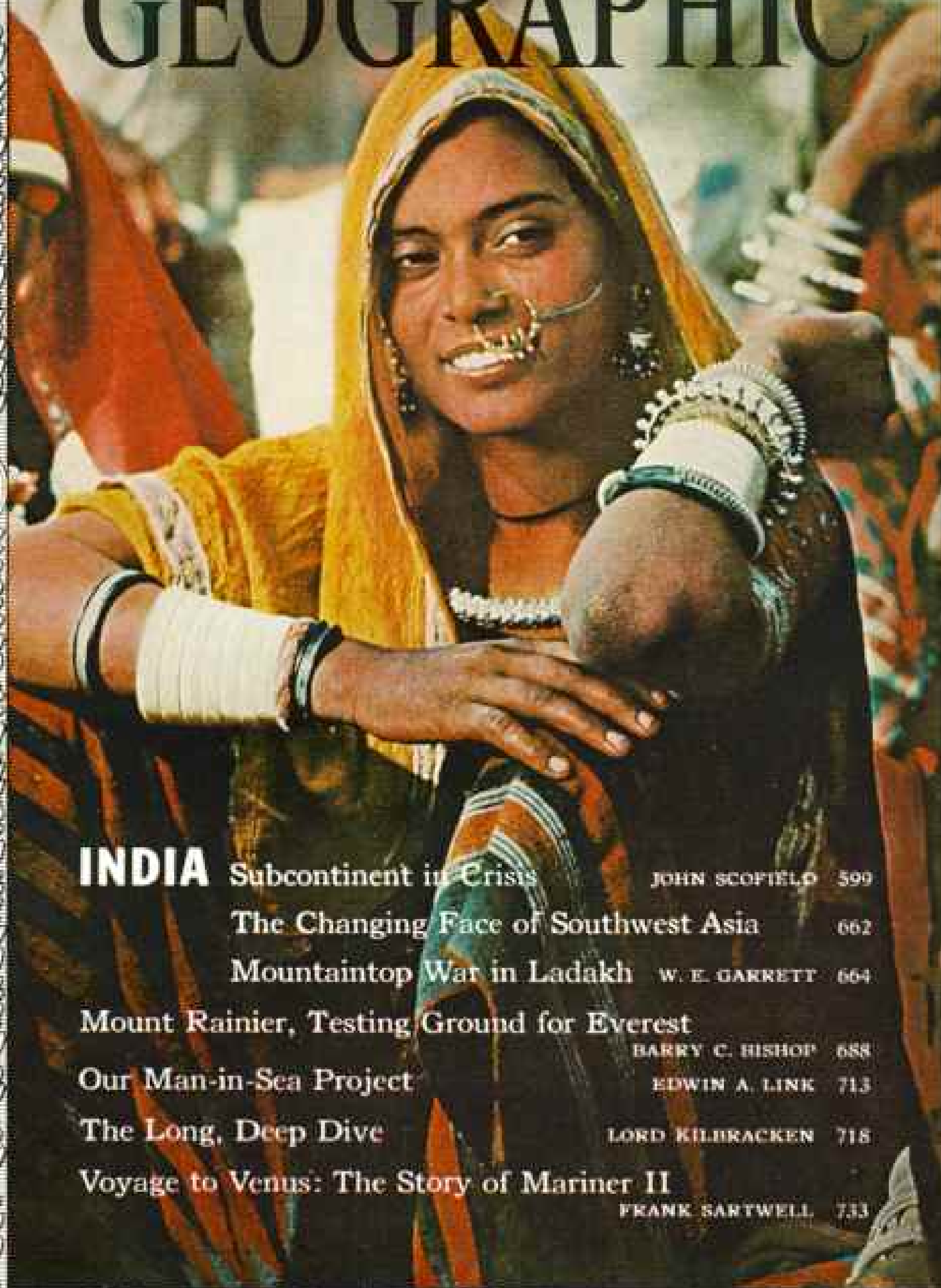


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COVER: Nose ring anchored to an ear adorns a Rajasthan beauty at the Pushkar fair (page 611).



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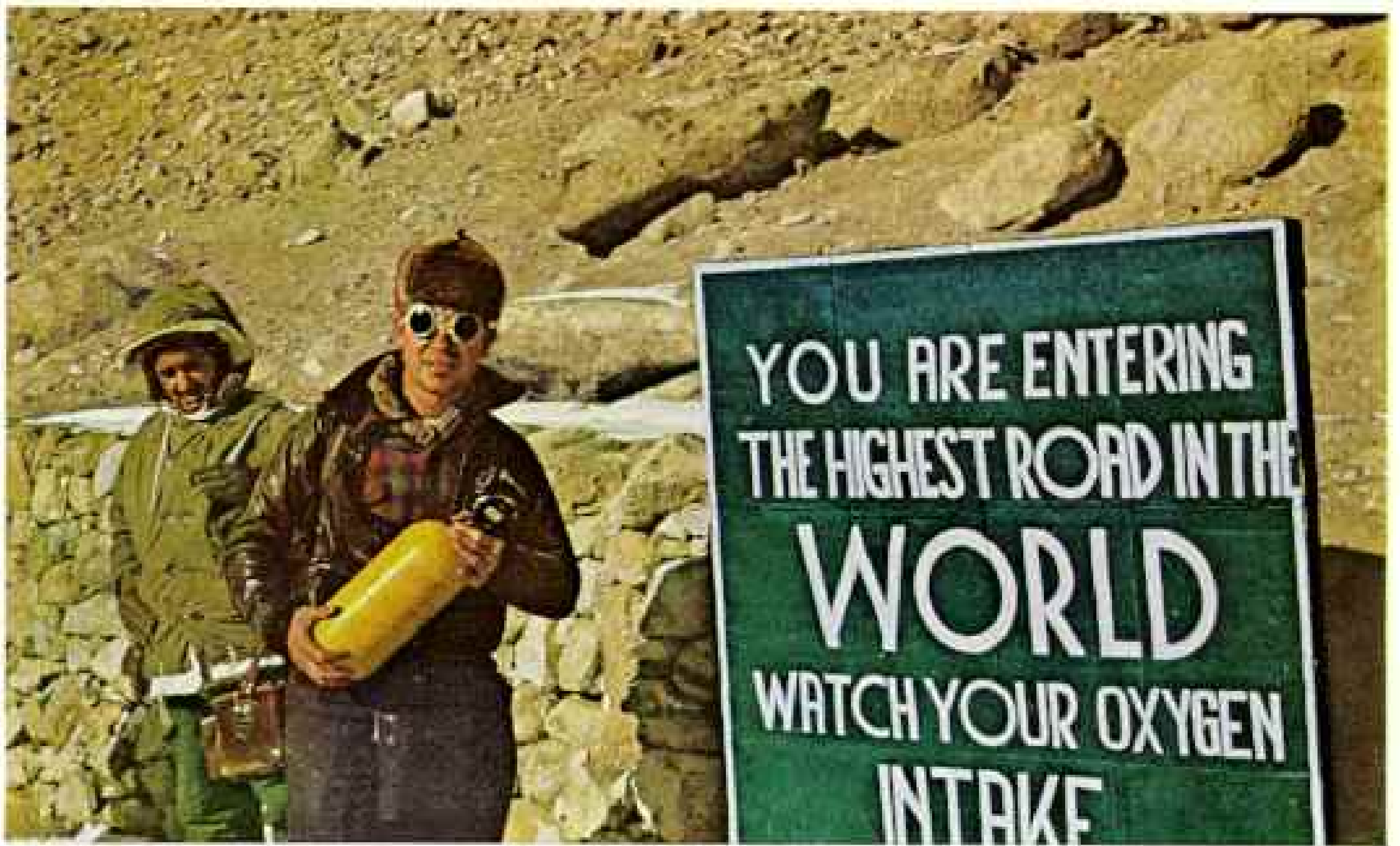


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Geographic staff man follows a high road to war in Ladakh

OXYGEN was just one problem that faced writer-photographer W. E. Garrett in reporting on last autumn's fighting along India's northwest frontier.

Getting to the three-mile-high battleground was unbelievably difficult. Snow blocked the only road, and all troops and supplies had to go by plane. Flights were often grounded by storms.

Bitter cold and thin air compounded the Indians' task of trying to halt the Communist Chinese forces advancing out of Tibet.

"No battlefield is pleasant," Mr. Garrett said, "but those of Ladakh's high deserts seemed beyond endurance."

Yet he found Indian soldiers digging in for two-year stays at 17,500 feet—as high as the world's loftiest settlement in Chile's Andes, 500 feet higher than most men can remain without physical deterioration.

Behind the front he saw a peaceful people who follow ancient ways, worshiping the Dalai Lama of neighboring Tibet.

Mr. Garrett brought back the most comprehensive account yet published of Ladakh's cruel, high war (page 664). Such timely reporting appears in each month's NATIONAL GEOGRAPHIC. You may share these reports with your friends by nominating them for membership on the form below.

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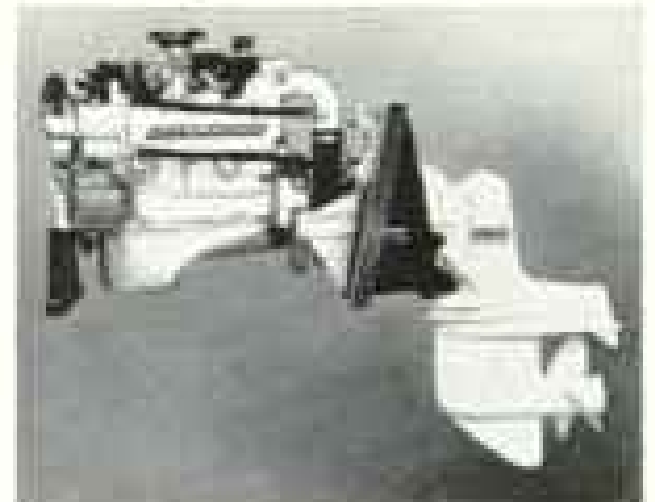
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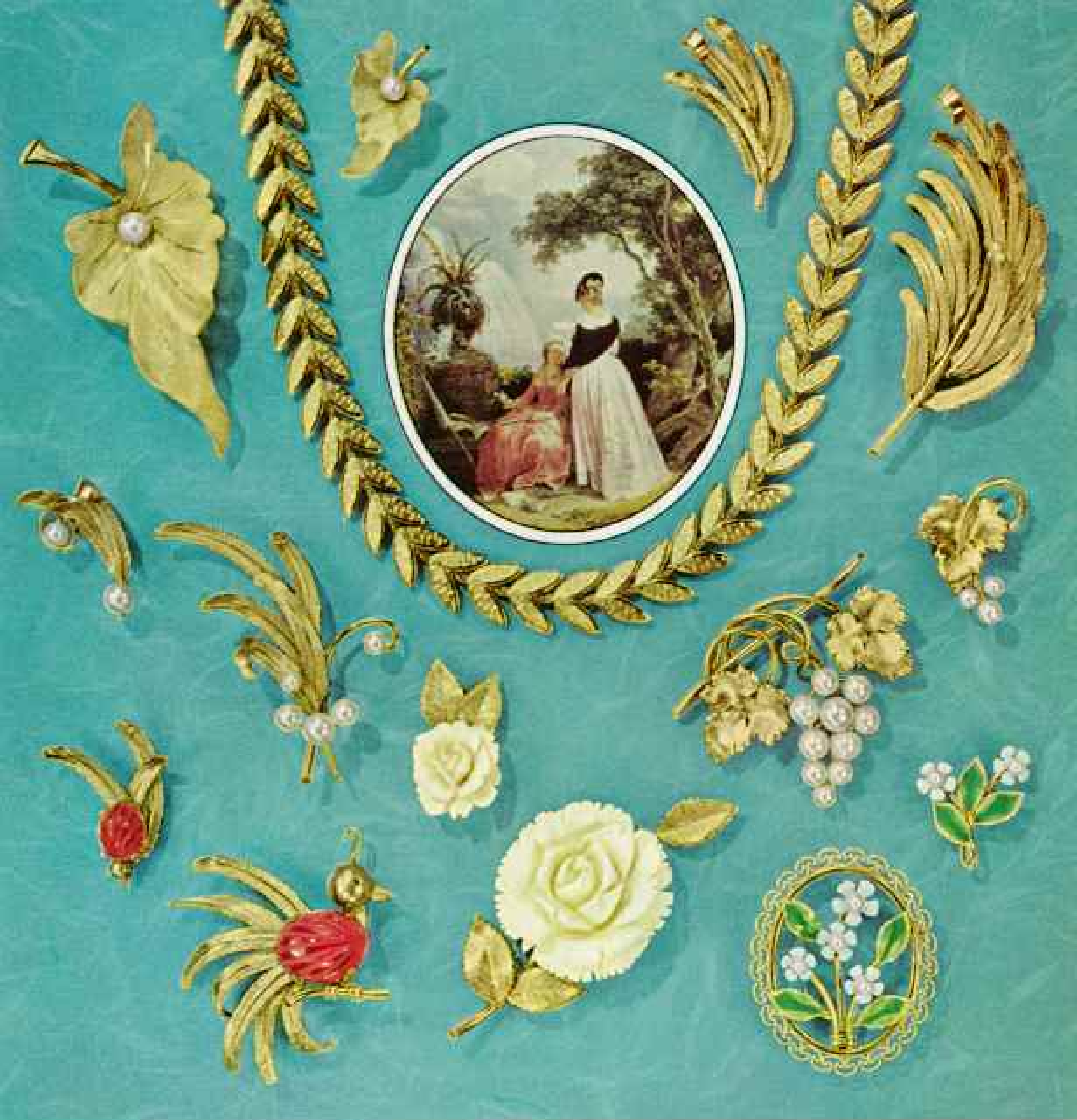
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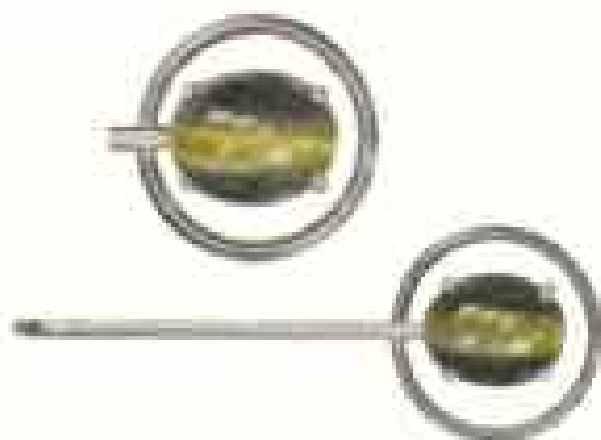
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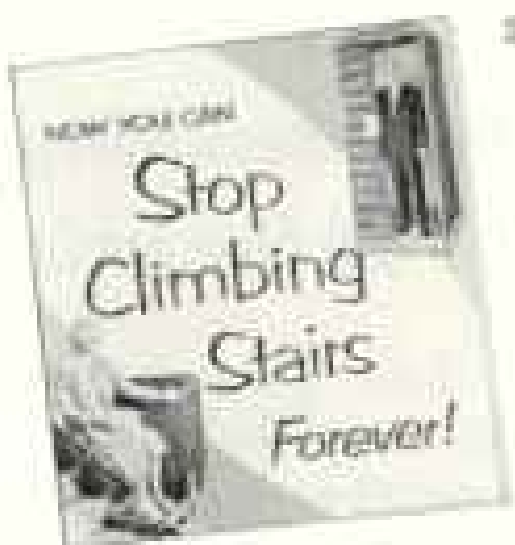


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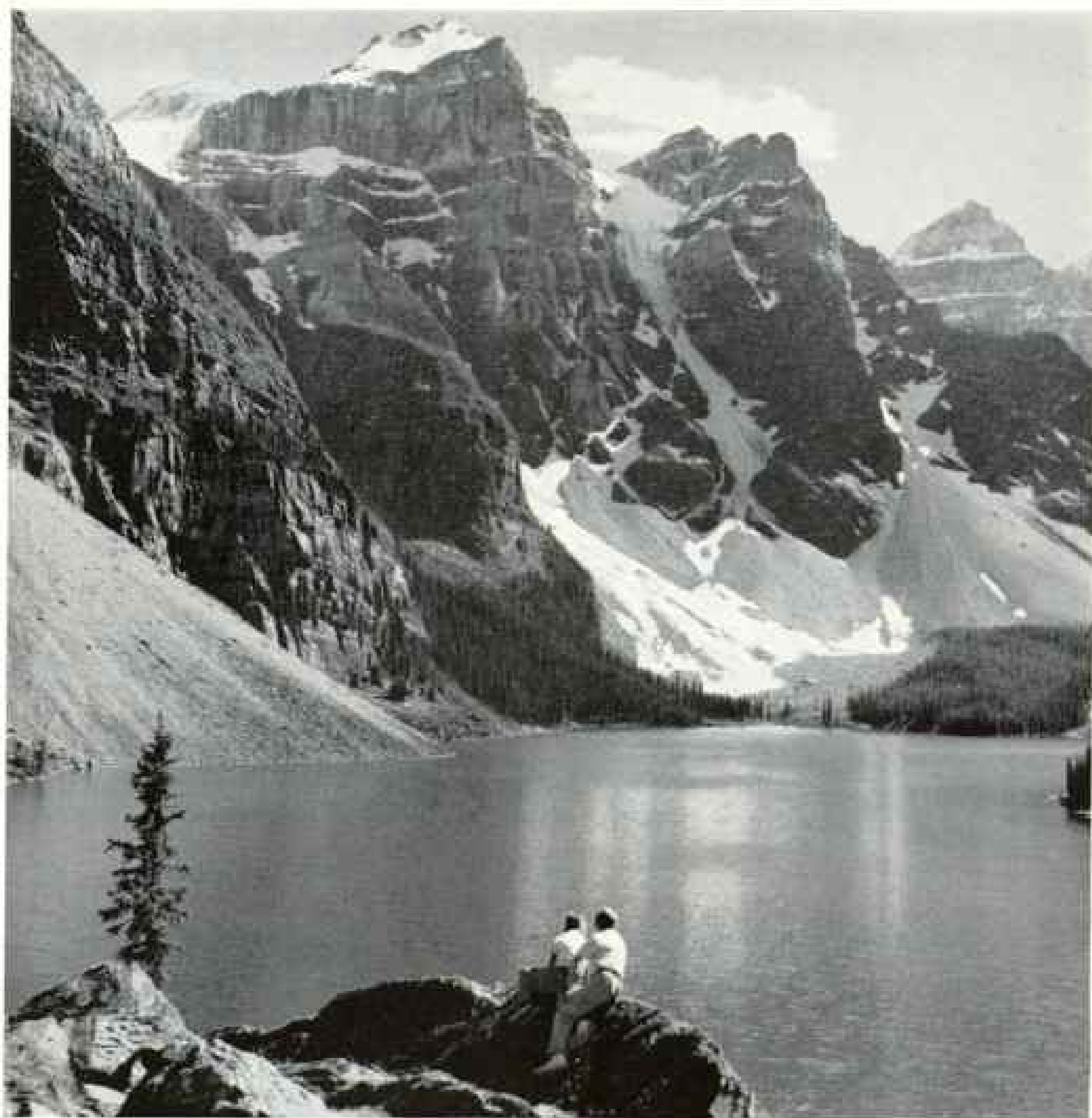
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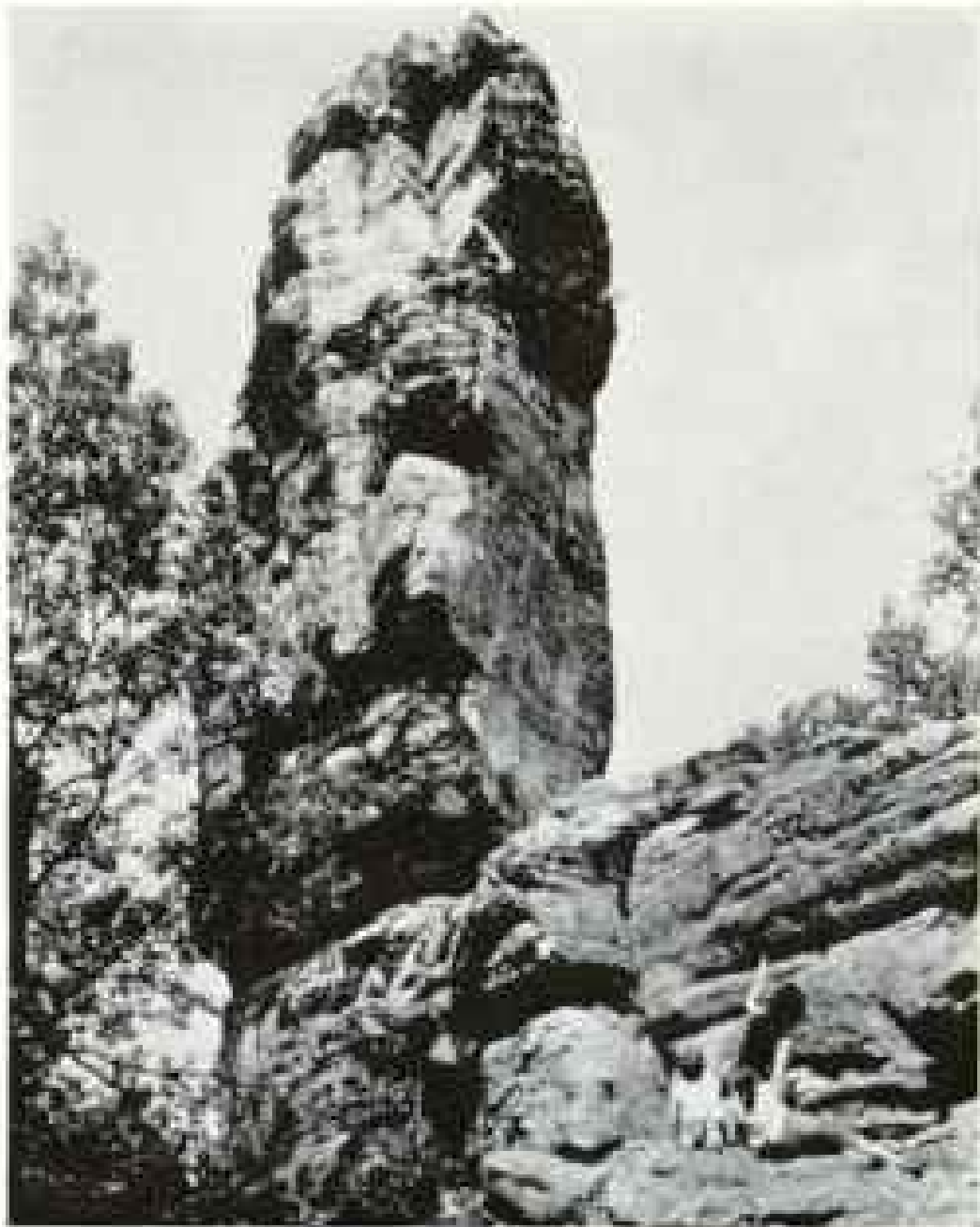
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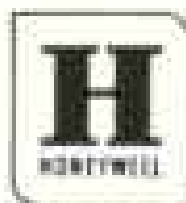
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I MET HIM ONE NIGHT in a Banaras hotel. Quite by chance, we had walked out together onto the darkened veranda after dinner. Now we stood chatting and listening to the nighttime sounds of an Indian city.

He was about eighty—a retired lawyer from Calcutta—dressed in an old-fashioned way and with an old-fashioned manner of speaking. We talked of the difficulty of explaining his country to anyone who had never been there.

"Look here," he said suddenly. "Suppose all Europe could somehow be united under one government, with one parliament and one prime minister.

"Now, take away two-thirds of Europe's area and three-quarters of its wealth," he said, "but leave most of its people. Let Spaniards speak Spanish and Bulgars speak Bulgarian. Let Turks mistrust Russians and Russians bluster at Englishmen. In short, leave everything else just as it has always been.

"Now," he asked in his courtly, rather Victorian manner, "what would you have?"

He paused impressively.

"Why, my dear sir," he said, "you would have something very like modern India."

Then he bade me goodnight—"Old men must have their sleep," he said—and left me alone to ponder his words.

Peril Unites a Land Divided

He was almost right, I decided—but not quite. He had overlooked one thing.

Even as we talked, Communist Chinese troops forced their way deeper into Ladakh and the North East Frontier Agency, and India's ill-armed *jawans* fought desperately to hold the world's loftiest battlefields.* Towns along the Himalayan border blacked out; home-guard forces in Calcutta and New Delhi frantically dug trenches and put up air-raid defenses. India's cherished neutrality lay shattered—perhaps forever—and the nation was united as never before.

By the time I left India, I decided that the old man was wrong altogether. India, I think—and the discovery surprised me—resembles the United States more than it does Europe.

As is true in my own country, no matter where I traveled—from Darjeeling, where the unbelievable mass of 28,208-foot Kanchenjunga dwarfs everything in view, to the wave-clawed southernmost tip of the subcontinent, from plush Marine Drive in Bombay to a Calcutta slum—I could never for a moment forget what country I was in. For, like the United States, India possesses a surprising unity despite its dramatic regional contrasts. (Refer to the 11-color



May
1963

NATIONAL GEOGRAPHIC

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India in Crisis

By JOHN
SCOFIELD

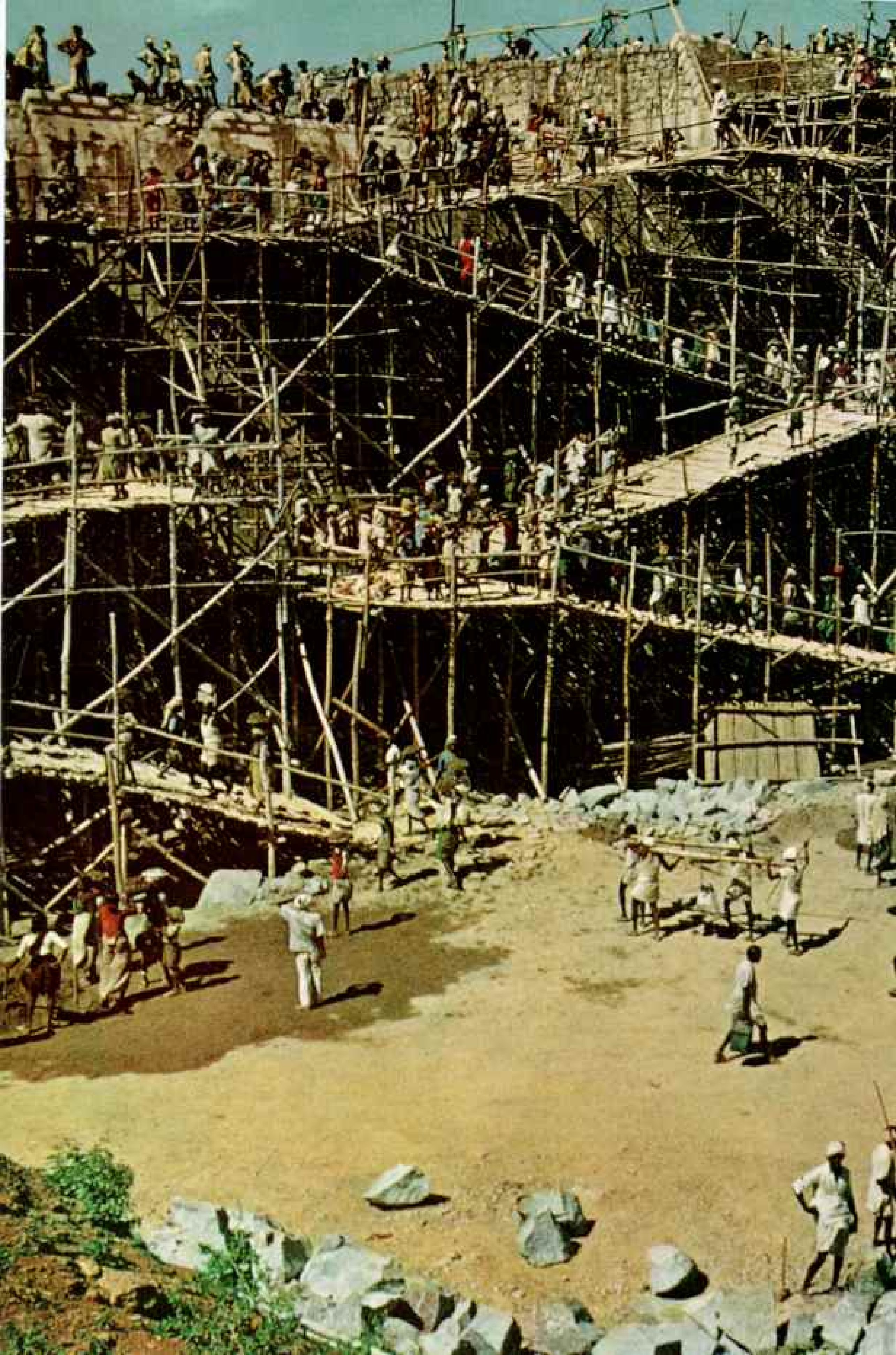
ASSISTANT EDITOR

Photographs by the author

Map Supplement, Southwest Asia, distributed with this issue.)

India showed me many faces. I was shocked and disturbed by the harshness and poverty of the life it offered. I was sometimes angered by my own inability to understand one aspect or another of this most complex of all nations. I was puzzled at times, and annoyed at others. But more often I was excited by the energy and imagination of the people who call themselves Indians

*For a firsthand report from India's three-mile-high battlefield in Ladakh, see page 664.





With Bare Hands, Indians Erect a Mighty Dam in Andhra Pradesh State

"This is the foundation of the temple of humanity of India, a symbol of new temples that we are building all over India," said Prime Minister Jawaharlal Nehru when he laid the cornerstone of the Nagarjuna Sagar project in December, 1955. With ceremony, he started construction of the world's largest masonry dam.

When completed, the barrier will back the Krishna River into a reservoir of 110 square miles. Brushlands, drawing water from the pool, will blossom into life-giving gardens, and turbines will provide electricity for homes and industry. Engineers hope to repeat the success of giant Bhakra Dam, far to the north, which has already transformed the economy of Punjab State.

Sheer muscle power lifts the structure inch by inch. Like the pyramid builders of ancient Egypt, some 125,000 workers pour out their strength in building dam and irrigation canals. Two-man teams haul 300-pound rocks up the bamboo ramps; women in ceaseless streams carry up pans of mortar on their heads. By using hand labor, India saves the hard currency needed to buy machinery abroad.

Thus the India of princely splendors and village poverty sails into the 20th century. But the need to arm for clashes on the northern frontier threatens to delay progress.

APPROXIMATE BY JOHN SULLIVAN,
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Turban and untrimmed beard mark a Sikh. His religion, which forbids him to cut his hair, began in the 15th century as a reformation of Hinduism. Forced to fight for their faith, Sikhs learned soldiering, and many served in British uniform. Their creed requires that they always carry a knife.

—before long there will be half a *billion* of them—and awed by the beauty their ancestors scattered over this vast land.

My survey of India began in a New Delhi that was trying desperately to adjust to being the capital of a nation at war.

I was there for Diwali, the Hindu's beloved Festival of Lights, but President Radhakrishnan had declared a national emergency. Normally, millions of tiny oil lamps would have outlined every home (page 624) and surrounded every floodlit public building, but the city remained obediently dark. It was a heartening display from a people so often accused of being hopelessly divided.

I sensed, too, a nervous vitality in New Delhi, particularly a few minutes before ten

on weekday mornings and again a few minutes after five, when thousands upon thousands of office-worker cyclists flow in unending streams along its streets.

Indians are enormously proud of New Delhi, which Great Britain handed over to them lock, stock, and barrel on independence day in 1947. The British had moved the capital here from Calcutta in 1911, built the spacious city to order, and occupied its imposing red sandstone buildings during their last years of administration.

I sometimes heard Indians criticize the British for such "high-handed" actions. But, after 16 years of running their own affairs, I think most of them have come to look on New Delhi in a different light—as a symbol of the free nation India has built on the firm footings left after 90 years of British rule.* And nowhere does that pride show more readily than among the Sikhs who drive the city's midget taxicabs.

"How long you been in India?" a bearded and turbaned driver would ask me.

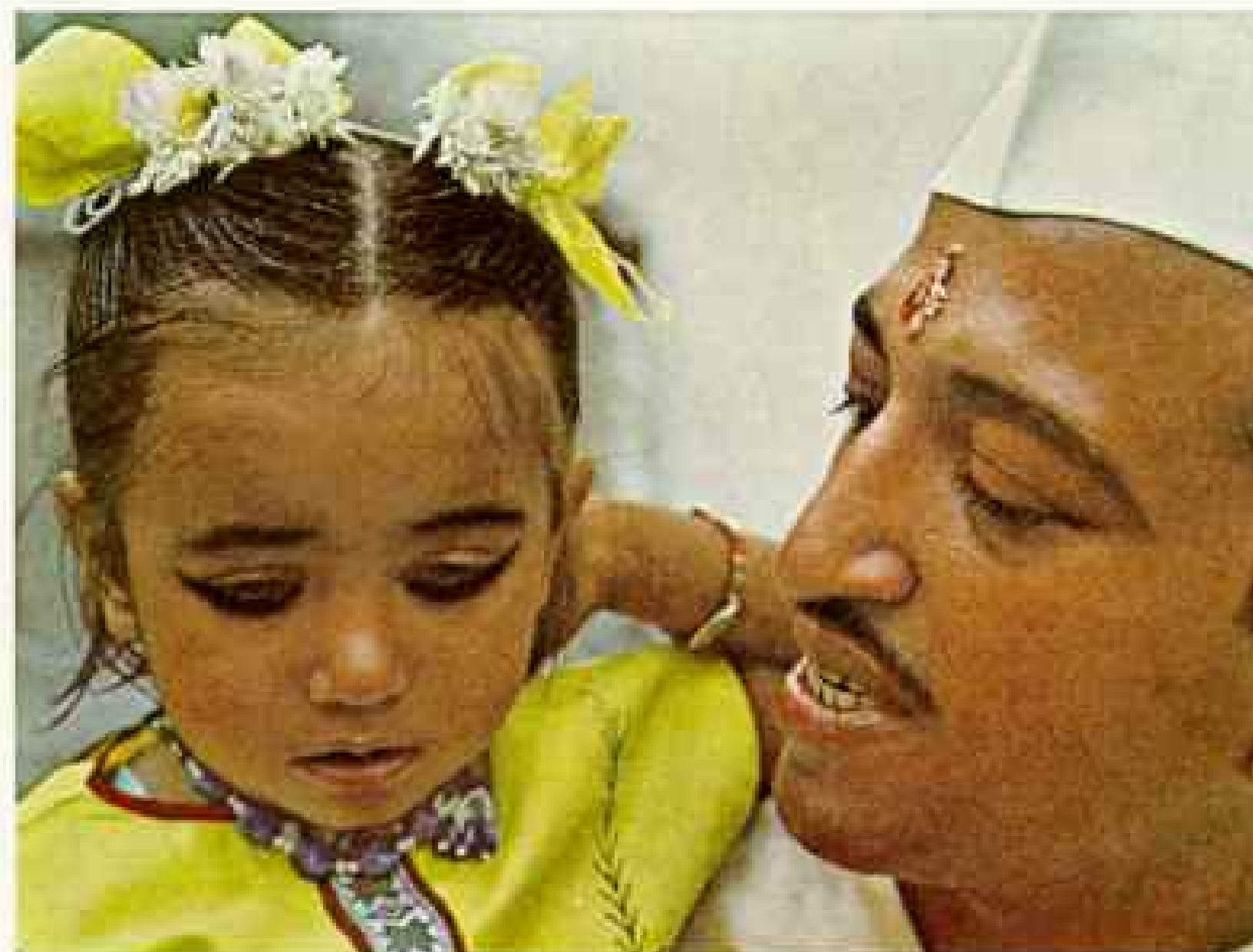
My answer might be two days or two weeks; eventually I was able to say that I

had been in the country for two months. But it made no difference.

"There the Prime Minister's house," the driver would say, not so much to inform me—I think he knew I had seen it many times before—but rather to express his own pride. Often when I passed, I saw crowds of simple villagers there, hoping for a glimpse of Mr. Nehru so that they might press a gold ornament into his hand as their contribution to the war effort, or simply express their approval of his leadership in this dark hour.

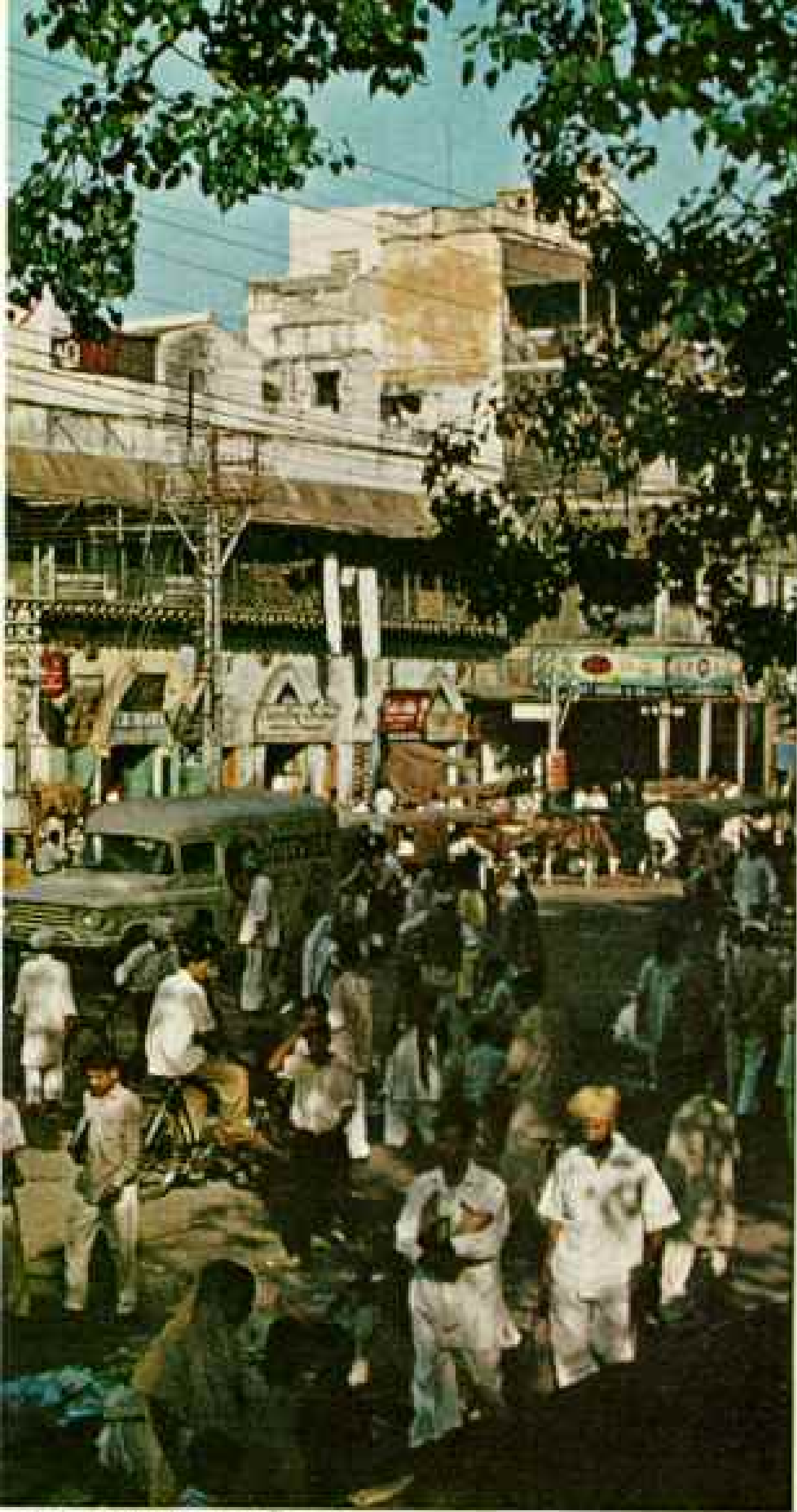
"This—India Gate," my driver would say. "That, India's National Museum.

*See "Delhi, Capital of a New Dominion," by Phillip Talbot, NATIONAL GEOGRAPHIC, November, 1947.



Halo of flowers and *tilak* on forehead proclaim the festival of Diwali. The celebrators: a well-to-do tobacco merchant and his daughter. A Brahman priest applied the dab of red paste as a sign of good luck. The man's sister added grains of rice so that this sign of her love might ward off evil influences.

A holiday similar to the Western New Year, Diwali is a time when old accounts are settled and new projects begun.



**Traffic Clogs Chandni Chauk,
Old Delhi's "Moonlight Crossing"**

This busy thoroughfare exudes the very essence of India. Vendors, setting up shops on the pavement, hawk an incredible variety of wares. Many operate on a shoestring. A dealer in coconuts, for example, may offer only one nut broken into several pieces. Others earn small fees by cleaning out ears or cutting toenails.

As if seen in a kaleidoscope, the pattern changes constantly. Women in saris and men in pajamalike suits stroll here and stop there, while bicycles dart everywhere.

Four-armed goddess Lakshmi, patroness of wealth, good fortune, and beauty, presides over bunches of radishes at Diwali time.

There, Supreme Court Building, built since independence."

With their country imperiled, the Indians' pride knows no bounds. And, indeed, they should be proud, for New Delhi's public buildings—which to so many of them symbolize India itself—rank with the most impressive anywhere in Asia (next page).

But to me, New Delhi often seemed to lack the press of humanity to make it truly Indian. When its green and pleasant spaces became somehow too orderly and antiseptic, I would flee to the hubbub of neighboring old Delhi.

I sometimes look back and wonder what was the most memorable sight of India, the one I would recommend to an unfortunate visitor who could see just one thing and no more. He would probably expect me to choose the Taj Mahal. But I would send him instead to old Delhi, to a street called Chandni Chauk—Moonlight Crossing—and assure him that he would find at least a little there of every kind of thing in India.

This extraordinary street starts only a few hundred yards from the brooding pile of Delhi's 300-year-old Red Fort. At this end of Chandni Chauk stands a strange little hospital, filled always with the soft flutter





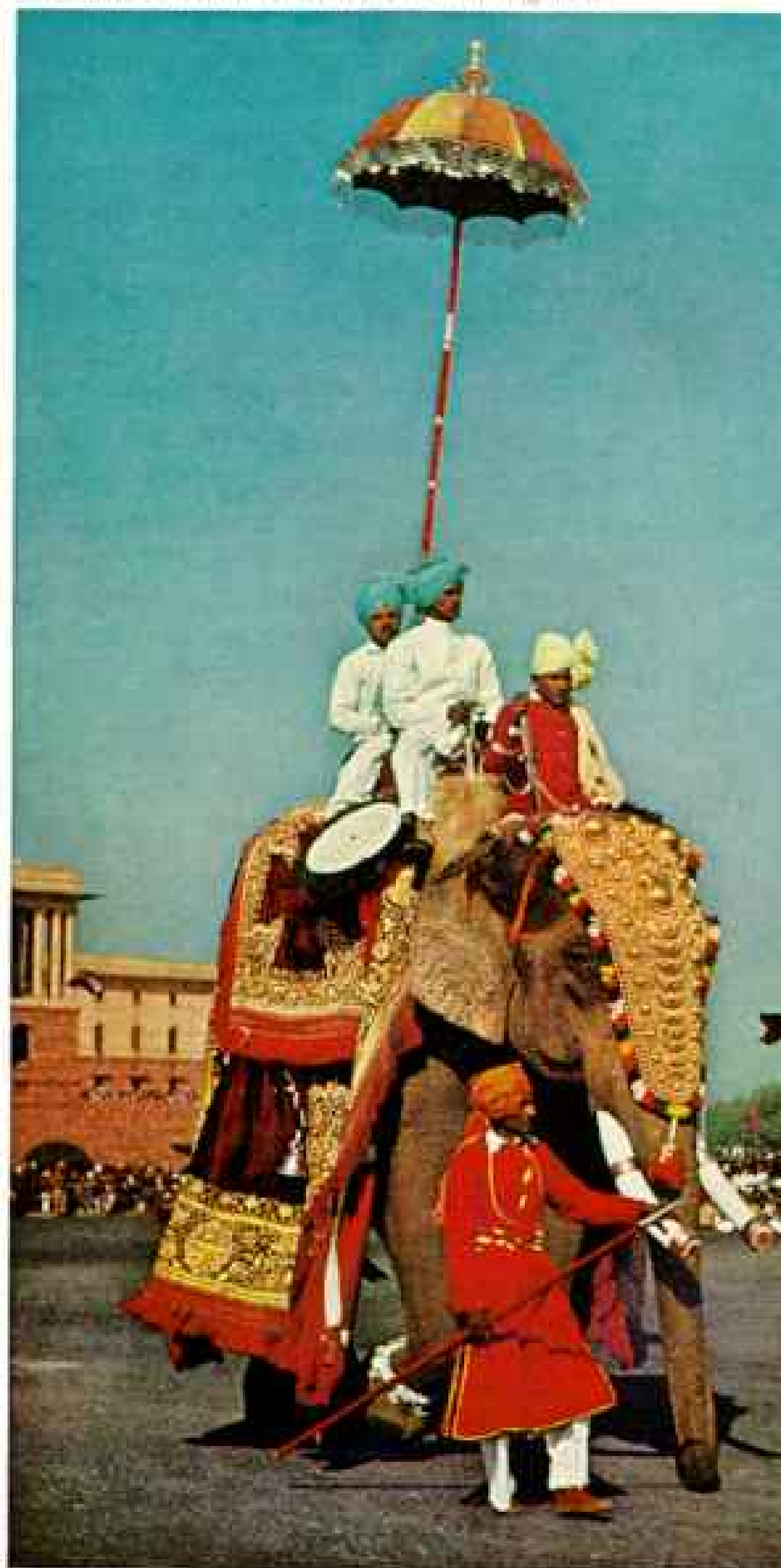


Thousands in New Delhi Cheer Parading *Jateans*, India's GI's

Ropes restrain crowds on the red-bordered Raj Path, or Government Road, on Republic Day, celebrated each January 26 since 1950. Lampposts hold loud-speakers to relay the message of India's President, who lives in the domed Rashtrapati Bhavan (center), India's White House. Dwight D. Eisenhower stayed here during his visit in 1959. Central Secretariat buildings flank the mansion.

Gaily caparisoned elephant carries blue-turbaned musicians. Under the guidance of the scarlet-clad mahout, the beast will lift its trunk in salute to the President.

INTRODUCED BY KILBERT BOY (LEFT) AND RAY ENGLISH (© U.S.A.)



of wings—a haven for sick and injured birds, operated by the Jains. These gentle vegetarians, whose religion stems from Hinduism, revere all living things; often I watched Jain mendicants trudging along the streets wearing gauze masks over noses and mouths lest they inadvertently breathe in some tiny insect and thus destroy it.

At its other end, Chandni Chauk simply ducks through the door of the Fatehpuri Mosque and disappears into the cool spaces of a courtyard.

In the mile or so between the hospital's recuperating birds and the mosque lies a microcosm of all India. Here, streetside barbers squat on the sidewalk of Moonlight Crossing, lathering their customers' dark-stubbed faces; only inches away, bare legs shuttle in unending procession along whatever narrow passageway remains clear. At a corner a man sits raptly, his white *dhoti* pulled daintily in around his ankles, while a member of one of the city's strangest professions, an ear cleaner, swabs his ear with a sliver of bamboo dipped in sweet oil.

Twigs Used as Toothbrushes

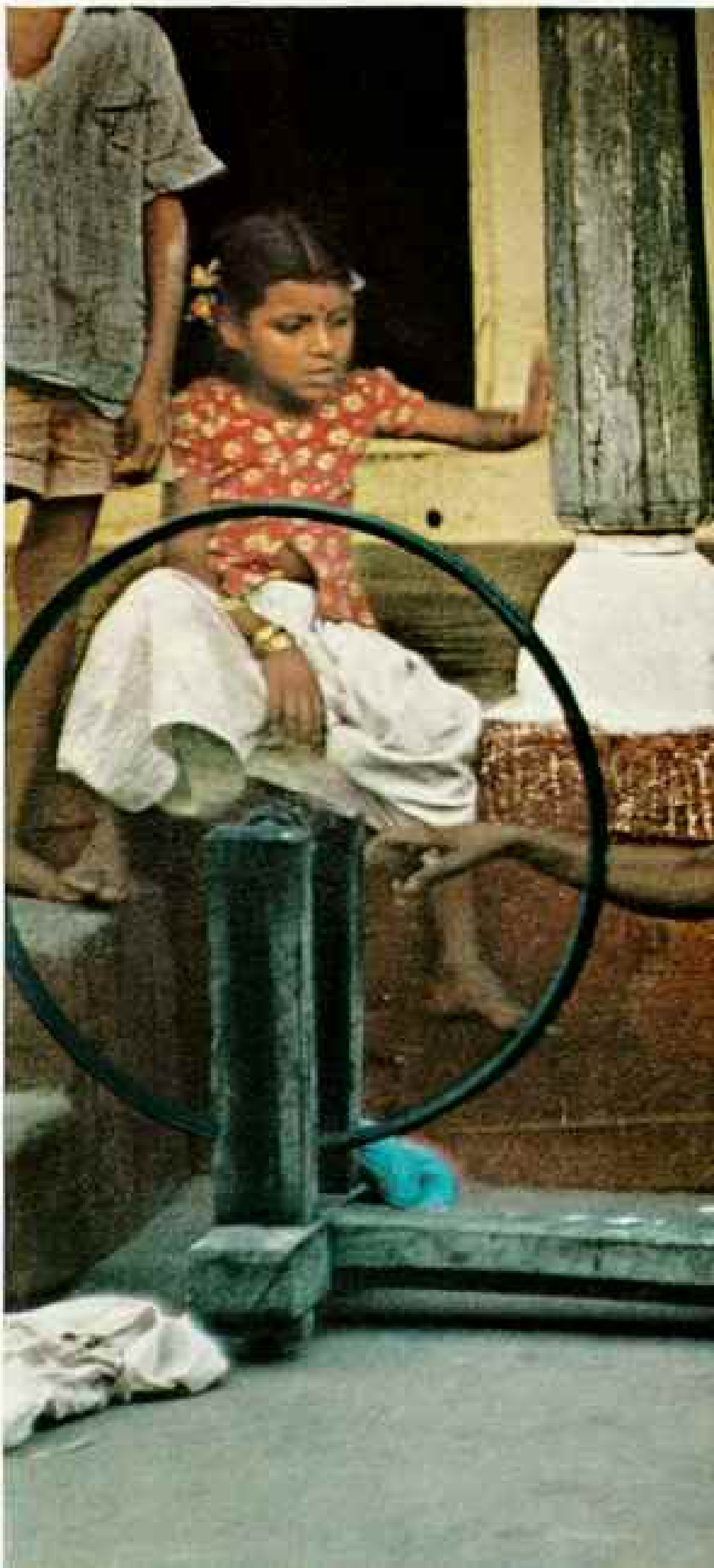
A vendor proclaims the virtues of his *neem* branches, bitter-tasting twigs that serve as toothbrushes. And over there, beyond the basin where all who enter must first wash their feet, and up cool steps of wet marble, squat a dozen bearded Sikhs, weighing out several tons of small coins contributed for the upkeep of their temple.

A few yards farther on, a bored snake charmer wheezes into a gourd-and-bamboo flute, and two cobras wearily spread their hoods. Nearby, a sweeper labors, a member of a caste so low that, until a few years ago, his shadow alone could defile a high-caste Hindu. He bends double hour after hour, pushing litter along the street with a brush of twigs bound together. Why, in so many parts of

India, has no one invented the broom handle?

It is the first morning of Divali, when Hindu merchants pray to Lakshmi, the goddess of wealth, for success during the coming year. I have been invited to the home of a prosperous tobacco dealer who lives just beyond Chandni Chauk to watch the blessing of new account books.

I walk up narrow stairs behind the rustling sari of a child with the enormous eyes of a doe, and enter a room crowded and noisy with good humor. In a corner the new ledgers lie piled. All last year's bills have been paid.



India's Spinning Wheels Symbolize Its Struggle for Independence

Mahatma Gandhi encouraged spinning to stimulate a cottage industry and help end India's dependence on British cloth. The wheel brought fresh income and self-confidence to the people. Top officials, including Nehru, still do some spinning for self-discipline. Members of this family work in their courtyard at Coimbatore, Madras.

The whole family has donned new clothes.

Now a Brahman priest dips his fingers in a red paste and draws on each new book the lucky swastika. Incense smoke coils fragrantly to the ceiling. Rice and flowers pile up before the framed print of Lakshmi. Then, abruptly, the ceremony ends and the priest's face relaxes into a smile.

Rice Grains Carry Sister's Blessing

The merchant bids me goodbye with the Hindu gesture called *namaskar*, palms pressed together, thumbs against breastbone. On his

forehead glows a spot of saffron and oil to which cling a few grains of rice. The rice is a special sign placed there by his sister, who hopes to ward off evil influences by this visible evidence of her love (page 604).

From the cool detachment of the merchant's house I return to the brawling, noisy world below: A cow, dove-gray and dignified, browses on discarded vegetable tops in the street. Behind the animal a clot of pedestrians, bicycles, small automobiles, scooter-taxicabs, and horse-drawn tongas tries vainly to clear a passage.

PHOTOGRAPHS BY JOSEPH NETTI © NATIONAL GEOGRAPHIC SOCIETY



It is always too much. After an hour or two I reel away, senses dizzyed by the impact of so much in so small a space. But, druglike, Chandni Chauk draws me back again and again to ponder the complexities of this ancient land.

40,000 Pairs of Hands Build a Dam

From Delhi I crisscrossed much of India, usually by plane. But periodically the Indian Government commandeered the nation's airliners to ferry troops and supplies to its embattled northern frontiers, and I turned to automobile, bus, or train.

On a flight that took me northwest from the capital I glimpsed Bhakra Dam, one of the immense projects by which India has dramatically changed the face of her land. Water sparkled in a huge reservoir; dynamos, I knew, hummed at the foot of the dam; and canals carried irrigation water to millions of thirsty acres, bringing new prosperity to the whole of Punjab State.

But no work of man—not even a 740-foot-high concrete dam—appears impressive from 17,000 feet. The lake was only a small sapphire glinting behind a tiny wall; the canals were only silver threads winding across a plain.

Weeks later I came to a similar project in the State of Andhra Pradesh, and saw on the ground what I had missed from the air. When I first glimpsed Nagarjuna Sagar Dam, I couldn't suppress a gasp.

The pyramids, I thought—this is how the Egyptians built them.

For here were 40,000 laborers swarming over an immense masonry dam—it will be the world's largest—that promises to change Colorado-size Andhra Pradesh from semi-desert to green fertility (pages 600-602).

Except for an occasional truck bringing boulders to the site, I saw no machines. Endless lines of women swarmed up and down improvised ramps that covered the face of the dam, each carrying a headload of mortar. Pairs of burly men swung 300-pound boulders between them from poles and staggered up the ramps. At the top, masons patiently placed the stones; from afar each one seemed no more than a speck of sand on the enormous structure. And so the dam rose another infinitesimal amount.

Nagarjuna Sagar taught me a great deal about India. At peak season nearly 125,000 people work on the dam and its two immense

irrigation canals. It seemed absurd, at first glance, that this staggering project, which will cost more than \$280,000,000, should rise by a method unchanged since the days of the Pharaohs. But "backwardness" has nothing to do with it.

"We could have built Nagarjuna with machines," explained the young Indian official who showed me the project. "It would have cost no more to import earth-moving machinery and compressed-air drills. But our dam would have been ready no sooner, and our money would have gone to Russia or Germany or the United States.

"By building Nagarjuna with our hands," he said, "we keep all the money in India. This is an important thing in a country that must guard its foreign exchange."

He was silent for a moment. "We had hoped to finish the dam by 1965. Now, of course, who can tell? The Chinese..." He wagged his head sadly.

And how about wages? Exactly how was India distributing this staggering sum among its workers?

"In very small amounts," the young Indian told me. "The women who carry mortar earn two rupees a day. Masons and the men who carry stones, more—as much as six or seven."

At 21 cents to the rupee, this seems little. And yet in local purchasing power—food and *khadi*, the beautiful handwoven cloth of India, for instance—one rupee equals nearly a dollar. In this land of job scarcity, two or three rupees a day for dawn-to-dark labor has been enough to attract workers to Nagarjuna Sagar from Madras, 250 miles to the south, and the unemployment-ridden Malabar Coast, which lies even farther away.

Peace Corpsmen Live as Indians

In Hyderabad, the capital of Andhra Pradesh, I gained a further insight into the Indian standard of living from an unexpected source: the United States Peace Corps. Fifteen of its dedicated volunteers, ranging in age from 19 to nearly 60, have taken up residence at Osmania University, where they live and teach on exactly the same levels as their Indian colleagues.

"Two hundred and fifty rupees—\$52.50 at international exchange rates—isn't much for a month," one of them told me, "particularly when at least half of it goes for food."

Dr. Carl Gibson of Middleton, Wisconsin,

(Continued on page 618)



PHOTOGRAPH BY JOHN SCOFFIELD, NATIONAL GEOGRAPHIC SOCIETY © N.G.S.

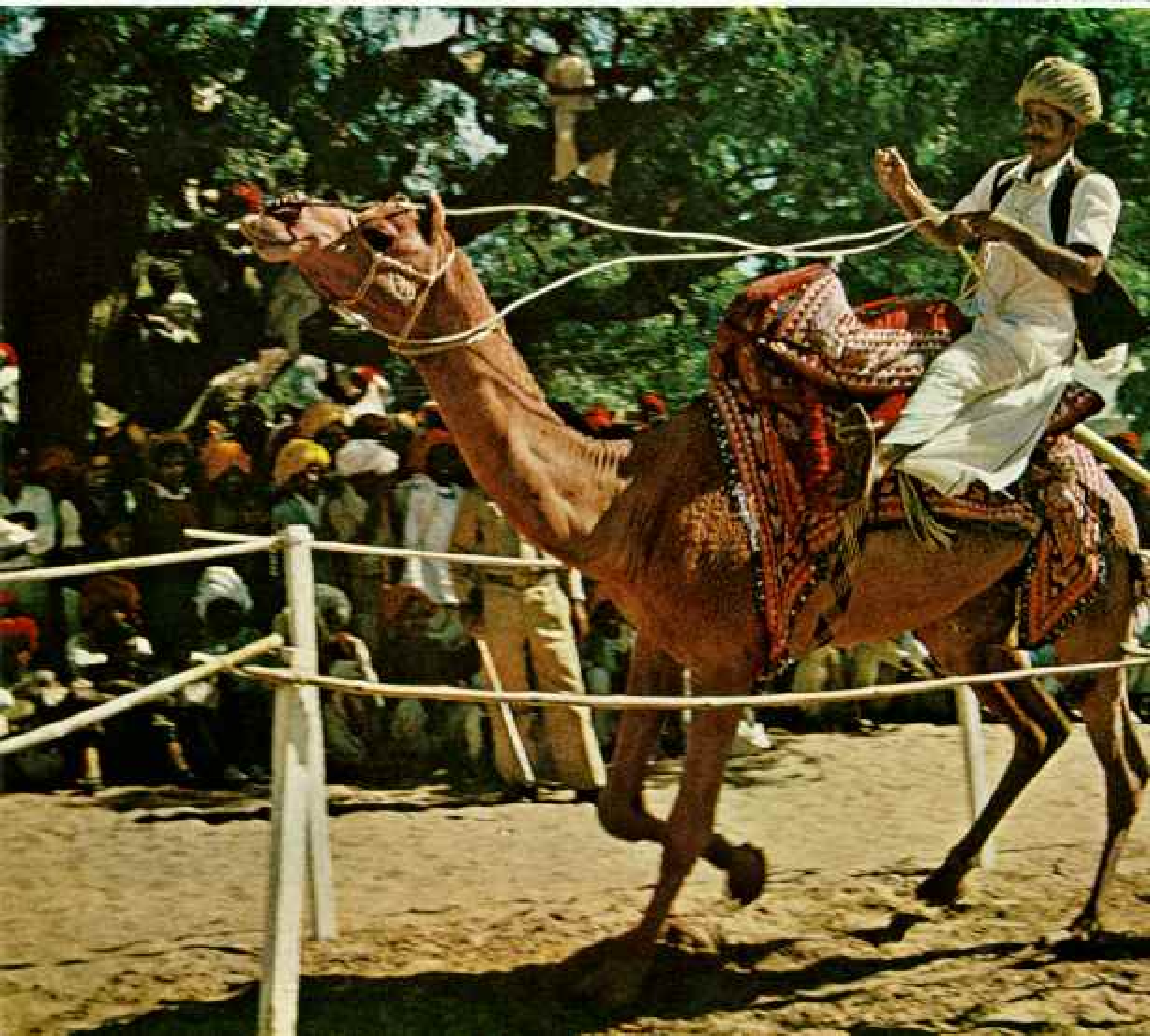
Bangled and jeweled beauty of Rajasthan puts on her finery for a festival. Gold ring adorns a nostril; a fine chain anchors it to an ear. Recently many Indian women donated jewelry and gold to support their country's fight against Communist Chinese invaders.

Rajasthanis make merry

WHEN THE MOON grows full in the fall, some 100,000 pilgrims set out along dusty roads of Rajasthan to bathe at Pushkar in India's most sacred lake. With them go herds of camels, horses, and cattle to be raced and judged at the *mela*, or fair, that accompanies the religious rites. The folk festival, known to Chinese travelers as early as the fourth century, provides a showcase

Handlebar mustache, gold earrings, necklace, and silver bracelet deck a Rajasthani dandy,

Camel racers test obedience, not speed. The winner gets a prize, often books or pencils. When a rider dismounts, he walks down his kneeling camel's neck and jumps off its head.



at the Pushkar fair

of village culture. Women don their gayest skirts and blouses; gold and silver ornaments jingle cheerfully as they walk. Men, descendants of famed warriors, boast of skill in stock breeding.

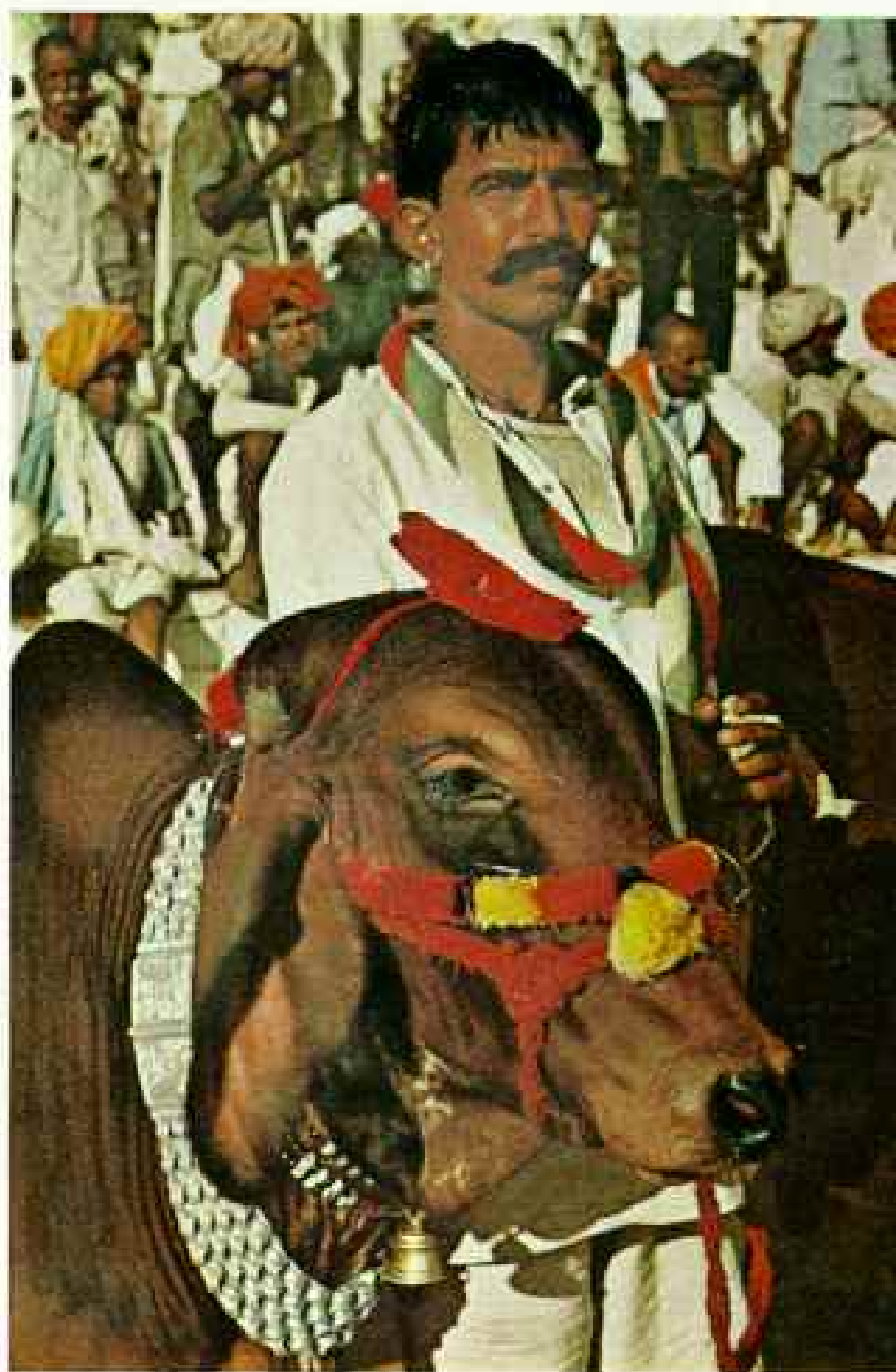
Oiled cattle march with dignity around judging rings, and camels testify to their masters' training skill (below).

Western-style shirt contrasts with turban wound from 18 yards of handmade cotton.

Silver collar and ribbon rosette proclaim a best-of-breed in the cattle contest. Spectators sit on their haunches as cozily as they would in chairs.



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**Cattle and Camels Camp With Their Masters
on Barren Hills Rimming Pushkar Lake**

As far as the eye can see, turbaned stockmen keep watch over their families and animals. Monsoon over, they live in the open air with no fear of rain.



PUSHKAR © NATIONAL GEOGRAPHIC SOCIETY

Water pots, blankets, and piles of provisions identify individual campsites. In many ways Pushkar resembles a county fair in the United States. Peo-

ple of Rajasthan's scattered villages make it a time of talk, an interlude of buying and selling, and an occasion of contest and camaraderie.





Ten Squirring Riders Cling to a Camel, But They Are Too Few to Win a Prize

Groaning and belching in protest, the beast staggers to its feet with laughing Rajasthanis clutching for a hold. The Pushkar fair tested camels' weight-lifting prowess. The question was not how many could mount but how many a camel would accept. The winner rose under the weight of a dozen men.

Clothesline of shirts for sale signifies that a vagabond merchant is open for business on the porch of a Pushkar home. Walls were painted with Hindu deities when the villager moved in with his bride.

Loaded truck rolls over the body of a prostrate man. Pushkar fairgoers wonder how it's done. Dramatically, the performer made a bed of broken bottles on a thick cotton quilt. Lying on the glass, he pulled up another quilt, then invited the driver to run over him. A moment later the man rose and walked away without a scratch. Faith, he said, protected him—but actually a steel sheet concealed beneath the top cover distributed the truck's weight.

ARND BRONKHORST © NATIONAL GEOGRAPHIC SOCIETY



and his attractive wife Jane both teach in Osmania's chemistry department. When I met Jane, she looked particularly chic in the distinctive garb of the Punjab—trousers and a long blouse of handloomed cloth, sandals, and a diaphanous scarf worn across the throat and down behind each shoulder. The style, spreading from the Punjab, has become almost nation-wide among Indian schoolgirls.

"The whole outfit cost less than \$3," Jane explained when I wondered how she and her husband could possibly get along on so little.

"We're given a bicycle each," another Peace Corps volunteer explained, "and provided with a free room in the university."

"Postage is our worst problem," he went on. "At nearly 30 cents for an airmail letter,

we have to hold our correspondence down. But that's the only way we're at a disadvantage compared to our Indian colleagues."

The Peace Corps group impressed me greatly. Not one member gave me a fine speech about self-sacrifice for the sake of humanity; yet I am sure each of them had signed up with deep convictions. And all of them looked forward with genuine enthusiasm to living for two years with Indians, *as* Indians.

Punjab Village Appears Unchanged

The great dams with which India tames her fickle rivers, the burgeoning steel mills, the rising literacy rate, and the around-the-clock pace of her universities, are all obvious signs of a nation on the move. But I think I



Rubies and diamonds embellish chessmen of enameled gold made at Jaipur, jewelry capital of India. Seen actual size, the horse represents the knight; the elephant with howdah, the king; the elephant at left, the queen. The game may have originated in India.

Stone latticework of Jaipur's Palace of the Winds once concealed ladies of the maharaja's court, who gathered behind screens to catch a glimpse of the world.

The red sandstone structure, built two centuries ago, forms part of the Maharaja of Jaipur's City Palace. Top two stories are false fronts.





© DORLING KINDERSLEY NATIONAL GEOGRAPHIC SOCIETY

Hoods spread, five-foot cobras sway with a Jaipur snake charmer to keep his hands in line for a strike. The man performs without danger; he has removed the reptiles' poison glands. He keeps his charges alive with regular feedings of milk and goat meat.

learned even more about India's progress in the place where at first glance it showed the least—in one of her sprawling, dusty villages.

I picked my village carefully, one whose 3,000 or so inhabitants had never asked for help through their government's Community Development Program. Here, I expected, I would find the timeless India, still marching in step only with the rhythms of nature.

At first, as I walked the fields and narrow lanes of Jharsa in the Punjab, 15 miles southwest of New Delhi, I felt that I was intruding on a way of life unaltered for centuries. Cows and water buffaloes contested my right of way. Powdered soil lay so thick in the narrow streets that it spilled in over my shoe tops. Women crouched in courtyards patting cakes of cow dung onto mud-brick walls where they would dry for use as fuel.

Woman Wins Seat on Village Council

A white-clad farmer guided an iron-tipped wooden plow behind a reluctant camel, and a man walked patiently in circles with a team of stately cows, operating a water wheel to irrigate his fields.

With Jharsa's mayor I passed a substantial home on which the builder had carved a figure of the popular Hindu god Krishna.

"Member of *panchayat*, she live there," the mayor said casually.

"She?" I asked.

"Yes," he said. "Widowed landowner."

This was my first inkling that appearances in Jharsa might be deceiving, this revelation that a woman had won a place on the eight-member village council. Woman's lot, I was to learn, has changed in India. Many have been elected to panchayats; a few villages have gone so far as to place themselves under the guidance of all-female councils.

Other surprises marred my picture of an "unspoiled" village. Bags of fertilizer, bought through low-interest loans from the village cooperative bank, filled the corner of a mud-walled barn. And a whirring electric motor raised water from a 60-foot-deep well far faster than the crude wheel I had seen only minutes before.

"Electricity from Bhakra Dam," the mayor explained. One household in four, he said, has electricity. Over a glass of tea he told me more about himself and his village.

"I am college graduate," he said. "Only college graduate who live and work here. People laugh at me. 'You should be teacher,

lawyer. Be a *babuji*—work at desk.' But I like being farmer, working with hands."

He produced a copy of a book, *A Guide to Community Development*, published only a few months before by the Indian Government. From its dog-eared appearance, I guessed that dozens of people had pored over it.

"Sixty percent of Jharsa people can read," he told me.

"Each house pays taxes. Laborer, one rupee each year. Big farmer, five rupees.

"Road you drive in on," he said, "we build. Well for drinking water. School for boys. Now we build one for girls.

"Every man rides bicycle," the mayor said with finality. "Every man wears shoes." For an Indian village, this was prosperity indeed. "You come back in ten years, I think you find a new India."

As we walked back through the lengthening afternoon shadows, I stopped to see Jharsa's boys' school. The headmaster led me toward a shade tree. Under it first-graders sat on mats and chanted words from a simple reader.

"We are short of almost everything," the headmaster said. "No benches; the children must sit on the ground. Over there the same." He waved toward a row of small classrooms.

"No benches," the headmaster repeated. "Not enough books. Not enough teachers. Educated people do not like to work in such a village."

But I think I detected something that may make up for all the shortages. Even among the first-graders struggling with their Hindi A B C's, there seemed to be a determination not to lose out, not to waste a minute of this precious gift. Hardly an eye was raised while I took photographs. Learning to read was more important.

Villagers Try to Catch Up With World

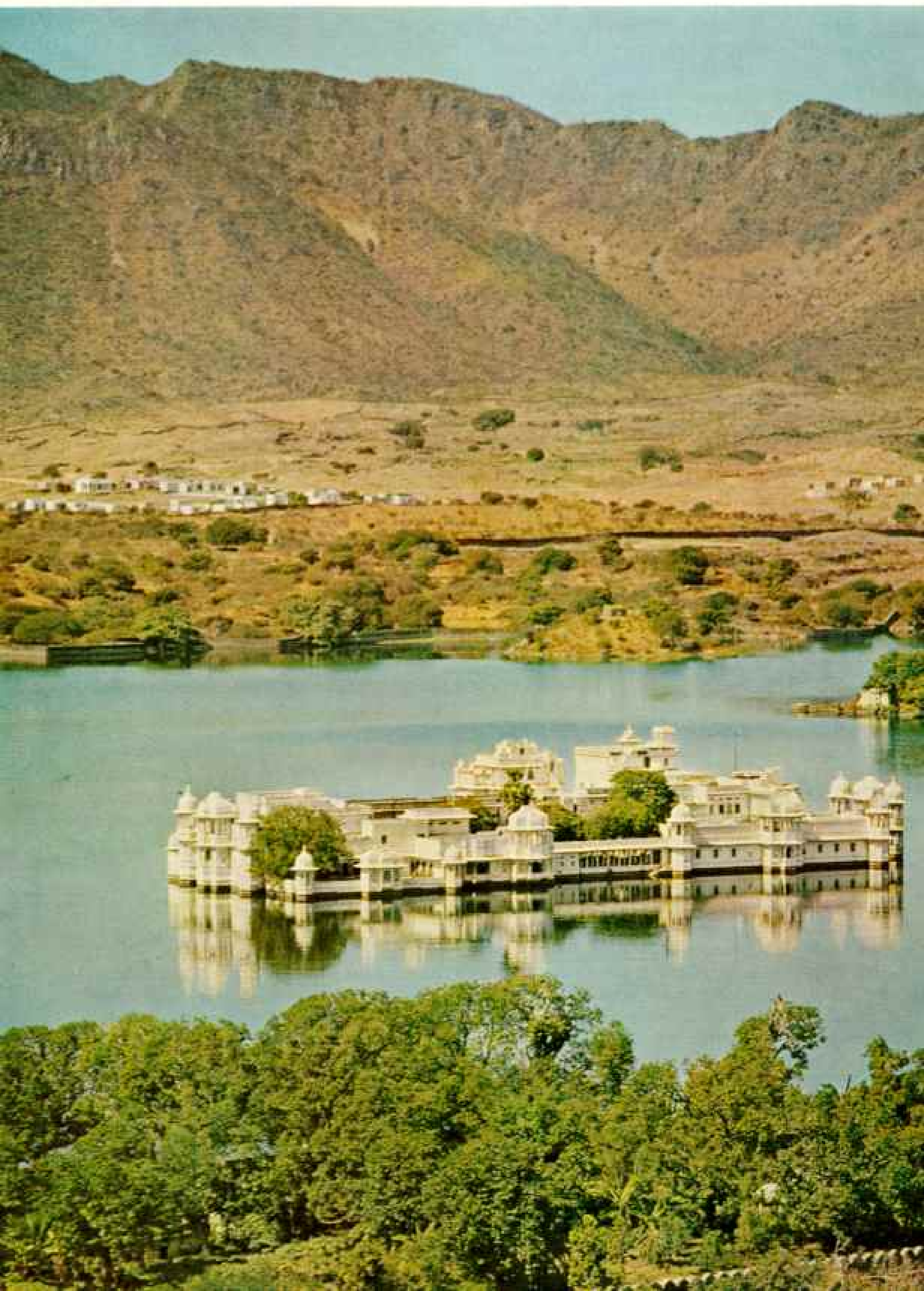
Later I asked a government community-development specialist whether the people of Jharsa were typical of other villagers in this desperate eagerness to catch up with the rest of the world—and in their awareness of how far they lag behind.

"Absolutely," he said. "Some villages have done more, of course, and some much less. But everywhere you will find the same feeling of urgency.

"That's why the Chinese attack has shocked even the farmers so deeply. They want to do

Like a marble boat, the former summer palace of Udaipur appears to float on Lake Pichola. Arid

hills of Rajasthan surround the retreat. Completed 200 years ago, the castle now pays its way as a



hotel. Court beauties took rowboats to the island; today's guests go by motor launch.

ENTAILHORE BY GERRIE WILSON, PHOTO RESEARCHERS © R. S. S.



so much; now their efforts may have to go toward fighting a war instead."

The story was much the same when I visited the friendly herdsmen of Rajasthan State. Fairtime had come, and thousands upon thousands of these bright-garbed tribesmen converged on Pushkar to bathe in its sacred lake—the Rajputs steadfastly remain Hindu despite the tides of Moslem conquest that swept over northwestern India—and to trade cattle, camels, and intervillage gossip (pages 612-17).

Maharajas Rule No More

Sarwan (he assured me he had but one name) peered out from under a *paga*, a turban wound of 18 yards of flaming-pink cotton. From his ears dangled heavy gold ornaments; he wore a massive silver necklace, two rings, and an anklet. An enormous mustache curled impudently above his smile.

How are things in India? Fine!

"Our own man, a chief elected by ourselves, represents us," he told me through an interpreter. "We can borrow money from co-op banks. Before, when the maharajas ruled us, we had to go to a private moneylender who charged 18½ percent a year."

He was groping for all the good things that had happened in Rajasthan since independence, when 22 of India's several hundred princely states had merged and started to march with the rest of the nation.

"And our panchayat, our village council, owns a radio so all can listen once a day in a central place."

Sarwan had recently married. I asked if he could read.

"No," he said. His face became animated. "But now there is a village school. When I have sons, *they* will learn." Then he turned his eyes firmly toward the donkey race that was about to start.

The fair was a huge success. Camels raced, and others struggled simply to rise to their feet, belching and groaning in protest, with their backs covered with riders (page 617). The winner in this hilarious contest managed barely to stand up with 12 turbaned villagers—they must have weighed close to a ton—clinging to his hump and neck.

Fat Indian cattle, totally unlike the scrawny animals I had become accustomed to seeing, competed for ribbons. Although most devout Hindus eat no meat, fine herds are raised here for milk, and as symbols of wealth.

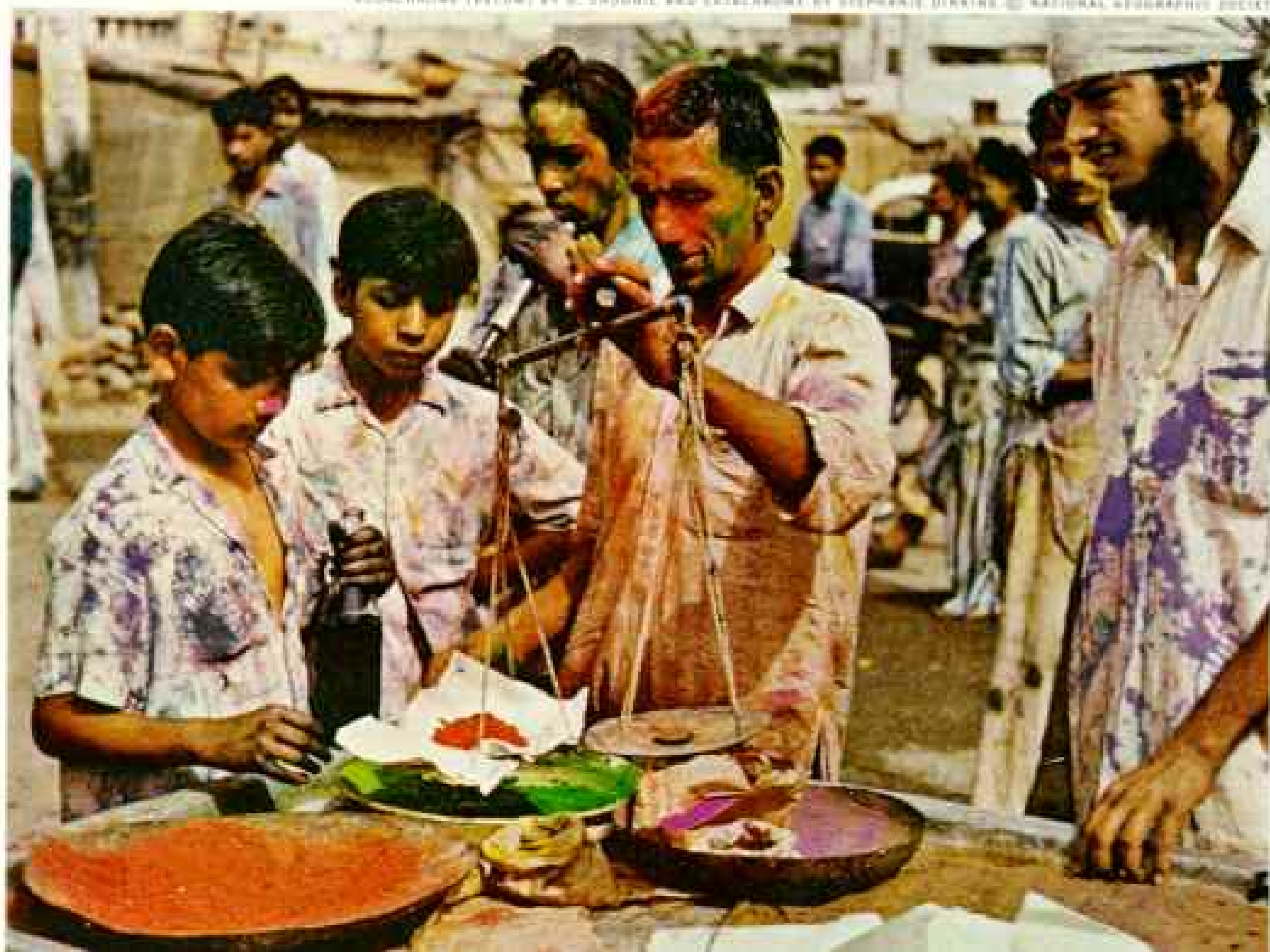
The grand prize winner—a magnificent



Candles outline balconies in Delhi during the gay Diwali festival, observed annually in early autumn. These two Sikhs join Hindus, Jains, and even Buddhists in enjoying the holiday. Indians paint their houses, buy new clothes, exchange visits, and offer prayers for prosperity. Nehru dimmed the last Diwali as part of the nation's austerity program.

Red dye weighed by a vendor will color water splashed on New Delhi celebrators during the riotous Holi festival in the spring. Merrymakers battle with buckets and squirt guns, sparing not even the police. Those lacking dye may even use mud or tar.

RODACHROME (BELOW) BY G. THORPE; RED EXTREMUM BY STEPHANIE JINKINS © NATIONAL GEOGRAPHIC SOCIETY



stud bull—wore a great necklace of hammered silver and garlands of orange flowers that flashed like tongues of flame against the sheen of his black, oiled hide. Silver anklets clanked musically above each foot as he was led before the judges.

The fair ended with a great burst of enthusiasm when Indian schoolboys shouted *Jai Hind*—"Long Live India"—and a muscular Hindu lay on a bed of broken glass and let a truck run across his body.

But even here, amid the fair's gaiety and good humor, the stark side of Indian life showed itself. On the path that led from the fairground to the sacred lake, the figure of a man lay sprawled. Knots of laughing women, wearing red and orange saris that made them look like huge bobbing tulips, swept unceasingly by, not even pausing in their chatter as they picked their way around the motionless form.

The man lay on his side in the dust with one arm flung out, the fingers still gently resting on a brass water jug. He was dead.

I never learned what had happened. No one seemed to know or care. In the end, I moved on, like the others.

Old Splendor Fades in Today's India

It seems a far cry from the dusty hubbub of villagers swarming at a country fair to the legendary splendor of India's past.³ India's policy of absorbing the princely states, which foretold the end of an opulent era, was essential if the lot of the villagers was ever to be improved. For taxes paid a few pitiful coins at a time by millions of simple village folk had supported the maharajas, and little had ever come back to the villagers for the betterment of their bitter lives.

In the swiftly changing India I saw, the last of the feudal rulers must make do with accumulated wealth, plus annual grants from the government that vary from relatively little for the humblest of rajas to a whopping 18 lakhs of rupees—the equivalent of \$378,000—to such ex-potentates as the Maharaja of Jaipur. Even this must seem a pittance; until 1949 he taxed a domain roughly the size of Vermont and New Hampshire but with three times their population.

A few fragments of the old glamour remain. I visited fairyland palaces throughout India. I saw golden howdahs in which maharajas still ride elephantback on their annual appearances before the populace. But for ev-

ery palace still pulsing with wealth and grandeur, another was shuttered and derelict, or soberly earning its keep as a hotel (page 622).

The easiest way to glimpse the lavish past, I discovered, was simply to visit a jeweler. One obliging merchant assembled a whole collection of Jaipur goldwork for me: a richly enameled snuffbox; a cup, graceful as a lily, that had belonged to a Mogul emperor; chessmen, old and new; a massive turban ornament from which a maharaja's ransom in rubies, diamonds, and emeralds had been removed.

Gems Glisten on Golden Chessmen

"This ornament cost me a quarter of a million rupees," the merchant told me. "Who but a jeweler could pay that much these days? To get my money back, I had to break it up and reset the stones in rings and pins—things modern people wear."

Obviously sighing for the good old days, he marshaled a platoon of modern chessmen before me (page 618). One was an elephant of enameled gold. Another, a horse; diamonds glistened around its base. A second elephant had ruby eyes.

"The last set of these I sold went to the Aga Khan—the old one. It was an antique, and cost him \$25,000." The price today, he estimated, would be twice that.

Even today goldsmiths in Jaipur, the capital of Rajasthan, cunningly fashion these gold-and-enamel chessmen; rich visitors sometimes take one home as an \$800 paperweight. And the City Palace of the maharaja still shelters two incredible water jars of solid silver, each taller than a man.

The present maharaja's father, I learned, was an exceedingly orthodox Hindu. During his lifetime he kept several servants busy filling the huge reservoirs from the holy Ganges, for he would neither drink nor bathe in water from any other source.

Snake Charmer Reveals Trade Secrets

But curiously, I remember Jaipur less for its plentiful gold and silver, its palaces, and its candy-pink houses than I do for its snake charmers (page 620). When darkness falls, a dozen or so of these itinerant folk congregate in an eerie little alleyway behind one of the main business streets. I had always been

³See in the NATIONAL GEOGRAPHIC: "Feudal Splendor Lingers in Rajputana," by Volkmar Wentzel, October, 1948, and "In the Realms of the Maharajas," by Lawrence Copley Thaw and Margaret S. Thaw, December, 1940.





curious about this strange profession and dropped by one evening to chat.

Bearded Chotu (like Sarwan at the fair, he used but one name) agreed to talk if I would wait until he finished his meal of *gram*, cooked chick-peas, which he dipped from a brass pot with his fingers.

Chotu's business philosophy was a mixture of poetry and practicality. "The snakes like the music I play," he said, "and do a dance for me." But he was completely realistic about the nature of the three five-foot cobras he carried in his round wicker basket for the benefit of passing tourists.

"When I catch a snake—we always catch our own snakes—I cut out the two little poison boxes it carries in its head."

Many snake charmers do this, Chotu explained, and my illusions about this particular Indian mystery vanished. Cobras live about a year in captivity, he said, with regular feedings of milk and an occasional bit of goat meat. I asked how you feed a cobra, even one whose poison glands have been removed.

Patiently, Chotu told me how he opens the reptile's mouth and pours the milk into its throat through a tube made from a sheep's leg bone. The meat he pushes through the tube with a blunt stick. He was plainly puzzled that a grown man should ask questions to which even a child knows the answers.

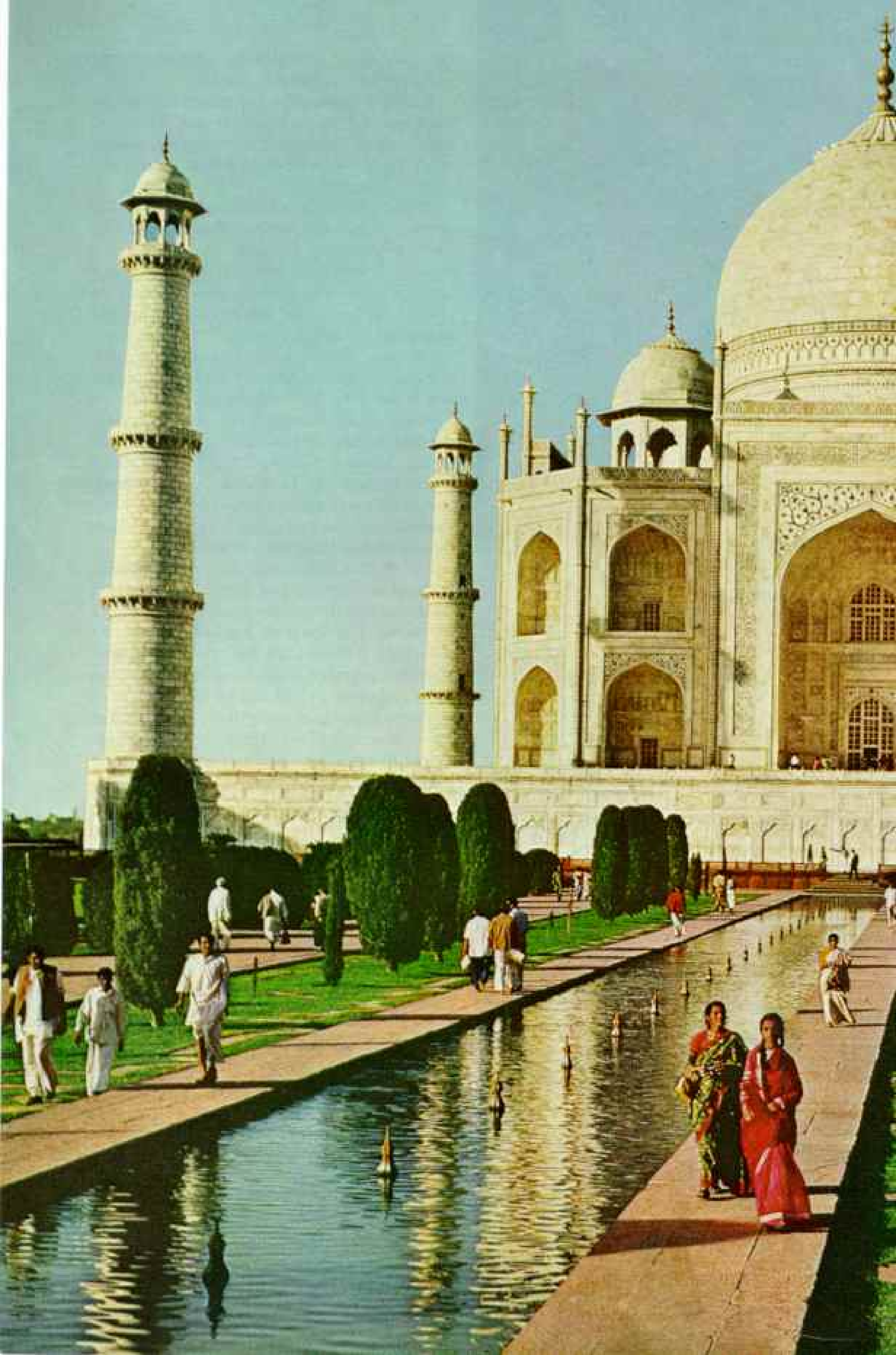
Chotu seemed suddenly ill at ease and broke into a long recitation in Hindi. My friend Ram Gopal Sharma, who had come along to interpret, turned to me.

Huge mustachioed heads will top 80-foot wood-and-paper effigies of Ravana, ten-headed demon king, and his kin slain by the folk hero Rama. During the Dussehra festival in New Delhi, torches set fire to the figures, and exploding fireworks cause the eyes to flash terrifyingly.

EXCERPTS BY S. VISHNU

Melody in Marble, the Taj Mahal Abides in Agra—a Monument to Love

Riches of the Orient awaited his command, but Shah Jahan stood bereft at the loss of his most prized possession, the Empress Mumtaz-i-Mahal. In 1631 she died bearing their 14th child, and the emperor spent 22 years building a tomb in her honor. Diamonds, sapphires, amethysts, and turquoises blossomed into flowers to adorn the walls. Shah Jahan's body lies near that of his beloved under the dome.







Gossamer silver wires, stitched onto silk, add glitter to a pattern of flowers. Craftsman works in Banaras, a city famed for its brocades and embroideries.

Gold Envelops Swaying Dancers on a Brocade Shawl Made in Banaras

Four young men of one family fashioned the two-by-six-foot piece of silk ornamented with pure gold thread. Its cost: \$62. Weaving by hand, they can complete only two inches of such an elaborate pattern in a day.

"He says he has to go now," Ram said. "It's time for his opium."

And so I learned that even the poorest of Indians can sometimes support a narcotics addiction. A snake charmer considers it a lucky day that brings him the equivalent of 30 or 40 cents; Chotu drank a cheap brew made from the outer pods of the opium poppy.

Elephants Wear Wooden Tusks

At nearby Amber, I made a startling discovery. The Maharaja of Jaipur's elephants wear false teeth.

Females, it seems, make the best saddle animals, but their skimpy tusks show up poorly on parade duty. Undaunted, the maharaja's stablemen ingeniously fit the patient beasts with substitutes of wood, painted a convincing dirty white.

Only one elephant at Amber had authentic full-size tusks—a regal giant that shuffled sleepily up and down the steep approaches to the city's rambling 17th-century palace bearing howdah-loads of visitors.



"A male," my Sikh driver whispered and shook his head in disbelief. "The maharaja's personal elephant, being used as a taxi!"

At times like these I thought most often of my ten-year-old son, who delights in everything that lives.

"India is a little boy's country," I wanted to write to him, "where troops of monkeys watch from the roadside whenever I drive by, and men with dancing bears hold out their hands for a coin. If you were here, you could ride a camel for a penny and feed green leaves to

an elephant. We would buy a monkey for \$2, and you could spend your allowance on a cageful of brown birds."

But I never wrote the letter, for he was 8,000 miles away in school, where snow lay high on the windowsills, and it would only have made him unhappy.

Who Designed the Taj Mahal?

Agra, a few hours' drive east of Jaipur, holds a distinction unique even in this land of overpowering spectacles. Men have raised pyramids so that their own careers should not be forgotten, but nowhere else has one created so stupendous a memorial to a beloved wife. The Taj Mahal, on which thousands of masons labored for 22 years, rose so that men should never forget the Emperor Shah Jahan's favorite, Mumtaz-i-Mahal (pages 628-9).

Curiously, historians cannot agree on who designed this most successful of the world's architectural treasures. One points to the Persian master builder, Ustad Isa. Another believes it was Geronimo Veroneo, a Venetian jeweler who lived in India. A third gives the credit to Shah Jahan himself.

Whoever it was, he seems to have thought of everything: that the visitor should glimpse the Taj Mahal first from exactly the right distance and in the right direction; and that the lettering on its face should increase in size as it rises from the ground—thus each letter appears to match exactly the one above and the one below it.

"One thing more," my grizzled guide offered. "Minarets lean ever so little bit out, so if earthquake shake them down, tomb in center not be harmed."

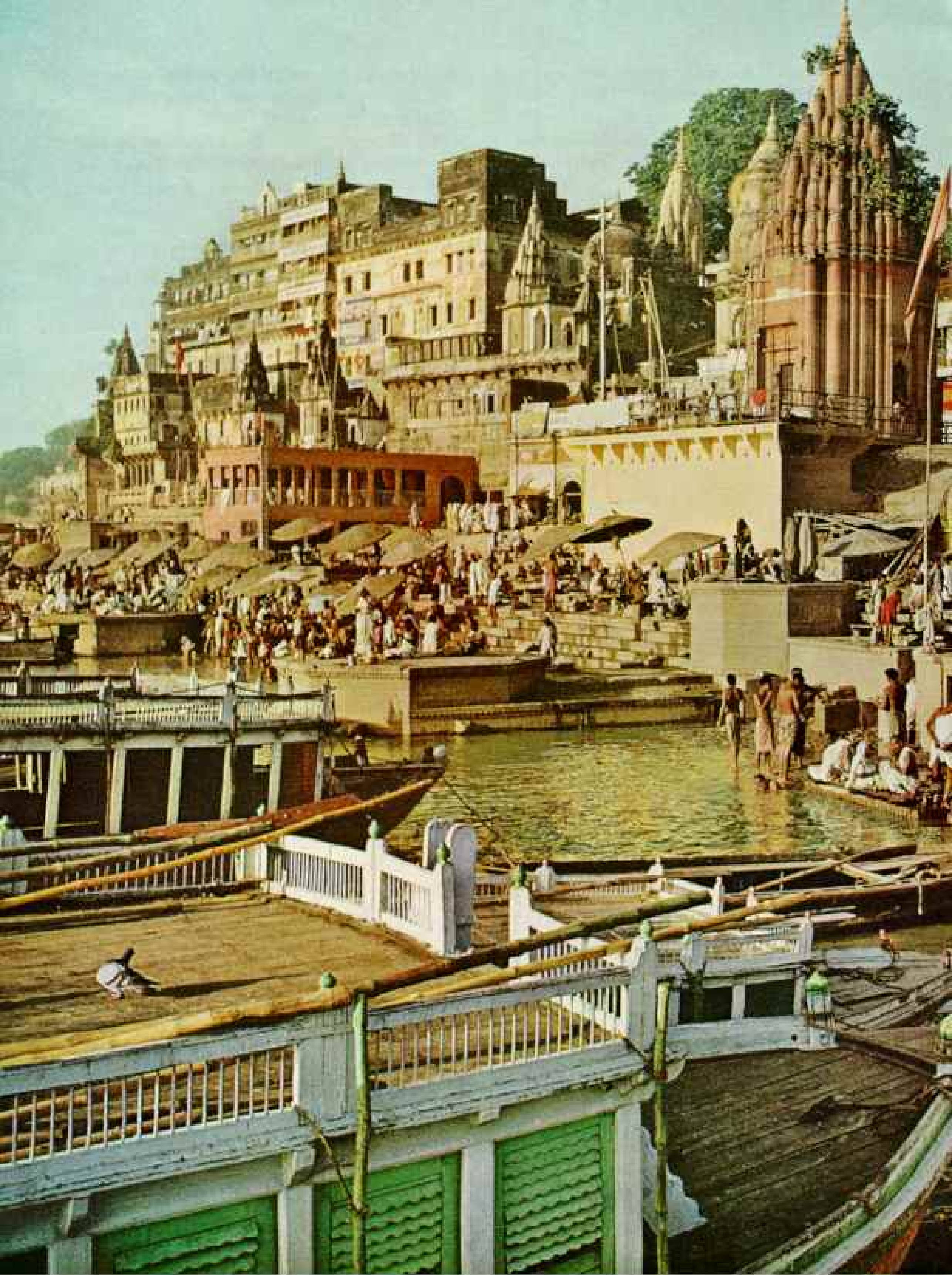
I was tempted to believe him. "After all," he said, "who know better than an old man who spend his life—as my father and grandfather spend their lives—showing people this very place?"

The builder's final triumph lies in the fact that nothing seems able to spoil one's pleasure on first seeing the Taj. It does not matter that no building could possibly live up to the advance publicity the Taj has been given. One doesn't even mind the importuning postcard vendors or the grimy urchins who shriek within the marble tomb itself. "Very fine echo," they shout. "Fifteen seconds."

In spite of it all, the Taj simply floats there, serenely adopting the rosy blush of morning's light and the crisp blue-white of midday, then slowly turning yellow and orange as afternoon advances, and finally seeming to grow taller in the purple haze of dusk.

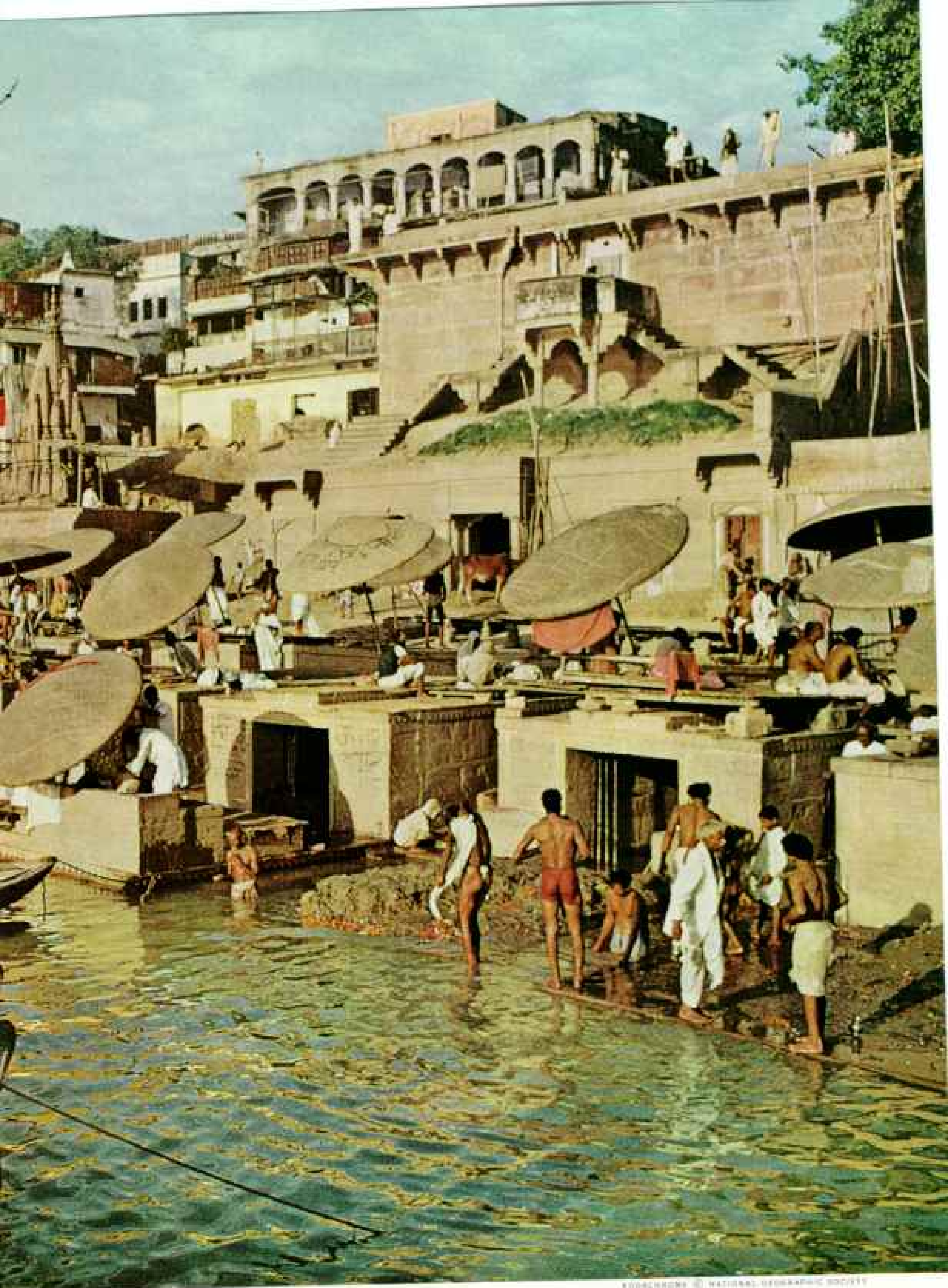
ILLUSTRATIONS BY JOHN BELFIELD, NATIONAL GEOGRAPHIC STAFF © R.G.P.





**Hindu Pilgrims Wash Away Their Sins
in the Ganges River at Banaras**

Born of a goddess's desire to save the condemned, the Ganges flows in holiness from its source to the sea. But at Banaras, religious capital of India, the river's waters take on special sanctity. Each year



STOCKHOLM © NATIONAL GEOGRAPHIC SOCIETY

thousands come here to die in the belief that if their ashes are cast into the stream they will be saved from reincarnation and united with God. Here at the Raj Ghat, or King's Steps, Brah-

man priests beneath straw umbrellas sit ready to administer luck-bearing tilaks. Shops, homes, and temples surmount the bank, and sightseeing boats ride anchoring ropes at the left.

For me, both of India's most moving sights were linked with a common preoccupation: death. But if the Taj Mahal preserves in a supremely personal fashion the love of one man for one particular woman, the burning ghats of Banaras lie at the other pole.*

To the educated Hindu, this teeming city on the Ganges stands supreme as a center of learning, a pleasantly old-fashioned university town. But to simpler folk, who flock in thousands to this holiest of Hindu cities, Banaras holds out a far more dramatic promise.

They look on death as an impersonal and unimportant bit of punctuation along their unending progression: birth, death, rebirth, and death again. If they can arrange to die

here, however, and have their ashes cast into the waters of Mother Ganges, they believe their souls immediately become one with God, free evermore of the cycle of rebirth.

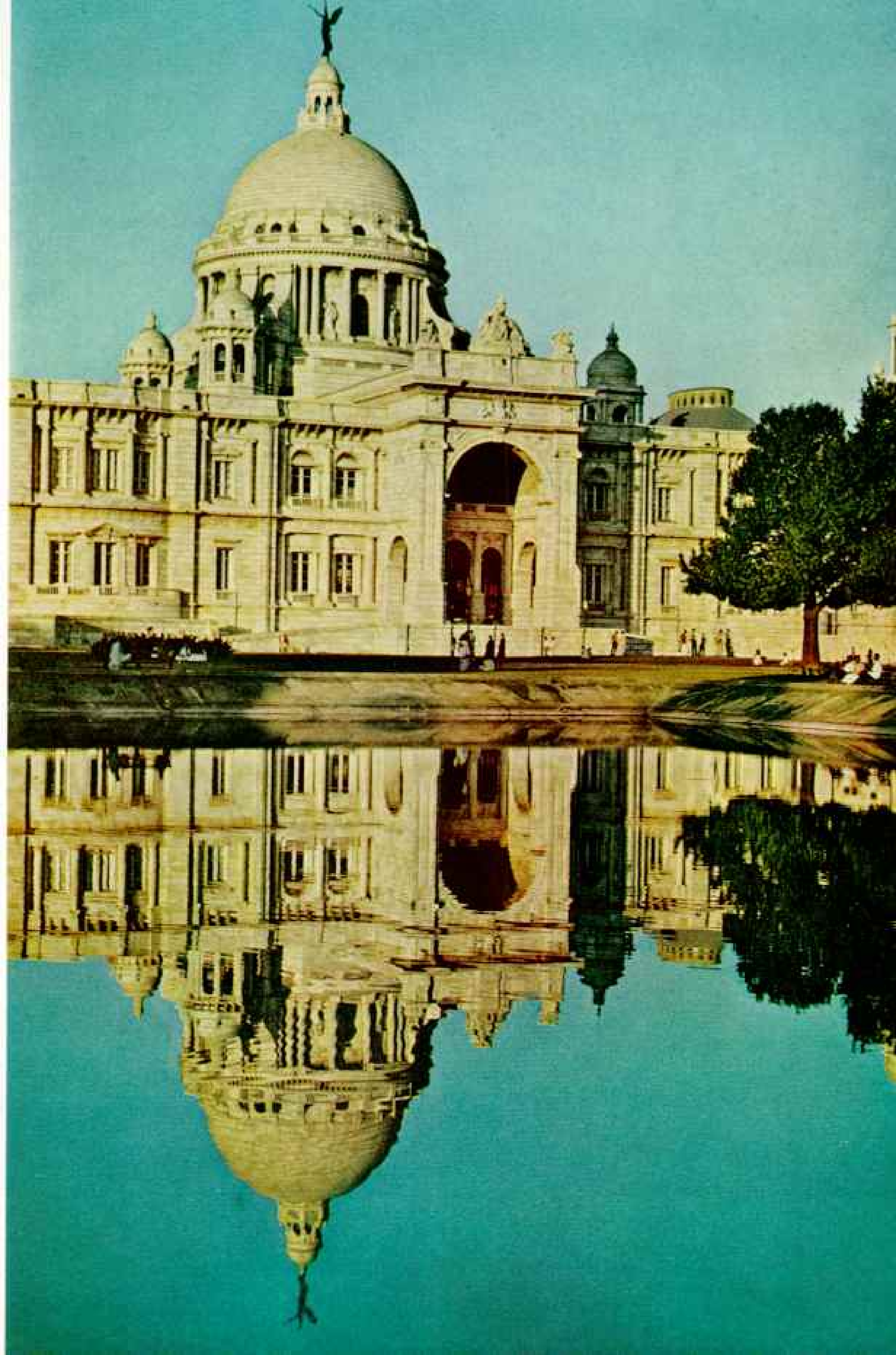
In some curious manner, though, the pall of gloom that should hang over the city never quite materializes. A funeral hurries by, the body borne high on a litter and covered with a length of scarlet Banaras brocade. But instead of a dirge, there is only the cheerful litany of bicycle bells from the swirling traffic that barely parts to let the mourners through. And on the riverbank the heaped bonfires crackle so merrily that I was able to forget the

*See "From the Hair of Siva," by Helen and Frank Schreider, NATIONAL GEOGRAPHIC, October, 1960.

Victoria Memorial in Calcutta: Sixteen years after gaining independence, India remembers its debt to Great Britain and preserves this imposing museum glorifying the history of British rule. Mirrored in a pool, the building dominates the Maidan, popularly referred to as the "lungs of Calcutta." On Sundays hundreds of thousands among the city's millions overrun the park for a sight of grass and trees.

India's made-at-home automobile, a Hindustan Ambassador, rides down the assembly line in a Calcutta factory. Some 85 percent of its components are produced in India, a nation in the infancy of industrialization. The plant turns out 50 of these little passenger cars and 25 Bedford trucks a day.







Commuters Swarm Across Howrah Bridge
Spanning the Silt-clogged Hooghly River

A quarter of a million people, crossing the bridge by foot, bicycle, and bus each day, flow through Howrah (left) to jobs in Calcutta. But suburbs fail



EDDREPHORE BY ALAN SILLIERS © NATIONAL GEOGRAPHIC SOCIETY

to drain off Calcutta's excess of population. Uncounted thousands, such as these bathers, sleep in the streets and grub out their lives on a pittance.

The Hooghly, which makes inland Calcutta a port, poses problems as well. Monsoon floods sweep mud into its bed faster than dredges can suck it out.

shrouded figures lying at the water's edge, awaiting their turns on the pyre.

Early morning is the time to go to the river, when both the living and the dead make their pilgrimages to the sacred water. While mist still rises from the stream and the first peach-bloom radiance of dawn touches the figures lining the banks, the scene takes on the soft unreality of a Whistler landscape. Then, as the rays gather strength, the magic disappears. The Ganges becomes a stream choked with filth, and small boys shatter the last illusion of sanctity with their profane and joyful splashing.

As I wandered the ghats one morning, a Hindu whose hair still streamed water nodded toward the dark river at our feet.

"You really should bathe in the Ganges," he said. "You will find it refreshing as well as spiritually uplifting."

I thanked him and walked on, thinking of the filth dumped into the river by the millions of people living along its banks. But to take a photograph I wanted (page 632), I waded into the turbid shallows.

Cows Nap on City Streets

When I left the river, soaked to the knees by the water of Mother Ganges, an orange-clad priest motioned me to him. Gravely he dipped his index finger into a gray paste of sandalwood and pressed it to my forehead, leaving a dime-size *tilak* to signify my purification in the holy river. Atop it he placed a spot of vermilion, to bring me luck.

I walked back slowly through streets choked with cyclists, scooter-cabs, horse-drawn tongas, and the inevitable sacred cows that in Banaras sometimes give the impression of outnumbering people. The Banarasi who was showing me through the town shifted his wad of blood-red betel nut—Banaras is famous for its fine *pan*, and almost the entire male population chews this mild narcotic—and nodded toward a family of cows that stood in rapt meditation while traffic tried vainly to get around them.

"If anyone in Banaras got independence in 1947," he said, "it was the cows. Since the British left, a law was passed that no cow may be slaughtered in this holy city."

But no legislation protects the animals from labor. While some doze the day away, blocking the busiest streets, others pull enormous high-wheeled carts loaded with firewood for the burning ghats, or walk endlessly up and down ramps drawing water.

At least one Banaras cow makes a living



Blocks of Offices and Apartments Attest the Building Boom in Bombay

India's most modern city owes its prosperity in part to expert management by a 131-man Municipal Corporation, which directs progress from the onion-domed building at right.

Crescent-shaped Marine Drive calls to mind Rio de Janeiro's fashionable Copacabana Beach. A ring of satellite industrial centers suggests Los Angeles and red double-decker buses duplicate Hong Kong's.

Drama unfolds in India's movie mill, whose 300 feature films a year rank second in quantity only to Japan's; the United States is third. Distributed in a dozen languages, Indian films show to audiences in Asia, Africa, the West Indies, and the South Pacific.

Here in Bombay, the Hollywood of India, director H. S. Rawail (center) coaches stars Sakhana (right) and Ameeta in *Mere Meh-boob* ("Beloved Mine").



PHOTOGRAPHS BY JOHN SCOFFIELD, NATIONAL GEOGRAPHIC STAFF © N.G.S.





Like a mirage in the sky, Himalayan peaks float above Darjeeling, which warily surveys

for its owner as an entertainer. The first time I saw it, the animal, clad in a jacket decked out with cowrie shells, paced restlessly within a tight knot of bystanders.

"The cow will identify the owner of any object," a skinny Indian announced.

While an assistant held his hands over the animal's eyes, the man collected a scarf, a wristwatch, and my eyeglasses. He put them in turn on the animal's back. It stopped first before the owner of the scarf, then beside the owner of the watch, and finally placed its head gently against my chest while I retrieved my glasses.

"Which of these two men owns the most expensive watch?" the owner of the cow asked, and pointed to my Indian friend and me. The

cow trotted around the circle and stopped before me. I would have sworn that it was eyeing my Swiss underwater watch.

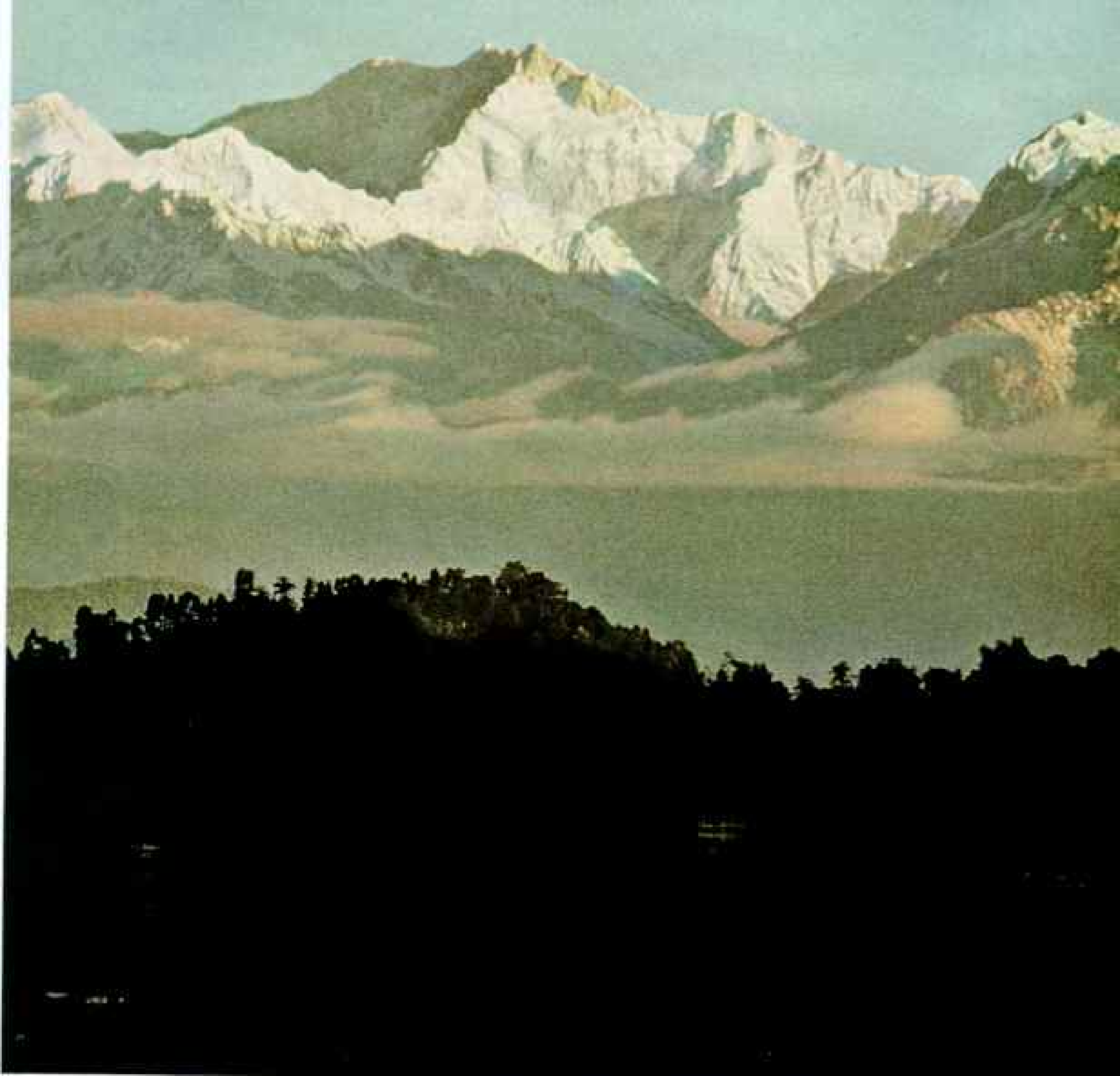
The crowd seemed supremely unimpressed by this second feat. After all, they seemed to say, what American does not own an expensive watch?

How was it all done? I haven't the faintest idea.

Misery Stalks India's Largest City

If Banaras at least has sanctity to compensate for its squalor and human misery, Calcutta lacks any saving grace—or so I thought on first acquaintance with this appalling, unplanned metropolis.

One afternoon, I remember, I walked down



ESKALAPHOVE (BOYS); BY JOHN SCOPFIELD, NATIONAL GEOGRAPHIC STAFF, AND ESTACHHOVE BY GEORGE HOLTON, PHOTO RESEARCHERS © N.G.S.

Tibet, Nepal, Sikkim, and Bhutan

Gilt box hanging from the neck of a young Tibetan refugee holds written Lamaist prayers. Her family fled from Tibet after China invaded the country in 1950.

Old Court House Street. A ruby-studded dagger in the window of Hamilton's venerable jewelry and silver shop caught my eye. The price tag was 7,650 rupees—more than \$1,600.

That night, strolling the same block again, I stepped over seven of the city's thousands of homeless people, shrouded like mummies, lying asleep on the pavement.

Calcutta is like that.

The city desperately needs housing. Of Greater Calcutta's 6½ million people, at least





20,000 literally lack any kind of shelter. For another 100,000, life is so wretched that they actually prefer the sidewalks to the hovels.

Periodically, cholera and smallpox break out among the city's packed masses. For months every year the Hooghly River becomes little more than a tidal estuary. The water on which Calcuttans must depend for all their needs slops back and forth with the tide, becoming filthier and more odorous as the hot, dry months pass.

During the monsoon, when rain finally arrives to swell the river, silt comes too. The river entrance is now so shallow that ships must come and go barely half loaded.

And there are the refugees. First came the thousands fleeing Bengal's disastrous famine of 1943, hoping desperately to find food in

the city. Those who survived stayed on. Then, in 1947, when India split into separate nations (maps, pages 662-3), Hindus began an exodus from East Pakistan that still continues.

Calcutta's ring of industry has drawn thousands of others. One resident in every two has come from somewhere else; whether refugee or immigrant means little to the men who try to solve the city's problems.

Refugees Make Home in Rail Station

Busy Sealdah Station, one of two railway terminals through which the city inhales and exhales a third of a million people a day, provides the most dramatic example of Calcutta's ills. When the human flood from East Pakistan crested in 1948, half a dozen families sought shelter in the center of the main hall,



ESQUADRONED BY JOHN BOFFIELD, NATIONAL GEOGRAPHIC STAFF © N.G.S.

Horse-drawn Tongas in Srinagar Vie With Pedestrians, Bicycles, and a Jeep

Citizens cross the First Bridge over the Jhelum River, a broad thoroughfare in the canal-fretted summer capital of Kashmir. Snow-blanketed Pir Panjal Range rises to the west.

Since the Chinese attack on nearby Ladakh, Srinagar moves at a faster pace. Its airfield serves as a depot for transshipment of military supplies. The drone of aircraft fills the skies, and soldier-driven jeeps nose through narrow streets.

Last year, for the first time, trucks drove from Srinagar to the 14,235-foot-high Chushul airstrip in Ladakh.

Steppingstones lead across a pool in Shalimar Garden, onetime retreat of Mogul emperors and now a public park near Srinagar.

where passengers had to climb over and around the refugees' tattered possessions to buy a ticket.

Now, nearly 15 years later, refugees still cling desperately to the same pitiful squares of space. The original squatters and their successors moved on long ago, but replacements always appear.

Calcutta Draws Ambitious Plans

I talked to one of Sealdah's squatters, a thin, middle-aged man from Dacca, in East Pakistan, who wore only a soiled dhoti and a sacred thread diagonally from shoulder to waist that marked him as a Brahman, a high-caste Hindu.

He had been a cloth merchant, he told me. I asked why he had left East Pakistan.

"Fear," he answered simply. "Nearly all the other Hindus had already left. I was afraid because I was alone."

That was three years ago. Now he and eight

(Continued on page 648)



India presents a sample of its 440 million faces

PEOPLE are India's pride—and problem. The nation's myriad faces all have mouths to feed and eyes that look questioningly for what the future may bring to a land that mixes automobile factories and wooden plows, jet aircraft and crossbows.

India is atomic physicists at Bombay and Naga tribesmen in Assam. It is ruby-decked maharajas and ragged street sweepers, Oxford-trained philosophers and unlettered farmers. It is tough Sikh soldiers, peace-loving Jain monks, Hindus, Moslems, Zoroastrians, Christians, Buddhists, and Jews. India wears fedora and fez, turban and Gandhi cap, the latest London fashion and the simplest loincloth. It speaks more than 800 languages and dialects, ranging from the Hindi of millions to Assamese tongues used by as few as half a dozen.

644

EDDACHIRIWE BY JOSEPH KETTLE



Lady in red, a 3-year-old of Trivandrum, accentuates her eyes with kohl, powdered antimony. Her parents, like millions of other Asians, believe the cosmetic protects eyes against disease.



Glass beads, bells, and nose stud adorn a Lushai woman living near Burma.

Hindus from central India bear staffs on Republic Day in New Delhi.



ERTAIKHOKE BY GEORGE HOLTON, PHOTO RESEARCHERS © NATIONAL GEOGRAPHIC SOCIETY

Quilt dealer in Jaipur puffs his hubble-bubble, which filters the smoke through scented water
Painted nose and forehead mark an Assam dancer leaning pensively across her drum.

ERTAIKHOKE BY WILLIAM E. HUBBARD



Male dancer from Orissa, a state in eastern India, wears make-up and long hair.





ETHNOGRAPHY BY ELLIE BERGAN, FOR © N.E.A.

Curls and tattoos mark a Toda woman. She embroiders while men do the cooking.

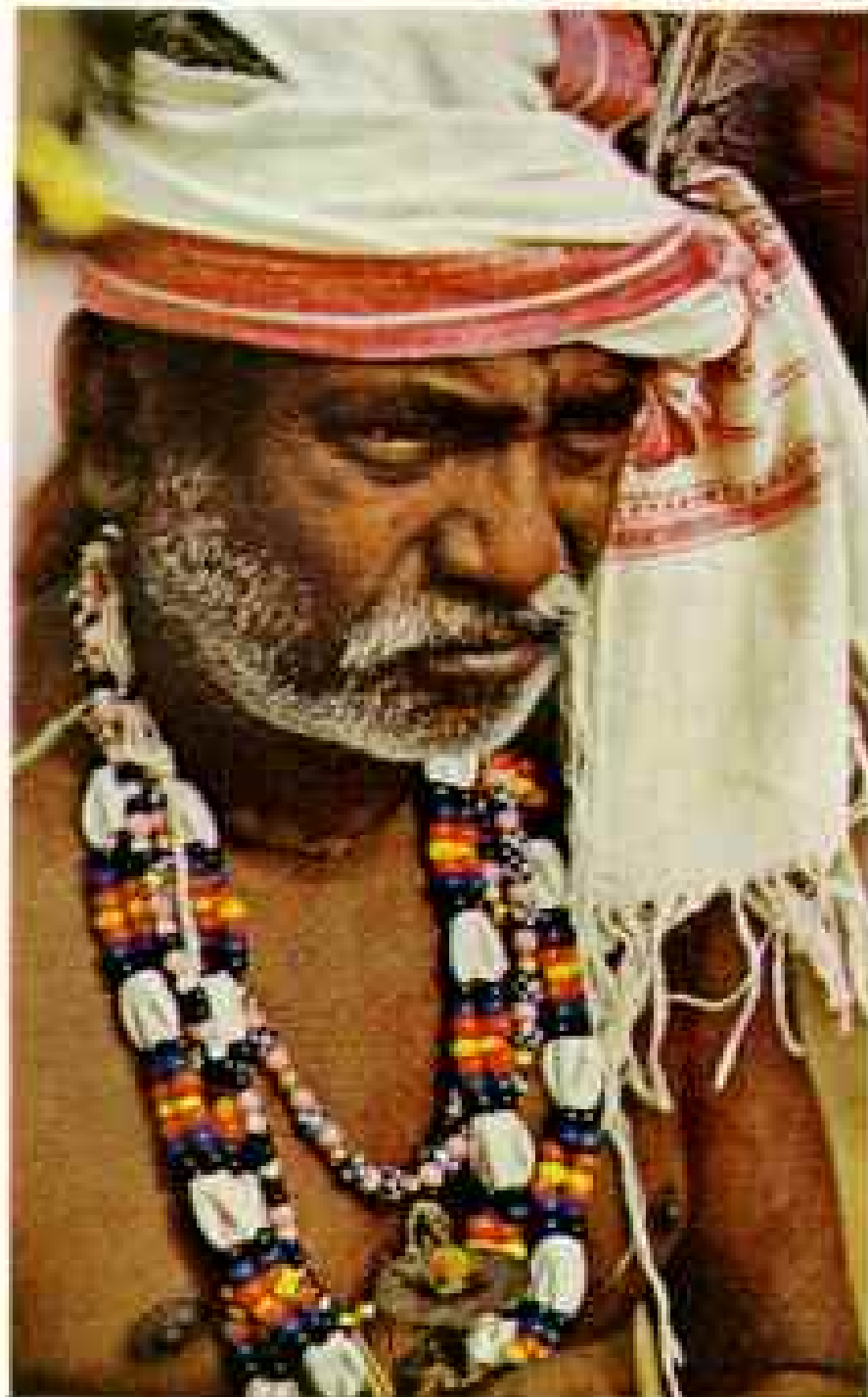
Woman of the north wears her wealth: huge gold nose ring and pounds of silver.



ETHNOGRAPHY (LEFT AND UPPER RIGHT) BY WILLIAM D. HERRICK

Bamboo-splint headdress proclaims a Naga, proud owner of a new wristwatch.

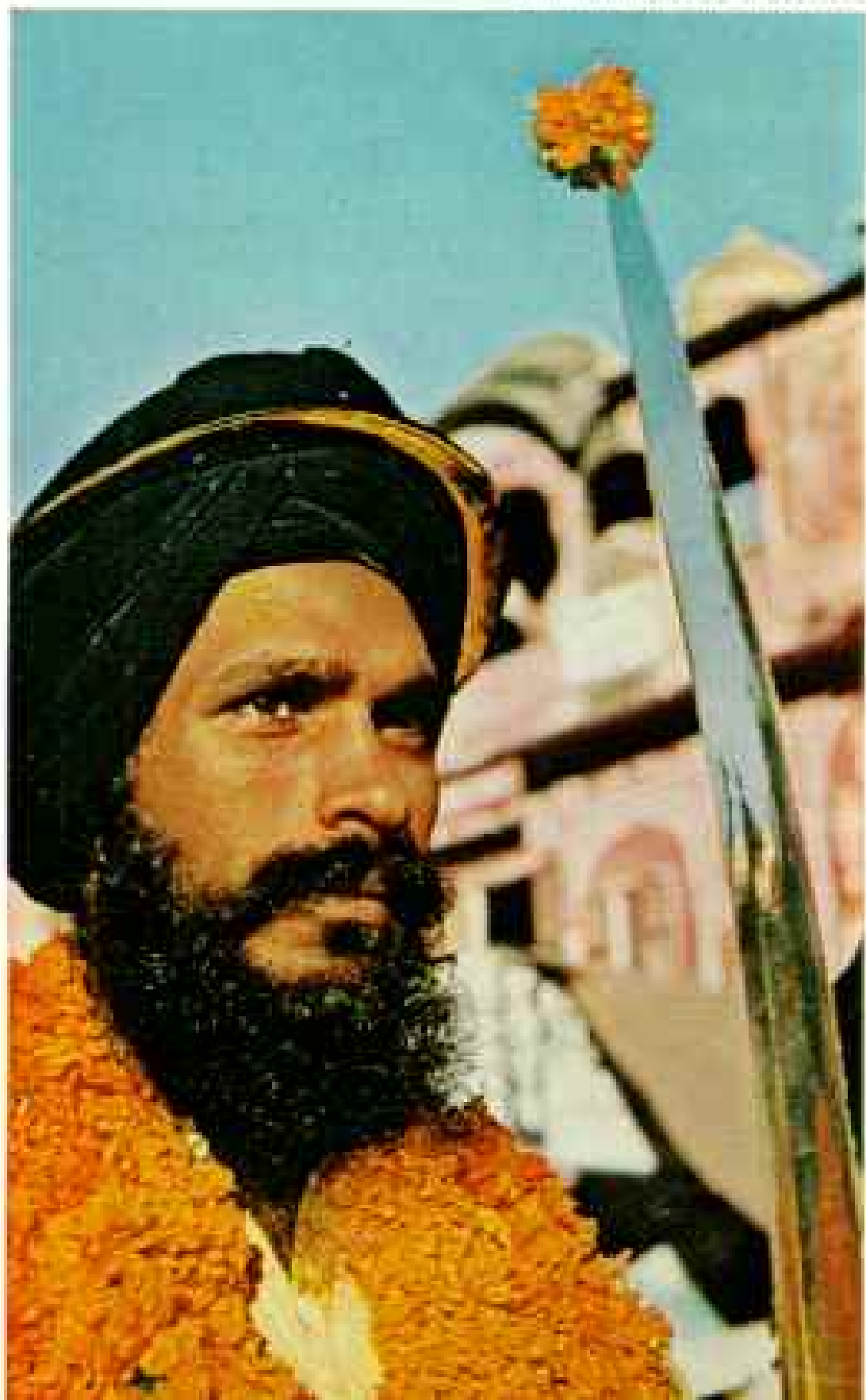
ETHNOGRAPHY BY VALERIE ROY

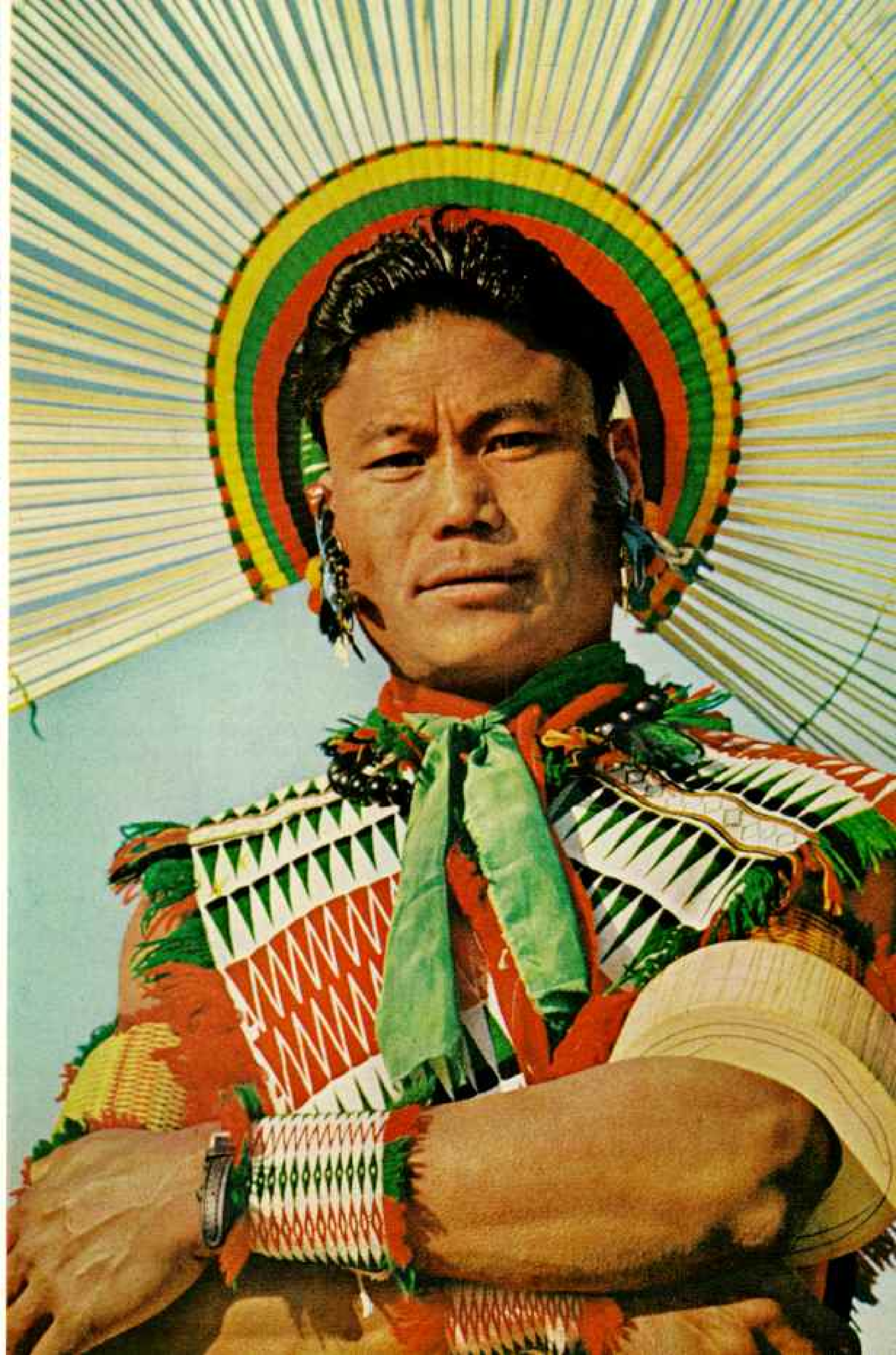


Bright beads deck the chest of a man from Uttar Pradesh, on Nepal's border.

Marigold tips the sword of a blossom-costumed Sikh festival-goer in Jaipur.

ETHNOGRAPHY BY JOHN SCOTLAND





family members barely manage in their strange preserve marked off from the station's ceaseless human traffic only by a line of battered bricks. He hawks fruit on the street; his wife and eldest daughter work in a factory making medicine droppers. Together, the family of nine scrapes together 80 or 90 rupees—about \$2 per person—a month.

Calcutta's catalog of problems seems endless. "In fact," said Lt. Gen. D. N. Chakraverti, who heads the city's Metropolitan Planning Organization, "name a difficulty a city can have, and we have it!"

But Calcutta does not intend to stand still. In a downtown office lined with maps and

plans for proposed housing developments, I listened for most of an afternoon while General Chakraverti's city planners told me what they hope to do.

Already, some progress has been made. Cholera has been reduced from one case per thousand people a year to a tenth of that figure. Forty million dollars has been earmarked for low-cost housing. Work has started on an ambitious project by which some of the Ganges River's abundant flow will be diverted into the lower Hooghly. Some seven years from now, Calcutta's water problem will have been solved. Hopefully, the added water will also eventually sweep away the accumulated silt that now chokes the river.

I think Calcutta will eventually overcome its problems, incredible as they are. For, within sight of the squalor and misery blossom wealth and industry (page 634). Though the seat of government was moved to Delhi 52 years ago, Calcutta stubbornly remains a hub of Indian vitality and the most Indian of the subcontinent's great cities.

After the raucous clatter of old Delhi and the inescapable misery of Calcutta, Bombay came as a pleasant shock. This huge doorway on the Arabian Sea radiates cleanliness, efficiency, and obvious wealth (page 638).

I found Bombay rich, too, with

Life-size Statues Swarm Over a Temple in Madurai

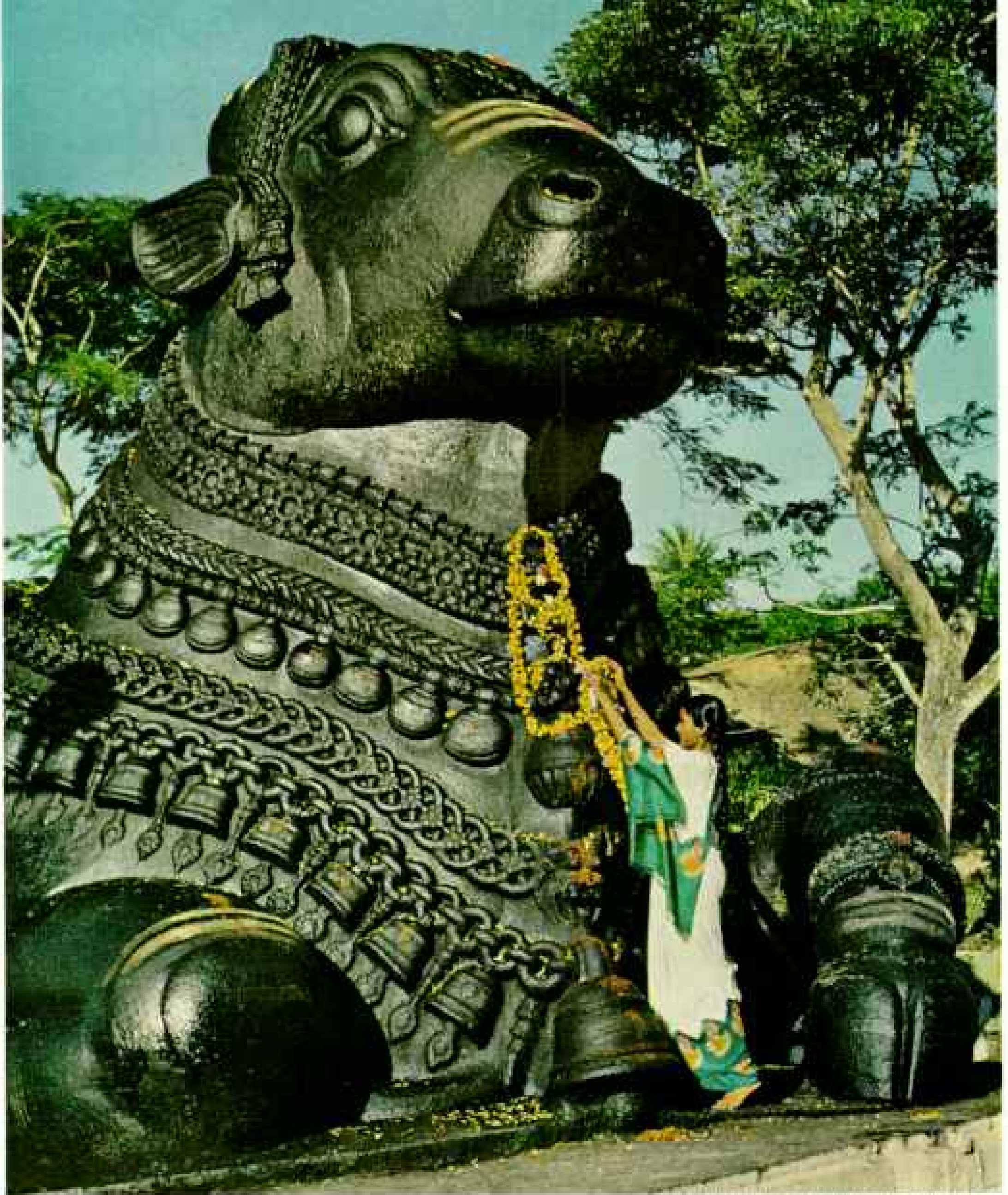
Like the carvings on Europe's Gothic cathedrals, the decorations of Hindu temples illustrate sacred texts for people unable to read them.

Glowing with fresh paint, these plaster figures tell the story of Minakshi, the fish-eyed goddess, consort of Siva. Hindus recently donated \$378,000 to refurbish the temple, which their forefathers completed in 1660.

Muscular figures support a corner of a temple in Madras.







STYLING: PHOENIX © NATIONAL GEOGRAPHIC SOCIETY

Hindu Pilgrim Offers Garlands to Nandi, Sacred Bull of Siva the Destroyer

Carved from solid rock, the 16-foot statue in Mysore bears the striped mark of the god on its head. Since 1659, the pious have kept the bull glistening with oil.

echoes of other cities. Its red double-decker buses and streetcars reminded me of Hong Kong. The dramatic arc of seaside apartment buildings along Marine Drive carries a strong hint of Rio de Janeiro. And a sacred cow would not look more out of place on London's Piccadilly Circus than it would amid the rush-hour traffic of solidly British Flora Fountain. In fact, Bombay was the only Indian city I visited where cattle do not enjoy undisputed right of way.

"Where are the cows?" I asked when I met

soft-spoken Dr. Nagindas N. Shah, a general practitioner then serving a one-year term as mayor of Bombay. Dr. Shah looked pained, as if this were a question he would much rather I had not asked. I sensed that the opposition of orthodox Hindus, who revere the cow as a mother, had made this a difficult problem for the city's 131-man Municipal Corporation to solve.

"Well," the mayor said finally, shrugging his shoulders, "animals are simply not allowed to wander about in metropolitan Bombay. We

are the only Indian city with such a law."

The mayor's expression brightened. "We have also built a government-financed dairy farm where 16,000 animals are cared for." This compromise, I guessed, was how city officials had been able to carry out so revolutionary a reform.

Bombay was not always India's wealthiest city. It started life as so fever-ridden a pest-hole that the European who survived two of its torrential rainy seasons was considered lucky.

"Not knowing what else to do with it," a Bombayite told me, "the British leased the city to the East India Company in 1668 for ten gold pounds a year.

"It was your American Civil War that gave us our start," he said. "When the Federal blockade closed off Southern ports, the world turned to India for cotton. Our cotton brokers grew wealthy overnight."

Even so, over-all prosperity was slow in coming; the city's 1881 census contrasted the misery of Bombay with the wealth and glitter of Calcutta. Fortunately, Bombay's affairs had been taken over by a band of dedicated industrialists and businessmen who formed a Municipal Corporation. I am sure they would be proud of their city if they could see it today.

Darjeeling View Spans Five Countries

Wealth, creating opportunity, has drawn all kinds of people to Bombay. Parsis, Jews, and Christians vie with Hindus and Moslems in the city's affairs, making it one of the most cosmopolitan places in the world. The visitor can hear dozens of languages and dialects spoken; ten of them, the mayor told me, are taught in Bombay's elementary schools.

Contrasts account for much of India's impact on the first-time visitor. I can think of none more striking than that between the prosperous, business-as-usual atmosphere of Bombay and the tensions that grip the snowy frontierlands of the Himalayan and Karakoram ranges.

Darjeeling occupies perhaps the only site on earth where five countries can be seen in one vast, heart-stopping panorama. Standing in India, I could look west across Nepal to Mount Everest on Red China's Tibetan frontier; directly ahead, the awesome mass of Kanchenjunga towered majestically out of the Sikkim Himalayas (page 640); to the east rose the mountains of Bhutan.

If the Chinese Communists decided to make a third thrust into India, everyone believed,

Sari-clad technician efficiently assembles a telephone at a factory in Bangalore; nearly completed instrument rides the belt in foreground. More and more Indian women are leaving the home to work in the nation's growing industries.



ILLUSTRATION © NATIONAL GEOGRAPHIC SOCIETY

it would most likely be here. And so Darjeeling and its smaller sister, Kalimpong, blacked out at night; it was an eerie feeling that took me back in memory to London blackouts of nearly twenty years ago. And the Chinese residents of the two towns, most of whom had lived there for years, had been bundled unhappily off to a detention camp on the hot plains of Rajasthan. Their shops and restaurants took on an oddly forsaken look; even when Indian employees were left behind, few customers ventured in.

In Kalimpong one rainy morning, I spent an hour in the local market, which partakes of almost every region of Central Asia. Close-cropped Bhutanese housewives jostled muscular Sherpas; bright-eyed Nepalese elbowed



ILLUSTRATION BY JOHN BULLFIELD, NATIONAL GEOGRAPHIC STAFF (ABOVE AND LOWER PAGE)

Covered freight boat, plying canals through verdant tunnels of palms,

Sikkimese and the local Bhotias. And always there were the Tibetans, cheerful as ever despite having fled their homeland ahead of the Chinese Communists.

Some of them had set up pitiful little street-side displays of their few remaining possessions: here a loose handful of turquoise beads, there a pair of embroidered felt boots. I spotted an elaborate silver butter lamp, looking strangely out of place amid piled cakes of dried yaks' milk.

"I don't want to sell the lamp," the handsome Tibetan woman told me, "but there is no food in the house."

Now I have a butter lamp, and the Tibetan woman has eaten—for a time, at least.

Back in Darjeeling, I called on genial, English-speaking Gyalo Thondup, an older brother of Tibet's exiled Dalai Lama, to learn more about the problems of these unhappy refugees.

"Tibetans have some firm ideas about places to live," he said. "They are accustomed to cold high plateaus, and find the heat of India difficult.

"The Government of India has been most understanding," he went on. "We had hoped to settle a great many Tibetans in the North East Frontier Agency, but that was exactly where the Chinese decided to invade India.

"Now my people are desperately frightened and think they will have to flee again. You saw them in Kalimpong, trying to raise a few rupees by selling whatever they had left."

U.N. Patrols a Disputed Border

Tensions were evident, too, the minute I stepped from my plane in the mountain-ringed Vale of Kashmir. Overhead, Indian air freighters droned clumsily eastward shuttling weapons and supplies to jawans fighting for



AND JOSEPH BETTIS © N. G. B.

ties up in Quilon, Kerala State

their lives in neighboring Ladakh. And a white jeep with the foot-high letters "UN" painted on it reminded me of another quarrel in this Central Asian hot spot—the long-standing feud over ownership of Kashmir itself, two-thirds of which India holds.*

In 1947 Britain's largest Asian domain elected to become two sovereign nations. Since then, India and its Moslem neighbor, Pakistan, have eyed each other warily across a 500-mile "cease-fire line" in Kashmir, patrolled by United Nations observers today representing 11 neutral lands.

"This is an uneasy frontier," a Swedish observer told me. "Last year there were nearly 600 incidents when Indians and Pakistanis exchanged fire across the line. Sometimes

*See "The Emperor's Private Garden: Kashmir," by Nigel Cameron, NATIONAL GEOGRAPHIC, November, 1958.



Young fisherman welcomes a visiting photographer with a smile and a gift. He caught the small crab in his net.

Balancing on a crude log raft, fishermen dare the surf near Madras. Before approaching shore, they lowered their tiny lateen sail.





Hollow square of British redcoats in 1780 resists an Indian assault in Madras State during the second Mysore War. Mounted lancer at right breaches a human barricade. Headless horseman at left keeps his saddle. Hand-to-hand combat at lower right pits bayonet against knife. Water carrier at center douses a flaming caisson. Col. William Baillie, who later died an Indian prisoner, directs the defense from his palanquin.

Painted on a wall of Tipu Sultan's palace at Seringapatam, the panel celebrates the destruction of Baillie's 3,700-man brigade by Hyder Ali, Tipu's father. Tipu's death in 1799 during an attack on Seringapatam ended the Mysore Wars, allowing Britain to consolidate her rule over south India.

military units get into the arguments, but even then they make few headlines.

"This is a forgotten war," he said. "After fifteen years, even the local papers are too bored with it to print anything."

I paused on a teeming street in Srinagar, the mile-high summer capital of Kashmir (page 642), to copy from a big orange-and-black billboard. JAMMU AND KASHMIR STATE IS AN INTEGRAL PART OF INDIA, it proclaimed in English in letters three inches high. IT HAS BEEN SINCE TIME IMMEMORIAL & SHALL CONTINUE TO BE SO ETERNALLY.

A Kashmiri wearing a boat-shaped cap of Persian lamb watched me take my notes, then laughed.



COUCHMAN BY JOHN TEBBEL, NATIONAL GEOGRAPHIC STAFF © R. A. A.

INDIA

RELICS UNEARTHED in the Indus Valley prove that a distinctive Indian culture existed there at least 5,000 years ago. Over the centuries, waves of invaders—Aryans, Greeks, Turks, Mongols from Central Asia, Persians, and Afghans—swept into the subcontinent, each to leave its mark and be absorbed in turn. Modern India, still reflecting these influences, preserves a heritage that gave the world its “Arabic” numerals and the first cotton textiles. From Indian sages came Hinduism and Buddhism, which claim nearly half a billion followers.

Today, Indians make up a seventh of humanity. They strive to raise their living standards by adopting industrialization from the West. Two things



thwart them: too many people on too little land, and a bellicose Red China on their northern frontier.

The massive Himalayas wall off India from Asia's heartland. Desert marks the northwest; brushy hills form a central plateau. Only the narrow coastal strips and teeming river valleys offer level, arable acres.

OFFICIAL NAME: Bharat, in honor of a legendary emperor. **GOVERNMENT:** Republic in British Commonwealth; 16 states, 6 territories. **AREA:** 1,259,995 square miles. **POPULATION:** 440,316,000, a complex mosaic of peoples varying from Indo-Aryans in Kashmir to nearly black Dravidians in the south. **LANGUAGES AND DIALECTS:** More than 800. About 40 percent of Indians speak Urdu or Hindi. English official at least until 1965. **RELIGION:** 85 percent Hindu. **ECONOMY:** Leads world in tea, sugar cane; second to China in rice. Mines iron ore, manganese, mica, coal, bauxite, and chromite. Chief industries—textiles, chemicals, steel. **MAJOR CITIES:** Greater Calcutta (6.5 million), Greater Bombay (4.2 million), Madras, commercial centers; Varanasi (Banaras), Agra, cultural centers; New Delhi, capital. **CLIMATE:** From arctic to tropical. **FOR INFORMATION:** Information Service, Embassy of India, 2107 Massachusetts Ave., N.W., Washington 8, D.C.

“Don't believe a word of it,” he said. He waved gaily as he walked on, shouting over his shoulder, “It is all propaganda.”

Before I could finish, another man had sidled up. He looked at me darkly. “We would vote tomorrow to join Pakistan—if we could vote. We are nearly all Moslems here.”

After a few days, I left the Vale of Kashmir. Ironically, I remember it now less for its role as an international trouble spot than for its landscape. Kashmir will live in my mind as a place of infinite peace—a high valley of apples, pears, and walnuts, with the *chinar* trees turning to New England reds and yellows in the autumn chill, and all around, the snowy barricade of the Himalayan peaks.

As I often do, I saved what I hoped would be the most idyllic part of my journey through India for the last. “If you miss the south,” one of my colleagues had warned, “you won't have seen India.”

At first I found the charm of this traditional, rather sleepy region difficult to describe. And then the answer struck me: its “Indianess.” While northern India had to busy itself for centuries surviving—and eventually absorbing—tides of Turkish, Mongol, and Persian invaders, the south quietly perpetu-



KODACHROME © NATIONAL GEOGRAPHIC SOCIETY

ated a Hindu world largely unmarked by these alien forces.

Today south India remains a land of palms and sea, a place of soaring temples, of elephants being scrubbed in roadside pools, and of village girls whose complexions glow like polished mahogany.

The southwest monsoon ends later the farther south one goes. When I came to Madras in December, I felt rain for the first time in nearly two months. Clouds dappled the sky; all day a moist breeze rustled the palms overhead and stirred the young rice as if it were the close-cropped hair of a boy.

Madras, like Calcutta and Bombay, lives by the coming and going of ships. Indians,

though, think of it more for its attainments of the intellect: the poets, philosophers, and scientists it has given the nation.

From this gateway to south India, I traveled to many places. There was the pleasant spaciousness of Mysore with its fairyland palace; its elephants that shuffled softly along the streets carrying their lunches—quaking bouquets of mimosa branches balanced on their tusks; and its uniquely fragrant “factory,” where \$100-a-gallon sandalwood oil starts its long journey to the perfume makers of the world.

Burgeoning industry makes nearby Bangalore (its name means “town of boiled beans”) seem a part of another age. Here a modern

factory turns out telephones for the nation (page 651); other factories create electronic equipment and machine tools. I asked to visit India's only aircraft plant. "Sorry," I was told, "it has been declared off limits," and I remembered suddenly how far I had traveled from the Chinese invasion and the fears of the distant northern frontier.

I sped through Ootacamund, a queer little relic of the Britishers' nostalgia for their distant homeland. "Ooty's" cottages and pastures lie 7,500 feet up in the lovely Nilgiri Hills of Madras State.

"Just like Surrey," a retired English army officer assured me, and waved toward misty "downs" where sheep grazed contentedly. I believe even a pack of foxhounds still makes its headquarters there.

Now that my journey has ended, I remember so many things about south India: The endless flow of lithe, dark-skinned people appearing for an instant in the headlights' beam at night, and then disappearing. The oranges and the fat, stubby bananas that were better than any others I have ever tasted. The brave fishermen of Madras who dare the stormy Bay of Bengal in frail rafts of logs lashed together and propelled by a tiny lateen sail (page 653). The head-wagging gesture that seemed, at first, to mean neither yes nor no; eventually I came to recognize it as the south Indian equivalent of "okay."

Most of all, I remember the State of Kerala and its Malabar Coast. Even after the delights of the rest of south India, the spice-fragrant

backwaters of this southwestern shore came as a special delight. But I would be less than honest to call this beautiful land a paradise. Jobs have not kept pace with education—Kerala's literacy rate ranks as India's highest. The "educated idle," particularly in Kerala's major port, Cochin, have fallen prey to discontent and its handmaiden, Communism.

Kerala has other troubles: leprosy and that merciless scourge of tropic shores, elephantiasis, which afflicts so many that residents know it as "Cochin leg." And yet it was difficult to keep my mind on problems when the landscape and even the people so often reminded me of that other never-never land of the Far East, the island of Bali.

Sea Brought World to Malabar Coast

Kerala and Malabar have always turned their faces to the sea, whence have come the many cultures that have left their stamp on this oddly different bit of India. Here may have been the "Ophir" to which King Solomon sent ships in his search for peacocks and apes and gold. Phoenicians visited these shores, and Greeks and Romans. The daring Portuguese arrived—Vasco da Gama touched here in 1498—and then came Dutch, French, and English.

I was reminded, in an odd way, of Kerala's strong ties with the sea when I visited Varkala, whose venerable temple dozes in a palm grove noisy with the cadence of waves.

Inside I found it not unlike temples I had seen elsewhere in India. But beside the shrine

Wading in ooze, women gather rice seedlings for transplanting near Tiruchchirappalli, in Madras State. Rice-short India eats more than she grows, even though she plants a third of the world's rice acreage. The subcontinent raises some four thousand varieties.

Itinerant blacksmith in Madras fits two shoes on each cloven hoof of a working bullock. He throws the animal on its side, ties its legs, and props them up. After shoeing the upper hoofs, he rolls the animal over and finishes the job.





a priest hammered on a huge bronze bell that looked strangely alien. Sure enough, I found an inscription in antique Dutch around its lip: ZEELAND: 1757 PIETER VAN BELSEN / MIDDELBURG MICHAEL EVERHARD.

Later I heard the story of Varkala's temple bell. Generations ago, when European merchants regularly sent their ships to southwest India for spices and cotton, a Dutch sea captain found himself becalmed off Varkala, within sight of the little temple resting in the shade of its palm grove. His ship's bell, cast by Pieter van Belsen and Michael Everhard only a few years before in Middelburg, in faraway Holland's province of Zeeland, hung silent in the calm.

One day blended into another, and no breath of air stirred the vessel's sails. Desperate, the captain sought the aid of Varkala's priest.

"My ship's bell is for the temple," he vowed, "if there will be some wind for me to make a move on."

That evening, the story goes, a breeze filled the Dutch ship's sails. She moved away from the Indian shore to start her long, hazardous voyage back to western Europe. And on a return voyage, the captain brought the bell ashore and saw it hung beneath the eaves of Varkala's temple.

Outwardly, little has changed along this magical coast since the voyages of Vasco da Gama. Lateen-rigged sailing ships swing idly at anchor off a dozen storied beaches.

Glittering crown and mask-like make-up distinguish a *kathakali* dancer in Calicut. Performed traditionally by men who spend years learning the stylized movements, *kathakali* dramatizes major episodes of the *Ramayana*. Singers unfold the story, and percussion instruments throb out the rhythm. Performances may last all night.

Make-up man devotes hours to painting a *kathakali* dancer's face. Different colors reflect the character of the deities being portrayed. Dancers often red- den their eyes by placing egg- plant seeds under the lids.

A Portuguese mariner of 450 years ago would recognize them instantly, though the Indian fishermen who sail them have no idea that their two-masted *machius* preserve almost unchanged the lines of a 16th-century caravel.

Crisp white churches, built centuries ago by the Portuguese, stand in startling contrast to palms and dark backwaters. And the lures of bygone centuries still draw mariners to Cochin port. The fragrance of cardamom, ginger, and pepper fills the city's warehouses, and its harbor echoes around the clock with the rattle of anchor chains.

To art-conscious Indians, the glory of Kerala and the Malabar Coast lies chiefly in the ephemeral values of the dance. For here originated south India's famed *kathakali*.





Surf pounds Cape Comorin, southernmost tip of India. Hindus take ritual baths

In Calicut—Indians know this venerable port on the Malabar Coast as Kozhikode, but its Portuguese name lingers on in the word “calico”—I watched nearly all of one night as gifted male dancers enacted the ages-old tales of Hindu mythology.

Despite the demands it makes on an audience (the performance I saw lasted nine hours) and despite the competition of the movies, kathakali has a devoted following. As many as a couple of thousand people sometimes forego sleep for a whole night to watch one of these marathon entertainments.

Kathakali, literally translated, means “story acting.” Wearing elaborate costumes

and facial make-up that requires hours to apply, kathakali’s versatile dancer-actors tell their story in stylized pantomime.

I asked C. V. Subramanyam, Secretary of the famed Kerala Kalamandalam—the premier institute for the teaching of kathakali—if this ancient and difficult art might not be on its way out. Were there still boys who would literally devote their lives from the age of 12 or 14 to mastering kathakali?

Mr. Subramanyam scoffed at my pessimism. “If anything,” he said, “kathakali claims more interest than it did even a decade ago. Half a dozen training centers produce a steady supply of skilled dancers, and groups have even



BEACHSCENE BY JOSEPH NETTLE © NATIONAL GEOGRAPHIC SOCIETY

in waters sanctified by ashes of Mahatma Gandhi

toured Japan and the United States." I knew, for my own interest in this extraordinary art form had been kindled years before when a troupe performed in Washington, D. C.

Samaritans Arrive in a Small Car

A few days after I visited Calicut, my journey ended at India's southernmost tip. I came to the beach before sunrise; now, as a lone boat struggled around a rocky promontory, I watched the sun's first rays glancing from the lashing waves. Here, where the Bay of Bengal and the Arabian Sea meet, lies Cape Comorin—the land's end of India.

Nearly 2,000 miles from Kashmir's snows,

I had come to the end of the long road south. Beyond lay only the empty reaches of the Indian Ocean and, 5,000 miles away, Antarctica. I could go no farther.

I have one more thing to tell:

One moonless night toward the end of my journey I stood on a road deserted save for the vague forms of villagers and their cattle returning from the fields. My taxi had struck a calf. The radiator was broken, and there was no hope of going on. The nearest town lay 38 miles away. The three of us—a young Indian civil servant who had come with me, the driver, and I—glumly assessed our chances of getting a ride.

During the next hour three vehicles passed us. The driver of one simply accelerated when we tried to flag him down in the dark; he was obviously afraid to stop. The other two, both trucks, were going the wrong way. We started to walk.

Another half hour passed. A small Indian-made automobile carrying three men stopped beside us. The Indians squeezed together onto the narrow front seat and the three of us crowded gratefully into the back.

With the friendly but startling directness that characterizes so many Indians, the

driver started to question me. Where was I from? What was I doing in India? I told him I had come from Washington, D. C., to gather material for a NATIONAL GEOGRAPHIC article.

"You Americans!" he said, after a moment of silence. "Last year I met a girl from New York; she asked me how many elephants I own. How do you answer a question like that? I'm an automobile dealer."

More silence. Then he turned toward me again.

"When you write your story," he said, "tell about Indians as they really are."

I promised him I would. THE END

The Changing Face of Southwest Asia

WITH THE WORLD'S two most populous countries facing each other across disputed, blood-stained borders, the National Geographic Society this month brings to its 3½ million member-families a new 11-color Atlas Series Map, *Southwest Asia*, showing the whole vast area where India and China meet.*

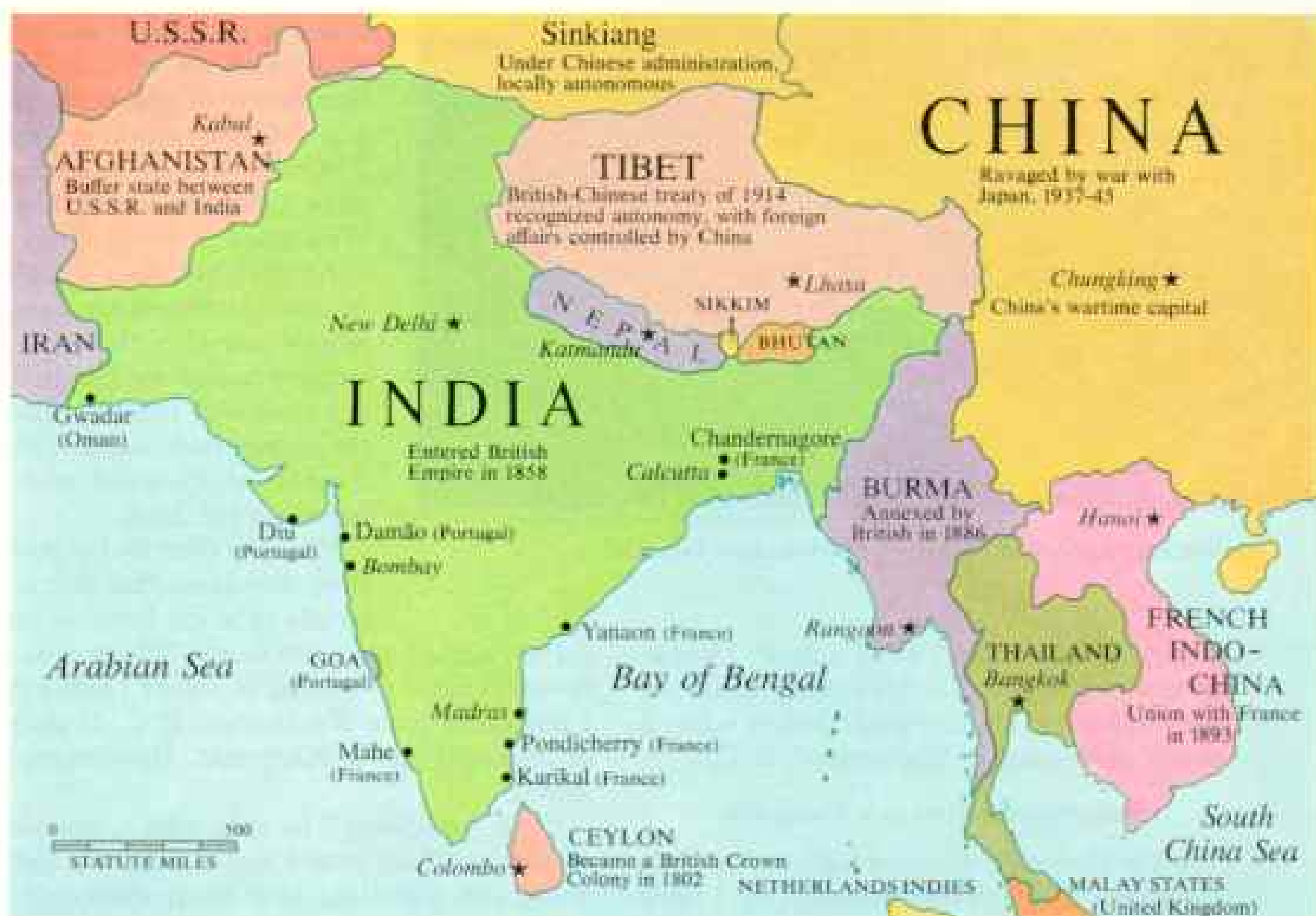
At the center of this timely, up-to-date map lies the great heart-shaped peninsula of India, so huge that it is often called a subcontinent of Mother Asia (see "India in Crisis," beginning on page 599 of this issue). Here live

440 million people, a population almost 2½ times that of the United States in a third the area. In China, beyond the world's highest mountains, dwell another 700 million—more than 22 percent of earth's people.

At two widely separated points on their common border, these giants have clashed in recent months, as the Communist Chinese pushed their claim to territories long regarded as part of India and Kashmir. The new map shows both the traditional boundaries and those now claimed by the Chinese in these hotly disputed areas on the northeast and northwest shoulders of India—the North East Frontier Agency, and Ladakh (see "Mountaintop War in Remote Ladakh," page 664).

Only a few years ago, India and China seemed well insulated from each other, not only by the mighty mass of the Himalayas but also by forbidding, little-visited Tibet and Sinkiang, which served as buffers.

Now Red Chinese expansion has brought Communist troops to the borders of India, as shown by the maps below. New names and



1946 After World War II, Great Britain remained as proprietor in India, Ceylon, Burma, and the Malay States. France retained a foothold in Indochina and, like Portugal, held enclaves in India. The Netherlands sought to reassert authority over the war-lost East Indies. But the twilight of empire was at hand in southern Asia; colonial regimes tottered, and civil war spread in China.

frontiers emphasize the other vast changes which have taken place since World War II: partition of British India into free India and Pakistan—the latter in two pieces separated by nearly 1,000 miles of Indian territory; the emergence of Burma and Ceylon as independent nations; and the splitting of French Indochina into Viet Nam, Laos, and Cambodia.

New Nation Tries New Ways

One of these young nations, Ceylon, defies Asia's tradition of male supremacy; it is led by the world's first woman prime minister. She is Sirimavo R. D. Bandaranaike, widow of the late Prime Minister Solomon W. R. D. Bandaranaike, an assassin's victim in 1959.

The Atlas Map shows that Ceylon has not always been an island. A 16-mile shoal known as Adams Bridge is a remnant of land that once made Ceylon part of India.

Iraq and Iran, on the Atlas Map's western edge, occupy historic lands as old as the Bible, as new as today's gasoline. Revolution recently shook Iraq, a traditional site of the Garden

of Eden. Pipeline and derrick symbols underline the whole region's importance as one of earth's great repositories of oil.

At opposite corners lie fantastic contrasts: Saudi Arabia's vast Empty Quarter, earth's least-populated area outside the polar regions, and teeming Calcutta, whose inhabitants crowd together 120 to the acre.

Across the new sheet a transcontinental dream takes shape—a 3,000-mile highway. Ultimately linking Turkey with Singapore, it would ribbon this map from Tabriz, in western Iran, to Burma's storied Mandalay.

Four insets supplement the new map. Three detail south Asia's great cities: Bombay, Calcutta, and Karachi. A fourth pictures the entire Moslem world, spanning the globe from west Africa to Indonesia. **THE END**

*Southwest Asia is the 38th uniform-size map issued by the Society in the past 5½ years; it becomes Plate 48 in the Atlas Series. A convenient Folio binds the maps; it may be ordered from the National Geographic Society, Dept. 89, Washington 6, D. C., at \$4.85. Single maps, 50 cents each; a packet of the 35 maps issued in 1958-62, \$10.50; a combination of the 35 maps and Folio, \$14.00.



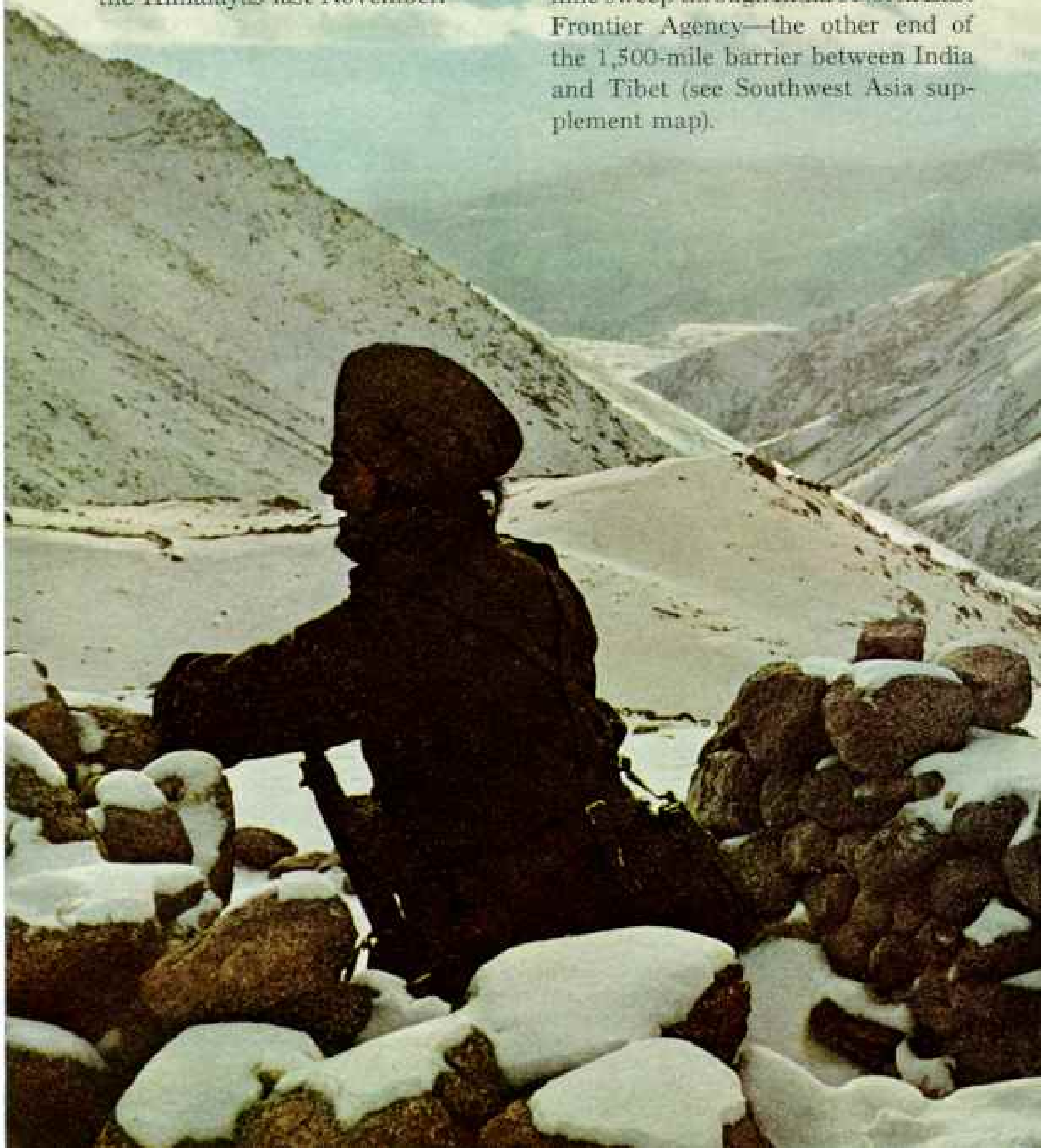
1963 Old names vanish; new names appear. Viet Nam, Cambodia, and Laos replace Indochina, and war splits Viet Nam into Communist north and pro-West south. Nationalists oust the Dutch and create Indonesia. India and Pakistan agree on partition but feud over Kashmir. Portugal and France lose their outposts. Communists seize power in China, swallow Tibet, and nibble at India's ramparts.

MOUNTAIN TOP WAR

ARTICLE AND PHOTOGRAPHS BY W. E. GARRETT National Geographic Staff

THERE'S A SWIRLING, top-of-the-world cold in Ladakh that can freeze a soldier's hand to his rifle steel. It's a cold that cruelly froze the feet of hundreds of Indian troops scattered by the Chinese charge over the Himalayas last November.

I had come to Ladakh, India's arcticlike district in Kashmir, to see this western target of the Chinese Communists' two-pronged attack on India. A few days before, I had been just ahead of their surprisingly quick 100-mile sweep through India's North East Frontier Agency—the other end of the 1,500-mile barrier between India and Tibet (see Southwest Asia supplement map).



IN REMOTE LADAKH

On my first night in Ladakh, it had been minus 30° F. in these high passes, but now we stood in the warming midday sun. Maj. C. S. Tanwar, of the Indian Army's northwest frontier forces, was telling me of his part in the recent battle at Chushul airstrip.

"Chinese loud-speakers had been telling us we were on their land and must leave peacefully. They didn't want trouble; they said. They wanted to be our friends. Then, during a bliz-

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GUARDING A HIMALAYAN PASS
in snow-scoured Ladakh, Sikh
sentries brave below-zero
cold and chilling winds in their
three-mile-high outpost.

ALBERT R. BRUCE



zard at 3 a.m. on the 18th of November, they started shelling us—about 600 mortar rounds altogether. By 3:30 several hundred Chinese were closing in."

The major made a gesture of fumbling with a bolt-action rifle. "Our hands were so cold we could get off only five shots a minute. We had to fall back. The company on our right was surrounded. Their area fell by 6:30, but we heard some firing until 8:00. Their commanding officer was a good friend of mine. Six of his men got out, all wounded; he didn't. There had been 130 men there."

Major Tanwar's cold frankness about his defeat was embarrassing at first. But as I began to understand the odds he had faced here,

the loss of only one ridge seemed a victory.

His men, like the rest of the Indian Army, were equipped with World War I Enfield rifles. They were trained for peace with China. They had been attacked by an army toughened by action in Korea and Tibet, firing the latest automatic weapons. Now a cease-fire proclaimed by the Chinese had stopped the fighting as suddenly as it had started.

What had brought about this Sino-Indian collision? Back in New Delhi, India's Prime Minister Nehru, still clutching at neutrality, had told me sadly: "We were betrayed."

Betrayed? Perhaps. But certainly not surprised. Even before 1954, Chinese maps were claiming all of Ladakh north of the Indus,



and repeated border clashes led to accusations that fill eight volumes of white papers.

Much of Ladakh's border is poorly defined and has never been surveyed. The part now occupied by India covers 27,000 square miles, which corresponds to the size of West Virginia. The inhabitants number 80,000. Pakistan occupies a large area in the northwest.

For at least six years the Chinese have maintained outposts in northeastern Ladakh, in an 8,000-square-mile area called Aksai Chin. They built a road there, to connect their Sinkiang Province with their strong points in Tibet (see map, page 673). An Indian patrol, sent to investigate in 1958, was captured.

Last October Prime Minister Nehru told

his soldiers to free Indian territory of Chinese intruders. Fighting followed, and on November 18 the Chinese launched a major attack. They captured another 2,000 square miles of Ladakh before the cease-fire.

U. S. Weapons Support Indians

Now the Indians had dug into new positions, and new weapons were arriving from Britain and the United States. I had landed at Leh, Ladakh's capital, with an arms shipment delivered by the U. S. Air Force, and traveled 65 miles to the front by helicopter.

As I talked with Major Tanwar, an Indian correspondent from the plains huddled behind our jeep, suffering from altitude sickness. Our New Delhi briefing on Ladakh had warned us: "Newcomers will experience difficulty in breathing, sleeplessness, and loss of capacity for sustained mental effort." Nobody had mentioned nausea, which was to afflict several of our party.

The major voiced sympathy. "The altitude bothers



Women Exchange Gossip on the Main Street of Leh

One of the world's highest inhabited lands, Ladakh does not dip below 6,000 feet even in its lowest valleys. Goatherds living at 18,000 feet suffer discomfort when they descend to Leh, the capital, a mere 11,550 feet.

Ladakh, a district in Kashmir, had close ties with Tibet until Communist China shut the border. A common religion, Lamaism, binds the two Mongolian peoples. Ladakhis dress in Tibetan style and speak a similar tongue.

These women, who gather near Leh's main intersection, wear loose-fitting, knee-length coats. Goatskin capes, fur side in, pad the shoulders for heavy loads. Chinese good-luck symbols decorate stovepipe hats. Girl at left prefers the cobra-like *peyrak*, a broad leather strap studded with turquoise and silver. Suitors can estimate her dowry at a glance.

everybody the first few days. During the battle two of my men died of heart failure."

Here the heart could not always be as strong as the mind's will to fight. The thin air of this rocky roof of the world starves the heart and lungs of the fighting man. Ladakh's lowest valley lies more than a mile above sea level. Its highest mountain, called K2, rises to 28,250 feet—only 778 lower than the summit of Everest.

As I made pictures of this rugged land, I was forcibly reminded of another natural enemy. Alternate heating and freezing pulverizes the bare rock slopes into a fine granite dust that seems lighter than air. Wind sweeps the dust into Sahara-like dunes, and flings it back in thin layers on the rocks. Dust billows behind every footstep and moving wheel, and mixes with the blowing snow. It scars lenses and sifts into the camera mechanism, joining with the cold to jam the shutter.

The Indian Government has restricted travel to Ladakh, but throughout history the most forbidding deterrent has been the terrain. It was 1631 before the first Westerners reached Leh, in its mountain-locked valley near the Indus River.

The first automobile road from the outside world was opened three years ago, but it is closed by winter weather. Several months in the year Ladakh can be supplied only by air.

Will Jeeps Grow Wings?

Many stories have grown up around the Ladakhis' reaction to airplanes. According to one, when the first plane landed in 1948, they brought hay to feed it.

Another story tells of a father pointing to the jeeps being unloaded from a plane and telling his son that these babies would grow up, sprout wings, and fly like their mother.

The big U. S. Air Force C-130 that had brought me to the airstrip near Leh was unloaded quickly. Soon it circled up and out of the valley, heading back to New Delhi for

The Author: W. E. Garrett in the past dozen years has covered Communist aggressions along an arc that spans half of Asia: Korea in 1950, Quemoy in 1958, Laos and Viet Nam in 1961, and now Ladakh in northwest India.

another load before a sudden winter storm could close the field. I tossed my bedroll into a jeep and rode up to Leh, which snuggles against a cleft in the mountains 500 feet above the airstrip.*

Empty Palace Recalls Days of Rajas

On a ridge 300 feet above the town stood a stone palace nine stories high, reminiscent of the home of the Dalai Lama in Lhasa. Another 700 feet higher rose a Buddhist *gompa*, or monastery (opposite).

"In that palace lived the rajas of Ladakh for more than three hundred years," said a guide. "The palace has been vacant for more than half a century. The present raja lost his property in the land reforms in 1950. Now he is a lieutenant in the Indian Army."

On my first walk through the 11,550-foot-high capital, the mental vagueness of hypoxia—oxygen shortage—made it easy for me to imagine myself a traveler in some earlier century.

It snowed gently, the tiny flakes falling so slowly that they seemed suspended in the air. The snow-filtered light softened the ugliness of Leh's wide dirt main street and the two-story buildings of stone and clay. Little Asian ponies with top-heavy loads were led by short, heavily robed Tibetan-looking men. I sidestepped slow-moving dzos, animals half yak and half cow that provide the Ladakhis with milk, meat, and transportation (page 675).

I passed women with baskets on their backs filled with firewood, millet grain, vegetables, and the miscellany of Asian barter. Most of them wore stovepipe hats with Chinese good-luck symbols decorating the sides and top (page 666).

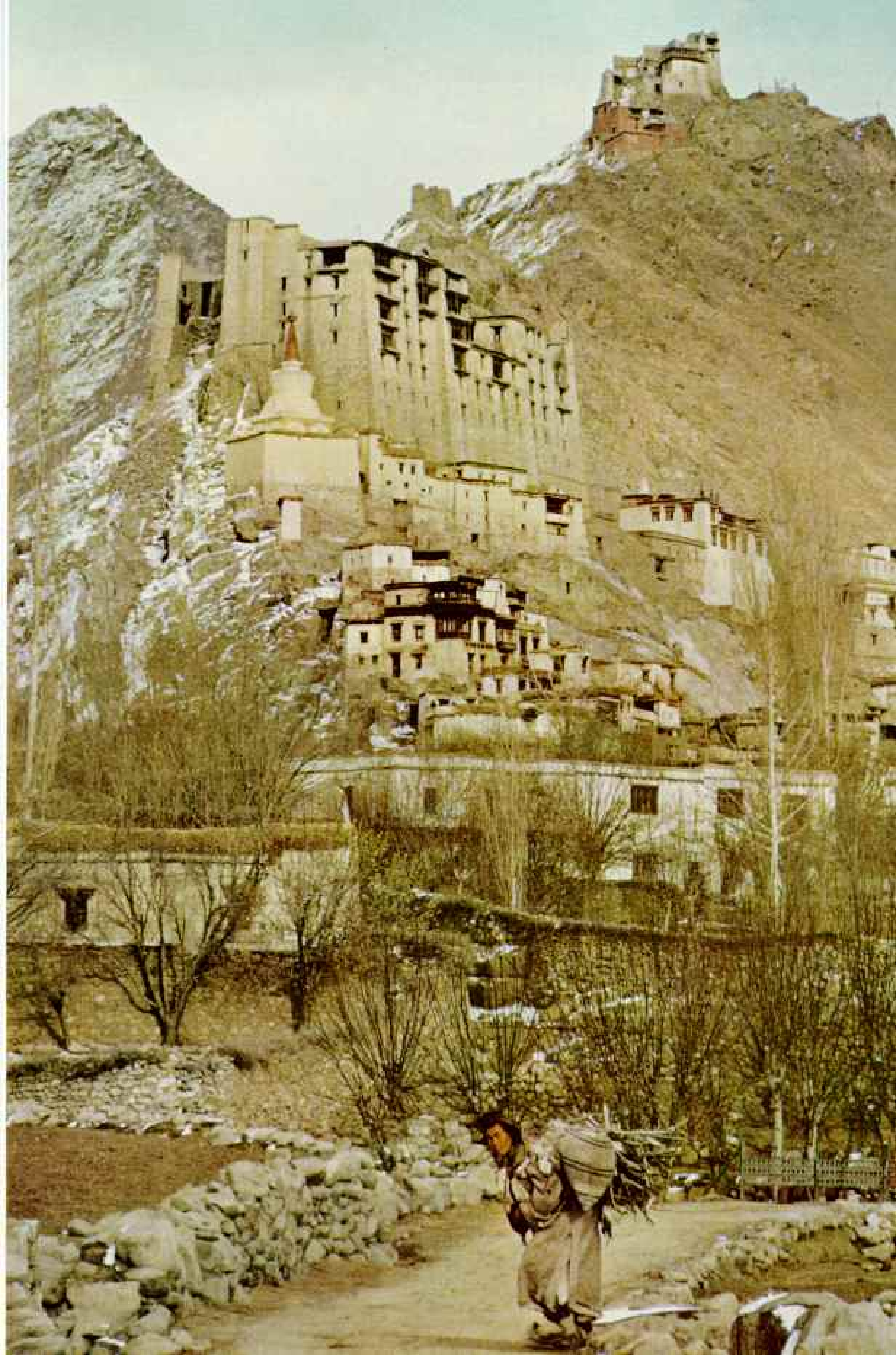
The main street served as a bazaar. Despite the cold, men and women milled there shopping and gossiping, much like farmers back in my American Midwest on their Saturday trips to town. Soldiers from south India, racially almost as novel to these people as I who had come from the other side of the world, strolled among them.

Occasionally I greeted a native with the

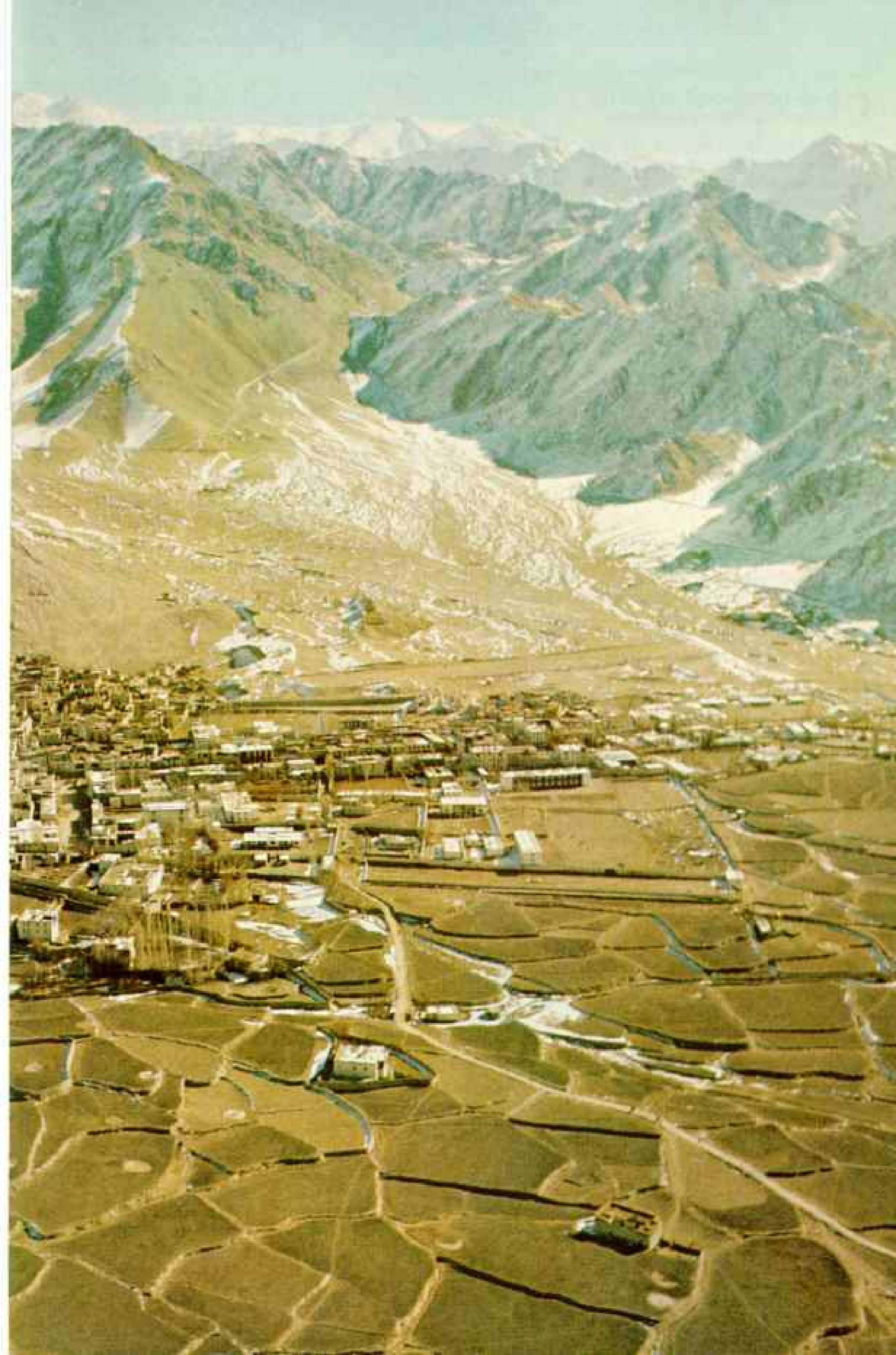
*See "A Journey to 'Little Tibet,'" by Enakshi Bhavnani, NATIONAL GEOGRAPHIC, May, 1951.

Nine-story Palace and Lamaist Temple Crown the Crags Above Ladakh's Capital

Unoccupied for half a century, the 500-year-old, 100-room mansion of the deposed kings of Ladakh suggests a Crusader's castle. Rock fences beside the trail wall off patches of precious topsoil. Trees have been dug up and replanted in an area above the natural timber line. Lone farmer carries firewood for sale in the bazaar of Leh.







Stone-fenced Fields of Leh Lie Fallow and Brown in Winter

Snow-crested peaks stab the sky on every hand; eroding granite spreads a thin soil on thirsty valley floors. Rainfall averages only three inches a year in this two-mile-high desert, but ditches, tapping snow-fed streams, turn these fields green and bountiful in summer. The valley grows apples, apricots, wheat, peas, beans, and barley. Sunlight is so intense that two crops ripen in a summer.

Leh, like the rest of Ladakh, has not one foot of pavement. It has no electricity or piped water, only one block of shops (page 674).

Trails to villages lead through the mountain passes.

Weaving center in Leh trains women to fashion rugs and shawls from the wool of sheep and goats. Graduates, sponsored by the Indian Government, go into the villages and teach others. Spinning wheels evidence the introduction of machinery; elsewhere yarn is still twisted by hand.

RESEARCH BY W. C. GARRITT, NATIONAL GEOGRAPHIC STAFF © N.G.S.



India, China, and Pakistan Carve Chunks of Disputed Kashmir

Communist China claims the Aksai Chin area, the province's high, desolate northeast corner. To link Tibet and Sinkiang, the Chinese occupied Aksai Chin and built a military highway. Open warfare broke out last fall following repeated clashes by patrols.

Since partition of the subcontinent in 1947, India and Pakistan have collided over Kashmir with arms and diplomacy. Today the United Nations polices the cease-fire line.

one word I knew in their Tibetan-Burmese dialect: "Jooley." It means "Good morning," "Good day," or "How are you?" and it always brought a friendly "Jooley" in return.

But one of my "Jooleys" brought a surprising "Hello" from an elderly, well-dressed man. We introduced ourselves.

Mr. Het Ram was a shopkeeper, the president of the local merchants association and, like most of Leh's businessmen, he was not a Ladakhi but an Indian from the plains. For 42 years he had traded in silks and spices between India and China, through the 18,290-foot Karakoram Pass. He had led many of his caravans himself (page 683).

Caravans Recall Romantic Past

On my boyhood bookshelves the Oriental caravans had seemed immeasurably far away, and deep in the romantic past of Marco Polo and the Chinese bandits. But here was a man who had recently lived this life.

"We carried wool, cotton, dyes, spices, and



MAPS COMPILED BY EDWARD N. SCHELL, DESIGNED BY FRIGERIAN GILYANOFF © R.L.S.

general merchandise to Yarkand and Kashgar in China," Mr. Het Ram told me. "We brought back silk, tea, and carpets. Sometimes we had a hundred animals but usually about 30. We used horses, camels, yaks, and even sheep."

I asked, "Did bandits bother you?"
 "Never."

Sensing my surprise, he went on: "Say that one year we would have 90 loads and only 30 animals. We would make three trips to the pass in the fall and leave the goods up there. In spring, when the passes opened, we would make three trips down into Sinkiang. Sometimes we left our merchandise at the pass for a whole year. Nobody bothered it."

"Then last year the Chinese soldiers turned back one of our caravans. The trade was slow anyway, but now we won't be going there at all."

Leh had long been a meeting place for caravans. Now the town was drab and quiet, but another shopkeeper told me of summers past when Leh was colorful and crowded. "We used to have Tibetans, Chinese, Afghans, and even a few Russians here. Business was better then."

Gritty face of an Indian jeep driver attests the Sahara-like dust storms that plague troops on the Ladakh front.

FOURCHROME BY ALISHA PARSON © R.L.S.



Drovers and Beasts Leave Leh's Bazaar Street

Farmers trudge in to trade barley and yak butter for the salt, sugar, and kerosene of Moslem merchants. Men wear thick felt trousers under coarse woolen coats girdled with leather sashes. Knitted boots have turned-up toes. Boy at right leads a dro, a cow-yak hybrid. A rare snowfall flecks the plaza where Ladakhis once played polo; now they compete on a proper field.

Even so, Ladakh has always been poor. Its sole industry is agriculture, but only one acre in ten can be farmed. The main crop is a loose-grained barley called *grim*—an unintentional comment on the land. The harvests barely suffice to feed all the villagers and the lamas. Without the traditional income from supplying the caravans, the country has become even poorer.

To build up Ladakh's economy, the Indian Government has launched an urgent program. Its success is the personal concern of an aggressive Sikh, Mr. H. S. Butalia, Deputy Commissioner of Ladakh assigned by India's Ministry of External Affairs. The bearded Mr. Butalia invited me for breakfast and talked of his problems as he warmed our plates over a stove in his bedroom.

"Our soil needs fertilizer," he said. "We have less than three inches of precipitation a year, so we must irrigate. For a start, we hope to make money feeding the Indian Army stationed here. We can grow excellent vegetables. But our villages are scattered and we need roads."

The Deputy Commissioner's enthusiasm touched on many phases of Ladakhi life.



"Our schools offer free books and tuition," he said, "and we plan free room and board for children of nomads. Fair-price shops are being set up for salt, sugar, and kerosene.

"People said trees wouldn't grow here, but already we have 3,300 acres of new poplars and willows. Now we must find some kind of grass that will grow here. Next year we hope to have electricity in Leh."

Cold Audience Warms to Films

I had heard there was a movie shown the previous night in a village nearby. Did Ladakh have many theaters?



RESEARCHERS BY N. J. GARRETT, NATIONAL GEOGRAPHIC EXPLORATION © N.G.S.

"We don't have any," said Mr. Butalia. "That film was run out of doors. We have a jeep with a generator to show educational films in the summer. We had quit for the winter, but the people asked us to continue. Last night they sat out there despite the cold, about 10 degrees Fahrenheit."

After breakfast Mr. Butalia proudly showed me his weaving center. Girls, women, and young boys spun, carded, and wove the local wool (page 672).

"Wool is our main export," he said. "We can make more money if we weave it into shawls and rugs, but we must improve our

weaving. These people will go back to their villages and teach others."

While talking to a weaving instructor through an interpreter, I learned that he had two fathers. Wasn't this a mistranslation? No, Mr. Tashi Phuntsog's family had practiced polyandry, the custom of one wife having more than one husband at a time.

Until recently polyandry was widespread in Ladakh, said Mr. Phuntsog. An eldest daughter married an eldest son. If he had two younger brothers, they would automatically be married to the girl also.

"The senior husband was master," Mr.

U.S. airlift to Ladakh runs a gantlet of clouds, gales, and 22,000-foot peaks. Flown by Air Force crews, 12 Hercules C-130's ferried Indian soldiers and supplies when winter closed India's only road into Ladakh. This transport spirals down from 30,000 feet to land on a sloping, 11,000-foot-high runway below Leh.

AP/WIDEWORLD





Phuntsog said. "But if he had to go away on a caravan, or to herd sheep, or to fight a war, the next brother took his place."

I asked, "If the senior husband had more than two brothers, what happened to them?"

They stayed single or went into a monastery, or they became *magpas*—that is, they married a widow, or a daughter of a family with no sons. Since these women carried the family name and property rights, a magpa had very little standing. His wife could divorce him by simply giving him a sheep and saying goodbye.

"And what about the younger daughters?"

They would grow up to be nuns, or simply spinsters.

"My mother died recently," Mr. Phuntsog went on. "But my fathers are alive and healthy. They are 74 and 76."

The Law: One Husband per Wife

I ventured that if polyandry could assure a ripe old age for husbands, it might be a good thing for the United States, where husbands commonly die before their wives.

Mr. Phuntsog, who was an only husband himself, smiled noncommittally. He said, "Polyandry was good for Ladakh because we have a poor country and it kept our population from growing too large."

The Buddhist Polyandrous Marriages Prohibition Act of 1941 forbids polyandry, and Mr. Phuntsog assured me that the custom has died out—"except in the smaller villages." No one can remember the last murder in Ladakh, and theft is unheard of, but this act probably makes criminals of many villagers even today. In the two decades since polyandry was outlawed, the once stable population of Ladakh has grown 16 percent.

The second evening in Leh my two roommates and I tried to fortify ourselves against another cold night in the government rest-house. We stoked the stove with precious firewood and latched the doors and windows.

In the middle of the night I awoke. The stove was cold, and I had a pounding headache. In the small room, three men and a stove apparently had used up what little oxygen the air could offer. I slipped out of my sleeping bag, pulled on my stiff boots, unlatched the door, and went outside.

Without benefit of countdown or rocket trip I had stepped into a lunar scene. Never had I heard such silence. The subzero cold seemed to quiet my own pulsebeat. The dust underfoot silenced my footfalls as if I were walking on talcum powder.

Donkey Caravan Plods Past Pagodalike *Chortens* Near Leh

Whitewashed structures of stone and sun-baked clay appear frequently along caravan trails. Built by devout Buddhists to improve prospects for the next life, chortens house relics or ashes of deceased lamas.

Lantern light reveals lamas guiding the author-photographer through the treasure rooms of Pituk Monastery, Ladakh headquarters of the Yellow Hat order of lamas.



I looked down five hundred feet to the frozen and lifeless Indus Valley and up thousands of feet to the peaks of granite and snow. No moon was in sight, but the barren landscape was not dark; it lay in a diffused gray-blue light, and what by day had been rocky textures now seemed soft and remote.

By contrast, the stars had never been etched so sharply. In the thin, unclouded atmosphere they looked down untwinkling, making me feel as if I were part of them and not of the planet earth.

Cold Climate Unhealthy for Germs

The cold soon drove me back to my sleeping bag, my headache gone. Now I understood why the Buddhists of Ladakh imagine hell as a place of bitter cold. Cold threatens them most of the year, and their houses of stone

and mud offer little protection. Rarely is there enough dung, straw, and scrub wood even for cooking. Fortunately germs do not thrive in the cold. The most common ailment is eye trouble, caused by dust and by the acrid smoke from the open cook fires in the villagers' one-room homes.

The next morning I had to thaw my tube of toothpaste before I could squeeze it. I sympathized with Ladakh's villagers, who are among the world's least-washed people. I found it convenient to abide by the local custom and forego a bath—at least until summer. A 1962 government pamphlet reveals plans for a civic improvement in Leh: "There is also a proposal to set up two Public Bath Rooms at suitable places in the town—one for ladies and the other for gents." I hope they will be heated.



KIDDOCHHUNE (ABOVE) AND DE SAKACHHONE (©) NATIONAL GEOGRAPHIC SOCIETY

Warmed by breakfast and hot tea, six Indian correspondents and I climbed into two jeeps. We carried emergency oxygen because we were off to visit army outposts along one of the highest roads in the world. Narrow, twisting, snow-covered, and hair-raising, it crosses the 18,370-foot-high Chang Pass.

This was the trail the caravans, such as Mr. Het Ram's, had followed from Leh into Tibet and China for centuries. Now the only caravans carried army supplies. Every curve revealed a new and more exciting view of the valleys and the peaks.

GEOGRAPHIC Pictures Teach Tentmaking

When we reached Zingral, at 17,000 feet, we had cups of hot chocolate around the stove in the middle of a round army tent. A local commander, Brigadier E. Sen, had heard I

was from the NATIONAL GEOGRAPHIC, and he had sought me out.

"You described how people in Outer Mongolia build their *gers*, or tents," said the brigadier, referring to a recent issue of the magazine.* "Well, I had a tent built according to your pictures. It's perfect for the cold of Ladakh. Now the design is standard in this area" (pages 680-81).

After this trip I had enough of jeeping in the Himalayas, at least for a while. When I was offered a chance to go from Leh to the front at Chushul, I was glad that I could ride over the Ladakh Range in a Russian-made helicopter.

The peaks rose higher as we flew east through desolate and unforgettably rugged

*See "Journey to Outer Mongolia," by William O. Douglas, NATIONAL GEOGRAPHIC, March, 1962.



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Chushul airstrip becomes a no man's land separating Indian troops entrenched in bunkers from Chinese in the distant hills. Shellfire last fall closed the strip, one of the world's highest at 14,235 feet.

Indian Outpost Defends a Forbidding Desert; Sky-high Passes Command a Road to Leh

Indian Army tents pock tawny dunes beneath barren Ladakh mountains. In the paralyzing winter cold, skin sticks to metal, and oil refuses to flow. Frequent freezes and thaws pulverize granite to dust. Brilliant summer sun lifts temperatures above 100° F.

Round *ger*, or tent, at lower center, a type used for centuries by Mongolian herders, came to Ladakh by way of the NATIONAL GEOGRAPHIC. Photographs of gers in a March, 1962, article on Outer Mongolia impressed an Indian brigadier. He noted the practicality of the prefab felt-and-frame homes, which the nomads assemble in less than an hour without nails or bolts. Studying the magazine's step-by-step pictures, he had a *ger* built and found it an ideal shelter.





passes, beside snow-covered peaks that slanted 1,000 feet above us. I asked the pilot, Flight Officer M. D. Lalvani, what our helicopter's maximum altitude was.

He replied: "The Russians' specifications say about 18,500 feet."

But the rugged thrust of mountains made flying unsafe below 20,000 feet. How could he get that much more out of this machine?

"At first we simply had to do it," he said. "On one day alone we had to take out 76 casualties. Mostly frostbite. I could see the bones sticking out of some of the men's feet. We couldn't just leave them there."

Our helicopter carried four passengers plus Lalvani and the copilot—it would have been a full load even at a lower altitude. Lalvani said: "We took out nine or ten on each trip."

Helicopter Pilots Called "Mad"

Lalvani had three days' growth of beard and he looked tired, but he still had a combat pilot's cockiness.

"A Russian test pilot came to see how we were using their choppers. When he saw, he refused to ride with us. He said, 'Either you are mad or you don't care for your lives.' I think their safety factor is too high."

Half an hour later we landed near Chushul, where Major Tanwar and the men of his regiment had dug in after their disastrous encounter with the Chinese. Chushul, at 14,235 feet, had been India's highest airfield. Now it was a no man's land.

At our urging, the major drove us to the middle of the field for a closer look at the outposts of the Chinese.

"See the little pimple on the edge of that ridge?" he said, pointing to the hills on the other side of the field. "That's one of their new positions. It's about two miles away."

The distance seemed a lot less to me. The major explained: "That's because of the thin, clear atmosphere." I said no, it was because of my distrust of the Chinese.

"They don't bother us now," he said. "But we don't go too close. The only casualties have been some wild horses—killed out there by our mines after the cease-fire."

How much longer, I wondered, before men would be blown up here once more? Certainly the Chinese were both observant and touchy. That night Radio Peking complained that our quick visit to the airfield had endangered the cease-fire.

After returning to Leh, I visited the religious center of Ladakh—the Himis Monastery, in a canyon 22 miles south of the capital.



Bactrian camels haul sacks of salt and millet out of Leh toward Karu village in the Indus Valley. Donkey bears a trader whose feet almost scrape the ground.

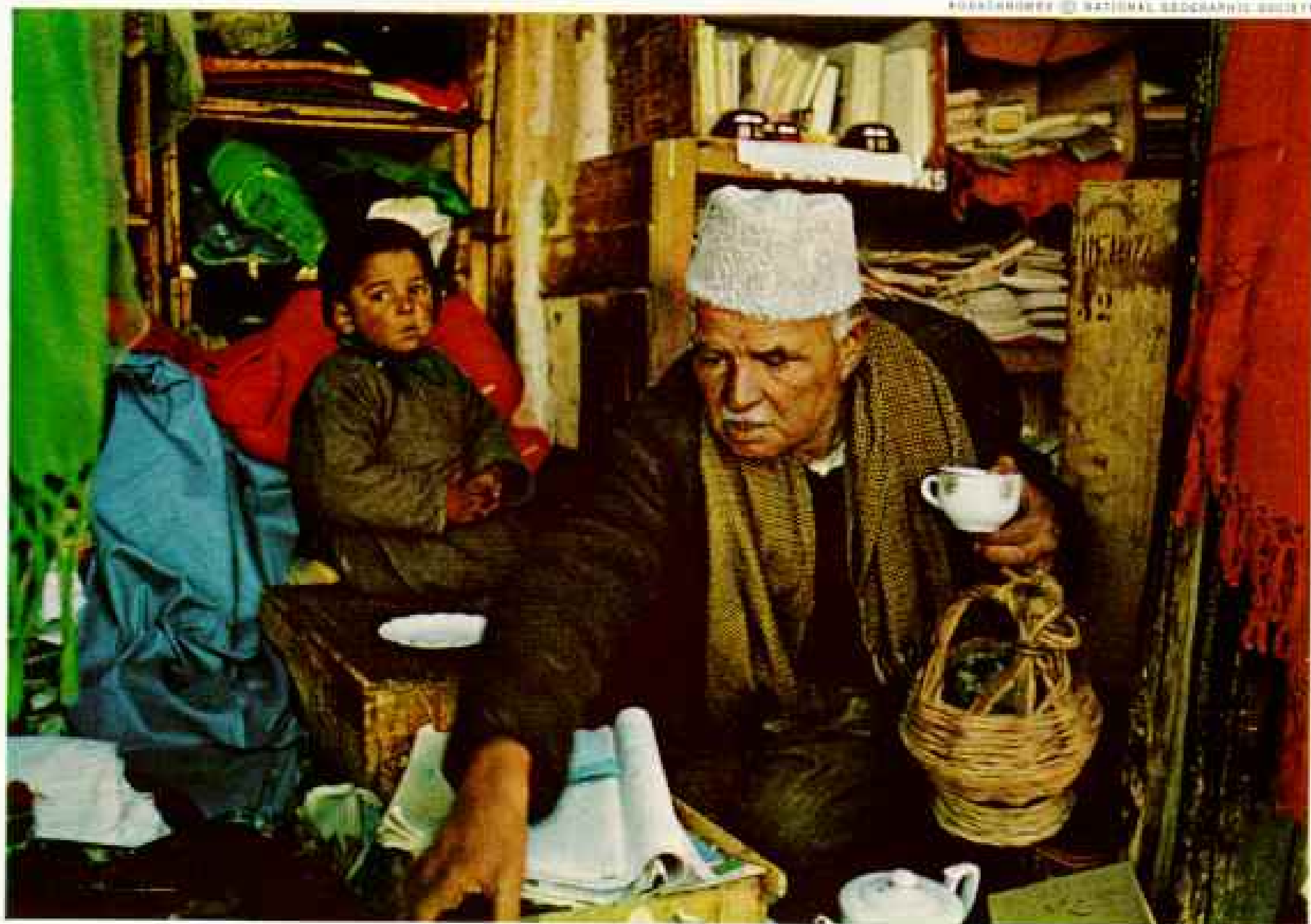
Combating the chill of winter in Leh, a Punjab shopkeeper wears a lamb's-wool cap, drinks hot tea, and holds a portable stove—a metal-lined wicker basket filled with glowing charcoal. For 42 years Het Ram led caravans through Karakoram Pass into China's Sinkiang Province. Blockade and skirmishes have gradually ended the traffic, crippling Ladakh's economy.

Mr. Tundup Sonem, a Ladakhi information officer, volunteered to be my guide. The army solved our transportation problem by lending us a jeep.

We set out along the dirt road that follows the banks of the half-frozen Indus, and soon passed the monasteries of She, Tikse, and Stakna, each a huge stone structure on a hilltop overlooking its village. Near each monastery we saw *manis*, or prayer walls, some



FOURTHMONEY © NATIONAL GEOGRAPHIC SOCIETY





ETHNOGRAPHY BY ELSA PARSONS © NATIONAL GEOGRAPHIC SOCIETY

Smiling face of a village girl in Kiari attests the cheerful temperament of the impoverished Ladakhis. Black lamb's-wool ear muffs stick out like wings from her turquoise-studded peyrak. Baby brother wears a helmetlike cap of wool.

half a mile long. These walls of unmortared field stones were about 20 feet wide and six feet high (pages 686-7).

"The villagers built them out of religious devotion," said Mr. Sonem. "Every stone on top of the wall has a prayer carved on it. The lamas carve these stones and sell them to the people. Each stone constantly offers a prayer for the one who donated it."

We stopped the jeep at the next wall and investigated. It was true. As far as we could see, the crude wall was covered with stones of many sizes, all beautifully inscribed with the words *Om Mani Padme Hum*—the basic prayer of Tibetan Buddhism. I estimated one stone per square foot, which would mean 100,000 prayers per mile.

We also saw many prayer wheels—small ones held by men as they walked, large ones mounted along the roads. The wheels contain many prayers—sometimes thousands—and each is wafted heavenward with every revolution of the wheel. The Buddhists of Ladakh believe that the more prayers one offers in a lifetime, the better are one's chances for a desirable reincarnation, and—ultimately—for nirvana, a complete escape from the cares of living, the highest goal of the Buddhist.

The Chinese Capture a Lama

In June thousands of pilgrims from all over Ladakh, and some from Tibet, jam Himis for the annual summer festival and devil dances. But on this cold December day only a few lamas scurried from one building to another, wrapped tightly in red robes.

We followed Mr. Sonem into the main temple, having taken off our shoes before entering. Behind the carved wooden doors young lamas sat on the cold stone floor, beating a ponderous rhythm on double-sided hanging drums. Older lamas chanted from ancient Tibetan prayer books. When we left, my feet felt as cold as if I had been skating barefoot on the frozen Indus River.

We couldn't meet the Skushuk, or head lama, of Himis. It is a tragedy of Ladakhi Buddhists that their equivalent of the Dalai Lama went to Lhasa to study and is now a prisoner of the Chinese.

"We hope that his next reincarnation will be found in Ladakh, so that Himis will have its Skushuk back," Mr. Sonem said. "But he is still young, and his next incarnation may be many years away."

Ladakh is often called Little Tibet or Western Tibet, because of its many centuries of religious and cultural ties to Tibet. Skushuk Bakula of Pituk Monastery, now the leading lama in Ladakh, had once threatened to bring Ladakh under Tibetan control. But today, after the Chinese destruction of the Tibetan lama system and the flight of the Dalai Lama to India, Ladakh is probably more like the old Tibet than Tibet itself.

Explosion Shakes a Monastery

One evening we had an audience with Skushuk Bakula. After an exhausting climb to the entrance of his monastery, we again removed our shoes and entered a small chamber lighted by kerosene lanterns. From the rafters hung religious paintings on scrolls, called *tankas*. In the center of the room was a gilded Buddha.

We were offered cushions on the floor, at the foot of the serious, slightly built Skushuk, who sat on a low platform. He signaled to two of his lamas who brought English tea and cookies. An interpreter told us that the Skushuk traced his reincarnations back to a contemporary of Buddha. He also holds the title of Minister of State for Ladakh Affairs in the cabinet of the Indian State of Kashmir.

More lamas entered and prostrated themselves three times as they must do whenever they come into the Skushuk's presence. They began playing drums and long trumpets.

Outside there was an explosion. The monastery shook. Was this the end of the cease-fire? Were the Chinese attacking the nearby airfield of Leh?

We rushed to the single window. In the last light of day we saw a black cloud of smoke and dust on the plain far below. When the interpreter could make himself heard in the confusion, we had the explanation: The army was blasting alongside the 900-year-old monastery, to extend the runway.

The eventual swoop of jets beside these monastery walls will symbolize great changes for lamas and villagers. Feeding the Indian troops will boost Ladakh's economy. New roads will be laid over old caravan trails. With more work available, fewer boys will be entering monasteries.

Today monasteries own half the scarce farmland, which they rent out. Land reforms have already divided large private holdings among the farmers. Until recently schools were found only in monasteries and were

Each Stone Atop a Mile-long Wall Near Leh Offers a Nonstop Prayer

Ladakh's numerous *mani* walls pray for their builders, Lamaists believe. Devout Ladakhis cover these monuments with stones inscribed with the Lamaists' chief prayer (an interpretation appears below). Travelers always pass to the left of such walls.



ཨོཾ OM—I invoke the path and
experience of universality, so that
མཎི MANI—the jewel-like luminosity of
my immortal mind
པདྨེ PADME—be unfolded within the
depths of the lotus-center of
awakened consciousness
ཧུམ HUM—and I be wafted by the
ecstasy of breaking through all
bonds and horizons.

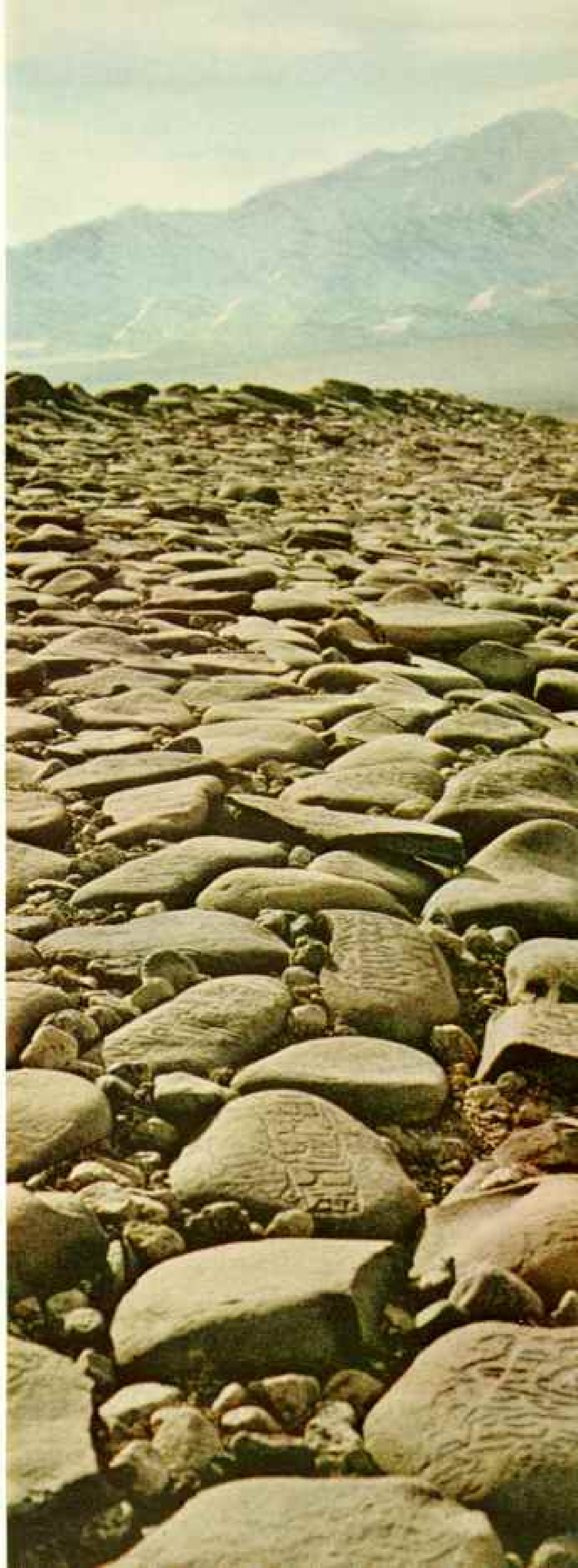
EXCERPTS FROM THE FOURTH DZIKI W.L.S.

only for lamas. Now every village has a secular school, and treatment in clinics is replacing reliance on religious cures.

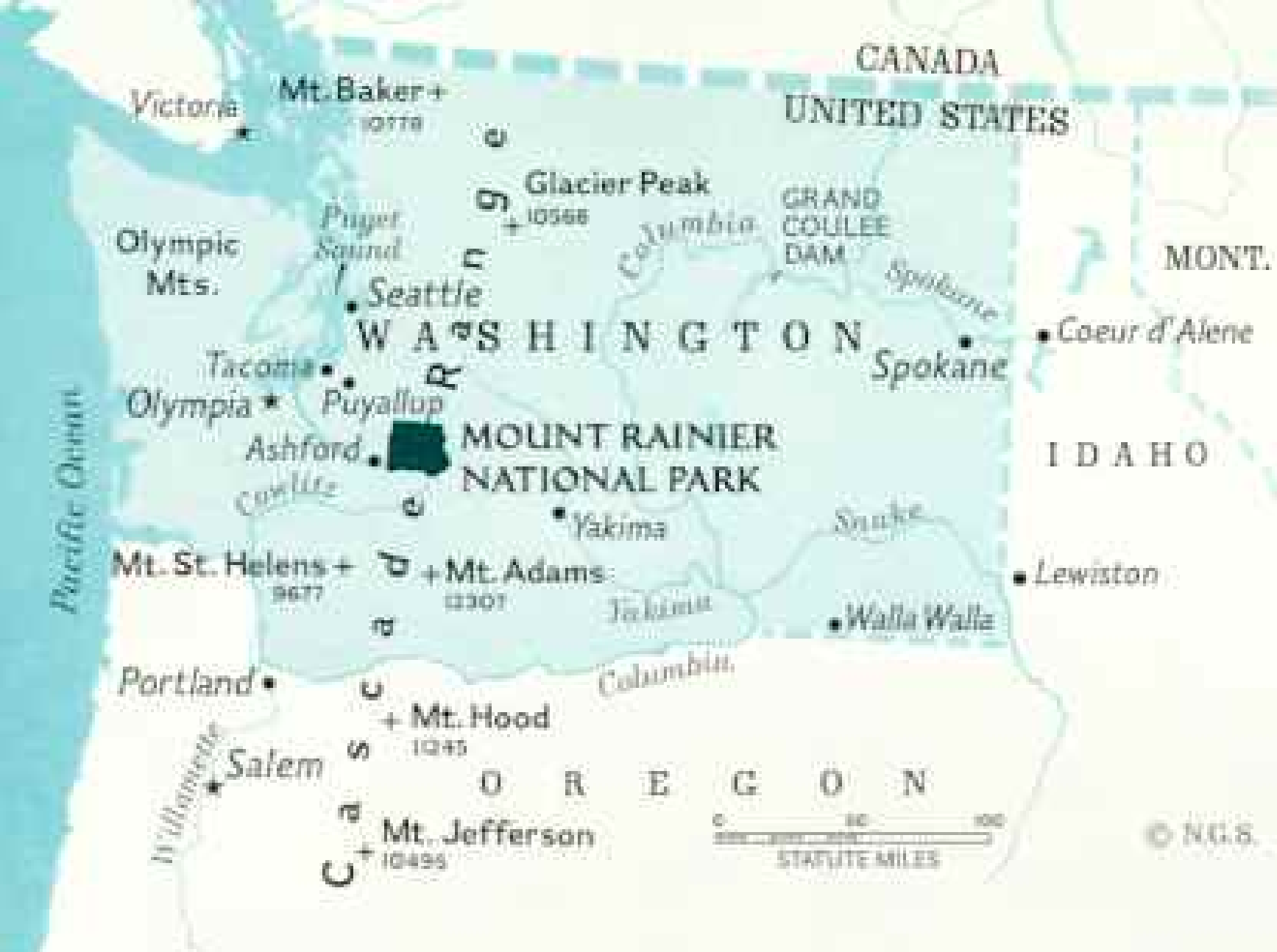
If further clashes with China can be avoided, Commissioner Butalia's planning will raise the standard of living. Ladakh will strengthen cultural and business ties with the rest of India. Inevitably, its quaintness and medieval charm will disappear behind modern buildings, irrigation and power dams, gasoline stations, and even billboards.

Should the next incarnation of the Skushuk of Himis be born in Ladakh, he will find that his antique earthly empire has crumbled and that a new culture is growing from the old foundations.

THE END







Mount Rainier: Testing Ground for Everest

Article and photographs by **BARRY C. BISHOP**
National Geographic Foreign Staff

OUR GAZE was on Mount Rainier, Washington State's many-glaciated jewel, but our thoughts were on a distant mountain more than twice as high—Mount Everest, mother of snows, proud monarch of the roof of the world, highest peak on earth.

Our party of expert mountaineers had assembled in Mount Rainier National Park for a week of shakedown trials and climbing in preparation for the American Mount Everest Expedition, 1963. We had several tons of equipment to test under Rainier's near-Himalayan conditions—nylon tents, two-way radios, down-filled underwear, medical kits, scouring pads, nesting aluminum pots, oxygen, rope, ice axes, and scores of foods, including watermelon rind, chutney, smoked oysters, and artichoke hearts.

It may seem that these tidbits are luxuries, but experience

Glacier-sheathed Rainier, king of the Cascade Range, forms an icy backdrop for climbers on neighboring Mount Pleasant. Towering above satellite peaks in western Washington, the 14,410-foot dormant volcano dominates Mount Rainier National Park. Here, last September, American climbers tested skills and equipment for an assault this spring on 29,028-foot Mount Everest.







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Handie Talkie undergoes a radio-communication check by Norman Dyhrenfurth, leader of the American Mount Everest Expedition. Rainier offered the near-Himalayan conditions needed to test men and gear for Everest.

Climbers Hope This Winch Will Lighten Their Loads

Driven by a compact motor, the 16-pound winch (opposite page, left) can pull thirty times its own weight up a slope. Special fuel keeps it running at lofty altitudes. Here it hauls a laden sled (out of picture) up Cowlitz Glacier. Drum at right reels in the cable.

Of 12 major attempts to scale Everest, only the British expedition of 1953 and the Swiss in 1956 have made it. The Americans will also try to conquer Everest's towering neighbors, 27,923-foot Lhotse and 25,726-foot Nuptse. Expedition scientists will obtain valuable data on the stresses caused by climbing the world's highest mountains.

has shown that tasty items will spur men to eat adequately when high altitude depresses hunger. Such foods will also make us crave water. Drinking large amounts of liquid—as much as possible when we near the 29,028-foot summit of Everest—will be absolutely necessary to stem the weakening effects of high-altitude dehydration.

If all goes well, we will be high on Everest by the time you read this article. Our best energies will be aimed at becoming the first Americans, and the third party in history, to scale this monarch of all mountains. We will also attempt its sister peaks, Lhotse and Nuptse. And our ultimate success will hinge in part on how well we did our homework on Mount Rainier last summer.

And why, you may wonder, did we choose Rainier, that picture-postcard peak within an easy two-hour drive of Tacoma or Seattle? What does this often-climbed, 14,410-foot landmark have in common with the breathless heights of near-inaccessible Everest?

Snow, for one thing—more than 83 feet a record season, piling up drifts deep enough to bury a three-story house, hurtling down in avalanches that can sweep a man away from sight and rescue.

Glaciers, for another—26 of them, the most found on any single mountain in the United States.

And, finally, fickle weather—the kind that can beset climbers with chilling fog, hot sun, and blinding bliz-



Author Bishop tries an oxygen mask developed by team member Tom Hornbein. Asleep or climbing, the party will wear masks above 23,000 feet.



AN ESTABLISHED LOWER LEFT: BY COLIN W. DICKIE AND ILLUSTRATED BY BARRY C. BISHOP, NATIONAL GEOGRAPHIC STAFF © N. G. S.

zard—and all in the space of a few hours.

More than a mountaineering venture, however, the Everest Expedition is making intensive scientific studies supported by the National Geographic Society, the State Department Bureau of Educational and Cultural Affairs, the National Science Foundation, the Office of Naval Research, the Air Force Office of Scientific Research, the Army Quartermaster Research and Engineering Center, and others. On Rainier we completed plans for these studies, ranging from the growth of glaciers to the psychological reactions of an exhausted climber.

Expedition Members Assemble for Tests

After Labor Day, when Paradise Inn normally closes for the year, 18 members of our 20-man team met there. They included some of the Nation's outstanding mountaineers.

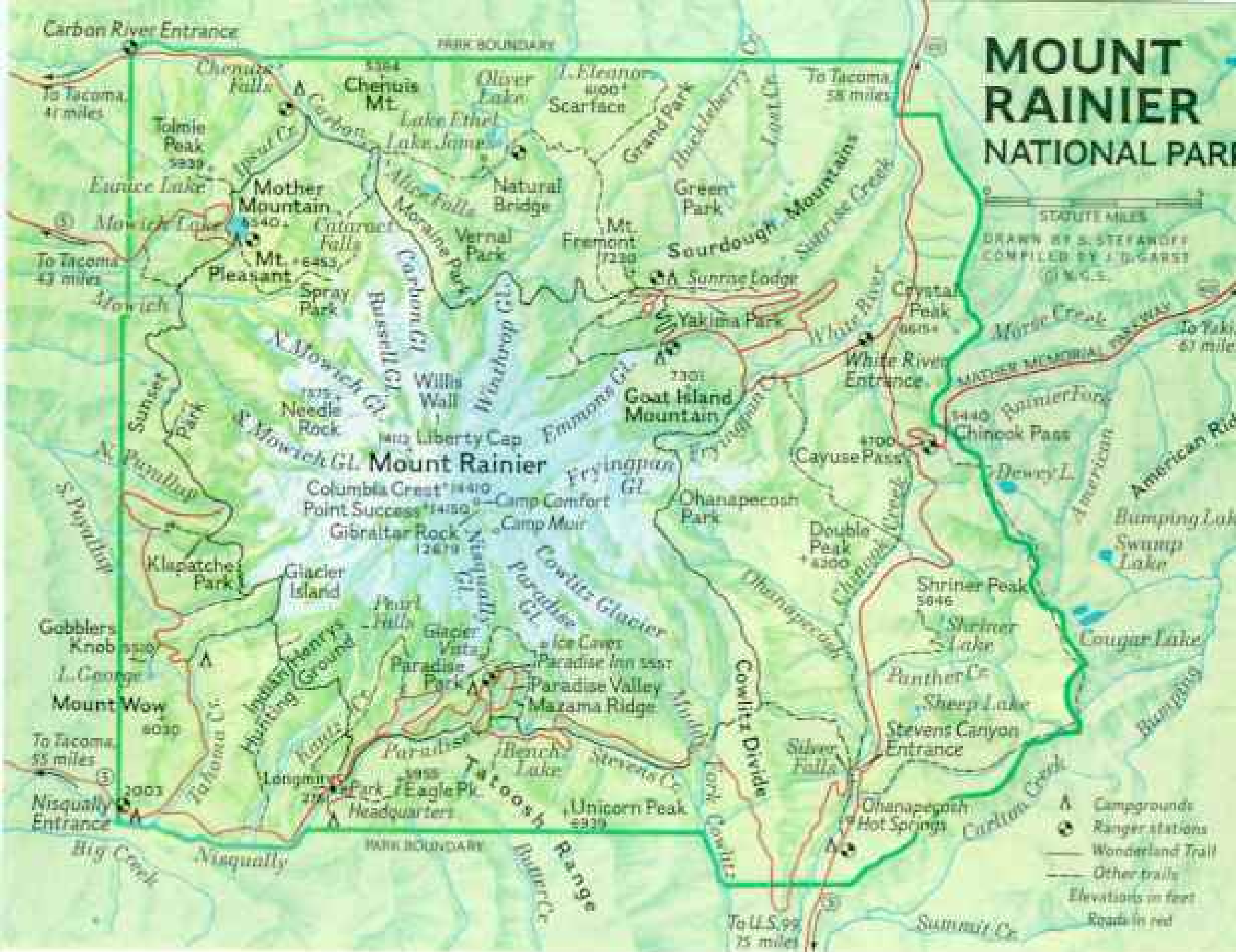
Norman Dyhrenfurth, the leader, comes from California, as does our deputy leader, Dr. William E. Siri. James Ramsey Ullman of Boston is probably the most widely known

because of his best-selling books on mountain climbing. Three of the group are medical doctors and five hold Ph.D's.

We soon found that first names would create confusion, for the list of 20 included three Barrys and four Jims. Odds against such extreme coincidence must be astronomical. We solved the problem with nicknames: The three Barrys became "B. C." Corbet, "Barry the Bear" Prather, and "Barry the Barrel" Bishop.

Mr. Ullman became "Pop," since at 55 he is oldest of our group. Dr. James Lester, who directs one of the psychological studies, was dubbed "Freud" and later simply "Sigmund." James Whittaker became "Big Jim." Lt. Col. Jimmy Roberts, a retired British Army officer with 12 Himalayan expeditions to his credit, will doubtless continue to be Jimmy. He was already in Nepal, arranging our transport.

On September 5 we set out under heavy loads for Camp Muir, high on Rainier's south slope (map, page 692). The day before, pack-horses had carried up half a ton of food, equipment, and scientific instruments.



Park map locates the Everest party's training base, Camp Muir, near Rainier's crown

On the way to Muir we all wore a new type of oxygen mask to test it and become accustomed to its use (page 690). This vital device was developed by Tom Hornbein, one of our doctors, with researchers of the Maytag Company. Vastly superior to masks I had used previously, it can be de-iced merely by squeezing the flexible exhaust tube, and its simple, one-valve construction makes breathing easier and reduces chances of malfunction.

With the mask on I felt as if I were wearing Cyrano's nose. And as we hiked through the fields of flowers near Paradise Inn, we

The Author: When he was three, Barry Bishop rode to the top of Mount Mitchell, North Carolina, on his father's back. At eight he was taken climbing in Colorado. Now, at 31, Bishop looks back on climbing exploits on three continents. He served in Antarctica as a scientific adviser to Admirals Byrd and Dufek. In the Everest region with Sir Edmund Hillary, he conducted National Geographic Society research in physical geography, a field in which he holds a master's degree. His report to members, "Wintering in the High Himalayas," appeared in the October, 1962, *GEOGRAPHIC*.

presented a strange picture to park strollers.

"What on earth," we were asked, "are you wearing those gas masks for?"

Big Jim Whittaker supervised the testing of clothing, and the little things we learned will save us much pain and peril on the slopes of Mount Everest. We lengthened our down-filled parkas four inches to protect our seats from cold when we sit in the snow. We will live in these parkas constantly, even sleeping in them at high altitude. We changed the pockets to allow easier access by hands in bulky mittens. We decided to use nylon zippers—lighter than brass and less prone to freeze up.

We discarded a leather climbing boot with opossum-fur insulation because the stitching caused leaks and blisters. We selected instead a boot with a removable felt inner sole that is more comfortable and easier to keep dry. This is just one of four types of boots we will need for the varying conditions we will encounter on our Everest climb.

Even our tents were modified. One yellow nylon tent material was a delight for photographers, but it transmitted so much light that

we would have risked snow blindness inside without dark goggles. We changed the color to deep orange.

One morning we wound our way through a jumble of crevasses to a high vertical ice face to test our ice screws—"coat hangers," as we called them—which bite into the ice like cork-screws.

Half a dozen of us attached a climbing rope and tried a tug of war against one screw. It refused to budge. When we tried the same test with ordinary pitons, or spikes, they popped out and sent us sprawling.

As a crucial test Dick Pownall leaped off a 40-foot cliff, with his climbing rope attached

to three screws at varying heights up the cliff. His trust was not betrayed: The top screw gave way under the force of his fall, but the second one held, stopping Dick before he hit bottom. Though such tests may sound risky, they assure us that for our Everest climb we will have the best equipment in the world.

Dick is also our food specialist, and he had brought more than a hundred varieties. Most were "freeze-dried," a new process that allows speedier meal fixing. The ten tons of food he selected for Everest include such varied fare as diced chicken, shrimp, beef-steak, and the delicacies mentioned earlier.

Every ounce counts on a high-mountain



Frosty fingers of 26 glaciers, more than the total on any other U. S. peak, grip the cone of Rainier. Visitor center at Longmire displays the mountain in miniature. Rainier's ice covers 40 square miles; long ago it may have reached Puget Sound. Naturalist William Banks points out features on this relief map of peak and park.

Stubborn Snowbanks at Paradise Inn Resist the Warmth of Midsummer Sun

Nestled in a valley on Rainier's south flank, the old inn offers overnight accommodations. The lodge closes on Labor Day, and snow sometimes buries it to the chimney tops by midwinter, permitting skiers to swoop down the steeply pitched roof. Before reopening in June, employees must dig their way to the entrance of the structure. Snowfall in the 1955-56 season totaled more than 83 feet, heaviest ever recorded in the United States.

This mid-July photograph shows fir- and hemlock-studded Mazama Ridge beyond the inn. Drifts melted by month's end.

Entrance tunnel through a summer snowbank admits visitors to the mist-cloaked inn. Many sightseers leave Mount Rainier without catching a glimpse of the oft-shrouded crest.



expedition; yet the list of paraphernalia we planned for Everest seemed endless. Butane stoves and lanterns, shovels, aluminum ladders, ski poles, insect repellents, signal mirrors, boot wax—these are but a handful of the items that will total 53,000 pounds when we start up Everest.

Trails Lead to Rugged Splendor

Stamina and teamwork are vital, and Rainier gave us opportunity to test both. To get into condition, I had spent the summer hiking the park's trails and exploring its wonders.

My wife Lila and I had arrived in early July, and we promptly ran into the problem of the peak's frustrating weather. Like many of the millions who have visited the park, we found Rainier shrouded by a gray veil of mist and chilling drizzle.



© BRADSHAW © NATIONAL GEOGRAPHIC SOCIETY

Then, after three impatient days, the veil unpredictably parted. As Lila got her first glimpse of the peak, high and lordly as a cloud, she caught her breath: "There it is—there's the mountain! I never dreamed it was so big!"

Mount Rainier's beauties stand out in our memories like cameos—some delicate, some resplendent, all exhilarating: shafts of morning sunlight filtering through groves of giant Douglas firs; deer grazing on the clipped lawns of park employees' homes; avalanche lilies blooming in alpine meadows; ragged islands of trees shrouded in mist, like specters draped in chiffon; milky glacial streams rushing over cobbled beds; fall colors seen from the air as the finest of Persian carpets; and above all, regal and imposing, the summit.

With the help of Park Superintendent John Rutter, Lila and I set up a base of operations

in a cabin at Longmire, just inside the park (map, page 692). Superintendent Rutter told us that Mount Rainier is the fifth oldest national park, established in 1899 by Act of Congress. The move was urged by farsighted citizens, including the National Geographic Society's first president, Gardiner Greene Hubbard.

"In the early days, Yakima and Cowlitz Indians camped in the park to pick berries and smoke salmon," recalled Herman Barnett, retired Chief Ranger, as we chatted at his home in nearby Puyallup.

"I remember trading them berries for deer-skins. And when cars began to appear, we posted a sign that read, 'Boys under 21 and women will not be permitted to drive automobiles between Nisqually Glacier Bridge and Paradise Valley.' The road was so nar-





PHOTOGRAPHS BY W. S. BARRETT, NATIONAL GEOGRAPHIC STAFF (LEFT), AND LILA W. BISHOP © NATIONAL GEOGRAPHIC SOCIETY

Snow-filled craters of Rainier, one inside the other, once spewed lava. No major eruption has occurred in more than 500 years, geologists say, but escaping steam still keeps parts of the crater rims free of snow. Climbers sometimes warm themselves over fumaroles. Distant Mount St. Helens rears its 9,677-foot head above the Tatoosh Range.

Climbers strike for the summit above the lavender-tinted clouds of dawn. They carry ice axes and wear dark goggles to prevent snow blindness. Several hundred climbers reach the crest each year. Washington's 12,307-foot Mount Adams (center) and Oregon's pinnacle, 11,245-foot Mount Hood (right), float like islands in the sea of clouds.

row then that it was on a one-way schedule."

Today, paved roads allow access to the park's 380 square miles, its nine campgrounds, and more than 300 miles of trail winding through virgin forests and meadows.

Almost everyone visits Paradise Park, on the southern slope of the mountain. Here, at 5,500 feet, overlooking the snout of Nisqually Glacier, we walked amid an ever-changing profusion of wild flowers (pages 702-03). As summer wore on and the snow melted, the blooms of avalanche lilies, glacier lilies, and pasqueflowers gave way to buttercups, followed by a blaze of paintbrush, heather, and blue carpets of lupine. Late in the season blue gentian covered the alpine meadows.

Until 1918 similar flower fields in Yakima Park on the northeastern slope vied with Paradise for floral loveliness. But grazing was permitted during World War I, and these meadows have never fully recovered.

Paths leading from the steep-roofed inn to

the Paradise flower fields are paved—not to make rambling easier, but to prevent erosion of the loose volcanic soil. It is this rich soil—plus more than a hundred inches of moisture a year—that produces the magnificent flowered meadows.

Like all protected areas, the park abounds in wildlife—130 species of birds and 50 kinds of animals. Bear and deer seem tame and are often in evidence; other creatures, such as the mountain goat, require a bit of looking.

Small Masked Bandit Asks a Handout

We searched the Paradise fields one day with Ken Fink, one of the rangers. An avid wildlife photographer, Ken knew where to look. He showed us a white-tailed ptarmigan on her nest in a clump of heather, only a few feet from the trail. When she saw us, she hissed and ruffled her feathers. Next we found a sooty grouse incubating nine speckled eggs. We took a quick look, then respectfully re-



PHOTOGRAPHS BY LILA W. WYDOP (UPPER RIGHT) AND BERT C. SILVER, NATIONAL GEOGRAPHIC STAFF

Swooping plane bombs Bench Lake with a silvery cloud of fingerling trout. Placid

treated as she beat us off with her wings.

Of all the park's creatures, Lila decided, the raccoons are the most appealing. In our cabin one evening, after doing the supper dishes, we returned to the living room to find a small gray bandit with a black mask over his eyes standing on hind legs in our doorway. We offered him green grapes; after eating each tidbit, he gave his jaws a wipe with one handlike paw and returned for another.

It is hard to deny such a forthright appeal; yet, as friends pointed out, wild animals may become so dependent upon human beings that they lose the ability to forage during the long winter.

Like many other Rainier visitors, we made the short hike from Paradise Inn to the ice caves in the snout of Paradise Glacier. This series of caves, extending roughly a quarter of

a mile, is continuously being carved where a subglacial stream lets warmer air blow in under the ice (pages 700-01).

On a hot day we found the caves' near-freezing temperature a pleasant relief in spite of icy water that dripped on us.

From the ice-floored caverns of the glacier, where footing is a problem, a few minutes' walk can put you in the middle of a quite different problem—traffic jams. On the frequent days when clouds hide Rainier, the park's roads are almost as quiet as its icy caves. But let the peak stand bathed in sunshine, and it acts like a magnet for thousands from Seattle, Tacoma, and other large cities nearby. A record 31,427 people streamed in last July 22, the season's first Sunday not marred by rain or clouds, and traffic crawled.

We found one way to escape the crowds



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surface mirrors Mount Rainier's image

and get a splendid look at Rainier—from a light plane with veteran mountain hopper Jimmy Beech at the controls. Jimmy operates a flying service from Ashford, six miles outside the Nisqually Entrance to the park.

Climbing clockwise, we flew close to the mountain walls and radiating ridges to catch the updrafts. The little plane labored to gain altitude, circling the peak in ever-higher spirals. Half an hour later we topped Rainier's 14,410 feet and stared down into the craters, two snow-filled, almost circular dishes, one inside the other (page 697). Although we were no more than 600 feet above the crest, we could not smell the sulphurous fumes or see the steam vents that warm the craters' rims.

Emerald and indigo lakes dotted the forest below the glacier tongues. To the east, line upon line of fading blue ridges rose to the



Bagged in plastic for an air drop, 3,500 young Yellowstone cutthroat trout get a final check. Ice helps tranquilize the small fry for their plunge, which they survive without ill effect. The U.S. Fish and Wildlife Service raises the fingerlings.

One mouthful at a time, mama marmot moves her brood to a new home in Paradise Park. The author took her picture with a telephoto lens as she rose on her haunches to look and listen for enemies. "I watched her move six babies, one by one," he recalls. "She made a seventh trip to salvage bedding."





PHOTOGRAPH BY STEVE L. BRIDGE, NATIONAL GEOGRAPHIC

white-capped crest of the Cascade Range. To the northwest, Puget Sound shimmered like quicksilver; the Olympic Mountains hid the Pacific. To the south, other snowy volcanoes appeared as satellites to Rainier: Washington's Mounts Adams and St. Helens, and Oregon's Hood and Jefferson (pages 696-7).

"Flying Fish" Pepper Alpine Lakes

Fish, not people, are Jimmy Beech's most numerous passengers. In fact, last year he carried some 80,000 trout fingerlings to stock the mountain lakes and help keep fishermen happy.

The fish are simply dropped from plane to lake without use of parachutes, we found out from Ranger Bill Butler.

"Doesn't it kill them?" Lila asked.

"No indeed," Bill said. "We put them on the plane in five-gallon plastic bags filled with water, as many as 5,500 to the bag. To help them survive, we add a bubble of oxygen to aid their breathing and a double handful of ice to slow their movements."

In Jimmy's plane we flew three fishlifts. As the aircraft skimmed 100 feet above the surface, Bill emptied each bag through a hole in the floor. We looked back to see the sun turn the fish-bearing cloud of vapor into a rainbow, as thousands of speckles, each speckle a baby trout an inch or so long, fluttered to the water (pages 698-9).

Because Mount Rainier's slopes are subject to earthquake, volcano, and mudflow, scientists maintain elaborate research stations in the area. Ross Bender, Chief Park Natural-



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Wind and Water Carve a Cave in Paradise Glacier

Symptom of a melting glacier, a cave such as this gets its start when frigid water erodes a tunnel beneath the ice. Air flows in and enlarges the opening.

Shape and size of the cavity change from year to year. In time, ceilings collapse. Park rangers close such caves to visitors at the first sign of weakening.

Hikers from Paradise Inn admire nature's handiwork. Icy water cascades from the overhang. Even on the hottest days visitors need jackets in the caves. Subglacial stream in the foreground flows into Paradise River.

STYLING BY LISA M. BISHOP © N.G.S.



Human toboggan skims down a snowy slope near Paradise Glacier. The Rainier Guide Service rents pants with plastic seats for this sport, called "tin pants" sliding.

Frozen grotto lures vacationists to the depths of Paradise Glacier. Flares illuminate the passageway and reveal how melting etches fairyland patterns on walls and ceilings. Filtered sunlight sometimes tints the interior a luminous blue.

STYLING BY LISA M. BISHOP © N.G.S.





WILLIAM POWELL AND ESTHER CURRIE

ist, took us to see the brand-new seismograph station at Longmire—one of 125 in a worldwide network for detecting and measuring earthquakes.

Inside a low building we entered a room painted solid black and lit only faintly by red ceiling lights. Here six black boxes hold galvanometers that record tremors of the earth's crust. Each galvanometer is linked to a delicate seismometer, or pendulum, in a separate, sealed room.

"We keep these rooms dark because the recording process is photographic," Ross explained. "Inside each box a tiny beam of light shines on a slowly moving strip of photographic paper. If the earth quivers, the beam of light will make a jagged trace on the paper, telling us much about the time, duration, and nature of the quake."

Scientists believe that Rainier and its sister volcanoes were born in mighty eruptions some two million years ago. They are among



(TOP PHOTO) BY LILA M. BASSER © NATIONAL GEOGRAPHIC SOCIETY

Carpets of Flowers and Glacial Ice Share Mount Rainier's Slopes

As summer sun banishes winter snow, alpine meadows dance with color. Sightseers find a vivid display in Paradise Park (foreground), so named because of a pioneer wife's exclamation at first sight of it: "Oh, what a paradise!"

Nisqually Glacier (center) originates near the summit. A frozen reservoir, it stores water as ice in cool seasons and, melting, releases it in warm periods. Runoff feeds the Nisqually River, whose dams generate power for Tacoma.



Avalanche fawn lily blooms as snows melt. Sometimes it pushes its way through receding drifts.



Western pasqueflower, one of the buttercups, bears seed plumes that suggest shaggy dish mops.



Magenta painted cup, a member of the snapdragon family, first blossoms late in July. Park visitors call it the Indian paintbrush.

volcanoes of the Pacific belt of fire in South and Central America, Alaska, Japan, the Philippines, the East Indies, and New Zealand. It is in this volcanic circle that earthquakes seem to occur most frequently.

Rainier's last eruption took place about 550 years ago, according to radiocarbon dating of tree trunks in the ash layers. Clouds of steam from the summit were last recorded in 1894. But Lute Jerstad, a fellow member of the Everest Expedition, tells us that as recently as 1961 he saw where a steam spout on the side of the mountain had hurled debris more than half a mile along a glacier.

Occasionally avalanches started by violent explosions of steam or by snow melting high on the mountain trigger large slides of glacial debris or volcanic rock. This debris becomes a mudflow.

Such avalanches have been known to cover 60 square miles with a sea of mud. The most recent mudflow, in 1947, carried glacial rubble for miles down Kautz Creek, tearing out the stream bed, washing out bridges, and uprooting or suffocating all the trees in its path.

Climbers Attempt New Route up Peak

In mid-August I took part as an instructor in a five-day mountaineering seminar (page 708) run by Dick McGowan, proprietor of a Seattle mountaineering store in winter and chief mountain guide at Rainier in summer.

Lila registered as a student to improve her snow and ice techniques for her own venture into the Himalayas in the spring of 1963. While the Everest Expedition goes about its work, Lila will be making a 500-mile trek from Katmandu in Nepal to Darjeeling in India, gathering material for a NATIONAL GEOGRAPHIC article. Some of the Nepalese passes on this route reach as high as 19,000 feet and are laden with snow and ice.

Our seminar operated from Camp Muir. Here, five toilsome hours from Paradise Valley, two low rock buildings squat in the gap of a ridge between Nisqually and Cowlitz Glaciers.

Each day I studied the right-hand wall of the Nisqually Glacier. Partly rock and partly ice, it soared perhaps a thousand feet, most of it seemingly straight up (pages 706-07). It offered a tantalizing route to the summit, shorter but infinitely more dangerous than the routes normally followed. No one had ever attempted it.

Ordinarily this icefall is constantly on the move, showering the rest of the glacier with frightening avalanches. Volcanic rock falls incessantly from outcrops on either side. But just before we arrived at Camp Muir, a storm had sheathed the rock and ice with snow. Since the storm, there had been no avalanches or rock falls, for the temperatures had been unusually low, hardening the protective snow cover.

Late one afternoon Lute looked at me and said, "I'm game if you are."

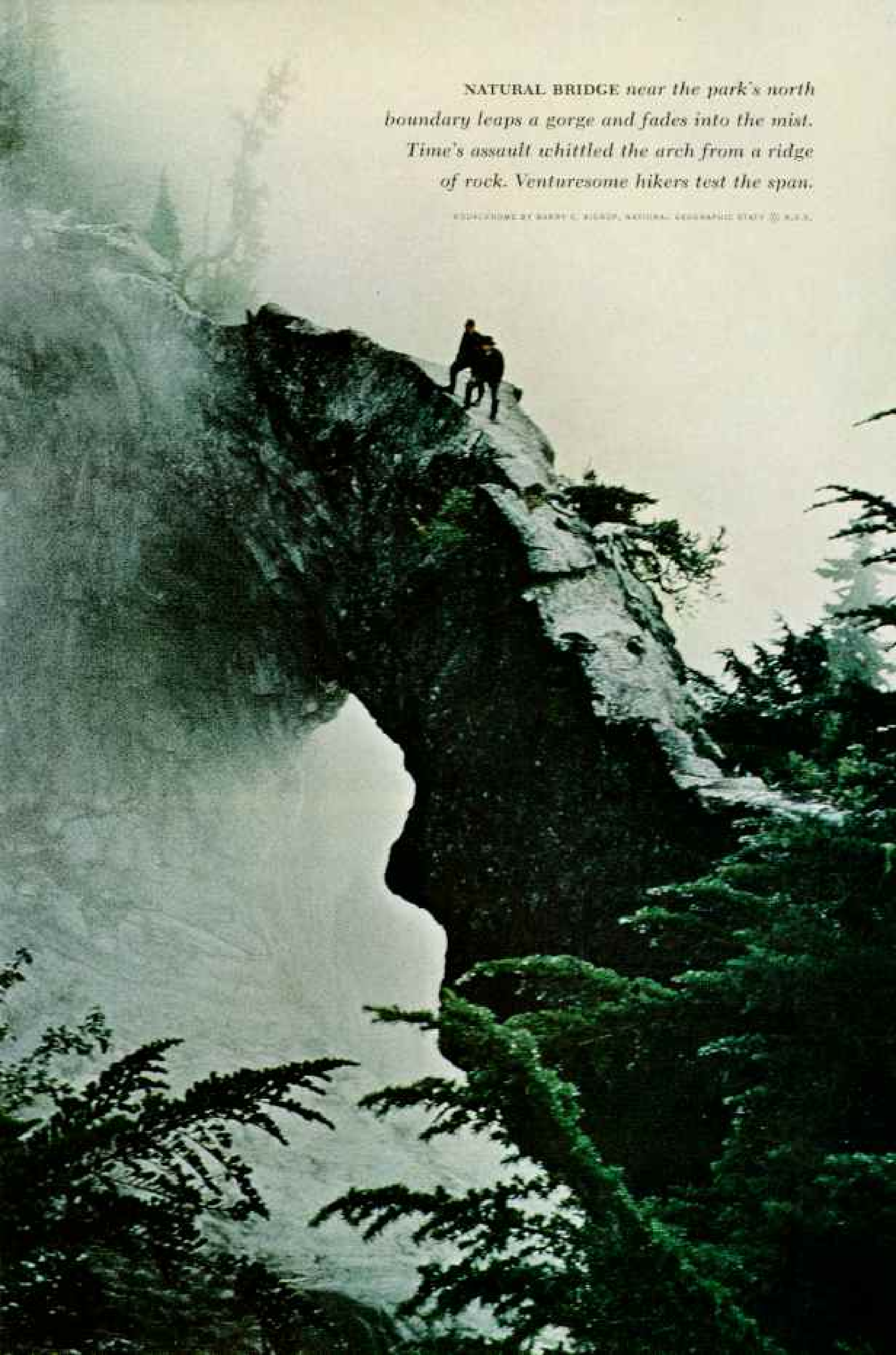
"Let's try it," I replied.

The climb had to be at night, when colder temperatures help keep the ice wall stable. Fortune favored us—a full moon rose in a cloudless sky. We pulled on down-filled clothing to stave off the penetrating cold, and donned plastic hard hats to protect our heads from falling ice and rock. We wore



NATURAL BRIDGE *near the park's north boundary leaps a gorge and fades into the mist. Time's assault whittled the arch from a ridge of rock. Venturesome hikers test the span.*

PHOTOGRAPH BY BARRY C. BILDER, NATIONAL GEOGRAPHIC STAFF





ALBERTSON © R. S. S.

Short cut to the crest: an icy wall between rock ramparts. In 1962 the author and a companion became the first to scale this face of Nisqually Glacier (center). Defying incipient avalanches, they climbed by moonlight.

Rainier Makes Its Own Weather, Forcing Clouds to Drop Their Moisture

Warm air can carry more moisture than cold air, and when water-laden Pacific winds sweep up Rainier's slopes, they cool and drop part of their burden, as illustrated in the painting:

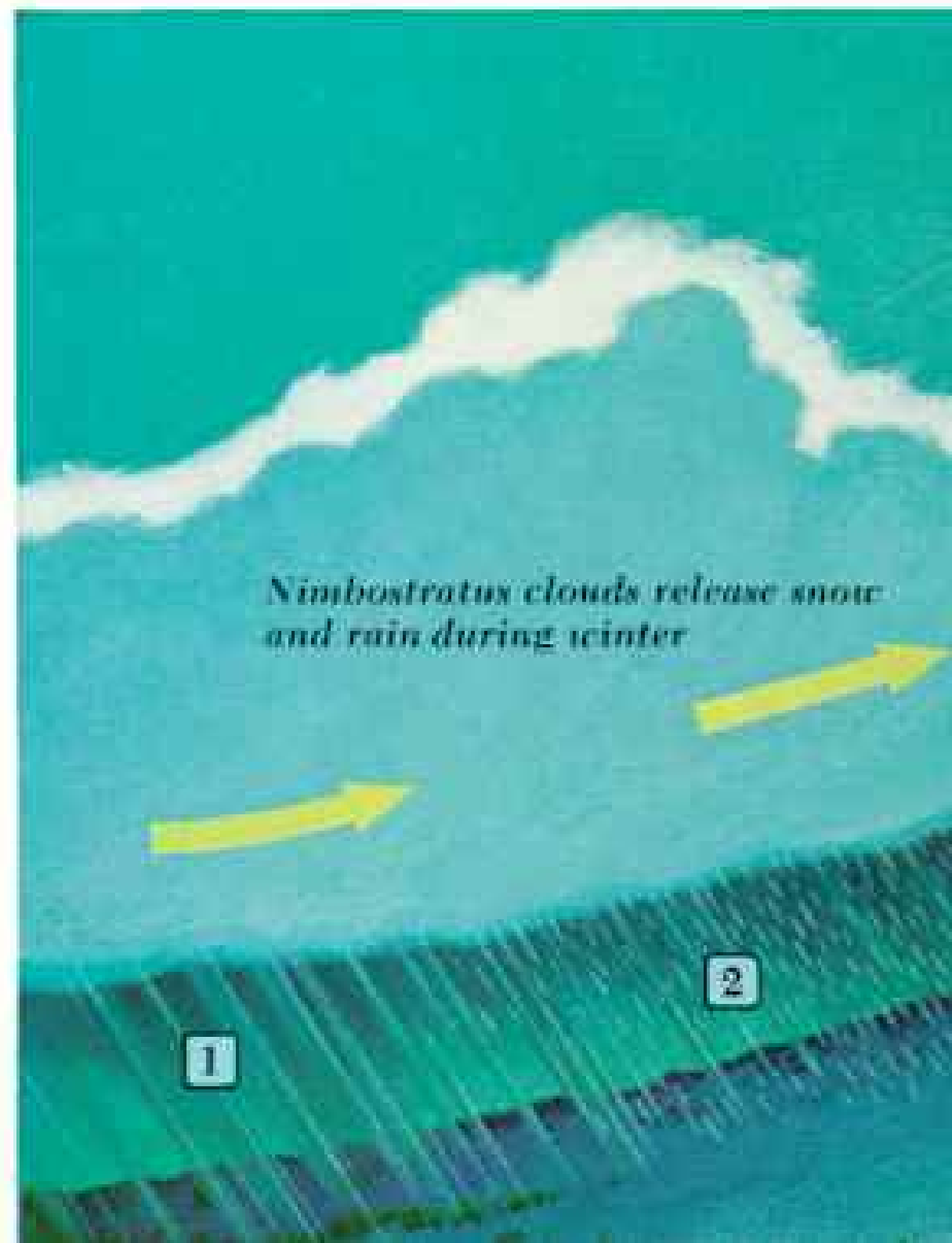
1—Rain pours down from clouds below 1,500 feet on Rainier's southwest slopes.

2—Snow starts between 1,500 and 2,200 feet, but at ground level it turns to slush.

3—Dense, wet snow between 3,500 and 7,000 feet blankets Rainier's midsection—more than 83 feet in a season at Paradise Ranger Station. Above 7,000 feet, it tapers off.

4—Cold, dry air above the 11,000-foot cloud level carries little moisture. But violent storms may drive vapor masses across the peak.

5—Inland slopes receive less snow because the clouds have spent most of their content.



Nimbostratus clouds release snow and rain during winter



down-filled mittens over silk gloves. Eight o'clock found us on the rubble-strewn glacier beneath the icefall (center of photograph at left).

The approach to the towering ice wall was by way of an outcrop of volcanic rock, 300 feet high, that sloped about 70 degrees. Smoothed by glaciers, it was virtually without holds for our fingers and toes. We had crampons, 12-pointed steel spikes to fit over our boots for ice climbing, and we decided to use these on the rock as well.

Lute led off. My eyes followed the rope tied to his waist as he maneuvered higher and higher. Sparks flew from his crampons as they scraped for purchase.

Ice Screws Anchor Climbing Ropes

Seventy feet up he found a ledge, anchored the rope, and belayed me up. Moving as fast as I could, I passed him, climbing 120 feet higher before I could find another belay position.

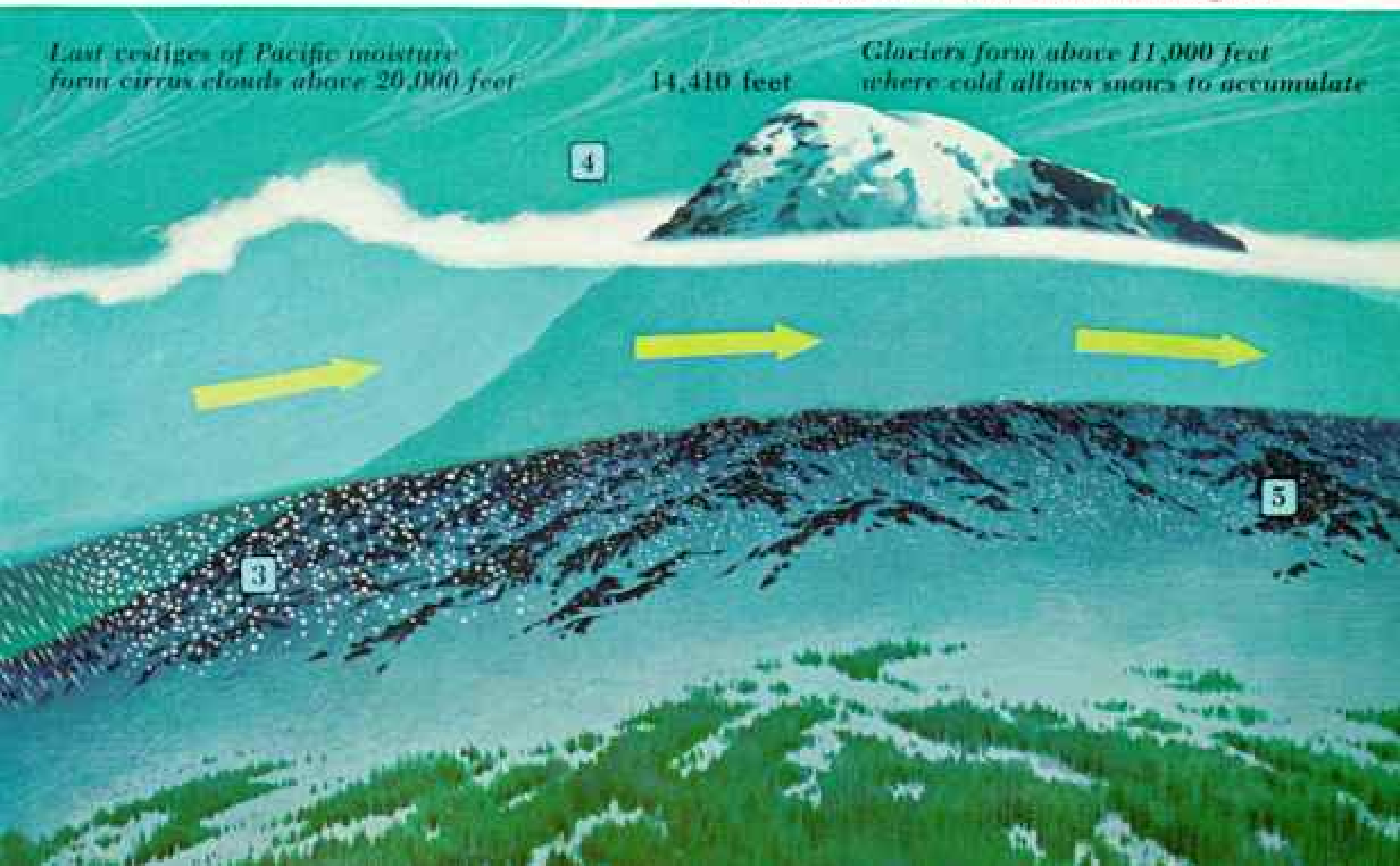
"This is just a psychological belay," I shouted. "Don't take any chances, because I can't really stop you if you slip."

Small nubbins of rock occasionally offered holds, but they were soft and usually crumbled away under our weight. Once we reached the ice above, we felt much better.

If the ice was less treacherous, it was no less steep. In some stretches it rose sheer for as much as 75 feet. There, as support for our ropes, we corkscrewed 8-inch steel ice screws into place. Seldom did we cut steps, for that took too much time.

Climbing by turns, we leapfrogged up the face for another 600 feet. The ice glowed an eerie, deep blue. 707

PRINTING BY DAVID WELTZER. RESEARCH BY STEPHAN SCHWARTZ © N. G. S.



Last vestiges of Pacific moisture form cirrus clouds above 20,000 feet

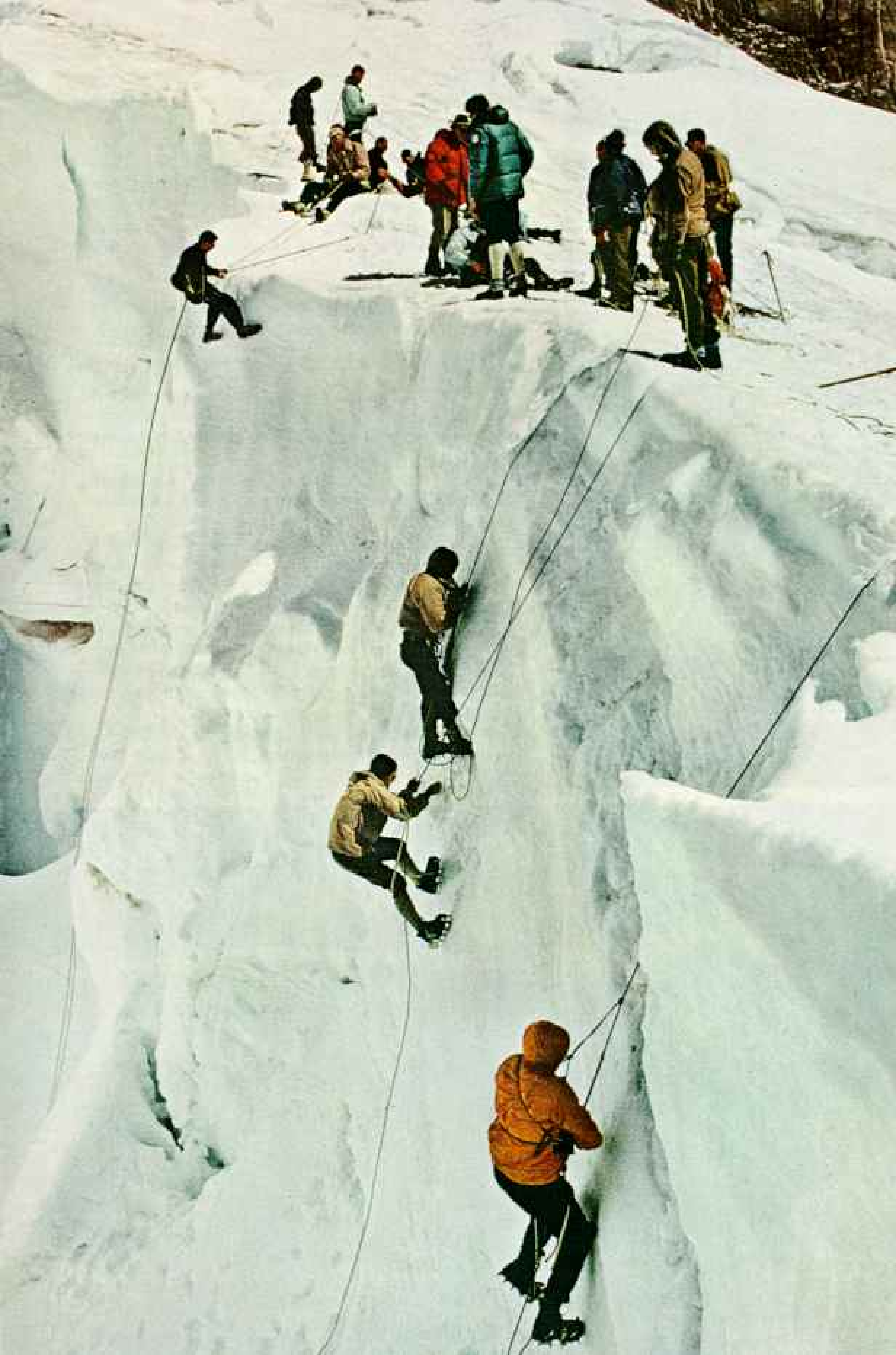
14,410 feet

Glaciers form above 11,000 feet where cold allows snows to accumulate

4

3

5



The night was windless, something rare on Mount Rainier, and we climbed in crisp, silent air. Lute was moved to verse, eloquently reciting "The Cremation of Sam McGee," as an antidote to the bitter cold.

By 10:30 we topped the icefall at 12,000 feet and ascended another 600 to Camp Comfort, a slightly sheltered outcropping where climbers using more conventional routes sometimes rest for the night. It would have been child's play to go the last 1,800 feet to the top, but we saved that for another time.

Later in the summer the icefall boomed and roared with tremendous avalanches, and our whole route calved away.

Were we foolhardy? No, not by the standards of experienced mountaineers. We took advantage of exactly the right combination of weather, temperature, equipment, surface, and moonlight. Still, I agreed with Lute's comment after the climb:

"If we'd seen that ice wall up close in broad daylight, we'd never have tackled it."

That moonlight ascent was my last major effort before our expedition set up camp for the final shakedown. There would be climbing, of course, to teach us to work as a team, but there were also countless scientific experiments to be conducted.

Climbers Serve as Guinea Pigs

We discussed these tests in evening conferences. I well remember the night that our scientific director, biophysicist Will Siri of the University of California's Donner Laboratory in Berkeley, warned us that we would be our own guinea pigs for many experiments.

In mock dismay we groaned in chorus.

"We're going to be subjected to extreme physical and mental stresses that will push us to, and perhaps beyond, our limits of endurance," he reminded us. "As all of you know from experience, when men climb to the heights, especially above 22,000 feet, they deteriorate physically and psychologically from the bitter cold, exhaustion, dehydration, and lack of oxygen.

"Under such conditions, men lose strength and motivation, they become irritable, they are unable to sleep, their appetites are shot, they lose weight, they become apprehensive.

"They even have hallucinations, such as

imagining a third man on the end of a two-man rope. We're going to study the effects of these stresses."

"My job, along with the doctors, is physiology. With the help of radioactive isotopes I hope to measure the changes that take place in our adrenal glands. Among other things, this will require collection of everyone's urine for 24-hour periods during the expedition."

We groaned again.

"Dr. Lester will ask us hundreds of questions and probe into our thoughts to determine what psychological changes take place.

"And Dr. Emerson, our sociologist, wants to find out how well we're able to communicate with one another under increasing stress. He'll use lightweight tape recorders so that our conversations and comments can be studied after the expedition."

Glacier Layers Unlock the Past

But not all our studies will be directed toward ourselves. Glaciologist Maynard Miller explained the work he will do on the Khumbu Glacier, where ice appears in identifiable annual layers, like the rings of a tree.

As one of his projects Dr. Miller will separate these layers year by year, melt them, and collect them in polyethylene bottles, a gallon of water for each year's snowfall. At the University of California at Los Angeles, Dr. Willard F. Libby will analyze these samples for tritium, a rare form of heavy hydrogen, to determine whether some of it comes directly from the sun during solar flares.

My own project, assigned by the National Geographic Society, is to measure the sun's radiation between 20,000 and 26,000 feet—higher than these measurements have ever been taken on the earth's surface.

For the first four days of the shakedown the weather was sunny, but one night a bitter storm struck Camp Muir with heavy snow and high winds. Our team was perversely pleased, for the blizzard allowed us to conduct tests under near-Himalayan conditions. It also created some excitement.

Maynard Miller was sound asleep on the Cowlitz Glacier when 60-mile-an-hour winds unmoored his tent and blew it, with Maynard

*See "Wintering in the High Himalayas," by Barry C. Bishop, NATIONAL GEOGRAPHIC, October, 1962.

Crevasse Becomes a Classroom as Student Climbers Learn Their Lessons

Up from a chasm on Cowlitz Glacier come three novices shod in crampons. Man beyond rappels down the ice face. These aspiring mountaineers took part in a five-day training seminar taught by the Rainier Guide Service and Mountaineering School.



KUJALAKHOMEE © NATIONAL GEOGRAPHIC SOCIETY

Rehearsing for Everest, climbers try out a two-man assault tent. External frame eliminates poles and simplifies pitching. Modifications after the shakedown improved the design and changed the color to burnt orange for better protection against snow blindness. Men wear oxygen masks and down-filled parkas of rip-resistant nylon.

Shrieking blizzard climaxes the shakedown on Mount Rainier and gives climbers a foretaste of Everest. Assault tent easily withstood 60-mile-an-hour winds, which battered down the weaker model beyond. Men test the climbing packs, oxygen masks, dark goggles, and windproof parkas they will use in the Himalayas.

inside, toward the gaping mouth of a crevasse. Bounced along in the cave-black darkness, Maynard awoke, confused and disoriented, and frantically tried to get out. His thrashing about was to no avail, but his shouts rose above the howling wind to bring help from two other men sleeping nearby. They stopped Maynard and his cocoon after a 75-foot slide—just three feet from the lip of the crevasse!

Weather Looms as a Major Challenge

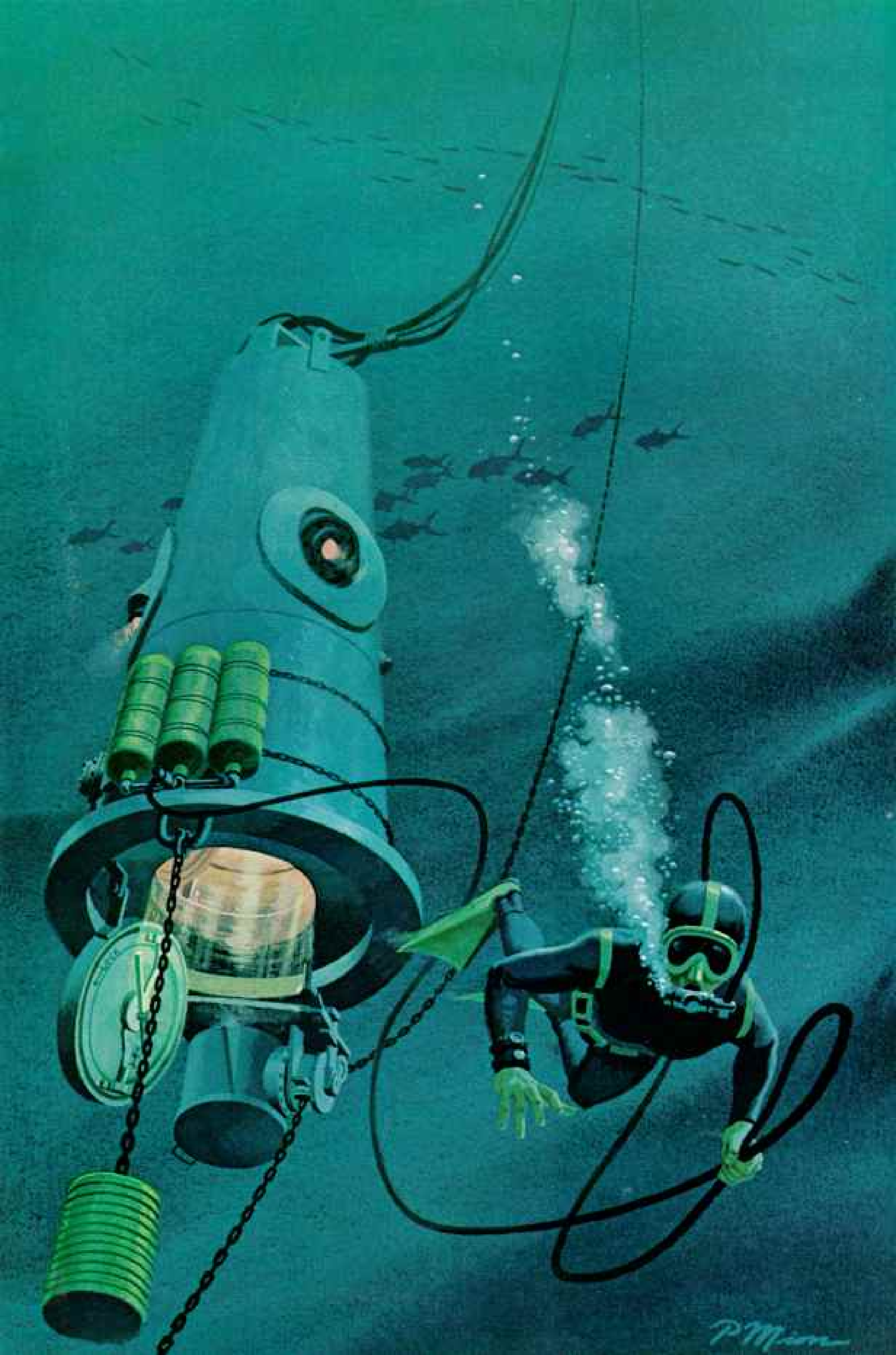
The storm not only prevented us from climbing to the summit, but it also prevented the packhorses from coming up from Camp Muir to pick up our equipment. We met this new challenge by carrying all our gear down to the inn in one trip. Four hundred pounds went down on our ski-toboggan, with five of

the team straining at ropes to keep it in check.

The rest of us shouldered gigantic packs, many weighing more than 120 pounds, and wallowed down the snow slopes. Big Jim and I staggered along together, laughing at each other's struggles to get up when we fell. After four muscle-aching hours we reached Paradise Inn, bringing to a rigorous end our Mount Rainier shakedown for Everest.

Lila and I came to Rainier in a chilling drizzle, and our shakedown ended in a storm. This, I think, is fitting, for it prepares us for the storms on Everest. It reminds us, as well, that only two of 12 major attempts to reach the summit of Everest have succeeded. But we have dedicated climbers, and we have superb food and equipment. The storm gods willing, we will succeed. **THE END**





P. M. Moore

ONE FEBRUARY DAY in 1962 I had the privilege of presenting to the National Geographic Society's Committee for Research and Exploration a project called Man-in-Sea.

The ultimate aim of this undertaking, I explained, was to enable men to live and work on the floor of the ocean at depths of 1,000 feet or possibly more for days, weeks, and even months.

"Working under water for weeks at a time!" I could feel a sudden tightening of attention in the room. These distinguished scientists and Society officers needed no one to tell them what such a development could mean to the world.

The average depth of the continental shelves is around 600 feet. If man could find a way to work there in safety and relative comfort, he would at once possess the key to more than 10,000,000 square miles of sea bed. He could tap the scientific secrets and mineral, animal, and vegetable wealth of these immense submerged plains, exploring ancient wrecks, mining diamonds or gold, farming the sea floor, feeding and herding fish like cattle.

Diver's Working Time Multiplied Manyfold

Most important, by *staying* down for long periods a diver would multiply many times the amount of useful work he could accomplish on the floor of the sea. No matter how long the dive, he would have to go through the time-consuming process of decompression only once. The time a diver on compressed air must spend in decompression after an hour at 300 feet, for example, is 7.63 hours—more than *seven and a half* times as long as he could spend in actual work. Man-in-Sea thus opened the prospect of intensive and continuous undersea work.

But I could feel a polite skepticism. How did I propose to solve the problems of nitrogen narcosis, the so-called drunkenness of the depths; and the dread decompression sickness, the bends?

In deep diving, man, not designed for living under water, faces grave dangers. Under pressure, his body absorbs gases contained in the air he breathes. Below 100 feet, nitrogen in the compressed air becomes narcotic, impairing the diver's faculties. His attention wanders, so that

Leaving his "house in the sea," a diver probes 200-foot depths in the Mediterranean. An artist's conception of the Link diving chamber shows how the aluminum cylinder combines the best of two worlds—the submariner's and the free diver's. Tests along the French Riviera last summer proved highly successful.

PAINTING BY FLOREN WIGNON © N.G.S.

Revolutionary diving cylinder has opened the way to new and unexplored frontiers—the vast continental shelves, with their promise of mineral wealth and scientific riches

Our Man-in-Sea Project

By EDWIN A. LINK



BOOTSCHPORE BY THOMAS J. ABRASCHOWICZ © N.G.S.

The Author: Edwin A. Link prepares to submerge for the first test of his ingenious underwater chamber. Inventor of aviation's Link Trainer and an expert diver, the retired industrialist now devotes full time to exploration of the world beneath the waves.



Moored off Villefranche, *Sea Diver* cradles the Link chamber on its afterdeck. World's first vessel built from the keel up for underwater archeology, it can range 7,000 miles.

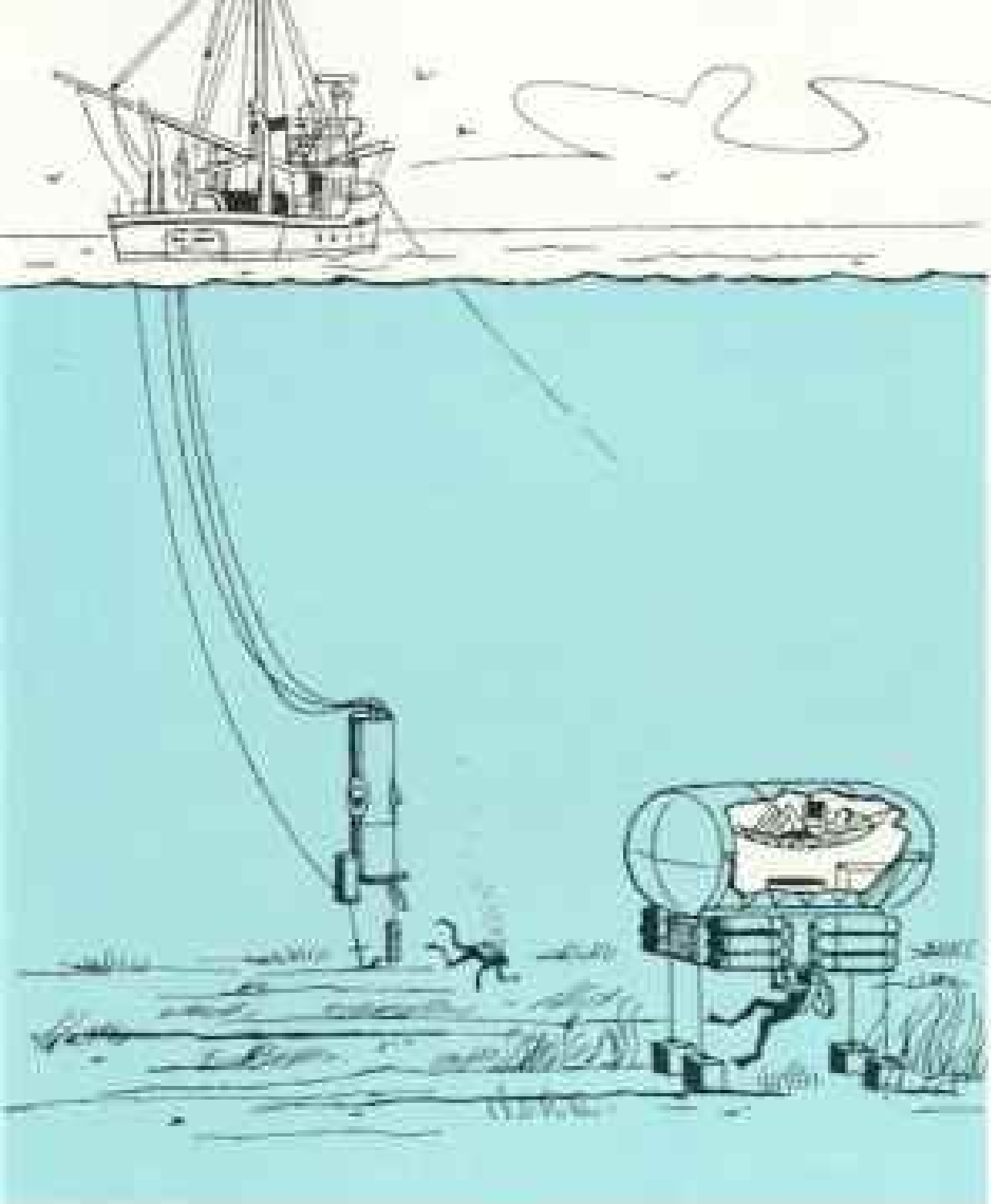
Living quarters on the ocean floor, cylindrical elevator, and large decompression chamber on deck—these are the three elements of Edwin A. Link's Man-in-Sea Project. The sea-floor dwelling is an underwater tent of tough, rubberized fabric. In it an off-duty diver relaxes in his hammock, while another enters from below.

This drawing by Pierre Mion is adapted from a sketch Mr. Link showed to the National Geographic Society's Committee for Research and Exploration early in 1962. Depth is greatly contracted; to show last summer's 200-foot dive in scale would require a drawing 16 inches long.

Ready for baptism, the cylinder swings from ship to sea. The diver who will ride it to the sea floor must swim down from the surface and enter a hatch at the bottom end (pages 712, 716).

PHOTOGRAPHS BY NATIONAL GEOGRAPHIC PHOTOGRAPHER RAYED LITTLEHALES © N.G.S.





he forgets to take normal precautions. This is nitrogen narcosis, and it has cost many a life.

If the diver stays down for a long time, and then comes up too quickly, gases dissolved in his body do not have time to pass off normally, and form bubbles. In his body tissues, the bubbles may cause itching and excruciating pain. In his circulatory system, they may obstruct the flow of oxygen to vital nerve and brain centers, causing blindness, paralysis, even death.

Because of these physical facts, dives to great depths have had to be sharply limited in time. Long ago it was discovered that if an ascending diver stopped at certain depths for varying lengths of time, gases absorbed by his body would pass off harmlessly. The catch is that so much time must be spent in decompression.

One answer to the problems of deep diving, I pointed out, would be to replace normal atmospheric air with an artificial mixture of oxygen and a non-narcotic gas. Years ago the United States Navy found that, by replacing numbing nitrogen with helium, narcosis of the depths was eliminated.

Another Hazard—Oxygen Poisoning

If a man breathes high concentrations of oxygen for a long period, he risks oxygen poisoning, which usually begins with nausea, progresses to muscular twitching, and ends in a convulsion. To avert this peril, the pro-

portion of oxygen in the artificial helium-oxygen atmosphere must be reduced as the depth of the dive increases. The object is to keep the absolute quantity of oxygen always the same as that at sea level.

The proposed long-range program was described to the committee as envisioning three major pieces of equipment: (1) an underwater pressure chamber affording houselike living conditions; (2) a smaller one-man chamber which would act as an elevator between the bottom dwelling and the surface; and (3) a large pressure-housing on the surface for comfortable decompression of several men at the same time (see drawing at left).

For the present we proposed to limit testing to the Stage 2 diving chamber, which would experimentally serve the function of the other two elements; besides carrying the diver from ship to bottom and return, it would double as a house from which he would emerge to the sea floor at will. It would also serve, aboard ship, as a decompression chamber.

Such a three-purpose diving chamber had already been built to my design through cooperation of the Smithsonian Institution and the Link Division of General Precision, Inc.

To this project the National Geographic Society now gave its powerful support, including a substantial grant of funds. First trials were planned for the summer of 1962.

Diver Exceeds 24 Hours at 200 Feet

"By the end of the year," I told the committee, "I hope to say that man can live and exist at 200 feet or more, coming back into this underwater house to eat or sleep, then going out to work or explore."

How this, and more, was accomplished off southern France last summer is told by Lord Kilbracken, in the following article.

We are grateful indeed to the U. S. Navy and its Sixth Fleet under Vice Adm. David L. McDonald for the fine cooperation given us in connection with these initial tests.

Besides the U. S. Navy and ourselves, other groups are working on diving problems.

The Swiss mathematician and diver, Hannes Keller, has gone as deep as 1,000 feet, but remained minimal time on the bottom, surfacing with drastically reduced decompression, using mathematical computations based on a secret mixture of gases.

Jacques-Yves Cousteau, the noted French undersea pioneer, has kept two divers in an underwater dwelling for a week, at a depth of 33 feet, from which they made sorties down to 80 feet.



Neither of these two approaches has combined the problems of remaining underwater at great depth for a long time.

Thus far we have been able to achieve both considerable depth and substantial duration—200 feet for 24 hours, 15 minutes in the dive described by Lord Kilbracken.

This summer we shall continue our experiments with animals at 400 feet for 24 hours or longer, in preparation for a program of manned dives.

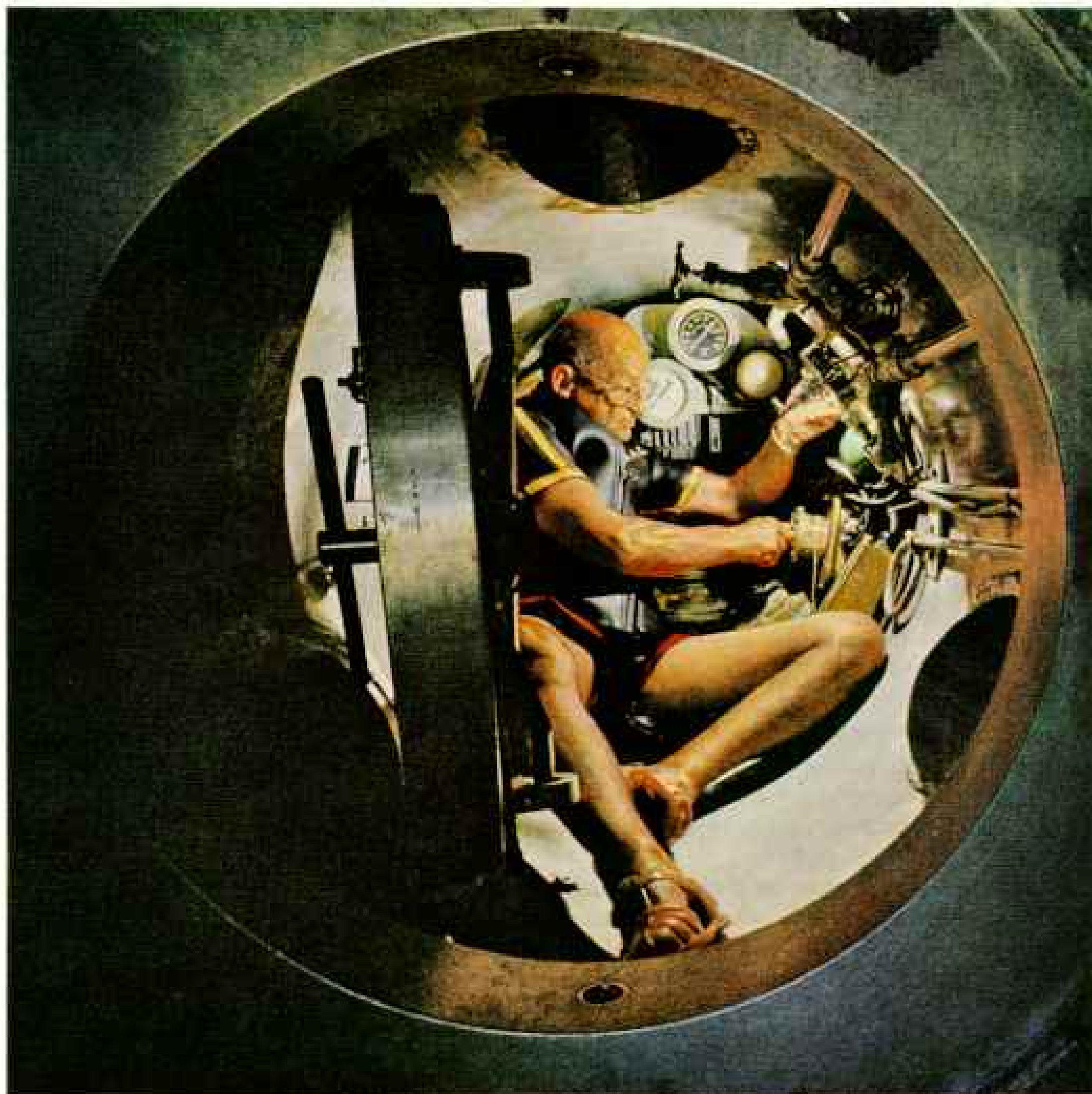
During these experiments, which we shall

conduct on the American side of the Atlantic, we plan also to test our Stage 1 large underwater housing for the first time. We are constructing it of rubberized fabric, instead of the steel originally specified. Inflated and anchored to the bottom, this "underwater tent" will house four divers, enabling them to sleep, eat, and work in safety and comfort.

We plan to continue Project Man-in-Sea in this unspectacular scientific manner, checking each step with care before proceeding to the next. * * *

Cloud of exhaust bubbles envelops diver Link as he climbs into the newly launched chamber from below. Although 58 years old, the inventor insisted upon making the first test dives himself. Eyelike port, one of three, enables him to scan the depths. Ballast rings hold the cylinder vertical at any depth and regulate buoyancy.

Zero hour approaches for the first major test. Designer Link makes a final check of the capsule's controls. He stayed submerged 8 hours at 60 feet.



*A diver dwells for more than
24 hours in the alien world
200 feet down in the sea*

The Long, Deep Dive

By LORD KILBRACKEN

Photographs by
BATES LITTLEHALES
National Geographic Staff

AHOY *Sea Diver!* Is the captain aboard?" I felt, I remember, like Ishmael joining the *Pequod* in Melville's *Moby Dick* as I stood last summer on the quayside at Monaco and hailed the chunky white motor-yacht. She lay stern-first to the quay, under the great cliff of the casino.

There was no mistaking *Sea Diver*. Her six-ton boom and lift, and the special research equipment on the afterdeck, immediately distinguished the 91-foot vessel from the 60 or 70 pleasure craft surrounding her.

I noticed, in particular, the unusual aluminum cylinder, 11 feet long and 3 feet in diameter, that gleamed enigmatically in the morning sunshine (page 714).

My hail was heard by the crewman—as I supposed him to be—who was working in shorts and sweatshirt beside the cylinder.

"Come aboard," he shouted. "I think he's somewhere below."

I made my way along the narrow gang-plank and we introduced ourselves. He was

Lt. Comdr. Robert C. Bornmann, a submarine medical officer who had been assigned by the United States Navy to observe and advise during *Sea Diver's* trials of a promising new diving device. He promptly led me below in search of Edwin A. Link, the vessel's owner and skipper.

I had met Mr. Link in London the previous spring, and with characteristic generosity he had issued me an open invitation to spend a few weeks on board. We found him in the engine room—in shorts, sandals, and an open-neck shirt—at work on one of the two diesels which give his vessel a cruising speed of 9½ knots and a range of 7,000 miles.

Inventor Turns From Sky to Sea

Only five years had passed since Ed Link's main interest and whole inventive genius had begun to shift from the sky to the waters under the sea. Till then, as is widely known, his life had been in aeronautics: He was a pioneer aviator who first flew as a pilot in 1926, and he made his name and fortune through that highly ingenious device, the Link Trainer, which simulates instrument flight without leaving the ground.

In 1959 Link resigned from the presidency of General Precision, Inc., to devote his full attention to underwater archeology and research. *Sea Diver*, built to his design and specifications at Quincy, Massachusetts, as his floating laboratory and base, was launched the same year.

Now he was engaged in a revolutionary Man-in-Sea Project, using undersea equipment of his own design, which could enable divers to do useful work at far greater depths, and for far longer periods, than had previously been possible. This could open up millions of square miles of unexplored sea bed for scientific research and commercial exploitation.

His project had strong American backing, including the support of the National Geographic Society and the cooperation of the Smithsonian Institution.

Link is 58, but he has the physique and enthusiasm—and the capacity for hard work—of a man two decades younger (page 713). His sharply intense features were burned

The Author: John Godley, third Baron Kilbracken, has written half a dozen books and many articles for magazines on both sides of the Atlantic. For service as an officer with the Royal Navy's Fleet Air Arm during World War II, he was awarded the Distinguished Service Cross. When not traveling, he lives in London or in his ancestral home at Killegar in County Leitrim, Ireland.



brown by the Midi sun. With his almost-shy smile and self-effacing manner, he told me of the vital implications behind his work—and of the problems and dangers he faced.

Frontier Lies Only Fathoms Down

"Although oceans cover 71 percent of our planet, they are virtually unexplored," he said. Man can go to great depths in a bathyscaph, but he remains a prisoner inside it. Such vessels are of limited value for the whole range of undersea operations which involve physical contact with the water.

The most obvious of these, Link went on, is salvage, but there are others no less important: prospecting and drilling for oil and minerals, bridge building and pile driving, even submarine cultivation and fish farming. Little useful work of this nature has ever been done below 150 feet, and virtually none at twice that depth.

A helmet diver—who is seriously handicapped anyway by his cumbersome equipment—could spend perhaps three or four hours at 200 feet, but he then would have to make a very slow return to the surface to avoid the bends. He would be exposed throughout the dive to the cold of the water, and he could not eat or drink.

Ed Link's basic objective, he told me, was

to get the best of two worlds—the submariner's and the self-contained diver's. He had designed and built a submersible compression chamber, which the diver could leave "in his skin" at depths down to 400 feet. Thus he could work for hours at a time, returning to the chamber for rest and refreshment whenever necessary. This device was the aluminum cylinder I had seen on the afterdeck.

The gradual return to surface pressure would still be as necessary as ever, but this could be accomplished in the relative warmth and comfort of the cylinder itself, under water or on the ship or shore.

"Come and have a look at it," Ed said, and led me out on deck.

The cylinder lay in its horizontal stowage position. It had been built in the United States, he told me, to his own specifications; it weighed, with ballast, 4,200 pounds.

Ed explained that it was only a research prototype. It could be the forerunner of far larger "sea houses," in which several men would be able to live and work at great depths for weeks or even months, but this was strictly a one-man model.

The cylinder has three airtight and watertight circular hatches. Two of these are back to back at the entrance. One opens outward to withstand external water pressure, and the



Like umbilical cords, two air hoses, a phone and power cable, and a winching chain connect the revolutionary Link diving cylinder to the mother ship, *Sea Diver*. Anchored chamber floats vertically, hatches open and atmosphere at a pressure equaling the sea's. Diver breathes helium-oxygen supplied by a hose from tanks on the chamber.

ILLUSTRATION BY PERRY WILSON © NATIONAL GEOGRAPHIC SOCIETY

P. M. ...



PHOTOGRAPH BY THOMAS A. BRIDGEMAN, NATIONAL GEOGRAPHIC STAFF

Tension grips *Sea Diver* as U. S. Navy Lt. Comdr. Robert Bornmann, medical adviser for the tests, measures the oxygen content in the mixture piped to Ed Link during a 60-foot dive. The successful test preceded Belgian diver Robert Stenuit's record 24 $\frac{1}{4}$ -hour stay at 200 feet.

Anxiety grows after Stenuit starts his ascent. His wife and author Kilbracken (right) reflect concern over a leakage of vital helium from the diver's breathing system. Engineer-mathematician William Marquet makes sure carbon dioxide in the breathing mixture remains at a minimum; yellow cylinders at left contain lithium hydroxide that removes the waste gas from the system.



"*Bonjour, Robert. Comment ça va?*" Mrs. Stenuit exchanges greetings with her diver-husband 200 feet below *Sea Diver*. Stenuit could hear her perfectly over the intercom, but his speech sounded unintelligible, somewhat like Donald Duck's, because helium in the breathing mixture affected his voice.



other opens inward to withstand internal air pressure (pages 726-7).

I could now see that the cylinder is divided into two separate compartments by the third hatch. Each of these compartments has an internal diameter of $35\frac{1}{2}$ inches. Immediately inside the entrance is a small air lock, $4\frac{1}{2}$ feet long. Beyond the third hatch, which also opens inward, lies the instrument-packed main chamber, with an effective length of 71 inches. This compartment would be the diver's living quarters.

"All the Modern Conveniences"

The diver can look out through three tilted portholes. When he wishes to leave the cylinder at any depth, he makes sure that the internal atmosphere has a pressure equal to that of the water outside. All hatches may then be opened; the cylinder retains its air as does an inverted wine glass in a basin of water. The diver, with breathing apparatus

strapped on, can come and go as he pleases.

On finally re-entering the cylinder to return to the surface, the diver first closes the hatches behind him. The internal air pressure is then slowly decreased in accordance with decompression schedules. The pressure of the sea outside the rigid cylinder is irrelevant. Cylinder and diver may therefore be brought back immediately to the parent vessel if an emergency arises.

"I assure you it's quite comfortable," Ed Link said with a laugh, when I feelingly told him that I wouldn't like to go down in it.

"My little 'sea-bungalow' has all the modern conveniences: electric light, heating, air conditioning, telephone. The breathing mixture is supplied from the ship, and the exhausted atmosphere is returned to it, by means of these two hoses. No face mask is necessary inside the cylinder."

"At shallow depths we can use compressed air," Ed told me. "But I intend to use a

721

PHOTOGRAPHS BY NATIONAL GEOGRAPHIC PHOTOGRAPHER WALTER LITTLEHALLE © N.G.S.





Choppy Seas Sink Supply Boat and a Ton of Vital Helium Tanks

Returning from Villefranche with 15 heavy cylinders of helium, *Sea Diver's* 19-foot auxiliary launch *Reef Diver* encountered a sudden Mediterranean wind storm. Despite the crew's best efforts, the boat began taking water over the stern. Moments later it sank in 240 feet of water. National Geographic photographer Bates Littlehales snapped the dramatic series of pictures below at intervals of several seconds.

The accident occurred while Belgian diver Robert Stenuit was submerged in the chamber at 200 feet. Loss of the helium compelled the crew to bring him up after a stay of just over 24 hours.

Mr. Link's chamber later enabled divers to raise the launch, the first instance of putting the cylinder to practical use. Part of the helium also was recovered.

Waves flood over the launch's stern



helium-oxygen mixture for all the long-duration deep dives, and no one knows exactly what its effects are going to be under these unprecedented conditions. An important part of the trials will be to find out."

While we were talking, Bob Bornmann was working on the gas analyzer, which had been giving trouble, and Link joined him.

"It's a vital piece of equipment—it measures the percentage of oxygen in the breathing mixture," he told me. "Doesn't look too good, Bob; let's strip her down."

I watched admiringly as they worked together. The analyzer, I saw, was built into the mixing tank, in which the appropriate gases would be mingled in the desired proportions by the control crew on deck.

Because helium is a rare and expensive gas, a "closed-circuit" breathing system would be used. Carbon dioxide contained in the exhaust would be absorbed by lithium hydroxide crystals upon its return to the ship. Oxygen would have to be added, but the same helium, in theory, would go round and round the closed circuit, like a stage army, although in practice there would almost certainly be slight leaks in the complex system.

High concentrations of oxygen can be toxic, and so the proportion of oxygen to helium must be decreased with increasing depth. At 200 feet, the diver would breathe 97 percent helium and 3 percent oxygen. During

ascent, the percentage of oxygen would be increased gradually by the control team aboard *Sea Diver* until, at 40 feet, it again reached 21 percent, the normal ratio of the air we breathe at sea level.

Link had already made several short dives, using compressed air, and all had been successful. Now, he told me, he had a two-stage program. After a further period of experimentation, he himself would spend eight hours at 60 feet—far longer than anyone had ever remained at that depth before. He would then decompress for six hours. For this dive he would breathe the helium-oxygen mixture.

If all went well, he intended to send an experienced young Belgian diver, Robert Stenuit, to a depth of 200 feet for 24 hours—possibly longer. This, of course, would be completely unprecedented.

Soon I met the other members of the *Sea Diver* team. First was the charming Mrs. Marion Clayton Link, who serves as quartermaster, looks after business details, and keeps a detailed log (she is a talented writer).*

The others were the Links' 21-year-old younger son, Clayton, an experienced and accomplished diver, who was working as a regular crewman during his vacation from Colgate University; Jay Elliott, Texan first mate

*Mrs. Link wrote of *Sea Diver's* underwater archaeological work in "Exploring the Drowned City of Port Royal," in the February, 1960, *GEOGRAPHIC*.



Shipwrecked crew struggles in turbulent waters

Stern-first, the craft plunges bottomward





ROBERT H. ROBERTS © 1954

Chamber bobs like a cork as it surfaces with Stenuit after his record dive. With inventor Link directing, crewmen hoisted the cylinder from the sea during a lull in a storm. "I am shaken like dice in a cup," Stenuit wrote in his log. "Through the port-holes I see the dark sky, then the ship, then the water, all dancing a mad ballet."

and chief diver; Dan Eden, English chief engineer; two English sailors, Pete Hudson and Roger Woods, and the Greek cook, whose name Ioannis had become Johnnie.

Ed Link Makes the First Major Dive

By August 10 Link was ready to sail to Villefranche-sur-Mer to carry out his trials. Within the great sweep of Villefranche Bay he could find whatever depths he might need without leaving sheltered waters.

This highly picturesque French harbor is the Mediterranean headquarters of the U.S.

Sixth Fleet—another point in its favor. Here we moored to a buoy in 65 feet of water—enough for the moment.

That afternoon, the inventor made a trial dive using compressed air, which gave me my first experience of seeing him in action. The cylinder was hoisted from deck and lowered into the sea, where it floated vertically, nine-tenths submerged. Jay Elliott was sent down to open the hatches.

Without ceremony, Ed Link then jumped into the water, wearing frogman's equipment—black rubber suit, swim fins, face mask,

He at once surface-dived beside the cylinder and felt his way down to its open "front door." Within seconds his voice came over the telephone: "I am inside the cylinder and about to close the hatches."

With hatches closed, Ed could winch himself to any depth along a chain secured to an anchor on the bottom.

"Ten feet—20 feet—30 feet," he reported. Then: "Preparing to emerge at 35 feet."

Link could raise internal pressure to equalizing level by closing the exhaust vent; he could then open the hatches and leave the cylinder, using self-contained equipment.

The trial dive lasted just over two hours at varying depths, with a brief descent to the sea bed at 65 feet. All went well.

At last the diver reported: "Experiment completed. Am about to return to surface."

A few moments later the cylinder broke the flat, calm waters beside the ship. A cable was attached, and it was hoisted on deck with its passenger still inside.

A decompression period of only 20 minutes was necessary, and this was almost completed by the time the cylinder was secured. Ed Link emerged grinning broadly.

"I feel fine," he said—and he looked it.

During the next two weeks, several more dives of varying lengths were made. By the evening of August 27, Link felt ready to make the dive which, if successful, would complete the first stage of his program: eight hours at 60 feet. This would be followed by six hours of decompression.

There is normally no danger of nitrogen narcosis at 60 feet, but Link was testing procedures for the deeper dives to come, when narcosis would be a hazard. To eliminate the danger, helium would replace nitrogen in the diver's breathing mixture, and it was necessary to know whether he would suffer ill effects. Ed Link therefore decided to use helium-oxygen for the 14 hours he would be breathing compressed gases.

In and Out of Cylinder at Will

At 8:21 next morning the cylinder was hoisted from its stowage position and lowered into the water. It had been filled with the two gases in the correct proportions for use at surface pressure: 79 percent helium and 21 percent oxygen. Clayton Link went down to open the hatches, which took him 25 minutes. It was 9:15 when Ed Link entered the water, and within seconds he reported that he was

safely in the cylinder. As soon as he closed the hatches, he telephoned:

"Ready to submerge."

He began winching himself down and reached 60-foot depth at 9:35. Internal pressure was then raised to the equalizing level of 2.8 atmospheres by Bob Bornmann and Dan Eden, who together manned the control post.

Link reported "all hatches open" at 9:42. He could now leave the cylinder, and return to it, at will. He made his first sortie soon afterward, drawing his breathing mixture through a rubber hose which connected his face mask to his air supply.

Diver's Voice Warbles Grotesquely

A single difficulty showed itself. When a man breathes helium, the gas has the effect of raising the pitch of his voice. The result is hard to describe; it sounds something like a recording that is played too fast. Even in the relatively low concentration Link was using, it was hard to understand him on the telephone.

The mail came aboard soon afterward. There were several letters for our test diver, and we sent them down to him, together with the morning papers. They were inserted in a screw-cap jar and taken down by his son. He then re-entered his "home" for half an hour of reading and dictated replies to urgent letters by telephone to the control post.

By now it was midday. Ed Link's lunch would be just the same as ours: macaroni and cheese with a salad, followed by fresh fruit and cookies. These were packed by Mrs. Link in plastic containers, sealed with tape, and taken down to him by Clayton at 1:15, together with a large flask of hot coffee.

"My meal has reached me in first-class condition," he reported. "I'm using a hypodermic needle to let pressure in before opening the coffee flask."

I believe Ed had a catnap after lunch—the phone was silent for a good 20 minutes—but then he came to life and spent much of the afternoon outside his "sea-bungalow."

An old friend and colleague of his, Dr. Harold E. Edgerton, of the Massachusetts Institute of Technology, was aboard *Sea Diver* with his recently developed "mud-pinging" apparatus (an echo sounder that penetrates soft bottom sediment to reveal the layers beneath). The two inventors now worked together at putting it through its paces—Dr. Edgerton in a dinghy, Ed Link on the ocean

floor. This was important research work, which proved that lengthy and useful tasks could be performed at this depth.*

At 5:35 Link had reached his record-breaking target. If he had spent eight hours at 60 feet without his diving cylinder, he would have had to remain in the water without nourishment for a further six hours of decompression. Not surprisingly, no one had ever done this.

Once he had closed his hatches, Ed Link could have returned immediately to the safety of the ship, though he would still have had to spend six hours in the cylinder while the pressure was gradually reduced to surface level. But he seemed in no hurry to return on board, and actually stayed submerged at varying depths till 9:05. By then he had eaten the excellent dinner, including hot roast chicken, that Jay Elliott took down to him.

Link still needed 2½ hours of decompression when he was hoisted aboard. In the horizontal stowage position, he could now lie down—for the first time since leaving his bunk that morning. He promptly fell asleep.

At 11:35 p.m., Bob Bornmann opened the hatches: "Time to wake up, Ed; you can come out now," he said. It was 14 hours and 20 minutes since he had entered the cylinder.

Ed Link was in the best possible form. He laughed and joked, gave his wife a hearty kiss, and then went straight to work on the dive's mass of technical data.

The first part of the program was thus successfully completed. I know well that Ed Link would have dearly loved to continue as the

guinea pig, but he felt the time had come to give way to a younger man.

Robert Stenuit, who arrived from Brussels with his attractive wife Annie five days later, is 29. He is a highly experienced diver: He spent two years diving for Spanish treasure galleons in Spain's Vigo Bay, and had worked with Link on archeological research in the sea off Syracuse, Sicily.

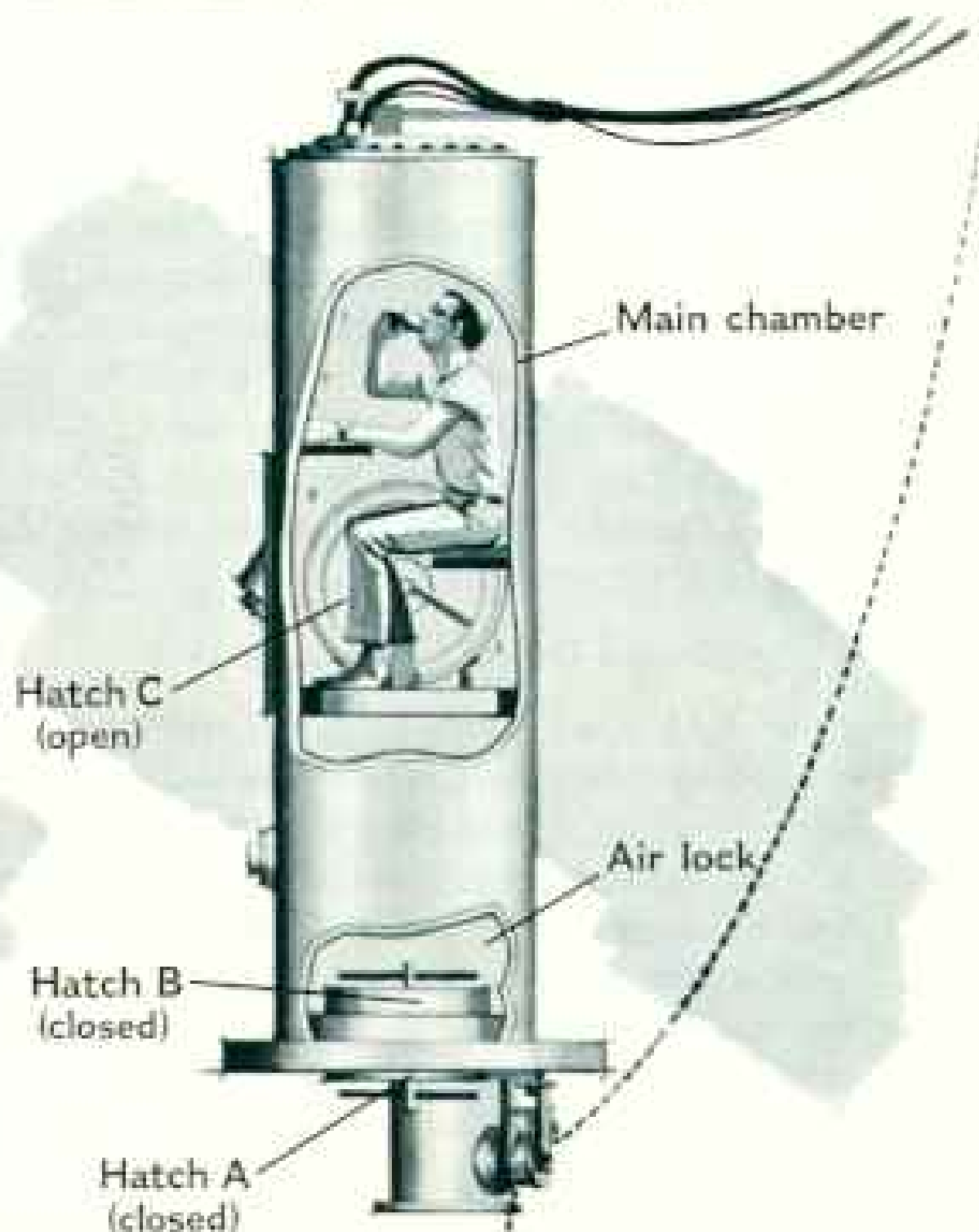
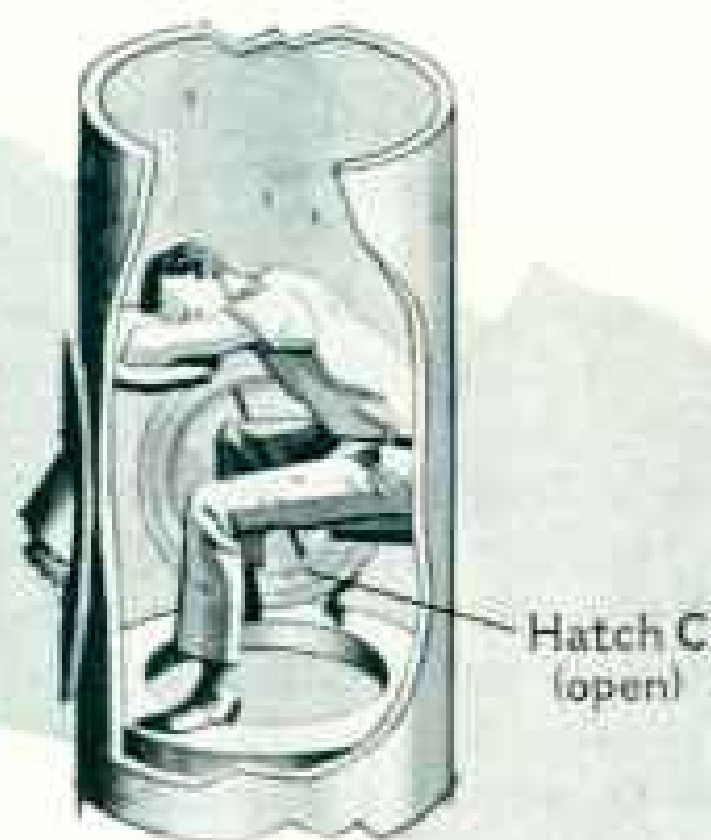
He is dark and good-looking, with a pleasant, diffident manner, and has something of the idealist about him. Also he is extremely tidy-minded and purposeful. He seems slight in build, but in fact has immense powers of endurance. However, his most important attribute is perhaps his complete sang-froid. Throughout the hazardous operation which lay ahead, he remained totally calm.

Objective: a Day or More at 200 Feet

The project is simply stated. Usually, a stay of one hour at 200 feet would be considered very long. Stenuit would stay there at least a full day—possibly two or three. It would be an advance as complete—and as important in its own way—as the orbits of the spacemen.

Stenuit arrived in Villefranche on September 2 and at once set about acquainting himself with the complex equipment. By next evening, he felt ready to carry out some practice dives, and accordingly spent most of the

*For 13 years the National Geographic Society has aided Dr. Edgerton in the development of deep-sea cameras, "pingers," and "boomers"—locating and sounding devices of great importance to oceanography.



following day—September 4—at varying depths, up to a maximum of 60 feet, using compressed air. All went well, and he now assured Ed that he felt fully confident to undertake “the big dive,” even though he had no experience with helium.

We moved to deeper water that evening, dropping anchor off the tip of Cap Ferrat, where our echo sounder showed 225 feet. The Sixth Fleet sent a submarine rescue vessel, U.S.S. *Sunbird*, to stand by throughout the dive, and she arrived at dawn next morning.

The weather had been perfect for a month, but now a mistral started to blow. This is the strong, cold wind which occasionally strikes the French Riviera, sometimes with great force. But it blew itself out within 18 hours, and no more than a day was lost.

Climactic Dive Starts Routinely

On the morning of September 6, Robert Stenuit entered the water on this important diving trial. The cylinder, prefilled with helium-oxygen and equipped with emergency rations for three days, had been lowered over the side at dawn. Stenuit blew a kiss to his wife, who watched from the afterdeck, then dived to the cylinder, which he entered at 9:50.

Since this was his first experience with helium, he began by making a series of acclimatizing dives at varying pressures without leaving the cylinder.

It was 10:50 when he started the dive proper. Internal pressure was raised while he was still near the surface. It reached the equiv-

alent of 200 feet (7 atmospheres) at 11:30, and he began winching himself down. He reached 200 feet at 12 noon, and the big dive was on. As things turned out, it was to be marked by unexpected drama.

Everything went completely on schedule for the first 20 hours. There was only one difficulty: We simply could not understand what Stenuit was saying on the telephone. He was breathing, at that depth, almost pure helium (97 percent), which so affected his voice that we could not even distinguish “Yes” from “No.” His speech was a grotesque combination of Donald Duck’s and Popeye’s.

Ed Link suggested that he should say “O.K.” instead of “Yes”—the disyllable could be picked out readily. For longer messages, he used the Morse code.

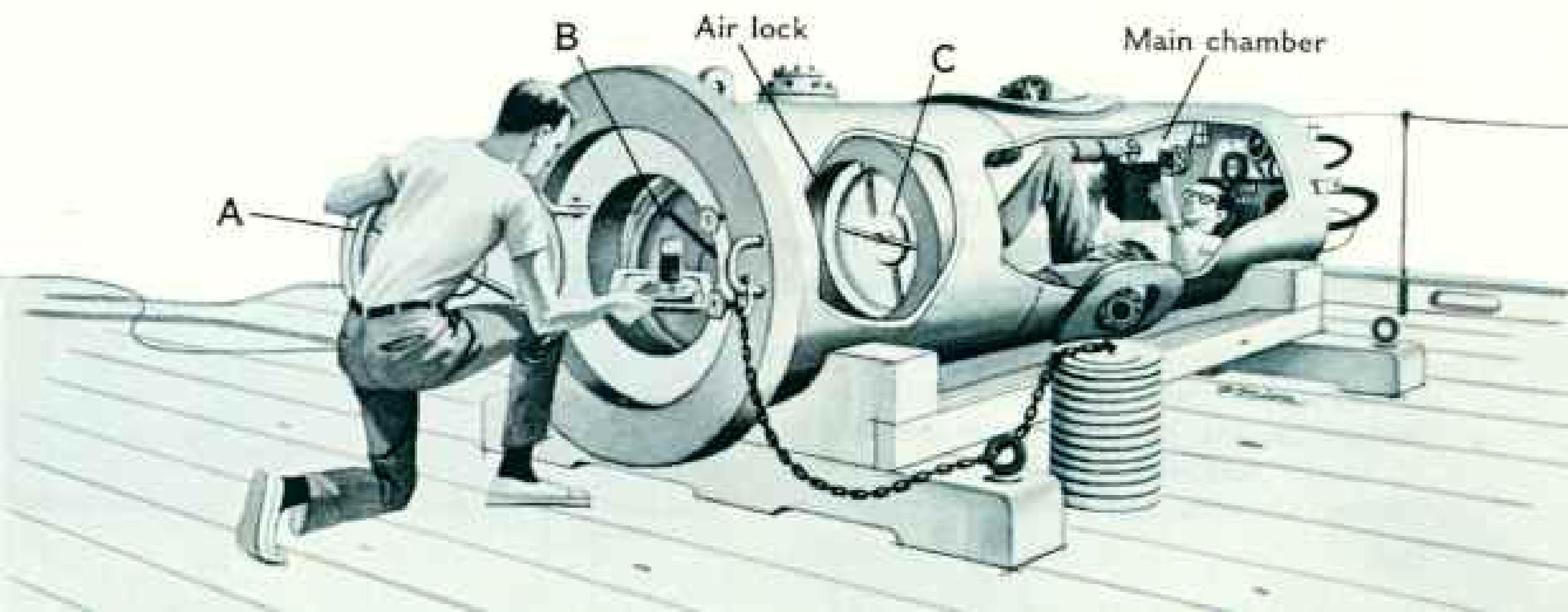
Stenuit several times left the cylinder to explore his environment and to simulate the performance of useful work; he was handicapped by the coldness of the water, which alone restricted each sortie, but otherwise was comfortable enough. He ate two meals and passed a reasonably comfortable night, though sleep was not easy in the cramped, semivertical position.

Next morning, things started happening. Stenuit reported “All well” in Morse at 7:00, and informed Ed Link that he felt quite prepared to spend at least 48 hours at that depth. Then it was discovered that there had been an unexpectedly high wastage of helium during the night. This was because of slight leaks in the breathing system, exaggerated

Sleeping or eating, an underwater dweller in the six-foot-long main chamber has hatch C open while hatches A and B remain closed (opposite page). The sea will not come in when he opens all hatches, because the chamber’s atmospheric pressure equals that of the water. Before going out, he will put on a rubber suit and breathing device.

Back aboard ship, the diver remains in the chamber for decompression that may last several days. To prevent loss of pressure, hatch C must be closed each time a crewman opens hatches A and B to place food in the air lock. Before opening C, the diver raises pressure in the air lock to equal that of the main chamber.

DRAWINGS BY FICHEL WILKIN © 1963





"Hello in there!" Iana Eden, daughter of *Sea Diver's* chief engineer, eyes Stenuit through a glass viewing port. Mrs. Stenuit stretches to peer through another port.

Seen Through a Porthole, Stenuit Drinks Coffee During the 58½-hour Decompression Wait Aboard Ship

Black needle on gauge at upper left registers pressure equivalent to that at a 70-foot depth. When the needle dropped to 53 feet, the diver felt a sharp pain in his wrist. Pain subsided when the pressure was raised to 70 feet and held there for 12 hours.

At first Stenuit believed he had suffered a mild case of the dread bends, but when he later felt similar twinges, he reported: "It is impossible for me, stiff as I am because of inaction, to determine if the slight pain is a simple cramp or an alarming symptom."

Full-course dinner, Stenuit's final meal inside the chamber, is passed in to him.

by the high pressure. There were 15 bottles left on board; each was lasting only about 90 minutes, and it had been calculated that the first 17 hours of the decompression period would have to be on helium.

At this stage, there seemed no cause for alarm. There were adequate reserves ashore. Mr. Link sent Jay Elliott, with Roger Woods and Pete Hudson, in the auxiliary vessel *Reef Diver*, to collect as much as was needed.

Rough Seas Swamp Burdened Launch

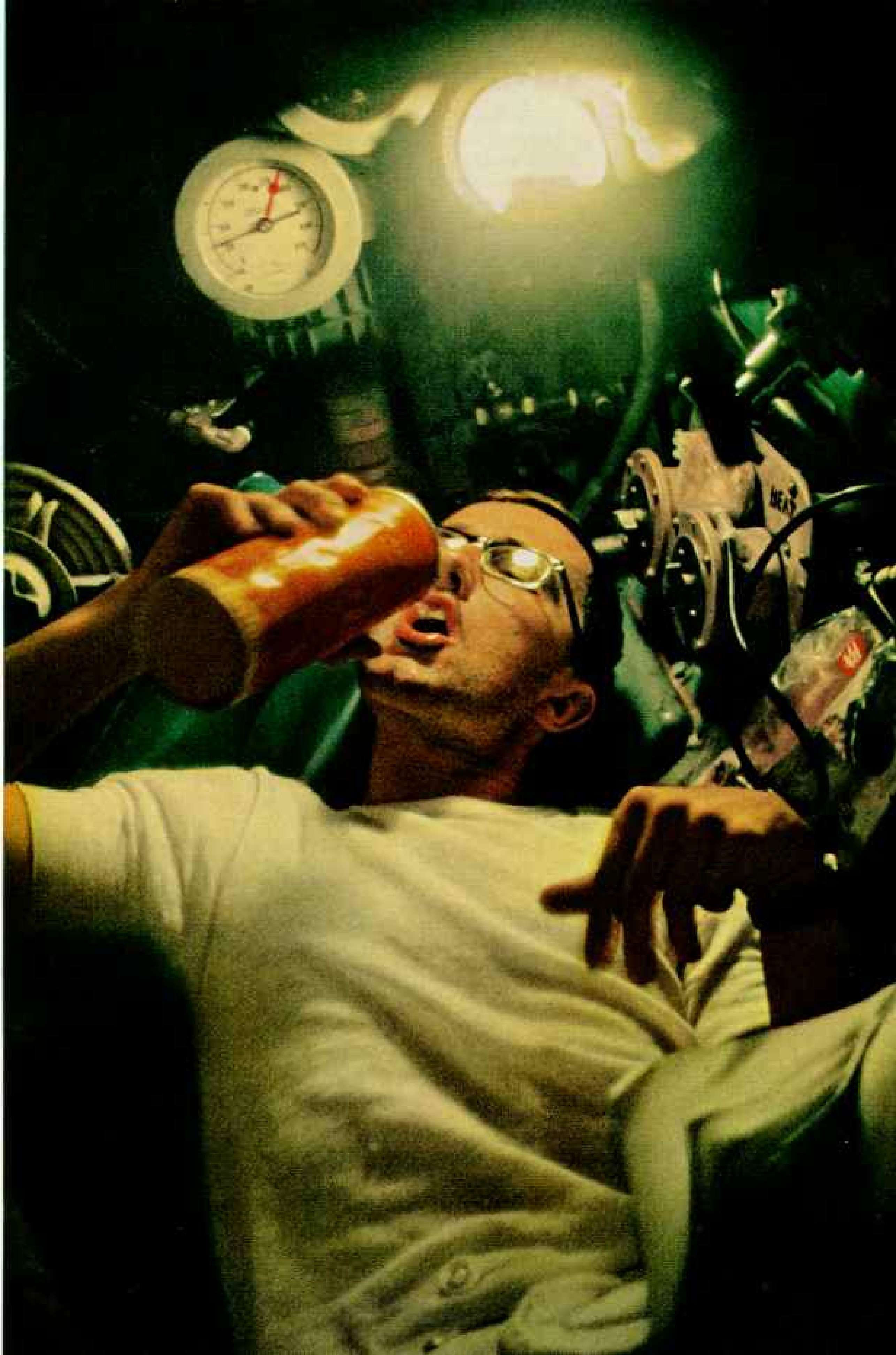
Reef Diver, a 19-foot launch powered by a 42-horsepower Perkins diesel with water-jet propulsion, set off toward Villefranche shortly after 8 o'clock. Soon a strong southwest wind sprang up. Within half an hour the bay, which had been millpond calm at dawn, was being lashed by a wind with gusts approaching gale force.

At noon, when *Reef Diver* returned, a really heavy sea was running. She had 15 bottles of helium aboard, weighing more than a ton.

As the men shifted weight, *Reef Diver* pitched violently. The stern was suddenly al-



ARRANGED BY NATURAL GEOGRAPHIC PHOTOGRAPHER PAUL LITTLEFIELD. © N.Y.



most awash. Moments later, she began taking water rapidly. Her bows rose hideously as the three crewmen tried their utmost to shift the load forward. They hadn't time. In a couple of minutes, *Reef Diver* reared up vertically, throwing them into the turbulent sea, and disappeared with her precious cargo beneath the waves (pages 722-3).

The danger of the situation now became apparent. We had 11½ bottles of helium left. If we began chamber recovery immediately, there would just be enough, if the leaks became no worse and if nothing happened to prolong the decompression schedule.

Stenuit was not told the reason for terminating the dive at once, and he objected strongly when informed at 12:15 that we were going to bring him up as soon as possible. He was prepared to stay at 200 feet for another couple of days.

In normal weather conditions, we could have brought him on board at once, though he would have had to remain in the cylinder for the long decompression period. But the sea was now so rough that it was considered safer to leave him in the water.

He reached 100 feet at 12:45, and began decompression at 12:50. He had been at a 200-foot pressure for 25 hours, 20 minutes (and at actual 200-foot depth for 24 hours, 15 minutes).

New Danger Replaces Helium Fear

With early evening there came a slight lull in the storm, and the crew quickly brought Stenuit on deck. It was a hazardous operation, with the cylinder swinging crazily, but the men accomplished it successfully. We now found that less helium was being lost than previously because of the lower pressure in the cylinder; *that* danger seemed over.

It was replaced by another. Standard decompression tables gave no information for a dive of this length. A conservative schedule was adopted, which called for 15 hours at the equivalent of 100 feet, and then 39 hours at progressively lower pressures.

At 4 o'clock next morning, I was standing with Bob Bornmann beside the cylinder as he began decreasing the internal pressure to the equivalent of 50 feet. At 4:50 when he had reached a pressure equivalent of 53 feet, Stenuit reported by telephone—his voice at this lower pressure was again comprehensible—that he believed he was getting the bends in his right wrist. Bob immediately held the pres-

sure. Two minutes later Stenuit came on the phone again. "It is definitely the bends."

This wrecked our decompression schedule. Pressure had to be increased immediately to the equivalent of 70 feet, and held there for 12 hours. It was fortunate, indeed, that the helium leak had diminished.

Stenuit now concedes that his "bends" may have been only a cramp. The decompression schedule seemed to be within acceptable limits as far as they could be calculated by inference—and this was to be confirmed by later experiments. But no unnecessary risks could be taken, and the symptoms were at once relieved when pressure was increased.

Under the revised schedule, there would be a total decompression period of no less than 65½ hours. This meant that Stenuit would spend almost 2½ days incarcerated in the cylinder after it had been brought on board.

Watery Domain Open to Man

We could see him through the portholes, and he could see us, but he had to remain hermetically sealed inside. It was, of course, an easy matter to get supplies to him by means of the air lock (pages 728-9).

At 6:20 a.m. on September 10 he left the cylinder—after 3 days, 20 hours, 30 minutes.

There can be no doubt whatever that Robert Stenuit's dive was an outstanding achievement. Besides proving Ed Link's theories, it had indicated, first, that the human frame can withstand the great pressure of seven atmospheres for an indefinitely long period. After more than 25 hours of it, Stenuit had felt no discomfort, and it seems unlikely that this will ever become a limiting factor, no matter how long a dive lasts. Second, it proved that no damage or discomfort is caused through breathing helium under great pressure for an unprecedented 25 hours.

The long, deep dive had also shown that only two relatively small problems remain before extensive research and exploration can take place at 200 feet—or indeed at much greater depths.

The less important of these is communication; it was a real handicap that Stenuit's speech was unintelligible. The simple solution is to equip the cylinder with a standard Morse transmitting key. It may also prove possible for the diver to train himself to speak understandably by cultivating a deeper voice.

The greater problem is that of cold. The water at 200 feet was so numbing that Stenuit



STUDELKORNE © A.S.S.

Returning to open air after 3 days, 20 hours, 30 minutes in the capsule, Stenuit reports to Ed Link. Doctors found the diver in perfect physical condition. Annie Stenuit beams her happiness.

could spend no more than a few minutes in it at a time. Link is now designing a rubber suit with wires embedded in it, to be heated electrically at very low voltage.

Stenuit's dive, though an immense step forward, is only a beginning. Link is confident that he will be able soon to keep a man at 400 feet for a week. This would make possible a useful working period over much of the vast continental shelves, which are virtually unexplored.

In a subsequent series of animal tests, Link proved to his satisfaction that such a target is well within his reach with existing equipment. For the most important animal test, an eight-month-old female goat was used. Goats have long been used for decompression experiments, and physiologists have much data to aid them in analyses. The goat was placed in the cylinder, and pressure was increased to the equivalent of 400 feet. After 13 hours on helium-oxygen, she showed no discomfort, and a shortened decompression schedule of only eight hours was tried.

This proved overambitious. The goat developed the bends after only 87 minutes when at the simulated pressure of 190 feet. The symptoms vanished when pressure was increased back to 350 feet. Pressure was in-

creased to 400 feet for a further 4 hours, 40 minutes. Then the animal was successfully decompressed in 26 hours, 51 minutes, of which the last 9¼ hours were on air.

Ed Link believes men may be able to use a 16- to 18-hour decompression schedule after a dive to 200 feet, and an 18- to 24-hour schedule after a dive to 400 feet.

"These would be maximums, irrespective of the length of time spent at those depths," he said to me. "After 12 hours, the diver's body is saturated with helium. Once this point has been reached, the body will not absorb any more of the gas; therefore, the decompression period remains the same, however long the diver has spent at any depth."

These schedules are much shorter than has previously been thought possible. It is startling to be thinking in terms of only 24 hours of decompression after spending a week—or a couple of months, for that matter—at a depth of 400 feet.

Link already has in mind a far larger "sea house" from which teams of divers could do useful work at depths up to 1,000 feet, and in which they could stay submerged "indefinitely." The wealth and knowledge of the oceans, hardly tapped as yet, lie glittering before mankind.

THE END





Venus shows a moonlike phase as it swings between sun and earth. Sunlight tints its atmosphere on the dark side.

Dragonfly in space, Mariner II coasts within 21,700 miles of Venus. Winglike solar panels gather energy from the sun. Dish antenna beams the space scout's findings to earth. Artist has added lines of motion to suggest direction of flight.

Mariner Scans a Lifeless Venus

By FRANK SARTWELL

National Geographic Staff

Paintings by DAVIS MELTZER

THE UNGAINLY, skeletal spacecraft sped past the planet, its pulsing instruments seeking data from a surface mantled by bright, lemon-yellow clouds. Man had reached heavenward, and for 35 historic minutes on December 14, 1962, brushed aside the eternal veil of Venus.

For the first time a "live" and functioning scout from earth had visited a neighboring planet. As it hurtled through a great 182-million-mile arc, this emissary, Mariner II, reported back some 9 million bits of data. Its historic report included these findings:

- No life as we know it on Venus.
- Surface temperature averages 800° F., far above the melting point of lead.

- Cloud cover solid, a dense blanket starting 45 miles above the surface, with temperatures ranging from 200° at the base to minus 60° at the top.
- A mysterious cold spot in the clouds over the southern hemisphere, which might indicate a surface feature—perhaps a mountain higher than Everest.

Mariner Weathers Hazards of Deep Space

Its mission over, Mariner sailed on. Now a planet itself, it circles the sun forever. And only now can the magnitude of its accomplishment be judged. The noted British astronomer Sir Bernard Lovell declares it "the most splendid scientific achievement in space."

On its way to triumph, Mariner survived assault by micrometeors. Atomic fragments from the sun, traveling at 500 miles a second, pounded it. Dizziness from a spinning launch threatened its ability to keep its head. That "tired run-down feeling," created by a power failure, afflicted it for a time. Finally, it suffered severe chills and fever, induced by the sun's heat and the deep cold of space.

Nor were these all the problems. There was, to begin with, the difficulty of hitting the target at all—a feat of marksmanship that has been compared to "sitting on a merry-go-round and shooting a bullet to hit a fast-flying sparrow over the horizon."

Incredibly, trajectory engineers determined that Mariner would have to be lobbed into space in the opposite direction from its rendezvous point with Venus. The explanation:

Earth and Venus are locked in solar orbits, with Venus closer to the sun. When an orbiting body slows down, the sun's gravitational pull draws it irresistibly inward. In order to leave earth's orbit and be pulled by the sun toward Venus, Mariner first had to be fired in the "wrong direction." The reason: to lose some of earth's orbital speed—which it had even when it sat "immobile" on its launching pad!

The engineers also had to determine precise speeds and courses for a near-collision of planet and spacecraft on a flight of 109 days.

Among the other perils of Mariner was the fact that the original design had to be discarded when a powerful second-stage rocket, the Centaur, refused to work in time for the flight. Without the strength of the Atlas-Centaur combination, NASA fell back on the Atlas-Agena rocket system that had propelled the Ranger series of moon probes.*

In Pasadena, California, scientists at the Jet Propulsion Laboratory of the California Institute of Technology, makers of Mariner, suddenly had to cut the craft's total weight from 1,150 pounds to 447 pounds. And they had to do it in only ten months—a deadline set by the immutable courses of earth and Venus through the heavens. They took the Ranger and hung on it some of the original Mariner equipment and instruments. The result was the hybrid "Mariner R."

"There's an advantage in having to work so fast," Dan Schneiderman, Spacecraft Systems Manager, told me. "You can't sit around and dream up tricky devices that might fail."

Three Mariners were built, at a cost of \$25,000,000. The task required 1,800 man-years of highly skilled labor. Part of this national investment vanished in flames on July 22, 1962, when the first Mariner was launched from Cape Canaveral, Florida. It flew only 290 seconds before it was deliberately destroyed (with its \$9 million worth of rockets) because it was off course.

It was later determined that the failure was caused by no more than a misplaced hyphen in the equations fed into a computer!

Spin Imperils Craft in Lift-off

A month later, on August 27, Mariner II was poised on its launch pad.

When the ten-story rocket lifted slowly, then faster and faster, from the Cape, another failure seemed imminent. The rocket began to spin. It rotated on its long axis 35 times during the lift-off—exerting "dizziness" stresses none of the equipment had been designed to absorb. Suddenly, the spin stopped. A launching official leaned back and muttered, "We've had our share of random failures; now we have a random success!"

Only 26 minutes after the flaming Atlas was launched came more good news: The rockets had done their jobs—putting Mariner into the correct orbit and then giving it the final push away from earth (pages 736-9).

An hour after lift-off, the craft "acquired the sun"; that is, it changed its attitude so that its solar panels, spanning 16½ feet, would collect the sun's rays for Mariner to convert into electric energy. Two days after launch, Project Manager Jack James ordered power fed into the "interplanetary" experiments—four of the six instruments aboard. Now, from

* See "Robots to the Moon," by Frank Sartwell, NATIONAL GEOGRAPHIC, October, 1962.




EXTRACTION BY JET PROPULSION LABORATORY

Gleaming Space Bird Flexes Its Wings in a Cape Canaveral Hangar

Surgically garbed engineers test Mariner's solar panels, which fold tightly against the craft's frame during launch. Once in space, the panels extend so their 10,700 cells can catch sunlight and change it to electricity. Shining gold and aluminum reflect sun's heat, protecting instruments. Mariner has now become a man-made planet, in endless orbit around the sun at an average speed of 71,000 miles an hour.

Mariner II unfolds in space




OVER THE ATLANTIC, 115 miles up, the Agena fires again, injecting the craft into a solar orbit that will take it past Venus. Speed: 25,536 miles an hour


EXPLOSIVE BOLTS separate Agena and the folded Mariner. Booster fires gas jet (symbolized in purple), veers from Mariner's path, and goes into a different solar orbit



AGENA FIRES a 2 1/2-minute blast, pushing Mariner into earth orbit for 16 1/2 minutes. Speed: 17,482 miles an hour



ATLAS CUTS OFF 4 1/2 minutes after launch. Nose cone springs away, and the Atlas separates from the second-stage Agena B



BLAZING ATLAS BOOSTER powers the spacecraft aloft from Cape Canaveral, Florida, on August 27, 1962

punched tapes or letters on teletype machines, scientists could read the first results of their effort (page 740).

Near the top of Mariner, just under the kegl-like all-directional antenna, was a cylinder the size of a beer can, housing a device to measure the magnetic fields of space.

On the base of the craft sat a metal plate, five inches by three. Its function was to respond, somewhat like the vibrations of a telephone's mouthpiece, as "cosmic dust," or micrometeors, struck it.

Near the plate was mounted a box from which three tubes projected. Together with a ball-like ion chamber, these Geiger-Müller tubes were to catch, count, and measure fast-moving cosmic rays. A fourth device trapped particles with less energy.

"Find Earth," Sensor Is Ordered

With these four instruments ticking off information, Mariner spun on through space, awaiting one of its most crucial moves—finding and "locking on" to earth.

Up to this time, Mariner had been transmitting data to earth through its omnidirectional antenna, which was relatively weak. But to cross the immense distances that soon would separate it from its home planet—much farther than had ever been spanned by any communication before—a powerful focusing antenna would be used. Hinged from the bottom of the craft, it had to point exactly at earth. Finding earth and locking on was the duty of the earth sensor, a device that worked somewhat like a photographic exposure me-



POWER-GATHERING solar panels unfold. Mariner tumbles through space, awaiting stabilization



BLASTS FROM GAS JETS (symbolized in purple), stabilize Mariner in flight position. One hour after launch, solar panels face sun. Dish-shaped antenna extends from bottom

D. Meltzer

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ter, picking up sunlight reflected from earth.

Since the device had to be sensitive enough to pick up earth even at the end of the voyage—when our planet appears no larger than Venus itself appears from earth—the instrument could not be turned on until seven days after launch. Earlier use could have burned out its mechanism, as the human eye would burn out if it stared at the sun through a lens.

When Mariner gave its sensor the "find earth" command, it was already 1,200,000 miles from its home planet. At the order, trouble immediately developed. The craft's radio signal lost strength instead of gaining.

Technicians in the control room at Pasadena frantically sought to trace the problem. Finally, 36 minutes after the mishap, Mariner II suddenly locked on earth and sent signals of the proper strength.

Later, scientists decided that a freak coincidence had caused the trouble. When the earth sensor was turned on, they believe, it happened to be pointing at earth already. Having seen its target, it automatically began sending signals through the narrowly focused antenna. But that first glimpse of earth was not enough to stop Mariner's rolling motion, and therefore the signal was cast around wildly in space instead of being aimed at earth. It took Mariner 36 minutes to make a complete roll back to its proper position.

All was well now—except that the spacecraft was not on course. Mariner's designers knew from the start that the Atlas-Agena combination was not accurate enough to set the craft on a perfect trajectory, so they built

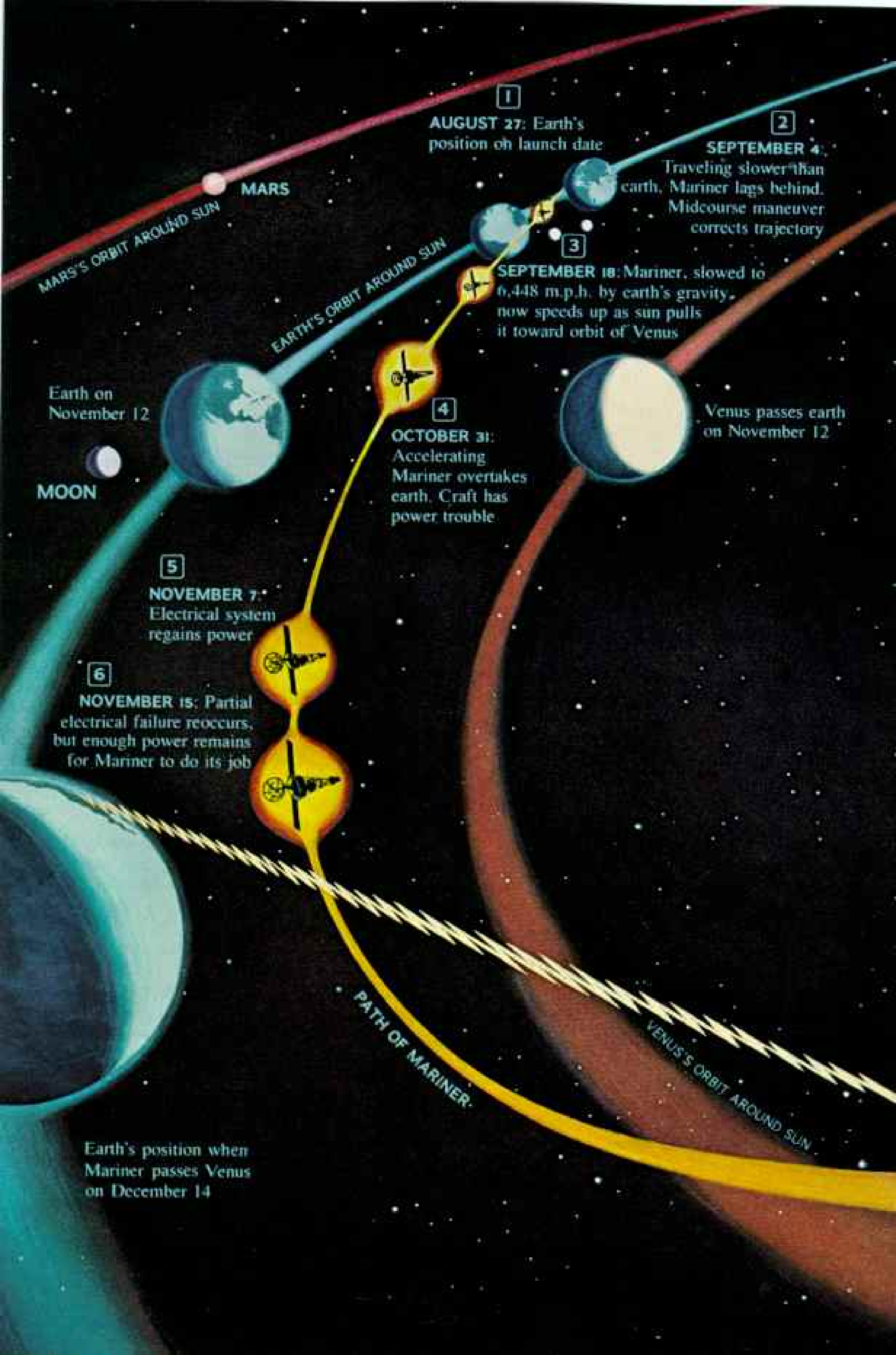
in a corrective rocket motor. After a week of tracking, they could determine Mariner's actual path. Without correction, they concluded, it would miss Venus by 233,000 miles. Mariner's instruments could work only in a narrow target area—between 8,000 and 40,000 miles from the planet. Success depended on a "midcourse maneuver."

Mariner Attempts a Critical Turn

On September 4, Mariner, then 1,490,000 miles out in space, was commanded from the tracking station at Goldstone, California, to release its locks on earth and sun and reorient itself so the rocket in its base would aim in the desired direction. When the craft reported itself ready, the command was given, "Fire!" The rocket burned for 27.8 seconds, delicately boosting Mariner's 60,117-mile-an-hour speed by a mere 45 miles an hour. It was enough.

Almost immediately after the rocket turned off, it was apparent that the maneuver was a success. In its new course, Mariner once more locked on sun and earth. In the Pasadena control room, Jack James, like any proud father, passed out cigars.

Four days later something moving at the speed of a bullet apparently hit the craft. Mariner shuddered, lost lock on the sun, then, three minutes later, regained it. All the symptoms point to an object weighing between a twentieth and fiftieth of a pound striking the spacecraft at 1,600 feet per second. Mariner weathered this blow, and another, 21 days later, without ill effect.



1

AUGUST 27: Earth's position on launch date

2

SEPTEMBER 4: Traveling slower than earth, Mariner lags behind. Midcourse maneuver corrects trajectory

3

SEPTEMBER 18: Mariner, slowed to 6,448 m.p.h. by earth's gravity, now speeds up as sun pulls it toward orbit of Venus

4

OCTOBER 31: Accelerating Mariner overtakes earth. Craft has power trouble

5

NOVEMBER 7: Electrical system regains power

6

NOVEMBER 15: Partial electrical failure reoccurs, but enough power remains for Mariner to do its job

MARS'S ORBIT AROUND SUN

EARTH'S ORBIT AROUND SUN

PATH OF MARINER

VENUS'S ORBIT AROUND SUN

MARS

Earth on November 12

MOON

Venus passes earth on November 12

Earth's position when Mariner passes Venus on December 14



VENUS: Position at
Mariner II launch

SUN

Mariner II's 182-million-mile swing from earth to Venus

MERCURY

MERCURY'S ORBIT AROUND SUN

8

WINGING PAST VENUS, Mariner continues
in solar orbit as a man-made planet

7

DECEMBER 14: Mariner II glides past
the sunny side of Venus 109 1/2 days and
182 million miles after launch. Findings
are radioed 36 million miles to earth

VENUS

Painting by

D. Mellyer

Research by Eugene M. School © N.G.S.

AOQ DXQ XZAIZXAZZKZZD XJ
 QKZZD XXDLKADRKHQ ZSQSG.
 S ZSQSGIQQGGXRS 700 DXQ
 ZOQ DXQ XZAIZAZVQQKSX XJ
 ZQKVA XXDRDZDRANGDSSQSAI
 Z DSQSAQGGGGXRSNZOK DNQ
 ZOK DNQ XZAIZGAVQQKZG XJ

Cryptogram From Space Tells Venus's Secrets in Coded Letters

Shakespeare's "full star that ushers in the even" hides beneath a blanket of clouds impenetrable to the strongest telescopes.

Mariner (right) scanned sun rays modified and reflected by Venus and sent back a stream of coded information. Men and computers translated these seemingly meaningless letters.

"QSGI" presents a microwave report on water presence and surface temperatures (later found to be 800° F.). "QQKS" gives infrared data on cloud cover (continuous, 15 to 20 miles thick) and cloud temperature (from 200° F. to minus 60° F.). Sensors detected no magnetic field and no Van Allen belt of trapped radiation.

Passing Venus, Mariner communicated with earth to a distance of 53.9 million miles, using only three watts of power. This means that radio contact is probably possible throughout the solar system, a finding vital to manned flight.

All this time, Mariner was telling earth about the unprobed areas it was voyaging. It discovered that throughout these regions the number of cosmic rays—energetic particles believed to originate outside our solar system—is constant. On the other hand, waves of high-energy sun particles, produced by solar flares, came at irregular intervals. Those detected by Mariner, however, were determined to be no hazard to the men who will one day sail the far reaches of this new ocean.

Mariner also confirmed the existence of a constant "solar wind." Made up of electrons and fragments of hydrogen and helium atoms, this energy stream rages from the sun at 200 miles a second when the sun is relatively quiet, with gusts up to 500 miles a second.

No Magnetic "Holes" in Space

Further, Mariner's magnetometer was almost constantly busy, reporting space to be filled everywhere by a faint magnetic field.

Only two bits of cosmic dust were detected along the way, indicating that these specks of matter are only one ten-thousandth as plentiful as those found near our planet—a

Mariner pierces the planet's veil



EARTH

5 ANTENNA FLASHES the information 36 million miles to Goldstone, California, for interpretation by scientists

D. Meltzer

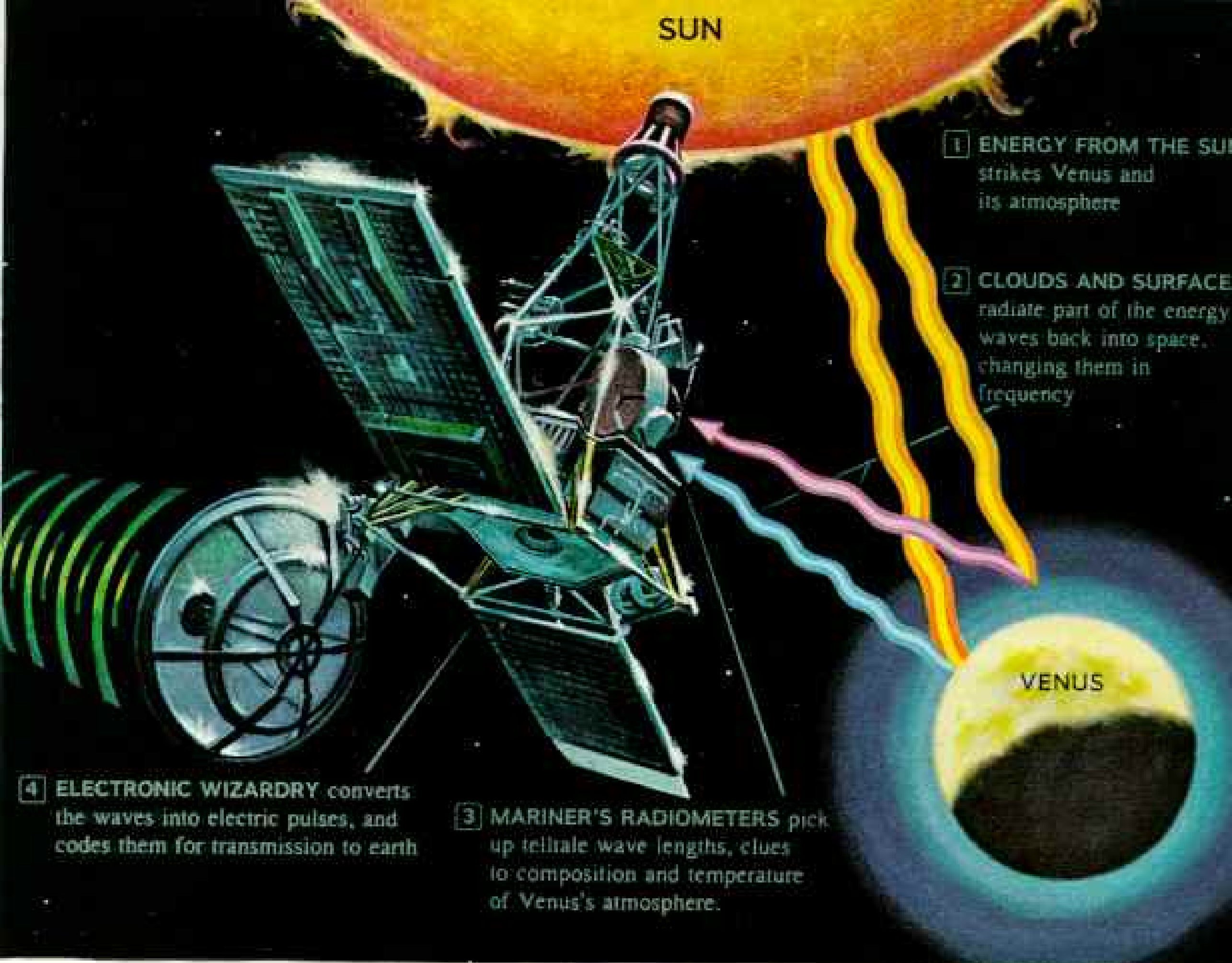
reassuring finding for spacecraft designers.

And, as it sped onward, the craft was giving scientists data that should provide the most accurate estimate yet of the mean distance from earth to sun. This so-called astronomical unit—nearly 93 million miles—is the vital measuring stick of our solar system.

For a month Mariner cruised without incident, its electronic brain sampling each instrument in turn and relaying its coded findings to earth.

Suddenly on October 31, the electric power aboard dropped alarmingly. In charge at the Jet Propulsion Laboratory control room in Pasadena was Space Flight Test Director Tom Bilbo. His desk, one of three so equipped, held three television consoles showing raw data as it came in. On a board nearby, assistants posted decoded information. These numbers left no doubt; the craft was in trouble.

Bilbo called Jack James, who happened to be in Tucson, Arizona. For several hours on the telephone they discussed the possibilities. It appeared that one solar panel might have shorted out. They decided to turn off the four instruments to conserve Mariner's power.



1 ENERGY FROM THE SUN strikes Venus and its atmosphere

2 CLOUDS AND SURFACE radiate part of the energy waves back into space, changing them in frequency

3 MARINER'S RADIOMETERS pick up telltale wave lengths, clues to composition and temperature of Venus's atmosphere.

4 ELECTRONIC WIZARDRY converts the waves into electric pulses, and codes them for transmission to earth

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James rushed to Pasadena to check solar panels identical to Mariner's. The city was cloud-covered; he sent engineers with panels in a plane to "look for sunlight." Finding some in the Mojave Desert, they landed and began tests. They duplicated Mariner's symptoms by causing a short circuit.

After a week of experiment, it was decided that the remaining panel could put out enough power to run the whole craft, since it was now nearer the sun. Orders to turn on the four instruments were prepared. The orders were sent as planned—even though the trouble had mysteriously healed itself a few hours earlier.

The power failure, perhaps caused by a meteor hitting the panel, cost the mission a week's interplanetary data.

Now another problem loomed: Mariner had chills and fever. Some parts were colder than they should have been, some were hotter.

The heat was serious. No one knew exactly how much heat vital electronic systems would take. Also, the battery aboard might explode, wrecking the craft. James called the battery designer. "What is the maximum temperature that our battery will withstand?"

Back came the only possible answer. "I don't know. I can only tell you how far we tested it: 120° Fahrenheit."

Every day, as the craft got nearer Venus, and nearer the blazing sun, the heat in vital parts increased. On December 5, the battery reached its test limit. The vital earth sensor hit 130°. There were still nine days to go.

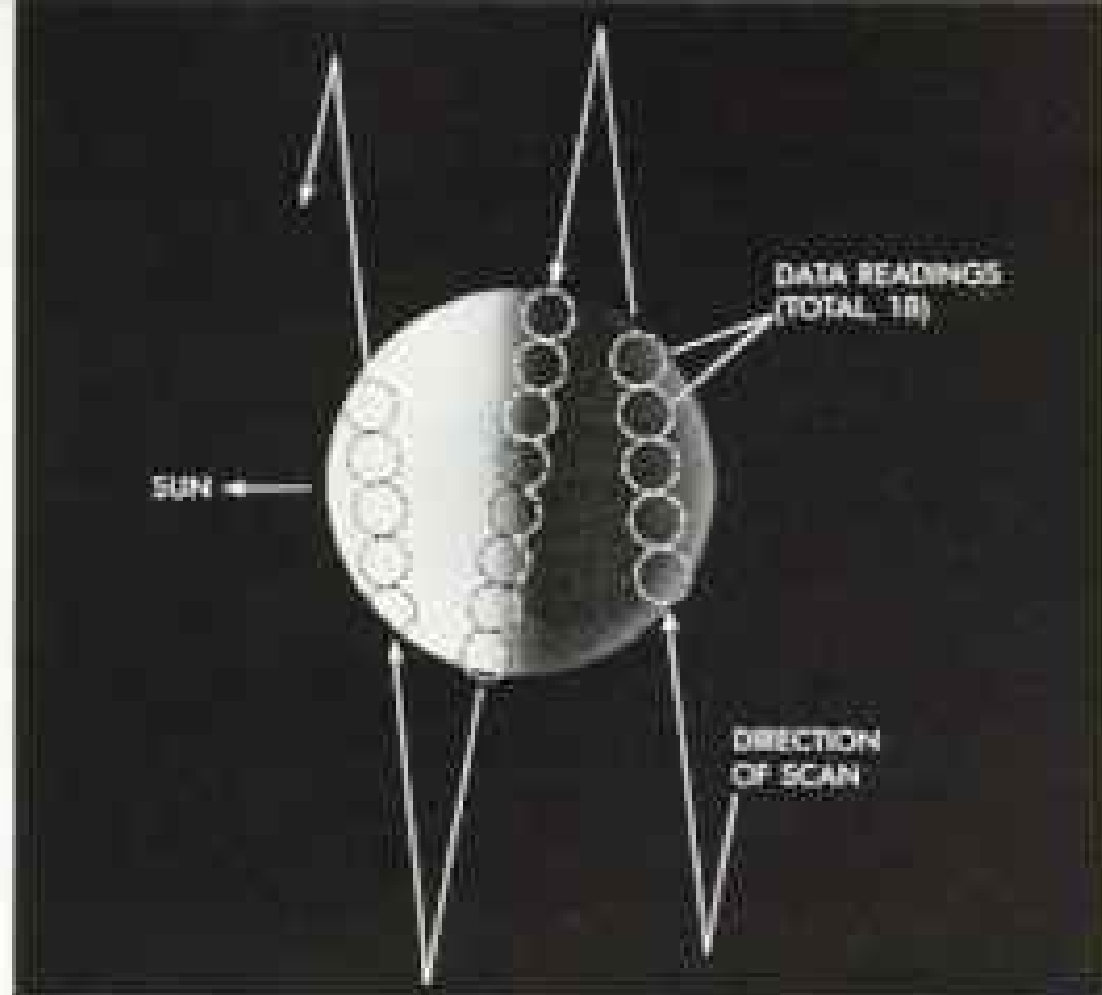
Earth Sensor Goes "off the Dial"

Already, the instruments that were to scan the planet seeking temperature and atmospheric make-up were performing imperfectly. As a result, there would be only 3 scans by these radiometers, instead of 15 (next page).

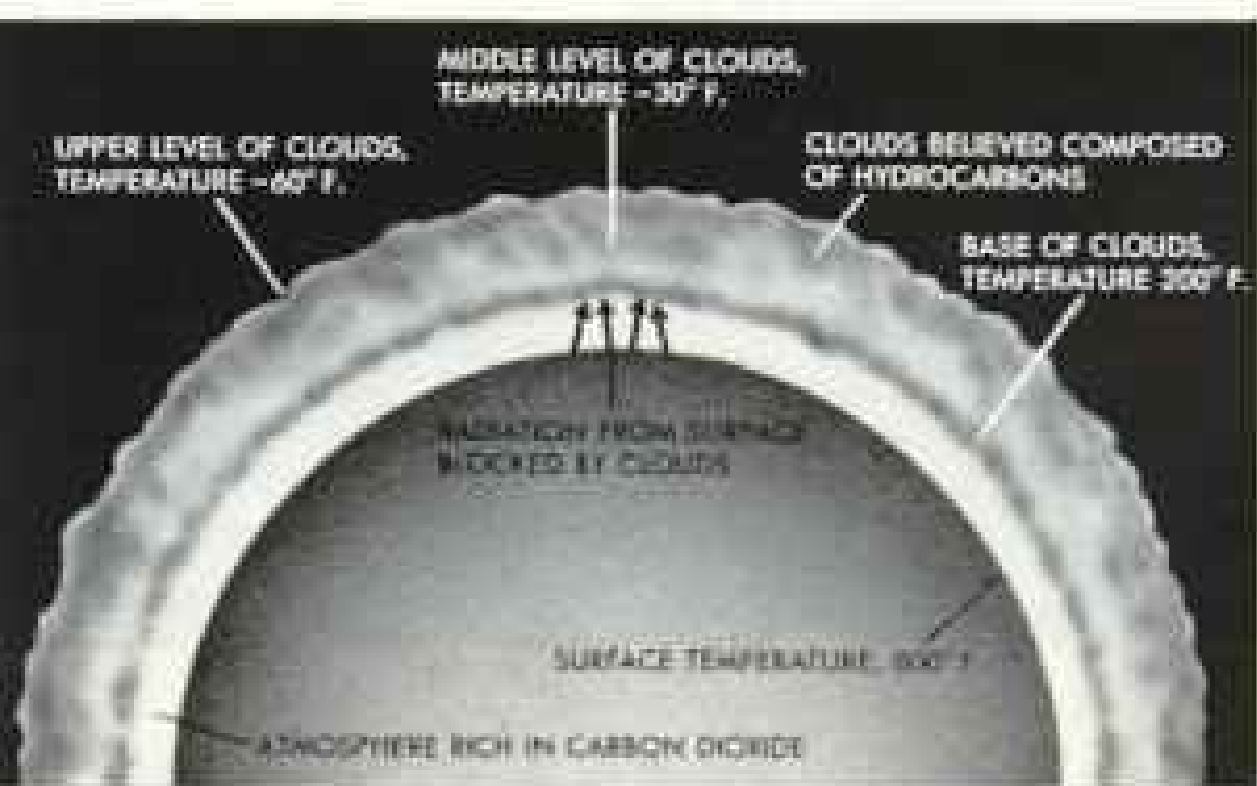
As I talked to the people in the control room during those last uncertain days, I found they divided into optimists ("It's been working 106 days; it'll work three more") and pessimists ("I'm afraid of that earth sensor").

One and all asked the same question when they came to work: "How's the bird?" Each day the answer was "fine," or "ticking away." But each day the temperatures were posted, and each day they were higher.

Then, abruptly, temperature data from the



Scanning Venus three times, Mariner's nodding instruments probed night side, sunrise line, and finally the day side. They reported solid clouds that produce a "greenhouse effect," blanketing the surface in a heat of 800° F. (below).



ADAPTED FROM ILLUSTRATIONS BY NASA

vital earth sensor became meaningless—it was so hot the reading was "off the dial." Now neither optimists nor pessimists would have any figures to base their hopes or worries on.

The night of December 13, 1962, was crucial. At that time Mariner was supposed to turn on the two radiometers, by a command stored in its electronic brain. About 50 persons manned the control room, quiet and tense, at 11:21 p.m., waiting for the signal. None came. Battery temperature had reached 129° F. Earth sensor temperature: unknown.

Mariner would again be in position to turn on its instruments by itself at 2:40 a.m. Everyone waited. Again nothing happened.

There was one more chance. The experiments might be turned on from earth through the Goldstone antenna. Venus would "rise" over Goldstone at 4:16 a.m. Everyone waited.

Goldstone tracked Mariner for half an hour to make sure of its aim, then gave the order. Mariner was so far away from earth that the radio command, traveling at the speed of light, took more than 6 minutes to reach the

craft and return. When the coded answer flashed back, it reported that Mariner had obeyed. And so, after 6 minutes and 30 seconds of utter quiet, the control room exploded with laughter and clapping.

Now, if only the solar heat didn't wreck something, success seemed sure. And, at 10 seconds before 1 p.m. on December 14, 1962, a still-vocal Mariner reached its closest point to Venus—21,700 miles—and sent its information 36 million miles back to its creators.

Venus—Searing, Dry, and Gloomy

After months of study, Mariner scientists reported to the world. Their findings, with other experiments, round out a fascinating picture of our nearest neighbor planet.

The atmosphere is hostile to man, rich in carbon dioxide, poor in water vapor and oxygen. Continuous cloud cover—15 to 20 miles thick and starting 45 miles above the surface—creates a "greenhouse effect," letting sun energy reach the planet, but preventing much of the heat from escaping into space.

Though astronomers had assigned a temperature of 600° to the surface, Mariner raised this estimate 200°. The searing surface is apparently dry and granular, perhaps sandy. Over it, slow winds circulate dense gases. Compressed in an atmosphere 10 to 20 times heavier than ours, the gases readily conduct heat around the planet. This explains why Mariner found no temperature difference between sunlit and dark sides.

The clouds keep Venus gloomy as well as hot. Apparently made up of hydrocarbons, they might be called smog.

Mariner's instruments found no planetary magnetic field at 21,700 miles from Venus, nor did they locate any bands of radiation like earth's Van Allen belt. The absence of such bands agrees with other observations that indicate a very slow—perhaps nonexistent—rotation of the planet. To an observer on Venus, if it does not rotate, the stars would seem to stand still, while the sun, rising in the west and setting in the east, would circle the planet in 225 days, the period of Venus's solar orbit. Thus Venus's day would equal its year.

As Mariner soars on in silent orbit around the sun, NASA's Dr. Homer E. Newell sums up the craft's verdict on an age-old question:

"With the surface of Venus hot enough to melt lead, the planet cannot support life as we know it." But biologists, he adds, reserve judgment on whether lower forms of life might exist in the planet's upper atmosphere.

"Investigation of that," the scientist concludes, "will have to wait until we get there."



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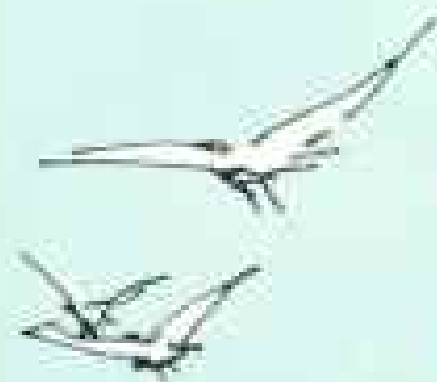
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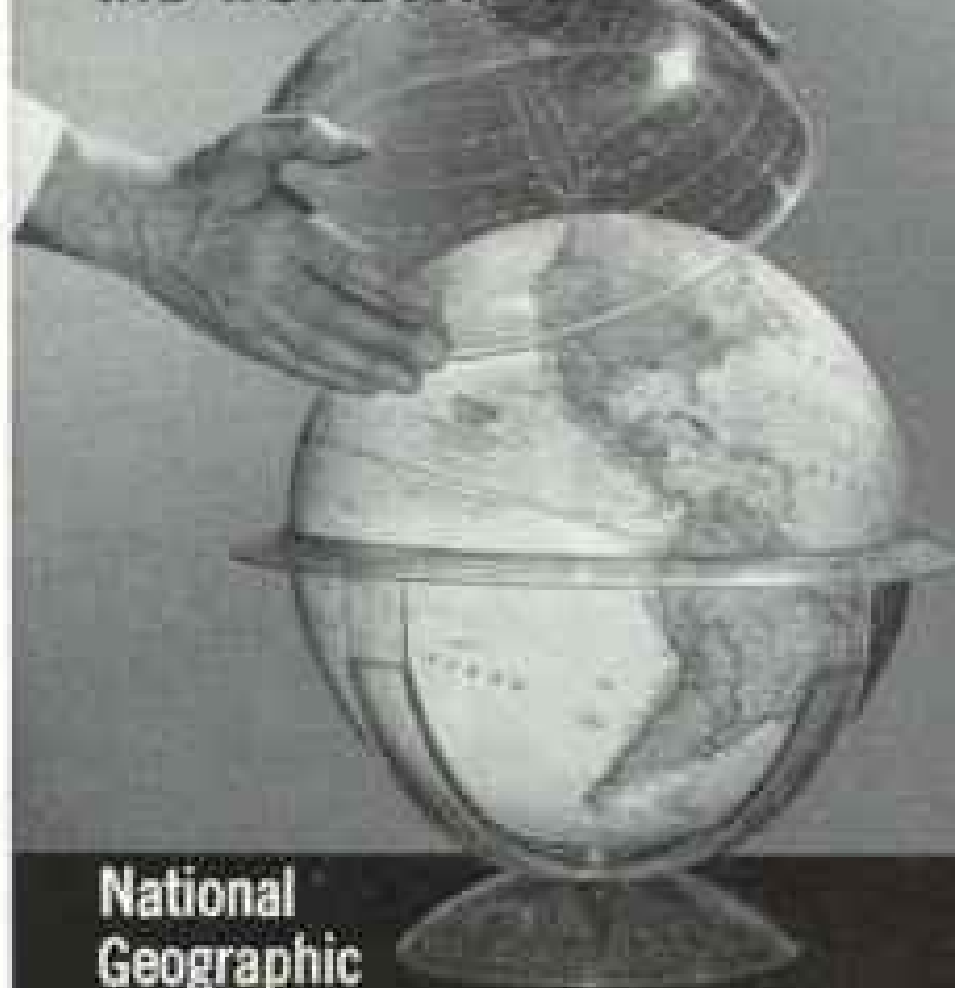
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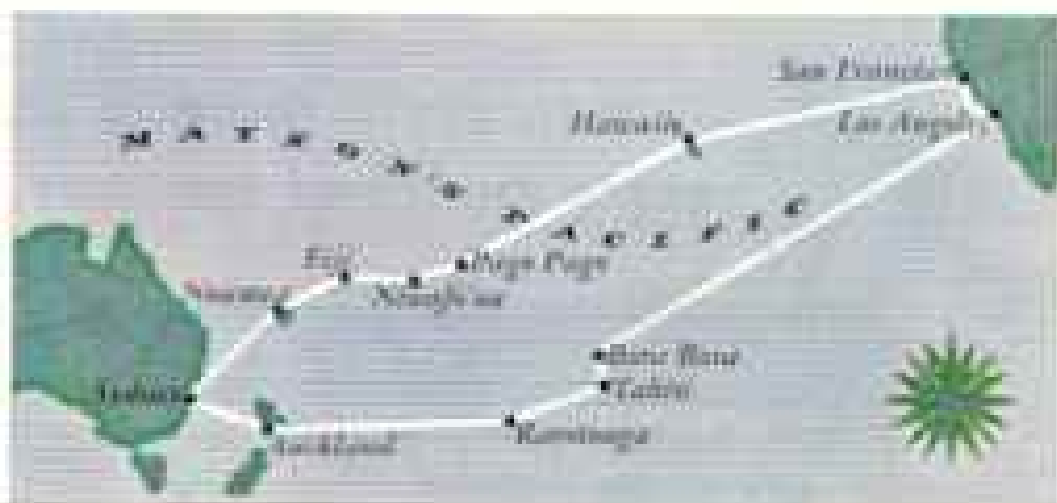
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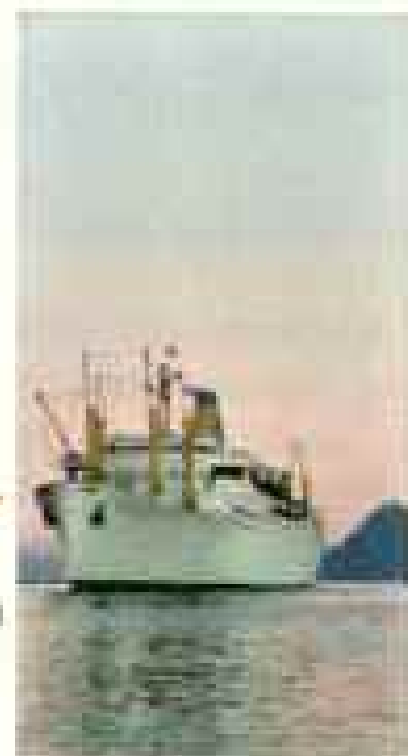
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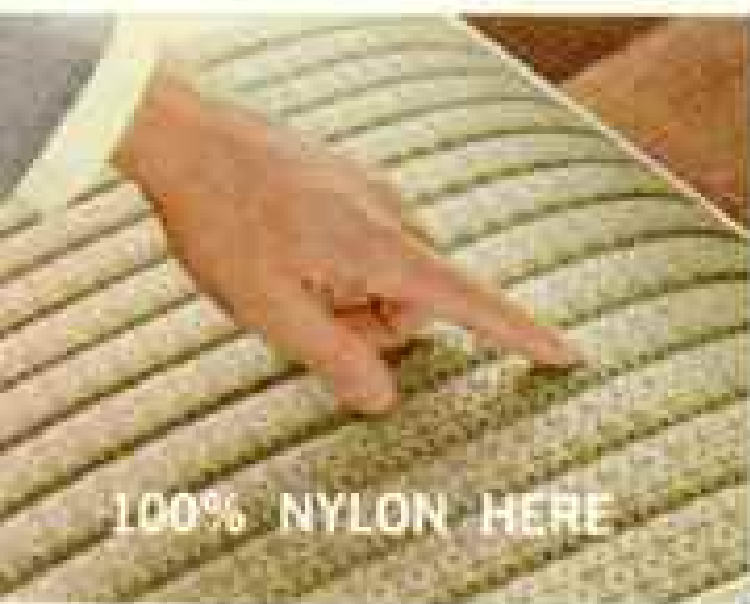
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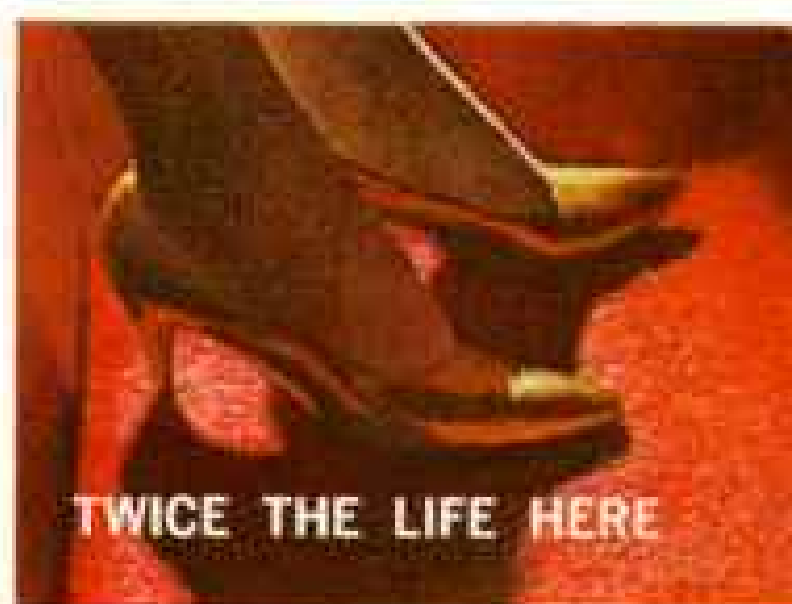
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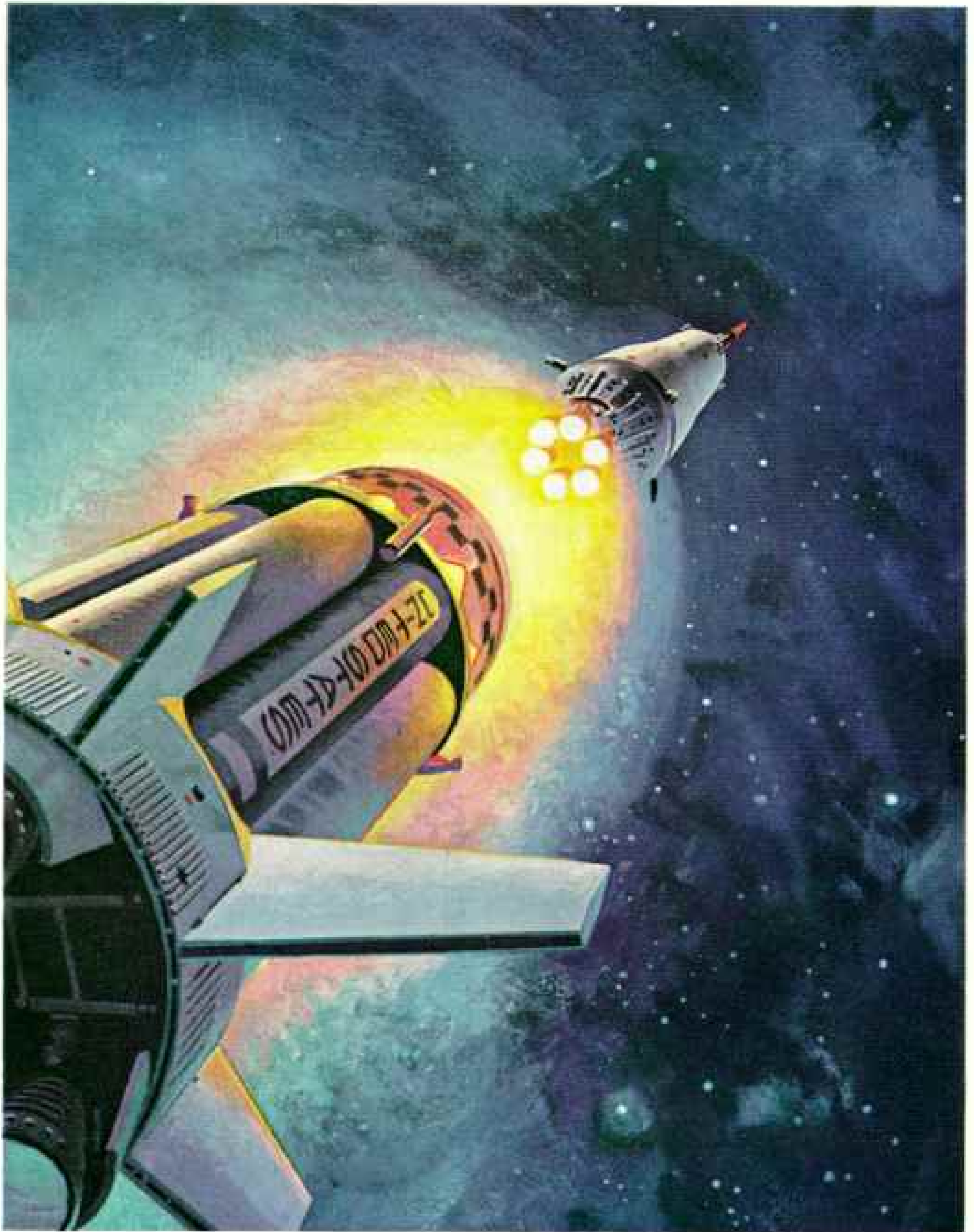
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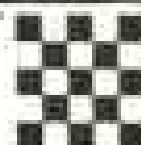
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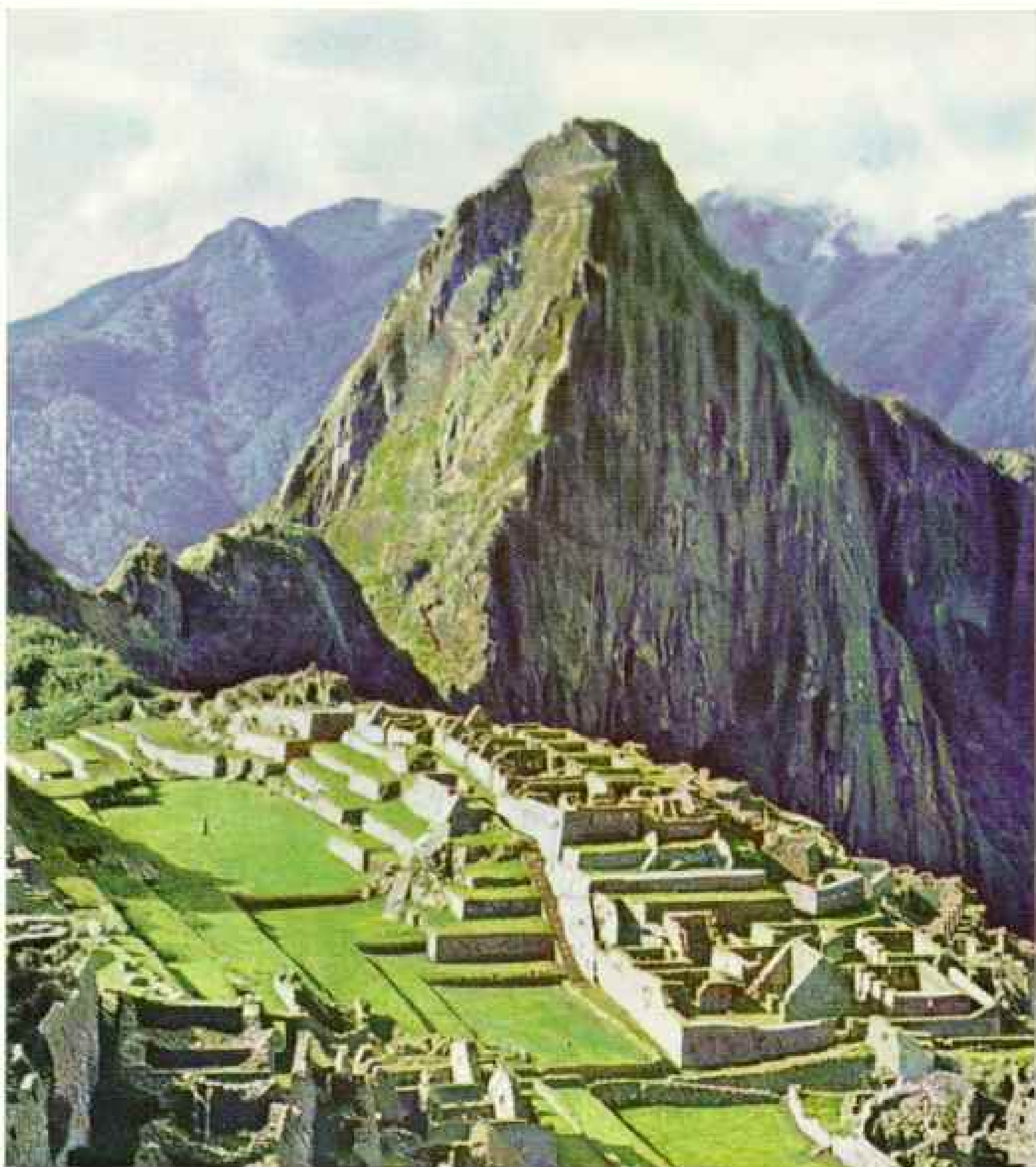
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No rains came; by thick or thin rings on the "tree calendar," scientists know that a long drought began in 1276, and in a generation, this civilization withered and died. But its grandeur remains and even today, more of its history is being revealed by the National Geographic Society working with National Park archeologists.

Detail from diorama showing Mesa Verde as it was 1150-1250 A.D.



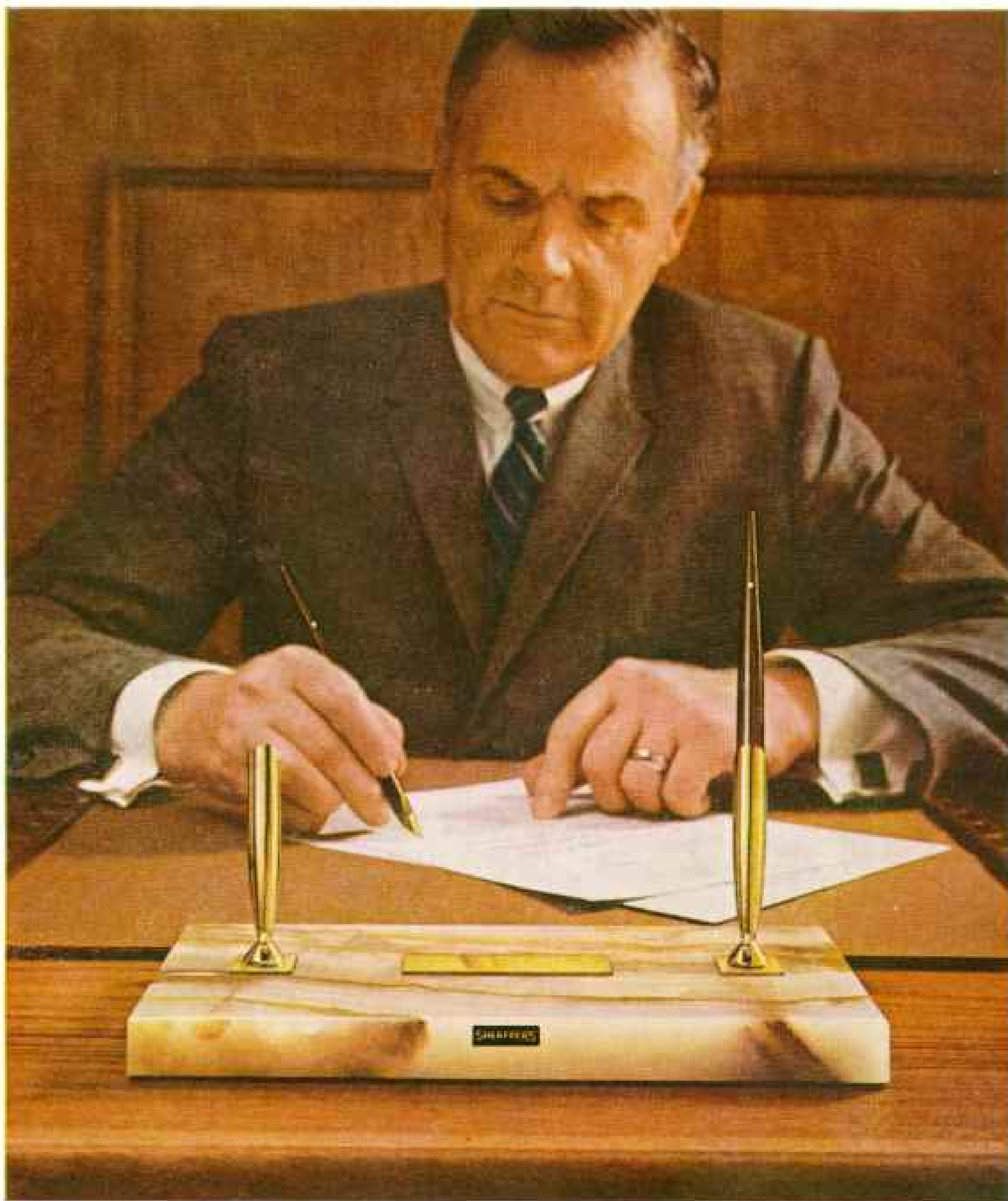
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