a truck spring. Possessing few guns, the forest people employ simpler weapons, each tribe having its favorites. Ubos and T'bolis prefer swords and bows and also hunt with poisoned arrows. Higaonons wield spears, while Mansakas use blowguns.

Heightening the peril of forests infested with snakes, insects, and poisonous plants, hunters line animal paths with snares, deadfalls, and spring-loaded spears. When human enemies threaten, the tribes guard trails with larger set-spears.

FRAIL FRONT LINE *against advancing civilization, the Ubo encampment of Mu Falen struggles beneath skeletal trees, killed by fires that cleared the land. The attack on Mu Falen's home spurred other Ubos of the region to gather defensively at this settlement.*

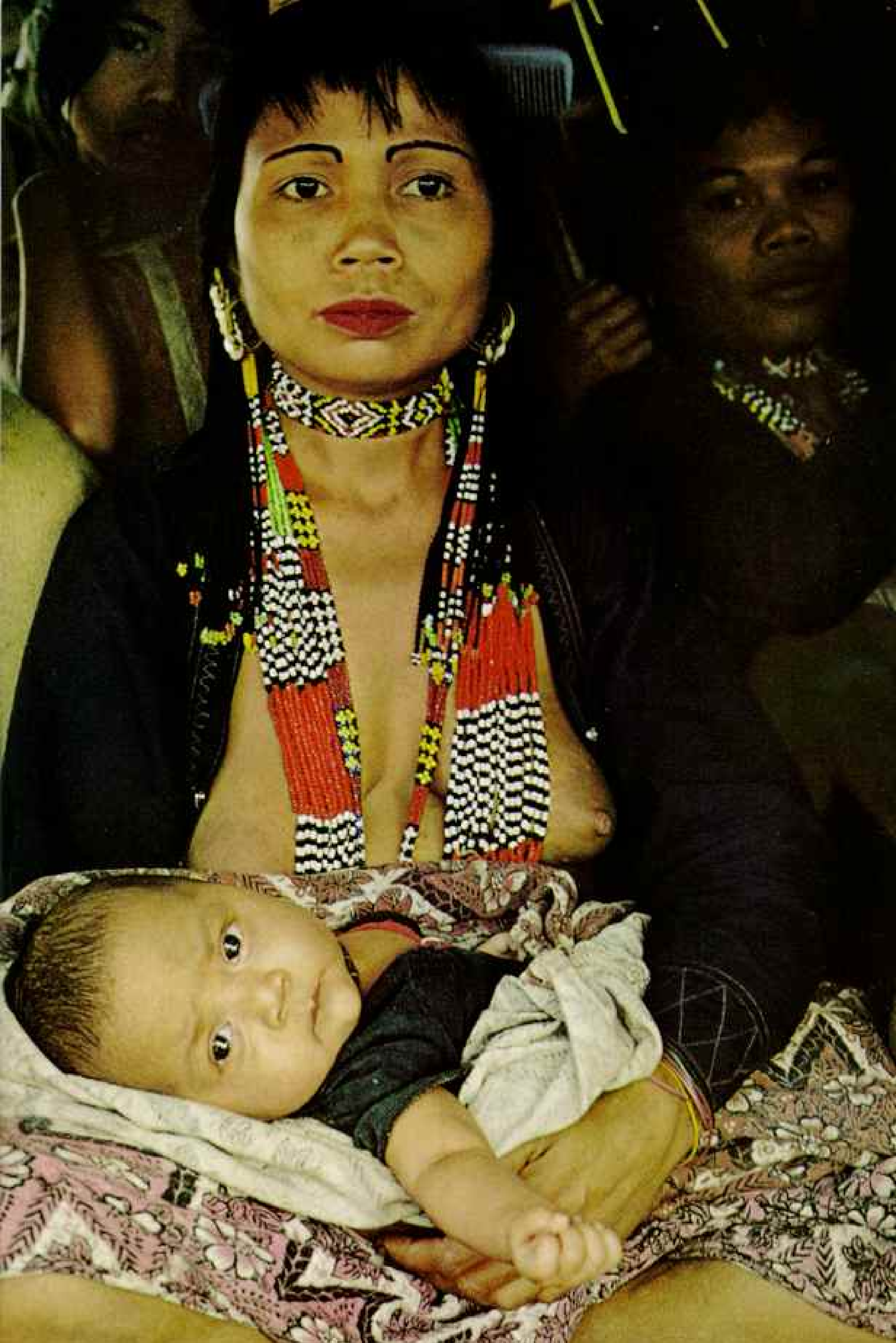






Cascades of earrings spangle Ubo forest youths who visit Ma Falen's area. For the occasion the girl donned festive beads and embroidered dress; the man wears only breechcloth and bush knife. Bulge below his beaded neckband betrays a goiter, a common affliction among people of the inland forests.

Remote in their jungle fastness, the Ubos never succumbed to the sense of inferiority that civilized Filipinos inflicted on many other tribes by demeaning their forest ways. Branding such degradation "a war of shame," Panamin struggles to bolster pride in the old ways even as it introduces new ones.



"Here are traps set on the way of the rat, on the way of the monkey, and on the way of the pig," he'd said, pointing to almost invisible paths. "Can you see the pig trap?" I could not. It was made of vines and saplings and looked like the rest of the undergrowth. Mai tripped it. The undergrowth convulsed and a heavy spear hurtled across "the way of the pig." "Set at a different angle, this becomes a trap for men," Mai added, smiling warmly.

I put aside thoughts of a walk in the woods and joined a circle which had formed around the best dancers of the Ubos, the T'bolis, and the visiting tribes, all performing in different styles to the same gong beat (page 248). Then a sudden storm broke, and everyone ran for the shelter of the thatches.

Darkness followed the rain, but the multitude in Ma Falen's house paid no attention to the hour. There were speeches, followed by delightful conversations in song.

"If only the U.N. worked this way . . ." said Elizalde.

Leaf Plates Hold Snake and Rice

Food was passed on big clean leaves. Snake and rice, and very tasty. Then, in accordance with an old and admirable custom of the Ubos and T'bolis, several young ladies came to sit with the honored guests, including Dean and me. These pretty people cuddled close, holding our hands, playing with the blond hair on our arms (their men have hairless skins), making loving feminine sounds, and kissing us jovially on the lips.

I noticed, as I had on other such visits, that some of the girls taking part in this happy hour were tiny, only six or seven years old. They dressed exactly as did the grown women of twelve or more, and it took a sharp eye in the dimly torchlit interior to distinguish between children and adults. To make things even trickier, it was—I was assured—impossible to distinguish between married and single women.

Still, it really didn't matter. The kisses and embraces, warming as they were, were only gestures of hospitality and friendship. At a given moment the girls would all get up and leave with kind words and affectionate pats. I didn't learn until later, browsing through an old anthropological monograph, that the one unforgivable familiarity was to touch a married woman on the elbow or heel. I gave quiet thanks to my Maker for the fact that I have never been much of a heel or elbow man.

A triumphant lad appeared suddenly at the entrance holding a large cobra he had skewered through the neck with an arrow as it crawled among the darkened huts. His arrival changed the mood of the meeting. The girls left. I stretched out among the people pressing close around me.

The air cooled, but its chill did not reach us clustered humans. The voices of the jungle night sang reassuringly. Their sudden silence would signal the approach of an intruder. So would the outposts, now watching the forest trails. This time, I thought, we are well armed. My hand verified the position of my weapons, hanging near my head.

"We?" I asked myself, trying to laugh away my self-bestowed membership in Ma Falen's group. Yet I knew that in that time and place I was, for the moment, one of them. Drifting into sleep, I remembered something Secretary Elizalde had told me, earlier that day:

"I love these people. I would die for them."

Rings Carry a Plea for Justice

At dawn the copter came to take us out, and I went to say goodbye to Ye Ellin. She sat cross-legged on her mat, arranging her lustrous black hair and her many necklaces. I knelt beside her, and she reached out, smiling, to take my hand in both of hers. Suddenly she pulled a ring from her finger and put it on mine. I kissed her and left.

I showed the ring to Elizalde as we waited to board the helicopter. "You've been honored," he said. "I was, too." He held up his left hand. "Ye Ellin gave me these."

"I noticed them when I first met you. You always wear them."

"And always will. They belonged to her daughter, the one who was murdered here. Ye Ellin said, 'Wear these rings for my daughter, and remember to tell your world that justice belongs also to the innocent.'" □

What does the future hold? A T'boli mother holds a wide-eyed child whose life Panamin promises to make more secure. To Secretary Elizalde she sang of her people's plight, bolstering his conviction that the conservation of human cultures must be considered at least as important as the conservation of any other natural resource.

Tektite II: Part One

Science's Window on the Sea

By JOHN G. VANDERWALKER

PHOTOGRAPHS BY
BATES LITTLEHALES
NATIONAL GEOGRAPHIC PHOTOGRAPHER

Portly robots linked arm in arm, the twin structures of Tektite II loom above the floor of Great Lameshur Bay off St. John, in the United States Virgin Islands. For seven months last year this sophisticated habitat, a joint project of Government, colleges, and industry, housed a series of research teams—including an all-female group—in one of mankind's most ambitious invasions of the world beneath the sea. These divers, using conventional scuba gear while studying coral respiration, glide toward a sea whip in the foreground.

CATACHROME © N.G.S.

IN THE TWILIGHT REALM 50 feet down, our neighbors call endlessly back and forth. As I prowl the reef with my partner Ian Koblick, I can recognize familiar sounds—the low-pitched grunt of the Nassau grouper, the frying-pan crackle of snapping shrimp, the staccato sounds of squirrelfish. Other noises rise and fade in the background, a muted symphony of whistles, clicks, and flutters that orchestrate everyday life and death in the sea.

It is not, I reflect, a notably silent world.

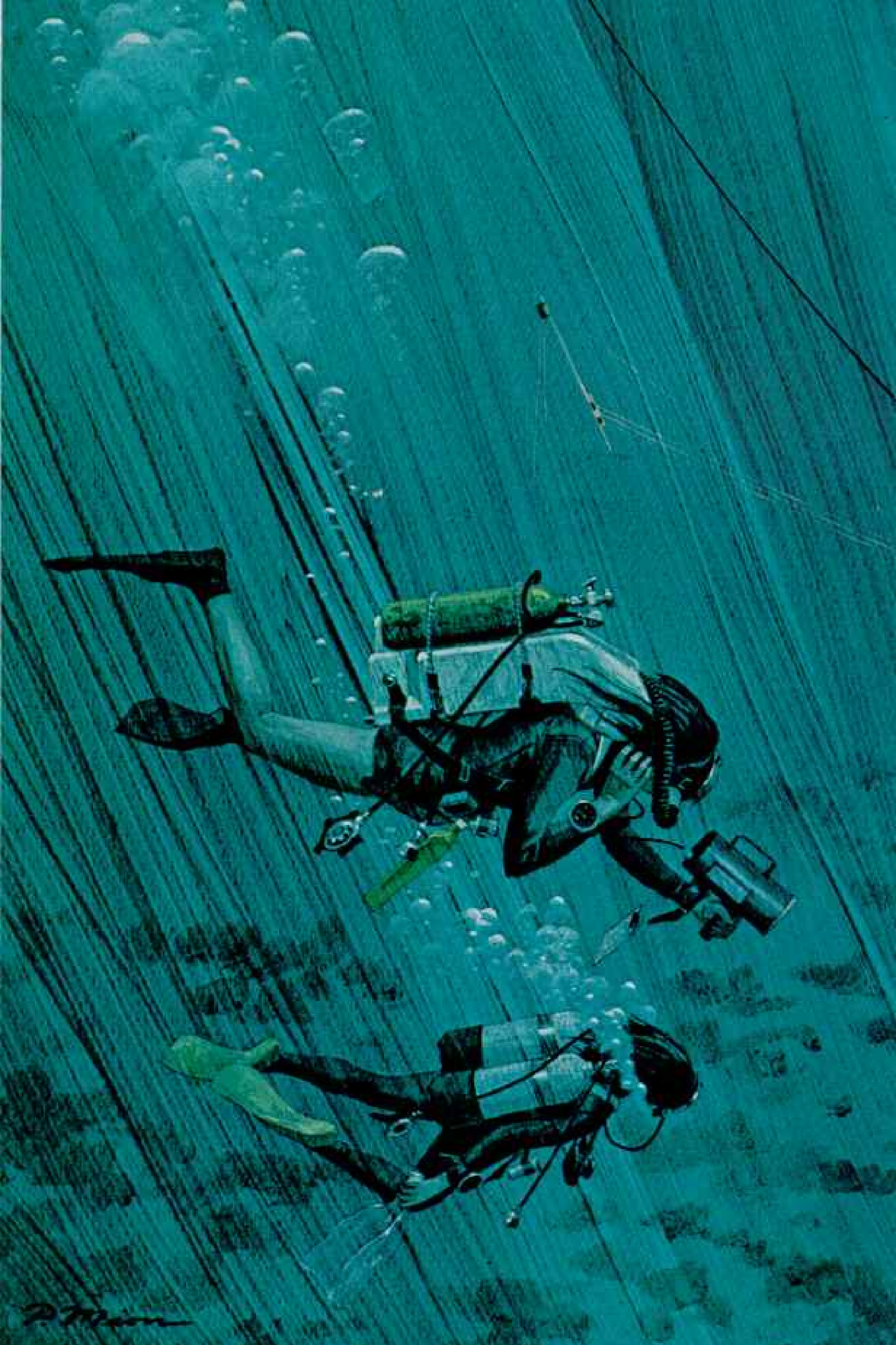
The reef is a familiar one. It lies in Great Lameshur Bay off the southeast shore of St. John, one of the U. S. Virgin Islands (map, page 265). In the past I have been a frequent visitor to the bay's azure depths, but always with conventional diving gear.

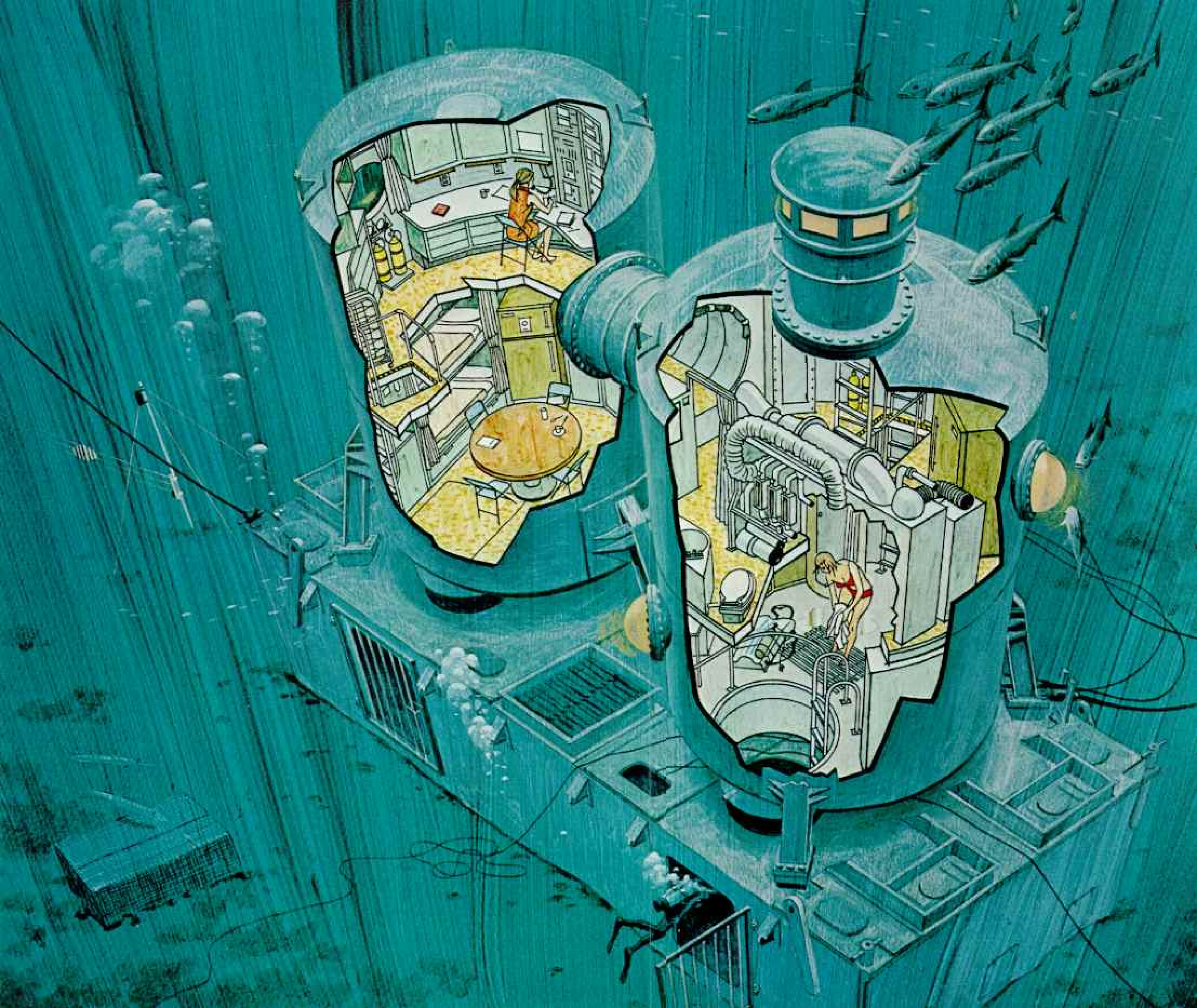
Standard scuba equipment tends to mask underwater sounds with its noisy bubbles. Also, its limited supply of air restricts a diver to little more than an hour. Now, thanks to new devices developed by the General Electric Company that recirculate air rather than discharge it, Ian and I breathe silently, and our diving limit is stretched to four hours. For the first time our ears register the minute and fascinating sounds of the deep.

In another sense our stay on the ocean floor is unlimited, for we are no longer visitors but residents. Sheltered in an arc of the reef half a mile behind us lies an undersea habitat, equipped with many of the comforts of home—television, bunk beds, panoramic windows, wall-to-wall carpeting, air conditioning, an electric stove, and a freshwater shower (cutaway painting, pages 258-60). Five of us will occupy the habitat continuously for 20 days, using it as an underwater laboratory and diving station. Other teams of scientists will follow us in one of the world's most comprehensive underwater research projects—a mission with the curious name of Tektite II.

The title signifies the broad range of our mission's sponsors and goals. Named after small glassy meteoritic nodules found on ocean floors as well as on land, the project seeks to advance man's knowledge not only of the sea but also of outer space and the best means of exploring it. Faced with the prospect of rotating crews on future space stations, the National Aeronautics and Space Administration joined other Government agencies in sponsoring the project. NASA's goal was to study the behavior of scientists working in rigid isolation.

(Continued on page 264)





Homeward bound from an afternoon's work, members of the women's team glide through gathering dusk toward the habitat, shown here in a detailed cutaway. Wearing a nearly bubble-free diving device that cleans and re-oxygenates air for rebreathing, the upper diver homes in on the habitat by training a direction finder on a sonic pinger in the shelter. A reserve air tank rides atop the rebreather, its mouthpiece ready for emergency use. The lower diver, carrying a plastic sample bag, trails bubbles from conventional scuba gear.

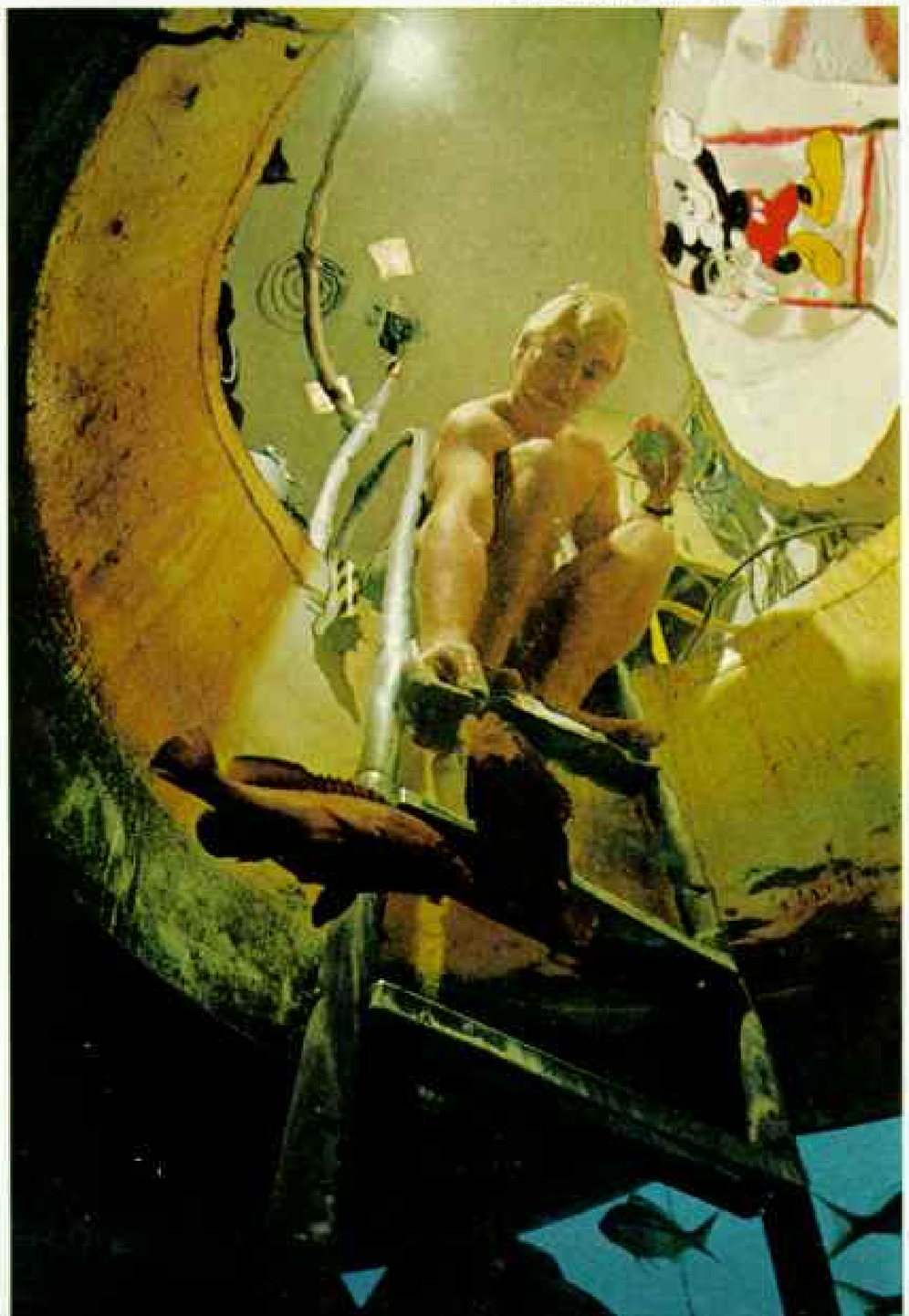
A third aquanaut (lower right in fold-out) passes through a barred shark gate —a barrier that proved unnecessary. An always-open hatch leads up into the habitat, where air at 2½ times surface pressure holds back the sea.

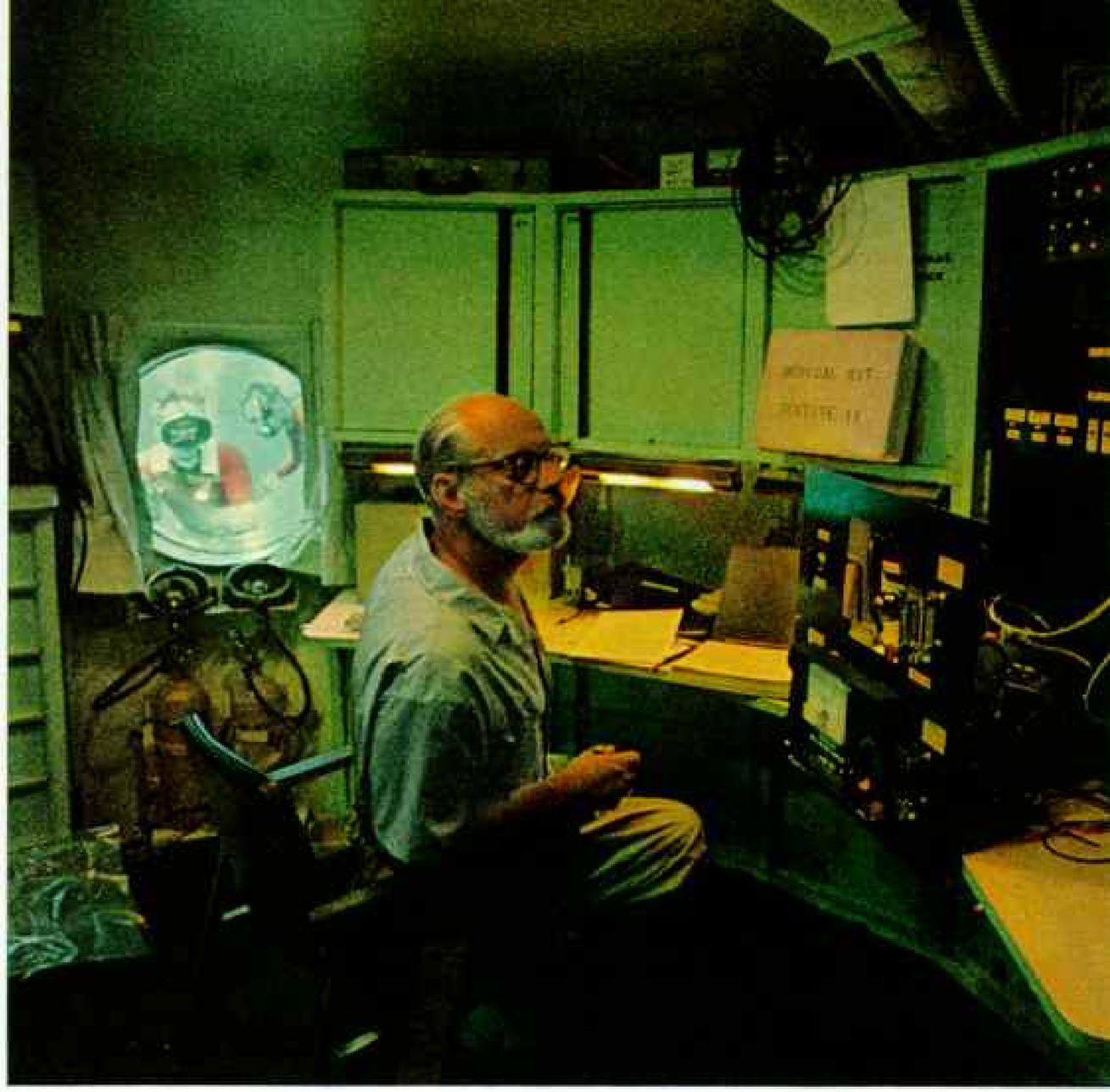
A diver towels off after a freshwater shower; above her, an air conditioner circulates the habitat's atmosphere of 9 percent oxygen and 91 percent nitrogen. The breathing mixture recirculates through a "scrubber" that chemically removes carbon dioxide; fresh air is added from the surface. Cylindrical tunnel leads to the bridge, or control room, in the chamber at left. There the fifth aquanaut monitors communications and life-support systems. Below her are comfortable living quarters.

On the sea floor scientists studying the effects of grazing have set up a wire cage to protect plants from large fish.

THIS PAGE FOLDS OUT

PAINTING (FOLDOUT) BY PIERRE WION, CATACHROMES © N.G.S.





Housekeeping on the bottom of the sea

AS SUCCESSIVE FIVE-MAN missions descended into the hostile sea, the teams found that their new home offered many amenities: a pleasant 80° F. temperature, wall-to-wall carpeting, hot and cold running water, stereo, television—and, outside, a gargantuan swimming pool and aquarium. Air conditioning maintained the humidity at a healthy 40 percent.

In the habitat control room (**above**), Mission 1 engineer Ed Batutis checks television screens that provide face-to-face contact with monitoring personnel topside. Window at extreme left frames two support-team divers.

Striking up a friendship with the natives (**left**), Mission 10 engineer Todd Atkinson feeds grouper that learned to beg at the habitat entrance. Their favorite foods: lima beans and tinned oysters. The hatch displays the emblem of Tektite's self-styled "Mickey Mouse Crew."

Mission 10 teammates (**right**) scorn canned music for Richard Heckman's singing. Left to right: Richard Chesher, Morgan Wells, and Lawrence McCloskey. The fifth member of the group, National Geographic photographer Bates Littlehales, stayed below for the entire 20 days of the mission.

When the all-woman team, Mission 6, took its turn in the dwelling (**upper right**), engineer Margaret Ann Lucas, right, and biologist Alina Szmant decorated the habitat with a crusading mobile. The women's reactions to isolation, like the men's, underwent constant TV scrutiny by NASA-sponsored psychologists, who will use their observations in planning future space missions. Tektite rules permitted only brief intrusions by outside photographers.


POLLUTION
KILLS...
everything!

Tektite II's prime concern, however, is the ocean environment, one of our most precious and increasingly threatened resources. Under the direction of the U. S. Department of the Interior, more than forty American and foreign scientists joined in this seven-month study of Great Lameshur Bay, with its wide spectrum of tropical marine life. A long list of universities and Government agencies participated in the project. The habitat itself was built by General Electric, Tektite's principal industrial participant.

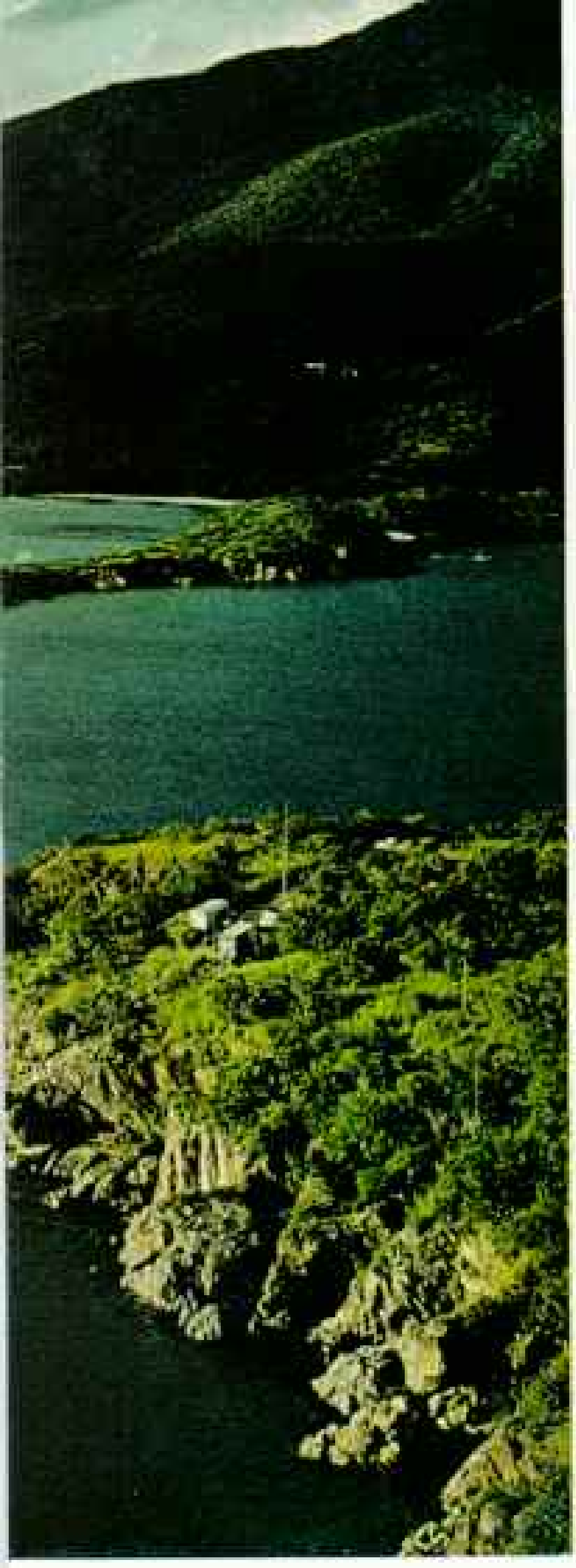
Others before us have lived on the ocean floor; in a sense we are the second generation. The first consists of such pioneers as Capt. Jacques-Yves Cousteau, Capt. George F. Bond of the U. S. Navy's Sealab program, Edwin A. Link, and their colleagues, whose development of undersea habitats gave man a key to a vast and unexplored world.*

These pioneers, however, are primarily divers and engineers, concerned more with techniques and equipment than with pure marine research. We, on the other hand, are scientists who have learned to dive in order to study the ocean environment in detail.

Daylight and Darkness Control Reef Life

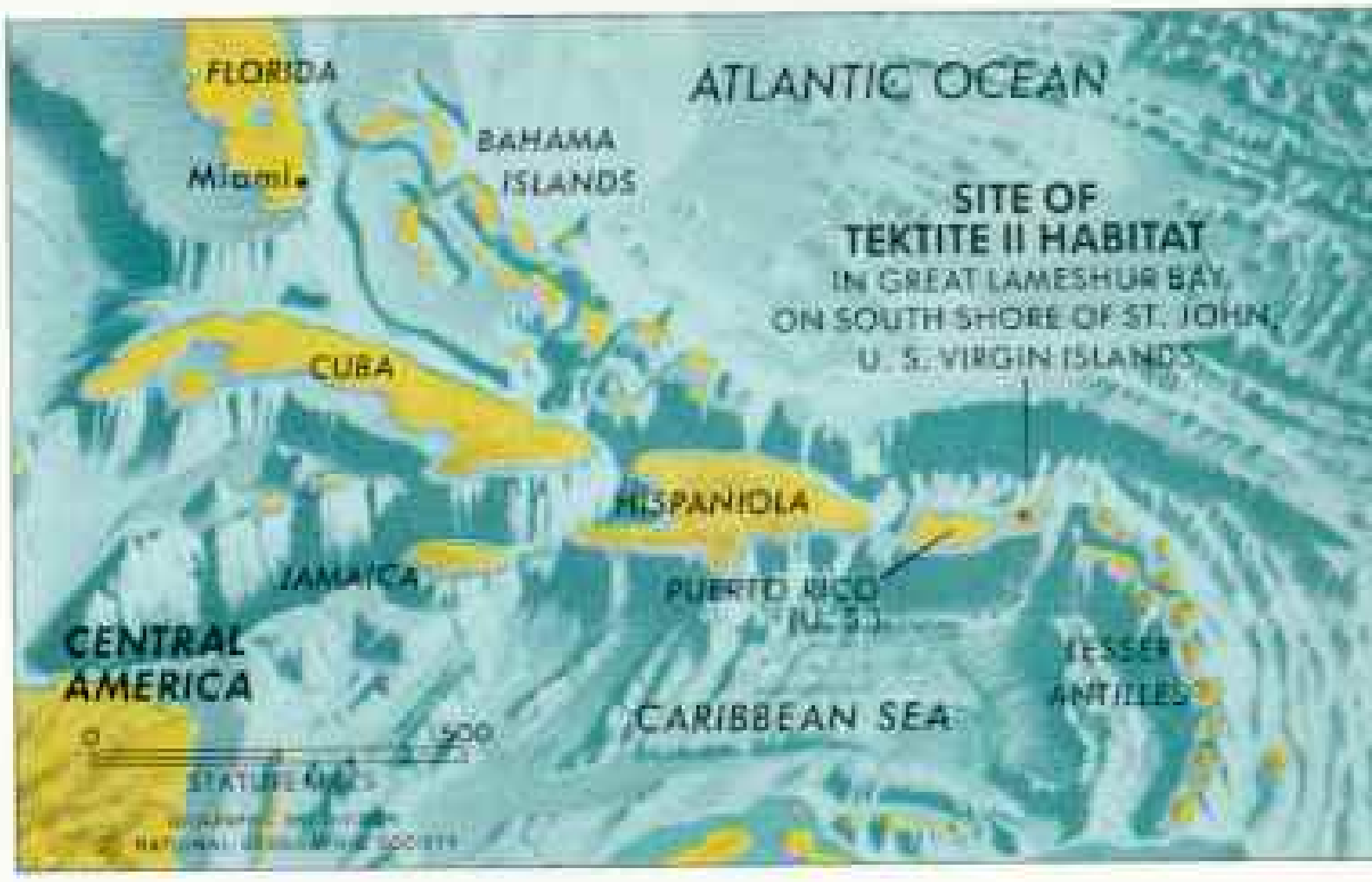
As Ian and I explore our endlessly varied domain, darkness wells from the ocean floor. Sunset along the reef signals a massive turnover of the inhabitants as daytime foragers give way to prowlers of the night. Amid the lengthening shadows, gorgeously colored parrotfish, butterflyfish, wrasse, and damselfish filter slowly back into the hidden crevices

*National Geographic has published many articles on experiments in underwater living. Notable among these are Captain Cousteau's "Working for Weeks on the Sea Floor," April 1966, and "At Home in the Sea," April 1964; and Edwin A. Link's "Tomorrow on the Deep Frontier," June 1964, "Outpost Under the Ocean," April 1965, and "Our Man-in-Sea Project," May 1963.



Aquanaut-author John G. VanDerwalker was Tektite II scientific coordinator. The National Oceanic and Atmospheric Administration biologist spent 20 days below.

Tektite's idyllic arena, Great Lameshur Bay laps dusk-dimmed hills of St. John. Boats at lower left moor over the habitat, monitoring station stands on the promontory. A decompression chamber lies at the end of the pier. The Virgin Islands and Puerto Rico rise from the same flat-topped submarine shelf (map, below).



and chambers of the reef, while the guardians of evening prepare to emerge: cardinalfish, amberjack, tarpon, brittle stars, octopuses, shrimp, and spiny lobsters. Reluctantly, Ian and I turn from this theater-in-the-wet and head back toward our own chamber on the sea floor.

To me the refuge is thoroughly familiar, for I spent two months in it early in 1969, studying spiny lobsters. As the name implies, Tektite II is the sequel to a previous project called Tektite I. During that initial experiment, I shared the habitat with three other men for 60 days at the same depth, 50 feet.

Now, in the eerie half-light, the habitat looms ahead, its massive twin towers jutting above the sandy floor beside the reef. From the base of the structure electrical and television cables, water lines and air hoses—our so-called umbilical lines—lead off toward the life-support equipment ashore, some 200 yards away. From the two compartments in each tower, welcoming cones of light pierce the shadows.

At the base of the structure, Ian and I enter a large flooded chamber and emerge through a hatch into the pressurized air space above. Since the hatch remains open all the time, our habitat must be constantly pressurized to match the inward force of water, equal to about two and a half atmospheres.

Ian and I are the last ones home. As we remove our diving gear, cheerful conversation drifts from the compartment overhead.

We had been down a week, and had already settled into an established pattern of living. Now we joined our colleagues in the pleasant routine of evening. First came an exchange of news on the day's activities. All of us had our individual jobs, but like Ian and me, Dr. H. Edward Clifton and Dr. Ralph Hunter generally worked as a team. Ed and Ralph,

Like colorful feather dusters, twin feeding organs of a tube worm rise from a brain coral. The white-tipped spirals filter out microscopic plankton swept against them by the current. A minnow-size sharknose goby, wearing blue and yellow stripes, patrols in the foreground.

To study the respiration of brain-coral polyps, Dr. J. Morgan Wells, Jr., seals a plastic dome against a specimen (**below**). By withdrawing samples of the trapped water with a syringe, he can measure the polyps' oxygen consumption.

Tektite II follows 1969's initial Tektite project, in which the author and three other aquanauts spent 60 days under the sea. The operation's name, taken from the small glassy nodules of meteoritic matter often found on the ocean floor, symbolizes Tektite's dual mission—a scientific survey of the sea frontier and, simultaneously, preparation for distant journeys into space.

both marine geologists of the U. S. Geological Survey, were studying sediment changes on the sea floor, particularly those caused by marine organisms. The fifth crew member was Charles C. Kubokawa, a NASA human-factors engineer concerned with the design and efficiency of undersea habitats.

Dinner generally was more notable for conviviality than for culinary artistry. NASA had furnished the habitat with the same packaged diet as that used by Apollo astronauts in their quarantine van after splashdown. While nourishing enough, it amounted to a selection of frozen dinners, easily warmed in our electric oven but rather monotonous.

TV Eye Watches From Shore Station

Every moment of our life in the habitat was scrutinized via television by monitoring personnel ashore. Should danger threaten either an aquanaut or the life-support system, a team of rescue divers would be at the habitat within three minutes. The same close watch was kept on all our diving expeditions, with surface escort boats tracking each team.

Rescue, of course, was not simply a matter of hauling an aquanaut to the surface, for he would very likely suffer the bends. Divers who have stayed at depth for long periods must return gradually to sea-level pressure, usually in a decompression chamber. The nitrogen forced into their tissues under pressure must be allowed to escape slowly, so that it will not form fatal or crippling bubbles.

But there is a limit to the nitrogen the human body can absorb. Whether a diver stays at a certain depth for two days or two months, he need decompress only once—in our case, for nearly 21 hours. Therein lies the value of underwater habitats. To spend the equivalent of 20 days on the bottom at 50 feet, as we did, a scuba diver working from the surface and coming back up each time without pausing to decompress might have to dive twice a day for several months.

Thanks to our two-way TV, our evenings were sometimes graced by conversations with our families. They could drop in at the command van ashore for a glimpse of us. And there were habitat-keeping chores to busy us. But with our bubble windows facing directly on the reef, we ran no risk of boredom.

Like all good drama, the show outside our habitat had both light and serious roles, and an endless cast of actors to fill them. No earthly comedian, for instance, ever staged a livelier routine than *Periclimenes*, a small shrimp.

All but transparent and roughly an inch long, *Periclimenes* makes its living as an undersea groom, combing the scales of willing fish for tiny edible parasites. Taking a stance atop one of the dark sea anemones on the reef, *Periclimenes* proceeds to play the sideshow barker, swaying beguilingly back and forth and beckoning to passing fish with its long whiplike antennae.

When a prospect approaches and remains still, *Periclimenes* leaps nimbly to work, nipping off minute crustaceans with the tweezer-like tips of its legs. Occasionally a fish will open its gill covers and allow *Periclimenes* to forage inside. No customer remains more than a few seconds. As he swims away, the shrimp bounds back to its anemone and resumes its promotion campaign.

I became fascinated with one such shrimp stationed near the habitat entrance. On my way past, I often swam quietly up to its place of business and extended my hand. Each time, the shrimp hopped faithfully aboard, picking away at the hairs on my wrist, though never managing to harvest one.

Rescue Mission Saves a Tarpon

Other figures in the undersea drama were infinitely touching. A member of a later habitat crew told me of a particular tarpon that he watched through the window one night.

"He was an old fellow," the aquanaut said, "battle-scarred and slower than the others, but he managed to make a meal off the smaller fish. In the early hours of morning the baitfish schooled and swam away, and the tarpon left, too—all except the old fellow. He suddenly seemed confused, drifting aimlessly around the habitat.

"Then an odd thing happened. From a distance beyond the reef came two young tarpon. They took up stations on either side of the old one and gently herded him away."

For all its sober scientific purpose, Tektite II had its moments of comedy, some of them ingeniously planned. One of our major concerns on entering the habitat was the occasional moray eel lurking among the air tanks in the lower hatchway. The moray has a vicious nature and teeth to match; when antagonized it can fasten like a vise onto a man's hand, laying it open to the bone.

One evening before Ian returned from a

survey of the reef, Ed Clifton booby-trapped the entrance. Removing the weights from a diving belt of black webbing, he tied an invisible monofilament line to one end and slipped the belt behind an air tank. Then he ran the line up into the compartment above, held it in his hand, and we all sat back to wait.

As Ian started up the ladder, Ed gave a jerk on the line, and suddenly a dark shape came slithering from among the tanks. One look was enough for Ian; thinking the belt was a moray, he exploded through the hatch, equipment and all, like a Poseidon missile.

Other pranks were directed at the monitors and psychological teams in the command van ashore. Part of the behavior-in-isolation study involved a television check every six minutes on the location and activity of each habitat crew member. We quickly learned the blind spots of the habitat cameras and occasionally enjoyed giving our observers the slip.

At the time it seemed a good joke on the psychologists, but now I'm not so sure. After the program ended, I asked Dr. Robert Helmreich, director of the behavioral study, what he had thought of our disappearing act.

"Great," Bob answered, smiling. "It's got all sorts of psychological implications. It'll make a fine chapter in the report."

The study of human behavior in isolation, based on observations of some 40 aquanauts, turned up some totally unexpected findings. Perhaps the strangest discovery was that the more religious the crew member, the less well he seemed to perform in isolation.

Equally surprising was the fact that scientists who had been sickly as children adapted

(Continued on page 276)

Confrontation of sea creatures: Biologist Dr. Richard H. Chesher faces a bulldog-jawed four-foot tarpon. Drawn by the lights and the small fish that swarmed around them, schools of the silvery game fish haunted habitat waters. Renowned for their spectacular fighting prowess when hooked, the tarpon proved amicable and unafraid when scientists invaded their nighttime domain.

Swim-in cleaning—prompt service. Scattered about the reef, the aquanauts found "service stations" where small marine creatures performed a vital chore —picking annoying parasites from passing fish. Darting amid its customers, a little Spanish hogfish grooms a school of bar jack (**upper left**), with no fear of being gobbled up. Tiny sharknose gobies, operating at a brain-coral station, clean a bizarre grouper called a coney (**lower left**).

For the scientists, photography played an indispensable role in

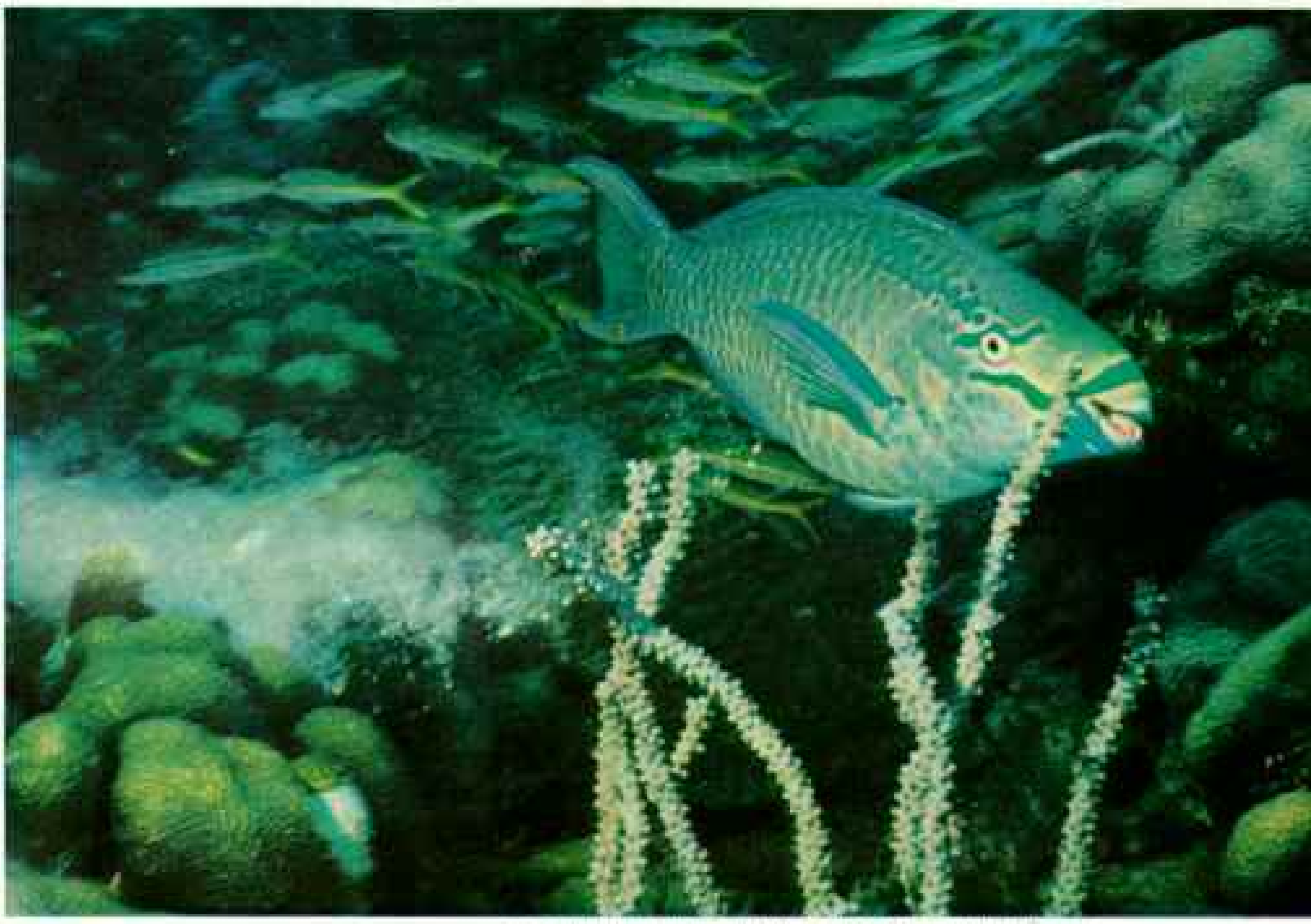
recording undersea phenomena. Here Dr. Chesher (**above**) uses an OceanEye housing designed by Geographic photographer Lisa Stiehales to protect a Nikon F camera.

Like snow on a winter forest, white sand powders a stark stand of fire coral (following pages). Yellow wrasse and a lone immature parrotfish glint in Great Lameshur's crystal waters. Tektite experiments showed the finely balanced coral ecology to be highly susceptible to pollutants—particularly some pesticides.

Leaving a trail of death, a flamingo-tongue (**above**) grazes on a living sea fan. The inch-long snail, whose appetite for coral inspired a Tektite study, can pull its leopard-spotted mantle back into a cream-colored shell, here concealed by the mantle.

Gnarled fingers of fire coral, thrusting up from the seabed, bristle with hairlike polyps (**left**). Emerging to feed on plankton, the creatures harbor a toxin that can inflict a long-lasting rash on careless divers. A brittle star entwines the branches; the stringlike creature is apparently immune to the coral's tiny hypodermics.

Finned silt factory, a foot-long parrotfish nibbles the reef with a powerful beak of small fused teeth. Digesting algae and other living matter, it expels the limy coral as fine white powder. Parrotfish inhabiting a reef produce much of its sediment.



FIRE CORAL (LEFT) ABOUT THREE TIMES LIFE SIZE; ENTIRE IMAGE © N.G.S.

better than those with a record of good health. Other top performers included those who had been either the eldest or the only child in a family, those who had worked during school, and those who had earned high marks in grade school—but not necessarily in college.

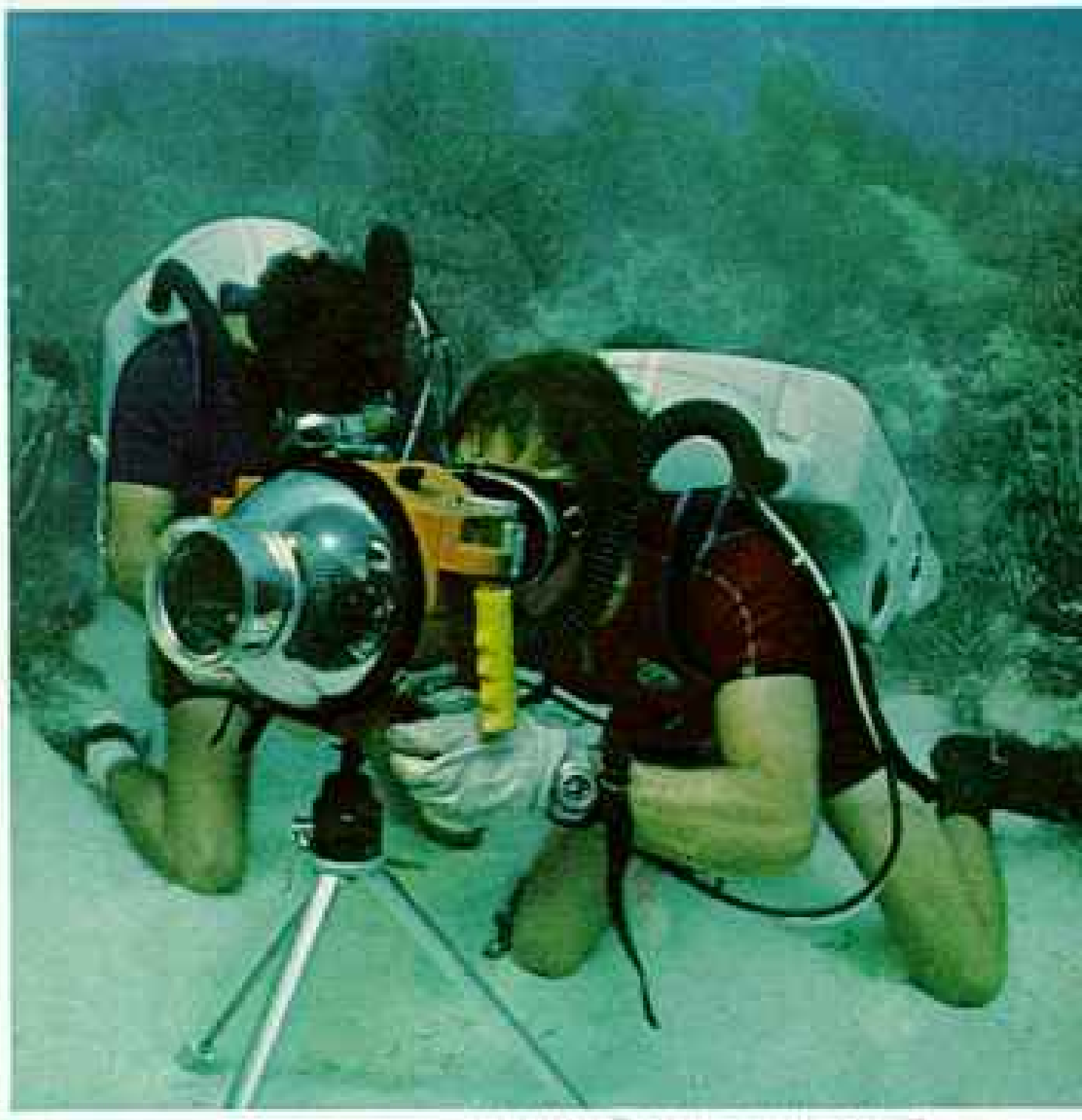
Eardrums Tell of Heavy Weather Above

Isolation produced surprisingly few annoyances. The only major one was the absence of privacy—the lack of opportunity to be alone with one's thoughts. In our own crew we solved the problem by allowing each member a few moments alone every day in a chosen spot—the engine room, bridge, storage compartment, or living quarters. Curiously, during those periods of cherished solitude the television monitors simply didn't exist for us.

We quickly adapted to other inconveniences, such as the variations in sound and pressure within the habitat. Whenever a sizable wave passed overhead, the weight of water on the structure increased, producing a momentary rise in pressure. The result was a sudden tightening in the ears and a wavering quality to the sound of our engine-room

Magnification makes a monster of a lizard fish, actually less than a foot long. The author (**below**), with aquanaut Ian Koblick, spies on the fish through a "wet telescope"—a camera with a 500-mm telephoto lens protected by a modified OceanEye housing.

Armed with such equipment and the new rebreathing units, which expel few noisy bubbles to frighten fish, Tektite crews could make unprecedented observations of marine creatures living undisturbed and unafraid.



EXTACHROMES © NATIONAL GEOGRAPHIC SOCIETY

equipment. No one ashore ever had to inform us of rough weather on the surface—we could gauge it by our own eardrums.

Experienced undersea housekeeper that I was, I sometimes misjudged the effects of the pressure in our habitat. One evening, shortly after we took up residence, I decided to surprise my teammates by baking a chocolate cake. The problem lay in getting the cake to rise. I dumped in what seemed like half a box of baking powder and crossed my fingers. The cake rose briefly, then deflated into a leaden mass. Nonetheless I served it up, and my teammates politely hacked their way through a portion of it. Surveying the remains, Ed Clifton searched for an appropriate comment.

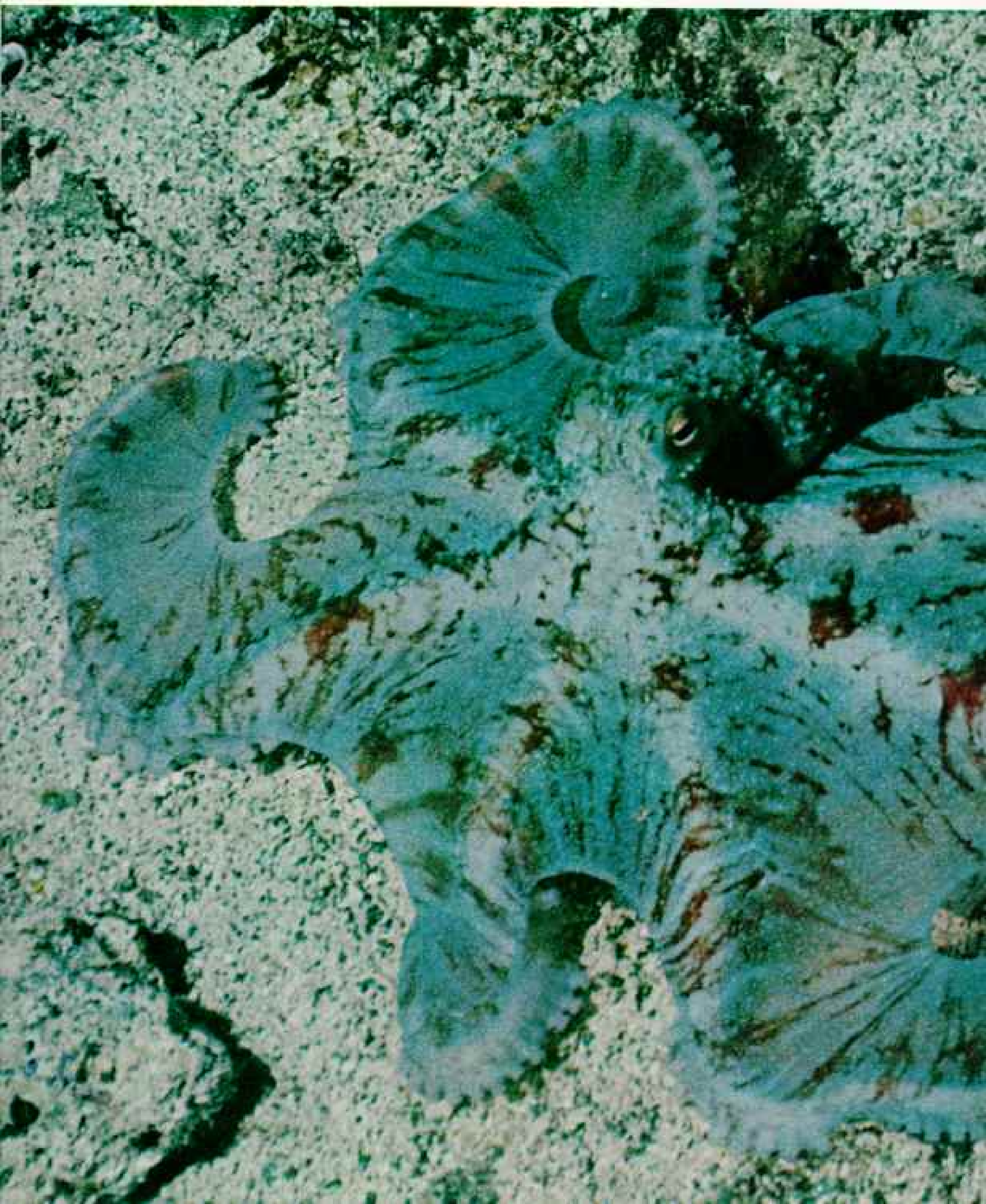
"Never mind, John," he said comfortingly. "It'll make great ballast in a storm."

Pingers Help Track Wandering Lobsters

Minor frustrations in the habitat only heightened the rewards of swims outside. On working forays from the habitat we split into our usual two-man teams—Ian Koblick and I to study spiny lobsters, Ed Clifton and

Midnight march of an army of arms

A PSYCHEDELIC BLOB moves eerily across the darkened ocean floor: an octopus on the prowl. Suddenly it sights another sea creature. Vaulting from the bottom with unexpected agility, the mollusk expands the webbing between its arms and drops like a



parachute to envelop a crab. Eight arms stuff the victim into the octopus's mouth; then it slithers on toward another kill.

Biologist John A. Couch found that the mollusk, which turns bluish-green when hunting, "changed color like a chameleon—browns, greens, grays—whenever afraid, excited, or eating." Tagging and observing octopuses, Couch and Dr. Eric Hochberg discovered that except for one nomadic species, all confined their movements to limited territories near their dens.

OCTOPUS VULGARIS, ALMOST LIFE-SIZE, UNDERWATER © N.G.S.

Ralph Hunter to study sedimentary processes on the sea floor. As habitat engineer, Chuck Kubokawa was more restricted to home base, but he frequently served as alternate diver on one of the teams.

Ian's and my study was not as esoteric as it sounds, for the spiny lobster *(Panulirus argus)* is an important source of food as well as of income in the Caribbean. Moreover, the lobster catch of the Virgin Islands has been declining over the past few years, for reasons not yet explained. A thorough knowledge of the lobster's life cycle and habits will one day help to reverse this trend.

During our first week on the sea floor, Ian and I spent many daylight hours surveying and marking the reef's lobster population. The latter job involved attaching color-coded tags to the carapaces of various specimens, so that we could recognize them as they traveled about the reef. For night-tracking purposes, we fitted several lobsters with miniaturized sonic pingers that we could home in on with portable direction finders. The pingers helped us develop new theories about the way lobsters navigate across the bottom in total darkness (page 284).

Despite many years of diving, I never cease to marvel at the color and variety of life on a Caribbean reef. Each morning as Ian and I emerged from the habitat, a great escarpment of coral loomed before us with its shimmering schools of fish, like some medieval fortress festooned with thousands of bright pennants. Mortised into the dark slopes of the coral, groups of brilliant anemones, sponges, and gorgonians spattered the living stone with intricate designs.

The behavior of reef creatures is equally colorful. One morning as Ian and I skirted the edge of the great undersea barricade, we encountered a small creature known as a smooth trunkfish, excavating a sizable crater in the bottom. The fish hung suspended head down above the sand, drawing water through its gills and squirting it in a pinpoint stream, exposing minute crustaceans that it would gobble for breakfast.

Poised to pounce, a trumpetfish hangs head down, mimicking an arm of a sea whip. When a victim swims toward the supposed safety of the coral branches, the foot-long hunter lunges to engulf its prey.

By far the most persistent forager I encountered was a gray-and-turquoise queen triggerfish that had her eye on a succulent but spiny sea urchin. The triggerfish repeatedly lifted the urchin off the bottom by one spine in an attempt to dive beneath and attack the creature's undefended portion. Each time, however, the urchin touched bottom first and set off directly toward the safety of the reef.

Finally the triggerfish charged head-on at its prey, receiving a spine or two in the nose while cracking it open. I'm convinced that the many triggerfish I have seen with purple noses were veterans of similar encounters; they had been tattooed by their pincushion prey.

Annoyed Lobster Mounts an Attack

Initial results of the spiny-lobster study added considerably to the knowledge I had gained the year before during Tektite I. Unlike his solitary New England cousin, the spiny lobster is a sociable creature, often crowding 15 or 20 strong into a single den. By comparing our head count against the past year's figures, we determined that the lobster population of Great Lameshur Bay reef had remained roughly constant.

The census was merely the first stage in our study. During our second week, Ian and I turned to the subject of lobster behavior and began prowling the sea at night.

Like the basket star, octopus, moray, and certain types of shrimp, the spiny lobster is nocturnal. Only when darkness overtakes the reef does he forsake the security of the den. Under cover of night he roams the sandy plains adjoining the reef, foraging for snails, oysters, clams, and other mollusks, keeping an eye out for his two great enemies, the shark and the giant grouper. Few other creatures care to trifle with an adult *Panulirus:* Pound for pound he is a match for most predators.

My New England friends, accustomed to the massive claws of their native lobster, consider *Panulirus* a poor defenseless crayfish. Although he lacks claws, *Panulirus* is surprisingly well armed. In addition to his spiny shield, he packs tremendous power in a set of ten sharp-pointed legs and in a mouth that can crack the quarter-inch-thick shell of a conch to get at the luckless inhabitant. Those who dismiss *Panulirus* as a timid and harmless creature would do well to consider Ian's brush with a six-pound male. Had it happened to an inexperienced diver, he could have been in serious trouble.

The mishap occurred during a short earlier dive, while Ian and another diver were surveying the inshore waters for lobsters. They were working with standard scuba gear at a depth of 35 feet, well separated but within sight of each other. Ian's partner had just spotted a young lobster and was reaching down to snare it, when some sixth sense made him glance in Ian's direction.

Ian was no longer on the bottom. A vanishing column of bubbles indicated that he had surfaced abruptly. Ian is an experienced diver, and nothing short of an emergency would cause him to leave a partner below without warning. Following Ian's bubbles, his partner reached the surface and found him grappling with a large male lobster.

Once Ian got rid of his attacker, he told what had happened. In a crevice of the reef he had spied a fairly large lobster, measuring a foot and a half in length. After snaring it with his nylon loop, he picked it up in the proper fashion behind the carapace and started loosening the loop.

"I must have held it too close to me," Ian said, "because the next thing I knew it had pulled my face mask down around my neck and pried the air regulator out of my mouth."

With only seconds to act, Ian took off for the surface 35 feet overhead. There he caught a breath and managed to free himself.

Had the accident occurred during our time in the habitat, Ian's predicament would have been even more serious. Prevented from surfacing under threat of the bends, he would have had to fight the lobster underwater for his scuba gear.

One of the major puzzles regarding the

Daddy longlegs of the deep, an arrow crab on a midnight stroll ambles past black-spined sea urchins and a tomato-red sponge (following pages). Tektite divers, logging countless night hours with their miner-type head lanterns, found that such daytime foragers as parrotfish and wrasse surrender the reef to a strikingly different nocturnal population.

ABOUT 6 TIMES LIFE-SIZE. EXTACHROME © N.G.S.

Prowling a thicket of sea whips, fans, and feathers, the author snares a spiny lobster. Back in the habitat, Ian Koblick installs a miniaturized sonic pinger on the carapace of nocturnal *Panulirus argus* (**below**). Tagging several of the commercially important crustaceans—one source of supermarket lobster tails—the two men were able to track them during their nightly roamings and gather valuable new knowledge about their behavior.

On an earlier tagging project, a six-pound lobster tore away Koblick's diving mask and air regulator. He surfaced immediately, and managed to disengage the creature without damage to himself or to the hitchhiking crustacean.

spiny lobster is its ability to trek long distances across the darkened sea floor and then unerringly return to its burrow. Even when we blindfolded the lobsters with tape during nocturnal forays, they found their way home. After close observation, we believe that *Panulirus* may navigate using familiar undersea currents and the sounds of animal life on the reefs.

Other habits of the spiny lobster emerged from our studies, several of them regarding food. One of the keys to survival on the reef is the ability to alter feeding habits with changing food supplies. Here the spiny lobster is well endowed, for when its favorite mollusks become scarce, it readily converts to a diet of crabs, sea cucumbers, sponges, worms, and spiny sea urchins.

Barracuda Lunges at a Diver's Light

Our nighttime search for lobsters led to several memorable encounters with other tenants of the reef. Late one evening, as Ian and I were returning to the habitat, we picked up a strong ping on our direction finders. We recognized it as coming from one of the tiny transmitters we had attached to various lobsters. With our underwater lights playing before us, we tracked the signal to a point not far from the habitat.

Rounding a large coral head, I saw the transmitter-equipped specimen on the bottom, and instantly sensed trouble. He was crouched in the defensive position lobsters assume in the presence of a shark or a big grouper. Playing my light in a quick circle around me, I discovered a three-foot barracuda hovering a yard or two away.

Never during our time on the reef had we actually been threatened by one of the large predators—barracuda, shark, or moray. But I recalled an account by marine biologist Dr. Walter A. Starck II of a barracuda that had charged his diving light, and I quickly held my lamp at arm's length. Sure enough, the barracuda lunged at the light, narrowly missing Ian and me as it passed.

Another event had its origin far from the habitat, and proved frightening in its weird effects. I had just left the hatchway for a daytime excursion when I was suddenly seized in a massive vibration of the sea, as though I were trapped in a bowl of gelatin being shaken by a giant hand. My first thought was of an explosion within the habitat. As soon as the turbulence ceased, I returned and scrambled through the entranceway. There stood Ed Clifton, grinning broadly at my puzzled expression.

"How did you like your first earthquake underwater?" he asked.

The habitat proved equal not only to earthquake but also to storms; we were cradled in the massive cushion of the deep. Only once in six months was the undersea work interrupted, during an alert for a hurricane, and that one veered away before reaching us.

One of the most magical experiences I can recall was swimming at night across the sea floor during a tropical lightning storm. In the eerie quiet of the deep, the landscape was illuminated every few seconds, as though it were being swept by some giant searchlight. I paused, hypnotized by the succession of momentary scenes that flashed before me like old-fashioned stereoptican slides. The thunder itself was inaudible, but I could hear far overhead the steady thrum of heavy rain on the ocean's surface.

Discoveries Lead to New Problems

Far sooner than we would have liked, our twentieth and final evening arrived. The following morning we were scheduled to slip for the last time through the luminous blue well at our feet into a world that had become peculiarly and unforgettably our own.

As for our scientific studies, the results had been rewarding. Ian's and my observations on the spiny lobster required further study, but we can already draw a few interesting conclusions.

The threat to the lobster population of the Virgin Islands—and possibly of other areas in the Caribbean—seems to lie not on the fringing reefs, where Tektite has shown there is more than enough food and shelter to go around, but among the coastal shallows and mangrove swamps, where young lobsters first become bottom-dwelling creatures. While Tektite II provided no ready solution to the problem, it told us something vital—where to search for the answer.

Our teammates had been equally successful. By observing and photographing test areas around the habitat, Ed Clifton and Ralph Hunter documented the extent to which sea organisms shape and alter the ocean floor (page 275). Chuck Kubokawa developed ideas on everything from simplified

"Break bread with a fish," says Dr. Sylvia A. Earle, "if you really want to get to know him." Though stopping short of actually dining with her subjects, she made an intensive study of algae—the staff of life for many fish. Here the botanist, leader of the all-woman Mission 6, shows engineer Peggy Lucas a handful of the plants. They meet at one of the habitat's hemispheric windows, which give a wide-angle view of the ever-changing seascape.

Later analysis of psychologists' observations revealed that the female crew performed as well as the men, logging even more hours of work. "We were always up before dawn," Dr. Earle recalls, "and out on the reef when the sun came up."

Patch of plastic grass aids a study by Dr. Renate True (**below**, left) and Dr. Earle. The green ribbons, which soon became covered with algae, attracted animal life as readily as real vegetation. The growth apparently made up for the oxygen that natural grass would have added to the water. Tektite II's women aquanauts won the Conservation Service Award of the Department of the Interior, Tektite's principal sponsor.

Quick and nourishing, frozen dinners greet the female team: Peggy Lucas serves Dr. Earle, left, Dr. True, center, and Alina Szmant. The mission also included ecologist Ann Hartline. Male divers occasionally fretted about monotonous meals, but the women liked the fare.

life-support systems to color schemes for space stations and future undersea dwellings.

Other crews that came before and after ours laid the foundations for study of other crucial undersea problems. One team, working with four different commercial pesticides, proved that even minute doses seriously affect the respiration of coral polyps. As it is, those builders of great reefs barely keep ahead of erosion—and in fact succumb to such predators as the crown-of-thorns starfish*—so even minor pollution could be fatal.

Another team concentrated on sonic communication among fish. Although man cannot differentiate very faint sounds under water, electronic recording devices captured a broad range of noises. Many are still unidentified, but their ultimate value to undersea farming could be immense.

If we can reproduce the feeding signals of various fish, we might be able to lure large numbers into submarine pens. At the same

*This killer was described by James A. Sugar in "Starfish Threaten Pacific Reefs," GEOGRAPHIC, March 1970.

Magic bouquet—now you see it, now you don't—sprouts from tiny vases of a tube-worm cluster. Spreading blossomlike appendages to feed on plankton, the worms quickly sheathe them in their tube homes when disturbed (**below**).

Roaming almost as if on land, Tektite II geologists gained insights into topography and the dynamics of sedimentation. Biologists studied the reef's vulnerability to man, and probed secrets of fish communication that could aid in future undersea farming.

Psychologists made intriguing discoveries about human behavior. The more religious the diver, they found, the less well he performed in isolation. Scientists who had been sickly as children adjusted better than those who had been healthy, and those born in small towns outdid those from big cities. Eldest children of a family reacted better than younger ones, as did those who had worked during school years.

time, we might be able to generate sounds that would scare away a species' natural enemies, thus throwing a protective sonic cordon around its spawning and grazing areas. Such plans, of course, are still far in the future. Further research may give them reality.

Slow Return to the Surface World

Morning came, and with it a final check-out by the television monitors on safety procedures and our return route to the surface. On departing from the habitat, we were to swim shoreward several hundred yards to a combination diving sphere and decompression tank that had been lowered to the sea floor. Once we had entered, the sphere would be raised to the surface and joined to a larger, more comfortable decompression chamber for our 21-hour transition back to normal atmospheric pressure.

Then the hatch would open on a world we had not seen for three weeks. By that time another crew would have succeeded us at our window in the sea. □

"I was suddenly reminded of swans . . . streaming across a moonlit sky"

Tektite II: Part Two

All-girl Team Tests the Habitat

By SYLVIA A. EARLE, Ph.D.
Illustrated by PIERRE MION

MOONLIGHT RIPPLED on the ocean floor, creating phantom shapes along the reef. As Renate and I glided homeward, 50 feet underwater, a school of giant amberjack came toward us in formation, swimming as one fish. They turned, caught the light, reflected silver, drifted lower, turned again, and disappeared into the darkness.

Overhead, several tarpon swam in silhouette, and I was suddenly reminded of swans I had seen on a winter night, streaming across a moonlit sky.

As we approached the lights of our habitat, two other women divers appeared out of the darkness of the reef, and we swam together toward the entry hatch. I emerged first into the lower compartment, or "wet room." As soon as the others had joined me, I called the command van ashore.

"Topside?"

"Go ahead, bottomside."

"We are home."

Deliberately I emphasized "home." To us, one of the clearest advantages of our 14-day sojourn in the sea was that we had become members of the reef community, occupying our own cranny among the corals.

I, a marine botanist with the Los Angeles County Museum of Natural History, was leader of the group. My fellow divers were Dr. Renate Schlenz True, a Brazilian-born biologist for Bio-Oceanic Research, Inc., of New Orleans; Mrs. Ann Hartline, an ecologist with Scripps Institution of Oceanography in La Jolla, California; and Alina Szmant, a marine biologist also from Scripps. The fifth crew member was Peggy Ann Lucas, our habitat engineer and a student of oceanic engineering at the University of Delaware.*

Renate was studying marine life on a bed of natural sea grass, compared with life on an artificial bed (page 287). Ann and Alina were observing the escape reactions of blue chromis damselfish from real enemies and from plastic geometric forms drawn through the water by a system of wires and pulleys. My job was to catalog marine flora in the area and to assess the influence of grazing fishes on various plants. For her part, Peggy was to report on engineering aspects of the habitat.

The question most frequently asked about our team was, "Why women?"

Dr. James W. Miller, Tektite II director, always replied, "Why not?" Nearly anyone in reasonably good health can enjoy the advantages of living and working underwater.

Big Brother Watches From Above

Initially, we felt strange in the habitat—not because we were underwater; that adjustment comes quickly—but because we were constantly watched. Our actions and conversations were monitored by TV cameras and microphones transmitting to the command van ashore. Likewise, we could glance at our own screens and see the watch director on duty. At first, this around-the-clock surveillance gave me a hair-prickling sensation.

Alina fastened a *Playboy* pinup to the outside of our shower curtain to tease the monitors. Perhaps in retaliation, a package of her brand of cigarettes was sent down—a useless item, since combustion was impossible in the habitat's low-oxygen atmosphere, reduced from the normal 21 percent to 9 percent

*Isolation studies barred visitors—including photographers—from Tektite II's all-female team except during two brief periods (pages 283 and 286-7). To ensure accuracy in his paintings, artist Mion journeyed to the author's West Coast home, where he photographed her in full Tektite diving gear in her swimming pool.—THE EDITOR

to compensate for the habitat's 2½ times sea-level pressure. Nonetheless, some wag from a previous crew had posted a sign above one of the bubble windows reading, "In Case of Fire, Break Glass!"

By the end of the first day I found myself completely ignoring, then forgetting, Big Brother ashore. There was simply too much to do to worry about the ceaseless scrutiny. I hoped that the reef animals would come to ignore *us* just as thoroughly, and continue their normal activities.

Soon a pleasant rapport developed with the watchers topside. Before every dive, we had to clear with them a seemingly endless list of safety precautions and work plans.

The whole scene seemed a little ridiculous at times. There we were, five aquanauts, intently watching what the fishes and other animals were up to. Meanwhile, teams of psychologists and other trained observers were intently watching what *we* were up to. And through our own viewing screens we could watch the watchers watching us—while fishes peered in through the portholes!

Far from being bored, we resisted sleep, ate meals hastily, and spent six, eight, or ten hours a day outside the habitat, exploring coral heads and quietly observing the comings and goings of our neighbors.

One morning at 4:45 I stood by the hatch with Ann Hartline and Peggy Lucas, each of us with a weight belt, compass, watch, depth gauge, knife, strobe light, yellow emergency balloon, sonic homing device, lantern, camera, collecting bag, and writing slate—all buckled, draped, or clutched somewhere on us. We wore standard twin-pack scuba tanks.

Sunrise Brings a Change of Cast

"Topside?" I call to the watch director.

"Go ahead, bottomside."

"We are ready to begin our dive."

"You aren't serious. The sun isn't up."

"Sure we're serious. It's great out there. Are we clear?"

The watch director chuckles.

"Go ahead, you wild women. You are clear."

The hour is perfect for our work. First light brings dramatic changes on the reef. Night creatures—active since sunset—return at last to their crevices. Others go to deeper water. Day creatures emerge from various burrows and dens. In less than an hour there is a spectacular transformation. This is the time to see just who is up to what on the sea floor.

We step from the habitat into the blue well in our floor and slip into the dark water. Then we swim away from the floodlights and, with only our portable lamps to guide us, cross the reef to a place where we have seen a small damselfish guarding its eggs. Luminescent organisms sparkle in the water about us.* An occasional bright flash indicates the presence of darting fish.

5:20 a.m. We find a likely spot at 70-foot depth and settle down. The damselfish are still in their rock crannies; the sandy plain beside the reef is quiet. We switch off our lights and wait. Black shades to gray, and several damselfish cautiously emerge from a small clump of coral.

"Gardens" of Eels Spring Up at Dawn

5:35 a.m. We notice the tip of a small black nose at the rim of a hole in the sand. Within minutes, dozens more appear, and soon an entire bed of garden eels has assumed the "up periscope" position.

By day these lovely slender fish extend more than halfway out of their burrows, swaying and bending continuously and feeding delicately upon passing small creatures. By night, who knows? Apparently the eels stay in their burrows, for although we always find their holes during evening dives, the owners seem to be tucked out of sight. Once Renate and I watched them retract at sunset, a process that began as the sun went down and lasted about 45 minutes.

6:00 a.m. We watch a bicolor damselfish drive away a young queen triggerfish that noses too close for comfort.

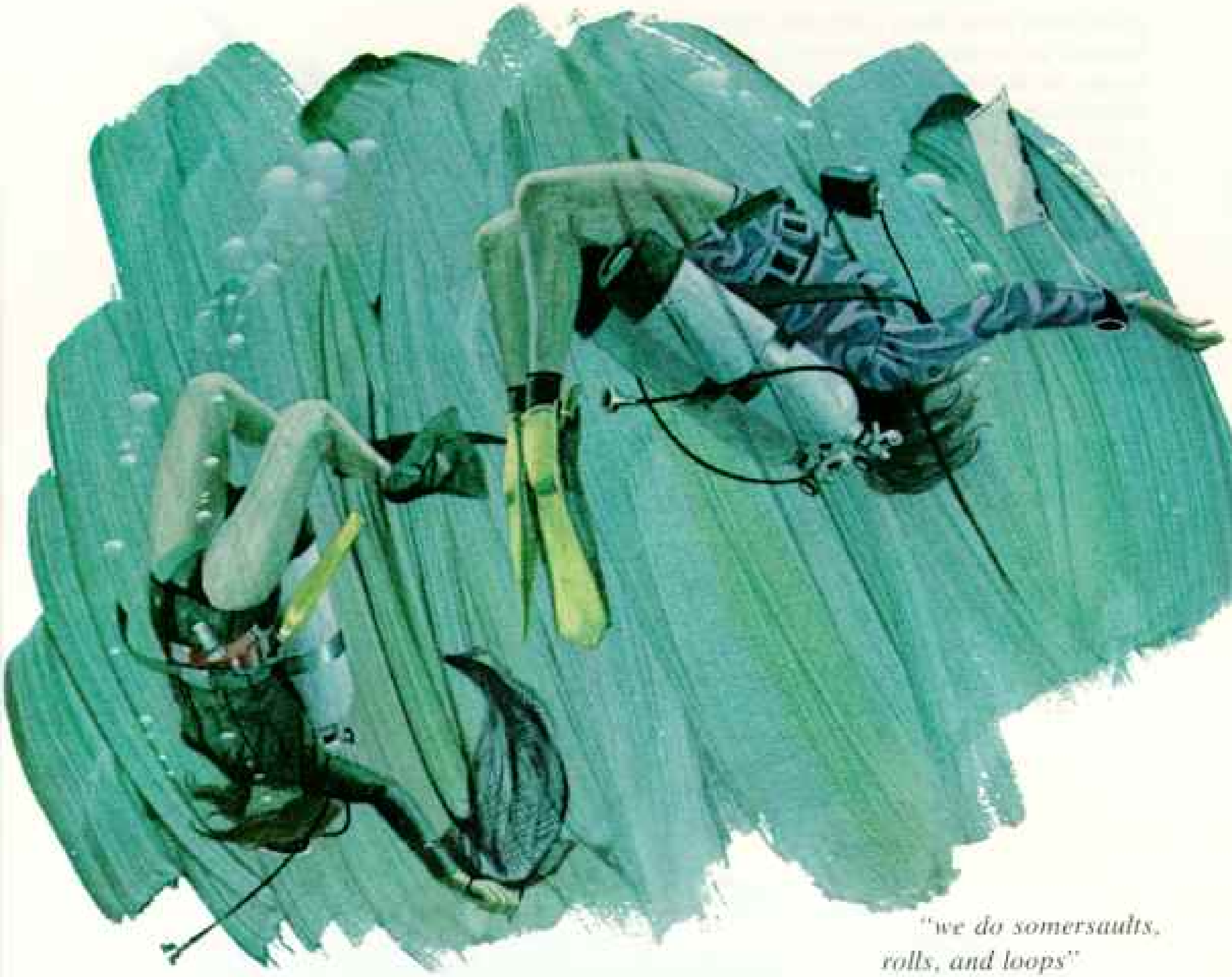
Not far away we find a basket star resting in a tight knot next to an anemone. By night we have seen the same creatures fully expanded; as they snare plankton in their lacy arms, they resemble large doilies waving above the bottom.

At last our air begins to run low, and we return to the habitat. Our sense of freedom and delight is so great that along the way we do somersaults, rolls, and loops.

Back home once more, we have breakfast, then proceed to the routine of bandaging minor coral cuts and abrasions.

In the afternoon Renate and I prepare for another excursion, this time using rebreathers, which emit few disturbing bubbles. Also, they will allow us four continuous hours on the sea floor. In that period we can visit Renate's

*Dr. Paul A. Zahl discussed the phenomenon of bioluminescence in "Nature's Night Lights," NATIONAL GEOGRAPHIC, July 1971.



"we do somersaults, rolls, and loops"

"the routine of bandaging minor coral cuts and abrasions"

grass beds, more than 1,000 feet north of the habitat, go on to one of my study areas, then return to the reef to observe the spawning damselfish and the grazing herbivores. With conventional scuba gear the same tasks would require at least three separate trips.

Renate and I are simply ignored by the reef population. We sit quietly near a coral head, and a trumpetfish glides by, nearly touching my faceplate. A lizardfish lands on top of my flipper—and stays there.

Away from the reef, on an open sandy plain, a batfish allows us to approach, and I hold it gently in my hand. It wriggles slightly and I release it. Instantly a large snapper strikes the small creature. Thwarted by the batfish's hard surface, the snapper releases it. Alarmed but alive, the batfish darts away.

Most active grazers—adult surgeonfish, parrotfish, angelfish, and other plant-eaters—seldom range more than 200 feet from the cover of the reef, lest they fall victim to the large predators. As we cruise, I speculate on the role of those predators in the balance of underwater life. If they were selectively

"I release it.
Instantly a large snapper strikes the small creature"

"A lizardfish lands on top of my flipper —and stays there"

removed from the sea (and many swimmers would like to eliminate all sharks!), would the reef ecology be disturbed? Might the population of small fish outgrow its food supply?

We did not regard sharks and barracuda as a major menace. They were there, but in general they went their way and we went ours. Panic, the greatest underwater hazard of all, presented no problem to our team; all five women were controlled and at ease, even when sticky situations developed.

Once I was the victim simultaneously of a sand-clogged regulator and of a faulty reserve valve while using scuba gear 70 feet down, some distance from the habitat. The instant loss of air could have been serious, but my diving partner, Peggy Lucas, coolly shared her mouthpiece. We returned to the habitat, taking alternate breaths from her tank.

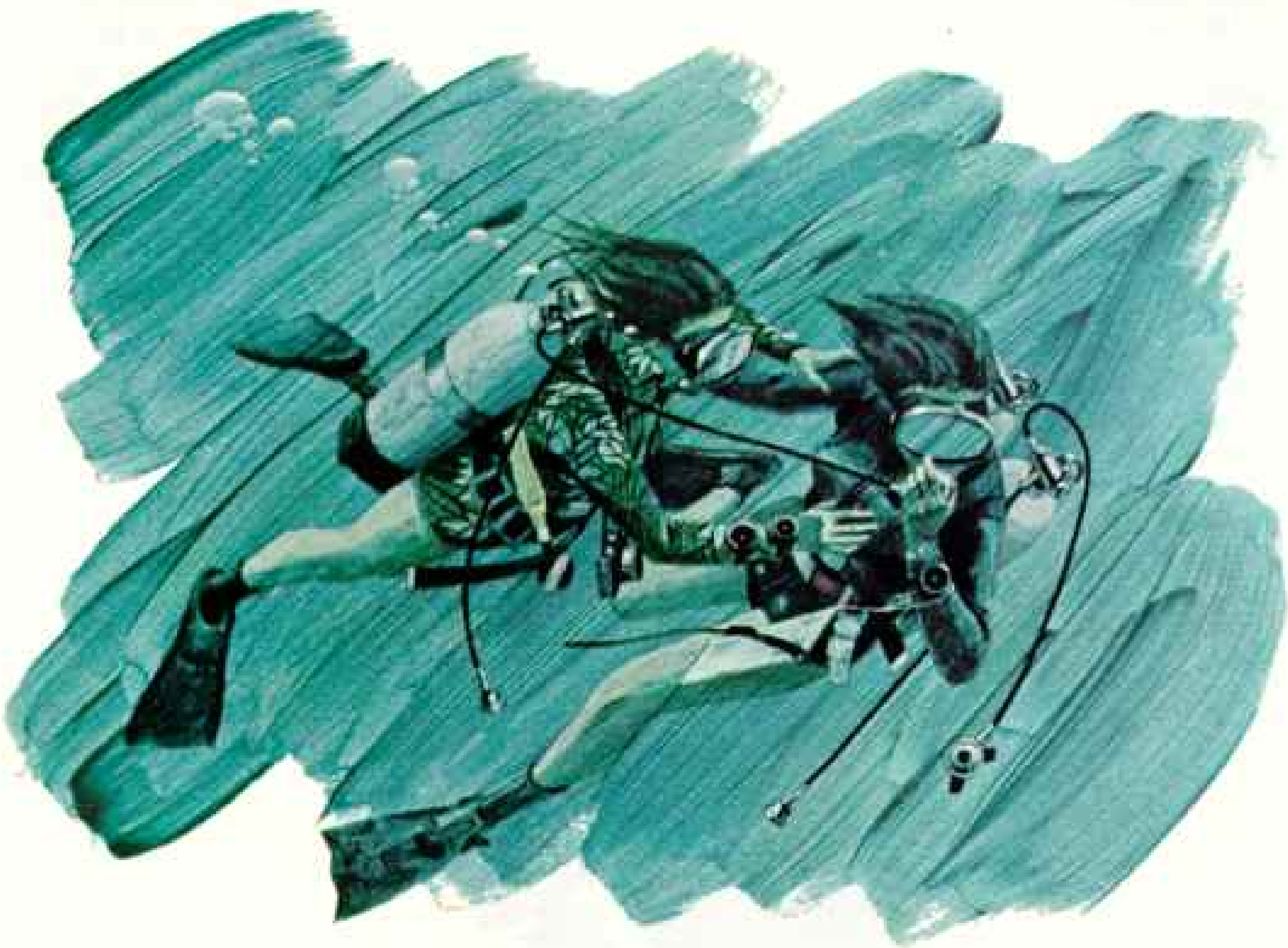
"Discrimination" Greets Returning Team

Our fourteenth and last day arrives. Ann and I leave the habitat early in the morning for a final look at the now-familiar reef. At the entrance we are greeted by five gray angelfish, a group we have seen frequently on our daily excursions. They come toward us slowly, gracefully—gray fish against dawn-gray water. They remain on the reef while Ann and I slip over the edge and glide down to the grassy plain beyond. There we gather a few pieces of the green alga, *Codium*, and later, near the habitat, place it in a pile to see what fish will be attracted.

Within moments, several parrotfish begin nibbling, then an angelfish approaches—not the pile, but the sprig I hold in my hand!

Finally, with regret, we return for the last time to the habitat. Three hours later we descend through the hatchway and swim toward shore, where the diving bell waits to carry us to the surface. Twenty and a half hours later, fully decompressed, we step once again on dry earth.

Throughout the mission special efforts had been made to treat the women's team like the men's—no favors, no extra assistance. But as we climbed down from the decompression chamber to the diving platform, we became aware of a reverse kind of "discrimination."



"We returned to the habitat,
taking alternate breaths from her tank"

No other team had been met by an applauding crowd, or given red roses when they returned! All of us felt a little guilty about the extra attention, because we had done nothing exceptional or different from the other Tektite teams. But we *were* the first women to use the habitat.

Scientifically, our two weeks had been productive. Renate showed that the artificial sea-grass patch became rapidly populated by small organisms, especially algae, growing on the plastic strands. They added oxygen to the water, as well as providing food for grazing marine life. The plastic bed thus proved as productive as natural grass. This principle is already used in fish-farming in areas lacking natural vegetation.

Ann and Alina's behavioral studies yielded results that oddly were almost the opposite of their original observations and impressions. To them, it seemed that the faster their plastic cutouts approached the blue chromis damselfish, the quicker was the getaway response. But later study of their films showed that the chromis really started their escape whenever the artificial predator got within a certain distance. Speed of approach was unimportant.

My own studies had turned up 153 different species of marine plants, including 26 never before recorded in the Virgin Islands. In addition, I was able to make new observations on the day-night behavior of garden eels and basket stars. The study also added new details on the habits of 35 different species of plant-eating fish and the breeding behavior of a deepwater damselfish.

In her appraisal of our habitat, Peggy found it functional and easy to maintain; its most critical shortcoming was lack of laboratory space. "Otherwise, it was like living in a luxury apartment," she reported. Her recommendation: closer cooperation between scientists and engineers in the design of future underwater laboratories and equipment.

Though our findings were predictably limited, they will serve to broaden a narrow field of knowledge. Only in the pooling of such bits and fragments can scientists begin to grasp the complexities of life on a submerged reef, and in the great ocean reaches beyond.

Each of us has a stake in that endeavor. Through a complex chain of reactions, an oil spill in San Francisco Bay affects the life of Midwesterners, just as air pollution in Chicago results in a less healthy New York City.

During many months Tektite II scientists gathered an overwhelming amount of data on Great Lameshur Bay, a healthy, balanced portion of the sea. The results will provide a model against which to compare—and, one may hope, to correct—disturbed and unbalanced parts of the undersea environment.

Classrooms of the Future—Underwater

The value of habitats was demonstrated to us early in the mission. They permit virtually unlimited diving time and complete commitment to the work at hand, an absorption that brings maximum results.

But it is not just the quantity of available information that makes habitat diving attractive. There is a distinct difference in the kind of observations that can be made by an observer who is an underwater inhabitant, rather than a hurried visitor with an air-tank passport limited to a matter of minutes. Plants and animals become familiar not just as species, but as individuals whose complex relationships are the key to their survival.

To me, the next logical step in underwater exploration is to move our laboratories to the environment itself. I envision classes in marine science conducted underwater, where the action is. Submarine farming, effective monitoring of the ocean, undersea mining and industrial work all seem closer at hand now that habitats have been proven possible, practical devices. □

Interstate Highways do a better job of getting you anywhere, but here.

Last year the accident rate on old highways was more than double the accident rate on the modern Interstate Highway System.

In fact every thousand miles of the Interstate freeway in use today saves 150 to 200 lives each year. That adds up when you consider there are about 30,000 miles of Interstate now open.

But we still have 12,000 miles left to finish. We could be saving 2000 more lives each year. That alone is reason enough to push the Interstate Highway System to completion without delay.

Let's get it finished.

Before more lives are.

We can make the world a better place to live in. Caterpillar machines will help.

CATERPILLAR

IT'S A LOT OF LITTLE CAR.

Admittedly, Vega isn't as inexpensive as some little cars you can buy.

But we didn't build Vega just to be an inexpensive little car. We built it to be a good little car. And it is.

One big reason is Vega's engine. It's a 140-cubic-inch overhead cam with an aluminum block. Very unique. Also very functional: it manages to be peppy and frugal at the same time.

There are other things that make Vega a lot more car than most little cars. Like interior room. Vega offers as much room per passenger as many big cars.

And Vega comes standard with an amazing array of features not normally found in little cars. For one thing, Vega comes standard with big 10-inch disc brakes up front.

And Vega comes standard with foam-filled front bucket seats.

And Vega comes standard with side guard beams in each door.

And a very refreshing power ventilation system.

And even a disposable engine air filter that lasts 50,000 miles—more than twice as long as the old kind.

Check Vega out at any Chevrolet dealer's. It's a lot more car than you expected it to be.

GM

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

VEGA
CHEVROLET

The Product 19 Story.

As America has become more nutrition-conscious, more people than ever are discovering Product 19.®

It is one of the country's leading high nutrition cereals.

Much of the story is on the front of the box.

The rest of the story is in the taste.

Product 19 is a delicious blend of four grains—corn, rice, wheat and oats.

The firm texture and pleasing taste have won thousands of new friends of all ages.

Kellogg invites you to join the growing number of people who are discovering how good tasting a high nutrition cereal can be.

You get 100% of the officially established minimum daily adult requirements for VITAMINS and IRON in one serving (1 oz.) of Product 19.