DOUBLE SUPPLEMENT: THE PACIFIC ISLANDS AND THEIR DISCOVERERS

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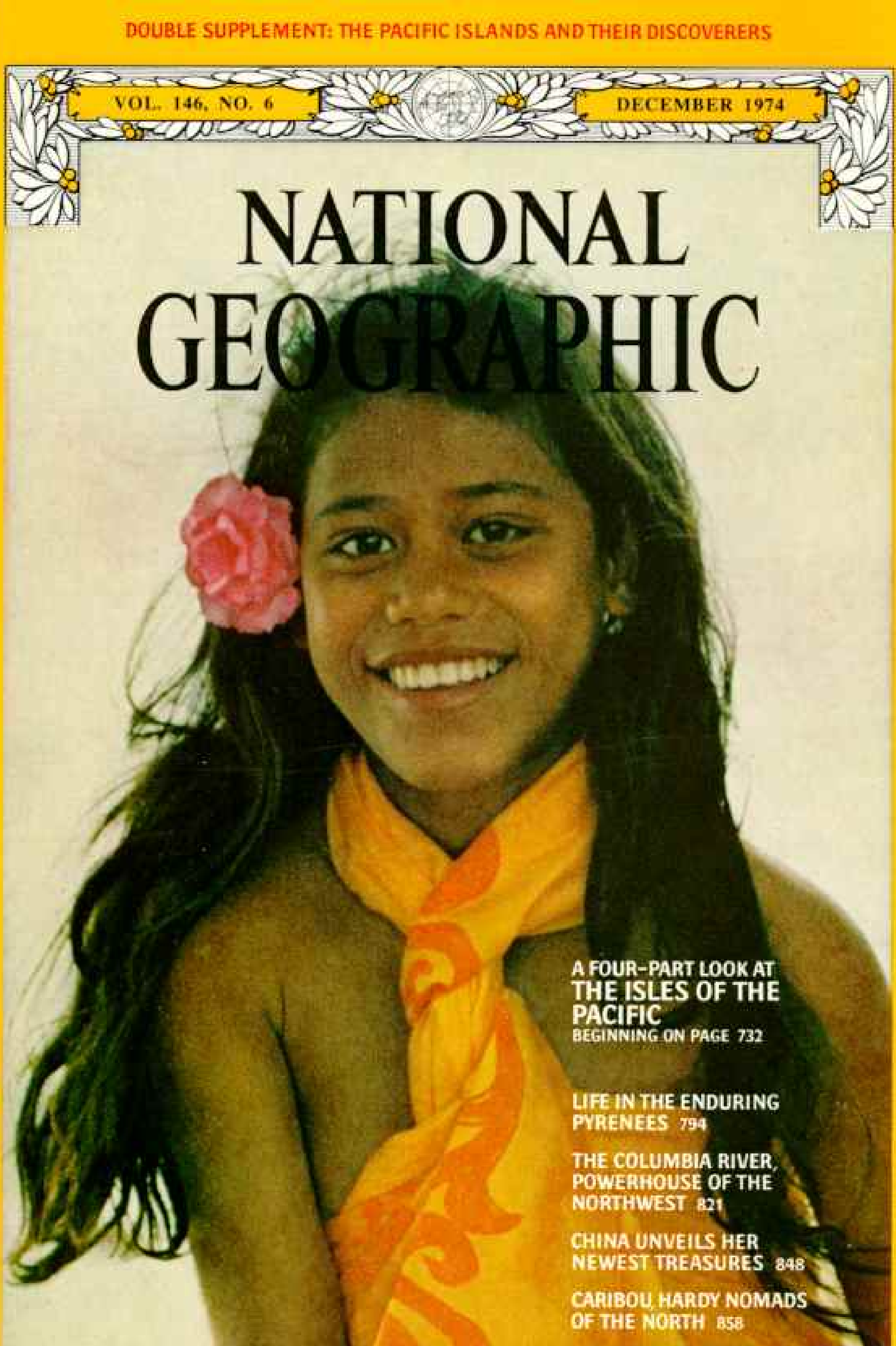

A FOUR-PART LOOK AT
THE ISLES OF THE PACIFIC
BEGINNING ON PAGE 732

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

HERMAN MELVILLE once described the relationship between human genius and man's perception of it as a "shock of recognition." I like to think that Melville, who wrote so eloquently of the Pacific and its peoples, would have enjoyed this month's four-part presentation on the Pacific Islands—for it all began with just such a shock.

Author David Lewis made a casual inquiry of a Tongan about sailing directions through a reef-studded archipelago. "I was flabbergasted by his reply," he recalls, "for it meant that the age-old lore of the sea by which the Polynesians had populated the Pacific was still known—by a few, but known."

David devoted three years to the search for that ancient knowledge, and found it, an achievement that helped earn him the Gold Medal of the Royal Institute of Navigation and the Superior Achievement Award of the Institute of Navigation of the United States, a rare double, richly deserved.

To bring this epic tale to our members, our editors, photographers, and writers logged a combined 200,000 miles of Pacific travel—though not without hazard. Photographer William Curtsinger was attacked and twice slashed by a shark while swimming in the lagoon of a remote and uninhabited island. The fact that David Lewis is a physician and had a supply of antibiotics probably saved Bill's life.

His colleague, Nicholas deVore III, found himself just in time to join a Micronesian crew for an extraordinary canoe voyage of 550 miles across the open ocean. Nick suffered from intestinal flu the whole way: "Nine days on a wet roller coaster." He was alert enough to notice, however, that the crew had added a new element to the ancient navigational repertoire of wind, wave, star, and bird—jet contrails, marking the Pacific sky and pointing the way to land.

Artist Herb Kawainui Kane, who grew up in the steep Waipi'o Valley on the "Big Island" of Hawaii, combines the talents of artist, sailor, and amateur anthropologist. "All Polynesian culture relates to the canoe," claims Herb. He and his friends in the Polynesian Voyaging Society hope to underline that point when they sail a 60-foot double-hulled canoe to Tahiti and back in 1976, using navigational techniques that the world thought were long forgotten.

Several times this past year we had the pleasure of "pulling out all the stops" for an article we thought deserved it—the world-ranging and timely story on gold, the survey of American wilderness at a crossroads moment, the achievement of our frontier in space, Skylab, our account of the glory of the Phoenicians, and that mind-dazzling summary of our new knowledge of the universe itself.

At the moment, our writers and photographers are sailing in the wakes of Columbus and Drake, ranging the new Alaska, exploring the remains of Maya and Celtic civilizations, probing the archives of the American Revolution—but we will let their work speak for itself in forthcoming issues.

It seems a shame that our popular associate in geographic adventure, the award-winning National Geographic Society television series, will be represented by no new programs this year. Word that we had been unable to obtain a commitment from the networks for prime viewing time reached my desk just before the news that one of last season's documentaries had won two coveted Emmy awards. In this case, the shock preceded the recognition.

Gilbert M. Grosvenor

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COVER: *"Eyes full and sparkling," wrote* Bounty *mutineer James Morrison of Polynesia's women. Photographer H. Edward Kim confirms the observation in this portrait of a girl of Bora Bora.*

ISLES OF THE PACIFIC — I

The Coming of the Polynesians

By KENNETH P. EMORY, Ph.D.

THE ISLES of the South Seas—bathed in warm sunlight in the midst of the vast Pacific—were surprise enough to their European discoverers. But more astonishingly, they were inhabited! And the tall, soft-featured, lightly clad people who greeted the Europeans possessed graces they could only admire, and skills at which they could but wonder.

How had these brown-skinned people reached the many far-flung islands of Polynesia? When? And whence had they come? The mystery lingered for centuries.

Not until 1920—the year I joined the staff of the Bernice P. Bishop Museum in Honolulu—was a concerted search for answers launched, with the First Pan-Pacific Scientific Conference, held in the Hawaiian capital. In subsequent years scientists fanned out over the Pacific to salvage whatever knowledge of their past the Polynesians retained. The field was vast, for Polynesia sprawls in a huge triangle, from Hawaii in the north to Easter Island in the southeast to New Zealand in the southwest. I have taken part in many of these expeditions from Mangareva to outlying Kapingamarangi, some 5,000 miles away and beyond the Polynesian Triangle.

After the Tenth Pacific Science Congress in 1961, scientists from New

Nomads of the wind, *shipmates drop sail as they approach Satawal in the central Carolines. The past of their seafaring ancestors, long clouded by mystery and*

NICHOLAS DEVORE III

legend, now comes dramatically to light after more than half a century of research.

Following the wake of ancient voyagers who sailed eastward from Asia, the author, dean of Polynesian archeologists, pieces together the story of one of the monumental explorations of all time —the peopling of the isles of Polynesia.

Classic beauty of the South Seas *shines from the faces of these girls of Papeete, Tahiti, daughters of an American father and a Polynesian mother. European voyagers so extolled the Pacific's brown-skinned women that their beauty*

THOMAS HEBERT

became the stuff of legend. Visiting Tonga in 1777 as a surgeon's mate on Captain Cook's expedition, David Samwell wrote of seeing "great Numbers of Girls . . . who in Symmetry & proportion might dispute the palm with any women under the Sun."

Wherever Polynesians sailed *in quest of new lands, they retained the tradition of an ancestral homeland to which their spirits would return after death. Its ancient name, Hawai'i, echoes in the names of several islands in eastern Polynesia, among them Hawaii and Samoa's big isle of Savai'i. An emerald necklace of surf-fringed reef adorns this Hawai'i—Raiatea in the Society Islands.*

Zealand, Australia, Europe, the United States, and Japan amassed a great store of new data on Polynesian prehistory. Their research was coordinated by the Bishop Museum and financed by groups in several nations, including the U. S. National Science Foundation.

Disciplines as diverse as archeology, linguistics, and botany now enable us to sketch the main outline of Polynesian origins, and even fill in many details of this dramatic first conquest of the Pacific Ocean.

The early island dwellers, lacking metals, shaped tools from stone, bone, and shell. We have found such artifacts

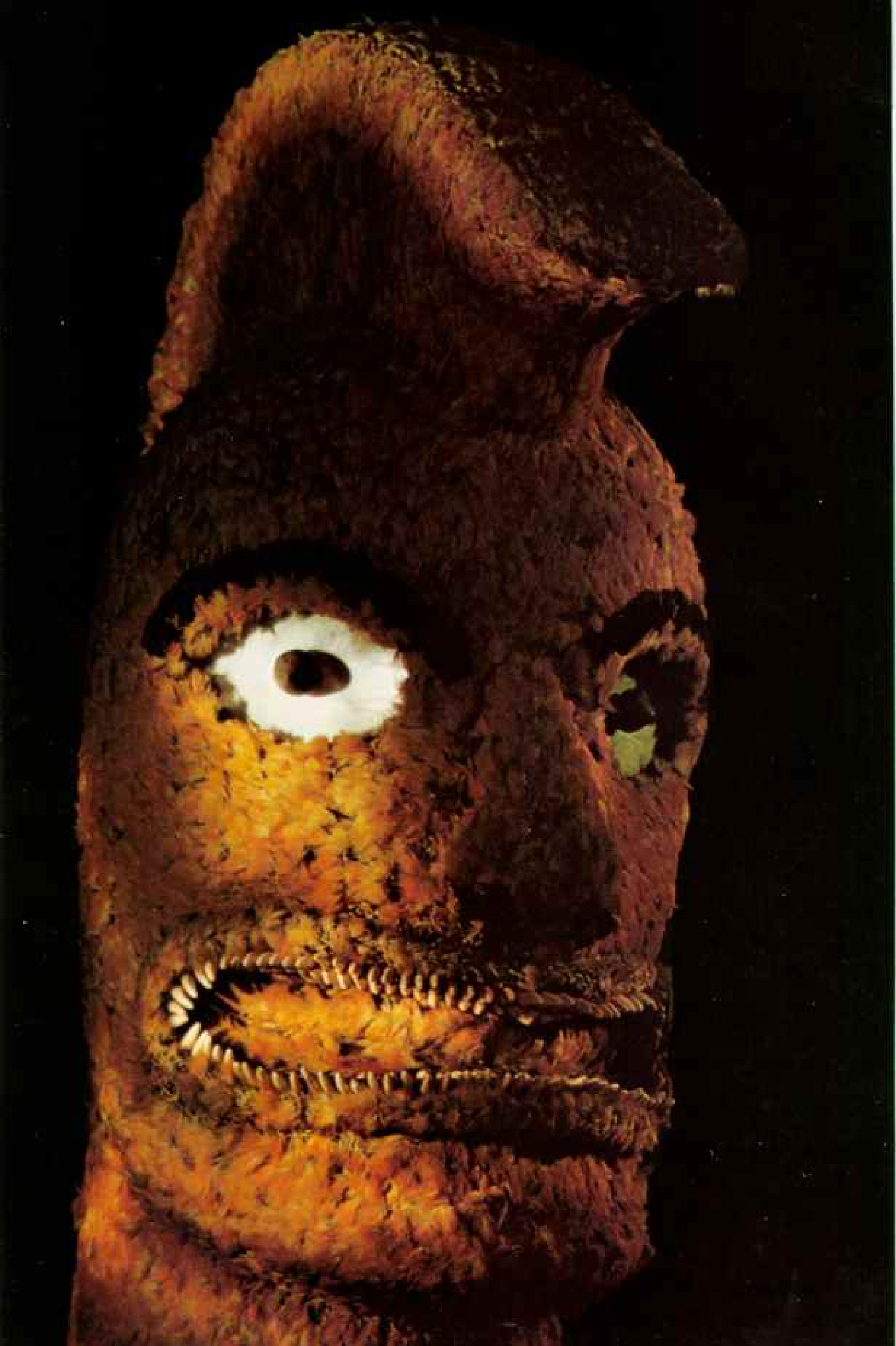
NICHOLAS DEVORE III

in association with radiocarbon-datable human bone and charcoal from ancient hearths. But nowhere in the islands of Polynesia have we uncovered archeological traces earlier than the Polynesians' own culture.

Had the first Polynesian settlers encountered an earlier people on the islands, one would expect that some vestige of an unrelated tongue would have survived. Linguistic researchers have detected none. They have found, however, that the languages of Polynesia have a common origin with those in Melanesia, Micronesia, and Indonesia. All of them belong to one great Austronesian family that extends as far westward as Madagascar.

Botanists tell us that of the food plants brought to Polynesia, all but one —the sweet potato from South America—came out of the islands to the west. So, we know, did the Asiatic jungle fowl, the pig, the dog, and the Polynesian rat. There can be little doubt, then, that the first inhabitants of the whole vast Polynesian Triangle came from somewhere to the west.

Human occupation of Oceania—those vast reaches of the Pacific encompassing Polynesia, Melanesia, and Micronesia—began on New Guinea.



There archeologists have dug primitive stone tools and charcoal more than 25,000 years old from campsites used during the last Ice Age, when sea levels were lower and the distances between Australia, New Guinea, and other Indonesian islands were much less.

When melting ice raised the level of the ocean and increased distances between landfalls, New Guinea and its dark-skinned inhabitants—Melanesians—became more isolated until the coming of the brown-skinned people out of island Asia—Indonesia, the Philippines, and Taiwan. In their outrigger and double canoes with sails of plaited leaves, the latter reached New Guinea and nearby islands about 4,500 years ago, but did not dislodge the Melanesians they found already living there.

Among the seafarers, who moved eastward in small groups at various times by various routes, were ancestors of the Polynesians. Using Fiji as a staging area, some eventually sailed on to uninhabited Tonga and Samoa.

To have developed the physical types, language, and culture that the Polynesians share in common, these Polynesian forebears must have been isolated for a time in a home group of islands. A chain of archeological discoveries leads us to believe that this isolation started in the islands of Tonga and Samoa roughly 3,000 years ago.

Beginning in 1909 in New Britain, archeologists have found a type of prehistoric decorated pottery at various Melanesian sites. Edward W. Gifford in 1947 excavated samples in Fiji, Melanesia's easternmost extension. Five years later, he and Dr. Richard Shutler, Jr., uncovered the same type at Lapita in New Caledonia. Now called Lapita-style pottery (right), these artifacts clearly trace the visits and attempted settlements of a maritime people moving along a Melanesian route toward Polynesia.

Lapita pottery was excavated by Dr. Jens Poulsen in Tonga in 1963-64, and has recently been found in Samoa as well—both in western Polynesia.

Tonga is the longest-inhabited island group in Polynesia, with radiocarbon dates as early as 1140 B.C. Thus we

JAMES SIBRA, UNIVERSITY OF AUCKLAND COLLECTION; LAWRENCE AND HELEN SIBRA, FROM THE SIBRA COLLECTION (BELOW); NICHOLAS DESORE III; BERNICE P. BISHOP MUSEUM, HONOLULU (FACING PAGE)

Keys to Polynesian ancestry, *Lapita-style pottery shards from the Reef Islands (above), Fiji (below), and other locales document the eastward movement of ancient voyagers through Melanesia to Samoa and Tonga, where some landed as early as 1140 B.C. Here, from a rootstock comprised of perhaps a few families, evolved over a millennium the language, physique, and culture of today's Polynesians.*

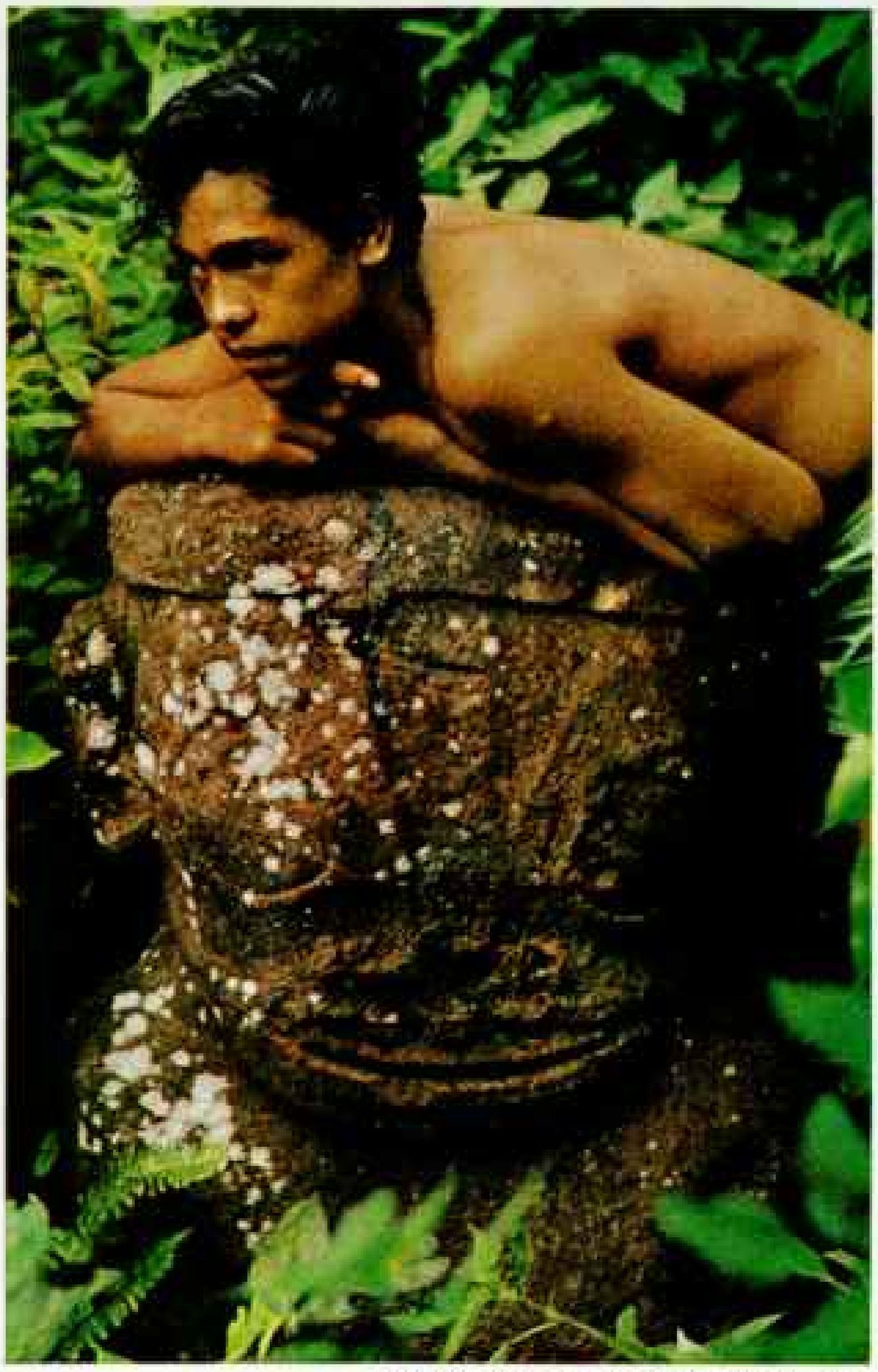
*Dogs' teeth, pearl-shell eyes, and the feathers of hundreds of tiny birds make up the fearsome image of Kukailimoku, the Hawaiian war god (**facing page**).*

Titans of past glory, *three of Easter Island's famed stone statues brood in the glow of a Pacific sunset. On this lonely outpost of Polynesia, early islanders carved hundreds of the monoliths from volcanic tuff, moved them as far as six miles, and erected them on stone platforms.*

How they did it was long a mystery. Scholars now conclude that sledges, ropes, and brawn provided the transport and that workers levered the giants to their upright positions inch by laborious inch on supporting mounds of stones.

Island tradition holds that the statues

NATIONAL GEOGRAPHIC PHOTOGRAPHER THOMAS J. ABERCROMBIE



NATIONAL GEOGRAPHIC PHOTOGRAPHER BATES LITTLEHALES

WILLIAM R. CURTSINGER

themselves walked to their locations upon the invocation of the priests' mana, or sacred power—power indeed, for the statues have no legs.

*Though separated by nearly three thousand miles of ocean, a stone image from Necker Island in the Hawaiian archipelago (**above**) shares the same smile as its counterpart in the Marquesas (**upper**). Archeologists conjecture that artisans of similar cultures carved the statues, and thus assume one of the voyaging links between the Marquesas and Hawaii.*

Awash in lacy surf, *Hiva Oa's beach of dark volcanic sand is as tranquil and inviting now as it was when Polynesian voyagers first reached the Marquesas from distant Samoa or Tonga some 2,000 years ago.*

As population increased and competition for land and food intensified, descendants of the voyagers set out in search of new islands, an intermittent exodus still under way when Capt. David Porter of the U.S. Navy visited the Marquesas in 1813.

conclude that Tonga's first settlers, the people who made Lapita ware, were the first true Polynesians.

Language ties indicate that this migration continued via Samoa eastward to the Marquesas, where the oldest sites in East Polynesia have been found.

Far to the southeast of the Marquesas lies evidence of a truly remarkable feat —a voyage to Easter Island, some 2,400 miles away, in the face of prevailing winds and currents. Polynesia's easternmost outpost, Easter Island is not only the most isolated inhabited island in the Pacific, but it is also only 15 miles long.

Assessing its chances of being discovered by early Polynesians, we can conclude only that their sailing canoes

BATES LITTLEHALES

were already capable of traversing the breadth of the Pacific, and that on one such voyage Easter Island was fortuitously sighted. Radiocarbon dating in 1955-56 indicates its discovery and settlement as early as A.D. 400—perhaps while the Goths or Vandals were attacking Rome on the other side of the world.

Dr. Yosihiko H. Sinoto, a Bishop Museum archeologist, and I visited Easter Island in 1969. There we were guests of Dr. William Mulloy, who had first been on the island as a member of Thor Heyerdahl's 1955-56 Norwegian expedition. We found Dr. Mulloy supervising the restoration of ceremonial platforms bearing colossal stone statues. These famous monuments have been variously attributed to inhabitants from a sunken continent and to a white-skinned, red-haired, bearded tribe from Peru.

As we examined the sites on Easter Island, our firsthand knowledge of the archeology and languages of the Society and Marquesas Islands convinced us that the prehistoric culture of Easter Island could have evolved from a single landing of Polynesians from a Marquesan island, fully equipped to colonize an uninhabited volcanic island. Their success in making this windswept 64 square miles, without an edible native plant, not only habitable but also the seat of remarkable cultural achievements, is testimony to the genius of these Polynesian settlers.

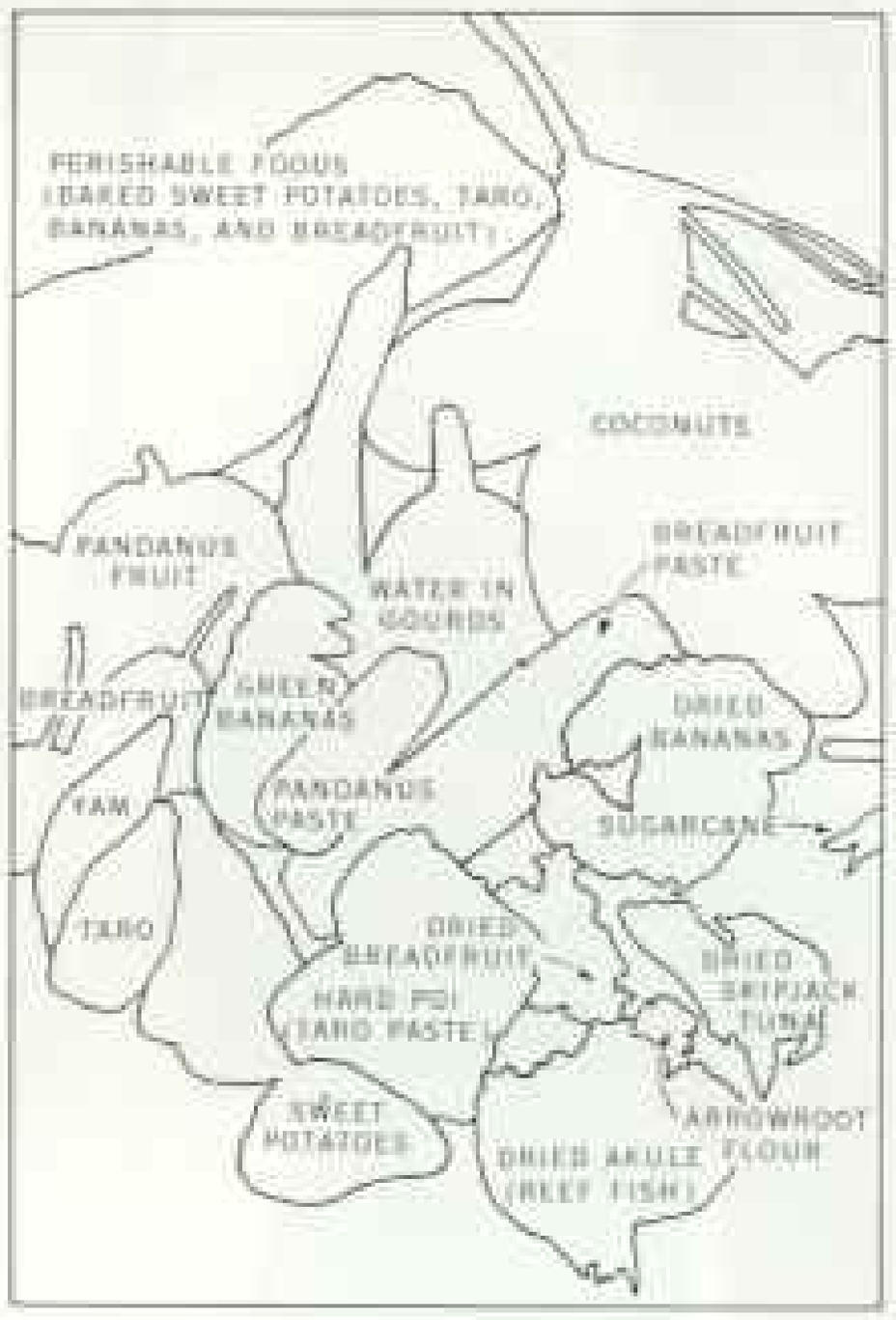
A study of excavated adzes, fishhooks, ornaments, and other artifacts indicates that Tahiti and the other Society Islands must have been settled soon after the Marquesas. Present information indicates that Hawaii and New Zealand were settled after A.D. 500. Radiocarbon techniques permit us to assign tentative dates to this entire Pacific migration: entry into West Polynesia about 1000 B.C., reaching East Polynesia about the time of Christ, completing the occupation by A.D. 1000.

These ancients were remarkable seamen, and no less skillful boatbuilders to have shaped craft capable of such voyages. Intriguingly, artist-researcher Kane suggests that the seagoing canoe may have helped "shape" the people:

"Its design favored the survival of persons with stamina, muscle, and ample fat to insulate the body from the deadly chill of wind evaporation upon spray-drenched skin. Rigorous selective pressures, oft repeated, may explain the physique and large size that distinguish Polynesians from other equatorial peoples."

Having reached the Pacific's farthest outposts, the early Polynesians possessed the skills to return. It is doubtful that one-way, or "drift," voyages could account for the early presence in the Hawaiian Islands, for example, of twenty-odd cultivated plants and domesticated animals of Tahiti and the Marquesas. (Computer simulations rule out the drift theory entirely.) Thus we conclude that early Hawaiians repeatedly negotiated the longest sea route in Polynesia, returning to Tahiti and then again to Hawaii, known as "Child of Tahiti."

To reenact this feat, Herb Kane and anthropologist Ben Finney have formed the Polynesian Voyaging Society. The society is building a 60-foot Polynesian double canoe, training a crew, and raising funds for the voyage and related experiments. As a Hawaiian event of the United States Bicentennial Year, this voyage will celebrate the discovery and settlement of Hawaii, and serve to recapture the unique knowledge, skills, and spirit of the Polynesian seafaring pioneers. □



Provisions for sea: *Roots, fruits, nuts, dried fish, and water-filled gourds (**facing page and key above**) enabled the Polynesians to survive passages lasting as long as two months.*

*No stranger to the sea, David Lewis (**below**, right) receives a tattoo on Satawal. The physician-turned-mariner visited the western Pacific isle while studying the voyaging techniques of the ancient Polynesians, a fascinating story that begins on page 747. In the December 1973* GEOGRAPHIC, *Dr. Lewis told of his storm-lashed voyage from Sydney to Palmer Station, the first solo passage to Antarctica.*

WILLIAM R. CURTSINGER, NICHOLAS DEVORE III (FACING PAGE)

Wind, Wave, Star, and Bird

By DAVID LEWIS

Photographs by NICHOLAS DEVORE III

THE OLD NAVIGATOR, Tevake, wore the wrinkles and silvered hair of age, and a serenity and steadiness of eye beyond any I had ever seen. I came to recognize that look in other master navigators of Polynesia, but none had quite so farseeing a gaze as Tevake.

In my elderly gaff ketch *Isbjorn* we were pounding through heavy seas somewhere southwest of the island of Taumako, in the western Pacific's Santa Cruz group.

No fewer than 15 people, including sleepy children, wailing babies, and a new bride recently purchased with feather money, occupied every bunk and foot of cabin space, wedged in with mats, taro pudding, breadfruit paste, *nyali* nuts, and a squealing piglet. It was a scene out of ancient Polynesia.

We were, in fact, reliving the Polynesian past. I had arranged this round-trip voyage between two remote islands solely for the purpose of learning how Tevake's ancestors had managed to find their way across, and colonize, the vast Pacific Ocean.

We had put out from Taumako before dawn, but the stars had not faded before heavy clouds shut down. Not so much as a glimmer of the sun broke through. Then a northerly squall swept down on us, laying the lee rail under and sending *Isbjorn* scudding through the tropic downpour. The wind veered northeast, east-northeast, finally southeast. My sense of direction was paralyzed from the squall's onset. At each subsequent wind change, I again lost my bearings.

Yet, for eight solid hours, with never a moment's respite, Tevake stood with his feet planted wide apart on the foredeck. He held a *lo lop* palm leaf as an umbrella, his sopping wet lavalava flapping around his legs, concentrating intently on the sea, unmindful of chill and weariness, his only movement an occasional gesture to the helmsman.

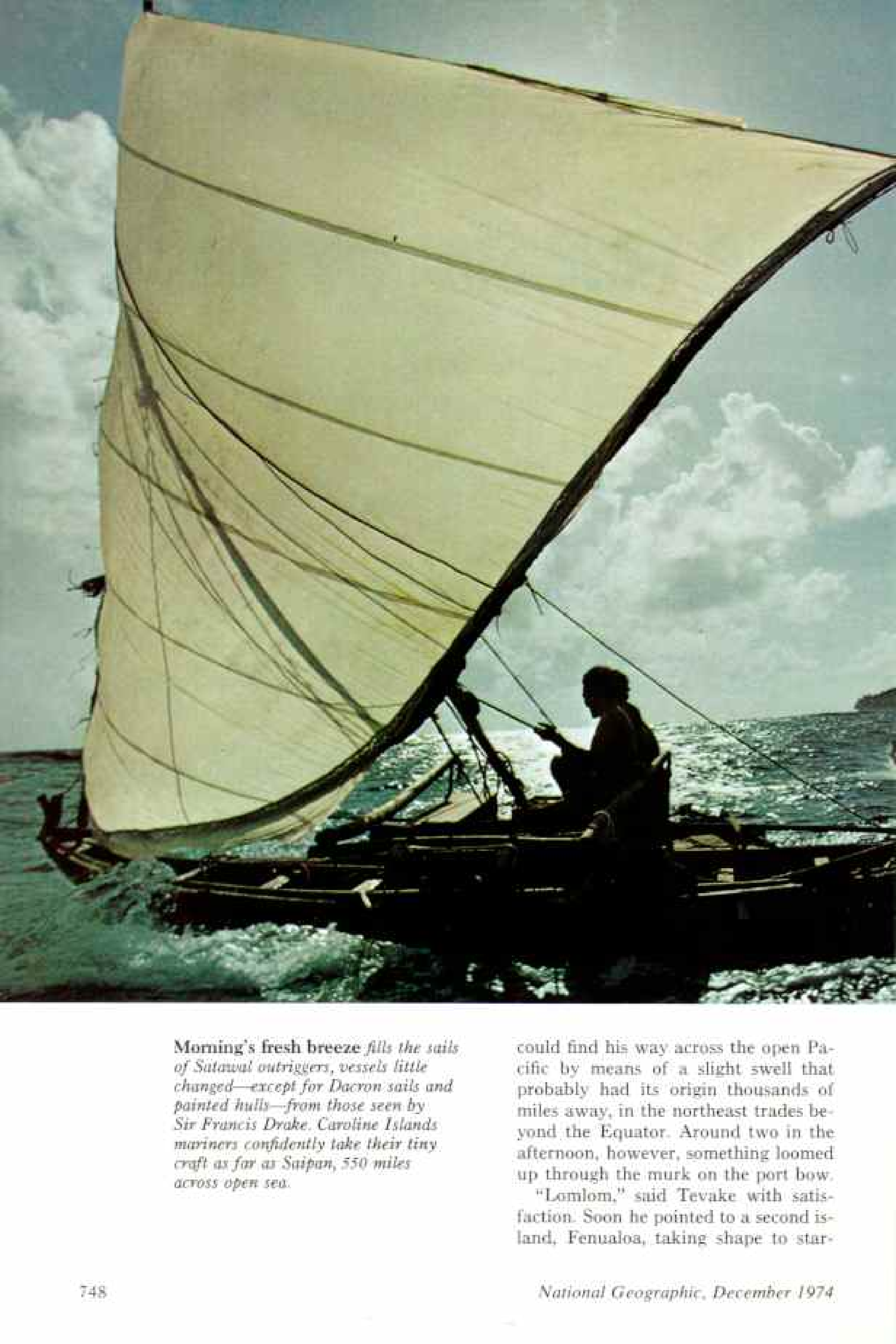
He held course by keeping a particular swell from the east-northeast, unfelt by me, dead astern.

"It is *hoa hua dele tai*, the sea wave," he said. "It lift up stern without rolling boat. Must wait for it long time, maybe ten minute. It not there all time."

It may seem incredible that a man

Without compass or chart, *Tevake pilots the author's ketch through Pacific waters, relying on an astounding knowledge of stars, currents, and barely perceptible ocean swells. The traditional voyaging skills preserved by the Santa Cruz Islander and a dwindling handful of other navigators explain, says Dr. Lewis, how ancient Polynesians could find and colonize a constellation of islands scattered over 15 million square miles of ocean.*

DAVID LEWIS



Morning's fresh breeze *fills the sails of Satawal outriggers, vessels little changed—except for Dacron sails and painted hulls—from those seen by Sir Francis Drake. Caroline Islands mariners confidently take their tiny craft as far as Saipan, 550 miles across open sea.*

could find his way across the open Pacific by means of a slight swell that probably had its origin thousands of miles away, in the northeast trades beyond the Equator. Around two in the afternoon, however, something loomed up through the murk on the port bow.

"Lomlom," said Tevake with satisfaction. Soon he pointed to a second island, Fenualoa, taking shape to star-

board. He had made a perfect landfall in the half-mile gap between them, having navigated for 50 miles without a single glimpse of the sky.

I am no stranger to the complexities of navigation, having three times crossed the Atlantic single-handed and circumnavigated the globe in a catamaran. Nevertheless, Tevake's feat impressed me greatly. He had unerringly passed the stern test of landfall using only the skills of his ancestors.

Devoid of written language or any instruments, guided solely by their senses, the early Polynesians ranged over an area bigger than all the Soviet Union and China combined (see the supplement map, **Discoverers of the Pacific**, distributed with this issue). For years scholars have debated whether this vast area was settled mostly by accident—by windblown castaways, by people wandering blindly—or by navigational skill of the first magnitude.

There is no longer any debate in my mind.

THOUGH I AM a New Zealander, the most memorable years of my childhood were spent in a miniature Tahiti called Rarotonga. There I attended a native school and listened enthralled to my Polynesian cousins retelling the glorious sagas of the ancient captains—Ru, Tangiia, Karika, and Kupe, the legendary discoverer of New Zealand, southernmost land in the Polynesian Triangle.

Years later the irresistible ocean lured me away from the respectable life of a medical practitioner in England, and I became obsessed with the mysteries of Polynesian voyaging.

In 1965, armed with a knowledge gained from the writings of early European explorers and missionaries, I set out to follow the traditional (and archeologically confirmed) migration route from the Tahitian archipelago to New Zealand, by way of Rarotonga.

"Sail a little to the left of the setting sun in November," had been the legendary Kupe's command. In a catamaran called *Rehu Moana*—"Ocean Spray" in Maori—I followed his directions.

Navigating entirely without instruments, steering toward stars setting in the southwest, and using the sun and swells as additional directional guides, as Kupe must have done, I reached New Zealand after 35 days at sea, with an error in latitude of only 26 miles.

Thus I proved to my own satisfaction that ancient tradition was correct. But a far greater surprise still awaited me. I was visiting in Tonga

Mother's deft hands *weave away the morning (**above**) as her child naps in a suspended cradle (**below**). Seagoing ancestors brought the loom from Indonesia to Micronesia centuries ago, but few modern-day blessings, or banes, touch tiny Satawal. Some island men wear watches as insignia of prosperity, but they do not need to know—much less care—what time it is.*

some months after my New Zealand voyage, and chatting one evening with a cutter skipper named Kaloni Kienga. I asked him for advice about traversing his reef-strewn archipelago.

"You head toward that star," he said, pointing to a member of the constellation Leo, "and when it has moved too high and too far to the left, you follow the next to rise from the same point on the horizon. Then the next, and the next, and so on until dawn. This we call *kaveinga*, the star path."

I was flabbergasted. What I had assumed to be long-lost knowledge was being expounded in practical detail. The millenniums-old art of Polynesian navigation still lived!

Kaloni went on, illustrating by motions of his hands the shape of the waves I should encounter. "There are three seas between here and Nomuka. By recognizing which sea you are in, you will know how far you have traveled, even on the darkest night. These things my father taught me."

If Kaloni still knew and used these ancient arts, surely there must be other islanders whose lore could be recorded and saved.

The Australian National University provided a grant, and with my son, Barry, I set out to find the surviving Pacific navigators and sail with them. I hoped to learn to read, as they did, the messages inscribed nightly across the "roof of voyaging" by the slow-wheeling stars, and by the ocean swells that marched rank on rank across the lonely wastes beneath.

We found such men and learned their skills. And, oddly enough, we found many of them not in the central Pacific—the heart of Polynesia—but in outlying islands to the west, in the Gilberts, the Carolines, and the Santa Cruz chain.

I had heard many reports of the veteran navigator Tevake, of the Santa Cruz Islands. "You will just have to chance finding him," said a district officer on Guadalcanal. "He may be anywhere. He has only an outriggerless dugout now, but even in this—and as old as he is—he can't rest from the sea. He is forever roving the archipelago

and far beyond, as far as Tikopia."

As luck would have it, I caught up with Tevake at his home island of Nifiloli, a strip of sun-bleached sand overhung with palms.

He was a striking figure, his wrinkled face distinguished by that sea-formed gaze. He agreed to take charge of *Isbjorn*, sailing her first to Taumako to pick up a bride for his son, and on a second trip to Vanikoro, about a hundred miles distant.

I had been duly impressed on the voyage to Taumako by Tevake's ability to detect surface currents and compensate for them. Usually they are no more perceptible to a seaman than is the drift of a free balloon to its occupants. Long ago Polynesian navigators correctly deduced that most Pacific currents follow the prevailing winds. Once a voyage had been accomplished, the mean set of the seas would be known, and passed on through the generations.

ON OUR SECOND VOYAGE, to Vanikoro, the waves were persistent and steep. Tevake said this indicated a current flowing a little east of north, and altered our course 18° to the right. He maintained that heading by keeping the brilliant star Canopus on our port bow. In the 3 a.m. darkness, surf breaking to port revealed the reefs of Utupua, a reference point we would have missed by a good ten miles had not Tevake corrected for the current.

On our trip back to Nifiloli from Vanikoro, *Isbjorn* pitched and wallowed clumsily along beneath the supremely indifferent tropic stars. Tevake stood thoughtfully by the rail.

"Of course," he said rather hesitantly, looking back at me over his shoulder, "you must know all about *te lapa*." I truthfully denied knowing anything about it at all.

"Then look." Tevake pointed over the side. "No, not on top, deep down. You see him all same underwater lightning." The phrase was apt. Streaks, flashes, and momentarily glowing plaques of light kept appearing well below the surface. Tevake explained that te lapa streaks dart out from directions in which islands lie. The phenomenon is best seen eighty to a hundred miles out and disappears by the time a low atoll is well in sight. He stressed that it was quite different from ordinary surface luminescence. Tevake told me it was customary to steer by it on overcast nights.

The following night after we hove to, lowering our sails to await daylight before threading the tortuous Matema reefs, clouds made the darkness more intense and te lapa more obvious. The flashes flickered along two distinct bearings. One series, Tevake averred, was "from" the volcano Tinakula, the other "from" Ndeni. Morning revealed the lofty Tinakula and Ndeni, both about 20 miles away in the directions Tevake had indicated.

What can be the nature of this sign? Oceanographers say it must be a form of bioluminescence, perhaps triggered by a backwash wave. At any rate the learned Gilbertese navigator Abera later described to me what he called *te mata* in terms identical with Tevake's, and the Tongan Ve'etutu spoke of the "glory of the seas, *ulo 'a e tahi*," which was clearly the same thing. None of these have, as far as I know, ever been described before.

I said good-bye to my friend on his home island with the perfect cone of the sacred volcano Tinakula looming against the sky. There was something symbolic in the old navigator's parting words. Pointing up at a circling tropic bird, he spoke with pride and regret:

"My name, Tevake, same as his. One time I young and like him I go far and free."

THE SEARCH CONTINUED as *Isbjorn* plied the seas to Tonga. It and Samoa lie in the heartland of old Polynesia.

Tracing the earliest settlement of the Pacific, scientists conclude from studies of artifacts (particularly a widespread archaic type of pottery called Lapita ware) that it was launched from somewhere in the islands of Southeast Asia. Through the millenniums, migrations swept generally eastward across the ocean, but ultimately the waves spread toward almost every compass point—

as far north as Hawaii, as far south as New Zealand, even westward again to the so-called Polynesian outliers in Micronesia and Melanesia.

The obscure people who made Lapita pottery reached Tonga before 1000 B.C. There, and in Samoa, they settled down and developed the language and culture we now call Polynesian.

From its cradle in the Tonga-Samoa region, Polynesian culture began its spread over the Pacific about the time of Christ. When Europeans arrived some 15 centuries later, they found Polynesians occupying a vast triangle that covers almost a fourth of the Pacific.

SOME YEARS AGO, in my catamaran *Reku Moana*, I called at Easter Island, a possession of Chile. An islander named Teao remarked: "*E hoa, David, riva riva te pahi*—Friend David, yours is a fine voyaging canoe." The words were much the same as the Maori spoken in my New Zealand homeland, 4,000 miles away.

How were these ancient master mariners able to strike so far afield, never knowing a compass or a chart?

Part of the secret, as the cutter captain Kaloni Kienga had so unexpectedly shown me, was by steering down the star path, kaveinga; picking a star that came up (or sank) in line with your island target, and then steering toward that star and its successors.

"A compass can go wrong, the stars never," declared another Tongan captain. Indeed the points of rise and set of stars do provide a directional compass every bit as accurate as the magnetic instrument—that is, for a Pacific Ocean expert who carries a map of the heavens in his head.

I was to find star-compass techniques still practiced over much of the Pacific. I was even more impressed, however, by the island navigators' uncanny ability to steer by wave motion—swells reflected from islands beyond the horizon. The skilled navigator comes to recognize the profile and characteristics of particular ocean swells as he would the faces of his friends, but he judges their direction more by feel than by sight.

Almost literally he "steers by the seat of his pants"—sensing the ocean swells through the scrotum.

The complex patterns produced by swells reflected and refracted among the islands are recognized by navigators throughout Oceania. The Marshall Islanders illustrate the process using so-called stick charts as teaching devices.

IN TONGA I became aware of even more sophisticated navigational concepts that were restricted to selected initiates. This closely guarded knowledge is the hereditary property of navigator families such as the Tuita (both the name of the family and the title of its head). Early in the past century, the Tuita Kahomovailahi, or Kaho, guided a lost royal flotilla to safety even though totally blind (pages 768-9).

"There are secrets only I and the devil know," Kaho had claimed, and I wondered whether those secrets had gone with him and his descendants into the grave. Through the kindness of His Majesty King Taufa'ahau Tupou IV of Tonga, I was introduced to today's distinguished Tuitas.

There was Fe'iloakitau Kaho, the 87-year-old great-grandson of the blind Tuita himself, whose modest home, little more than a shack, was adorned with the faded signed photographs of the European royalty who were his friends. I met the leading Tuita, with whom I sat for hours cross-legged on mats before the kava bowl; and finally Tonga's most distinguished traditionalist, Ve'ehala, governor of Ha'apai. Together they revealed to me the fragments that remained of their jealously guarded lore.

Ve'ehala explained how overhead stars were once used to determine latitude. "That star," he said, pointing up at Sirius, "when it rises to its highest point in the sky, will stand directly above Vanua Levu, the second island of Fiji. When it is right over your canoe, you know you have reached the latitude of Vanua Levu.

"Such a zenith star that points *down to* an island we call a *fanakenga* star. It is quite different, of course, from a kaveinga compass star, low down on the horizon, that you steer by."

I had long suspected that Polynesian

seafarers sailing to tiny, distant islands "expanded" such difficult targets by first steering for whole archipelagos, guided by their knowledge of land clouds, bird zones, altered swell patterns, and the like.

Ve'ehala now confirmed my theory. He gestured toward a dim line of very high trees. "You see those *puko* trees? We have a Tuita navigator's proverb that says, 'It is enough that we strike the *row* of puko trees.' You need not hit a particular tree. In the same way a canoe captain would aim for the middle of the group, instead of for an individual island."

FROM TONGA I AIMED my own "canoe"—salt-stained old *Isbjorn*—westward, toward Micronesia and the scattered archipelagos of the Gilberts, the Carolines, and the Marianas, all scenes of intense fighting during World War II. There we have a unique and priceless window into the seagoing past of the Pacific; there the navigating arts of Polynesia survive as nowhere else. Probably this is because the European impact was felt in Micronesia later than in Polynesia proper, by about a century.

Passing through the Gilberts, I heard tidings of a great *baurua*, or voyaging canoe, being built on the remote atoll of Aranuka, and promptly changed course.

When I hove to off the atoll, however, the fringing reef, lashed by bursting swells, looked unassailable. A fishing canoe with two men came by. One of the men, Tekiera, looked *Isbjorn* over and shook his head, explaining that only a light canoe could surf over the reef, even at high tide.

"But I can take you ashore," he offered. "You swim good?"

I clambered down into his rocking canoe. A few strokes took us to the break of the surf, where Tekiera and I slipped over the side and waited.

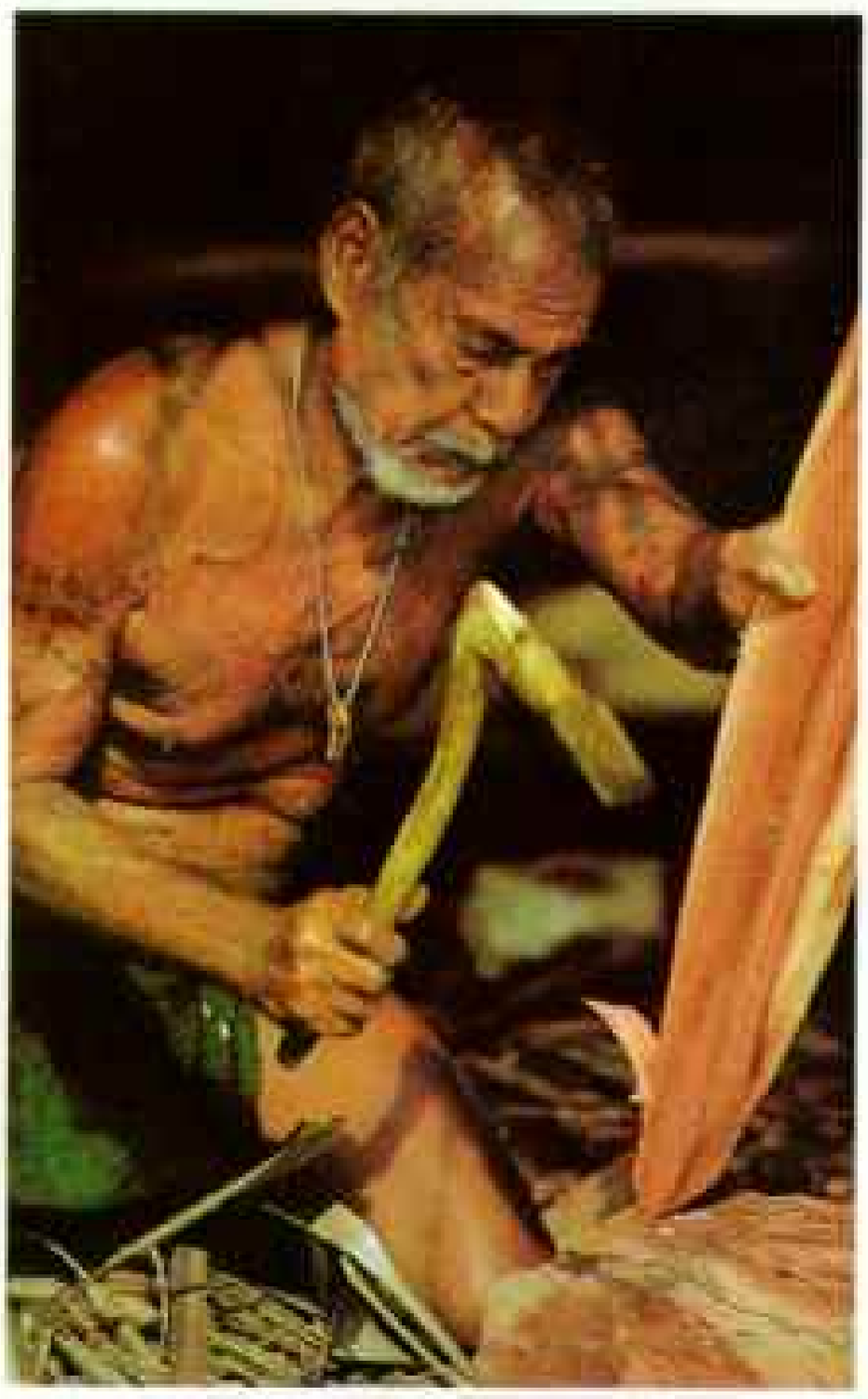
"Now swim!" I launched forward at full speed. Domed coral heads came into view beneath the swirling backwash, and my feet touched the reef.

"Hold," cried Tekiera, but a wave climbed, tottered, collapsed in a welter of cascading foam, and sent me tumbling upside down. Twice more I was somersaulted before I hauled myself, cut and bleeding, onto the dry reef.

Once ashore, I was escorted to the large meetinghouse, the *maneaba*, with thatched eaves that stood only four feet above the ground and a roof that soared upward to a crisscross of massive beams a full forty feet overhead. The trade wind blew cool through the lofty building.

There I was greeted by the villagers, who grinned as Tekiera mimed my

Good to the bare bones, *a freshly caught fish makes a tasty lunch for a Satawal youngster. Schooling includes reading, writing, arithmetic, and navigation, covering such questions as which stars to steer by when sailing the 100 miles from Yap to Ulithi.*



With monumental patience,
*a Satawal canoe maker shapes a paddle with a steel adz, a task his forebears performed with tools of clamshell or stone. In the ancient manner, shipbuilders still caulk hull planks with breadfruit sap (**below**), after heating it with burning sennit, a cord made of coconut-husk fibers.*

*Braided three times by sailors in the canoe house (**right**), sennit becomes rope for ship's rigging, stout enough for the 1,100-mile round trip between Satawal and Saipan. The navigators for these voyages enjoy a status higher than island chiefs.*

WILLIAM R. CURTSINGER

acrobatics on the reef. A feast of marinated raw fish, taro, and cooked pandanus served on shiny leaves was washed down with palm toddy.

The great voyaging canoe I had come to see was a glorious thing, traditional in every way. The planks, hand-sawed on the island from local *te itai* trees, were lashed together every few inches with cord made of hand-rolled coconut fibers. The ribs were bound in the same manner, and sticky breadfruit sap supplied the caulking. The massive outrigger float measured 23 feet.

Though only three-quarters planked up, the baurua was already a thing of beauty, with slim graceful lines, long curved ends, and the promise of great speed, strength, and flexibility. The craft would be used to carry people to nearby islands to take part in communal events. It had not occurred to anyone that navigational instruments or charts might be needed.

It must have been in such vessels that Pacific Islanders had made their great voyages of discovery and colonization. They date from the advent of the New Stone Age, when newly developed heavy woodworking tools made it possible to adz planks and join them to the frames of boats, just as bark or skin had been sewn in earlier times.

The swift and capacious vessels of the Lapita navigators were probably little changed by Captain Cook's day. In 1769 he recorded canoes "much faster" than his *Endeavour*.

Most were 55- to 60-foot V-sectioned craft, built of wide planks lashed to the frames with sennit and caulked with breadfruit sap. Hoisting their mat sails, they could cover 100 to 150 miles a day in open-sea conditions. In Polynesia the double canoe was the preferred style; in Micronesia, the single outrigger. Both were constructed with adzes of basalt or clamshell, drills fashioned from shark's teeth or shell.

With Polynesian ability to preserve food for long periods, a range of 5,000 miles in not-too-unfavorable winds was possible for these great canoes—ample for exploratory probes eastward.

The Polynesians generally sailed into the *(Continued on page 771)*

ISLES OF THE PACIFIC — III

The Pathfinders

SEVEN PAINTINGS BY
HERB KAWAINUI KANE

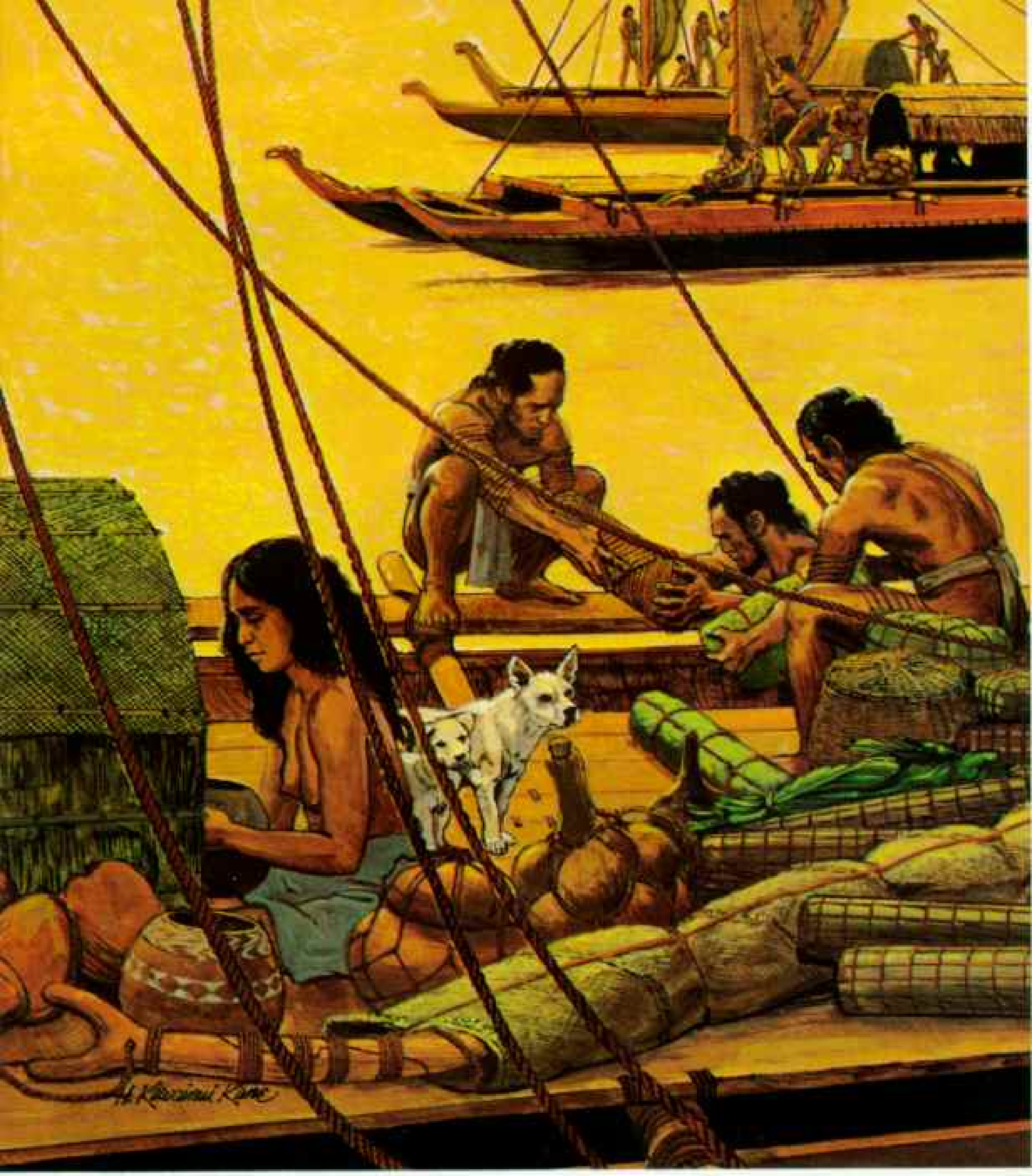
EASTWARD INTO THE UNKNOWN, Samoans spearhead one of the great maritime ventures of all time—the exploration and settlement of Polynesia. In wooden canoes stitched with coconut-fiber rope and rigged with sails of woven leaves, these mariners who knew no instruments navigated 2,100 miles and made their landfall at Nuku Hiva in the Marquesas around the time of Christ.

Within a millennium their descendants—homing in on undiscovered islands revealed by such slight cues as the flight path of a bird—had found every habitable speck of land in an area of the Pacific bigger than North America and Europe combined.

In this portfolio, Hawaiian artist Herb Kawainui Kane (KAH-nay) depicts Polynesian sagas of heroic exploration and vengeful battle; he also portrays the canoes and navigational techniques of Oceania in the map supplement, **Discoverers of the Pacific**, that accompanies this issue.

Limned in volcanic rock on Hawaii, a petroglyph (**below**) shows the sail used by ancient voyagers of that island chain.

WILLIAM R. CURTSINGER

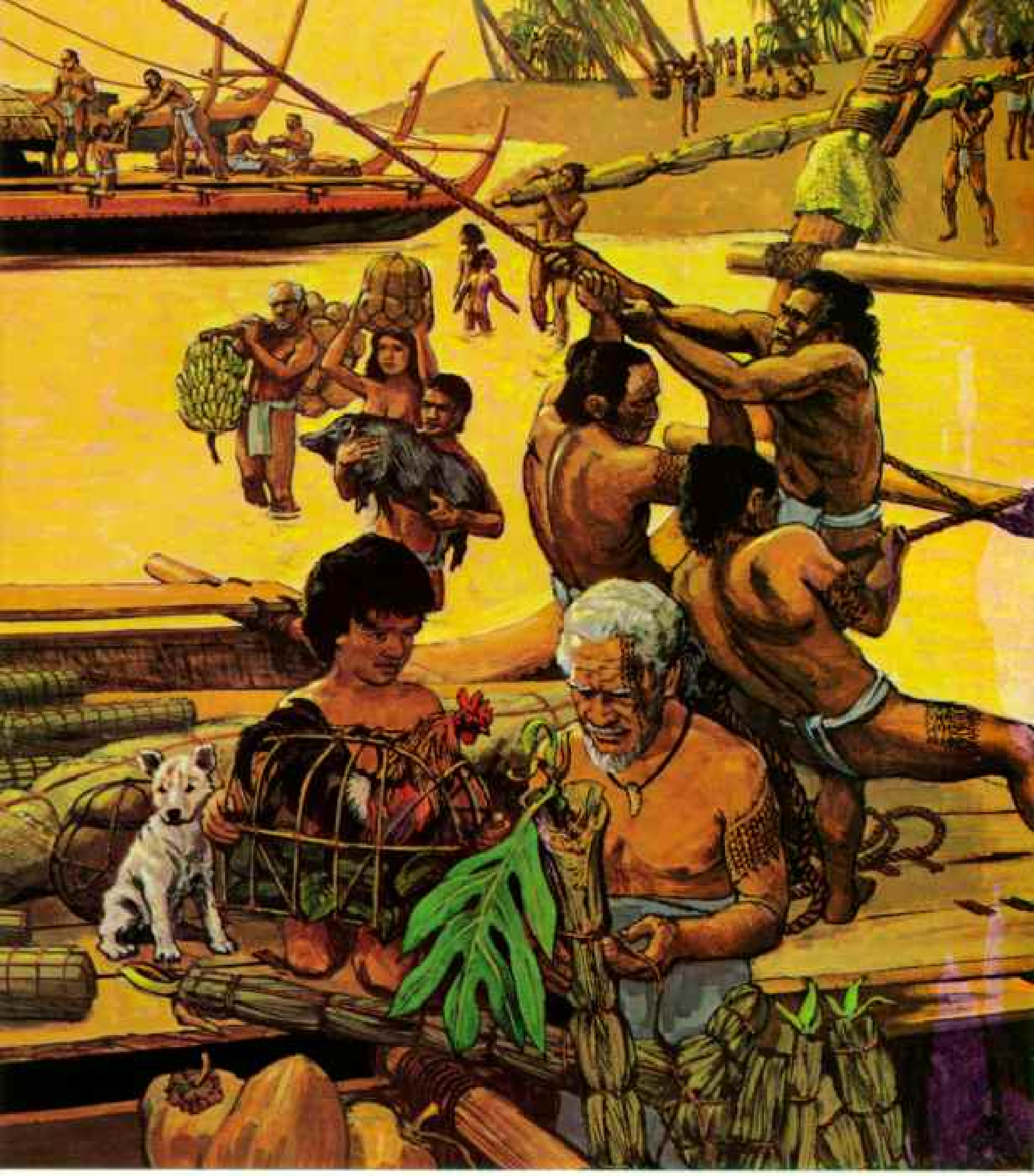


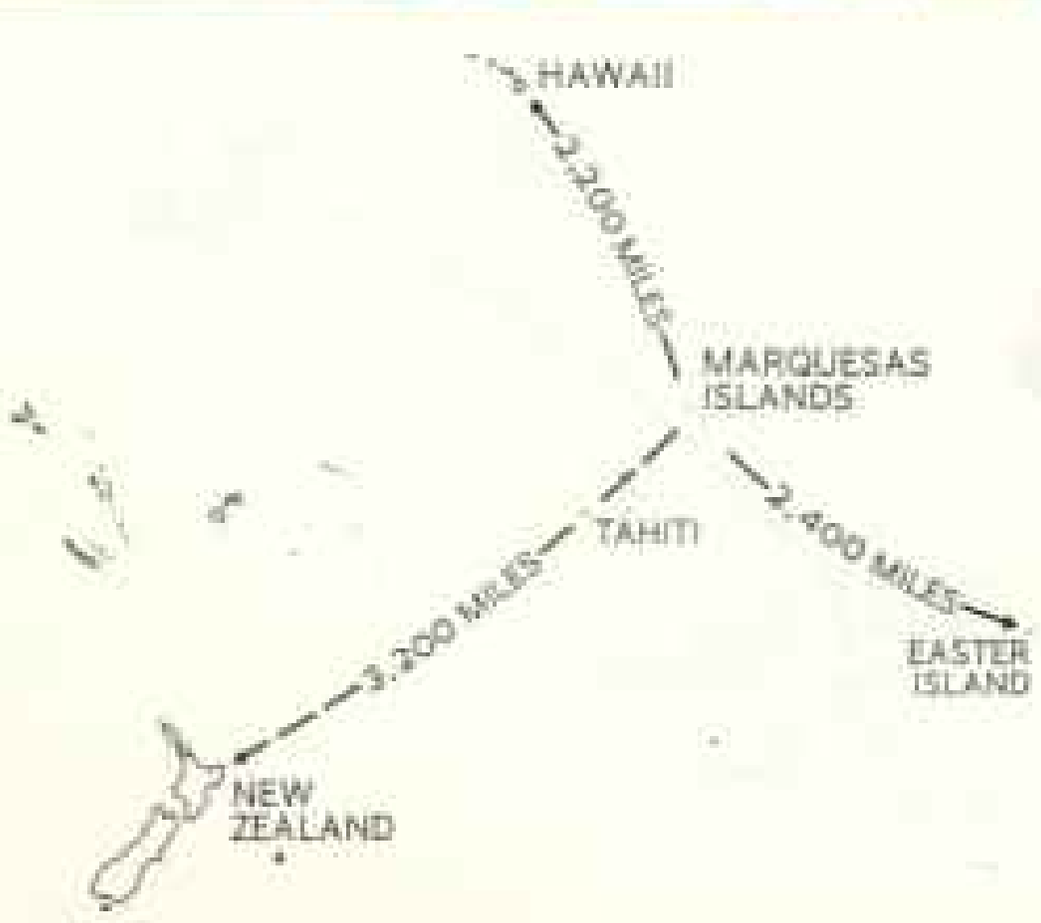
Desperate Marquesans take to the sea

FRUIT OF THE LAND provides rations for the sea as Marquesans begin the search for a new home. They stock double-hulled canoes with fruits, dried fish, breadfruit paste wrapped in pandanus leaves, and water in gourds. Domestic pigs, fowls, and barkless vegetarian dogs accompany them.

Harsh necessity may have forced such departures. When drought struck and clans fought over food, the defeated often sailed in quest of new lands. Thus Polynesians of Marquesan culture found Easter Island, Hawaii, and—via Tahiti—New Zealand.

Similarities between ancient Marquesan fishhooks (middle two at right) and Hawaiian counterparts confirm a link between the two island groups, scholars believe.





PHOTOGRAPH BY NICHOLAS DESORE (b); FISHHOOKS COURTESY BISHOP MUSEUM

This Tahitian war club *is older than the similar* patu *of the New Zealand Maori, indicating a voyaging tie from the Society Islands to New Zealand.*

NICHOLAS DEGRE III

An octopus leads Kupe to New Zealand

SURFING SHOREWARD on long Pacific rollers, the sea rover Kupe and his followers behold the mountainous coast of North Island, New Zealand. Their 2,400-mile voyage began in pursuit of a thieving octopus, tradition tells, and ended with the discovery of Polynesia's largest landmass.

The octopus stole Kupe's bait while the islander was fishing near his Raiatea home. Kupe became so enraged that he set out in pursuit of the beast, which fled all the way to New Zealand. Kupe finally slew the monster in Cook Strait and returned to Raiatea to tell the people about the great island he had found. Others retraced his route, "to the left of the setting sun in November," and colonized the new land.

Ru selects a star and discovers a new land

CALM AND COURAGEOUS in the midst of a storm, the navigator Ru, arm outstretched, asks the sea-god Tangaroa (**below**) to clear away the clouds so he can see his guiding star and set a course toward a new island.

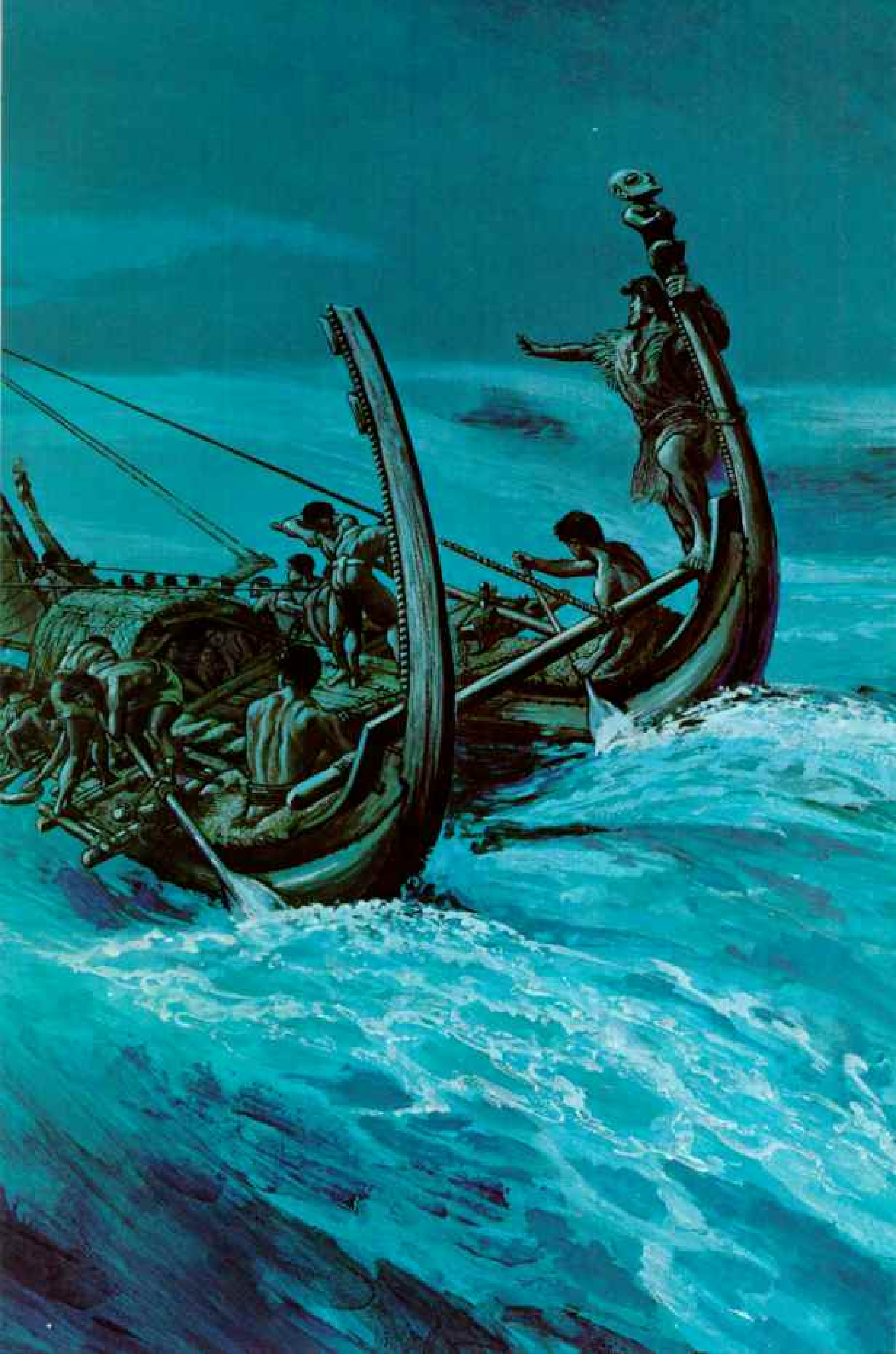
Descendant of seafarers, Ru was chief navigator of Raiatea at one of the times when population had outstripped food resources. "The valleys are thick with people," he told his family. "I have selected a star, and beneath that star there is a land that will provide us with a new home."

Ru's brothers and wives protested that they feared the perils of the sea. "That is woman's talk," he responded. "I, Ru, know the ways of the sea. The winds and the currents are open and known to me. Fear not and I will take you to a larger and better land than this."

Legend does not record how Ru knew that he would find land, but his confidence calmed his family's fears. The clan departed in a newly built canoe called *Te Pua-ariki*—"The Chiefly Flower." With Ru and his relatives went twenty maidens chosen for virtue, strength, and beauty. At sea they encountered a storm that raged for three days and nights. With his crew near panic, Ru finally invoked the aid of Tangaroa to return his guiding star to view.

GORDON ROBERTSON, COURTESY BRITISH MUSEUM

The clouds parted (**right**) and three days later, so the story goes, Ru and his company landed at Aitutaki, whose inhabitants still celebrate the achievement of the island's legendary discoverer in song and dance.



The "Relentless Pursuer" finds his quarry

SEEKING REVENGE, the Tahitian chief Tutapu storms ashore at Rarotonga to battle his half brother Tangiia and the Samoan Karika. The dispute began, says the legend, when the brothers quarreled over hereditary rights. After a series of battles, during which Tangiia's two sons were killed, his men stole one of Tutapu's gods. Tangiia then fled Tahiti, followed by his vengeful brother.

Grieving for his homeland and his fallen sons, Tangiia roamed the seas for years. After a skirmish, he and Karika became friends and settled together on Rarotonga.

There Tutapu, whose unremitting chase earned him the title of the "Relentless Pursuer," finally tracked his brother down, but was slain in the fight that followed. Tangiia and Karika remained to rule Rarotonga.

Basalt adzes, *unearthed at the Rarotongan village of Avarua, include a Samoan type* **(upper)**. *It perhaps dates from the 13th century, about the time of the alliance between Tangiia and the Samoan Karika.*

NICHOLAS DEVERE III, COURTESY COOK ISLANDS LIBRARY AND MUSEUM SOCIETY, RAROTONGA

Kamehameha battles for Hawaii

WAR CANOES COLLIDE in the crunch of combat during the battle of Mokuohai, a duel for power between the Hawaiian chiefs Kamehameha and his cousin Kiwalao. While the chiefs and their warriors engage each other on land, their fleets literally slug it out at sea.

Aboard one of Kamehameha's canoes, left, a warrior whirls a canoe breaker—a volcanic stone lashed with sennit, capable of piercing a hull or smashing a skull. Unveiling the feathered visage of Kamehameha's war-god Kukailimoku, a priest directs the god's *mana*, or sacred power, against the opposition.

Clad in feathered capes and helmets, rival chiefs clash. One clasps in his left hand a dagger of *kauila* wood rimmed with shark's teeth, a fearsome weapon called *lei o mano* —ivory of the shark. Beneath, a brawny paddler parries a spear.

Kamehameha's canoes advanced in a line that stretched from headland to headland off a beach called Mokuohai, overwhelming the enemy. In the bitter fighting ashore Kiwalao fell, stunned by a stone from a sling. One of Kamehameha's lieutenants, himself wounded, dispatched Kiwalao by slashing his throat with a lei o mano.

Victory in this 1782 battle spurred the ambitious Kamehameha to a quest for kingship of all the Hawaiian islands, a goal he finally attained in 1810.

"Tell the king we are in Fijian waters"

THE YEAR, about 1820. The event: the return of King Taufa'ahau to Tonga after a tattooing ceremony in Samoa that solemnized his coming of age. The location: somewhere south—or was it west or east?—of Samoa. No one knows. The king's navigators have lost their way. In dire puzzlement the navigators murmur among themselves.

In another canoe, the aged and blind Kaho—Tuita Kahomovailahi—a navigator of low rank, asks his son Po'oi, "What are they saying?" The boy replies that the navigators are lost. Kaho orders his canoe turned into the wind. As the sail luffs and the vessel slows, he climbs onto the starboard hull and,

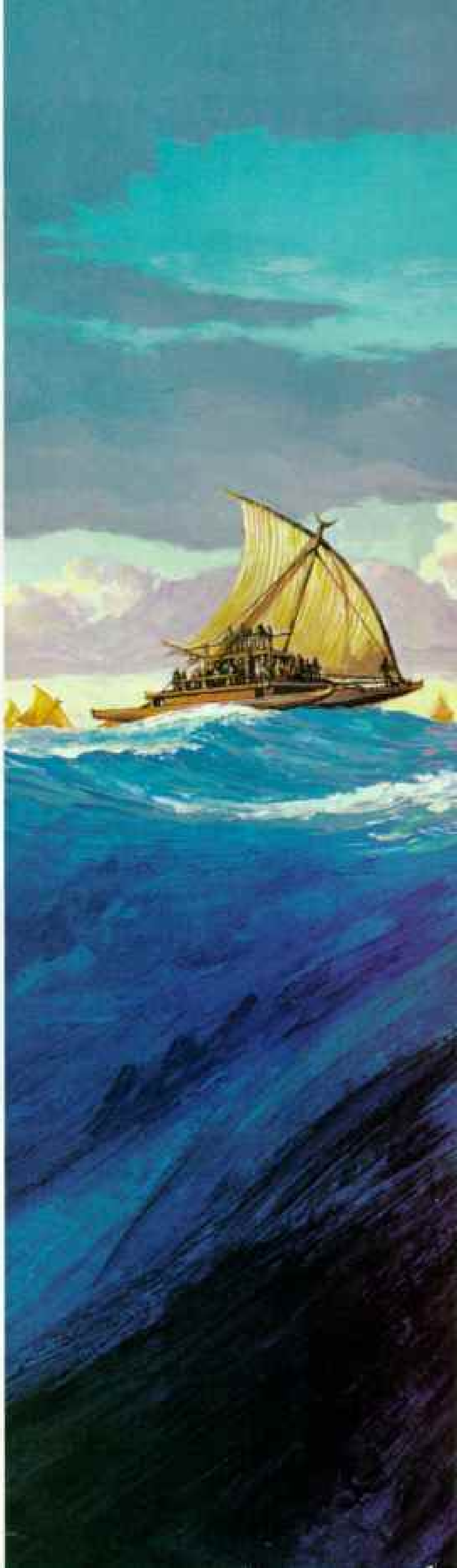
held fast by his son, dips his hand into the sea (**right**). Then he announces, "Tell the king we are in Fijian waters."

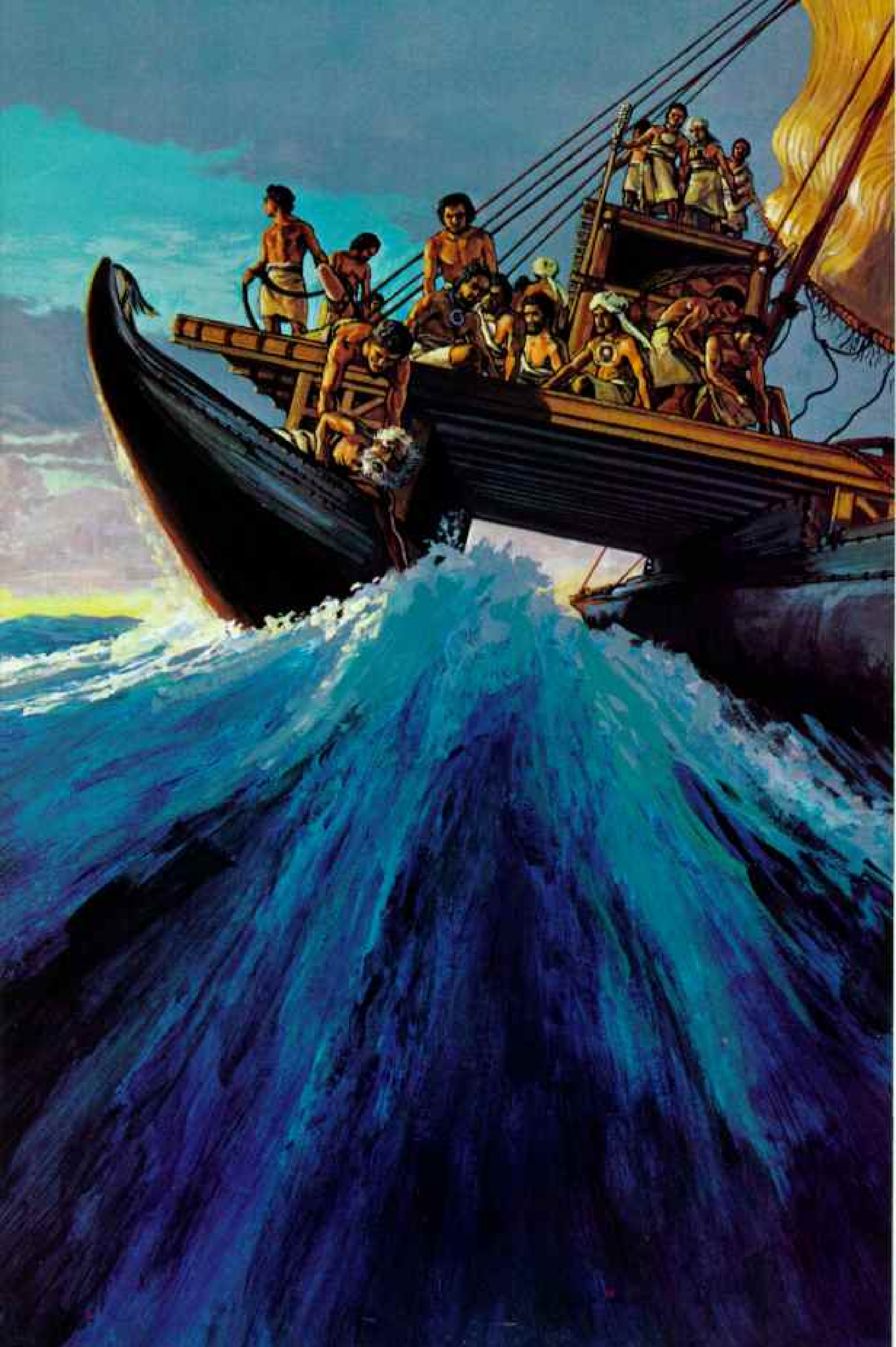
"That is the old blind one," the king's navigators scoff in disbelief.

"What should we do?" the king himself asks Kaho. "Our food and water are almost finished."

Kaho requests the location of the sun. Then he says, "Tell the king that when the sun is in the middle of the sky he will see land." A few hours later the flotilla reaches Lakemba, an island in the Lau Group east of the Fijis. In gratitude, the king makes Kaho his chief navigator and a noble. From this time, he and his descendants become known as Fafakitahi—Feelers of the Sea.

Almost 150 years later Kaho's great-grandson revealed that his ancestor's act of touching the sea was designed to impress the superstitious Tongans. Kaho knew land was near because his son had reported to him the presence of a fish-eating bird that never ventures far from land. □





(Continued from page 754)

Wind, Wave, Star, and Bird

wind by tacking, coming about and changing the side of the sail presented to the wind, as modern sailors do. The Micronesians (and the Polynesians of the Tuamotus and some western island groups) changed course by shifting the sail from one end of the canoe to the other, with the same side always to the wind. Thus the vessels were "double ended," with bow and stern having the same design.

Both outriggers and the method of tacking by changing ends seem to have originated in Indonesia. They spread not only eastward into the Pacific but also westward across the Indian Ocean, as far as Madagascar. In A.D. 77 the Roman scholar Pliny the Elder described ships from Ceylon as having "bows at each end."

I wonder what Pliny would have said about a canoe of stone. I had heard of one on the island of Beru, not far from Aranuka. When my son and I reached the island and located the "stone canoe," it proved to be a teaching device that I had never before encountered. Built by the father of the navigator Temi Rewi, and modeled on one his father had made, it was a simple array of stones enclosing a larger flat rock. The origin of the device has been lost in time.

Rewi's son sat upon the central stone imagining himself in a canoe, while his father taught him the star paths and currents of the southern Gilberts. A little later, the "canoe" was used to represent an island. By their size, shape, and angle, the stones at the four corners represented the swell patterns around the island. The tallest, for instance, depicted the main swell from the east.

Rewi lowered his voice: "Look under the seat stone." There, hidden from view, was a rounded lump of brain coral. "This secret stone," said Rewi, "represents the sea-god, who is the most important of all. He helps us sail over the sea because he rules the sea."

After leaving the hospitable atoll of Beru, I found at Tarawa, also in the Gilberts, a wiry old *tia borau*, or man for voyaging. His name was Iotiabata Ata, and his ultralight 30-foot canoe was a perfectly balanced sailing machine, outrigger alternately flying airborne and slicing clean through the waves.

Iotiabata took me on a voyage from Tarawa to nearby Maiana to show me, when we were well out of sight of land, how the massing of trade-wind clouds over the invisible islands, and their breaking up as they drifted downwind, indicated the position of both atolls. Though their lagoons lay below the horizon, I could see clearly the green reflection on the undersurface of the clouds, and pointed it out to Iotiabata.

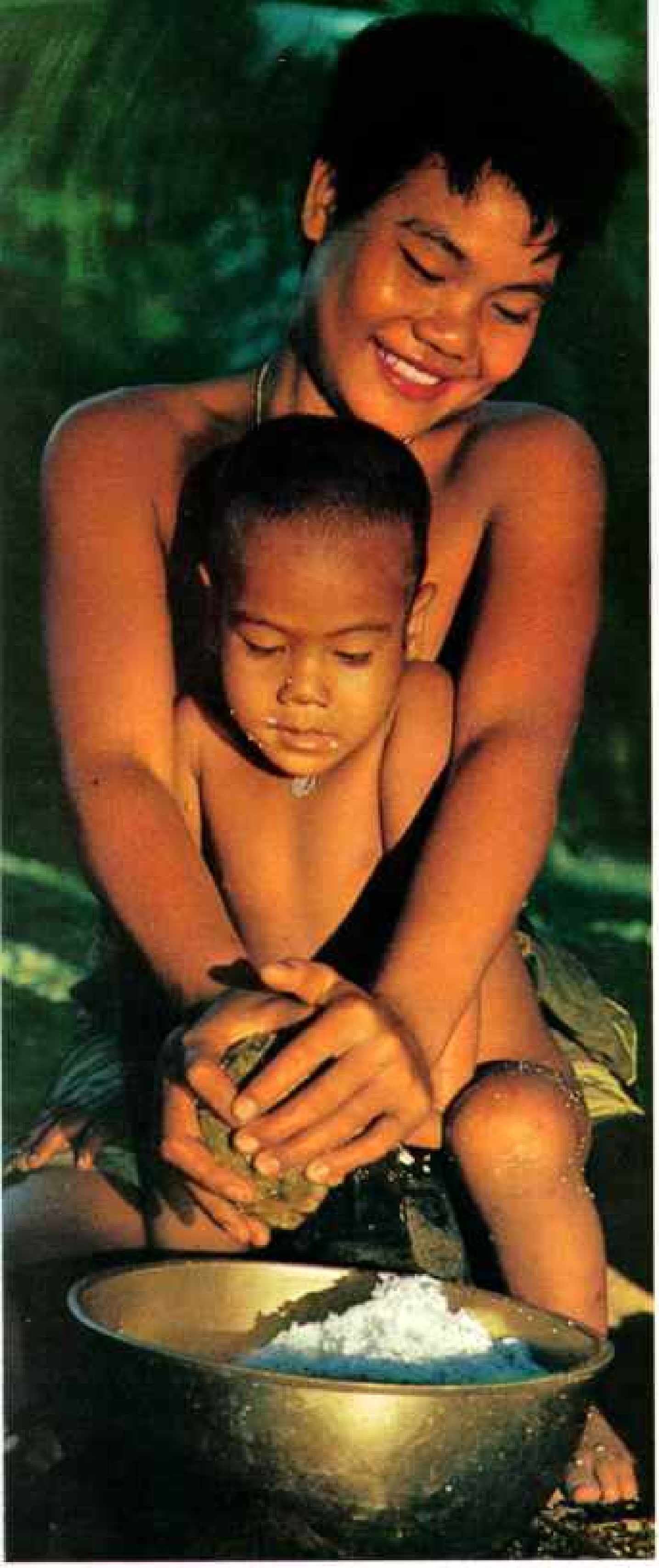
"I did not wish to embarrass or insult you by mentioning this green," he said. "For after all, you are a navigator, of a kind, yourself—and even Europeans notice this obvious sign."

I was somewhat chastened as I continued in *Isbjorn* to the Caroline group.

ALONE in all the world, the Caroline Islands of Puluwat, Satawal, Pulusuk, and Pulap retain an entire traditional blue-water voyaging society. Oceanic voyaging without charts or instruments persists as a way of life. Of Puluwat's 400 people, 18 are trained *ppaiu*, navigators with status higher than chiefs. In a recent 16-month period, Puluwat's 15 big sailing canoes made 73 interisland passages.

In such a setting, one might expect to find an exceptional navigator. I found him seated in his canoe house, a man of only 46 who had been initiated as a navigator more than twenty years earlier and had roved through the central Carolines ever since. His thighs were tattooed with the traditional mark of the sea, leaping porpoises, and his shoulder with a more modern emblem, the Rising Sun of Japan.

Old man of the sea, *Valeilei once rolled the sennit and swung the adz, helping to build the canoes he voyaged on. Now locked to the land, he passes the day in a Satawal canoe house and looks longingly toward the sea.*



In the lap of learning, *a boy watches as coconut meat, destined for a cooking sauce, is grated into a bowl.*

His name is Hipour, and he is now my "name brother." Together we made two voyages—a relatively short one in Hipour's canoe to Pulusuk in the Carolines, and a six-day journey in *Isbjorn* to Saipan in the distant Marianas that confirmed my rediscoveries of ancient navigation techniques.

Hipour's 25-foot voyaging canoe was moored in the lagoon, cocooned in mats to protect it from the sun. Unwrapped, its tall red-and-black sides swept up in bold sheer lines toward identical bow and stern. Massive crossbeams supported an outrigger float.

Though Pulusuk lay only 40 miles to the south, no seamanlike precaution was neglected. The muscular tattooed islanders put aboard spare poles, spars, coils of rope, and hanks of cord. Next the mast, yards, sail, and steering paddle were loaded, and finally food for our crew of eight: baskets containing leaf-wrapped bundles of freshly cooked breadfruit, as well as sour fermented breadfruit that would keep for ten days or longer. Drinking coconuts were tossed into the canoe, along with those indispensable instruments, the bailers.

Hipour gathered in the rope that is the main means of steering; his son-in-law Teruo took the helm, and we slipped out of the shelter of the palms to where the sail felt the thrust of the trade wind. The canoe leaped forward into the sea wrack frothing in the channel and porpoised over a dozen lines of rollers until it was well clear of the land.

Hipour kept the two main Puluwat islands, Alet and Puluwat itself, just overlapping astern. He showed me the three important swells that were running, the most helpful being the Big Wave from Altair ($8\frac{1}{2}^{\circ}$ north of east) that we held on our beam.

As the land dropped far astern, a crewman stationed at the mast noted the sun's exact height at the time of the island's disappearance.

Then we were alone at sea, together with the slow-arching sun, the wave lines, and the seabirds. Yet these allies ensured that the canoe's steadily extending track was as precisely known as if drawn by the most sophisticated instruments. Had we sailed by night,

our star course would have been a shade to the left of the Southern Cross risen midway to its zenith.

"We sail this way," Hipour explained, "to go around Maihun—Reef of Spirits That Eat Canoes."

Trolling lines were put over the stern, and before very long fish were flapping in the bilge among the bright-green drinking nuts. The first few caught were eaten raw, with handfuls of breadfruit. Later a crewman lit a fire of dry coconut husks in an aluminum pot half filled with gravel; more fish were thrown on the fire, without gutting or scaling, and quickly scorched before being eaten.

I lay down on the rough-hewn planks, pulled a mat over myself, and went to sleep, and thus missed the first sighting of Pulusuk. Evening was near when I awoke, and the atoll was growing larger minute by minute. We had averaged $4^{3}/_{5}$ knots.

The moment the canoe glided through a gap in the reef, a line of men waded out, took hold, and guided her to a sandy mooring. Under a sinking quarter moon we splashed ashore and seated ourselves cross-legged facing the Navigator-Chief Beiong and Pulusuk elders to go through the rituals of greeting, while curious women and children peered shyly out at us from around cooking fires under the palms.

CHIEF BEIONG proved to be a gentle-mannered, quietly impressive man. "How could some men have been so foolish as to forget every reef and island under the stars?" he asked when he learned of my mission. "Here we have not forgotten. For a navigator, it is a matter of dignity to struggle upwind for five days without compass to Truk for cigarettes instead of waiting for the big ship to arrive."

He told me the story of a canoe from the island of Woleai, also in the Carolines, which had been storm driven far to the southeast and headed for the nearest landfall, Kapingamarangi, a remote Polynesian outlier.

"They knew the star course," the chief said, "but none of the crew had been there before. When they landed, they could not understand what was said, for the Kapingamarangi tongue was quite different from their own."

Had they truly reached Kapingamarangi, or were they somewhere else? Being navigators, they were too proud to ask. Instead they lingered for nearly a week until they heard children at play mention the island's name. Then they sailed home, their dignity unimpaired.

WE, TOO, SAILED for home—Hipour's island of Puluwat—where we began planning an ambitious round-trip voyage of more than a thousand miles.

An ancient sea route had been kept open between the Caroline and Mariana archipelagos from time immemorial. It had been abandoned after Spanish massacres in the Marianas in 1686. Although later cautiously reopened, the old trade route had apparently not been sailed since early in this century.

The Carolinians had retained memory of the sailing directions in their songs. Could Hipour retrace the route, using only these word-of-mouth directions some three generations old?

He accepted the challenge with enthusiasm. The trip would be made in *Isbjorn*. We unshipped the compass and stowed the sextant, the charts, and our wristwatches below. The crew consisted of Hipour in command, Ulutak the interpreter, and Barry and myself as unskilled labor. The route was the traditional one—to uninhabited Pikelot, a hundred miles to the north, then across 500 miles of open ocean to Saipan.

We set out from Puluwat in the late afternoon. The land receding astern was watched intently, to assess the direction and strength of the current.

Within the main Carolines voyaging area, the North and South Equatorial Currents approach each other, both flowing strongly west; they are separated by an equally brisk equatorial countercurrent that runs in exactly the opposite direction. Since these streams continually vary in width by as much as a hundred miles, and transitory but strong recurving segments flow between them, the set at any one time

Towering waves *menace a Satawal outrigger on a stormy ride to distant Saipan. Togomei anxiously searches the swells while helmsman Kaboy stands on the steering paddle for leverage against the roiling sea.*

"Time and again I thought we'd be swamped," reports photographer Nicholas deVore, "but the crew knew exactly what they were doing." After nine heaving days in forbidding squalls, clammy fog, and winds as high as 50 knots, they made the Saipan landfall.

may be north, south, east, or west—and can change without warning.

Hipour knew alternative star courses for every possible current. He began by using the famous Pleiades as our guide. When that star cluster set around eleven o'clock, we kept the Big Dipper and Polaris aligned with appropriate portions of the rigging, about 20° before the starboard beam.

A little before dawn I noticed a bright star that was strange to me. Nudging the dozing Ulutak, I asked what it was.

He repeated my question to Hipour, who grinned and replied, unexpectedly in English, "Satellite!"

A shout near midmorning announced that we had passed over a deep reef, which was revealed by the lighter blue of the sea. Hipour bore away westward, and we streamed fishing lines astern. Soon a dorado was flapping on deck, followed by a large barracuda—or rather its head and formidable jaws. The body had been sheared clean away by a single bite of a shark.

"Ow!" yelled Hipour, miming great pain. He rubbed an old puckered scar on his thigh, legacy of a shark that had attacked him as a boy while he was spearing fish off a reef.

An hour later Ulutak raised Pikelot ahead. We had sailed a hundred miles to a perfect landfall on a 500-yard-long speck in the sea. Because of the safety screens provided by the series of deeply submerged reefs and the zone of homing birds, the navigation is regarded as routine. Parties frequently sail from

Puluwat to Pikelot on the spur of the moment, while drunk on palm toddy. They always arrive.

Toward sunset, we reluctantly issued forth into a wild sea, using the motor to assist the drive of the canvas. Saipan's actual direction from Pikelot, said Hipour, was a shade to the left of the setting Little Bear position, or about 345°. (Laying off this bearing on the chart after our return, I found it to be almost precisely as he had said—344°.)

But this was not the steering course for Saipan. We should encounter a west-going wind and current the whole way, he had been taught; counteracting these in moderate winds would call for a heading toward the North Star. However, in strong winds such as we were encountering, it had been customary to make an even greater correction for the first hundred miles or so.

Our course for the moment would, therefore, be toward the rising Little

Turtle kabobs—*intestines skewered on coconut fronds—broil over a crackling fire as the voyagers to Saipan hole up on West Fayu, just one day out of Satawal, hoping for a favorable wind.*

"We waited a week," laments deVore, who labeled the turtle innards as "crunchy, juicy, and very tasty." The main course, the rest of the turtle, roasts beneath the coals.

Here the voyagers also took the opportunity to patch the leaking hull of the Pacifica, *one of two canoes to make the journey. They hauled the boat ashore by brawn over a bed of coconut-log rollers.*

Bear, 10° or 12° east of north, although Saipan actually lay 15° or 16° west of north. When, in the navigator's judgment, the time was right, we should alter course to due north.

FOR FIVE MORE DAYS we sailed, reading only sun, stars, and swells.

One morning, as I steered by the sun shining through the wheelhouse window, I realized how automatic the processes of observation and judgment were becoming. The sun at this hour was curving away southward, yet I needed no conscious effort to adjust course. With the far more experienced Hipour or Ulutak at the helm toward evening, the steering star that became visible in the darkening sky would always appear right on the forestay.

The fourth evening from Pikelot we hove to at nightfall, for Saipan could not be far away. We estimated we were about opposite and well to windward (east) of Saipan, and had overcompensated for wind and current. Long swells from the east, undisturbed by any unseen island, reassured us that the Marianas must lie in our lee. The great height of these islands, the relatively short distances between them, and the reported abundance of homing birds, including boobies, formed a continuous "screen" in our lee. Only at night could we pass through it unwittingly.

In the morning we got under way, following a course designed to cut obliquely through the Mariana chain. Before long, Hipour and Ulutak, who had been intently scanning the sea, began to make out occasional pairs of terns, noddies, and boobies. Later in the morning they spotted a distant flock of five boobies circling after fish; at noon, four boobies and a noddy. The casual observer may not notice seabirds, even close inshore. That day brought home to me how many can be seen by men whose lives often depend on it.

Around 4:30, a wheeling flock of a dozen boobies appeared and excitement mounted. Land must be very near; could we but keep the birds in view until dusk, they would fly unerringly toward it.

Visibility deteriorated as the tense afternoon wore on. Ulutak's eyes had become red and bloodshot; he had now climbed into the lower rigging. Then his triumphant yell announced the sighting of an undulating object 16 to 18 miles away, in the haze over the port bow—unmistakably an island.

Three of the boobies broke off their fishing and flew off low and arrow straight toward the distant bit of land. It proved to be Farallon de Medinilla, the first island beyond Saipan and 50 miles north by east of its bigger neighbor. I recalled the saying of the Tongan navigators: "It is enough that we strike the *row* of puko trees."

Saipan itself materialized out of the haze soon after noon the next day. That evening, exactly a week after leaving Puluwat, we nosed alongside the pier, with Hipour and Ulutak calling excitedly to compatriots ashore. A European lady gazed down disparagingly at me on *Isbjorn*'s weatherbeaten deck.

"That," she said to her husband in a penetrating voice, "is a most degenerate-looking old half-caste."

That night we celebrated. Hipour and Ulutak, wearing only their scanty breechclouts, were completely at ease as they did the rounds in the company of the old half-caste.

WHAT HAS BEEN preserved in Puluwat is not only the heritage of Micronesians and Polynesians. It is the last legacy of uncounted generations of the great captains of all mankind. Hipour paid me a true compliment following our successful voyage to Saipan and back.

"*Your* name will from now on be 'Hipour'. *I* shall be called 'David'."

In token of my "adoption," Hipour suggested I might like to be tattooed. This was how I found myself, rather to my own alarm, lying on a mat before the men's house. A bamboo instrument tipped with frigate-bird bone was poised, while onlookers cheerfully regaled me with predictions of how much it was going to hurt (not very much, it turned out).

The scene was one from yesterday—the pandanus-thatched houses under the palms, the circle of grinning, tattooed men in their breechclouts, some with hanging earlobes, the giggling bare-breasted women. Nothing was of this century. Nothing, that is, except the tattooing pigment. It was concocted not from some exotic herb, but from the contents of an old flashlight battery!

Barry and I bade a reluctant farewell to Puluwat that night after reinstalling the compass for the long 1,500-mile haul to the Gilbert Islands. The next noon sight showed we were 40 miles off course. A search brought the culprit to light—a knife, lying forgotten beneath the compass bracket, that had affected its magnetism.

"We would have been far better off," remarked Barry, "to have kept on using the stars."

IN THE 1,700 AND MORE sea miles sailed without instruments as a pupil of the last great navigators, I had learned to steer by star horizon courses, to find latitudes of islands by knowing their zenith stars. I had learned, too, the various methods used by the Pacific navigators to expand their small targets into wide screens, marked by cloud formations, bird zones, wave patterns broken by islands, and other signs. I had seen the mysterious te lapa flashing far under Pacific waters.

What my friends Tevake, Hipour, Iotiabata, and the others had demonstrated beyond argument was that the ancient methods of navigation were also fully adequate for deliberate two-way voyages across those enormous empty sea-lanes that we know the Polynesians crossed many times a millennium ago.

Mine is the migrating bird
Winging over perilous regions
of the ocean,
Ever tracing out the age-old path
of the wandering waves. . . .

So runs the Tuamotuan *fangu*, or sacred chant. But now, in the words of Te Rangi Hiroa, New Zealand's most distinguished Maori scholar, "the glory of the Stone Age has departed out of Polynesia."

A few months after I returned to my home in New Zealand, Tevake wrote to ask if I was setting down all that he had taught me, adding that he was beginning to feel very old and was rapidly becoming weaker. I replied immediately, reassuring him.

Months later I heard the sequel. The spirit of Tevake, the dying tropic bird, could not be confined but must soar one more time to ultimate freedom. The veteran navigator had bade formal farewell to his family and lifetime friends on Nifiloli and, seating himself in a one-man canoe, had paddled out into the ocean he loved on a voyage of no return.

Winged navigators, *gannets soar above their New Zealand rookery. Along with frigates, terns, and boobies, they roost ashore and feed at sea. Dawn and dusk flight paths point the way to land—journey's end for weary mariners.* ALFRED M. BAILEY

Toy canoes glide *on a silvered sea,*
an outrigger returns home, and lazy
afternoon settles over Satawal. A boy's
play betrays his dream: to feel the swells,
to follow the stars, to steer a man's
canoe along the seaways of those
who have gone before him. □

ISLES OF THE PACIFIC—IV

Problems in Paradise

By MARY and LAURANCE S. ROCKEFELLER

Photographs by THOMAS NEBBIA

Setting an example, *the King of Tonga officiates at a dedication ceremony for the Polynesian realm's first national parks—a group of four. Holding an abacus, a simple but versatile computer he uses to promote understanding of mathematics in Tongan schools, the monarch briefs conservationist-author Laurance Rockefeller.*

SMOG PRESENTS NO PROBLEM for a kingdom of Polynesian farmers who own only 300 motorcars. "Besides," adds the king, "this island is so flat that sea breezes blow right through from any direction."

Thus it seemed to us all the more remarkable that His Majesty Taufa'ahau Tupou IV, King of Tonga, was setting a wise example of environmental conservation for the South Pacific islands. We stood beside him as he proclaimed the first four national parks in the history of his realm: a beach area, an archeological site, and two parks on offshore reefs. We hoped that this heartening act would serve as an example in other remote Pacific areas we saw on a recent 28,000-mile trip.

The editors of NATIONAL GEOGRAPHIC proposed this environmental survey at a fortunate moment. Mary was already planning to inspect Pacific projects of the Young Women's Christian Association. We soon found our separate missions fused, for the values of humanity and nature are merging worldwide into a single new concern.

Our good friend, the late Charles A. Lindbergh, who also attended the dedication of the Tonga parks, saw great promise in the Pacific. He remarked during our meeting with the king: "The Pacific area is still open to the degree that our American West was years ago. Thousands of square miles can be set aside and protected and used for the benefit of people. Here is a great opportunity." We shall certainly miss this far-seeing and dedicated conservationist.

The late Charles A. Lindbergh joins the Rockefellers (right) *to witness the power of an ocean blowhole on Tongatapu. A dedicated conservationist, the "Lone Eagle" of aviation history felt deep concern for the future of the South Pacific, where pockets of pollution already serve notice that the onrush of technology needs careful control.*

Beauty Survives, But Problems Lie Ahead

Like General Lindbergh, we found the South Pacific still a paradise. We explored islands with a true Garden of Eden quality. We met hundreds of friendly people. And we swam in lagoons where brilliantly hued fish showed no fear of man.

A Fiji photographer told us of the ease of making photographs in the South Pacific with an underwater camera; the visibility often exceeds 150 feet. And looking at the teeming fish in those serene and crystal-clear lagoons, we pondered the future of aquaculture—farming the sea. Someday, much more of man's essential protein supply could come from such places.

But we also found some danger signs. Many Tahitian residents were deeply worried about nuclear tests in the atmosphere of French Polynesia. So were people farther west, as

Mary saw in Fiji, where YWCA girls were lettering placards for antitest demonstrations. And in their social center in Suva a popular local composer of rock music strummed a chorus with this refrain: "Polluting and poisoning an ocean means destruction of humanity."

French Scientists Defend Nuclear Tests

French officials, of course, differ sharply with such sentiments, as we learned at the Laboratory of Radiological Surveillance on Tahiti. Here French scientists test specimens collected in at least 15 island locations.

"Since 1966 we have tested everything," said Dr. P. Guillermin, then deputy chief of the laboratory: "Seawater, soil, fish, plant life. We conclude definitely that people here have not been exposed to radiation that would be dangerous to health. Actually, the radioactivity in certain parts of France—in our native rocks—is greater than one can find here. And in South America's Andes—ah! They have ten times the radiation of the earth here."

Still we found many people worried about the tests. A New Zealander wondered if "anyone knows the danger of flying a supersonic jet through that high-altitude fallout?" The Prime Minister of Fiji, Ratu Sir Kamisese Mara, smiled wryly when the subject came up. "If nuclear testing is so safe," he said, "why don't they test in the Mediterranean?"

Such thoughts were voiced at the fifth South Pacific Forum, when area leaders met on Rarotonga in the Cook Islands. And though disapproval failed to halt the 1974 French atmospheric nuclear tests, President Valéry Giscard d'Estaing has now acknowledged the power of world opinion; as of 1975 all French tests will be underground.

Other environmental problems seem less dramatic than the explosion of nuclear bombs, but solutions may be more complex. Consider, for example, the pollution of ocean waters.

At the Aquarium de Nouméa, in New Caledonia, we asked distinguished marine biologists Dr. and Mme René Catala-Stucki about underwater life on the reef.

"In this shallow water," Mme Catala-Stucki said, "if one minute organism dies, so do others. Life on the reefs off Nouméa was damaged seriously. But now, to our great satisfaction, marine life is reappearing."

Ominous mushroom blazes *over France's atomic testing ground at Mururoa atoll, 800 miles from Tahiti. French authorities insist that fallout poses no danger to humans, despite the skepticism of islanders and the protests of nations on the Pacific rim. Wages and employment in nearby Tahiti have escalated with the influx of French scientists and military personnel, but island culture continues to erode.*

They cite the oil dumped by ships entering Nouméa's harbor: "Oil comes onto the reef, there is not enough oxygen, then the minute algae die—and that's only the beginning."

We wondered about the vast strip mines on New Caledonia, cutting away at a third of the world's proven nickel reserves. What about mining silt that drains onto Pacific reefs?

"Here, oil is worse," said Mme Catala-Stucki.

Similar oil-pollution problems face the fisherfolk living around the harbor of Apia in Western Samoa. But in neighboring American Samoa, Governor John M. Haydon showed us a new sewer line being installed to ring Pago Pago Harbor. And harbor police there now levy about $4,000 in fines each month, enforcing an antipollution law.

Flying over the eastern part of American

COMMISSARIAT ENERGIE ATOMIQUE (FRANCE)

Samoa, we made a brief aerial inspection of Rose Atoll, an obscure yet fascinating scrap of land. Through a few random clouds we saw an almost-square, uninhabited atoll some two miles across (pages 788-9). Its reef supported two islets, one a mere sandspit and the other some 350 yards long and "well wooded, which gives it a very pleasant look of freshness." So wrote a French observer in 1819.

"Untamed" Atoll May Succeed for Science

Later visitors tried unsuccessfully to tame Rose by planting coconuts. But, like many atolls, it has a porous soil structure that lets rainwater percolate straight through, and there is no freshwater source there other than rainfall. The coconut palms died, and no people ever settled permanently. To this day no one knows the amount of that rainfall.

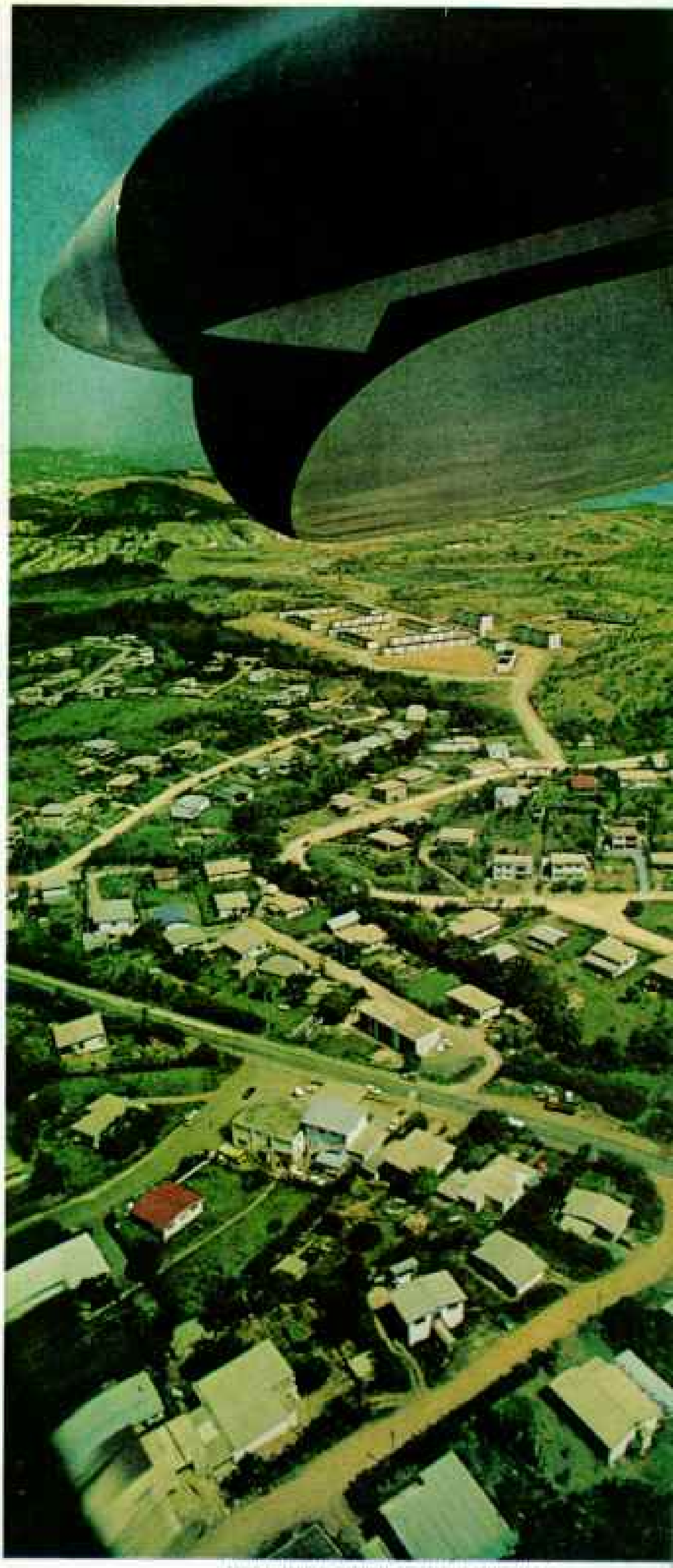
And yet this inhospitable, remote little wildlife refuge is gathering international importance. A young Peace Corps zoologist running a turtle hatchery some 200 miles to the west, on the island of Upolu, told us that Rose is an important nesting ground of the shy, rare green sea turtle. And a research bulletin of the Pacific Science Board went even further: "Conceivably, Rose may soon be the only refuge left for breeding of the seabird and turtle faunas of the Central Pacific."

For such reasons, Rose Atoll has been proposed by numerous ecologists as a U. S. contribution to an international project: Islands for Science. Under this plan, a number of islands around the world would be set aside permanently and exclusively for scientific study. Lawyers are now drafting a treaty to make it possible. We wish them success.

Raw wounds of strip mining *deface the nickel-rich mountains of New Caledonia* (**left**); *silt flows downriver to soil coastal waters. The Melanesian island started booming economically in 1970, when prices and demand for nickel rose sharply.*

A smelter churns out air-polluting smoke (**below**) *as Mr. Rockefeller confers with an official of Société Le Nickel. Aware of environmental hazards, the company plans an extensive clean-up program.*

A cosmopolitan city whose heart is reminiscent of Paris, New Caledonia's capital of Nouméa sprawls into a suburb (**right**). *Private homes renting for $400 to $600 a month jostle new shops, and the odors of Gallic cooking mingle with the smell of freshly poured concrete.*



DAVID L. ARNOLD, NATIONAL GEOGRAPHIC STAFF (ABOVE)

The study of marine life in these areas is coming none too soon. In recent years fishing fleets have gone to sea with the most expensive equipment in history. Yet, even as worldwide need for food increases, the catch of world fisheries has faltered and in some recent years even declined.

The evidence is troubling: intensive, indiscriminate fishing and abuse of our fishing waters have begun to impinge upon this worldwide source of protein. Eventually, uncontrolled marine harvests and factors such as pollution could upset the biological balance of all the oceans. Many edible species of marine life could be seriously depleted. So, just as primitive man abandoned the nomadic life of the hunter for farming and animal husbandry, modern man is turning toward the old dream of large-scale aquaculture.

The Japanese began intensive aquaculture in the 19th century, and now operate more than 160 major marine and oceanographic research institutes, some of them comparable to U.S. agricultural experiment stations. Across southern Asia, from the Philippines to India, commercial aquaculturists have begun to raise milkfish, a food species that subsists on plant life. In other places the oyster, salmon, and shrimp industries are moving toward mass-production aquaculture.

True aquaculture eventually will develop its own brood stock. Today's fish farmer raises his fry from larvae or from eggs taken from female fish. But recently Dr. Ziad Shehadeh, using the facilities of the Oceanic Institute in Hawaii, has been working with mullet. He has succeeded, under laboratory conditions, in hatching mullet from eggs laid by captive fish. The long-range prospects are exciting: 12 adult mullet used as brood stock could

theoretically provide up to three million fry.

Unfortunately, aquaculture and clean water—with its dearth of food organisms—are incompatible. A decision will have to be made to determine which is more important: the clarity of coastal waters, or the wealth of precious protein which they could offer.

Misguided Imports Damage Islands

Our friend Gene Setzer, Vice President of the National Audubon Society, observes that the well-being of birds is "significant for all forms of life—like the miner's canary." In such terms, our Pacific augury is not entirely encouraging. On Tahiti we saw many noisy mynas, a species introduced from India to control Tahitian wasps. The wasp still thrives, and the myna has proved an aggressive competitor of indigenous birds.

Beneath Mount Vaea in Western Samoa, where birdsong once reminded Robert Louis Stevenson of "the hails of merry, scattered children," we saw only the energetic bulbul, another alien from India.

Yet on neighboring Savai'i, we were pleasantly surprised. We had heard that loggers had destroyed the forest habitat of many birds. One species found only on Savai'i and Upolu islands, the tooth-billed pigeon, had seldom been reported in recent years; some ornithologists feared for its survival. So it was with excitement that, during our brief inspection of Savai'i, Gene Setzer found a tooth-billed pigeon, and officially reported the fact. But when he told a Samoan woman about his sighting of this rare bird, her reaction took him aback. "Yes, a marvelous bird!" she agreed. "Simply *delicious!*"

In the South Pacific, man has a long history of biological meddling. "Our mistakes were

Sand specks *of Rose Atoll National Wildlife Refuge* (**left**), *each a few hundred yards long, are important nesting grounds for the green turtle. In nearby Western Samoa, biologist Wayne Witzell measures hawksbill turtles* (**above**) *in a hatchery program.*

made early," said P. H. C. Lucas, Director of National Parks and Reserves in New Zealand. Indeed, he sketched a textbook case of ecological calamity.

"Before the Polynesians came," Mr. Lucas told us, "New Zealand had no mammals except bats. The birds had no real enemies, so unique species evolved—like the kiwi and certain rails—without functional wings. The vegetation had never known a browsing mammal. Well, the Polynesians brought rats and dogs. Then European sailors brought pigs that went wild. British settlers wanted deer hunting, so we had a whole rash of deer—red deer, Rusa, Virginia white-tail, you name it. Your Mr. Theodore Roosevelt even gave us the start of an elk herd."

Sports-minded citizens even set up acclimatization societies to introduce new animals to New Zealand. They imported some 220 species, of which about 70 became established in the wild.

"The forest floor was soon overgrazed," said Mr. Lucas. "At Egmont National Park, for example, we had goats eating trees from the ground up and Australian possums eating from the top down. Heavy rains brought accelerated runoff and erosion—and a whole series of floods throughout New Zealand in the 1920's and 1930's.

"It was a near disaster. So in the mid 1930's government policy changed. Instead of protecting these introduced species, we established a bounty system to encourage hunting.

Now New Zealand exports about 5½ million dollars' worth of venison a year to markets around the world. Our basic policy is working. At Egmont, for example, the old vegetation is now returning."

New Zealand today enjoys a good environmental reputation—fine national parks, clean hydroelectric power, and low population.

Other successes can be reported from Australia. "When I was a student at the University of Melbourne," recalled one young woman, "we marched in demonstration to save the kangaroo. I guess we succeeded."

Indeed they did. Mr. D. F. McMichael, now Secretary of the Department of the Environment and Conservation, insists that "we have good reason to believe that Australia has more kangaroos than ever before." Population estimates run into the millions. The reason is improved habitat plus government protection. Sheep raisers need permission to cull kangaroos on their land.

Australian environmentalists are alert. Although they complain that "we're lagging behind the U.S.A. and Europe in our auto-emission controls," they have made a good start with laws and agencies working to combat all forms of pollution.

Neither the problems nor solutions seem surprising in developed communities. But consider this story, told us by our friend Charles Lindbergh. Visiting a few years ago on Tutuila in American Samoa, the pioneer aviator was entertained by the chief of a fishing village.

"As part of their feast," said General Lindbergh, "the people brought out corned beef and canned herring from New Zealand.

"I said, 'Chief, don't you have any native fish from the reef?'

"The chief said, 'No. We no longer do any reef fishing. All the men work in a canning factory at Pago Pago. No time to fish. The boys go to school. They can't fish.'

"So then I asked, 'How do you feel about the effect of civilization on your village?'

"The chief pointed to a palm tree covered with a strange growth, and he said, 'Civilization is like that weed on our palm trees. You cannot get it off, and it always kills the tree.'

"'How do *you* like civilization?' I asked.

"'Oh,' said the chief, 'I *like* civilization.'"

That chief, I fear, spoke for all mankind.

Soon after we had pushed our way through the Tahitian traffic in Papeete, a friend showed us a book with this description by a French visitor: "It was Europe . . . under the aggravating circumstances of colonial snobbism, and the imitation . . . of our customs, fashions,

Flush with wages *from a U.S.-financed tuna cannery in Pago Pago, an American Samoan draws himself a beer from the tap on his dashboard* (**left**), *which also boasts a stereophonic radio. A portable TV lets him watch mainland football games, taped for local broadcast.*

In Tahiti (**below**), *an acculturated couple pampers the mechanical fruit of their new affluence.*

BOTH BY DAVID L. ARNOLD

vices, and absurdities of civilization. Was I to have made this far journey, only to find the very thing which I had fled?"

Those words of artist Paul Gauguin were first published in 1901. Whatever Papeete's problems today, they are not new. But growing populations—and growing cities—endanger the ease of island life.

Western Samoa has one of the highest birthrates in the Pacific—a fact that puts a premium on land available for food production. Thus when loggers cut down forests, pressures arise to oppose the replanting of trees. This leads to a questionable exchange: present and future timber harvests for larger crops to feed a growing population but, in the long run, the specter of dangerous erosion.

Fijians Flock to the Big City

In Fiji the birthrate has declined, but the population has been moving to the capital, Suva, creating new social dislocations. "In about five years we've gone through fifty years of cultural change," said Ruth E. Lechte, the observant YWCA executive there. "I know one girl who has a master's degree from the Australian National University at Canberra; her parents are simple villagers. She says, 'I love them, but in two hours we've said everything we can say.'

"And about 70 percent of all Fijians are under 30 years of age. In his village a young man has never been anonymous since he was a day old. He always has a fulfilling place in society. Then he comes to Suva and no one knows him. He feels lonely, so he goes to a pub and gets drunk." Miss Lechte and the YWCA are fighting such problems with social centers, counseling, and leadership courses.

A psychiatrist who has long observed the Pacific island peoples offers them this advice for mental health:

"Live your own culture," he suggests. "Recover it where lost. Enrich it where possible. Acquire as much of foreign technology as you can without identifying with the culture from which it stems. Add . . . the rediscovered truth that, 'Life is a lifelong learning process.'" Such is the prescription of Dr. Karl Schmidt, formerly of the South Pacific Commission, an eight-nation organization that itself provides much cause for hope.

From its Nouméa, New Caledonia, headquarters, commission specialists review the ecological problems of four and a half million people scattered over more than seven million square miles of ocean. One problem is the rhinoceros beetle, scourge of all islanders whose economies depend on coconuts.

Insect pathologist Karl J. Marschall gave us the background: "In 1909 Western Samoa imported rubber plants from Ceylon—shrubs to use as a windbreak. The larvae came in the

Surf's up, *along with high-rise hotels and the cost of living in tourist-packed Honolulu. Here on Waikiki Beach, mainlanders practice their surfing stance. Tourism poses bittersweet problems for the Pacific, where opportunity remains for wise development.*

straw packed around the roots. In two years, the beetle spread like wildfire through Western Samoa."

And beyond: It reached American Samoa about 1912, the Wallis Islands in 1931, Fiji in 1953, and Tongatapu in 1961. Named for its rhinolike horn, the beetle behaves more like a rodent than an insect, devouring that most delicious of salads, heart of palm. Lately research has brought success: Scientists have found two enemies of the rhinoceros beetle—a virus and a fungus—that show great promise in controlling this pest.

In such ways modern man makes restitution for his past mistakes. We can take some comfort in the words of Capt. James Cook, probably written on the last of his three voyages to the islands around Tahiti: "I own . . . it would have been far better for these poor people, never to have known our superiority in the . . . arts that make life comfortable. . . . it may be too late to go back to their old less perfect contrivances. . . . For, by the time that the iron tools of which they are now possessed, are worn out, they will have almost lost the knowledge of their own. A stone hatchet is, at present, as rare a thing amongst them, as an iron one was eight years ago. . . ."

Cook was right. It is too late to go back. But with wisdom and restraint we can still move forward. In the serene South Pacific, man's opportunity endures. □

The Enduring Pyrenees

By ROBERT LAXALT

Photographs by
EDWIN STUART GROSVENOR

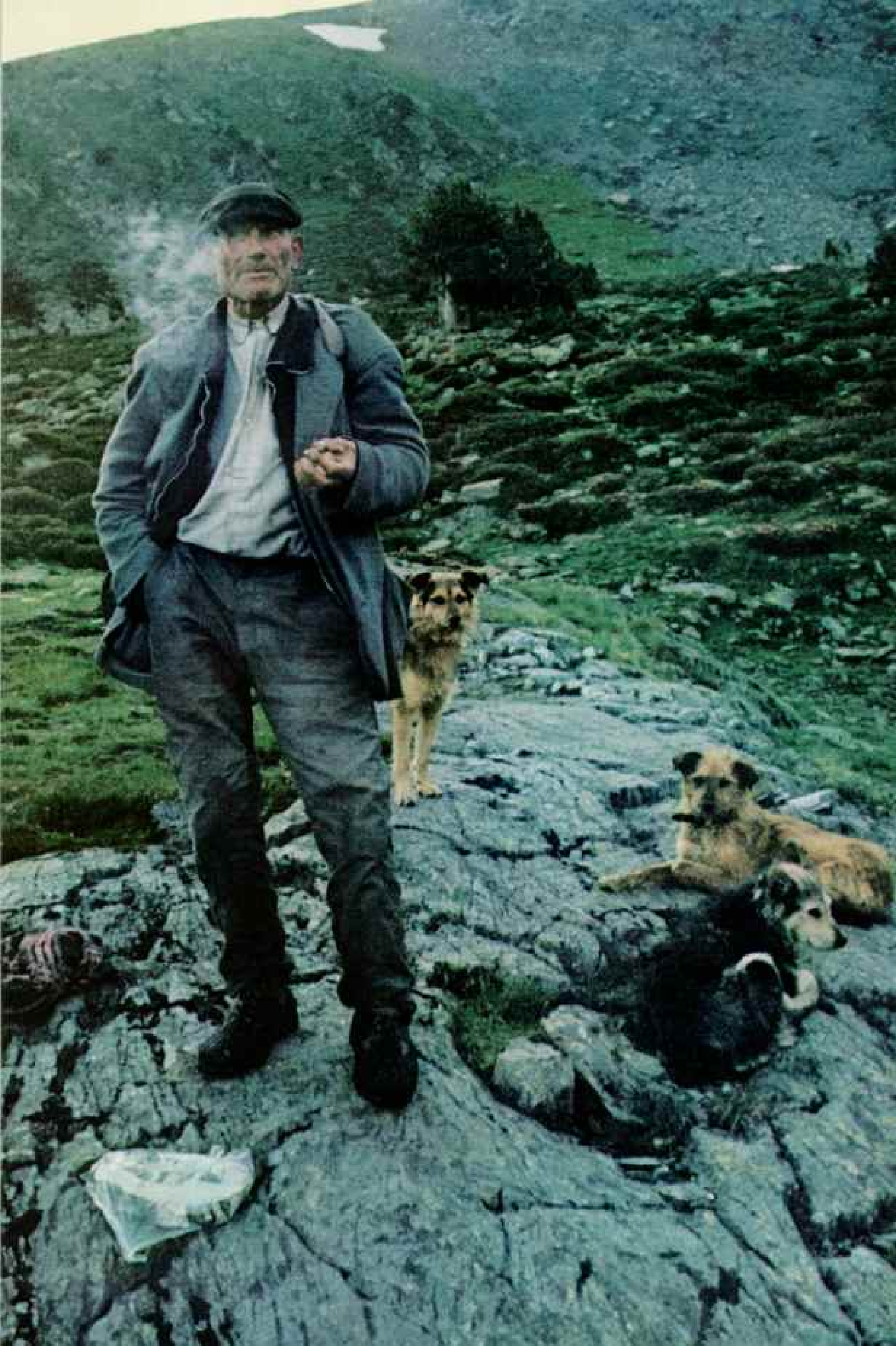
HE MUST HAVE BEEN TALL in his youth. One could see that in the sweep of shoulders beneath his high-collared mountain jacket and the long-boned hands that clasped the rustic shepherd's staff. Age and hard work had shrunk him in body, but there was enduring strength in his weathered face.

In a low-lying part of Gascony they had warned me against the Aragonese shepherds who roam the high Pyrenees, saying they were a hostile lot. But I have found that mountain folk are much the same everywhere —and that flatland people are prone to confuse reticence with hostility.

Leaving our car in the valley, my wife, Joyce, and I had hiked up to a grassy knoll to picnic on cheese, bread, and wine. A breath of wind had brought to us the faint tinkle of bells, and we followed the sound, clambering up hillsides and over moss-covered rock.

The mountain where we met him lay almost astride the meandering Pyrenean frontier dividing France and Spain. It was a green mountain sprinkled with the golden buttercups of June and gashed along its flank by a

Strangers to "progress," Andorran shepherds watch road builders far below carve a thoroughfare into their mountain realm. The uniqueness of the Pyrenees, born of long isolation, now draws throngs of outsiders, quickening the pace of change in once-remote communities.



torrent of frothing water. Peaks jagged as primitive spearpoints surrounded us, and a profusion of waterfalls dropped in white plumes to the valley floor.

This is the wild heart of the Pyrenees, the mountain chain that stretches for 270 miles from the Bay of Biscay on the Atlantic side to the Mediterranean Sea (maps, pages 798-9). Raised by shifting landmasses and shaped by Ice Age glaciers, the Pyrenees encompass about 21,000 square miles and boast 40 peaks exceeding 10,000 feet. Thrusting out of the Malditos massif, the 11,168-foot Pico de Aneto towers over all.

"Up here, at least," the shepherd said, "it's beautiful country. But I'm not so sure about what's happening down there." His arm swung out in the unconfined gesture of a mountain man, sweeping over the valley beneath us.

Long and narrow, the Vallée d'Aure in the central French Pyrenees testifies to the breakdown of the centuries-old isolation of the mountains. The shepherd's gesture took in brightly painted new chalets and resort hotels. These stood on the outskirts of medieval hamlets with gray stone houses, guarded by the turrets of fortified churches. Ski lifts soared to the high peaks. Gigantic water pipes, two abreast, plummeted down the hillsides to a hydroelectric station. Once-secluded meadows bloomed with the blue and yellow and red tents of campers.

Money Once Lured the Young Away . . .

Though Aragonese Spanish was his native tongue, the shepherd spoke in meticulous but distinctly accented French. "Before the tourists came, we were tranquil and content here. But our children saw their shiny cars and fancy clothes, and they imagined that everybody outside of our valley lived that way. They told us our life was one of hard work and poverty and little joy." He shook his head, and I knew then what caused the sadness in his gray eyes. "I lost my two sons to progress," he said. "They went away to the big cities for money."

The shepherd turned away from us to follow his sheep. "Times are changing," he said over his shoulder. "But I don't know why they should."

As Joyce and I descended the mountain, a ragged fringe of clouds began to obscure the sharp peaks, signaling an approaching storm. We passed rude stone farmhouses and newly mown fields. Men and women hurried to gather hay before it was soaked by rain. A black-shawled grandmother, perched atop a wagon with wooden wheels, spread the hay that others pitched up to her.

Urging us toward the car, rain lashed our faces and thunder and lightning bounced among those tight mountains in a deafening cannonade. Then I realized what was missing in the hayfields: the presence of sons.

. . . But Now It Keeps Them at Home

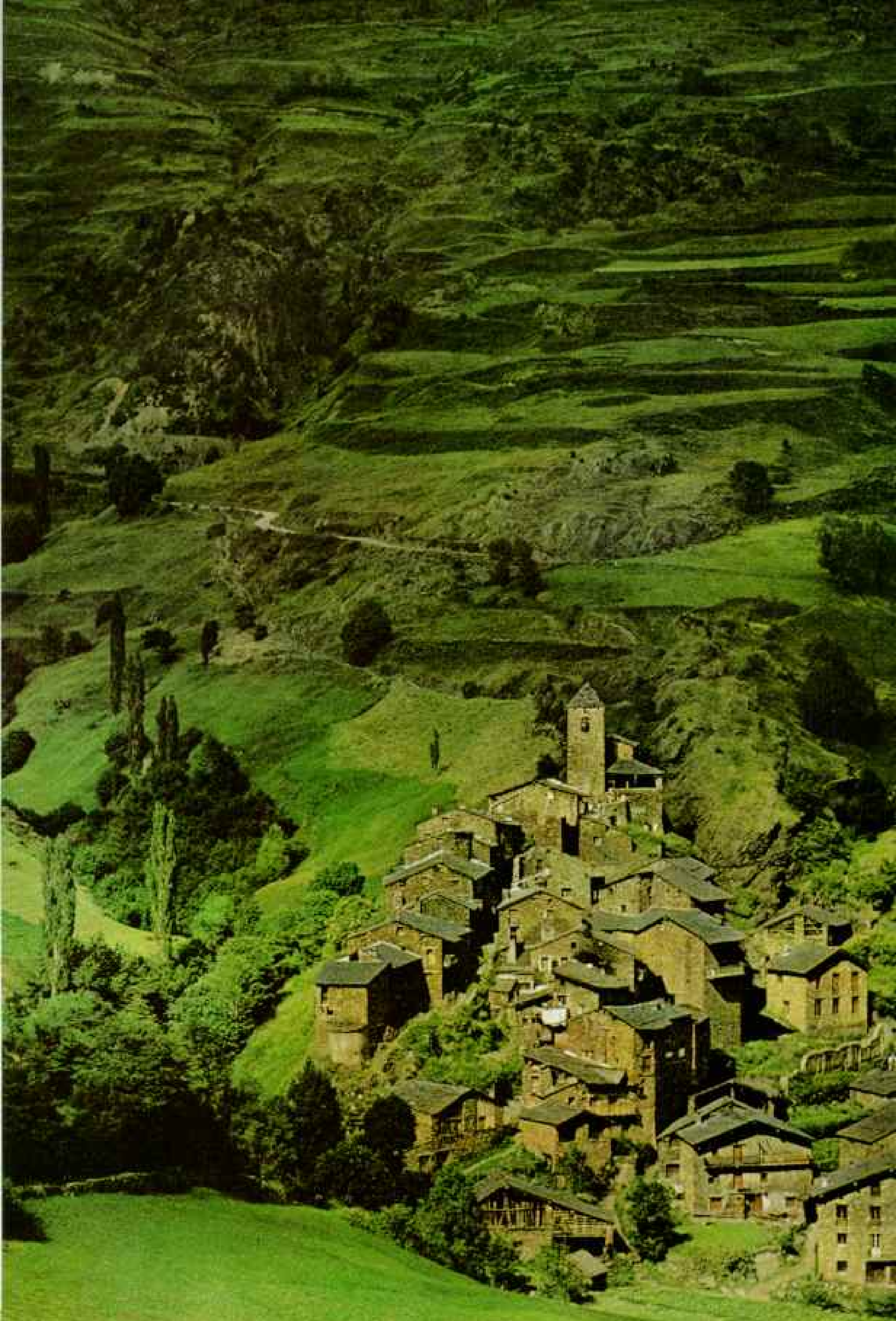
I spoke of the shepherd's sadness with Maurice Jeannel, a montagnard with alert, hazel eyes and strong hands. Historian and author, he has the reputation of knowing the fastnesses of the Pyrenees better perhaps than any other living man. We talked on a street in the nearby village of St. Lary—a street thronged with vacationists, trout fishermen, and city children whose faces were flushed by the fresh mountain air.

"Until a few years ago," Jeannel said, "that shepherd's lament could be heard in villages from one end of the Pyrenees to the other. But the exodus of our young in St. Lary has begun to reverse itself. The ones who are growing up now rarely leave."

He pointed to the street, crowded with visitors. "All these people need accommodation. Our young may not choose to work on the farms, but they find good jobs in hotels and restaurants, as carpenters in construction, as alpinists and hiking guides in the summer, and as ski instructors in the winter." He shrugged philosophically, "Progress works changes, but it has its benefits, too. There is prosperity here now."

Because the peaks intercept storms from the north, the Pyrenean slopes facing France are drenched with moisture, while the Spanish uplands are arid. Another division of this region is political: the boundary between France and Spain. *(Continued on page 801)*

Island of yesterday, the Spanish village of Os de Civis near Andorra might have been lifted from the pages of *Don Quixote*. Stair-stepped rooftops and split-level pastures show how Pyreneans have adapted to the steep terrain. In the geologically young range, farmers terrace rocky croplands to retain precious soil.



Queen of resorts and resort of kings: Biarritz earned its extravagant title in the 19th century, when European royalty bathed against the shadowy backdrop of the westernmost Pyrenees. "I have but one fear," said Victor Hugo in extolling the natural beauty of the spot, "... that it may become fashionable." Until World War II, only high society flocked to this quiet French town beside the Bay of Biscay. As if in remembrance of that earlier star-studded heyday, an antique aircraft swoops past the resort and its golden beaches. Today, as hotels outnumber the elegant villas of the rich, the middle class, too, shares the delights of Biarritz—Hugo notwithstanding.

Tourists have fanned out into the rolling Pyrenean foothills as well, to explore the land of the Basques, and have swept over almost the entire range that stands between France and Spain. Though lower than the North American Rockies, the mountains present a formidable international barrier of precipitous peaks and rugged crags.


The Pyrenees
STATUTE MILES
Elevations in feet
Biarritz
Bayonne
St. Jean de Luz
Ustaritz
La Rhune
St. Pée sur Nivelle
San Sebastian
Sare
SOULE
BEARN
GASCONY
Pau
Tarbes
Lourdes
Toulouse
Béziers
St. Gaudens
F R A N C E
Foix
Roncesvalles
NAVARRA
Pamplona
Tiermas
Ordesa National Park
Cirque de Gavarnie
San Juan de Plan
ARAGON
Pont de Suert
Durro
Llavorsí
Os de Civís
Cortinada
ANDORRA
Andorra
Santa Coloma
Port d'Envalira
SPAIN
La Molina
Seo de Urgel
Rigat Palace Hotel
Perpignan
Montes Albères
GERONA
CATALONIA
Gerona
HUESCA
Huesca
S P A I N
Col, Puerto, Port ... pass
Valle, Vallée ... valley
Pic, Pico ... peak
Montes ... mountains

Trading opinions along with produce, farmers gather on market day at St. Gaudens in the French foothills of the central Pyrenees. The range's 270-mile length shelters three distinctive groups. In the lower mountains to the west dwell the proud Basques: blood type and language place them apart from all of their European contemporaries. The frank and uncompromising Aragonese are located

in the central Spanish Pyrenees and to the south. To the east live the Catalans, a maritime power in the 13th and 14th centuries, and a strong political force during the Spanish Republic of the 1930's.

Yet Jeannel spoke of the Pyrenees as if they were one region. "The Treaty of the Pyrenees that France and Spain signed in 1659 created the frontier," he said. "Illogically it divided ancient peoples of common stock and language who share both sides of these mountains. In this part of the Pyrenees, as an example, we belong politically to France but have cultural ties with Aragon. After centuries of isolation, a recent thing like a boundary means very little. Even the advent of modernism will simply add another layer of civilization without erasing our old essence."

Historic Corridor to Conquest

My own ancestral race, the Basques of the western Pyrenees, was divided by that arbitrary frontier. Yet these oldest and purest of Pyreneans, whose language and blood type hint at an ancestry totally different from that of other European peoples, were bound by ties no boundary could divide.* The same holds true for the more numerous Catalans, at least six million, who spread across a generous third of the chain from northeast Spain through the tiny principality of Andorra and over the mountains into France.

Of the local languages of the Pyrenees, Basque is a unique tongue whose roots still mystify philologists, while Catalan stems from Latin. Both languages have incorporated influences of Spanish and French, which, even though the use of Catalan increases, are becoming the common means of communication throughout the Pyrenees.

Despite their forbidding aspect, the Pyrenees have seen the great surges of European history. They were a passageway for the Celts, for the conquering armies of Hannibal and Caesar, and, in the dark days of the Roman Empire, for the invading hordes of Vandals and Visigoths. After these intruders came the Arabs, who swept out of North Africa early in the eighth century, conquering most of Spain and penetrating as far north into France as Poitiers, where they were checked in 732. This massive invasion occupied only a few years, but nearly eight centuries passed before the Moors were defeated in Spain by Ferdinand II of Aragon and Isabella of Castile in 1492.

The long-lasting Moors laid their imprint only lightly on the remote mountain valleys of the Pyrenees, so that very little physical

*Robert Laxalt wrote of his forebears in "Land of the Ancient Basques," in the August 1968 GEOGRAPHIC.

Highland hog butchers carve home-grown stock at San Juan de Plan, a peak-sheltered enclave yet unaffected by outsiders. Nearly self-sufficient, these Aragonese raise their own meat, eggs, and vegetables, and sell milk to lowlanders for a small income. In the dim light of a dwelling (**right**), women stuff blood sausages and then boil them in a caldron over the open hearth. Upland hams are salted and slow-cured in cool basements.

evidence remains of their presence. After crossing the old invasion routes and the new passes over the mountains, I wondered if the modern rush to the Pyrenees was not changing the life of these mountains more swiftly than all that had gone before.

One of the places where changes are particularly evident is aristocratic old Biarritz on the Bay of Biscay, at the western extreme of the Pyrenean chain (pages 798-9).

The gnarled trees by the sea still bend to the westerly breezes there, and the long combers still crash white against the monstrous rocks in the bay, filling crusted pockets that gush as if bleeding from a hundred wounds. Lovers watch the sea from protected hollows in those rocks.

But while standing aloof from the restless turmoil of the sea, Biarritz on the land attests to a collision between the traditional and the modern. Vividly colored hotels and apartment houses brashly intrude beside the staid facades of the grand old hotels that witnessed the comings and goings of Empress Eugénie, Napoleon III, Bismarck, and Queen Victoria. The famous Hotel Victoria appears abandoned, its ornate balconies empty, its gabled windows shuttered.

Villagers Unfazed by Innovations

At the other end of the Pyrenean chain, in Gerona Province, the leisurely tempo of old Spain still holds sway. All along the route from La Molina in the region of Catalonia to the Province of Huesca in Aragon, villages of brown-walled houses with roofs of red tile lie like caps over hilltops that command the valleys below. They seem to wait for invasions that will come no more.

Women hang out their washing on balconies in the hot, dry sun. Shepherds graze sheep and goats on hillsides of little forage, and nut-brown children with sunny smiles drive mule carts on dusty roads. They seem oblivious to the furious activity near La Molina, in the pine-forested mountains above them.

I went to see the manifestations of all that activity: a growing cluster of hotels and, on the slopes above La Molina, 80 miles of ski runs and lifts.

One of the prime movers in this development is former Spanish Olympic skier Felipe Rigat Tortorici. In his late thirties, he seems young to be an entrepreneur. But his athletic frame cannot contain a Catalan enthusiasm for what he and his associates have wrought.


BONNADAL

Bargain capital of Europe, Andorra's metropolitan area—originally three villages—spills down a valley in one urban stream. Refugee traffic in both global conflicts and in the Spanish Civil War launched the economy of the pocket principality, loosely protected by France and Spain. Token taxes and duties allow merchants to offer the lowest prices on the Continent, bringing not only money but also traffic jams, air pollution, and neon glitter to the main street (**left**), here decorated for the yuletide. *Bonnadal* means "Happy Christmas" in Catalan.

"We Catalans initiate almost everything of importance in Spain," he says proudly. "In three years we hope to have the facilities to accommodate 20,000 people winter and summer." He guided us through the luxurious rooms and gourmet restaurant of his Rigat Palace Hotel. They had a Catalan flavor of burnished wood and gleaming tile. "Have you ever seen such elegance in tourist resorts anywhere?" He did not seek an answer.

Bucolic Road Leads to Bedlam

La Molina has some way to go to equal the changes that have been wrought in nearby Andorra. Nowhere has development so altered the old character of the Pyrenees as in that fabled principality that embraces fewer than 190 square miles.

The approach to Andorra, however, is deceiving. From the drab French valley rising beyond Foix, we mounted toward Port d'Envalira, coming upon rough stone villages and enjoying the fragrance of fresh-cut hay. At the edge of the sinuous road, precipitous drop-offs were hidden in thick mist. When there was a rent in this curtain, one could glimpse green mountains and horses grazing near early-summer snowbanks.

At the top of the 7,904-foot pass we came upon a flock of sheep and a young Andorran shepherd, who turned to look at us with startled eyes. With his blade face, long woolen stocking cap, and draping leather cape, he seemed a figure from the past.

In an instant the mist that had enveloped everything gave way to brilliant sunlight, and far below us a valley was shimmering with dew and veined with a silver stream. As we descended along the road, stone walls laced the hillsides, enclosing solitary farmhouses. Scattered villages huddled under their rooftops. It was as if we had come upon a storybook kingdom (upper left).

Then our route led down to the valley floor. Here the roads were clogged with diesel trucks belching black fumes. Steam shovels and graders gouged the meadow grass. Bulldozers toppled old stone buildings. Finally reaching the capital, Andorra la Vella, we found a traffic jam of monumental proportions. A lone policeman with curling mustachios tried vainly to cope.

"Andorra is fully involved with progress," said Casimir Arajol Duro, a gentle white-haired Catalan who is president of the local tourist office. "The population has more than

Lethal bite from a lumberjack's saw dooms a mossy patriarch in the Forest of Irati, one of the largest woodlands in western Europe. Rapid industrial growth among the commercially aggressive Basques draws lowland workers, who help dilute the highly distinctive Basque culture.

Ewes stand quietly as young Catalan shepherds separate them from their lambs (**facing page**). Human residents have vacated their side of this structure in Durro, symptomatic of the urban migration that diminishes the Pyrenees' farm population.

doubled in ten years to 25,000 people, and it will probably double again in less time. There are already 215 hotels in Andorra, and three or four new hotels and dozens of new businesses come into existence each year. Andorra is poor no more." He paused, then added hesitantly, "Perhaps we have gone too fast in this business of change. But we are moving now to preserve our old villages."

Many Frenchmen and Spaniards, as well as tourists from everywhere, travel to Andorra to shop at bargain prices; Andorra imposes only modest duties. Stores bulge with radios and cameras from Japan, cigars from Brazil, peasant skirts from Afghanistan, and liquors from all points of the compass.

Actually a principality, under the protection of the Bishop of Seo de Urgel in Spain and the President of France, Andorra employs but 25 policemen and has no army, since it has never had a war. Catalan is the official language. Political campaigns for membership on the ruling General Council are unknown. A candidate who files for office is simply assessed by the citizenry in casual café conversations.

Andorra Captivated Europe's Conqueror

A short drive from the capital took us to the village of Santa Coloma and its 12th-century Romanesque chapel. A shy, dark boy, whose family was entrusted with the key, led us into the sanctuary, which held a rare primitive statuette of the Virgin. Child-size, of carved wood, and about as old as the little chapel, it is one of only a handful of such pieces that still exist.

I asked our young guide if we could go up into the tower, an Andorran landmark.

"It's a little dangerous," he said. Then, making a quick decision, he said, "All right, I will show you."

We inched around a spiraling stairway, brushing aside veils of cobwebs, and climbed up rotting wooden rungs, some of which gave way beneath our feet. From the belfry I looked out upon the old Andorra that Napoleon is said to have found so incredible he wanted it preserved as a museum piece.

In the distance rose an encircling ring of mountains under snow. At lower elevations were deep forests, tobacco fields in young growth, and, along the Valira River, stately poplars. At our feet was revealed an intimate view of Santa Coloma, a view that had been denied us by the high courtyard walls that

High-stepping salute to Pyrenean zest draws a crowd at the Catalan village of Pont de

Suert. The dancers are Aragonese, invited to a fiesta to display their regional artistry.

shouldered the winding streets. Through open doorways we could see women in their kitchens. Children laughed at play, men worked in little vegetable gardens, and chickens and pigs wandered at will.

That view leaped unexpectedly into my consciousness in another village. But this time the experience was painful.

Situated on a high knoll in the dry Spanish badlands of Aragon, medieval Tiermas has seen the passing of a hundred generations. Once its women paused to visit at the fountain and men conversed there after returning from the fields below at the end of the day.

Today weeds sprout in the streets. Houses stand empty with broken windows. Leaning in dark entranceways are straw brooms no housewife will ever wield again. The church that was the core of life totters in neglect.

Of Tiermas's 800 inhabitants, only a handful remain. At the fountain in the square, I talked to an old man in tattered garments, and with pathetic remnants of shoes on his feet. "Do you see that reservoir down there?" he asked. "Seventeen years ago it was a fertile valley. It was where we raised the crops that were our existence. Then the government decided they needed a reservoir there to irrigate the dry plains beyond. They bought our farmland and paid our people for their houses, and then located them somewhere else."

"There must have been sadness when the people of Tiermas had to go away," I said.

"Yes," he answered. "But for the young, money managed to change that. In my case, I am very poor, and also very old. It is much too late for me to think of leaving."

I turned to watch a crippled man prodding a burro with a stick. The man continued: "We are all that's left—the old who don't want to leave their homes and the crippled who are afraid to go out into the world."

I left him standing alone by the fountain.

Animals Take Over a Village at Dawn

Joyce and I went down the rocky road and took the highway past the man-made lakes that provide precious water to the parched lower regions. We had seen a classic confrontation between old and new—but one that was, in all times, inevitable.

Days later, in the central French Pyrenees, our road climbed a river-cut chasm toward Gavarnie, famed for its awesome bowl-like cirque, carved by a glacier long melted. It was evening when our car pulled into the village of Gavarnie, which seemed almost as quiet as deserted Tiermas.

Our room in the inn held an iron bed with a feather quilt. Dinner was a feast of trout fresh from a local stream, roast lamb, and the robust wine of the house. Afterward we explored the silent streets.

I was awakened at dawn by a commotion outside and threw open the shutters to a sight I shall never forget. The village was still locked in the shadow of the peaks, but the streets were filled with horses and donkeys trotting to hitching posts, where they would be hired by sightseers bound for the Cirque de Gavarnie or into the mountains. Fully 300 animals clip-clopped along without guides. All seemed to know where they were going, except a young gray donkey that was turning in circles. A girl darted out of the shadows, caught him by his tufted mane, kissed him affectionately on the head, whacked him resoundingly on the rump, and sent him in the right direction.

Home of the Eagle and the Izard

When the sun cleared the peaks, we rented two of the little short-coupled horses. Crossing a low bridge and following a swift stream, we took the climbing path toward the cirque, which is in France's National Park of the Pyrenees—142,000 acres along the frontier. A few miles across the border lay Spain's National Park of Ordesa. The parks shelter rare flowers, birds, and such animals as the izard, the goatlike antelope also known as the chamois.

The immense amphitheater of the Cirque de Gavarnie burst into our view, and I understood why Victor Hugo called it "the Colosseum of nature." Only nature could have shaped this two-mile-wide bowl (page 816). The brutal rock wall reared a mile above the floor. On the upper reaches, snowy patches reflected the morning sun in blinding shafts of light. Standing beneath that overpowering mass, I knew what it was to feel diminished to the size of an ant.

Several years ago, on a trip to the Basque region in the west, my wife and I climbed above timberline and saw shaggy ponies running free on the high plateaus. Called *pottokak* by the Basques, these animals are believed to be descendants of certain races of prehistoric horses painted on the walls of caves such as Lascaux in France. When I first saw the pottokak, their numbers had been reduced

Dress, umbrella, and smile abloom, a Catalan woman and her hay-burdened beast wait out a drizzle in Spain's Valle de Arán. Near the center of the Pyrenees the range splits, enclosing this fertile trough roughly ten miles wide and thirty long.

to 4,500 by hunters, who killed them for meat to be used in salami. Then Paul Dutournier, the honorary Mayor of Sare in the Basque Province of Labourd, waged a successful campaign to provide the ponies with refuge.

The mountain of La Rhune, looming ghostlike behind the old fishing port of St. Jean de Luz on the French side of the frontier, is today one of the principal pottokak reserves. From the Col de St. Ignace we mounted La Rhune on a funicular that passed over tangled forests of beech and oak. On the soft green plateaus above, we now saw colts gamboling through purple lupine while their slate-colored mothers browsed. In the span of a few years, the herd has grown almost tame; no longer do they flee at man's approach.

I like to think it a proper coincidence that descendants of prehistoric horses should find a home on La Rhune, a mountain that perhaps played a role in the ancient history of the Basques. Here their warrior ancestors may have engaged in pagan worship and fertility dances; isolated, fiercely resisting change, they were belated converts to Christianity. In 1609 their tenacious hold on primitive beliefs brought about one of the bloodiest chapters in Basque history.

Hatred of Basques Led to Burnings

From La Rhune's summit we looked down upon St. Pée sur Nivelle, where Pierre de Lancre conducted sorcery trials.

"De Lancre was a fanatical man, driven by a hatred of all things Basque," historian Eugène Goyheneche told me in nearby Ustaritz. "Appointed by Henry IV of France to investigate sorcery, de Lancre convinced the king

that the Basques practiced devil's rites on La Rhune. By torture and bribery, he turned neighbor into informer against neighbor. Before his reign of terror was done, he had burned hundreds of men, women, and children at the stake—thus adding to the large number of victims of the sorcery trials that swept through Europe."

On the outskirts of St. Pée sur Nivelle stands the crumbling chateau where Pierre de Lancre stayed during the trials. We wandered through its dank interior, where the very walls seem to shriek of agonies suffered there. A lizard of mottled green and black scurried up a wall and watched us from a ledge, sending a chill up my spine. When we quit that sanctuary of evil, sunshine had seldom been so welcome.

Pagan Monuments Survive in the Mountains

In some remote mountain villages of the Basque country, Catholic masses on certain feast days still are celebrated to the accompaniment of ceremonial dances from pagan times. Pagan monuments have been found throughout the region.

Our search for one of the pagan ritual sites took us on a tortuous pilgrimage up a hill that rises in the old Basque Province of Soule. Through mist so thick the way was almost invisible, we went to road's end by car, then continued afoot. At the top stood the Chapel of the Madeleine. Recently reconstructed, the chapel enshrines a Christian altar. But it also contains an almost undecipherable stone marker inscribed in Latin and cloaked in time-dimmed mystery. The most likely explanation: it was dedicated to Heraus, "goddess of the red dust," and was part of a pagan sanctuary maintained by the Romans on the hill of Madeleine two thousand years ago.

It is strange to find such relics only sixty miles by road from one of Christendom's most venerated shrines.

In spring and summer the streets of Lourdes are jammed. Priests, nuns in habits of black, blue, or white, and monks in sandals mingle with tourists from far corners of the world. The air is alive with many tongues.

It was at the Grotto of Massabielle in 1858 that young Bernadette Soubirous, of an impoverished family, saw visions of the Blessed Virgin. Bernadette said the Virgin had caused a spring to flow from the cave, and wished processions to be made there.

Today pilgrims stand patiently in line before fountains whose waters, many testify, have helped to work cures. Old women in black scarves sit on stone benches, clutching rosaries. But the most moving spectacle at Lourdes is of hundreds of sick and crippled people on stretchers and in wheelchairs. They look with beseeching eyes at the white-robed statue of the Virgin in her rock niche, and the sound of their prayers is like the rustle of autumn leaves in the wind.

From the tower of the Chateau of Lourdes we witnessed a candlelight procession (upper right). Legend tells that from an earlier tower at this site, Moors looked

Rivers of candlelight flow past the basilica at Lourdes as the faithful recall a miracle reported more than a century ago. In 1858 a French shepherd girl named Bernadette said that visions of the Mother of Christ came to her in a nearby grotto; the resulting religious fervor attracts three million pilgrims and visitors a year. As the able-bodied walk slowly by the church, the infirm lie before the grotto itself (**right**), murmuring supplications for good health.

out upon the besieging soldiers of Charlemagne in 778. Within the battlements of the present fortress, staircases and sentry walkways, now deeply worn, knew the tread of other armies that surged across the Pyrenees.

Today the castle houses the Pyrenean Museum, whose collections—furniture, costumes, and examples of architectural styles—are unmatched elsewhere in the mountain realm.

Many of the old styles have changed, of course, and some have disappeared. But other Pyrenean manifestations endure. One is the character of the people. The Aragonese are often described as stubborn. Catalans speak of their pragmatism. In the region of Béarn, hotelier Jean Touyarot, who guided us through the sprawling chateau in Pau where Henry IV was born, told me the Béarnais are romantics with a positive outlook. "Our old dictum still applies," he said. "A man who cannot at least promise to do something for a friend is a very poor man indeed."

Secrecy an Inviolable Tradition

Among Basques, restraint and the guarding of village secrets are living traditions. The code of silence was demonstrated in 1970 during the trial of young Basque revolutionaries in Spain. Two days before the trial began, a West German consul accredited to

Summer hockey in the square of Llavorsí, a Catalan village, reflects growing enthusiasm for this sport. The Basques, however, still remain faithful

Spain was kidnapped in San Sebastian. The consul was spirited over the mountains by other revolutionaries to a French Basque village, and held hostage against the chance that the youths would be sentenced to death. One of the villagers told me:

"Many of us in the village knew he was here—even the location of the house where he was held prisoner. We were disturbed, but the revolutionaries promised they would not kill him. That satisfied us, so we ignored the whole affair. In time, they drove the consul to Germany and released him unharmed." The man shrugged. "It never occurred to us in the village that our secret was anybody else's business, or particularly the government's." Even now my informant is not pleased that I am telling this four-year-old tale; the code of silence still holds.

to *pelota*, or handball, and jai alai, a high-velocity variation that they originated.

Such an attitude toward government has long made it easy for smugglers to operate between Spain and France. As a result of a simple courtesy—giving a man a ride—I learned much about this vintage enterprise.

We had taken the road to Roncesvalles, one of the great pilgrimage routes to the tomb of St. James in Santiago de Compostela in Spain. At Puerto de Ibañeta a footpath led us down to the narrow defile where, according to legend, Charlemagne's rear guard, commanded by the heroic Roland, was massacred in 778. The battle inspired the French epic poem, the *Song of Roland*, which alleges that Saracens did the deed. But most accounts of the engagement agree that Basques, not Saracens, were actually the attackers.

Strict Code Guides *Contrabandistas*

Along the road we noticed a man on foot and offered him a ride. Upon reaching his village, he insisted that he reciprocate with coffee and brandy.

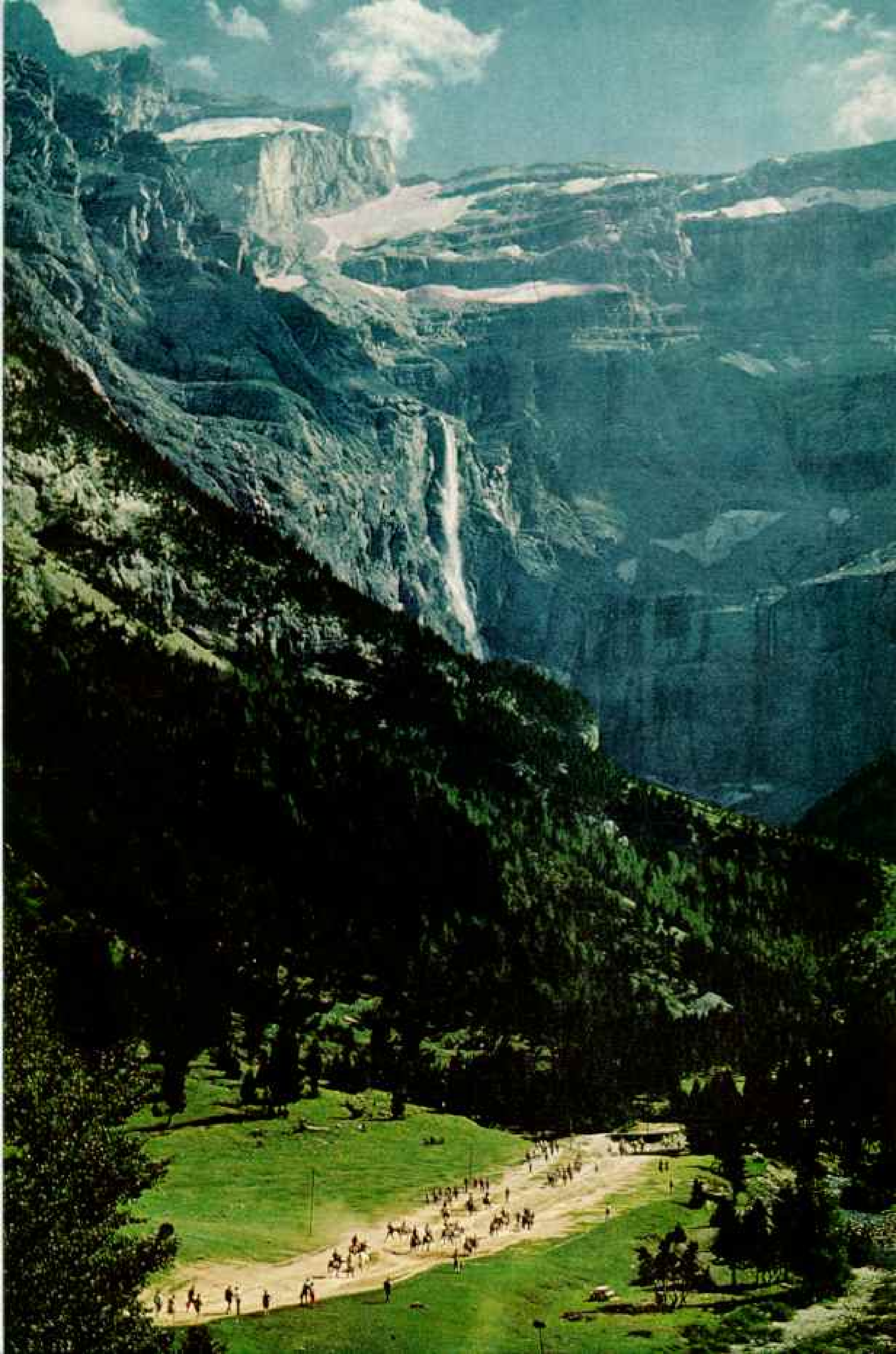
He took us to a bar of whitewashed walls and bare tables, around which men were talking in conspiratorial tones. Our companion explained casually that they, like he, were smugglers of such traditional Pyrenean contraband as livestock and Spanish lace.

Two Spanish policemen in green uniforms and black leather belts were drinking by a window. As I glanced at them apprehensively, our companion explained, "They police villages, not the frontier, so the business of contraband is not their concern."

The *contrabandista* took no offense at my curiosity after he learned I was of Basque blood, and therefore, as he put it, could be trusted to protect his name.

"To be a good smuggler," he said, "one must have these characteristics: strong legs and sound wind, the eyes and ears of a cat, and, of course, an elastic conscience."

I asked how a smuggling operation worked. He bent over his drink and said: "It is really very simple. Say that I and my comrades want to smuggle 50 Spanish mules, which because of their strength are much in demand in France, across the frontier. Knowing that the frontier guards are unhappy about going out in storms, we naturally wait until a stormy night. We dress in dark clothes and choose the



most difficult route over the mountains. One man goes ahead about 400 yards to keep an alert for the guards. The rest follow at intervals of 30 paces, each leading three or four mules. If all goes well, we make 16 miles by midnight to a rendezvous with our counterparts on the French frontier. It is all very simple." He grinned.

"But what if the frontier guards see you?"

His grin faded. "Well, now, that part is not so simple." He bent forward again and said, "You must understand that after all these years, we have had to reach an understanding with the law. It is this: If a frontier guard sights us, he shoots his pistol once into the air. That is our signal to leave the mules and run. The guards confiscate the mules, which is all they really care about anyway."

"What if you try to fight them for possession of the contraband?"

He wagged his finger at me. "That is bad, very bad. One hothead beat a guard nearly to death with his walking stick. We could not protect him because he had broken the accord. The guards had the right to shoot him." He added laconically, "Which they did."

When I asked if the smugglers dealt in narcotics, he replied heatedly, "Never! No business of little packages for us. If one were to try it, we would ensure his arrest ourselves."

Once a Year Pamplona Goes Wild

By design my wife and I arrived in Pamplona, the capital of Navarra, when the gay ten-day Fiesta de San Fermin was officially over. For most of the year this old walled city is a place of reserved demeanor. But during the fiesta in July, Pamplona honors its patron saint by throwing off restraint like a winter coat and immersing itself in wild abandon. Twice before I had participated in the dancing, singing, and running of the bulls. Now I simply wanted quiet.

But the sidewalk cafés were filled. Around the bandstand in the park people danced alternately to rock music and the fandango. A weary man in a wine-spattered shirt explained that the fiesta was indeed over: "But you must understand that a week is required for the excitement to run itself out."

Formerly a time of mingling for the people of the Basque country, the July fiesta in Pamplona now draws visitors from half of Europe. Not nearly so well known, but to my mind far more representative of festivals in the Pyrenees, is the spirited Bastille Day celebration

Toughening up, French paratroops plod along on a grueling two-day hike in heights near Gavarnie. Rock and ice climbing has long attracted mountaineers to the Pyrenees, and skiers lured by newly developed resorts are making fresh tracks on the range's inviting slopes.

Bedecked in snow and plumed with a waterfall, the Cirque de Gavarnie rears a mile from the valley floor (**opposite**). Glaciers gouged this amphitheater, where spectators ride horses and donkeys from one scenic box seat to another.

Planned stampede swirls through the streets of Pamplona during the July festival made famous in Ernest Hemingway's novel *The Sun Also Rises*. The running of fighting bulls commemorates the martyrdom of the early Christian San Fermin, the city's patron saint. As with other customs once uniquely Pyrenean, the flight before the fierce but

frightened beasts now carries an international flavor; many a T-shirt seen among the daring youths carries the name of an American university.

at St. Jean Pied de Port in the French Province of Basse Navarre.

We reached the town on the eve of July 14, and with good fortune found a room in the Central Hotel. Typically Basque, the little inn was immaculately clean. The windows sparkled and the wide oak boards of the floor, hand-rubbed with beeswax, gave off a soft, warm glow.

Our dinner was Basque too, beginning with the pork pâté of the hotel, followed by *pipérade*, an omelette with tomatoes, mild peppers, and crisp slices of bacon. The main course was a Basque delicacy, milk-fed lamb, with meat so tender that it flaked away from the bone. A bottle of Irouléguy, the *vin rosé* of the region, was one of the most delightful wines we had ever tasted.

Explosion Heralds a Holiday

Next morning Bastille Day began literally with a bang. In the hotel I was leaning against the open window, my eye casually sweeping rooftops where pigeons dozed in the gentle sun. An explosion of firecrackers in the town square shattered the stillness. The pigeons flew straight up.

The day was filled with contests between villages in jai alai and handball, tugs-of-war between veritable brutes of mountain men, and harrowing woodchopping with the axmen balanced on logs. Most spectacular of all was the somersaulting of young men over the horns of charging wild cows. Some ran forward to meet the animal, leaping at the last possible instant. Others stood stock-still, then sprang high as the cow passed beneath them. A miscalculation of a split second and the daring somersaulter could have been mortally battered by the impact.

The evening throbbed with contests between troubadors, the vibrant singing and staccato dancing of the Aragonese, intricate steps of the Catalans, and stylized ritual dances of the Basques. Then participants and spectators alike swarmed to the main square for dancing and revelry that continued until first light of dawn. My ears rang with the sound of music and the piercing Basque battle cries that Roman legions and barbarian invaders had heard in these mountains more than a thousand years ago.

My historian friend Maurice Jeannel had been right. Progress may alter the face of the Pyrenees, but it will be a long time before it erases the essence of its peoples. □

HOPES AND WORRIES ALONG
THE COLUMBIA RIVER

Powerhouse of the Northwest

ARTICLE AND PHOTOGRAPHS BY
DAVID S. BOYER
NATIONAL GEOGRAPHIC STAFF

A TELEPHONE CALL dragged me out of bed at midnight. "Better look now," the voice said. "You may never see it again."

I pulled the window drape and stared out at an awesome sight—a great river coursing over the greatest spillway in North America.

Engineers had opened all 11 gates. They had even switched on the giant floodlights that cast rainbow colors on the cascade, almost twice as high as Niagara Falls (pages 822-3). Perhaps a hundred million gallons a minute hurtled over Grand Coulee Dam in Washington State and plunged 340 feet back into the Columbia River.

Draining an area larger than France, dropping 2,650 feet in its 1,214-mile course from the Canadian Rockies to the Pacific, the Columbia and its tributaries generate almost three times as much electricity as all 100 or more rivers of the Soviet Union's Volga system, ten times as much as the Colorado, thirteen times as much as the Mississippi. As much in a year as 7.9 billion gallons of oil!

Already the Columbia accounts for a third of all hydroelectric power in the United States. But that's not enough. Upstream and down, I would see men by the thousands working day and night to build new dams and increase powerhouse capacity at old ones.

Galloping down a glacier-scarred peak in the Canadian Rockies, a brook rushes to nourish the infant Columbia. Harnessed for power, irrigation, flood control, and navigation, this mighty river —more than any other in North America—has been tamed to do the bidding of man.

More kilowatts for a world caught up in an energy crisis. Power to accommodate more industry, bigger cities. But at what cost, I wondered, in human values, wildlife, the environment? In damage to the still-unspoiled reaches of the river? To the region's quality of life?

Even the beauty of that cascading water at Grand Coulee would be sacrificed. Added turbines would mean that nearly every drop would eventually go through powerhouses, and virtually none over the dam, Rod Hartman told me. Rod, who had gotten me out of bed to see the sight, runs a tourist motel at Grand Coulee.

"They say they'll put in some colored fountains for the tourists," he said. "Ha!"

In Portland, Oregon, the Columbia's only big city, publisher-conservationist Oral Bullard told me of his concern. "Fifty years ago there wasn't a dam on the Columbia. She was a wild river of sheer beauty."

Then came Rock Island, Bonneville, Grand Coulee, The Dalles, eventually 11 mammoth hydro plants. They brought clean, cheap power that spawned an economic empire across the underdeveloped Northwest. At times there was enough electricity left over to ease power shortages in southern California.

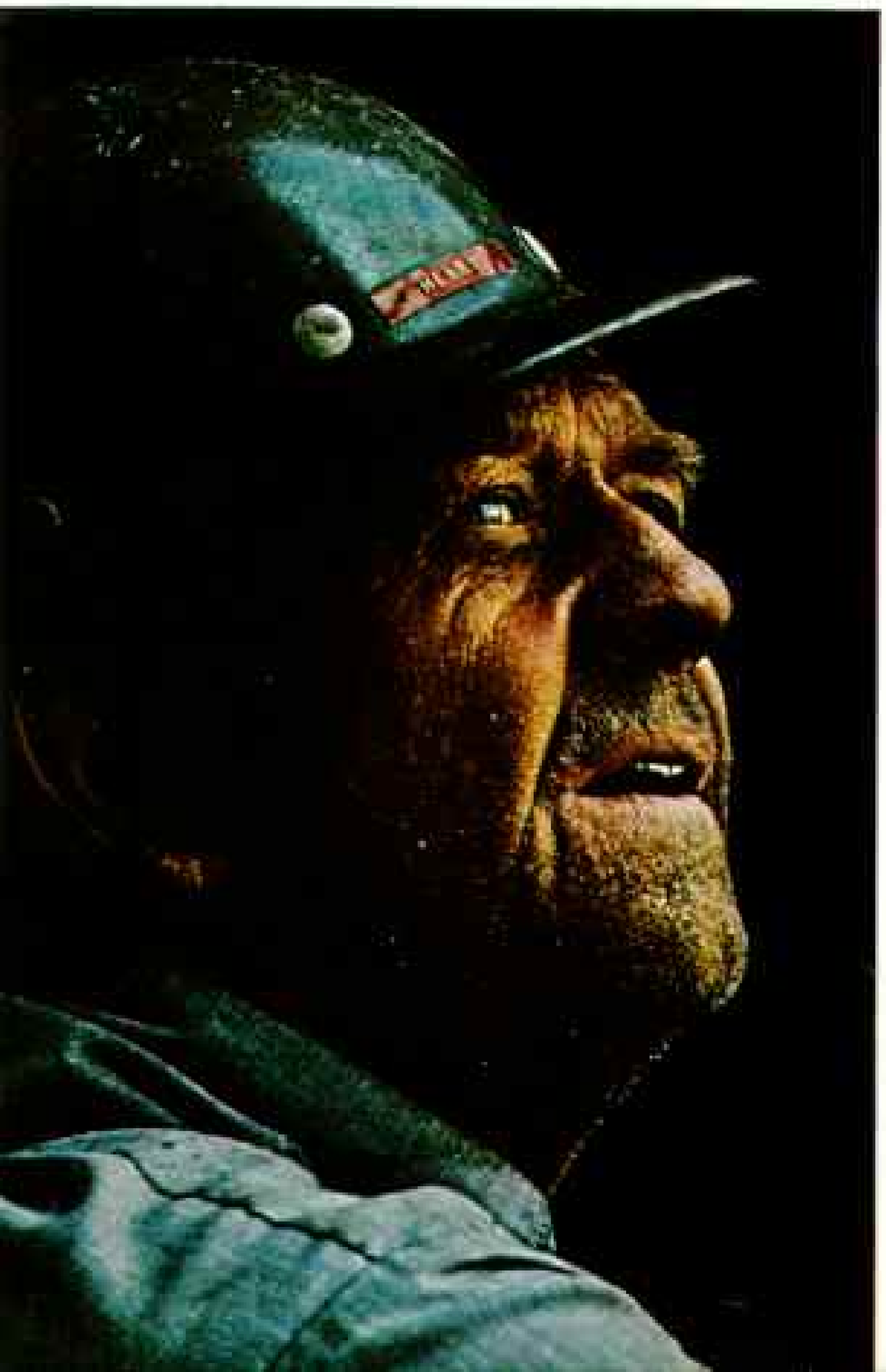
"Now, those who want to keep the Columbia's empire growing say they'll need the equivalent of a new Bonneville every year," Oral went on. "Already they've changed the Columbia into a staircase of lakes, a shipping channel, an irrigation and flood-control system, and a power plant a thousand miles long. It's no fun to see a lovely wild thing tamed and hurt and broken."

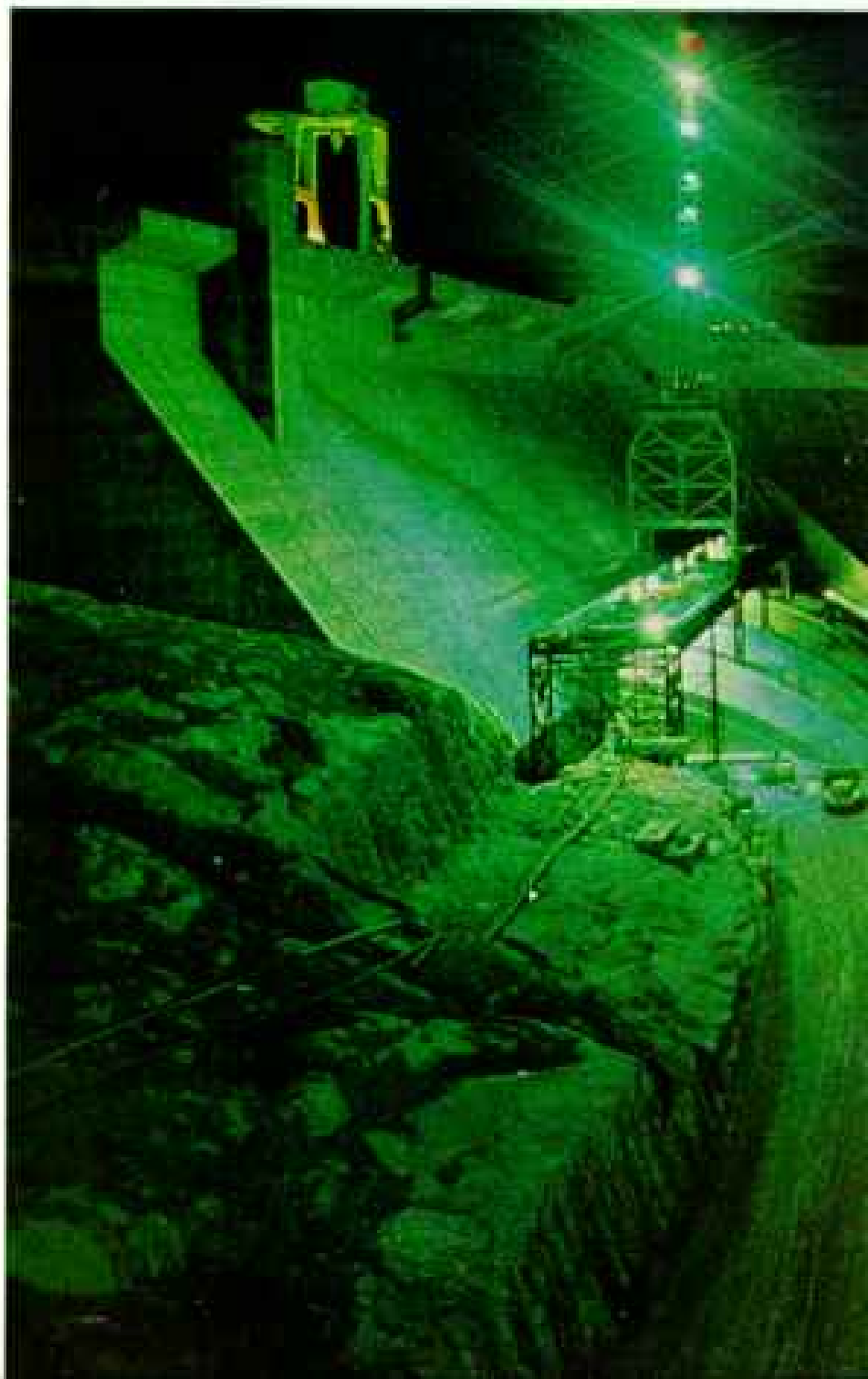
A River Harnessed, but Still Beautiful

By car, by boat, by plane, and on foot, I would follow every curve of the Columbia, and come to know all her moods. In places she certainly has been "tamed and hurt and broken," condemned to labor for man. Yet, of all the world's great rivers I have seen, I found her the most beautiful.

Out of British Columbia's mountain country of snow and glaciers the river is born,

Dynamo of progress, Grand Coulee Dam, largest on the Columbia, drew acclaim as an eighth wonder of the world when it was completed in 1942. Now construction worker Henry Beecher





pure and tumbling, cascading down the slopes of the Rockies like liquid jewelry of apple-green jade.

From Columbia Lake the river courses 500 miles through a blue-forested Canadian alpine wilderness—a wilderness being invaded by powerhouses and reservoirs.

For 500 miles more the Columbia winds through rolling Washington State wheatland, digging her canyon deep through volcanic rock—the sere land on either side coming to life with new towns, new industries, and new farms, all thriving on water and power from the river.

Gathering tributaries from most of Idaho, Washington, and Oregon and parts of Montana, Wyoming, Nevada, and Utah, the Columbia cuts through the Cascade Range, flanked by lush forests and watched over by the white-capped volcanic cones of Mount Hood, Mount Adams, and Mount St. Helens. She rolls onward past the river industries of Portland, Vancouver, and Longview, flows beneath the hulls of oceangoing ships, washes lush island farmland, and moves majestically to meet at last the maker of her summer rains and winter snows, the Pacific Ocean (map, following page).

Along the way I met people who fear for the future of this queen of western waters. Others seem glad to have found her, for themselves, in time. Coming from many places, they are able to live and work here because the Columbia *is* developing. They love the river for what she still is, and hope she'll never change. They know she will, though. They themselves are helping to change her.

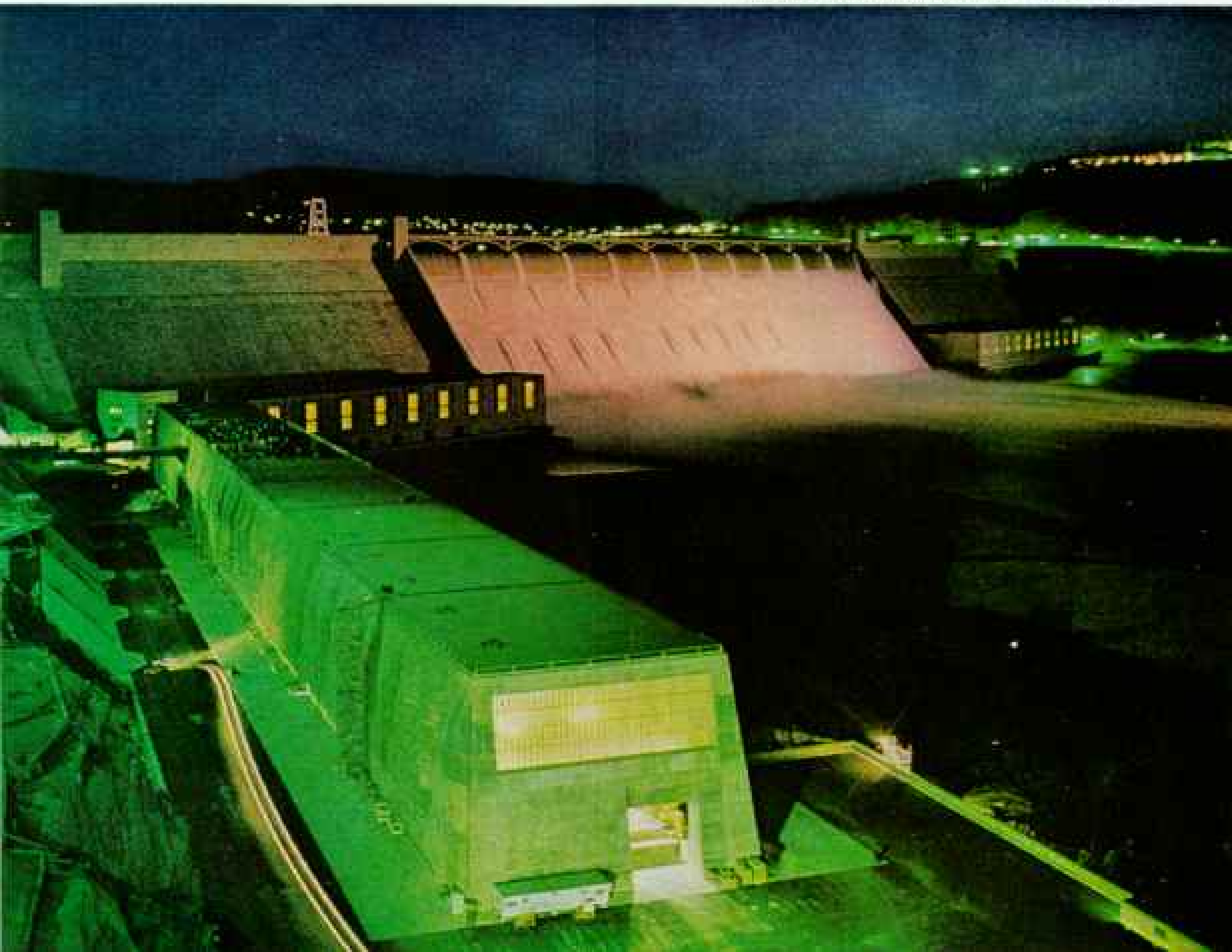
Switzerland Once Looked Like This

High in the Canadian Selkirks I looked down a glacier toward the thickly forested Columbia valley. With me was Guy Messerli, a mountain guide from Switzerland.

"You could drop my entire native land into this Columbia River corner of Canada," he said. "This is what Switzerland must have looked like long ago, before there were so many people."

helps build a third powerhouse (foreground), whose turbines will boost Grand Coulee's total output to 6,280,000 kilowatts, making it the world's No. 1 producer of hydroelectricity.

NATIONAL GEOGRAPHIC PHOTOGRAPHER JAMES P. BLAIR (BELOW)



The Powerful Columbia

COLOSSAL RIBBON of energy, the Columbia has been a key to development of the entire Pacific Northwest. Now weekenders water-ski on scenic lakes, farmers plant fruits and vegetables on land once arid, factories work around the clock, and residents have less fear of the river's tantrums.

Guy teaches mountain climbing in summer and alpine skiing in winter, and so helps swell the flow of tourists to his wilderness.

Where the mountains fade into the flat lands of southeastern Washington, and Grand Coulee Dam creates a lake 150 miles back to the Canadian border, I stood at water's edge beneath two powerhouses. Amid a turmoil of concrete trucks, cranes, scaffolding, and steelworkers, a bronze-helmeted deep-sea diver came bubbling up from the river depths. An assistant unscrewed the faceplate and poked in a lighted cigarette.

Hal Marchant grinned: "I was just down checking this cofferdam. In a few months, we'll take it out." In 1978, water that used to go over the spillway will flow through six of the world's largest turbines in Grand Coulee's $460,000,000 third powerhouse. That will add 3,900,000 kilowatts to the Columbia's power, making Grand Coulee the largest hydro producer in the world.

Marchant, a retired Navy captain, heads his own diving company, lives in a lakeside ranchhouse in Electric City, and has a special way to appreciate the river that provides his livelihood. He took me up in his floatplane. "Flying along the Columbia and over these magnificent mountains," he said enthusiastically, "is like going to church."

Home With an Eternal View

Where the sagebrush melts into the Cascades in the Columbia Gorge, I saw another face of the river through the eyes of Anders Anderson. He gestured down from his new home, perched on an 800-foot valley wall.

"Nobody will ever block this view with high-rise apartments." Only the Columbia, the concrete ribbon of a superhighway, and toy train tracks flowed through the gorge.

"My wife and I drive hundreds of miles along the river every week, and we still stop to take pictures."

Andy is a supervisor at one of the Columbia's six aluminum smelters. Their 25 electrolytic potlines, each longer than a football field, produce a fifth of all U. S. aluminum. Increased power on the Columbia could mean more potlines. More people. ("Additional power would bring another industry into Spokane every month," a Spokane politician told me.)

But not all the emphasis is on bringing more people to the Columbia. For years Oregon's Governor Tom McCall has been trying to convince the world that "Oregon's a great place to visit, but we wouldn't want you to live here."

Since the days when only Indian tribes congregated on its banks to dipnet migrating salmon as they leaped up its foaming cataracts, the Columbia has been a magnet, drawing men to share her bounty.

Today the Columbia sends you her canned salmon, lumber and paper from her forests, apples from her world-famous orchards, grain and vegetables from her rich soil. Some of her aluminum goes into Washington-built Boeing 707's and 747's. More goes into high-tension lines that carry Columbia hydropower in giant-towered strides across the Pacific Northwest.

Columbia Furs Paid for China Teas

The quest for gold and a Northwest Passage to China brought 18th-century mariners to the Pacific Northwest. They hoped to find both with the legendary Great River of the West mentioned by earlier Spanish seafarers. They found no gold, no transcontinental passage. Only furs. But furs proved more golden than gold in the rich markets of China.

In 1792 an American, Capt. Robert Gray of the *Columbia*, sailing around Cape Horn from Boston, discovered the mouth of the river and named it for his ship. British explorers James Cook and George Vancouver had barely missed it. A power struggle for the vast Columbia country was soon on.

President Thomas Jefferson sent explorers Meriwether Lewis and William Clark over the Rockies. Down the Columbia's largest tributary, the Snake, they made their way, reaching the lower Columbia in 1805 and reaffirming the U. S. claim to the river.

Several years later one of Canada's greatest fur traders and explorers, David Thompson, discovered the Columbia's headwaters. To stake a British claim, Thompson and his Indian paddlers boldly carried the Union Jack by canoe down the entire river, portaging around its falls and cataracts.

But at the mouth of the Columbia he discovered a fur-trading post flying the Stars and Stripes. Built by scouts of the wealthy New York trader John Jacob Astor, it had been christened Astoria.

During the War of 1812, though, Astoria passed to the Canadians. Explorers of the Hudson's Bay Company and the North West Company built trading posts along the river

Yoke of earth below the Rocky Mountains, Canada's Mica Dam (**right**) stands ready to further harness the river's waters. Only an overflow tunnel, here reflected in a puddle (**above**), and a turbine await final touches. Teaming up with the United States to extract more power from the Columbia, Canada built this and two other dams to control the river's headwaters.

In the haste to put Mica Dam to work, the reservoir behind it was allowed to flood thousands of acres of unharvested timber. Only prime trees were salvaged; the remaining debris still clogs the lake.

and its tributaries. For decades the Columbia country was more British than American.

Then came U. S. pioneers of the Oregon Trail in covered wagons, establishing homes, farms, schools, missions in the fertile Willamette Valley, where Portland would rise.*

Contention over the Columbia country mounted. In the 1840's it nearly precipitated another war between the two nations when the pioneers, then the politicians, took up the battle cry, "Fifty-four Forty or Fight!"

Fortunately, confrontation turned into compromise—at the 49th parallel rather than north of the 54th. The boundary treaty cut the river and its country in two: British Columbia to the north, Oregon Territory (from which Oregon, Washington, Idaho, and part of Montana would emerge) to the south.

River Developers Faced a Long Fight

More than a century later, in 1964, came a treaty to reunite the river economically. It provides for dam building, water storage, flood control, production and distribution of electric power. Also achieved in controversy, it chafes nerve endings even today.

Still, it has helped to weave a strong fabric of mutual interest and goodwill. United States citizens and Canadians, sharing their mountains, their frontier way of life, and their boundary-crossing river, use a phrase that shows they consider their border as scarcely even a fence between neighbors. "Across the line," they always say.

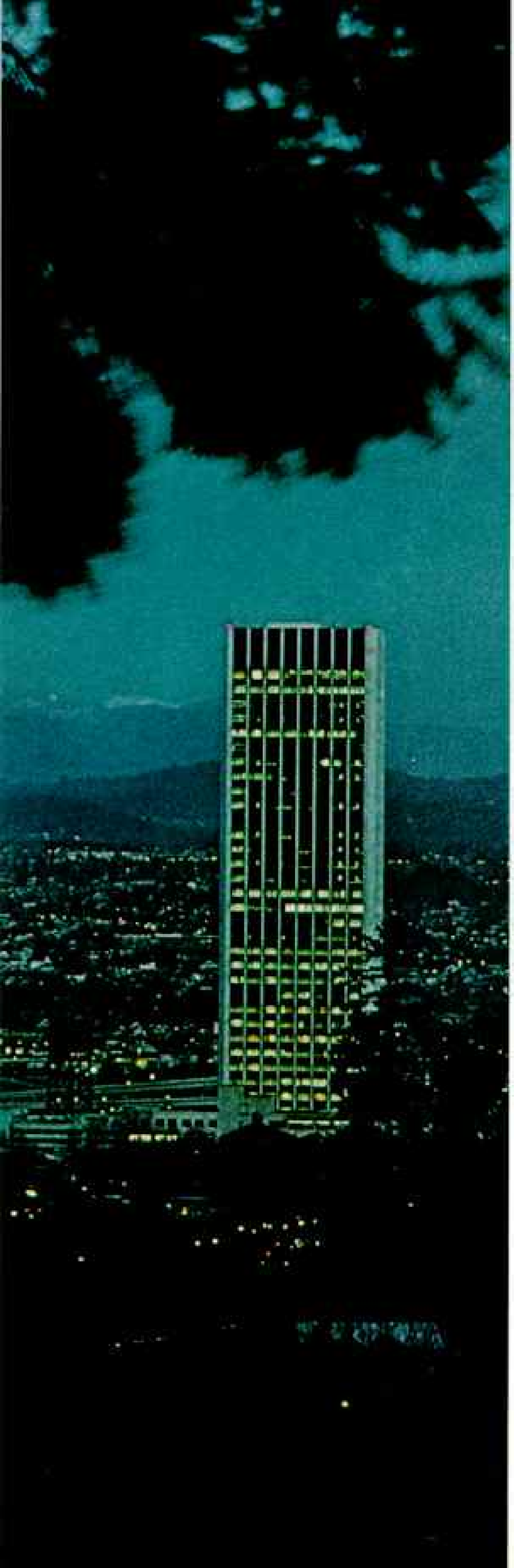
A few men who helped prepare the way for international development of the Columbia are still active in the river's destiny.

In Wenatchee, Washington, nestled in arid mountains checkered green by irrigated apple orchards, I talked with Kirby Billingsley. At 70, Mr. Billingsley is a commissioner of Chelan County Public Utility District No. 1, which built Rocky Reach Dam. Power from such locally and publicly owned dams, pooled with that from large federal dams, is distributed throughout the Western States and to Canada by the U. S. Bonneville Power Administration in Portland.

"Federal power on the Columbia began with the battle to build Grand Coulee Dam," Kirby told me. "Rufus Woods, publisher of the *Wenatchee Daily World*, started it in 1918. As his editor I was in on the fight for years. At first we were the only Washington State

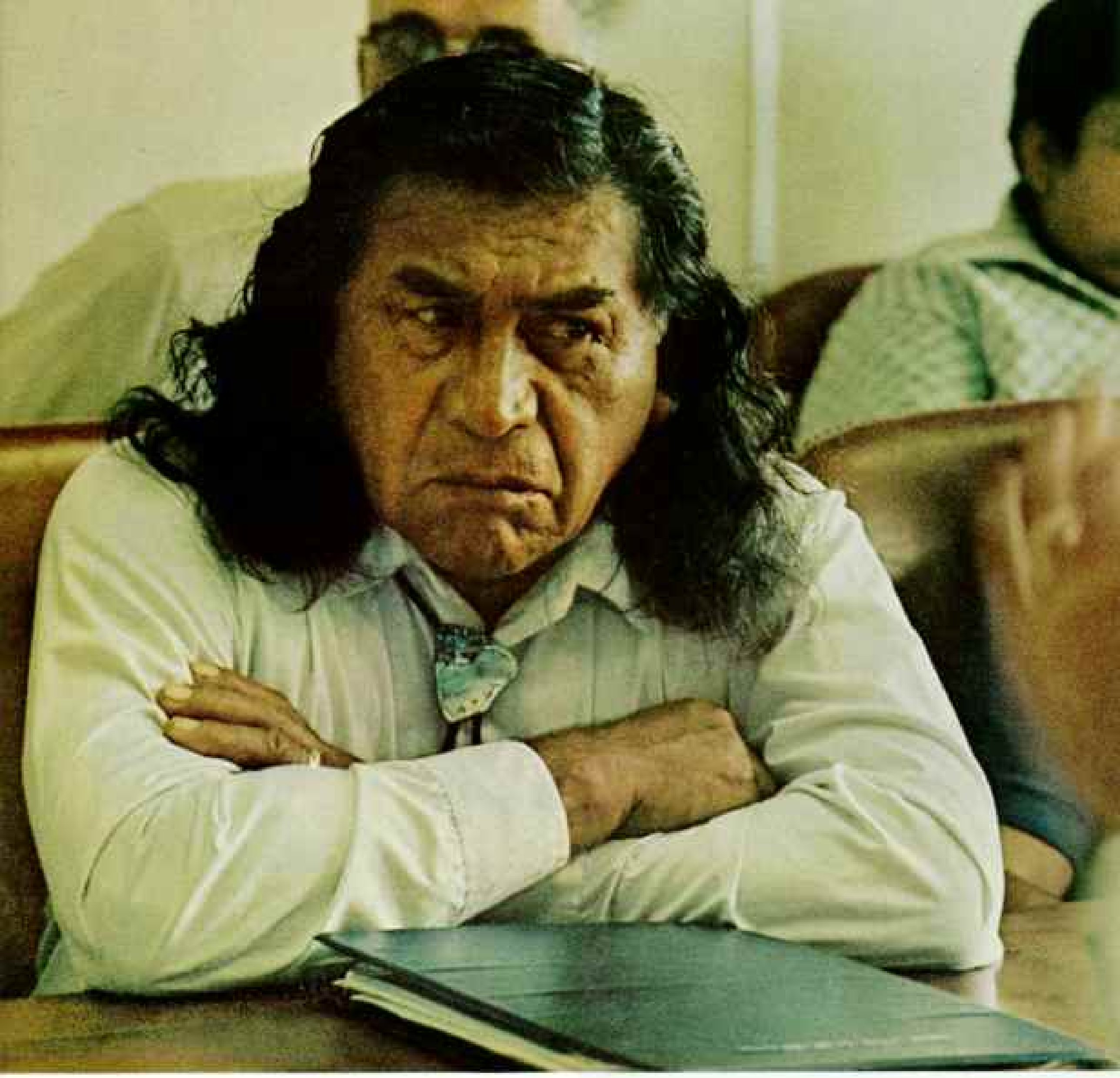
*See "A River Restored: Oregon's Willamette," by Ethel A. Starbird, in the June 1972 GEOGRAPHIC.


HILTON



Snow-robed monarch aglow in the setting sun, Mount Hood reigns over Portland, a city that owes its prosperity to the Columbia. Though a hundred miles from the sea, Portland has emerged as one of the busiest ports on the Pacific Coast, a depot for shipping raw materials drawn from the entire Columbia-Snake River system.

Abloom with flowers year round, Portland takes special pride in the beauty and variety of its roses—a fact celebrated each June by a ten-day festival (**above**).



daily newspaper in favor of Grand Coulee. Private-power interests had the press practically sewed up. They were 'antifederalism,' 'antisocialism,' and for themselves."

FDR Took the Idea and Ran

In Spokane, where he still practiced law at 90, I found another old Grand Coulee warrior, Clarence C. Dill. The former U. S. Senator lifted the glasses from his still-twinkling eyes, leaned back, and let his memories flow:

"I got reelected in 1928 by championing proposals for a federal dam. Some places they still introduce me as the 'Father of Grand Coulee.' The honor might better go to Rufus Woods, or to others. But I'm like a setter pup. I sit up and wag at the compliment.

"I first spoke to Franklin Roosevelt about Grand Coulee after dinner at his Hyde Park home in 1930—a year before he'd even declared he was running for President. He was blowing cigarette smoke and bubbling with ideas on how to halt the Great Depression."

Building a big dam sounded to FDR like a fine way to put a lot of men and money to work. After he was elected in 1932, he allocated $63,000,000 for a low dam. Just plain started it, as a Bureau of Reclamation project to irrigate dry areas in Washington State.

"Didn't even ask Congress," Senator Dill said, chuckling at the memory.

When members of Congress found out, they were upset. But Grand Coulee Dam made sense for the country's future, so Congress

A century of frustration shows on the faces of Indians gathered in Portland, Oregon (**left**), for a meeting with state and federal biologists on seasonal fishing rights. A United States District Court ruled in 1969 that four tribes are entitled to "a fair and equitable share" of the Columbia's salmon. But commercial and sports fishermen still catch most of the fish below the Bonneville Dam, leaving few to reach Indian territory upriver, so the decades-old controversy remains unresolved.

In the tradition of his forefathers, Billy Heath uses a dip net to hoist salmon from the rushing Deschutes River, an Oregon tributary of the Columbia.

JAMES P. BLAIR

voted $450,000,000 to do the job right, to build a high dam—a concrete structure larger than the Great Pyramid of Egypt. The largest hydroelectric dam the world had ever seen.

Work began in the winter of 1934. Payrolls for the jobless! A bright tomorrow for the Columbia country!

But what about the millions of kilowatts to come from Grand Coulee's generators? What would anybody do with all that power in the underdeveloped Northwest? The scattered dry-land wheat farmers of central Washington didn't have electric refrigerators—or even electric lights. Well, first things first. Grand Coulee would water their dusty topsoil. And one day I would meet their progeny, multiplied and replenishing the earth, packing

Fire! The chilling cry sends men hurrying to battle an enemy that can ravage as many as 24,000 acres in 24 hours. In British Columbia a helicopter experimentally bombards flames with 960 gallons of water mixed with chemical retardant (**below**). A ranger descends by line (**left**) to extinguish a small fire set by lightning; the daring technique saves time getting to the blaze and eliminates the danger of parachuting into the dense growth. Protecting the valuable lumber resources of the U.S. Pacific Northwest has been a federal and state effort since 1911, when rangers were first sent to the region.

their deep freezes with produce from the Columbia Basin Project.

Against the interminable gray backdrop of unirrigated lands, Columbia River water arched across green fields from giant sprinklers on wheels. Near Quincy a roadside stand stopped me—a visual magnet of melons, squashes, apples, onions, corn, cucumbers, cauliflower, and other bounty of the basin cornucopia. Weighing my purchases, the farmer's wife tossed in a free handful of green peppers, a smile, and a comment:

"Before the irrigation canals came, you could buy this land for about ten dollars an acre. Now it goes for up to eight hundred."

At one of 11 potato-processing plants in the basin, I watched white-capped workers tending an all-electric production line for quick-frozen French fries.

"Idaho and Maine grow more potatoes," James Vickerman told me. "But nowhere near as many bushels an acre as this sagebrush country. When all the planned canals are built, we'll irrigate a million acres. Then we may be number 1 in everything but name. If they'd just stop selling our Washington product as Idaho potatoes!"

Water for the basin is channeled through a canyon. Some 23,000 years ago, during the last Ice Age, a gigantic glacier blocked the Columbia precisely where Grand Coulee Dam stands today. The backed-up river burst its banks. It gouged a hundred coulees across a vast basaltic plain laid down by ancient lava flows. When they built the dam, engineers enlisted the largest of these canyons—Grand Coulee—as their primary storage area.

Locks Keep Traffic Moving

As one dam after another stairstepped the Columbia, navigation kept pace by way of locks around the man-made barriers.

"I brought in a lot of the concrete for both dams and locks," tugboat captain Wayne Bateman told me as he aimed a train of barges into a lock at McNary Dam. As he cut power, they slid in like a Cadillac squeezing into a narrow garage. "Now we can go from the Pacific to the Columbia's Tri-Cities—Richland, Pasco, and Kennewick—and on up the Snake a hundred miles, nearly to Lewiston, Idaho. Mostly petroleum products we're pushing up today. We'll come back down with mostly wheat."

New dams helped, too, as an additional curb on floods, scourge of the Columbia. In 1948, near Portland, the temporary wartime city of Vanport virtually had been wiped out.

Floods are still feared in places. Puget Island, near the mouth of the river (pages 842-3), is one of them.

"We're below the water's crest here, like Holland." In a rainstorm, dairy farmer Charles Emerick was showing me the big pumps at work on his pastureland, squirting water over a dike into the Columbia. "When the 1948 flood breached the dike, every island family had to be evacuated."

Why live below flood level? Emerick's 170 Holstein cows and his fields of hay and corn were the answer—some of the richest dairyland in the Pacific Northwest.

Need for Power Prompts a Treaty

Agriculture and flood control, yes. But it was mainly the demand for power that precipitated the Columbia River Treaty with Canada. Floodwater held back "across the line" would make possible not only Grand Coulee's giant new generators, but new ones at every other U. S. dam downstream.

Senator Dill's words came back to me:

"That treaty took some doing! British Columbia's Premier, W. A. C. Bennett, was a tough bargainer. We had to pay him cash on the barrelhead to build the dams upstream. To get the money, we had to sell bonds, then build transmission lines to California, and mortgage half the electricity we could produce from water stored in Canada. Mortgage it for 30 years. We even had to pay Bennett a premium for the flood damage we would avoid downriver!

"Now they've got a new Premier—David Barrett. He doesn't like those storage dams. Or the treaty. He's got a strange notion that Bennett sold British Columbia down the river. You'd better have a talk with Barrett."

I did. In Victoria, Premier Barrett lighted a foot-long cigar, scowled, and used some blue words. "It's true. Bennett did sell us down the river. We got $273,294,661 from the U. S. Interest over the years made that $458,000,000. Bennett told us that would be enough to build all three of our projects—Duncan, Keenleyside, and Mica. But before we're through, power lines and all, it's going to cost us nearly three times that much!"

There are other costs too: Farmers, ranchers, townspeople flooded out. Forests inundated. Trout streams lost. Winter rangeland for big game gone.

There's plenty of room at the top for skiers in the Canadian ranges along the Columbia.

"Well, when we build dams in the future, we'll count in the human and environmental costs. You can bet on that!"

David Barrett's necktie and shoes were off now. Pacing the carpet in stockinged feet, he stabbed the air with what was left of his cigar. A lot of wounded politicians in British Columbia can tell you he's a fighting man—with cigars, facts, and vocabulary. He's not called the "Profane Socialist of the North" for nothing.

"And we'll harvest all the timber in advance," he concluded. "Even in British Columbia we don't have enough natural resources to drown trees any more."

With Al Larsen, logging superintendent for Canadian Cellulose, I surveyed some of those resources from the air—Canadian forests second in wealth of timber only to the West Coast rain forests. The gleaming Columbia was thawing. Clusters of dark matchsticks—truckload-size bundles of logs—waited by the thousands along the banks for spring floods to sweep them into the current.

"I'm glad the Premier understands about drowning the timber," Al said. "When some

These vacationists whirl from valley to peak by helicopter to ski the virgin powder.

forest ranger gives our loggers hell for leaving a high stump from a tree cut in deep snow; I think about all that forest flooded behind Mica Dam—enough to supply a pulp mill for 30 years. It makes me ill."

Floating Timber Harvested by Tugs

I went to Mica, where B. C. Hydro was blasting out one of the largest underground powerhouses on the continent (page 827). Behind it, the once-wild river was backing up for more than 120 miles. The artificial lake spread long fingers, drowning forests in valleys once coursed by wilderness streams.

Loggers in tugboats were salvaging timber that had surfaced. Logger Vic Kelley and I stared at the flotsam of forest debris.

"They say we're getting 85 percent of the millable stuff," Vic said. "Well, I know that there's lots of good cedar still under there. If we'd had more time, we could have salvaged it. Cedar will float for years."

But Vic Kelley knew that more floating timber would only add to another problem.

"How'd you like to be a moose or an elk trying to swim this lake and getting trapped

in all that junk? The reservoir should have been cut clean before we filled it. But Canada was in a hurry. The treaty with the U.S. set a date to store water. We made it, too. But at what a price. It'll be years before you'll want to put a fishing line or a small-boat propeller into this mess."

B.C. Hydro engineers were already surveying for other dams and reservoirs. One at Revelstoke Canyon could flood 80 miles of the white water that roars down from Mica to Revelstoke, a gateway to Canada's Glacier National Park.

This last wildly beautiful Canadian reach of the Columbia, plus a stretch of sagebrush wilderness near Hanford in Washington, are virtually all that remain to be tamed; and the U.S. Army Corps of Engineers has long had plans for Ben Franklin, a dam at Hanford.

A strong citizens' campaign had been mounted to save the Hanford area as a scenic river and wildlife refuge. And environmentalist David Barrett was obviously hoping to preserve the river above Revelstoke. In view of the energy crisis, though, I wasn't about to give odds to environmentalists.

"With or without those last dams, the Columbia's about reached its limit as a hydro source," Premier Barrett had told me. Now what? Nuclear power plants?

"They're building 'em downstream in the U.S., even though they're still having accidents with atomic wastes. We're gonna hang tough here, and watch a long time, before we get into the atomic act. We believe in development in British Columbia. But we believe in safety, conservation, and people first!"

"Incident" Brings a Flurry of Protest

"We call them incidents rather than accidents at Hanford."

Dr. Richard Foster, Program Director for Environmental Sciences at Hanford, put it that way. He had come here 30 years before, to an arid and forbidding enclave half the size of Rhode Island, together with hundreds of other scientists and 50,000 construction workers. Their supersecret project: to produce plutonium for the world's first atom bomb. Dick Foster's job was to monitor atomic levels in fish in the river.

"We had an incident just recently," Dick admitted. "Another leak in our underground storage of high-level atomic wastes." I remembered reading the flurry of stories and criticism in the press.

"We've got to improve our waste-storage techniques. And we are. But there was never any real danger. Those radioactive elements didn't penetrate to the water table."

The long-term problems of storing toxic wastes, however, remain unsolved. As more nuclear plants are built, more wastes accumulate. Environmentalists say that floods, earthquakes, accidents, and sabotage all make those wastes potentially dangerous.

Nuclear Plants Are Heavy Drinkers

During the 1950's when the U.S. and the Soviet Union were locked in an atomic-weapons race, the Atomic Energy Commission had eight reactors operating at Hanford. All eight of these top-secret giants in the guarded desert produced plutonium for atom bombs —a row of monsters gulping billions of gallons of river water daily for cooling, and pouring heat and chemicals and some low-level radioactive pollution back into the Columbia.

"Even so, there was no radioactive buildup that hurt the river ecology," Dick said. "We checked the fish constantly. No threat to them, or to people who ate them. We still check, but the radioactivity is inconsequential."

Comparatively little waste heat and effluent go into the river today. Four of those eight Hanford reactors are mothballed; the other four stand dead and gutted, tombstones marking the dark period of cold war. One new reactor alone produces plutonium for nuclear weapons, and much of its waste heat is converted into commercial electricity in nearby steam-turbine generators of the Washington Public Power Supply System.

WPPSS is building a second commercial nuclear plant just a few miles away and will soon begin a third. Deputy managing director Larry Humphreys told me that the first plant uses a million gallons of river water every

Family flotilla, three generations of Haglunds assemble for a reunion at the grandparents' houseboat home four miles from Astoria, Oregon, near the Columbia's mouth. Supported by gill-net fishing, Oscar and Lisett raised 12 children, four of whom still catch salmon for a living. Chief Joseph Dam, built without fish ladders, bars salmon from upper streams, but the fish can bypass other dams on their travels.

Magic of water transforms dry soil of the Columbia Basin into rich green cropland. Pumped from man-made Franklin D. Roosevelt Lake into the natural waterway of steep-walled Grand Coulee, the Columbia's waters flow as far as 160 miles south, irrigating half a million acres. Swinging in circles and walking across rectangular plots, automated sprinklers spray life into fields.

Testament to the basin's rich soil and long season, onions are bagged for market (**below**).

two minutes for cooling—ten times the water used by Portland, a city of 375,000, in the same time span. Only 32,000 gallons will be needed for No. 2, because of recycling and cooling towers to be built to meet new environmental standards.

A cooling tower almost as high as the Washington Monument and much bigger around looms over the river near Rainier, Oregon. The plant, being built by Portland General Electric, will go into operation late in 1975.

And PGE proposes six more atomic powerhouses on the Oregon side of the Columbia. Cooling towers? No. Ponds and pipes. The plan is to distribute the water to farmers, to irrigate land and protect crops against frost.

Thermal irrigation opens prospects for tender new crops that could survive cold weather and mature in an artificially lengthened growing season. Pulpwood forests could mantle barren areas. Heated greenhouses offer a controlled environment year round. The waste heat from a 1,000-megawatt nuclear plant could heat 500 acres of greenhouses, making possible an estimated $12,000,000 crop of vegetables annually.

Such hopes for the future I heard from Leonard Perkins, Director of Business and

Community Relations for AEC at Hanford. "In a heated, humidified greenhouse, you could get 12 crops of radishes a year."

But the vision of atomic dreamers goes far beyond: shopping malls in inflatable, atmosphere-controlled cocoons; perhaps entire cities enclosed.

How Much Growth Do People Want?

No one knows how many nuclear plants may finally rise at Hanford, but new towns and industrial complexes will likely rise with them—powered by nuclear energy directly or by steam created in cooling the reactors.

How fast will it all materialize? A thousand questions are involved. Will the fear of atomic power halt its advance? What about power from the sun, the wind, or geothermal sources underground? These are constant, renewable sources, and perhaps, when they are developed, less costly. Some scientists believe they should have priority over nuclear development. Most significant of all may be the question: How much growth and development do people of the Columbia River empire really want? Or need?

"Even before the energy crisis hit," says a nuclear planner of the Joint Power Planning

Council at Portland, "we figured we'd need the equivalent of one new 1,000-megawatt power plant every year. With gas, oil, and water in short supply, the day of atomic energy is here. It's firm power, too. If your river runs low, hydro plants are in trouble. One day we'll use hydro mainly for peaking —as reserve power for hours of heavy use."

Crisis Hits the Columbia

Last year the river did run low, and the hydro plants were in trouble. Little snow had been recorded in the northern Rockies the preceding winter. The meager runoff became a matter of mounting concern. When spring rains were light, a foreboding of disaster began to be felt at powerhouses on the Columbia and its tributaries. The worst drought in 43 years had begun.

By midsummer, turbines at some U. S. dams stopped spinning. Washington, Oregon, Idaho curtailed use of electricity. The Great River of the West had run short of power.

With Dick Tatum, at Aluminum Company of America's plant near Rock Island Dam, I watched molten aluminum being tapped at 1,778° Fahrenheit. Elsewhere on the river, acres of potlines were going cold and workers were being laid off.

It's a risk aluminum companies accepted years ago when the dams were being built. The gamble was on "interruptible" power. It cost less than guaranteed power. This year's interruption cost money and jobs.

But might not nuclear plants one day face similar uranium shortages for atomic power?

To start solving that problem, the Atomic Energy Commission is spending $300,000,000. At Hanford it is building a pilot plant and testing unit for the nation's upcoming generation of atomic breeder reactors.

"Breeders will enable us to stretch our uranium reserves. Burning both plutonium and nonfissionable uranium 238, they'll produce power and at the same time create plutonium—more than they consume."

Atomic physicist Dr. Ersel Evans sees breeder reactors as the best prospective answer to the energy crisis. Perhaps even until the day that science makes a breakthrough with atomic fusion, to use as fuel the plentiful hydrogen of the sea rather than the uranium of the earth.

"With breeders," Dr. Evans said, "one year's U. S. production of uranium would equal 13 times the total energy we can hope to extract from our largest oil field, the North Slope of Alaska.

"Nuclear energy, after all, makes up the sun and gives the earth its interior heat. We should stop being so frightened about it."

Perhaps. But there is increasing concern over radioactivity in the air and water, plants, animals, and humans. The battles are not yet over, nor the final answers in.

Meanwhile, every possible gallon of the Columbia is made to flow through a turbine —not once but many times. The result, at every dam: increasingly dry spillways.

That's a mixed blessing for the salmon.

"About 140 million fingerlings are released on this river system every year," Richard Duncan told me. Dick is a fish biologist for the U. S. Army Corps of Engineers, which built Bonneville, The Dalles, John Day, McNary, and Chief Joseph Dams. "Our problem is to get the fingerlings safely downriver, either over the spillways or through the powerhouses."

Water plummeting over the spillways releases excess nitrogen and other gases. "For many, it's fatal," Dick said. "Lots more are stunned and are easy pickings for predator fish and birds. Fortunately, the gases also affect the predator fish, and that holds down the toll."

Penstocks Give Fish the Bends

With less spill, it is the turbines that loom as the fingerling killers of the future. The blades kill a few. The whirling of the water kills others. But at the high dams, far more die when they pop to the surface after the trip down and through the penstocks. It's the sudden release from pressure. The bends.

"We lose 10 to 30 percent of them at every dam they pass. We're testing bypasses to guide fish out of the penstocks. So far, they're not completely effective."

Dick is part of a $200,000,000 effort, over 40 years, to save the Columbia salmon. Other federal and state biologists are pushing to complete a comprehensive birth-to-death study of migrating fish populations. Fingerlings are branded, tagged, tattooed, or finclipped, and so can be identified en route downstream—or several years later when they return from the sea as adult fish making their way over the dams to spawn in the very waters where they began.

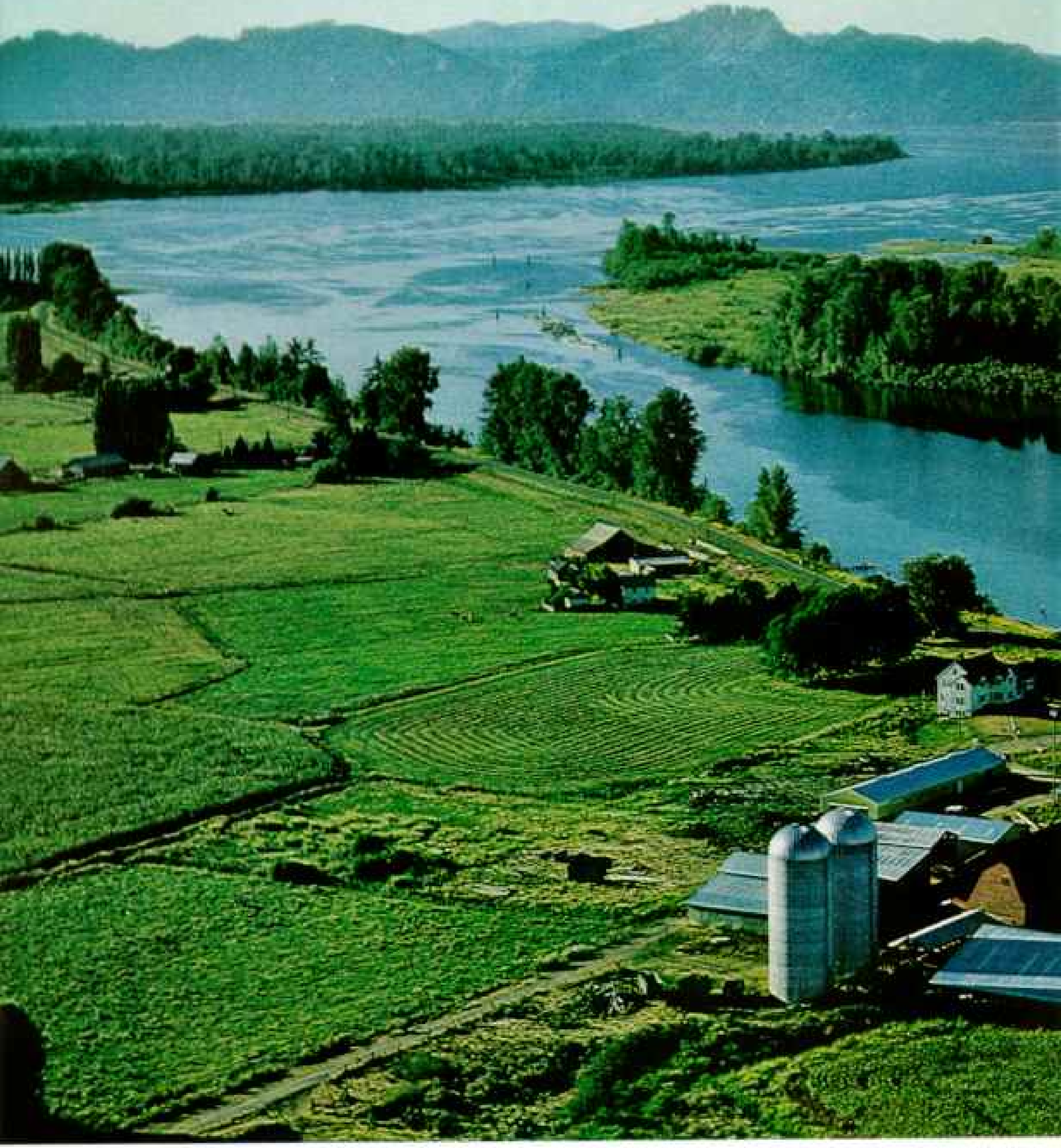
I sat in a little elevator over a fish ladder atop The Dalles Dam. Here Opal Townsend sits for eight hours a day, with ten minutes off every hour, counting fish.

Salmon, steelhead trout, shad, lamprey, and other sea migrants swarmed over the ladder's narrow top step. Opal's fingers played over the keys of an electronic adding machine. Whenever a fish darted back *down* the ladder, she subtracted one of that species. (Skeptical biologists once secretly checked Opal's figures by catching and hand-counting a day's fish. Her tally proved amazingly accurate.)

Though she answered a score of my ques-

(Continued on page 846)

Aye, aye, ma'am. A licensed skipper at 18, Shirley Heasley guides 56-foot *Check Mate* across a perilous bar at the Columbia's mouth. Since age 11 she has helped in her father's charter-boat business. One job (**left**) is hauling in prizes of fishermen who win their bouts with fighting salmon.



"**Food should be prepared** with butter and love," say Charles and Myrna Emerick, who pasture 170 Holsteins on their 350-acre Puget Island farm (**above**, foreground). The Emerick children, Craig, 6, and Paula, 4½, help with the chores (**right**). Here they give milk to calves, which must be bottle fed for six weeks.

Nurtured by fresh water, beef and dairy farms line the banks downstream from Bonneville Dam. Until recently, this low land was washed by spring floods. Today dams and dikes control the river's rampages; since 1948 the Columbia has flowed harmlessly past farms like the Emericks', which lies below flood level.

Waiting to be sorted into the mills, 800-foot log rafts end their river journey at Weyerhaeuser's 670-acre facility at Longview, one of the world's largest wood-processing

complexes. Lumber, the most important industry in the Pacific Northwest, once relied on the river as sole means of transportation. Today, railroads carry an increasing share.

first counting-period, she never took her eyes off the fish.

During her break, Opal added a fifth of her 50-minute total to round out the hour's count. She still watched the water. "What a pity. All those beautiful fish, and I'm not allowed to count them."

Salmon Swim a Comeback Trail

Today salmon return to streams where, until recent years, none had ever run. A fishway around a 60-foot cascade, for instance, has made it possible to establish a new salmon population on the Wind River, a Columbia tributary in Washington State.

At the federal fish hatchery 20 miles upstream, I found assistant manager Don Zirjacks stripping eggs and milt from spring salmon. The fish had spent the summer in the hatchery's holding pens, eating nothing and ripening for spawning.

"We got our first brood stock in 1955 from the fishways at Bonneville Dam," Don said. "Now we have about 5,000 fish making their way here up the Wind River every spring. We take their eggs in September, and release about 2,000,000 five-inch fingerlings in April."

Most of the Columbia salmon catch is taken offshore in the Pacific, though tens of thousands of sportsmen fish the river and its tributaries when the salmon are running. Commercial gill-netters are allowed on the lower river during the peak periods.

On a sandbar near Astoria, I came upon 58 members of a fishing family (page 836). They were broiling ears of corn and toasting hot dogs around a huge driftwood fire. Oscar Haglund and his wife, Lisett, raised 12 children on a houseboat, and all nine sons became gill-netters.

"We started fishing with Dad when we were about 6," Marvin Haglund told me. "Dad let Oscar Junior and me go by ourselves when he was 10 and I was 9. The two of us used to catch as much as a ton on a big night.

"When the dams came, the catch got smaller. Things have improved since then, but there are still fewer salmon in the river than before.

"Individual fish are bigger, though. Artificial spawning and selection of the fittest spawners produces better fish."

The proof of that might be in the catching and the tasting. At five o'clock on a misty morning I went out through the mouth of the Columbia on a salmon charter boat. Before noon, nearly 3,000 boats were churning the estuary like a convention of ducks on a pond.

All twelve of us aboard caught a limit, three salmon, cohos and chinooks.

"On an average weekend charter trip," skipper Larry Heasley observed, "your catch will cost you about three or four dollars a pound, figuring the boat and tackle, food, lodging, and transportation."

I looked with renewed astonishment at the wall-to-wall boats around us.

"This Labor Day crowd is probably putting a million bucks into catching salmon today. And as you see, we do catch them."

Hatcheries, fishways, research, regulation. Money, work, concern. Add them up and you

Tossed by a bucking torrent, two adventurers challenge the Deschutes, a northward-flowing tributary in Oregon. After decades of gentling, the Columbia itself no longer runs wild and free, but efforts to halt pollution and retain the remaining beauty of its course foretell a better future for this giant among western rivers.

get a comeback for the Columbia's salmon.

Revival of the salmon runs is also tied to reducing pollution in the Columbia and its tributaries. I flew with Coast Guardsman James Stoudt on a biweekly helicopter flight that monitors pollution. The crew surveyed riverbanks, recording progress of new municipal sewer systems and efforts by industries to reduce pollution of the air with smoke and of the water with logs or chemicals.

"In 1975 they have to meet new state and Environmental Protection Agency standards," Jim told me. "Looks like most of 'em will make it."

Saving the Columbia for Everybody

Suddenly, the chopper banked, circling over a ship. A telltale oil slick spread behind it on the water. Radio and intercoms crackled; notebooks and cameras went into action.

"We'll have a boat patrol boarding that ship within about 15 minutes," Jim said.

Even with all the region's growth, the Columbia is still one of the cleanest big rivers in the world. Fortunately, it was a late starter among industrial rivers and, in an era of environmental consciousness, seems to be staying fit for fish and man.

On a warm September Sunday afternoon, I skimmed along the lower Columbia from Portland to Bonneville Dam with helicopter pilot Jim Robertson. Sunlight was glistening on the ruffled water, silhouetting in silver little flotillas of sailboats; motorboats were towing water-skiers, carving white skidmarks in swirling patterns that foamed and faded; fishermen were trolling from boats and casting lures from river shores and islands; and from the beaches, hundreds of families were in for a swim.

As evening approached, many of them gathered around driftwood fires on the sand, barbecuing fresh-caught salmon and steelhead trout, toasting marshmallows, and watching the sun sink into the Columbia.

People were appreciating the charm of their river not only here, I knew, but in hundreds of places all the way from the Rockies to the Pacific—appreciating it, but wondering how long it could be made to last. □

China Unveils Her Newest Treasures

PHOTOGRAPHS BY ROBERT W. MADDEN
NATIONAL GEOGRAPHIC PHOTOGRAPHER

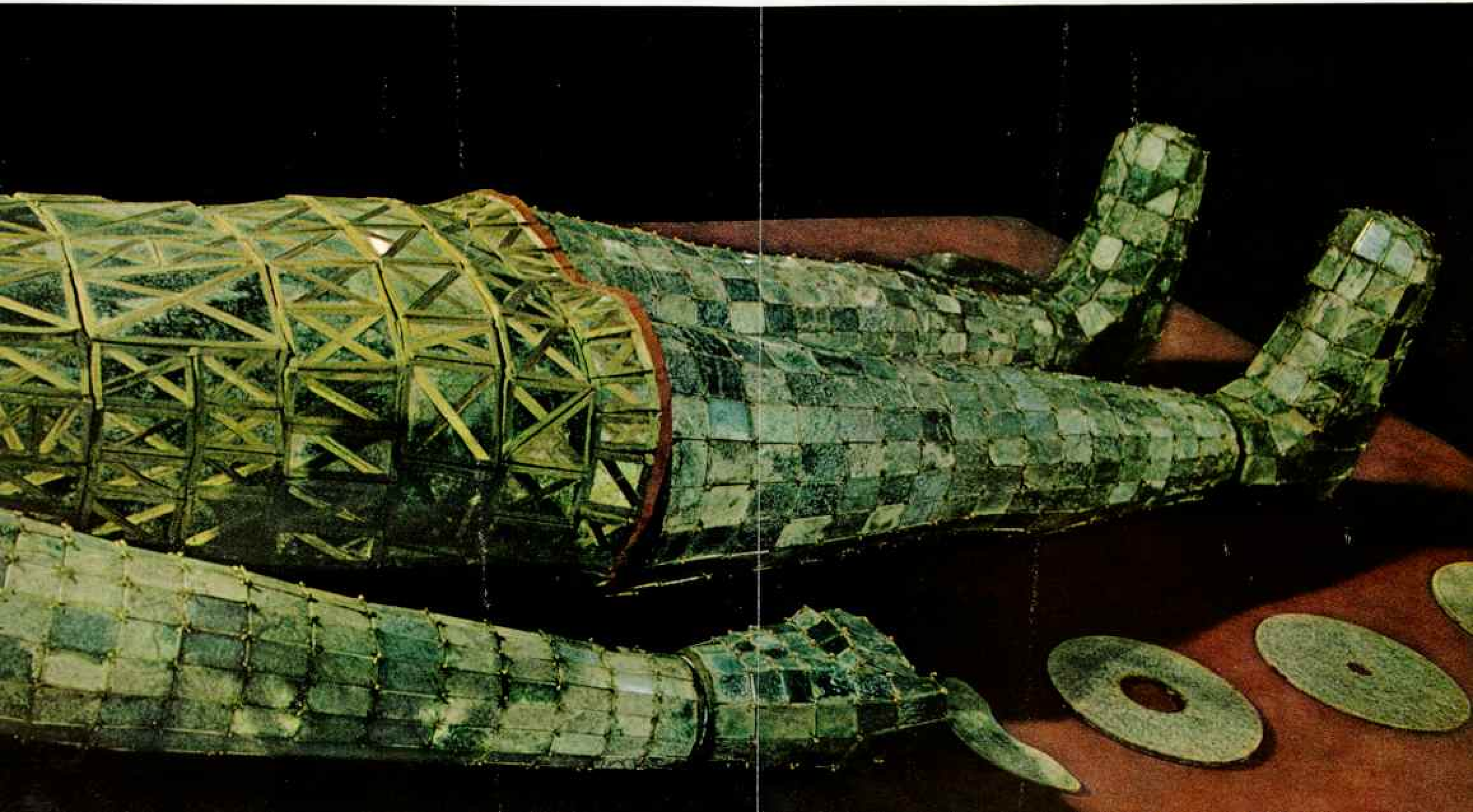
TO FEND OFF the ravages of time, the wealthiest Han Dynasty nobles of 2,000 years ago commissioned funerary armors of precious jade—a material capable, they believed, of preserving the human body forever. This magnificent burial suit, long-hidden gift of ancient artisans, highlights a startling array of archeological finds now touring the West as a goodwill gesture of the People's Republic of China.

Fashioned for Tou Wan, a Han princess, the regal shroud incorporates 2,156 handcrafted jade plaques, and probably took ten man-years to complete. The gold wire, some 24 ounces in all, that links the plaques attests to Lady Tou's social rank. For less exalted members of ancient China's aristocracy, silver or copper wire was used.

Inlaid jade enhances the gilded bronze headrest the princess used as pillow for her final sleep. By each hand lay a ritual *huang*, a crescent of jade. Her attendants also had placed at her sides jade disks called *pi*, symbols of heaven.

The exhibit's 385 artifacts, all unearthed since 1949, span almost the whole of China's cultural development—from a stone hammer more than 400,000 years old to fragile 14th-century porcelains.

Nearly two million people have seen these Chinese treasures in Paris, London, Vienna, Stockholm, and most recently at the Royal Ontario Museum in Toronto, where this photograph was made. The show is scheduled to move to Washington, D. C., this December and then to Kansas City next spring.

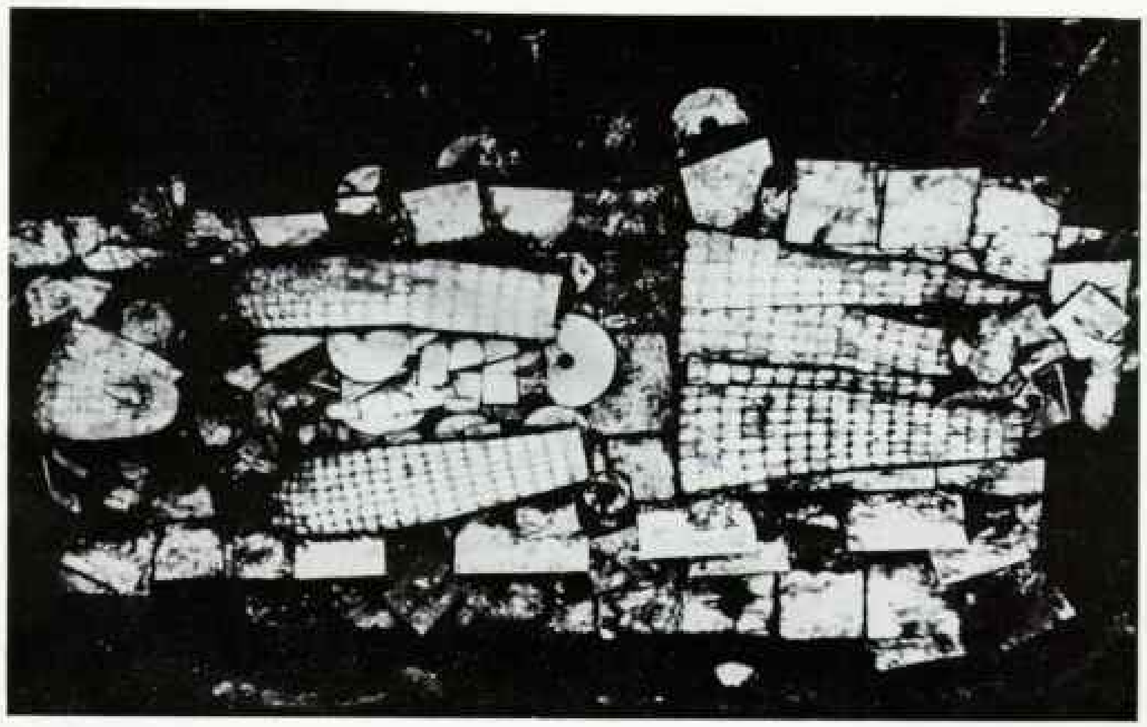


The suit that failed: Tou Wan's jade shroud (**below**, as found) fell short of its purpose, to guard its wearer's body through eternity. Archeologists who opened the tomb of the princess found only a pinch of dust. In a companion sepulcher they located a bit of tooth amid a similar suit's disjointed plaques.

When excavated in 1968, the two multichambered tombs at Manch'eng held 2,800 Han Dynasty artifacts. The second jade suit belonged to the princess's husband, Liu Sheng, half brother of Emperor Wu. Liu Sheng followed a philosophy inscribed on a bronze vase found in his tomb: "May good fare fill your gate, expand your girth, extend your life, keep sickness at bay." A tell-all historian of the time reported that the prince loved to drink and was notably fond of women.

Proud cavalcade escorted a Han official named Chang to his final rest at Wuwei. In the lead strides the famed flying horse (**following pages**). An umbrella shades one of the official's chariots; a wife may have ridden in the cart that followed. The bronze figures give these visitors to the Toronto show an unexcelled look at Han harnesses, bridles, and carriages.

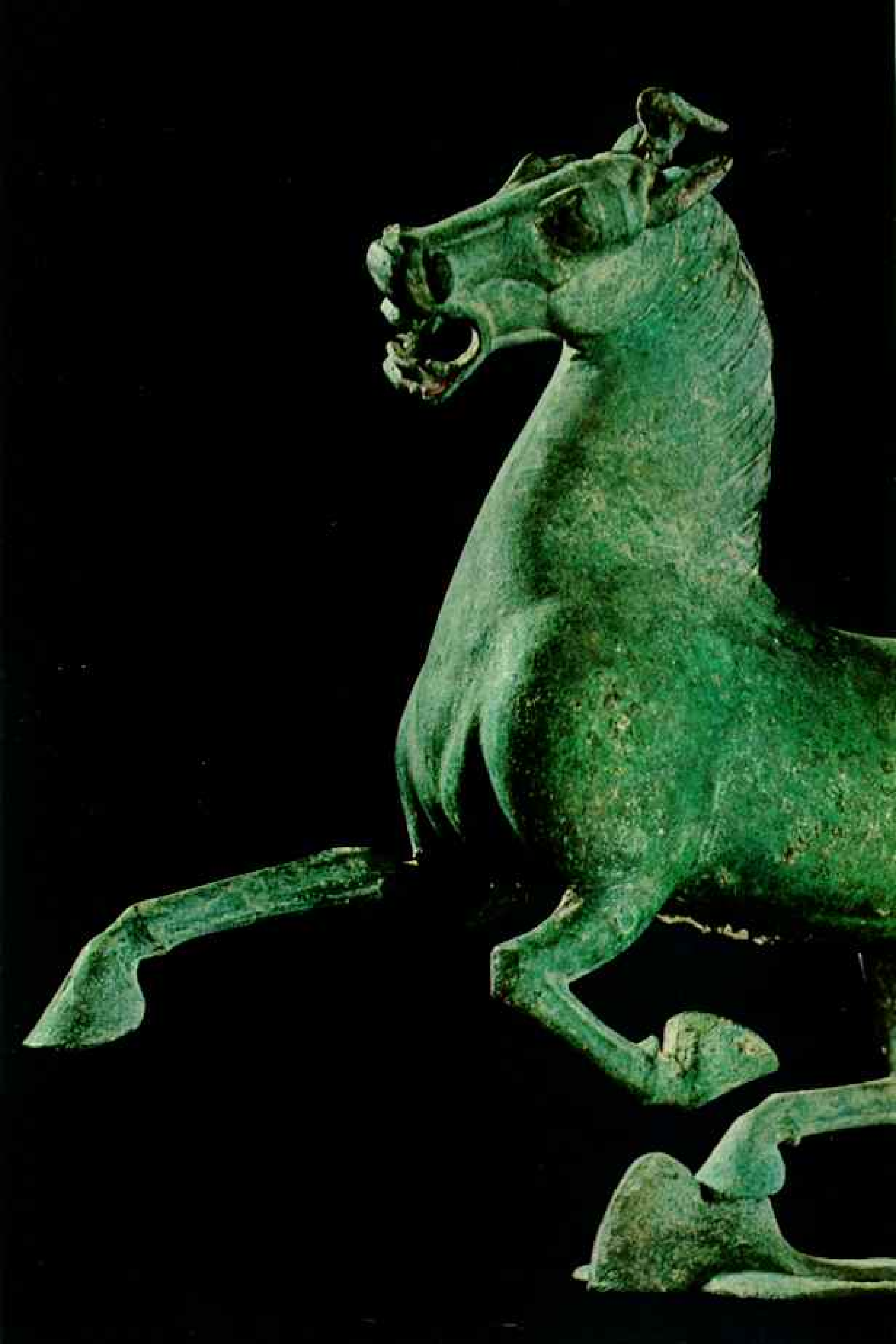
The leggy animals that served as models for the miniatures had been so coveted by Emperor Wu that he sent expeditions to the Fergana Valley in central Asia to seize them from their owners. Valuable as breeding stock, the swift, sinewy horses were considered "celestial," an idea reinforced by the animals' special peculiarity, "sweating blood." The phenomenon, unexplained until recently, occurred when burrowing parasites attacked capillaries until they bled.



Masterpiece in miniature, this gilded bronze leopard with inlaid silver spots and orange gemstone eyes would fit into a child's hand. One of four found in Liu Sheng's tomb, it may have been placed there as a symbol of military valor. The cat also recalls the royal taste for hunting with leopards and cheetahs.

Politically attuned archeologists cataloging the exhibits in Peking explain that such lavish objects "expose the extravagance and decadence of the feudal ruling class." Also, they give credit to the working class for many technical advances of ancient times: making paper, improving methods for manufacturing iron tools, brocading silk, and using acupuncture needles of gold and silver—all skills reflected in the exhibition.

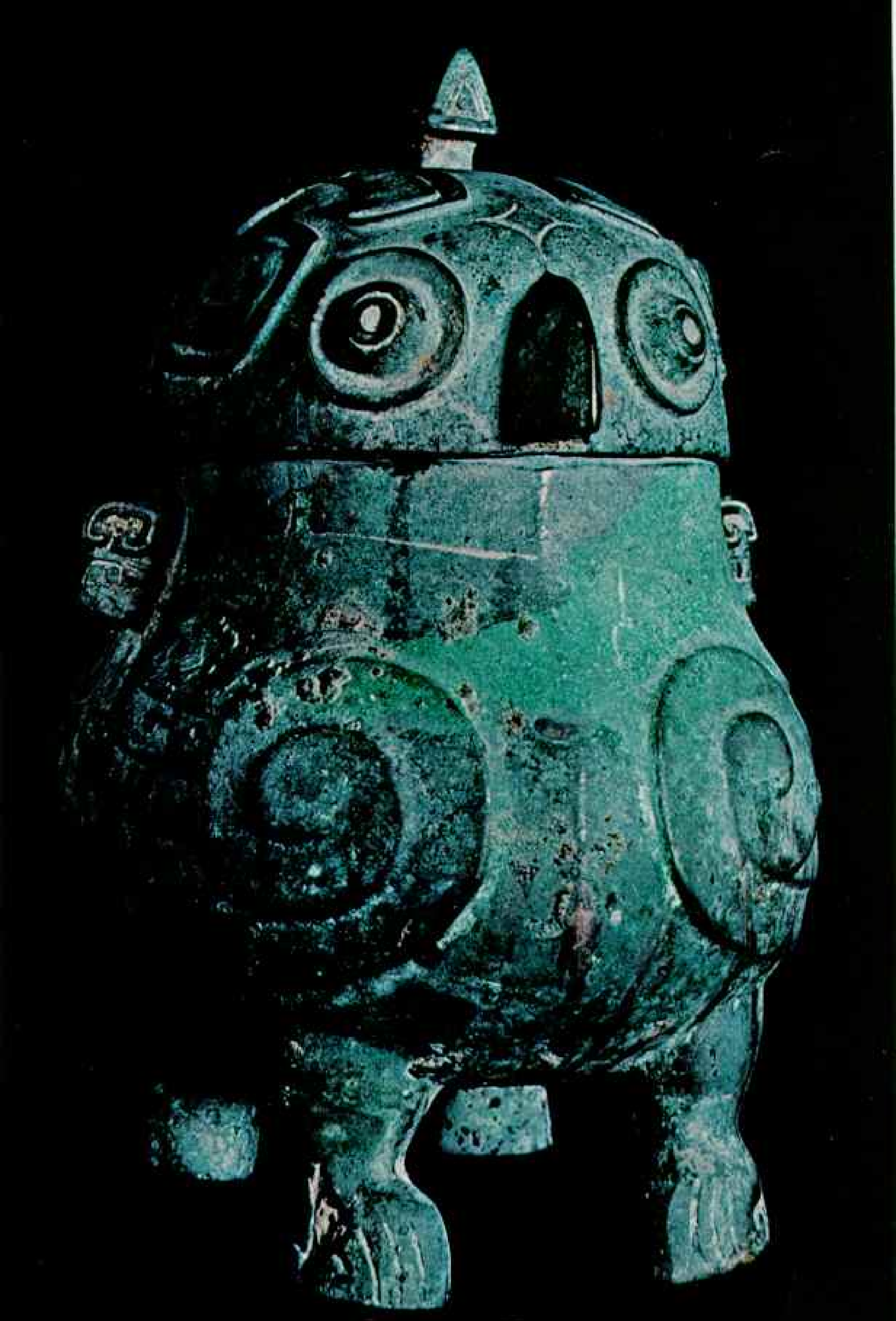
THREE TIMES ACTUAL SIZE



ALL FROM ROBERT HARDING ASSOCIATES, TIMES NEWSPAPERS LTD.

Whistling and dancing, 15-inch-high pottery figurines from Chiaotso hark back to the 14th century, when Mongols of the Yüan Dynasty encouraged such dramatic performances.

Pacing the centuries, the flying horse steps lightly on the back of a stylized swallow in flight, a brilliant conception suggesting speed.



Enigmatic owl stares from an eight-inch-high wine vessel found at Shih-lou. Shang Dynasty bronze workers had mastered complicated alloys and casting techniques more than 3,000 years ago.

"**A Chinese cowboy,**" a Canadian viewer remarked at the sight of this exuberant horseman. Beard and big nose mark him as a central Asian. Archeologists in 1962 found him in the tomb of a T'ang princess buried at Ch'ienhsien 1,256 years earlier.

"**He who knows** does not speak. He who speaks does not know." The kneeling handmaiden (**below**) calls to mind the words of Lao-tzu, legendary founder of Taoism. Some 2,200 years ago mourners placed the pottery figure near the funerary mound of China's first emperor, Ch'in Shih Huang, at Lint'ung. Farm workers who found her in 1964 immediately notified authorities. Such newly awakened public pride in China's cultural heritage led to the preservation of many of the objects in this glittering art display. □

All items exhibited

ROBERT HARDING ASSOCIATES, TIMES NEWSPAPERS LTD. (FACING PAGE)

Snowy-throated bulls and a young caribou graze in an autumn field on

Caribou: Hardy

FOR AT LEAST a quarter of an hour the cow caribou walked in circles, raising and lowering her head and peering about nervously.

Her behavior intrigued fellow biologist Don Frickie and me. Camped on a ridge a thousand feet above the ice-choked Kongakut River, in the vast Arctic National Wildlife Range of northeastern Alaska, we were studying caribou as they migrated toward their calving grounds. I focused a telescope on her.

"She's having a calf," I said excitedly. "I can see its legs."

We rushed closer, hoping to witness the birth. But the calf was born in the three or four minutes it took us to get near. We watched from about 20 yards away as the mother nudged and licked the wet baby, urging it to get up.

The calf wobbled to its feet, started to follow the cow, then collapsed. The mother lay beside the calf, licking it and grunting. Then

the eve of their migration to winter ranges more than a hundred miles away.

Nomads of the North

ARTICLE AND PHOTOGRAPHS BY JIM REARDEN

she moved away a few feet and bobbed her head, an attraction signal. The calf tried valiantly to rise. Again it fell, was licked, and rose. Eventually the mother led the calf to a rocky mountainside, where they bedded down for the night.

That tiny, wet, struggling creature faced an uncertain existence. One scientist who studied a caribou herd found that 40 percent of the calves died in their first year. Though common, calves' deaths are not easily accepted; I once observed a cow as she stood for three days, head down, near her lifeless offspring.

But if it survived, the animal born near the Kongakut that day early in June would develop a body marvelously suited to rugged mountains, vast hummocky tundra, snow, ice, howling winds, and, often, scant food.

Unlike deer of most species, it would never call one mountain or one valley home. It would roam all its life, gregariously keeping the company of its own kind, its travels

Across the mountains and tundra of Alaska roam 400,000 barren-ground caribou in 13 separate herds (**left**). Their numbers fluctuate with the food supply, the seasons, and the depredations of man. But none of those poses the threat that Alaska's 800-mile oil pipeline does. The conduit, four feet in diameter, may create a fateful barrier; already, caribou have shunned experimental underpasses and ramps designed to help them negotiate the man-made obstacle. A planned network of oil-pipe feeder lines and a proposed natural-gas line could further imperil these stately members of the deer family.

BOTH BY GEORGE W. CALEY

Racing toward a roundup, Canadian and Alaskan biologists pursue caribou crossing the Porcupine River (**above**). One flailing captive (**opposite**) gets a bright-colored ear tag. Such tags and numbered, color-coded nylon collars help scientists trace the animals' movements to see if they always return to the same winter ranges and whether "little families" exist among the 100,000-plus members of the Porcupine herd.

influenced by the search for food, by weather and snow conditions, and by the harassment of predators and summer insects.

At birth it possessed the instinct to respond to its mother's bobbing head. It knew, or would shortly know, the pose that caribou assume when a wolf or some other threat is near—hind legs spread and slightly crouched, tail flagged—as well as other meaningful gestures and calls.

Able within four to six hours of birth to follow its mother at a walk, it would, by the second day, be strong enough to run with her. In its third day it might outrun her. From thirteen or so pounds at birth it would grow to twice that weight in ten days, nursing frequently on milk rich in butterfat. Within four weeks it would sprout antler spikes.

If mother and calf followed the pattern of the majority of their herd, they would, in about two months, commence a 400-mile trek from the North Slope across rugged mountains and valleys to a winter range.

Buffalo of the North Country

During the past quarter of a century I have made many trips to study, photograph, and hunt *Rangifer tarandus granti*, the barren-ground caribou. At present 400,000 of these animals roam Alaska in herds that vary in size from 240,000 to 230. The largest, the Arctic herd, occupies a range of some 140,000 square miles—about the size of North and South Dakota combined—on the northern and southern slopes of the Brooks Range (map, page 860). Ten herds are found entirely within the state; three wander from Alaska into Canada, where a closely related animal, the woodland caribou, is found. Both types of caribou are kin to the reindeer of Scandinavia and Russia, source of the 30,000 domestic reindeer in Alaska, which are kept mostly for meat.

As bison were important to Indians, explorers, and settlers of the western United States, so caribou were important to early Alaskans. Even today the people of many remote villages depend upon caribou for food as well as for clothing and bedding material.

Anaktuvuk Pass—which takes its name from the Eskimo word meaning "place of caribou droppings"—is such a village. Shadowed by peaks of the central Brooks Range, the 2,200-foot-high pass that cradles this tiny settlement is on a caribou migration route.

I remember a flight over Anaktuvuk Pass that I made in 1952 with Clarence Rhode, regional director of the U. S. Fish and Wildlife Service. Rhode, his son, and a companion were lost on another flight in the Brooks Range in 1958.

Swooping low over the village, then the home of sixty seminomadic Eskimos and some hundred sled dogs, we saw that most of the homes were caribou-skin tents. Nearby stood a "caribou fence," a half-mile-long double line of about seventy low sod piles, arranged to resemble men so as to frighten caribou toward waiting hunters.

Successful Hunt Makes Work for All

Recently I flew back to Anaktuvuk Pass, arriving on a day in late September when snow lay on the ground. The tents had been replaced by insulated frame and sod houses; a school, built in 1961, had ended nomadism for the residents.

Several thousand caribou had passed near on the previous day, and the villagers had killed many. Four-poled platforms held frozen and drying meat. I watched Ellen Hugo wield her *ulu*, the semicircular knife traditionally used by Eskimo women, as she swiftly reduced three large bulls to skins and portions of meat.

"Most of our food is caribou," she reminded me as she flicked the blade through the meat. "We use skins for winter pants, gloves, socks, and parkas. Heavy bull skins make good mattresses or seats on sleds."

She held up the thin skin of a leg and explained that it is best for making *kamgich*, the boots that are worn in winter. As she scraped a fan of back sinew, she added, "This is better than regular thread for sewing skin." The sinew is dried, and pieces of it are split off as needed.

She removed a long 20- to 30-pound wedge of back fat from one of the bulls. "We use this for cooking, or we eat it plain. But as a treat we use it for *akutuq*."

Akutuq is whipped fat, with added bits of cooked caribou meat. I later sampled some that had an almost ice-creamy taste.

Now grown to about 130 residents, the village of Anaktuvuk Pass needs some 500 caribou a year. Several times in the past two decades the village neared starvation when animals were scarce. But as Mrs. Hugo finished her work, she turned to me and said, "We don't need as many caribou now; snowmobiles don't eat meat." The Eskimo and

Indian villagers of northern Alaska have largely abandoned dog teams in favor of the gasoline-consuming "iron dog."

A chill wind whispered at dark. I welcomed the warmth of the sod-insulated log house I shared with Arctic John, who, like most residents, is one of the Nunamiut—the inland Eskimos. Tall, dignified, courteous, a man of probably more than 80 years (he was born about 1890, he thinks), Arctic John has the Eskimo name of Itashluk. But when he introduced himself, his weathered face creased with a smile as he said, "They call me Hills-man." He was proud of this title, apparently self-bestowed, and it seemed to fit; Arctic John has spent most of his life hunting in the mountains. "I know nothing else," he said.

He had shot two bull caribou that day and left them in the snow. Next morning I accompanied the old hunter to his kills. Working bare-handed in a cold wind, he skinned and quartered an animal and covered it with the hide. Freezing quickly, the hide would protect the meat from ravens. A relative who owned a snowmobile would later haul the meat home. If necessary, though, the cache would keep safely in the snow for months, unless found by wolves or wolverines.

Caribou Figures in Song and Art

Later we climbed a hill and Arctic John studied the broad, rolling pass with binoculars. Diamonds of new snow sparkled in the sun. For four hours he patiently watched, but no caribou appeared. Once a distant shot reverberated from the mountains.

"Someone shoot at Happy New Year Hill," Arctic John said. Smiling at my puzzlement about the name, he explained that an Eskimo hunter had killed many caribou there one New Year's Day, then composed a song to honor the event. "You like to hear?" he asked. Moving his hands and body in rhythm, he sang lustily in Eskimo, ending with a rousing "Happy New Year!"

Back in the village I watched Molly Ahgook make caribou-skin masks that resembled Eskimo faces. She prepared the skins by clipping the hair close and dyeing them in tea to produce a gold color. Then she clamped the wet skins on forms to dry. Later I watched her sew a ruff of wolf fur around a dry skin. She used hair from the lower leg of a caribou for the beard and moustache of an old man's face. Long hair for an old woman's face came from the mane of a bull.

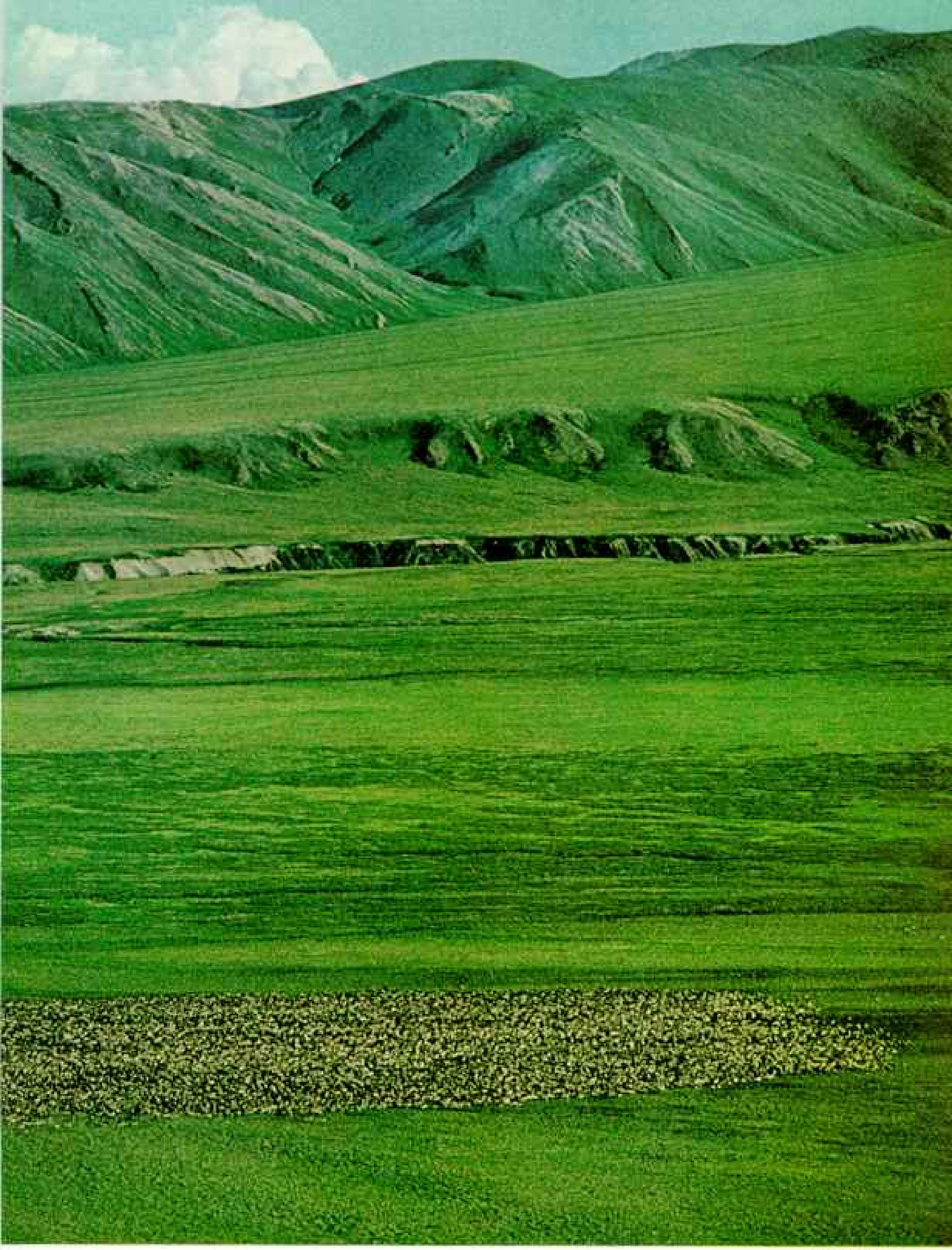
The Eskimos of Anaktuvuk Pass prefer bull caribou, which provide more meat, and which, at least in early fall, yield more back fat than cows. Bulls weigh about 325 pounds, cows about 200. The average bull of this herd stands about 50 inches high at the shoulders; cows are several inches shorter. Each year both sexes grow and shed antlers; those of a mature bull may be five feet long.

Anyone who has been close to a passing herd in the fall will remember the noises: the clicking of feet, the grunts, the clattering of antlers. No one knows why caribou feet click with each step; it may be the sound of snapping tendons or of moving bones. A single animal's clicks may be heard plainly at 30 paces. Records describe the awe with which northern

(Continued on page 868)

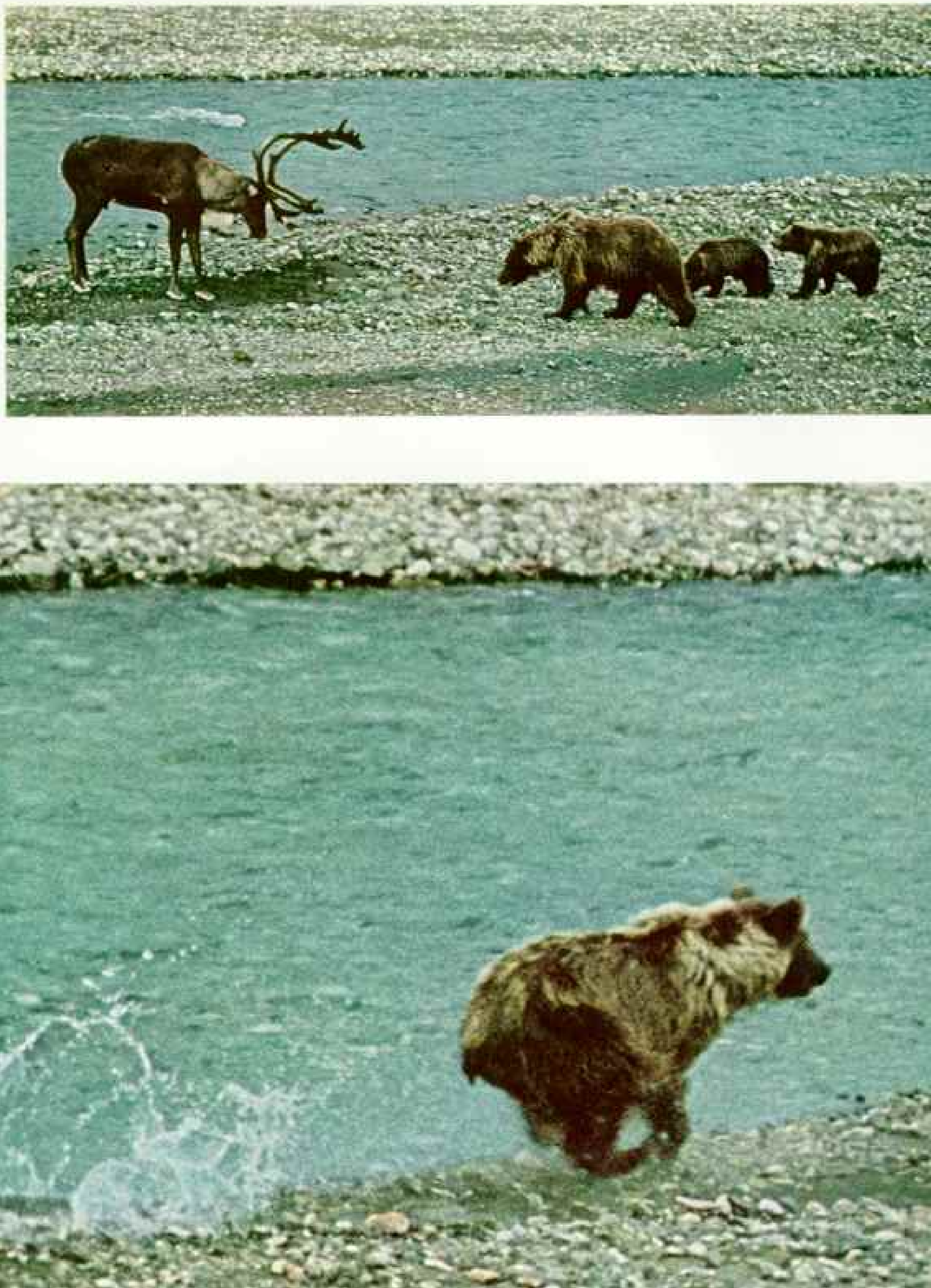
Drenched and shivering after nearly drowning, a calf stranded on an island gets a tender toweling from Don Frickie of the Arctic National Wildlife Range. Deposited on the stream's bank, this 2-day-old was quickly reunited with its frantic mother.

Living torrent of 60,000 caribou—about half the Porcupine herd—streams alongside the Firth River in Canada's northern Yukon Territory. Their clicking hoofs resound for miles as the animals migrate to this high country to escape swarming summer insects.



GEORGE W. CALEY

Like most herds, the Porcupine caribou journey to winter ranges as cold weather approaches; mating takes place en route. In spring the herds make exhausting treks to their calving grounds in smaller bands, one often following another's scent.



Seven-minute showdown between antlers and claws

GIANTS OF THE NORTH square off for a death struggle in the wilds of Mount McKinley National Park when a mother grizzly with two hungry cubs stumbles upon a lone bull caribou, already wounded but still full of fight.

A pack of wolves had cornered the bull the previous night. He fought them off, but not before they slashed gaping wounds in his flanks. Exhausted and losing blood, he retreated to a gravel bar in a small stream, his head drooping, barely moving all the next day.

In late afternoon, the menacing growls of the grizzly sow startle the bull into his classic defense posture (**left**)—rear legs splayed and head down. As the bawling cubs watch, the two circle warily. Suddenly, the bear crashes through the water, and the bull lowers his four-foot antlers even farther to meet the onslaught.

"By this time," photographer Velma Harris remembers, "I was shaking so much from excitement that I didn't even know what I had filmed." For the rest of the drama, see the following four pages.

explorers witnessed herds of these noisy animals passing for days or even weeks.

However, caribou usually scatter over a wide area, and a migration is more likely to be an intermittent stream of animals moving in one direction at about 20 miles a day.

Animals Follow Invisible Signs

I recently spent the first two weeks of October on the Alaska Peninsula. For several days I waited, scanning the empty tundra. Finally 400 caribou appeared on the low rolling hills that slope to the Bering Sea.

Reaching the Egegik River, the leader, a cow—females often lead herds—trotted downstream. The sun dropped below the horizon, and the animals following her became dark silhouettes against the golden sky.

The leader swam 150 yards across a narrow part of the river. The others followed, single file. Beyond the river the caribou disappeared under a low-hanging full moon. Two days passed before I saw another band; they followed the same route.

I have often seen caribou bands trailing one another by a matter of hours or days, yet using exactly the same route. For a long time I wondered how they could follow one another with such certainty.

A clue came on another trip to the Alaska Peninsula with my brother, Don, his son, Steve, and my wife, Audrey. On a high ridge we startled a magnificent lone bull. He reared on his hind legs, great antlered head high, white mane flying, then ran forward for half a dozen giant steps before his front hoofs touched the ground again.

"I've never seen anything so magnificent!" Don exclaimed as the bull galloped away.

We sat down and played our glasses over the area. Hours later, six caribou approached. They didn't see or smell us; the wind was behind them. Yet when they came to the spot where the bull had reared, they became alarmed, then detoured and fled.

"How did they know about that bull?" Steve asked. "He's been out of sight for hours."

The answer, it seems, is that caribou follow odors left by others of their kind that have passed hours or perhaps days before. That leaping, rearing bull had left a special odor. He performed what scientists call an

Three hundred fifty pounds of fury strikes back as the caribou rams his rack

"excitation leap," during which an alarm scent is given off, probably by a gland exposed by wide-spread hoofs. Caribou of both sexes and almost all ages perform this leap.

"What are all those trail-like marks down there?" a newcomer to Alaska asked me as we flew over the mountains and tundra north of the Arctic Circle one day. I replied that they were caribou trails.

"There aren't that many caribou in the world," he said in disbelief.

But there are. Or there have been.

Same Route Next Year? Maybe Not

Trails worn into arctic or subarctic soil by thousands of sharp hoofs remain visible for decades, perhaps centuries. I've spotted them in parts of Alaska where caribou haven't been seen for half a century or more. A herd may follow the same path for years; their repeated migrations have been known to cut trails two feet deep. Then, for no obvious reason, the animals may switch to other routes.

One February weekend I drove along a road that led to an abandoned gold mine in the Wrangell Mountains of southeast Alaska. Finally I reached Devils Mountain Lodge, home of guide Bill Ellis. Two of his sons, Cole and Kirk, offered to lead me to a cabin near which caribou were wintering, and soon our snowmobiles were zipping over the snow-covered ice of Jacksina Creek.

A young moose fled ahead of us. Cole stopped, explaining, "That moose will run himself to death if we don't give him a chance to get off the river."

I moved into the cabin as the boys departed. Icy winds whistled through the unchinked logs and the cracks in the floor.

Training my glasses on the sunlit ridge 3,000 feet above, I saw about 300 caribou. Snow lay deep on the slopes and in the valley, but atop the ridges it had blown thin. The animals had sought this area to feed, and the snow looked as if it had been dug with a thousand shovels. I mounted a telescope on a tripod and watched.

A cow chopped and pawed at the snow with the sharp edges of her front hoofs, tossing white showers behind her, until she fed. Then she walked slowly, her head low, searching for the scent of favored plants.

squarely into the bear's chest—but the bear thrusts a slashing paw past the antlers.

The fittest survives

LIKE A BULLDOGGING COWHAND, the grizzly grabs the caribou by his antlers and neatly flips him into the stream (**upper pictures**). The end comes swiftly as the helpless bull succumbs to ripping teeth.

"In seven minutes it was all over," said photographer Harris, "but the bears' feast lasted for five days. They'd eat, sleep for a while, get up, wander off, then come back to the carcass." Here the cubs supplement their share with milk from mother (**right**).

This grizzly family enjoyed a windfall; bears seldom kill caribou because their quarry can generate bursts of speed as high as 45 miles an hour. Normally, only calves and the wounded fall prey. Wolves hunt more successfully, taking full-grown adults as well as straggling young.

Weather and tormenting insects sometimes drive herds at such a relentless pace that calves, exhausted by the trek, drown during river crossings. For adult caribou, hunters remain one of the most consistent perils, accounting for perhaps a quarter of the annual toll. Eskimos, Indians, and white riflemen claim some 10,000 to 15,000 a year. Bag limits protecting some herds, plus fewer sled dogs to feed in the villages, however, have substantially reduced the yearly harvest of a decade ago.

ALL BY VELMA HARRIS

Finding some, she chopped and dug again.

Foods important to caribou include sedges and grasses, especially during the warm months. Willow shoots and leaves, dwarf birch, and horsetail *(Equisetum)* are also frequently on the menu. Mushrooms, available in summer and fall, are a favorite food of this hoofed gourmet. In winter, lichens (genus *Cladonia* and others) are the staple.

I have observed in summer that caribou eat only tender new shoots. So little do they take that I had to be almost on my hands and knees to see where the animal had cropped. The effect on plants is minimal; some may even be stimulated to faster growth.

Such selective feeding enables caribou to thrive on alpine and arctic plants that are sparse and fragile, while other large herbivores can scarcely exist for want of food.

I watched the caribou feeding on the Jacksina ridge until dark. Then I sawed a small dead spruce into firewood and huddled near the stove under several layers of clothing. The animals resting 3,000 feet above me in the cold starlight were, like me, heated by energy released from plants. But they were warmer.

Nature Outfits Caribou for the Cold

Although humans regard winter as the North's difficult season, with temperatures plummeting to minus 60° F. or even lower, caribou apparently fare best then. For one thing, they are no longer bothered by summer pests: mosquitoes, blackflies, and botflies. And as fall arrives, they become prepared for the cold. Their coats grow dense and long, and they are at their handsomest. Their trim, rich cinnamon-brown sides contrast with white necks and snowy ventral manes.

Consisting of long, brittle guard hairs and short, fine, curly underfur, the caribou's coat is its greatest asset for keeping warm. While the body temperature remains at about 103°, the temperature of the legs and hoofs may drop to about 50° during winter to further conserve heat.

Caribou have their own "snowshoes"—large feet. The two front toes of each foot and the two dewclaws at the rear are all well developed to distribute and bear the animal's weight. During winter, hoof edges grow long and the foot pads shrink and become horny. The animals walk on the thin crescentic rims of their hoofs, which provide traction on hard snow and ice.

One recent March, I accompanied Loyal Johnson and Greg Bos, game biologists with Alaska's Department of Fish and Game, as they helicoptered into the Wrangell Mountains to gather data on the Nelchina herd. I remembered those caribou from my 11 years with the department.

In 1945 the herd numbered about 10,000. By 1962 there were about 71,000. In 1972 the herd was down to 10,000 again.

Caribou herds frequently grow too large for their available food supply. Their range then deteriorates, and overcrowding causes a drop in the birth rate. The animals start wandering farther afield. As the Nelchina herd increased, so did its migration distance—from 370 miles in 1955 to 980 miles in 1964.

No Single Reason for Herd's Decline

As we flew over a high snow-covered ridge, a band of a hundred or more caribou appeared. "Land there," Greg directed the pilot.

The two biologists leaped out with a spotting telescope and notebook. Greg called out as he observed the sex of the adults and the number of calves. Loyal recorded. Such information is basic to learning the herd's reproduction rate.

Some factors in the abrupt decline of the Nelchina herd can be pinpointed. A large segment may have joined another herd—not unusual in times of rapid increase. Calf mortality was high during severe winters in the late 1960's. "In 1971 the herd swam the Susitna River at high water four times, almost immediately after calving," Loyal told me. "Many calves drowned," he said, shaking his head at such caribou carelessness.

Another possible factor was a liberal hunting season from 1963 into 1972, with an individual bag limit of three. These generous regulations were set by state wildlife officials to try to keep the expanding herd within the capacity of the range, and thus to avert the usual rapid decline. (Biologists estimate that a healthy herd on good range can sustain an annual kill by hunters of about 15 percent.) When officials realized the herd was shrinking too fast, they reduced the season to 42 days and the bag limit to one.

Other information on the diminishing herd came from the Department of Fish and Game laboratories at Anchorage. I went there to talk to Charles V. Lucier, the laboratory coordinator. He explained that he is able to determine the age of caribou by studying razor-thin cross sections of caribou teeth

under a microscope. The teeth are collected from hunters' kills—considered a good sampling of a herd.

"We cut the teeth into sections about 200 microns thick with a rotary diamond-faced saw," he explained. "In ultraviolet light the cementum surrounding the tooth root is seen as a series of contrasting bright and dull bands." I peered into the microscope eyepiece and saw the growth rings, which are counted like the paired annual growth rings of a tree.

Caribou over 10 are old. Bulls usually do not breed until at least 2 or 3, but cows may breed at a year and a half.

Examining teeth from Nelchina kills, Mr. Lucier determined that the number of females 2 to 5 years old had dropped drastically —from 77 percent of the killed animals in 1968 to only 43 percent in 1971. This meant that the herd had experienced a staggering mortality of young animals, from which, of course, all increase in herd size must come.

Most of Alaska's caribou herds have known the boom-and-bust cycle that the Nelchina herd experienced. In the 1930's Alaska had an estimated one million caribou—more than twice as many as today. In the 1950's the number may have dipped below 200,000.

Disease, heavy snow conditions, and perhaps a dozen other factors play a role. Hunting, however, is probably less of a factor in reducing caribou numbers than it was ten or twelve years ago, in part because many villagers, like those at Anaktuvuk Pass, have turned to snowmobiles and no longer require meat to feed sled dogs.

Exhausted Cows Push On

Next in size to the Arctic herd is the Porcupine herd of more than 100,000 animals, shared with Canada. Named for a tributary of the Yukon River, the herd calves largely within the nine-million-acre Arctic National Wildlife Range, largest animal refuge in the U. S.

It was a calf of the Porcupine herd that Don Frickie and I had observed immediately after its birth that June day. On that trip, hoping to witness the spring migration, I had waited for several days beside the Kongakut River with Don, assistant refuge manager, and Averill Thayer, the manager.

We scanned mountain and valley with binoculars. One day Don suddenly exclaimed, "There!" He had spotted a dozen cows only 100 yards away, walking single file over the edge of a hill toward us.

"They look terrible, don't they?" Ave said.

Ribs and hip bones projected from gaunt frames. Their coats were pale, hair tips worn and bleached. Shiny black spots of hide showed. Udders were full, for all the animals were pregnant. Their flashing hoofs appeared too large for their thin legs.

They would calve within days. The energy drain of maturing fetuses, the 400-mile migration, and a diet of dormant vegetation all had taken a toll. Yet they were vigorous and traveling. My, how they traveled! They filed down the mountain to the ice-choked Kongakut, plunged through the shallows, and swam

TOM MEARDEN (ABOVE) AND GEORGE M. CALEY (FOLLOWING PAGES)

Newborn legs a-quiver, a calf responds to its mother's anxious head bobbing and wobbles to its feet. Just two feet long and weighing only 13 pounds at birth, it will be able to outrun a man after 24 hours.

Spiked thicket of burnished antlers flows across a river (**following pages**) as the Porcupine herd heads south through blowing snow during its fall migration; adults will mate in two weeks. Caribou are the only members of the deer family in which antlers adorn both sexes.

Reaping the tundra's harvest, hunter Johnny Rulland packs freshly killed caribou onto his sled (**above**) to haul to his village of Anaktuvuk Pass (**below**); there the meat will be hung to dry. Nowadays "iron dogs"—snowmobiles such as the one outside this Anaktuvuk Pass home—offer job competition to man's best friends.

Before the dawn of the trading post, many native Alaskans depended almost exclusively on caribou during certain seasons. They still use them for food, and their hides for mattresses, foot gear, and other items of clothing. Hunters caught in blizzards have held off starvation by eating their caribou-hide sleeping bags.

"The courtesy and manners of a prince": Thus author Jim Rearden describes "Arctic John" (above), here enjoying a favorite delicacy, the raw kidney of a caribou. After a recent illness the hunter moved to Fairbanks, but the crowded city leaves him unimpressed. "Too much big timber. Can't see," the Eskimo complains.

the channels, steadily heading northwest.

Another day 34 caribou grazed below our camp. A gray wolf approached, and the caribou broke into a gallop across ice at the river's edge. When the caribou reached hummocky ground, their marvelous running ability easily carried them out of the wolf's reach.

Oil Quest Shapes Caribou's Future

While wolves and other predators have some impact on caribou numbers, range conditions and weather probably have greater influence. But in the end, the activities of man may have the greatest effect.

Wildlife experts continue to be concerned about the four-foot-diameter hot-oil pipeline that will carry oil from the Prudhoe Bay fields on the North Slope to the port of Valdez, crossing the Brooks Range and vast stretches of tundra. Now under construction, the 800-mile-long pipeline will be above ground in much of the permafrost—about half its length. It will be paralleled by a highway that will be open all year (map, page 860). Also, two natural gas pipelines have been proposed, one going east into Canada from Prudhoe Bay, the other alongside the oil pipeline. The routes cross traditional caribou ranges.*

Other pipelines may eventually lead from the 23.5-million-acre Naval Petroleum Reserve No. 4, which adjoins the Prudhoe Bay fields, and possibly from additional northwestern Alaska sites, where extensive petroleum studies are being intensified. And other roads could someday branch off from the one between Prudhoe Bay and Valdez.

It appears doubtful that caribou will freely cross any large aboveground pipeline. At the Prudhoe Bay fields, which are ranged in summer by about 3,000 animals and intermittently crossed by thousands more, wildlife researchers used two simulated pipelines to study caribou behavior.

They counted 5,599 animals approaching a 10,200-foot-long barrier built to the approximate size and height of the aboveground hot-oil pipeline. Only 994—17.6 percent—crossed over the two gravel ramps that spanned the 6- to 8-foot-high impediment. Fewer than 5 percent used the four underpasses; a small number crawled beneath the structure. Of the rest, 42.4 percent went

*See "A Look at Alaska's Tundra," with articles by Russell D. Guthrie and Paul A. Zahl, NATIONAL GEOGRAPHIC, March 1972, and "Will Oil and Tundra Mix?" by William S. Ellis, in the October 1971 GEOGRAPHIC.

Art from the Arctic: Masks crafted from caribou hide take shape under Molly Akgook's deft fingers. Local dealers pay her $15 for creations that may fetch ten times as much in New York City shops. The tourist trade and the Alaskan oil boom define the modern life-style of Molly's people in Anaktuvuk Pass. They need the oil to heat their homes and also need the jobs the pipeline will provide; yet they still depend on the caribou, whose way of life the pipeline may forever alter.

around the barrier; 34.4 percent turned back after approaching.

The other study was made with a simulated 24-inch feeder pipeline that eventually stretched 7,100 feet. Most of the animals—75.4 percent—went around. Another 9.5 percent reversed their direction; only 8.3 percent used crossing ramps, while 6.8 percent passed beneath. Research is continuing.

Low caribou population density and the opportunity to roam wide areas are essential to the well-being of caribou. While pipelines and highways are unlikely to become absolute barriers, every aboveground structure in their range will affect their movements.

An Omen From Scandinavia?

The experience of Norway with wild reindeer may be a preview of what can be expected. There, well-traveled highways and railroads have obstructed the animals' movements. One herd abandoned its traditional wintering grounds after several years.

As Alaska builds cities, roads, pipelines, power lines, and railroads, vast areas will be partitioned, shrinking the available range.

More tourists, hunters, lodges, snowmobiles, cars, aircraft, and fishermen on wilderness streams will increase the stresses.

The eons-old nature of caribou to move, seeking new pastures and escape from insects and bad weather, or perhaps even seeking new sights—man still does not understand all the whys of their wanderings—will no longer serve as a full-fledged survival mechanism. Animals driven from their chosen range cannot always be expected to find suitable habitat elsewhere.

Dr. Robert LeResche, a leading Alaska scientist, believes that the vast herds of a quarter of a million or so animals are probably a thing of the past in eastern Alaska and western Canada, and that the days of even moderately large herds are numbered.

Alaska's barren-ground caribou are graceful, abundant, unpredictable, spectacular, and lovely. The caribou *is* the North. Few animals are capable of surviving in so many different types of terrain, from rugged, steep mountains to the hummocky lowlands, from the mild Alaska Peninsula to the deep cold winters and warm summers of interior Alaska. Like the bison of our Great Plains, the caribou is a creature of the vast, wide-open spaces.

And when the wide-open spaces of the northlands disappear, so will the caribou. □

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U1274

Oakland, California, 1928. The "Southern Cross" prepares for its historic flight to Australia. Union Oil airplane fuel is selected to power the "Southern Cross" on the first leg of its journey.

Anti-pollution laws enacted around the country in recent years have presented oil companies with a number of challenges which are being overcome as technological advances permit. Among the most difficult were finding a way to manufacture solvents made up of hydrocarbons low in tendency to form smog, and a means for making jet fuels that give little smoke when burned.

At Union Oil, a research team headed by Dr. Hal Huffman came up with a refining process which solved both problems. We call it UNISAR. In addition, UNISAR reduces the cost of making jet fuel and solvents and helps stretch our scarce petroleum resources, since it also upgrades the oil it treats. In that manner, low-quality crude oil can be made to yield clean-burning jet fuel and high-grade solvents.

The UNISAR story is just one example of how Union Oil's researchers can start out to solve one problem and end up solving several. Imaginative researchers like Dr. Huffman and his colleagues, who can make our oil resources go farther while they help reduce pollution, help Union Oil keep up with the changing times. And your changing needs.

Union Oil Company of California

UNION 76

The pioneering Spirit of 76 lives at Union Oil.

Today, the pioneering Spirit of 76 is men like Dr. Hal Huffman helping keep the skies bluer with UNISAR.

Because it's aluminum, this transport helps hold down fuel costs —by delivering more per trip.

A trailer's empty weight determines how much gasoline it can deliver when it's full—without exceeding weight limitations. So, in most states, trailers built with aluminum components can carry as much as 780 gallons more per trip. Safe, sound and legal. Enough to "fill up" the 20-gallon tanks of 39 extra cars.

You are looking at an aluminum trailer that weighs 9,450 pounds with accessories. A trailer of equal capacity, but made of a heavier material, could weigh as much as 15,720 pounds. That's why the mathematics of legal load limitations favor aluminum. Even when the trailer is running empty, fuel savings mount up because of its lighter weight.

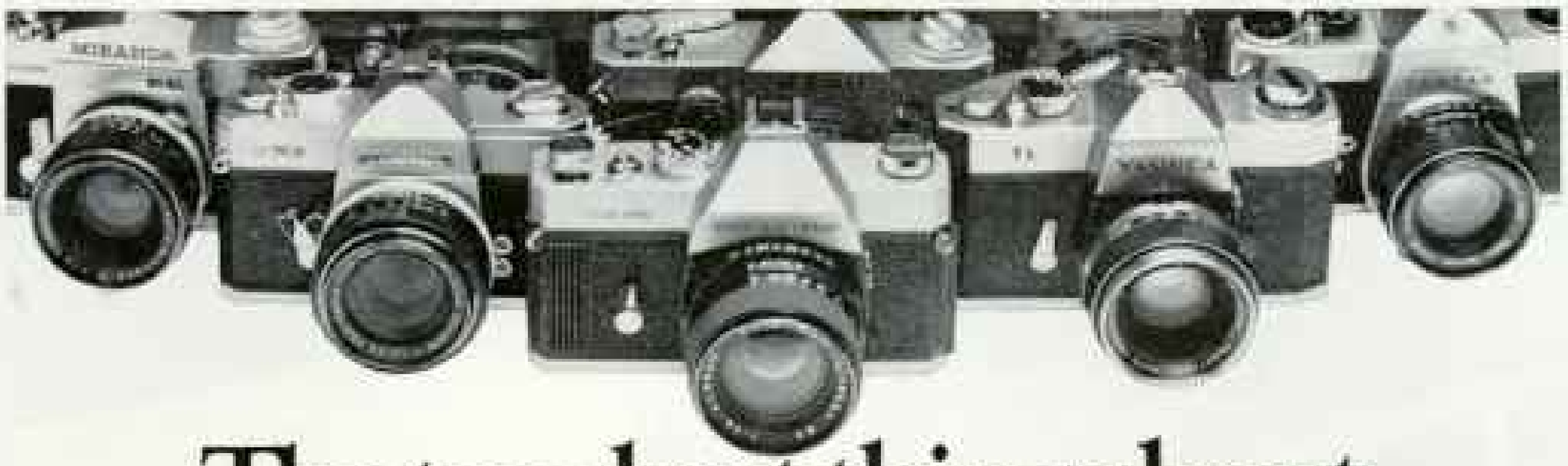
Bonus payloads have always been one of the big reasons why so many over-the-road trailers are made of lightweight aluminum. Alcoa® aluminum disc wheels and truck components of aluminum can reduce weight even more. And now when saving energy is more important than ever, aluminum continues to help truckers deliver greater payloads and save energy.

Strong, lightweight aluminum alloys can also help cars become lighter and less expensive to operate. Saving gas, brake wear, tire costs and even registration in some states.

Aluminum helps save energy in your home, too. When properly applied over reflective aluminum foil, Alcoa Siding forms a protective insulating envelope that can help reduce heat loss through your walls. You can be more comfortable the year 'round and cut down on heating and cooling bills. Clearly, aluminum is its own best advocate. A metal that's basic to our way of life. If you would like to know more about how aluminum is helping to conserve energy, write for our free brochures. Write Aluminum Company of America, 343-M Alcoa Building, Pittsburgh, PA 15219.

The reasons for using aluminum are found in aluminum itself.

ALCOA



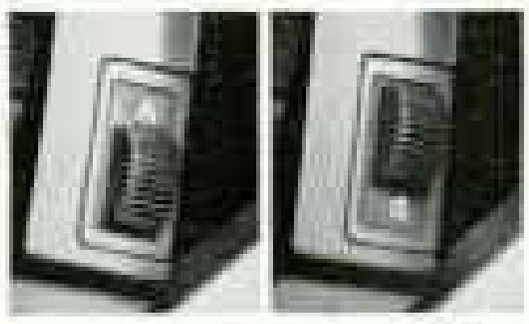
The toughest thing about 35mm photography is deciding which camera to buy.

If you're confused about 35mm single-lens reflex cameras, it's no wonder. There are all kinds of cameras, all kinds of prices, and all kinds of features and accessories.

Maybe we can help clear the air.

Metering systems: spot or averaging?

Spot meters are best for some kinds of lighting situations, while averaging meters are best for others. So to get the most value in a camera, narrow your choices to the ones that offer *both* metering systems.



The Creative Switch.

The Mamiya/Sekor DSX 500 and DSX 1000 incorporate both spot and averaging meters in one camera. You pick the right one for the shot with the Creative Switch. It's located up front under the lens where it's handy. As you look through the viewfinder, an arrow tells you which system you're using. So instead of just taking photographs, the Creative Switch helps you create them.

Lenses and accessories to grow with.

Whatever camera you pick, make sure it has a variety of lenses and accessories available. Mamiya/Sekor offers a wide range of interchangeable lenses —from a 21mm super wide-angle to an 800mm telephoto. Plus a variety of accessories so you can build your own system as your photographic skills and interests grow.

Quality is where price and value meet.

Price is only one aspect in selecting a camera. You'll find there are features you won't want to do without. At Mamiya/Sekor, we've got a price/value story that's hard to bear.

We have a quality story, too, and a two-year warranty. If there's a defect in parts or workmanship the first two years, we'll fix it free.

Sound like we're talking your language? Then see your dealer or write for more information.

mamiya/sekor

Mamiya/Sekor 35mm equipment is marketed exclusively in the United States by the Bell & Howell Company.

BELL & HOWELL

For the complete story on Mamiya/Sekor SLR cameras, write:
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2201 W. Howard, Evanston, Illinois 60202

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They don't break, they don't need batteries, and they'll still be fun a year from now.

These two gifts are not only unbreakable, they're unforgettable.

The Post Office's new edition of Stamps & Stories has pictures of every U.S. stamp design ever printed and all the 1973 commemoratives. They're all in full color and so are the illustrations of our memorable stories behind the stamps. Including one about how Leif Erikson was sailing from Norway to Greenland but never made it. A storm blew him to a place which later became known as America. You can read even more stories like this in Stamps & Stories for just $2.

Our Mint Set is a special collection of all of 1973's special stamps. Everything from a "Love" stamp to a jumbo Boston Tea Party stamp. The Mint Set has 33 mint stamps and costs only $3.

So get Stamps & Stories and the Mint Set at your Post Office. They both have Santa's stamp of approval.

Stamp Collecting. For the fun of it.

Your Postal Service

Which is true? The threat of a crippling metal shortage or the promise of ample supply? Both, to some extent. The key is abundant supply at acceptable cost.

Domestic metals are indeed less abundant. Much of our nation's easily-accessible, high-grade mineral ore is gone. We import most types. There's no prospect we'll ever be completely self-sufficient. Recycling extends our supplies somewhat, but over the long term we must develop new mineral sources.

We know there are untold amounts of lower grade ores in the ground. The problem they pose is one of cost. It's expensive to find, mine and process these ores and then reclaim the land for useful purposes. But unless we're totally irresponsible, we can have the metal we need without a drastic change in our life style.

We should start by taking inventory now of all mineral ores still available on both private and public lands. When we know the extent of our resources, a responsible mineral industry can develop them . . . at an acceptable cost to meet critical needs *and* protect the environment.

And we should encourage this same action in other countries. We say this not only because Caterpillar makes machines used in mining, not only because it takes metal to make those machines; but because mineral resource development is essential to the great hope for a better life for all the peoples of the world.

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There are no simple solutions. Only intelligent choices.

CATERPILLAR

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Be ready for that one radiant smile. All you need is the holiday spirit and a camera that won't slow you down. A Minolta SR-T.

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And when subjects call for a different perspective, Minolta SR-T cameras accept a complete system of interchangeable lenses from "fisheye" wide angle to super-telephoto.

Christmas smiles come but once a year. Be ready for them with a Minolta SR-T. For more information, see your photo dealer or write Minolta Corporation, 200 Park Avenue South, New York, N.Y. 10003. In Canada: Anglophoto Ltd., P.Q.

Minolta SR-T 102/Minolta SR-T 101

Minolta helps you capture the smiles of Christmas.

When identified by a factory-sealed "M" tag, Minolta 35mm reflex cameras are warranted by Minolta Corp. against defects in workmanship and materials for two years from date of purchase, excluding user-inflicted damage. The camera will be serviced at no charge provided it is returned within the warranty period, postpaid, securely packaged, including $2.00 for mailing, handling and insurance.

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Put it all together in Air Force ROTC.

Getting offshore

It takes time. The Exxon gasoline you're filling up with today may have come from an oil field we started looking for 8 years ago.

Geological survey. Eight years ago, Exxon began to explore a piece of acreage 75 miles out in the Gulf of Mexico.

Our geologists examined rocks from the bottom of the Gulf and along the shoreline. They used special devices to locate possible oil-bearing rock thousands of feet below the seafloor.

From this information, they created a vertical "picture" of the rock layers to find strata that looked promising.

These studies can take very little time, or up to six years. This one took four.

In 1970, convinced that the chances of finding oil were good, Exxon bought the rights to drill exploratory wells. This was the only way we'd find out for sure if there really was oil there.

Exploratory drilling. We started drilling for oil in mid-1971. To do it, we used a mobile drilling rig. The cost of leasing and operating this rig was $24,500 a day.

Working round the clock, it took us 25 days to drill the first well. It was 8,500 feet deep—and we discovered gas, but no oil.

We then drilled a second hole. Fortunately, we hit oil. To find out how big the field was, we drilled several more wells. They outlined the size of the field and confirmed that oil was down there in commercial quantities.

Exploratory drilling can often take as long as five years. We were lucky. It had taken us just two years.

The next step was to design and construct the oil-producing platforms which would replace the mobile rig. These huge platforms would be anchored to the seafloor directly over the field.

Platform construction and installation. We started building the twin drilling and production platforms in 1972. Construction took 16 months.

Each offshore platform has to be built specifically for the area it will work in. You have to take into account water depths, wind and wave action, earthquake possibilities, and other factors. This is why an offshore platform built for the relatively calm Gulf will be different from one built for the fierce North Sea.

Our next step was to tow the steel structures out into the Gulf. We then sank them in place in 235 feet of water, and anchored them with pilings driven into the seafloor.

Then we added the platform decks. These included the crew's quarters as well as facilities for producing the oil.

oil to you.

Production drilling. When everything was shipshape on the platform in early 1973, we began to drill the first production well that would actually bring the oil to the surface. We drilled four wells in 1973, and seven more in 1974.

The wells are drilled straight down for a few hundred feet, then slanted away from the platform base. This greatly increases the area that can be tapped from one platform.

Frequently, we use several platforms in developing an oil field. These platforms, like the individual wells, must be placed carefully to insure that the oil is recovered as efficiently as possible.

Underwater pipelaying. While the platform crew was drilling the production wells, bargemen and welders were busy laying the underwater pipeline that would take the oil from the platform to shore.

Aboard a pipelaying barge, coated sections of pipe move along a track and are welded together. Then the welds are inspected by X ray. The joints are also given a protective coating and the continuous pipe is slipped down onto the seafloor.

To get the oil to shore from our new producing platform, we simply had to lay a section of pipeline that linked our platform with a main pipeline nearby. If this main artery had not existed, and we had to lay one, then the entire pipelaying job might have taken several months. As it was, we did it in one month.

Refining and delivering to you. The crude oil that started coming to shore this year from our production platform in the Gulf was carried by another pipeline to a nearby Exxon refinery.

Gasoline made from this crude was shipped to Exxon service stations through product pipelines and by tank trucks.

And the gasoline you're filling up with today may have come from that field we started looking for eight years ago.

U.S. offshore oil now supplies 11% of America's needs. Within ten years it will have to supply considerably more.

This is why Exxon is looking today for the oil you'll be needing in the 1980's.

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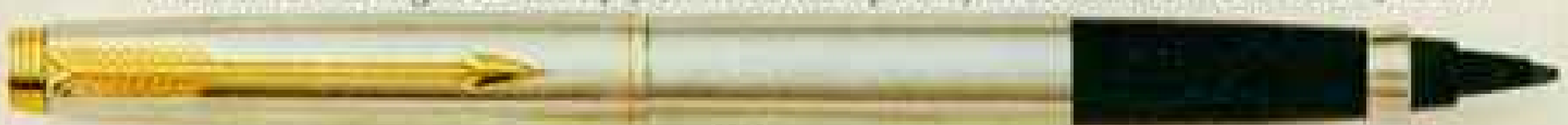
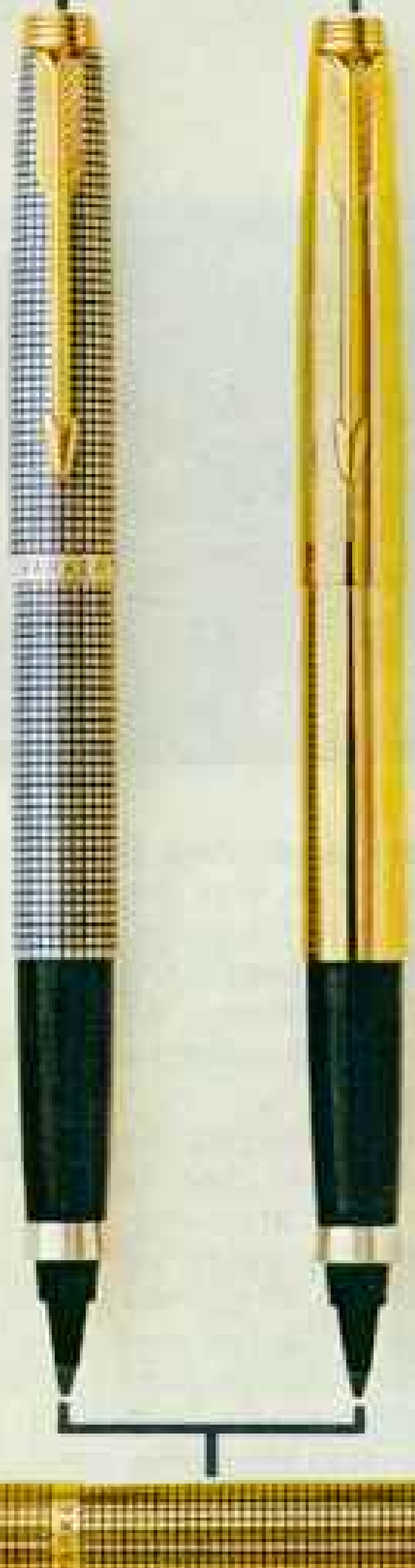
Dashing good looks and smooth, smooth writing.
The Parker 75 Flighter soft tip pen in contemporary brushed stainless steel. $12.50.





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The Allemande, model FW4AE

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So, we put your ideas and ours together and came up with something new in console listening. Zenith Allegro 4-channel with a choice of end-table speakers or built-in speakers.

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New Zenith Allegro with built-in speakers.

The Caledonia, model FW4TF, in Pecan finish (also available in Dark Oak finish as model FW4DF)

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The surprising sound of Zenith.

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FOR YOUR FAMILY TREE

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Dan Cates on the Cates' thirteenth visit to Bermuda.

"In the late afternoon we like to take the ferry into town. It's ten minutes and the prettiest ride in the world. I like to sit up on the prow and feel the breeze in what's left of my hair."

"Bermuda is so gentle. There's an atmosphere of total relaxation. We find an awful lot to occupy us... in a mild sort of way."

"Bermuda is a very special place for me... I met my wife here."

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December 1, 1974 to March 15, 1975

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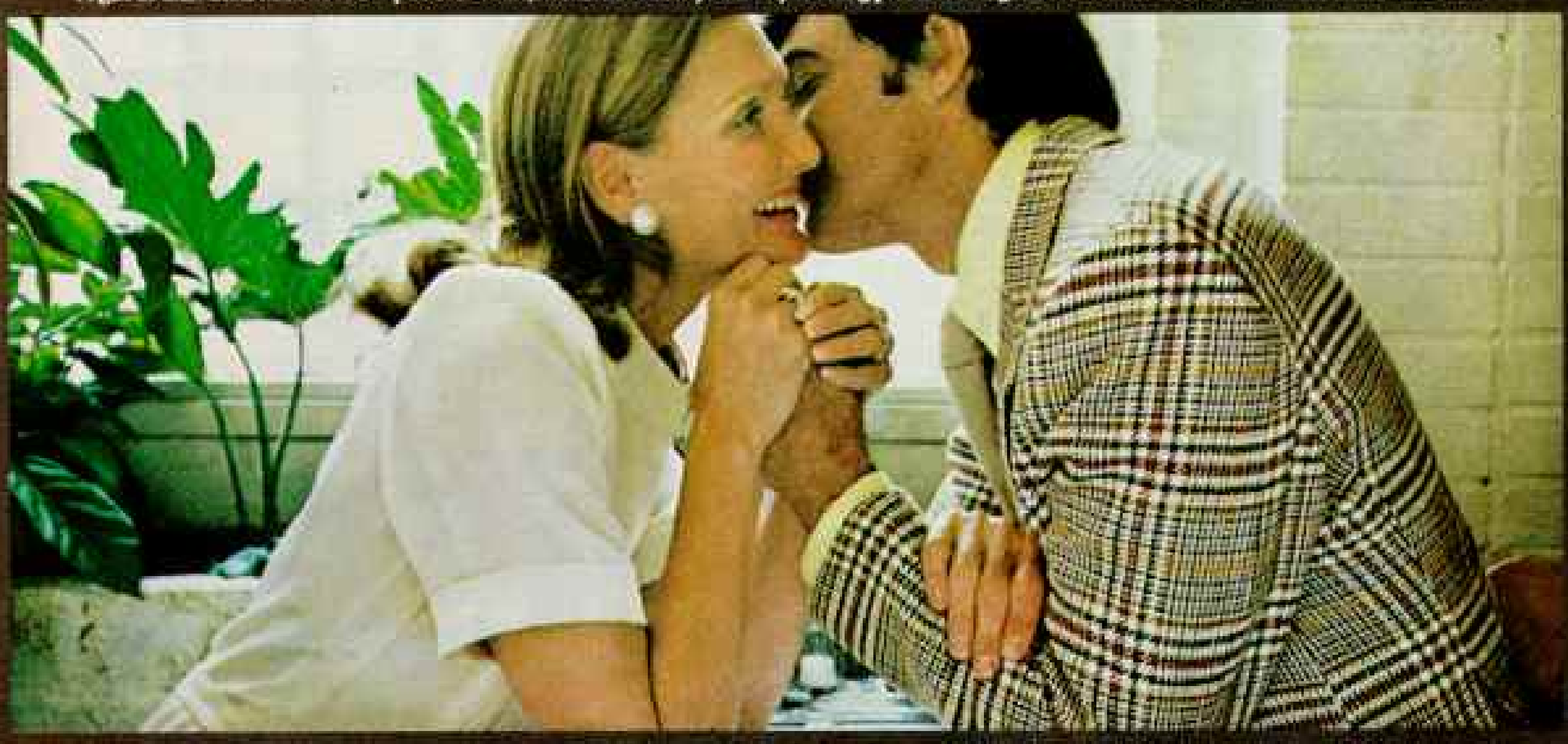
On our 11th anniversary,
instead of going to work,
we came to the city and played like
two little kids all day long.
And after the penny arcade,
two Bogart films, too many hot dogs
and ice cream cones, I told her
how much I love her
with a kiss and a diamond ring.

A gift of diamonds need not be expensive. Your jeweler can show you many exciting pieces starting as low as $100. De Beers Consolidated Mines, Ltd.



A diamond is forever.

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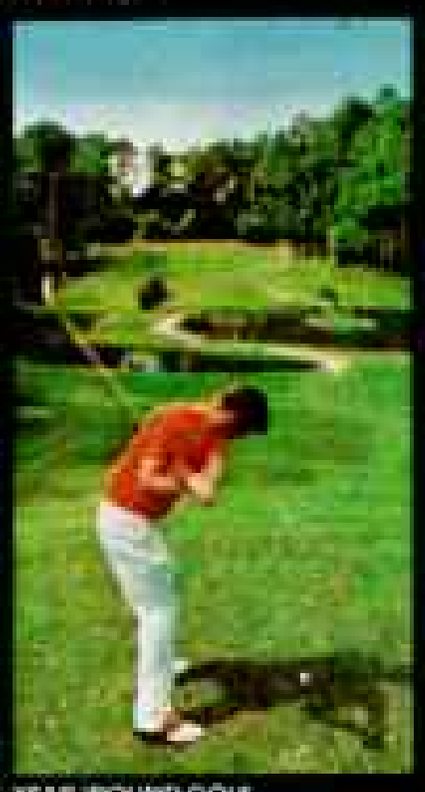

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Audition an organ with some of the same criteria a conductor would use to audition an orchestra.

First consideration: Size.

Like an undersized orchestra, a too-small organ could lack the right combination of power, range, and color to satisfy your musical appetite.

Since modern organs last for decades, underbuying is an enduring mistake.

If you do need a small instrument, make sure it incorporates the advantages of big instrument technology.

Yamaha makes a full range of organs, and even the small models have considerable variety and power.

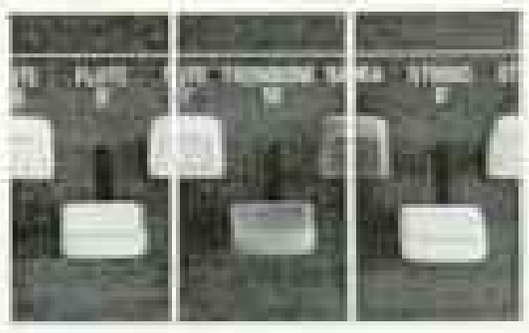
Conductors need a *large range of sound* to work with, and so do organists.

The smallest organ you should consider should have a minimum of three divisions worth of range for versatility: two keyboards and a pedalboard.

Larger organs, like the Yamaha E10R, have extended keyboards for wider tonal range.

One organ, the Yamaha DK40, has five divisions of sound instead of just three.

Choose an organ with a selection of tone colors from *each basic family* of the orchestra: brass, woodwinds, and strings.



Don't expect literal imitations of their sound. Rather, look for similarity in terms of sound character.

Avoid organs with whole families of color missing. Even the smallest Yamaha provides colors from the three basic families, and most also have a fourth family, percussion.

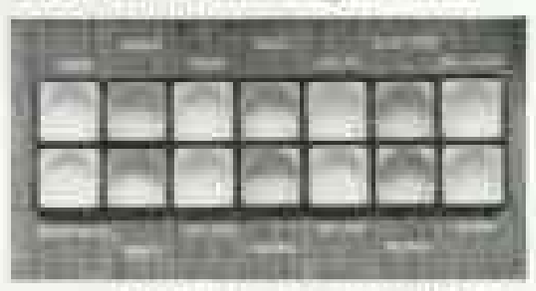
Yamaha *Auto Rhythms* borrow the rhythm section of the orchestra electronically.

They automatically play a variety of beats—from rock to bossanova—at the speed and volume level you predetermine.

Another Yamaha feature, ABC (Automatic Bass Chord) adds full harmonic accompaniment (and makes full-sounding organ music easier to play).

When an orchestra requires a *unique sound or effect*, it usually brings in extra musicians.

Many Yamaha Electones have those extras built right in.



Banjo, accordion, piano, harpsichord, chimes, Hawaiian guitar, and vibraphone are available.

So are Wah Wah (New Orleans jazz), Repeat (mandolin style), Glide (steel-guitarish), and Touch Vibrato ("crying" strings).

There are other extras, and it's helpful to try them all.

Like a fine orchestra, a fine organ can be called upon to do almost anything in the world of music.

If it's appropriately matched to its job.

For more information on organ buying, see your Yamaha dealer.

He'll make you feel like Toscanini.

YAMAHA

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