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A CARAVAN PICKS HIS WAY OVER ICE BUILDERS IN AFGHANISTAN'S WAKHAN CORRIDOR.

Winter Caravan to the Roof of the World

ARTICLE AND PHOTOGRAPHS BY
SABRINA AND ROLAND MICHAUD

ON THE RUSSIAN SIDE of the river they are growing restless. Powerful searchlights sweep across the drifting ice to the Afghanistan side, probing for us. A car moves slowly back and forth along the far bank.

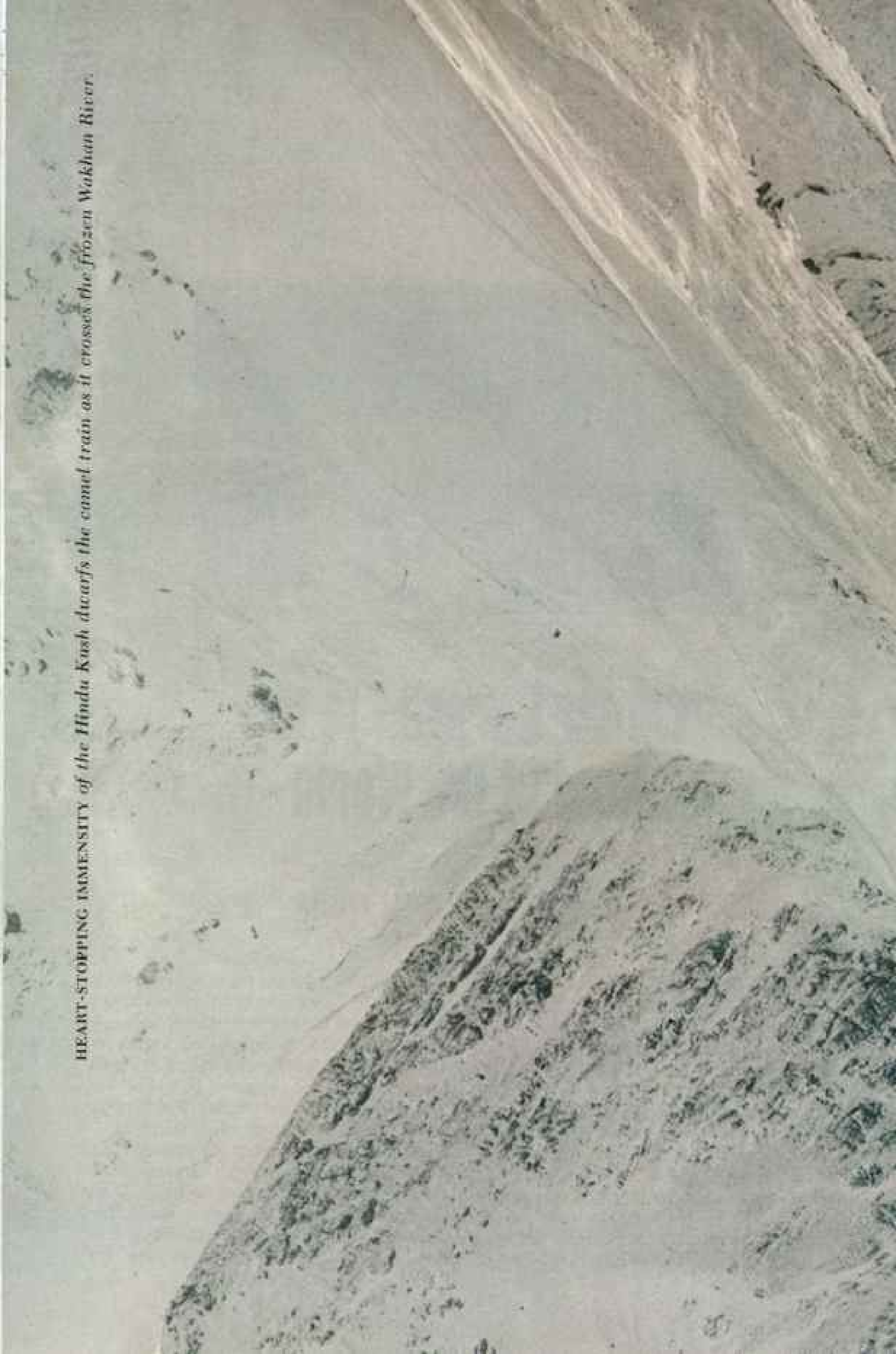
Our own vehicle groans and whines in a sandbank; despite its four-wheel drive, we cannot break it free. The noise upsets Abdul Wakil. He draws and loads his revolver.

The son of a Kirghiz chieftain, our stocky guide would be more comfortable on the back of a horse, more at home on the high treeless plateau of the Little Pamir, the range

near the Chinese border far to the east. He is nervous not only about the Russians across the river. Who can say that bandits no longer prowl this bleak, impoverished corner of Afghanistan? It is better, he feels, that we do not call attention to ourselves; he will set out on foot to seek help. Abdul Wakil takes our flashlight and vanishes into the night.

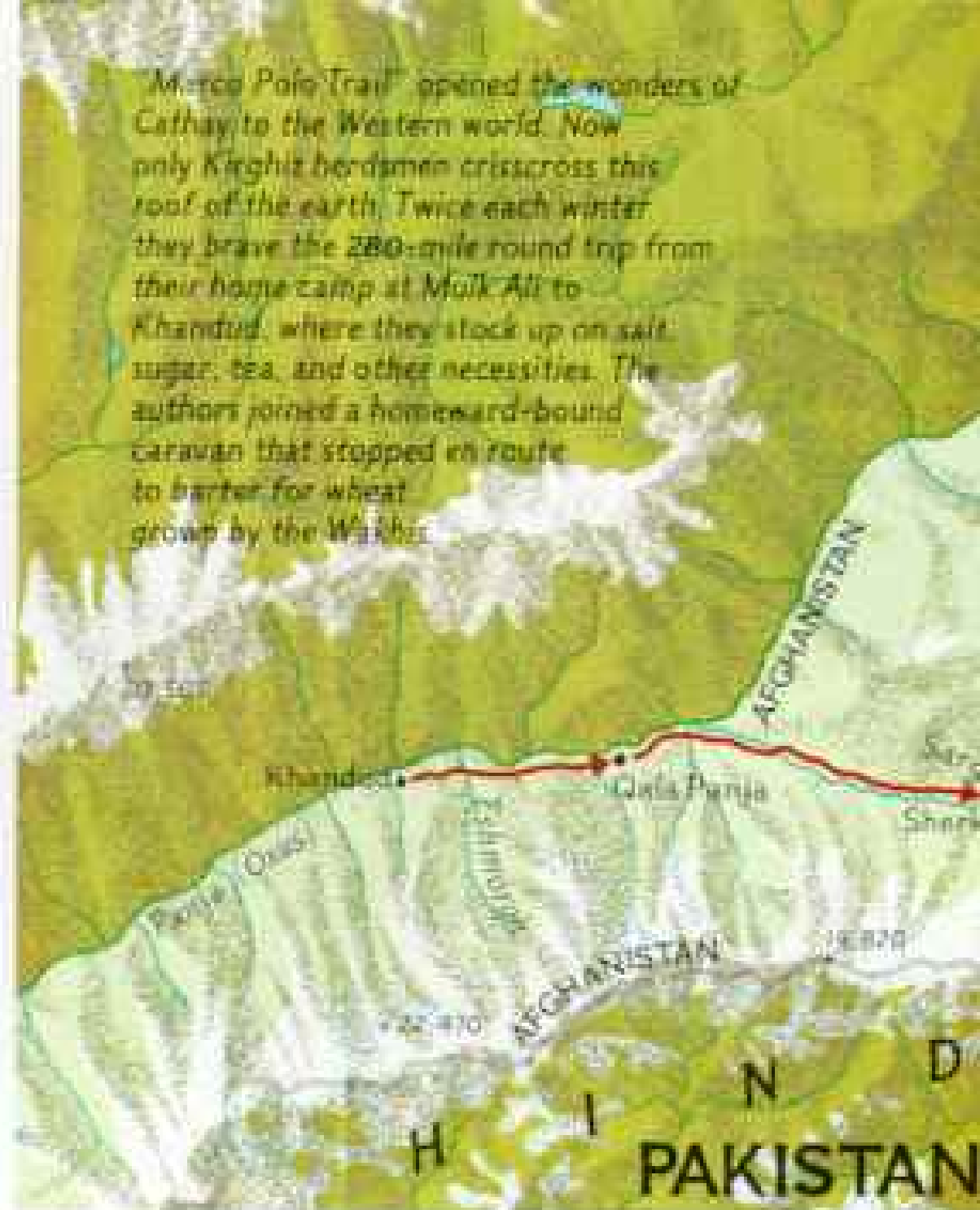
Now we are alone with our stranded car, Roland and I, on watch in the darkness somewhere on the Afghan bank of the Panja River—the Oxus River of the ancient world. The slightest sound startles us, and the inquisitive Russian searchlights keep us on edge. We

HEART-STOPPING IMMENSITY of the Hindu Kush dwarfs the camel train as it crosses the frozen Wakhan River.





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begin to wonder what we are doing here.

We had come this far to join a camel caravan on a rigorous 140-mile winter trek through the Wakhan corridor—the gnarled finger of northeastern Afghanistan that thrusts between the U.S.S.R. and Pakistan to touch China’s vast Sinkiang Province (maps, above). By exceptional favor, the Afghan king—His Majesty Mohammed Zahir Shah—had authorized our trip through this remote pocket of his country.

Silk Road Crosses the World’s Rooftop

In Kabul, the capital, our friend Rahman Qul had given us permission to ride with his camel train. It would be led by his eldest son, Abdul Wakil, who would meet us at Khandud, the principal town of the Wakhan, where Kirghiz cameleers come westward to trade twice each winter.

Part of our route would follow the old Silk Road once trod by Marco Polo. It would take us along the frozen Wakhan River, into the high country dubbed *Bam-i-Dunya*—“Roof of the World”—to the nation’s least accessible region, the Pamirs, where Rahman Qul’s people camp with their flocks.*

*Among the few Westerners to visit this remote valley, Jean and Franc Shor traveled the Wakhan corridor two decades ago and became the friends of Kirghiz chieftain Rahman Qul, as told in the November 1950 *GEOGRAPHIC*. In the September 1968 issue, Thomas J. Abercrombie reported on a journey into the corridor as part of his comprehensive coverage of Afghanistan.

Zasie II, our sturdy mini-jeep, had brought us without incident nearly 500 miles from Kabul across the Hindu Kush—mountains so lofty, the natives say, that even the birds must cross them on foot. To reach Khandud, we had traversed the rugged province of Badakhshan, famed for its horses, lapis lazuli mines, gold panners, and women with skins so fair that “one can see the water trickle down their throats when they drink.”

“How will we recognize Abdul Wakil?” Roland had wondered when we drove into Khandud. But the bulky, bandy-legged silhouette waiting on the road ahead could be no one else.

Garbed all in black, wearing high boots and a hat with earflaps that looked oddly like yak horns, he was a formidable figure, utterly unlike the Wakhi peasants we had seen.

He greeted us curtly. His face—it might have been the face of Genghis Khan—was impassive as he read the letter of introduction we had brought from his father.

“*Zud borem*,” he said. “Let us go quickly.” The caravan had already departed; he telephoned ahead for it to await us in Qala Panja, the next sizable village.

Abdul Wakil climbed into the car, and we set out at four in the afternoon for Qala Panja, ordinarily only half an hour away. As we bumped along the track, Abdul Wakil smoked constantly and said not a word.

(Continued on page 443)



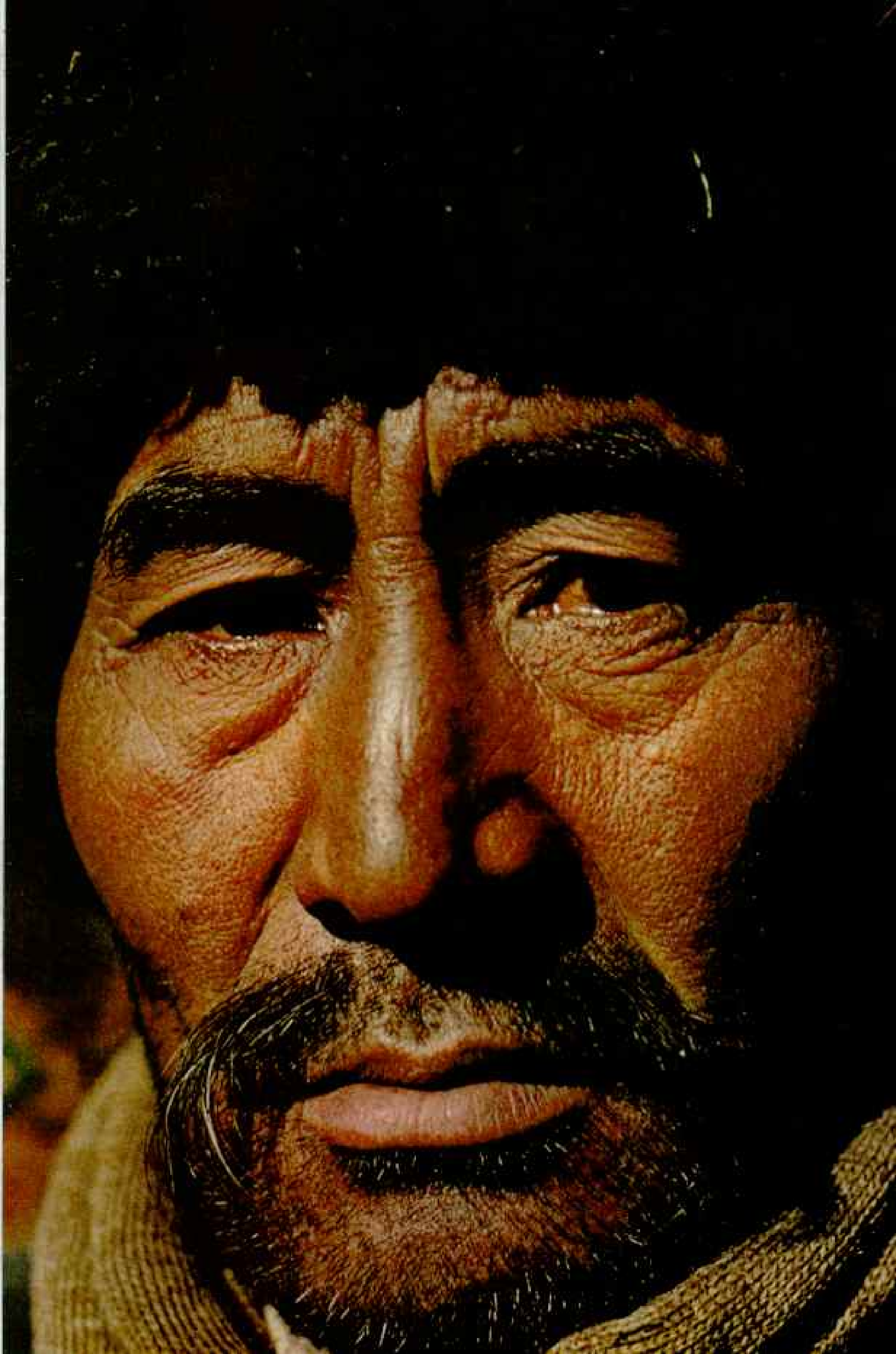
French husband-wife team, Roland and Sabrina Michaud are among the few Westerners to thread the Wakhan corridor in winter. Caravan leader Abdul Wakil made this picture—the first he ever snapped—with the Michauds' Polaroid camera. The hospitable Kirghiz gave the authors their fur caps.

“Needles piercing the flesh,” Sabrina Michaud called the savage snow-laced gales that buffeted the caravan (following pages). Extra-long sleeves protect the cameleers' hands from frostbite on the climb to a 12,000-foot-high pass. The temperature did not rise above 16° F. during the ascent.









At the Eshmorgh River we found the ford concealed beneath a thick crust of ice.

"Where can we cross?" Roland asked.

Abdul Wakil, still silent, alighted from the car and walked out onto the frozen river. He knelt and put his ear to the ice attentively, as a doctor listens to a heartbeat. He advanced with small steps, like a marionette, and listened again.

I followed too carelessly. Thump! I picked myself up and mimicked his mincing step. Behind this bizarre ballet Roland drove slowly, with Zasia's door open, ready to leap out. Here and there the ice groaned, and cracks streaked the surface like lightning.

"*Inja khub nist*—This spot is not good," warned Abdul Wakil. He could hear the river flowing beneath the crust. Tense and absorbed, we did not notice that night had fallen. Finally we cleared the last stretch. Two hours to travel less than half a mile! Abdul Wakil smiled at us for the first time.

Beyond the ice lay sand—and darkness. And beside the Panja River, still six or seven miles from Qala Panja, Zasia's wheels spun noisily and helplessly in a trap of sand.

Rent a Horse and You Get Its Master

Now Roland and I sit quietly beside the car, watching the sweeping searchlights from the Russian side of the frontier river, waiting for Abdul Wakil to find assistance.

In an hour he returns with only one man and a lantern. Zasia will not be freed tonight.

We remove our sleeping bags and camera gear and stumble off through the sand.

A voice calls out from the blackness. We stop in our tracks. Abdul Wakil pulls out his gun. "*Kist!*" he demands: "Who is it?"

The voice identifies itself; Abdul Wakil pockets his revolver. Two Afghan soldiers emerge from the shadows. The assistant commissioner of Qala Panja, awaiting our arrival, has sent them to search for us.

We trudge on until several buildings loom in the darkness. We enter one of them and, after a cup of tea, fall asleep, exhausted.

In the morning Abdul Wakil recruits a dozen Wakhis. They pull Zasia out of the sand and we proceed to the village. Here we

leave the car, sort out our luggage, and negotiate for horses. After lengthy haggling, Abdul Wakil hires six of them for us and our equipment. Each comes with its owner, who will travel on foot; a Wakh horse is not rented without its master.

These natives of the Wakhan are farmers who grow wheat, barley, and chick-peas. They look almost European, speak a Persian dialect, smoke opium, and sometimes work as guides. Their women, tall and slim and light complexioned, raise the children and tend the animals.

Manhood Judged by Skill in the Saddle

In Qala Panja, Abdul Wakil is furious. He hardly touches the pilaf, the rice-and-meat dish prepared in our honor by the commissioner. The official has allowed the caravan to slip by, despite Abdul Wakil's telephoned request to detain it. Now we will not overtake it for several days.

"If they want to photograph camels I can have as many as they want brought in here," the commissioner grumbles defensively. Abdul Wakil does not even bother to reply.

In the morning we saddle our horses and take up our pursuit of the caravan.

Following the gravelly bank of the Wakhan River, Roland and I tire quickly. Rostam, owner of Roland's horse, cannot understand why we sometimes dismount and walk. In this region a man is judged by his horsemanship. "*Borem, borem!*" Abdul Wakil exclaims impatiently. "Let's go, let's go!"

We stop for the night at Sherk, at an altitude of 9,300 feet, after seven hours of riding. A wealthy landowner welcomes us. His young wife kisses my hand in greeting, and I return the gesture. She smiles, and I know I have done the right thing. Next morning she offers me a cloth-wrapped loaf of bread on a tray for the trip. And I place a packet of tea and a small bottle of perfume on the tray and hand it back to her; it should not be returned empty.

Today we cross the Wakhan River on the bridge at Sargaz. It is so narrow and fragile that we must proceed one at a time. I close my eyes and entrust myself to my horse, but even the animal seems nervous. A bit farther

Born to the mountains and high plains, this Kirghiz herdsman descends from nomads who rode with Genghis Khan. Today he and fellow tribesmen graze herds of goats, yaks, and sheep, which they milk and use for barter.

on, the riverbank is strewn with giant honey-colored rushes.

"*Name inja chist?*" I ask Sultan Shah, who owns my horse. "What is the name of this place?"

"*Jangal*," he replies. The forest. The word evokes something far different from this dry brown landscape.

A frightened hare bursts from a thorny bush and zigzags ahead of us. Abdul Wakil shoots it with his revolver. The gunshot echoes repeatedly, a flat, dismal sound. We will have rabbit pilaf tonight.

At Rorung, at an altitude of 10,500 feet, we halt for the night with a friendly Wakhi family whose house perches over the valley. Far below, the frozen Wakhan winds like a ribbon across dark-gray sands. We enter the stone house through a series of doors and rooms built like a maze to ward off wind and cold. Several anterooms shelter the family's livestock; the large living room, hub of home life, is lighted and aired only by a hole in the ceiling. Four elevated, felt-padded alcoves serve as dining and sleeping quarters.

In the small kitchen, women kneel beside a narrow fireplace. They pat slabs of dough against its baking-hot walls and remove the bread with tongs when it is cooked. Roland and I sleep in one of the alcoves. Parents, children, grandparents, and visitors settle in the others. They sleep naked under their covers.

French Marriage Customs Puzzle Kirghiz

We ride the entire following day on the *dasht*—a tranquil and monotonous plain. We splash through a marshy meadow, and Abdul Wakil brings his horse alongside mine. "Is Roland Michaud a rich man?" he inquires.

"No, Roland Michaud does not own any land," I reply.

"Nor any livestock?"

"No, but he has studied a lot."

"Studying doesn't make money. How was he able to buy you then?"

"In France, the money does not matter so much. It is better to have a good education."

He remains silent for a long time, mulling over this conversation.

Abdul Wakil is wealthy. He owns some 10,000 goats and sheep, 100 yaks, 17 camels, and 12 horses. This gives him much prestige in the Wakhan, where peasants come to kiss his hand eagerly. He bestows a great honor simply by talking with me, a mere woman.

"If there were good roads, I would have several cars," he asserts.

He doesn't realize that Zasia and its contents would cost his 17 camels and more.

Toward night we enter a valley where the muted sounds of a settlement rise with the evening mist. It is Sarhad, the last Wakhi village this side of the Pamirs. We are at a crossroads of three worlds. To the north lies the U.S.S.R.; to the south, Pakistan. We are moving east, toward the Little Pamir (map, page 439), where a cluster of caravan trails—the old Silk Road—leads directly into China.

"*Al-hamdu lillah*—Praise be to God. All 17 of them are here," Roland informs me, peering down the path ahead. We have caught up with the camel train.

Trade Changes as Politics Change

I share his happiness. A full moon shines like an egg yolk in the lapis lazuli sky, and the valley unfolds like a felt rug beneath mountains painted blue in the January cold.

Beside a few stone dwellings the 17 camels graze amid sweet rushes. Five swarthy Kirghiz cameleers squat around a fire, savoring their bowls of salted tea.

"*As-salam aleikum*—Peace be upon you." One hand on the heart, Moslem fashion, we greet the camel drivers.

"*Aleikum as-salam*," each responds.

Here is Anal, who is in charge: small, unobtrusive, precise. Then Schahchik, whose eyes are green. There is pockmarked Suleiman, hunter, cook, jack-of-all-trades. Then Ay Bash, ever smiling, the most Mongol-looking of the Kirghiz. And finally Abdul Wahid, a refugee from Russia, enigmatic and pensive.

These men, like Rahman Qul and Abdul Wakil, descend from Turco-Mongolian nomads of the Russian Pamirs and Chinese Turkistan. After the Bolshevik Revolution many drifted to the Afghan Pamirs with their herds and flocks. In summer milk products make up their basic diet, but in winter when there is little milk, they depend on bread and tea—hence this caravan.

In the past their marketplace was Kashgar, in Sinkiang. But in the 1950's, when political events in China inhibited trade with Kashgar, the Kirghiz began coming westward to stock up on tea, sugar, cloth, and other supplies at Khandud, and to trade for grain with the Wakhis on the way home.

The next morning we witness a scene that gives us the key to the commerce between Kirghiz and Wakhis. Abdul Wakil takes over:

"Eddy Mohammed, is it you? My father tells me you have wheat to sell."

"I am poor and have very little of it," Eddy Mohammed says, hoping to increase the price. "But refresh yourself first. I have so little wheat that this business will soon be settled."

Abdul Wakil is not fooled. He drinks his tea and the dickering begins. Eddy Mohammed quotes a price—too high.

"*Intaur nashud*—It won't do," says Abdul Wakil. "Rahman Qul has told me you have agreed to one sheep for ten seer of wheat." A seer is almost 16 pounds.

"I, too, am a Moslem," Eddy Mohammed cries out, shocked that his word is being doubted. And he recites the *Shahada*, the profession of Moslem faith. But with all the caravaneers on Abdul Wakil's side, Eddy Mohammed gives in.

Despite old antagonisms, the Kirghiz and Wakhis depend upon each other. This bartering of tallow, felt, or livestock for wheat remains a practice among them, even though Afghan bank notes are coming into use.

Sacking Wheat Becomes a Noisy Affair

Since sheep do not accompany this caravan, there are none on hand for delivery. They will be sent to Eddy Mohammed later.

A large rug is spread out on the dirt floor so that not a grain of wheat will be lost. The Wakhis bring forth a sample of their harvest. The Kirghiz reject it—it contains too much dust. The next is satisfactory. Abdul Wakil fills a *piala*—the teabowl that serves as a standard measure in both the Pamirs and Wakhan—and begins transferring wheat into a sack held open by two cameleers.

Both sides carefully count the bowlfuls; at 30 the first sack is full. Suleiman sews it shut and fetches another. The counting goes on.

"*Si o do*," the Wakhis announce with the next bowlful. "Thirty-two."

"*Si o yek!*—Thirty-one!" the keen-eyed cameleers protest.

"*Si o do!*" ... "*Si o yek!*" the argument rages, punctuated by cries of "*La ilaha illa llah!*"—There is no god but God! Allah's greatness finally shines forth. He has favored the count of the honest Kirghiz. It takes two hours to fill the 12 sacks.

After we leave Sarhad, we are forced to stay close to the river. The valley quickly narrows to a gorge (pages 436-7). We are riding on the river's frozen surface. Single file, men, horses, and camels tread cautiously. With a velvety step, the camel's large and flat feet do well on this skating rink, but the iron-shod horses often slip.

On a glass-slick trail, a caravaneer sprinkles sand to prevent a slip that could mean tragedy. Three times, when camels fell on perilous slopes, tenders risked their lives to free the beasts of their awkward loads so they could get on their feet again.

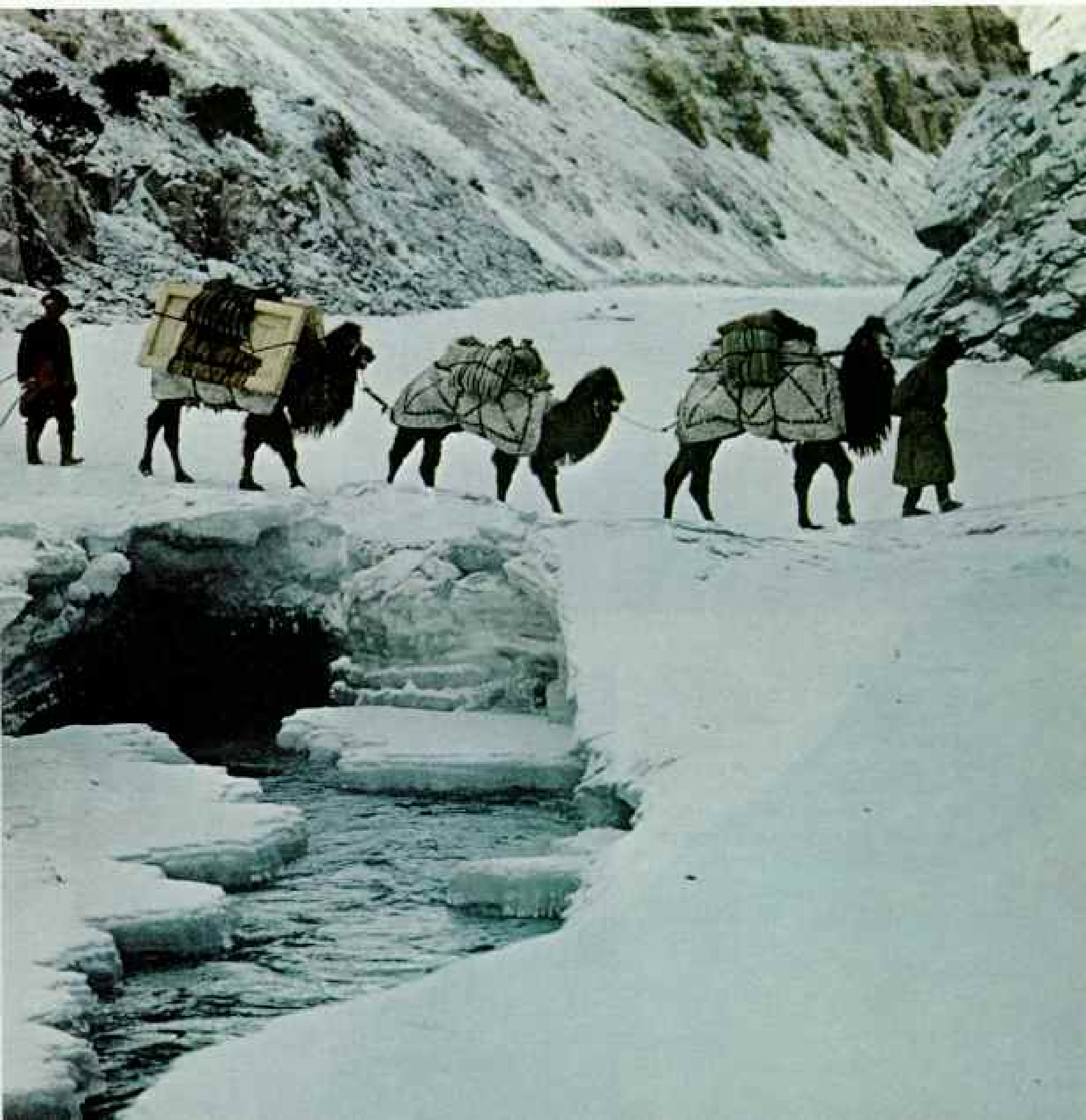


Utterly exhausted after 9 hours on the trail, a 16-year-old sheltered by a windbreak of unloaded cargo warms himself with tea (below). Kirghiz and Europeans alike suffered from the cold and wind. Roland Michaud recorded temperatures reaching -10° F.



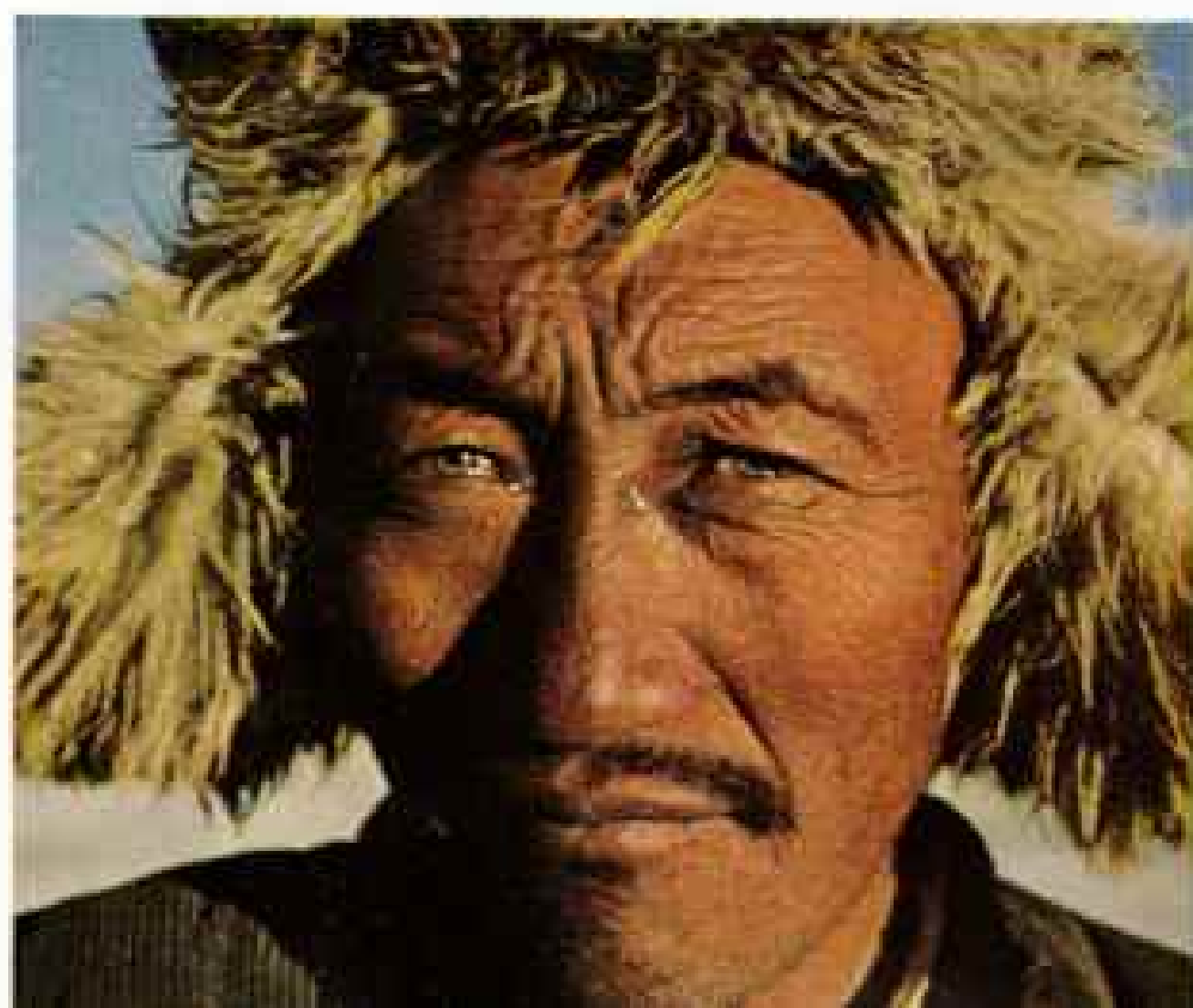
Hitched head to tail and tail to head, camels “cool out” before they are allowed to lie down. The position prevents them from collapsing on the frozen soil and catching cold while still overheated.

Skirting danger, the caravan slowly crosses the frozen Wakhari River (below). Here, where a horse crashed through and drowned the previous year, men cautiously dismount to guide their heavily laden camels. “Often I heard the crust crack,” recalls Sabrina. “All I could do was hold my breath and pray.”





Where stoics weep: The wind's fierce lash draws tears that immediately freeze on the faces of beast and man alike. But camel and Kirghiz share more than winter's wrath. Feeding and protecting the camel, the owner takes in return the wool and services of a creature able to transport 600 pounds.





"Here, last year, a horse broke through the ice and drowned," Abdul Wakil tells me (pages 446-7). We zigzag across the river time and again. With experienced eyes the Kirghiz pick the safest path.

The gorge closes in with tormented walls, and our own throats tighten. A witch, with a wave of her magic wand, seems to have immobilized the cascades all around us. The ice on the river is more than three feet thick, yet we can still hear the water as it flows swiftly beneath us, and in places the crust cracks ominously.

By early afternoon the gorge has become

too narrow, the ice too treacherous; we abandon the river and begin to climb a pass. Ay Bash opens a bag of sand and sprinkles it on a steep trail so icy that even the camels balk (page 445). The cameleers coax them on with tugs and shouts.

"Look out!" Roland suddenly cries, on a narrow ledge over a dizzying precipice. My horse has slipped and fallen on its forelegs. I pull on the reins and the animal struggles to its feet. Fear dampens my brow as we climb onward. We stop every 50 yards to rest the animals, then move again.

Ahead, one of Suleiman's camels slips and collapses on the frozen path; it kneels and tries to crawl. Ay Bash and Schahchik run to its rescue. Risking their own lives, they unload the animal so that it can stand up, then load it again, and move on. Men and animals are suffering, struggling, clinging to the mountainside.

Altitude and Fatigue Take Their Toll

At last the bent figures ahead are silhouetted against the leaden sky. Yard by yard we cross the snowy crest and begin the slow descent. In the distance the river twists and turns like an opalescent dragon. With dusk setting in, the mountains seem enormous, overpowering. We pull our coats tighter, feeling pathetically small.

Fatigue overcomes me, and I stop to rest. Each passing cameleer smiles and says, "*Manda nabashi!*—May you not be tired!" I manage the customary reply, "*Zenda bashi!*—May you live long."

The caravan plods onward, becoming a series of black dots against the snow. I finally catch up with it at a primitive stone shelter in which the six Kirghiz will sleep. Roland and I occupy a similar shelter nearby, together with our horse owners.

The Wakhis spend much of the night chatting around a fire. As for us, after heating some tins of food and preparing tea, we drift off into a deep dreamless sleep, despite the fact that our hut is infested with rats and drowned in acrid smoke.

I am happy to leave this gloomy shelter, one of several in the valley. Bundles of firewood lean against the outer walls, intended for occasional visitors. This evidence of mutual help among Pamir travelers comforts me. Fire is vital here. We understand why (before the advent of matches) the caravaner's *chaqmaq*—his flint and steel (page 452)—was among his most prized possessions.

Once again we ride on the frozen river. Then, in the afternoon, we depart from it for good to begin the climb over new passes, ever higher. I am frightened on the narrow trails beside steep precipices, but my fear becomes secondary in the fight to hold my own and reach the next stage.

Finally we branch off to enter a sheltered basin. There we see our first yurts. A Kirghiz and his family appear from one of the round felt tents. He approaches Roland and Abdul Wakil, and kisses their hands in greeting. His wife and daughter help me from my horse and take me inside to the fire. They remove my coat, scarf, and headdress, and pull off my boots. "*Qawi asti*—You are strong," they tell

me; and smile indulgently when, contrary to custom, I immediately stretch out, sighing thankfully.

The thick felt of the yurt is an excellent insulator against the cold (page 452). Inside, against the willow frame in sacks, boxes, and trunks, the Kirghiz family keeps its belongings. Most treasured of all are the meager supplies of tea, sugar, and salt. Tea is so valuable that a Kirghiz carries it on his person, in a *chaikhalta*—a small embroidered tea sack. Sugar is so precious that the tea is usually drunk with salt; salt is so rare that it is used only in tea.

The women stir up the fire, pushing aside some embers to heat the *choqun*—the kettle.



Stretched out in the shape of a star, our feet toward the yak-dung fire, we spend a good night with the hospitable Kirghiz family.

All Energies Focus on Battling Cold

Out on the exposed sweep of the plain the next morning, the wind bites more cruelly than ever. My toes grow numb, and I must move them constantly. I rub my nose to keep it from freezing. Roland, too, suffers from the cold. Icicles hang from his beard and mustache, but his hands are especially numb. Not only must he work his cameras; he promised a French scientist that he will make meteorological observations along the way.

We head northwest, leaving the Wakhan

behind. It is -4° F., despite the sun and blue sky. Only the camels seem comfortable. Unruffled and aloof, as magnificent as lords, they glide silently onward, occasionally scooping up a lump of snow with their tongues. The cameleers, their faces buried in headgear and collars, do not exchange a word. They are saving their strength to fight the cold.

Roland's altimeter tells us we have reached a height of 12,795 feet. We feel a sense of almost literally standing on the Bam-i-Dunya—the Roof of the World.

With my last drop of strength, I reach the Aq Jelga encampment. Collapsing in a yurt, I burst into tears. The mistress of the house takes off my boots and socks and rubs my feet

with the heat from their own massed bodies. This herd belongs to Kirghiz chief Rahman Qul, who arranged for the authors to join the caravan.





Greeted by a wintry blast, one of the cameleers ventures from a yurt at Mulk Ali. Made of heavy felt lashed to a willow frame, the tent is a snug home, warm in a land where even summers are cool.

Inside the tent (opposite), a cheerful blaze warms hands and supper—a "fondue" of dried yogurt cooked with water, fat, and chunks of bread.



Until matches came, stone and steel kindled Kirghiz campfires. Herdsmen produced sparks with this brass-mounted *chaqmaq* by striking the curved steel at the bottom against a piece of flint.





Small beneath his burden, a boy trudges toward Mulk Ali with a load of kindling.

Three wives share a roof in the yurt of Abdul Wakil (opposite). Here wife number two, Bibi Turgan, coaxes the flames as she brews tea. Sabrina chats with Bibi (meaning "lady") Orun, first and eldest and therefore the leader among Abdul Wakil's mates. The master of the house entertains the women by plucking a tune on his *dambura*.

She wraps raw wool around my toes, one by one, and advises me to leave them like that, even in my boots. I smile through my tears, and comfort myself with a cup of salted tea.

In the morning the thermometer registers 1° F. Small flakes are falling from the sky, and the encampment's yaks, with morose expressions, huddle in their coats.

Camels Seem to Tread the Clouds

We begin to ride through the bleakness with our 17 camels. Now and then we pass a cluster of yurts. No humans stir, but dogs throw themselves at our horses, yelping. A picture engraves itself on my mind: that of Roland's horse kicking the muzzle of a dog that is nipping at its tail.

A dismal day. Sky and earth merge into one. I can no longer tell whether the camels are undulating on snow or clouds. There is nothing to catch the eye. No tree, no shelter—only the white world of a seemingly infinite plain. Roland is taking the needle blows of the wind on his face. He fumes as he reloads film; a drop of moisture falls from his mustache into the open back of the camera, and instantly freezes on the shutter. The wind is now blowing up a storm, reducing visibility to less than 200 yards. The temperature is -22° F. Icicles hang from the camels' beards.

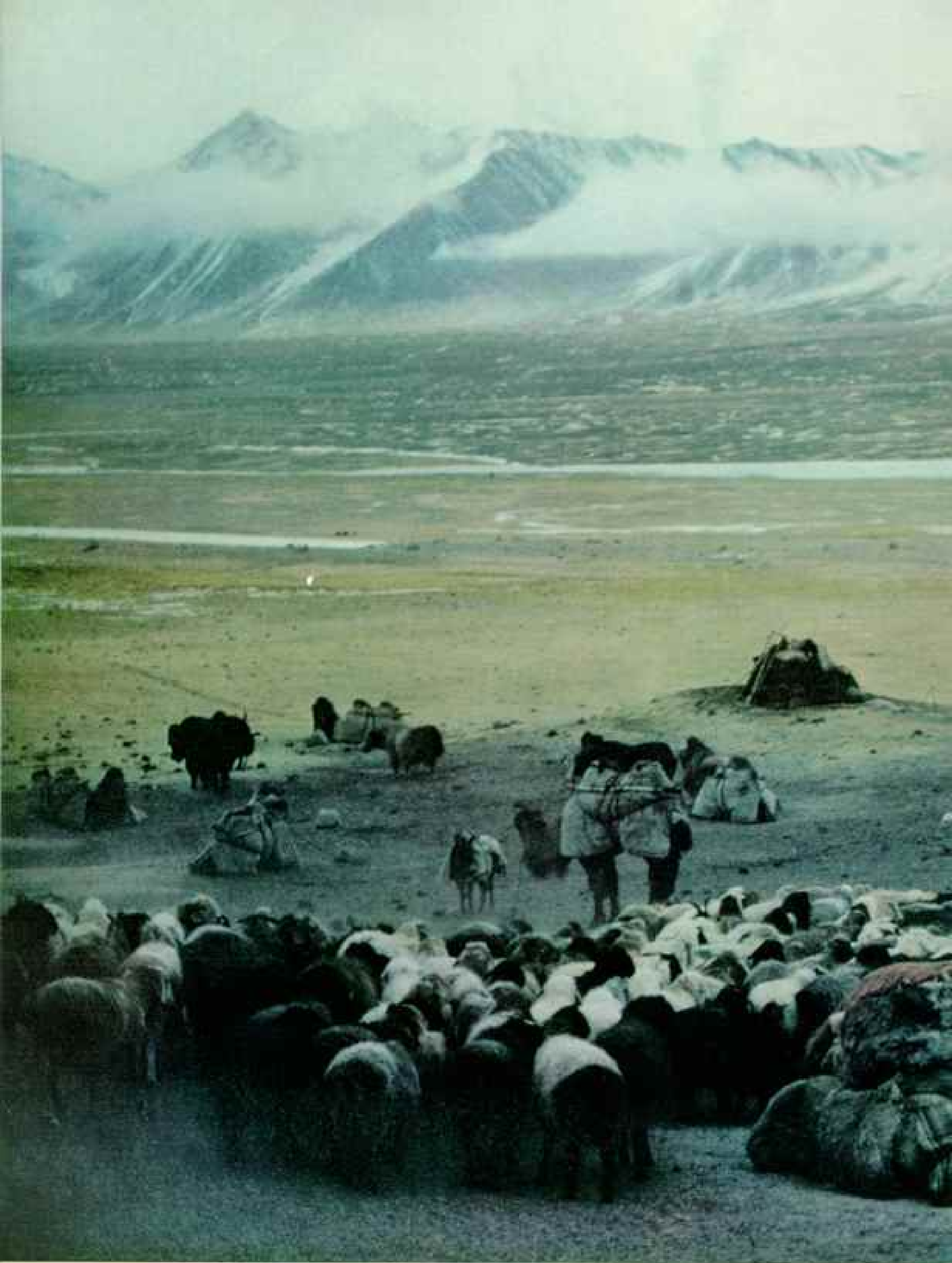
Everyone is exhausted when we stop for the night. Even Ay Bash, his eyebrows white with ice, tells me of his fatigue while he ties the camels together by two's, head to tail and tail to head, to prevent them from collapsing on the frozen ground while still overheated (page 446). After two hours in this upright position, called *chapar*, the beasts are untied and allowed to settle for the night.

These double-humped Bactrians are found in the semidesert regions of China, Mongolia, and Tibet. They are powerful and robust, averaging more than six feet tall at the hump, and their weight can exceed half a ton.

The two enormous humps, as high as 18 inches, are a camel's reserve bank. Together they may hold more than 200 pounds of fat that the animal's body can draw on when other fare is lacking. The beast can survive for weeks without food. But as it uses up its stored provisions, the humps shrink, sometimes almost vanishing.

"The camel is our most valuable animal," Anal tells us. "It is worth 8 yaks or 9 horses or 45 sheep." Not only can it carry a load of 40 seer—more than 600 pounds—but it also yields prized wool for Kirghiz fabrics. It is





Cloud-veiled peaks fence Kirghiz pastures. Sheep, goats, and yaks return to Mulk Ali as chill evening envelops the camp. The authors showed the yurt's owner, Rahman Qul, a photograph



of himself in a copy of the November 1950 *GEOGRAPHIC* they had brought with them. That issue recounted the Wakhan adventures of another husband-wife team, Jean and Franc Shor.

this thick underfur that protects the Bactrian camel in the extreme cold of the high plateau of central Asia.

"The wool is beautiful and precious to us," Anal says, "so valuable that I must keep a watch over our camels to prevent the Wakhis from coming and pulling out tufts of it."

Camp Looms Like an Oasis

Today, *Inshallah*—Allah willing—we shall reach our final destination.

At a pace slower than normal, the caravan gets under way. From time to time a cameleer modestly steps away from the trail for *jawab-i-chai*—literally translated as "the reply of the

tea." The weather is cold, but beautiful. We are surprised that at this altitude the ground is almost bare of snow.

We stop to let our horses graze. Anal tells me proudly, "A single blade of Pamir grass is as good as a haystack." Lost in the immense, rippling plateau rimmed by fantastic mountains, we find ourselves at 12,000 feet; the peaks around us soar to 18,000.

Mulk Ali, the winter camp of Rahman Qul, looks like a handful of children's blocks in the distance. But its two stone buildings, its three yurts, its walled enclosure to protect goats and sheep from the cold, constitute an oasis of warmth and sustenance. Some thirty



Baby's homemade bottle, a lamb-skin sack holds a porridge made from flour and water. The unsweetened mixture barely sustains year-old Zulaikha (right). The mother, unable to nurse her baby, would be reluctant to use yak or goat milk even if cold weather had not reduced the supply; animal milk, she believes, causes illness in infants. "When babies are born in winter," a Kirghiz woman told Sabrina Michaud, "they often die."



people live here in isolation, having only themselves to depend on in their struggle against the hostile winter (pages 456-7).

Perhaps a hundred such camps are spread over the Little Pamir. The nearest neighbor is several hours away by horse. The Kirghiz are very individualistic, but visits are frequently paid; they are the best diversions.

As for the summer camps, they are only yurts and are never situated more than a day's ride from the winter settlements. Their *raison d'être* is largely economic; moving herds to the higher pastures permits the regrowth of grasses on the lower, winter grazing lands. But one must also understand that these sons

and daughters of nomads feel an almost physical need to bow to the rhythm of the seasons. Having summer and winter encampments helps satisfy that urge.

Understand, too, that only wealthy chiefs like Rahman Qul are able to organize a large caravan such as ours. The poorer encampments sometimes buy wheat from Rahman Qul. Visitors to any camp, as well as very poor families, are usually fed and lodged free.

Our arrival creates a great stir at Mulk Ali. There have been practically no men here for a month. Akbar, third son of Rahman Qul, 21 years old, is in charge. Akbar ushers me into the *mihmankhana*—the guest quarters—a



Chores leave little time for leisure



Cooking the day's bread, Bibi Tokhto spends all morning over a hot griddle (left) at Mulk Ali. Often she devotes afternoons to melting ice for water.

Baring her long hair in the privacy of her yurt, Bibi Tokhto enjoys a shampoo. Kirghiz women never go out without head scarfs—red for single girls, white for married. Opening hearts and tents to Sabrina, the women gave her glimpses of camp life seldom seen by outsiders.



Swathed against the cold, a Kirghiz woman milks a shaggy yak. This versatile pack animal of central Asia also yields wool, meat, tough hide, and tail hairs that can serve as a fly whisk.



Visiting friends of Abdul Wakil's family take tea and biscuits during a Moslem festival, a relief from daily routine. The guests traveled 20 miles to pay the call—a treat in the lonely Pamirs.

stone house filled with warm furnishings: a felt carpet, quilted covers, and multicolored pillows. It is heated by a *bukhari*, the traditional Afghan stove, brought here by camel. Akbar immediately offers me tea, then leaves to greet Abdul Wakil and Roland.

I am not alone for long. A woman enters and embraces me. By Kirghiz protocol, it is Abdul Wakil's first and oldest wife, Bibi Orun. She welcomes me warmly, then five other women enter. After exchanging the traditional polite phrases they sit down and watch me silently. Suddenly, a young boy rushes in, announcing the arrival of Abdul Wakil. The women scurry off. Abdul Wakil drinks some tea in the guesthouse before going to his own yurt to see his family again.

The next morning I decide to pay a visit to the women, and, to respect their customs, begin with Bibi Orun. On the way a fierce sheep dog tethered to a yurt leaps up, showing me its sharp teeth. Its ears are cut off, and it wears a spiked collar as protection from the wolves that attack the herds. Bibi Orun sees my fright and scares the dog away with a well-aimed stone.

Abdul Wakil's yurt is calm, clean, and

orderly, thanks to the three childless women. But a yurt without children is a great misfortune. If, in another year, his third wife, who is 15 years old, does not bear him a child, he will take a fourth wife.

Abdul Wakil cleans his rifle while Bibi Orun sews a *khaltu*—a sack. From time to time she gives an order to Bibi Turgan, who is baking bread, and Zeba Khanim, who is washing clothes. (Khanim, like Bibi, means "lady.") Bibi Orun treats the younger wives like a mother.

I am surprised to see no jealousy among the wives. "Three women and one husband—doesn't this create any arguments?"

Bibi Orun laughs. "When a man is just and good, as well as master of the yurt, there are few problems," she replies. "Besides, it gives each of us less work to do."

Girl Babies Rate No Wet Nurse

As the days pass, I spend much of my time in Rahman Qul's yurt. There are many people and activities there. I am now greeted as "Sabrina jan—dear Sabrina." I grow particularly fond of Bibi Jamal, wife of a son of Rahman Qul (page 463). She spreads a blanket



beside the fire and makes me sit there. Bibi Hawa, a wife of Rahman Qul, prepares a porridge for Zulaikha, a weak one-year-old baby whose frail little body reminds me of a rag doll (pages 458-9).

Bibi Jamal alertly senses my concern and explains that Bibi Hawa is not able to give milk; since her birth, Zulaikha has been fed only porridges.

"Then how did she feed her other child, Mosaddegh? He is handsome and healthy."

"Mosaddegh is a boy and had a nurse."

At three years Mosaddegh, adorable and spoiled, has everyone wrapped around his little finger. He spills the glass containing Zulaikha's meal. Bibi Hawa patiently puts more flour in the glass and pours boiling water over it. No milk. Not even sugar.

"Yak milk sometimes causes diarrhea that can kill children," she says. As for sugar, she does not know whether it would do any good for her baby girl.

I suggest that she replace the water with milk very gradually, and persuade her at least to sweeten the porridge.

Busy Days and Star-filled Nights

Day after day, I note how monotonous are the tasks of the Kirghiz women. The entire morning is spent preparing the bread that is their winter staple. They bake enormous quantities of it, since they must also feed the cameleers, who are without wives here, and occupy the third yurt of the camp. A woman is expensive among the Kirghiz, and I suspect that some cameleers have married poorer Wakhis. In several villages I have noticed them scatter to various homes where the children had a certain Kirghiz look.

Following the noon meal, the women melt down ice for water, or sew, or groom themselves. Then they prepare the evening meal and, after dinner, go right to bed.

Despite our shortness of breath, insomnia, and headaches from the altitude, we become passionately attached to our new lives. We are delighted with the relationship that has grown between us, city dwellers of the West, and them, tent dwellers of the Pamirs. And

not for a moment do our hosts display anything but kindness and good humor.

Abdul Wakil shows an interest in photography, and Roland teaches him to use the Polaroid camera. The meteorological observations also interest him. Carrying an anemometer, he accompanies Roland on his four or five daily walks and takes readings as conscientiously as Roland himself. Often, the icy northwest wind blows with gusts of 30 miles or more an hour. No snow falls during our stay, but we record no temperature higher than 25° F. On cold, cloudless nights we never tire of contemplating the Pamir skies studded with twinkling stars.

"Italian" Ash Pleases Kirghiz Palates

Our hosts teach us many things. Roland compiles a Persian-Kirghiz glossary of caravan terms, noting that the Kirghiz write with Arabic letters. They also help us put together a small herb collection. For this we follow Mirza, the young shepherd, into the mountains, where we gather a score of plants; he tells us the local name for each.

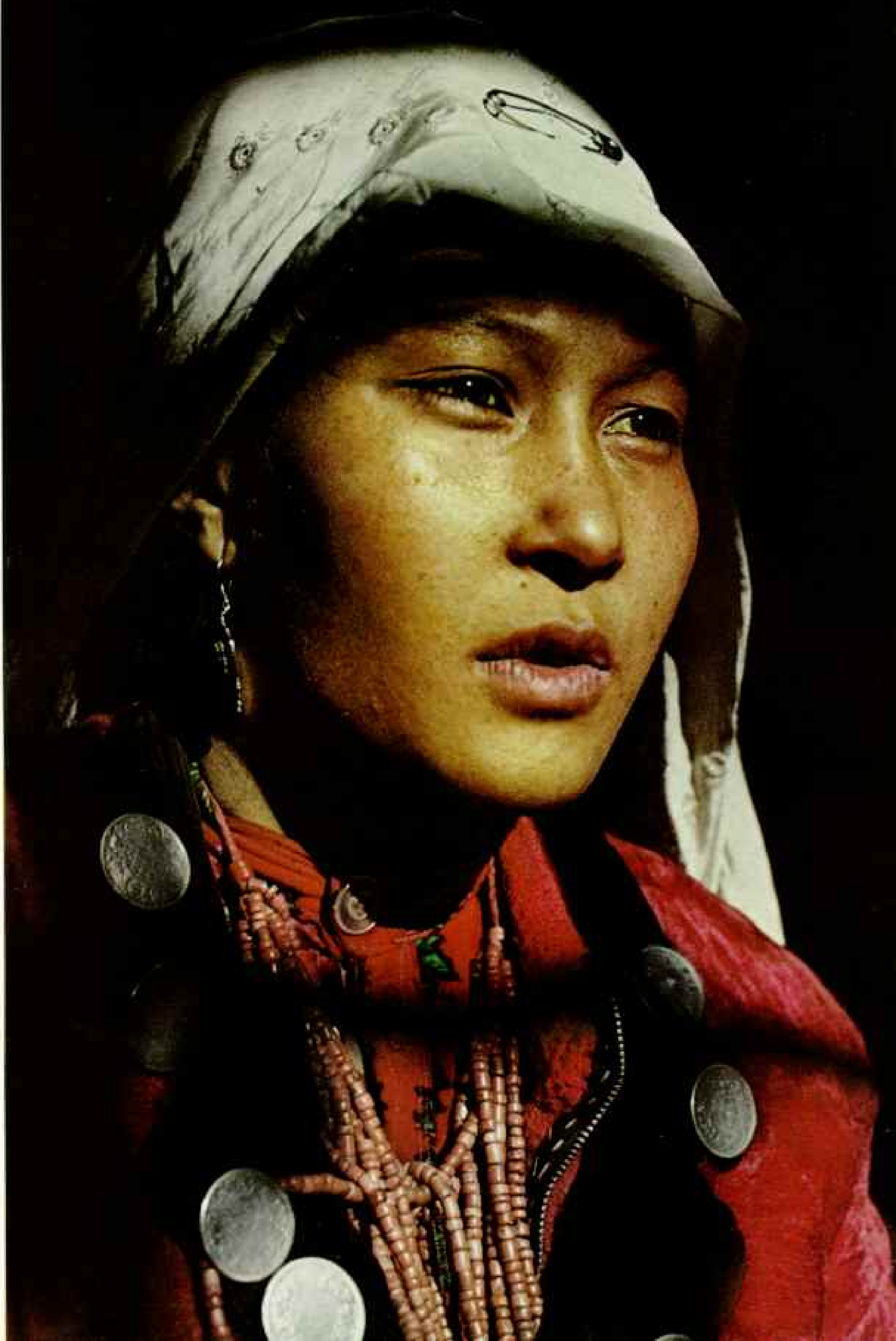
Our days pass quickly.

"Sabrina jan," Bibi Jamal asks me one morning, "will you eat with us or in the mih-mankhana?"

I tell her I will eat today in the guesthouse. I am tired of the monotonous meals: yak meatballs, soup with mutton as tough as leather, and especially *ash*, which appears at every lunch. This is a sort of noodle cut from bread dough, usually boiled with bits of meat and onion. It is never cooked enough for our taste, and lingers like paste in our mouths.

I decide to introduce our friends to ash, Italian style. I spread out my camp stove and kitchen utensils. All the men watch me with interest, helping me at times to peel onions and garlic—frozen, of course, but still pungent. In half an hour my "spaghetti" with tomato sauce is ready. Abdul Wakil and Akbar eat with us. Unable to feed all the others who look on, we adopt their own custom, sharing the meal with the chiefs and distributing an occasional morsel here and there. The Kirghiz eat with gusto. Abdul

Sorrow shines from a mother's eyes. Bibi Jamal recently lost her 3-month-old daughter, the only child of five years of marriage. Wed to one of chief Rahman Qul's sons, she is his only mate. But a home without children is poor indeed, and her husband may soon take another wife so that he may have a son.





Days of hardship still ahead, the Michauds start home with the second winter caravan from Mulk Ali. In spring these high pastures will be green, and the herds will again produce

Wakil asks, "Where can I buy such a meal?"

While on the trail, the caravaneers eat only twice a day—morning and evening—in order not to interrupt the slow walk of the camels. At the winter camp, the Kirghiz are forever busy preparing their favorite dish, *qurut*.

Qurut is a hard, dried yogurt slowly mixed with water into a paste. Heated, with bits of bread and fat added, it resembles a fondue (page 453). In this season qurut is the only dish having a milk base, since the animals produce very little milk in winter. Thus we feel deeply honored when our hosts offer us a full bowl of milk every day.

The task of milking the yaks falls to the woman. This "piece of prehistory," as Roland

calls the yak, always seems to be in a bad mood. But its step is sure, it does not fear the mountain torrents, and with great endurance it can carry 150 pounds—a fourth the load of a camel—across 15,000-foot passes. Its dry dung provides the most common fuel—and one of the best—on the high plateaus of central Asia. Its hair can be braided into strong rope, and its hide furnishes tough leather.

Warm Gifts Help Fight the Chill

In two days the second and last caravan of the winter will take to the road toward Khandud. We will return with it.

What excitement in the camp! The men shoe the horses, test the ropes, check the



enough milk to supply the Kirghiz. But when snow and cold return, the men will gird once more for their grueling treks, a test of will and strength worthy of the sons of Genghis Khan.

trappings and felt padding of the camels. The women mend food sacks for the journey.

Each one silently thinks about the trials ahead. The women prepare bread in great quantity for the trip. It will sustain the caravaneers for more than a month.

Attentive host that he is, Abdul Wakil has noticed the shortcomings of our cold-weather clothing. He instructs Bibi Orun to make each of us a *tomaq*, the Kirghiz fur headgear, and *paypaq*—thick felt stockings. Then he collects all the spare boots in the camp. I find myself equipped with a pair belonging to Akbar; Roland receives a beautiful pair made by Kazaks in Sinkiang.

In the atmosphere of an Oriental bazaar,

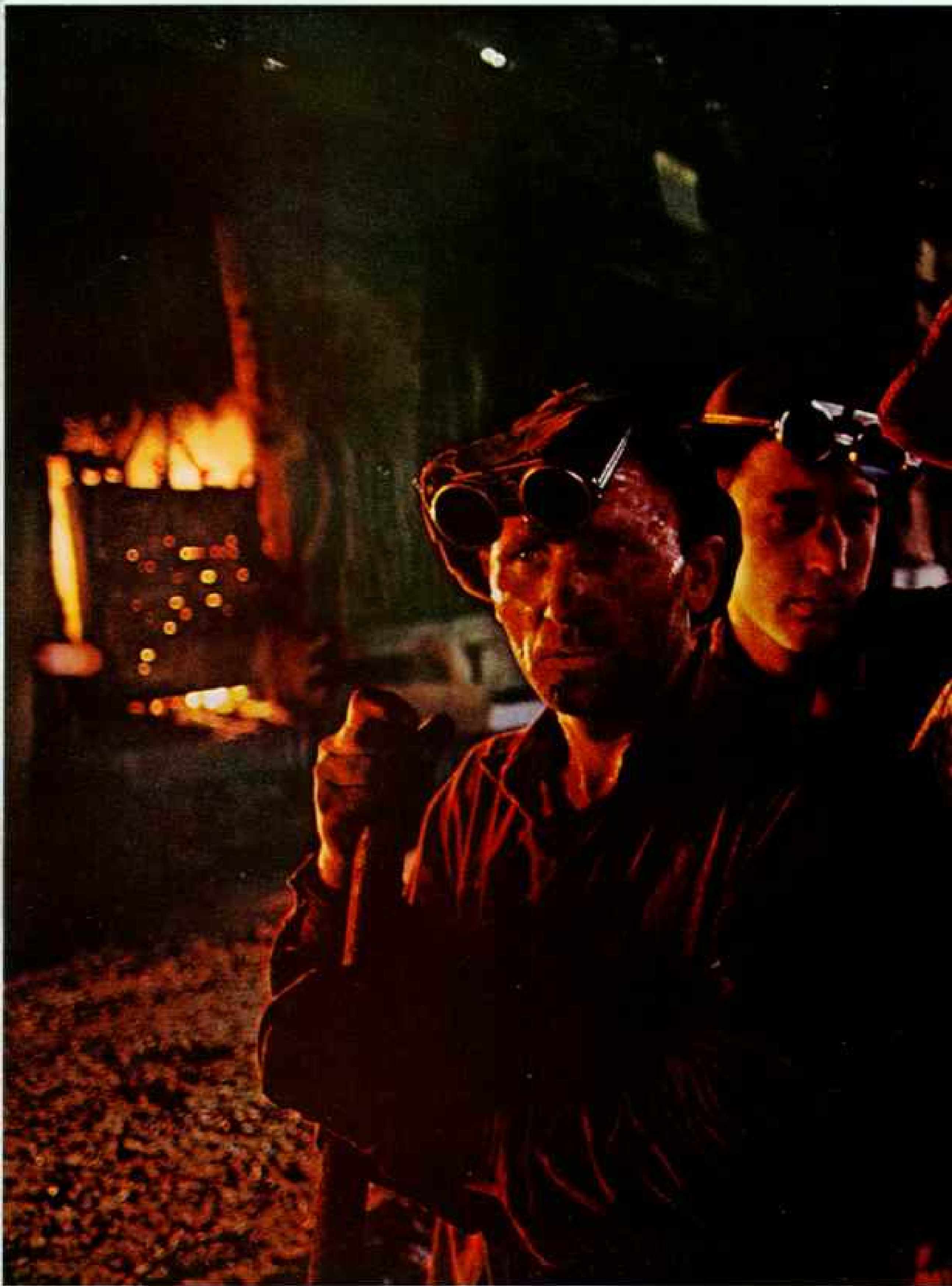
the caravan is loaded with felt rugs and goat-skins of sheep fat to be bartered for Wakhi wheat, and we bid the women farewell.

I kiss them affectionately on both cheeks. They return my kisses Kirghiz style, on the lips. Bibi Orun will not let us leave until we have swallowed the last drop from a bowl of warm sweetened milk she has prepared.

"It is very good against the cold," she tells us. Bibi Orun helps me mount and leads my horse to the edge of camp, and hands me the reins:

"May God be with you," she says.

We are more moved than we want to be. But already the caravan heads out, and we are delivered to the biting wind. □





SPRINGTIME OF HOPE IN POLAND

By PETER T. WHITE

Photographs by
JAMES P. BLAIR

WITH NATIONAL GEOGRAPHIC STAFF

SPRING WAS WARMING the Polish People's Republic. Larks sang high over freshly sown fields of rye, and along the country roads sprouted blue sprinklings of forget-me-nots. Little girls brightened villages and towns in their white dresses for first Communion, and everywhere young men's fancies fiercely turned to bicycling—to the international rally called the Peace Race.

Of all the 33 million Poles, some 15 million would be watching this race on TV: Warsaw-Berlin-Prague in 16 days, with competitors from 17 countries.

"The theme is international understanding," says my interpreter, "but the main thing is that a Pole must win! Did you know that Poland makes the world's best bicycles?"

I didn't, but I had heard how Poles love to exaggerate, to go to extremes in word or deed. Quite a few here in their bustling capital of Warsaw told me so themselves.

"Take fashions," says a stylish lady editor. "Where else do girls put on such enormous sunglasses, or so much eye shadow?"

"Take eating," adds a youth from Warsaw University. "On Christmas day about 10 or 11 o'clock it's fish, pâté, beef loin, sausages, red beet soup, and pickled beets, cucumbers,

When food prices soared in 1970, Polish workers like these steel-mill hands triggered riots that put a new leader in power. Economic reforms now point to a brighter tomorrow, but many Poles, mindful of the fate of past promises, remain skeptical.

and onions. That's breakfast. At 2 or 3, lunch—the same. And again for dinner, about 6. It's all repeated the next day. Can you imagine, there were 40 ambulance calls at Christmas just to pump out stomachs!"

Easter means another two days of joyous overeating—not to mention one's name day.

"Or take cars," says an engineer. "A car is such a luxury that it's treated as the most important part of the family. So on Sunday a man can think only of washing and polishing the thing—he'll drive 500 yards from home to the Vistula River and wash away, while his wife and kids get mad and madder. In the end he'll be so tired, or it'll be so late, that they drive straight home."

The lady editor: "That's a typical Polish exaggeration! More likely, when they finally get off on their excursion, the man drives so fast and inexpertly that he has an accident."

The engineer: "Now you are exaggerating! I haven't driven much, but I can safely go 90 miles an hour..."

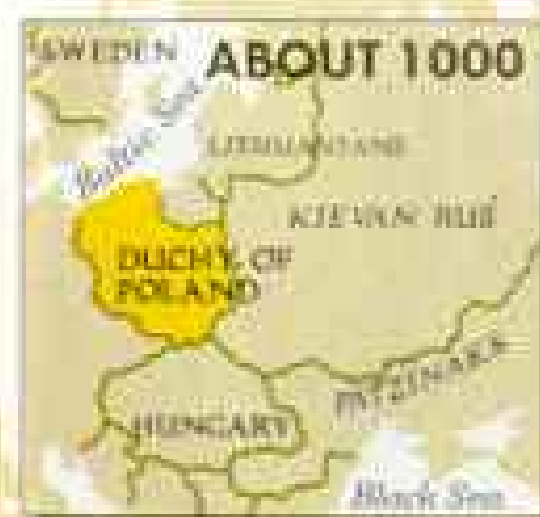
AND YET some things the first-time visitor is likely to hear and find surprising are not exaggerations at all.

For instance, I had always thought of Poland as being in eastern Europe. Not so, say the Poles. We are the heart of the Continent. Really? Draw a line on a globe from easternmost Europe, in the central Urals, to Lisbon in the extreme west; and another line from the northernmost point in Norway to southernmost Greece. Those lines intersect near Warsaw.

Or consider Poland's scenic variety. True, 90 percent of it stretches monotonously flat or modestly hilly. But in the north sparkle hundreds of lakes in Mazury and hundreds of miles of surf and sandy beaches on the Baltic Sea. Mountains rise in the south, in the High Tatra, as jagged and spectacular as the Alps (page 498). A truly untouched forest of the plain stretches in the northeast, in Białowieża National Park.

I want to sample all this, of course, but first I wander around Warsaw on a sunny Sunday. In Łazienki Park, on a platform beneath a three-times-life-size statue of Fryderyk Chopin, a young woman at a Steinway plays the master's mazurkas and polonaises. Hundreds sit unfidgeting on stone benches, raptly, as if enjoying these gems for the first time.

In another greening enclave, next to the 768-foot-high Palace of Culture and Science, thousands crowd the annual outdoor book



Poland emerged as a state in the late tenth century, when dukes of the Polanie—inhabitants of the Warta River basin—united neighboring Slavic tribes under Mieszko, first recorded Polish ruler.



Successful wars, treaties, and dynastic unions ballooned Poland's size. By 1492 territories of Lithuania, Hungary, Prussia, Bohemia, and Pomerania came within its sphere of influence.



Wars and civil strife toppled the nation from its 16th-century zenith of power. By 1667 Poland's size had been considerably reduced as expansionist neighbors nibbled away at the borderlands.



The stack became a feast in the 18th century. In three partitions between 1772 and 1795, Russia, Prussia, and Austria completely devoured Poland, erasing the country from Europe's maps.



Revival came in 1807 and 1809, when Napoleon conquered Prussia and Austria and reestablished a Polish state. After his defeat in 1815, the Russian-ruled Kingdom of Poland was established.



After World War I, with Germany and Austria-Hungary defeated and Russia weakened by revolution, Poland emerged as a parliamentary republic. It remained free until Nazi Germany invaded in 1939.

Baltic Sea

Elevation in feet
Administrative regions of Poland bear the same names as their capitals, shown thus



DRAWN BY AL FRED L. JERARDY
COMPILED BY HAROLD G. HANSON



GERMAN DEMOCRATIC REPUBLIC

U.
S.
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R.

HITLER'S JUGGERNAUT stormed into Poland from the north, west, and south on September 1, 1939, meeting fierce but futile resistance. Sixteen days later the Soviet Union—then a German ally—invaded from the east, and subsequently banished thousands of Poles to Siberia. By war's

end, Russians and Poles had joined forces against Hitler; the Nazis had killed an estimated 6,000,000 Poles—half of them Jews; industry and agriculture lay devastated; and 2,000,000 Poles had been deported to Germany for forced labor.

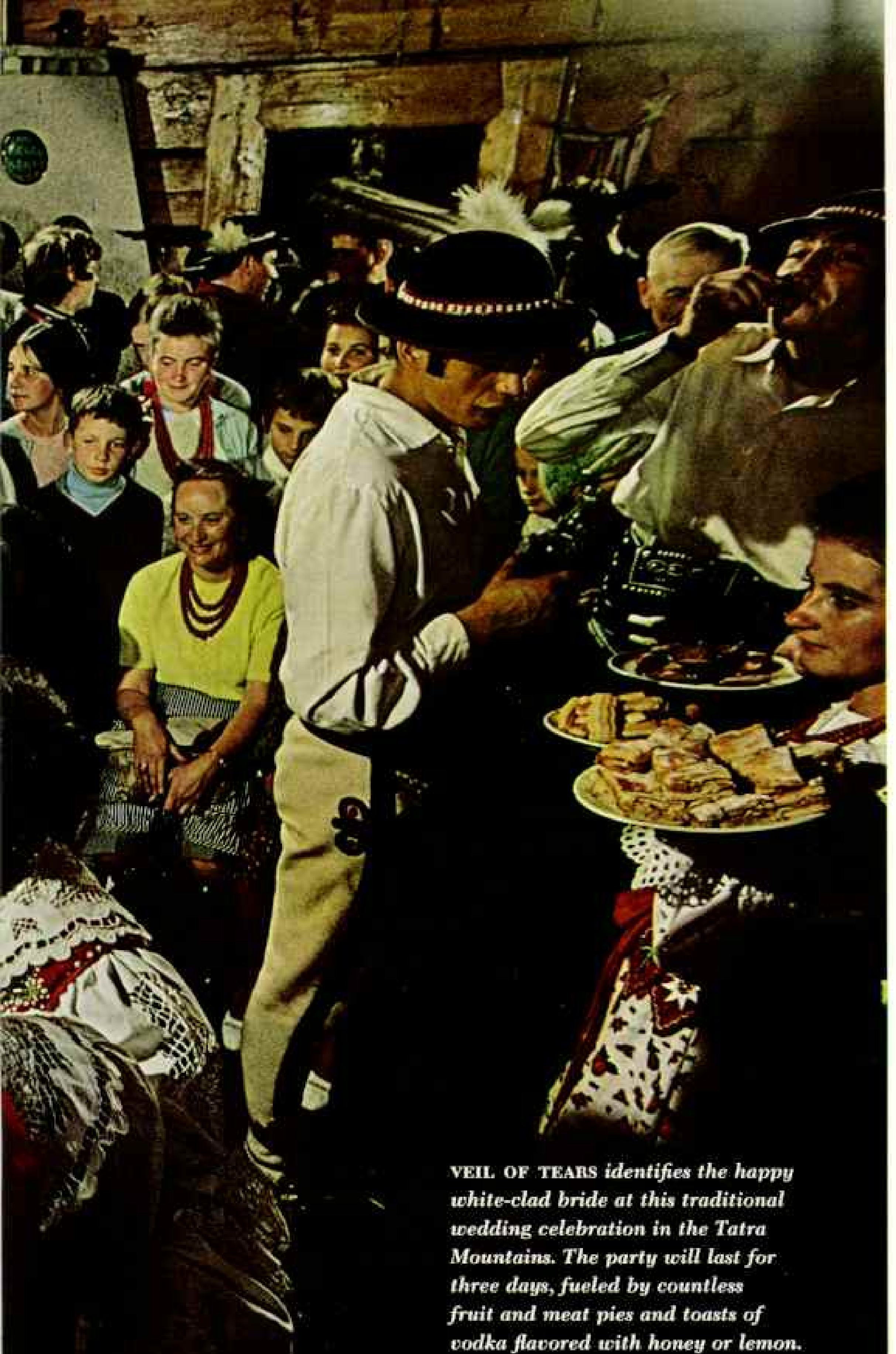
Modern Poland, its present borders established by the Allied Powers, occupies approximately the same territory it did at its birth more than a millennium ago.



AREA: 120,664 square miles. **POPULATION:** 33,000,000. **CAPITAL:** Warsaw, population 1,300,000. **GOVERNMENT:** Actual power in the Polish People's Republic resides with the Politburo of the Polish United Workers' (Communist) Party; the elected 460-seat Sejm holds legislative authority. **ECONOMY:** Dominated by industry—steel, coal and copper mining. **RELIGION:** Predominantly Roman Catholic. **CURRENCY:** One zloty (100 groszy) equals 5 cents U.S. at the official rate, and half that much at the tourist rate.







VEIL OF TEARS identifies the happy white-clad bride at this traditional wedding celebration in the Tatra Mountains. The party will last for three days, fueled by countless fruit and meat pies and toasts of vodka flavored with honey or lemon.

fair: 57 publishers, from the Defense Ministry to the Social Committee Against Alcoholism, are selling at 90 kiosks. Indefatigable authors are autographing.

By now I have an inkling of what's in the back of everyone's mind, something that makes this a very special spring. Poles call it simply "the changes," meaning dramatic changes in the leadership and policies of the PZPR, the Polish United Workers' Party—that is, the Communist Party; and because Poland is a Communist country, the significance of these changes cannot be exaggerated.

"You have come at an interesting time," a senior bureaucrat assures me as we browse side by side. "This is the most hopeful moment in Polish history since World War II."

WHAT EXACTLY had happened? One of those indefatigable authors takes me to dinner. He says it's a long story, but he'll try to make it brief.

"We had a party leader named Gomułka; he was extremely well liked. But over the years he became less and less popular. Why was this so? He asked people to work harder, but they found their standard of living not rising, but going down. They felt frustrated and helpless.

"Now switch to December 12, 1970. The government announces new prices: Lower for razor blades, TV sets, refrigerators—fine, but higher for food! Meat up 17 percent, lard 33 percent! Incredible, raising food prices just before Christmas! It's the last straw. Shipyard workers in Gdańsk go on strike. They march on provincial party headquarters, asking to be heard. The demonstration turns into a riot, party headquarters burns, there's bloodshed. More strikes, in Gdynia and in Szczecin, more blood.

"Gomułka and some others in the Politburo want to call out more troops, but still others say no, dozens are dead already, we don't want to kill thousands. The moderate faction prevails and makes one of their number the new leader—Edward Gierek, an ex-miner, the party chief from our most prosperous region, Silesia. Gierek calls off the troops. He meets with the workers, he promises improvements for everybody. Since then, every

week, big news! Higher pensions. Food prices rolled back to where they were, and frozen for two years."

And a new political style. Gomułka was remote, Gierek is everywhere. Day after day I see him in news photos, with youth activists, with hard hats, with lady machinists.

"He knows what Poland needs to pick up steam," a Western diplomat tells me. "Look at agriculture. Eighty-three percent is in private hands—12 acres is average, 120 is the limit. But farmers had to deliver fixed quotas of pigs or steers, milk or grain. Gierek promised to end the quotas. Overnight, the outlook for Polish farmers became a lot brighter."

This much was certain: Never before in a Communist state had a wave of popular, non-revolutionary demonstrations led to such a change in the whole tone of political life so fast as here in Poland. What it would lead to in the long run was, alas, far from certain.

Poland has a 770-mile border with the U.S.S.R. (map, page 469). Would the Russians send tanks, as they did to Czechoslovakia after the Czech leadership changed course?

"That was in people's minds, and in the minds of our politicians too," a Polish journalist recalls. "The new leadership convinced Moscow they were still loyal Communists." So far, the Soviets were providing credit, and feed grain to help Poland produce more meat, so that Gierek could keep his promises.

But would he? "That's what people asked Gierek in all those meetings. 'How do we keep things from turning sour again?' He told them, 'It's up to you; you must keep pressing to control the leadership from below.' Sounds great, but how to do it, that's the big question."

That week there is another of those blithely skeptical Polish political jokes. *What's the real difference between Gomułka and Gierek? There isn't any—but Gierek doesn't yet know that we are aware of this.*

I drive south for the most vigorous fun-making in Poland, the Juwenalia in venerable Kraków, a 2½-day pre-exam carnival of students at Kraków's 608-year-old university.

Fifteen minutes from Warsaw's center I'm in the country. Orchards in white bloom, green meadows with black-and-white cows.

(Continued on page 478)

Risen from World War II devastation, Warsaw stands as a monument to Polish pride and determination. Germany's troops punished an insurrection by methodically leveling almost the entire city. Modern structures replace the old in most areas, but Old Town, in the foreground, has been restored to its 17th-century Baroque elegance.





Martyr's memorial reminds fellow workers of the price Stefan Masiewicz paid for his part in a drama that promises to better the lives of all Poles. "Died 14 December 1970," the hand-scratched lettering says, "killed by the M.O."—the national police.

Riots flared after a pre-Christmas announcement of higher food prices dealt a staggering blow to workingmen already beset by low wages, a housing shortage, and an unresponsive



bureaucracy. Masiewicz and others at the Lenin Shipyards in Gdańsk were the first to take to the streets in protest; the unrest soon spread to other cities. At least 45 died in the ensuing disorders, which ended Władysław Gomułka's predominance after 14 years and brought to power Edward Gierek, a more sympathetic leader.

Daughter's hug greets Henryk Stoliński as he arrives home from his job at the Gdańsk shipyards. Like others who

weathered "the events of December," he already benefits from changes they brought. His salary has risen more than 10 percent, and working conditions have measurably improved. But his daily routine remains much the same: After welding plates on a bulb-nosed freighter ordered by Colombia (below), he cleans up (center left), then returns to his small but comfortable apartment for supper and, often, the delight of watching a favorite team prevail in a televised soccer game (bottom left).





Pity the poor postman! All the mail for this 2,000-foot-long apartment building in Gdańsk (above) comes to the same address, No. 10 Lumumba Street. The new 11-story structure is part of a complex housing 40,000 people. It offers tenants a shopping center, orchestra, club-rooms, and restaurants.

Apartment residents need travel only four miles to mingle with foreign tourists on the popular Baltic Sea

beach (right) at Sopot, one of three cities comprising the metropolis of Gdańsk-Sopot-Gdynia.

Still rebuilding the 55 percent of the city destroyed by World War II, Gdańsk—which the Germans called Danzig—hastens housing construction at the urging of party leader Gierak.





Brown fields and an occasional tractor, but most of the plowing is horse-powered and the sowing is by hand, mostly by women.

In passing, I glimpse the industrial towns of Radom and Kielce, three ruined towers of a castle, a new motel. I am frequently delayed at railroad crossings, but I don't mind. To see such magnificent steam locomotives at home in Washington, I'd have to visit the Smithsonian Institution. People sidle up to inspect the waiting autos. Ah, a Volvo! A Ford Capri!

My car gets short shrift; it's only a Polski Fiat, made near Warsaw, but, oh, it has power-assisted disk brakes on all four wheels. I need them. There's no speed limit outside the towns, and I cannot help getting into the swing of the Polish highways: speed up, then slow down fast—there's a child, or a rubber-wheeled horse wagon full of coal or manure. Hitting a chicken is no crime, says my interpreter, but hitting a goose can cost you money. I assure him of my nonaggressive attitude toward everything Polish, including geese.

After four hours we're in the heart of Kraków, in the Main Market surrounding the 16th-century Cloth Hall. It's bedlam. Pirates and cavemen, Batman and Zorro, a red-haired Cleopatra. A skeleton in a top hat misdirects traffic. The police don't interfere. At Juwenalia time the students own the town (pages 482-3).

Whistles! Horns! Bells! Youths hop in a circle and sing, "The dean is our best friend!" to the tune of "Battle Hymn of the Republic." Then, instead of the dean, it's Mao. Then Nixon. Finally, "Władysław was our best friend!" Who? Władysław Gomułka.

Decorum reigns briefly in a sports hall for the selection of the girl student who is *najmilsza*—the sweetest. All the candidates look luscious, but I am informed that what counted most heavily in the preliminaries was ready wit. Really?

"You see Ela there? She was given two minutes to do a striptease. She said, 'Oh, that means to present myself naked. Very well, I shall bare myself, I shall bare my soul.' She just talked and talked. . . ."

THE RECTOR of the university, Professor Dr. Mieczysław Klimaszewski, is a geographer. He also is a vice president of the Council of State, thus ranking as a vice president of Poland. I met him at the university's Geographical Institute, where

he delivers lectures himself because he likes to be in regular contact with the young.

"They differ from the youth in America, and even in Western Europe, because of our historical and geographical position, which has brought us so many rounds of invasion and destruction. So often we have had to start anew, to rebuild and rebuild again, which is a task of the youth. Now Poland is changing its economic structure, from being primarily agricultural to being primarily industrial. Already 52 percent of our population is urban. This change stimulates the young. They want to be in the forefront of it."

Rector Klimaszewski also presides over the Polonia Society, created to keep in touch with people of Polish origin abroad. "There are at least six million in the United States, perhaps ten million," he says. "We send them books and urge them to visit Poland. Many are young and speak no Polish at all. But we are particularly interested in them because we know that there are people in the United States who do not speak well of Poland, who think of us as a nation without history, without culture. That is why we are so glad when such young Americans come for special courses here in Kraków. We want them to be loyal to the United States, but we also want them to be proud of their Polish origins."

And what a history! It speaks to the visitor on Kraków's Wawel Hill, from the royal tombs in the Wawel's Gothic cathedral, from its lofty Renaissance palace. Of a kingdom that arose a millennium ago, that triumphed over the Tatars and the Teutonic Knights, until by 1492, after Poland had for a century been united with Lithuania, the Jagiellonian dynasty held sway from the Baltic to the Black Sea, over Prussia and the Ukraine, and eastward to within 100 miles of Moscow.

Then, torn by Turks and Cossacks and Swedes, Poland weakened and shrank. By the end of the 18th century it was carved up by Russia, Prussia, and Austria. Poland re-emerged only at the end of World War I (maps, pages 468-9). But in those 120 years of bondage, what fiery uprisings, what heroes!

Down in the market I see an engraved granite slab where Tadeusz Kościuszko mustered the insurgents of 1794. He had fought in the American Revolution, he helped fortify West Point. George Washington asked that he be made a general. Congress voted him tracts of land. Could his gallant Poles—half of them

armed only with scythes fashioned into pikes—prevail in their own country?

They nearly did, liberating much of the country. Then they were overwhelmed, and Kościuszko, severely wounded, was captured by the Russians. He died an exile in Switzerland, asking in a will that his American investments be liquidated to buy Negro slaves and set them free. He remains Poland's most revered patriot to this day.

More uprisings, more repressions, through the 19th century. Hoping to gain support for their homeland's liberation, Polish exiles formed legions and fought for Napoleon in Spain and Santo Domingo, for Garibaldi in Italy. "Poland is not lost forever," they sang, "while our lives remain. . . ." The song would become the Polish national anthem.

Again in World War II, Poles fought the Germans, not only at home but also at Narvik in Norway, at Tobruk in North Africa, in Russia, France, and Italy. On the critical day of the Battle of Britain, 26 out of 56 Luftwaffe planes shot down were credited to Poles flying with the RAF. One of the saddest songs I heard in Poland recalls the Polish infantrymen who died in the taking of Monte Cassino.

DRIVE EAST to Łańcut—fast, so as not to miss the last of the May chamber-music concerts in the palace there. Highway E-22 rolls through lush country, through Tarnów, noted for a fertilizer plant and thundering folk dancers. The car radio reports the Peace Race, and my interpreter is annoyed. A Belgian won yesterday's lap; today it's a German. What's going on? Are these umpires blind?

After Rzeszów—a provincial capital full of machine shops, office buildings, and miniskirts—I nearly run afoul of a meandering truck full of cardboard and rags. "The truck goes from village to village to buy this stuff," says the interpreter. "We need it to make paper, we don't have enough wood." I need the chamber music; it helps me to unwind.

Next morning the palace at Łańcut swarms with sight-seeing groups from factories and schools, Scouts, kids with guitars, handicapped kids with crutches. Brisk ladies point out cannon and stag heads, dark portraits and gilded Louis XVI furniture, the trappings of the Polish aristocracy. Łańcut was one of their showplaces, built by a Lubomirski, whose grandson married one of the Czartoryskis, who left it to a Potocki, whose

grandson married one of the Radziwills. . . .

Last year 300,000 visitors came, says the curator. "It is good for the children to learn the vocabulary of art. It is good for everyone to see the richness of the life of the magnates, who were one of the main forces in our history. Łańcut is evidence of the highest level of European culture."

I find myself much taken with the Princess Izabella Elżbieta z Czartoryskich Lubomirska, an 18th-century magnate. Not only because she owned 14 towns and 365 villages, and river ports, factories, and breweries—plus palaces in Lwów, Warsaw, and Vienna, and a wing of the Palais Royal in Paris. She knew Voltaire and Marie Antoinette, Goethe and Jefferson. "She was not tall," wrote a contemporary, "but full of charm." A great lady of the Enlightenment.

"A great scandalmonger too," adds the curator. "It is difficult to be proud of every one of these magnates. Many did absolutely nothing for the people."

The last aristocratic owner of Łańcut, Alfred Potocki, departed for Austria as the Soviet Army closed in toward the end of World War II, and took the most valuable art with him. The Germans gave him a special train because he had been friendly. But he was an exception, says the curator; most Polish aristocrats fought in the resistance.

There are still quite a few of them left in Poland, and they still marry one another.

In Łańcut's main square a sign proclaims "Socialism is charting the course for world development." Four dozen stores reflect what can be found in any Polish town of 10,000. Three dozen of the shops—food, clothes, yard goods, hardware, appliances—belong to MHD, a state-owned trading enterprise, or PSS, a nationwide cooperative. A custom shoe store belongs to an invalids' cooperative.

But a dozen shops are private: a hairdresser and a baker; G. Wasylewicz, ladies' hats; and Jan Paczka, selling paints, glue, and soap powder, all privately produced.

I ask a saleslady in the MHD food shop if she has better lettuce than the private competition. She says no, it's the same.

The saleslady in the private shop agrees: "The prices are the same too, set by the government. But sometimes I can sell a little cheaper, because I grow things myself. The government sets only maximum prices."

(Continued on page 486)





Half a million strong, festive Poles parade through Warsaw on May Day, a holiday honoring the country's laboring class. Factory and shop workers arrive singly or in organized groups to participate in the annual event.

In previous years, their route through



the city was lined with posters of former Communist Party chief Gomułka. But in 1971 the well-dressed throng (left, lower) followed new party leader Gierk through the streets, past posters on the "Eastern Wall" (upper left) featuring slogans and symbols celebrating Poland's technological and industrial progress. An impressive row of modern office buildings, stores, and apartment houses, the Eastern Wall extends along a main Warsaw thoroughfare. Across the avenue, Gierk (above) addresses the multitude from a rostrum in front of the Palace of Culture and Science, the tallest building in Warsaw.

Living canvas for whimsy's brush, a student in Kraków (below) turns paint into fashion for Juwenalia, a zany festival that preserves medieval student high jinks. Street dancing (right) helps erase the cares of school life during the May celebration.



Less than thrilled by the goings-on of Juwenalia celebrators, a police officer dons a scowl. Most adults view the merrymaking with amused tolerance.



Undaunted by nightfall, Juwenalia revelers swarm to the lighted Main Market (right) and cluster around a statue of Romantic poet Adam Mickiewicz. Cloth Hall's 16th-century facade looms beyond. The building, now housing a branch of the National Museum, once drew merchants from all over the world to this old town square, one of the largest in medieval Europe.

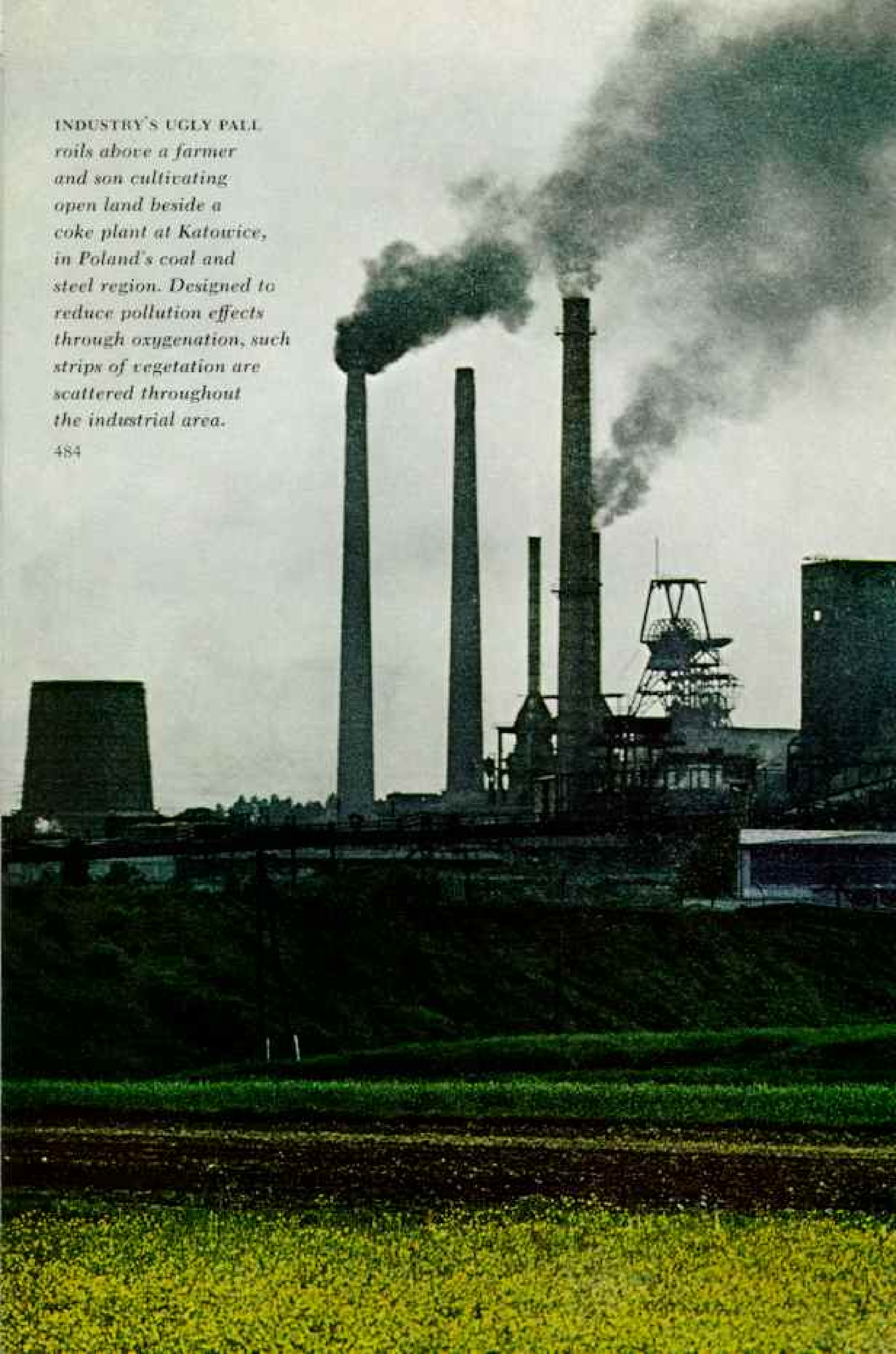


Situated at the crossing of several international trade routes, Kraków—a populous settlement since the eighth century—developed early as a major mercantile center. Poland's capital from 1320 to 1609, Kraków established its Jagiellonian University in 1364. Still education oriented, the city today has 11 institutions of higher learning.



INDUSTRY'S UGLY PALL
roils above a farmer
and son cultivating
open land beside a
coke plant at Katowice,
in Poland's coal and
steel region. Designed to
reduce pollution effects
through oxygenation, such
strips of vegetation are
scattered throughout
the industrial area.

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In M. Jachowica's notions shop I see a tiny plastic Model-T Ford. Private workshops turning out plastic items like this—or watchbands, or little things for hardware stores—can make fortunes. So can private growers of strawberries, flowers, and vegetables. The most fortunate few drive expensive German sports cars.

Before leaving Łańcut, I stop at a gas station. It's a hybrid: The state owns it and grants a franchise to a private operator; the more he sells, the more profit he makes.

The general rule is that no private enterprise may employ more than 50. Out of ten million working Poles, half a million are

privately employed, and these official figures do not cover the six million in the overwhelmingly private agricultural sector.

As we head for the Bieszczady, the Carpathian Mountains in Poland's southeast corner, our car radio flashes the Peace Race finish. The final winner is—SZURKOWSKI! Justice has been done. There'll be records set tonight—in vodka.

From the road I see brick houses going up in the hilly farmland, replacing the old wooden ones. The finest of these, with thatch roofs, open central fireplaces, and separate but equal sections for cows, have been taken to an outdoor museum in Sanok, as showpieces



Hulking headquarters of the Teutonic Knights, Malbork Castle rose beside the Nogat River in 1276, after the German crusading order conquered Prussia. Poland acquired the fortress in 1457 and transformed it into a favorite hideaway for royalty.

a smell of paint. "Adding two rooms upstairs," he says, "for vacationists. Some city people like to sleep in the hay; they think it's romantic. But others like their comfort."

In May it dawns early. There's light shortly after three a.m., and a little after four an edge of fire rises over the hazy Bieszczady skyline; five minutes later there's the sun, in a red-gold haze. The air is soft.

From Ustrzyki Górne, in the very southeastern tip of Poland, I walk up through a beechwood and needle forest, up along little streams, up past the tree line, where the wind makes silvery waves in the grass.

Up another 600 feet along a wind-whipped ridge and I am on top of Polonina Caryńska, surrounded by the majesty of the Bieszczady. I can see nothing man-made: to the horizon, green mountains and green valleys.

Three miles south lies the Soviet border. The Czech border is five miles to the southwest. But from here, at this moment, all is unbounded. It is an indescribable joy.

PERHAPS I stayed up there too long. Perhaps it was the haunting wind. It struck me then, as it must sooner or later come to most visitors, how much this verdant Poland—so various, so beguiling, so alive—is impelled by memories of indescribable horror.

Thousands of plaques and monuments attest to places of torture and execution, on city streets, in forests, in vast concentration camps (following pages). Here 50 were hanged, or 3,000 burned alive; 80,000 were harried and starved to death there, or 800,000 gassed. The memorials do not accuse Germans; it was the *hitlerowcy*, the Hitlerites.

Of the victims, hundreds of thousands were Soviet prisoners of war. Millions were Jews from Poland and all Europe. But millions were Poles who were not Jews. And so, for a third of the country's population—for anyone over 39 now, who was at least a teen-ager then—the slaughterhouse that was Poland is more than a matter of history and impersonal numbers. It is a matter of one's own vivid recollections, one's own grief.

of folk architecture. I especially admire one that had belonged to the Dołżycki family. I visit Tymoteusz Dołżycki because I've never met a man whose birthplace went to a museum.

He is tall, blue-eyed, white-haired, with a creased face, strong teeth, and a black cap, every inch the *soltys*, or chief, of the village of Komańcza. He has been chief for 25 years. How does one get to be *soltys*?

"By being the best man of all," he says. He has been reelected every 3 years. He has 27 acres, 2 cows and 3 calves, 2 horses and 4 sheep. He grows potatoes and barley. His son just became a doctor of medicine.

There's a noise of sawing in the house, and



“There is only one way out, through the chimney.” Hitler’s executioners killed more than 360,000 Jews at Majdanek (above), one of the dozens of crematorium-equipped extermination camps established in Poland in World War II. At the largest, Oświęcim-Brzezinka—the infamous Auschwitz—Nazis systematically murdered an average of more than 2,200 persons a day for 4½ years.

Thousands of suitcases, like that of the infant Thomas Fischer (left), remain at Auschwitz as gruesome reminders of the Europeans of 28 nationalities brought here to die after being told they were moving to resettlement areas. Poles maintain the camps as museums in the belief that preserving the memory of such horrors will keep them from ever happening again.



Those who are younger are constantly confronted with the Hitlerite years in plays and movies, in novels and comic books and on TV. Back in Warsaw the director of PTTK, the national tourist organization, tells me that young people are especially encouraged to see the places of "martyrology." For each visit, children get points toward special badges.

Why is such a nightmare kept so strenuously alive? "Because we don't want it to be repeated. *Nigdy więcej!* Never again!"

I find this thought expressed many times; it is a deep Polish feeling. It surfaces unexpectedly, even during my visit to a plant that supplies half of Warsaw with meat, most of it in the form of 21 varieties of sausage.

In a borrowed white coat I follow the making of the plant's top sausage, the four-inch-thick Krakowska: mixing of meat and spices, filling into skins, smoking over oak fires. As

I sample the delicious result, I learn that soon the Krakowska won't be smoked for five hours anymore. "We'll add a powder to give it the smoked taste," says the director, "we must do this to expand production."

But will it still taste as good?

The director whistles through his teeth. "We all realize that development brings disadvantages. Isn't it true that more Americans have died in car crashes than in wars?" Then it comes: "Well, it's better to die in a car crash than in a war! *Nigdy więcej!*"

As deep, though more complicated, is Polish feeling toward the Russians—so often enemies in the past, now allies, and under no circumstances to be criticized in public.

Every Pole knows that only through bitter fighting and luck did their resurrected country survive its clash with the Soviets after World War I. And in 1939, 16 days after Hitler's

onslaught came from the west, Stalin's armies rolled in from the east. They occupied much of Poland and dragged off hundreds of thousands of Polish citizens to Siberia, until Hitler turned on the Soviet Union too. After Hitler's defeat, moreover, Stalin took over a great slice of what until World War II had been eastern Poland, including the cities of Wilno and Lwów.

The Poles regained slices of prewar eastern Germany; Poland thus shifted about 130 miles to the west, so that the present borders roughly outline the area of the first Polish kingdom of a thousand years ago (maps, pages 468 and 469). But the memory of lost homelands still tugs on Polish heartstrings. One night, in private, I heard people sing songs of Lwów. They had smiles on their faces, but in their eyes were tears. Yet even they did not question the Soviet alliance. "Who else would help us against the Germans?"

EN ROUTE NORTH to the Baltic, I savor spring in western Mazury: green meadows with lupine blooming blue, languid magpies, red brick castles built and lost by the Teutonic Knights (pages 486-7). On Vistula Bay, within the walls of the fortified cathedral of Frombork, a new museum makes ready for 1973: the 500th birthday of Mikołaj Kopernik, or Nicolaus Copernicus, the Pole who revolutionized astronomy.

He studied at Kraków, Bologna, and Rome, and became a physician, theologian, and commander against the Teutonic Order. The last half of his life he spent in Frombork, administering the cathedral, observing the skies, and writing a six-part work, *De revolutionibus orbium coelestium*. It established that the earth is not the center of the universe but revolves, along with the other planets, around the sun. It built the foundation for man's flight into space.

Off the port and shipbuilding center of Gdańsk, guns boom and missile boats speed by—the Polish Navy on maneuvers where Polish men-of-war plied in the Middle Ages. The Teutonic Knights took Gdańsk in 1308 and called it Danzig, but by 1466 Polish kings were sovereign here once more. Their portraits mark the ducats struck in the city's golden age, when Poland included the Ukraine and was the granary of Europe and Gdańsk its trading port, rich in Renaissance and Baroque architecture.

Prussia made it Danzig again, after the partition of Poland in 1793. Those architectural treasures crumbled in the fires of World War II. Today they stand splendidly restored. Impressive, too, for sheer size, is a cooperative apartment project (pages 476-7) where the 12,000th family has just moved in.

A 2,500-foot-long block is nearly finished. I see plots of grass with signs: Teddy Bears. Bisons. "These are groups of children," I am told, "each assigned to care for a plot, to teach social responsibility. If the buildings are well kept, and everybody makes his payments on time for a year, the payments drop. If not, they go up."

Beautiful Baltic beaches beckon. Sopot (page 477). Hel. Łeba, where wind and sea constantly add sand to wild dunes up to 150 feet high, protected in a national park lest 150,000 annual visitors stomp them down. One must stay on staked paths.

May I now pass along a few hints on Polish pronunciation?

For "ck," as in Branicki or Potocki, say "tsk," as in—ahem—Trotski. That's right, Potolski. When it comes to all those "cz's," be fearless. The city and province of Bydgoszcz is simply Bydgosz-tsh. And when coming to the great Baltic port of Szczecin, as I am now, take your time and try to say: Sh-tsh-e-tsin.

OK? Please say *tak*, meaning "yes." Or *dobrze*, pronounced *dobehte*—"good," or "OK."

Szczecin, near the mouth of the Odra River, hums with the goings and comings of freighters of many flags. Mainly it's Polish coal going to Denmark, France, Italy; iron ore coming from the U.S.S.R., Sweden, Brazil. Also grain. At a 50,000-ton storage tower, the *Komiles* from Leningrad discharges wheat.

Szczecin's shipyards build freighters and trawlers for Britain, India, Kuwait. "They pay cash," I am told, "in hard currencies." That's what Poland wants to import most of all.

On the docks, among black-headed gulls and heavy hoists, I see soldiers with submachine guns. They watch, lest a Pole without a passport jump onto a foreign ship. I follow ore barges south along the Odra, which forms the border with the German Democratic Republic; Germans call it the Oder. Near Ognica I stop and sit on the grass, to enjoy a restful scene: the river, gentle green hills, great-crowned trees, a distant cow.

Oh, oh, here's a soldier with a submachine gun. He politely asks for my documents. I

may stay and finish my picnic. The amiable soldier keeps standing by.

Strange that this border should be so closely guarded. Who'd want to sneak out into East Germany? It's not that, I learn; the danger is Western agents sneaking in.

The soldier says he's 20 and was born here. His parents came from central Poland, after the Germans who used to live here left. Those who didn't flee with the retreating Nazis were deported after World War II. It's the same story in Frombork, Gdańsk, and Szczecin.

Germans coming to visit their former farms used to say that one day they'd be back for good. But they haven't said that lately. The Bonn Government has recognized Poland's western frontier, in a treaty signed in December 1970. This makes Poles breathe a little easier—it's another reason why this is such a hopeful spring.

FOLLOW the Odra through Słubice, Wrocław, and Opole to Koźle, the inland port connected by a canal with Gliwice, in the Upper Silesian Industrial District. Imagine 13 townships bunched much like Los Angeles. Downtown is Katowice, with brand-new blocks of glass and concrete and a huge park.

The district boasts Poland's highest standard of living; here hard hats are king, especially miners. On festive occasions they wear black uniforms with gold embroidery, medals, and feathered hats. I witness a Silesian rite of spring: the awarding of swords to outstanding mining-school graduates.

Billboards proclaim Poland tenth in the world in industrial production, ninth in copper and steel, fifth in coal. A quarter of all this comes from right here, and I find it depressing to be hardly ever out of sight of mine towers, slag heaps, blast furnaces, and smokestacks producing smog (pages 484-5).

It is a relief to come upon extensive woods, carefully maintained to help purify the atmosphere. I walk in this forest and breathe deeply. It just stopped raining, and the air is clear and invigorating.

Back in Katowice I had brushed my hand against a wall and found it streaked with brown-black grime. Now in the forest I take a shiny leaf, still pearly with water, and look at it closely. I see black specks on it. I brush the leaf against my notebook. It's the same brown-black grime.

And I wonder. How many attractive things

in Poland might, on closer inspection, turn out to be flawed? It's a nagging feeling I've had all along—under the surface, what's the reality? And so I've asked all kinds of people, What's it like to live here?

"Terrible," says a pretty blonde in Kraków. "Wonderful," says a pretty brunette. Both are from upstate New York, studying at the university.

Says the blonde: "Every month you've got to stand in line six hours, to buy your meal tickets!" The brunette: "I never wait more than ten minutes. You've got to know when to go, or you send a friend. You've got to know how to operate. . . ."

Blonde: "Those rules in the dorm—boys can visit only twice a week, and have to be out by 10!" Brunette: "Come on, guys sneak in all the time. . . . I wish I could stay five years." The blonde can't wait to go home.

A Polish-born real-estate man from Los Angeles has been driving all over in his big red car. He says the country is in a mess. "Look at these glum faces of the people waiting for a bus. No wonder, they don't have any incentive! But they won't tell you the truth because you go around with a government interpreter."

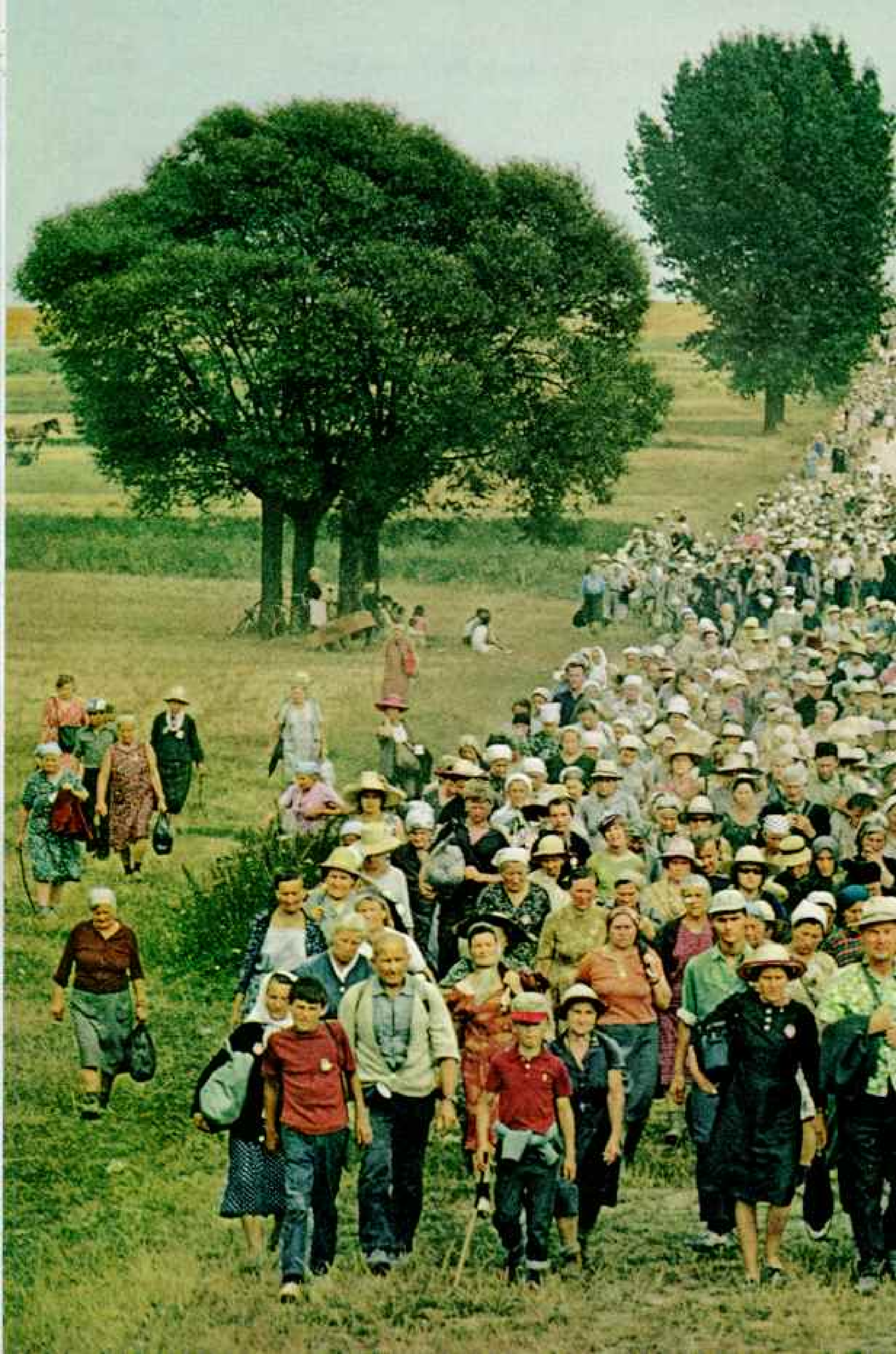
Sometimes, though, I go alone. I speak German, and so do many Poles over 40—it's a legacy of the occupation, or of forced labor in Germany. What I hear and see leaves me leery of simple answers.

In a village I meet a couple about to visit their daughter in the factory town of Polkowice, and I give them a lift. The daughter teaches school, her husband is an electrician in a copper mine. Eighteen months ago they put down money for a cooperative apartment in a five-story building.

Father notices a shaky railing in the stairway, a badly fitting door. "This'll have to be fixed," he says. Mother is wide-eyed. Electric refrigerator, gas hot-water heater, and a bath! Her own home is a big comfortable farmhouse, but to her these tiny rooms are pure luxury—veneered furniture, Persian-style carpets!

For all this, the young husband works extra hard. He gets a month's vacation, in a resort belonging to the mine; the rest of the year he takes only two Sundays off each month. He seems full of incentive to me.

Another fine interpreter-less day I hear a
(Continued on page 496)



MARCH OF FAITH: *Each August more than a million people journey to Częstochowa to honor the Virgin of Jasna Góra Monastery. This group of some 8,000 pilgrims walked 130 miles from Warsaw. Tenaciously Catholic since 966, Poles for 300 years have hailed the Blessed Virgin as "Queen of Poland."* 493







JASNA GÓRA MONASTERY

Catholicism's voice in an overwhelmingly Catholic nation, Stefan Cardinal Wyszyński welcomes pilgrims arriving at Czestochowa. Among the country's most formidable public figures, Cardinal Wyszyński has never ceased his struggle against government restriction of church activities, even though his opposition resulted in a three-year prison term in the 1950's. Poland's new political leadership appears eager to ease strained relations between church and state.

Beyond the cardinal, within the Jasna Góra basilica, resides the object of the pilgrims' veneration, Our Lady of Czestochowa (above). She never appears this way in public; always she wears one of her "gowns"—overlays of gem-encrusted gold and silver. Poles credit her with saving the country in 1655. The presence of the icon at the monastery, Poland's only unconquered fortification, gave 230 defenders the strength to repel 4,000 Swedish invaders. Legend also tells that a would-be thief slashed the Madonna's face—then fell dead.

rotund, middle-aged Pole speak his mind on the beach at Sopot. I say it's beautiful here, the sand, the sun...

"Yes, but life is not beautiful for Poles. One works hard all day and has nothing. There isn't even enough sausage..." (He reaches into a bag, brings out a sausage sandwich, and eats. He has six more sandwiches.)

"Now take the directors of all the enterprises, they're party people, they don't work hard, but they have everything. They steal! Why, the party isn't even run by Poles; they're all Jews! Some of these Politburo types can't even read and write!" (Stupendous exaggerations! Fewer than 10,000 Jews are left in Poland, none in the Politburo. Poland's literacy rate is 98 percent; the Politburo's can safely be put at 100 percent.)

I point to new apartments facing the sea and say it must be nice to have such a view.

"*Nie*, everybody's too tired to look out. What can you expect from a system like this?"

Others told me the problem is not the system, it's certain attitudes.

An engineer said in Gdańsk: "In our factory a man had five children and very little money. I was on the Workers' Council and we had funds to help people, so the council gave him some money. One morning I thought I'd watch this fellow. He came in late and smoked a cigarette. Then he made tea. Then he went to chat with other workers. Then he made some private thing on a factory machine, and then he went to the factory store and stole some sheets of tin.

"Could we fire him? Oh, no! We gave him a warning, and he behaved better. But this kind of attitude is met in Poland. There's a lot of waste, because there's not enough respect for public property."

A retired manager of a state enterprise answered me simply: "What's wrong in Poland? People—from top to bottom!"

Back in Warsaw, a lady tourist from New York wants to know what things cost in Poland. It's a question of what and for whom.

In Warsaw she can pick up bargains in silver or leather or linens. She can get a very good meal in any Polish town for the *złotys* she gets for \$1.50; or take the waters in a Polish spa for \$3.25 a day, including bed, food, and medical services. She can buy a Polski Fiat—like my zippy four-door sedan—for as little as \$1,330.

But for Poles that car would cost roughly

six years' wages for an unskilled worker; or four years' for a miner or policeman. Or two years' salary for a director.

On the other hand, workers get bonuses, and contributions toward buying apartments. Higher education is free for those who qualify. Vacations are extremely cheap.

I told a Pole what I spent to have a tooth fixed, and he was astounded—that in a civilized country like America dental work isn't free. American hospital bills sound as far-fetched to Poles as the idea of six years' salary for a car sounds to us.

But the harsh fact is that an hour's pay of the average Polish factory worker buys only half a pound of meat. And so in most city families both husbands and wives hold jobs. Nearly everybody looks for ways to save money and to earn extra income—just to make ends meet, or to save for something, for a washing machine or a hi-fi.

Women, by the way, are commonly found in the full range of occupations—street sweepers, crane operators, doctors, administrators. Most of them do not expect their men to share the shopping, cooking, or housework. But they do expect to be made much of as ladies, and they are, as I saw reflected in Poland's high rate of hand-kissing.

Even traffic policemen are said to do it occasionally, when relieving traffic policewomen. I walked up to one of those pretty girls in white jacket and black mini-skirt, a tanned, blue-eyed blonde with lots of eye shadow. A silvery Polish eagle flashed from her cap. I asked her, Is it true?

"It's not in the regulations," she said. "Regulations call only for a salute. But it's very nice, don't you think?"

Later that day I noticed a news photo: Comrade Gierak, First Secretary of the Party's Central Committee, kissing the hand of a lady worker in a helicopter plant near Lublin.

IT IS THE MORNING of the Thursday after Trinity Sunday, the Feast of Corpus Christi, a holiday in the Polish People's Republic, where the overwhelming majority are Roman Catholic. After the traditional procession in Warsaw, His Eminence Stefan Cardinal Wyszyński will speak, undoubtedly about the changes. What will he say?

By now I realize how powerfully the Church speaks to Poles. One Sunday in Sannok, among a congregation overflowing onto

the church steps, I heard the amplified voice of the priest ring across the square:

"Our real mother must die, her heart which beats only for her children's happiness must stop. But our Heavenly Mother remains forever. We can always count on her; the love of all the mothers in the world is as nothing to the love of Mary for us all. . . ." A tall man next to me swallowed hard, a young woman with a baby carriage fumbled for a handkerchief.

The priest's terminology is significant too: Most-Sainted Lady Mary, Queen of Poland. It has been that way since the 1650's, when with the help of a miraculous icon the monastery at Czestochowa was the only Polish stronghold to withstand the Protestant Swedes. Every year the Virgin of Czestochowa is the focus of a vast pilgrimage (pages 492-5).

In thousands of Polish churches, banners mix the letter M for Mary with Polish eagles—a reminder of all those years of foreign oppression when the Church provided the sole public outlet for nationalist emotion, when in a way the Church *was* Poland.

And here's a joke of Gomulka days: *The congregation kneels, but one man remains standing. Whispers: Why don't you kneel? Because I'm an atheist. Then why are you in church? Because I'm against the government.*

Now tens of thousands crowd before St. Anne's in Warsaw as the silver-haired cardinal speaks with quiet passion, his gold-and-ivory staff in his left hand, his golden ring flashing from his right. "We are waiting for the promises recently made to be fulfilled. . . . In Warsaw we need 50 more churches. . . . In the whole of Poland, after 17 years of restraints on church construction, we need thousands. . . . we wait for deeds, not words!"

I saw a tiny makeshift church trying to serve thousands—with 16 masses each Sunday. "It is to cry," said a parishioner. The problem isn't money; to build a proper church requires a construction permit, and a permit for materials. Would Gierek grant enough to reconcile crusty old Cardinal Wyszyński?

What kind of man is Edward Gierek, on whom so much depends? I was eager for a close-up impression; I got it, at the 40th international trade fair in Poznań.

Exhibiting or just shopping here are businessmen from Düsseldorf and Milan; engineers from Irkutsk and the People's Republic of China. Edward Gierek is touring the major

exhibits. In the U. S. pavilion the American Ambassador waits. This will be his first chance to talk with the man who for six months has been the leader of Poland.

Here he comes, with a swarm of Politburo members, ministers, and security men in black raincoats. During the ensuing chat, I stand four feet away.

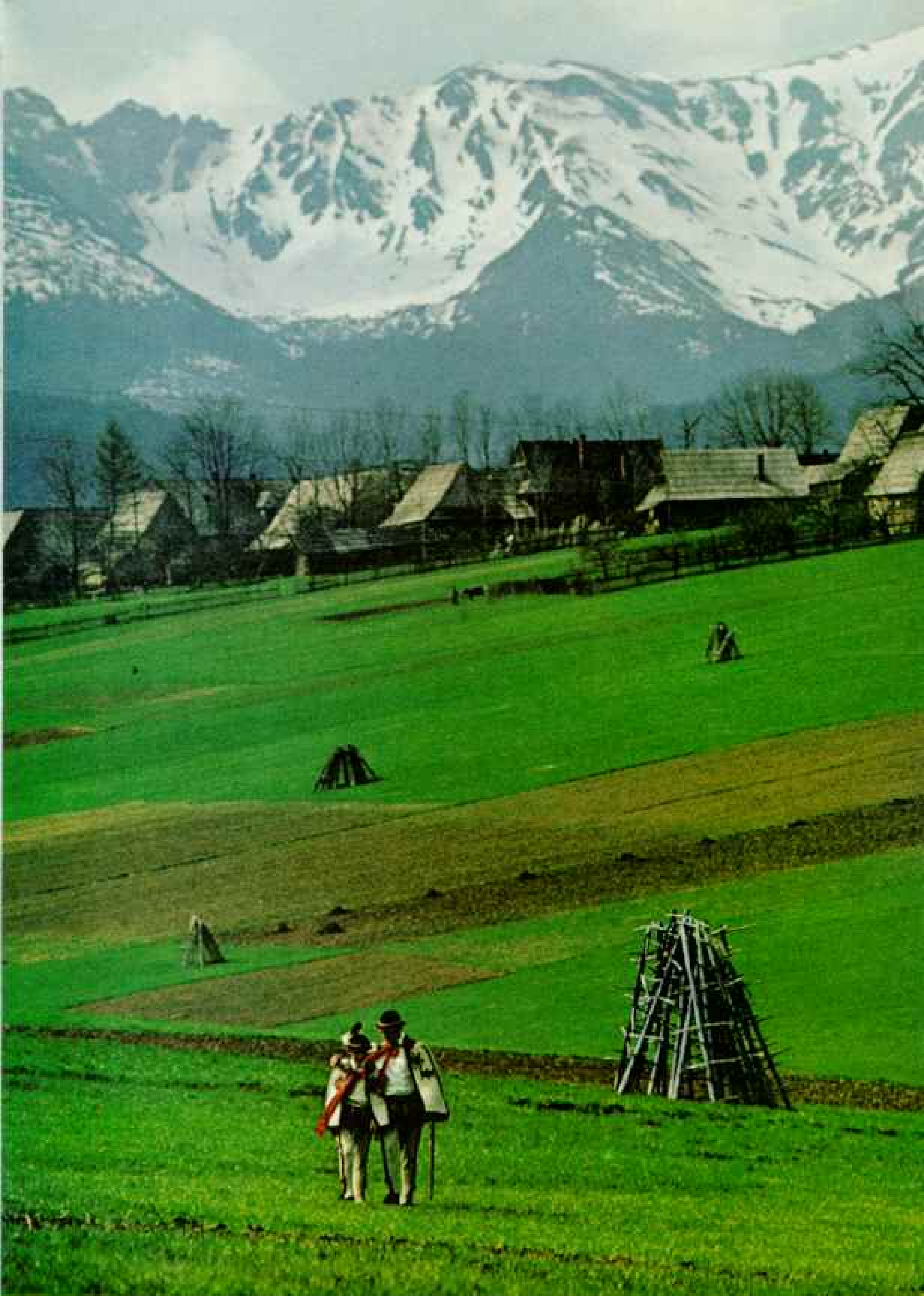
Prime Minister Piotr Jaroszewicz stresses that Poland would like more licenses for American industrial processes, saying, "We hope. . . ." Gierek breaks in: "In Poland we say hope is only half the matter. We hold talks and talks, but apparently some ears cannot hear. . . ."

No doubt about it, this stocky man with the gray crew cut is tough. Two months after this encounter, the U. S. Government at last grants a license the Poles want badly: an oil-cracking process for their refinery at Plock, which converts crude oil from the U.S.S.R.

ON MY LAST SWING through Poland I stop at the state museum of Oświęcim-Brzezinka, the place the world knows as Auschwitz. By 9 a.m., 18 buses are in the parking lot. The exhibits are detailed and heartrending, a monument to cold-blooded human bestiality on a scale unparalleled in modern Europe. This inferno alone murdered four million people in less than five years.

That night, at the Hotel Giewont in Zakopane, in the Tatra Mountains, vacationists from Warsaw are dancing. Visiting Americans are dancing, too. Watching them, I feel that America can be everlastingly proud to have helped put an end to Auschwitz.

Driving through foothills of the jagged Tatras, I notice new brick houses with stone foundations and wooden gables. This used to be the poorest part of Poland, whence many emigrated to America. A mountaineer in a battered black felt hat tells me at Bukowina Tatrzańska: "Nearly everybody here has relatives in America. If they send an invitation, and if you can get an American visa, the government may let you go for a visit. My neighbor just came back after a year and a half in Chicago. He worked as a butcher, two shifts a day. His young wife stayed behind, she was very sad. Now she is so happy! They bought land, they're building a house, they have a car. You should see her new clothes! In Poland you could work all your life and never have all that. . . ."





Sheep hush their bleating when a *góral*, or mountain man, plays on his goat-headed *kobza* (above), a Polish counterpart of Scotland's bagpipes.

In their storybook land, a father and son take a Sunday stroll (left). At home in the High Tatra of southern Poland, the *góral*s cling to traditional attire and customs.

Elsewhere in the swiftly modernizing People's Republic, old habits and costumes emerge only for special events. During the harvest festival at Opole, in southwestern Poland, students relive the past through the graceful dances of their forebears (right).



School is out, and I pick up a teen-age couple with rucksacks. The official hitchhiking season has begun.

Anyone over 17 can buy a green hitchhiking booklet; it provides accident insurance, and contains sheets of coupons. The hitchhiker holds up his booklet and, after he is picked up, he gives the driver a coupon for every 25 kilometers; drivers turn in these coupons for a lottery; first prize is a Polski Fiat. Should a hitchhiker misbehave—well, there's his number on the coupon.

This was mentioned to me by the police colonel in charge of crime prevention and traffic safety for all Poland. "Those little booklets introduced order into hitchhiking."

He also told me why young people wear the number of their school on their sleeves: "So they'll be easy to identify. If they behave improperly, we send special postcards to their parents. It works very well."

Such devices, plus 380,000 auxiliary police, may explain why I could see people walking in the parks even after midnight.

In eastern Mazury, where the beautiful lakes are, I go sailing with students vacationing at the International Yachting Center at Giżycko. The biggest lake measures only ten miles across, but there are many of them, connected by canals. Blue water, green meadows, and woods for camping.

But what a pity about the beautiful trees lining the roads. They'll have to go, a traffic engineer tells me, because trees are stronger than cars and the number of crashes is appalling. A bus has just hit a tree, trying to avoid a driver who didn't stick to his side of the road; 71 children are hurt.

The annual death rate from motor accidents has reached 13 per 10,000 vehicles. That's almost three times as many as in the U. S., and so, in a way, it seems fortunate that Poland has only one vehicle for every 12 inhabitants. (In the U. S. it's three for every five.) But Gierek promises "universal motorization," through a cheap small car. Roads must be widened, or at least made safe from trees. When a driver sets out on a journey, one tells him "*Szerokiej drogi*," meaning "I wish you a wide road."

ANOTHER LONG DRIVE induces long thoughts. Will the Polish harvest be sufficient? Can Gierek stay the course?

One of his aides tells me: "Before, the leadership thought of doctrine. Gierek thinks along pragmatic lines; he is a pragmatic patriot. Of course there are thousands of people—especially in small places, small kings—who are not happy about the changes. But millions support Gierek, especially the youth. This makes him very strong."

In the primeval forest of Białowieża National Park, on the northeastern border with the U.S.S.R., I lose myself among the giants. Oaks and lindens up to 130 feet. A 156-foot spruce. It's a green and awesome day.

I get to the lodge so late that again I've missed Poland's favorite TV program, "Bonanza." It runs on Sunday afternoons, with a spoken Polish translation. But I'm in time for the daily "Goodnight to Children," at 7:20. It's a cartoon about a boy who helps birds. He has a magic pencil—whatever he draws begins to exist. A cat attacks some birds' nests, so he draws a fire engine and hoses the cat away. Then he draws birdhouses with refrigerators and bathrooms, with all the marks of a high standard of living.

The birds in their beautiful homes sing in gratitude. The boy draws himself a piano and plays a cheerful accompaniment. I wish I had such a pencil, so I could draw for Poles the things they want, and protect them from all the marauding cats of the world.

Next morning I see the famous European bison, once nearly extinct but now bred back to a herd of 230. From a stockade wall, the veterinarian who looks after them points to a charming bison bull calf, 15 days old. His parents are Poleszuk and Polarna. Would I care to name the baby? The name, like that of all purebred bison in Białowieża, must start with the letters PO.

I think and think and say—Pontuk!

The veterinarian asks what it means. I say it sounds Polish to me, and strong. May he grow up to be a brave Polish bison.

And I think of all the charming Poles I met. On their journey toward a better life, I wish them all a wide road. □

Stalwarts of the national economy, independent farmers like wheat grower Kazimierz Steinborn share their city cousins' cautiously hopeful view of the future. Recognizing the importance of privately owned farms—which comprise 83 percent of Poland's croplands—the government has now extended to them many of the incentives formerly granted only to state-owned cooperatives.



By PATRICIA
DES ROSES
MOEHLMAN

Photographs by
IRA S. LERNER
and the author

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Getting to Know the Wild Burros of Death Valley

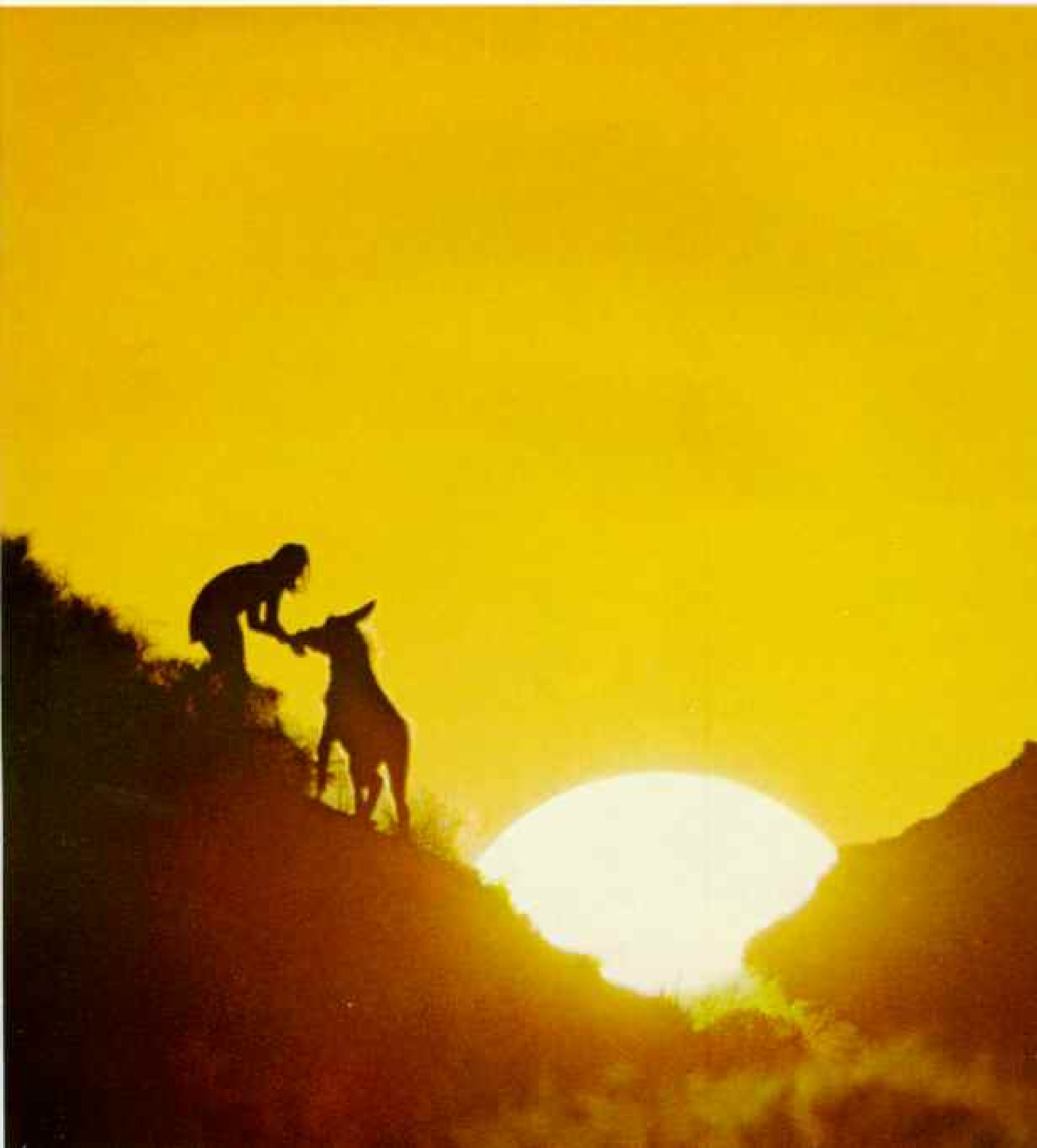


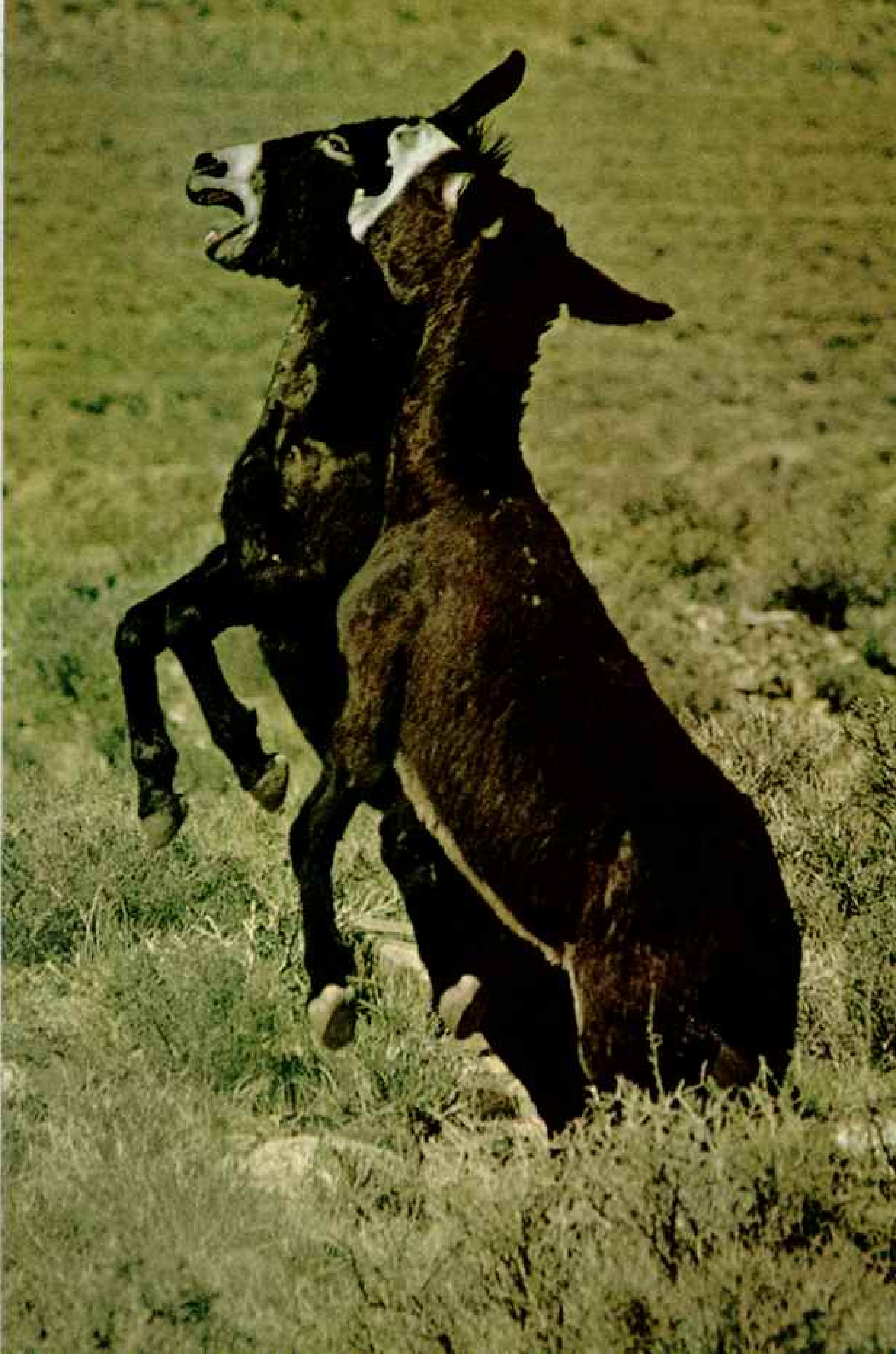
MOTHERING A FOUR-LEGGED ORPHAN was the last thing I expected to do when I began my study of Death Valley's wild burro population. I had planned to keep my distance from my subjects, to affect their behavior as little as possible, and to protect my objectivity as an observer. But, as far as Sweet Pea was concerned, my resolve went out the window.

I was returning to my study area in Death Valley National Monument after a trip east and stopped at Wildrose Ranger Station to see if I had any mail. My knock brought Anne Farabee, wife of Ranger Charles (Butch) Farabee, to the door. Behind her stood a small fuzzy animal with big ears

Sharing a sunset with Sweet Pea, the author ends another day in her study of wild burros. On most federal lands, a new law protects these "living symbols of the historic and pioneer spirit of the West." But the statute omits national parks and monuments, where the continued existence of the burro has become an issue.

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and a sign around his neck that said "Merry Christmas, Patti." He had the softest coat I have ever touched.

"We rescued him from a coyote near the water tank," Anne said. "We couldn't find his mother, so we tried to get a group of burros to accept him. They wouldn't, so we brought him home and gave him a name."

That night, as I led Sweet Pea to my winter quarters in a cabin at the ranger station, I realized what a rare and rewarding companion I had acquired. The monument's rules prohibit pets for residents, but Sweet Pea officially became a research animal, and he proved invaluable for the insights he gave me into burro behavior.

Sweet Pea joined me when I was about halfway through an 18-month study of the wild burros of Death Valley's Panamint Range (map, below). Despite increasing public attention to the fate of these animals, I discovered that relatively little was known about their behavior and place in the life system.

Brays rend the air as jacks battle in Death Valley National Monument's Panamint Range—focus of the author's research. Descended from the wild ass of northeast Africa, *Equus asinus* reached the New World with the Spanish in the early 1500's. Today more than 10,000 range Western lands, the free-roaming progeny of animals abandoned or lost over the years.

FIG. 1. LEHMAN



Our Western States contain more than 10,000 wild descendants of those sturdy symbols of the Old West, the pack animals of Spanish padres and grizzled prospectors. Today perhaps 700 inhabit the southern Panamint Range on the western flank of 140-mile-long Death Valley. They need fear no predator of consequence, except man.

Burros Provoke Opposing Views

Now men debate whether the burro fits into Death Valley's ecosystem. Critics say it pollutes water holes and eats away vegetation that holds the soil and sustains insects, bird life, and mammals as large as desert bighorn sheep. Defenders maintain that burros are not numerous enough to cause appreciable damage. A key to this question is numbers: How many burros will the land support?

The responsibility for deciding, as well as for devising a management program, rests with the National Park Service. Its guiding policy calls for restoration and maintenance of the land and its life-forms as they were before the white man came. There are those within the park system who see the burro as exotic—that is, non-native—and advocate total removal from the monument. Others would keep small herds in areas accessible to tourists, in deference to the animal's place in frontier history.

Another viewpoint—and one that I share, based on my observations—favors a management program that would retain the burros at a level the area would comfortably support. We might remember that *Equus*, the genus to which all asses, horses, and zebras belong, originally evolved on this continent and had a niche in the ecosystem perhaps as recently as 8,000 years ago.

In any event, before the Park Service makes a final decision on Death Valley's wild burros, other interested Government agencies and the public will have a chance to comment, under procedures set up by the National Environmental Policy Act. I hope my research will prove helpful in the formulation of a humane policy.

My study area covered about a third of Death Valley's Emigrant District, a 300-square-mile section in the Panamint Range. The region includes 11,049-foot Telescope Peak, highest point in the monument.*

*Rowe Findley wrote of "Death Valley, the Land and the Legend" in the January 1970 *Geographic*.

Topographic maps in hand, I set out to learn the terrain soon after arriving. I observed burros along both slopes of the mountains and down into Death Valley to the east and Panamint Valley to the west.

I identified 211 burros in my area, perhaps a sixth of all those within the boundaries of the monument. My group included 110 adult males, 51 adult females, and 50 adolescents and foals.

Mating Urge Turns Jack Jealous

The eight-square-mile tract of high desert called Wildrose Basin provided my best observation area. There, abundant plants and water attracted the burros in the spring and early summer. Learning to recognize most

individuals, I assigned each a number and name—until I ran out of names.

One was Brown Stud, a small hairy animal that dominated a quarter of a square mile of territory. He permitted other males to cross on their way to water, and even to mingle with females there. But if a jenny came into heat, Brown Stud became inhospitable. An intruding male had only to approach the female, and Brown Stud would lay back his ears and stand ready for combat. This threatening gesture usually discouraged the male. When it didn't, a fight erupted.

Braying, grunting, and growling, two burros in combat create pandemonium in a cloud of dust. Feet pound the ground. Teeth flash fiercely. But I noted that there's always more



PATRICIA D. WITENBERG (LEFT); IRA S. LESTER

On the alert, young jacks keep an eye on the author, who approached no closer than 30 yards to minimize her influence on their behavior. Different colorations and markings enabled her to identify and to keep track of more than 200 individuals. Black-muzzled burro on the right—unusual among predominantly white muzzles—she dubbed Blacknose.

Championing the burros' cause, schoolchildren throughout the country helped launch a barrage of letters to Congress that led to a law affording some protection for the oft-maligned creatures.

"Death Valley Patti": After long hours of observing her subjects, Miss Moehlman prepares a meal. Living out of a knapsack in summer, sheltering in a small wooden house in winter, she endured hardships that would win a prospector's sympathy. Her 18-month study of burros, undertaken for a doctoral thesis, received financial aid from the National Geographic Society, the National Science Foundation, and the University of Wisconsin.



bluff than blows, more braying than blood (pages 504 and 508-9).

In late May I moved from the cabin to a clearing on Piñon Mesa, about five miles southeast of the Wildrose Ranger Station. From this 6,500-foot height, I could look west across the Argus Range and far, far away to the snow-topped Sierra Nevada—a cooling sight during the hot months. For shelter and sleep I had a tent.

Burros sleep and browse with apparent indifference to rain and snow, thunder and lightning—and most of all to summer's mercilessly hot sunshine.

In winter, snow sometimes blankets the mountains down to about 6,000 feet. Though it snowed at 4,000 to 5,000 feet, where I

spent much of the winter, the flakes rarely remained long on the ground. Nevertheless, the cold often numbed my glove-clad fingers and night temperatures in the 20's were common.

In summer, when the temperature crept into the 90's—and that was some 30 degrees cooler than the floor of Death Valley—I donned a lightweight shirt, shorts, sandals, and floppy cotton hat. I carried a canteen everywhere, and sometimes emptied it over my head to avert a sun-induced headache.

My faculty adviser, Dr. John T. Emlen of the University of Wisconsin's Department of Zoology, arrived in June to see how my project was progressing. We set up our tents in the Wildrose Campground and made daily treks

(Continued on page 512)





And stay out! Chasing an intruder (right), Brown Stud—a dominant male—defends his claim to a nearby jenny in heat. Normally, trespassers crisscross Brown Stud's domain with impunity.

Dominant males may establish territories that cover a quarter of a square mile. Other males wander in bachelor groups that continually change membership. Females with young are the only stable social grouping observed by the author.





Courted by two suitors, Shag, the female at left, finds herself the subject of a biting and shoving match. Melees between rival males rarely cause serious injury. Observing many such contests, the author noted that the resident male prevailed in every battle.



Noses help in the search for a mate. Jacks (above) tell whether a jenny is coming into heat by inhaling deeply. Recent research indicates that many mammals have special scent organs that may be sensitive to concentrations of female hormones.

Wooing on the move, a pursuing male crowds tightly against a female as other potential suitors race alongside (following pages). Often the harried jenny will lash out with rear hoofs at her eager retinue. After mating, male and female go their separate ways.





into burro areas. Dr. Emlen's powers of observation, developed by years of experience, soon proved useful.

One morning, as we watched several burros that were browsing sporadically, Dr. Emlen pointed out something I had missed. One burro seemed to find a single plant engrossing. His nose remained deep in the tufts.

Finally the burro moved away, and Dr. Emlen and I examined the plant, a barrel cactus. The tough, sharp spines (opposite) that discourage most browsers had been neatly plucked out, and the inside pulp eaten. A human would need pliers to remove those spines, but not a burro. Wild burros find sustenance in some of Death Valley's prickliest plants, principally spiny hopsage, desert-thorn, blackbrush, and horse brush.

Burro No Help in the Kitchen

Sweet Pea started on a less thorny diet. I bottle-fed him on a milk substitute. It was always an accomplishment to get it mixed and into the bottle without mishap as he nudged my hands impatiently. My plans to have him spend his nights outside were reversed when coyotes began to draw near the ranger station after sunset. Soon he was the nightly occupant of the cabin's spare room.

Once a week I stood on a scale with Sweet Pea in my arms, his spindly legs kicking the air. Deducting my weight, I determined his. In only three months he weighed a hefty 88 pounds. That was the last time I lifted him. At about four years of age, he will reach full growth, perhaps 400 pounds and 11 or 12 hands—44 to 48 inches—at the withers.

Sweet Pea readily accepted me as his new mother. When Anne Farabee and I took him for a stroll, he trotted between us, kicking out to discourage Anne from walking too near me. A foal acts the same toward an older sibling when walking with its mother.

In the loose social organization of burros, the only stable unit consists of a mother and her offspring. Similar behavior is found among African chimps, I had learned while assisting Dr. Jane van Lawick-Goodall at Tanzania's Gombe Stream chimpanzee research station in 1967.*

With a 12-month gestation period, a mature female burro can drop a foal—and occasionally twins—every year. She may come into

*Dr. van Lawick-Goodall reported on her studies in the August 1963 and December 1965 *GEOGRAPHICS*. She also wrote a more detailed account in the book *My Friends the Wild Chimpanzees* for the Society's Special Publications Division.





Desert menu for tough-lipped burros includes spiny hopsage (far left) and barrel cactus (left). The cactus would be rejected by most browsers, but some burros manage to pluck off the spines to reach the pulp within. This ability to eat off the "thin of the land" made them particularly valuable to Spanish conquistadors and desert-probing prospectors.

Their ardor unchilled, two jacks (below) pursue a jenny through new-fallen spring snow in the Panamint Range. Clambering after them to heights of 10,000 feet, Miss Mochlman found them seemingly unaffected by the temperature extremes of the area.

PATRICIA D. MOCHLMAN (ILLUSTRATION BY E. LEVINE)





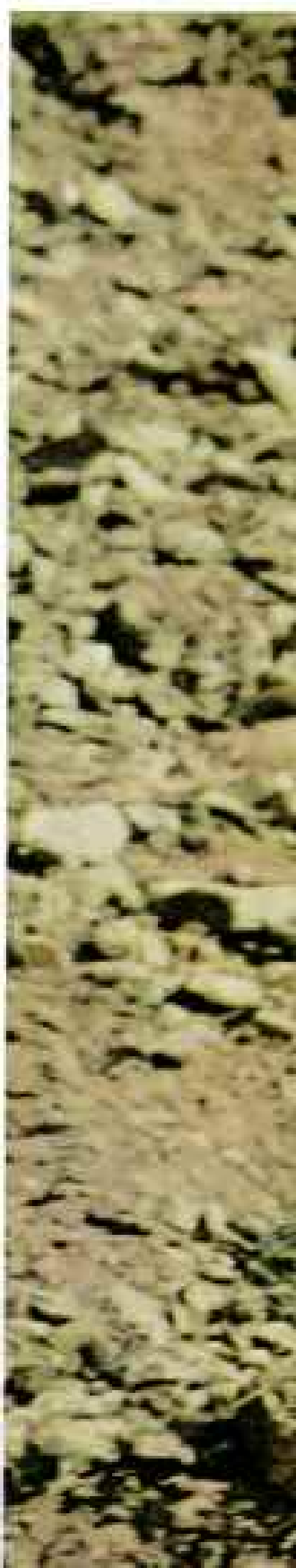
MS. S. LEBRON (RIGHT), PATRICIA S. MOELHMAN



Foster mother: Patti bottle-feeds five-month-old Sweet Pea. Friends rescued the burro from a coyote when it was only two or three days old. Keeping the long-eared tyke for her observations, Patti found that he brayed softly at her approach just as foals in the wild bray for their mothers.

Sampling a magazine, Sweet Pea plays in his adopted habitat. "He was constantly getting into things," Patti reported, "just like a puppy." Now Sweet Pea lives near Miss Moehlman's parents' home in Texas.

Snuggling up to its mother, called Boldface, a foal wears an unusual spotted coat. Though only a week old, the little burro has already started nibbling on desert plants. The mother allows unlimited nursing for only the first few days after birth, but regular feedings continue for about a year.



heat again within six to nine days of giving birth, although my observations showed that only 5 of the 51 jennies had two foals within a two-year period.

Still, if the life-span of wild burros approaches that of domestic donkeys—about 25 years—the animals have a potentially high rate of multiplying, and this has raised the specter of burro population explosions. Among the females I observed, however, only about 30 percent had new foals. Adult males, apparently because of dispersal to other areas, decreased by 45 percent, and the total population declined from 211 to 201. Of course my study was limited in territory. A comprehensive investigation of population growth and dispersal patterns is needed to determine the animals' long-range impact on the whole area.

One evening in early summer, the season when most foals are born, I was invited to dine with Ranger Earle Curran and his wife

Rachel at Emigrant Ranger Station. They asked about new foals.

"I've counted six, including a brown-and-white female paint," I replied. "That makes four spotted burros in this district."

Mother Wants No Visitors

The mother of the paint was Boldface, a brown burro with a white stripe down her nose (below). Although normally tolerant of my presence, Boldface would not let me come too close for the first five days, and I had to do my watching through a telescope. If I got within 50 yards of her foal, she gave a warning snort and trotted off, with her baby following close behind.

The foal spent a great deal of time lying down or sleeping, but at intervals of 15 to 20 minutes she would walk up to Boldface to nurse. After five days Boldface refused to allow her offspring to nurse that often, and the little burro began eating spiny plants.



Apart from eating and sleeping, burros spend time grooming themselves and each other. Standing parallel to a grooming partner, a burro will use its teeth as a back scratcher, while the partner reciprocates. Often the males just stand and bray in response to vocal blasts from burros miles away.

Both young and old alternately sleep and browse around the clock. Older animals sleep on their feet, but may lie down in winter months to keep warm. Foals sleep on the ground, and sometimes rest by leaning—eyes closed, head down, ears drooping—against their mothers.

When my fieldwork neared an end, I faced the question of Sweet Pea's future. Burro social organization being so fluid, I knew that

Sweet Pea probably could join a bachelor or nursery group. One female, I noticed, had three or four yearlings in tow. I was concerned, however, about the possibility of a burro reduction program, and decided that Sweet Pea would be safer near my parents' home in Texas.

About then, the dreaded Venezuelan equine encephalitis virus crossed the Rio Grande. It had killed thousands of horses and donkeys as it spread northward. Before moving Sweet Pea to Texas, I made a 300-mile round trip to a clinic near Los Angeles to have him vaccinated. Sweet Pea now grazes peacefully near Austin on a grassy 425-acre plain he shares with two horses.

At this stage in my research, I see no ecological basis for elimination of Death Valley's



burros. Contrary to widely held belief, the burros I observed did not strip the land, foul water holes, or endanger other animals.

Although heavy browsing occurred within a mile of water, my first appraisal of vegetation data indicates that plants on which burros feed do not suffer severely.

I noted that burros, rather than frightening other animals away, share the watering area with small rodents and birds. I do not deny that bighorn sheep might be affected by burro overpopulation, but to condemn the burro is to oversimplify a complex question, one that involves such things as climatic cycles and human population pressures. What we need is a program of burro management based upon systematic factual knowledge

of the animals' role in the environment, so that we can say with certainty at just what point burro numbers start to take a toll.

Sweet Pea Prompts Sweet Memories

I am in Texas now, analyzing my findings, and I visit Sweet Pea whenever I can. Watching him trot in the field, I recall the sights and sounds I remember best of Death Valley: the humor and furry charm of the long-eared foals, the fierceness and bluff of the adult males, the gentle, no-nonsense attitude of the proud jennies. How much longer, I wonder, will Death Valley's burros enjoy their free-ranging state? How long will others be able to see them as I have?

For many, many years, I hope. □



1989 S. LARSEN

Through a glass brightly: Miss Mochilman pierces the dark with a starlight scope—a night-vision device developed by the Army and on loan from the Smithsonian Institution. Amplifying available light, it proved invaluable for nocturnal observations.

As the desert earth cools in evening-darkness, a group of burros (left) approaches a watering hole. Patti observed that they would browse for a time, sleep awhile—

mostly on their feet—then browse again.

A one-burro reception committee named Hocked remained on all-night duty at the watering hole for more than a month, braying a welcome to all animals that turned up. Young foals showed a special interest in smaller fry—the rabbits, birds, and ground squirrels that came to drink.

We're Doing Something

By WALTER ORR ROBERTS



About the Weather!



VINCENT J. SCHAEFER

ONE WINTRY MORNING an indignant lady telephoned Washington's most popular TV weather forecaster with this frigid blast:

"I wish you'd come out here and scoop this six inches of 'partly cloudy' off my driveway!"

Information at the disposal of the weatherman the evening before had not seemed to justify a snow forecast. Then, during the night, the essential ingredients of weather—temperature, humidity, atmospheric pressure, and winds—had changed enough to produce a snowfall. As far as the irate householder was concerned, the weatherman had goofed.

Ask the man in the street if weather reports are reliable, and he may think of all the times he has been caught without an umbrella. The truth is, however, that weather forecasting has become remarkably good. Moreover, it is going to get even better.

Behind these optimistic statements lies an exciting story of scientific developments, in some of which I have been privileged to play a role—of satellites whose unblinking eyes watch the birth of every storm around the globe; of new sensing devices that easily pierce darkness to take the temperatures of clouds; of fantastic computers that digest billions of bits of information and in minutes draw complete weather maps; and of a global study of the weather that is harnessing international effort on an unprecedented scale.

It's a story also of tragedy and violence. But the tragedy is increasingly being averted

Cloud of his own creation hovers over a scientist after he threw a can of hot water skyward in Yellowstone National Park. The numbing winter air—45° F. below zero—enables him to observe clouds as they might behave in earth's frigid upper atmosphere.

National Geographic editors spent five years searching for photographs that would best portray the power and fury of the weather and how man attempts to understand and even control it.



by swift warnings. And the day is coming when the violence of giant storms may yield to the strategies scientists are now devising.

There's a strong wind blowing in weather science these days, and it will do a lot of people a lot of good. Weather hazards, by conservative estimates, cost the United States 1,200 lives and 11 billion dollars in property damage annually.

As a boy in Massachusetts, I would often go down on gray mornings to the dock at Cuttyhunk Island and watch Capt. Frank Veeder head his stubby swordfishing boat out to sea. I would wonder what kind of weather lay ahead of him on the open Atlantic.

In those days, people depended a great deal on weather lore. For clues that bad weather was coming, they paid attention to the twinges in the rheumatic joints of older folk, or watched the erratic behavior of beasts and birds. In such rhymes as "Red skies in the morning, sailor take warning; red skies at night, sailor's delight," they distilled the experience of generations.

They may not have known, incidentally, how venerable that particular bit of lore really is. Read Matthew 16:2, 3:

"When it is evening, ye say, It will be fair weather; for the sky is red. And in the morning, It will be foul weather to day: for the



Driving the sea before it, Hurricane Betsy batters Miami. The 1965 storm took 75 lives and caused damage estimated at 1.4 billion dollars.

The swirling anatomy of Hurricane Camille, the 1969 killer that snuffed out more than 320 lives, is exposed (right) at the National Hurricane Center in Miami. Color added to a satellite photograph charts the storm's moisture content; whitest areas indicate the fiercest downpours.



sky is red and lowring. O ye hypocrites, ye can discern the face of the sky; but can ye not discern the signs of the times?"

Today's mariners—and farmers, and resort owners, and construction men, and all the rest of us who watch the weather each day—seldom need depend on folklore. The National Weather Service (formerly the Weather Bureau) provides detailed forecasts covering two and three days ahead. Since February 9, 1970 (the 100th birthday of the Weather Service), less detailed five-day forecasts have been available daily. And for \$3.50 a year the Weather Service will send you 30-day temperature and precipitation outlooks by mail twice a month.

Today's Forecasts: Bolder and Better

How accurate are today's two- and three-day predictions? Let the weathermen tell you.

Allen D. Pearson, Director of the National Severe Storms Forecast Center in Kansas City, points out that "forecasts are now much more precise than they used to be. They are couched in less cautious language."

Arthur Gustafson, who is in charge of San Francisco's forecast center, says, "Now we do better on two-day forecasts than we did for one day in the early '60's. And a decade ago, who would have dared tell you anything about Sunday's weather on Wednesday?"

Dr. George Cressman, Director of the National Weather Service, puts it explicitly: "The national average verifications show that we can forecast today's or tonight's temperature to within about $3\frac{1}{2}$ degrees, and tomorrow's to within about $4\frac{1}{2}$ degrees. If you count a forecast of over 50 percent chance of rain as meaning it will rain, and under 50 percent as meaning no rain, our national averages show about 87 percent hits for today, and about 80 percent hits for tomorrow."

To this Al Pearson adds a caution:

"Weather forecasts are made for wide areas, not for pinpointed spots. Suppose the prediction is for 10 percent chance of rain, yet rain falls in one corner of that area. The man who is getting drenched screams, 'Ten percent! Don't those guys see what's up there?' He may not realize that most of the forecast area is as dry as can be.

"Don't forget," says Pearson, "a prediction of only 10 percent chance of rain does not guarantee *no* rain. In fact, if we predict 10 percent chance of rain on 10 different days, by all the laws of probability it should rain on one of those days!"

So fast is weather science improving that Dr. Joseph Smagorinsky, one of today's most respected meteorologists, foresees that we can expect increased accuracy of forecasts over periods of up to several weeks, sufficient to be useful for economic planning and for weather-hazard warning.

Whether two- to three-week forecasts can ever be made with the same accuracy we now enjoy for two or three days is a matter of vigorous controversy. The answer depends on feverish research now going on with computers, mathematics, techniques of observation, and satellites. And of these, perhaps most fascinating is the weather eye in space.

Last summer as I worked on this article, a stubby object known as NOAA 1* was circling in earth orbit, passing northward over California. It resembled an oblong packing crate with three purplish blue wings attached at one end (page 525). The wings, covered with solar cells to produce electricity for the satellite, always faced the sun, and the spacecraft itself kept one side turned toward earth.

Within the next hour and 55 minutes, NOAA 1 made a complete circuit of the globe, passing near the North Pole and then sweeping south over Arabia and the Indian Ocean to Antarctica and back north again.

Multiple eyes in the spacecraft scanned the swift-moving panorama 900 miles below. Two TV camera systems caught the glint of oceans and ice fields, the white expanse of clouds, the familiar outlines of continents and islands. More important, instruments known as radiometers detected heat and light radiation from earth, cloud, and sea.

Unwinking Eye Scans the Entire Globe

As Canada passed beneath, a radio command came up from an 85-foot antenna near Fairbanks, Alaska, operated by the National Environmental Satellite Service.

"Give us your pictures," it signaled.

Like an obedient child, NOAA 1 turned on magnetic tape recorders that had stored pictures from one of its TV cameras. Electronic impulses that encode patterns of light and dark went by radio from the spacecraft to the ground station, from which they were relayed to weather stations all over the United States. In hours, forecasters had the pictures on their desks, showing storm patterns that

*NOAA takes its name from the new National Oceanic and Atmospheric Administration, which includes the National Weather Service, the National Environmental Satellite Service, and several other agencies of the Department of Commerce.

would affect you and me the following day.

NOAA 1 made such a picture every 260 seconds. Each covered a square some 2,000 miles on a side, an area of four million square miles. Cloud patterns as small as two miles across could be distinguished.

As the spacecraft made its orbit, the earth rotated nearly 29 degrees to the east. Thus each successive orbit, and each successive strip of photographs, was displaced westward. Since the strips overlapped, NOAA 1 captured a progressive portrait of the globe. It scanned every spot on earth at least twice each day.

Cloud Pictures Free for the Taking

NOAA 1's second camera system, known as APT (Automatic Picture Transmission), did not store its pictures. Instead, the electronic signals were continuously broadcast to earth, free for anyone who wanted to pick them up.

Some 550 weather stations all over the world, in 94 countries and territories, have their own APT receivers for picking up these signals and converting them to pictures. Even less advanced nations can afford them. In fact, they are so simple that in Montgomery County, Maryland, high school students put together a receiver.

I always find it impressive to watch APT pictures come in. As a wide sheet of paper slides slowly from the machine, an electric needle moves rapidly back and forth, burning a pattern of light and dark. The needle makes 600 passes in two and a half minutes to complete each picture—each pass corresponding to a scan made by the TV camera. The individual lines blend to form a continuous picture, just as on a TV screen.

The original NOAA was launched December 11, 1970, and unexpectedly went dead last July. Another is scheduled to be put in orbit sometime this spring. In the interval, other weather satellites of an earlier generation have taken over NOAA 1's tasks.

Two dozen older weathercraft—most of them smaller and less elaborate—keep the now-silent NOAA 1 company as they circle earth in space. Most are also dead; only five can still send back pictures.

In a lower orbit, for example, flies TIROS 1, which excited the world with the first useful television pictures from space in April 1960 and inaugurated a revolution in weather forecasting. More than a million and a half satellite pictures have flooded to earth since that time.



ROBERT W. HAGLER

The world is his weather station: Dr. Walter Orr Roberts spurs a global meteorological study as President of the University Corporation for Atmospheric Research in Boulder, Colorado. The corporation, supported by the National Science Foundation, manages a laboratory in which some 600 scientists and technicians investigate the atmosphere.

An astronomer, Dr. Roberts was elected president of the American Association for the Advancement of Science for 1968. Here he holds the instrument package of a ten-foot GHOST balloon (background) used for charting air movements.

Far above NOAA 1, two quite different spacecraft hang like silver spiders over the Equator. Known as ATS (Applications Technology Satellites) 1 and 3, they do not orbit the earth. Or, more properly speaking, they move just fast enough to keep up with earth's rotation. Thus each always hangs above the same spot on earth, and for this reason they are called geosynchronous or geostationary.

Although the ATS satellites belong to NASA, the Weather Service makes extensive use of their remarkable photographs. From the lofty vantage point of 22,300 miles, ATS cameras can see almost one entire side of earth. This means that at frequent intervals we can take a fresh look at cloud patterns over the United States and over the spawning grounds where much of our weather is born.

Heat Pictures Add Vital Data

Spectacular though they may be, TV pictures from space may prove less valuable in the years ahead than information from scanning radiometers. These instruments are already carried by the NOAA satellites. They detect and measure radiation not only in the form of light, but also in the form of heat—the energy of long-wave infrared radiation. Since heat is what drives the great engines of the ocean and atmosphere to produce our weather, that information can be of great value to weather scientists.

But we will not be deprived of pictures from space. Radiometer scannings can be converted to images similar to those made by TV cameras. And since the radiometers work with both infrared and visible light, they produce excellent pictures on the night side of earth as well as the daylit side, making 24-hour global coverage possible.

David S. Johnson, Director of the National Environmental Satellite Service at Suitland, Maryland, explains the remarkable things weathermen can learn from infrared:

"In addition to images, infrared sensing from satellites gives us the temperatures of earth, sea, and clouds, to an accuracy within 3° F. It helps us estimate how high the cloud tops are, and therefore what kind of clouds we are seeing. Moreover, we can interpret the readings to give us a profile of temperatures at various levels in the atmosphere. This information is absolutely essential for making longer-range forecasts than those now possible.*

*Finally, some of the new devices will even measure water vapor at different heights, and

others may report on the total levels of such pollutants as dust, carbon dioxide, nitrous oxide, and sulfur dioxide.

"These infrared sensors represent a truly great leap ahead for the 1970's."

In the latter part of this year a brand-new weather satellite called GOES (Geostationary Operational Environmental Satellite) is scheduled to join the ATS spacecraft 22,300 miles above the Equator. Stationed at 100° west longitude, over the Pacific Ocean 1,350 miles south of Mexico City, it will be the first of a new series of earth-synchronous weather eyes.

Weathermen refer to GOES and ATS spacecraft as "natural-disaster satellites," because they are so useful in early detection of severe storms. After a polar-orbiting NOAA spots a potential storm, 12 hours must elapse before its spiraling path around the globe brings it back for another look. But GOES, from its steady vantage point, will take a new look every 20 minutes. If a thunderstorm developing from cumulus clouds seems likely to produce tornadoes, GOES may be able to give warning in time.

Satellite Asks Questions of Earth

GOES will do something else NOAA is not equipped to do: It will collect weather information from remote stations anywhere in its field of view. Rain and river gauges, drifting buoys, ships, and perhaps balloons and aircraft will, on command from the spacecraft, radio their findings directly to GOES, which will relay them to the computers in satellite headquarters at Suitland, Maryland.

So capable is GOES, in fact, that it could interrogate as many as 40,000 remote stations every six hours, and send back to earth pictures containing a maximum of a hundred billion bits of information each 24 hours. Handling the mathematics involved in digesting such a torrent of information challenges even the fastest modern computers.

If all this seems like a great surplus of information, listen to the late John von Neumann, the celebrated mathematician who nearly a quarter of a century ago pioneered the idea of computers for analyzing weather:

"The hydrodynamics of meteorology," said von Neumann, "presents without doubt the most complicated series of interrelated problems not only that we know of but that we can imagine."

*See "Remote Sensing: New Eyes to See the World," by Kenneth F. Weaver, GEOGRAPHIC, January 1969.

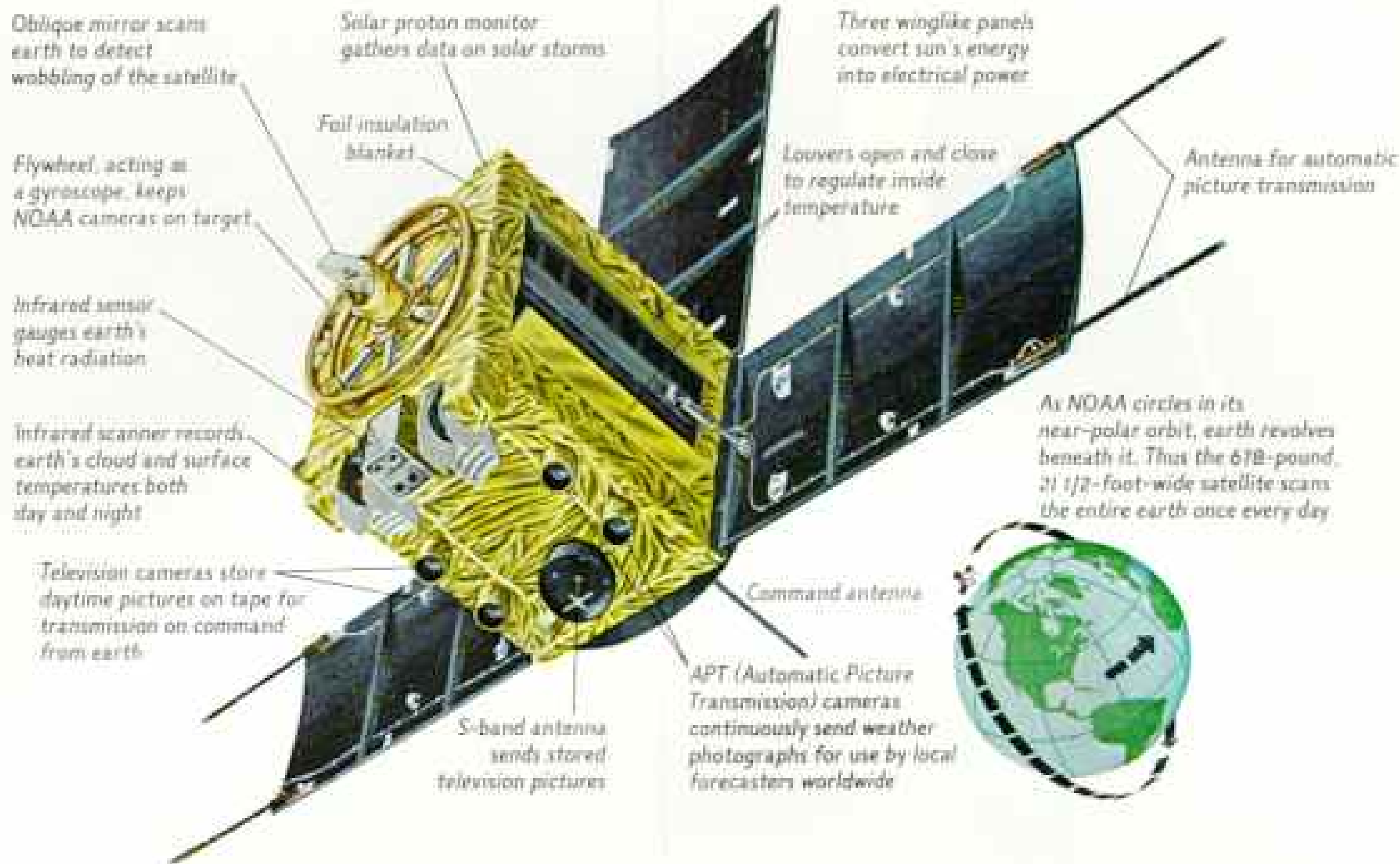
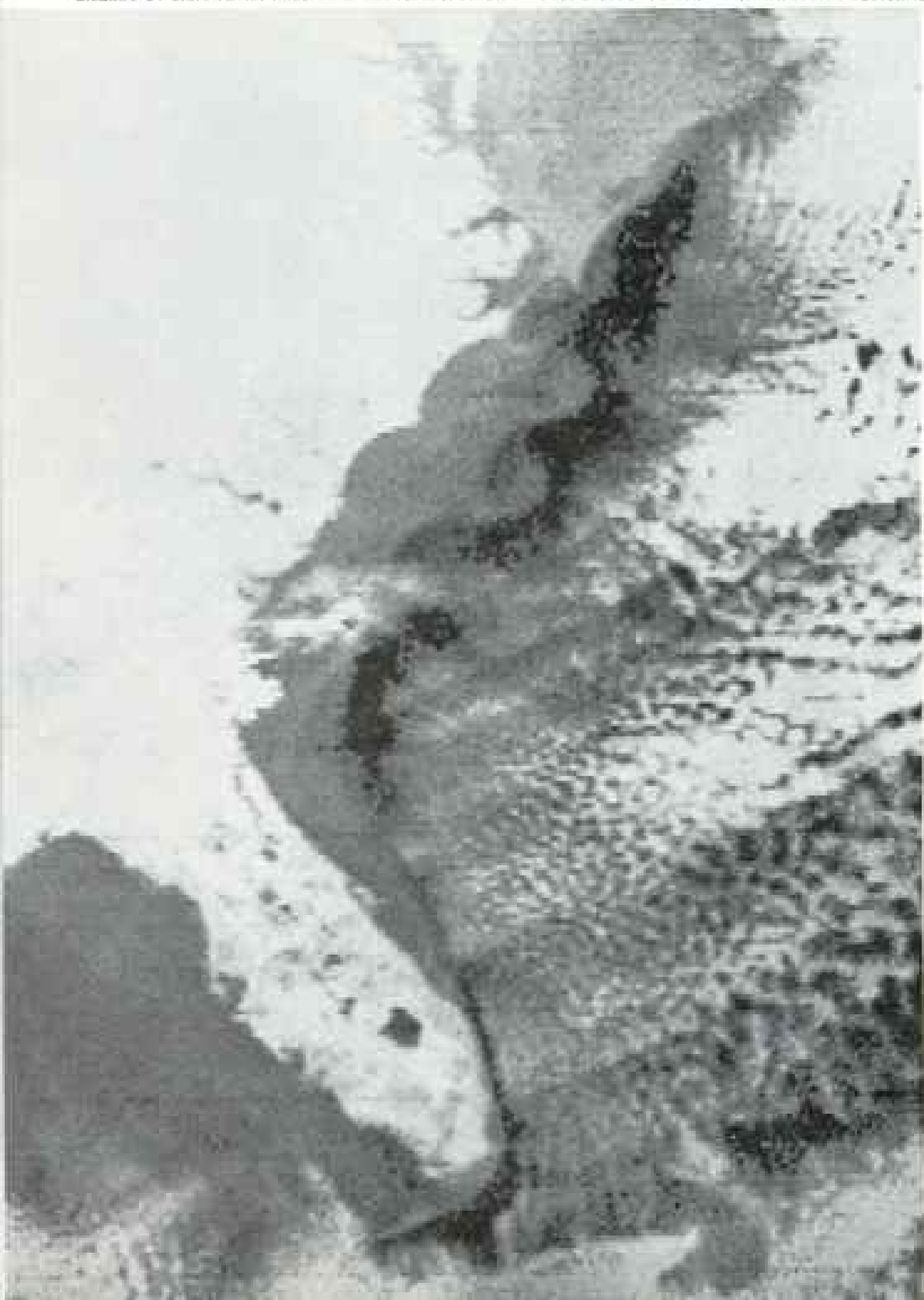


DIAGRAM BY STAFF ARTIST ROBERT W. NICHOLSON; NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (GLOBE)



High-spying weather eye, a gleaming satellite scheduled for launch this spring carries a battery of sophisticated detection devices. Named for the National Oceanic and Atmospheric Administration, NOAA 2 will orbit every 115 minutes (small diagram), sending back overlapping views of the globe's changing weather from 900 miles in space.

Catching nature at one of her tricks, a satellite infrared image reveals massive eddies along the western edge of the Gulf Stream. The swirls occur, some oceanographers theorize, when a storm drives wedges of inshore water into the stream.

Here most of the Gulf Stream—recorded as nearly black because it is markedly warmer than surrounding water—hides beneath cool clouds that show as mottled white.



Three million volts of man-made lightning strike a model of the Concorde (above), the British-French supersonic transport. The fiery encounter shows where protective devices will be needed to channel lightning bolts harmlessly back into the atmosphere. Airliners are struck an average of once every 10,000 flying hours.

Forked tongue of fire jabs at a hillside near Lugano, Switzerland. Photographed through a diffraction grating, the bolt forms a spectrum; atmospheric gases radiate characteristic colors under enormous electrical potentials and temperatures five times hotter than the surface of the sun.





To understand this assessment, you must realize how fiendishly complex is earth's atmosphere and its weather systems. The 20-mile-deep blanket holding the world's weather contains 5.6 million billion tons of air, approximately one and a half million tons for every person on earth. A gigantic witches' brew, four billion cubic miles in volume, it churns and flows in constant turmoil.

Heated by that great atomic-powered furnace the sun, the air rises in vast updrafts, especially in the tropics, sucking up the incredible quantity of more than 1,000 billion tons of sea water a day. The gigantic updrafts arc poleward, deflected to the east by the earth's rotation, then sink to earth at about 30° latitude to move back toward the Equator (diagram, pages 532-3).

At higher latitudes, where most people live, the wind circulations are even more complex, characterized by migrating cyclonic cells, thunderstorms, jet streams, and high-pressure areas a thousand miles wide—all modified by every mountain, every plateau, every body of water, every lowland.

If you think about how much heat it takes to boil away a kettle of water, you begin to get an idea of the tremendous amount of energy taken up by daily evaporation from the seas. The energy involved corresponds to 100,000 times the total electric generating capacity of the United States in 1970.

One Storm Equals a Hydrogen Bomb

Every bit of this energy—this heat of evaporation—lies stored in the vapor-laden air. When the vapor condenses again, either as cloud droplets or as falling rain, the same fantastic amount of energy is given back to the atmosphere as heat. Meanwhile, the energy may have been transported thousands of miles by the circulation of the winds. Wherever it turns up, it will markedly affect the weather.

A single thunderstorm can release to the atmosphere energy equivalent to a megaton hydrogen bomb. And since some fifty thousand thunderstorms break forth on earth every day, the daily energy released to the atmosphere equals billions of tons of TNT.

Small wonder that such energy can express itself with explosive violence, and that the large-scale movements of the atmosphere are so complex. And small wonder that science is forced to stretch itself to the utmost to

describe and predict the total workings of this monstrous machine we call weather.

Prospects for success would seem dim indeed except for a great worldwide effort now under way. The United States and more than a hundred other nations have banded together, under the aegis of the World Meteorological Organization and the International Council of Scientific Unions, to develop in the 1970's a new understanding of global weather processes. It is called the Global Atmospheric Research Program (GARP). A related program, the World Weather Watch, seeks to develop an adequate worldwide observation and forecasting system.

Success will depend on three very difficult achievements:

1. Electronic computers that can efficiently perform hundreds of millions of mathematical operations per second. Best estimates indicate that these computers must have a hundred times the capacity of today's finest machines. Technology is moving so fast that we can confidently expect such capacity within a few years.

2. A fully realistic theory, or mathematical model, of the workings of the intricate processes that generate our weather. This model must include all the physical forces affecting the atmosphere. For the entire globe it must describe in numbers and in equations the oceans, landmasses, and mountains; the changes of temperature, reflectivity, and moisture; the distribution of the nuclei around which moisture condenses or freezes; the cloud patterns; the wind velocities; the temperature, pressure, humidity, and density of the atmosphere at thousands of points and at many levels. In some models it takes half a million pieces of data just to describe the atmosphere at a single instant.

The model must put all these things together in terms of numbers so the giant computer can calculate how the winds will flow, the temperatures change, and the rains come down. Such numerical models, on a promising scale, are already being used by the Weather Service in its forecasting.

3. A truly global network of stations to make weather measurements at least daily.

Already more than 10,000 people in the United States are engaged in professional weather research and forecasting, plus 13,000 volunteer observers. Around the world some 25,000 surface weather observations are made

every day—and coded for global radio and telegraphic exchange. Ten thousand land stations in more than 130 countries, as well as 6,700 ships, have weather-measuring equipment. In addition, more than 1,200 daily measurements of winds and temperatures in the upper air are made from balloons.

Vast as this amount of information may seem, it is desperately incomplete. No more than 20 percent of the globe is adequately covered by weather observations. We know very little about what is happening over the oceans, and the ocean-dominated Southern Hemisphere is politely termed a "data-sparse area."

It is not enough to measure the winds near the surface. Air movements at much higher levels—in the stratosphere—influence world weather enormously.

The stratosphere air that sweeps across the central United States today may, a mere two or three days ago, have been somewhere over the mid-Pacific and quite out of range of detailed measurements. It is not unusual for a parcel of air to circumnavigate the globe in mid-latitudes in only ten to twelve days. So it is obvious that longer-range weather forecasts will require observing the air parcels in their complete circuit of the earth.

Weathermen Turn to GHOSTS for Help

The cost of covering the entire globe with ships and other conventional weather stations would be prohibitive. So we will depend heavily on satellite soundings with infrared sensors. In addition, other novel techniques are being considered, including the GHOST balloons (page 523) pioneered by Vincent E. Lally and his colleagues in Boulder, Colorado, at the National Center for Atmospheric Research (NCAR), where I have my offices.

GHOST balloons (the word stands for global horizontal sounding technique) are unusual in that they do not continue to rise through the atmosphere until they burst, as do ordinary weather balloons. Rather, they level off and drift with the wind at a pre-determined altitude in the stratosphere.

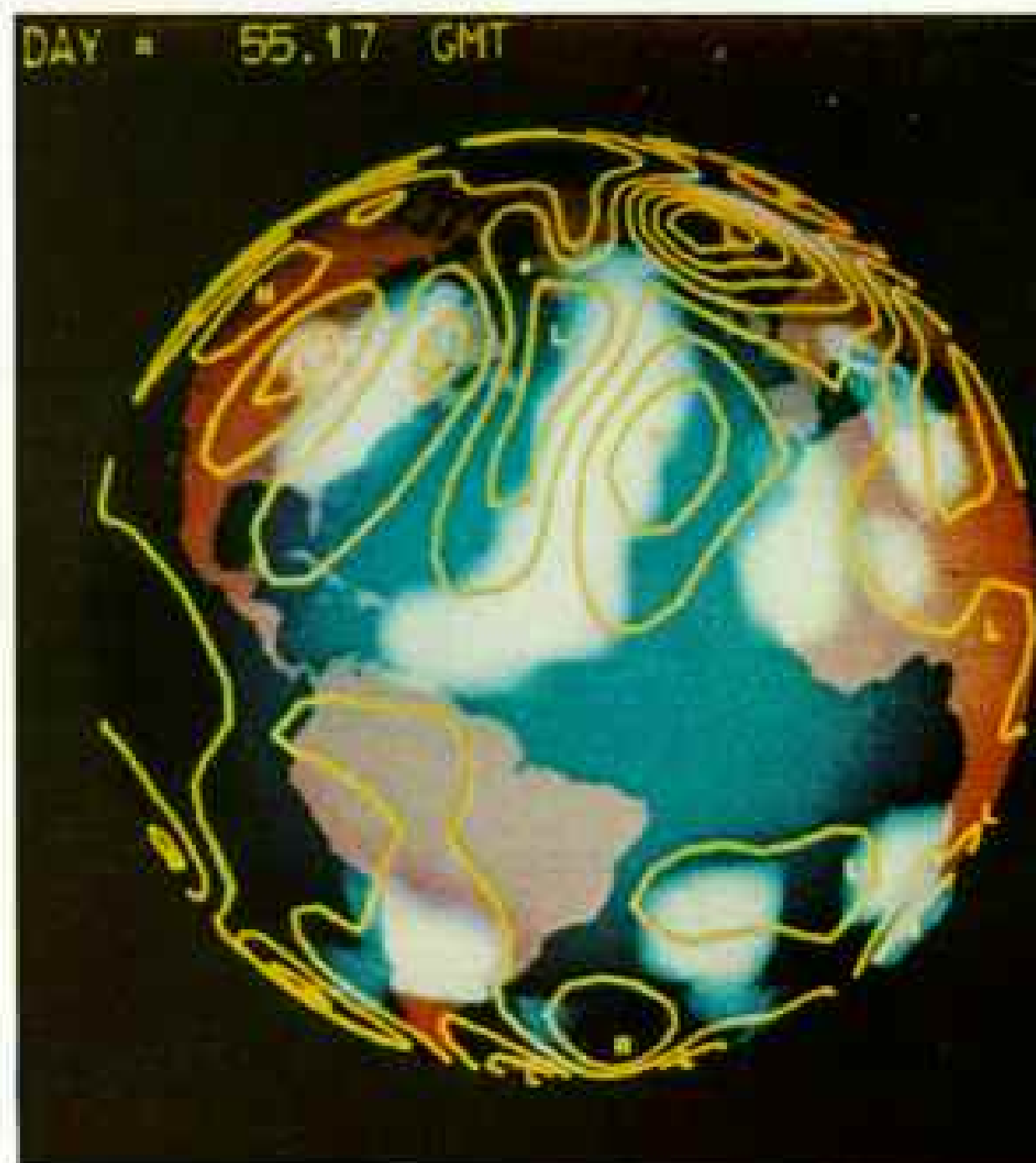
Mylar, a very thin, tough plastic almost impervious to helium, enables the balloons to maintain pressure for many months. Just enough helium is put in so the balloon will completely expand at approximately its intended altitude. When the density of the helium-filled balloon system balances the

density of the outside air, the balloon floats at that altitude, rising and falling only a hundred feet or so as temperatures vary.

Simple instruments carried by the balloon measure temperature and humidity. A tiny sun-powered radio broadcasts the data and the balloon's positions, from which wind velocity can be determined. The payloads are so fragile that jet engines in ground tests have gobbled them up with no problems. The balloons, we believe, represent about one "sparrow power" of threat to a plane.

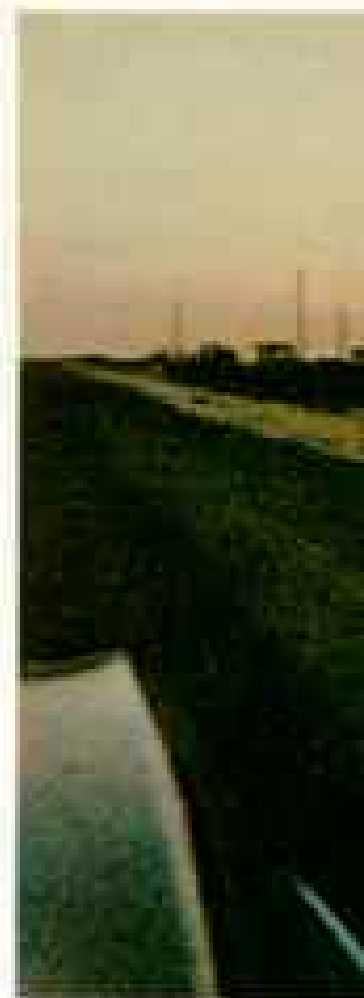
Since March 1966, NCAR has launched some 350 balloons from New Zealand and other Southern Hemisphere sites. Stations in many nations have helped us track them. Success has been sensational. One GHOST flew for 467 days, steadily radioing back useful data.

For the worldwide weather program, we
(Continued on page 534)



NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

Drawn by a computer, this theoretical weather map is based on previously collected real-life data. By comparing the map with what actually happened, scientists refine a mathematical model of the atmosphere. Faster computers now in the making promise more accurate long-range forecasts.





JAMES H. DODD (TRUCK); AND (LEFT) BIRNLEY L. KRAL (UPPER LEFT); ATMOSPHERICS INCORPORATED



Rainmakers to the rescue: To wring out reluctant clouds, Homer F. Berry stokes a brazier of flaming charcoal impregnated with silver iodide. As he drives about the countryside trailing sparks, the fire's updraft carries smoke aloft, where its billions of minute silver iodide particles may cause the air's moisture to condense as raindrops.

Farmers of parched west Texas had offered Mr. Berry, a retired Air Force officer, \$10,000 to generate five inches of rain in 30 days. But

the clouds were not suitable; less than three-fourths of an inch of rain fell.

Under more favorable conditions, a downpour to gladden farmers' hearts cascades from clouds over the Dakotas (left). It fell after scientists flew through the clouds with silver iodide flares burning on the wing struts of their plane (above).

Earth's awesome weather machine

ITS FUEL is the sun's prodigious energy, striking earth with 240 trillion horsepower. Its throttle is the planet's movement—the spinning and tilting that sets the cadence of days and seasons. Its mighty engine is the atmosphere itself, a vast enveloping sea of air.

In this simplified model of earth's weather machine, prepared in close cooperation with Dr. Chester Newton of the National Center for Atmospheric Research, the sun beats directly on the Equator (lower circle). Toward the Poles, the rays pierce a greater amount of atmosphere and fall obliquely across a larger area of earth. This greatly reduces their power and creates the heat imbalance that drives the churning atmosphere.

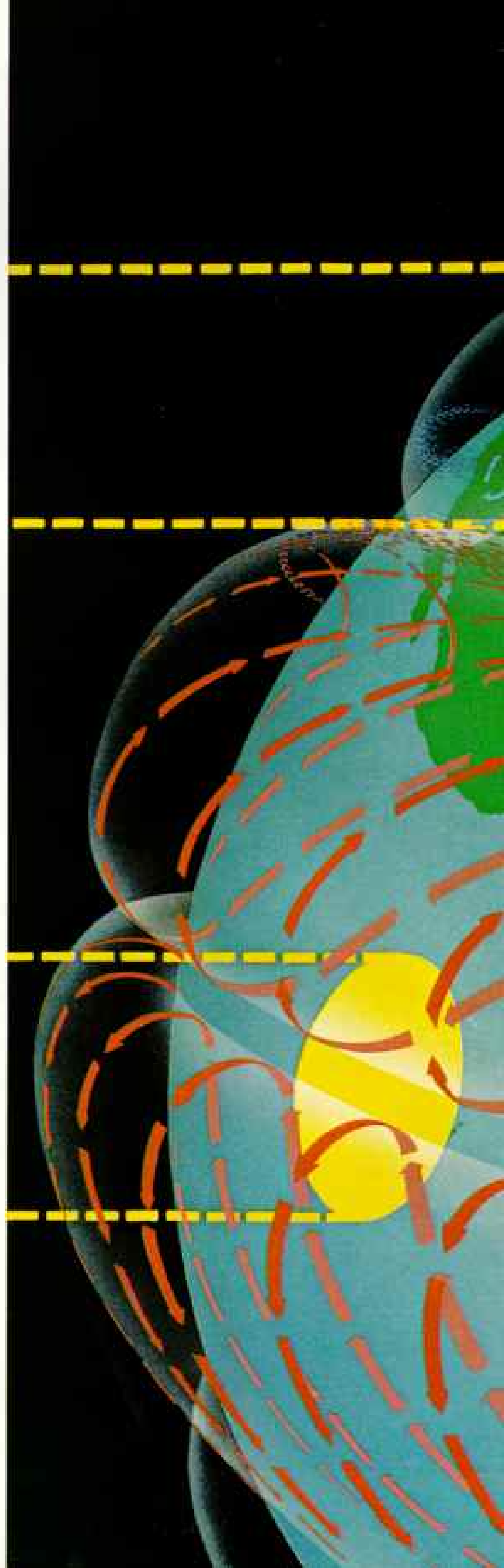
Two huge belts of moving air, the North and South Hadley Cells, girdle earth at the Equator. In the Northern Hemisphere, heated air rises near the Equator and drifts northward (red arrows). Its momentum from earth's rotation deflects it to the east—a phenomenon known as the Coriolis effect, which also influences the flight of airliners, rockets, and migrating birds.

As the high cool air approaches the latitude of Florida, some of it races on east in the subtropical jet stream. But most of it slows and descends in the horse latitudes and follows the Hadley system back southward to replace rising equatorial air. As it returns, earth's rotation deflects it westward (pink arrows)—the steady trade winds sought by ships of sail. Another part of the descending air turns northward. Earth's rotation veers this wind right to become the westerlies that prevail over middle latitudes, including the United States.

At its northern edge the Hadley Cell merges with the Polar Cell that sits atop earth like a cap. Here the circulation takes the form of huge surface eddies—the familiar high- and low-pressure cells of the weather map. In the painting a high of cool heavy air, driven clockwise by earth's rotation, swirls over New England, and another lies over the Rockies. Between them a low rotates counterclockwise over the Great Plains. Where the air currents collide, these cells breed turbulent weather, such as often roils across the U. S.

Sweeping around the planet from west to east, the powerful rivers of air known as jet streams vary in altitude from 30,000 to 40,000 feet and meander north or south. The streams reach velocities of 100 to 300 miles an hour, often speeding eastbound jetliners across the North Atlantic in an hour less time than westbound flights.

STAFF ARTIST ROBERT W. SCHILLER







HERBERT LANGFORD, NCSA

Wispy wake of the jet era, a contrail created by an airliner's exhaust grows into a cirrus cloud over the Colorado Rockies. Meteorologists fear such man-induced effects may disturb the earth's weather system.

may need many of these balloons, especially in the tropics, and hundreds of new buoys scattered in remote parts of the ocean. And we will need several more geostationary satellites spaced strategically around the Equator. Japan and France are both considering launching such spacecraft.

Dr. Robert M. White, head of the National Oceanic and Atmospheric Administration, estimates that this expanded weather observation system will save our nation more than a billion dollars a year. I believe Dr. White's estimates are conservative. I have seen quite genuine optimism for success among the scientists with whom I have worked for eight years in GARP's planning meetings.

While scientists in many countries seek to understand and predict the weather, others search for ways to tame, or at least alter, the

severe weather conditions—the storms and droughts—that plague mankind.

In western Texas last spring a group of farmers sorely beset with drought offered a private rainmaker \$10,000 if he could produce five inches of rain within 30 days. Day by day the rainmaker chased clouds across Stonewall County in an old pickup truck with a pot of charcoal and chemicals glowing and smoking in the back (pages 530-31).

At the end of the month: failure. Less than three-fourths of an inch of rain had fallen. In ancient times the unsuccessful rainmaker might have lost his head; in this case he lost only his contract.

Downpour Follows Airborne Seeding

A few weeks later Government scientists sought to ease a severe drought in southern Florida. Flying into the tops of clouds with a four-engine research plane, they dropped scores of burning flares that spewed out trillions of microscopic crystals of silver iodide.

In the six hours after this seeding, five inches of rain poured on the grateful citizens of the Miami and Everglades areas.* The drought, while not broken, had been substantially reduced.

These two examples characterize the history of rainmaking—a story of frequent failure and occasional resounding success that may or may not have been related to the deliberate interventions of man.

One early failure came in the 1890's, when Congress provided \$9,000 for tests of rainmaking by sending explosives aloft with kites and balloons and by firing cannons. Perhaps the legislators had read the Greek writer Plutarch, who had noted 18 centuries before that "extraordinary rains pretty generally fall after great battles." But the experiments in 1891 and 1892 produced more smoke than rain.

Since that time a more scientific approach has been developed. We know that if air containing a good deal of water vapor is very clean, it will often drop in temperature below the level at which condensation normally takes place, yet without producing clouds. Such air is called supersaturated. Similarly, water droplets in nature are often "supercooled" well below freezing without turning to ice, if there is an absence of nuclei.

A cloud droplet cannot form without a condensation nucleus. A mote of dust, a salt

*South Florida's water problems were described in "The Imperiled Everglades," by Fred Ward, NATIONAL GEOGRAPHIC, January 1972.

crystal, or a tiny chemical droplet will do. Particles so small that 300,000 of them could line up within one inch work very well. Similarly, the formation of snow crystals can sometimes be stimulated by some kinds of nuclei.

A quarter of a century ago, Dr. Vincent J. Schaefer of the General Electric Research Laboratories was experimenting with supercooled clouds. He found that a bit of dry ice (frozen carbon dioxide) dropped into supercooled fog in a chest-type home freezer immediately filled the air with glittering ice crystals. Later, from an airplane, Schaefer seeded a supercooled cloud with several pounds of crushed dry ice. Throughout several miles of cloud, fine water droplets turned to long streamers of snow.

Shortly thereafter, Dr. Bernard Vonnegut, also then at G. E., found that microscopic particles of lead iodide and silver iodide could trigger rainfall in supersaturated clouds. The science of cloud seeding was born.

Until recently, however, scientists were cautious about claims. Often cloud seeding did not produce rain, and when it did there were gnawing doubts about whether it might have rained without the seeding.

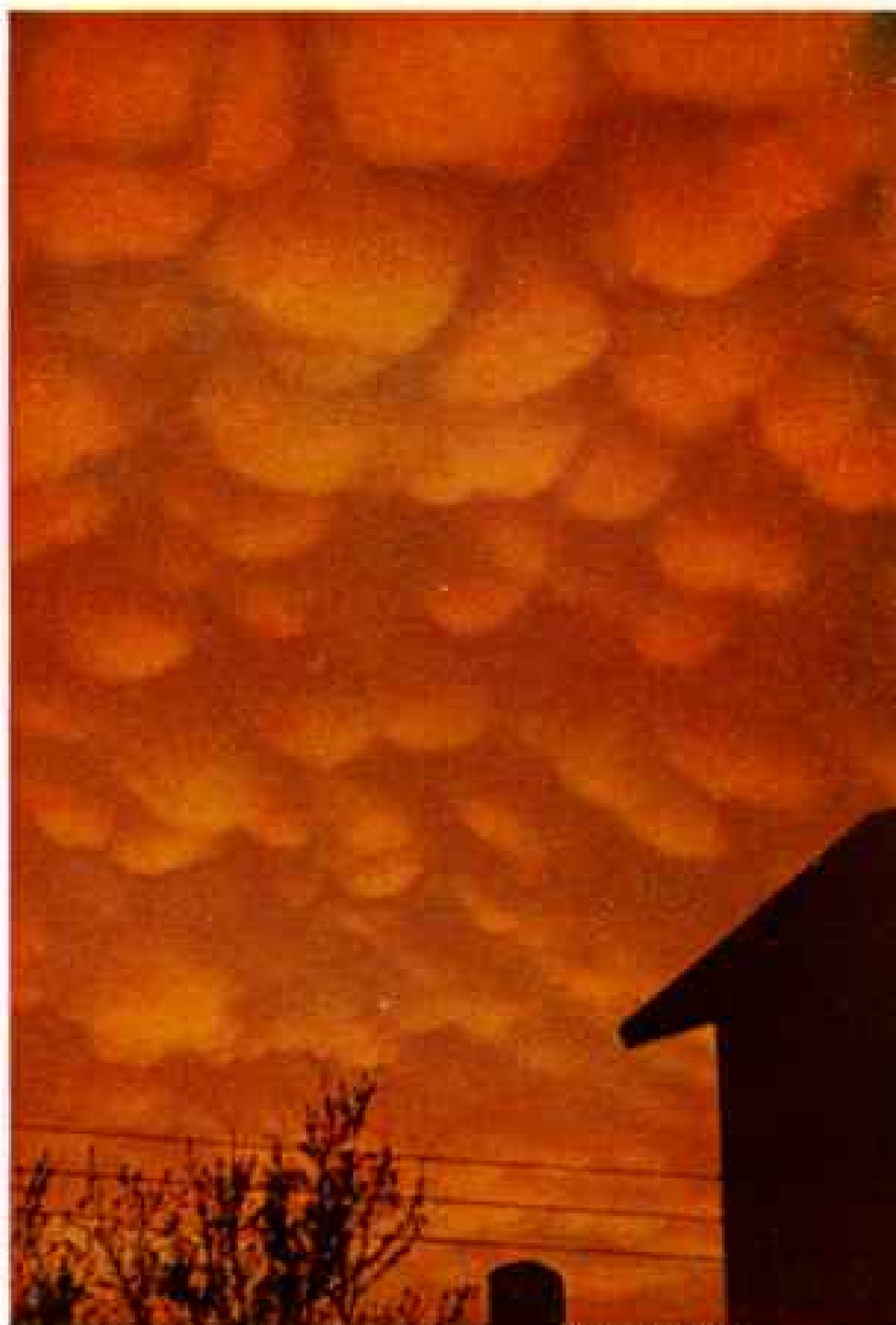
But recent work by Dr. Joanne Simpson, Director of NOAA's Experimental Meteorology Laboratory at Miami, Florida, has developed a new approach and banished much of the doubt about whether rain can be increased from tropical cumulus clouds. Dr. Simpson has used a computer to determine which clouds will respond to seeding. In repeated tests, using silver iodide smoke from planes, the rainfall has been increased by an average of 140 percent, with a probability of only about one in 200 that this difference could have occurred by chance.

And the experiments pay off. Dr. Simpson estimates that in the seeding trials in southern Florida last year benefits exceeded costs by a factor of thirty to one.

One Man's Rain, Another Man's Pain

Paradoxically, not everyone approves of cloud seeding. One economic interest may benefit from increased precipitation, but another may suffer. Some farmers or ranchers may be pleased, but how about the resort operator? And what if there are floods? Already lawsuits have resulted from weather-modification efforts, and rainmaking planes have been shot at by farmers "for interfering with God's weather."

In August 1969 the space-borne cameras



CHARLES W. SHERRILL

Like smoke from a celestial fire, clouds linger in an evening sky after a tornado struck northern Wisconsin. The unusual formation, called mamma, often portends the approach of a hailstorm or twister.

of weather satellites revealed the embryo of a storm in the Atlantic Ocean. Succeeding satellite pictures showed the disturbance to have the whirling cloud vortex of a tropical cyclone. Since it was the season for hurricanes, the men of the National Hurricane Center (part of the Weather Service) in Miami kept a careful watch on the storm's erratic path as it swept across the Caribbean and into the Gulf of Mexico.

Additional information came from ships at sea, from hurricane reconnaissance squadrons of the U. S. Navy and Air Force, and from a weather radar fence that runs from Texas to Maine. Soon it became clear that this storm would reach hurricane force, and that it would be a killer. Hurricane warnings were flashed to Gulf Coast communities in Mississippi and

(Continued on page 541)



Long reach for the weather

WHEN BLIZZARDS HOWL across the Colorado Rockies, this gaudy 12-by-20-foot kite carries instruments nearly 20,000 feet aloft. Thus man monitors one of his most successful efforts to change the weather: the seeding of snowstorms whose melt feeds

the Colorado River—life stream of the arid Southwest.

After seeding snow clouds from silver-iodide generators atop the peaks, scientists send the kite up carrying a replicator (lower left). It exposes coated film that records the imprints of snow crystals (below). These have shown that nuclei may increase snowfall by more than 50 percent.

Silver iodide particles excel as cloud-seeding nuclei because their crystalline structure closely resembles that of ice.





LOWELL J. BOGREN (OPPOSITE); COWAN HOLFF, NCAR (THIS)

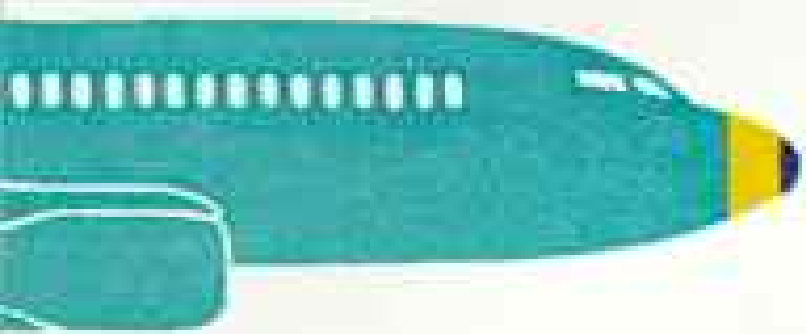
Scouts of the stratosphere, balloons take on helium at Palestine, Texas. Small pilot balloons will detect low-level winds that could disrupt the launch.

Able to drift for hours in the no-man's-land 80,000 to 135,000

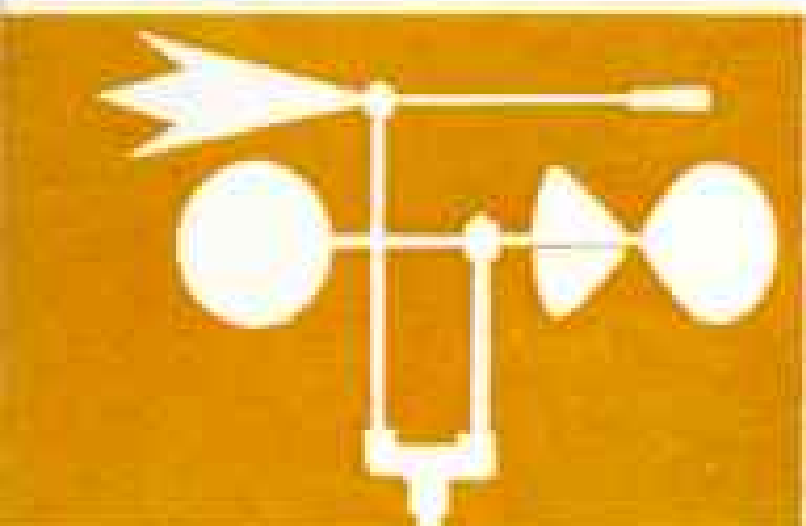
feet up—too high for aircraft and too low for satellites—the balloons' instruments, parachuted to earth, yield data on the chemistry of the stratosphere. Thus scientists extend their reach ever farther into earth's ocean of air.



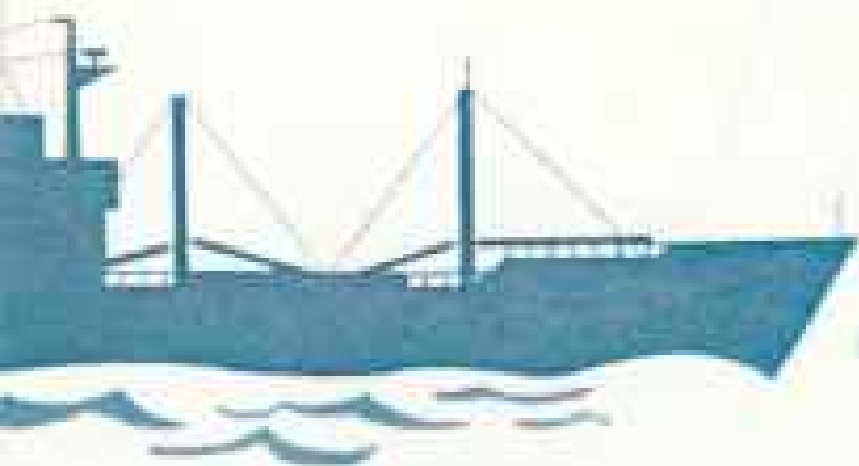
Coordinated by the World Meteorological Organization, national weather offices (white dots) collect data from a vast network of stations and dispense ever more reliable forecasts.



Commercial and military aircraft around the world make some 2,500 reports a day using an international shorthand code understood by weather computers.



More than 1,000 U.S. surface stations daily record barometric pressures, winds, temperatures, and humidity.



Crisscrossing lonely ocean areas, where much of the world's weather originates, ships radio at least 2,500 reports a day.

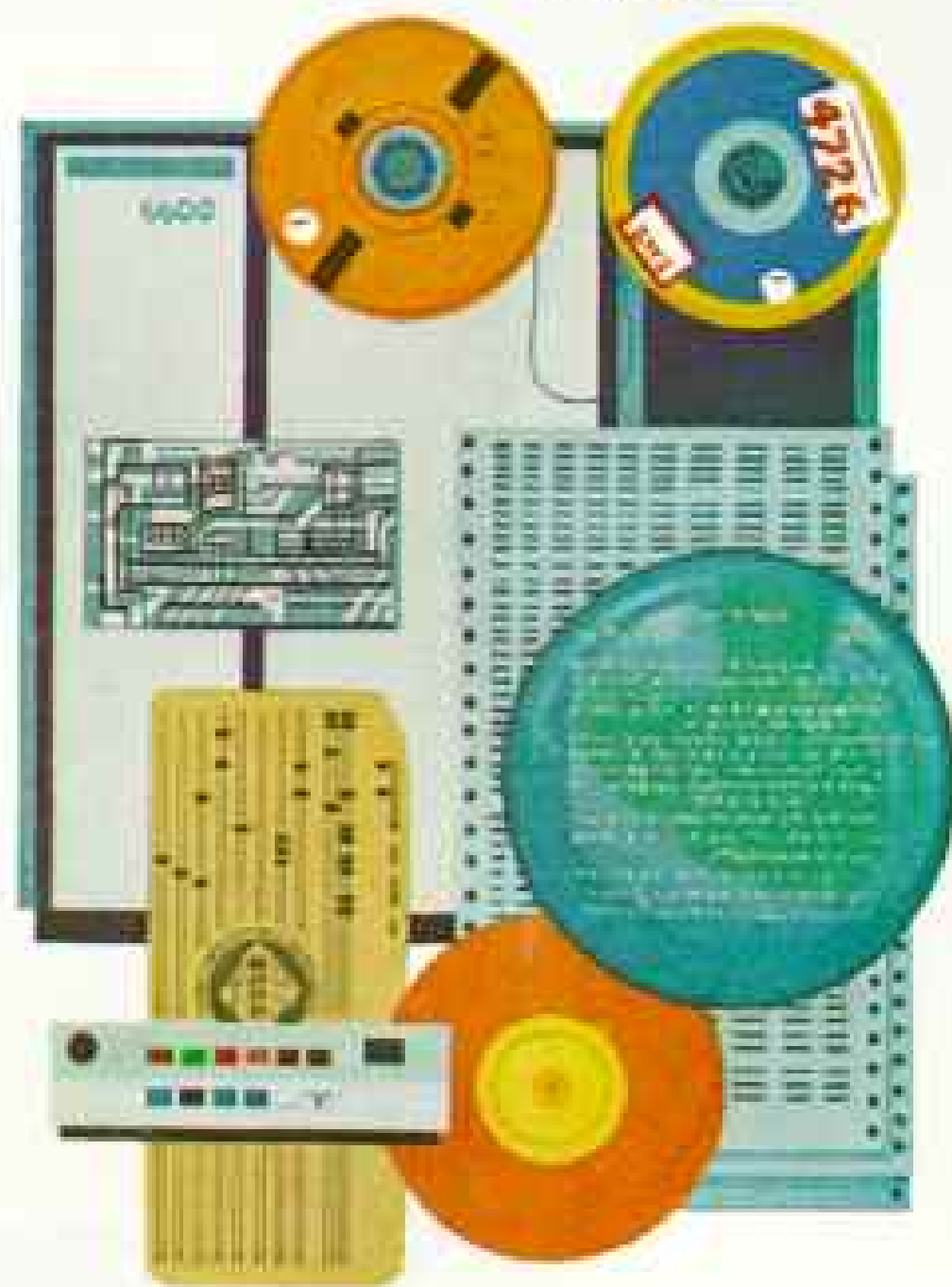


Released twice a day from U.S. weather stations, balloon-borne radiosondes record and transmit atmospheric conditions as high as 100,000 feet.

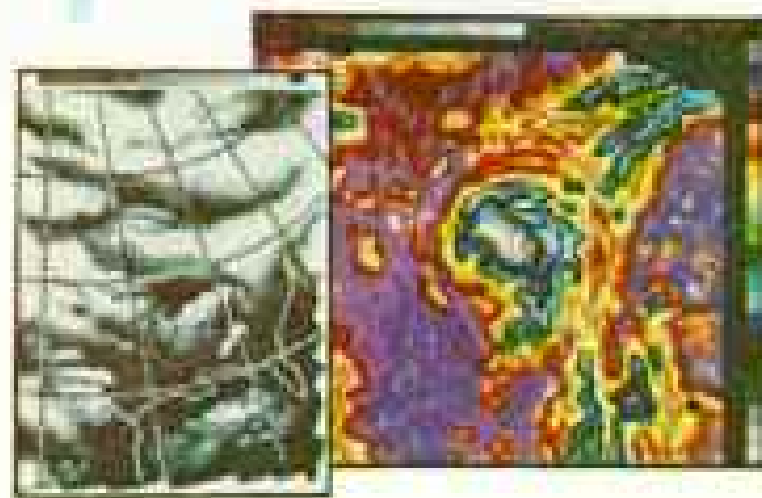


Two ATS satellites hover stationary over the Atlantic and Pacific, reporting global cloud movements.

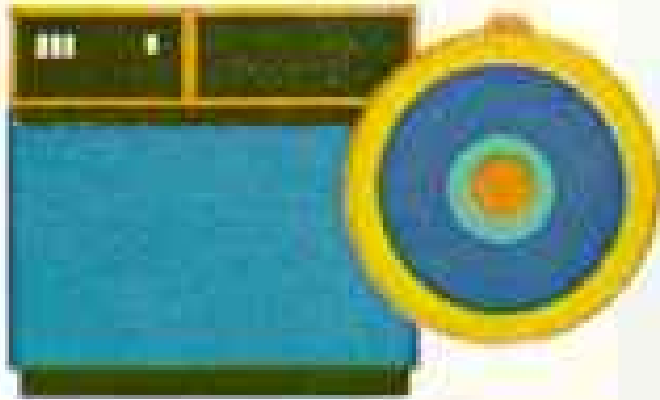
Pouring into the National Meteorological Center at Suitland, Maryland, torrents of weather data in many forms feed into three computers for storage.



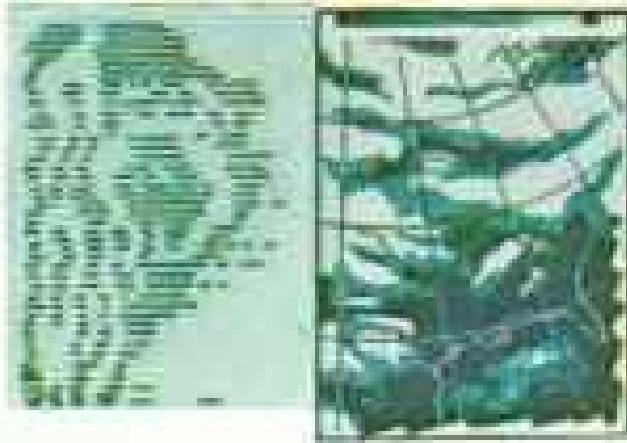
Every 12 hours other Suitland computers print out forecast maps of Northern Hemisphere weather.



ATS satellite pictures help meteorologists analyze cloud cover (left) or a swirling hurricane whose image has been color enhanced by a densitometer.



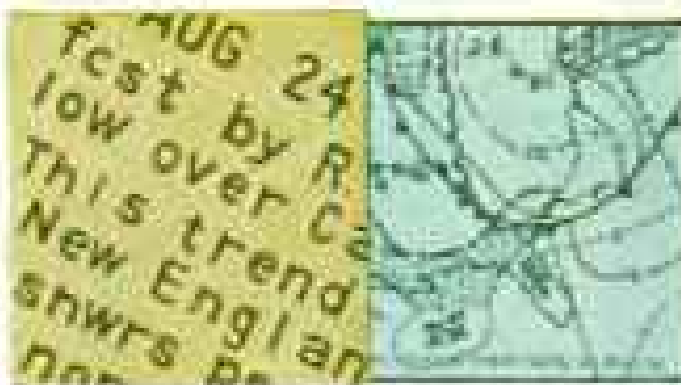
Data stored on magnetic tape permit a variety of research, such as weather's role in recent plane and ship accidents.



As an aid to local forecasters, a computer turns out numerical maps of wind speeds and facsimiles of satellite pictures.



Utilizing data from radar and satellites, a Weather Service meteorologist checks and refines the 24-hour and 5-day national weather forecasts.

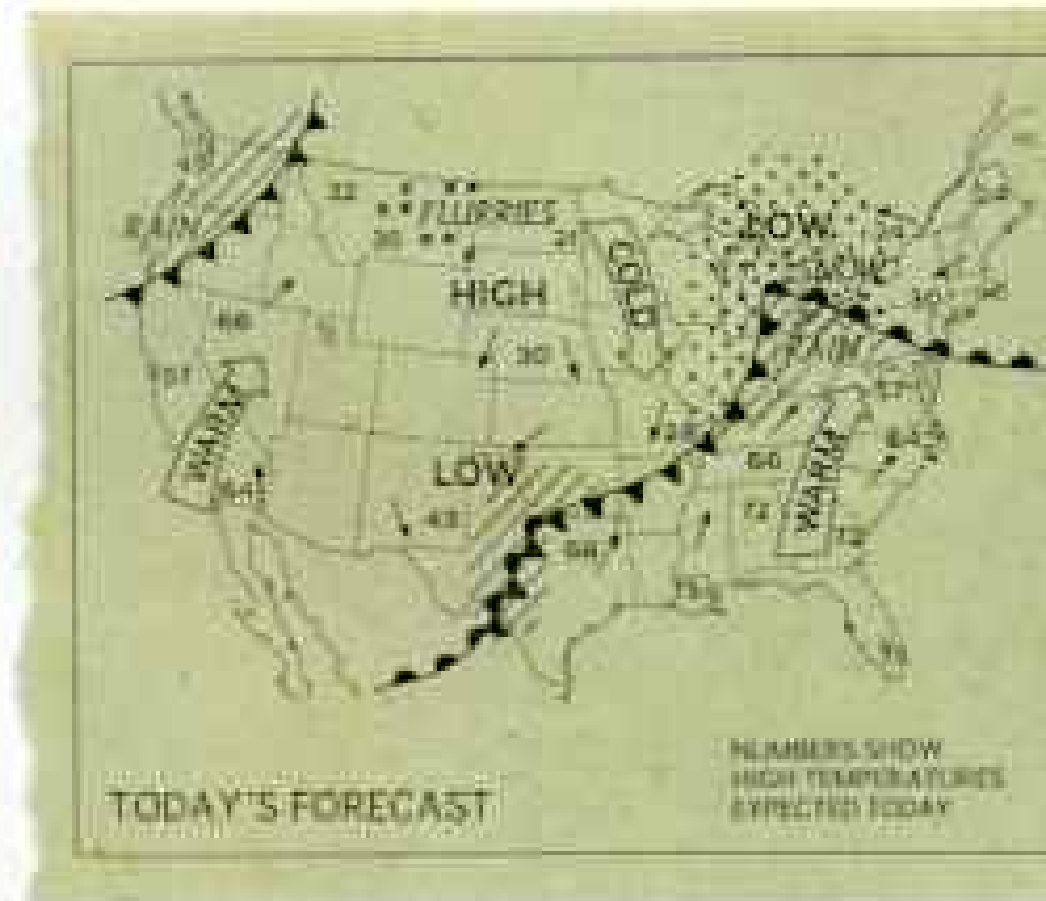


Prepared both in written and map forms, the forecasts flash from Suitland to local weather stations and then to other users, such as newspapers and TV stations.



Radar at weather stations aids local forecasters, whose observations are relayed for the national forecast.

The miracles behind your daily weather map



"THEY'RE calling for showers; better wear your raincoat to school," admonishes a Pittsburgh mother after reading her morning paper. Her faith in the weatherman is justified; he predicts today's weather with more than 80 percent accuracy, thanks to a worldwide network gathering raw data (far left column), compiling and analyzing it (middle column), and producing detailed forecasts for fast dissemination (right). Benefits are incalculable, from airline storm warnings to frost alerts for citrus growers. Evacuation broadcasts before Hurricane Camille saved an estimated 50,000 lives. STAFF WRITER ROBERT C. MAHO



Space Age will-o'-the-wisp, barium vapor glows 100 miles above Alaska. Ejected from a rocket-borne cannister, the cloud turns from red to green as atoms fluoresce under solar ultraviolet. The experiment enables scientists to measure ionospheric winds and other phenomena affecting the lower atmosphere.

To observe such experiments in winter's cold, University of Alaska scientists take refuge in heated viewing bubbles (lower left) atop the university observatory near Fairbanks.



Stuccoed with rime, Mount Washington Observatory in New Hampshire sparkles in rare December sunshine. A meteorologist clears ice from instruments atop the 6,288-foot peak. Beyond the trestle of a cog railway, chains moored in bedrock secure a building against winds that have been clocked at 231 miles an hour—strongest ever measured on earth's surface.



Louisiana that lay in the path of the storm. On the night of August 17 Hurricane Camille roared ashore. Winds exceeding 200 miles an hour and tides surging 24 feet above mean sea level smashed and leveled whole towns on the low-lying coast.

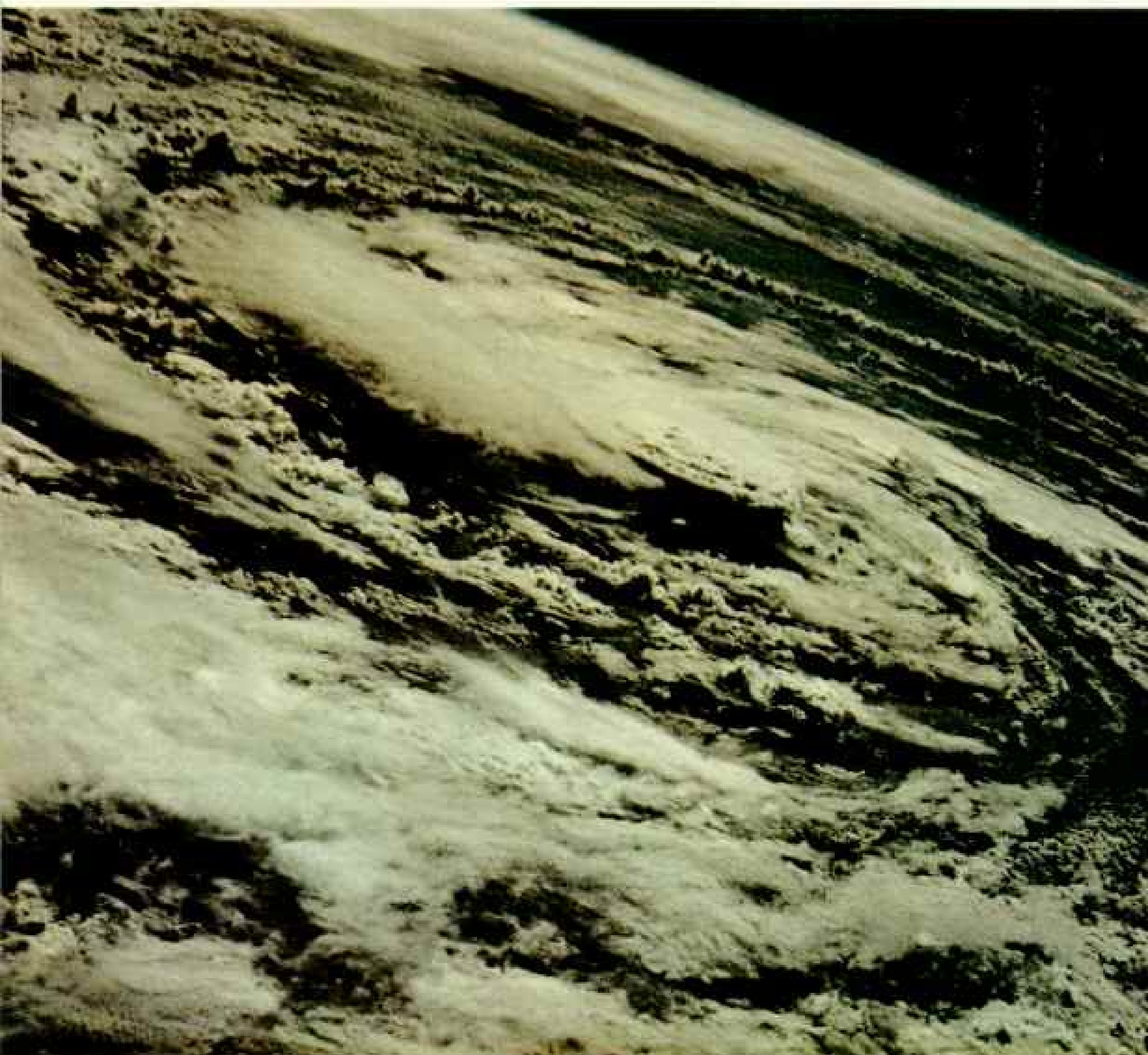
It was the most intense storm to hit North America in modern times. Property damage reached 1.42 billion dollars—a record for a single hurricane.

Relatively speaking, the loss of life was astonishingly small. The dead and missing exceeded 320, of whom more than a hundred died in floods in Virginia, where the hurricane dropped 27 inches of rain in eight hours.

Had it not been for prompt warnings from the Weather Service, the death toll might have been staggering. Because of the warnings, more than 75,000 persons fled to safety. Some 50,000 of those might have died, according to Government estimates, if they had not been warned in time.

The awesome power of rampaging weather was revealed again on November 12, 1970, when a tropical cyclone swept in from the Bay of Bengal to strike East Pakistan and leave between a quarter and a half million people dead. It was the greatest natural catastrophe of this century. Satellite pictures, received by APT stations in Pakistan, gave





warning of the storm. But the crowded populations of the coastal islands did not get the word, and they were overwhelmed by mammoth tidal surges.

Debbie Yields to Stormfury

The Weather Service may properly be proud of its effective storm-warning system, which annually saves many times the total cost of the Government's weather program. But Dr. Robert H. Simpson, Director of the National Hurricane Center, believes that it may be possible to do more, that eventually we can learn how to weaken the fury of a hurricane.

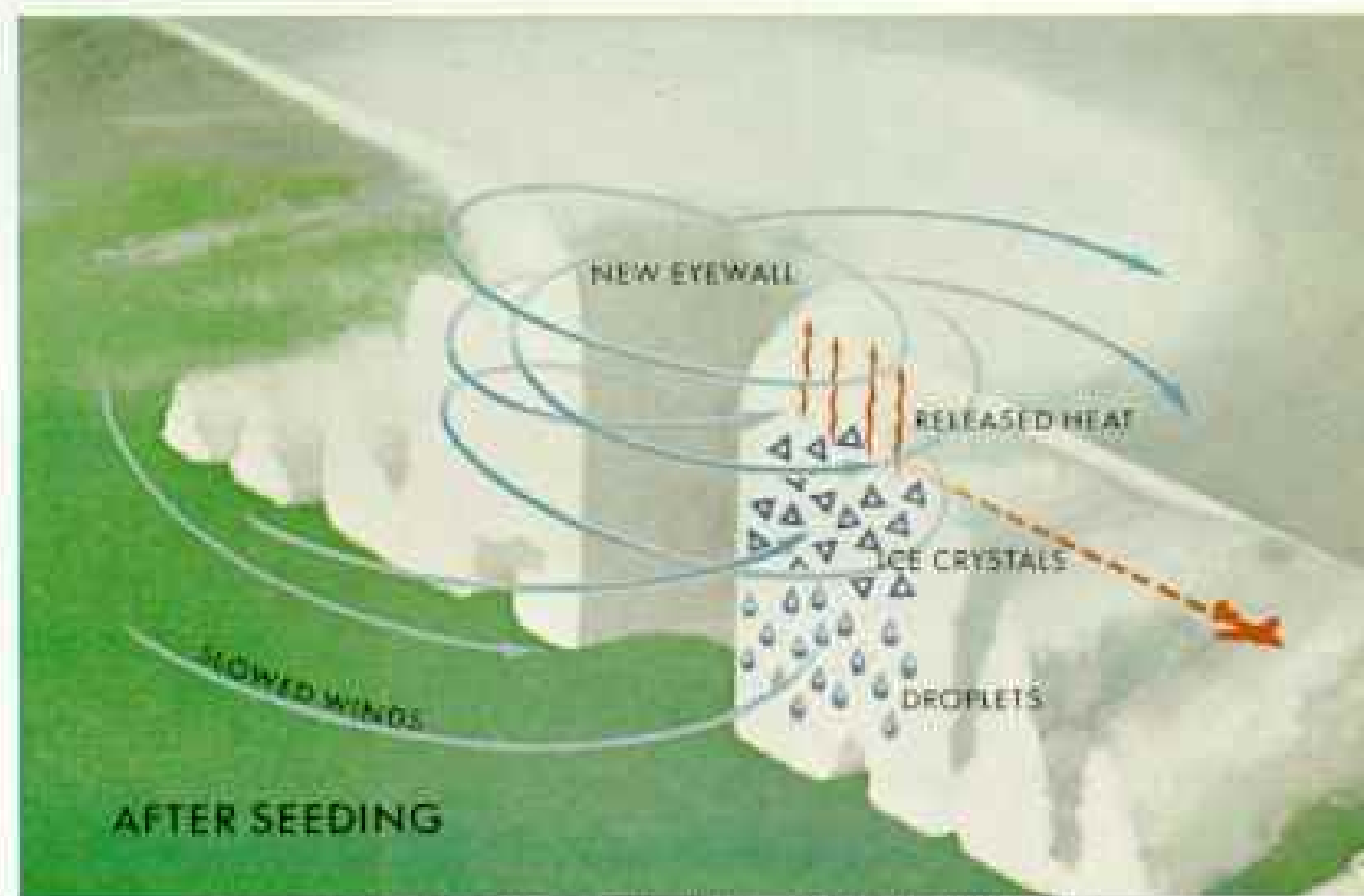
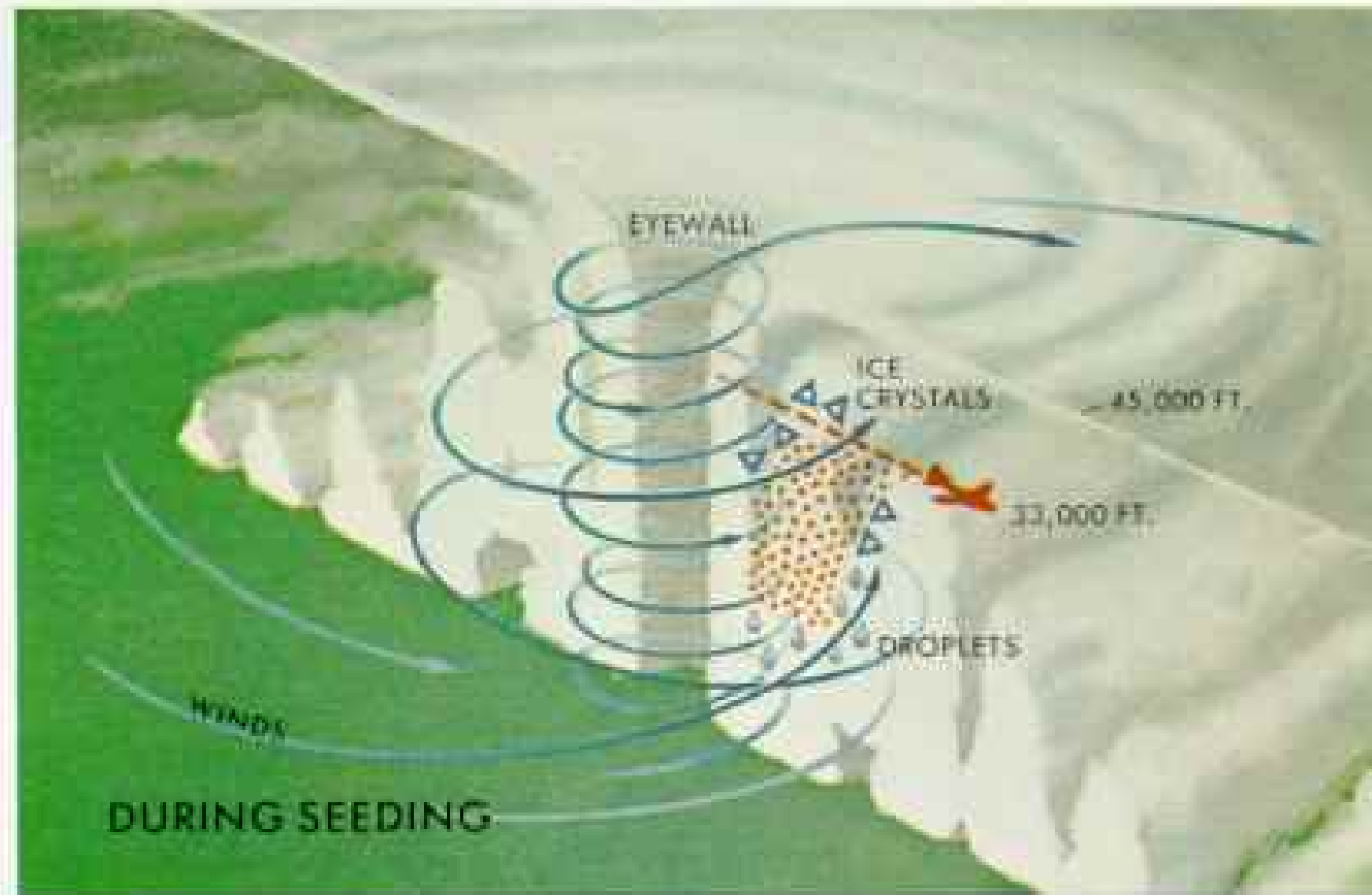
A decade ago Dr. Simpson suggested that

hurricanes might be altered by cloud seeding. If nuclei could be introduced into the rain clouds near the eye of the storm, transforming water droplets to ice crystals and thus releasing heat, the balance of forces in the hurricane might be upset, he reasoned.

Project Stormfury, set up in cooperation with the Department of Defense to test this theory, has seeded four hurricanes, collecting fairly convincing evidence in one case. On August 18, and again on August 20, 1969, aircraft seeded Hurricane Debbie. Five times during two eight-hour periods, specially equipped U. S. Navy planes flew through the eyewall of the hurricane, where the winds are strongest (opposite, upper), and laid down



Sparring with a hurricane



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA) STAFF ARTIST WILLIAM M. BONE

SWIRLING MAELSTROM, Hurricane Gladys spins over the Gulf of Mexico in 1968. Seen by Apollo 7 from 111 miles up, the cyclonic storm heads toward Florida.

Even as Gladys flared with 90-mile-an-hour winds, instrument-laden aircraft plunged into the seething air mass. The planes fed data to Project Stormfury, a national effort to study these weather tantrums and learn how to tame them.

Stormfury sometimes attempts to turn a hurricane against itself. Flying through a storm's eye (**upper**), an airplane

seeds the turbulent eyewall clouds. The nuclei greatly increase freezing, which causes the release of tremendous amounts of heat. The heat disrupts the eyewall, causing it to rebuild outward (**lower**). This extending of the wall slows the leviathan's winds, just as a spinning skater slows himself by thrusting out his arms.

Stormfury's weather warriors shy away from claims of even partial victory, but statistics show that after their most successful assault—on Hurricane Debbie in 1969—winds slowed as much as 31 percent.



curtains of silver iodide particles 16 to 23 miles long and more than 15,000 feet deep.

Meanwhile research aircraft flew across the storm, measuring the winds. On August 18, several hours after seeding, wind velocity dropped from 98 knots to 68 knots. On August 19, with no seeding, the storm re-intensified. On August 20, again after seeding, winds fell off 15 percent.

Dr. R. Cecil Gentry, Director of Project Stormfury, is cautious about these results. "It could have just happened," he admits. "However, when we analyze other storms, we conclude that wind changes this great have not occurred in any of 50 hurricanes that we have studied but not seeded."

A final answer may not be far off; Project Stormfury is continuing its experiments each hurricane season.

Desirable as all this might seem, tampering with hurricanes could also produce undesirable side results. Many parts of the world depend heavily on moisture received from these great storms. Hurricane Inez in 1966, for example, threatened the U. S. Gulf Coast with grave property damage—which fortunately did not materialize. But rains brought by the same hurricane filled the reservoirs of large portions of the Mexican altiplano with sufficient water to assure favorable crops for at least a season.

Whirlwind Poses Different Problems

The tornado—most violent of atmospheric phenomena and the most destructive over a small area—is not so easy to detect in advance as the hurricane. Space cameras cannot see tornadoes; at best, all they can make out are the types of thunderstorms most likely to produce these intense, brief, and unpredictable whirlwinds.

Yet swift warnings are essential. During the 11-year period from 1960 through 1970, 7,428 tornadoes were reported in the United States. They killed more than a thousand people, and might have killed many more except for the efficient warning system. Not a single state has been spared the lash of

the tornado, although it is the special scourge of the Plains States (pages 548-9).

Oddly enough, tornadoes seem to be almost a North American specialty. They occur more often in the United States than anywhere else in the world.

In Oklahoma, in the heart of tornado country, the National Severe Storms Laboratory seeks to learn what makes tornadoes tick, and that's not easy. In Kansas City, the National Severe Storms Forecast Center maintains a ceaseless vigil, constantly analyzing atmospheric conditions across the country and coordinating the reports of hundreds of local Skywarn networks.

When an area is threatened, a tornado watch goes out via radio and television. When one of the terrifying funnels is sighted, or when radar picks up an echo with the shape of a hook or a flying eagle, characteristic of a tornado-producing cloud, every means of communication is mobilized to warn people to take shelter immediately.

Tornado Alarm All Too Successful

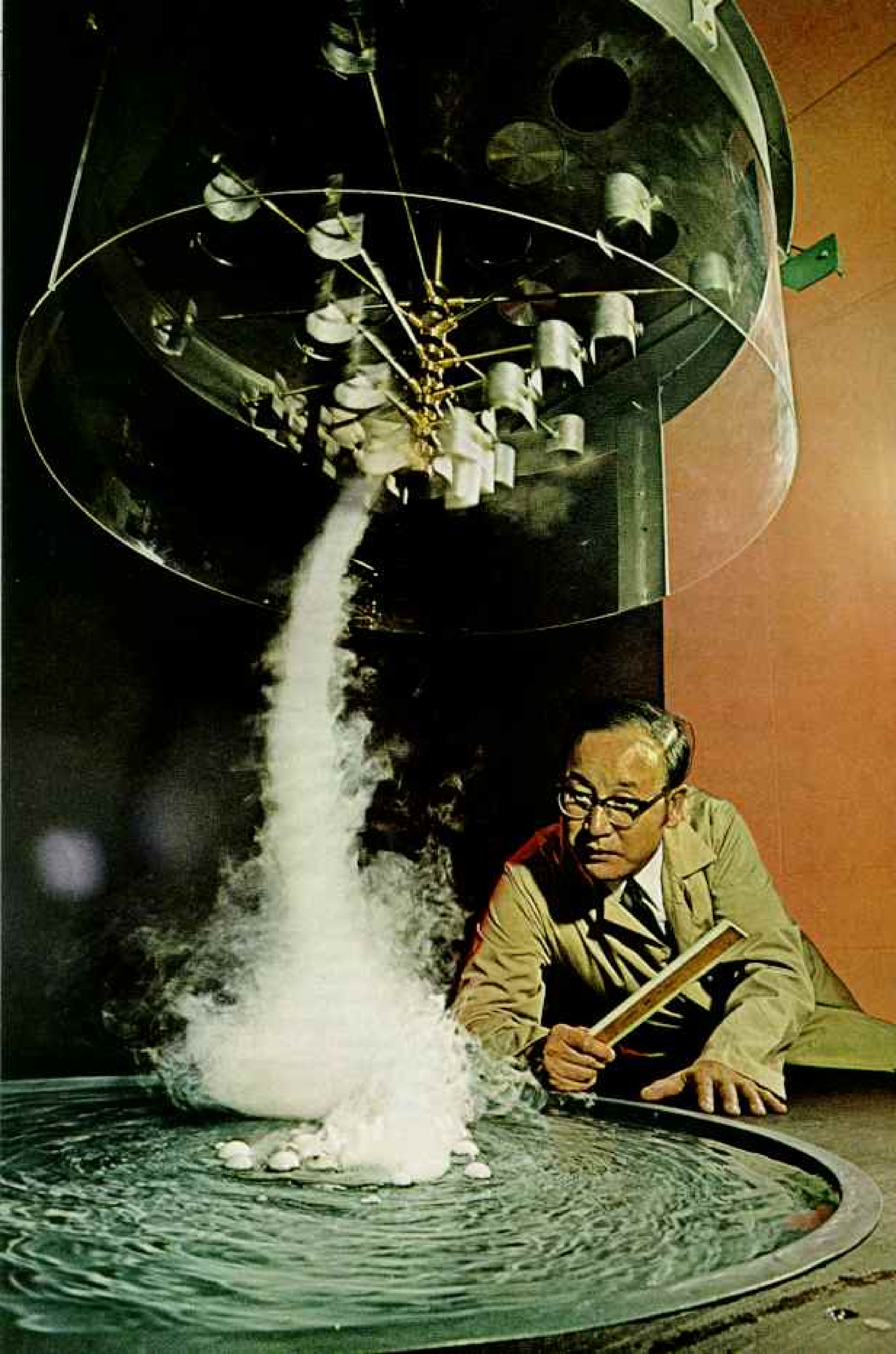
Allen Pearson, who for years has headed the forecast center in Kansas City, tells about an encounter with a lady who was displeased with the warning system.

"She called me up to protest that the tornado watch had kept her in her basement for five hours, and nothing happened," says Al. "I tried to explain that we didn't want to alarm her; we just wanted her to be aware. Unfortunately, the same thing happened again five months later. She was really angry that time; we had given a warning but there was no tornado.

"Two years later, we had a really big storm. The lady came up out of her shelter to find her house blown away. She got me on the phone and said, 'Now, that's more like it!'"

If anyone ever figures out how to mitigate the fury of a tornado, that man may be Dr. T. Theodore Fujita of the Department of Geophysical Sciences at the University of Chicago. His intensive studies during the past 20 years of the behavior of these devastating

Goring the earth, a tornado roars across a wheat field near Kingfisher, Oklahoma. Scooped-up debris darkens the vortex; streaks within the funnel reveal a second, inner core—a tornado feature not commonly visible. Each year hundreds of twisters wreak death and destruction on "Tornado Alley," a wide belt across the Great Plains where warm and cold air masses frequently collide. AP/WIDE WORLD



funnels have earned him the sobriquet "Mr. Tornado."

A visit to Dr. Fujita's laboratory is a fascinating experience. With the aid of skilled machinist Vincent Ankus, he has built a wondrous tornado machine (left). A few minutes' preparation and the flick of a switch—and before your eyes miniature funnels dance and spin as do their lethal counterparts on the plains of Texas.

Wind force for the machine comes from an overlapping series of rotating cups, turning slowly at the outside but more rapidly toward the center, so that the suction is greatest in the middle.

Several feet below this apparatus sits a large tray filled with water. Dr. Fujita adds chunks of dry ice. The water bubbles like a devil's caldron, with "smoke" from the dry ice writhing and flowing above it.

Heat Tames a Man-made Twister

Mr. Ankus turns on the machine. Instantly the smoke whips into a dazzling funnel, dancing erratically about the pan as it feeds into the exhaust fan above.

Now Dr. Fujita experiments to see what will affect his miniature maelstrom. He positions a framework of electrical wires so that they extend through the funnel; nothing happens. But when he turns on the current and the wires glow red, the funnel seems bewildered and tends to break up. Heat is poison to it.

Next he pokes a ruler into the spinning cloud. If held out flat, there is little effect; if

turned on edge, the funnel falters. Similarly, if suction is made uniform over the area of whirling motions, the action is damped.

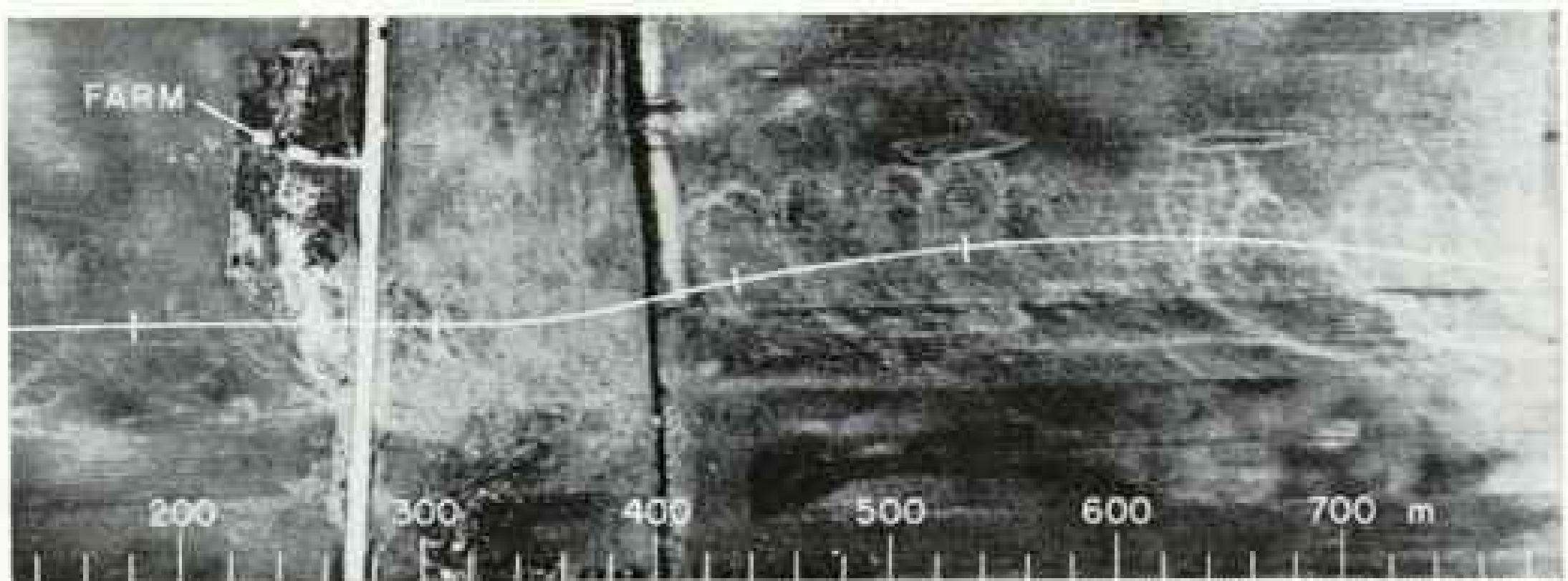
Says Dr. Fujita, "I hope that within ten years we will learn from experiments like these how to modify real tornadoes."

Suction Spots Cause Super Violence

Dr. Fujita shows visitors a picture of a tornado aftermath in which one house is totally destroyed and the next is virtually undisturbed. Such variable damage is common, supposedly because the tornado skips and jumps. That may not be the answer at all, the scientist believes. Instead, the heaviest destruction may be caused by areas called "suction spots" in the funnel wall, which Dr. Fujita was the first to explain.

"A tornado moves across country at an average speed of about 30 miles an hour," he says. "The funnel itself rotates at speeds that may vary from 50 to 200 miles an hour. But carried along in the wall are three or four, sometimes five spots, that have an additional rotation of as much as 100 miles an hour. They may measure only a twentieth of the diameter of the funnel, but the suction in that small area is much greater than within the tornado as a whole."

Dr. Fujita discovered this phenomenon when he noticed in his voluminous file of photographs of tornado destruction that the worst damage often appeared along spiral lines. Each series of loops marked the devastating track of a suction spot (below).



ARVIND K. BOCCACCIO (LEFT), T. THEODORE FUJITA

Laboratory twister sucks up dry-ice vapor at the University of Chicago. By spinning overhead wind cups as fast as 20 revolutions a second, Dr. T. Theodore Fujita simulates the motion of the parent cloud that creates a tornado's funnel.

Spiral wake of an Indiana tornado (above) betrays the presence of hidden fangs. Dr. Fujita discovered that the pattern, common to many twisters, stems from small but incredibly violent "suction spots" that spin within the funnel wall (see text above).

Birth of a twister: Spotting a suspicious cloud near Salina, Kansas, on May 11, 1970, two highway patrolmen radioed a warning, then leaped from their squad cars and started clicking their cameras. Seven minutes later they had recorded one of the most dramatic known sequences of a tornado's fearsome growth.

Pudgy and harmless at first, the incipient twister bulges from the cloud base two miles away. Already, winds probably coil below, perhaps even reaching the ground 3,000 feet beneath.

Finally the cloud elongates, tapers, and takes on its dreaded spin. Its winds probably now reach 200 miles an hour. Happily, this tornado swept across largely open land.



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RONALD BRUNNENBERG COLLECTION/RETNA





HENRY FERTZ AND G. VERNON DAVIS, KANSAS HIGHWAY PATROL



◀ Three tornadoes in two hours swept Fridley, Minnesota, on May 6, 1965. Winds estimated at 200 miles an hour caused only two deaths in the Minneapolis suburb but demolished 425 homes; 1,100 more were severely damaged. Houses intact amid the ruins illustrate the storm's fickle wrath.



A "roll" cloud leads a thunderstorm across Patrick Air Force Base, Florida. Warm currents,

Remarkably enough, this brilliant scientist, who has contributed so much to our knowledge of tornadoes, has yet to see one of the storms in action!

While not as dramatic as tornadoes, hailstorms cause even more economic loss. In a deep-freeze cabinet here at NCAR lie the pieces of a knobby, grapefruit-size lump of ice (page 553). It is the largest hailstone ever known to have fallen in the United States—17½ inches in circumference and 1.67 pounds in weight. It struck the earth during a severe

storm at Coffeyville, Kansas, in September 1970, together with hundreds of other huge stones that crashed through roofs and put enormous dents in automobiles. A local newspaper shipped the chunk to NCAR in an insulated box packed with dry ice.

Fortunately, few thunderstorms produce such lethal missiles. Yet much smaller hailstones can do tremendous damage, smashing wheat fields flat and stripping corn to ribbons. Total losses from hail in this country run as high as 300 million dollars annually.



JAMES AL MEYER

driven upward as the cooler storm air advances, shape this usually harmless arcus cloud.

"Hail Alley"—an area extending from southeastern Wyoming to western Kansas—bears the brunt of U. S. hail damage. Here the National Hail Research Experiment, a cooperative effort involving NOAA and a number of universities as well as NCAR, will try in the next few summers to find out just what happens inside hailstorms and whether man can modify or prevent them.

Experience in the Soviet Union already indicates that cloud seeding may be the answer. The theory on which the Russians operate,

developed by Dr. G. K. Sulakvelidze, suggests that hailstones grow as they move slowly through freezing levels, buoyed by strong updrafts reaching as much as 65 miles an hour. When the weight of the ice finally exceeds the force of the updraft, the stone falls to earth. From two miles up, if it is no more than three-quarters of an inch in diameter, it may totally melt before it reaches the ground.

Guided by this theory, the Russians have set up batteries of anti-aircraft guns and rockets in the wheat fields of the Caucasus.



Harvest of heartbreak: Cornstalks bow to a deluge of ice near Viroqua, Wisconsin. Hail destroys 200 to 300 million dollars' worth of crops and property each year—a greater toll than that taken by tornadoes.

Fighting back at man's ancient scourge, Australian farmers aim rockets into clouds that threaten their vineyards with hail (below). The missiles will explode at 4,000 feet and spew cloud-seeding chemicals, perhaps causing rain to fall instead.

In the Soviet Union, scientists claim success in hail suppression by firing chemicals into storms with rockets and batteries of antiaircraft guns.



RURAL LIFE PHOTO SERVICE (LEFT); BRUCE MOORE, BLACK STAR (RIGHT); NATIONAL CENTER FOR ATMOSPHERIC RESEARCH



Record-breaking hailstone, this knobby giant weighed $1\frac{3}{4}$ pounds before being sawed into sections in a cold room at NCAR (top). It and other grapefruit-size missiles rained down near Coffeyville, Kansas, in 1970, crashing through buildings and pounding huge dents into cars.

Gemlike in polarized light, a thin section of the Coffeyville specimen (above) exhibits the crystalline structure of hailstones—a pattern that tells much about their growth. Water flowing to the top as the stone fell through supercooled clouds created the irregular knobs.

Shroud of the cities: When a blanket of warm air overlying a cool heavy layer traps a city's smoke, the inversion breeds the grimy pall known as smog. A deadly fog (right) darkens New York City in a 1966 inversion that was blamed for scores of deaths. Learning how buildings and freeways affect the movement of air in a city, Colorado State University scientists simulate an inversion over Denver by flooding a model of its downtown area (below) with air cooled by dry ice.



When radar pinpoints the position where hail is beginning to form, salvos of explosive charges containing silver iodide are fired high into the storm clouds. The tiny silver iodide crystals serve as freezing nuclei; they scavenge out water vapor and turn it to sleet before it can become damaging hail. The Russians say they have reduced hail damage by 85 percent in some regions, and they now apologize if hail falls in the seeded areas.

Is a New Ice Age Coming?

I have mentioned several examples of man's deliberate efforts at weather modification. In the view of some scientists, man may also be modifying the weather inadvertently through his pollution of the atmosphere, and the changes he is bringing about may be of the utmost concern.

Of course, even without man's intervention, world climate has varied considerably in historical times. Between 550 and 500 B.C., for example, about the time of Cyrus the Great of Persia, an abrupt change appears to have affected the entire Northern Hemisphere. In my opinion, it may have altered the course of Western history.

Northern Europe, before that time, had seen centuries of relatively mild and favorable weather. Then, about 500 B.C., the change for the worse seems to have shortened the growing season in Scandinavia radically. Cold, stormy weather closed Alpine passes of central Europe that had been open trade routes for at least 1,300 years. It may well be that the legend of the "Twilight of the Gods" comes from the hardships attendant upon this climatic disaster. It was nearly a thousand years before northern Europe fully recovered from this adverse period.

Later, the major part of the 11th century A.D. was warm and favorable in northern Europe, leading to Viking explorations and Leif Ericson's voyage to North America. But the 13th, 14th, and 16th centuries saw periods of worsening climate in northern Europe, with disastrous crop failures and famines. Similarly, the early part of the 1800's had increasingly bitter weather.

In the late 1880's a gradual but steady warming trend set in. In the United States it continued until about the middle of this century. Could it have been at least partly caused by man? Some scientists think so; they



LOWELL J. COONIA (LEFT), SUSAN WICKHART, PHOTO RESEARCHERS

blame it on the enormous increase in the industrial burning of fossil fuels—coal and oil—which pours vast amounts of carbon dioxide into the atmosphere. Since carbon dioxide permits the sun's radiation to pass through the atmosphere but tends to trap heat radiating out from earth, it might be responsible for the warming.

There were dire predictions that, if the trend continued, the world might warm up enough to melt the icecaps of Antarctica and Greenland, raising the seas and inundating all the world's great seaports.

But since about 1940 the trend has clearly reversed; we are now in a cooling phase. And again the finger may point to man. Some ecologists are convinced that man's pollution is building up a layer of particles in the atmosphere that—together with volcanic dust—blocks more and more of the sun's energy.

Airborne particle pollution has doubled in the Northern Hemisphere since 1910, from dust, smoke, and the invisible particles in automobile exhausts.* And the rate of such pollution is rapidly increasing.

*Gordon Young discussed "Pollution, Threat to Man's Only Home," in the December 1970 *GEOGRAPHIC*.

Could this mean a new ice age? The Russian climatologist M. I. Budyko has suggested this sobering possibility.

And only last summer a report in the journal *Science*, by Dr. S. I. Rasool and Dr. S. H. Schneider, echoed the threat: If the rate of pollution increases during the next 50 years as much as the authors expect it to, the average surface temperature of earth could well drop by about 6° F. This decrease may sound small to the layman, but to scientists it would be a large and serious change.

"Sustained over a period of a few years," says the report, "[it] is believed to be sufficient to trigger an ice age."

Fortunately, the authors hold out one bit of comfort. Within 50 years, they suggest, nuclear power may have replaced fossil fuels in energy production, and contamination of the atmosphere may have been curtailed.

Mark Twain, years ago, said that "everybody talks about the weather, but nobody does anything about it." The remark was not original with him, but no matter. If Twain were here today, I'm sure he would change his mind. Man *is* doing something about the weather, for good and for ill. □

Easter Greetings From

WHEREVER Ukrainians live, an ancient and beautiful folk art flourishes anew each Eastertide. An outsider marvels, watching the ritual unfold. On a table he sees a lighted candle and a lump of beeswax. Nearby lies a *kistka*, a small writing instrument. Half a dozen jars of brilliant dyes stand at one side. In a bowl rest pagan symbols

of the life force—freshly laid eggs, white, blemish free.

Now a handsome dark-haired woman wearing an embroidered peasant blouse seats herself, bows her head, and makes the sign of the Cross.

"*Bozhe blahoslovy i pomozhy,*" she prays. "God bless and help us." As her sun-worshipping ancestors decorated eggs in joy



the Ukrainians

at the rebirth of spring, so she commemorates the rebirth of man.

She picks up an egg. Swiftly, surely, she writes on it with the kistka, flowing straight lines of melted beeswax onto the curved surface. Her basic design emerges, and she dips the egg in the lightest

(Continued on page 562)



*S*YMBOLS OF SPRING'S REBIRTH, eggs glow with brilliant designs created with wax and dye. Ukrainian communities fashion the keepsakes for Easter gift giving, a hallowed custom brought from their east European homeland.



WORK OF WORSHIP produces a token of love. Twenty-one-year-old Christine Ambroziak (left) of Minneapolis, Minnesota, asks God's blessing as she decorates an egg to present to her beau on Easter morning.

Mrs. Luba Perchyshyn, also of Minneapolis, demonstrates the technique she learned from her mother. Some people first empty the eggs through pinholes, but Mrs. Perchyshyn does not; the contents eventually dry up. Her tool is a *kistka*, a brass cone mounted on a stick.

Heated over a candle and filled with beeswax shavings, the cone flows with the melting, soot-blackened wax, as a pen flows with ink (1). These first lines shield the egg's natural white during the many dye baths that follow. Mrs. Perchyshyn adds successive colors with the dye dips or a brush, covering each new tint with more wax from the *kistka* (2).

A bath in yellow (3) shades all areas of the shell not yet protected. After drying the egg with tissues,

she creates designs in yellow by covering areas of that color with wax. Then she repeats the process of waxing (4) and dyeing with progressively darker colors. The last bath this egg receives is black.

Warming the egg over a candle melts all the wax (5), and polishing with a tissue reveals the various colors (6). A coat of varnish adds protection and luster.

Some women become masterful artists, creating as many as a hundred different designs each season. The rooster drawn here represents fertility and fulfillment. Blessed and displayed in the home, the eggs signify God's protection, especially against fire and lightning.





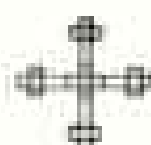
In the language of symbols, a triangle represents the Trinity, and netting suggests Christ's fishing for men.



The fish became a sign of Christ because an acrostic from the Greek words for "Jesus Christ Son of God Savior" is ichthys—Greek for fish.



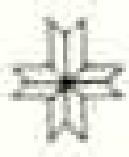
Wheat, betokening a bountiful harvest, reminds that since early times the Ukraine has been a breadbasket of Europe.



Emblem of the suffering, death, and Resurrection of Christ, the cross appears in many forms.



SHUTTER V. 04432



When Ukrainians accepted Christianity in 988, the eight-pointed star, then the sign of a sun-god, became a symbol of Christ.



Dots depict stars in the heavens, and also recall Mary's tears when, a legend tells, Pilate refused her plea for mercy.



Deer and other animals of the Carpathian Mountains signify prosperity.



Waves and ribbons circling an egg, without beginning or end, suggest eternity.

dye bath—yellow. A succession of other designs in wax and dippings in ever-darker dyes ensues; the technique is akin to batik.

Finally she wipes off all the wax—and behold! A fragile jewel. A breathtaking delight. A coat of varnish seals the pattern; the yolk will eventually become a dry lump and the white will turn to dust. The ornate shell will last indefinitely.

Ukrainians call these intricately decorated, exquisitely colored Easter eggs *pysanky* (from the verb *pysaty*, to write) and pass the tradition down from mother to daughter.

In America it thrives best perhaps in Minneapolis and St. Paul, to

“I had to
decorate
an egg”

the intense satisfaction of 84-year-old Alexander A. Granovsky, a leader of the Ukrainian community in the Twin Cities and an authority on the art and culture of his homeland. An entomologist, he is a professor emeritus at the University of Minnesota.

“When I came to St. Paul in 1930,” Dr. Granovsky recalls for a visitor at his home, “I found a depressed spirit. My people—poor peasant immigrants, most of them—were submerged in the American melting pot. They were ashamed to show their national costumes, to make the beautiful Easter eggs.

“I tried to encourage them. I told them to be proud. ‘We came here not only with our hands,’ I said. ‘We brought a great cultural heritage.’”

The short, stooped scientist sorts through his *pysanky* collection as he talks—fifteen hundred decorated eggs, each different, four decades in the gathering, probably the largest collection in the United States. He handles the eggs as deftly as he handles words.

“Gradually our heritage renewed itself. A few women had always decorated eggs for their own satisfaction; now others joined in. Soon bookstores and gift shops in New York, Philadelphia, Cleveland, Chicago, and elsewhere began to place orders. Here in the Twin Cities this lovely

tradition was reborn in America.”

One who never put it aside is Mrs. Marie Procai. Much of *pysanky*'s popularity in the U. S. today may be traced to this gentle woman's love for the art. She brought the technique with her nearly 60 years ago as a 15-year-old immigrant girl, having learned it from her grandmother in the western Ukraine.

“Three weeks before Easter she would begin,” Mrs. Procai says softly, memory bright as Eastertide's sharp sunlight. “She made *pysanky* by the stove where she baked bread. When I came to Minneapolis, I was homesick. At Easter, I had to decorate an egg. It was something in me.”

For a *kistka*, she used the metal tip of a shoelace. At first, her lines of wax looked like noodles. She persevered. In time she began presenting eggs to friends. Then she started giving demonstrations in department stores.

Today Mrs. Procai and her daughters, Mrs. Luba Perchyshyn and Mrs. Johanna Luciw, operate a Ukrainian gift shop. They handcraft thousands of *pysanky* a year, shipping them throughout this country and abroad.

Even a ham-handed male beginner can receive encouragement at the gift shop. “Anyone can become proficient,” Mrs. Perchyshyn, a vivacious brunette, reassures him. “It's just a matter of practice. I love to do this. Sometimes I get up at 4 a.m. and work until midnight.”

Mrs. Perchyshyn takes from 15 minutes to several hours to decorate an egg, depending on the complexity of its design. But simple or complex, similar symbols are used. All have meaning. When she traces an eight-pointed star, for example, she harks back to a sun-god worshiped by the early Ukrainians; a triangle symbolizes the Holy Trinity; a fish, Christianity; a bird, fertility.

Blessed by a priest, *pysanky* are believed to contain talismanic powers. People exchange them after Easter services as gestures of friendship. Girls offer their best handiwork to their favorite young men, and friendship takes on a new dimension. Displayed at home, *pysanky* serve as

protection, some Ukrainians say, against fire and lightning. Mrs. Perchyshyn often gives eggs featuring a hen or rooster motif to childless married women.

One antique belief is especially intriguing: The fate of the world depends on the making of pysanky. Should the custom cease, evil in the form of a chained monster will burst his fetters and devour us all. In a year of few eggs, his chains loosen and evil spreads. In a year of many, the monster cannot move.

Love conquers evil. After church services on Palm Sunday, women's auxiliaries hold their annual Easter egg and bakery sales. In the auditorium of St. Michael's Ukrainian Orthodox Church in Minneapolis,

bountifully laden tables stand along both sides of the room, across the front, and on the stage. Parishioners and visitors mill about in jovial fellowship, festive for a festive occasion. Ladies of the church have fashioned and donated more than fifteen hundred pysanky. All will be sold before the afternoon is out.

At one table, children in national costume are busily decorating eggs. A spectator asks pert 10-year-old Jill Haywa to hold up her handiwork.


She does, and he pronounces it lovely. "Are you making it for your boyfriend?"

Head bobs, blond tresses fly, blue eyes widen. "I'm going to make him a better one than this," she whispers. "There's a rumor he loves me." □

Ukrainians in Winnipeg, Manitoba, bring eggs and bread to Holy Saturday services.







Diving With Sea Snakes

By KENNETH MACLEISH

SENIOR AMERICAN EDITOR

Photographs by BEN CROPP

AT FIRST it was only a motion, a fluid curve rounding into a recurve on the coarse sand of the sea floor. Distinct from the restive darting and questing of the uncountable kinds of fish that crowd Australia's Great Barrier Reef, it was a movement that has evoked human fascination and fear since man became man.

Motion merged into matter. The sea snake moved away, lissome and unhurried. I followed, finning along the surface.

An air-breather fashioned in the forests of the earth, this cousin of cobras has become a water animal, destined to remain forever a creature of the sea. His family, the Hydrophiidae, is large and varied. Its members are probably the most numerous snakes in the world. Yet they are the least known of reptiles; few people of the West are aware that sea serpents, monsters of every mythology, actually exist. And they are perhaps the most venomous of vertebrates.

Death lunges at the author near Australia's Swain Reefs. The olive sea snake struck repeatedly during a two-minute attack. Had the stubby fangs of *Aipysurus laevis* penetrated Mr. MacLeish's quarter-inch-thick wet suit, he probably would have died. No antivenin exists for this species.

Science knows little about these sea creatures. For this expedition, the author joined forces with a team of Australian divers and an American herpetologist studying sea-snake behavior, venoms, and anatomy.



Lidless eyes ever open, an olive snake sleeps beneath corals that forest the warm transparent waters of Saumarez Reef (above). Another noses about for food (right). Slower than the fish they eat, the sinuous hunters trap finned quarry in reef crannies, quiet them with powerful venom, and swallow them whole. These relatives of cobras, which breathe air but feed on the bottom, rarely venture deeper than 100 feet. Some can stay down for two hours or more before having to come to the surface.





A large and undeterminable number of human beings—Asian fishermen, mainly—have died from the bites of sea snakes, some of which possess a venom many times more virulent than that known for any land snake. Despite the fact that short fangs and—in some cases—small heads may make biting difficult, despite the reluctance of certain genera to attack even when provoked, bites do occur and fatalities follow.

The bite itself is painless. However, after several hours the legs of the victim become paralyzed, his eyes close, and his jaws lock. He may live for several days before convulsions and respiratory failure bring death.

Beware of the Surfacing Serpent

"Snake country," Ron Isbel had said, easing his 43-foot steel-hulled *Sea Hunt* into the shelter of a reef. The "country" was all beneath the surface. Here in the Swain Reefs, 160 miles from Queensland's coast, only a few treeless sand cays rise above the sea.

We had come to this remote region of bursting surf and treacherous shoals to observe and photograph sea snakes underwater—something few divers and fewer scientists have done. We hoped to study their foraging and feeding patterns, their relationship to other reef animals, and their behavior toward man, a matter of considerable personal interest to us, the potential victims.

The Swain group, and the Saumarez Reef beyond in the Coral Sea, contain superb settings, the extreme clarity of water we required, and several species of sea snakes. So said Ben Cropp, one of Australia's best divers and undersea photographers, when he suggested our expedition. Dr. Harold Heatwole, an American herpetologist at the University



of New England, in New South Wales, agreed.

They were right. As we swam along that first day, a second snake appeared, then a third. Ben, Hal, and I converged on them. Eva, Ben's wife and diving partner, joined us. Before long, we knew, one of the snakes would come up for air.

"That's the worst time," Ben had warned us. "That's when they notice you, and sometimes come right at you."

Suits Protect Against Cold and Quarry

Ben and Eva set their underwater cameras for close range. Hal and I tested our snake sticks—aluminum rods with pistol grips at one end and tonglike jaws at the other. We were covered head to toe by diving suits of foam rubber to protect against the July chill of the austral winter—and the possibility of snakebite. Although at least one offshore sea snake, *Astrotia*, can bite through quarter-inch neoprene foam, the suits offered fair protection against the shorter-fanged species.

One of the snakes left the bottom, angling sharply upward. He saw us, shifted course, came straight in. His unmarked mustard-yellow skin showed him to be an olive sea snake, *Aipysurus laevis*. His kind could reach better than six feet in length, with a heavy body and a mouth big enough for serious biting. He had a neat, blunt cobra head and the cobra's large dark eye. His face was pleasant, fixed in a small smile.

He kept on coming.

What would he do? Probably nothing.

What *could* he do? Kill one of us, perhaps, if he could pierce our rubber armor. He came within six inches of my right leg. But the jaws remained closed, the pace leisurely. He took a single breath, and headed for the bottom.

Snake hunting is a sometime thing. We moved around the Swains, sometimes finding a solitary olive snake on the prow around the foot of a coral head, sometimes seeing no serpentine sign at all. Then, one morning, a new and imposing kind of sea serpent came winding and glittering into the hazy edge of my field of vision. As it swam closer, I saw a pale and dark-patterned body as thick as my arm, and a broad unsmiling head.

I dove too soon and grabbed too quickly.

My snake stick caught the animal well back along his body. Immediately he turned, snapping viciously, and began sliding back toward my right hand.

The jaws of the snake stick could not hold him. I resisted the impulse to drop snake and snake stick and do my best to walk upon the water (there being no way to get out of it), made a left-handed grab for a point just behind the gaping pink mouth, and held on. My foam-rubber gloves, I reasoned, would protect me if I missed and he didn't.

The snake threw a couple of coils around my arm, braced to bite if my grip should loosen. I made urgently for the distant boat, crawled up the ladder, flipped my victim into a wet burlap bag, and sat down to do a little serious breathing.

Hal came aboard to view my catch.

"Great!" he said. "*Astrotia stokesii*. Not common here. He's a big one."

"I know," I said, stretching and flexing my cramped fingers.

"He was really trying to bite you."

I nodded in fullest agreement.

"Let's find out what would have happened if he had," I suggested.

We found a paper-wrapped candy bar, stuck it in a finger of the glove and offered the glove to *A. stokesii*. He clamped down on the finger. I pulled out the candy bar. There were neat fang holes in its wrapper.

"That's interesting," said Hal, with masterly understatement.

Close Calls, but No Catastrophes

Other snakes turned up. We collected several, all olive snakes. One demonstrated the versatility of the serpentine head by dislocating his jaws and sliding the top one over to hang a fang in my gloved finger. That one, fortunately, did not penetrate. Hal flipped another snake into the boat, only to meet him coming down the ladder as he was going up. Again, no telling bite was delivered.

Next morning we strapped on Aqua-Lungs and fanned out across a new stretch of bottom. Ben beckoned to me from 75 feet away. As I swam toward him, I saw him maneuvering to get shots of a pair of snakes. Mating? I couldn't tell. There was reason to believe that

Tangling with trouble, Eva Cropp clings desperately to an olive snake that attacked as she tried to snare it. When the three-foot reptile snapped at her gloved hand, Mrs. Cropp pulled its tail, causing the head end to react by holding fast to the stick. She eventually maneuvered her catch to the boat, where captured snakes were studied and their venom collected.



this midwinter period was the mating season, and we had planned our visit with that in mind. Some scientists had suggested that sea snakes are most aggressive at mating time.

I never did find out whether Ben's two snakes were mating or not. As soon as I got near them, one turned and came at me; not with the normal soft, sinuous movements of his kind, but swiftly and jerkily. Sea creatures betray their intentions by the way they move. Their faces may be expressionless, but their bodies are eloquent.

The snake coming at me seemed bent on urgent business, and his body language said so. I picked up the first defensive weapon that came to hand: a large, stiff sea slug.

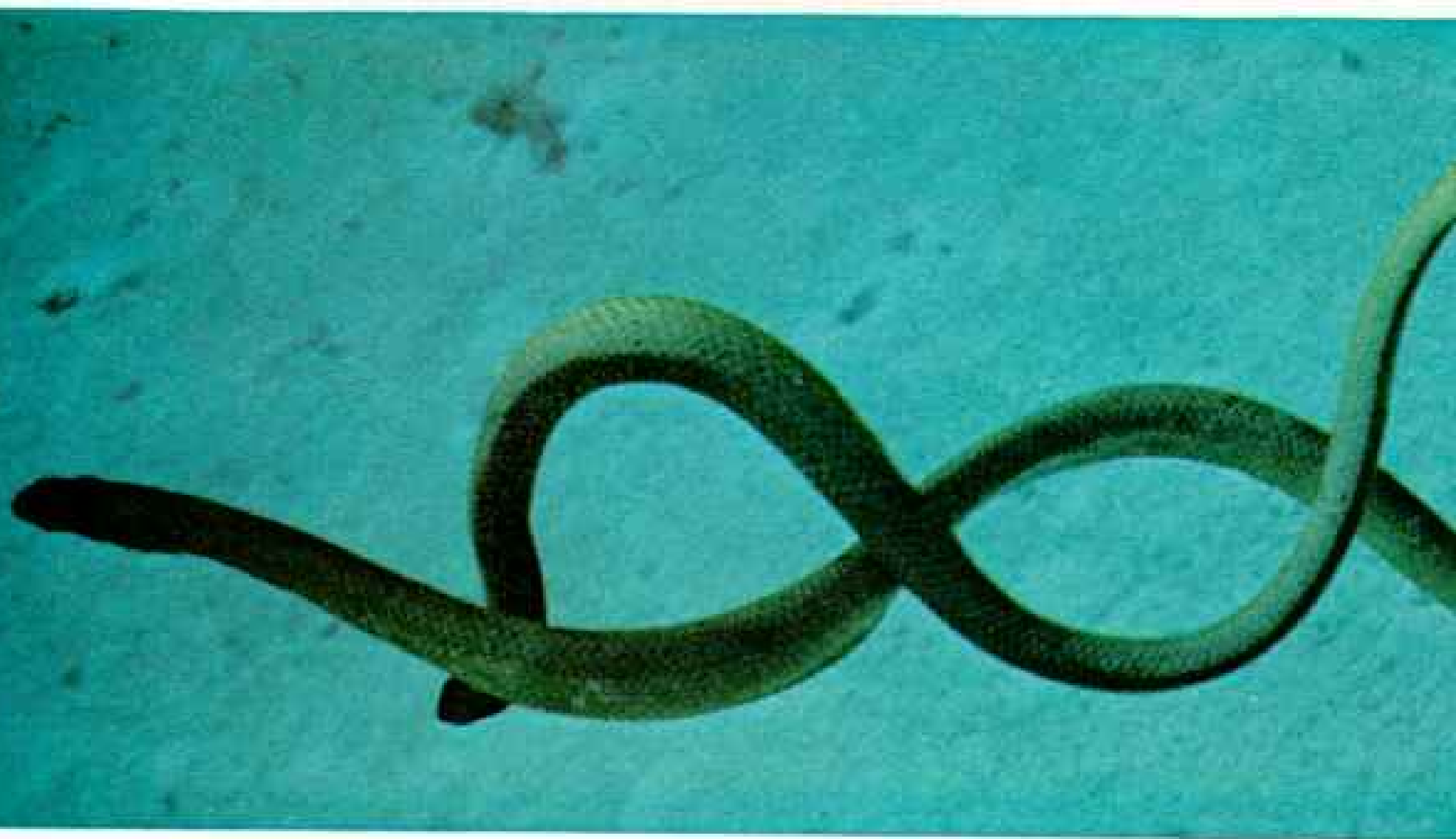
As the snake darted close, I pushed it away with the slug. A saffron blur streaked over my right shoulder. I felt a tug on my arm and saw a gaping mouth bite and bite again. I dropped the sea slug and grabbed the writhing body, pulling it free, then releasing it before the head could reach my fingers. The snake vanished, to reappear between my legs. He snapped at my flippers and got his short fangs

into my left leg—or rather, into the thick rubber that covered it.

This onslaught (pages 564-5) lasted close to two minutes. Dedicated photographer that he is, Ben kept shooting pictures instead of wasting time and great material by coming to my aid. At last my tormentor headed for the bottom, still twitching with rage. According to the laws of nature, I, the intruder, was defeated and would soon be dead—as I probably would have been, had I been swimming in my own skin instead of a rubber one.

Scientist Keeps His Homework on Ice

In a few days' time we had a good number of snakes aboard, all of them of the olive variety except for the heavy, muscular beast I'd caught the first day. Since he was unique in our collection, and since *Astrotia stokesii* is hard to remember, we called him Claude—I suppose because the name was so perfectly inappropriate. Several of the snakes had died, for no apparent reason, as sea snakes sometimes do in captivity. The dead animals had gone into the boat's refrigerator, there to keep



Mating olive snakes entwine in a living caduceus, the familiar serpent symbol of medicine. The pair will shortly rise and separate, as do the two olive snakes (right) floating above a coral bed.

Little is known of mating behavior, but olive males appear to be sexually active in July. Females are impregnated with sperm that may be stored until ovulation, sometimes weeks—even years—after mating. In

fresh until Hal could get around to them. Now it was time for him to catch up on his herpetological homework.

There are about fifty kinds of sea snakes; most occur—and probably evolved—in warm south Asian and Australian coastal waters. A few species are found as far away as Japan and the Persian Gulf. One, the yellow-bellied *Pelamis*, has crossed to tropical America's west coast, and lives by the million in the Bay of Panama.

Sea snake species differ in form and behavior, but have certain features in common.

"We're trying to find out how life underwater has affected the bodies of these creatures," Hal said, laying out limp specimens and sharp implements. "Some of the adaptations are obvious: The flattened, rudderlike tail; the nostrils set on top of the snout instead of on each side, and equipped with flaps to keep them closed underwater; the smaller size of the broad belly plates that land snakes use in crawling.

"But there are others you can't see at a glance, like the specially adapted gland in the

mouth that helps get rid of salt from the sea water they drink. I'm looking for more of those internal changes." Hal opened the body cavity of a snake and injected brightly colored latex into the veins and arteries.

"This stuff will harden, so that later, at the university, we'll be able to study the whole circulatory system."

"What about the lungs?" I asked. "Some sea snakes can stay down for two hours or more between breaths. How do they manage?"

"Here's part of the answer," Hal said, exposing a membranous sac three-quarters as long as the snake itself. "Like most snakes, sea snakes have only one lung, but theirs is a big one. Part of it is lined with blood vessels for oxygen absorption. But here, at the very end, there's a simple sac in which air is stored.

"Another device for stretching a dive is a controllable heartbeat. These animals can slow their pulse rate by 50 percent when they go under.

"But diving time varies with species, activity, and water temperature. The biggest have relatively bigger lungs and can stay down



most species, fertilized eggs develop within the mother, and the young are born alive. A few sea snakes lay eggs ashore, safe from marine predators.



longer. An active snake has to come up more often than a resting one. And as the water gets warmer, diving time gets shorter."

As he reached for the next specimen, something about the first caught his attention. "Hah! Look here. A male, and in breeding condition. Here are masses of sperm cells, ready to be implanted in the oviducts of a female. The females of many species—sea and land—can store these cells inside their bodies for weeks or even years, until they have eggs ready for fertilization. The sperm fertilizes the eggs in the oviduct. In many species of sea snakes the embryos develop there and are born alive."

Some Snakes Immune to Others' Venom

Our lesson in reptilian physiology was interrupted by a commotion off the starboard beam. Ron, it appeared, had slipped unobtrusively overboard (as usual) and now surfaced in a state of perceptible agitation (not at all as usual). He was treading water, whirling over his head a large olive snake that he held bare-handed by the tail, and uttering loud and fervent sounds. The full text of his message was garbled by the waves that submerged his mouth, but its gist was clear: "Somebody get this [blubble] snake off me [blubble] hands." We threw him a burlap bag to wrap it in.

Ron came aboard smiling and breathing just a little deeply. (Topflight Australian divers like Ron, Ben, and Eva do not go in much for gasping.) He was also sucking his finger.

"Bite you, did he?" I asked, sure that he

had not. Ron enjoys a joke now and then.

"Yeah, well, he sort of scratched me. I'll be 'right." Then, seeing my look of concern and rising to the occasion, he intoned: "Ow! I've been bitten and I'm going to die. This is the end of me! Boss [glancing heavenward], here I come. Soon you will all hear the drumming of me heels on the deck and see the rolling of me eyeballs as the convulsions seize me."

Hal persisted. "Did he get poison in, do you think? I've got some antivenin. It's not for olive snake venom—there's no serum for any of these reef snakes yet—but it works for one of the coastal species, and it might help."

"No, Hal, he never got to chew on me, just dragged a fang across the skin. If anything got in, I've sucked it out."

Whether he had, or whether the sea snake had withheld its venom (as these animals can do at will), Ron suffered no ill effects.

Since no scientific studies had been published on the poisons of the two species we had collected, Hal ran some preliminary tests. His laboratory mice proved Claude and the olive snakes to be intensely venomous, and both genera proved themselves immune to their own and each other's venom.

Having fairly sampled the Swains, we pushed on to the Saumarez Reef, 50 miles away to the east. Here, we knew, were other species of sea snakes and a different underwater environment.

We got under way at midnight in order to arrive after nine in the morning. You can't feel your way into a complex of coral heads when the sun is low and the surface of the sea



Shipboard scientist, herpetologist Dr. Harold Heatwole (left) fills a sea snake lung with water to determine its volume. Nearly three-quarters as long as the snake itself, the lung terminates in an air-storage sac that allows the animal to take long underwater tours after a split-second breath.

Struggling killer yields its venom to science. An instant after this photograph was made, *Astrotia stokesii* drove its fangs—concealed here by tissue of the mouth—through the collecting jar's rubber cover. The visible teeth serve only to hold prey.



reflects its light. Ron, Ben, and I took turns at the helm during the night passage, watching the compass's red glow and the white-topped black masses of the big beam seas rolling in out of the darkness.

Although there is no dry land on the Saumarez Reef, it boasts a landmark visible for miles; a U. S. Liberty ship, high and almost dry on the outer coral rampart, rising 80 feet above the white water that swirls around it. Blown onto the coral by a cyclone in 1945, the *Francis Preston Blair* still looks from a distance like a ship under way instead of the forlorn, rust-rotted ruin she is. We sighted her at dawn, and by midmorning we swung at anchor behind the reef on which the sad hulk stood. On the ocean side a few hundred yards away, cobalt breakers as big as houses exploded in slow frost-white cataclysm and almost palpable thunder.

Tiny Head Holds Deadly Peril

Beneath the surface we found a marine world different from that of the Swains. Extraordinary visibility—up to 200 feet, we reckoned—and a smaller fish population gave it an empty look, a sense of ocean and remoteness from the realm of man. But the snakes were there. I spotted a slender tiny-headed specimen on the first dive, and added *Microcephalophis gracilis*—one of the two most venomous sea snakes—to our list.

Exploring the reef edge, Ben found a mating pair, small dark creatures of a still unnamed species. The two intertwined for a moment and then rose straight up, still half encircling each other, to separate at the surface. The male made a quite understandable lunge at me before heading off over the reef-top, as his mate subsided gently to the sandy bottom. We let them go.

Other snakes appeared: first an olive snake, which came to inspect our swaying anchor chain with apparently amorous fascination. We followed it on its rounds, noting again that, like others of its breed, it passed by little fish without so much as a snap of the jaws.

I had noticed this curious behavior before and wondered at it. Unlike *M. gracilis* and some other small-headed snakes that live on fish eggs, the olive snake is a fish eater. But how did it stay alive if it never pursued a fish?

This time I knew. Hal had explained that this particular species cannot catch fish unless it corners them in crevices. Placed in an aquarium with free-swimming fish, the olive snake will starve.

A silvery flash near the foot of a coral cliff caught my eye. I swam over and saw, for the first and last time, a snake that had proved itself a successful hunter. It belonged to the dark new species (probably part of the *Aipysurus* clan), and it held in its mouth a perfectly motionless fish about 2½ inches long, gleaming white, with a few liver-colored spots: a crevice dweller, seized by stealth in the *Aipysurus* tradition.

Later I put on an Aqua-Lung to explore the base of a superb bommie (as Australians call a coral head), a 50-foot monolith rising out of pure sand. I eased along the bottom, peering into caves and crannies and feeling something like an olive snake myself. A glossy little black snake appeared, gentle as a kitten. It made no attempt to bite as I slipped it into a net bag.

I showed Hal my new acquisition.

"Do you know what you have here?" he asked, peering closely at my little shiny black snake. "Do you know what this is?" he added rhetorically. "This animal is a melanistic variant of *Emydocephalus annulatus*." He meant a black version of the turtle-headed, ringed sea snake.

"That makes five species so far. Not bad," I said.

"Happiness is another species of sea snake," said Hal.

Even Sharks Shun Sea Snakes

The next morning we collected another *M. gracilis*, which we found with its minute head stuck into a hole in the sand from which it was probably ingesting fish eggs (right). We watched it for 37 minutes, not wishing to interrupt its meal, until cold, boredom, and the arrival of a large shark moved us to unplug it from the bottom.

During the entire span of its leisurely meal, *M. gracilis* protruded blind and unprotected from an open expanse of sand bottom, exposed to attack from any predator. The processes of evolution could not have allowed the species to develop such relaxed eating habits if there had been any danger that they would lead in time to the extinction of the species. Obviously, this and other sea snakes have few enemies.

Apart from some Asians, who eat sea snakes and sell their skins, sea eagles are the only creatures proven to feed regularly on these reptiles. They seize them on the surface as they come up to breathe, and drop them on rocks to kill them.

Sharks? Despite the fact that Hal has occasionally found snakes in sharks' stomachs, trawlermen report that these scavengers, which eat everything else they throw overboard, will not touch sea snakes.

Other carnivorous fish? The hordes of ten-to hundred-pound snappers and groupers that seem to dominate Australian reef life are all capable of eating snakes, and are largely protected by their heavy scales from the bite of a counterattacking reptile. Yet we had watched hundreds of such fish ignore living—and dead—sea snakes, and seen that the sea snakes have no inbred fear of them. An observer of the life cycles in snake country would be tempted to risk a generalization: "Flesh-eating fish don't eat sea snakes." And he would be wrong.

Like most generalizations, this one needs a qualifier. The qualifying word is "Pacific." "*Pacific* flesh-eating fish don't [normally] eat sea snakes" is probably a defensible proposition. Some Atlantic fish of the same snapper and grouper families, according to a fascinating study by Dr. Ira Rubinoff and Dr. Chaim Kropach of the Smithsonian's Tropical Research Institute, *will* eat sea snakes when they are given the opportunity. Which, in nature, would be never, since there aren't any sea snakes in the Atlantic.

It appears that the genetic conditioning of the present Pacific fish signals to them a fact that their forebears had to learn the hard way: "If you eat sea snakes, you die." And fact it is. For though sea-snake meat is edible, and the venom harmless when digested, a snake swallowed whole may bite the stomach lining of its captor and kill it. And unlike sharks, which often mangle their prey before swallowing it, snappers and groupers down theirs intact.

Thus, in theory, Pacific fish died, and eventually their kind became programmed not to eat snakes. Exceptional fish with an appetite for snakes were selectively killed off before they could spawn more snake eaters. But according to the Smithsonian study, Atlantic

Like a magician's rope, willowy *Microcephalophis gracilis* rises from the sea floor, its buried head probing a hole for fish eggs. On such food-hunting forays the serpent engorges itself with sand that passes through harmlessly. Eyes covered and body exposed, this five-foot specimen fed for nearly 40 minutes, ignored by carnivorous fish.



Underwater taste test

ISTRIGUED by the fact that hungry fish instinctively avoid live sea snakes, Eva Cropp experiments with dead ones as food. A coral trout snaps up one snake (right), only to drop it a moment later (left). Others also rejected the entrée, illustrating an inbred distaste for sea snakes among most carnivorous fish of the Pacific. Over myriad generations, those that gobbled snakes often paid for their appetites with their lives, leaving the snakes few marine enemies; even sharks usually shun them. A lone Maori cod proves the exception, however, by gulping down an entire dead snake (below).

Only man and sea eagles are known to regularly eat sea snakes. Thick feathers protect eagles as they snatch serpents surfacing for air. In some parts of Asia, smoked or roasted sea snake meat is considered a delicacy.







Lethal trio varies widely in size and color. Light-hued *Astrotia stokesii*, the most massive sea snake, can reach the thickness of a man's forearm. But in deadliness it bows to one of the sea's most poisonous reptiles, *Microcephalophis gracilis*, whose name means "slender small-headed snake." The snub-nosed olive snake at right can grow to six feet.

carnivores, uninhibited by any such genetic mechanisms, gulp down whole snakes and sometimes die as a result. Occasionally they regurgitate the living reptile before dying, which suggests that the individual snake (and not his posterity alone) may benefit by biting.

In any case, it is probable that if Atlantic fish and sea snakes are brought together in large numbers, as they might be by the proposed sea-level Panama canal, there would be an ecological crisis. At first, the fish may attack the snakes. But as soon as the Atlantic carnivores learn what their Pacific relatives already know, and avoid the deadly reptiles, sea snakes might infest the Caribbean.

Hand-fed Fish Prove a Point

Dr. Rubinoff and Dr. Kropach were working with *Pelamis*, the only sea snake found on the west coast of tropical America, and with tank-adapted American fish. Yet we felt that their theories should apply equally to the Australian reef creatures. We decided to try a similar test in nature at Heron Island, an attractive little resort whose undersea surroundings are protected from spear fishermen and collectors. Fish at Heron eat what divers hand them. Would that include sea snakes, or pieces thereof?

We headed for Heron, 20 hours away, to find out. Ben, Eva, and I set up our feeding station about twenty feet down. Soon a dozen assorted members of the grouper family had rallied around.

As Ben photographed and I watched, Eva took bits of coral trout from a plastic bag and held them out to the circling fish. A sort of

feeding frenzy developed; the groupers occasionally broke away to tear into a school of little fish and emerge with chomping jaws.

Now Eva tossed out a small dead sea snake. Instantly three or four fish rushed at it, bit it, and dropped it. Next came a piece of skinned snake. A blue cod swallowed it at once, then broke out of the feeding circle in apparent distress, gulping and stretching his gill covers. He retired to deeper water, his appetite clearly ruined for the moment.

As a final test Eva tied a dead snake to a piece of trout flesh. Repeatedly, the fish struck, dislodged the piece of bait and ignored the snake. Then a Maori cod, bolder than the others, seized both snake and bait at the same time. He swallowed the meat and perhaps, in the process, got part of the snake down his gullet (preceding pages). In any case, like the blue cod, he stopped, gulped, and headed for deep water. There he holed up in a tiny cave and proceeded to swallow the entire snake.

Which, I suppose, only goes to prove that the soundest theories admit of exceptions.

Still, the main point was abundantly re-established: That sea snakes, those deadly invaders from the landmasses of the earth, live safely in the murderous jungle of the coral reef through the magic of the venom that some of them—the egg eaters, for instance—never use.

Neither hiding nor hurrying, these migrants from the airy realms of brush and forest now live unfeared and unfearing in the stone wilderness of coral seas, untroubled aliens at home in an alien world. □

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COVER: Winter rouges the cheeks of a Kirghiz child romping beside his yurt (pages 435-65). **ROLAND WICKHAM**

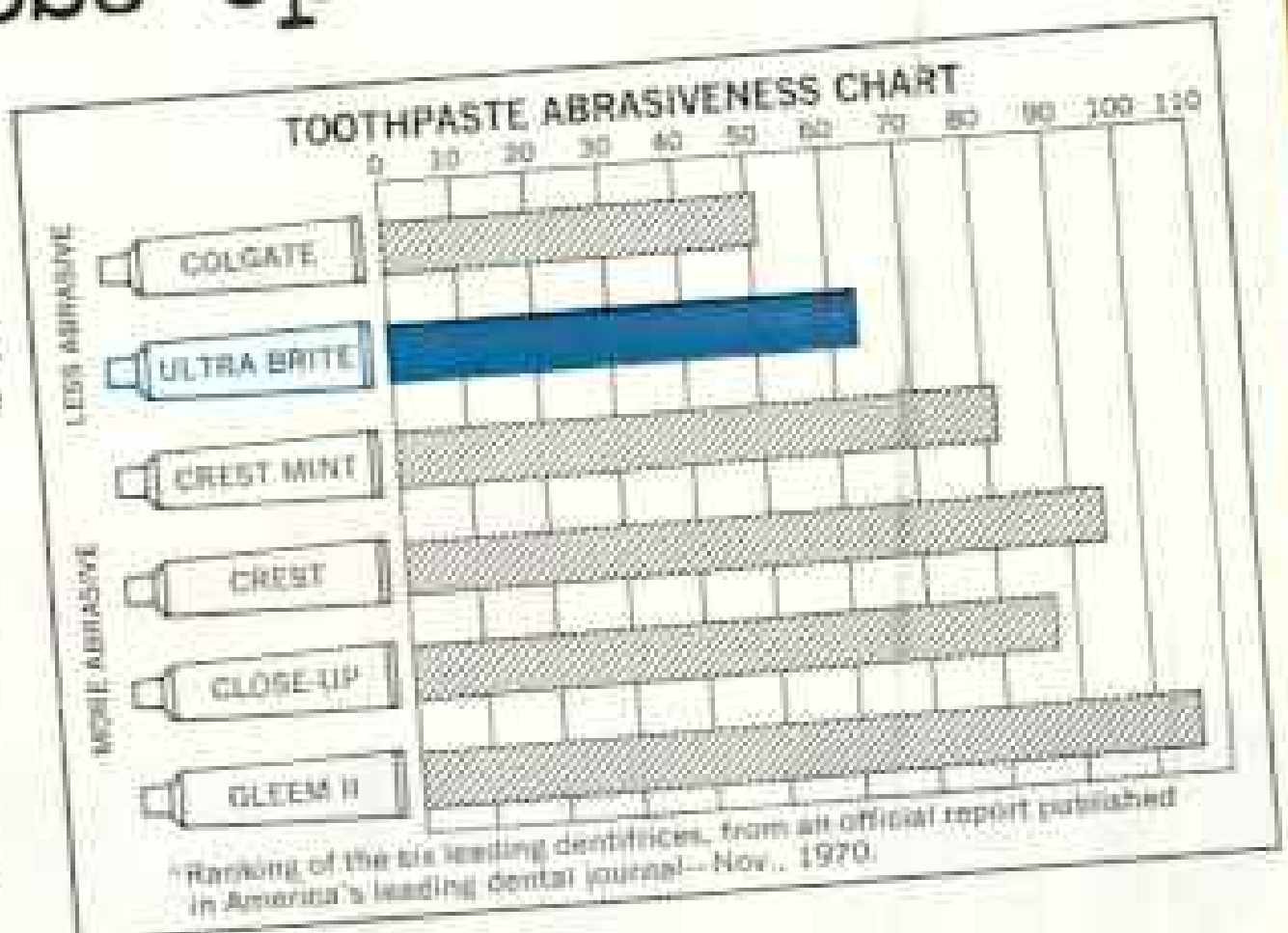
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No leading toothpaste is harmful to tooth enamel. However, some toothpastes do their job more gently than others. As the chart at right indicates: among the six leading dentifrices, Ultra Brite is less abrasive than Crest, Close-Up and Gleem II. Other dental studies confirm that Ultra Brite does not harm teeth. This is especially significant since Ultra Brite is best known as a whitening and brightening toothpaste. Ultra Brite can get your teeth their brightest with demonstrated safety for teeth.





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805 feet of it to make our smallest size tire.

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Firestone
500 Steel Belt

the people tire

Up from a realm of perpetual night

MAN'S RESTLESS PROBING of his planet turns up some strange creatures. From 27,230 feet down in the Puerto Rico Trench—deepest gash in the Atlantic floor—marine biologists led by Dr. Gilbert L. Voss netted this scientific trophy (actual size, below), the only vertebrate known to live at that crushing depth. The tapered bottom dweller—the fifth specimen of *Bassogigas profundissimus* ever taken—can survive pressure 830 times greater than that at the surface.

For nearly a decade the National Geographic Society has sponsored the deep-sea research of teacher-scientist Voss, here helping a University of Miami graduate student preserve a squid's circulatory system with an injection of latex (right).



ROBERT F. SIBSON



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Washington, D. C. 20036

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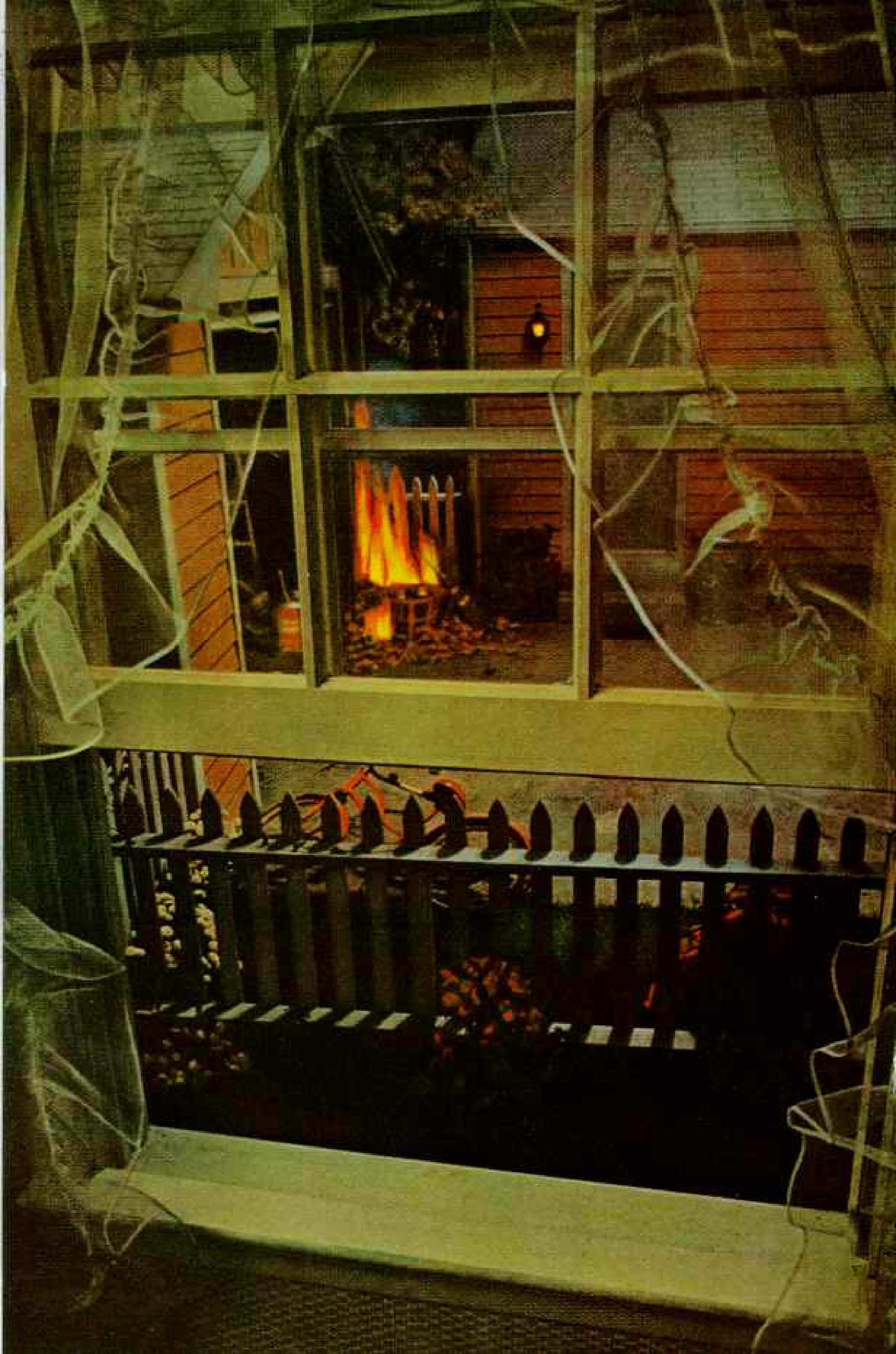
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CHECK ONE



If your six year old saw something like this, would he know how to phone for help?

It's too important a question to leave to chance.

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In General Telephone areas, six and seven year olds are taught to dial "0", give their name and tell our operator where they are and what's wrong. While older students are trained to dial emergency numbers direct—because that's the fastest way to call for help.

But of course, we can't reach every kid. We need your help at home. (Which is why

we're running this ad.)

Copy down the emergency numbers listed on the inside front cover or first page of your telephone directory. Add your family doctor's number. And the number of the nearest hospital. Next, tack up the list near your phone. Then get your kids to memorize it, just in case it gets lost.

By the time they're through memorizing those numbers they're going to have every grownup in the house knowing them, too. (Which is also why we're running this ad.)



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Chevelle Malibu Sport Coupe at the Taos Pueblo in Northern New Mexico.

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Try one on your family and budget for size. At your Chevrolet dealer's. You're likely to discover why Chevelle is America's most popular mid-size car.



Chevrolet

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at the price.
Have a good
time.

24⁹⁵*



Polaroid's new Square Shooter 2

CUT RINGS AROUND OTHER MOWERS

New Bolens[®] rear engine rider
gives you better traction,
more maneuverability,
improved visibility.



The new Bolens riding mower is more than a shortcut to a great looking lawn. It's built the Bolens way with lots of features you'll appreciate. Rugged 7 hp engine. Optional electric starter. A safety seat that stops the engine if you're not firmly in the saddle and completely under control. And this new rider cuts a generous 28" swath that makes short work of lawn chores.

The new Bolens riding mower. Turns on a dime. Muscles its way over the most rolling lawns. And lets you see what you're doing every minute. Look one over at your nearest Bolens dealer. He's in the Yellow Pages.

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So unique, it's patented! This rotary lifts the grass, cuts it, chops it into tiny particles and blows it back to ground level where it becomes mulch to feed your lawn, retain moisture and keep your grass green. In 3½ and 4 hp models, push and self-propelled.



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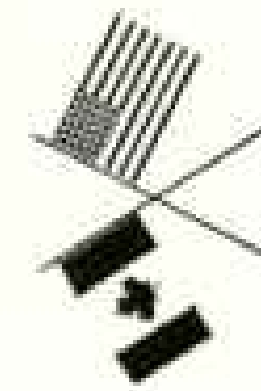
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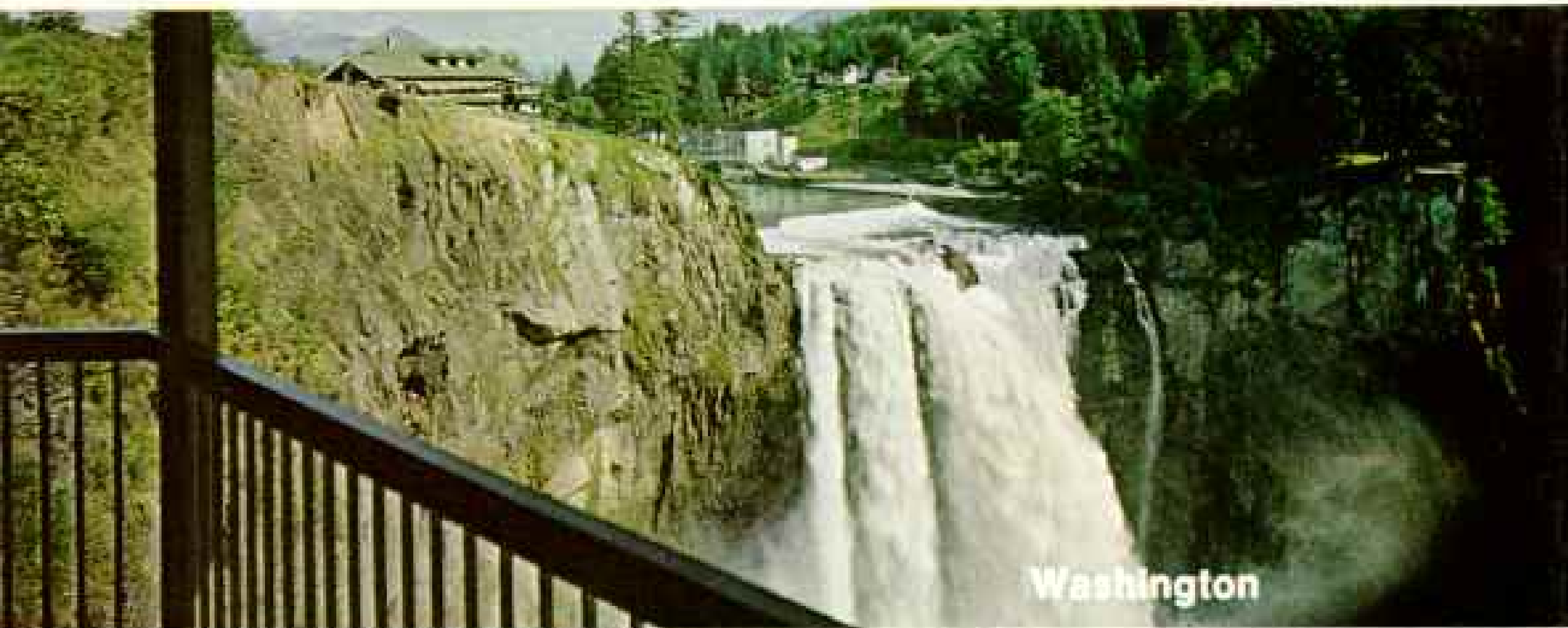
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4. New Perma-Shield Gliding Window. Weathertight, weatherproof, glide open picture windows.

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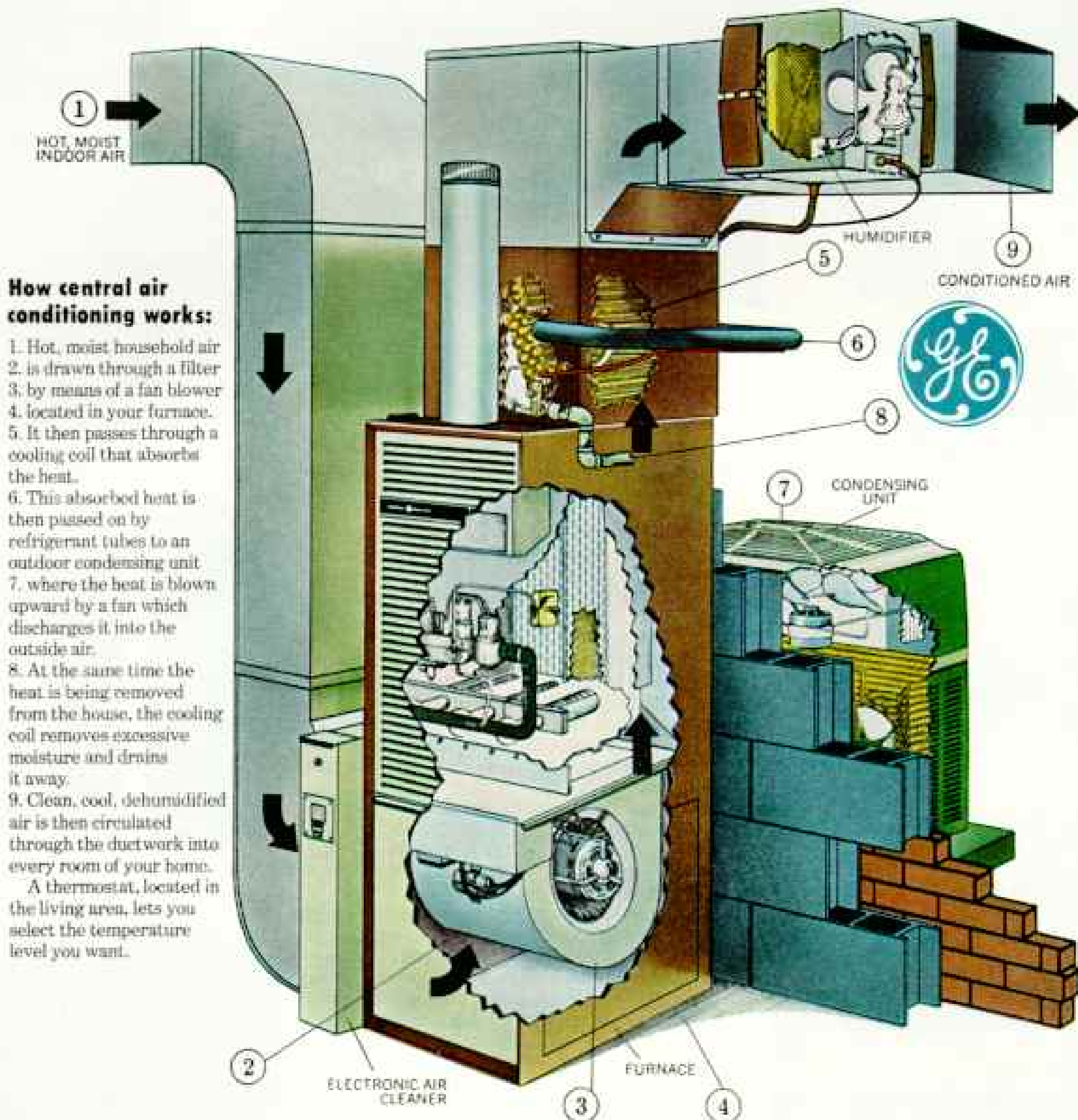
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ANDERSEN CORPORATION BAYPORT, MINNESOTA 55003



Once you understand how central air conditioning works,



How central air conditioning works:

1. Hot, moist household air
2. is drawn through a filter
3. by means of a fan blower
4. located in your furnace.
5. It then passes through a cooling coil that absorbs the heat.
6. This absorbed heat is then passed on by refrigerant tubes to an outdoor condensing unit
7. where the heat is blown upward by a fan which discharges it into the outside air.
8. At the same time the heat is being removed from the house, the cooling coil removes excessive moisture and drains it away.
9. Clean, cool, dehumidified air is then circulated through the ductwork into every room of your home.

A thermostat, located in the living area, lets you select the temperature level you want.

Central air conditioning is one of the best investments you can make for your family. In terms of comfort, well-being, and good living.

Properly applied and installed, a central air conditioning system will give you cool air distributed evenly throughout your entire home. With proper care, it will give you years of reliable service and comfort. It could increase the value and salability of your home.

The cost could be much lower than you might think.

Particularly if you have a forced warm-air furnace to begin with. Because, for both heating and cooling, a fan and ductwork are required.

So if your house has an adequate forced warm-air furnace and ductwork, you're halfway there:

The purpose of these pages on central air conditioning is to help you make a wise investment.

We believe a careful reading will reward you well for years to come.

you'll understand why General Electric's works so well.

GE builds quality into its components.

From the preceding page, you know basically how central air conditioning works. Now if you'll consider our equipment, you'll learn about some of the quality we build in.

The GE Climatuff™ compressor has a remarkable record of reliability.

Every GE condensing unit has a GE Climatuff compressor, the heart of the whole system. This compressor has a remarkable record of reliability in over 500,000 installations. What makes it so good? It's designed for the job and manufactured with careful attention to quality. It has design features like a quick-acting thermal overload control to prevent motor burnout; a centrifugal oil pump for complete lubrication of all moving parts; internal spring mounts to cut vibration; and unique, super-strong motor insulation that resists refrigerant contamination and helps to withstand unusual voltage surges. All together, these features make a compressor that's the envy of the industry.



GE's efficient Spine Fin™ coils help prevent leaks.



Only GE central air conditioning units have Spine Fin condenser coils. The big advantage is that Spine Fin coils are permanently bonded to

continuous copper or aluminum tubing. This eliminates over 90% of the brazed joints, the spots where leaks can occur to cause failures. On an equal weight basis, they're almost twice as effective as conventional plate fin coils. That's why GE needs only half the weight for heat transfer surfaces as competitive units.

Now for the condensing units.

The Executive model can give you operating costs up to 15% lower than other compressor models of the same capacity. This is our top-of-the-line model, with an automatic two-speed fan so that it loafs along quietly on moderate days, but has plenty of reserve power to shift automatically into high air-flow on a scorcher to keep you cool and comfortable.

The Executive comes to you with a five-year Protection Plan at no extra cost. During the first year, under normal usage, there is no charge for parts or labor

(except for filters, exterior panels or grilles). During the last four years, a labor charge only for replacement or repair of covered parts. Parts and labor for repair to the compressor or leaks in the sealed system are covered for the entire five-year period.

We also have a Deluxe model that offers you matched component reliability. It features a classic appearance and a manually operated two-speed fan.

Our Deluxe model carries a one-year parts only warranty plus an additional four-year parts only warranty for the motor compressor. (Labor, diagnostic calls and local delivery of parts not included.)

Top air discharge is better. It means that hot air is directed upward; not sideways at the bushes. The noise is directed upward and not toward your neighbor's house. GE top discharge brings in air from four sides at low velocity which helps to prevent clogging of condenser surfaces with leaves, grass clippings, etc.



GE's National Service Contract.

We make available a National Service Contract directly to the purchaser of a Deluxe unit at an attractive low price (\$109.00 plus local or state taxes on a 36,000 BTU/H cooling system). It covers service, both parts and labor, required as a result of normal usage from the second through fifth year from date the equipment is installed. Service is performed by an authorized GE Central Air Conditioning servicer of your choice. (Be sure to read the contract for details of coverage and exceptions, such as normal maintenance and filter replacements.)

How are you ready for total cooling comfort?

Your GE Central Air Conditioning dealer will determine the cooling comfort system that's right for your home and pocketbook. He's well qualified to figure your requirements, to install properly and to provide complete service.

You'll find your dealer's name in the Yellow Pages under "Air Conditioning Equipment and Systems." And if you'd like more information, please clip out the coupon and send it to us.

General Electric Company
Appliance Park, AP4-206A
Louisville, Kentucky 40225

NG-472

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Herbed French Dressing

- | | |
|-------------------------|------------------------|
| 1/4 cup Mazola Corn Oil | 1 teaspoon paprika |
| 1/4 cup wine vinegar | 1 teaspoon dry mustard |
| 1 clove garlic, split | 1/2 teaspoon tarragon |
| 1 1/2 tablespoons sugar | 1/2 teaspoon thyme |
| 1 teaspoon salt | 1/2 teaspoon oregano |
| | 1/4 teaspoon pepper |

Measure all ingredients into jar. Cover tightly; shake well. Chill; remove garlic. Makes 1 cup. Serve on fresh, crisp salad of greens, carrot curls, cherry tomatoes, sliced radishes, scallions and cucumber.



MAZOLA-HIGH IN POLYUNSATURATES, TOO.



Too bad ol' Abe didn't have a Winnebago for his campaign tours...

"The kids sure enjoyed that stop . . . Mount Rushmore! Lincoln, Washington, Jefferson and Teddy Roosevelt carved on a mountain . . . with their faces taller than a five-story building. Winnebago sure has made this a great trip. And so convenient! Everything we need is built-in—kitchen, bathroom, bedrooms—the works. Sure beats last year when we spent half our time stopping at restaurants and trying to find motels with room for five people and a dog."

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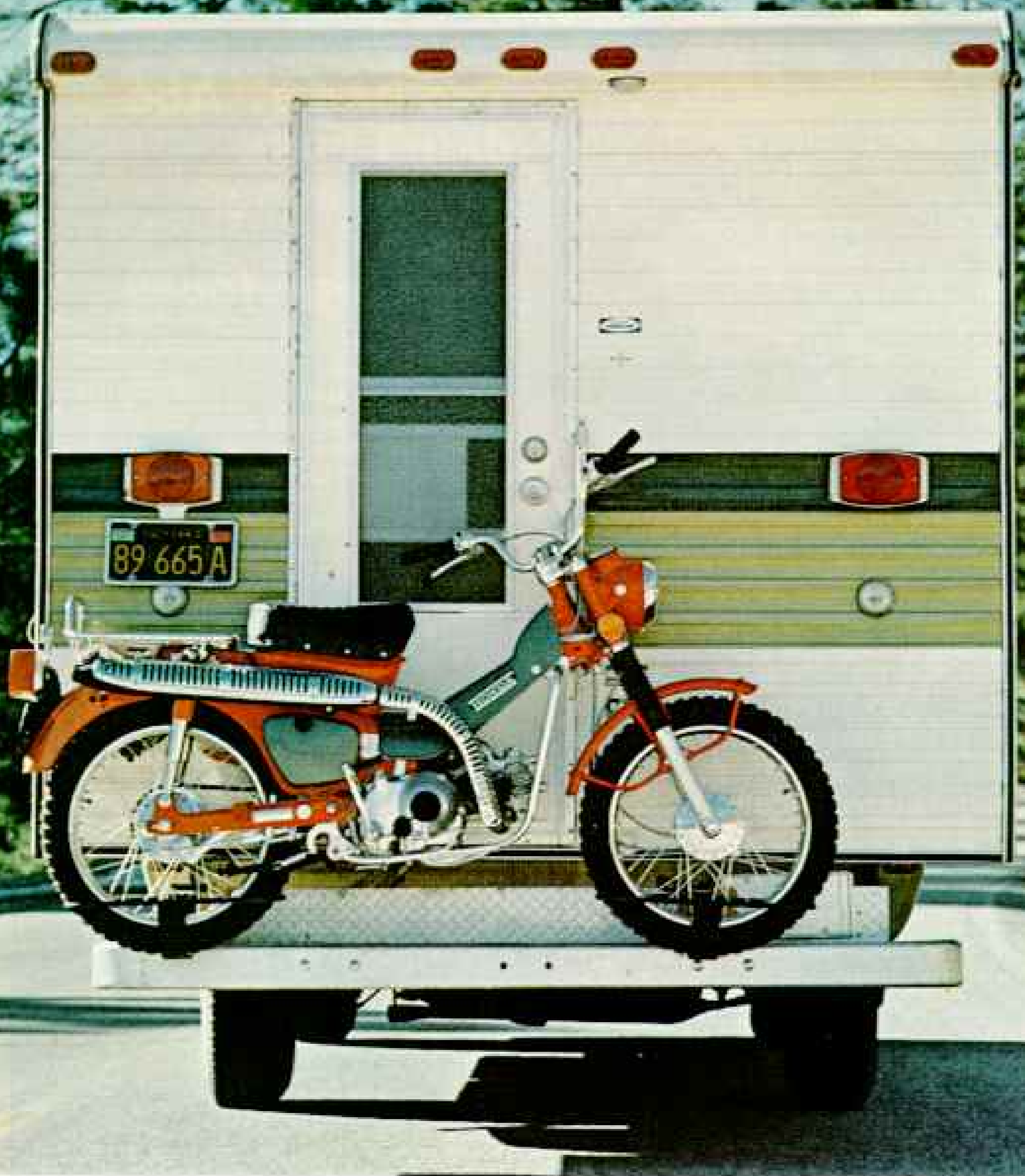
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City _____ State _____ Zip _____

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America's best-selling motor home



Pick up America's favorite hitchhiker.

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The Trail 90 is America's favorite trail bike because it has the most to offer.

A famous Honda four-stroke engine for dependability. Swivel-lok handlebars for



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The Honda Trail 90.

Come...take your time
in our Picture Province



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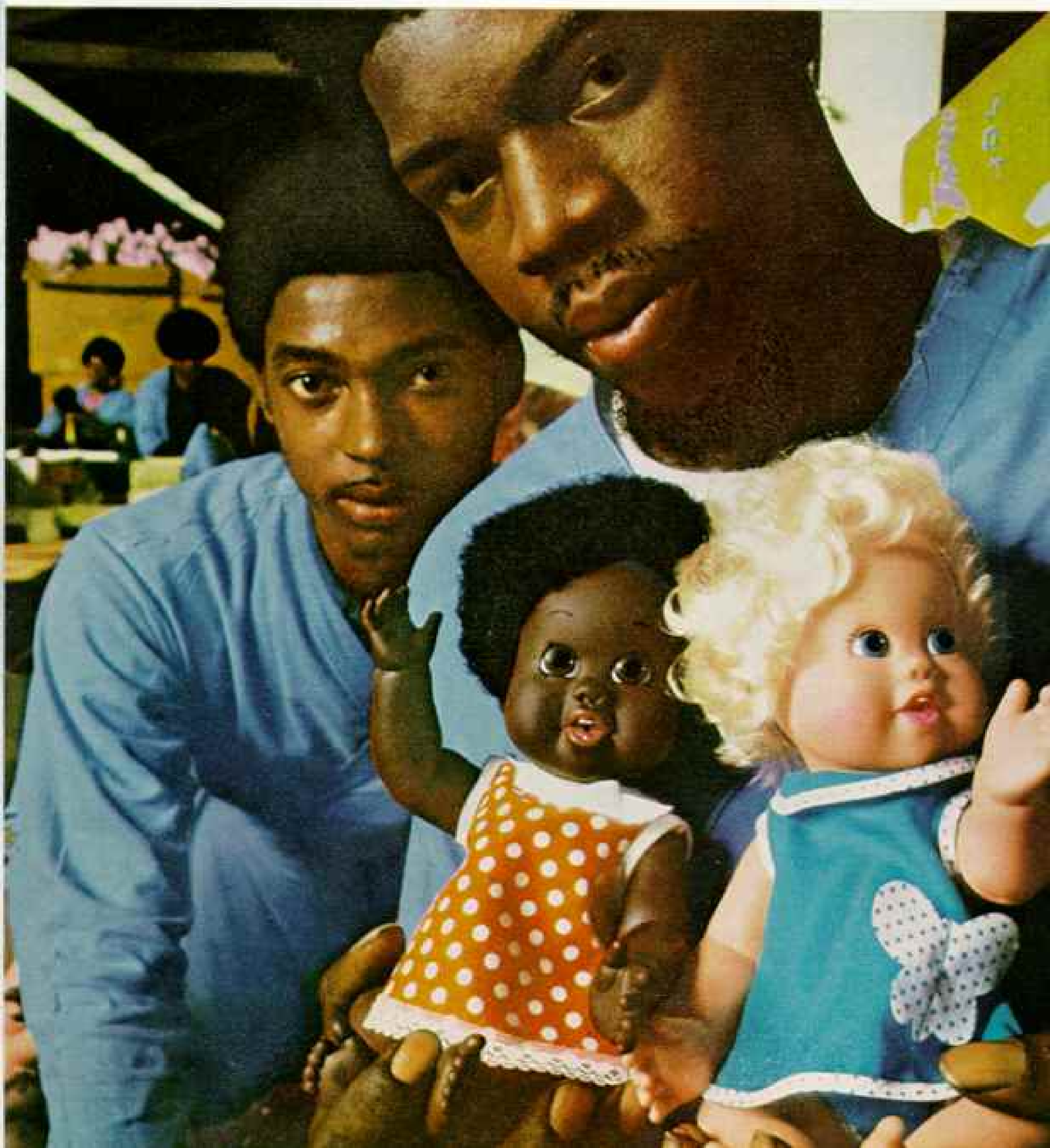
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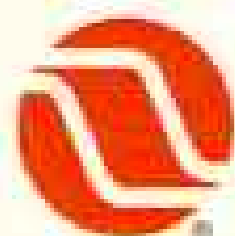
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Scenery. Bluffs, springs, caves, lakes, hills. Mother Nature works overtime in Missouri. The panorama is constantly changing. And you'll like the change. Always in color. Always in season. Come see.



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MAIL TO:

MISSOURI TOURISM COMMISSION, DEPARTMENT NG-42
BOX 128E, JEFFERSON CITY, MISSOURI 65101

MISSOURI:
bet you didn't know
we had it in us!

Wanted: Lighthouse peepers!



You will qualify if:

- you get a kick out of packing the kids into your station wagon and driving off to a big adventure in Maryland's Chesapeake Bay Country!
 - you're interested in rediscovering the unique charm of lighthouses!
 - you love browsing through quaint fishing villages dating from the 17th Century and still lived in!
 - you appreciate some of the most delicious seafood in the world!
 - you really like to roam through unspoiled country where the salt air and the sun and the dunes and the beaches make you forget such things as tourist traps!
- If you meet the above qualifications, come to Maryland. We guarantee you one of the most exciting vacations you'll have for years to come!

Maryland . . . just an oyster shell's throw from Washington, D.C.!



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SO MUCH OF AMERICA DID

May we send you a colorful Maryland Travel Kit? Write:

Maryland Division of Tourism
Suite NG-42, State Office Building,
Annapolis, Maryland 21401

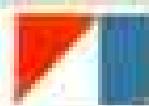
EVEN IF THE SPORTABOUT WEREN'T THE ONLY WAGON OF ITS KIND, YOU'D STILL HAVE A GOOD REASON TO BUY IT.



When you buy a 1972 Hornet Sportabout, you get the only wagon made in America that gives you sleek, racy looks, a rear lift gate and 60.8 cubic feet of cargo space.

You also get a car that's been road-tested and checked over so thoroughly that we make this promise: If anything goes wrong and it's our fault, we'll fix it. Free.

And, if we have to keep your car overnight to fix it, over 1900 dealers will loan you a car. Free.



When you buy a new 1972 car from an American Motors dealer, American Motors Corporation guarantees to you that, except for tires, it will pay for the repair or replacement of any part it supplies that is defective in material or workmanship.

This guarantee is good for 12 months from the date the car is first used or 12,000 miles, whichever comes first.

All we require is that the car be properly maintained and used for normal use and service in the fifty United States or Canada and that guaranteed repairs or replacements be made by an American Motors dealer.

Finally, you get a name and toll-free number to call in Detroit if you have a problem. And we promise you'll get action, not a runaround.

Nobody in the business does all this for you after you buy a car.

Which is probably why people who've never bought a car from us before are buying one now.

**AMERICAN MOTORS
BUYER PROTECTION PLAN**



In less than a second this vacation could end.

Too many vacations end on our highways. Especially on the older roads.

Many of our highways are dangerously outdated. 200,000 miles of primary roads were built over old horse and buggy routes. Those older roads simply can't carry today's high-speed traffic.

It's a chilling fact that last year's death rate on our older highways was more than double that of the Interstate System.

What's being done? Not nearly enough.

What should we do? Upgrade secondary roads. Make them wider,

straighten them out, improve visibility on them. And close the gaps in the Interstate System.

We can't ignore these needs. Because too many people are taking one-way trips on our outdated highways.



We can make the world a better place to live in. Caterpillar machines will help.



CATERPILLAR

Caterpillar, Cat and D are trademarks of Caterpillar Inc.

If it costs 46% more to repair a car today than in 1961, what about a telephone truck?

With 100 million phones to care for, our fleet now numbers 110,000 trucks.

And with auto repair costs rising 46% since 1961, you can imagine what that's done to our budget.

We've been doing some of our own repair work, but our costs went up just as much—from \$230 to \$340 per truck.

Our total running expenses from \$612 to \$823 a truck.

And to get the money to buy new trucks, we're having to borrow at interest rates that have almost doubled since 1961.

Despite rising costs like these, residential telephone rates have gone up only 8% overall since 1961. And long distance rates have actually gone down. While the cost of living has gone up 37%.

Obviously, this can't go on. Because the cost of providing you good telephone service is going up, telephone rates are going up, too—but based on the last ten years, far less than most things you buy.

AT&T and your local Bell Company.

