

VOLUME CVIII

NUMBER TWO

THE NATIONAL GEOGRAPHIC MAGAZINE

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The National Geographic Society and the Royal Ontario Museum in 1951 explored and measured newly found Chubb meteor crater, 11,500 feet in diameter, in northern Quebec.

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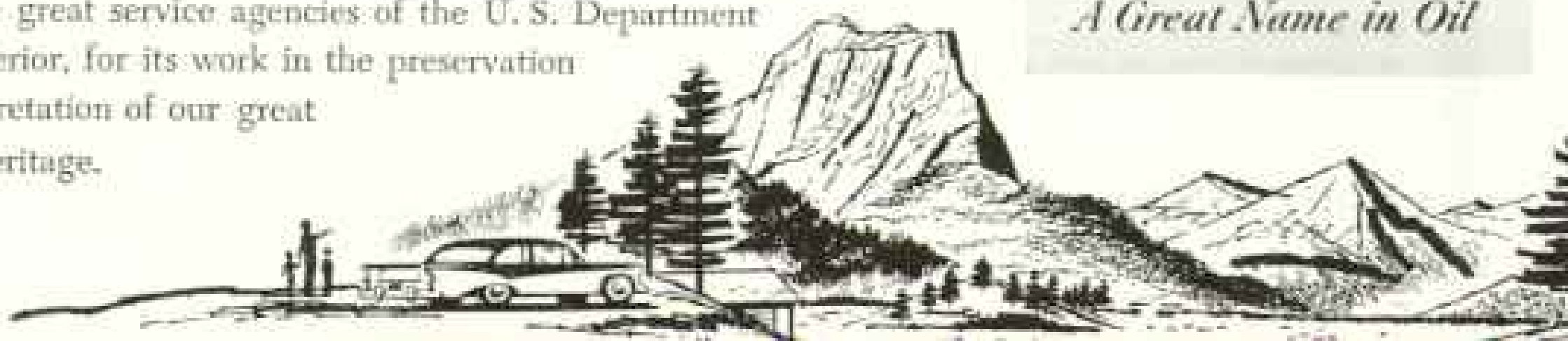
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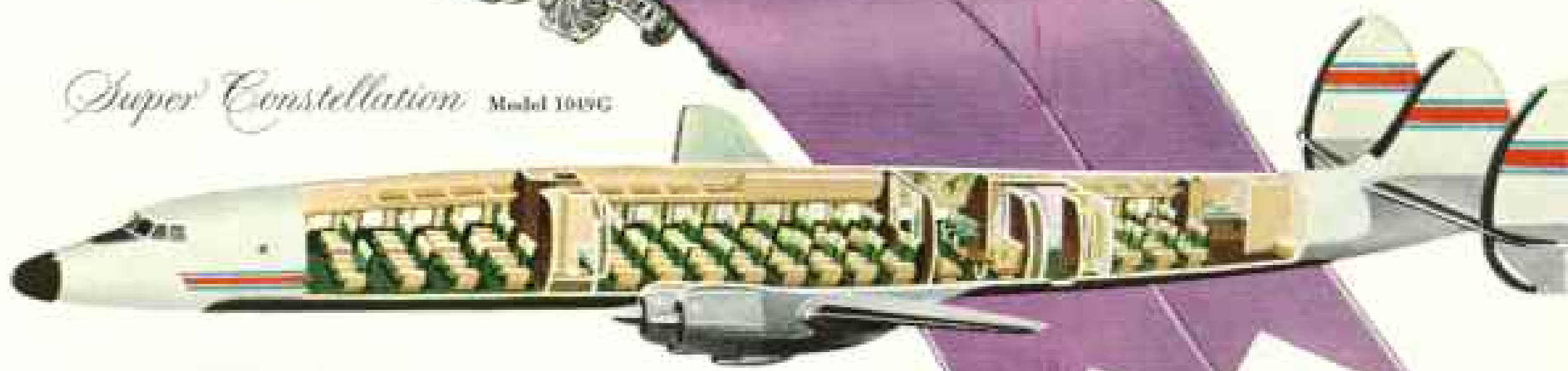
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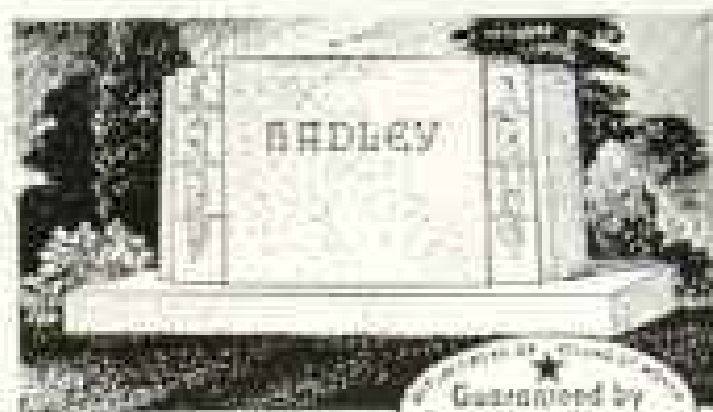
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"The Three Musketeers"... and HIGH BLOOD PRESSURE

MEDICAL GUIDANCE, *rest and weight control* . . . these might well be called "the three musketeers" fighting high blood pressure. For when they work together . . . as "The Three Musketeers" did . . . they may help protect you against the less serious type of this disorder, or prevent complications if you have it. This form of high blood pressure, so-called "essential hypertension," accounts for more than 90 percent of all cases.

Victims of hypertension are often individuals of great drive who are inclined to push themselves beyond sensible limits. To lessen strain on the heart, a leisurely pace of living is desirable.

Among other things, the doctor may recommend intervals of rest during the day . . . and he will perhaps recommend at least eight hours of rest every night. He will also urge patients to avoid situations which cause great tension, such as needless arguments.

In addition, he may suggest other things to relieve stress and worries that tend to keep blood pressure up. Mild exercise is not only usually permissible, but even encouraged. In fact, things that help divert the mind from daily troubles and keep the patient from becoming pre-occupied with blood pressure levels can mean the difference between living a useful or an unsatisfactory life.

Weight control may be important, too, in relieving high blood pressure. Extra pounds are burdensome to the heart. Since the heart works harder when hypertension is present, weight loss helps to lighten its load.

Of course, the doctor's help is needed. Regular check-ups will enable him to discover complications early . . . if any occur . . . and start treatment that may keep them under control.

Today more can be done for high blood pressure than ever before. In *selected* cases, great improvement can often be obtained by special diets or surgery.

Several new drugs are also used now which may lower pressure and relieve symptoms. No drugs, however, should ever be tried unless they are prescribed by a physician and taken under his supervision.

If the doctor's advice is followed and if the patient learns to lead a *life of moderation in all things*, high blood pressure can be successfully controlled in many cases. If neglected it may cause serious damage to the heart, kidneys and brain.

To detect this condition early, everyone should have periodic medical examinations. This precaution is especially necessary for those who are middle-aged and older, are overweight, or have a family history of the disease. When discovered early, hypertension is usually easier to control.

Metropolitan booklet, *Your Heart*, gives many more facts to help you understand what high blood pressure is, what its symptoms are, and how it affects the heart and blood vessels. Just clip and mail the coupon below for your free copy.

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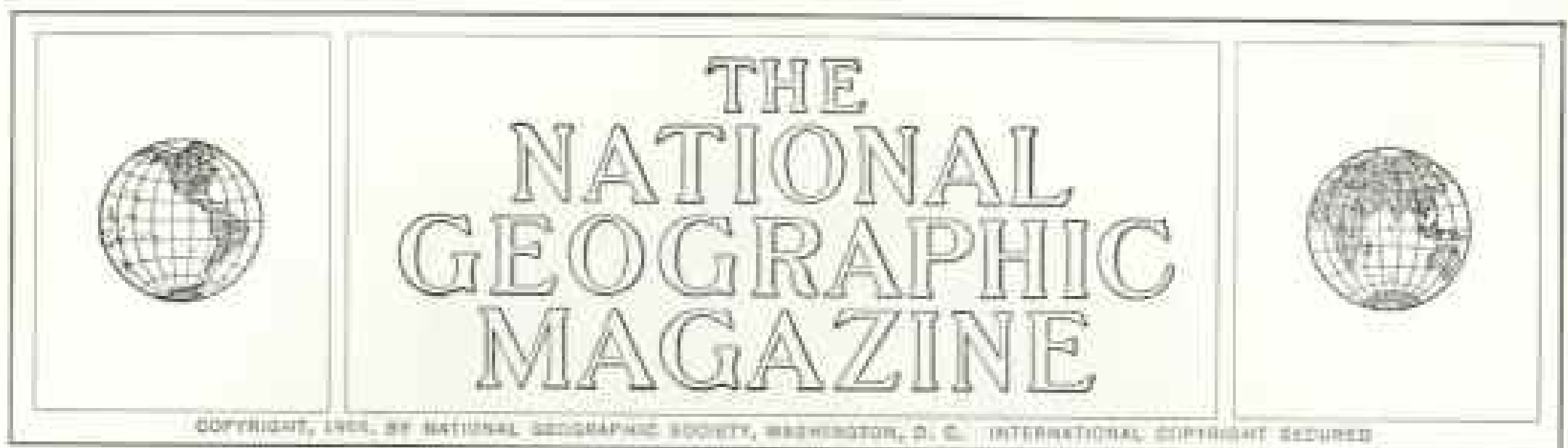


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Calypso Explores for Underwater Oil 155

The Persian Gulf's Pirate Coast Yields Its Secrets to Science;
in the Indian Ocean, Aqualung Divers War on Sharks

BY CAPT. JACQUES-YVES COUSTEAU

Leader, National Geographic Society-Calypso Expeditions

ONE day a quiet Englishman with an umbrella came to the Marseille dry-dock where the research ship *Calypso* was fitting out. He asked if my crew and I would be interested in an underwater geological survey.

"Why not?" I said. "But what brings you to us?"

"The chief geologist of my company read your book *The Silent World*," the visitor replied. "He said, 'These people have imagination. Go sound them out on the idea.'"

So it came about that last year we took on a novel mission: a search for oil-bearing structures under the Persian Gulf off the former "Pirate Coast" of Trucial Oman, for the British Petroleum Company, Ltd.

Ship Freed for New Adventures

For more than a year *Calypso* had been engaged in the salvage of a 2,200-year-old Greek wine ship at the bottom of the Mediterranean off Marseille.* With the support of the National Geographic Society we had unraveled the fascinating story of her mission and her fate more than two millenniums ago. In literally thousands of Aqualung dives we had brought up a large part of her long-lost cargo of graceful wine jars and dinnerware. But the underwater excavation stretched on, and the ancient ship grew in estimated size with each ton of mud we removed.

Thus our research ship, equipped and manned for far oceans, was reduced to a

lighter handling an agelong overdue cargo of wine jars. We could not leave the wreck to be sealed over with mud nor could we play slave to it any longer.

To continue this important archeological work, I enlarged the *Calypso* "navy" by one stout 60-foot ex-fisherman, the *Espadon* (swordfish). *Espadon* took our place above the wreck and freed *Calypso* for new tasks.

From Snow to Coral Reefs

On our wide afterdeck we installed a marine gravimeter, a complex instrument that helps prospectors locate oil (pages 164, 165).

We left Marseille in a snowstorm and made our first working stop in the Gulf of Suez below Zafarana Light. There in smooth water we tested equipment, adjusted delicate mechanisms, erected a folding anti-shark cage, and mended nets.

Ready for work, we left the Gulf of Suez and headed south (map, page 160).

I am attracted to lonely islands such as Daedalus Reef, where an Egyptian lighthouse is rooted in a submerged coral table some 55 miles from land. The reef, a treacherous shadow in the sea, is the crest of a steep submarine coral mountain. The lighthouse rests on it like an observatory of Neptune reared into the alien world above.

"Riquet," or Henri Goiran, our smallest

* See "Fish Men Discover a 2,200-year-old Greek Ship," by Capt. Jacques-Yves Cousteau, NATIONAL GEOGRAPHIC MAGAZINE, January, 1954.



© National Geographic Society

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↑ *Calypso's* Skipper Scans the Sun-swept Red Sea

Radar antenna behind Captain Cousteau picks up ships and land features within a 40-mile radius.

↓ Afterdeck cluttered with gear, *Calypso* steams south through the Suez Canal to search for oil beneath the floor of the Persian Gulf. There, despite sharks, sea snakes, squalls, and sandstorms, divers made 400 samplings of the sea floor in two months.





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† "Skyscrapers" Hug
a Rock Mountain
in Cramped Mukalla

"An Arabian Nights city," the author describes this port on the Gulf of Aden. A white fort perches high on the 300-foot limestone cliff. Mosque minaret caps the city skyline.

Mud-brick towers average five stories in height; elongated windows make them appear even taller. Here a homeowner's wealth may be judged by the amount of whitewash on exterior walls. In many dwellings the first floor serves for storage, the second for servants, the third for guests, and those above for family use.

→ Smoking a hookah as he sews, a Mukalla tailor demonstrates his skill with a Singer.

© Kodachrome by Louis Muller and camera (left) James Dugan



diver (page 162), took a mooring hawser out by dinghy. He waded in on the table top and looped the hawser over a clump of coral. Out on the precarious jetty to the reef's edge came a figure in shorts and another in a white burnoose. The first man sent the burnoose running back to the lighthouse, and he brought a man with a rifle.

The man in shorts—Hassan Fuad Hanno, the lightkeeper—quickly realized that we were not an enemy. He went back to the house and changed into uniform, lunched aboard, and took a *Calypso* party over his comfortable little island. He had been 24 years in the Egyptian lighthouse service.

Reef's Scenery Delights Divers

Meanwhile, our Mediterranean divers were reveling in the Red Sea reef. Of the team, only chief diver Frédéric Dumas and I had viewed those beautiful scenes before. The divers came up yelling "Incredible! How amazing are the fish down there!" They were disappointed only that they had not seen any black coral. That could wait: Dumas and I knew where the black forests grew, from which a lucky fisherman's net or a naked diver's plunge brings up coral for the sheik's prayer beads.

I wanted to show our young divers the wonders of Marsa Qabatt (Marsa Umbeila), a blue cove framed in bright coral ledges under the red hills and lilac mountains of the Sudan. As we anchored there, from a mound fort on shore arose a solitary coast guard, a small half-clad Nubian with a shock of curly hair. He helped us moor, and we asked him aboard for lunch.

The coast guard's name was Hadji Iam. The first name is one of great distinction among Moslems, meaning that he had made the *hadj*, or pilgrimage to Mecca.

Our cook served frankfurters and salt pork. We remembered pork is taboo to Moslems. Riquet tried to warn the guest by grunting like a pig. Hadji Iam was puzzled. He ate the pork with relish, not knowing what it was—may Allah forgive him!

First View of Southern Cross

That night, heading south, we saw the Southern Cross for the first time, and in the morning the deck was littered with flying fish.

Early one day we arrived at the melancholy Zubair Islands, bare volcanic heaps off Yemen. The main island, Jabal Zubair, appeared as a

black pile devoid of life except for a rank of huge white booby chicks.

In the sea beneath this desolation teemed a furious jungle of life. The divers were amazed at the sights a few feet under: five-foot moray eels, sharks, schools of silvery caranx, or jacks, and huge *Tridacna* clams with their scalloped, fleshy lips wide open.

Albert Falco, expert diver, went down with Dumas (page 181). He stirred up a 20-foot manta, or devilfish, which sailed away with whipping "wings." Half a dozen sharks encircled them. Dumas said they were "very bothering."

I asked Falco, a man of few words, what he thought of the Red Sea. "*C'est beau*," he said. "*C'est sérieux*." Beautiful and serious it is.

We ran for Djibouti, in French Somaliland, and took a pounding in heavy southwest winds. Spray sailed over the high radar antenna. *Calypso* rolled so heavily that the bell on the wheelhouse rang.

In the quiet haven of Djibouti, underwater inspection revealed storm damage to our starboard bilge keel. This meant a trip to Aden, where *Calypso* eased into a floating drydock.

The mishap knocked three days out of our schedule, but they were pleasant ones: *Calypso* has many friends in Aden. One, Antonin Besse, left his business interests to sail with us as deck hand and diver. In Aden also we took aboard two more scientists—Wallace Brown, a Canadian geophysicist, and Allan Russell, a geologist from Australia. Russell traveled light; his dearest possession was a geological hammer made in Illinois for the British Everest Expedition.

Mukalla, the "Skyscraper" City

En route to the Pirate Coast to begin the oil survey, I could not resist a short visit to the Arabian Nights city of Mukalla. It was plain sightseeing—and what a sight!

Under a great reddish-brown mountain on a strip of beach stands a white "skyscraper" city of urban architecture unusual for an Arab country (pages 156 and 159). Mukalla's white-washed towers, mud bricks on stone foundations, average five stories in height.

Mukalla is the gateway to the Arabian peninsula's fertile Hadhramaut Valley behind the coastal mountains.* It has sky-

* See "Into Burning Hadhramaut," by D. van der Meulen, NATIONAL GEOGRAPHIC MAGAZINE, October, 1932.



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Kudschimov by Louis Meitz

↑ "Is It Becoming?" A Shopper Ponders in Mukalla's Open-air Market

Mukalla contains few permanent shops; roaming peddlers and roadside merchants conduct a thriving trade. Here a townsman debates the purchase of a Western jacket and umbrella. Indonesian-style sarong and loose-fitting turban are standard city dress.

↓ Somber Faces Belie the *Calypso's* Warm Welcome in Mukalla

Sightseeing in the port, the author and his crew found townspeople friendly and hospitable. These tribesmen drape the blanket-like *rudi* over one shoulder. Amulets hang from leather straps about the neck. Grease coating the skin protects against sun and wind.



scrapers for the same reason as Manhattan—too little land. There is a narrow pass through the mountains at the western end of the city, and it is closed by a heavy gate against possible roving brigands.

In the Gulf of Aden on a dazzling day we sighted, miles ahead of *Calypso*, a long line of white foam, like breakers on a submerged reef. The charts showed no reefs. We drew

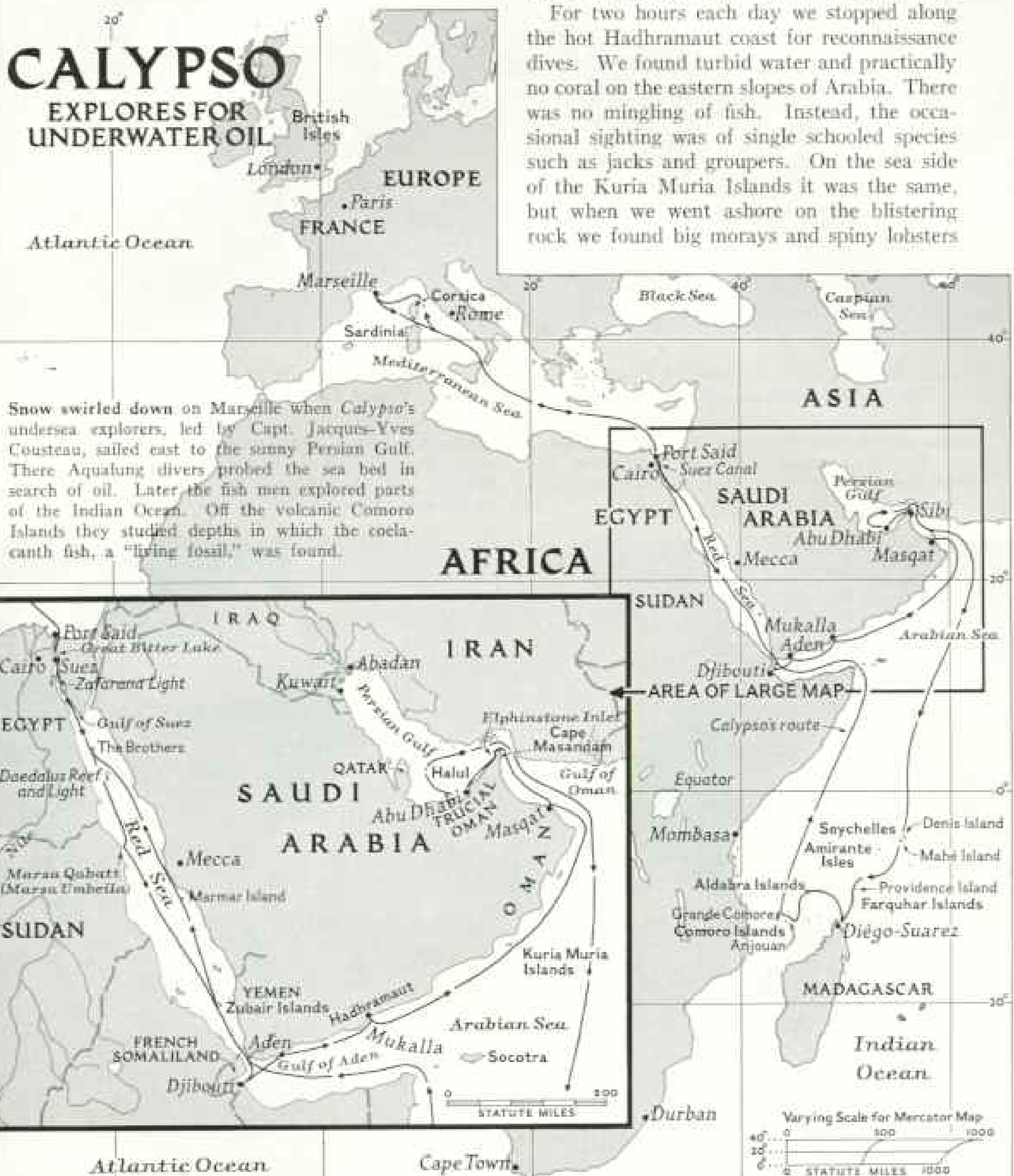
near and saw that it was a stupendous school of porpoises advancing abreast in frenzied leaps. There were literally thousands of these mammals, more than most experienced seamen had ever seen.

The porpoises soared 20 feet out of the water, contorted their bodies at the top of the arc, and hit the surface with loud splashes. They reminded me of hearty young Rugby players glorying in the shock of scrimmage.

For two hours each day we stopped along the hot Hadhramaut coast for reconnaissance dives. We found turbid water and practically no coral on the eastern slopes of Arabia. There was no mingling of fish. Instead, the occasional sighting was of single schooled species such as jacks and groupers. On the sea side of the Kuria Muria Islands it was the same, but when we went ashore on the blistering rock we found big morays and spiny lobsters

CALYPSO

EXPLORES FOR UNDERWATER OIL



Snow swirled down on Marseille when *Calypso's* undersea explorers, led by Capt. Jacques-Yves Cousteau, sailed east to the sunny Persian Gulf. There Aqualung divers probed the sea bed in search of oil. Later the fish men explored parts of the Indian Ocean. Off the volcanic Comoro Islands they studied depths in which the coelacanth fish, a "living fossil," was found.

Varying Scale for Mercator Map
 40° 0 100 1000
 20° 0 1000
 0 STATUTE MILES 1000
 © National Geographic Map

—the latter fine food—in small tidal pools.

We stopped briefly at Masqat, the fortress capital of Oman, which shelters in a cliff-walled cove flanked by two old Portuguese forts. Masqat is a favorite port of call, and sailors have made it a custom to climb the cliffs and advertise their ships in big white letters, such as U.S.S. *Isle of Luzon*, H.M.S. *Falmouth*, H.M.S. *Mauritius*, and *Jeanne d'Arc*. The latter was a reminder for me. I was a French Navy cadet on *Jeanne d'Arc* when the name was painted in 1932.

Boatmen came out to *Calypso* to barter sea shells. Our men had bigger and finer shells drying on the deck, but they played the game by trading cigarettes for the local wares. But when the boatmen saw our beautiful mollusks, they started bidding cigarettes for them. Our men soon won back their cigarettes and sold several shells for cash.

No Shore Leave for Diving Dog

One deck hand never got ashore—Bonnard, our Portuguese water dog. This is a recognized breed, almost unknown outside Portugal and the Azores, where fishermen have bred the animal as a water retriever. Bonnard would dive 10 feet under for objects. He also loved shore leave, but quarantine regulations kept him aboard.

In Masqat's shaded *souk* (market) our shore party spotted the unmistakable hairy black shape of a Portuguese water dog, alone and with the air of owning the place.

"Bonnard!" they yelled, and hastened to take him aboard before he was clapped into quarantine for six months.

The dog surprised them by backing off and bristling. They surrounded him. As they did so, a big, frowning Arab waded in and took up the animal. It was his. It seems that 300 years ago the Portuguese owned Masqat, and only their dogs and forts are left.

We rounded the Masandam Peninsula into the Persian Gulf and gave the geologists a thrill by going into the Elphinstone Inlet (page 168). The inlet is a spectacular branching fjord carved through limestone layers known as the Masandam formation. I doubt, however, that many geologists have made a pilgrimage here. One reason is that the inlet has the reputation of being "the hottest place on earth."

The divers soon went down to see what it was like under water. They came up shouting happily with great armloads of misshapen

rocks—clusters of oysters embedded in coral. The bivalves were among the best I have ever tasted.

We moved into the last recess of the inlet and in the fading light of evening came upon the village of Sibi, a collection of low mud huts under a striated cliff 400 times the height of the houses. Sibi's 100-odd dwellers, small and slight, were the most primitive people I have encountered anywhere, and I have seen the interior of Borneo.

Children Throw Chocolate Away

In the summer these descendants of pirates climb the great cliff out of the inferno and work in inland date orchards. When the furnace cools, the Sibi people lower themselves into the abyss again.

They came next morning in boats, begging for fresh water and razor blades, indicating the latter want by drawing a fingernail graphically across the throat. We filled their containers from our dwindling tanks.

Elders stripped the children so they would shiver appealingly in the chill. We gave the children chocolate, and they threw it into the water. Apparently they had never seen chocolate.

The geological survey off the Pirate Coast was an experiment, to determine whether diving could contribute to submarine prospecting. The concession area southeast of the Qatar peninsula covers about 12,000 square miles, with depths ranging from 20 to 200 feet or more.

Oil-bearing domes had been found in neighboring concessions on land. The indications were good for finding oil under our area, which was controlled by the Sheik of Abu Dhabi (page 166). Our job was preliminary survey. If it gave positive indications, the next stages would be seismic exploration and test drilling.

How the Gravimeter Works

The marine gravimeter detects variations in the strength of gravity under the sea floor. A very slight anomaly in the gravity of the earth might indicate a dome containing black gold.

Given an anomaly, the next step is obtaining rock samples, which may yield helpful information on geological structure.

Russell told of a test-drilling job elsewhere when the drill had gone down thousands of feet, bringing up promising samples of sedi-





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↑ Lateen Sail Billows
Above an Arab Dhow

Naturally curved timbers rib this *arbab*, one of the oldest surviving ship designs. Arabs smear sheep fat, lime, and shark intestines on the hull to combat barnacles.

→ Arabian traders dine on roast mutton and rice aboard their dhow. *Calypto* diver Goiran (in 3 o'clock position) delighted his hosts by donning Arab garb.

← Above: Veiled women draw brackish water from a desert hole near Abu Dhabi. Pure water costs more than high-octane gasoline.

Below: Henri Goiran chats with bodyguards of the Sheik of Abu Dhabi (page 166).

© National Geographic Society

Photographs by Louis Malle





Scientists Probing for Underwater Oil Drop a Gravimeter into the Persian Gulf

Location of oil deposits may sometimes be detected by variations in the tug of gravity. This bell-like machine, lowered into the depths from *Calypto's* starboard quarter, will measure such variations on the gulf floor.

mentary rock. "Then it brought up a fragment of granite, and the drilling superintendent broke down and cried like a baby." It meant no possibility of oil in that locality.

Our rocks would be bagged and carefully labeled with the exact position of the ship and date. In a laboratory in London technicians would classify them for treatment (pages 171 and 173).

The usual way to get marine geological samples is by a heavy bomb-shaped device called a drop corer. Our model weighed a third of a ton, had tail vanes like an aerial bomb, and fitted in its nose was a tempered steel coring pipe.

Rock Crumples Hard Steel

At our first geological station we dropped the corer in 45 feet of water. When we hauled it in, the coring pipe was missing from the nose. Two divers went below and found it, bent into an S, lying on a flat bottom of sand. The super-tempered cutting mouth was crumpled like a paper napkin.

Mystified, the divers delved into the sand. An inch or so underneath was rock like armor plate. Tests on the pipe in England had

shown it capable of coring several inches into limestone. What rock was this?

We fitted another coring pipe and dropped the bomb. The pipe came up still attached, but it was bent into a Z and the cutting edge was smashed. Now two of our four coring pipes had been ruined on the first station, and we had many more stations to go.

Two men swam down with a crowbar and pried some fragments from around a mollusk hole. Dumas thought he could get a bigger sampling with a pneumatic chisel. We rigged a compressed air pipe, and he sank with the drill.

Dumas hung in nice balance above the sea floor and applied the chisel to a mussel boring. He turned on the power and was bounced 10 feet off the bottom.

Each time he tried to dent the rock the stabbing chisel sent him flying. He surfaced and added weights to his belt. We also lowered the anti-shark cage so that he could cling to it for leverage. At length he obtained a few chips.

We tried sending down a man with a cold chisel and another with a big maul. One held the chisel upright and the other pounded on

it as if driving a tent stake. It is an extraordinary physical feat to swing a hammer through a substance at least 800 times the weight of air while one has no purchase on the earth. However, it was the best way we found, short of blasting, and it obtained about 150 rock samples from the 400 stations where observations were made (page 170).

We had set out to survey 200 stations in two months in a weird sea-in-a-desert subject to sudden squalls and sandstorms. The water was as cold as we had found it in winter diving in the Mediterranean. The team had no place to go on infrequent shore leaves, and the supposedly sterile Persian Gulf was found to be well populated with nuisances.

Sea Snakes Watch Work

We protected the divers against sharks by stationing the anti-shark cage beside them on the floor (page 177). They could scuttle inside and close the door if necessary. The

asylum was all right against sharks, but the worst menace in those waters could slither between the bars. There were several varieties of poisonous sea snakes. They were quite inquisitive and came close to see the work. Praise be, none of our people was bitten.

On Halul Island we met Anthony Mould, an Englishman who lived a hermitlike existence providing radar fixes for survey ships. He showed us a pearl divers' graveyard.

"This chap bought it from [was killed by] a shark," he said. "This one, snake; those two, sharks."

Mould had often seen schools of whales passing the island. Sterile sea, indeed!

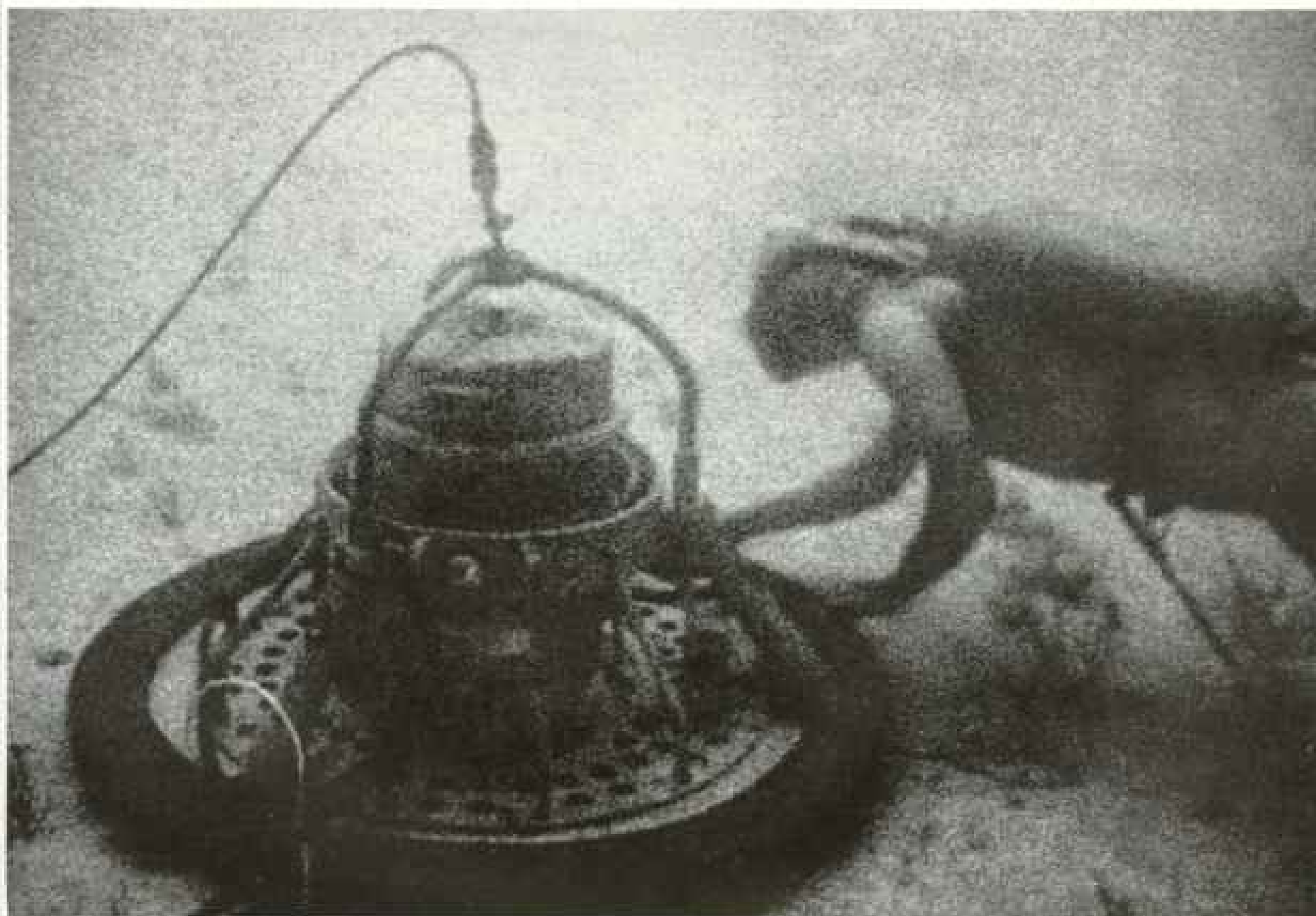
We completed twice the number of stations we had planned and left Trucial Oman waters with "Station No. 400" chalked big on the wheelhouse wall.

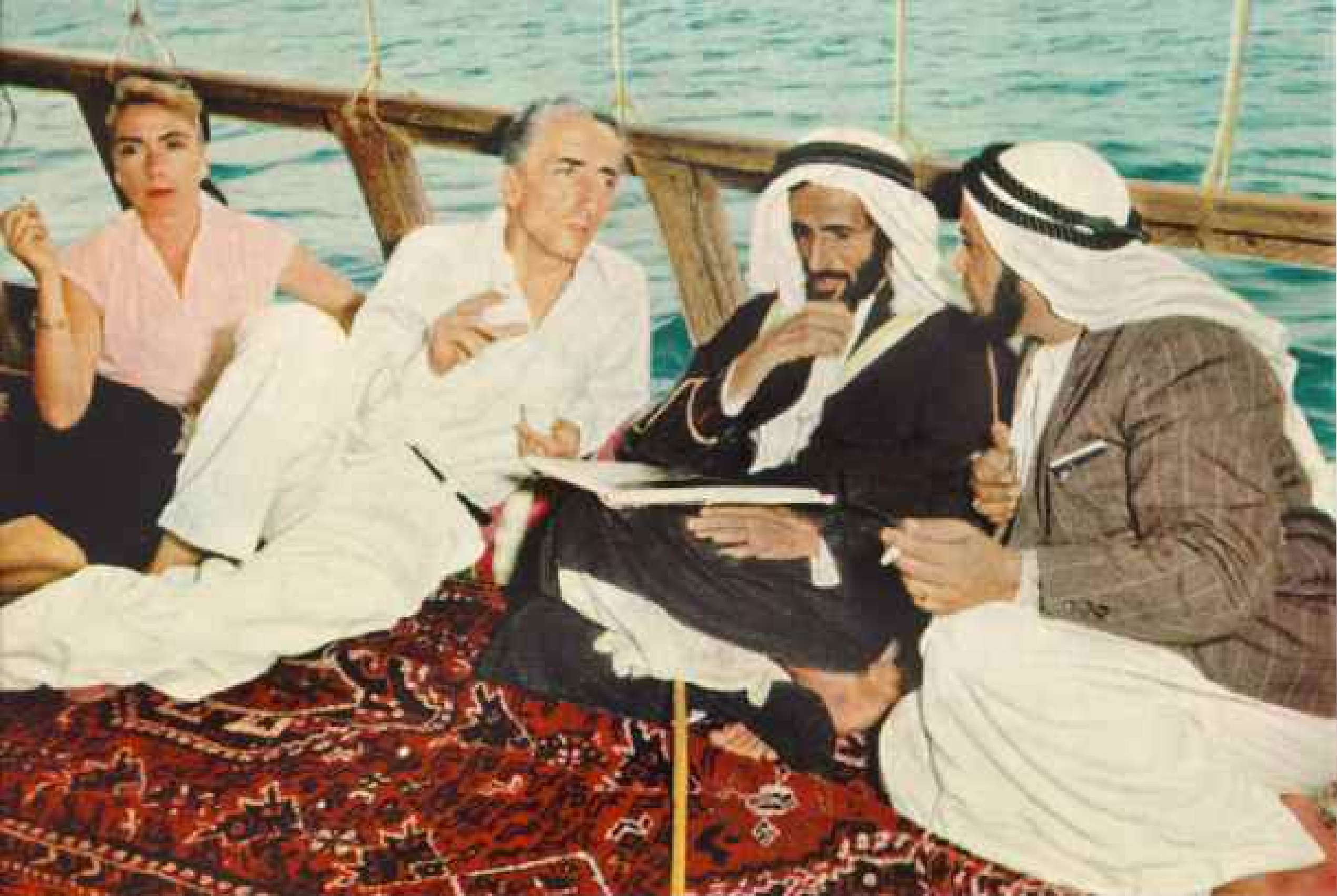
In a holiday spirit we left the Pirate Coast bound for 2,500 miles of blue water and atolls of the Indian Ocean. *Calypso* had a

Man and Machine Explore the Murky Sea Bed: Aqualung Diver Checks the Gravimeter

The complex instrument made hundreds of descents off the Qatar peninsula, surveying a 12,000-square-mile underwater concession. This cable connects to a control panel in the divers' ready room aboard *Calypso*.

British Petroleum Co., Ltd.





© National Geographic Society

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Kodachromes by Louis Mathe

↑ Tales of Adventure Fascinate a Sheik

Through a Lebanese interpreter (right), Captain Cousteau regales the Sheik of Abu Dhabi with accounts of underwater exploration. The ruler studies undersea photographs in the author's book, *The Silent World*. Simone Cousteau, lone woman aboard *Calypso*, accompanies her husband to the Sheik's dhow.

↓ Dhow's Deck Converts to Banquet Table

Welcoming *Calypso* scientists and divers, the Sheik of Abu Dhabi joins them at an Arab feast. Diners squat cross-legged before bowls of lamb-and-rice curry, fruit, sweets, and other delicacies. Dark-robed Sheik sits beside the author at left. Dhow owner Pat Hillyard, an oil company representative, stands at right.



newly won distinction—she was now the official oceanographic ship of France, endowed by the Ministry of National Education. In Paris a special commission of the National Scientific Research Center and the Ministry was interviewing marine scientists who wanted to work aboard. We left the gulf with the first assigned party, two biologists under Dr. Gustave Cherbonnier.

We ran out of a Gulf of Oman monsoon and sailed into crystal days on the wide ocean. Low clouds hung around our world as we journeyed on alone, off the ship lanes. We stirred hosts of flying fish and came upon fin-back whales, a huge sea turtle basking on the surface, a mysterious scarlet blanket of eggs floating in the ocean, a green coconut, and a dolphin, which flashed like a living rainbow.

"Thar She Blows!"

One April morning near the Equator 600 miles east of Africa, the lookouts called "Whales!" I turned to pursue and saw the misty spouts of sperm whales. There were three big beasts in the pod, swimming abreast, lazily and dipping a few feet under.

Falco grabbed a harpoon and rushed to the whaling pulpit on the stem, for we wanted a whale for photography and scientific study. We have chased many blue whales, earth's largest mammal, but these sperm whales, an estimated 60 feet long, seemed the grandest in creation.*

Whale chasing with an 11-knot ship is not serious: leviathan is too fast and powerful. It was a guessing game. After he sounded, could we bend the ship to his surfacing? After several passes we had wonderful luck. The three sperms arrived from the abyss directly ahead and slowly ran up their misty banners.

Falco poised the harpoon and waited. Slightly to port, a mammoth glided underwater. Falco waited until the great dorsal hump wheeled into the air, then threw the harpoon.

The weapon glanced off the whale's back like a toothpick, and the huge animal turned across our bows. I was nearly knocked off my feet by the crash of the ship against the giant. Loose gear clattered. The glass fell out of the chartroom door.

Shoulder to shoulder, moving slowly, the whales turned off our course. The one in the middle was hurt or winded, and its comrades seemed to be helping it along. The injured

animal could not dive, and its companions apparently stayed up to aid it.

Now we could pursue them on the surface. I listened with the headset of the echo sounder to the sounds of the air—tiny mouselike squeaks—escaping from the beast's nasal valves. The injured whale seemed to be shrieking repeatedly as the vast bodies lumbered along, plowing wide wakes.

Then the watchers began to yell and point. From all quarters of the sea whales arose in pairs and converged on the white ship and their struggling companions (page 176). I believe they answered the shrieks of distress. Perhaps zoologists won't agree, but I am convinced these noble creatures have a sense of solidarity. In 15 minutes there were 27 whales around the ship. Two babies were seen swimming crazily alongside big cows.

I turned *Calypso* and overtook the big three again. This time Capt. François Saoût was in the pulpit as we drew close to the limping whale. Saoût put his massive back into a harpoon thrust.

"The harpoon is in!" the watchers yelled.

With the shaft sticking from its back, the whale fell back to starboard. Saoût paid out his line. The skipper tried to keep a slight tension on the line to feel his quarry, but the rope went slack and he hauled in a free—and bent—harpoon. Dumas ran for another iron. We crossed the whales again, and close by the ship their thin spouts became rainbows that drifted over the men.

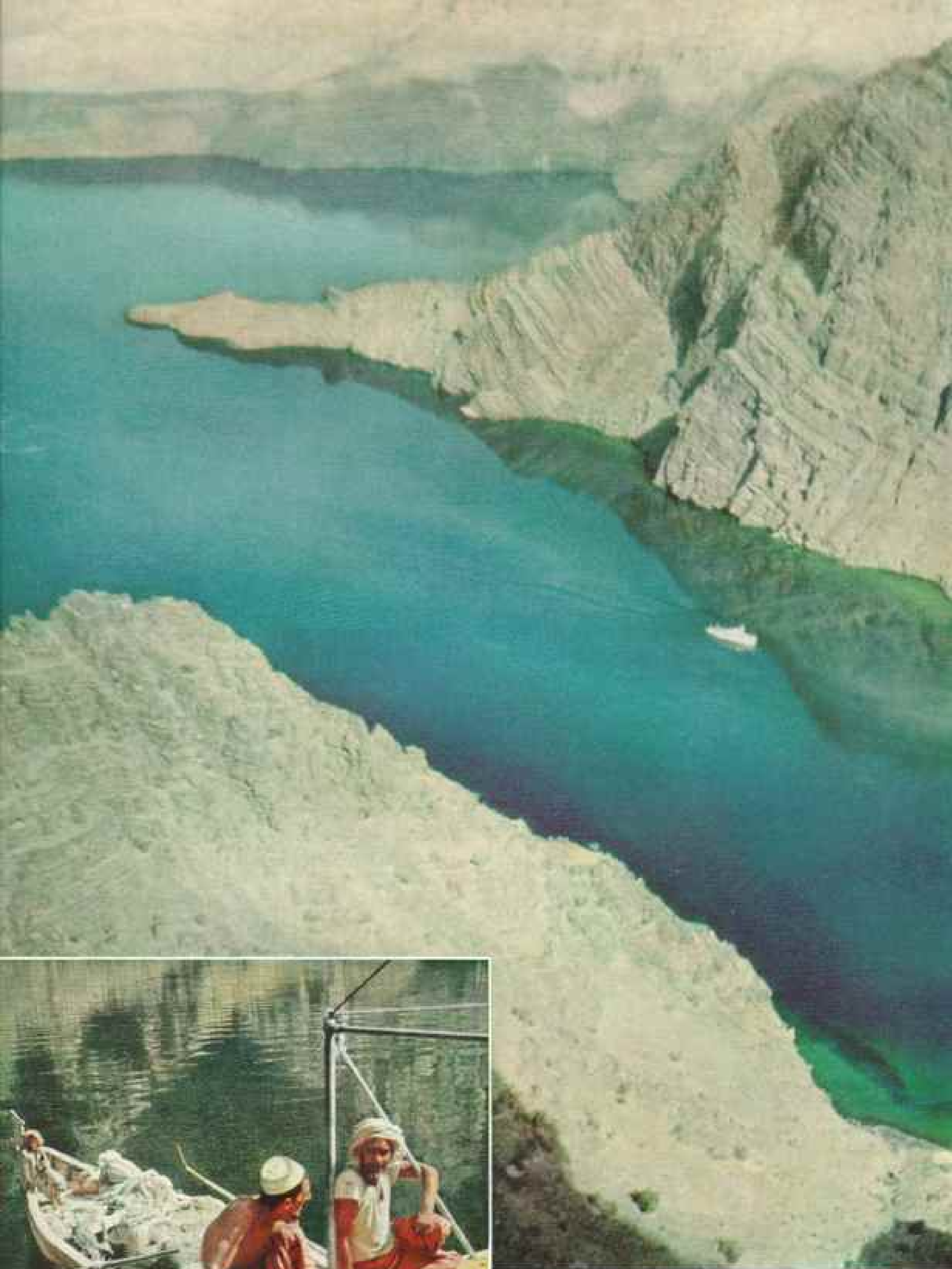
Saoût threw again, and the spear was fixed in a whale. It pulled out, and the skipper reeled in. Nowadays whalers use harpoon guns, but Saoût and *Calypso* were giving good accounts of themselves.

Whale Hits Propeller, Stops Engine

We came among them again. Saoût watched the pale bulks shimmering under the sea and waited for a whale to surface under him. Only once or twice did a whale escape by turning up its flukes and diving deep. They curvetted along as if under a social compunction to stay with their stricken one. The whale with which we had collided appeared still unable to dive.

Then came a second shock on the ship. We felt a thud in the after part, and *Calypso* faltered. The bridge phone rang. It was the

* See "Whales, Giants of the Sea," by Remington Kellogg, NATIONAL GEOGRAPHIC MAGAZINE, January, 1940.



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← **Parched Fishermen Beg Water**

Primitive Sibi tribesmen rowed out to meet *Calypso* in boats laden with empty receptacles. Crewmen gave them nearly all the fresh water aboard.



Toylike *Calypso* Sails into Elphinstone Inlet, Called "the Hottest Place on Earth"

Villagers of Sibi (right) flee the fierce summer heat to work at inland date oases. *Calypso* was the first powered vessel to enter the inlet in 20 years. After a grueling 3,000-foot climb, photographer Malle maneuvered the ship into camera position by walkie-talkie from atop the baking limestone cliffs.



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200 Feet Deep, a Diver Chisels the Flintlike Floor

When coring pipes crumpled, Aqualungers swam down and chipped off specimens of rock for laboratory testing (page 164).

chief mechanic, from the engine room. "Commandant, the port engine has stopped!"

I said, "Try to turn it over. I think we had a whale in the propeller." In a moment I felt the port diesel join up, and the phone rang. "Okay, commandant."

Passing thoughts of what had happened to the port screw were lost in the events that came now. Off the port after quarter we saw a bright red patch in the sea, a baby whale with four deep incisions through hide and blubber, scored in parallel lines across its back. Our propeller blades are very sharp.

Bull Whale Surveys Scene

The infant was about 15 feet long and probably not more than three months old (sperm whales are 13 to 14 feet at birth). The little whale tried to rejoin the pack. The others fell back around it, but the infant was sorely hurt.

Then we saw a marvelous thing. Off the port bow, closer to us than all the pack, arose a tremendous black bull. His massive square head climbed out of the water like an elevator,

and, streaming waterfalls, he rose against the sky to perhaps three-quarters of his length.

He was the chief, apparently, and he turned his small eyes around the horizon like a periscope before he fell back on his tail and submerged in foam. It was a surveillance and a superb act of defiance.

If, as I believe, whales have a tribal compact, they must also have a chief. He must have given an order to retreat and abandon the wounded, for the pack, including the adult which had crashed *Calypso*, vanished and was not seen again.

The baby was left alone, staining the sea with blood. A big shark glided into the scene. Plainly the unfortunate collision victim was mortally in-

jured and would have to be dispatched. Saouï thrust deep into the wounded whale. The haft fell away, and the iron was fast. Two more sharks swam toward the whale, which drifted off to port.

Our electric winch brought in the whale. Six sharks were present as it was drawn up to the stern; they made no move to attack the helpless animal while it was alive.

Boatswain Albert Raud lowered the drawbridge diving platform on the counter and jumped down on it. He and another crewman got a shackle over the whale's flukes as the sharks patrolled a few feet away. Thus we were able to hoist the heavy body against the ship, and the winch was freed to lower the anti-shark cage beneath the whale.

Divers slipped on fins, masks, and Aqualungs, tested their knives, and stuck them into belt sheaths. We were going down to observe and photograph what happened under water. This was a good opportunity to learn something of the behavior of sharks. After all, sharks are the main problem of divers.

The sharks were sniffing at the whale. Saouf and Raud got down on the diving platform and jabbed at them with boat hooks. The cook threw out some garbage, and the sharks gobbled it.

We swung the cage off the stern and secured it while two divers entered with cameras. They were going to hang from a half-inch cable with 12,000 feet of water under them.

It was not necessary to discuss what to do if the cable parted. They knew. There were two possibilities: to sink with the cage and be crushed by pressure, or to bail out before it reached 300 feet and make their way to the ship through the sharks.

As the cage went down, the men with boat hooks flailed away joyously, smashing the sharks on the head as they lined up for the whale. It was a big battle in the war of men against sharks, and the men were ahead for once (pages 177-179).

With engineer André Laban I dived to photograph the scene. To shoot without interference of cage bars, we kept the door open and held out the camera with head and arms exposed. The door opening is three by four feet. It hinges upward on the inside and must be tied up while one is filming. The man inside was ready to cut the lashing if a shark made for us.

The sharks turned up toward the whale with their mouths open and sniffed along the flanks for a good bite. Underwater I could not see the pikemen buffetting them from the platform, but would see a graceful shark suddenly writhe and break off when he could stand it no longer. One swam

past the side of the cage, turned quickly, and drove his snout smartly against the bars. The cage shook, and Laban and I looked up at the cable. It held all right. We were raised to the ship.

Since life was not yet extinct, Dumas got out his rifle and gave the coup de grace to the whale with a bullet.

Their Prey Dead, Sharks Attack

It was the signal for the sharks to attack in frenzy. The prey was dead, and they would not be denied. They set their teeth in the whale at the water line, with their flat noses above water, and shook their bodies like terriers to loosen the flesh.

The voracious sharks seemed completely

A Paleontologist Pores Over Calypso's Rocks

Bagged and labeled with the ship's exact position and date of discovery, specimens from the Persian Gulf arrive in a London laboratory.

British Petroleum Co., Ltd.



oblivious of the hammering boat hooks as they ate. They did not go underneath, where they could have eaten with impunity.

The next team in the cage sighted a newcomer, a blue shark 12 feet long. It glided from the depths and watched the others eating for a while before it struck.

Saoût hooked a shark in the gills and hauled it up on the platform; it was so surprised that it came out supinely. Then it suddenly burst into fury and beat up a waterspout that hid Saoût. When the water subsided, Saoût was still aboard, grinning at a broken staff. The shark was gone.

More shark hooks were thrown over on lines, and Dumas began shooting into the water.

The big blue was killed and hauled aboard. Biologist Cherbonnier cut it up for study. A sailor seized a bit of whalemeat from the stomach and baited a shark hook with it. The deck was soon covered with the flopping creatures, and barefooted men were hopping away from their tails and jaws.

Night was coming. Inky cumulus lay on the horizon against a rose-orange sky, and the sea was violet. We threw the shark bodies into the sea and sailed on.

King Neptune Comes Aboard

That night each man was handed orders from the Minister of the Equator, Kingdom of Neptune, to stand ready to receive King Neptune aboard next day when we crossed the line. Fourteen people had not yet crossed the Equator, and it was necessary to initiate them with due solemnity.

In the morning, cannibals, comic cops, a fireman, a monk, a barber, and several musicians appeared on deck. At the appointed hour there came from the sea over our bows an astronomer with a sextant made of a bottle; he announced King Neptune and Queen Amphitrite. Up came Saoût in a gleaming crown and a regal beard of yarn, with a be-rouged radioman as his consort.

After a royal procession around the decks we got down to business. The novices were placed in a barber chair on the edge of an improvised canvas pool, lathered, shaved, and dumped into the water, where the cannibals ducked them three times. As they emerged, the cook threw flour in their faces and the fireman hosed them down. Then the cook gave them sweet buns to signify membership in the watery kingdom.

When all were inducted, somebody yelled, "Bonnard! Bonnard hasn't been initiated."

Electrician Paul Martin placed the dog in the barber chair. Bonnard's tail wagged wildly as he was lathered. The cannibals immersed him three times and handed the dog to the cook. Bonnard shook free and dived back into the pool. The cannibals gave chase, and Bonnard was held tight for the rest of the ceremony. He gobbled the bun and returned to the pool. When we let the water out, he was still there. His eloquent tail indicated that he had enjoyed the fun as much as anybody.

In eight days we had sighted only one ship. Then came the cry, "Land!" We rang the bell and blew the foghorn as a green fringe emerged on the edge of the sea—Denis Island, northeasternmost of the Seychelles group. A rainbow appeared over it as we drew near.

Denis is an island of South Sea dreams, a copra plantation with graceful, polite people speaking French, although the islands have been British for more than a century. We had no difficulty understanding the swinging Seychelles patois.

Calypso left Denis with the deck piled high with green coconuts, plantains, and other fruits and a small gray pig, gifts of the islanders. Next stop was the Seychelles' capital, Victoria, on Mahé Island.

Mahé is a sight for a sailor. Unlike the common tropical island structure of coral or lava, it is made of peaks of black and red granite, heaved into the air in ages past by some cataclysm of the ocean floor. The towering mass has weathered into noble rocks and is rich in greenery. Around its base, 120 feet under water, lies a coral shelf formed around the Seychelles in later ages.

"Chinese" Gordon's "Garden of Eden"

We got a tremendous reception in this delightful place, which "Chinese" Gordon once declared was literally the site of the Garden of Eden. Gordon's statement is open to question, but it certainly is an idyllic place.

Several members of the National Geographic Society were among our first callers, along with the French colony and the genial British Governor, William Addis, and his staff.

Most of the 37,000 inhabitants wanted to visit *Calypso*. Every small boy yearned to descend the tube at our bow to the underwater observation chamber on the forefoot.

White-robed Brothers of Christian Instruc-



Experts Seeking a Clue to Rocks' Geological Age Focus on Wafer-thin Slices

In London's Beaufort House laboratories, 3,000 miles from the Persian Gulf, scientists assay oil potentialities in submarine rocks gathered by the Cousteau expedition. Tiny sea shells embedded in the rock help determine its age. Here paleontologists identify the minute fossils.

tion, two of them New Englanders, brought the entire rosters of their schools, and one couldn't climb a ladder without spilling several Girl Guides. Small fry marched in endless ranks down the long jetty to visit *Calypso*.

The French consul gave us a monumental party at a tropical hotel right out of Joseph Conrad. Artists had hung murals of Aqualungers and mermaids in silver on black velvet. Far into the night we danced waltzes in double time, and our crew turned up in 19th-century straw sailor hats, still the bonnet of the islands' harbor navy.

The Seychelles are one of the few outposts one cannot reach by landplane. A wartime survey for emergency landing strip sites in the Indian Ocean found the islands too mountainous. The only way to reach there is by the Bombay-Mombasa-Durban boat or by an occasional cruise ship.

Sometimes it takes air mail four months to or from the islands. Consequently, there are few tourists, but there is lavish hospitality



British Petroleum Co., Ltd.

Doodling Pad? No, Magnified Fossils

Technicians slice the rock on a diamond-impregnated wheel, then grind each piece to transparency. This limestone section, enlarged 100 times, may show traces of corals, sea urchins, and fish teeth and bones. A favorable analysis will lead to drilling.

for those who wander upon the "earthly paradise."

From Mahé we sailed to Providence Island, a dependency of the Seychelles. It had been devastated by a cyclone the previous year. Many coconut palms had been shorn off at the top, and most of the buildings blown away. The topless palms thrust high into the air like the fakir's line in the Indian rope trick.

The proprietor showed us the ruins of a plantation his grandfather had won from a bare sandspit. Son and grandson had labored 50 years to bring it into production. Despite his plight, the planter sent *Calypso* a pirogue loaded with melons and other fruits, gourds, and a delicacy none of us had ever expected to taste—hearts of palm, "the millionaire's salad."

A palm heart is obtained by cutting down a mature tree. To serve 10 costs about \$200, we were told. But the trees of Providence were killed in the cyclone, and the planter sent us away as billionaires—in hearts of palm, at least.

A Surfeit of Seafood

We kill fish only to eat on *Calypso*, but we couldn't eat all the boys took the night before sailing. The surface was teeming with needlefish attracted by our lights. One man, in the launch with a trident, transfixed eight in half an hour. Another tried shooting them near the surface with a spear gun. It takes expert marksmanship to shoot from the air through the surface, account for the optical distortion of water, and hit fish an inch and a half thick. He took nine in 13 shots.

People often say to Calypsonians, "You must eat a lot of fish." The fact is, we eat meat twice every day, so that fresh fish comes as a treat from the spearmen who go "shopping" on order for such delicacies as cold boiled barracuda, rock bass, groupers, or needlefish. Flying fish landed on our decks almost every day of the tropical cruise. The boatswain gathered them in the mornings before scrubbing down.

At the Farquhar Islands we explored a fine old wreck. Above the surface it displayed rusting boilers and engine rods like the skeleton of a stranded marine monster. Beyond the curtain of water the wreck was a circus of life, the bones tapestried with coral and brilliant little creatures parading all about. Ships that go down make cities in the sea and, as they slowly dissolve, contribute to geology and

life. Sunken gold means little to the man who has seen old tropical wrecks.

At Diégo-Suarez, Madagascar, *Calypso's* bottom was scraped, and then we called briefly at the Aldabra Islands, whose giant land tortoises and marine life we planned to investigate in a later National Geographic Society expedition.

Our next task was fishing for a very strange fish, the famous coelacanth *Latimeria chalumnae*. For this we sailed to the Comoro Islands (Archipel des Comores). The species was supposed to have become extinct some 70 million years ago, but in 1938 naturalists were electrified by the appearance of a living coelacanth from South African waters. Since then, seven more have been taken from the Comoros, six of them under the personal direction of J. Millot, professor of comparative anatomy and director of the Institute of Scientific Research in Madagascar of the Paris Museum of Natural History.

Our type of fishing was not for the fish itself; the coelacanth is so important to science that Millot enlisted *Calypso* merely to study its environment with Dr. Harold E. Edgerton's depth cameras and our echo sounders.*

The little-frequented Comoros are populated by people of mixed Malagasy, Negro, Arab, and Persian stock. Indians, and a few French. The islands are green-clad volcanic ranges with gray lava glaciers tonguing into the sea over snowy coral beaches. High peaks and ridges plow furrows in the clouds. The ports are fortresses built of weathered lava blocks. The islanders export perfume essence, vanilla, sisal, copra, and the coelacanth.

The famous fish were caught close to the steep underwater cliffs off Anjouan and Grande Comore Islands. It meant danger to

(Continued on page 183)

* See "Photographing the Sea's Dark Underworld," by Harold E. Edgerton, NATIONAL GEOGRAPHIC MAGAZINE, April, 1955.

Calypso Pauses Outside Aldabra, → Remote Indian Ocean Atoll

The remodeled American mine sweeper met smooth seas and fair skies in the Indian Ocean after running out of a monsoon in the Gulf of Oman.

Above: *Calypso*, riding at anchor, rolls in the wake of her launch. A diver peers from the whaling pulpit. Aluminum bridge and twin masts make the ship easily identifiable.

Below: Speeding launch carries Captain Cousteau across the barrier reef to Aldabra.





← Whales Plow Wakes
in the Indian Ocean
as *Calypso* Gives Chase

Nearing the Equator 600 miles east of Africa, lookouts spotted this pod of sperm whales. The leviathans swam lazily abreast on the surface, occasionally dipping under.

During the pursuit a baby whale ran afoul of *Calypso's* sharp propellers. Blood spurts from its back (below). Mortally wounded, the creature soon fell behind the pack.

Caged Against Sharks, →
Divers Head Below

With the dying whale lashed to the ship, divers go down to film and study underwater shark attack. Hanging by a half-inch cable, they watched hungry jaws rip into the mammal. Should the thin cable break, divers would sink with the cage and be crushed to death by pressure, or bail out and swim up through the man-eaters.

↓ A ravenous blue shark nuzzles the descending cage.

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Kodachromes by James Huggan (above,
left and right) and Louis Muller

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Flickering Shafts of Sunlight Play upon an Underwater Drama of Shark vs. Whale

"From below the scene was aerial," writes the author, "with the zeppelin hulk of the whale rolling in a cloud of blood turned yellow by the sea's filter. In the stratospheric blue, sharks circled like jet planes. They slid past the cage, staring at us with their terrible lifeless eyes. To film without interference of bars, we kept the yard-square door of the cage open and, with head and arms exposed, held out the camera."

✦ Upper, left: Remoras, or shark suckers, became dislodged from their hosts during the fray and fastened themselves on *Calypso's* hull. Suction discs enable this live remora to cling to the back of crewman Maurice Léandri. Below: Tugging like terriers, two sharks tear chunks of blubber from the dead whale.



◀ *Calypso* Berths Beside a Reef and Launches Divers to Film Red Sea Coral Gardens

Here, off Marmar reef, divers plunged 230 feet to make the deepest color pictures they had ever attempted with hand-held instead of automatic cameras.

With the ship anchored bow and stern to the sharp coral sea wall, floodlight cables are lowered straight down. Rubber tires bobbing in the water protect the hull from jagged rock.

Aqualungs Strapped in Place, → Flipped Cameramen Head for Their Submerged Studio

Filming at 230 feet usually required six divers. Two manned cameras, two held the lights, and a pair served as actors.

So clear was the water at 200 feet that they were able to distinguish black coral trees another 100 feet below.

↓ Photographer Albert Falco, lit by a flash bulb, maneuvers his 16-mm. camera into close-up position on the reef wall 125 feet down. Natural light reveals mushroom-shaped coral in background.

Freed from gravity's shackles, this fish-man moves in perfect balance, able to roll over on his back, float motionless in the current, or glide ahead with languid ease. Flippers on his feet propel him at a speed of two knots. Hands act as rudders.

© National Geographic Society.
Illustration by Louis Malle and Jacques Bertrand





← Comfortably Seated
on the Ocean Floor,
Frédéric Dumas Picks
Sprays of Coral

At the foot of a huge porogonian, *Calypso's* chief diver dislodges specimens with a hammer and bags them at his waist. Shark hilly, a three-foot stick tipped with nail points, dangles from his wrist.

Dumas wears only trunks; Indian Ocean waters are warm even at 145 feet. Absolute pressure on his body at this depth is more than 79 pounds to the square inch, yet he feels no discomfort. Compressed air flows by tube from the tanks on his back to a rubber mouthpiece; inhaled air raises pressure within his body to that of the surrounding sea.

Exhaled air bubbling up from his exhaust valve assumes the shape of a dancing genie.

↓ Gaily colored butterflyfish swim clear of a coral ledge 60 feet down in the Indian Ocean. A drab squirrelfish trails the gaudy trio.

A school of pelagic fish, hunting prey, swims by at upper right. Snowy particles of plankton, minute animal and plant organisms, fleck the waters.

© National Geographic Society
Kodachromes by Jacques-Yves Cousteau
(above) and André Labau



the dangling flash cameras if they were to get close enough to tell us of the coelacanth's environment. I decided that the cameras were to be expended if necessary. Edgerton, the indefatigable "Papa Flash," was back in Cambridge, Massachusetts, building better ones for a forthcoming National Geographic Society-Calypso expedition.

Now, off Grande Comore, we were going to drop the camera against a jagged reef 2,500 feet down and abuse the unit further by hauling it up level as *Calypso* drifted toward shore. Two men held their hands on the taut wire to feel the vibrations of the camera bumping the reef. When it bumped, they winched it up 15 feet and felt for the next collision to haul the camera 15 feet farther. In this methodical fashion it stumbled up the reef stairs, flashing every 17 seconds in the abyssal dark—an agent of men seeking a footnote on a fish.

Diners Rush to Free Camera

After two hours the winchman popped in at dinner and yelled, "The camera is trapped!" The diners rushed to the afterdeck; the messman entered with a platter of steaks and goggled at a deserted table. I went to the bridge and got power from the engine room to attempt to free the camera.

I heard a chorus from aft: "The camera is free!" We went back to cold steak.

Presently the camera, still flashing, came back like a phosphorescent squid surfacing in the night. Its struts were bent, tubes were scarred, and clamps displaced, but nothing vital had been damaged and Professor Millot had some new photographs to study.

Homeward bound in the Red Sea, we stopped at Marmar Island, a submerged coral table with a small crescent of burnt land above water. Around the island lie the ruins of a fringing coral reef, broken down in places like a neglected garden wall. The encircling reef is shallowly submerged, so that navigating through the breaks is delicate work.

The table and the toothy reef fall vertically 600 feet, and they have some of the Red Sea's most extravagant coral gardens. That we had learned in 1951.* Now we wanted to go very deep for color photographs with powerful lights carried down on trailing cables from the ship. It was the deepest color work we had ever attempted, in the blue zone around 230 feet, and required the dispatch of five or six divers at a time—a photogra-

pher or two, a team to hold lights, and one or two others who served as actors (page 181).

We coned *Calypso* inside the stockade, and sailors took the stern anchor away in a boat and dumped it on the brilliant table, where blue and gold surgeonfish wandered among yellow antlers of fire coral. It was a blissful anchorage. The cook, not usually eager to dive, donned snorkel and mask and thrashed away from the diving platform with a can opener to pry up souvenir shells.

Diving deep, we fetched up specimens of enormous *Tridacna*, the "man-eating" clams of undersea fiction. Half shells of these bivalves, usually more than three feet long, sometimes serve as holy-water fonts.

A west wind rose in late afternoon. As the last diving party came aboard, we were rolling in a stiff breeze. Then the anchor cable parted, leaving a good anchor on the desolate reef. We manned a launch and a dinghy to recover it while *Saoût* reversed screws against the wind to hold *Calypso* in place.

I was up on the after crane watching the boats in the failing light and felt the unusual sensation of spray over the stern. We were in danger of being swept on the rocks.

Out in the dinghy, a sailor was clinging to the lost anchor. Others roared around in the dark in the launch, shining a flashlight on the rim of the coral table to guide *Saoût*, who was holding the ship in place at half-speed astern.

Second Anchor Planted

The wind blew harder. The moon would not be up for two hours. I realized that we could not recover the anchor. I called the launch in, and we lowered another anchor into it. We fed the cable out as the launch plunged into the waves. Somehow the second anchor was planted on the shallow coral.

If this anchor did not hold, *Calypso* was in great peril. We could not drop bow anchors; the water was too deep. The ship would be left struggling in the wind between the island and the treacherous reef wall. It was too steep to register on the echo-sounding apparatus before we crashed. If the anchorage failed, I planned to circle Marmar all night as tightly as possible, using a radar fix on the island and playing the searchlight on the table reef. If the radar failed, we would

* See "Fish Men Explore a New World Undersea," by Capt. Jacques-Yves Cousteau, NATIONAL GEOGRAPHIC MAGAZINE, October, 1952.

send a party ashore to build a beacon fire.

We recovered the boats. The second anchor seemed firm. The crewman came back with the dinghy. It was his saint's day. The ship held the mooring.

The wind died down in the night, and at first light we recovered the stranded anchor. Fresh capricious breezes blew up, turning the compass nearly twice. I decided to weather this nonsense by berthing *Calypso* along the edge of the reef as if it were a pier. This would enable us to drop lighting cables directly into the submerged "studio."

We edged alongside into the breeze blowing off the table and laid bow and stern anchors on the coral. The divers placed rubber-tire fenders between hull and sharp reef, exactly as in dock. We stared down at dazzling coral heads 18 inches below our water line and had the sensation of shipwreck (page 180).

Coral Berth Holds Ship Safely

The film location made the position worth while. Below us the water was crystal clear. At 200 feet, among trees of black coral, we could see 100 feet farther down the wall by natural light. We photographed with pyrotechnic torches and tried shadow effects on the gorgeous coral cliff.

At another location farther north we had a look at the submerged topography under the wreck of a big Arab *boom* careened at the edge of the burning sand. Falco surveyed the site with a snorkel mask and noted so many large nosy sharks that we moved on to the Brothers islands.

Two of our divers and the motion-picture photographer, Jacques Ertaud, who had flown to Aden to join the homeward passage, dived to survey one of the two Brothers. They found shy sharks and bold fish. Four men dived to get shark pictures, since the piscatorial film extras in this area seemed more tractable than the tough guys at our previous location. What happened has entered *Calypso* folklore as "the tragic dive."

Photographer Louis Malle led his comrades down the reef to spot sharks for the interconnected flash-camera team. Around 100 feet down Laban lost sight of Malle and swam on deeper, looking for his bubbles or the grayed-out figure of the leader. Malle was not to be found. At around 150 feet Laban called a halt. The trio decided with grunts and gestures to look for sharks on their own.

Simultaneously Riquet saw a pair of sharks

below, and Raymond Kientzy saw three gliding against the sky above. Riquet darted down and came to the end of one extension cable, and Kientzy climbed to the end of his cable, leaving Laban, who hadn't seen anything, holding a camera, pulled this way and that. Laban expostulated in a cloud of bubbles while his light holders continued to haul in different directions. A fearful tangle ensued. The trio surfaced, fuming and vowing that they would never speak to one another again.

Malle popped up in the middle of the uproar, demanding to know where everybody had been. "I found some lovely sharks," he complained.

That dive indicated the fatigue of the team after six months of hard diving and sailing 18,000 miles. I decided to let down deliberately—no more work except routine watches. We started a continuous game of cards in the mess and played through the Gulf of Suez, Great Bitter Lake, the Canal, and the dash home to Marseille.

The western Mediterranean was brawling in a stiff west wind, as bad as any gale I have known in many years of sailing this sea. Off Corsica a sailor came to the bridge and said, "Something in the wake! I think it's Bonnard!"

Riquet said the dog had been closed up in the mess and ran to look. Bonnard was not there. From the open bridge wing we saw a black dot tossed in the frothing waves far astern. We turned back and hurled life rings. The dog must have slipped out of the mess as someone opened the door for an instant, and he had gone to the open afterdeck to enjoy his kind of weather; he reveled in the roughest and wettest. A wave had carried him off the diving deck.

Home to Marseille

We circled twice. It would have been the same for a man overboard in that sea. The water was cold, and Bonnard couldn't have suffered long. We did not even see our life rings in the 20-foot waves which toppled in flying white veils.

Bonnard was finished with the sea, and there were tears among us. We regained course. Finally we sailed inside the island of Grand Congloué, hooting for the inhabitants, who ran out and waved. Then *Calypso* passed the breakwater of the Vieux Port and came home to Marseille.

Astronomers Throughout the World Receive the First Section of the National Geographic Society-Palomar Observatory Sky Survey

BY IRA SPRAGUE BOWEN, Ph.D.

Director of Mount Wilson and Palomar Observatories

BENEATH the huge dome sheltering the 200-inch Hale telescope of the Palomar Observatory in southern California a treasure lies hidden. Three floors below ground in Pasadena, 90 miles away, a similar treasure is buried.

Now, we astronomers do not set much store by buried treasure. We work in the freedom of space and are inclined to hold with Plato, who remarked nearly 2,500 years ago that "Astronomy compels the soul to look upward and leads us from this world to another."

Originals and Copies Safeguarded

What we have locked in the vault in Pasadena are the priceless original photographic plates of the National Geographic Society-Palomar Observatory Sky Survey. The dome of the Hale telescope at Palomar protects a complete and exact copy on glass.*

With the unique 48-inch Schmidt telescope-camera, after seven years of strenuous work, we have virtually finished photomapping the heavens to a depth of 600 million light-years. That is some 3,600,000,000,000,000,000 (three sextillion, 600 quintillion) miles.

As members of The Society read these words, the first sections of the Survey, each composed of 200 photographic prints containing billions of star images, are being sent out to observatories, universities, and scientific institutions on every continent. Over the next few months the remaining sections of the 1,758-plate atlas will be delivered.

Thus an extremely valuable and indeed unique picture of the universe will have been furnished to the world of astronomy. I am persuaded that it will stand for many decades as a monument to mankind's quest into the unknown and perhaps the unknowable.

Noble as were the concept and, I think, the execution of the Survey, still during the years of work there were moments of disappointment, often relieved by comic interludes.

The Sky Survey was the first project of the newly built 48-inch Schmidt camera, of a type perfected in 1930 by the German optician Bernhard Schmidt. The instrument can photograph a section of the sky as large

as the bowl of the Big Dipper in one exposure (page 188). In only seven years it has covered the whole sky that can be photographed from Palomar. It would require a telescope like the 200-inch Hale 10,000 years to record the same area—from a declination of 27° below the Equator to the North Pole.

As in the case of all new and intricate instruments and undertakings, there were difficulties at the beginning. In the first few months of the Survey more than two-thirds of the photographic plates exposed had to be discarded because of flaws in the emulsion, error in focus, or a slight blurring of the star images caused by motion during exposure or by disturbances in the air above. Roughly 45 percent of all the photographs taken have been rejected for these reasons.

* See "Mapping the Unknown Universe," by F. Barrow Colton, NATIONAL GEOGRAPHIC MAGAZINE, September, 1950.



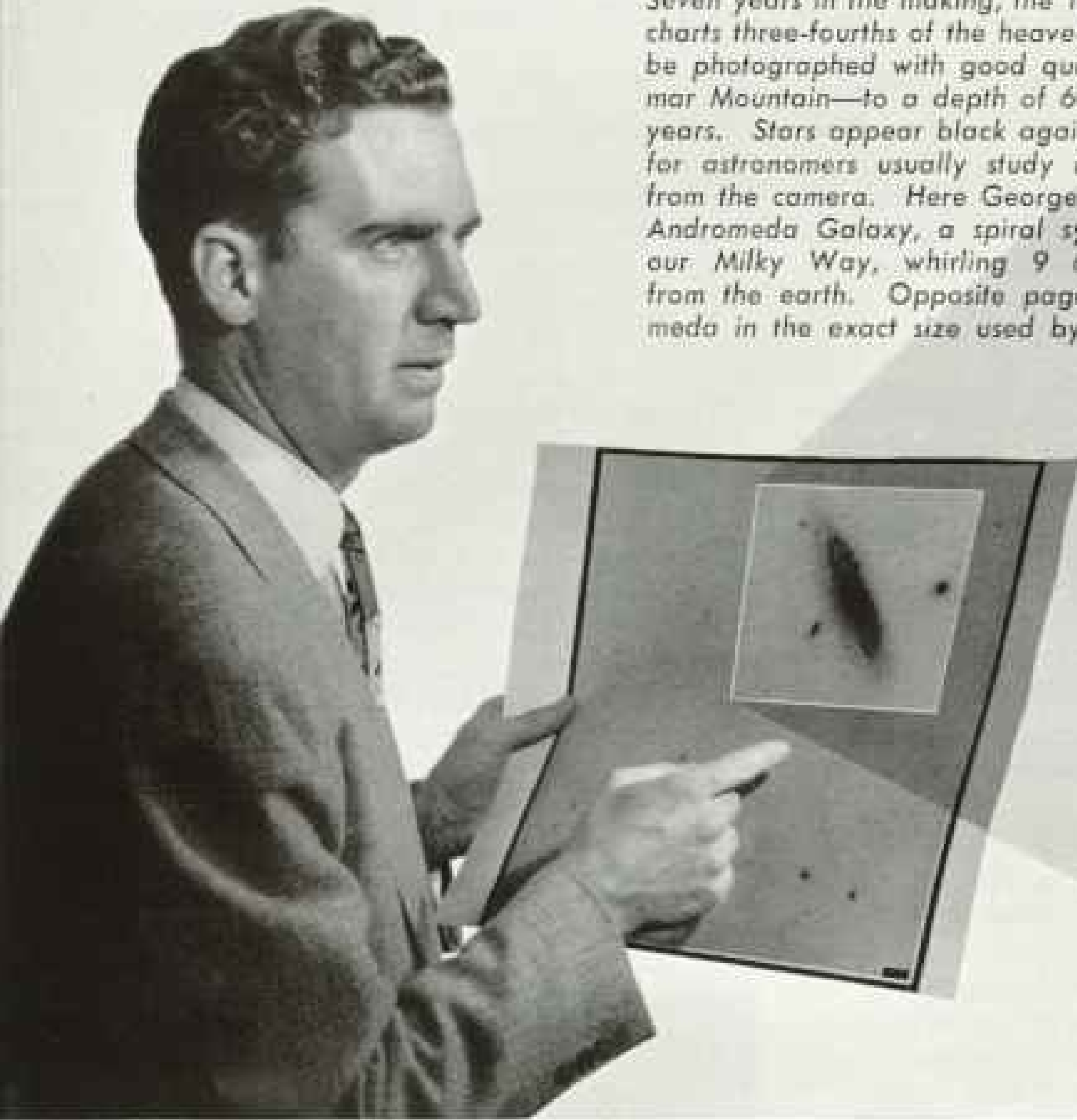
Richard Hart

Author Checks the Spectral Lines of a Star

In collaboration with his colleagues at Palomar, Dr. Bowen conceived and supervised the unique Sky Survey, a project undertaken jointly with the National Geographic Society. One of the world's foremost astronomers, he has received many honors.

Sky Survey Plates Unlock Secrets of the Stars

Seven years in the making, the 1,758-plate atlas charts three-fourths of the heavens—all that can be photographed with good quality from Palomar Mountain—to a depth of 600 million light-years. Stars appear black against a white sky, for astronomers usually study negatives direct from the camera. Here George O. Abell scans Andromeda Galaxy, a spiral system similar to our Milky Way, whirling 9 quintillion miles from the earth. Opposite page shows Andromeda in the exact size used by the Sky Atlas.



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Milton Hymen

The standards we set for the Survey were high, so high that for a time they seemed impossible to fulfill. That was why so many plates were rejected and why it took us seven years instead of four, as planned.

Once Dr. Gerard P. Kuiper, a distinguished astronomer of the Yerkes and McDonald Observatories, was visiting at Palomar and admiring some of the Sky Survey plates.

"These are superb," Dr. Kuiper said. "I have seldom seen such definition."

"They are good," replied Dr. Rudolph Minkowski, who directed the Survey project. "But they are not good enough. We are making them again."

Dr. Kuiper shook his head in disbelief; but the new plates were much superior.

The astronomers who operated the Big Schmidt and produced the Survey plates—Dr. Albert G. Wilson, now director of the Lowell Observatory, Messrs. Robert G. Harrington, George O. Abell, and others—found

the work exciting and rewarding as new celestial objects came into their ken. But it was sometimes cold, lonely, and heartbreaking.*

Once Mr. Abell was observing on such a night as astronomers pray for; the light from countless stars pierced down through a beautifully clear and steady Palomar sky. The "seeing," as we say, was excellent.

Afterward Mr. Abell took his photographic plates to our darkroom and started to develop them. That is quite a ticklish job, and nobody enters the room while Survey plates are being developed.

"Presently," he recalls, "somebody flung open the door." It was Charles E. Kearns, able night assistant for the Big Schmidt.

"Get back! Close the door! Have you gone mad?" Abell shouted.

"Relax," Kearns said. "It really doesn't

* See "Our Universe Unfolds New Wonders," by Albert G. Wilson, NATIONAL GEOGRAPHIC MAGAZINE, February, 1952.



matter. We forgot to take the dust cap off the Big Schmidt!"

It was true. The plates were perfectly blank. Some priceless seeing time was lost, but we never made that mistake again.

I mention this lapse, these successes and failures, so members of The Society will understand that, although we were dealing with the sublime, the making of the Sky Atlas was a very human operation.

Millions of Objects Recorded

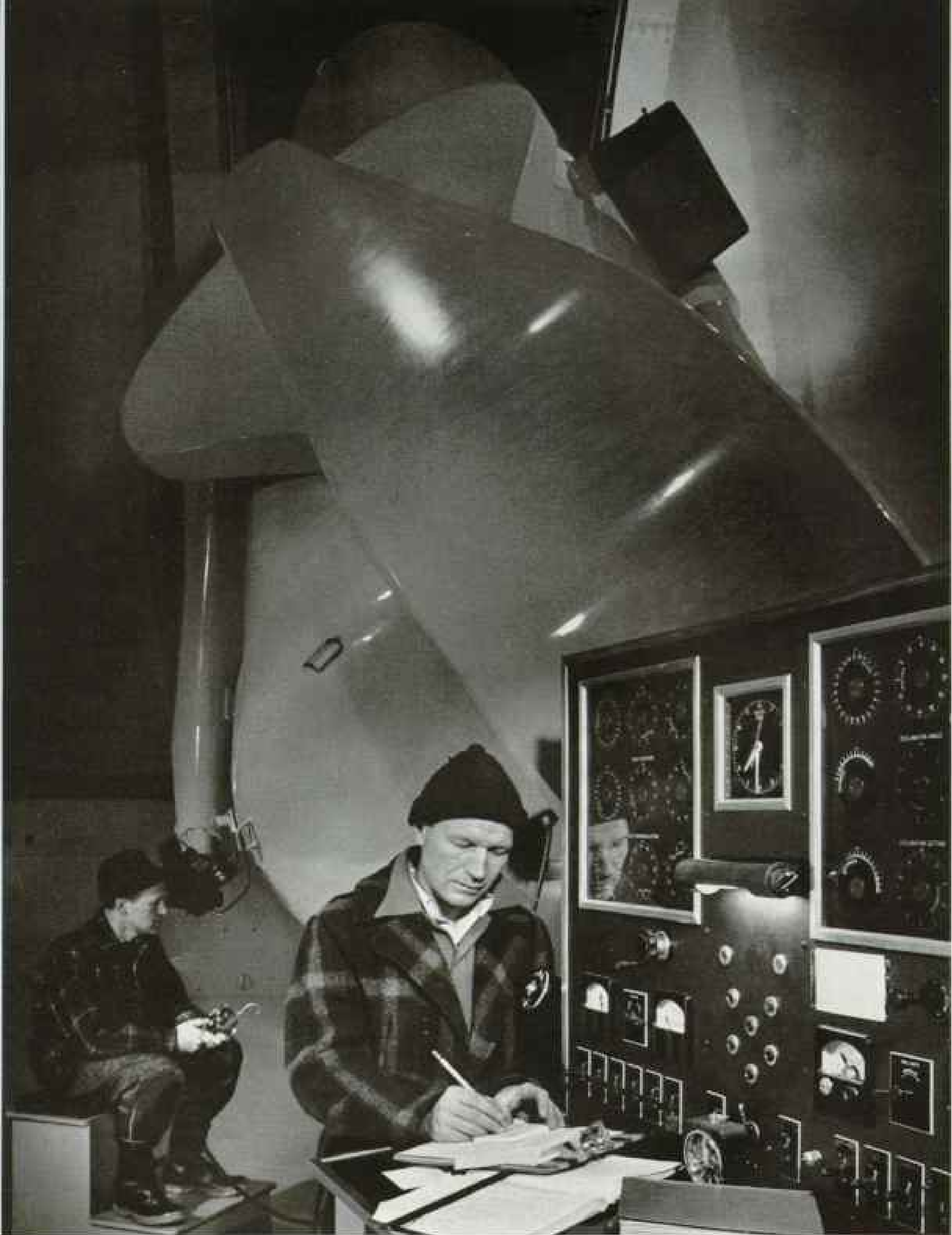
We gave to it some of the finest minds in astronomy. We worked with an incomparably accurate instrument, the Big Schmidt. We had near-ideal seeing conditions on Palomar Mountain; we had the wholehearted backing of the National Geographic Society; and we enjoyed the vast resources of the Eastman Kodak Company in the preparation of the best possible emulsions and plates for the job. In spite of the human element,

or perhaps because of it, the integrity of the Sky Survey is a source of pride to us all.

The millions of new objects—stars, nebulae, and stellar systems recorded for the first time by this Survey—will require years of work to be exploited fully by the many astronomers who will have access to the atlas.

Dr. Lee A. DuBridge, president of the California Institute of Technology, which, with the Carnegie Institution of Washington, D. C., owns and operates the Mount Wilson and Palomar Observatories, believes the Survey will keep astronomers busy for a hundred years—a conservative estimate.

Moreover, the record of the skies at the present time will become increasingly valuable to astronomers. Thus when an occasional star flares up to millions of times its original brightness to form a nova, or new star, the atlas will provide a record of the original brightness and temperature of the star before the outburst occurred. Hence it



Pointing Through the Dome, the Big Schmidt Photographs a Big Dipper-size Patch of Sky

Palomar Observatory put into professional use the first Schmidt telescope, an 18-inch model. Its phenomenal success inspired construction of the 48-inch, or Big Schmidt, which made the entire Sky Atlas.

To counteract the earth's rotation, Big Schmidt turns slowly from east to west. Astronomer Robert Harrington, watching a guide star in the eyepiece, holds an electric "guiding head" which realigns the instrument if it drifts off course. Joseph Stehlik checks the control panel.



Sky Survey Reveals an Exploding Star

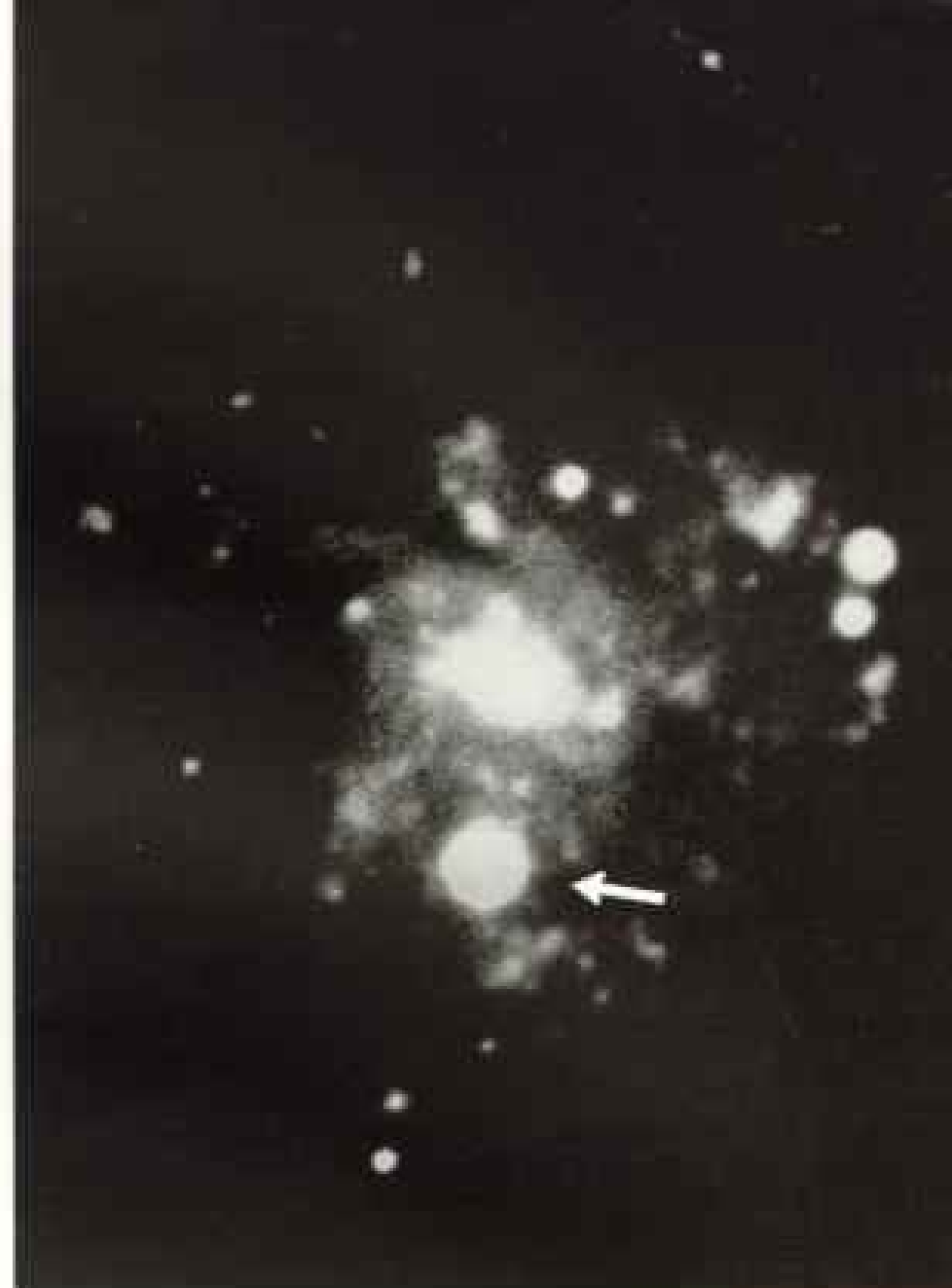
↑ Spiral galaxy NGC 5668, photographed by the Big Schmidt in 1952 as a routine chore, shows an ordinary galaxy composed of swirling stars, nothing to cause excitement. In 1954 an unusual disturbance was noted.

→ Rephotographed with the 200-inch Hale telescope, the same galaxy blazed with the fire of a celestial catastrophe, the titanic explosion of a star that, according to one theory, overdrew its hydrogen fuel reserve.

Arrow points to the new supernova. Light from this giant started its journey through space about 20 million years ago.

In comparison, man's hydrogen bomb is as mild as a falling feather. In round figures, the supernova produces 10,000,000,000,000,000,000,000 (10 septillion) times more energy than the bomb.

© National Geographic Society—Palomar Observatory Sky Survey



will help astronomers to learn the reasons for such stellar explosions.

Comparison of these original plates with others of the same region taken years later will permit the astronomer to pick out the stars that have changed position and are therefore either moving with very great velocity or are unusually close to the earth.

Thanks to the great light-gathering power of the 48-inch Schmidt camera and the length of the exposures given to all plates, the Sky Survey records all stars down to a brightness of about one-millionth that of the faintest star that the naked eye can see.

Previous Surveys Far Outdone

Indeed, this Sky Atlas will record stars and other objects out to distances in the universe three to ten times as far away as in previous photographic surveys. The new atlas therefore maps a volume of space at least 25 times as great as that recorded in any previous survey of the whole sky.

Often I am asked to outline in brief capsule form the uses of the Sky Survey. It can't be done. Its versatility for the astronomer is almost without limit. There are certain important areas, however, where the Survey already has demonstrated its value.

First in importance, it is a complete record of the sky visible from Palomar Mountain

as it appeared in the mid-20th century. It provides for the first time an atlas of the whole sky on a uniform basis with the detail that only a big instrument can show. Like a pirate's map of a treasure island, it shows astronomers where to dig, so to speak, revealing objects worth investigating with the 200-inch Hale telescope or other large instruments. Thus comets, asteroids, unusual stars, clusters of stars, nebulosities, galaxies, and clusters of galaxies are all recorded.

For example, the late Dr. Edwin P. Hubble discovered 25 years ago that all very distant objects are receding with a velocity proportional to their distance, thus leading to the theory of the expanding universe. To test this theory, many distant clusters of nebulae must be located and their velocity measured. The Survey plates have proved invaluable to Dr. Milton L. Humason, who has been extending Hubble's work. He has already found clusters receding at velocities of about 38,000 miles per second.

Second, because the Survey has made exposures of each field on separate red- and blue-sensitive plates, astronomers will be able to differentiate between cool red stars and hot blue stars. This feature will help in selecting stars for spectroscopic observations and in classifying them.

Third, astronomers now will be able to de-



Palomar Astronomers Inspect Each Page of the Finished Atlas for World-wide Distribution
Dr. Bowen (pointing) and Dr. Rudolph Minkowski view the plates on a light box. James McClanahan and Hendrik Rubingh file approved prints. Unlike most volumes, the atlas is not bound.

termine how the stars, nebulae, and galaxies are distributed in space. We have known for some time that stars by the billion congregate in great disk-shaped structures like our Milky Way. The Survey records many millions of such stellar systems, known as galaxies. We still need much further information on how these galaxies group themselves to form clusters of galaxies, which are the largest known structures in the universe.

Fourth, the Survey is proving its value in the new science of radio astronomy—investigating those strange radio noises reaching the earth from unaccountable distances. Often the noise seems to come from an invisible object. But sometimes the sources can be determined and photographed. These are permanently recorded in the Survey.

Now we have all but finished what is surely the most extensive map of the sky ever conceived by the mind of man. It will be sent to purchasers wherever astronomy is studied.

As director of the Mount Wilson and Palomar Observatories, I want to thank my colleagues for their work on the Survey and for their wholehearted support of the monumental project—Dr. DuBridge, Dr. Humason, Dr. Minkowski, Dr. Walter Baade, Dr. Wilson, Mr. Harrington, and Mr. Abell.

The intricate and skillful task of printing each plate separately many times, for the massive copies of each volume, was the responsibility of Mr. James McClanahan and Mr. Hendrik Rubingh.

The National Geographic Society was the prime mover and the mainstay of us all in the production of the Sky Survey. We are grateful for the unflagging support of Dr. Gilbert Grosvenor, Dr. John Oliver La Gorce, Dr. Melville Bell Grosvenor, Dr. Thomas W. McKnew, Dr. Lyman J. Briggs, chairman of The Society's Research Committee, and the late Assistant Editor of the NATIONAL GEOGRAPHIC MAGAZINE, Mr. F. Barrows Colton, whose death on August 10, 1954, saddened all who were associated with the Survey.

The National Geographic Society—Palomar Observatory Sky Atlas is now launched, but the celestial wonders locked within its plates have scarcely been touched. Over the next two years astronomers at Palomar and at observatories around the world will examine the plates meticulously.

As soon as possible thereafter, their findings will appear in The Magazine for the benefit of the 2,150,000 member-families of the National Geographic Society, whose support made the Sky Survey a reality.

Following the Fur Trader's Canoe Highway, Author and Family Find Northland Travel Still an Adventure

BY RALPH GRAY

National Geographic Magazine Staff

TWELVE years before Lewis and Clark blazed their historic trail across America, fur trader Alexander Mackenzie painted his name in vermilion-stained bear grease on the rugged coast of British Columbia and thanked God for bringing him safely through Canada's wilderness.

This first man to cross the continent north of narrow Mexico was as spellbound by the limitless and fruitful land as are today's trans-Canada travelers. Struggling westward, he reported "mountains and valleys...wide-spreading forest...lakes and rivers" succeeding each other in bewildering array.

Sixteen decades later, I traced the Scottish explorer's general route from Montreal to the tiny Pacific fishing port of Bella Coola—and saw the many changes man had made. The beaver-pelt provinces which Mackenzie added to Montreal's fur empire had flowered into farms, cities, pulp and paper operations, fisheries, oil fields, lumbering and mining communities (color map, page 198).

"Passions and Fears...to Control"

Mackenzie and his companions "possessed no accommodations or conveniences but such as could be contained in the burden on [their] shoulders." I traveled in a Plymouth station wagon, also by airplane, boat, jeep, and horseback.

To a list of other hardships recounted in the preface of his journal, Mackenzie added, "I had, also, the passions and fears of [my followers] to control and subdue." Here I was one with him, for my three children accompanied me, and they were just of an age to need occasional controlling and subduing.

But after three months and 15,000 miles of living out of a station-wagon tail gate, I had to admit that Judith, 13, Mary Ellen, 11, and Will, 7, had come of age as National Geographic travelers.

For their mother the trip provided the first real opportunity of seeing her native land. Jean, my wife, was born in Winnipeg, Manitoba, two years after her parents had migrated from Scotland. The family moved

to the United States when Jean was only 9.

"I've never been back," she reminded the children as we crossed the border and headed for the St. Lawrence River and Montreal.*

Now all thoughts turned to picking up "Mackenzie's Track." I followed a side road that ran to the river. On the left bank stood Canada's leading metropolis—the French world's second city and one of North America's busiest ports (page 192).

Rapids Mark the Trail's Start

There, at the head of deepwater navigation, French Canada long ago planted its most flourishing outpost. In midstream we saw wild waters frothing at their last rocky obstruction before tidewater.

"Lachine Rapids," I said. "They stopped the French ships. But beyond, Indian canoes took explorers on through the wilderness, searching for a Northwest Passage."

A birch-bark canoe highway pushed inland via lakes and rivers, a veritable national road of Canada. Guided by Indians, Champlain marked the trail along the Ottawa and French Rivers to Lake Huron's Georgian Bay. Others extended it into Lake Superior. Following the Lake of the Woods route, a native-born Canadian, La Vérendrye, arrived at the site of Winnipeg in 1738; there a fort was built.

Furs were the lure. National rivalries over beaver pelts helped bring about the downfall of French Canada. Britain formally annexed the land in 1763, about the time Alexander Mackenzie was born in Scotland. He arrived

* See "Sea to Lakes on the St. Lawrence," by George W. Long, NATIONAL GEOGRAPHIC MAGAZINE, September, 1950.

In previous articles in the NATIONAL GEOGRAPHIC MAGAZINE, Mr. Gray has brought American pioneer history vividly to life by revisiting the scenes of great events and presenting them as they appear today. His "Vacation Tour Through Lincoln Land," in the February, 1952, Magazine, won a Freedoms Foundation award. In the June, 1953, issue appeared his memorable article, "Following the Trail of Lewis and Clark." Mr. Gray, Chief of the National Geographic Society's School Service, retraced Mackenzie's track just 160 years after the Scot reached the Pacific. The photographic survey of the route in color required nearly two years, 1953-54.—The Editor.

Where Big Liners Stop, → Mackenzie's Trail Begins: Montreal, Canada

Long before Canada as a nation was ever dreamed of, Alexander Mackenzie made two epic voyages west of Montreal. The Scottish fur trader became the first man to cross North America north of Mexico, beating Lewis and Clark to the Pacific Ocean by 12 years.

Braving unknown perils, crossing inland seas, threading white-frothed gorges in birch-bark canoes, the explorer laid the basis for Canada's future as a continental power.

Following Mackenzie's track, the author and his family traveled 15,000 miles by car, boat, plane, jeep, and horseback across Canada's vast expanse. They noted the country's bountiful growth despite wilderness areas still as untouched as when Mackenzie passed.

The *Empress of Canada*, once a familiar sight in Montreal harbor, burned in 1953.

Page 193, lower: At the start of their trip in Montreal, Judith, Mrs. Gray, Mary Ellen, and Will ride up Mount Royal in a victoria.

↙ Northwest of Lake Superior the family pilgrimage pauses to check its bearings.

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Illustrations by B. Anthony Stewart
(lower) and Ralph Gray; National
Geographic staff

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in Montreal at 16 to seek his fortune in the fur business. Young, ambitious, and born to lead, he soon started west.

I pointed upstream to the head of Lachine Rapids.

"There, just beyond the white water," I said, "is where western explorers took to their canoes. There is the beginning of Mackenzie's track."

"But we're going to see Montreal before starting out, aren't we?" Judith asked.

Indeed we were. And in between sight-seeing jaunts I picked up fragments of the story of Mackenzie and his associates of the North West Company.

This rival of the Hudson's Bay Company, 20 years after its founding in 1779, wrote up more fur business through Montreal than did the older enterprise in all its branches. The partners' wrangling helped destroy North West after three flourishing decades.

North Westers who had wintered as far west as Grand Portage were eligible to join the Beaver Club of Montreal.

Celebrations Launched Canoe Journeys

From one of the 12,000 volumes in his private library, Dr. Victor Morin, Montreal antiquarian, read me a description of a boisterous Beaver Club dinner to which Mackenzie invited a Colonel Landmann. The meal of many courses began at 4 p.m. Then followed toasts. Twelve men consumed 120 bottles of wine before the night was gone.

After such celebrations the fur "peddlars" and their French *voyageur* canoemen headed up the unpeopled Ottawa River. We followed their route by car, trying to visualize the roadside river dotted with bark canoes.

Mackenzie's first voyage west was by way of Niagara, Detroit, and Mackinac. On subsequent journeys, however, he traveled the Ottawa River-Georgian Bay-Lake Superior-Lake Winnipeg route, methodically logging everything but the number of paddle strokes. To follow the famed track that showed Canada the route to transcontinental greatness, my family and I had the best possible guide—Mackenzie's own *Voyages from Montreal on the River St. Lawrence, Through the Continent of North America to the Frozen and Pacific Oceans in 1789 and 1793*.

At appropriate places as we rolled west, Jean read to us of the portages, *décharges*, and chutes along the grand canoe route reaching to Lake Athabasca.

Ottawa's Parliament Buildings now stand in an area known to fur traders only for three difficult portages (opposite page).^{*} Long before the Canadian capital became a reality, Mackenzie observed that the time might not be far distant "when the lands will become settled from this vicinity to Montreal."

West of Pembroke we encountered the first of many sudden contrasts in this nation, second only to the U.S.S.R. in size. We left open farm and dairy country and entered the bush, that vast "Spruce Curtain" that divides east and west Canada and is little changed since Mackenzie's time. From here almost to Winnipeg, except while crossing Lake Superior, we penetrated the strange barrier of rolling, wooded, granite-pocked terrain that covers about half the nation.

Towns Are Islands in a Sea of Green

In this sea of green the only inhabited islands are mining towns, pulp-plant centers, resorts, and an occasional clear farming area. In between, in the deep woods, highway and railroad cling to each other for comfort.

Near North Bay we crossed the height-of-land portage where the canoeists left the Ottawa system and entered the Great Lakes watershed.

Aboard *Chief Commanda*, mail and supply boat for summer camps on Lake Nipissing, we cruised down the French River, now dammed, whose smooth depths hide the rocky guts the voyageurs threaded.

On Manitoulin Island we spent the night beside the channel used by westerling canoe-men en route from Georgian Bay to Lake Superior. The *S. S. Kewatin* picked us up at Sault Ste. Marie, and we sailed across the world's "largest and most magnificent body of fresh water"—Lake Superior.

Docking in Fort William, we felt we had reached Sir Alexander's true realm; for at last we were in "the country North-West of

^{*} See "Exploring Ottawa," by Bruce Hutchison, NATIONAL GEOGRAPHIC MAGAZINE, November, 1947.

Modern Voyageurs, Junior Size, → Confer on Ottawa's Parliament Hill

Canada's lawmakers have met here since the 1867 Confederation that established the nation. Coronation decorations dressing the front of Parliament Building proclaim Commonwealth ties. The Peace Tower commemorates World War I dead; its bells chime the hours like Big Ben.





Lake Superior," whose tortuous waterways led him on to exploits for which he was knighted.

Fort William and Port Arthur are to Canada today what Grand Portage was to the North West Company: a transshipping point between west and east (page 208). Our car retrieved from *Kewatin's* hold, we crossed into Minnesota, to see the spot where north men met Montrealers each July to tie together

the ends of the fur empire (page 204). *Cour-curs de bois* from the Saskatchewan, Churchill, and Athabasca countries were "regaled with bread, pork, butter, liquor, and tobacco." They derisively called their eastern colleagues pork-eaters because of their civilized fare.

Pork-eaters carried all provisions needed for the north over the 9-mile-long *grande portage*. North men put the goods into their

← Fox and Otter Yield Their Pelts to the Knives of Cree Trappers

Seeing furs like these, Mackenzie and other "lords of the lakes and forests" built North America's first big business. In one year the North West Company bought 184,400 skins, the explorer reported.

Today the demand for pelts has lessened, but, in the James Bay area, Thomas Cheechoo and his wife retain the skills of their ancestors.

Canadian National Film Board

canoes, about half the size of the pork eaters', and started out for Rainy River, Lake of the Woods, the Saskatchewan, and Athabasca, end of the pre-Mackenzie line.

After visiting the Rainy Lake-Rainy River district, we reached Kenora and took a cabin overlooking several of the 14,000 islands and one of the innumerable bays of the Lake of the Woods.*

A short airplane flight gave me a view across the old portage site to the Winnipeg River. This outlet of the lake was the route followed by La Vérendrye in 1737 and later by Mackenzie.

Heading for Winnipeg, we noticed a difference in the terrain near Beauséjour, Manitoba. We had left the bush. Jean, nearing her old home, and I, also prairie born, welcomed the flat, warm expanse of Red River Valley.

Early Settlers Came from North

From this fertile black loam rises Winnipeg, Canada's fourth metropolis (354,000). I offered a prize to the first child to see its tall buildings. Soon Will spotted the dome of the Manitoba Legislative Building.

"Strangely enough," I told the children, "Winnipeg's first settlers came from the north, by way of Hudson Bay. And they came partly as the result of Mackenzie's writings, even though, as fur trader, settlement was the last thing he wanted."

I explained how Thomas Douglas, Earl of Selkirk, seeking new homes for displaced Scottish crofters, learned of Red River Valley from Mackenzie's journals: "The country . . . consists of plains covered with herds of the buffalo and elk, especially on the Western side. On the Eastern side are lakes and rivers, and the whole country is well wooded, level, abounding in beaver, bears, moose-deer, fallow-deer, etc., etc. The natives, who are of the Algonquin tribe, are not very numerous. . . . There is not, perhaps, a finer country in the world for the residence of uncivilized man."

"Why not civilized man, also?" Lord Sel-

kirk probably wondered, and he began laying plans for Canada's first prairie settlement.

Winnipeg partakes of the space and ease of the surrounding prairies. Many of its citizens came from lands as diverse as England, the Ukraine, and China.

"Let's see your old home first!" the children demanded of their mother.

"I don't remember the address, but I think I'll recognize the house," Jean said as we circled about suburban St. James.

Suddenly she exclaimed, "There's Britannia School. Not changed a bit. Turn here; this is the street. At this corner there was a well where everyone on the block pumped their household water. And look at the concrete sidewalks! The wooden ones used to float off every spring when the Assiniboine flooded."

Since the days of La Vérendrye, the junction of the Red and the Assiniboine at Winnipeg has been a pivotal point. Here the two rival fur companies set up posts from which to control the fur harvest. Later, as the prairies filled with farmers and ranchers, the Canadian Pacific and Canadian National Railways funneled all trans-Canada shipping through Winnipeg.

Hudson's Bay House welcomed me enthusiastically (page 207). But when I heard an official mutter to a colleague, "Mackenzie wasn't our man, you know," I felt like someone who had wandered into the wrong lodge. R. H. Chesshire, manager of the Fur Trade Department, told me how, after years of bitterness, and even bloodshed, his company had absorbed North West in 1821.

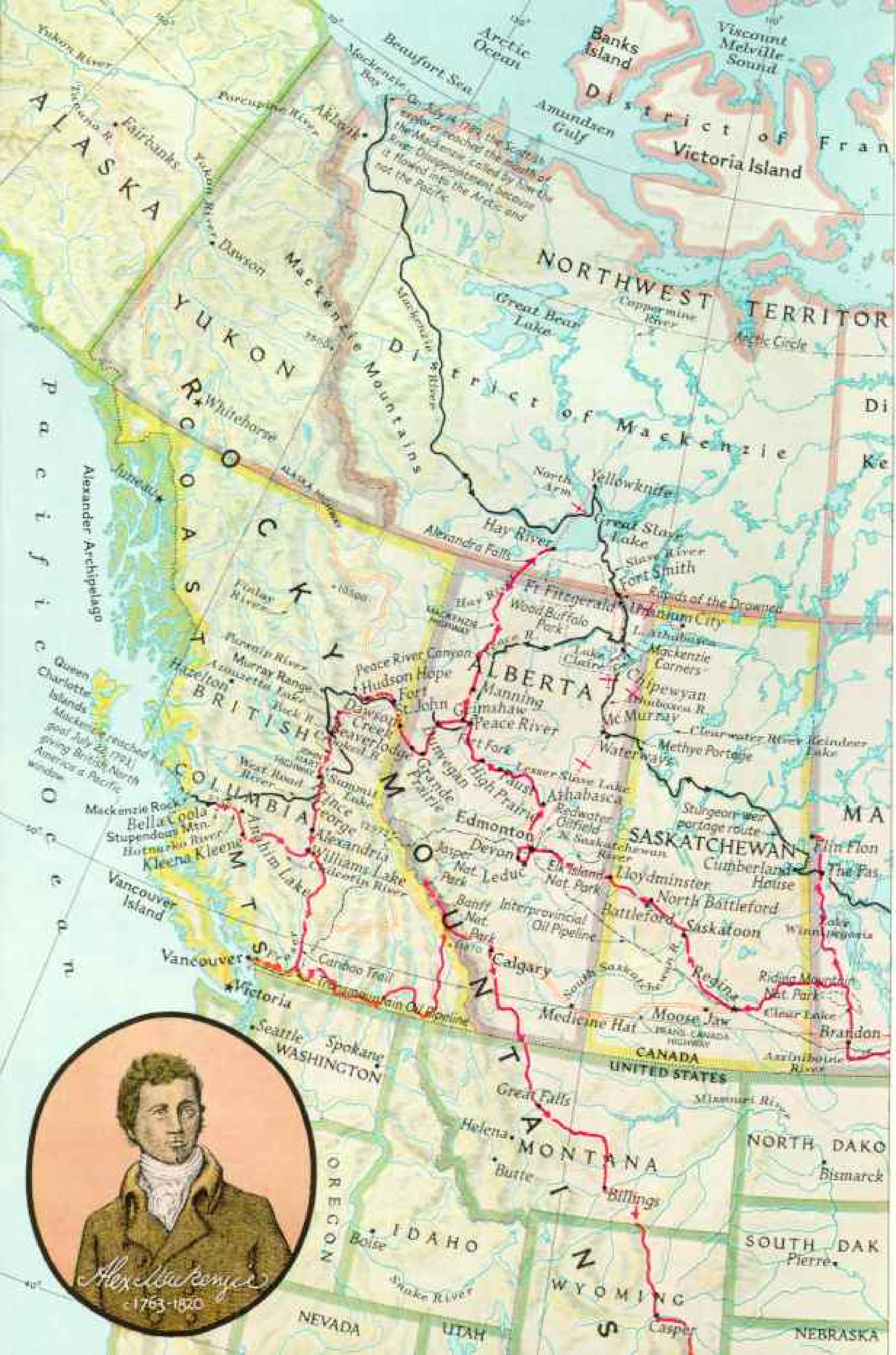
Playground for the Prairies

After a look at Lake Winnipeg's milky blue waters, over which Mackenzie paddled to the mouth of the Saskatchewan, we pushed west across Manitoba's fertile wheat lands. Turning north, we saw rising ahead the poplar-covered escarpment known as Riding Mountain. Here one of Canada's most popular national parks provides a playground for the prairies (page 214). On the shores of Clear Lake I left my family encamped while I made a three-day dash north.

Soon I was driving through the bush again. Scattered farm clearings punctuated the otherwise solid green walls beside the dusty road.

Suddenly I was in The Pas, a small city

* See "Men, Moose, and Mink of Northwest Angle," by William H. Nicholas, NATIONAL GEOGRAPHIC MAGAZINE, August, 1947.



MACKENZIE TRACK RETRACED



In Mackenzie's two history-making voyages across Canada, he traveled 12,500 miles by canoe, 500 on foot.



laid out in checkerboard pattern and backed against the mighty Saskatchewan. Logs that float down the long river to reach Manitoba's largest sawmill, The Pas Lumber Company, reverse Mackenzie's pioneer route. The explorer followed the river west to Cumberland House, then took the complex Sturgeon-weir trail north to the Churchill River.

Mackenzie passed near Flin Flon without suspecting that one day northern Manitoba's largest city would rise here from the wilderness, its smelters fed by rich ores. Here gold, silver, copper, and zinc were concealed from Mackenzie by "banks of black and grey rock . . . occasionally interrupted with a ridge or bank of lime-stones."

From Flin Flon to McMurray, Alberta, Mackenzie's track meanders through the lakes and streams and dark sprucebrakes of northern Saskatchewan.

Regina Once "Pile of Bones"

Returning, I picked up my family, and soon we rolled onto the Regina plain. Ahead of us the skyline of Saskatchewan's capital pinpricked the vast dome of prairie sky (page 211). Approaching closer, we made out the gleaming towers and spirals of oil refineries and the soft limestone of the "State Capitol," as my children persisted in calling Canada's impressive provincial legislative buildings.

Just west of Regina we visited the Royal Canadian Mounted Police barracks, western training center for the force (pages 212 and 213). At Ottawa my son Will had talked with his first Mountie, Constable Gordon Allan, and hadn't been quite the same since.

"Maybe Constable Allan has been transferred out here," he said hopefully as we entered the museum. But when he saw half a dozen scarlet-tunicked stalwarts, Will forgot his first love and started playing the field. Eavesdropping on their conversations, I pieced together the following story.

Sitting Bull and some of his braves camped at a place called Pile of Bones in 1881, while hiding out in Canada following the Custer Massacre. Many Indian buffalo hunters had stopped there before them. The bones of the animals, bleaching beside a small creek, gave the camp its name.

White settlers threw together a few sod huts at Pile of Bones. Then the Canadian Pacific tracks reached the spot, and the North West Mounted Police made it their headquarters. And Sitting Bull's camp, renamed Re-

gina in honor of Queen Victoria, became the capital of the Northwest Territories.

Regina remained the seat of Canada's huge undeveloped western and northern domain until 1905, when Saskatchewan and Alberta became provinces. Both are celebrating their golden jubilees this year.

Trending northwest to Saskatoon, we bisected Saskatchewan's grain-bag heart. Waving fields of still-green wheat crowded the road on both sides. Like bold marks on a graph, grain elevators signified by their number the relative importance of each town. The province produces more wheat than all the rest of Canada and also yields nearly a third of the nation's oats and barley (page 214).

The area needed rain. Next day a steady, soaking drizzle ruined the opening of the Saskatoon Exhibition, one of Canada's great fairs. We had timed our arrival to coincide with the exhibition and were disappointed, but no one else seemed to mind.

"No, sir, this is farm country," said one of the fair's organizers. "We want this rain."

The farther west and north we went, the newer the country became. At Lloydminster, a bustling farm and oil-refining center on the Alberta line, we found that family albums told the town's entire history.

J. G. Dickinson, long a National Geographic Society member, was the first to spin out his personal story.

"I crossed the Atlantic with my older brother in 1903," he said. "Lloydminster, you know, sprang up overnight that year when a complete colony of us arrived from England. We had to carve homes and a new life out of the wilderness. Some were so ignorant of horses that they put marks on the animals to remember where the harness went."

Nearly 2,000 Sought New Life

Mrs. C. Wetton, recorder of the colony's history, told me she believed that the Lloydminster group, nearly 2,000 strong when it arrived, was the largest single emigration of British peoples to Canada.

"Saskatoon was then the end of the Canadian Northern. The settlers put their belongings into covered wagons and rolled slowly across 200 miles of empty prairie. After taking up their claims, they pitched tents and built flimsy shacks. Several froze to death the first winter."

Now the town spread before us as we drove north on the 110th meridian, its main street,



Oil Derrick and Plume of Smoke Interrupt the Neat Patterns of Alberta Fields

This well, one of thousands around Edmonton, has just blown in; the derrick will soon be moved to a new site. Here oil wastes are burned off. Underground pipes carry crude oil to near-by refineries.

to the exhibition grounds where all Lloydminster was celebrating its golden jubilee (page 219). Original colonists, wearing gold-printed ribbons, were pointed out as objects of historic interest.

All across Canada, especially in the west, people had told us, "Wait till you get to

Edmonton. You haven't seen anything yet!" Now we were approaching this oil capital of Canada, gateway to the north and an air crossroads of the world.

We crossed the chalk-colored North Saskatchewan and pulled up to the "high level," where most of the city stands. From the



← Tiny Curling Brooms
Decorate Tartan Tams
Made in Winnipeg

Displaced Scottish crofters founded Canada's metropolis of the plains in 1812. Though immigrants from all the world came later, as the Dominion burst the bounds of its eastern forests, Scottish influence remains throughout much of Canada.

Winnipeggers still practice Highland dances and games. The city advertises Canada's largest bonspiel, or curling meet. In the sport of curling, players slide heavy stones across an ice-floored arena, somewhat after the manner of bowling. Team members with brooms frantically sweep the ice in the stone's pathway, thus affecting its speed and direction.

Cockaded tams are particularly popular during curling season. These are cut of MacLaine of Lochbuie tartan.

↓ Winnipeg's booming textile houses produce a wide variety of sportswear in the patterns of Scotland. This girl, wearing Fraser tartan, marks a bolt of Royal Stewart so that lines will match in the finished garment.

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Endorsements by National Geographic
Photographer J. Bayler Roberts



brink of the river's north bluff loom the turrets and towers of Macdonald Hotel and the dome of the Legislative Building.

Everywhere we were reminded that Edmonton is one of Canada's fastest growing cities, that Alberta is the key to the country's future, that Greater Edmonton's population had passed 200,000 (page 217).

Present prosperity and future hopes rest on oil and natural gas, in addition to agriculture. A new era began in February, 1947, when Imperial Oil, Limited's, No. 1 well blew in at Leduc, a few miles south. Now, several industrial districts are going up. One of them includes such giants as a \$76,000,000 Celanese plant and a \$13,000,000 producer of polythene, a plastic. Pipelines were completed to Superior, Wisconsin, in 1950 and across the Rockies to Vancouver in 1953 (page 224).

Alberta produces 240,000 barrels a day from more than 4,000 wells (page 201). Twenty-four new wells were added the week I was in Edmonton. Ray Sluzer, geologist and superintendent of Imperial's wildcat department, drove us to the Leduc field to watch a drill crew at work only two miles from the discovery well. A derrick stabbing the sky guided a diamond-headed drill down toward the 5,300-foot pay level.

Back to Mackenzie's Track

But I was becoming anxious to follow Mackenzie's track again. At the airport I boarded a DC-4 headed north. As we circled McMurray, I glimpsed the Clearwater River cutting a swath through the spruce.

Seventy miles up this stream lies Methye Portage, the height of land between eastward- and northwestward-flowing rivers. Traders shattered the silence with whoops of joy as they surmounted the 13-mile carry and put their canoes in downhill water. Even Mackenzie forgot his Scottish reserve in describing the scene: "Within a mile of the termination of the portage a very steep precipice . . . rises upwards of a thousand feet above the plains beneath it, [and] commands a most extensive, romantic, and ravishing prospect."

This key to the Athabasca country was discovered in 1778 by Peter Pond, Mackenzie's Connecticut-born associate. The Yankee's discoveries brought success beyond his wildest dreams. He found Crees and Chipewyans happy to sell furs for a song, in order to avoid the long trip to Hudson Bay. By reaching the Athabasca country, he and other Mont-

realers succeeded in drawing a ring around their Hudson's Bay competitors, diverting to Montreal furs from most of the untapped regions of the northwest.

In 1787-88 Pond and Mackenzie spent a winter at the company post near the west end of crescent-shaped Lake Athabasca. By the yellow light of tallow lamps, they whiled away long evenings poring over sketchy maps. Pond had previously pushed on to Great Slave Lake and learned that a great river drained it at its western end.

Mackenzie and he knew of Capt. James Cook's account of his last voyage—the one during which he discovered Russians plundering sea otter and seal on the Alaska coast. They convinced themselves that Cook Inlet, on the coast of Alaska, was the mouth of the river draining Great Slave Lake. By following this watercourse, they reasoned, they would reach the sealing grounds and cut themselves into the Russian monopoly.

Global strategy in a half-known world! Pond, a calloused but aging 50, was too old to test the great dream. Mackenzie was the man "to go down the river and from thence to Unalaska and so to Kamchatka and thence to England through Russia."

In June, 1789, the Scot set out. He made an epic dash from Fort Chipewyan to the mouth of the Mackenzie River. When he discovered that it emptied into the Frozen, or Arctic Ocean, he named it the River Disappointment and sadly turned back.*

Peace River Route Comes Next

The 26-year-old explorer's ace in the hole now was the Peace River, the giant tributary of the Mackenzie. Indians had told him it rose in the mountains near the west coast. At once he began preparing for his final assault on the continent—the almost superhuman ascent of the Peace four years later.

My plane, slanting earthward above the 60th parallel, landed at Fort Smith, headquarters of the District of Mackenzie. This well-planned "Little Ottawa" of white frame buildings is home for about 500 civil servants, Indians, and Oblate fathers. Airplanes and summer supply boats connect with "the outside."

At the Mackenzie Hotel talk was of the get-rich-quick variety. The click of Geiger

* See "On Mackenzie's Trail to the Polar Sea," by Amos Burg, NATIONAL GEOGRAPHIC MAGAZINE, August, 1931.





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Automobile Roads and Steamer Lanes Replace Birch-bark Canoe Routes of Mackenzie's Day

↑ During World War II Canada pushed through her first coast-to-coast highway. More than half the Trans-Canada Highway, from St. John's, Newfoundland, to Victoria, British Columbia, already is paved. The Gray family followed this artery where it parallels Mackenzie's route.

← Before international boundaries were marked, Montreal's fur traders established western headquarters on this bay near the west end of Lake Superior. The palisaded fort of Grand Portage, restored, stands in what is now Minnesota.

Here as many as 1,200 men rendezvoused each July to sell their furs, buy provisions for the long winters, and celebrate. Mackenzie marveled when the roistering stalwarts shouldered 180-pound loads and walked the 9-mile *grande portage* to get around the falls on Pigeon River.

↓ At Sault Ste. Marie, Ontario, a giant lake freighter slips silently through the Canadian Soo lock. Spearlike gear at the bow helps the helmsman steer the ponderous craft.

Opposite, lower: Canoes and bateaux of an earlier time used the now-restored lock of the North West Company's original Soo Canal.

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Restorations by Ralph Gray, National Geographic Staff



counters was an all-but-audible metronome cadencing the conversation, for uranium was the fervent dream of all. The gold of Yellowknife reared its blond and lovely head. Lowly lead and zinc elbowed in because of the near-by Pine Point development.

"Did you see any buffalo as you flew in?" I was asked.

"Buffalo in the north woods!" I exclaimed.

"Of course. We've got remnants of the only natural herd of wood buffalo in existence, grazing in the largest national park in the world. With plains bison, the herd now totals about 12,000."

Off on Aerial Bison Hunt

At that moment I walked E. H. Essex, superintendent of Wood Buffalo Park.

"I'm flying down to Chip to check a couple of forest fires," he said. "We may see a herd. Care to come along?"

With the pilot, Essex and I squeezed into a small seaplane and taxied into the choppy, swift waters of the Slave. Soon we looked down on the white crescents of a 16-mile series of rapids that drops 109 feet and constitutes the only unnavigable stretch between end of steel at Waterways, Alberta, and the Arctic.

At Fort Fitzgerald we saw barges lined up waiting to have their cargo unloaded for the portage over the winding road to Fort Smith. During its four-month shipping season this Ol Man River of the North moves thousands of tons of northbound freight.

Like a writhing snake, a brown river coiled in from the west.

"The Peace River," Essex shouted above the motor. Just east of us the brimming stream made a 90-degree turn to the north and became the Slave. This was "Mackenzie Corners," where the explorer's two historic trails diverge (page 220 and map, page 198).

Flying across the marshy delta, we soon were over Lake Athabasca and circling the point where Fort Chipewyan huddles. To me this isolated village evoked all the loneliness of hundreds of similar remote settlements. After landing, I was surprised when Sgt. Maurice R. Lynn of the Royal Canadian Corps of Signals said, "I've been stationed farther north in out-of-the-way places, but I asked for a transfer here where my children would have more advantages."

The sergeant and his little boy walked with me to the historic cairn overlooking the lake.

There I learned that the original Fort Chipewyan was across the lake. That was the place where, Mackenzie noted, "I made my headquarters for eight years and from whence I took my departure, on both my expeditions." The post was moved to its present location about 1804.

Flying back to Smith, we circled over Lake Claire and across the grasslands near the mouth of the Peace. Suddenly Essex pointed to a herd of about 300 buffalo, looking like black ants far below us. Just then a slight change in the sound of the motor made the pilot streak to the nearest water, where a landing could be made if necessary. He followed the Slave River all the way home.

Flying back to Edmonton, my companion was genial L. A. C. O. Hunt, District of Mackenzie Administrator. We discussed the fabulous mineral finds of recent years.

"Sometimes I feel that we don't know much more about the true potential resources of this district than Mackenzie did," Hunt said. "We've only scratched the surface in a few places along the rivers and lakes. Who knows what ores we may find? And minerals aren't all. Crops can be grown along the Mackenzie River all the way to Aklavik."

Reunited, my family and I drove north out of Edmonton in a downpour. Destination: Yellowknife, metropolis of the north. As pavement changed to muddy gravel, our car radio announced that 4½ inches of rain had fallen during the night, great news for travelers who would have hard-surfaced roads for only 75 of their next 2,500 miles!

At the curbless town of Athabasca a filling-station attendant studied the inscription on our car-top trunk: "Across Canada via Sir Alexander Mackenzie's Track."

Mackenzie's Tracks "Washed Out"

"You won't find many of Mackenzie's tracks around here," he quipped. "The rain last night washed 'em away. You may even find your highway washed out in places."

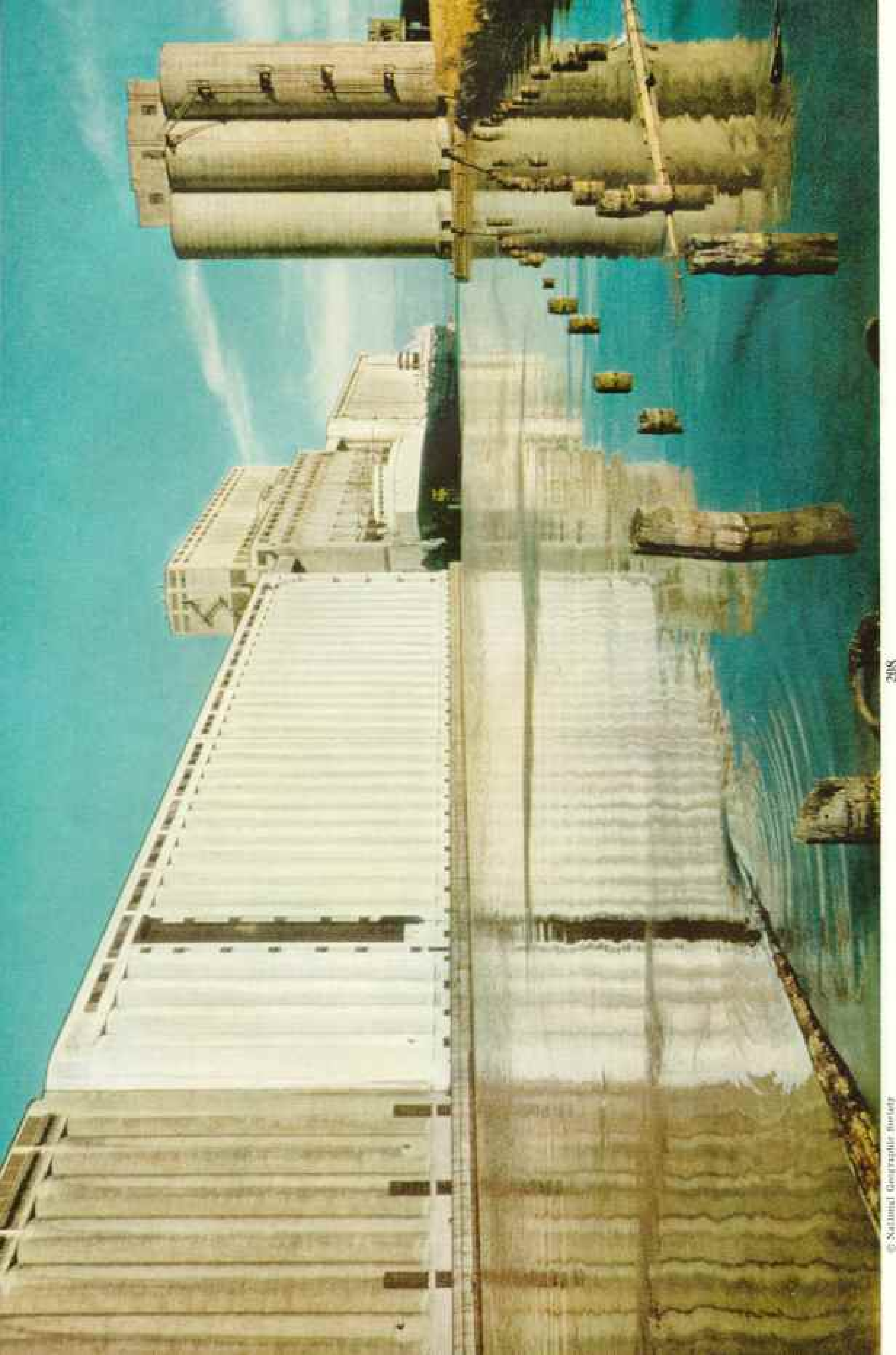
A bus marked "Peace River" splashed out of town, and, encouraged, we followed in its wake. Huge diesel trucks pounded up behind us, passed at the first wide space, and left us blinded with flying mud. Wallows and swales were filled floor-board-deep with water, and, as we passed Lesser Slave Lake, it was hard to tell the lake from the highway without a road map.

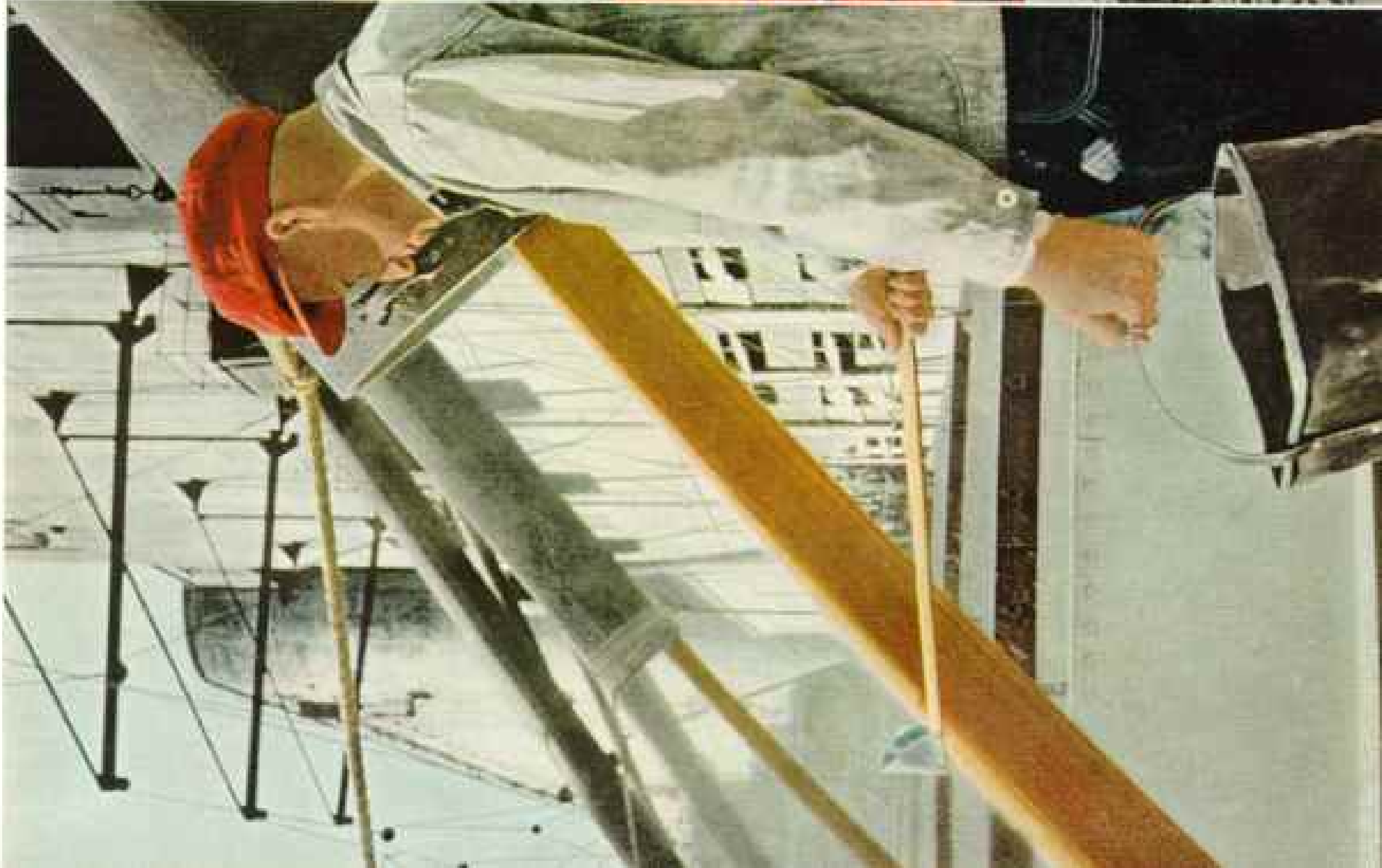
(Continued on page 215)



Hudson's Bay Company Posts and Stores Dot the Length and Breadth of Canada

At Winnipeg headquarters a girl in a Hudson's Bay blanket coat points with a narwhal tusk to the firm's northernmost outpost, Arctic Bay. This organization fought Mackenzie's North West Company and absorbed it in 1821.





↑ **Canada's Mightiest Wheat Bin, Bulging with 9,000,000 Bushels, Dwarfs a Freighter**
To Port Arthur and Fort William, twin Ontario ports near the west end of Lake Superior, rolls the golden flood of grain from the prairies. Cavernous elevators like Saskatchewan Pool Terminal No. 7 (above) unload as many as 30 railroad cars an hour.

Here the block-long *Scott Mizer* swallows an 800,000-bushel bite out of the elevator's store. The author, after his own voyage across the world's largest body of fresh water, watched the ships being loaded and sent eastward through the Great Lakes.

← A scoop samples the continuous cascade of wheat streaming into ship holds.
↓ The Board of Grain Commissioners, headquartered at Winnipeg, inspects and grades every carload.

© *Kaufmanns* by National Geographic Photographer J. Bayler Roberts





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↑ **Radioactive Cobalt Saves Lives at University Hospital, Saskatoon**

This cancer-fighting device at the University of Saskatchewan produces the power of a million-volt X-ray machine with cobalt irradiated in the atomic pile at Chalk River, Ontario. The Professor of Nursing demonstrates the controls to twin student nurses.

↓ **A New Uranium Bloodhound Comes to the Aid of the Prospector**

The lightweight waterproof Scintillometers being assembled in this Winnipeg plant detect radioactivity far more sensitively than the old reliable Geiger counter in the man's hands. Discoveries with these devices help maintain Canada's high rank as a uranium producer.







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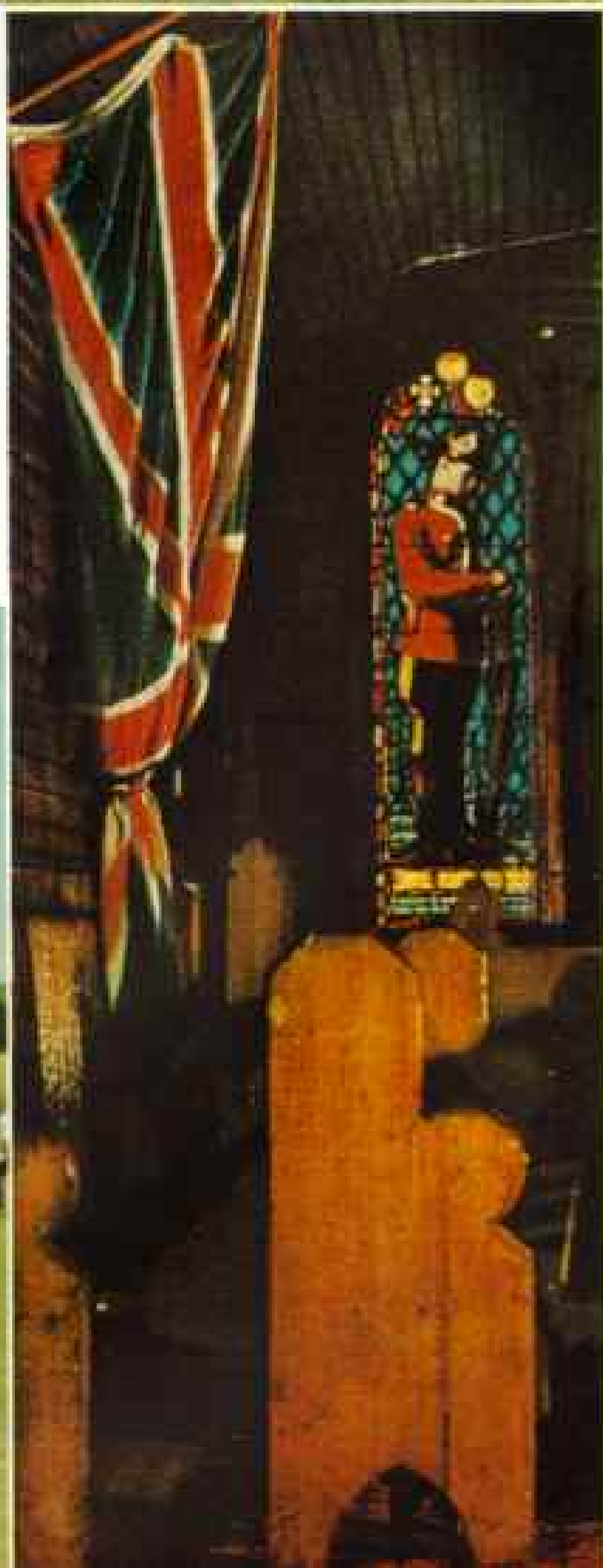
↑Parading Mounties Give Regina an Eye-filling Spectacle

Few Royal Canadian Mounted Police are still mounted. On the job, automobiles and airplanes serve as their steeds. But when picked lads from all Canada come to this prairie city to learn the skills of modern police work, the tradition of the saddle is not forgotten. On annual Mounted Sports Day recruits at the training college compete in mounted drills and contests. Staff members hold separate competitions.

This summer the Mounties join other groups in hailing Saskatchewan's 50 years as a province. Regina, the capital, celebrates the golden jubilee amid memories of the Mounties' part in bringing order to the old Northwest Territories. The red-jacketed troops made it possible to carve two new provinces—Saskatchewan and Alberta—out of bare wilderness in 1905.

↓At full gallop a Mountie "carries a peg," a sport copied from the Arab tactic of uprooting tent stakes of enemy encampments.

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✦ After a Tour of Duty
the Quiet Chapel Waits

Constable C. A. Poytress shows visitors through the Regina post's unique retreat—perhaps the only church in the world used exclusively by policemen. It dates from 1895, when the wife of the North West Mounted Police commissioner suggested the need for a chapel at the isolated barracks.

Eager workers converted a canteen that had been moved in sections across the prairie to Regina. Former residents of the Maritime Provinces donated the stained-glass windows.

The faded Union Jack (left) and the Canadian Ensign flew at Fort Walsh, a post established in 1875 in what is now southwest Saskatchewan. A near-by museum recalls stirring events of frontier history.

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Photographer J. Victor Roberts

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Kodachromes by Baljit Gray (above) and J. Taylor Roberts, National Geographic Staff

↑ **Wayfarers Rout Trail Dust
in Riding Mountain National Park**

Clear Lake beach at sundown makes a peaceful spot for reading, wading, and car cleaning. Another part of this Manitoba lake shore offers a popular resort—Wasagaming—a north-woods haven for prairie-dwelling Canadians and touring Americans.

↓ **Scientists Foil Wind and Bees
in an Experimental Wheat Field**

University of Saskatchewan technicians impregnate individual plants with pollen, then cover them with bags to prevent natural pollination. By such devices new strains are developed. One hybrid—the marquis—cut ripening time six days.

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We dipped into our food box for the day's second meal on wheels, and soon it was night. After each car we met, I stopped and slithered forward to wash the headlight lenses. At the end of 344 spongy miles, we skidded to the curb in front of our hotel in Peace River.

We went to bed taking more seriously the comment of an Edmonton oil executive: "It may have been more difficult crossing Canada in Mackenzie's time—but I doubt it!"

But next day was bright and sparkling. Grain elevators told us we were in farm country again.

Farming in the Far North

At Manning, the "northernmost midwestern farm town in North America," the first crop was taken out in 1929. A pioneer flavor still clings to the settlement; we sensed the drama of Canadians meeting the challenge of their almost limitless frontier.

"Of course, there's more to it than that," one man told us. "We bought Crown lands for almost nothing when we came. Also life is freer and easier here. Back east, when I was young, things were so strict you couldn't spit on Sunday."

As we drove north through scraggly bush and muskeg on the remaining 300 miles of the Mackenzie Highway, there was little except the smooth, well-kept road itself to show that anyone but us was alive in the world. This, the only road leading into the Northwest Territories, carries little through traffic except for refrigerated trucks loaded with fish from Great Slave Lake.

Nearly everyone reaches Yellowknife via the daily flight from Edmonton. In doing so, they miss one of the Territories' outstanding scenic wonders, Alexandra Falls (page 228).

Sleeping on the Bias

The town of Hay River stretches two or three miles along the river of the same name, where it empties into Great Slave Lake. Frame buildings are sprinkled along the shore, backed by tiny homes.

The hotel sags in the middle where the heat of the building has melted the underlying permafrost, allowing the foundations to settle. Inside, the slant had pulled the hall partition away from the floor in our room. The tilt of the beds dumped the downhill child out at least once each night.

Walking along the dusty street, I was tapped from behind by a gnarled cane.

"See here, young man," an imperious voice said, "are you the National Geographic feller who's in town?"

I turned to see a gaunt man of many sub-arctic winters. His longies protruded beyond the sleeves of his work shirt, and his heavy trousers disappeared into laced boots.

"I'm a member, you know," he continued. "W. R. Menzies. I run a fish business here. Two or three other operators and I take 6,000,000 pounds from Great Slave Lake every year. We truck 'em to Peace River, then on to Chicago, Detroit, and New York by refrigerated rail cars. That's a long way to take fresh fish, but we do it."

Later, from Yellowknife, I boated to mid-lake and watched fishermen reel in their fish-studded gill nets, and then clean and box their catches on huge floating barges. The planning and distances involved in the \$2,000,000 Great Slave fishing operation reminded me of Mackenzie's fur empire.

Menzies and I sat on a plank in the shade of the cookhouse, while he talked about the promise of the District of Mackenzie. With his cane he drew a map in the dirt showing how the Mackenzie Highway could and should be continued down the valley to Aklavik.

A Confirmed Bush Rat

"You may think it funny," he mused. "I have a 12-room home in Edmonton and two fine places at Faust, Alberta. But I'm not happy unless I'm up here in the bush in my old clothes. The North bit me years ago, and I guess I'll always be a bush rat."

In the Hay River Airport a colorful wall poster urged us to "Fly to Fiji." Instead, we took a plane for Yellowknife and with prospectors and Indians soared across Great Slave Lake in an hour.

Looking down at this lake—larger than either Lake Erie or Lake Ontario—and scanning the flat surrounding wilderness, I heard Jean tell the children, "I came a long way from home to make my first air trip!"

Mackenzie's journal told us that he had required 14½ days, fighting ice, winds, and mosquitoes, to get his followers and canoes across the lake. He landed "at three lodges of Red-Knife Indians, so called from their copper knives."

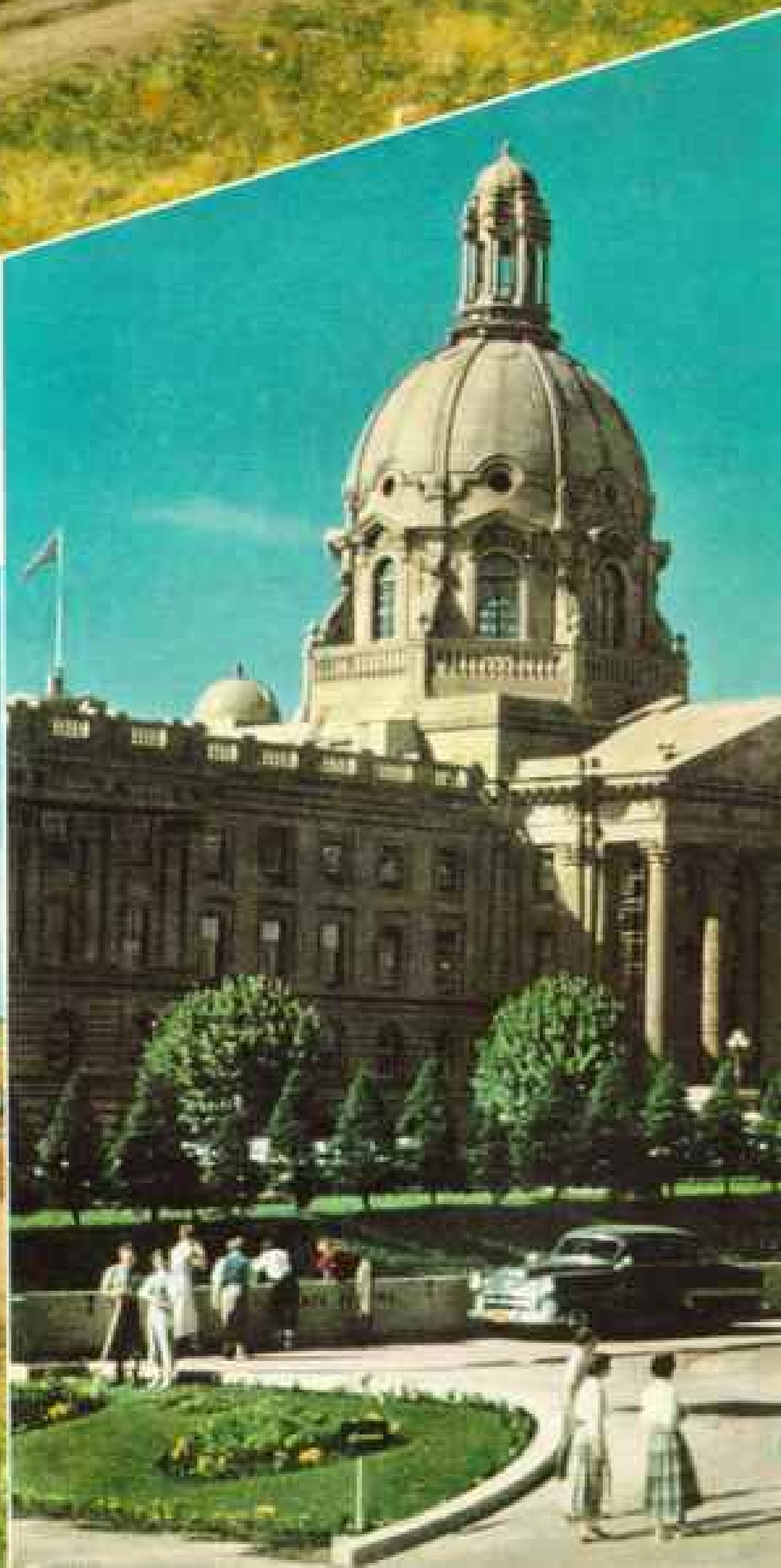
Mackenzie assembled "these Copper Indian people" to report that his countrymen would return and buy many skins if the Indians trapped enough beaver to make it worthwhile.



↑ RAILS End, Highway Begins

In this far country roads have names instead of numbers. Alaska Highway takes off at Dawson Creek, British Columbia. From zero milestone (cairn, far left) it shoots past the grain elevators. ↓ At Grimshaw, Alberta, the Mackenzie Highway plunges toward Yellowknife, Northwest Territories.

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↓ Edmonton Symbolizes the Phenomenal Growth of West Canada

Before 1900 Edmonton was little more than a trading post. Now, in the grip of an oil and natural-gas boom, it is one of Canada's fastest growing cities. Each month 1,200 new residents add to the population—already beyond the 200,000 mark—and each year many new industries arrive.

In September thousands of visitors will jam the already crowded city to observe Alberta's golden jubilee.

Here the ultramodern Alberta Government Telephone Building outglitters the domed Provincial Legislative Building.

*Ketchumers for Ralph Gray and
(below) J. Daxler Roberts,
National Geographic Staff*

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A fur trader first and last, Mackenzie then departed for his dash to the Arctic Ocean.

The metal these Indians used was bartered from the Coppermine River region to the north. Little did they realize that a much more valuable yellow mineral lay under their own hunting grounds. Dogrib Indians, who drove these Indians out of the area, became known as the Yellowknife band.*

Thus, when the first gold brick was poured in 1938, the mining community springing out of the rocks and muskeg was already equipped with its colorful and appropriate name.

Yellowknife today is a spot of frenzied activity in the midst of one of the world's largest remaining empty quarters. Its 3,300 inhabitants are surrounded by 1,250,000 square miles containing only 13,300 additional people.

Taxis seem more prominent there than in New York. Several radio-dispatched ones met us at the airport.

"We have 32 miles of roads," our driver told us. "Few people here have their own cars, so we put as much as 5,000 miles a month on our cabs. In winter, to avoid trouble starting, we keep the motors running all the time."

Nylons Invade the Frontier

Though Yellowknife is an isolated outpost, it is civilized. With its hotels, radio station, 40-bed hospital, civic clubs, stores, dairy farm, curling arena, churches, and movie palace, it tries to be like any other Canadian community. Year-round homes are scattered everywhere, many with flower gardens. Over tea, ladies discuss civic betterment.

Old-timers bewail the passing of the frontier. Jock McMeekin, salty editor of the *Yellowknife Blade*, told me: "Yellowknife isn't what it used to be. Wives of miners get off the plane in high heels and nylons and wear them all the time they're here. I'm heading for Uranium City."

Everyone said Yellowknife would really boom if the world market for gold improved. Two mines now produce.

At Giant Yellowknife Gold Mines, Limited, Jean and I watched a gold brick being poured. Sweating men tipped a bullion furnace and directed the molten brilliance into a mold, where it quickly solidified. After it cooled, a workman handed me the burnished object, the size of a building brick. Its unexpected 60 pounds nearly disjointed my arms. Its value—about \$25,500—was even more sur-

prising. This was the boiled-down essence of ore containing $\frac{3}{4}$ ounce of gold per ton.

After retracing our route to Peace River, I coaxed our car along the merest suspicion of a road beside the stream which Mackenzie described as "being the route by which I proposed to attempt my next discovery." Here we reached the cairn marking Fort Fork, Mackenzie's winter camp of 1792-93 (page 232). Having left Fort Chipewyan on October 10, he raced the coming of solid ice to reach this point on November 1, preparatory to pushing on to the Pacific in the spring.

In April and May Mackenzie bought the winter's catch of skins from Indian hunters and shipped it in six canoes to his cousin Roderick at Fort Chipewyan. He also sent "a couple of guineas; the rest I take with me to traffic with the Russians."

In a 25-foot canoe light enough for two men to carry, Mackenzie loaded "provisions, goods for presents, arms, ammunition, and baggage, to the weight of three thousand pounds, and an equipage of ten people." With him were Alexander Mackay, a Scottish clerk of the company; six French Canadians (two of whom had accompanied him down the Mackenzie); two Indians; and a dog. On May 9, 1793, they embarked into the unknown, while those left at the fort "shed tears on the reflection of those dangers which we might encounter."

Beauty in the Wilderness

Danger, hunger, and backbreaking toil soon would come, but at the beginning the travelers moved through an idyllic world. Their leader reported "the most beautiful scenery I had ever beheld...The ground rises at intervals to a considerable height...at every interval...in the rise, there is a very gently-ascending space or lawn...Groves of poplars...vary the scene, and their intervals are enlivened with vast herds of elks and buffaloes."

The landscape still delights those few travelers who cross Canada via this northern route. At Dunvegan we eased our car onto a fidgety ferry and crossed the Peace River. Climbing 500 feet to the level of the prairie, we drove through the productive farming area around Grande Prairie. At Beaverlodge (page 222) we saw the distant Rockies where they extend northwest from Jasper National Park.

* See "Nomads of the Far North," by Matthew W. Stirling, NATIONAL GEOGRAPHIC MAGAZINE, October, 1949.



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Illustrations by Ralph Gray (above) and J. Bayler Roberts, National Geographic Staff

↑ **Chain-driven Farm Truck, Vintage 1907,
Gives the Gray Family a Bumpy Ride**

On the immense prairies of Saskatchewan, Canada's mechanized farming reaches its highest pitch. This "auto-buggy" and other farming relics were resurrected for Lloydminster's 50th anniversary celebration.

↓ **Eskimos, No Strangers to Planes, Take
the Quick Way Home from Edmonton**

This air crossroads gained renown in the 1920's and '30's as the home of far-ranging bush pilots. Here a group of Arctic dwellers, after government hospitalization, board the daily "mixed freight" to Yellowknife.

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British Columbia now lay before us in all its magnificence.* But before we lost ourselves in the maze of ranges that vault Pacificward, we traversed more prairie. Dawson Creek seemed to lie in the center of a great upturned palm of green grass and gold grain (page 216). Traffic materialized from nowhere, bound to or from Alaska (Fairbanks: 1,525 miles).

War-built Highway to Alaska

Here suddenly was all the hustle of a prosperous U. S. Highway 40 crossroads town in Ohio. In our motor court at Mile 1½ of the Alaska Highway our neighbors hailed from Indiana, Michigan, Iowa, and New York.

We breezed along the wide, smooth thoroughfare built in record time by U. S. Army Engineers during World War II.† A giant suspension bridge crosses the Peace River near where Mackenzie observed "The country is so crowded with animals as to have the appearance, in some places, of a stall-yard, from the state of the ground, and the quantity of dung which is scattered over it. . . . We

this day saw two grisly and hideous bears."

Turning west beyond Fort St. John, we followed a side road that became more and more doubtful. It alternately clung to the steep face of hills paralleling the Peace or forced precarious passage at the water's edge. Jean and the children shut their eyes as we rounded hairpin curves and dislodged clods that fell 100 feet into the river.

Slowly mountains ahead came closer. Spots of snow gleamed beyond the blue foothills. Finally we entered a wooded dell and came upon a sort of ghost town that hadn't completely given up the ghost. A whitewashed Hudson's Bay post faced a rustic hotel, and beyond lay a store and a few homes.

"Hudson Hope," I announced.

Indians before Mackenzie and all water travelers since have deserted the river at this point to portage around Peace River Canyon.

* See "On the Ridgepole of the Rockies," by Walter Meyers Edwards, NATIONAL GEOGRAPHIC MAGAZINE, June, 1947.

† See "Alaskan Highway an Engineering Epic," by Froelich G. Rainey, NATIONAL GEOGRAPHIC MAGAZINE, February, 1943.



Mackenzie Corners: Watery Paths Diverge in a Wilderness Still Unmarked by Man

Peace River, flowing from the lower left, makes a turn in north Alberta and becomes Slave River, seeming to disappear over the top of the world into the subarctic distance. Smaller stream at right is both inlet and outlet of near-by Lake Athabasca; its current reverses, depending on water levels.

In 1789 Mackenzie canoed north down the Slave, discovered Mackenzie River, and followed it to the Arctic. Returning here from Montreal in 1793, he paddled up the Peace en route to the Pacific.

Ralph Greer, National Geographic Staff

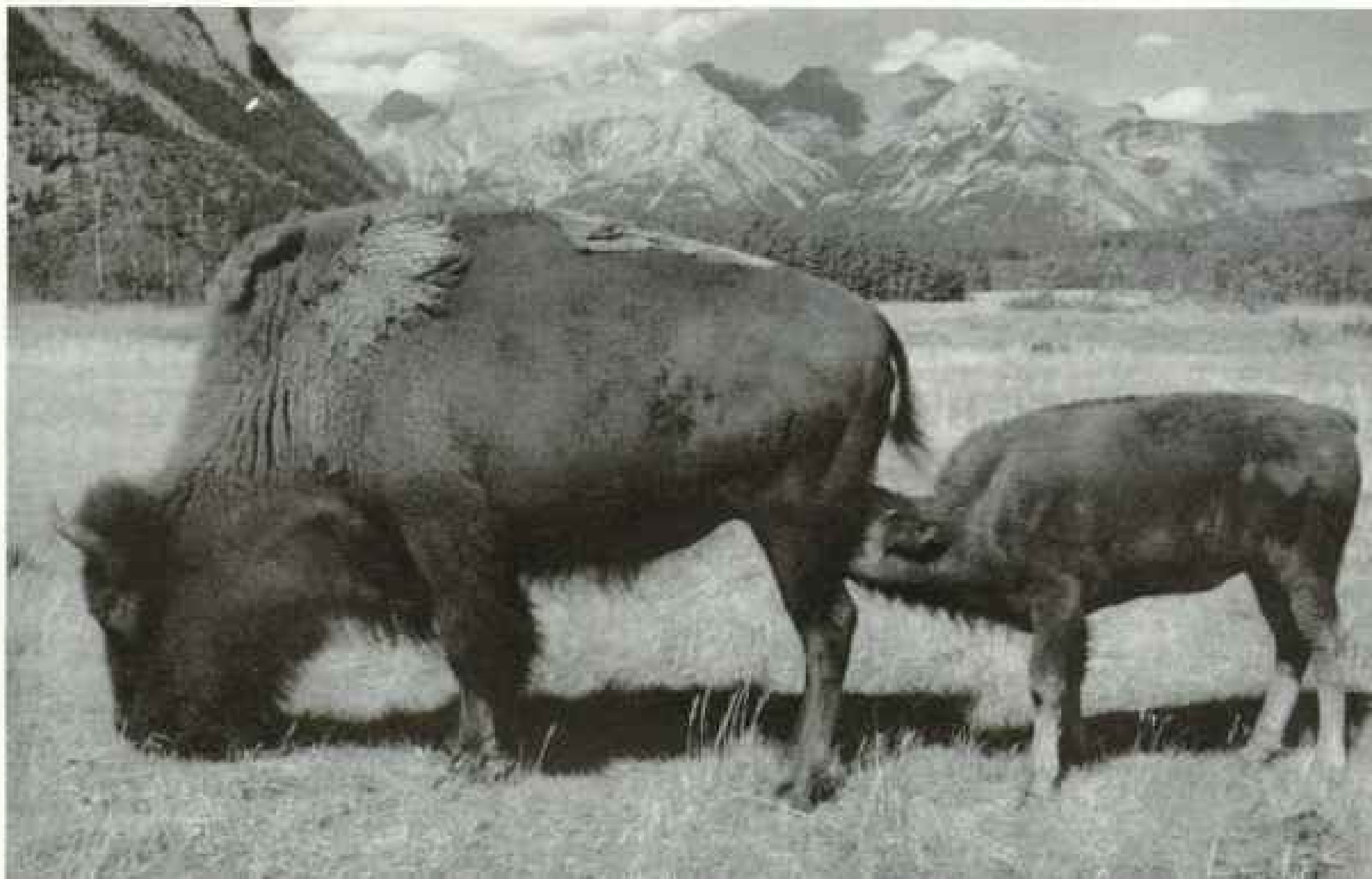
Alone among great rivers, the mighty Peace cuts completely through the backbone of the Rocky Mountains. Within its 25-mile-long canyon, footed at Hudson Hope, the cascading water drops 270 feet. Mackenzie, courageous and overconfident, breasted the frothing whiteness in his already weakening canoe. There followed one of exploration's epic battles between man and Nature. Mackenzie's tight-lipped comment, "I must acknowledge ... some risk," was the understatement of the century.

Water roars through the canyon like a runaway freight train. But the doughty Scot gauged it coolly and said that by crossing to the other side "the river appeared to me to be practicable, as far as we could see: the traverse, therefore, was attempted, and proved successful. We now towed the canoe... and in endeavoring to clear the point of the

↓ Nature's Pipeline in Banff National Park: Grass to Buffalo Cow to Nursing Calf

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Robert Lindo, P.O.



Wheat-colored Fields → Yield Grass Seed for the Lawns of America

When Mackenzie discovered the Peace River area, he described it as glowingly as if he were a travel agent. Though separated from central Alberta by inhospitable bush, this sub-arctic parkland enjoys a climate and soil like that of more southerly regions.

Thus, where imagination pictures a frost-bitten desert, endless acres flourish beneath the northern Alberta sun. Farmers measure land in sections, or mile squares.

The area, larger than Nova Scotia, had only a few hundred settlers half a century ago. The railroad brought new immigration in 1915; and today's population exceeds 54,000.

This farm, near Beaverlodge, is part of five sections owned by Leslie and Rowe Harris, English brothers who settled here with little money 25 years ago. They raise fescue, a hardy grass introduced into Canada from European countries.

When the crop heads out, these northern farmers cut it with combines, sack the seeds, and sell them to be mixed with bluegrass and other lawn seeds.

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← **British Columbia's
Frontier Recalls
Wild-west Days in
the United States**

Two decades ago this land near Anahim Lake was almost unknown territory. Then pioneers, lured by marshy upland meadows, came in with herds, contesting land rights with Indians and moose.

The settlers carved out ranches in a region where jack pines, beset with subzero winter temperatures, crack open with the sound of rifle shots. Soon the immemorial glaciers of surrounding peaks were looking down on Texas-like scenes.

Here cowboys round up Herefords on Dave Christensen's ranch. Beyond the distant mountains the land remains nearly as unexplored as when Mackenzie saw it.

*Kodachromes by Ralph Gray,
National Geographic Staff.*





A Welder Joins Pipe Sections, Bringing Alberta Oil One Step Nearer the Pacific

Abundant water power and minerals supply Canada's skyrocketing industry; manufacturing rings up three times as much income as agriculture. The transmountain pipeline, here inching toward Athabasca River in western Alberta, now pumps oil over the Rockies to Vancouver. Another pipeline carries black prairie gold to the east.



Ike Sing's General Store Serves Cowboys and Indians at Remote Anahim Lake

The genial Chinese-Canadian, unofficial mayor of this trading post in British Columbia's cattle country, helped the author traverse the almost roadless region farther west (page 230). Here a Chilcutin squaw buys a sweater.

island, the canoe was driven with such violence on a stony shore, as to receive considerable injury. . . . We could now proceed no further on this side."

Using small rocky islands as shields, the explorers recrossed, only to find that "the current on the West side was almost equally violent with that from whence we had just escaped. . . . Here we unloaded, and carried every thing over a rocky point of an hundred and twenty paces. . . . one false step. . . would have at once consigned the canoe, and every thing it contained, to instant destruction."

Canoe Broken and Repaired

Camping on a narrow shelf, the voyagers renewed the battle the next morning. "We now, with infinite difficulty passed along the foot of a rock, which, fortunately, was not an hard stone, so that we were enabled to cut steps in it for the distance of twenty feet; from which, at the hazard of my life, I leaped on a small rock below, where I received those who followed me on my shoulders. In this manner four of us passed

and dragged up the canoe, in which attempt we broke her."

After repairing the craft, the men pushed on. At one point "in the distance of two miles we were obliged to unload four times, and carry every thing but the canoe. . . . At five we had proceeded to where the river was one continued rapid. . . . a wave striking on the bow of the canoe broke the line. . . . Another wave, however, more propitious than the former, drove her out of the tumbling water, so that the men were enabled to bring her ashore. . . . The men were, however, in such a state. . . . that it would not only have been unavailing but imprudent to have proposed any further progress at present, particularly as the river above us, as far as we could see, was one white sheet of foaming water. . . . I was, therefore, perfectly satisfied, that it would be impracticable to proceed any further by water."

Next day the party reconnoitered a brutal portage route over a mountain that rose directly from the water's edge. But, said their leader, "a kettle of wild rice, sweetened



Ukrainian-Canadian Girls of Alberta Wear the Bright Dress of the Old Country

In Canada, less a melting pot than the United States, many groups retain Old World customs. These fair bakers at Elk Island National Park draw fresh bread from ovens in the manner of their ancestors in southeastern Europe.

with sugar...with their usual regale of rum, soon renewed that courage which disdained all obstacles...and they went to rest...I sat up, in the hope of getting an observation of Jupiter and his first satellite."

From Hudson Hope we drove 14 miles west, coming out upon the canyon at an abandoned coal mine, whose rickety hopper gave us a splendid view of the tortured river 300 feet below (page 232). A short distance upstream, at the head of the canyon, Mackenzie's three-day portage ended, and the party proceeded in quieter water.

New Road Aids Tourists

For our part, we raced threatening clouds back to the Alaska Highway. From Dawson Creek we followed the John Hart Highway southwest. This artery, opened for its first full season the year we traveled it, roughly parallels the Peace River, joining the Pacific States and British Columbia's heartland with the north.

Near Azouzetta Lake, a mountain-ringed gem, we camped at the foot of snow-specked Murray Range. Next day we crossed the Parsnip River.

Here we studied the journals, trying to learn how Mackenzie, an astute pathfinder, could have so completely misjudged the Parsnip country. He correctly journeyed up the Parsnip, but, near our present location, he missed the Pack-Crooked territory—a canoe superhighway leading to an easy portage over the Continental Divide at Summit Lake.

Instead he led his now grumbling men farther up the Parsnip into a bewilderment of headwaters, beaver ponds, mountains, and unfriendly Indians. Finally, on June 12, 1793, he reached the carrying place and crossed the Divide. He sighed with relief: "We are now going with the stream." He had reached the upper waters of the Fraser, the canyon-set river which joins the Pacific at Vancouver (pages 236 and 238).

But a rock-filled tributary crushed and swamped the canoe and nearly drowned him and his party. Ready to mutiny, the men, after "rum enough to raise their spirits," listened to a rousing talk from their leader. He appealed to their pride and honor and mentioned "the courage and resolution which was the peculiar boast of the North men."

The talk inspired the men to repair the canoe. A few days later, on a portage, it broke in the middle. The craft, whose light-

ness Mackenzie extolled at the start of the trip, had been so weighted by constant patching that it was nearing its end.

Depending on Indian informants with sketchy knowledge of the way to the "Stinking Lake" (as they called the Pacific) and on native guides who had to be guarded to keep them from deserting, Mackenzie improvised his route. Passing the site of Prince George, today's bustling trade and lumber center, he scooted down the swift Fraser River to a point near present Alexandria. Here he turned back on advice of the Carrier Indians, whose friendship he had gained by boldly going among an armed and truculent band.

The natives described the length and difficulty of the river ahead and the shortness of an overland trail behind them that led directly west to the ocean by way of the West Road River.

Mackenzie must have realized that he would never meet the Russian sea-otter hunters. With much soul searching he gave up his dream of finding a broad water avenue to his destination. At this point his canoe, leaking like a sieve, traveled its last mile. The party spent five days constructing a stronger craft.

Leader Shoulders 70-pound Pack

On July 4, 1793, they cached their new canoe, pemmican, gunpowder, and other articles at the mouth of the West Road and started overland. Mackenzie himself shouldered a pack of 70 pounds, 20 pounds lighter than the Canadians' burdens.

They climbed into the strange blue-and-white world of the Coast Mountains and slogged 13 days past alpine lakes, through stony, wind-swept uplands, pelted by rain and snow, before reaching the green, sheltered luxuriance of Bella Coola Valley.

Having killed a deer, Mackenzie wrote, "we stopped to dress some of our venison, and...made an heartier meal than we had done for many a day...To [this] comfort...I added that of taking off my beard, as well as changing my linen, and my people followed the humanising example."

Their beacon for the final miles had been "a stupendous mountain, whose snow-clad summit was lost in the clouds."

Before my family and I were to see that towering peak (9,250 feet high and still bearing the descriptive label its discoverer gave it, Stupendous Mountain), we entered on our



Lazing Through Flat Sprucebrakes, Hay River Suddenly Jumps a 109-foot Ledge

Seldom seen and rarely photographed, these amber-hued waters rank as one of Canada's most impressive cataracts. The river's name derives from meadows upstream where Indians gathered hay.



Alexandra Falls Thunders in a Wilderness South of Great Slave Lake

Mackenzie Highway, only road connecting Northwest Territories with "the outside," leads the rare north-country motorist to the spot. The Gray family lingered for a camp lunch on the flat rimrock.

own final adventure of the Mackenzie Trail.

At Williams Lake, the cow-town shipping point for much of British Columbia's stock, we left the Cariboo Trail and, for the last time, urged our faithful car along the byways. We struck west into the Chilcotin ranch country, and soon the narrow road seemed to be little more than a cattle run.

Ranches became fewer and farther between. To the southwest long-fingered blue glaciers sat octopuslike on mountaintops. Rivers ran aquamarine from the milky melt of perpetual ice fields.

49 Miles in 4 Hours—by Car

By evening we had crawled 164 miles and had reached the vicinity of Kleena Kleene. At a rustic hunting and fishing lodge beside a lake we asked where the town was.

"This is it," Bruce Kellogg, the owner, told us. "On this road, where anyone lives, that's a town."

It rained during the night, and Bruce warned against going on to Anahim Lake. But, conscious of the little time left before my children must report for school a continent's width away, I skidded onto the road after lunch and second-gearped the 49 miles in 4 hours, getting stuck only twice.

Here, 65 straightline miles from Pacific tidewater at Bella Coola, the road ended for us. We had to leave our Plymouth behind, just as Mackenzie had cached his canoe against his return. But instead of the capricious and thieving Indians our predecessor relied on for guides, we were aided by the Bella Coola District Board of Trade, which had worked out every detail of our route through the Coast Mountains.

"See Ike Sing for Everything"

The key to everything was to contact Ike Sing at Anahim Lake. This wasn't hard, since his log store, catering to ranchers, cowboys, and Indians, stood practically alone (page 225). In a cowboy hat, the smiling Chinese came through the chill mist to greet us. He started a fire in the log cabin we were to occupy, put on some coffee, and said he'd call us when dinner was ready.

No further campaign was necessary; we decided we liked Ike.

That night I sat around the store's red-hot oil-drum stove and talked with lounging cowhands. It had been a wet summer. Cutting enough hay from the mountain meadows to

winter-feed the stock was a matter of economic life or death. But water had remained all season in most of the saucerlike depressions where the grass grows.

Everyone's head turned to the door when a rancher walked in.

"Ike," he said, "I want to order two more outboards for my hay mowers."

This land of "Grass Beyond the Mountains" is still frontier (page 223). Its numbing isolation was the most pronounced we experienced. Throughout our trip we found the price of gasoline a good yardstick of accessibility; here it was 75 cents a gallon.

But from mere isolation we plunged into two days of oblivion. Ken Stranaghan appeared in a jeep and drove us 18 miles in four hours over a kidney-jarring track to his ranch at the foot of "the Precipice." His blue eyes glittered with suppressed excitement as he eased the jeep down the 1,000-foot face of the cliff to his valley ranch on the Hotnarko.

First Time for Rider and Horse

Next day Jack Weldon, his only neighbor, helped round up horses for the 18-mile stretch ahead. Looking at Mary Ellen, Jack said, "Never ridden before? Then we'll give you Red here. He's never been ridden, so you two can start out even."

It had rained again during the night and, as we rode, our chapless legs wiped dry thousands of leaves and jack-pine needles. Ken set a fast pace, as had Mackenzie's Indian guides, and often had to stop for his tender-foot charges to catch up (page 234).

Ken showed us a golden eagle and later gave my family a harrowing half hour by throwing rocks at two grown grizzly bears.

(Continued on page 239)

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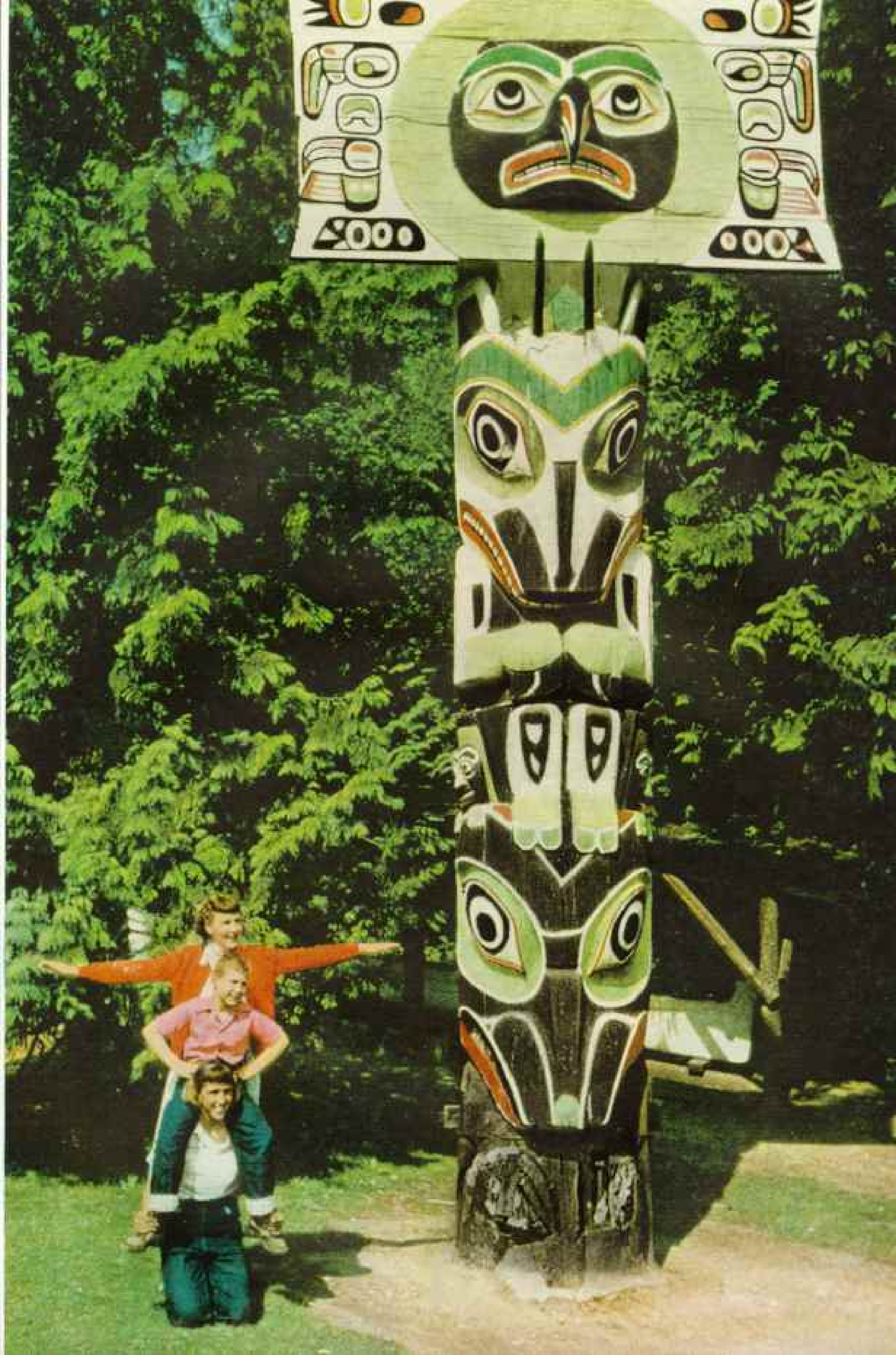
The Higher the Totem Pole the Greater the Prestige Among British Columbia's Indians

Totem poles of the Northwest coast Indians began as carved house posts, described by Mackenzie in his journal. Images of birds, fish, and mammals depicted clan ancestors, commemorated historic events, ridiculed rival tribesmen, and even on occasion crudely portrayed the artists. The poles had no religious significance. Some were 60 feet high.

This Haida totem, originally from Skidegate, Queen Charlotte Islands, stands in Vancouver's Stanley Park. Top of the pole behind the crosspiece is hollowed out to receive the remains of the dead.

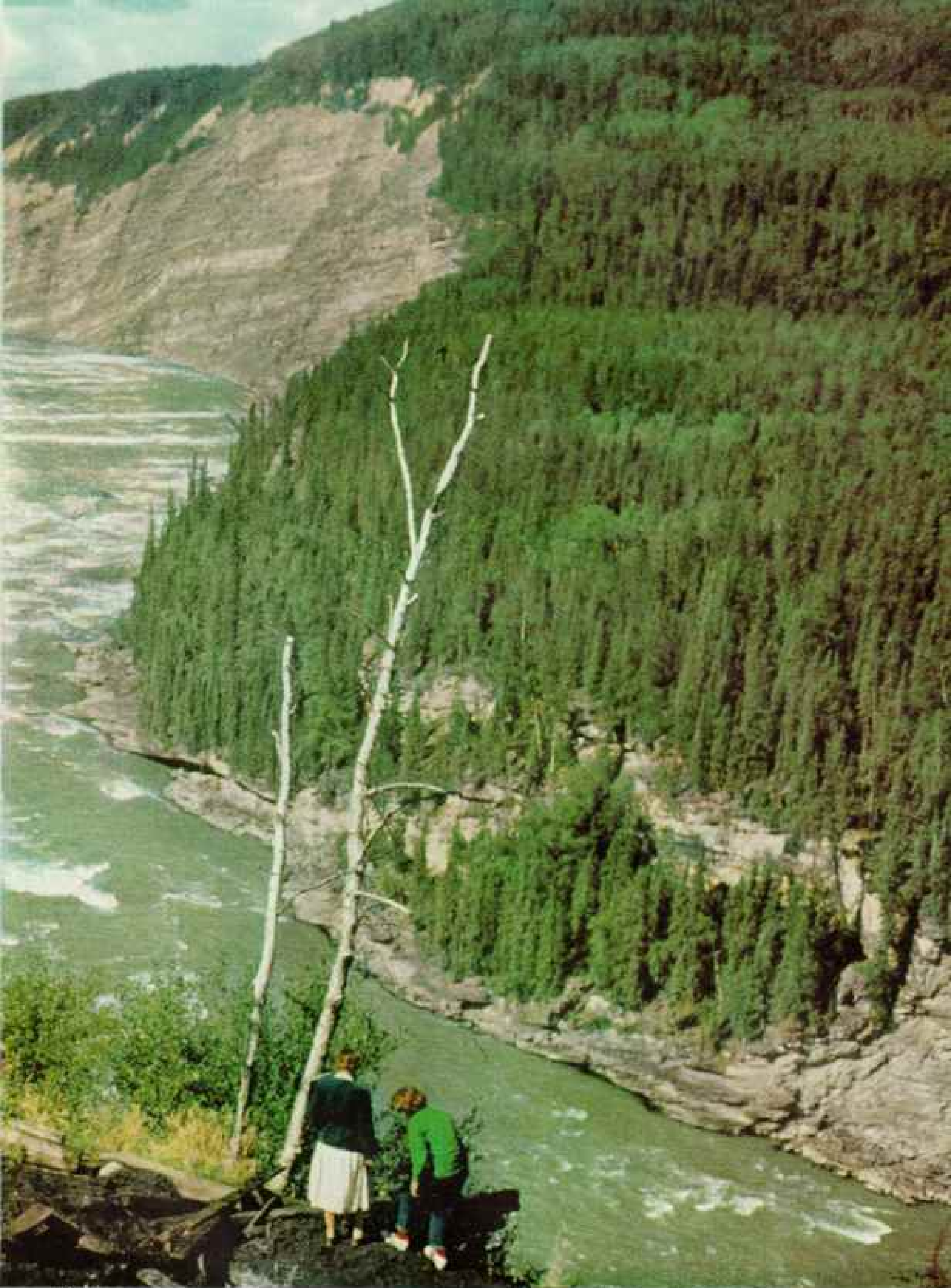
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Reduction by Ralph Gray, National Geographic Staff





Mackenzie Wintered Opposite This Cairn
At Fort Fork he reported cold so severe that axes
"became almost as brittle as glass."



Peace River Canyon: "As Far as We Could See... One White Sheet of Foaming Water"

So wrote Mackenzie when he portaged around this nightmare of navigation. He noted "a bituminous substance" in cliffs where a few coal mines operated later. This photograph looks out from the hopper of an abandoned mine.



↑ Rugged Pack Trail Leads to Mackenzie's Footpath

The explorer cached his canoe and walked the last lap to the Pacific. The author left his car at Anahim Lake and herded his family through the Coast Mountains, flushing a pair of grizzlies on the way. The trails meet in Bella Coola Valley.

Mackenzie Rock: Trail's End

Boating from Bella Coola as did his historic predecessor, the author traversed a deep fiord in the Pacific coast and reached the rock where Mackenzie daubed his triumphant message in red ocher and bear grease in 1793.

Natives told Mr. Gray that the explorer's inscription had weathered and disappeared in a year or two. These words, slightly different from the original, were carved much later on the same spot. Passengers on the weekly steamer to Bella Coola can read the letters with glasses.

✚ This monument on Mackenzie Rock acknowledges Canada's debt to the explorer's almost single-handed conquest of the continent. His fateful exploit "stimulated the commercial development which saved a coast on the Pacific to Canada and the Empire."

© Kodachromes by Ralph Gray,
National Geographic Staff

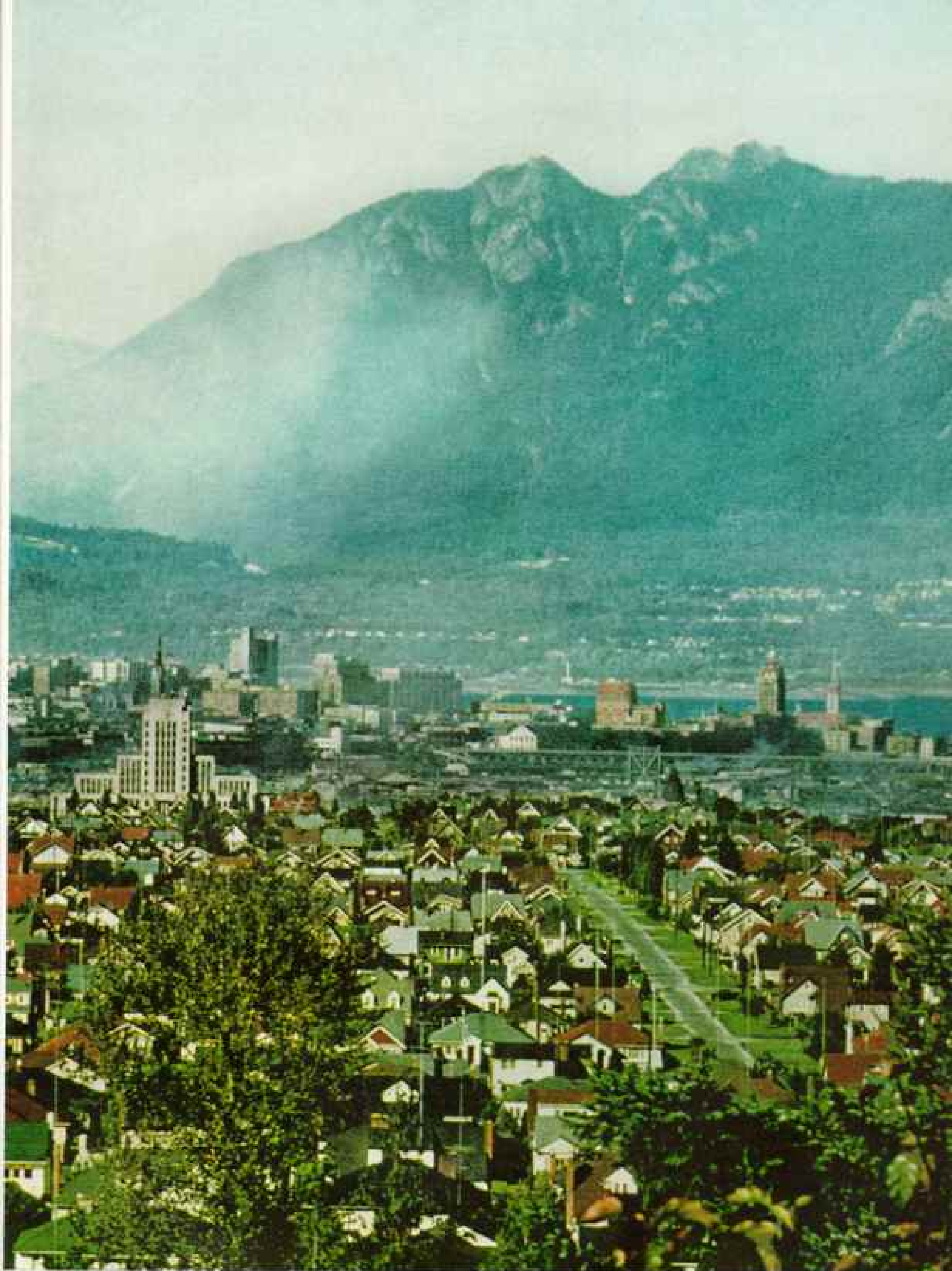
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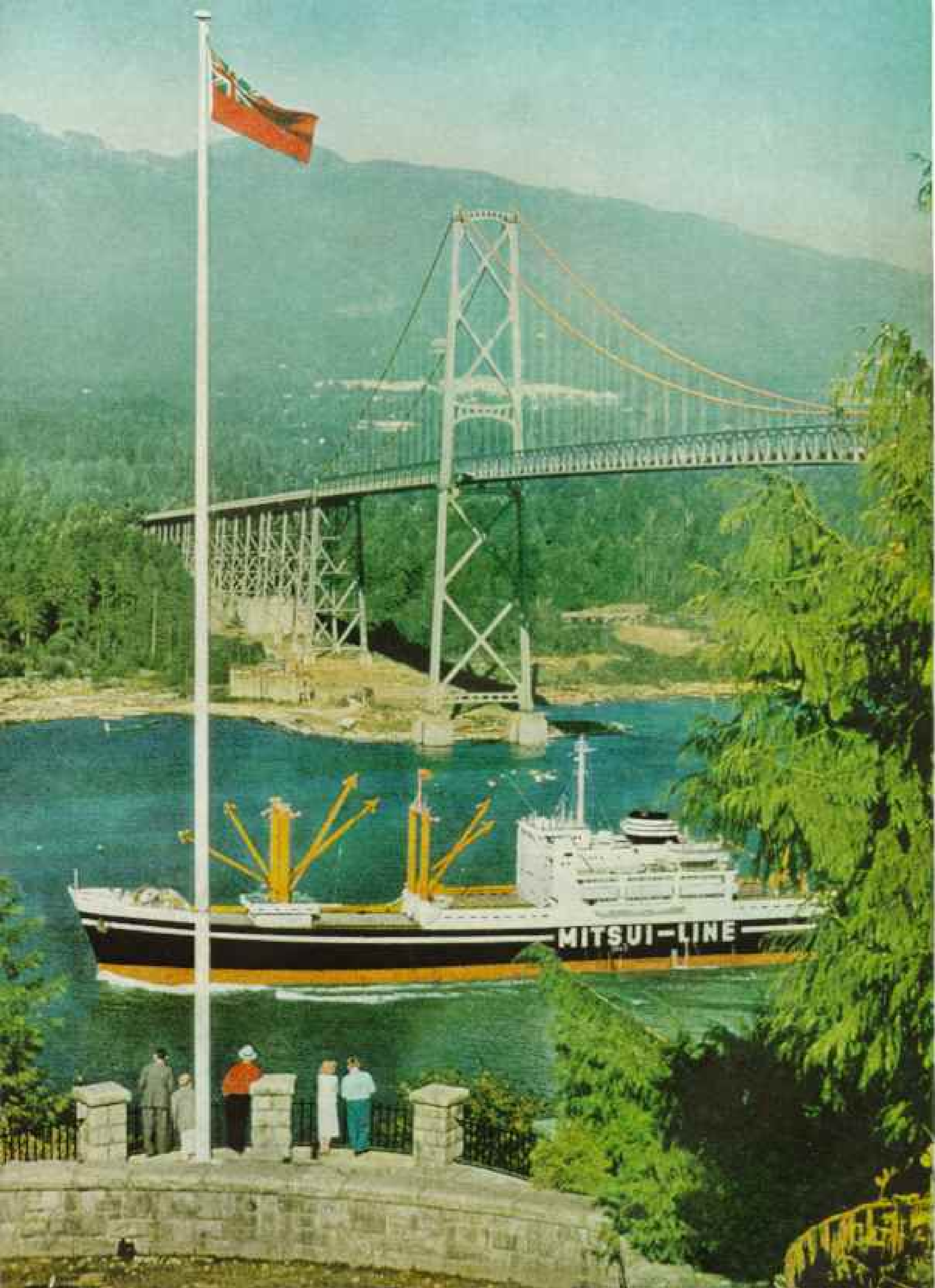
Underbrush Burns on Vancouver's Hills to Clear Space for Spreading Suburbs

The protected harbor, hidden except for a portion at far right, cuts riverlike along the edge of the city. The ocean lies to the left. Through Canada's third largest metropolis—one of the busiest and most scenic ports in the British Commonwealth—funnels most of the Nation's Pacific air and sea traffic.



Extending Mackenzie's Route, Fraser Braved Awesome Canyons to Reach This Point

In 1808 the North West Company sent Simon Fraser down the river his forerunner had abandoned for an overland march to the Pacific. Thinking it the Columbia, he was disappointed, but his pathfinding added the Fraser River to the North American map. Near its mouth Vancouver rose to give Canada a western Montreal.



Japanese Freighter Threads the Needle of Vancouver's First Narrows

Knifing orientward, the ship passes under Lions Gate Bridge, as seen from Prospect Point in Stanley Park. Straits of Georgia and Juan de Fuca still separate it from the open Pacific.

Bert Robson's snug cottage provided a brief respite of warmth and food. The rest of the ride was through a chill drizzle. Will, bouncing saddleless on the rump of Judith's horse, reached the end of his endurance. I carried him the rest of the way.

And then, pointing up for the last time the contrasts in this varied nation, we reached the inland end of the Bella Coola Valley road and found a taxi waiting!

Stupendous Mountain Near Trail's End

Mike Christensen, the driver, showed us Stupendous Mountain (its snowy head still in the clouds) and the Mackenzie Trail that winds down the steep northern wall of the valley. As he drove he spoke of Mackenzie's visit as though it were only yesterday.

Mike had named his taxi company for the valley's discoverer. Nowhere did we find people more conscious of the pathfinding Scot than in this British Columbia valley with its Spanish-sounding name settled largely by Norwegians from Minnesota.

Whitish Bella Coola River brawled beside us. The valley opened out. We looked in wonder at mile-high walls pinnacled by glaciers and festooned with wispy waterfalls. Mike dodged among 200-foot-high Douglas firs with trunks as thick as his car. He pointed up a side road toward a "plank orchard," where crews were felling and milling the giant trees.

Then came the farms. The sun broke through, but a gentle rain kept falling, light as mist blown across a city square from a fountain.

"Some people pray for rain, some for sunshine; so the good Lord sends both at once," Mike explained.

Farm Offers Food and Shelter

The valley has no hotel, but Jalmer and Gudrun Gaarden made us welcome in their roomy farmhouse. Mrs. Gaarden's meals, produced without running water or refrigeration, were truly staggering. Her father, B. F. Jacobsen, had preceded the main group of colonists from Minnesota who settled the valley in 1894.

A more recent immigrant is Clifford R. Kopas. In 1933 he followed Mackenzie's trail by horseback from the prairies, accompanied by his young wife and fortified by the jingle of a few dollars in his pocket. With a small stock of goods he set up a

store. Today he is president of the Bella Coola District Board of Trade, the organization largely responsible for pushing a pilot road through the mountains to Anahim Lake.

When widened and improved, this artery will give Canada its third highway outlet to the sea—at the point where Mackenzie "came to a village, consisting of six very large houses, erected on pallisades, rising twenty-five feet from the ground. . . . From these houses," the explorer reported, "I could perceive the termination of the river, and its discharge into a narrow arm of the sea."

With Kopas I viewed this climactic point. Here the first crossing of non-Spanish America was completed.

Further Travail in Store

"But Mackenzie's ordeal wasn't ended," Kopas told me. He wanted to see open ocean and make a celestial reading. His Bella Coola Indian guides thought he "should be satisfied with having come in sight of the sea." They vanished, leaving him a leaky canoe in which to penetrate the long channel and to stand off hostile, thieving, and trade-wise natives.

"I don't think those trouble-making Indians were Bella Coolas," said Clayton Mack, a member of the tribe that still fishes its ancestral grounds. Owner of a gasboat in the local salmon fleet, Clayton was taking us on our final lap—40 miles along mountain-edged channels to Mackenzie Rock.

The sun pierced the fog as we neared our final objective. Will's quick eyes detected a momentary icefall among the snowbanks on the 3,000-foot fiord wall beside us. Mackenzie Rock, a speck on the waterline, loomed large on close approach and dwarfed our boat (page 235).

The children scampered up the rock where Mackenzie had set up instruments and determined his position amid a band of astonished and threatening Indians.

Then, to the great relief of his jittery and exhausted followers, he turned back, mission accomplished.

"Here's the inscription," shouted Judith. We gathered round, our own relief mixed with awe, and drank in the words we had come so far to read, the words the continent conqueror triumphantly daubed on the rock: "Alexander Mackenzie, from Canada, by land, the twenty-second of July, one thousand seven hundred and ninety-three."



Aviation Medicine on the Threshold of Space

Service Doctors, Facing Medical Problems Unknown on Earth,
Make Possible Man's Exploration of the Hostile Heavens

BY ALLAN C. FISHER, JR.

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National Geographic Magazine Staff

With Illustrations by Luis Marden, National Geographic Staff

THROUGH the centuries earth's unexplored frontiers—jungle, desert, polar ice—have fallen before the determined assaults of man. But the last, the greatest, and the most dangerous frontier of all is just 17 miles from your home.

If you would seek it, look up at the stars or scan the blank and seemingly guileless blue of the sky. There, high overhead in the outer reaches of the ocean of air, is the untamed borderland that the men of aviation medicine call their vertical frontier.

A more apt term for the challenge of the upper atmosphere could scarcely be coined. Danger always courts the unwary frontiersman, claims the unlucky. So it is in high-altitude flight, for man's Garden-of-Eden body has no natural defenses against an ascent into the air-starved heavens. Nevertheless, we continue to fly ever higher, ever faster.

On June 16, 1954, Maj. Arthur Murray pierced the sea of air to a height of 90,000 feet, or approximately 17 miles, the highest

known altitude yet attained by man. Thus his record mark, established in the U. S. Air Force rocket-powered Bell X-1A, can be regarded as the beginning of the vertical frontier, a point of new achievement and a point of departure for the future.

When Major Murray reached the peak of his flight, more than 97½ percent of the atmosphere's mass lay below his wings. Outside his cabin the density of the rarefied air had dwindled to ¼ of the life-sustaining density at sea level.

A New Concept of Altitude

"Reckoning the X-1A's altitude in terms of thousands of feet above sea level doesn't give us the proper perspective," observes Dr. Heinz Haber, brilliant astrophysicist and authority on high-altitude survival (page 270). "If we express that altitude in terms of atmospheric mass left below, then we see immediately that we're running out of air. Less than two and a half percent of the atmosphere is left to conquer, and then we are in actual space."

Major Murray's personal feat was also a triumph for aviation medicine, one of the medical profession's newest specialties and certainly its strangest. Air Force and Navy flight surgeons are charged with protecting the flyer against his hostile environment, and few pills or palliatives help. Almost daily these service doctors wrestle with problems that an earthbound physician might not encounter in a lifetime of practice.

Among the chief areas of concern are the effect of cosmic rays upon tissue, the danger of strong centrifugal forces and very high-intensity noise, ejection from aircraft, design of oxygen equipment and pressure suits, and even the phenomenon of weightlessness, totally new in man's experience.

Universities and foundations throughout the United States work with the military on research into the human factors of flight. Allied with the medical doctors are a host of

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← Dummies in Pressure Suits, Like Fiction's Men from Mars, Float in "Space"

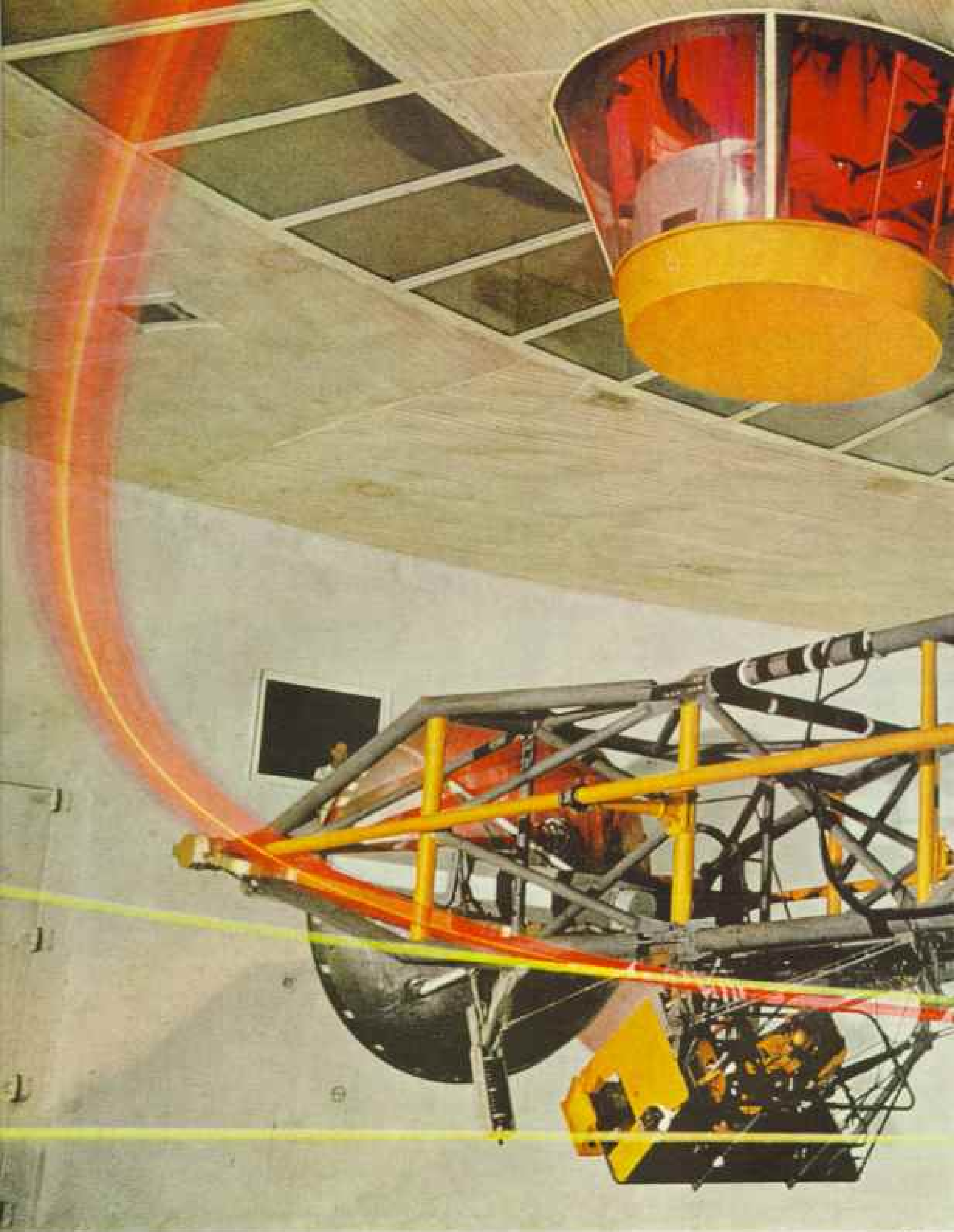
Man's efforts to reach the frontiers of space carry him regularly into the near-vacuum of the upper atmosphere, where life is most precarious. Only 12 miles above earth's surface, air pressure is so negligible that man, without protection, cannot breathe even pure oxygen and his blood bubbles like uncorked champagne.

Aviation medicine defeats such lethal dangers with emergency pressure suits like these garments developed at the Navy's Aeronautical Medical Equipment Laboratory in Philadelphia. When inflated they enclose the flyer in a lifesaving artificial environment for high-altitude flight. Either suit could be worn in space, where men would float weightless in their cabins (pages 248, 254, and 256).

To illustrate weightlessness, these figures are suspended against a symbolic painted background.

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Illustrations by National Geographic Photographers
Robert F. Dixon and Donald McEain



A Human Guinea Pig, Whirled in a Glowing Circle, Rides the Navy's Centrifuge

When high-speed turns in flight pile up centrifugal force, pilots feel they are being squashed like a bug under a boot. This centrifuge at Johnsville, Pennsylvania, largest in the Nation, duplicates the force. Straps hold the volunteer in a cab (lower right, above) slung beneath the revolving 50-foot arm. Often a man rides inside the arm's metal spheroid, a miniature altitude and heat chamber. A blister houses the operator and his control panel overhead. Time exposure records the vivid lights tracking the cab's flight, and a speed flash stops its motion.



Skin and Muscles Sag Under Centrifugal Force, Twisting and Aging the Face

Flight surgeons refer to centrifugal pressure as the G force: one G equals the pull of gravity, or a pilot's weight. Sharp turns multiply that value. This engineer, circling at 36 miles per hour, endures four G's (below). Now he "weighs" four times his normal 220 pounds. His face is distorted compared with its natural appearance (above). Downward force, draining blood from the head, will black out his vision in about 10 seconds. Upward force would pool blood in his skull and cause temporary visual "red out," a more serious problem.

specialists: astrophysicists, biologists, engineers, biochemists, psychologists, pilots. They must constantly envisage the future and keep their research ahead of new aircraft.

Recently I toured the Nation and spent many weeks among these men. I flew with them, talked with them endlessly, inspected their laboratories and their schools for flight surgeons. The significance of what I saw and heard was well expressed by Maj. Gen. Dan C. Ogle, Air Force Surgeon General.

"The Nation's air supremacy and safety may depend upon aviation medicine," he told me. "What good would new, high-performance aircraft be if man could not tolerate the stresses? Frankly, I feel a sense of urgency about our work. We are already in an area that requires adaptation of man and machines to space."

Space Is Nearer than You Think!

Indeed, many of the conditions found in space also exist well within the atmosphere. If this statement surprises you, bear in mind that our benign yet cruel ocean of air thins out very rapidly.

It helps to think of the atmosphere as an ocean. We live at or near the bottom, where pressure from above is greatest, just as it is under water. At sea level the air packs a pressure of 14.7 pounds per square inch, and it consists of about 21 percent oxygen, 78 percent nitrogen, and one percent other gases.

Everyone knows that our bodies require oxygen, but few are aware that we must breathe it under pressure or die. When you inhale, the chest wall and diaphragm pull away from the lungs. This produces the lungs' negative pressure, or suction. Atmospheric pressure then pushes air in, and your lungs can drink their fill.

If you climb a high mountain, the percentage of oxygen in the air remains constant, but the atmosphere's pressure and density drop. For example, at 18,000 feet the pressure is half that at sea level, and it dwindles rapidly the higher you go.

An average man has less than two minutes of useful consciousness at 30,000 feet. If he should venture without protection to 50,000, he would become unconscious in 11 to 17 seconds. Soon brain damage would ensue from hypoxia, or oxygen starvation, and in a few minutes he would die.

A fate even more horrible awaits man at 63,000 feet. There pressure is so negligible

that blood at body temperature effervesces like champagne. Tissue bloats and bursts.

Aviation medicine vaults these deadly barriers in ingenious ways. Air compressors, for instance, keep the atmosphere in cockpits well below actual flight levels. This military technique has been adapted to our big modern airliners, so it isn't new.

But military aircraft fly far higher than commercial planes. For this reason it isn't possible to pressurize fighters at a constant, safe level. Then, too, suppose a pilot suddenly lost his pressure at high altitude, either through mechanical failure or through enemy gunfire. How would he breathe?

Aeromedics, who are also gifted gadgeteers, have developed valves that feed an air and oxygen mixture to the flyer's mask at low levels. Farther up, these valves deliver 100 percent oxygen to compensate for increasing height. Eventually, however, the cockpit altitude in the plane exceeds 34,000 feet, and there is no longer sufficient pressure for the lungs to assimilate even pure oxygen in the amount necessary for normal function.

When that happens, the aircraft has attained a height well in the stratosphere. For example, a fighter cruising at 55,000 feet may have a cockpit altitude of 45,000, far above the safe pressure level.

But your fly boy's doctor friends are still taking good care of him. When the air pressure about his body falls below the safe minimum, an automatic valve forces oxygen into his lungs under slight positive pressure. That pressure slowly increases the higher he goes.

Increased pressure within the lungs reverses the normal work of breathing. It isn't necessary to draw in a breath, but a conscious effort must be made to exhale and clear the lungs. Flyers tire, and speech is difficult.

What the Well-dressed Pilot Wears

At a 48,000-foot flight level or above, not even pressure breathing suffices if a pilot accidentally "loses his floor," or cabin air. External pressure is then far less than the pressure in the lungs, and man cannot tolerate the strain. For this eventuality aviation medicine has developed its "man from Mars" suits.

These weird-looking garments provide the external pressure necessary for survival. For example, the Air Force T-1 suit fits like the flyer's skin (page 246). Tubes around arms and legs inflate automatically in an emergency, tightening the suit in a girdlelike grip.



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Photographs by Luis Marden, National Geographic Staff

↑ "The Dunker" Douses a Navy Aviation Cadet During Survival Training

This cockpit mock-up, developed at Pensacola, Florida, teaches escape from aircraft ditched at sea. After sliding down its track, the dunker turns upside down under water. The cadet must free himself from safety harness and swim to the surface of the pool.

↓ Breath Bubbles from the Flight Mask of a Flyer "Trapped" Under Water

The Navy has found that standard oxygen equipment works under water. Pilots pinned in wreckage could breathe half an hour awaiting rescue, as demonstrated by a researcher (left). His companion wears experimental breathing gear used in rescue work.





X-ray Movies Film a Pilot's Heart and Lungs Laboring under a Pressure Suit

Sudden loss of cabin pressure at high altitudes triggers a valve that brings this Air Force T-1 suit into action. Tubes along the arms and legs inflate with explosive suddenness, stretching the fabric taut as a drumhead. Mechanical constriction of the suit is comparable to the air pressure of the Navy's suit (page 240), but is tolerable for only 10 minutes. Here a movie camera (right), synchronized with X-ray tube (left), films a series of fluoroscope images. A doctor observes from his lead-lined shield at the Aero Medical Laboratory, Wright-Patterson Air Force Base. Appropriately, girdle manufacturers helped develop the suit.

Fully inflated, it is too tight to be worn for more than 10 minutes, but it gives the pilot precious time to seek lower altitude.

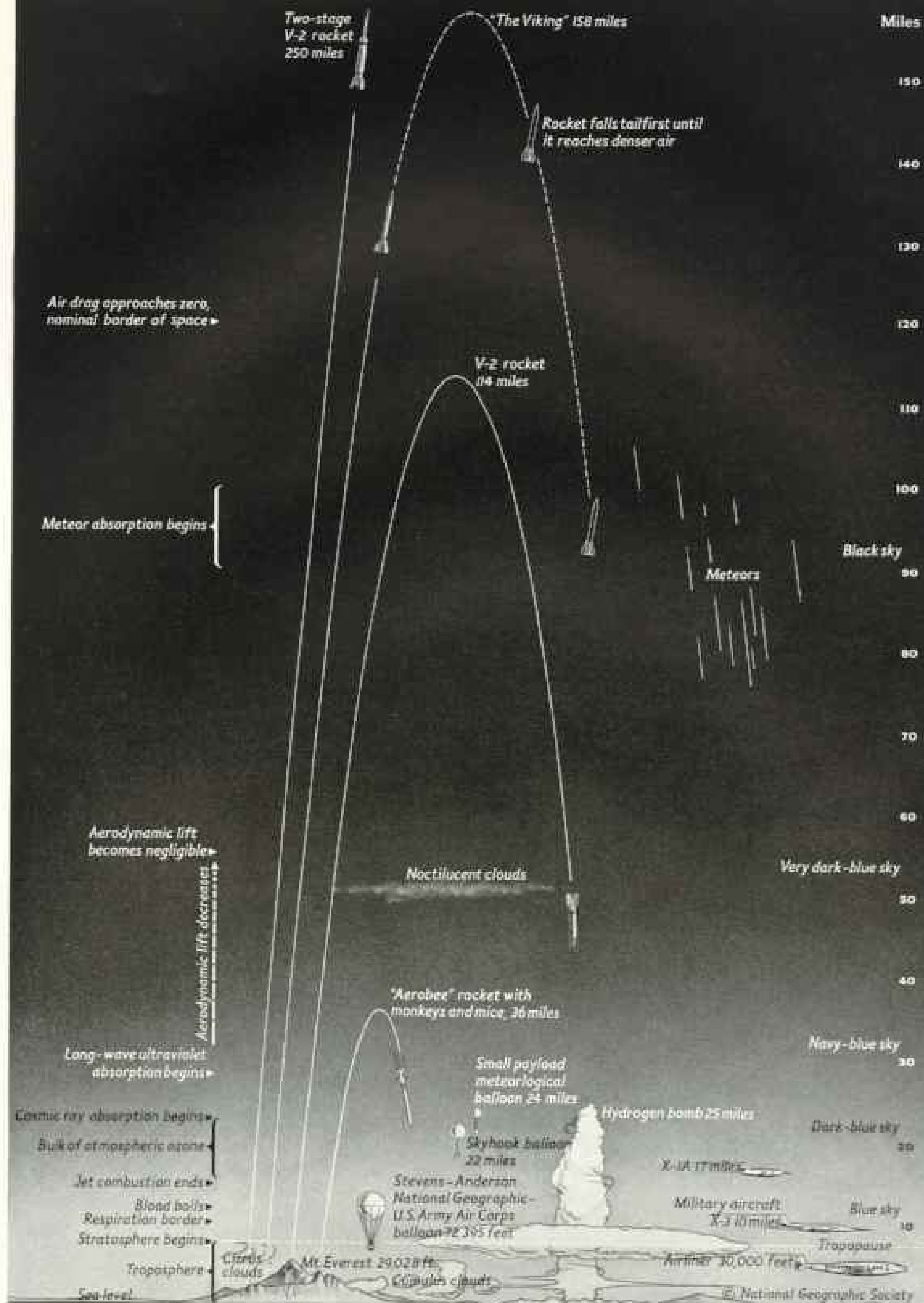
The Navy, with Air Force support, has developed a newer suit. Unlike the T-1, it does not apply mechanical pressure. Instead, the inside of the garment inflates with air. The flyer then wears, in effect, his own pressurized cabin (page 240).

Various models of both suits have been tested successfully at great heights in altitude chambers. Thus equipped, the flyer can breathe readily, and his blood will not bubble.

The Navy suit will protect him for hours against a near vacuum.

But without pressure garments, loss of cockpit atmosphere can be a very "hairy experience," as the pilots say. Witness the case of Sherman Pruitt, Jr., test pilot for Northrop Aircraft, whom I met at Edwards Air Force Base, California.

Pruitt was flying at 49,000 feet recently in a Northrop F-89 fighter. Normally its pressurization system is one of the safest, but this particular plane had been modified for test purposes. Suddenly a pipeline con-



Massive Forces Oppose Man's Conquest of the Vertical Frontier

Many hazards, as yet little known, lurk in space. Without earth's shielding atmosphere man will bear the full brunt of cosmic and ultraviolet radiation—possibly deadly—and risk collision with meteors. Intense sunrays, undiffused by air, will dazzle pilots crossing their path and bake the surfaces of space ships at furnace heat.



← Weightless Objects Float Like Thistledown in a Jet Cockpit

When a pilot flies a high-speed parabola, or roller coaster arc, he can free himself of gravity's pull for about 30 seconds. Centrifugal force throws him up; gravity pulls him down. Briefly the two forces cancel each other, and the flyer floats in his safety harness. Loose objects, such as these cigarettes, matches, and pencil, swim lazily before his eyes.

Flight surgeons differ on the possible effects of prolonged weightlessness, a future hazard. The author thought momentary weightlessness pleasant.

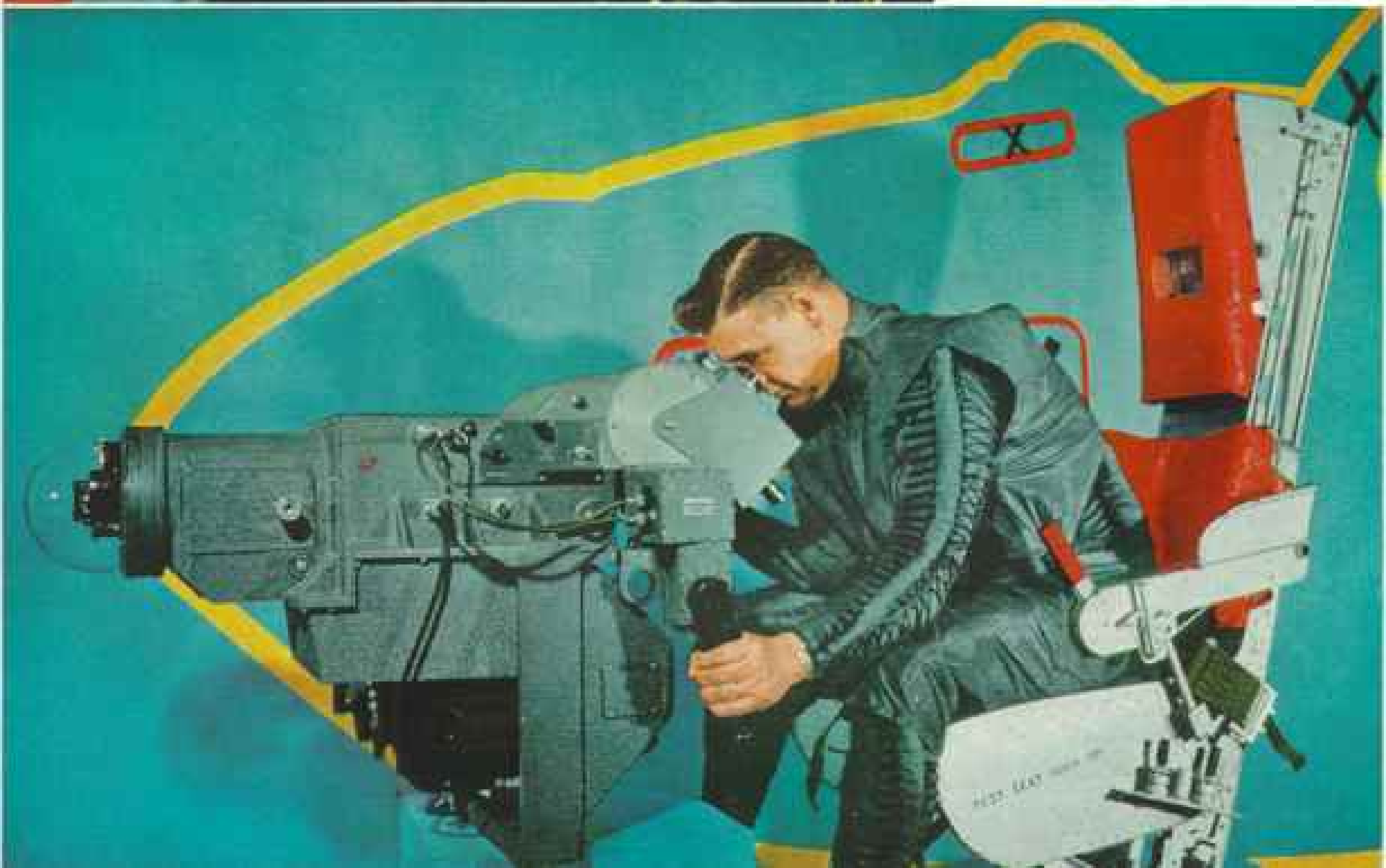
↓ Direct Vision Yields to a Bulbous Eye

Having hurdled the sound barrier, designers now face a thermal barrier. Even in the thin atmosphere of 30,000 feet, air resistance would heat plane surfaces to 300° F. at twice the speed of sound.

To reduce friction, ultra-streamlined planes of the future may eliminate transparent canopies and use periscopes, such as the one being tested by this pilot in a heat-resisting suit. X's mark old-style canopies in the outline of a B-17 nose.

© National Geographic Society
Endochromism by Louis Marden (above)
and David S. Boyer

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nection broke; Pruitt's atmosphere burst from the cockpit in an explosive decompression.

"Moisture condensation buried me in a thick fog," he said. "Loss of pressure tore the breath from my lungs so fast that my oxygen mask fluttered. I realized I only had about 11 seconds of consciousness, so I put the plane in a power dive. It seemed it took me an eternity to act, but it was probably only an instant.

"I thought, 'I'm going to auger in and no one will know what happened.' But I got down to a safe altitude without passing out and landed unhurt, although I did experience some pain under my eyelids from the force of the decompression."

Ironically, Pruitt had a T-1 suit hanging in his clothes locker, but he hadn't taken time to put it on. He does now, though.

Barriers in the Sky

Earlier we said that space conditions exist well within the atmosphere. This fact becomes readily apparent now that we have seen what can happen to the flyer. Without protection, he would suffocate at relatively low levels. But at 50,000 feet and above, free air cannot contribute even fleetingly to his respiration. Similarly, his blood would boil just as readily at 63,000 feet as it would on the airless surface of the moon.

These two significant altitudes represent "physiological conditions of total space equivalence," says Dr. Hubertus Strughold. A distinguished physiologist, he heads the Air Force's Department of Space Medicine at Randolph Air Force Base, Texas.

Dr. Strughold also points to a third space condition within the domain of manned flight. Air compression for cockpits becomes impractical at about 80,000 feet. The machinery required is too large, and it generates too much heat. Moreover, the air contains noxious ozone, which rots rubber, corrodes metal, and poisons man. So the pilot must have a sealed cabin with a built-in atmosphere, just as if he were in space.

Major Murray's X-1A has a sealed cabin, but it is designed only for very brief dashes into the upper atmosphere, not sustained flight. Under Dr. Strughold the Air Force has developed an experimental hermetic cabin, forerunner of the enclosed environment of the space ship (page 252).

Physicists can prove that minute traces of the atmosphere extend 600 miles from earth.

However, this fact has little significance for Dr. Strughold and his colleagues. When man reaches 120 miles, or 630,000 feet, he will have encountered in some degree all of the medical problems characteristic of space, among them cosmic and ultraviolet radiation, meteors, weightlessness, and the darkness of the void.

Air drag is nonexistent at a height of 120 miles; the atmosphere's molecules and atoms are far too few to reduce the coasting velocity of any aircraft. Here, for all practical purposes, space begins.

Dr. Strughold, who was chief of the Aero-medical Research Institute in Berlin during World War II, can foresee increasingly daring and higher forays into the vertical frontier, eventually culminating in manned space flight after years of research. Such development is generally regarded as inevitable.

But this Air Force expert makes a sharp distinction between *space flight*, which is temporary in nature, and *space travel*. The military is much too absorbed in present problems to speculate about interplanetary voyages, so stigmatized by the fallacies and exaggerations of the comic pages.

Eyes twinkling, Dr. Strughold exclaims, "Ja, we must keep this space travel on the ground!"

Globe-circling Ships in Space

However, the scientists write and talk very seriously about possible man-made satellites. These bizarre vehicles would coast in space around the earth, held in their orbits by centrifugal force balancing the pull of gravity. An unmanned satellite might be feasible now, experts say, but a manned vehicle would be a project for the future (page 270).

Meanwhile, the services are probing space with unmanned rockets. A two-stage V-2 zoomed 250 miles, reaching a speed of 3,600 miles per hour. The Navy Viking has attained 158 miles above earth. Medical researchers regularly sample the upper atmosphere between 75 and 100 miles with Aerobee rockets. Instruments record data and then are retrieved by parachute.

Two macaque monkeys have ridden an Aerobee to 36 miles before being parachuted down in the rocket's nose section. They were recovered in excellent health and spirits; one now lives in the National Zoological Park of the Smithsonian Institution, Washington, D. C. (page 255).



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← **A Volunteer Researcher
Endures Hyperventilation,
Suspected Killer of Pilots**

Under severe stress a pilot may breathe three or four times normal rate, upsetting Nature's balance of oxygen and carbon dioxide. This hyperventilation, or "overbreathing," causes dizziness and loss of coordination, followed by muscle spasm, and may account for many mystifying accidents.

Dr. Robert T. Clark, Jr., physiologist at the School of Aviation Medicine at Randolph Air Force Base, Texas, and his staff have developed a respirator that forces men to breathe several times faster than usual. Here he studies its effects.

Above: The volunteer, breathing normally, manipulates a control stick.

Center: Fingers stiffen and lose their grip after five minutes of forced overbreathing.

Below: After 11 minutes, spasms gnarl the hands, weld eyelids shut, and pucker the face. With mask removed, the subject soon recovered.

Opposite: Plastic tubes connected to a student's mask collect exhaled air before a training flight. During maneuvers the instructor (right) takes additional samples. Analysis of carbon dioxide content tells whether the student overbreathes.

© National Geographic Society



An F-80 (left) Drops from Formation, Enacting the Fatal Dive of a Hyperventilated Pilot

Tests on student pilots show that many hyperventilate at times because of fear or nervousness. Overbreathing, they could become dizzy and confused and lose control before realizing their danger. The Air Force teaches its men that normal, controlled breathing can save lives. Even holding the breath for brief moments may help.



A scientist once told me that no one ever tires of witnessing rocket take-offs. I dismissed his statement as overenthusiasm—until I saw an Aerobee launched at Holloman Air Force Base, New Mexico.

It was sunset of a winter's evening, and a razor wind punished our little group of observers standing in the desert. For endless seconds we had been staring at the launching site, about 1,200 feet away, where the javelin-shaped Aerobee rested on its tail in a metal tower. Twilight silhouetted the firing crew's squat concrete bunker.

This "shoot," officers told me, had been weeks in preparation. Scientists wanted high-altitude pictures of a sunset, but weather conditions had not been right. Tonight's would be the third try after two last-minute postponements on previous evenings.

A loudspeaker at my back blared, "X minus

ten seconds . . . nine . . . eight . . . seven . . ." The unemotional voice continued its count until, very suddenly, a volcano erupted on the firing stand. Smoke obscured the Aerobee's tail, but I could see the rocket move slowly upward. As it neared the top of the launcher, a downward gusher of flaming gas appeared.

Roaring sound waves billowed upon us, but distance and wind had sapped them of much of their original strength.

Once clear of its launcher, the 1,250-pound Aerobee accelerated rapidly toward its maximum speed of 3,600 miles per hour. It flew straight up, a fiery lance thrown by man at the heavens. Soon the naked eye could see only an orange speck in the sky. With binoculars I followed the light until it was lost in the stars.

Rocket flights, plus high-altitude research with unmanned balloons, are revealing the full

magnitude of aviation medicine's next big hurdle, cosmic rays (page 273).

These swift rays are atomic nuclei that constantly bombard earth from outer space.* Fortunately for earth dwellers, the particles are smashed to even tinier fragments as they strike molecules of air. So our atmos-

* See "Trailing Cosmic Rays in Canada's North," by Martin A. Pomerantz, NATIONAL GEOGRAPHIC MAGAZINE, JANUARY, 1953.

Experimental Cabin Shuts Out the World Like a Bank Vault

This metal chamber at the Air Force School of Aviation Medicine simulates the sealed environment pilots must have above 80,000 feet. Refrigeration cools the air, and chemicals remove carbon dioxide and water vapor. Scientists plan experiments here with air-purifying algae (opposite page).

Dr. Hubertus Strughold, chief of the Department of Space Medicine, inspects the chamber before a "take-off."





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↑ This Mouse Recluse Is a Space Pioneer

Without leaving the Aero Medical Laboratory, the rodent contributes to knowledge about an enclosed environment, such as men would need in a space ship cabin. He lives for a month at a time in this jar, his needs fully supplied.

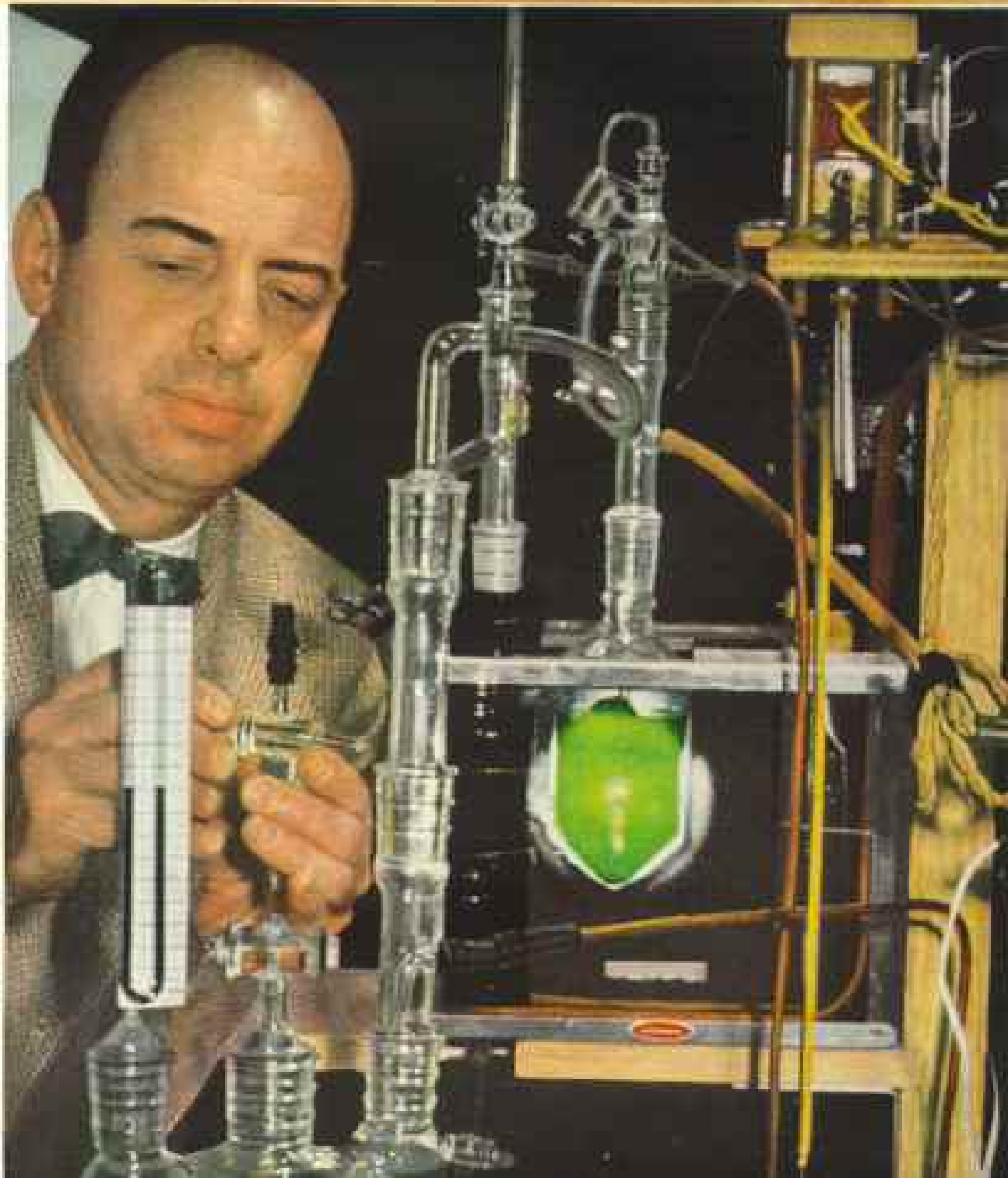
Green Algae Produce → Life-giving Oxygen

In photosynthesis, plants absorb carbon dioxide and give off oxygen, the opposite of human respiration. *Chlorella*, one of the algae, performs this function with special efficiency. The Air Force theorizes that tanks containing the minute plants might renew a space cabin's atmosphere.

Here Dr. Jack Myers experiments with gas exchange at the University of Texas. Air containing five percent carbon dioxide bubbles through the algae solution. Enough oxygen to keep a small frog alive passes into a collecting bottle.

© National Geographic Society

Kodachromes by David R. Bauer (above) and Lois Marlon



phere is a shield, equal to a lead plate about three feet thick. Here on earth we are subjected only to secondary radiation, or the debris of the shower, and we tolerate it easily.

But some primary rays penetrate the atmosphere to 70,000 feet. Above that height their number increases until, at 120,000 feet, very few of the rays are stopped. Most of this primary atomic radiation is believed to be within accepted dosage limits. Indeed, less than one percent, the so-called heavy particles, seems dangerous. These heavy rays are the nuclei of elements such as iron—even tin and molybdenum have been recorded—and they travel at nearly the speed of light. Striking tissue, they leave an ionized, or electrically charged, path that destroys cells.

What will these tiny celestial bullets do to man during long exposure? Can we risk hits in such vital spots as the brain, the reproductive glands, or the retina of the eye?

Danger from Cosmic Rays

On these questions opinions are often divided. Nuclei, even when classed as heavy, vary in weight. Some experts believe the "light heavies," so to speak, are not dangerous; others believe they may be. Until more is known about the heavy primaries, we can't be positive. Shielding is impossible for weight reasons. But a balanced, general viewpoint of the radiation problem would seem to indicate that it is probably not critical, at least during limited flight periods.

Yet a note of caution is added by Dr. Hermann J. Schaefer, a former German scientist and one of the Navy's radiation experts:

"We must distinguish between apparent damage and possible unnoted genetic damage. Also, we know that the mean life expectancy of animals is shortened by long exposure to low dosages of densely ionizing rays. We don't know why this is true. But it is a fact that the life expectancy of persons who fly among primary rays for long periods may be shortened."

Cosmic radiation poses no problems for your family physician, nor does another bizarre threat to flyers; the G force. But imagine your doctor's surprise if you were suddenly four times your normal weight—or had no weight at all! Yet such cases are commonplace to the flight surgeon.

In his terminology, one G equals the force of gravity. Your body, normally subject to

the constant tug of gravity, is "under one G"—that is, it has its normal weight. But changes in acceleration may alter that value. A sudden turn in a car, for example, will push you against the door frame with a force greater than your weight.

The flyer actually experiences a rapid change in weight if he whips around in a high-speed turn. When the centrifugal force is from head to foot (positive G), his blood drains from the upper part of the body; his facial tissue and internal organs sag (page 243). Suddenly he feels as heavy as a bronze statue. Between four and five G's he "blacks out" in 10 seconds as vision fails from loss of blood supply to the eyes.

But the flyer's plight is worse when the force is from foot to head (negative G), as in an outside loop. The blood pools in the skull, which seems about to burst. His vision will "red out" from blood congestion in 10 seconds at three G's. If the force is prolonged, eyes and brain may hemorrhage.

After long research, aviation medicine developed a suit that gives him tolerance for an additional two and one-half positive G's. It has five pneumatic bladders: one on the calf of each leg, one on each thigh, and one on the abdomen. These bladders inflate automatically in tight maneuvers. Their pressure on arteries and veins reduces blood pooling.

Problem of No Weight

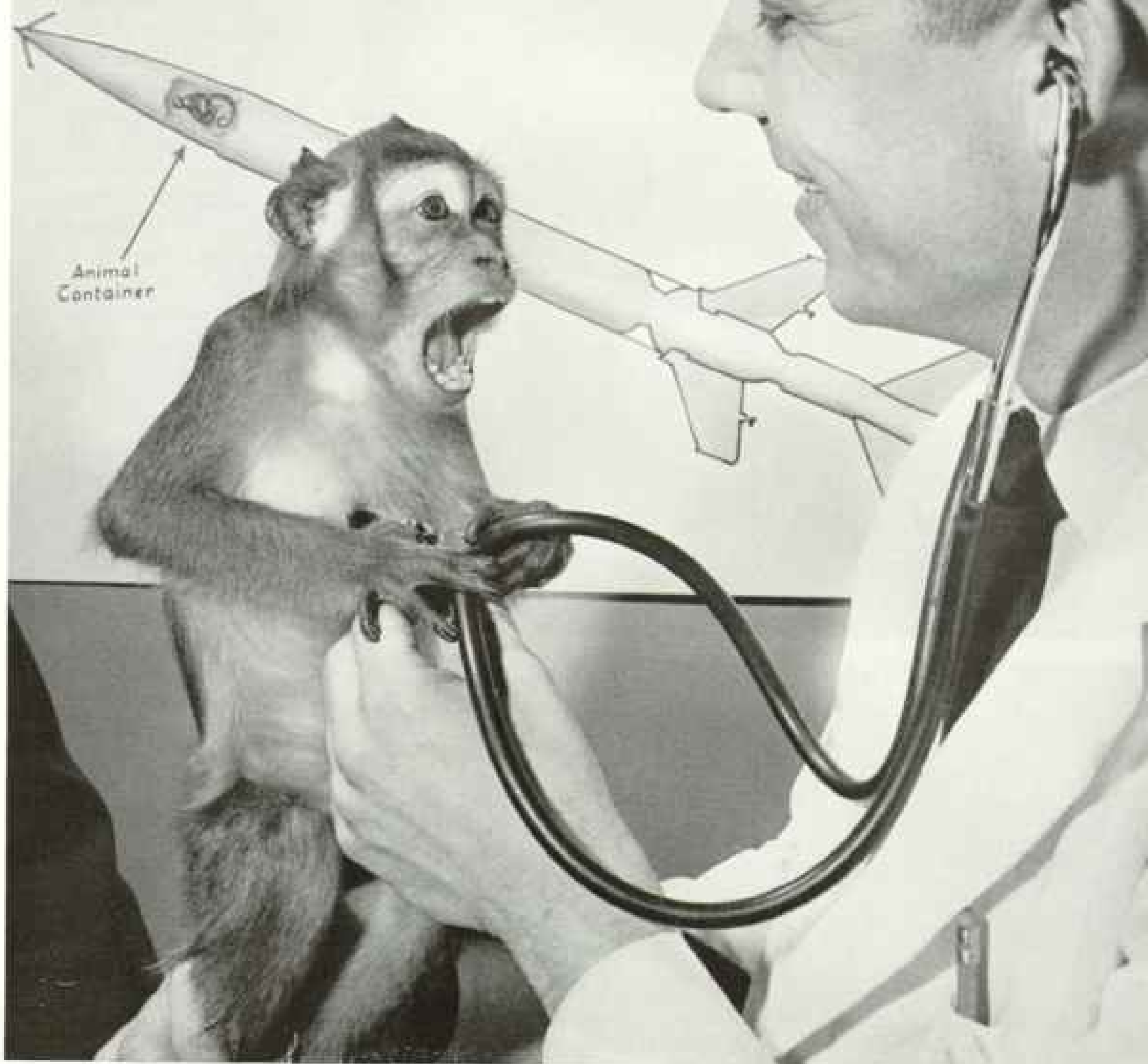
However, no such simple solution is in view for the problem of weightlessness (zero G). Indeed, man may just have to live with it, a prospect that worries some flight surgeons.

Now you probably are thinking, "Wait a minute! I've always had weight, perhaps even a mite too much. How could I possibly lose all of it?"

Well, quite easily. Ever ridden a roller coaster? As you went over a rise, you were lifted slightly from your seat. Butterflies as big as pigeons fluttered in the pit of your stomach, giving you a queer sinking feeling.

For an instant you had only a fraction of your weight. Centrifugal force threw you up while gravity pulled you down, and the two forces tended to cancel each other.

That's what happens in a high-speed aircraft when it flies a parabolic trajectory, or roller-coaster arc. For a time the pilot floats in his safety harness a few inches above his seat, entirely free of weight. Loose objects in the cockpit hang in mid-air (page 248).



"Take a Deep Breath!" A World's Record Holder Obliges During His Annual Checkup

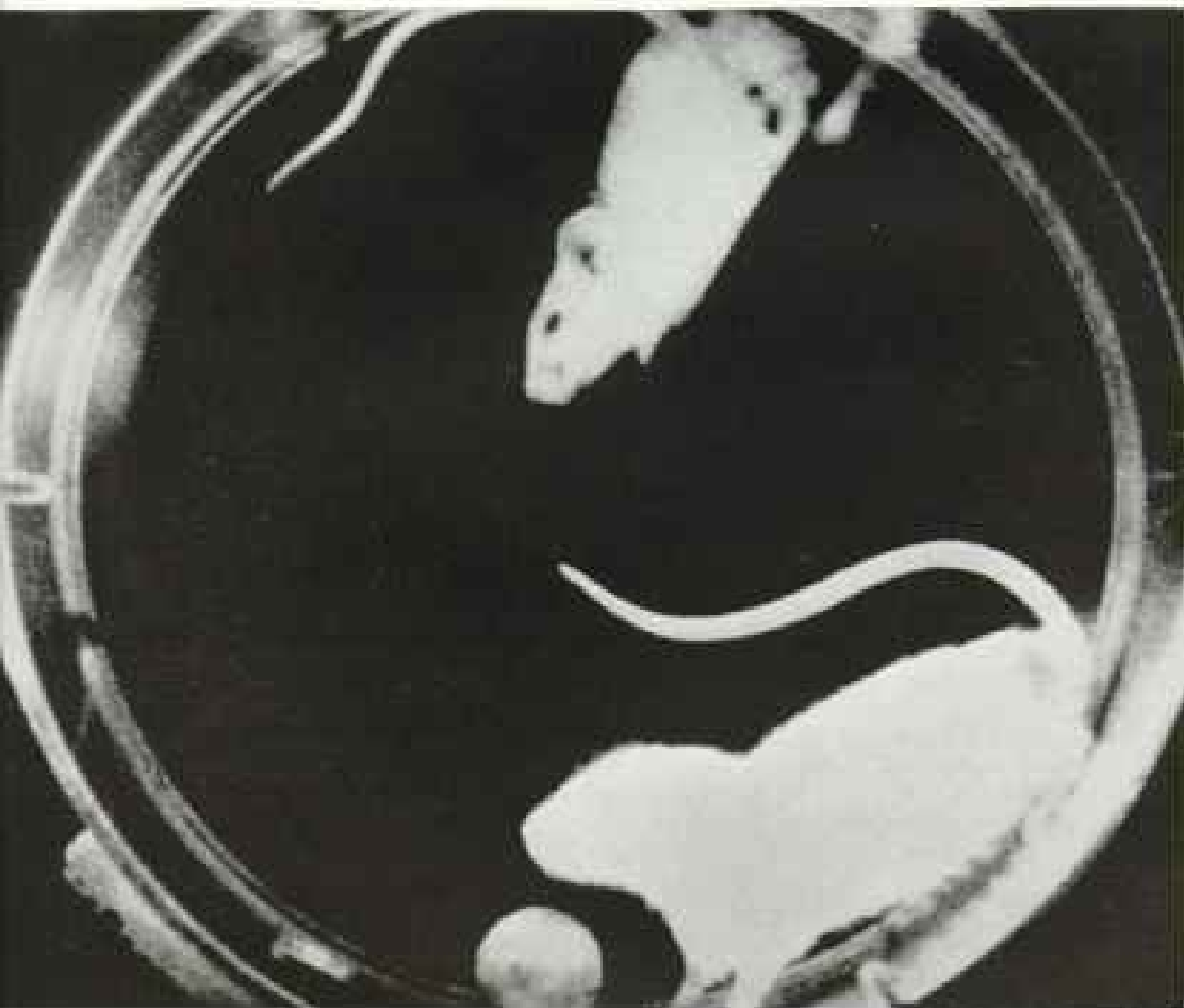
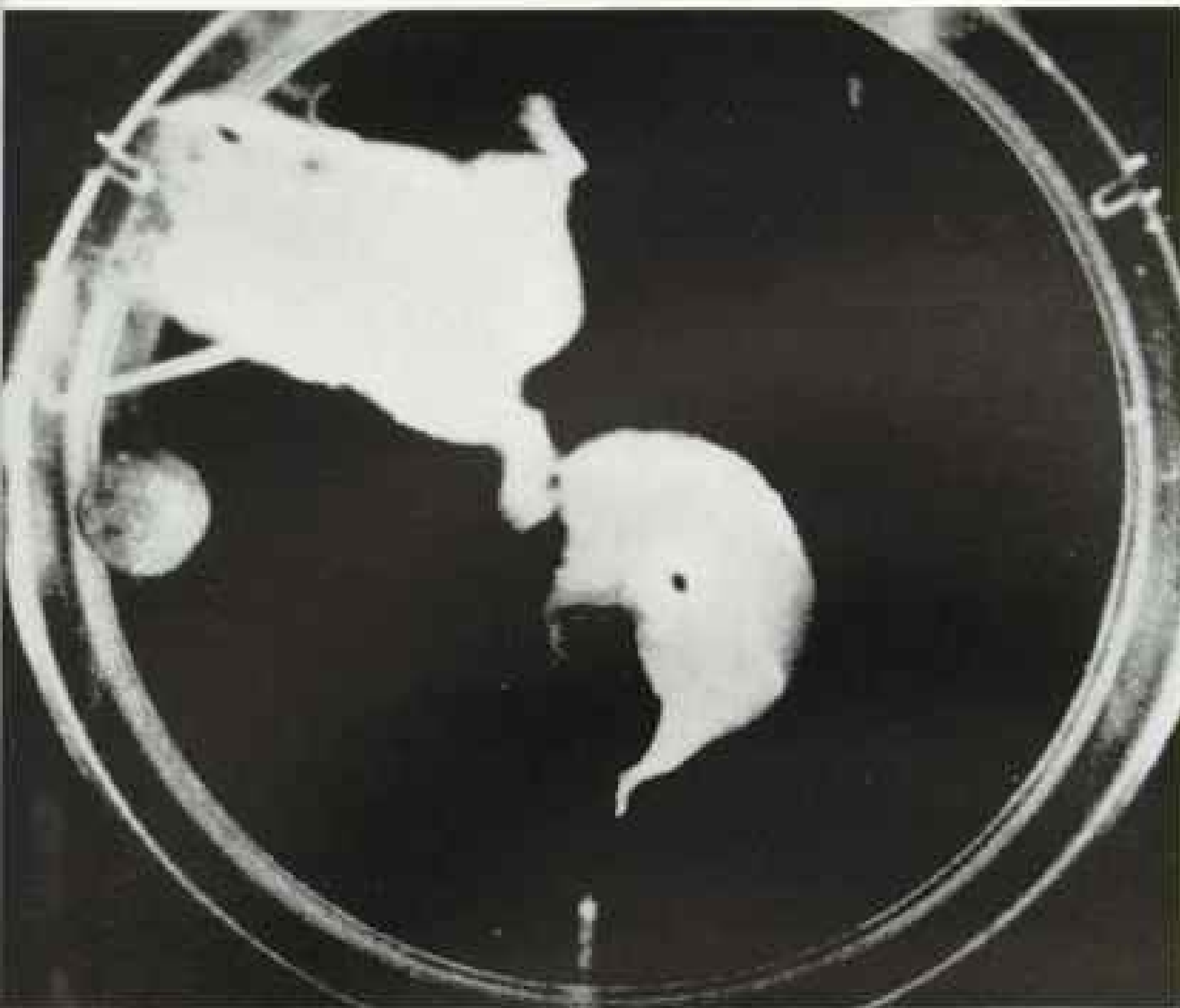
This Philippine macaque has traveled higher than any other living creature. He rode an Aerobee rocket 36 miles up in 1952, then parachuted to earth uninjured inside the rocket's nose (page 249). Another monkey, since dead of natural causes, also made the trip. An Air Force veterinarian examines the survivor at the Washington, D. C., zoo. Periodic checkups have detected no latent effects.

Duration of weightlessness depends upon the length of the parabola, the aircraft's speed, and other factors. Some experimental pilots, flying trajectories carefully calculated with the help of engineers, have maintained the condition for about 30 seconds. In general, however, the military pilot lacking such help cannot produce zero G for longer than six to eight seconds. A lengthy parabola is seldom flown in combat, though some maneu-

vers produce weightlessness for a few seconds.

From the time standpoint, weightlessness might not seem to be much of a problem. But the flight surgeon has pressing reasons for concern.

Various senses keep you attuned to the reassuring presence of gravity, your support against it, and your normal one G weight. One of the most important of these message receptors is a pea-sized organ containing otoliths,



U. S. AIR FORCE, OROLOG

Weightless Mice Scramble for Support

Below: These rocket-riding rodents are calm under normal gravity. Rear mouse clings head down to a paddlelike support.

Above: Weightless, the animal nearer the camera thrashes in mid-air, floating with a rubber ball. He has no paddle for support, but the other mouse grabs a foothold and seems less disturbed.

found in the inner ear. If the forces acting on your body change, as they do during a fall, the otoliths warn the brain.

Doctors reason that an identical warning is telegraphed when a flyer becomes weightless. They ask themselves: Shouldn't the flyer feel that he is falling into a bottomless pit? Will other orienting senses, principally sight, override the otoliths' message and tell him that he is not falling?

Answers to these questions are being sought, and with urgency. Air-breathing engines may have a ceiling of about 80,000 feet; so increased emphasis in the near future will be given aircraft with rocket engines—independent of the atmosphere—in which relatively long periods of weightlessness will be normal.

In a rocket vehicle of the future, coasting with dead engines, zero G will exist as soon as the last traces of air drag vanish at greater heights. If air drag ceases to interfere with the free flight of the craft, a parabolic or elliptical trajectory will result, bringing about weightlessness. For a body traveling along a celestial orbit, the force of gravity is exactly balanced by forces of inertia.

When the rocket motors cut off, pilot and crew are deprived of support given by the push of acceleration. They float weightless so long as their aircraft coasts in very thin air. As it returns to earth, denser air gives support and weight returns.

So, strange as it seems, we have no weight without support against the pull of gravity. You can prove this with a simple experiment, if you care to sacrifice the bathroom scales. Place some heavy object on the scales, hold both at eye level, and let them drop. The weight indicator will snap back to zero as soon as you release your support.

Zero G May Handicap Pilot

Unfortunately, there is little agreement among pilots and flight surgeons concerning the effect of weightlessness. They describe it as a weird sensation, but that's about all they agree upon.

Scott Crossfield, test pilot of the National Advisory Committee for Aeronautics, has tried weightless flights lasting 20 to 30 seconds. He reported a feeling of "befuddlement" during his first flights, but later he experienced little difficulty beyond a tendency to overreach for controls. Some other pilots have reacted similarly.

Maj. Charles (Chuck) Yeager, former pilot of the X-1A, flew parabolas for medical research. During one experiment in a jet aircraft, he felt as if he were being rotated, and found the sensation so disconcerting that he pulled out of the arc.

His successor in the X-1A, Major Murray, told me he had found weightlessness confusing. "At times you have the sensation of falling," he said, "and there is a tendency to reach out and grab something."

Natural Athletes Have Advantage

Dr. Heinz Haber believes there will be great individual differences in reaction to zero G. He feels that the "kinesthetically gifted," such as natural athletes, particularly high-board divers and pole vaulters, will adapt quickly.

"Most people will find prolonged weightlessness a difficult thing," he added, "and it may even become an incapacitating illness."

On the other hand, Dr. Strughold thinks only the "transitional stage," or adaptation, may be uncomfortable, and Dr. James P. Henry of the Air Force is even more optimistic.

"In the skilled pilot weightlessness will probably have very little significance," he says.

Dr. Henry, physician-scientist of the Air Force's Aero Medical Laboratory, helped plan three rocket experiments that carried monkeys and mice higher than man has ever been.

These animals were weightless for only two to three minutes, compared to hours or days that could be expected in an orbiting vehicle.

Instruments revealed that loss of gravity had little effect on the monkeys' blood and heart action. Most researchers believe it won't directly disturb man's circulation, either, but he might develop a sort of motion sickness with accompanying digestive and circulatory disturbances.

Of the two mice that went aloft in the second experiment, one was normal, the other lacked the organs of the inner ear, including the otoliths. Perhaps significantly, the normal mouse was badly disoriented by weightlessness. The other, grown used to a life without full sense of gravity, behaved better.

Some medical personnel are flying weightless parabolas in T-33 jet trainers, searching for additional information. One such acquaintance suggested to me:

"I intend to try it. Why don't you see what it's like?"

How Feather Lightness Feels

Later, with no small misgiving, I did. Maj. Austin A. (Gus) Julian, Jr., a crack test pilot, took me up in a two-seater T-33 at Edwards Air Force Base. We zoomed quickly up to 20,000 feet. After Gus had leveled off, I placed a package of cigarettes atop the instrument panel. Then I loosened my safety harness so I could float with little hindrance.

"Ready?" Gus asked over the intercommunication system. He dived slightly to pick up speed, then up and over we went.

Suddenly I was off my seat and looking down at the instrument panel. The cigarettes, instead of floating, rose like a rocket and smashed against the transparent canopy. That was the last I saw of them. Dust from the floor whirled about my face.

"A little too much G," said Julian. "Let's do it again."

Once more we flashed upward. This time the maneuver was just right. I rose from my seat and stayed suspended. I felt like a feather pillowed on a cloud. My arms and legs floated tranquilly, effortlessly. Weightless dust swam lazily before my eyes.

It was the strangest sensation of my life, but curiously pleasant. I felt vaguely that something was different in the region of my stomach, yet there was no nausea or sensation of falling. It seemed a matter of regret when we pulled out of a gentle dive and I slumped



Rocket Smoke Trails the "Fastest Man on Earth" as He Streaks 632 Miles an Hour





Colonel Stapp's Railed Sled Plows into a Water Brake with Explosive Force

Lt. Col. John P. Stapp, 45, is his own guinea pig in the study of wind blast and deceleration, problems experienced by pilots during ejection (page 268). He endured a wind pressure of 1,100 pounds a square foot in this run. The brake jerked him to a stop with a peak force 55 times his own weight.

Describing his sensations, this courageous flight surgeon told the author he felt "like a fly riding the nose of a .45-caliber bullet" (page 271).

← Assistants at Holloman Air Force Base strap the colonel to his seat before the trial. Adjustment and testing of belts take an hour and 20 minutes. The sled is named "Sonic Wind No. 1."

→ Anxious colleagues surround Colonel Stapp after the violent deceleration. His vision blacked out for several minutes, and he thought he had suffered detached retinas. Three days later he sported a beautiful pair of shiners (inset). Except for this temporary injury, the colonel was unharmed. He returned to his duties after a few days of rest in the base hospital.



back in my seat. We had been weightless about eight seconds, Julian said, though it seemed much longer.

Gus flew four more parabolas. During one I squeezed my eyes tightly shut to remove visual orientation. Still I felt only a pleasant, dreamlike release from my body; there was no sensation of falling. On another run I again closed my eyes and tried touching my right hand to my oxygen mask. It proved difficult. I had to compensate frequently for the arm's cobweb weight and tell myself to move it slowly and carefully.

Luis Marden of the National Geographic

Electronic Wizardry Checks Mind and Body During Flight

Capt. Norman Lee Barr, Navy flight surgeon, straps a silver plate to a pilot's leg. Electrical impulses picked up from this and other attachments are transmitted by radio to the Naval Medical Center, Bethesda, Maryland. There instruments record the subject's temperature, brain waves, heart action, and breathing as he flies at 40,000 feet.

National Geographic Photographers John E. Fincher and Donald McBurn



staff flew 40 parabolas with another test pilot, Capt. Milburn G. Apt, to get the remarkable picture of weightless objects on page 248. While weightless, he had to focus and shoot one camera as another floated gently around his head.

He, too, reported "no sensation of falling," and both our pilots agreed.

Yet our reactions may not be typical. Moreover, even loose safety harness probably gives some reassuring tactile pressure that the mind can identify with support. Unfortunately, no one today can stay weightless long enough to give hard and fast answers.

But rocket aircraft now on the drawing boards will go far higher than the X-1A. When they come into use, the answers will follow.

Later Gus put our T-33 through a series of rolls and sharp turns. Temporary weightlessness may seem pleasant to some people, but few have a kind word to say about the sensation of "pulling G's," or multiples of weight.

Weight Quadrupled

On one turn the cockpit indicator read four positive G's for about eight seconds. I felt as if a mound of stone were crushing me down in the seat, bending me over the dual control stick. A slight grayness stole across my vision, and, no matter how hard I tried, I could not move. Temporarily I weighed 660 pounds, instead of my normal 165.

As we snapped back to level flight, Gus commented cheerfully, "Since you don't have a G suit, that's about all you can take without blacking out."

Finally we "headed for the barn," or home, and

found unexpected trouble. Julian, to my consternation, had to make a night belly landing because the left main wheel would not come down. With the other two wheels also retracted, our T-33 raised a spectacular trail of sparks as it slithered down the concrete runway. For a few moments we were severely jostled when the plane spun off the runway before skidding to a stop.

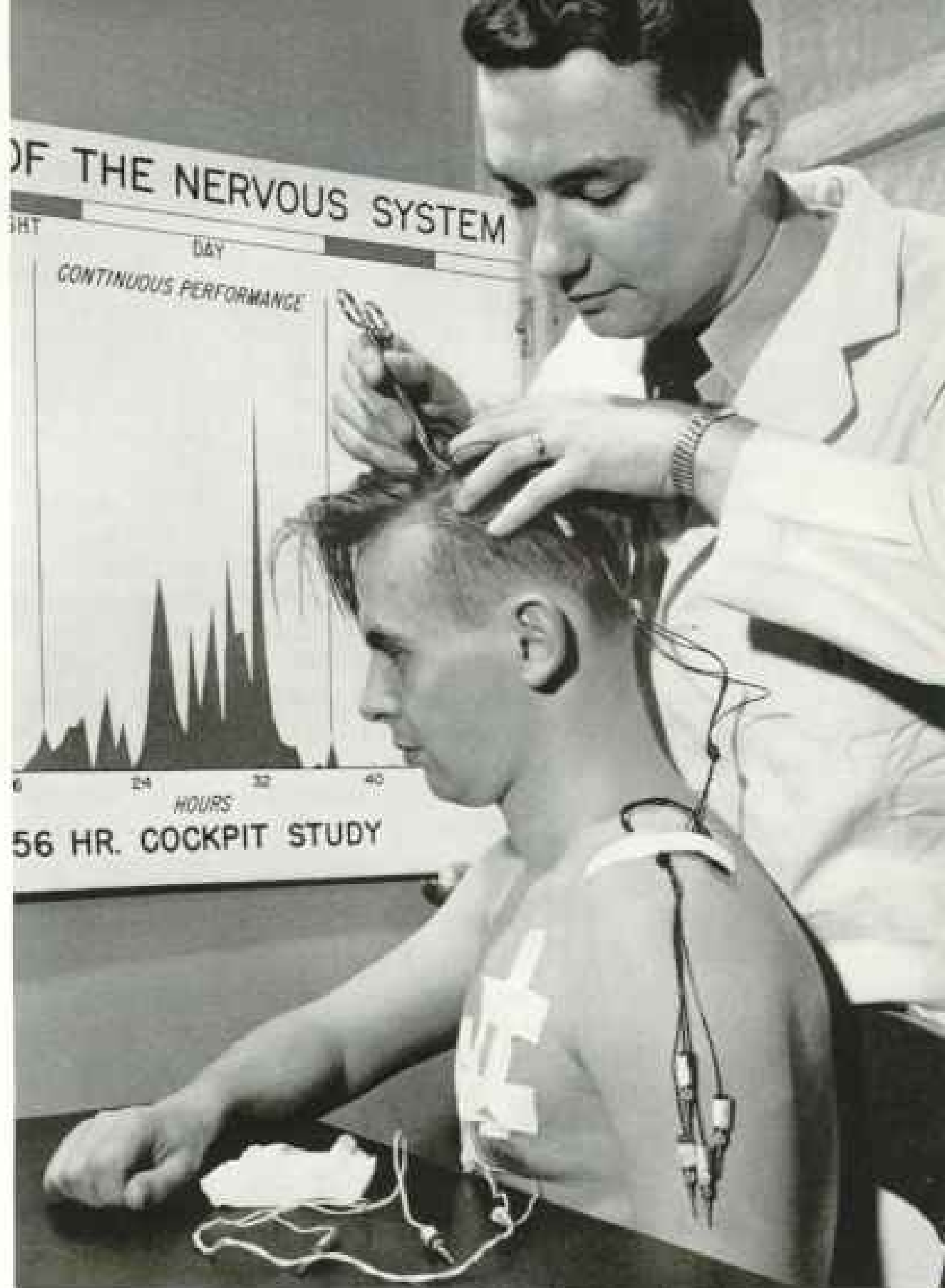
Harness Protects

But, thanks to an aviation medicine development, neither of us was injured. Tight safety harness, fitted across shoulders and abdomen, kept our bodies from jack-knifing into the instrument panels.

It is far worse to land a jet on two wheels than on none at all. For a time Julian had not been sure that he could retract our gear and make a safe landing, so he had instructed me again on ejection, as he had before take-off. This escape technique is another contribution of aviation medicine, and it has saved many lives.

Every jet flyer sits atop a giant firecracker. In emergency he can jettison his canopy and trigger an explosive charge that will blow him and his seat out of the aircraft. Then he must release his seat belt and open his parachute. A small oxygen bottle strapped to the leg or parachute assembly keeps him breathing in rarefied air.

New devices now coming into use will separate pilots from their seats and open their parachutes automatically. One of these gadgets is, in effect, a little time clock sensitive to atmospheric density. It can be set to release a parachute at any height below 20,000 feet.



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National Geographic Photographer Robert F. Stone

Needles under the Skin Detect the Effects of Fatigue

A doctor at the Aero Medical Laboratory gently attaches needlelike electrodes that will pick up the volunteer's reactions during a marathon experiment in a grounded cockpit. Background chart diagrams another man's performance in an earlier test lasting 56 hours. When that session ended, the subject, still going strong, went home and watched television.

But recently increased jet speeds and altitudes have complicated the ejection problem. Wind blast may tear away helmet and oxygen mask. Seats may tumble or spin briefly at an initial rate of more than 180 revolutions per minute, creating dangerous cyclic G forces.

Douglas Aircraft, working with aeromedical personnel, has developed several promising experimental ejection methods. One is a seat that sprouts wings to give stability against tumbling (page 268). Another is a capsule, shaped like a fat letter B, in which the pilot sits. If necessary, he can close the capsule's doors and blast himself from the cockpit.

His streamlined cocoon will protect him against wind blast and lessen tumbling.

It also promises another advantage.

A man falls more rapidly in thin air. Soon he may begin to spin about at a dangerous rate. Yet he cannot release his parachute until he slows down in the denser air at 20,000 feet. Above that height the opening shock of the parachute could break his bones.

Here again the capsule offers protection. Being streamlined, it is less likely to spin, and it shields against wind and cold. At safe altitude an automatic parachute opens and floats man and capsule to earth. Other methods, still on paper, would eject an entire cockpit or the nose section of an aircraft.

But these devices add weight to an aircraft, and weight reduces performance. On such matters aeromedics and the engineers try to work out a compromise. Many believe some kind of stabilized seat will be safe enough—if man can survive the long free fall.

Bailout from a Stratoballoon

An answer to that "if" will be sought by two young Air Force officers, Capt. Edward G. Sperry and 1st Lt. Henry P. Nielsen, in one of the most daring research projects in the history of aviation. They plan a series of six balloon flights, culminating in an altitude of about 90,000 feet, or possibly even higher than man has ever been. At the peak of each ascent one of the men will jump, at which time the balloon will be cut adrift.

As the jumper hurtles earthward, warm clothing and a pressure suit will protect him against the thin subzero atmosphere. A small drag chute will prevent tumbling. In safe air he can pull his ripcord or let the big parachute blossom automatically. Meanwhile, the remaining partner will ride their spherical gondola down to an altitude of about 20,000 feet, using a drag chute on the gondola for stabilization. Then he, too, will bail out. A specially designed parachute will ease gondola and instruments to earth.

Many members of The Society will recognize the gondola's name, *Explorer III* (opposite page). It honors the historic balloon

Explorer II, which set a world's altitude record of 72,395 feet. The ascent, made November 11, 1935, was sponsored by the National Geographic Society and the U. S. Army Air Corps.*

At this writing *Explorer II* still holds the record for a manned balloon. But Sperry and Nielsen are planning their flights for the near future at Holloman Air Force Base, New Mexico. They may exceed even the X-1A's height during their final ascent.

Jumping into space is no new experience for these young men. They test and develop escape equipment for the Aero Medical Laboratory, Wright-Patterson Air Force Base, Dayton, Ohio, and hold jointly the world's record altitude for ejection, 45,200 feet.

Much of the information needed by the services in planning new ejection techniques has been obtained by a courageous Air Force physician, Lt. Col. John P. Stapp. Riding rocket-powered sleds, he has risked his life repeatedly to study rapid deceleration.

His early experiments simulated crash impact. By braking to a rapid stop, the colonel proved that he could briefly withstand a force 45 times his own weight. The shock, taken from chest to back, did not cause blood pooling; hence the amazing tolerance.

Pilots also experience abrupt deceleration immediately after ejection. In recent experiments Colonel Stapp has been determining how much force the pilots can take, and for how long. He also investigates wind blast, but he cannot simulate the erratic tumbling of an ejection seat.

(Continued on page 271)

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Explorer III, Named for The Society's Historic Balloon, May Reach New Heights

What will happen when men bail out at extreme altitudes and fall many thousands of feet before denser air slows them enough so parachutes may be opened safely?

Capt. Edward G. Sperry (right) and 1st Lt. Henry P. Nielsen, Air Force parachutists, will seek the answer with this balloon gondola. Rigged for jumping, they wear pressure suits and carry parachutes and oxygen gear. Red nylon coveralls simplify tracking during a jump and spotting afterward. Nielsen examines his helmet face piece.

The seven-foot sphere of laminated glass fibers weighs 1,300 pounds with crew and gear. The name honors *Explorer II*, sponsored in 1935 by the National Geographic Society and the U. S. Army Air Corps, in which Capt. Albert W. Stevens and Capt. Orvil A. Anderson set a world's altitude record of 72,395 feet.

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Kodachrome by National Geographic Photographer Robert P. Hixon

* See, in the NATIONAL GEOGRAPHIC MAGAZINE: "Man's Farthest Aloft," January, 1936, and "Scientific Results of the World-Record Stratosphere Flight," May, 1936, both by Capt. Albert W. Stevens. See also "National Geographic Society-U. S. Army Air Corps Stratosphere Flight of 1935 in Balloon *Explorer II*" (Contributed Technical Papers, Stratosphere Series, No. 2), published in 1936 by National Geographic Society, Washington, D. C.



EXPLORER III

USAF



"Mickey Mouse Ears" → Deaden Jet Noise Aboard a Carrier

One jet engine with afterburner—a tailpipe device for added power—equals the combined sound of a thousand 75-piece orchestras. To lessen the earsplitting racket, military men working near jets wear earplugs and experimental helmets like these.

Aboard the carrier *Midway* this landing signal officer and assistant guide a plane to deck. Muffs filter out high-frequency noise but permit conversation to be heard.

←Flaming ram jets on rotor tips power this Hiller Hornet in a night flight, creating in time exposure a weird pattern of light as the helicopter descends.

↓Dazzling peach-colored flame roars from an F-100's afterburner at Edwards Air Force Base, California.

Kodachromes by Luis Marden,
National Geographic Staff

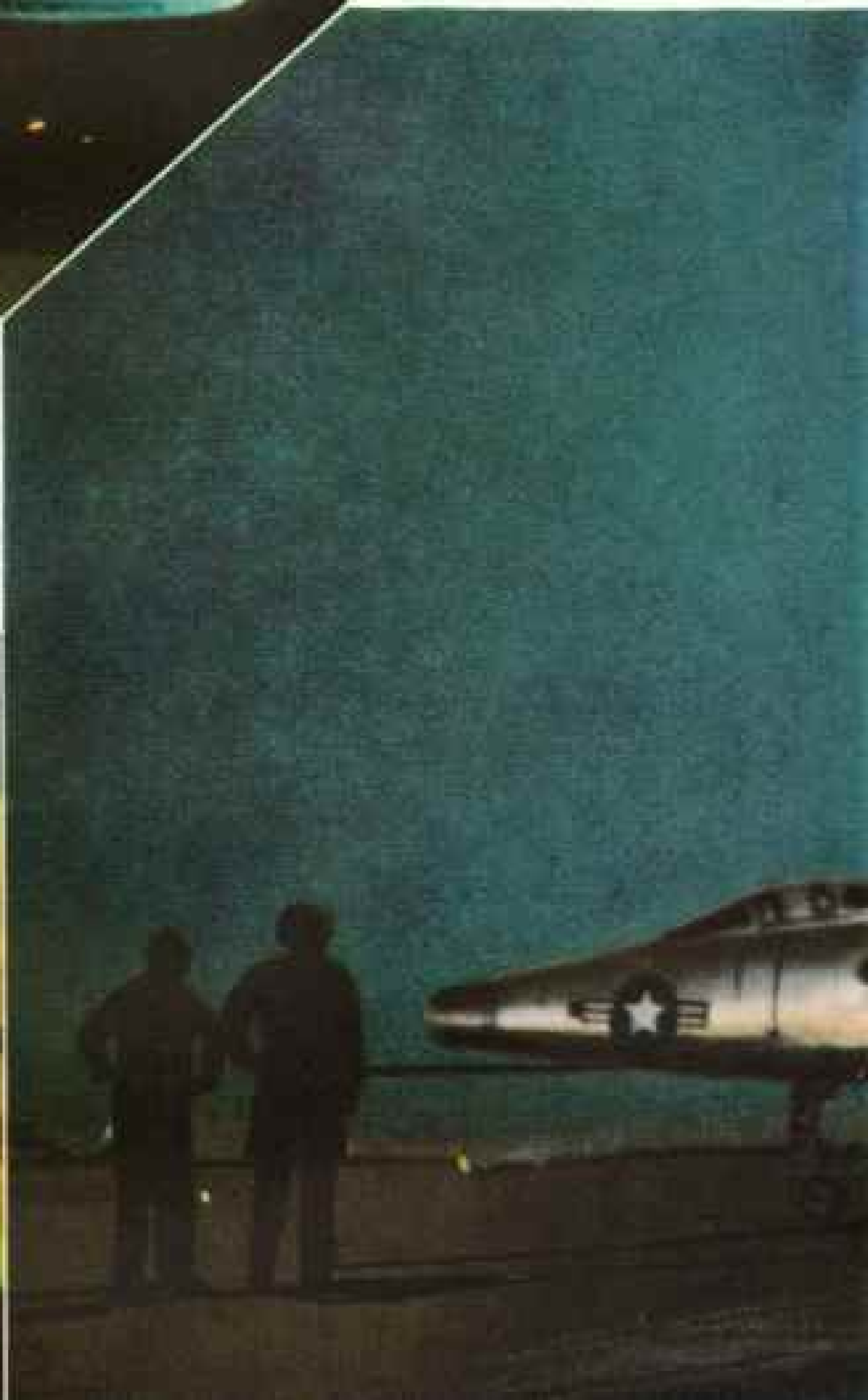
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↓ A Man-made Thunderclap Is Born

Simulating flight at supersonic speed in a wind tunnel, an F-100 model generates a series of shock waves. Similar waves from low-flying jets have created powerful sonic booms that shattered windows and damaged chimneys. Higher flight paths are solving this problem.

Kodachrome by North American Aviation, Inc.









← Nurses "Flying" at 30,000 Feet in a Low-pressure Chamber Witness the Peril of Hypoxia

Hypoxia, or oxygen starvation, is even more insidious than hyperventilation (page 250). If a mask feeds insufficient oxygen, the effect is akin to drunkenness. A flyer loses coordination, yet he may feel elated and believe he is performing skillfully.

Flyers learn to recognize this false sense of well-being during chamber "runs" duplicating high-altitude conditions. These flight nurses undergo indoctrination at Gunter Air Force Base, Montgomery, Alabama.

Her mask removed, one girl fumbles with a pegboard as coordination wanes. Soon the kneeling instructor will restore her oxygen. A doctor, always present at chamber "ascents," watches through a window (center). Dangling glove demonstrates air expansion under lessening pressure. Limp at sea level, it balloons as altitude increases.

Opposite, lower: At 30,000 feet an unmasked nurse begins turning the pegboard arrows upward.

↓ Less than three minutes later, her task only half finished, she loses consciousness.

→ A candle flame illustrates the effects of oxygen deficiency. Beginning at bottom, pictures show the flame at sea level and at 30,000, 40,000, and 50,000 feet. Given plentiful oxygen, the candle burns with uniform brightness caused by glowing particles of carbon. In thin air, combustion efficiency dwindles. Ten seconds at 50,000 feet killed the flame.

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 Kodachromes by Lulu Marchon, National Geographic Staff





↑ Sleek, High-speed X-3 Seems Spare as a Needle

Even when standing still, this Douglas research aircraft looks as if it is breaking the sound barrier. Its high-speed design creates a survival problem for the pilot. If he had to eject in a standard seat, wind blast would hurl him dangerously head over heels.

← A Seat That Sprouts Wings Keeps the Pilot from Pinwheeling

Stabilizing fins spring out in 1/100 of a second after the X-3's pilot ejects. He drops in his winged throne to 15,000 feet where the 300-pound seat separates from him automatically and his parachute opens.

Engineers have even designed the airman's helmet against supersonic wind. Slots on top create a partial vacuum that prevents headgear and oxygen mask from tearing away.

© Illustration by U. S. Air Force and Kolutchene (left) by Lois Marden, National Geographic Staff

← **Tumbling Violently,
a Test Dummy Hurtles
from an F-94 Cockpit**

Aeromedics assigned to ejection research have blasted themselves from many planes, but they avoid needless risks. Carefully designed dummies often serve in experiments. Instruments on the lifeless forms record the effects of ejection.

Flying 460 miles an hour, this F-94 conducts a test for the Wright Aircraft Laboratory. The plane skims 200 feet above ground, critically low for safe parachute descent. A powder charge propels dummy and seat, weighing 300 pounds, at an initial speed of 60 feet a second. → Whirling upside down, they clear the tail. A moment later the dummy will separate from the seat, and parachutes will ease both to earth.

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Kodachrome by U. S. Air Force

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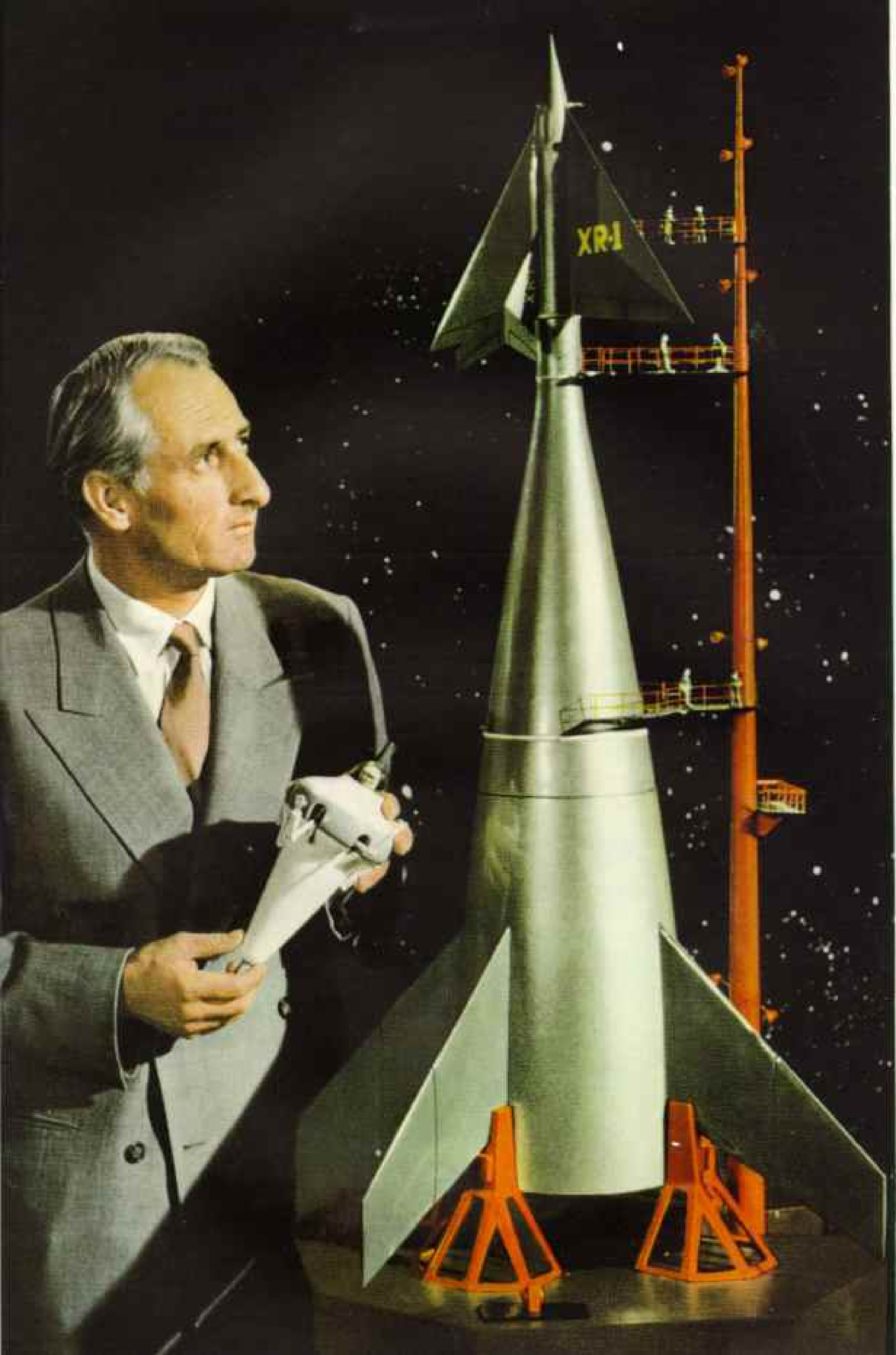


↓ **X-3 Pilot Rides to His Cabin in an Elevator**

Pilots ejecting upward from future supersonic aircraft might run the danger of striking tail surfaces. This plane ejects its seat downward. An electric motor lifts seat and pilot, Joseph Walker of the National Advisory Committee for Aeronautics staff, into the jet's belly.

Kodachrome by Lyle Martin, National Geographic Staff





On his last run the colonel sped down a 3,500-foot rail track at a top speed of 632 miles per hour (page 258). He exposed himself to a wind pressure of 1,100 pounds per square foot, equivalent to the blast a pilot would feel if he ejected at 50,000 feet while flying twice the speed of sound. The sled braked to a stop in little more than a second, subjecting its rider to a peak force of 35 G's.

"Like a Fly Riding a Bullet"

I met quiet-spoken Dr. Stapp at Holloman Air Force Base. He is a middle-aged bachelor who looks and talks like a college instructor, as indeed he once was. He takes a detached, analytical attitude toward his work and often speaks of himself dispassionately as "the subject." Yet, at my urging, he gave a vivid description of his sensations during the 632 miles-per-hour run:

"I felt like a fly riding the nose of a .45-caliber bullet. And the wind blast? It was like having my head caught in a vise, even though I wore a helmet with a face shield.

"When the sled started, I was watching the ditch between the rails. Almost instantly the ditch was nothing but a blur, and then I blacked out visually after two and a half to three seconds.

"The rockets burned for only five seconds, and when the sled emerged from propulsion my eyes detected a quick change from black to yellow. As we entered the water brake, the light seemed to be salmon-colored.

"I couldn't open my eyes after the sled

stopped, so I pushed the eyelids up with my fingers and found that I could not see human figures, although I continued to see the salmon color. I thought I had suffered detached retinas, but when they laid me down on my back my vision gradually returned.

"I found myself discussing the run in reverse—deceleration first, rather than acceleration. I couldn't narrate what had happened in chronological order."

Colonel Stapp smiled good-naturedly when I asked him if he suffered from the jitters before his sled run.

"Oh, I slept all right the night before. I always do. Perhaps it's because I know exactly what is going to happen to me!"

Pilot Is Here to Stay

With so many human problems piling up, why doesn't military aviation get frail man out of the airplane? We live in a great scientific age of guided missiles. Let's make everything automatic!

But this just won't work. Scientists point out that "frail" man has a much greater tolerance to vibration, shock, and temperature change than does an electronic brain. Man also boasts another advantage, summed up for me by Edgar Schmued, vice president in charge of engineering for Northrop Aircraft, Inc., in Hawthorne, California:

"A day is near when in many types of manned aircraft the pilot will be monitoring instead of flying the aircraft," he said. "Nevertheless, the pilot is not being replaced, because he is still the finest emergency-control system ever devised. Any automatic device can only perform within the limits designed into it. Outside of their prescribed performance, automatic systems are helpless, and it is then that the human brain shows the vast superiority given by its Creator."

Not all of aviation medicine's problems concern only military personnel. One may affect *you*, and the aeromedics constantly seek ways to protect you from it.

In a word, the problem is noise. Airplanes have always made a lot of it, but they will raise even more of a racket in the future. New jet engines with powerful afterburners generate 150 decibels, a fury of sound equivalent to 1,500,000,000 people all talking at once (page 265).

Nothing in man's previous experience approaches that intensity. A hydraulic press creates 150 decibels. This may seem com-

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◀ When and If Man Conquers Space, Will He Ride Such a Rocket Ship?

Far from being a toy, this model represents a serious scientific proposal for flight into space. A four-stage vehicle, the ship would tower 180 feet and weigh 1,410 tons. Three booster rockets would drop one by one, leaving only the crew-carrying fourth stage shaped like a paper dart (above). It would circle the earth as a satellite 1,072 miles high.

Dr. Heinz Haber, physicist at the University of California, holds a "capsule" that a crewman might wear if he ventured outside the satellite. Dubbed the "Coke bottle," the capsule protects against bullet-fast meteoric dust; it can be maneuvered by jet nozzles at top and bottom. Mechanical arms, similar to those which handle radioactive material, would be used for work outside the ship.

Dr. Wernher von Braun, U. S. Army rocket expert and a developer of Germany's V-2, designed this four-foot-tall model for a Walt Disney television series.



Helium Fattens a Plastic Balloon at Lowry Air Force Base

This instrument-carrying balloon, used for stratosphere research, is of strong, transparent polyethylene like that in which market vegetables are packaged. Inflation begins inside a "covered wagon" launcher near Denver, Colorado.

Below: Canvas shroud pulls away when the craft is ready for release. After hours aloft the instrument crate parachutes down. A \$25 reward awaits its return. Finders may keep the deflated plastic bag; they often use it in packaging meat for home freezers.

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parable, but sound energy doubles with each three additional decibels. Thus an after-burner creates nearly 100 times the sound energy of a hydraulic press in an automobile factory.

Wherever possible, the military routes jet flights away from residential areas near airfields. Blast fences and pits help deflect ground noise upward. But as yet little can be done to muffle the engine itself.

The shattering sonic boom also may concern you. When a plane passes through the sound barrier, it creates powerful shock waves (page 264). If the plane is low enough, the waves hit the earth. Usually they are heard as two explosions, one from the front of the plane, the other from its tail surfaces.

In some areas, principally in the West, windows have been shattered and chimneys damaged by the booms. Conceivably they might hurt eardrums, but the chance of direct injury to humans or animals is remote.

The Air Force has been studying these man-made thunderclaps in order to eliminate the annoyance. Personnel of the Wright Air Development Center recently exposed themselves to booms in the desolation of California's Mojave Desert. They were working against time.

Until recently the shock waves could be created only by power dives. Generally the direction of these waves could be predicted; pilots could "aim" them at uninhabited sections. But new fighters, such as the F-100, will fly supersonic in level flight, creating continuous shocks beneath their paths.

The Air Force now concludes that these

shocks will be insignificant on the ground if the pilot flies at 25,000 feet or higher. And, unless over desolate terrain, the speed boys will fly at that height out of consideration for you.

But the services cannot eliminate all the noise. If it should trouble you in the future, just bear in mind the moral of this incident:

In 1954 an irate woman called the headquarters of the National Aircraft Show at Dayton, Ohio. Officials were busy, so a visiting Navy pilot answered the telephone.

"This is dreadful!" complained the woman. "Airplanes are making so much noise I can't hear myself talk."

"Are they enemy planes?"

"Certainly not!" she snapped. "They're American. I can see them."

"Then thank God, madam," said the pilot gently, and hung up.

For you the noise of aircraft can be only a temporary annoyance, but for military personnel who must work around jet engines it is a constant hazard to hearing acuity. All ground crewmen wear earplugs and take regular audiometer tests. As each new aircraft goes into production, aeromedics test its noise level and work out safety rules, such as the length of exposure possible without hearing loss.

Above 145 decibels the body seems to vibrate from the intensity of sound waves. Flight surgeons believe they may have to develop a special suit to protect ground crews against this hazard.

Noise on the confined area of a carrier deck has become, quite literally, a headache for the



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Mice Packed in → Wedge-shaped Cages Prepare to Go Aloft

Dozens of mice fill a balloon gondola for an ascent to 100,000 feet, where they will be showered by primary cosmic rays. These super-swift rays, atomic nuclei of mysterious origin, are absorbed by the atmosphere at lower levels. At times their painless "hits" leave the hair of black mice streaked with gray. Scientists examine the rodents after the ascent for signs of radiation damage.

Above: A polyethylene balloon floats in the sky like a monster jellyfish.

U. S. Air Force, Official



Navy. There is just no way to escape it, as Luis Marden and I found out for ourselves. We were guests of the Navy for a week's Atlantic cruise aboard the carrier *Midway*, a 45,000-ton mobile airport.

The men of the *Mid* were conducting landing qualification tests for jet pilots. Sleek Banshees and Cougars circled about and plummeted down to the deck hour after hour. Catapults shot aircraft off the bow seconds after they taxied into position.

Everywhere tornadoes of sound whipped around the deck crewmen. Near the island superstructure, where I stationed myself, the level at times reached 125 decibels. But I knew that the catapult crews, who must work directly beneath the jets, endured 135 to 140 decibels.

Helmets Can Be Too Blissful!

Some of the men wore experimental noise-reducing helmets with thick, built-in ear muffs (page 265). I tried one, and it gave blissful protection. Perhaps too much, several crewmen said. If your back is turned to a taxiing aircraft, they pointed out, your ears may not warn of its approach.

"But we must have some kind of helmet," a grim young deck officer told me. "Neither the Cougar nor the Banshee has an afterburner. Imagine what it will be like when all our planes have afterburners!"

Long exposure to extreme noise tends to make men fatigued, tense, and irritable. This is particularly true of the catapult crewmen.

I approached one of these youngsters at the close of a grueling afternoon qualification period. He was slumped on the catwalk that rims the flight deck.

"A rough day for you," I ventured.

"Rough!" he exploded. "I feel lousy! If even the captain so much as frowned at me now, I'd kick him over the side."

When I left, he was staring morosely at the sea.

But the flight surgeons will come up with an answer to this lad's discomfort, just as they have solved many other thorny problems. In doing so, they have gained a respect bordering upon veneration from the men in their care. "Doctor" to the pilot and his crew means a wise friend and confidant who shares their danger.

Flying as crew members, all surgeons attached to squadrons log the same number of air hours required of pilots. In addition,

Navy sky doctors receive pilot training, but currently are not permitted to solo. The Air Force gives such training only to doctors accepted for a five-year intensive course of specialization in aviation medicine.

There are some exceptions. Regulations permit each service a quota of about 15 physicians who are also rated pilots. These chosen few sweat out the same training, including jets, given combat pilots.

Flight surgeons not only take their chances in "hot" aircraft; they are quite willing, in effect, to swallow their own bitter pills. They ride centrifuges, suffer explosive decompressions, and eject from aircraft, all for research.

Small wonder, then, that when flight surgeons speak, their wards listen with respect. "Doc" gives his pilots and crewmen a very careful indoctrination in all the problems of survival. He answers their questions, sees that they receive training in the use of equipment, and keeps a vigilant watch over their health, including mental attitudes.

Surgeons have found that a pilot's early background and the motives that led him to seek flight training are of critical importance in his success or failure. Research psychologists have developed many ways to test prospective pilots. Their ideal type is a youngster from a large family who enjoys bodily contact sports, builds and drives "hot rods," likes all kinds of people, believes in some religion, and is daring but not foolhardy.

Aviation Medicine Once Scorned

Perhaps it was inevitable that aviation medicine, because of its strangeness, had to fight for recognition. Older flight surgeons told me they endured for years the derision and scorn of many physicians in private practice who thought flying and medicine had nothing in common. Even within the services there was little understanding or appreciation.

Maj. Gen. Malcolm Grow, first Surgeon General of the Air Force, is known for his pioneering in aviation medicine. He sponsored and built it within the Army when there was no separate air arm. At each step he faced limited funds and stubborn opposition.

"More than once they taunted me with, 'Grow, do you really think the airplane is here to stay?'"

"Aviation medical personnel were outside the pale," he recalls. "We were thought a lot of crazy guys with our heads in the clouds."

But recognition, when it came, was doubly



A Flyer's Protective Clothing Is as Multilayered as an Onion

Men in line (right to left) wear light cotton underwear, pressure suit, sleeveless air-cooled ventilating garment, and winter coveralls. This combination protects against bitter cold during ejection, severe cockpit heating (page 248), and other perils of high altitude. Seated flyer wears full flight gear, including parachute and oxygen equipment—a total of 92 pounds. Survival equipment from a seat pack lies at his side. World War II flyer (rear), in his two-piece winter garb, lacked pressure and ventilating suits and tough protective helmet with visor.



Smoke Pours from Roaring Rockets, but This Craft Never Leaves the Ground

Anticipating jet and rocket ships yet unbuilt, the Navy uses a teetering cockpit to study vertical take-off. While rockets blast from the tail, the cockpit can be suddenly tilted in its tower mount. The pilot, flat on his back, rights the craft with controls that alter the direction of thrust.

sweet. World War II gave aviation medicine great impetus. Then, in 1953, the American Board of Preventive Medicine made the new practice a specialty. About 150 old-timers, among them General Grow, received specialist ratings as members of the Founders' Group.

Today 50 young Air Force surgeons are embarked upon a five-year course of study and supervised practice leading to board certification. Soon the Navy will establish a similar course.

The once-struggling Aero Medical Association, an organization for flight surgeons and

their scientist colleagues, boasts nearly 1,900 members. Many also belong to its subsidiary group, the Space Medicine Association.

Service schools for flight surgeons have been called the world's most unusual medical institutions. Most of their courses cannot be found in standard medical curricula. Their faculties spend far more time in research than they do in teaching.

The U. S. Air Force School of Aviation Medicine traces its lineage back to 1918 when Army medical officers opened a ramshackle laboratory in Mineola, Long Island. Now,

after several moves and two world wars, the school occupies space in 41 different buildings at Randolph Air Force Base, Texas.

Through the years it has trained approximately 8,000 flight surgeons, including many Navy doctors, for the Navy did not establish its school at Pensacola, Florida, until 1939. Air Force nurses, medical technicians, and physiological training officers, or equipment specialists, attend a branch school at Gunter Air Force Base, Alabama (page 266).

Randolph's young physicians, fresh from civilian internships, labor long hours during an intensive nine-week course, graduating as aviation medical examiners. Then they must complete a year of supervised field practice before winning the coveted title of flight surgeon. The school also offers refresher and advanced courses for senior flight surgeons.

Where Dreamers Are Wanted

General Ogle, the Air Force Surgeon General, believes research needs more "dreamers," men with minds unfettered by medical convention. He has such men at the School of Aviation Medicine. For proof, just consider a few of their research projects.

The Indians of Peru live and work in thin Andean air above 16,000 feet. Obviously they adapt to oxygen deficiency—but precisely how? The school, seeking answers, has financed studies by Peruvian scientists, and it sent three young physicians to join the Indians as guinea pigs in experiments.

A glass lens concentrates sunlight, creating heat. Will the lens of the eye concentrate glare from an atomic bomb, burning the retina? School research found the answer—yes, it will—and worked out safe distances and other protective measures.

Mental stress decreases your normal number of eosinophiles, a type of white blood cell. School scientists pondering this fact asked themselves: Will blood tests before and after flights reveal pilots who are particularly subject to strain? Apparently the tests detect these men, but research continues.

Can we prevent or lessen airsickness? Doctors take volunteers on rough air rides, known as "burp runs," and experiment with drugs to control nausea.

Will other drugs keep pilots alert and efficient despite fatigue? Volunteers spend hours in flight simulators under medication. Someday, the Air Force hopes, pills may help bring exhausted flyers safely back to their bases.

The school integrates its work closely with that of the Aero Medical Laboratory, one of the many facilities of the Air Research and Development Command. This laboratory also conducts scores of research projects, most of them aimed at equipment development, and helps plan the experiments of a special laboratory in Alaska, maintained for studies under conditions of extreme cold.

Long ago the Air Force school outgrew present facilities. Brig. Gen. Edward J. Kendrick, its commanding officer, says a new \$8,000,000 home soon will be built at Brooks Air Force Base near Randolph.

Navy physicians, unlike those of the Air Force, receive flight surgeon rating as soon as they graduate from Pensacola. Their course of study is longer, lasting 22 weeks instead of nine. Since opening in 1939, the school has presented its distinctive wings to nearly 2,000 fledgling surgeons.

Capt. Julius C. Early, the commanding officer, had a word of warning as I began my visit:

"You may think you see a duplication of effort between our research and that of the Air Force. But look at it closely, and you will find we often investigate along converging lines of pursuit. In addition, each service has some problems of its own that require separate investigation."

Schools Work in Close Harmony

I did take a close look and found that the Air Force and Navy faculties confer often on methods of approach, cheerfully swap their secrets and discoveries, and exchange lecturers.

Capt. Ashton Graybiel, a former Harvard instructor and one of the Nation's leading heart experts, directs Pensacola's medical research. At the moment one of his most pressing problems is noise.

The Navy, working with the Central Institute for the Deaf at St. Louis, is building a mobile acoustic laboratory to take aboard carriers. There the infernal racket of jets will be recorded and analyzed by its various frequencies or wave lengths. Scientists will check personnel for effects of noise exposure and experiment with new types of protection.

Noise-harassed carrier men have invented a limited number of hand signals for communication. But for years the deaf have been able to "talk" easily with their hands. Ohio State University scientists will try to develop a simplified version for carrier use.

Pilots, too, must live with noise, both from their engines and from transmission difficulties in their radio frequencies and equipment. Under such conditions, what words are most intelligible to them?

Scientists from Ohio State, working at Pensacola, give about 10,000 word tests each year to air cadets. The youngsters sit in a noise-filled room and record what they think they hear over radio headsets.

To date, 60,500 words have been studied. Armed with this knowledge, the university wordsmiths are developing a streamlined language free of poor intelligibility.

No Time for Tongue Twisters

One scientist told me that a jet pilot travels 125 feet in the time it takes to say "top." The flyer no longer has leisure to puzzle over messages.

Basic research at the school is throwing new light on mysteries of the blood and heart. Ultimately these projects may have profound significance for the public.

Anemia, a deficiency in red blood cells, is an old scourge of man. Sometimes it is due to lack of iron, and iron may restore the cell substance, but not the count, to normal. Yet the Navy has discovered that it can increase the number of red cells in rats as much as 25 percent above normal. The animals are given protein-free extract from the blood of anemic animals.

This project, undertaken with the aid of California Institute of Technology, may one day help flyers breathe more easily, for red blood cells carry oxygen. But it may also lead to a new treatment for anemia.

In related work, the scientists are labeling these additional red cells with radioactive tracers. They want to find out if the spleen is stimulated to manufacture the cells or merely releases some that have been stored.

Captain Graybiel takes particular pride in the school's new vectorcardiograph. This complicated machine projects radarlike pictures of the heart's electrical field. Three pictures are shown simultaneously, one for each of the heart's dimensions.

Conventional electrocardiographs, such as your doctor's, give reliable information, but Navy doctors believe this new technique will be able to detect some heart ailments much earlier than before. It should also help to determine the effects of certain stresses encountered in flying.

Through personal research Captain Graybiel has demonstrated that varying G forces can subject the flyer to bewildering illusions. For instance, he might see the Washington Monument bend like a reed in the wind.

Here again the otolith, so important in weightlessness, is the villain. If a subject seated upright is whirled at moderate speeds on a centrifuge, he feels that he is changing position. Stationary objects appear to shift location. Gravity is felt as a force pressing upon him at an angle from the side.

Captain Graybiel gave me a ride on his centrifuge so I could see for myself how disconcerting the phenomenon can be. I sat beneath a black hood and fixed my gaze on an illuminated vertical bar. As the centrifuge gained speed, my chair seemed to tilt on its side, even though I knew it was bolted firmly to a platform. And the vertical bar, just as firmly fixed, promptly tilted at an angle!

My eye, like my body, had been fooled. The same thing may happen to a pilot during changes of acceleration. He suffers what Captain Graybiel calls the oculogravic illusion.

Other ear organs, the fluid-filled semicircular canals, also play tricks. A child delights in turning about in a circle and then stopping suddenly to watch the room whirl around. The youngster excites his semicircular canals, and they require time to return to normal.

This illusion is anything but delightful to a pilot snapping out of a series of fast rolls. Fixed objects on the horizon seem to sail off into space—the oculogyral illusion.

Box Takes Off and Flies

Captain Graybiel investigates this phenomenon with a Link trainer, or cockpit mock-up, that revolves on a pole. I volunteered as a subject, and again I rode in darkness, this time staring intently at a box outlined with tiny lights. As the trainer braked to a rapid stop, the box soared up and away like a bird.

Subjects for the captain's eerie rides include deaf persons who have lost the inner ear's labyrinth. Significantly, these people do not experience the illusions that plague normal men.

So, in schools and laboratories, in fast jets and high-flying balloons, the men of aviation medicine continue their quest for new facts and new methods. At times their problems seem insurmountable. But they yearn for the stars, and each year their work carries some lonely pilot to new heights on the vertical frontier.



Skunks Want Peace—or Else!

BY MELVIN R. ELLIS

With Illustrations from Photographs by Charles Philip Fox

THEODORE ROOSEVELT might well have been describing the attitude of skunks instead of outlining a foreign policy when he recommended that the United States speak softly but carry a big stick. If ever an animal served as an example of how to live in peace by being perpetually prepared to wage devastating war, it is *Mephitis mephitis*, the striped or common skunk.

Yet a truly ornery "polecat" probably never

lived. And to shout "Skunk!" at contemptible people is to libel one of Nature's least offensive creatures.

The skunk, native of every State and parts of Mexico and Canada, couldn't care less, even if it knew of the indignities heaped upon it. That is the nature of the beast: aloof, unconcerned, indifferent to all—except other skunks.

All animals, except man and sometimes fool-

ish dogs, respect the skunk's desire to avoid trouble. Only in rare emergencies, when starvation stalks the land, will coyote, cougar, and mink risk the skunk's noxious barrage, just as animals will sometimes dare the rattlesnake's fangs and the porcupine's quills.

Almost from the moment of birth, skunks are "loaded for bear" or anything else which threatens to disrupt their well-ordered lives. Once, while making the pictures accompanying this article, Charles Philip Fox exploded a flashbulb near a nest of eight two-week-old baby skunks. Though blind, one youngster emitted an odor that kept the photographer at bay (page 283).

Despite its seemingly overwhelming desire to go its way in peace, the skunk, if handled while young enough, makes a reasonably good pet. Even in the wild it is not a true isolationist. It has only minor objections to sharing its burrow with a fleeing rabbit, and it

will tolerate an itinerant woodchuck. It will stroll of a summer evening alongside the opossum, or it may bed down in the lower flat of a raccoon's apartment—or in just about any animal's burrow.

But threaten it, force a fight, and the consequences are terrible. In a flash the skunk discharges, through twin nozzles just inside the anal tract, an atomized spray of stinging, acrid, yellowish liquid.

Aroma Hangs On for Weeks

On damp nights weeks later the aroma hangs like an invisible mist to remind all who pass that here someone made the mistake of challenging a skunk.

Chemists know the skunk's secretion as *n*-butyl mercaptan. Sulphur, an important component, helps give the fluid an evil odor.

Despite its offensive character, the skunk's musk, like that of some other animals, can

be put to pleasing use by man. A refining process leaves a liquid that serves as a fixative in the making of perfumes.*

Our little valley, within sight of Milwaukee's skyline, was a skunks' favorite when we moved to it seven years ago. With only their white stripes showing on black nights, they paraded across our lawns, in our fields, and down

* See "Perfume, the Business of Illusion," by Lonelle Aikman, NATIONAL GEOGRAPHIC MAGAZINE, April, 1931.



The Skunk as a Pet? His Mistress Adores This Frisky Fellow

The skunk, if deodorized and trained at an early age, makes an engaging pet. Children delight in frolicking with the affectionate creatures. Jimmy, playmate of Barbara Fox, gently grasps her finger between sharp teeth as he rolls in the clover. He revels in having his ears and stomach scratched (page 288).



"Move Along, Chum, I Got Here First," Bristles Jimmy Skunk to Bobby Coon

A fondness for eggs spells grief to the skunk caught raiding a farmer's poultry house. Here a lone egg strains a friendship between pets of an Alexandria, Virginia, family. Jimmy outglares his rival and laps up the delicacy.



282

Mother Nuzzles Her Day-old Brood

Four to six is the usual skunk litter, but this female bore eight. "They chirped like a nest full of ever-hungry baby sparrows," reports photographer Fox. Pink skin patches will produce white fur.

↓ This day-old baby—wrinkled, blind, toothless, and hairless—measures a mere three inches in body length.

National Geographic Photographer John K. Pletcher



our roads, keeping the mouse and rat population at a reasonable level.

We were the first family to come having both children and dogs. The few families of adults who had preceded us lived in peace with the skunks by avoiding them.

But eager dogs and willful children learn the hard way, and that first year and into the second the valley reeked of skunk. Today skunks still inhabit the valley. So do children and dogs. But it is a rare evening when the breeze carries the odor of aught but blossoms from the orchard or the warm, fertile smell of growing things from the marsh. The children and dogs have learned the wisdom of walking around a skunk, and that is the way Mephitis would have it.

A Fateful—and Wrong—Decision

As a small boy I had my own hard lesson. Evening shadows were on the pasture when another youngster and I vaulted a stone fence into the middle of a family of skunks.

Time stood still. A meadow lark on a near fence post stopped singing. The cows we had come to bring in lifted their heads as if in anticipation. It was a moment of great decision, and we made the wrong one.

Instead of remaining motionless and per-



283

Blind but Far from Defenseless, a Baby Skunk Aims His Gas Gun at an Intruder

Two large glands under the tail, each with its own duct, provide the skunk with a double-barreled weapon. Firing its potent yellow fluid by muscular contraction, the adult animal possesses a deadly aim at 10 feet—farther if a "tail" wind blows favorably. When a flashbulb exploded, photographer Fox obtained this rare photograph of a two-week-old skunk, too young to spray but able to emit a sulphurous odor, showing resentment at being disturbed. Brothers and sisters, unaware of the episode, sleep blissfully.

↓ Hustling from the den, mother skunk retrieves a month-old baby that wandered out on a sight-seeing safari.





mitting the skunks to amble off, we turned to flee. We might have come off only faintly-scented had we turned in opposite directions. As it was, we turned in upon each other, smacked our heads together, and went down dazed. The six skunks, a mother and five half-grown youngsters, switched their sterns about, and then all 12 guns belched salvo after salvo of malodorous fluid over our inert forms.

It wasn't until years later that I learned that each of those six skunks mounted two weapons. I didn't know then how they could bring the nipplelike muzzles erect and focused outward, and by muscular contraction fire both guns at once or one at a time. Nor did I know how each mature skunk's gas gun was capable of from four to six successive discharges accurate

← Forward... March!

The skunk usually sleeps by day and traipses through woods and fields by night. At dusk these nine-week-old babies trail behind mother in search of insects and rodents. The rising sun will find the brood back in their burrow.

↓ Sunlight spells caution. A wary youngster emerges from his dark den.

284





285

"Not One Step Closer," Adolescents Seem to Warn

Nearing adulthood, these youngsters sport glossy fur and bushy tails. They wait at the den entrance for mother, who will lead them on another food foray. She will teach them to smell out turtle eggs buried in the sand, to snatch minnows from shallow pools, and to track down grasshoppers, beetles, and snakes.

✚ Growling and squawling, brothers wage a tug of war over a fat frog.

from 8 to 15 feet (depending on the wind) without hesitating between blasts for reloading.

But my friend and I were in no condition to study the skunk's anatomy close up. Half-blinded, terribly sick, suffocated right unto unconsciousness, we wanted but one thing—to get out of there!

Like cubs being dive-bombed by hornets, we went scrambling and bellowing and sobbing and retching for the creek. The water helped some, but eventually we discovered that time was to be our only real salvation.

Mortified, we crept home. Notice of our coming preceded us, and already a guard stood at the kitchen door, and an escort was waiting to guide us to the barn.

The horses stomped in their stalls as we passed. The bull rattled his chain and rolled his eyes. And while the calves in the next pen threw up their heels and looked wild-eyed, we were undressed and scrubbed with lye soap strong enough to blister the shell off a turtle,



Today we'd probably have gotten a tomato-juice rubdown or an ammonia rinse, both of which are considerably more effective, but still not completely purifying in cases of extreme saturation such as this.

Victims Banished from House

The lye soap helped some, and after our clothes had been buried and we'd been dressed in ragged overalls which could be similarly disposed of, we sat on chopping blocks downwind of the house and picked listlessly at plates of beans and pork chops. That evening we were bedded on the downwind porch with burlap for covering.

Perhaps this assault, which we considered unprovoked, as well as the fact that skunk pelts were bringing from \$2 for those with the wide white stripes to \$6 for the nearly all-black specimens, turned us into hunters of the skunk.

We located the den, consulted old-timers, and after the first cold snap had sent the skunks into their burrows until the weather moderated (they sleep lightly and roam on warm nights), we dug down to the master bedroom.

Cautiously we covered the bundle of half-sleeping skunks with loose earth. As each poked its nose up through the loam, we dis-

patched the animal with a .22-caliber rifle. There were eight, and they made us \$24 richer. Then there was the skunk fat to be rendered and kept as "cold medicine."

Today we'd be hard put to get \$5 for the eight skins. As for a cold remedy, we'd sooner tar and feather our chests.

The eight happened to be evenly divided as to sex. In all the dens into which we subsequently pried, there was a near-even ratio of females to males, though some naturalists maintain the male skunk winters with a bevy of females. Those we have found have always seemed to us to be family groups. In the event of an open winter, however, such groups may well be dispersed, for Father Mephitis, something of a Don Juan, usually takes his family obligations lightly.

"Child of the Devil"

The skunk's scientific name, incidentally, refers to its noisome weapon of defense. The Latin *mephitis* means "a noxious or pestilential exhalation from the ground." An old French-Canadian epithet for skunk is *enfant du diable*, or "child of the devil."

In the name Chicago, given first to the river and later to the city, there is recognition of the skunk's ability to assault the sense of smell. The word supposedly derives from the

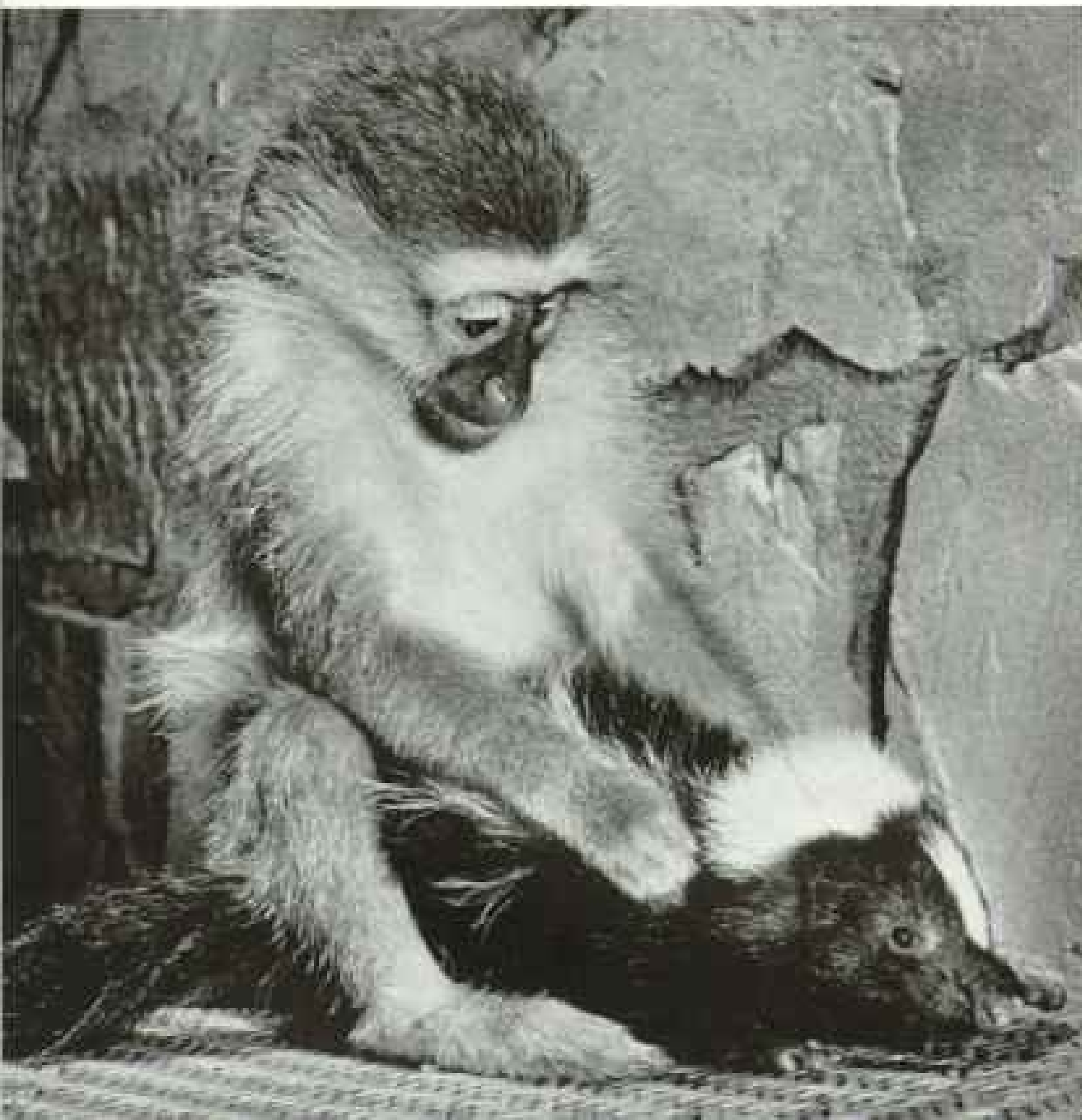
Algonquian *Se-kaw-kwaw*, meaning "place where the skunk cabbage grows." (The malodorous skunk cabbage was once believed—erroneously—to be a favorite food of skunks.)

Fundamentally, the striped skunk and its subspecies lead somewhat similar family lives whether they be natives of Ontario or Mexico, New Hampshire or Oregon.

"Hold Still, Jimmy"

National Geographic artist Walter Weber experienced anxious moments when his new pet, a green monkey from Africa, first met this tame skunk. His worries proved groundless. Bouba, the monkey, treated the skunk like a doll; he cuddled it, carried it about, and gave it a daily grooming.

National Geographic Photographers
Robert F. Sisson and Donald McLean





\$19.95 Buys a Baby Skunk—Guaranteed Safe—at This Washington, D. C., Pet Shop

A simple operation, performed by a veterinarian, removes scent sacs. The young skunk is inexpensive to feed, housebreaks rather easily, and keeps itself clean. It makes an excellent mouser.

Mephitis usually has from four to six youngsters. About nine weeks after the husband comes visiting, the babies arrive nearly naked, blind, and helpless. Birth usually occurs during the latter half of April or the first two weeks in May, and in rare instances the single litter may number as high as ten. Though there is but a hint of fuzz on the newborn, less than on a peach, the white stripes are clearly discernible as if tattooed into black skin.

The mother skunk is devoted. A youngster that leaves the den prematurely is promptly seized by the scruff and hauled back home (page 283).

The youngsters shown on page 282 were born May 10. They chirped constantly, like a nest full of ever-hungry baby sparrows. Within a week the fuzz on their bodies became

clearly evident. Mother skunk renovated the den about this time, redecorating with more leaves and fresh, dry grass.

A week later each baby had grown a silken coat of very short hair. It was at this time that the youngsters were startled by the explosion of a flashbulb, and Fox acquired an unusual photograph of a blind baby unerringly aiming its double-barreled gas gun at the source of irritation (page 283).

On only one other occasion during the months Fox worked with skunks did any of them so much as threaten by stamping their forefeet, a warning as unmistakable as the rattler's *whirrrr*. That was the day young Peter Fox mistook a female skunk for Jimmy, his pet (page 288). The boy was divested of his clothing on the spot, and a sadder and



**"Hold a Skunk by the Nape of the Neck":
Jimmy Serves as a Docile Model**

Peter and Barbara Fox, more fortunate than city youngsters, learn about wildlife at their country home near Oconomowoc, Wisconsin. Here their father, who made these pictures, teaches them to lift the pet without hurting him. Jimmy's loose skin helps protect against enemies. If clutched by a foe, he can twist about and bite his tormentor.

◀ Finding this female on the lawn one day, Peter mistook her for Jimmy. When he began to romp with her, she became angry, stamping her displeasure with stiffened forepaws. Too late Peter discovered his error. Irritated beyond endurance, the female triggered her atomizer and sprayed the boy from head to foot.

➔ Page 289, above: Stripped of his foul-smelling garments, a chagrined Peter trudges homeward. Barbara, holding her nose, carries the clothes on a pole.

Below: Funeral for shirt and pants: Father shovels a grave. Peter, sadder but wiser, awaits the burial.







Bluffing a Bobcat, a Spotted Skunk Upends Himself

When hunger grips the wilderness, some predators may risk an evil dousing for a full stomach. If danger threatens, the spotted skunk may throw body and hind feet into the air and bristle its tail. The animal can hold the pose for five seconds. Like its larger striped cousin, however, it usually sprays with all four feet on the ground.

wiser Peter went naked to the bathroom for a scrubbing.

While the striped skunk stamps its feet in warning, a smaller spotted relative has a unique habit of standing on its forefeet, like a youngster showing off (above). Naturalists say that though this may be a warning, the spotted skunk (*Spilogale*) has been observed playing in this fashion.

The hog-nosed skunk (*Conepatus*), more commonly found in Mexico and parts of South America, is the most un-skunklike of the tribe. About as large as the common striped variety, it has a long, almost naked muzzle, like the snout of a hog. It uses this snout to root in the ground for insects.

Skunks often live in peace with human neighbors. Our friends, the Earl Marsh family,

spent three months last summer at L'Anse, Michigan, sharing their house with some skunks that had taken up residence beneath the kitchen floor. Though the Marshes often met Mrs. Skunk and her offspring on the back porch or in the near-by woods, no indiscretions were committed by either humans or skunks. It was a very harmonious design for living.

Last fall, with the moon low and the frost on the rushes, I came to launch my duck skiff on the waters of Sinissippi Lake, only to find a mother skunk and four full-grown youngsters parading around and around my boat like soldiers on a drill field.

It was a game of follow-the-leader, with each skunk shuffling in exactly the same manner as the one ahead. As I watched I was reminded of an Indian ceremonial in which the braves circle the fire in a precise pattern.

But a northern flight of lesser scaups was in. Their wings were on the wind. My dogs were restless in their crates in the back of

the station wagon. So, when the marching skunks gave no indication of moving off, I decided to take steps.

Moving a hundred feet downwind, I squeaked as convincingly as I could in imitation of a mouse. The old girl stopped in her tracks. I squeaked again, and then she came galloping with that peculiar rolling gait which identifies the skunk, and all her young trailed after.

Young Appetites Keep Mother Busy

Mr. Fox's photographic models began moving about the den at the age of three weeks, and by the time they were four weeks old they started exploratory trips to the spot of sunshine at the mouth of the burrow. About the fifth week the young began requiring meat, and it was then Mrs. Skunk was hard



San Francisco Traffic Gives Wide Berth to a "Headless" Skunk Roaming the Streets

His head caught inside a tin can, this unhappy creature wandered in circles until an SPCA agent removed the headgear. Much to the agent's relief, the animal proved to be a de-scented pot.



put to keep their stomachs comfortably filled.

At this time in the life cycle the mother skunk's constant search for food takes her abroad during daylight, though she prefers to hunt only at night. Snakes, grasshoppers, crayfish, beetles—an endless variety is presented the youngsters.

At six weeks the young began making short forays with their mother and spent some hours each day frolicking like kittens at the den entrance. Soon their education began.

They learned how to smell where the foolish turtle left such a strong scent while laying her eggs and how to dig them out with stubby, powerful front paws. Side trips were made to the marsh for frogs, and an argument was likely to ensue as to who was entitled to what (page 285).

They left their naked paw prints where minnows had been trapped by receding waters, and they learned which stumps were rotten enough to house beetles and insect larvae.

They discovered how to lurk among the rushes in which the blackbird had built its nest, and perhaps there is the reason you heard a bird cry out that night last summer.

From kindergarten in late spring to college in the autumn, the mother skunk teaches the youngsters everything she knows. Then when the first snow falls, and beetles become scarce and frogs have hibernated, the family may raid a henhouse or perhaps even move in beneath the floor of the roost. But count every chicken or chicken egg as a bonus well deserved for the constant pressure the skunk keeps on rat, mouse, and insect populations.

As the temperature dips in northern States, the skunks make fewer forays, and at last, as winter closes in, they go below and sleep. But comes a southern breeze and its warmth edges down the den below the frost line; then the skunk ventures forth to tramp old trails

and perhaps eat a snack before going back to sleep for another month.

My personal experience with skunks during these brief winter expeditions would indicate that the animal is neither so alert nor so indignant at being accosted then as during warmer months.

Teeth, Too, Used as Weapon

My young Labrador retriever Ace scooped up a beautiful black skunk during one January thaw and insisted on bringing it to me. Instead of spraying the dog, the skunk rolled in its loose skin and fastened its teeth into Ace's soft upper lip. Nothing the dog had ever retrieved before had bitten him, so he dropped the skunk and retreated—for which I was immeasurably grateful.

My Irish setter Patsy, wise in the ways of skunks, barged within two feet of one before either was aware of the other's presence. She froze on point, and the skunk did likewise.

They stood motionless for several minutes. Then, as if by agreement, each inched backward ever so cautiously, and when five feet separated them they turned and went about their business of hunting as if nothing had happened.

Skunks brought into close proximity to man at an early age rarely exhibit belligerence later, except occasionally to strangers. George Speidel, director of Milwaukee's zoo, usually keeps all resident skunks deodorized, however, since one of a litter of seven broke faith and, of all times, during its first appearance on television. Speidel was handing the skunk to announcer Gordon Thomas when the youngster leveled off and let go.

The deodorizing operation is a simple one which any veterinarian can perform, preferably while the animal is very young. If handled regularly thereafter, the skunks become as docile and amiable as kittens.

Tame skunks can be kept indoors, since they are reasonably easy to housebreak. However, they would much prefer quarters out of doors. Commercial dog and cat foods, cereal, bread, meat—practically any edible thing is food for Mephitis.



Squat Skunk Sports an Outsize Fur Coat

Coats and muffs made from glossy skunk pelts once sold under such trade aliases as Alaska sable or black marten. With pointed muzzle, beady black eyes, and small ears, the skunk resembles its weasel and mink relatives. Long claws equip it for digging.



One Chilling Look, and Hungry Bantams Retreat

Deodorized pet skunks have been used in all sorts of publicity and advertising schemes. They have posed with movie stars and with prize cats being photographed next to a can of cat food.

Skunks occasionally are taken for strolls on New York's Fifth Avenue. Harnesses have to be used, since the skunk, being a member of the weasel family, can slip right out of a collar.

Unfortunately, owners of some deodorized skunks have allowed the animals to wander off, to become wild again. Bereft of their spray guns, they are as helpless against attack as soldiers sent unarmed into battle.

Fur Out of Fashion

Today the ladies rarely wear skunk fur, just as they seldom choose the gorgeous sunburnt gold of the red fox.

Until the Federal Government enacted laws requiring the specific labeling of fur products retailing at \$5 or more, skunk occasionally came to market under fancier names. Early in 1955 *Mephitis* assumed a new role—raccoon. The Davy

Though often denounced for destroying birds, the skunk aids man by eating vast hordes of cutworms, potato beetles, white grubs, and other crop ravagers. "Count every chicken or chicken egg as a bonus well deserved," suggests the author. Jimmy, the Fox family pet, thrives on a varied diet of bread, raw meat, potatoes, milk, and canned pet food. As these Bantams edge closer to his dinner bowl, mild-mannered Jimmy neither snarls nor growls; his pose and expression make it clear he does not wish to be pestered while dining.

↓ The skunk takes a bleak view of cold weather. Frosty temperatures make him drowsy. Head cradled in paws, this young animal snuggles in a bed of shavings.

National Geographic Photographer John E. Fletcher





Baby Doll Rides the Buggy, Barbara Provides the Push, and Jimmy Guards the Rear

A pet skunk can be trained to wear a harness and be walked on a leash. Some travel about the world: Willie, mascot of an Arctic weather station, got to within 1,500 miles of the North Pole. A New York fancier takes his de-scented pet on the subway; he always gets a seat. Young Barbara Fox finds Jimmy an eager walking companion, although sometimes he prefers to ride in the carriage.

Crockett craze, which set the Nation's small fry to fighting imaginary Indians, was responsible. Quickly exhausting the supply of coon-skin scraps to make the low-priced frontier caps, manufacturers began dyeing and using other furs, including skunk.

Even when the skunk's fur brought good prices, and even when in some areas a bounty was paid for its scalp, since some thought the animal was spreading disease, these inducements rarely made serious inroads on the over-all skunk population in the United States. But many fall victim to speeding cars.

Farmers, particularly those with duck and

fish ponds, have special reason to respect the little black-and-white animals. Eggs of snapping turtles, those relentless enemies of pond life, are a choice item in skunk diet.

Resourceful as the white-tailed deer, unabashed as the porcupine, prolific enough and glad to live beneath the doorstep of civilization where insects, its principal fare, abound, *Mephitis* has a better chance than many other animals for survival.

That's just fine with me. Because every time I see a skunk or get a whiff of its feral stench, I'm reminded to mind my own business—a sure way to keep out of trouble.

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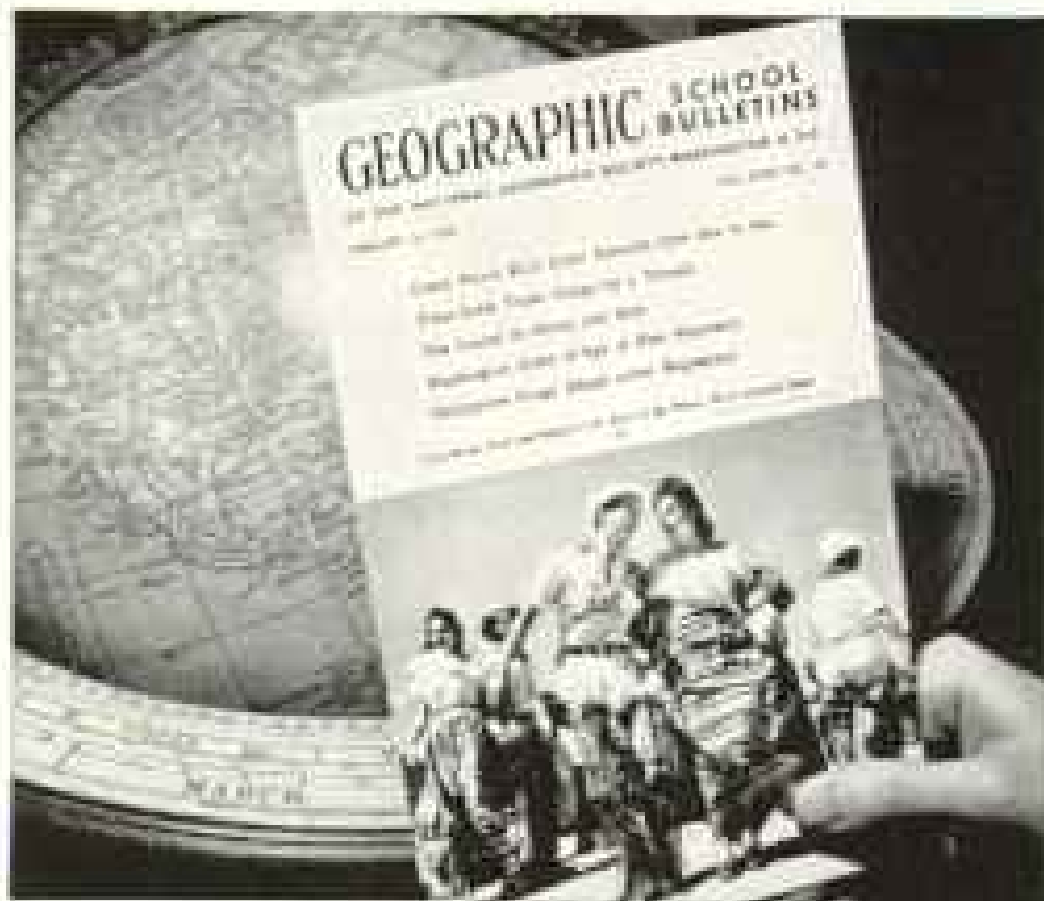
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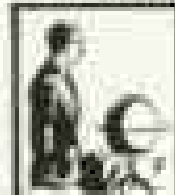
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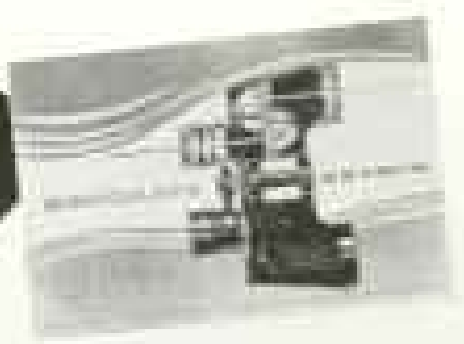
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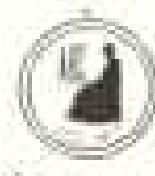
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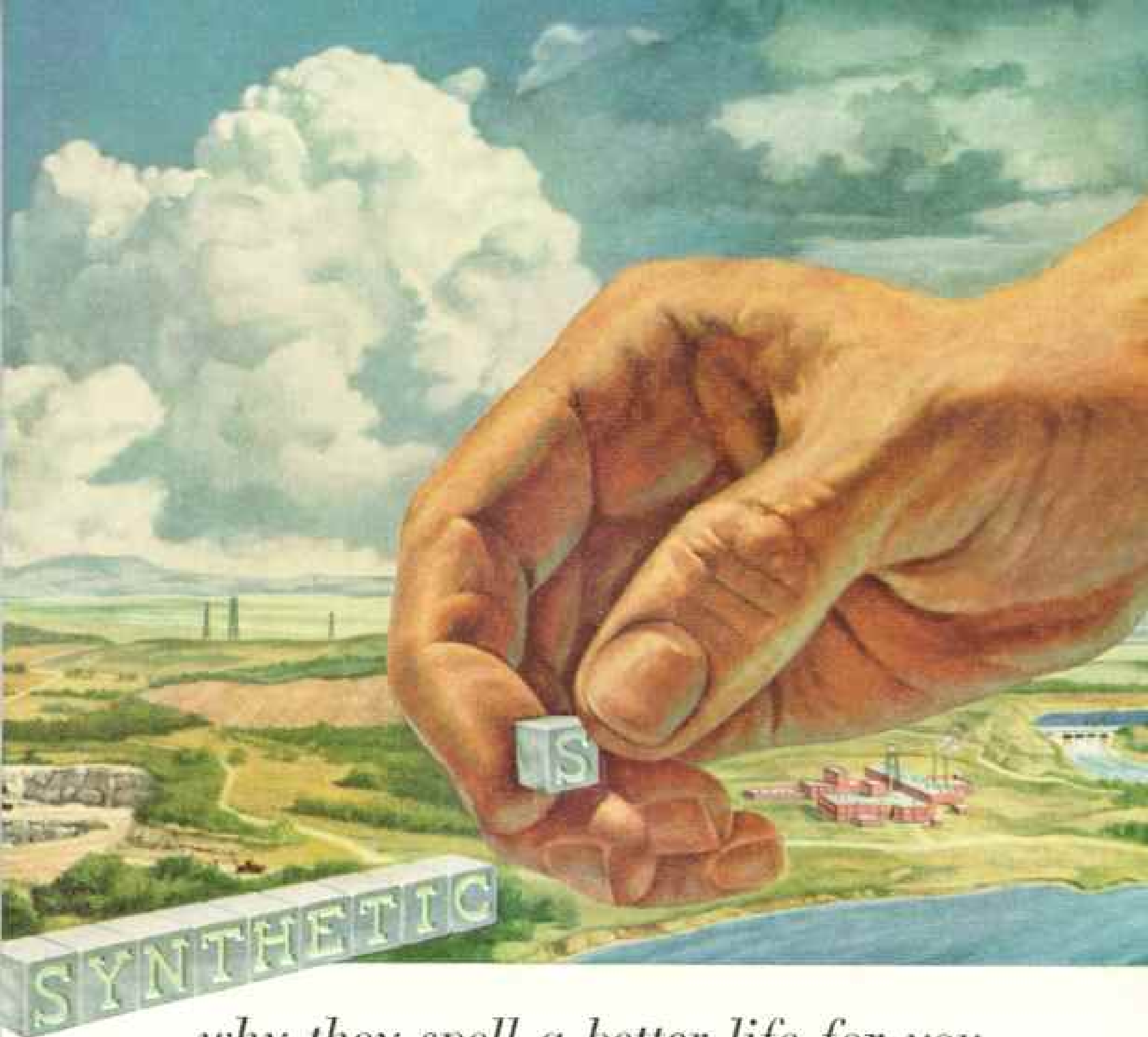
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