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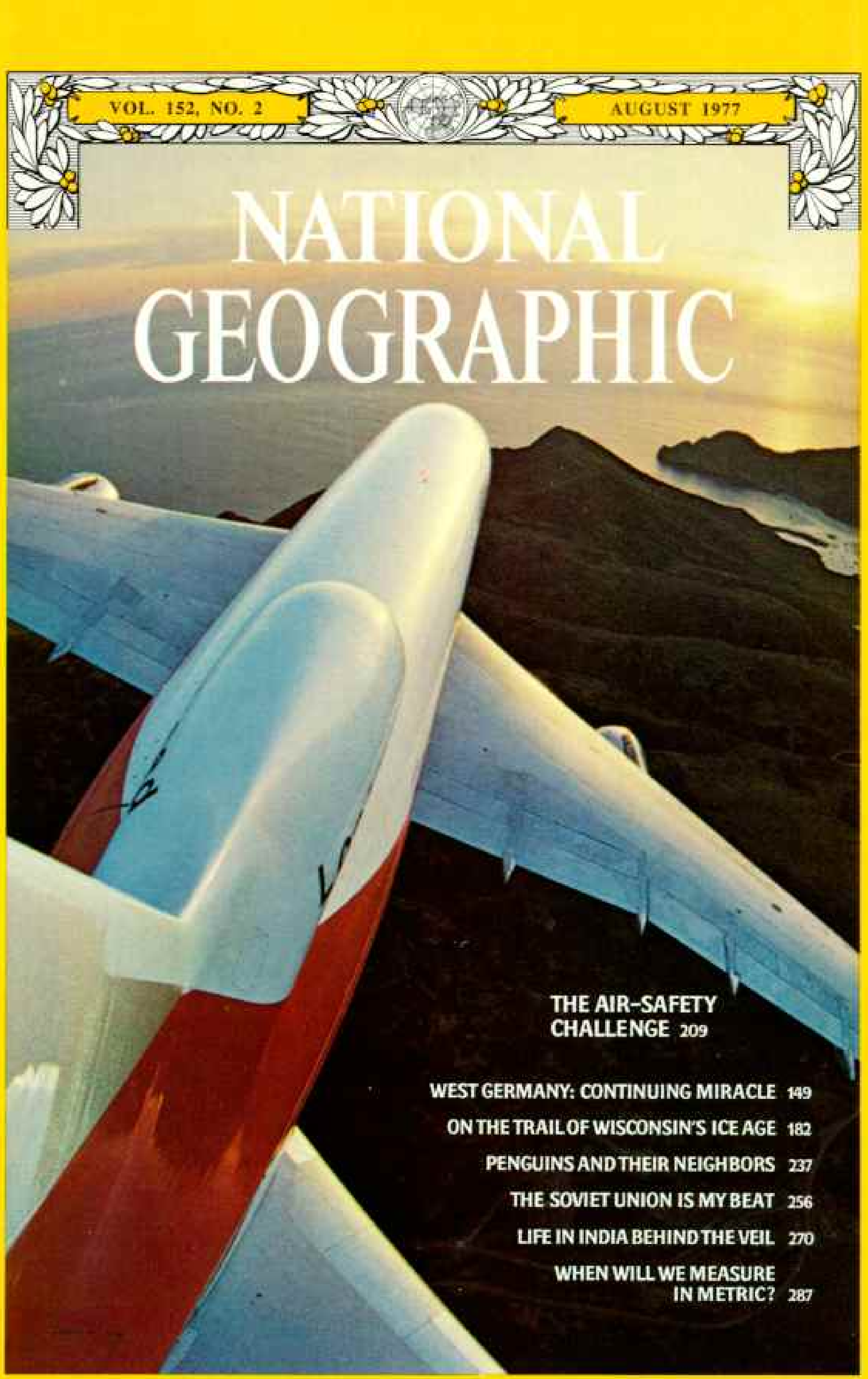

OFFICIAL JOURNAL OF THE NATIONAL GEOGRAPHIC SOCIETY WASHINGTON, D. C.

ALMOST since the time of Columbus, a mystery has cast its shadow across the New World. How and when did the first Americans arrive in this hemisphere? Modern anthropology has answered the "how": The forebears of the American Indians migrated from Asia. No one can know what pressures drove these nomadic hunters from their ancestral lands. But evidence strongly indicates that they entered North America by way of Alaska.

Your Society has now joined with the National Park Service in an attempt to cast more light on the "when." In 1976 Dr. W. Roger Powers and Dr. R. Dale Guthrie of the University of Alaska, digging at Dry Creek in the mountains of central Alaska, uncovered the remains of ancient human occupation. The area surrounding their dig holds rich archeological promise. Lush grasslands are as hospitable to game and man today as they were in the deep past. The Society and the Park Service are supporting a three-year, $600,000 project aimed at finding the earliest traces of man at this gateway to the New World.

Bering Strait, scarcely 50 miles of open water, now separates Asia and North America. But, as recently as 18,000 years ago, when Ice Age glaciers imprisoned much of our planet's water, sea level stood some 300 feet lower. Siberia and Alaska were linked by a corridor of open land perhaps 1,000 miles wide.

For decades archeology seemed to show that the first Americans arrived some 12,000 years ago and proceeded, through several millennia, to drift southward with the game and the seasons. But recent years have brought provocative discoveries. Carbon-dating of bone implements found in the Canadian Yukon suggests man hunted there more than 25,000 years ago; an obsidian blade from a Mexican site may be 23,000 years old. Excavations in Siberia have disclosed evidence of migration toward America between 20,000 and 30,000 years ago.

In the past, collaboration between the Society and the Park Service has unearthed Wetherill Mesa's prehistoric culture in Colorado. Now, continuing the quest, we hope to penetrate even further into the murky frontiers of man's past in the Americas.

Gilbert M. Grosvenor

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COVER: *A Lockheed TriStar wings over the California coast on an air-safety test flight (pages 206-208). Photograph by Bruce Dale.*


COMMERZBANK

The Federal Republic of Germany has emerged as Western Europe's strongest, most prosperous nation. How did it happen? And what does the future hold?

West Germany: Continuing Miracle

By JOHN J. PUTMAN

Photographs by
ROBERT W. MADDEN
BOTH NATIONAL GEOGRAPHIC STAFF

A generation removed from the ashes of war, Frankfurt am Main today stands tall as West Germany's hub of finance. German emperors once held coronation banquets in the medieval city hall. Beyond its gabled rooftops, new bank towers attest proliferating wealth.

IT IS NOW TEN YEARS since Konrad Adenauer, first Chancellor of the Federal Republic of Germany, died at 91. On a summer day, when the sunlight streams into the house in the village of Rhöndorf where he lived for years, it is difficult to find shadows of the evil he remembered. It is a pleasant but unpretentious house, with paintings, records, and books. The windows look out on the Rhine and beyond to the Eifel hills.

Only a bronze candlestick recalls that evil. Adenauer had taken it himself from the basement of Gestapo headquarters in Cologne after the war. He kept it on his shaving stand, as a reminder, while he helped shape the future of West Germany.

"He was thinking very much about why so much evil could have been possible under the National Socialists. If such evil could have any meaning . . . any good result, it would be to make the German people immune from any sort of totalitarianism again."

A RECOLLECTION OF KONRAD ADENAUER BY HIS PERSONAL SECRETARY, DR. ANNELIESE POPPINGA

It remains a useful reminder, in light of what has happened to postwar Germany. Three decades after the end of the evil, an uneasy posture of penance has been altered, transformed now into something more comfortable and familiar to the German character: pride.

The pride is readily understandable.

Only seven years after surrender, German factories rebuilt with U. S. Marshall Plan aid were churning out a trade surplus; by the end of the sixties the surplus had grown twentyfold. The now-famous *Wirtschaftswunder*—the "economic miracle"—propelled the Federal Republic into the role of Western Europe's most powerful economic force.

Even the recent global inflation and recession, which checked West Germany's growth for a time and left it with a million unemployed, did not alter that dominant position. Europe had become, according to the respected British journal *The Economist*, a "two-tier community," with the Federal Republic "all alone on the top tier."

How did the West Germans manage to avoid the plagues—spiraling inflation, labor strife, a weakening currency—that have afflicted other nations? And can Germany remain Western Europe's most substantial monetary and military bulwark?

Complex questions, important questions. I have journeyed across the Federal Republic from Bonn to Berlin, from Munich to Hamburg, seeking the answers (map, page 155). In the process I found many of the roots of the West German phenomenon, including a remarkable political stability; a cooperative labor movement; a social calm; the industrious German nature itself. But the story starts with money, and for an examination of money, you go to Frankfurt am Main.

The shiny, soaring towers of Frankfurt house the giants of German finance, among them the Big Three commercial banks: Deutsche, Dresdner, Commerzbank. They bankroll much of German industry (even own shares of it) and most of export and import business. Their directors sit on the boards of scores of companies and so help shape the Federal Republic's industrial course.

One of those directors told me a little about his city, symbol of the new financial *Reich*. He gestured toward a window: "Look at it, a sort of Houston or Osaka. A new city. Rebuilt after war's destruction. No center. Little sense of beauty. Just people trying to outperform each other. A cruel kind of competition.

"Still, I wouldn't want to live anywhere else. Here you sense a vitality, an easiness to do things—because you do not have the burden of your past. The old history has been abolished; tradition has been swept away."

Many Frankfurters seek something of the old Germany in the nearby Taunus, walking the forested mountain trails on weekends. But a distinct, non-German flavor permeates

Captains of the Big Three strongly influence the financial course of a nation that, almost alone in the industrialized world, has managed to minimize inflation and keep its currency strong. From left, Robert Dhom, Commerzbank; Jürgen Ponto, Dresdner Bank; Wilfried Guth and Wilhelm Christians, Deutsche Bank. German banks are expanding overseas for a bigger slice of the international money market.

the city: the green fatigues of the U. S. military colony; the babel in the bar of the plush Frankfurter Hof, where foreign businessmen close many deals. I found it most evident in Turkish, Greek, and Italian groceries near the *Hauptbahnhof*—the main railway station.

Those noisy, aromatic emporiums cater to the thousands of *Gastarbeiter*—"guest workers"—who throng the city streets. They and their families now represent 18 percent of the population of Frankfurt and Offenbach, a ratio approached in Munich and Stuttgart.

Germany's two million foreign workers occupy a vital rung on the nation's labor ladder: the bottom one. They wash the dishes, man tedious assembly lines, collect the garbage, push the construction wheelbarrows that most German workers tend to spurn.

I turned from the teeming downtown area of the financial capital of West Germany and

drove toward the outskirts for a look at some money. At first glimpse I felt disappointed.

The underground vault beneath the Deutsche Bundesbank, the central bank of the Federal Republic, holds only 6,178 bars of gold. They looked dull and dusty, and their value totaled only 292.6 million deutsche marks—about 125 million dollars. Most of the Bundesbank's gold, I learned, is held in the Federal Reserve Bank of New York and in

An inferno of molten steel silhouettes workers filling ingot molds at the Thyssen steel complex in Duisburg. German producers, under stiff competition for the world market, have weathered recent slumps in foreign orders for crude steel by branching out into the manufacture of industrial machinery for the oil-rich Middle East and the third world.

the Bank of England. Most of the Federal Republic's foreign currency reserves (about 25 billion dollars, the largest reported in the world) are invested in securities and deposits, mainly in the United States.

The Bundesbank stands amid spacious, well-planted, discreetly fenced lawns. I was reminded of an American university campus —but for the armed guards, the Mercedes-Benz sedans with radiotelephone aerials, the armored trucks laden with cargoes of currency.

Charged by law with maintaining the stability of that currency, the Bundesbank has independent powers to do so. It exercised that power firmly and dramatically in early 1973, to pull West Germany abruptly out of the speeding "world inflation convoy." The maneuver sent shock waves through banking corridors around the globe.

Quiet as a whisper and nonpolluting, the experimental Transrapid train—here on its test track near Munich—may represent the future of high-speed, intercity public transit. Developed jointly by aerospace and locomotive firms, the government-financed, electric-powered vehicle floats about half an inch above twin rails on an air gap created by magnetic force. Planners envision a European network, with an early link between Munich and Hamburg.

ON THE 12TH FLOOR of the bank building, I talked with Dr. Otmar Emminger, then vice president and now president of the institution. A trim, dapper man and a financial wizard, he summarized that fateful fiscal drama for me.

The United States, he said, had allowed its balance of payments to get out of order, buying enormous amounts of European goods, while Europeans were buying much less from the United States. By the early 1970's Europe had been flooded with dollars.

"Those dollars were overvalued," said Dr. Emminger, "and our marks were undervalued. But by the Bretton Woods agreement we had to buy—at a fixed rate—any amount of foreign exchange that came in."

Money managers sold dollars for marks as fast as they could. To supply them, the Bundesbank had to create more marks, thus feeding West German inflation. By late February of 1973 Bundesbank officials felt the situation had grown intolerable.

"On March 1, when we had to accept and convert 2.7 billion dollars in one day, we called it quits. We closed down the foreign-exchange markets. That day had seen the largest single purchase of foreign money by any central bank in history, a movement that is not likely to be repeated. This was the real breakdown of the old system that we had followed since the end of World War II."

When the markets reopened, the fixed exchange rates were gone, and the world was on a "floating system" that allows currencies to find their own values on the open markets.

The Bundesbank had slammed the brakes on West German inflation. But not without cost. Interest rates soared; money grew tight; the German real estate boom burst. There were thousands of bankruptcies.

"It was painful, very harsh," Dr. Emminger said. But West Germans accepted the "correction." Burned *(Continued on page 158)*

West Germany

When the Federal Republic of Germany came into being in 1949, under the watchful eyes of the Western occupying forces, its cities still lay in ruins from the massive bombing raids of World War II. Hard work, U. S. Marshall Plan aid, and favorable world economic conditions led to an astonishingly rapid recovery. Even 12 million refugees from the East, at first a burden, became an asset: They swelled the ranks of workers, entrepreneurs, consumers. This human tidal wave also helped break down regional and class barriers. The republic has come of age as one of Europe's healthiest democracies.

AREA: 95,976 sq mi. **POP.:** 61,967,000. **LANGUAGE:** German. **RELIGION:** Protestant, Roman Catholic. **ECONOMY:** Manufacturing, trade, finance. **MAJOR CITIES:** West Berlin (pop. 2,062,000); Hamburg (pop. 1,700,000); Munich (pop. 1,300,000); Bonn (pop. 284,000), capital.

DRAWN BY LEO B. ZEBARTH
COMPILED BY GUS PLATIS
NATIONAL GEOGRAPHIC ART DIVISION

Feast for the pocketbook but often a famine for the eye, the Ruhr district holds one of Europe's most awesome concentrations of heavy industry. Though making headway in pollution control, factories such as Thyssen's coke plant at Duisburg (**right**) continue to spew out noxious gases. In the Ruhr, 11 cities with populations of 150,000 or more coalesce into one megalopolis of 4 million people. In an effort to improve the quality of life, fingers of parkland, called *grüne Lungen*—"green lungs"—have been planted.

South of the Ruhr at Leverkusen, the Bayer chemical works employ professional "sniffers" (**above**) to ferret out evil smells. The global firm also enjoys the fragrance of fortune, holding more than 100,000 patents, and selling some 6,000 products.


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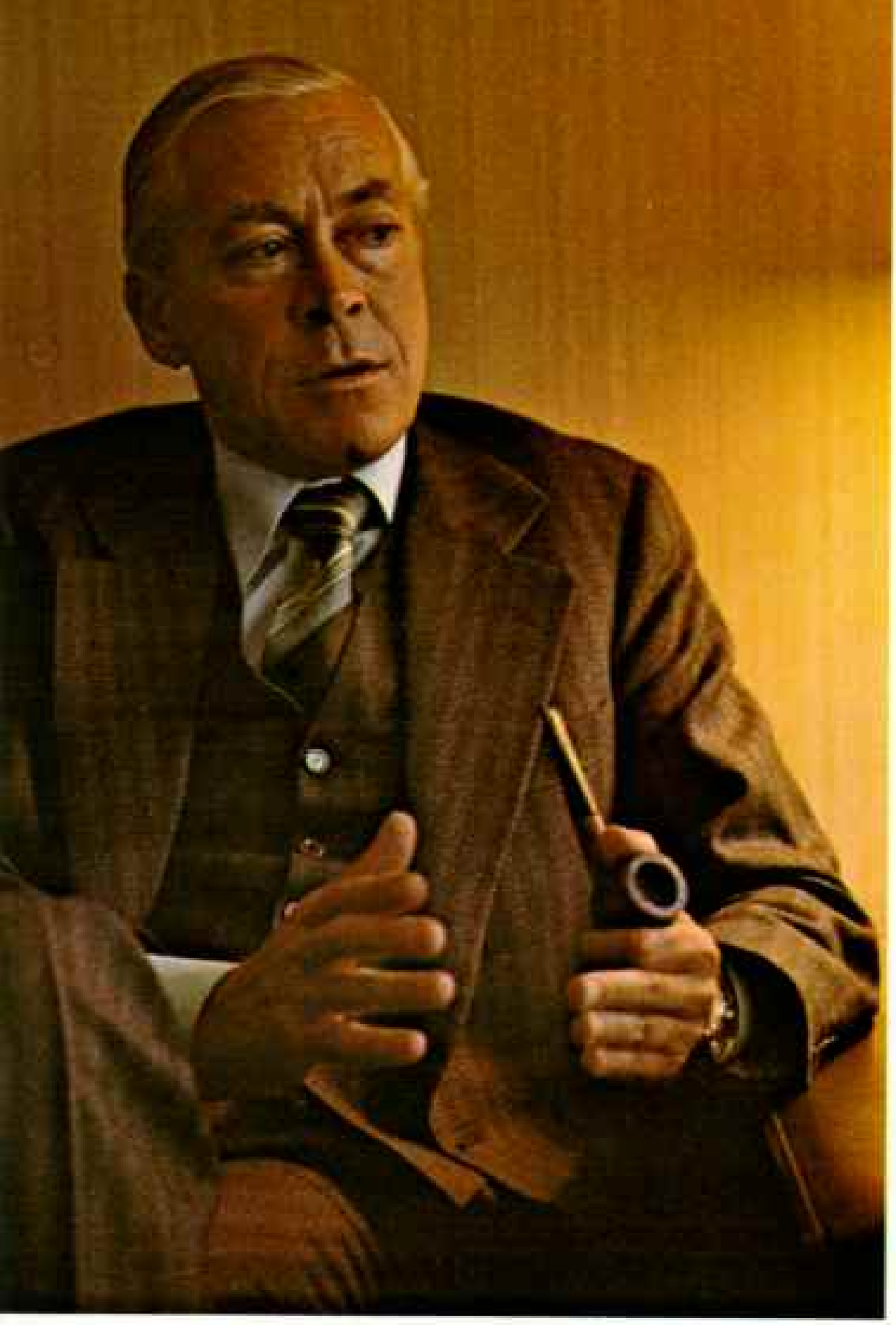


Caught off base by a worldwide recession, Volkswagen suffered its first losses in 1974-75. New chairman Toni Schmücker (**above**) explains how his "extreme action" of letting 23,100 workers go in 1975-76 helped put VW back on its feet.

into their national memory was the inflation of the 1920's, when money presses ran round the clock and the mark tumbled from 64 to the dollar to 4.2 *trillion* to the dollar. The price of a restaurant meal went up, literally, while customers ate. Family savings vanished. Later came a devastating depression.

From that cruel, unstable decade had grown all the things represented by the bronze candlestick on Adenauer's shaving stand.

I BOARDED the Van Beethoven express and rolled down the Main and Rhine Valleys. There were castles and vineyards, but I would remember more the industrial plants: Hoechst, Ford, Bayer, Mannesmann, and many others. My fellow passengers, businessmen mostly, hitched their coats on the hooks by each window, snapped open briefcases, and went to work. A melodic voice announced each stop in advance. Passengers scrambled for the doors. There's little time to waste on the Van Beethoven express.

I pondered the plants I had passed. They seem astonishingly immune to labor strife. In the first half of 1976, the total days lost by strikes per 1,000 workers was 70 in Britain and 177 in France, but the German rate was

Growing acceptance of new models—like these mid-priced Dashers being assembled in Wolfsburg—have since added 6,000 to the work force. VW now plans its first U.S. assembly line for production of its new bread-and-butter car, the Rabbit.

only 19. Little wonder buyers concerned with on-time delivery ordered West German.

How did such impressive restraint by organized labor come about? In Düsseldorf I left the train and sought the answer from leaders of the Federation of German Trade Unions. It owns the Bank für Gemeinwirtschaft, one of West Germany's banking giants, a symbol of the wealth the unions have amassed.

In one of the bank's offices I was greeted by Ludwig Rosenberg, a former president of the federation. A tall, elegant man, he had been born into a Jewish family in Berlin 74 years ago, joined the labor movement after World War I, fought in the political street wars of his native city, and fled Germany when the Nazis came to power in 1933.

He was among those who came back from exile or from Nazi prison camps to draw up a new labor-union system. He stretched out in an armchair and recalled those days.

"We threw out the Nazi labor laws and started over. We wanted first to rebuild Germany, to get back on our feet. This required a careful wage policy so there would be money available for capital investment to rebuild. We have a saying in Germany, 'You must not slaughter the cow if you want to milk it!' "

The elite meet at Baden-Baden for international horse racing, social event of the year at this famous resort. Built over the ruins of baths where Roman legionaries once soothed their wounds, the Black Forest spa has been a favorite haunt of Europe's gentry

since the early 19th century. Its posh casino now lures Germany's new generation of super-rich entrepreneurs.

And so the trade unions held back in those early years. But in good years they pushed. "In the mid-fifties we began to tell management: 'Look here, we're over the mountain, we want now to have real wages, fair wages.'"

The "milk-cow" approach paid off—in real, not inflated, wage gains. Today the average blue-collar worker enjoys an annual income of 27,000 marks—$10,800.

But when Mr. Rosenberg and his colleagues sat around a table in the late 1940's devising new labor codes, they had more than wages on their minds. During the Weimar Republic, trade unions had been fragmented along political and religious lines; they failed, along with the republic, and then came the Nazi era. After the war Rosenberg and his colleagues deliberately created a federation of only 16 unions, free of political or religious ties. (Britain, by contrast, has more than 450 unions.)

They asked for problem-solving devices, some of them tried during the Weimar Republic: works councils to solve problems at the factory level; special labor courts to handle problems that eluded the works councils. They agreed that no strike could be called without the approval of three-fourths of the workers involved.

And they determined on a policy of *Mitbestimmung*—"codetermination"—which would put workers' representatives on the supervisory boards of large corporations.

"It was," Mr. Rosenberg said, "a uniquely German solution. The goal was stability."

WORKERS' REPRESENTATIVES in the board room? The recent rescue of Volkswagen proves the benefits of this concept. I took the autobahn northeast, through the farmlands of Lower Saxony, to Wolfsburg. The Volkswagen plant, begun by Hitler to make his "people's car," dominates the city. The four stacks of its power plant rise above all else, totems to industrial might.

It was in early 1974 that Volkswagen plunged into the red. A year later its losses had grown to nearly a billion marks, a record for German industry.

There were more problems than the widespread recession: Volkswagen had relied too long on the Beetle while others moved into the small-car market with flashier models; the shift to floating exchange rates sent VW prices soaring and sales plummeting in the

U. S.; 12,200 workers had been added a year or so before the recession hit; and management and labor were not getting along well.

A new chairman was called in, pipe-puffing Toni Schmücker, noted for his ability to work with unions (page 158).

"A couple of months after I came, we actually had difficulty meeting the payrolls," he told me. "We were making cars not according to market demand but according to the number of workers we had. We were sinking."

Among his solutions: cutting the work force by 23,100, a fifth of the employees. "An extreme action, but our backs were against the wall. And everyone here knew it."

Mr. Schmücker presented his proposal to the supervisory board of the company. Two-thirds of the board represented the owners, private persons, and the state and federal governments; one-third represented the workers.

One board member recalled the meeting: "It was the first vote at VW that was not unanimous. The workers' representatives voted against the layoff. But the owners had the majority. Once the vote was taken, the unions cooperated fully. There was no strike, no violence. The people just went away."

They did not go away empty-handed: Each left with a "golden handshake," an average of 10,000 marks—$4,000. Schmücker and the workers' representatives had agreed on a plan. "We said that if people must leave, they should be paid to do so," a member of the works council explained. "Once this was settled on, we encouraged older men to retire early, working wives to leave, and foreign workers to go home with their savings and perhaps start a business. It went pretty well; it could have been worse."

The workers' representatives voted in favor of a second proposal—to build an assembly plant in the U. S. to make Volkswagens more competitive there. "It should have been done ten years earlier," Eugen Loderer, president of the Metalworkers Union and a VW supervisory board member, told me. To safeguard German jobs, the workers had won agreement that cars from the American plant would not be sold outside the U. S. or Canada, and that additions to the plant would have to be approved by the supervisory board.

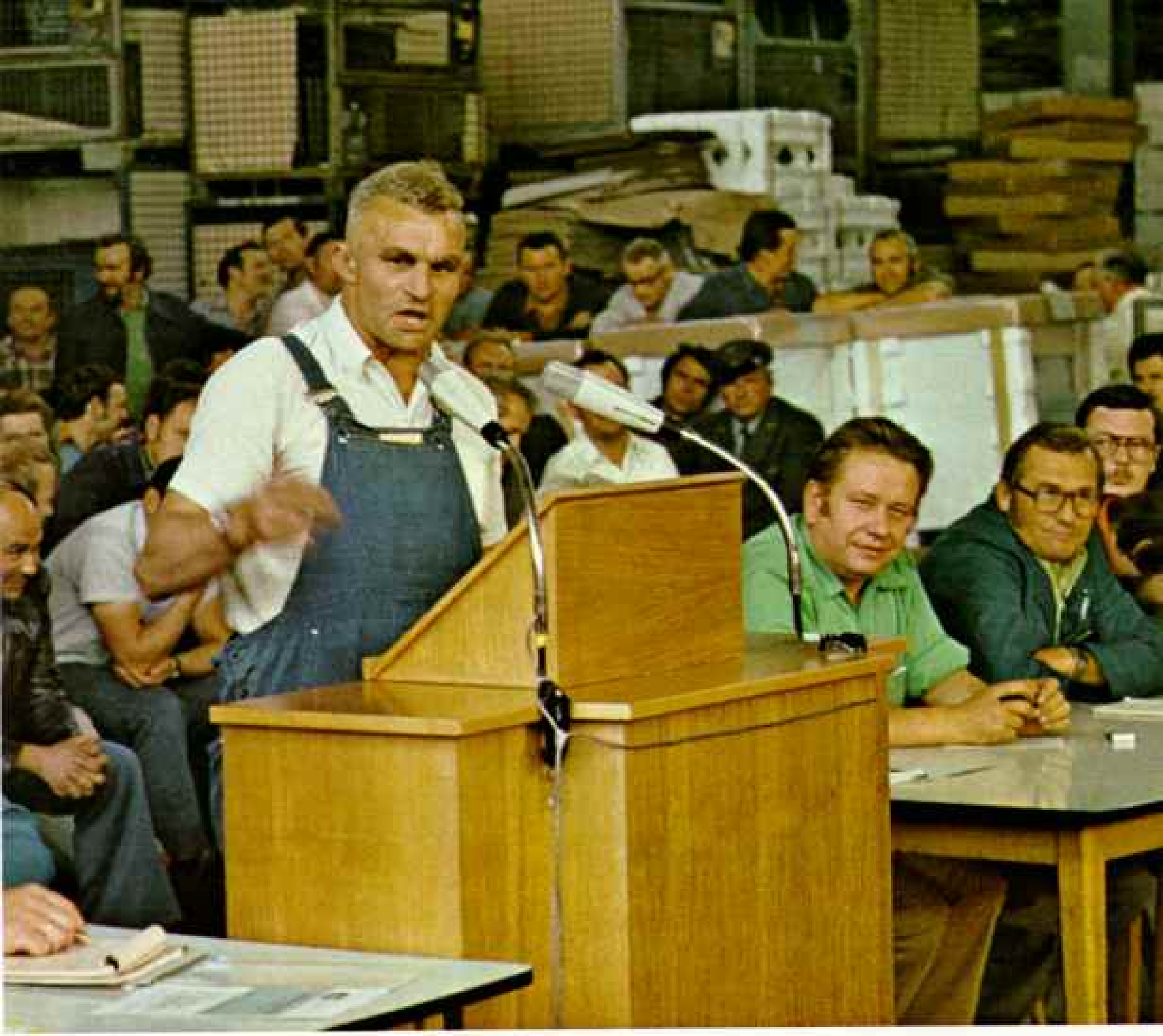
The episode illustrates the power of Mitbestimmung: To force a company to take the

interests of its workers into consideration before making a major decision, and to provide a mechanism for finding peaceful solutions.

When I left Wolfsburg, Volkswagen had just projected a profit of one billion marks, wiping out previous losses. The company—with its Rabbit—was back on the road.

I WAS BACK on the road, too, bound for Hamburg, the Federal Republic's greatest port (pages 164-5) and second largest city, after West Berlin. I was curious about the German workers' reluctance to strike. Hamburg dockworkers, handling nearly 50 million tons of cargo a year, last struck in 1951—for only a few days. I wanted to know why.

At the city-owned Hamburg Port and Warehouse Company I found six workers on their breakfast break at the company canteen.



Muscle and restraint, twin trademarks of German unionism, find exercise at AEG-Telefunken in Rothenburg ob der Tauber, as employees (**right**) hear fellow metalworker Leonhard Albig air his views (**above**); their union president, Eugen Loderer, left, listens attentively. West German unions wield political clout. Their latest victory: a law expanding the number of workers having a near-equal voice on company supervisory boards. Germans rarely strike, and often cooperate where Europe's other unions would confront.

Crossroads for a booming foreign trade, Hamburg handles nearly 50 million tons of cargo a year along 40 miles of modern docks. Situated 60 miles up the Elbe River from the North Sea, West Germany's second largest city (after West Berlin) services

ships bound to and from 1,100 ports of the world. Accordingly, Hamburg has more consuls than any other city except New York.

They were sipping beer and playing *Klaberjas*, a favorite card game.

They were pleased to talk about their strike policy: "We feel related to the company." ..."I have a family. Why strike? My insurance is due every month."..."West Germany has a million unemployed. If we struck, there might be more loss of jobs. We don't want that. We feel a kind of duty."..."If I get 10 to 12 percent more, then maybe the rent goes up too."

And so the workers don't strike, but they use pressure, which varies according to industry's economic health. One said: "When we were discussing the 1976 contract, there was a recession. So we settled for a small wage increase. But as the 1977 contract came up, you could see the upswing. The warehouses were full."

And so when the offer of the employers seemed low, many employees decided not to work any overtime. "Well, the company must have this overtime or break down. It was shocked—it stood on its head. It had to hire farm workers from Lower Saxony—people who didn't know how to drive a crane or a truck. This went on for about four weeks."

The result, after hard negotiations: A 6.7 percent salary increase. And instead of having to work every second Saturday, the men now have to work only every fourth. And if a man has worked ten years at the company and is 50 years old, his job is safe. "That's important to us—we are growing older."

WHAT KIND OF LIFE, I wondered, would a dockworker's pay buy? At a large apartment complex in Hamburg, Werner Kopp welcomed me into his comfortable, tasteful home. He works for a container terminal, and his wife, Ursula, is a computer programmer. They have a daughter, 6.

Werner's monthly take-home pay is 1,800 marks, $720. His chief expenses are the rent, 500 marks, and a day-care kindergarten for his daughter, 220 marks. The Kopps own a car and a color TV. Like many West Germans, they have quit the church to avoid a government-collected church tax.

Werner was in good spirits: That day he had driven from a train and into a container the 25,000th Mercedes automobile to be shipped to Japan. There had been a small celebration, a pretty model, photographs.

Werner had no complaints: "We live a little. We have friends in, and on weekends go for drives. My daughter keeps me on my feet. We're always feeding the ducks on the lake, or visiting our granny.

"Last year we took a two-week holiday in Bulgaria; before that we were in Mallorca. If you need more money, you can work extra hours, and there is a program to advance in this work."

What more did he want? "I went to school only nine years. I want my daughter to have it better; I want her to go to secondary school."

AND SO HAMBURG seems as content as anyplace else in the Federal Republic, and as free from the pall that hung over the Third Reich. Yet that bronze candlestick has a devilish way of cropping up.

A small sign at 29 Schäferkampsallee marks the Jewish community center. There are 1,400 Jews in Hamburg; there were 25,000 in 1933. Günter Singer, the community center's director, explained:

"When the Nazis came to power, about half the Jews emigrated; later the Nazis took away the remainder. Only a few families came back. Today we are a mixed group, mostly refugees from Eastern Europe."

Mr. Singer said the Jewish community had no discrimination problems, but recently another difficulty has come up. "Hamburg is very liberal toward criminals. A murderer sentenced to life can be released after 15 years if he is judged to be resocialized. Now the state has freed some Nazi criminals. They say what is fair for common criminals should be fair for these others.

"Two Nazis, we didn't mind. They were old, half dead. But now they've released one who is only 61, and was very cruel.

"He has a Jewish name, but is not Jewish. And he had the crazy spleen that whenever he met a Jew with that name—Rosenbaum—he shot him himself. He was convicted for the murder of 148 Jews, and now he is free and lives next door to a family of our community. And that family has children. We are protesting."

Mr. Singer thought about the past. "Maybe in the beginning we could have done more to save ourselves. But who thought in '33 and '34 that it would end the way it did?"

For Mr. Singer, the era ended in a concentration camp. "My God! How could we have survived? Minus 35° Celsius we worked without warm clothing. Wooden shoes, no socks. No shawl. Paper bags wrapped around our bodies. The walkways were icy and steep. In wooden clogs, it's very difficult to walk on ice.

"We had to sit and slide going downhill, and the S.S. with whips and sticks were at

Heady evidence that Germans are not all work and no play, some 1.4 billion liters (375 million gallons) of wine and more than 9 billion liters of beer are consumed each year. At the Breisach wine cooperative (**right**), a worker appears dwarfed among towering tanks gleaming with running water that carries off the heat of fermentation. This facility on the Rhine, supplied by 22,800 vintners, corks half a million bottles a day.

Renowned for mug-carrying ability, beer maids like this one in Munich (**left**) serve up the national drink. Beer halls and gardens continue to thrive here despite the rising popularity of discotheques.

our sides. Even today, whenever there is ice on the sidewalks, it comes into my mind.

"My wife will say, 'Look how you walk! Why are you so attentive? Now go on and walk.' But I cannot. I am still frightened of falling down."

Mr. Singer is short, rotund, well tailored, vigorous of manner. On the street you would probably take him for another prosperous Hamburg trader on his way to lunch at the posh Overseas Club. Except on those days when there is ice.

THE TRADERS AND SHIPPERS dispatch West Germany's goods from Hamburg to the world. Some of the nation's products are truly prestigious, the envy of foreign manufacturers: those sleek Mercedes sedans, for example, that my friend Werner Kopp drives to shipside.

At the Daimler-Benz plant near Stuttgart I found the company coolly working off an order book that stretched two years ahead for delivery on its most popular Mercedes models. Each working day some 500 proud purchasers from Germany and abroad arrive at the factory to pick up their cars personally.

But the world doesn't beat a path to the doors of most companies; they must sell. The Germans are good at it. It is vital. One-fourth of West Germany's gross national product comes from exports. And the world, and its markets, change.

Among companies that have adapted to change is Siemens, the 130-year-old electrical giant now headquartered in Munich. The old Bavarian capital remains for me the loveliest of German cities. Its great avenues, baroque palaces, smart shops, artists' colonies, and beer halls bespeak a traditional love of life.*

*See "Bavaria: Mod, Medieval—and Bewitching," by Gary Jennings, NATIONAL GEOGRAPHIC, March 1974.

Skimming cold waters, a wind surfer on Kiel Bay keeps warm in a wet suit (**above**). On the island of Sylt, refugees from the city catch the weak sun in sandpits and other shields against chilly North Sea breezes (**right**). Determined travelers, Germans now throng balmier Mediterranean shores on paid vacations averaging five weeks.

When Siemens came south from Berlin after World War II, its officials joked that it introduced a Prussian spirit into the city. The marriage is symbolized by the office of Siemens's chief executive, Dr. Bernhard Plettner. It is Spartan spare, but in an old Bavarian palace close by the opera house.

Back in the fifties, Plettner, an engineer by training, foresaw the day when the company would want to step up overseas sales.

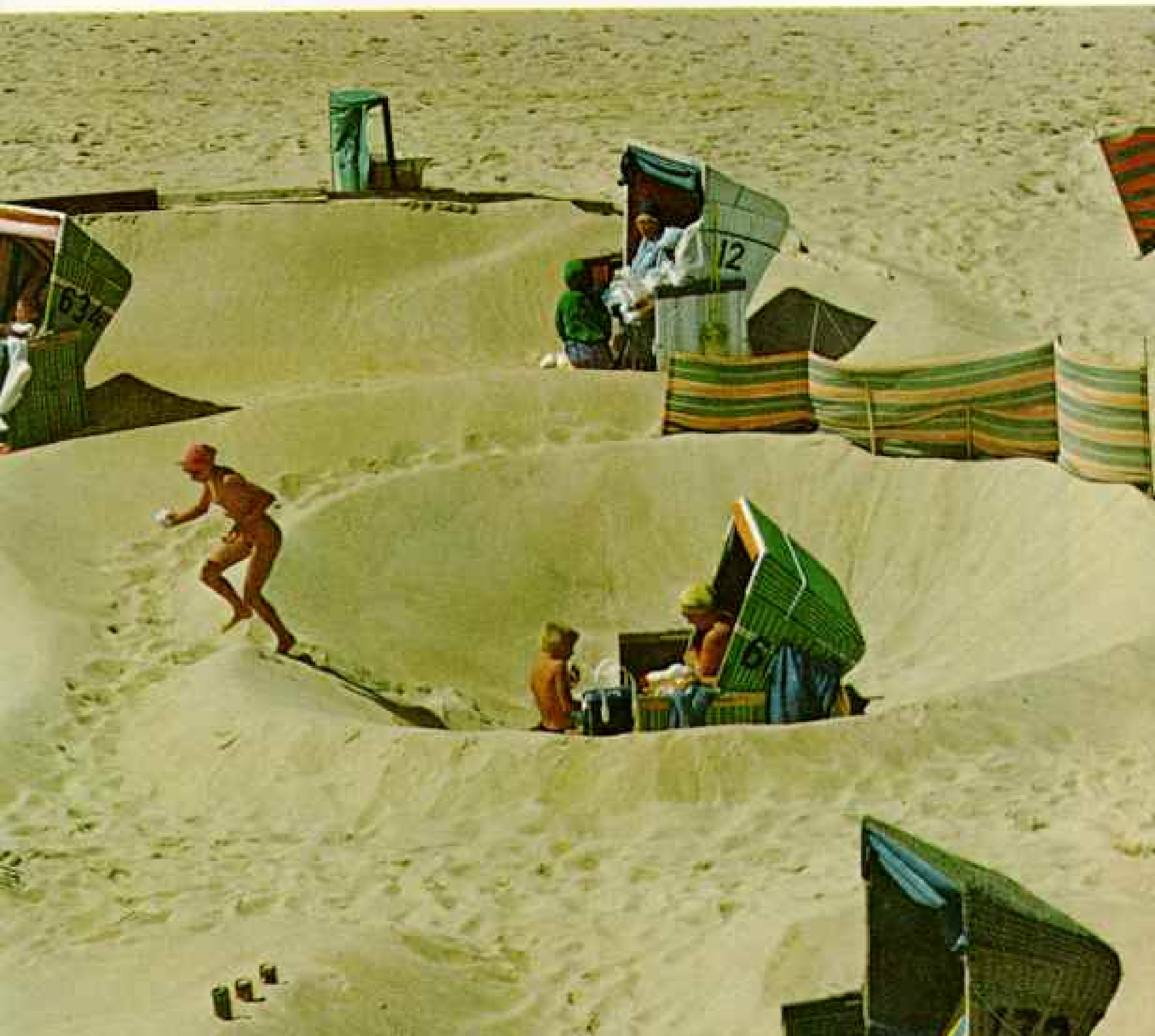
"I thought when we did, we would want to offer not parts of a power plant, but the whole system. All in one package, guaranteed to deliver so many kilowatts per hour. The developing nations would lack the expertise to assemble these packages. They might not want to get into the details."

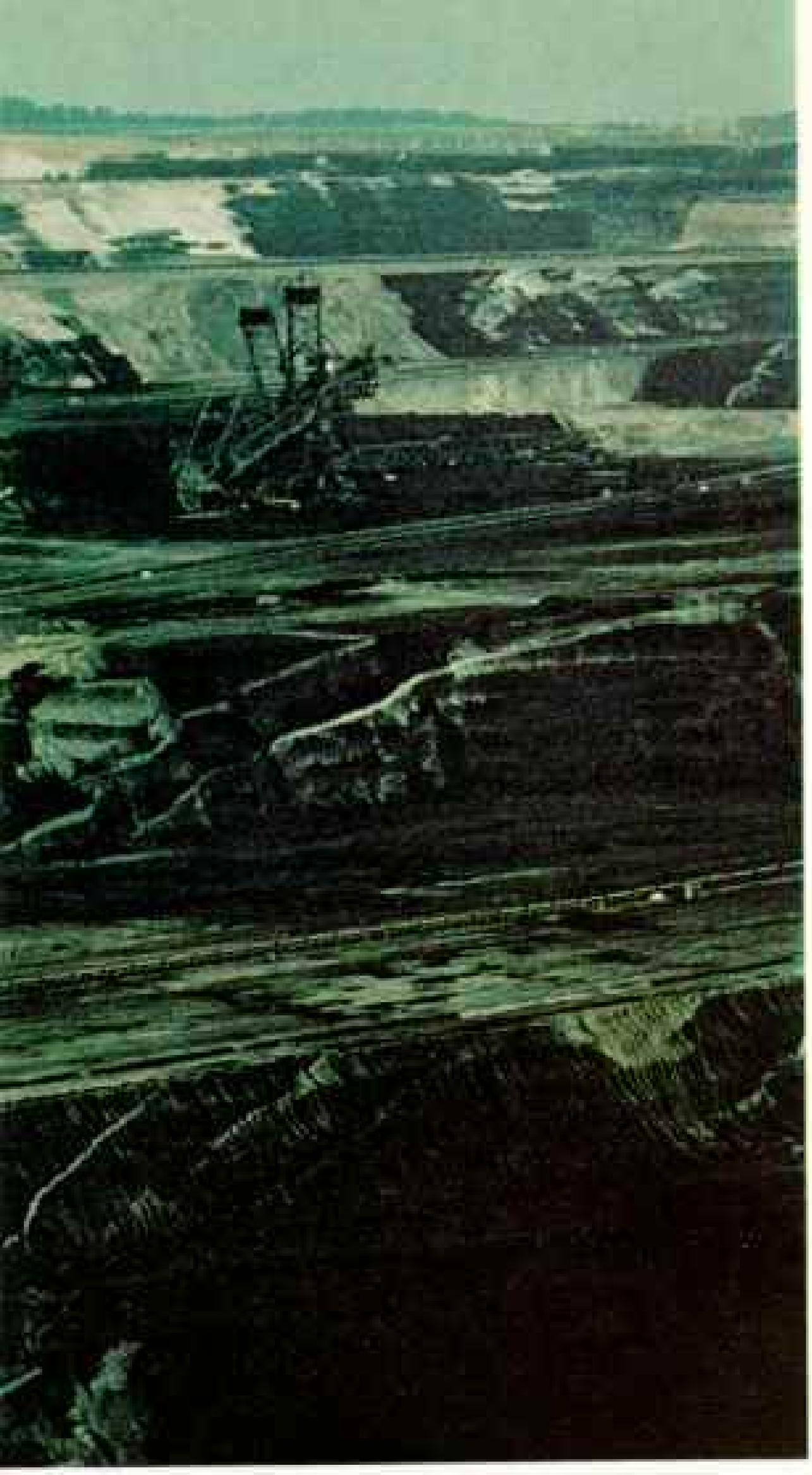
Dr. Plettner's foresight proved correct. In time, domestic orders slowed, but overseas "systems" grew to account for half of Siemens's sales: A complete power system for an Indonesian steel mill; a telephone and telex system for Finland; a nuclear power system for Brazil—"reactors, uranium refineries, reprocessing and enrichment plants, and, of course, the high-voltage lines."

Siemens has gambled big on nuclear plants. Now it waits out vigorous opposition. Near riots protested the construction of such plants in Germany, and the U. S. has voiced deep concern over the Brazil deal.

In the meantime Siemens will sell you a light bulb, a mining hoist, a steam turbine. And its hundreds of agents are well positioned. One executive said: "There's not a contract tendered in the world they don't know of. Within minutes they are in touch."

IN THE CHEMICAL INDUSTRY German companies equal or surpass their formidable American competitors. The reasons are partly historical. The Bayer company, for





Mammoth earth scoopers dwarf barely visible automobiles (**above,** left foreground) in the world's largest opencut brown-coal mine, near Cologne. Most of the 50 million tons of coal removed each year travel along miles of conveyor belts directly to a power plant. The three-mile-wide pit and four others owned by the Rheinbraun company provide enough coal for a third of the country's electric power. Since land in this densely populated nation is a precious commodity, reclamation laws and technology are among the world's most advanced. The pit will be filled with overburden from new mines, and company-paid farmers will spend five years revitalizing the replaced topsoil for crops such as sugar beets (**left**), raised on the site of a refilled mine.

instance, grew up with chemistry: developing dyestuffs, then inventing aspirin—a patent that expired and a trademark they lost in the lucrative U.S. and Canadian markets after World War I.

Little matter. Bayer holds more than 100,000 other patents. I talked with Professor Dr. Herbert Grünewald, its chief executive, in the Bayer tower at Leverkusen on the Rhine.

"We have the philosophy to be strong in our own field, chemistry. Nothing else, no conglomerate."

He stepped to windows overlooking the 840-acre plant: 600 buildings, 1,600 chemists, 35,000 employees in all. Vapor swirled from scores of pipes.

"All our plants are modern, constantly renewed. And with these facilities are combined the know-how from generations in the business. We make 6,000 products, and we try to use 100 percent of the raw chemicals. Nothing should be wasted."

A third of Bayer's capital investment this year will go overseas, most to build new Bayer plants in the U.S. "It is the largest chemical market in the world," the professor said. "Du Pont, Monsanto—they've been in Europe for years. We're just following their example, going to America."

It is a strategy that a growing number of German companies and banks are adopting.

ON A CLOUDY AFTERNOON I climbed into a small plane and flew along the River Ruhr. To the north lay the traditional heartland of German industry: 5.6 million people, one of the densest concentrations in Europe. City after city—Duisburg, Oberhausen, Essen, Bochum, Dortmund—merged one into the other, each with huge smoke-belching factories at their core.

The Ruhr remains the greatest industrial area in West Germany, producing 70 percent of its iron and steel. But the industrial picture had changed and, I would learn, is still changing. Many of the mines that for decades had supplied Germany and other European nations with their coking coal were closed. Their seams were too deep, too thin, poorly structured. Other energy sources were cheaper; the mines that remain open rely in part on subsidies.

Steel, too, has suffered. Over Bochum I looked down on the legendary name KRUPP

painted on the roof of a mill. The great cannon maker of three wars had been driven against the wall a few years earlier. More recently, large blocks of Krupp shares had been sold to the Government of Iran to raise capital and stimulate sales there.

The problem with steel? An economist told me: "Japan, for example, can produce it more cheaply. Our future lies in customized machines and systems. Here we are still tops."

ONE STEELMAKER still in the black was Thyssen, largest on the Continent. But here, too, machinery sales weighed heavily in the profits. The great Thyssen complex at Duisburg, where the Ruhr meets the Rhine, holds Europe's largest private port, 14 blast furnaces (pages 152-3), two of the world's largest converters, rolling mills, power plants, sintering plants, even a cement plant to utilize slag from the furnaces.

When I talked with Thyssen's chief, Dr. Dieter Spethmann, he told me of company plans to build production facilities overseas and to continue prospecting for iron and coal in Australia and North America.

But Dr. Spethmann was more interested in talking about Thyssen's new step to strengthen the consensus between industry and labor.

"Soon we will do our first sale of stock to our workers. At half price. Five shares per capita. I am very interested about the results.

"We wish to know what can be achieved in a capitalist society that is evolving like ours. It intrigues me to find at the end the worker, the individual, paid to his satisfaction, in a social environment that gives him the feeling of warmth, and surrounded by human beings who feel like him. A man or woman represented on the supervisory board of his company, and also owning stock in the company."

For this captain of German industry, the strengthening of the bonds of consensus were as vital as raw materials and sales.

A few months later I returned to Thyssen to check on results of the offer. Some 70,000 employees had bought shares, 51 percent of those eligible. Thyssen had gone into the market and bought 350,000 shares at 120 marks each, then sold them to the workers at 60.

Union leaders originally opposed the plan but eventually supported it. One explained: "At first we *(Continued on page 177)*

Oktoberfest! Cheered on by townsfolk waving the state flag and refreshed along the way by *Fräulein*s with mugs of beer, brass bands from every corner of Bavaria parade through Munich on opening day of Europe's biggest bash. For two weeks of beer-soaked abandon, ending on the first Sunday in October, Münchners annually relive an event dating from 1810, when Bavaria's King Maximilian I, to fete the marriage of his son to a Saxon princess, decreed a celebration that evolved into a harvest festival. Becoming more extravagant with the years, the unabashed revelry seems to belie a strong conservatism inherent in Bavarian character.

EULOGY IN STONE *to a musical genius, Neuschwanstein Castle beckons from its Alpine setting far behind a country church near Füssen. Bavaria's King Ludwig II was so taken with Richard Wagner's operas that he built this castle expressly to capture the spirit of their soaring romantic strains.*

Dudes in Deutschland: Love for things American reveals itself in German fascination with the Wild West. Stores in many cities supply cowboy garb for those eager to emulate the rough-and-tumble heroes of TV and movie screens. At the Texas Cowboy Club in West Berlin, Germans remember the Alamo with cannon salvos and a flag raising (**right**). Later they'll mosey down to their saloon to greet their ladies, while an ersatz country band pantomimes to a square-dance record.

(Continued from page 172) thought that if workers became stockholders, it might give the company a way to disguise their true interests, to confuse them a bit. But the moment we had the conditions of ownership, it became impossible to recommend against buying."

I stopped by the Alte Wache, a bar across from Thyssen's main gate. The air was heavy with the smell of beer. Billiard balls clicked in a side room. I joined some steelworkers at the stand-up bar. What had they thought about the stock plan?

Franz had rejected the offer. "I do not believe that workers should supply entrepreneurs with their capital."

Heinz, a rangy man in a turtleneck and leather jacket, laughed and called himself *ein Hüttenknecht*—loosely translated, "a servant of the company." He had worked for Thyssen 20 years, and his father had worked for the company before him.

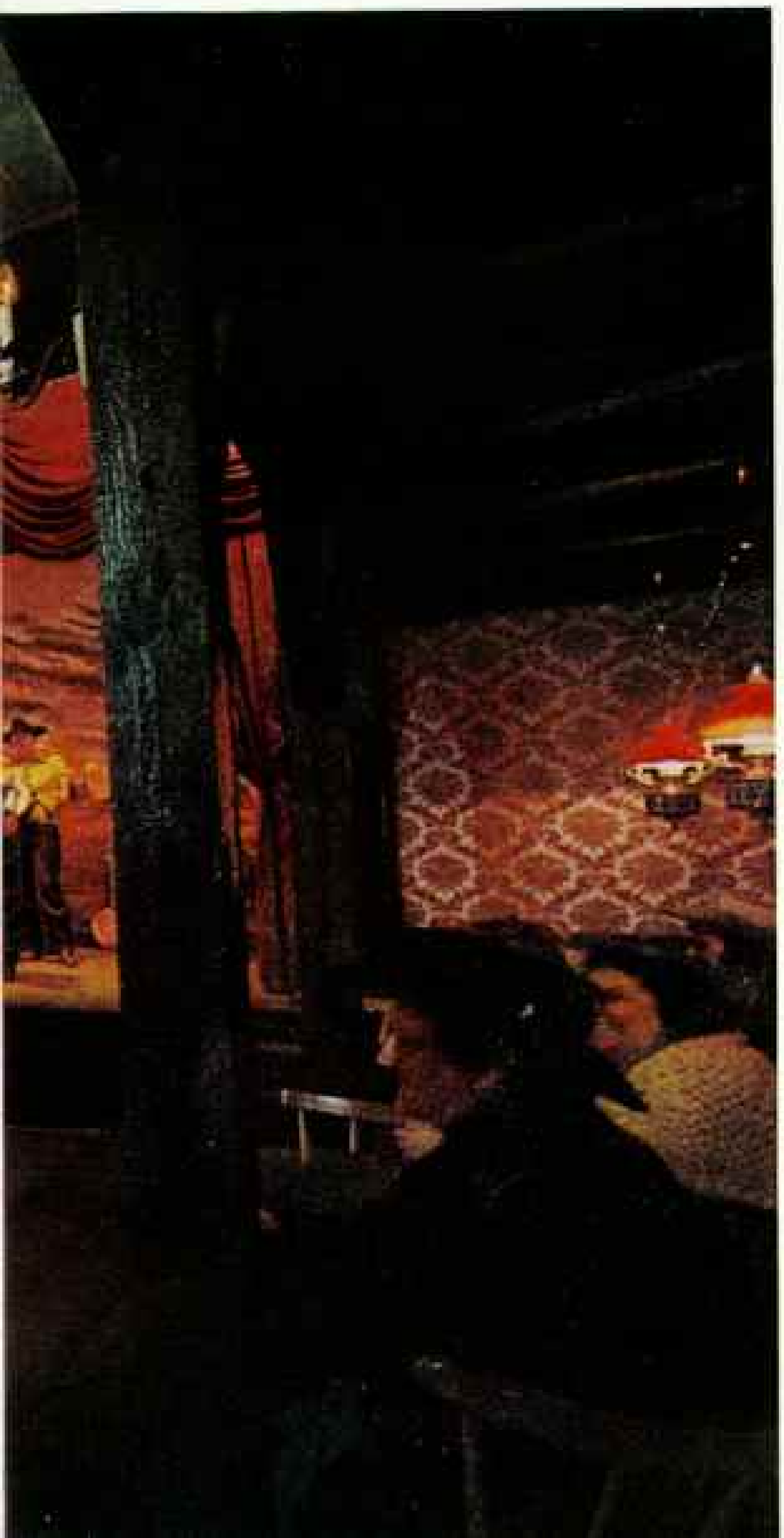
"Those of us who are born here, our attitude is to stay and work. We are used to it." He had bought the five shares "for capital security." He pulled a snapshot from his wallet, showing a pretty little cottage, set on green grass.

"I'm paying for this now, renting it out. When I retire, I'll move there." His wife worked, and the bank account was growing.

Mehmet, the Turkish bartender, drew another beer and said, "I bought the shares. I'll buy them at the next offer, too." He had come to Germany 14 years earlier. With his steelworker's wages, he had bought the Alte Wache, which his wife usually runs.

One of his six children came in, popped open a soft drink, and sat down. She spoke German, no Turkish. Mehmet said he had no plans to return to Turkey, or even visit. He was content.

Heinz and Franz gulped their beer and pushed toward the door: "Poor devils, we have to go to work now." They left with the purposeful stride of German workers.



HEINZ, the Hüttenknecht with shares in his company, embodies the "social market" system that has governed West German economic life in the postwar years and is the final ingredient in that nation's success. Its architect was Ludwig Erhard, who later served as Chancellor.

When I called on Dr. Erhard in Bonn some months before his death, he was 79 and clearly ill. Yet as we talked, he reached for a cigar, the symbol of his public life, and called for champagne. "I like to talk about those days; I have pleasant memories."

"Those days" center around 1948 when he served as top finance official for the Allied occupation government. When the Allies ordered a currency reform, Dr. Erhard ordered another reform on his own—ending rationing and controls. "The shops, up to then empty of goods, suddenly filled."

His philosophy: "Free competition, free formation of prices. The government would be pushed back as far as possible, its only function to provide a framework within which private people could carry on their activities.

"The individual citizen should enjoy maximum freedom, but at the same time he would also have to carry his responsibilities. Both go together. From the beginning we insisted that we would have no system in which the workers, the weaker segment, could be hurt. They would, instead, share."

This social market system, early embraced by Erhard's Christian Democrat party, was later largely adopted by the Social Democrats, who now govern.

Could the old warrior, in those early days, foresee how strong economically West Germany would become? "The trend, yes. But the depth, the breadth, the volume of it—no."

IRONICALLY, while the Federal Republic emerges as the strongest nation in Western Europe, there is uncertainty. Many suspect that what has worked in the past may not fit in the future.

There are real problems. One million are jobless. Labor points out that capital investment has gone to automate, increasing production but creating few jobs.

Businessmen complain about taxes and an

Gastarbeiter—guest workers—once 2.6 million strong, came in the 1960's to help West Germany achieve a boom. Nearly two million still hold jobs, in a nation undecided about their future. Here Turkish women sew in a West Berlin park.

"unfriendly atmosphere" from governing Social Democrats. The government in turn must deal with an unusually large deficit—45 billion marks—and a pension plan that is tied to the cost of living and has grown too costly.

And there is the memory of the past: all the things that went wrong.

Some dreams have faded, among them the dreams of a United Europe, strong enough to protect itself and compete on even terms with the United States and the Soviet Union.

There is a final uncertainty, one that is forgotten from time to time amid the shiny new towers of Frankfurt, Munich, Hamburg. Then, in Berlin, you remember: You see the Wall, guards, barbed wire; you see a city grown older and grayer than those in the West, a city where nearly every fourth person is over 65 years of age.

West Berlin is today an industrial island: 30 big manufacturers, 3,000 smaller ones, producing electrical goods, food products, cigarettes, women's clothes. A federal subsidy and tax breaks help keep the city alive, linking the two economies. "We are as healthy, or as sick, as the Federal Republic," said Klaus Schütz, then mayor. His problems: attracting younger people and more industry. He could offer the amenities of a great city, financial incentives for both individuals and companies, and easier access. Businessmen now confidently schedule truck, rail, and barge deliveries across East German borders.*

BUT THE WALL remains, its presence sensed even when not seen. "We realize," the mayor said, "that there is no one who can take it away. So we are trying to put holes in it—not with bombs or tunnels, but by talking with the other side. It is easy now for West Berliners to go to the other side; we hope in the next few years to make it easy for East Berliners to come over here.

"Someone asked me the other day—it was the 15th anniversary of the Wall—what I envisioned for the year 2000. I said I don't think there will be a wall with precisely this same inhuman aspect, but there will still be a border. I do not think we can easily overcome this division of Europe, which is also the division of Berlin."

That division has been sealed for three decades by arms. For many, nuclear war is unthinkable, but the history of Europe is also a history of war. At the West German "Pentagon" on a hill overlooking Bonn, I talked with Brig. Gen. Horst-B. Schuwirth, an aide to

*John Putman reported on "East Germany: The Struggle to Succeed" in the September 1974 GEOGRAPHIC.

The gray, grim presence of the Berlin Wall persists as the focal point of 840 miles of border barricades, flesh-stripping fences, and minefields. Currently being strengthened, all are designed to keep East Germans, like this soldier at work on the Wall (**right**), out of the West. But thousands from West Germany may now visit in the East, as trade between the two increases. Tensions eased with the East-looking foreign policy of former Chancellor Willy Brandt (**below**, at right), who won the 1971 Nobel Peace Prize for his efforts. His successor and fellow Social Democrat, Helmut Schmidt, at left, continues to pursue *Ostpolitik*, but shines more as a guardian of domestic stability.

the minister of defense and a strategy expert.

The general was broad-shouldered; a scar on his cheek recalled four years on the Russian front. His collar was open. He poured us a whiskey and pointed to a large wall map.

"You can change anything you like about the situation, except the number of kilometers from the Baltic to the Alps. Nine hundred. We have little depth; only 50 kilometers from the border to Hamburg. Therefore we must rely on the concept of forward defense. Otherwise we lose too much."

How might an attack come? "Along the Elbe to cut off Jutland and Norway. Through the Fulda Gap to Frankfurt, then quickly across the Rhine to cut us in two. Or perhaps through Austria, to utilize the plain south of the Danube for tanks."

The response: "Air strikes to diminish their tank force, then our own tanks and mechanized infantry. We can maintain some days of strong conventional defense, enough for NATO leaders to consult on use of nuclear weapons.

"Nuclear weapons are the key. The defense plan envisions three steps: Direct opposition, perhaps nuclear, at the point of attack; deliberate escalation, probably nuclear; and finally a major nuclear response.

"We feel there must be a linkage between these steps, so that an aggressor cannot know exactly how we will respond; so he will not know with what step he is committing suicide.

"By this theory, the theory of an incalculable risk, we hope we can maintain peace."

We finished our whiskeys, and the general bade me a pleasant afternoon.

I WALKED for a time through the older parts of Bonn. It is a pretty city: rococo palaces, chestnut trees, fine old houses with great bay windows, university students riding bicycles. I thought of Adenauer. He had urged this "small town in Germany" as the new capital; his own beloved house was nearby. He drew strength from it and the family within.

The era that he, Erhard, and the others forged may be ending. The future belongs to a new generation with fewer memories of bronze candlesticks. One of that new generation, a government minister, told me: "I think we've done about as much as possible here at home. I think we should begin to concentrate more on international problems. Not because we want to, but because with our economic strength, we have the responsibility."

Many Germans disagree strongly, but with wealth comes power. Will the government of the Federal Republic pursue the example of its commerce and industry in seeking a larger, stronger role on the international scene?

A world not lightly touched by German power in the past waits and watches with understandable interest. □

On the Trail of Wisconsin's Ice Age

By ANNE LABASTILLE, Ph.D.

Photographs by CARY WOLINSKY

STOCK, BOSTON

I WAS DANGLING from a nylon rope, halfway down a sheer 100-foot palisade. Below me the St. Croix River, which flows in the Interstate Park between Wisconsin and Minnesota, glinted greenly in the summer sun.

Above me Pitzi, my German shepherd, poked his head anxiously over the cliff edge and woofed uncertainly. I looked up to reassure him and, seeing the mighty rock face rearing against the sky, was suddenly staggered by the strength of the glacier's rushing meltwater that had carved this gorge.

I was face-to-face with the handiwork of the awesome Wisconsin Ice Sheet that had covered this region 10,000 to 20,000 years ago. Few places on earth have a greater variety of geologic phenomena left by glaciation. Pitzi and I were traveling through Wisconsin on the trail of the Ice Age.

A human head appeared beside Pitzi's. "You'd be just like bait on the line for some Ice Age fish!" shouted Dr. Adam Cahow, a professor of geography at the University of Wisconsin at Eau Claire. I shuddered, rappelled rapidly to the cliff bottom, and unhooked myself. Adam scrambled down the side of the palisade and soon paddled up with Pitzi in the bow of our canoe.

The tall, black-haired Scotsman has the uncanny knack of seeing the land as it probably looked at various stages of the glacier's advance. "Where you were hanging," he explained, "was underwater at one time. Meltwater from the glacier filled this entire valley." *(Continued on page 188)*

Shimmering relic of the glacial age, a tiny lake beckons the author's party during an autumn foray into Wisconsin's ice-sculptured countryside. The continental ice sheet that blanketed most of the state left an eye-catching legacy of lakes and landforms, now to be linked by a cross-state trail.

Huge chunks of ice deposited in glacial debris created depressions, many kettle-shaped (facing page). More than 10,000 became lakes, others bogs and swamps. Hundreds remain dry. More lakes were formed as the ice gouged rock basins or dammed streams with debris.

Boulders and loose rock embedded in the moving ice scratched bedrock like a giant rasp, leaving clear marks of its passage. Grinding action of silt particles polished rock surfaces and produced fine "rock flour" that gave a milky cast to streams containing glacial meltwater.

Glaciers probably never reached Wisconsin's southwestern quarter — a region largely devoid of rocky glacial debris, or drift.

From 600 to 800 miles of trail eventually will cross the state. Yellow lines show completed sections. Dots indicate proposed trails; dashes mark bicycle routes.

• *Ice Age National Scientific Reserve*

PAINTING BY JAIME QUINTERO
RESEARCH BY MELISSA M. FARRAR
NATIONAL GEOGRAPHIC ART DIVISION

Wisconsin's showcase for its Ice Age legacy

WINDING across the state, a hummocky, irregular ridge called a terminal moraine, deposited at the glacier's front, marks much of the Ice Age Trail. When completed, the trail will offer hikers, bicyclists, and cross-country skiers a grand tour of glacial features from Sturgeon Bay to the St. Croix River Gorge. Citizens are blazing the narrow route across private property and public parks.

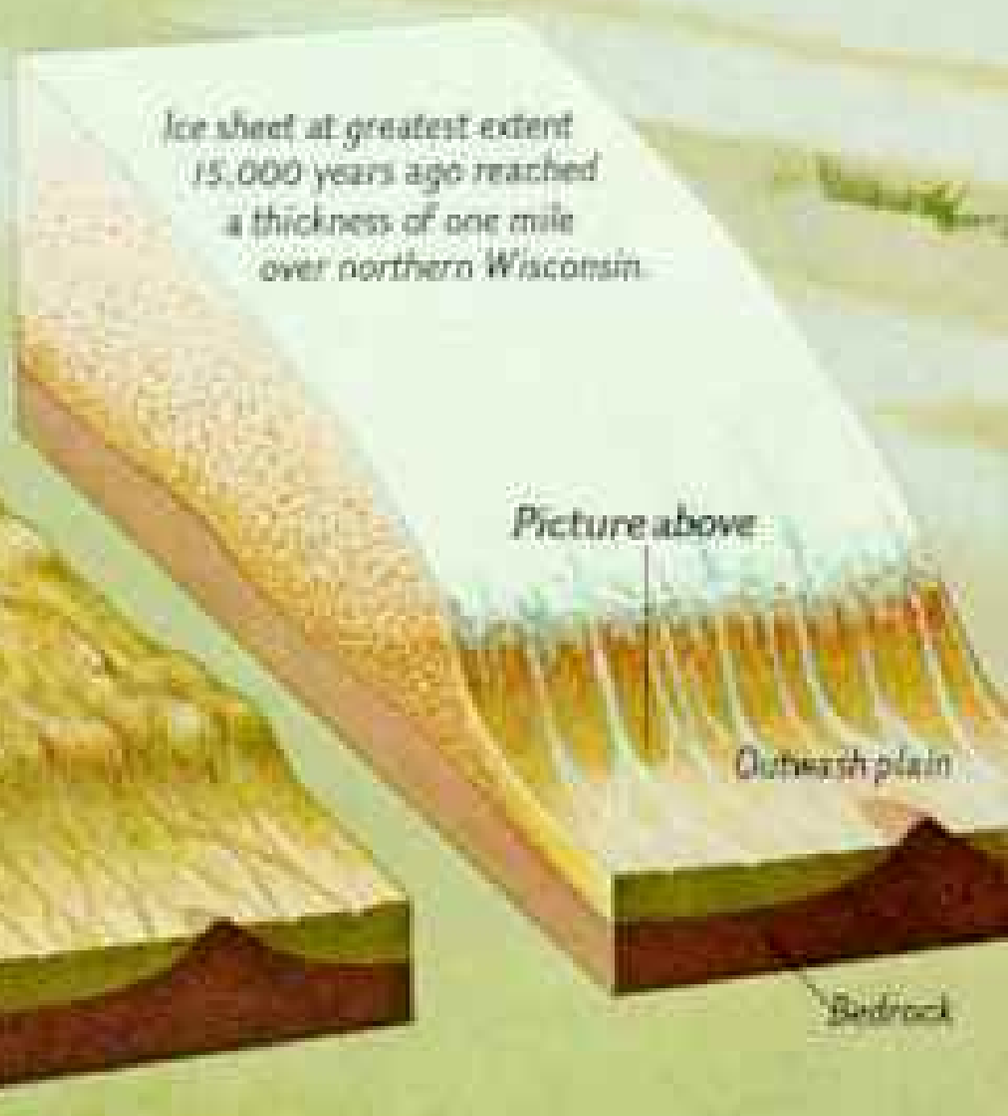
A bleak, icy, turbulent origin

FORMED about 100,000 years ago from compacted snow that turned to ice, the glacier attained a thickness of two miles in its northern Canadian birthplace. Fostered by the continental climate —colder and wetter than found today—the glacier moved southward. Beyond its farthest point of advance, mammoths grazed and glacial meltwater deposited sand and gravel in an outwash plain.

Vast loads of rock and debris are dumped as if by conveyor belt at the foot of the glacier by the constant flow of the ice sheet.

Ice retreats, exposing drumlins, hills of sand and gravel. Debris-laden runoff pouring into holes in the ice leaves rounded kames, while streams tunneling under the ice create winding eskers — some of them miles long.

Ice sheet at greatest extent 15,000 years ago reached a thickness of one mile over northern Wisconsin.



PAINTING BY WILLIAM H. BOND
NATIONAL GEOGRAPHIC ART DIVISION

From icy waste to land of plenty: Forests that flourish around a glacially formed lake bear verdant testimony to Wisconsin's fertile soil, windblown glacial silt. As much as 16 feet thick, the rich earth nourishes timber and farm crops alike. Preserved spruce stump (**below**) at Two Creeks Buried Forest, covered by glacial debris, offers proof of a moderate climate before the last Ice Age onslaught. Pen-size rough-stemmed horsetails (**above**) are living descendants of tree-size plants that grew 300 million years ago. Pioneers used them to scour pots.

(Continued from page 182)

I climbed into the canoe, and we set off through the St. Croix Dalles. There the glacier had diverted the river through a system of breaks in the rock strata. Torrents of icy water pouring through the gorge had torn loose chunks of rock to leave blocky bluffs, and had scoured out supersize potholes shaped like beer barrels.

"Interstate is the Yellowstone of Wisconsin," Adam said. "It was our first state park and has now been made a unit of the Ice Age National Scientific Reserve. I like to bring my students here. It makes them feel humble."

Breath of the Arctic Remains

Adam took me to another "humbling," almost pristine place, the rock formation called the Blue Hills Felsenmeer. "Just imagine," he said, eyes sparkling, "an immense glacier rising above you, milky meltwater rushing down this gulch, a frosty climate cracking up the old Precambrian bedrock. Talus slopes that look like a giant had plowed a furrow through a sea of stones."

Pitzi and I hopped and picked our way up the gulch between the enormous hillsides of angular rock fragments (pages 200-201). Cold air wafted out of the rocky recesses, making me shiver. A sparse growth of reindeer moss, lichens, ferns, and dwarf birches—some of them relics from colder times—clung to the rocks. Like the Alaskan tundra, Felsenmeer seemed almost as boreal in August 1976 as 10,000 years ago.

The Felsenmeer and the other spectacular formations we saw that day are only a small part of the vast complex in which the remains of Wisconsin's Ice Age are being preserved. Many of the formations are already protected in the Ice Age National Scientific Reserve (part of the National Park System but administered by Wisconsin) and in certain of the 139 State Scientific Areas. The Ice Age Trail, the first section of which opened in 1973, will run between 600 and 800 miles when completed. It will approximately follow the moraines—long ridges of debris left by glaciers—and eventually link eight of the nine scientific reserve units (map, page 184).

Adam has personally scouted, marked, and cleared more than a hundred miles of trail, helped by his children, students, and volunteers. He is one of 11 chairpersons in the privately financed Ice Age Trail Council, which coordinates work on private property. The council is dedicated to completing the remainder of the trail in ten years.

"Let me show you *my* piece of the trail," Adam said, and took me and Pitzi for a stroll along the Chippewa Moraine, a picturesque jumble of low wooded knobs and small round lakes and swales. Blue jays called raucously. A beaver slapped its tail on the water.

"This was the dead end for the Chippewa Lobe of the last ice sheet," Adam explained. "It paused here perhaps a thousand years, constantly dumping loads of rock and dirt, then retreated (diagram, page 185). It also left big chunks of ice buried in the moraine. These later melted to form lakes and bogs shaped like kettles."

The Wisconsin was the last great North American ice sheet spawned during the Pleistocene Epoch. Its sister ice sheets had begun about two million years earlier and had already come and gone when this young juggernaut crept out of the northern wastes 100,000 years ago. Heavy snowfalls accumulating in northern Canada gradually turned to ice that began to spread like plastic putty under its own weight, forming a mammoth glacier that in places was 10,000 feet thick.

As it scrunched along, generally southward, the ice sheet plucked up and entrapped trillions of tons of soil and stones. These became its special tools for gouging, grinding, and polishing. Highlands were scraped down and valleys filled.

The late Wisconsin ice mass, the most recent major event in North America's geologic history, sent six main lobes into what is now the area of the state: the Superior, Chippewa, Wisconsin Valley, Langlade, Green Bay, and Lake Michigan. These lobes, marking the farthest advance of the ice mass, reached their southern limits about 15,000 years ago, then began to backtrack. A series of lesser advances continued another 5,000 years.

Capriciousness was surely a trait of the glacier, I thought, when I visited Langlade County with Joe Jopek, extension agent from the University of Wisconsin. "I'm going to show you some of the great resources we inherited from the glacier," Joe said. We were driving past acre after acre of thriving potato farms; then, unexpectedly, acre after acre of stony fields. "There's a saying you

Pioneer spirit undampened, Congressman Henry S. Reuss tells a television reporter after a rainy walk along a just-opened stretch of the trail: "It's like walking across a gigantic fossil—you really get a sense of what happened here thousands of years ago." The Wisconsin outdoors buff coordinated efforts to create both the trail and the Ice Age National Scientific Reserve, nine widely scattered parks encompassing nearly 40,000 acres.

need two farms in Wisconsin's glaciated country. One to farm and one to pile rocks on!" Joe explained that the glacial outwash (layered sand and gravel) of these Antigo plains is among the best in the world for potato growing. "But the rocks," Joe concluded, "some people call them 'Antigo's No. 1 potatoes!' "

It's Hard Living on Soft Ground

In northern Langlade County, Joe showed me where the glacier had left a huge area of pitted glacial outwash that stretches to the Michigan border and Lake Superior, and has become part of the famed lake and bog country of Wisconsin. There are 15,000 lakes in the state, most of them formed by glaciers, and this northern Wisconsin region has one of the largest concentrations of lakes and lakelets per square mile on earth.

Glacially formed bogs, Joe explained, have made Wisconsin a top commercial cranberry producer, vying with Massachusetts for the lead. But there are still *wild* bogs that don't get into the statistics. Joe took me to one with Fred Braun, one of the largest private landholders in Langlade County (page 194). Straight as an old tamarack, Fred kept up a running lecture as we cut cross-country. Overhead an early flock of geese slanted by. Silver-green sphagnum moss and maroon cranberry vines carpeted the bog.

"It's a soft land," Fred explained from under his stained canvas hat. "The glacier smoothed things out and left a lot of fine bogs like this one. But it's not soft living here. This is character-development country!"

We stopped for lunch by five huge pines, and Fred pulled a loaf of wild-cranberry bread and a jar of palest honey from his old knapsack. "Back in the 1890's," he said, "the craze hit Wisconsin to drain wetlands for farming. Well, the dry peat bogs accidentally caught fire and burned for months, even under the snow. We lost about two-thirds of our wetlands. I'm lucky to have this."

When we had eaten lunch and picked our fill of berries, Fred led us back. As we said good-bye, he handed me the jar of flaxen honey. "So you'll remember Wisconsin," he said shyly. "It tastes of those swamp flowers."

A few days later I met another man in next-door Marathon County who knows how to glean the glacier's bounty. Robert Hoeppner is a gaunt, keen-eyed woodsman who supports his family of five partly by trapping and selling furs. In trapping season he ranges from ten to twenty miles a day and brings back skunk, beaver, muskrat, mink, otter, and raccoon skins.

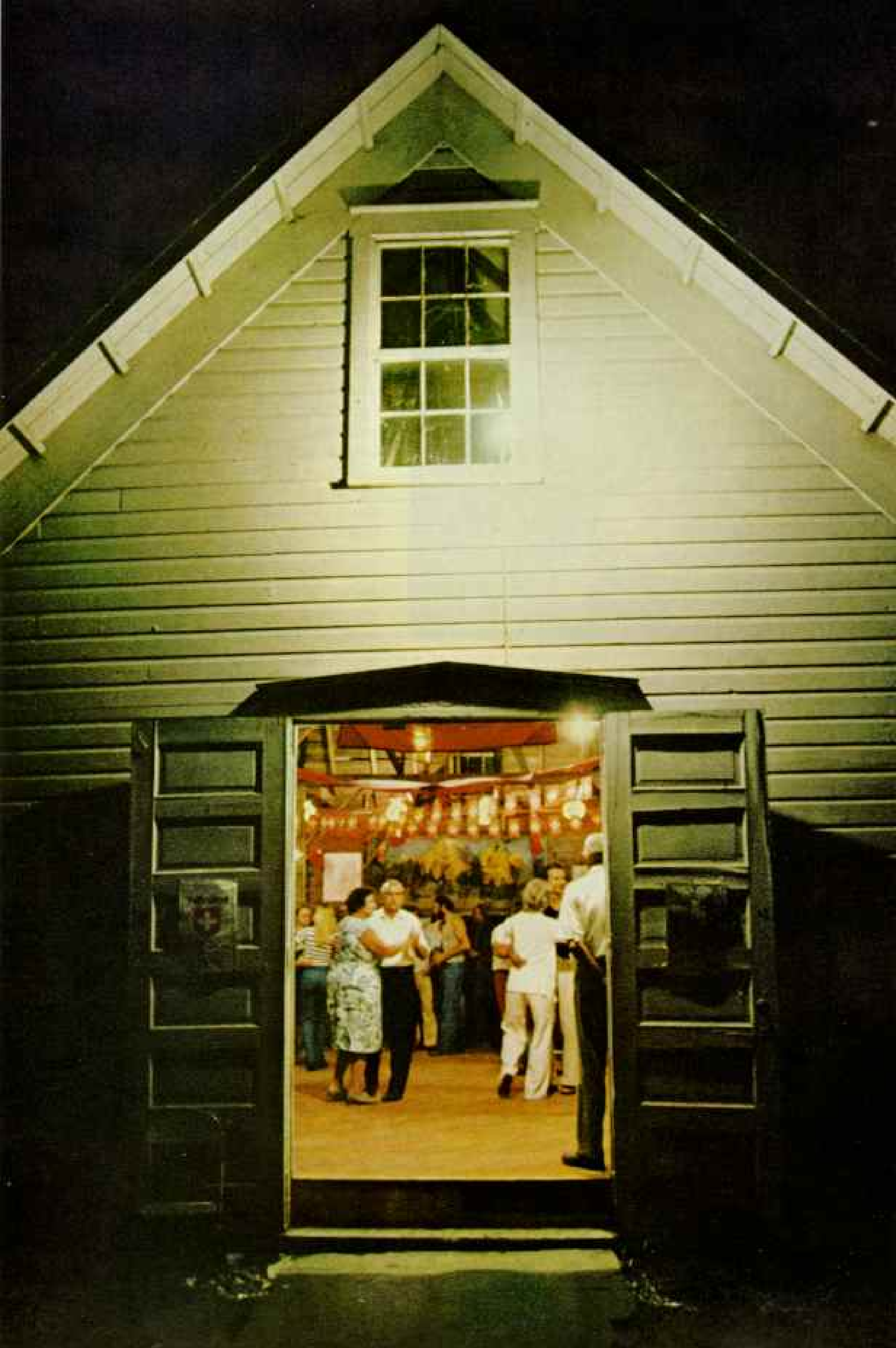
Like Fred Braun, Robert Hoeppner is an ardent conservationist of wetlands. Not only do they sustain the wildlife he depends on, but he senses the overall impact that wetlands have on the total environment.

"You can't take the hands off a clock and tell time," he stated flatly. "Well, you can't take trees off the *(Continued on page 193)*

After dairying's done, the Thull family of Kewaskum gathers with friends (**below**) for a few rounds of sheepshead, a central European game similar to skat.

Most weekends Bill Thull (**left**), here emptying milk from a tank into a portable collector, leads the family orchestra at area picnics and parties. Tuba player Fred Palmer (**facing page**), a "city guy" from nearby Mayville, adds the group's oompah-pah.

Born on the farm, which he runs with his three sons, Bill follows a tradition that began in the U. S. in 1846. His grandfather was among thousands of German immigrants who settled in Wisconsin that year, attracted by the rich soil. Where the land was rocky, they turned to dairying. Today the state's 1.8-billion-dollar dairy business is the nation's largest.



land and draw down the water and have the whole thing work right. Clocks or land. All the parts have to be there and go together as God made them."

Marathon, the largest county in Wisconsin, has a long section of Ice Age Trail, but since it is the state's leading dairy county, not much genuine wilderness remains. The wilderness, however, is never far away.

Returning to the trail I passed the Dells of the Eau Claire River. Again, the ice sheet was responsible for this miniature Interstate Park with its palisades and potholes. The Dells is a 190-acre county park, but at its heart is a tiny plot of private land. On it live Peter Beach and his wife, Susan.

"How did you come to live in such an unusual place?" I asked the burly, bushy-haired former advertising copywriter.

"I just decided to sit out a couple of dances," he replied. "We're city people who've lucked out here in the Dells. I've slowed up life 90 percent. I have time to write, paint, and dabble in advertising. To me this is consistently the loveliest place I know."

Yellow World Embraces the Author

I swung on my backpack northwest of Marathon County in the Chequamegon National Forest, wildest part of the Ice Age Trail. My weekend walk was like floating through one of Fred Braun's honey jars. Every sugar maple and trembling aspen had turned a luminescent yellow. Flurries of saffron leaves sifted down on my shoulders and crunched underfoot like cornflakes. Eskers—narrow, winding ridges left by subglacial streams—were studded with golden birches and dark hemlocks. A brilliant September sun backlit the entire canopy like a halo.

In many areas of northern Wisconsin the glacial soils are ideally suited for trees, especially maples, which thrive in heavy, moist moraine earth. Trees have been harvested here since the early 1800's, and Wisconsin was the leading lumber state from 1899 to 1904. First the giant white pines were felled, lumber for local use and later for the frame houses on our prairies. Next the hardwoods were cut for the woodworking industry, and finally the aspens for pulpwood. Today Wisconsin is first in the nation in paper production.

Wisconsin's glaciated landscape has exerted an extraordinary influence on its inhabitants. I passed close to John Muir's boyhood home, Fountain Lake Farm, near Portage. Muir arrived in Wisconsin in 1849 from Dunbar, Scotland, as a boy of 11. He described the "wavering westward way" to "sunny woods, overlooking a flowery glacier meadow and a lake rimmed with white water-lilies. . . . This sudden plash into pure wilderness . . . how utterly happy it made us!"

"**My father cleared eighty acres** with a crowbar, but this field was just too much," recalls Ralph Zamrzla (**above**). Two lobes of the glacier that converged near his Antigo farm deposited the rocks.

The hills of southern Wisconsin helped banish homesickness for Swiss immigrants who founded New Glarus in the 1840's. The town's annual Volksfest helps keep traditions alive with choral singing, yodeling, and a barn dance (**facing page**).

Homemade sauce is ahead for Fred Braun, plucking wild cranberries (**above**) from a bog on his Antigo timberland. Where the glacier left a depression below the water table, wetlands developed—vital wildlife habitat and key to one of the nation's biggest cranberry crops. In the late 1800's thousands of acres were drained for farmland. To the dismay of conservationists, tracts are again being drained; since 1970, seven percent of the state's remaining privately owned wetlands have been dried up for farming.

Working wild-rice beds on the Wolf River, Larry Shadick poles as John Schuster whacks kernels loose. Non-Indians, they use an old Indian technique—the only one permitted for gathering the no longer plentiful grass grains relished by natural-food devotees and gourmet cooks. On good days the pair can gather 200 pounds, which they sell to wholesalers for up to 90 cents a pound.

The 30-foot-deep lake (now Lake Ennis) is protected within the 169-acre John Muir Memorial Park and Muir Lake Scientific Area. Muir himself tried unsuccessfully to buy 40 acres of the homestead when he was a poor young man in order to make a nature sanctuary. How fitting that later he became the "father" of our National Park System.*

Clearly the small glacially formed lake and meadow molded much of young Muir's thinking on nature preservation. He became one of the pioneers who recognized the impact of the Ice Age in America. His "glacial rambles" took him to Alaska five times between 1879 and 1899. As the first thorough explorer of Alaska's Glacier Bay in 1879, he discovered what is now Muir Glacier. A century later the glacier is retreating at an amazing three feet a day—among the fastest ice withdrawals ever recorded. It now stands 30 miles from where John Muir first set eyes upon it.

The Ice Age Trail switches from hike to bike north of Muir Park and continues as such 220 miles southeast. Near the winding Wisconsin River in Sauk County it comes within a few miles of Aldo Leopold's "shack." Here the Wisconsin countryside bewitched another naturalist philosopher and helped formulate his ideas about forestry and wildlife. Leopold was a key figure in organizing the national wilderness system and a giant in the wildlife management profession.

He also gained national admiration and devotion for his book, *A Sand County Almanac*, published posthumously in 1949, a potpourri of "shack sketches," in which he distills his lifetime of observation on ecology, land ethics, and aesthetics.

I found my way one hot August day to the shack. Approaching on bare feet, I surely

*Harvey Arden described "John Muir's Wild America" in the April 1973 NATIONAL GEOGRAPHIC.

Pitzi stands lookout duty as the author abandons herself to the serene St. Croix, whose upper section was one of the first waterways to be included in the National Wild and

startled the two residents picnicking under the trees. Yet with utmost graciousness, Aldo Leopold's daughter Nina and her husband, Dr. Charles Bradley, rose and invited me to share their lunch of cheese and bread. I gazed toward the weather-beaten cabin as at a shrine, the campfire with its hickory crossbar, hook, and pot; the peaceful prairie patch; oaks, pines, and surrounding marshes.

Everything was drenched in tranquillity. This flat sandy country is just inside the terminal moraine, hence trampled by the mighty ice sheet for only a short time.

Family Carries On Leopold's Work

"Father became widely known as a philosopher and ecologist only after his death," Nina said, her handsome tanned face wistful. "But his family and friends always knew he was 'thinking like a mountain.'"

"What did you all do here?" I asked.

"We planted prairie flowers and grasses to try to restore the land's integrity. And we planted a lot of pines." She smiled. "Father used to say, 'I love all trees, but I am in love with pines.'" Nina gestured toward a pine plantation. "I helped him plant those. Now my husband and I are thinning them out to build a retirement home and a study center."

Far away across a mauve-colored marsh, I detected the hum of an interstate highway. It was not there when Leopold penned his *Almanac*, yet it seems to lend a subtle insistence to some of his loveliest paragraphs entitled "Marshland Elegy":

"A sense of time lies thick and heavy on such a place. Yearly since the Ice Age it has awakened each spring to the clangor of cranes. The peat layers that comprise the bog are laid down in the basin of an ancient lake. The cranes stand, as it were, upon the sodden pages of their own history. These peats are

Scenic Rivers System. Isolated patches of white water and passage through a majestic gorge add to the river's popularity among Wisconsin and Minnesota vacationists.

the compressed remains of the mosses that clogged the pools, of the tamaracks that spread over the moss, of the cranes that bugled over the tamaracks since the retreat of the ice sheet. . . . Their annual return is the ticking of the geologic clock. . . . The ultimate value in these marshes is wildness, and the crane is wildness incarnate."

The International Crane Foundation at nearby Baraboo shares the same mystical attachment to cranes as did Aldo Leopold. "Saving cranes saves earth's wetlands," reasons Dr. George Archibold, a director and chief research scientist (page 202). "We work to preserve all 15 species of cranes through research, habitat protection, captive propagation, restocking in the wild, and education."

As we talked, George poured a pail of fresh water and set it inside a large wire pen. Stalking sedately beside him was a statuesque European crane. "We hand-reared Olof from an egg," said Dr. Archibold paternally. "He follows us all over the grounds."

Artist Inspired by Ice Age Country

Through George I met Owen Gromme, Wisconsin's, and some say America's, finest wildlife artist, formerly a curator at the Milwaukee Public Museum. His superb "Salute to the Dawn" (whooping cranes at their nest) is the masterpiece in the International Crane Foundation's lobby.

"I may not be the best wildlife painter," Mr. Gromme remarked as he led me into his spacious studio, "but I think I'm the oldest." At 81, he still produces oils and watercolors at a brisk pace. At least 15 canvases stood on easels in varying stages of completion.

"Most of my paintings show habitat due to glaciation," he said cheerfully. "The glacier was responsible for our scenery, the wildlife, *and* the economy. If you want to get right down to basics, everything in Wisconsin is tied up with the 'big gouge.'"

I tarried awhile in Sauk County to study the creative work of the ice sheet there. Pitzi and I went rock-climbing again at Devils Lake. Standing by the Devils Doorway, a rectangular space between two columns of rock on the east bluff, I marveled at how the ice had licked over a flank of the ancient Baraboo Range and pressed a tip into each end of the pre-glacial Wisconsin River gorge. On melting 13,000 to 16,000 years ago, it left a moraine that plugged the gorge, forming 1.5-mile-long Devils Lake (pages 204-205). The Wisconsin River had to shift its course, moving nine miles eastward and cutting a new channel. The cliff-ringed lake is deep, spring fed, and a picture-book example of glacial action.

Giant Beavers Roamed the Bogs

Wondering about the animals that frequented Wisconsin during the Ice Age, I stopped at the University of Wisconsin in Madison and spent a fascinating morning with John Dallman, curator of paleontology.

"Mastodons were roaming the boreal forests that formed after the glacier retreated," he said, stroking a very large skull on display. "We found this specimen almost intact in a bog. I estimate it lived 11,500 years ago, weighed five tons, and stood nine and a half feet tall."

From a museum cabinet he pulled out the skull of a giant beaver. "This fellow was seven feet long and weighed 500 pounds. These beavers managed until the climate warmed and the bogs dried up. They were just too heavy to move around on dry land."

"What else?" I marveled.

"At the glacier front, probably mammoths, musk-oxen, and caribou. In the forests farther from the glacier, there were elk. Fishermen sometimes snag elk antlers on their hooks right in the lakes ringing Madison."

"Were human beings living here then?"

"Not quite yet," answered Mr. Dallman. "The first human beings in Wisconsin, as far as we know, came about 9,400 years ago. That's roughly a thousand years after the ice sheet left the state. No doubt they were big-game hunters, living off mammals and maybe gathering berries and fishing in the wetlands left by the glacier." *(Continued on page 203)*

Savoring their memories after raising nine children, Ted and Pearl Arrowood enjoy retirement in Bryant, Wisconsin. Ted, a former lumberjack, came north with Kentuckians to work Wisconsin's forests, a leading source of pulpwood and timber. A portrait of Mrs. Arrowood and her sisters, now a family heirloom, recalls a visit to the county fair.

Quarried by the climate, rocks litter a gorge (**left**) in the Blue Hills Felsenmeer Scientific Area, part of a 19,000-acre network of 139 preserves set aside throughout the state for research and teaching. Repeated freezing and thawing during the Ice Age cracked the angular quartzite chunks from the walls of the chasm, which had been carved by torrential glacial runoff.

Formed by a subglacial stream, an esker (**below**) winds like a giant molehill across a farm near Kettle Moraine State Forest. Probably more than a thousand of the gravel-rich formations remain, despite the quarrying of many for building materials.

All but annihilated in Wisconsin during the Depression, when they were shot for food and their nesting grounds drained, sandhill cranes were rescued by tough state conservation laws. Here a flock roams at the International Crane Foundation (**above**) near Baraboo. Through studies of the now flourishing birds, biologists hope to find ways to help the survival of still-endangered species, such as the whooping crane.

Raised by humans, Tex rejects the advances of other cranes. By keeping the female whooper company, research director Dr. George Archibold (**left**) hopes to increase chances she will lay an egg after artificial insemination.

While in Madison, I took a flight with George Knudsen, chief naturalist for Wisconsin's Department of Natural Resources, another man who sees through geologic eyes. He pointed down at vast rectangular cornfields. "The glacier gave us many gifts. Those ice sheets made thousands of extra acres of farmland by rounding and filling. Those wetlands over there"—pointing to Horicon Marsh—"teem with waterfowl. In fall when the Canada geese leave, the whole landscape seems to take off. I've never seen so many live bodies outside of New York City.

"Then there's the gravel and sand left by the glacier—a 35-million-dollar business here. Some of those materials hitchhiked down from northern Michigan, Lake Superior, and Canada—maybe 400 to 600 miles. Imagine the fuel and trucks it would have taken to import them!"

Congressman Pens a Trail Guide

The world-renowned Kettle Moraine State Forest was my next stop on the trail. The moraine was formed at the junction of two major lobes, making an interlobate glacial dumping ground. I was joined by Congressman Henry S. Reuss and his wife, Margaret, a professor of economics. Mr. Reuss is a strong advocate of the Ice Age Trail system and the scientific reserve (page 189). He has published a hiker's and biker's guide describing both.

"This country reminds me of an enormous sandbox," joked the Congressman, as we drove along the Kettle Moraine Scenic Drive. Everywhere the moraine lumped and humped along in knobs and cones of sand and gravel. "Looks like some gigantic Neanderthal brought home a load of dirt for his kids to play in."

Next morning I drove on north alone along the scenic drive. Neat new country homes nestled on the wooded moraine and on the round sand-and-gravel hills called kames. Subdivision signs read Kettle View, Kettle Moraine Hills, Forest Run, Cedar Lake Hill. Milwaukee commuter development was popular in the Kettle Moraine country.

In addition, gravel-and-sand pits were gnawed into the shoulders of the moraine and the sides of the narrow, sinuous eskers. Several ski resorts had cleared the forest on steeper slopes for their runs, and on some of the now naked knobs, ruts from trail bikes

Nestled in the Baraboo Range, Devils Lake embodies Wisconsin glacier power. After diverting the ancient Wisconsin River, the ice piled debris at both ends of its abandoned

had begun erosion. I was beginning to realize that the "gifts of the glacier" could be threatened.

Pitzi and I reached the northern area of the Kettle Moraine State Forest and set out again south on the Ice Age Trail, which transects it. I planned to walk the 25-mile section over the Labor Day weekend.

During the days red-tailed hawks spiraled overhead. White-tailed deer tiptoed through reddening copses of sumac. Each evening barred owls chorused from the branches of big bur oaks. Crickets trilled in the prairie grass beneath. And within an emerald swale, a pair of sandhill cranes trumpeted majestically before wheeling into the sky.

My last stop on the trail of the Ice Age was at Two Creeks Buried Forest near Lake Michigan a few days later. I scrambled down a reddish clay cliff to find a famous site where the glacier, in a late advance, had buried spruce trees only 11,850 years ago (page 186), and where logs and stumps have been preserved by a layer of glacial till (unsorted debris from the glacier). I found a chunk of ancient trunk and cradled it gently in my hands.

That night I camped high on the dunes of Point Beach State Forest beside whispering jack pines. A horned owl hooted once as a bronze half-moon eased above the lapping waves. Sitting beside my flickering campfire, I found it hard to believe that the Wisconsin Ice Sheet had created the final form of both Lakes Michigan and Superior. Its work has given the state 820 miles of shoreline on the Great Lakes, several important shipping ports, and a lake-tempered climate where apple and cherry orchards flourish.

After a dawn walk along the beach, Pitzi and I found ourselves on the most bizarre section of Ice Age Trail so far. We scurried past the Point Beach nuclear power plant under immense spans of high-tension wires that crackled overhead. Huge high-line towers

route through the mountains. Water slowly filled the valley of the old streambed, creating the state's premier vacation retreat—just a mile's hike away from the Ice Age Trail.

strode ruler-straight across oat fields. In the background two nuclear reactors loomed against the blue-gray lake. From time to time a powerful loudspeaker blatted bleakly from the plant headquarters.

To me this was the ultimate paradox: a Pleistocene pathway juxtaposed with the highly technical world of today. This brush with industrial development set me worrying about the probable prognosis for Wisconsin's Ice Age heritage.

Landowners Pose Major Hurdle

I asked Milwaukee attorney John Zillmer about this. His father, Ray Zillmer, who died in 1961, first had the vision of saving evidence of the Wisconsin glaciation. He had interested the National Park Service, had got the state and federal governments to concert efforts, and deserves most of the credit for the nine-unit national scientific reserve.

"What's the future of the Ice Age Trail?" I asked John, who had hiked thousands of miles in Wisconsin with his father.

"It is a viable project and *can* be completed," he replied. "Our main concern is to get 100 percent cooperation from the landowners whose property the trail must cross. I'm sure folks will come around. I remember when people said my dad and I were nuts for hiking in the Kettle Moraine country. Now just about everybody wants to get outdoors."

But there is a larger question to answer. If the Ice Age Trail is, indeed, completed, how long will there be Ice Age country for it to traverse? Gwen Schultz, a professor of geography at the University of Wisconsin in Madison and author of *Ice Age Lost*, warns that not enough attention is being given to conservation of ancient glacial features.

"The Ice Age fortune has been bequeathed to us for our lifetime," she told me. "How we handle it determines how much of it will be left for future generations." □

"CLEARED FOR TAKEOFF"
"CLEARED TO LAND"

THE AIR-SAFETY CHALLENGE

By MICHAEL E. LONG

Photographs by BRUCE DALE
BOTH NATIONAL GEOGRAPHIC STAFF

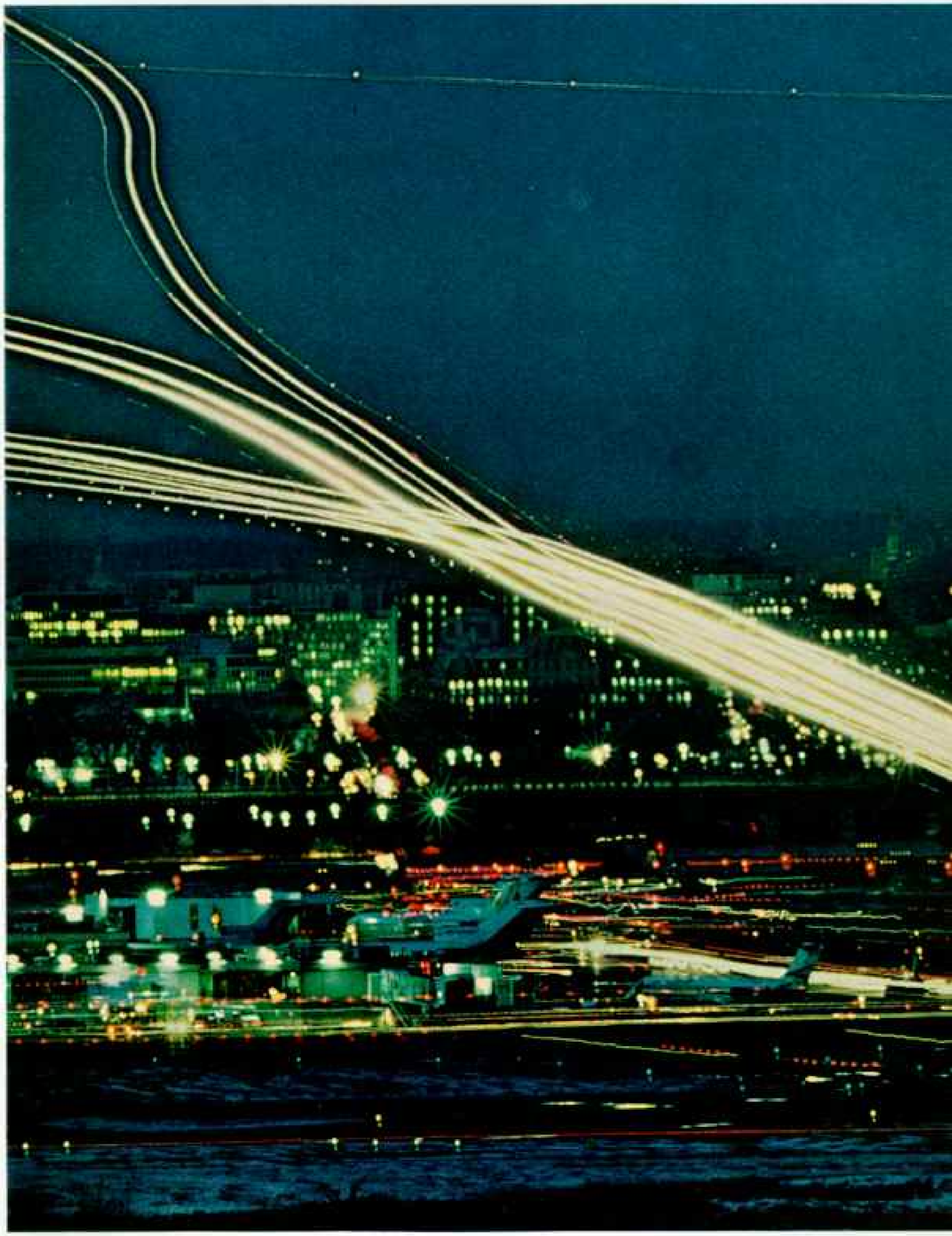
"There are two critical points in every aerial flight—its beginning and its end." —ALEXANDER GRAHAM BELL, 1906

AT 30,000 FEET the sky is blue, the sun bright. As your jetliner descends around cotton-ball clouds, the captain announces that things might get bumpy. Now, seat belt fastened, you're on final approach to your destination.

From clouds dark as a bruise, rain slants across your window. The airplane bounces to the beat of unseen winds. Suddenly the engines roar. A wing dips, then rises with tantalizing slowness. Moments later you break out of the rain, the ground rushes past, you're on the runway.

It's an experience many air travelers have had, ably handled by the professionals up front. In 1976 United States air carriers safely transported 229 million passengers to their destinations. In only four fatal crashes out of nearly five million flights, 45 people lost their lives. As the saying goes, the skies are friendly indeed.

But as Dr. Bell noted three years after Orville Wright's first successful flight, operations on or close to the ground—takeoff or approaching to land—are a different matter. Of the two, approach and landing is the most unforgiving phase of flight. "It's where mistakes and malfunctions bite you faster," says Webster B. Todd, Jr., chairman of the National Transportation Safety Board. "You're descending, your speed is slow. Tolerances are not what they were at 25,000 feet." *(Continued on page 213)*



The magnificent jet propels air safety to new heights, yet accidents still occur. Records show that takeoff and landing remain the critical phases of flight. One long-range solution is increased automation. A Lockheed TriStar touches down "hands off" at Palmdale, California (**overleaf**); a time exposure by a remotely operated camera attached to the aircraft's vertical tail fin blurs city and runway lights.

"In the groove," the light paths of successive jetliners merge during final approach to National Airport at Washington, D.C. While U.S. air-carrier total accidents

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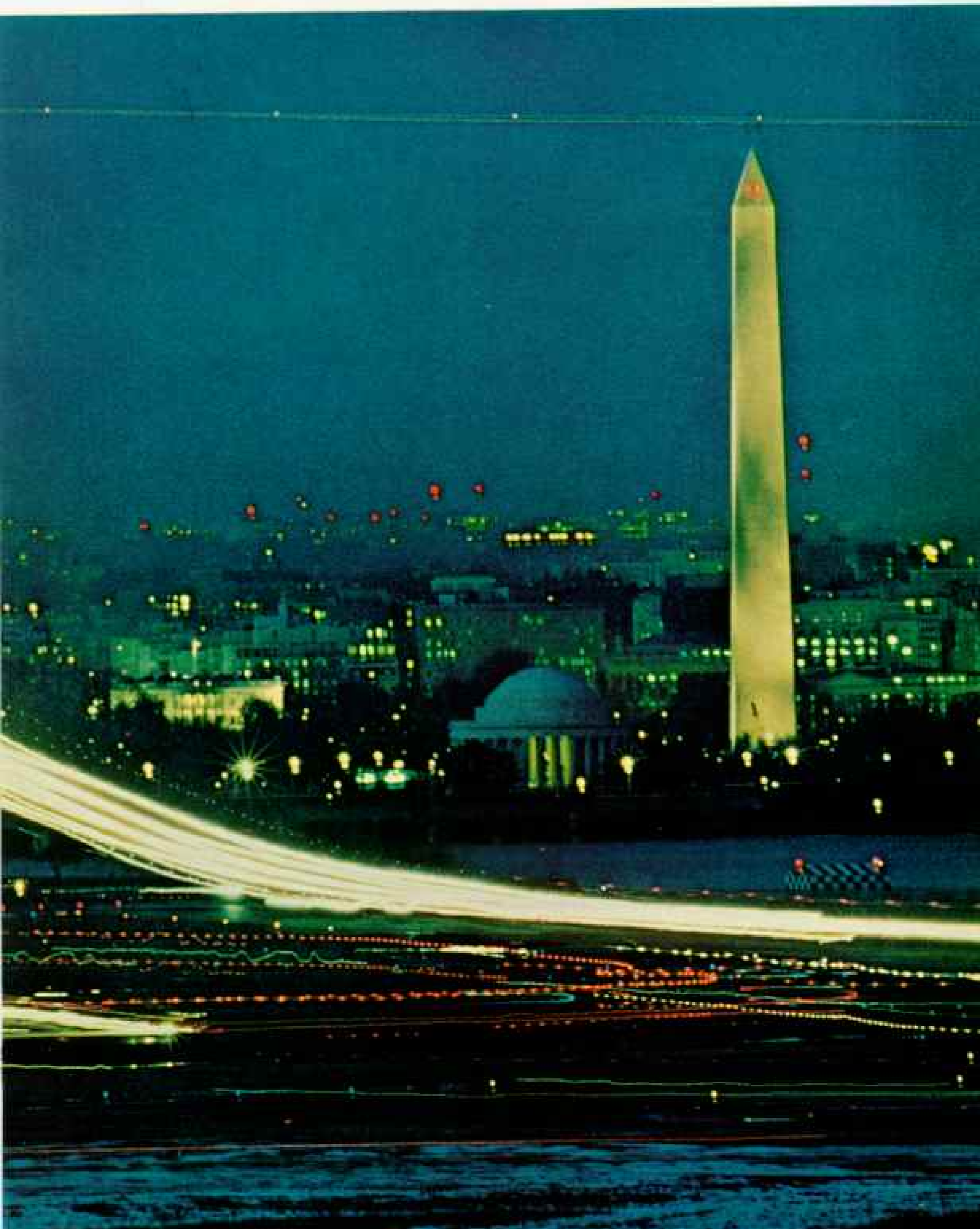


decline, a tiny handful of fatal approach-and-landing crashes has remained virtually constant for 25 years. The cost, both in lives and in aircraft, has become prohibitive.

Letting an autopilot take the controls, pilots of a Flying Tiger Boeing 747 monitor instruments at cruise altitude (**above**) en route to Anchorage, Alaska. The flight engineer keeps track of fuel consumption.

When a pilot approaches a weather-obscured runway, he flies by instruments, then switches to outside visual references. Investigating this process, engineers at NASA's Langley Research Center in Hampton, Virginia, beam infrared light into the eye (**left**) to trace its movements among flight instruments (**right**). The device, an oculometer, may yield the answer to an old question: What are the minimum visual references required to land an airplane?

In number, approach-and-landing accidents are few—during most years you can count on the fingers of one hand the fatal mishaps suffered by U. S. air carriers. But they are the dominant killers in an industry whose overall safety record equals or excels that of any other mode of transportation.

Over the past quarter of a century or so the number of U. S. air-carrier fatal accidents has dramatically declined. There have been peaks and valleys, from a high of 25 in 1951 to a low of 4 in 1976. Yet the number of fatal approach-and-landing accidents remains stubbornly constant, never fewer than two, never more than six.

The pattern is worldwide. "Approach and landing is the heart of our safety problem," Dr. R R. Shaw, an assistant director general of the International Air Transport Association told participants at a flight-safety seminar in Malaysia in 1975.

Getting Down Is the Tough Part

Examining accident statistics of the free-world jetliner fleet and of Western-built jets operated by Communist countries, the Flight Safety Foundation of Arlington, Virginia, found that approach-and-landing mishaps comprise nearly 60 percent of all fatal accidents since 1959. (Include takeoff accidents and the figure becomes 85 percent.)

What is causing these accidents? What is being done to prevent them? Pursuing answers, I talked with airline pilots and safety officers, with accident investigators and federal aviation officials. I rode with airline and flight-test crews on 32 flights in the United States and Europe.

Flying with them was like coming home. As a U.S. Marine Corps pilot in the late 1950's, I flew a jet fighter, now of ancient vintage, the Grumman F-9. As a flight instructor I taught acrobatics and instrument flying to Navy and Marine Corps students in the propeller-driven North American T-28.

Considering this a hazardous occupation, my life insurance company required an extra premium, also demanded of airline pilots at the time. Today, with declining accident rates, airline pilots pay the same as bank clerks. I feel safer in a jetliner than in my bank, certainly safer than on my bicycle. More Americans were killed on bikes last year than in U. S. air-carrier accidents during the past four.

The problem, one safety expert explained, is that hull losses—the trade term for airliner wipeouts—and suits resulting from passenger fatalities cost more than bicycles. The takeoff collision of two Boeing 747's last March at Tenerife in the Canary Islands (pages 228-9) took 580 lives. Insurance settlement for the aircraft was 63 million dollars; lawsuits filed by relatives of passengers amount to billions. This will have a major effect on future insurance rates applied to carriers.

Nightmare Flight Tests Pilot's Skill

Accidents. Accidents. What about all those millions of uneventful flights and happy landings? To experience one, I joined Capt. Lynden Duescher on the flight deck of a United Airlines 747 in San Francisco. Strapping myself into a seat behind the captain, I listened as he and his two crew members, like shoppers in a supermarket, completed their checklist:

"Fuel—main pump on; hydraulic pumps—auto, normal . . . ; warning lights—out."

"Let's go," said Duescher, advancing the throttles. The whine of the engines surged into a reassuring roar as we sped down the runway. But we were no sooner airborne than one of the engines began to lose power. Next, a section of the wing flaps refused to retract. When the landing gear came up, fire erupted in one of the wheel wells.

With the coolness born of long command, Duescher directed his crew in procedures that restored order to the malfunctioning aircraft. We climbed to 24,000 feet, where the cabin-pressurization system failed. We donned oxygen masks as Duescher began an emergency descent to 10,000 feet. Problem rectified, he returned to altitude and resolutely proceeded to his destination, Chicago.

En route, a radio receiver failed and flight instruments went haywire. The number-two engine caught fire and was shut down. On approach to the runway at Chicago's O'Hare International Airport, oil pressure dropped on number-three engine. It too was shut down. Duescher faced a delicate situation, an approach with only two engines functioning.

He made a fine landing.

No passengers deplaned, because there were no passengers. We had never left San Francisco; we had never arrived in Chicago. In truth, we had never left the ground at United's Flight Training Center in Denver.

We were in a flight simulator, a boxy contraption on spiderlike legs. Inside was a fully instrumented 747 flight deck. A TV tube, masterminded by a computer, displayed the world outside with astonishing fidelity. The simulator's hydraulic legs flexed to counterfeit the feel of flight. Only the sweat on Duescher's face was real.

Simulator exercises, part of the "recurrent training" that the Federal Aviation Administration requires of airline pilots every six months, keeps emergency skills honed. With computer technology, simulators have become so realistic that the FAA permits the airlines to use them instead of airplanes for most training. The idea has paid off. The last fatal training accident, which occurred during a landing approach, was in 1972.

The actual flights I made with various airlines—Air France, Allegheny, Continental, Pan American, and United—were routine. I was hoping to encounter a foul-weather landing approach, but the weather did not cooperate. Finally I got the point: There's not that much bad weather.

Kudos for Jet Age Technology

The prime reason for the steady decrease in air-carrier accidents, National Transportation Safety Board experts told me, is that marvelous machine, the jet airplane. Jet engines perform for phenomenal periods with routine maintenance.

There's also "redundancy." This means that when an instrument or a system malfunctions, there's at least one more standing by to take its place. The Boeing 747 has four independent hydraulic systems.

The safety board investigates air-carrier accidents and establishes "probable cause." Its findings usually come in plurals, because

Noise is the norm where cities coexist with jetports. A youngster holds his ears as a jetliner appears to skim buildings in densely populated Hong Kong. Actually it's a routine path to the runway, just a quarter of a mile away. An approach-light bar, one of a chain that extends out from the runway, appears to bridge the street at center.


UNITED
TAXI
CONCORDE
STOP NOISE
STOP
CONCORDE
BAN
CONCORDE

BEAK FIGHT FOR AIR FRANCE (ABOVE) AND NATIONAL GEOGRAPHIC PHOTOGRAPHER OTIS IMBODEN

Bird of the future or endangered species? A Concorde practices foul-weather landings at Lille, France (**above**). The supersonic transports' inaugural flights to Dulles International Airport at Washington, D.C., last year were greeted by a small band of protesters (**left**), vanguard of continuing concern over the SST's noise.

Despite the uproar, pilots recognize a major safety feature of the Concorde—more power to weight than any transport in the world. They also like the delta-winged plane's excellent low-speed handling qualities, important for takeoff and landing. "It practically lands itself," says a test pilot.

most air accidents are chain reactions involving the links of the system: pilots, weather, air-traffic controllers, airports and airways facilities, and the airplane itself.

The factors most often blamed are pilots and weather.

Here's what that sounds like in an NTSB accident report: ". . . the probable cause of the accident was the pilot's failure to execute a missed approach when he lost sight of the runway environment in heavy rain."

Is "Human Error" a Fair Finding?

Human error. It's a firecracker topic. "A guy's not going to fly himself into the ground just for the hell of it," one captain said.

"Accident investigation does a pretty good job of telling what happened and how it happened," said Capt. J. J. O'Donnell, president of the Air Line Pilots Association. "But it doesn't tell *why* it happened."

At Ames Research Center near San Francisco, a team of National Aeronautics and Space Administration researchers are probing that question. On my way to talk to them, I had an accident.

I had taken the wrong freeway exit. Concerned about being late, I hurriedly drove into a parking lot and backed out—right into another car entering the lot. Fortunately the damage was minor, a broken taillight.

When I explained what happened to Dr. Charles Billings, spokesman for the NASA group, he said, "What you experienced was the combination of an error—not looking where you were going—and a circumstance we call an 'enabling factor'—the guy coming in behind you. Put them together and they can produce an accident."

I guessed that my error occurred because I was in a hurry. Dr. Billings agreed, but explained that flying is much more complex than driving. Just take the problem of information transfer: A pilot gets data from his instruments and the airplane's warning systems; from the charts, manuals, and regulations he carries in his black bag; and from people—his company dispatcher, air-traffic controllers, other crew members.

"If the pilot is given wrong information and makes a bum decision," Dr. Billings commented, "sure, he's made an 'error.' But we would argue that the error was built into the system. The pilot could hardly have avoided

making it. We're trying to look beyond the error to what caused it, to get from the symptom to the disease."

Working with airline crews in simulators, the NASA team injects suspected error-producing factors into the normal routine. "We hope to serve as an early-warning system," Dr. Billings said, "to identify hazards before they cause airplanes and people to get bent."

Another early-warning apparatus operated by NASA and the FAA enables pilots, air controllers, flight attendants, indeed anyone, to report potential flight hazards with immunity from FAA disciplinary action. Since the program began in April 1976, NASA has forwarded more than 300 "alert bulletins" to the FAA for dissemination throughout the U. S. aviation system.

Dealing With an Old Enemy

Fog, snow, haze, rain. For years they have contributed to more than half the fatal approach-and-landing accidents. Recently another enemy has been pinpointed: low-level wind shear—any sudden change in wind speed or direction.

If you've ever walked from the calm of your home into a stiff wind, you have encountered one type of wind shear. In aeronautical terms, you went from a no-wind condition into a strong head wind. Here's what can happen when jetliners encounter shear.

On the afternoon of June 24, 1975, the wind recorded on the ground at New York's John F. Kennedy International Airport was moderate, but lightning flashed from nearby clouds. To a veteran air-traffic controller, the bolts seemed to linger in the air for two, three, perhaps five seconds. "I had never seen anything like it," recalled Richard Nelson. A rain shower hovered over the approach course to Runway 22 Left.

Six miles out from the runway Capt. John H. Bliss of Flying Tiger Line readied his McDonnell Douglas DC-8 for landing. Flaps down. Wheels down. Approach speed—152 knots. In the long cabin behind him, 141 head of Pennsylvania breeding cattle, en route to Budapest, browsed in their stalls.

"Tiger 161 cleared to land," the tower advised. Scarcely a minute later, after passing through the rain shower, the aircraft was perilously low, rocked by turbulence and clawed at by winds approaching hurricane force. Bliss fought for control—"like a cat on a hot tin roof," a pilot on the ground noted. He landed safely and immediately demanded a runway change for following aircraft. The tower replied that the wind on the ground was just 15 knots.

"I don't care what you're indicating," Bliss said. "I'm just telling you that there's such a wind shear . . . on that runway you should change it to the northwest."

The tower did not reply. Another jetliner, Eastern Airlines Flight 902, was in trouble. At 400 feet above the ground Capt. Clifton L. Nickerson watched the airspeed of his Lockheed TriStar dip suddenly from 150 to 118 knots. Nickerson immediately applied full power to his engines, pulled the control wheel back to stop the descent, and sat helplessly as the aircraft sank anyway—through 300 feet . . . 200 . . . 100.

He pulled the yoke back farther, but still descended. Carefully he raised the nose higher. Higher. "I was funneling all my years of flying experience into those moments," the 57-year-old captain later told me. Finally at a mere 60 feet above the ground, the aircraft leveled off. Eight chilling seconds later, Nickerson flew out of danger and proceeded to Newark to land. Several passengers reprimanded him. Nickerson said nothing.

Luck Ran Out for Flight 66

Meanwhile two other aircraft experienced airspeed drops, which they did not report after landing safely. The next was Eastern Flight 66, a Boeing 727. First Officer William Eberhart, who was flying the airplane, said, "Gonna keep a pretty healthy margin [of airspeed] on this one." Flight 66 entered the rain shower, and at 500 feet the crew turned their windshield wipers to high speed.

"Stay on the gauges," commanded Capt. John W. Kleven as the descent continued.

"I have approach lights," said Kleven. "Stay on the gauges . . . runway in sight."

"I got it," said Eberhart.

"Got it?" asked Kleven.

"Takeoff thrust!" exclaimed Eberhart, calling for maximum power.

These were the final words transcribed from the cockpit voice recorder of Flight 66. A little more than a second after they were uttered, the craft crashed short of the runway,

NATIONAL GEOGRAPHIC PHOTOGRAPHER JAMES P. BLAIR

Disaster is the exception, but training is the rule. To meet stiff requirements set by the Federal Aviation Administration, Eastern Airlines flight attendants practice survival at sea, actually in a swimming pool in Miami.

killing 113 people in the worst single-plane disaster in U. S. commercial aviation history.

As part of its investigation, the NTSB reenacted the accident in a 727 simulator. Computers programmed the winds encountered by Flight 66. Experienced pilots "flew" numerous approaches. Their instructions: Land if possible, make a missed approach if necessary, don't crash. Of 54 approaches, only five were successful.

One of the pilots told me, "I crashed five times in six approaches. I didn't believe a wind existed that could so overwhelm an aircraft."

At low altitude Flight 66 experienced shear, in the form of a suddenly decreasing head wind and a strong downward wind from the thunderstorm. The result was a loss of lift—the force produced by airflow around the airplane's wings.

"The pilot must add power immediately," said Cliff Stout, director of flight operations for the Douglas Aircraft Company and a pioneering researcher in wind shear.

Stout and other experts all told me that shear can be a capricious adversary. In an increasing head wind the airflow around an airplane's wings—hence its airspeed—increases. A pilot's natural reaction is to reduce power, as a motorist going downhill eases pressure on the accelerator.

Suppose the head wind decreases. Additional power is necessary, but the power has already been reduced. Put it back on? You bet, and right now. But the situation can be complicated by the acceleration characteristics of the jet airplane. For all its virtues, the jet engine does not react as fast as the old-fashioned piston engine.

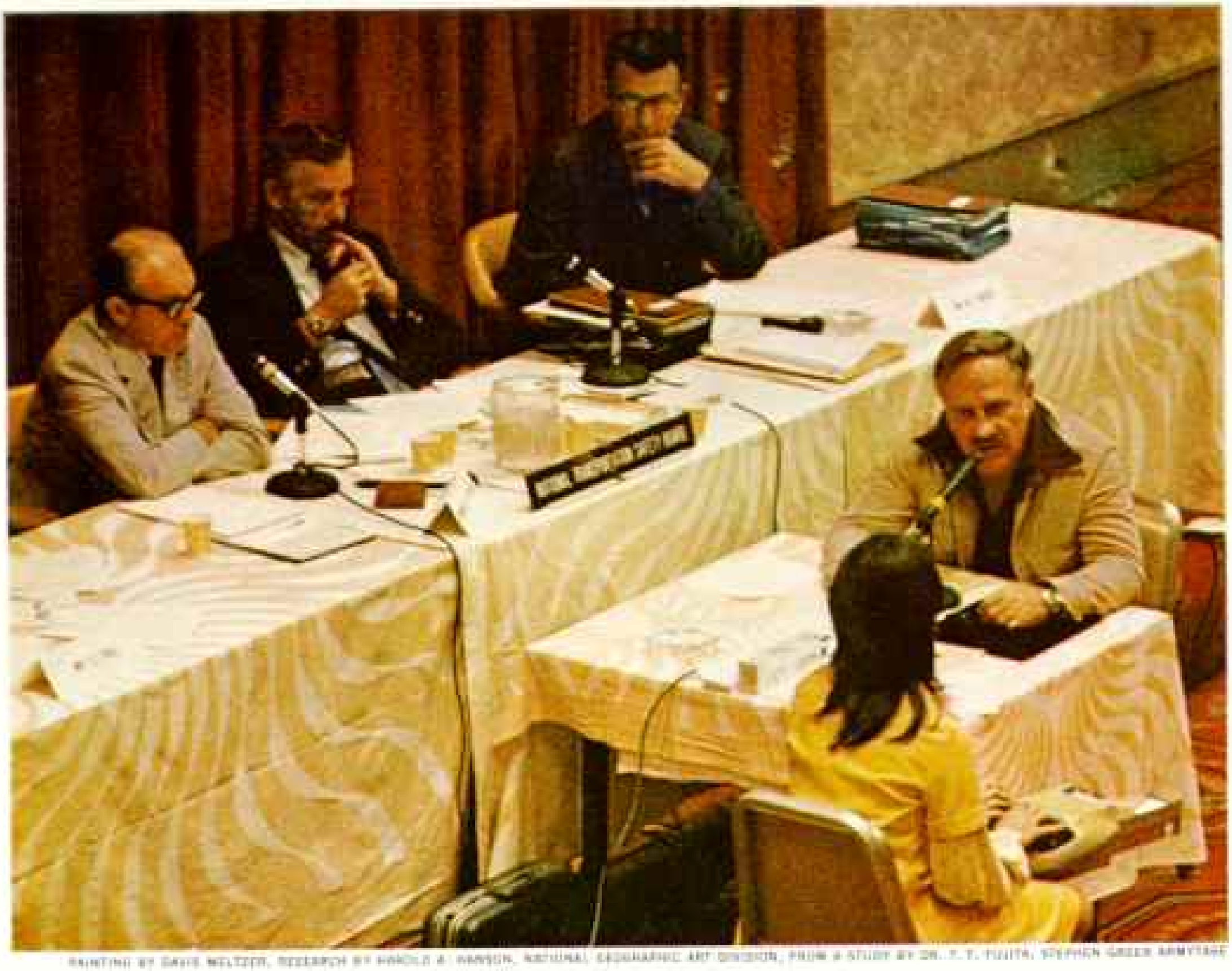
Rare Storm Type Identified

Wind shear's most severe tantrums are rare, short-lived, and difficult to predict with accuracy. At the request of Capt. L. Homer Mouden, manager of flight safety for Eastern Airlines, the JFK thunderstorm was analyzed by Dr. T. Theodore Fujita, professor of meteorology at the University of Chicago. Poring over some 3,000 bits of weather data, Dr. Fujita concluded that he had identified a new, rare, fast-moving thunderstorm (page

Flight 858 LANDS (3·48 p.m.) after flying through downburst cell 1

Flight 902 ABANDONS APPROACH (3·58 p.m.) after clash with cell 2

Flight 66 CRASHES (4·05 p.m.) during encounter with cell 3



PAINTING BY DAVID MEITZER, RESEARCH BY HAROLD A. HARRISON, NATIONAL GEOGRAPHIC ART DIVISION, FROM A STUDY BY DR. T. T. FUJITA, STEPHEN GREEN-ARMYTAGE

Jetliners ran a gantlet of violently changing winds at New York's John F. Kennedy International Airport on June 24, 1975. Later analysis of the thunderstorm by meteorologist Dr. T. Theodore Fujita of the University of Chicago revealed the existence of avalanches of air he calls "downburst cells," a form of windshear—sudden changes in wind speed or direction.

Allegheny Airlines Flight 858 passes through the first cell (**left, top**), presumably less intense than others. In cell two (**left, center**) Eastern Airlines Flight 902 suffers a drastic airspeed loss. The pilot applies maximum power to abandon his approach.

"Pushed to the ground by the extraordinarily strong third downburst cell," according to Dr. Fujita, Eastern Flight 66 strikes the ground short of the runway, killing 113 people (**left, bottom**). The crash spurred a multimillion-dollar FAA program to help pilots recognize and fight wind shear.

Cliff Stout (**right**), director of flight operations for the Douglas Aircraft Company, led the industry in analyzing how jet aircraft react to shear, now regarded as a significant factor in many accidents previously ascribed to pilot error.

He landed. Capt. John H. Bliss testifies at the National Transportation Safety Board hearing after the crash of Flight 66. Despite encountering wind shear in downburst cell two of the JFK storm, Bliss (**above,** right) successfully landed a few minutes before disaster befell Flight 66.

NICK KELSH

Horizontal tornadoes revealed by smoke and balloons whirl in the wake of a 747 in a NASA–FAA study at Rosamond Dry Lake, California (**above**). The heavier the airplane, the more severe the upset hazard to smaller aircraft following too closely.

Encountering the invisible vortex of a jetliner on approach to Stapleton Airport, Denver, pilot Bob Langenwalter suddenly found himself looking at the runway from a ninety-degree angle. "Like hitting a brick wall," he recalls. He managed to level his small airplane just as he crashed. Unhurt, he was flying again in two weeks.

The twisting effect of a vortex, outlined by dye, on a following aircraft is studied underwater (**facing page**) at Hydronautics, Inc., in Laurel, Maryland. More needs to be known. Meanwhile FAA requires strict separation standards—as much as six miles.

220), which—from its shape on weather-service radar—he called a "spearhead."

"Downdrafts are so severe," Dr. Fujita told me, "that I call them downbursts." For Flight 66 this was an avalanche of air descending at around 1,300 feet per minute.

"The rain showers beneath these storms may look innocent enough," he said, "but I guarantee you the winds are formidable. Something must be done."

Something is being done. After the crash of Flight 66 the FAA declared war on shear. The agency embarked on a four-year, 15.5-million-dollar program, including the development of ground-based devices to detect shear and airborne equipment to help pilots combat it. The first ground-based system is expected to be operational this year.

An aviation meteorologist told me that, after analyzing weather data, he concluded that shear had been a factor in 30 accidents worldwide in the past ten years. The Air Line Pilots Association had asked the FAA to investigate shear since the early 1960's.

In 1958 Northwest Orient Airlines began to develop a method of forecasting shear related to certain weather fronts. By 1962 they had succeeded. Northwest's method is now a weapon in FAA's war.

Ironically, it took the crash of a wide-body jet in 1973 to prove shear beyond doubt. These airplanes have computers that record many kinds of aircraft-performance data. Engineers put the data together, and for the first time fingerprinted an actual shear.

The fatal crash of Flight 66 brought final action. "It's another example of 'tombstone safety,'" said Wright Brothers Memorial Trophy winner Jerome Lederer, president emeritus of the Flight Safety Foundation.

At the Controls of the Big One

One day near Seattle, Washington, Jack Waddell, Boeing's chief test pilot, invited me along for a flight in the 747SP, the long-range version of the 747. About forty miles north of Boeing Field, cruising at 3,000 feet, Jack asked me to sit in the captain's seat.

"I've been telling you this is an easy aircraft to fly," he said, "and now I'm gonna prove it. When you're ready, punch that little black button and start flying." I hesitated. The button would disconnect the autopilot.

Jack doesn't hesitate. He pushes the button

and says, "You've got it." With some concern I grasp the yoke, which connects me with 300 tons of airplane. Old habits return as I scan the flight instruments, including a crossbar gadget called a "flight director."

"Keep those bars centered. It's so easy I think a monkey could do it," Jack says, bolstering my confidence if not my self-esteem. Air-traffic control interrupts, clearing us to descend to 2,200 feet.

Jack adjusts airspeed, heading, and altitude markers above the instrument panel and says, "Keep the bars centered and we'll go down." So we do. Leveling off, I am wondering when he is going to take over.

"You're forty feet low. Watch that altitude, now," he commands. Air-traffic control interrupts again with three startling words: "Cleared to land."

"I'm giving you flaps and gear," says Jack. "Get off those instruments and let's have some fun." I glance up. The runway is six miles away. It looks like a candy bar.

"Like sliding down the pole," says Jack. "You're a little fast. Put your hand on the throttles and get her down five knots to 150. Just like an F-9. No different."

Fourteen hundred feet. "Got a little crosswind," he observes. "Eleven degrees left drift. Notice how light those ailerons are? Guy's really got to be careful with them." Ailerons are the hinged panels on the wings that help turn the aircraft.

Seven hundred feet. "Raise the nose just a hair," Jack says. "Everything's fine."

Three hundred feet. The candy bar is becoming a big black runway. I am a little to the right of centerline and I am going to stay there. Those ailerons.

Over the runway, Jack speaks faster. "Ease that nose up—higher—now hold it right where it is, rightwhereitis. Don't do anything." Suddenly I feel him firmly on the controls.

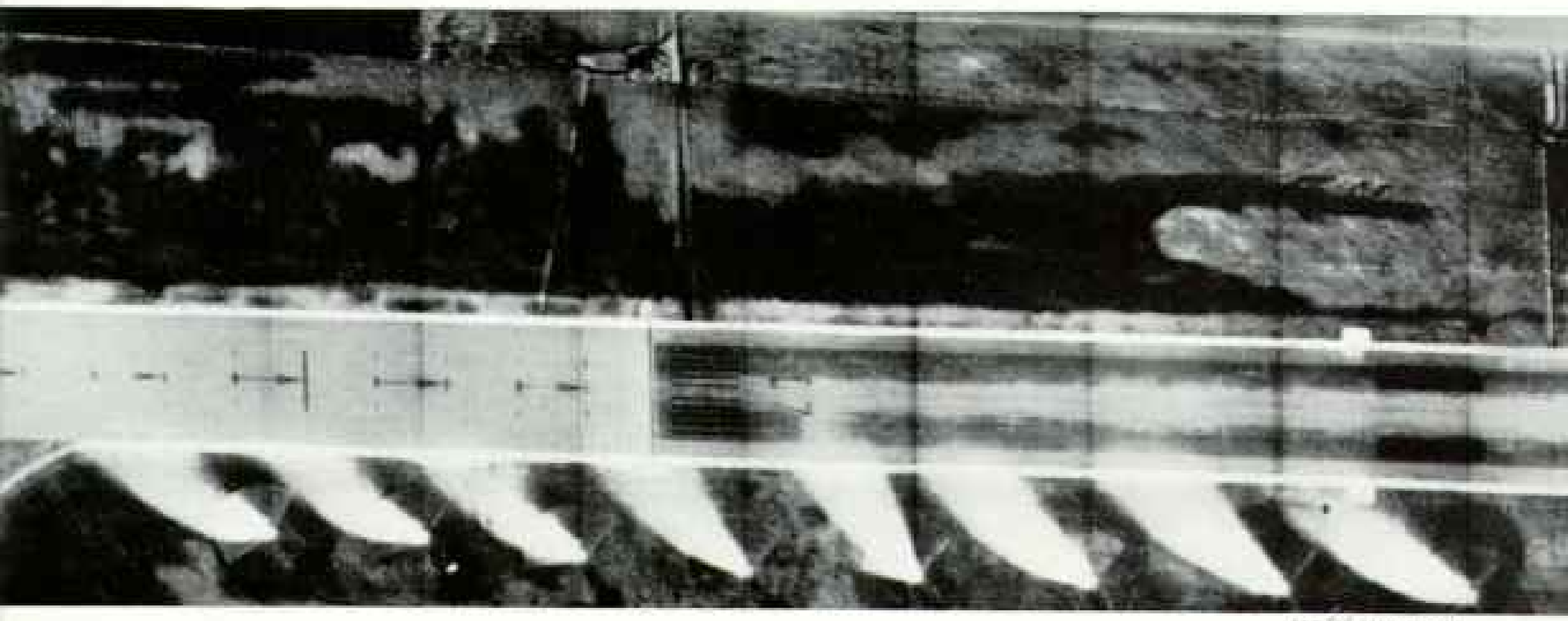
Touchdown.

Am I asking you to believe that I stepped right into a 747 and landed it? No. But there's something I'd like you to understand: During that approach I had no trouble keeping the aircraft lined up with the runway. But I had to keep referring to the flight director and other instruments to maintain the proper descent angle. The name of this problem is "vertical guidance."

Pilots Pinpoint Crucial Issue

After several crashes took the lives of 467 people in 1974, Richard P. Skully, director of FAA Flight Standards Service, asked six retired airline captains of outstanding reputation to take a close look at the U. S. aviation system and recommend ways to do things better. "I told them to fly anywhere, to talk to anybody," said Skully.

Months later the captains filed their report, with numerous recommendations. The one thing they considered most important, the



SOCIÉTÉ BERTIN & CIE

Fog-fighting jet engines, their heat plumes revealed by infrared film, blast across the landing zone of a runway at Orly Airport outside Paris. Pilots can order the Turboclair engines ignited to dispel enough fog to permit an approach or a takeoff.

one thing that was unanimously mentioned by the nearly 1,000 pilots they interviewed, was the "lack of vertical flight-path guidance" during approach and landing.

Vertical guidance. What is it?

Suppose you're driving down a sloping highway on a foggy night. The road controls your angle of descent. Now imagine the road is gone, that you are flying instead of driving. What can tell you whether you are below, above, or on your approach path—something that gives you vertical guidance?

At many U. S. air-carrier airports the Instrument Landing System (pages 230-31) gives a pilot an electronic ramp to guide him toward the runway. By scanning his flight instruments, he knows he is on this ramp. Instrument Landing Systems, or ILS's, are installed on the approach ends of some 500 U. S. jetliner runways.

The ILS electronic ramp does not guide the pilot—or the autopilot—all the way to the ground. At some point the pilot has to go "head up," looking for outside visual cues that will enable him to land. This transition period from instruments to outside visual references can last five or six seconds.

What does the pilot need to see when he is transitioning from instruments to the real world? I have asked the experts this question from Los Angeles to London, and their replies would fill a book. Basically, they disagree; sometimes they fuss.

Understand first that low-visibility approaches are few. They're like the very tip of the needle at the bottom of the haystack. Then what's the fuss?

The NTSB has long recommended that the FAA forbid pilots to go below a predetermined "Decision Height" unless they can see the runway. The Air Line Pilots Association has made similar recommendations. The FAA maintains that its regulations setting Decision Heights for various aircraft and runway facilities are safe.

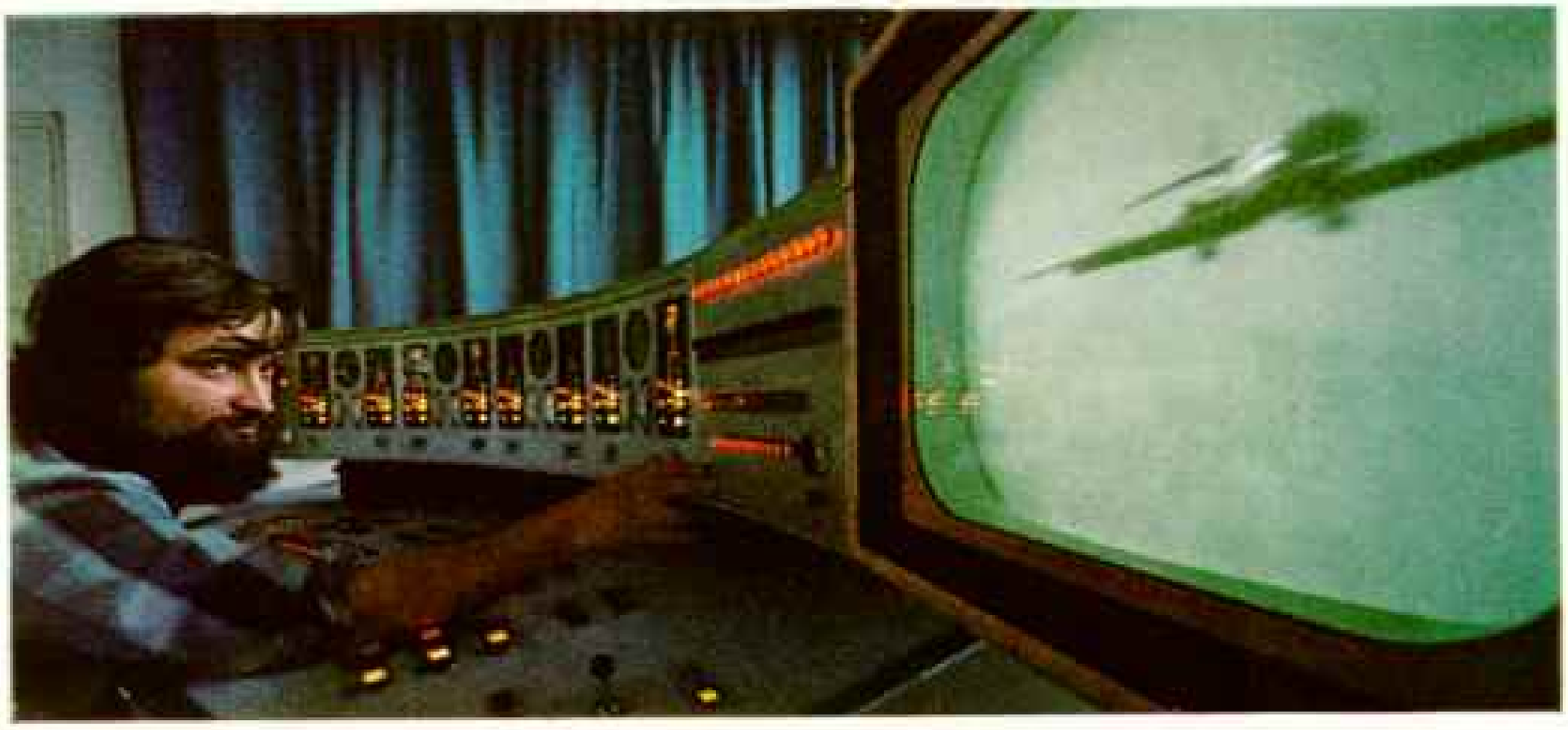
Opinions Vary on Need to See

But there are continuing questions even within the FAA. Dr. Stanley R. Mohler, chief of the Aeromedical Applications Division of the FAA's Office of Aviation Medicine, said he thinks a pilot, when transitioning, should see his "aiming point"—the point, roughly a thousand feet down the runway, where he wants to land. The FAA does not require this.

Usually a pilot may "legally" continue his descent if he can see some of the approach lights that extend out from the end of many runways (page 233). He sees them before he sees the aiming point.

How does this affect the safety of a bad-weather electronic-ramp approach when the visibility on the runway can be as little as 1,200 feet?

Retired Trans World Airlines Capt. Robert N. Buck, who flew many of these approaches



It takes only a minute for the Turboclair system to clear fog. In the control room at Orly, a French Caravelle on final approach shows on the TV monitor. Other airports, including fog-plagued Los Angeles International, are studying the system.


AIRCRAFT CRASH TE

ALL BY JAMES F. BLAIR

Crashing to save lives, a Piper Navajo (**above, right**) begins a controlled descent to impact (**above**) at NASA Langley's former Lunar Landing Research Facility, where Neil Armstrong and other astronauts trained to land on the moon.

The Piper Aircraft Corporation donated 32 Navajos—all flood damaged by Hurricane Agnes—thus enabling NASA to begin the first free-flight-crash test program in the world.

"We've never before had real aircraft to crash under controlled conditions," says NASA's Dr. Robert Thomson, making a post-impact check of dummy occupants (**left**). Thomson and the manufacturers hope the long-range program will make a dent in such little understood areas of crash protection as seat and airframe construction.

Tragedy at Tenerife. On a foggy runway in the Canary Islands last March, a KLM 747 nearing takeoff speed smashed into a taxiing Pan American 747. Aviation's

into foggy Paris, told me, "If you're confident that your autopilot is working, you're 'in the slot' at the 100-foot Decision Height. You've arrived. You don't normally see the aiming point here, but you do a second or so later. The worst that can happen is a hard landing."

Captain Buck is talking about a brief period of "ballistic" flight that occurs after the pilot disconnects the autopilot and proceeds visually. During this period the aircraft is "aimed," but the pilot cannot yet see his aiming point. On some approaches this interval can last four or five seconds. Remember this.

The autopilot can't be used on a runway that does not have an ILS; there's no electronic ramp for the gadget to lock on to. Here the pilot flies the entire approach. He descends to a specified height where, according to the regulations, he must see the "approach threshold of that runway, or approach lights or *other markings identifiable with the approach end of that runway*. . . ."

There's been a fuss over the phrase I've italicized, even among the guys who make these rules in FAA's Flight Standards. "The phrase . . . is ambiguous to the extreme," an internal memorandum stated. "A motel sign, building, or other object could possibly be established in a pilot's mind as being 'identifiable' with the end of the runway, and this is not the intent of the rule."

Rules Are Not Unbreakable

Nevertheless, the rule remains the same. Recently the FAA has begun to install a radio "fix" at the point where the pilot should be seeing the required visual references.

Occasionally a few pilots "bust" minimums —descend below minimums in order to land.

PHOTOGRAPH BY RUSSIA, KAPPA PRESS/LIAISON

worst calamity took 580 lives; stunned survivors stand near the Pan Am craft's left wing. Investigators are still sifting evidence to determine probable cause.

"We can't tell you how many times they make it," said NTSB Chairman Todd, "but we can tell you once or twice when they didn't."

Are you "shocked"? Why? Have you never run a red light in a hurry to get home? The FAA recognizes the "subtle but strong pressures on the pilot to land, deliver his passengers, and avoid costly diversions when weather conditions are marginal."

In the low-visibility environment, pilots occasionally face a subtle and dangerous foe —the visual illusion. An example: On an approach through patchy clouds, a captain looked up when his first officer called, "Approach lights."

"I seemed to be unbelievably *high!*" the captain recalled. Resisting the temptation to lower the nose, he checked his instruments, which told him he was still on the approach path. He landed safely.

The effects of this illusion have been known for decades, but since it's rarely encountered, pilots can be surprised.

"Patchy clouds can tempt a guy to go visual too soon," said Capt. Paul Soderlind, former director of flying for Northwest Orient. "He breaks out a bit, disregards his instruments, and tries to do it by the eyeball method. I feel this is the worst hazard of all."

There's a lesson here, and on this point there's no fuss. Let Capt. Frank Ormonroyd, flight technical manager for British Airways European Division, speak for everybody: "The lower we go on instruments, the safer we get."

Make the Choice—and Get the Blame

Suppose that a pilot can't see anything at all at Decision Height, or that he sees only some of the approach lights, which offer him

Electronic landing aids—the pilot's foul-weather friends

RADIO BEAMS transmitted to the flight deck give pilots an electronic ramp to guide them toward the runway in low visibility.

Narrow beams of today's Instrument Landing System

MLS segmented, or zigzag, initial approach

Microwave Landing System

Scanning beams of the MLS provide coverage to an altitude of 20,000 feet and fan out into an arc, 15 miles wide at the outer-gate distance. Automated aircraft of the future will use the signals to fly curved, segmented, or path-stretching initial approaches. Thus a pilot can avoid noise-sensitive areas, steer clear of obstacles, and enjoy better traffic separation. Aircraft with different speeds will use MLS gates, or entry points, at varying distances from the runway.

Glide path for both ILS and MLS. ILS path is fixed, MLS path can vary.

Instrument Landing System

The ILS glide-slope beam provides the proper angle of approach; the localizer beam provides direction. Together they define the glide path, the path a pilot wants to follow to the runway.

MLS outer gate for faster aircraft, some nine miles from runway

High-speed MLS initial approach

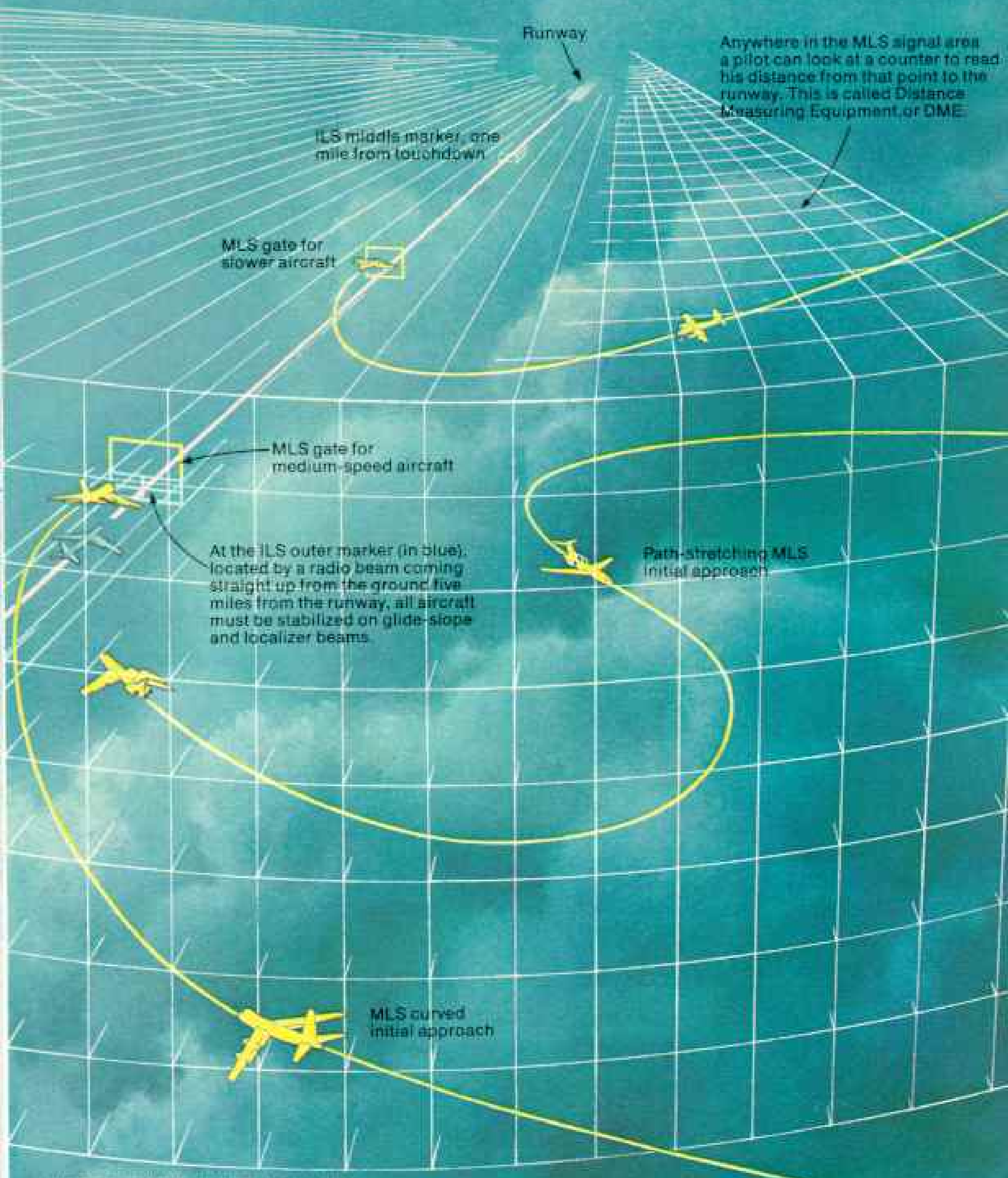
ILS initial approach

Glide-slope beam

Localizer beam

(ILS) funnel blue aircraft in diagram toward the airport in single file. Scanning beams of tomorrow's Microwave Landing System (MLS) will practically calibrate the sky to permit aircraft more flexible initial approaches.

But even with MLS, aircraft on final approach to the runway will be stabilized on the electronic ramp, just as they are on ILS today. The new system will coordinate the arrival of aircraft with differing approach speeds to make maximum use of the runway. Now being considered at the international level, MLS could be installed in the early 1980's.



PAINTING BY DAVID MILTZER, RESEARCH BY HAROLD A. HARRON IN COOPERATION WITH JAMES E. GRACE, AVIATION CONSULTANT, NATIONAL GEOGRAPHIC ART DIVISION

little vertical guidance. What should he do?

"The rules require the pilot to decide whether the visual guidance is 'adequate,'" said Dr. Edward S. Calvert. "If he crashes, then by definition he made the wrong decision and can be blamed."

Dr. Calvert retired in 1965 from the Royal Aircraft Establishment after a distinguished career studying the low-visibility landing. Bent and gray, he is described by a pilot friend as "one of the most unboffinlike boffins that ever was." "Boffin" is British slang for scientist. Though Calvert never learned to fly, he speaks a pilot's language.

"Even in quite good visibility," he told me in Camberley, England, "visual guidance in the vertical plane is poor until the pilot's eyes are about 100 feet above the ground."

Hearing this, I realized why I had to check the flight instruments during my approach in the 747.

Dr. Calvert explained that he and his colleagues developed a clear-day guidance aid. Next time you land, you might notice the lights beside the runway at the touchdown point. Pilots use the relationship between them for vertical guidance.

They say, "Red over white, you're right" (on the approach path). "Red over red, you're dead" (below the approach path). Don't let that scare you. You've heard about "pilot error." This is "pilot humor."

Dr. Calvert continued: "With automatics as good as they are now, you can afford to do a few seconds of ballistic flying in low visibility before attempting to fly visually. During this time you are not really seeing enough for vertical control, and the legal implications of that are quite unpleasant for the writers of the regulations.

"But with high-quality automatics, do you need to? No harm'll come, provided you don't encounter shear and have to correct something, or have an illusion and think that you have to. Without seeing the aiming point in those situations, it's a very serious business."

For Iberia Air Lines Capt. Jesús Calderón Gaztelu, approaching Boston's Logan Airport on December 17, 1973, it became serious business. After an autopilot approach, Calderón disconnected and switched to visual flight. Fortunately no one was killed when the McDonnell Douglas DC-10 crashed. In its report the NTSB blamed an encounter with wind shear, which resulted in an increased rate of descent that Calderón "did not recognize, and may have been unable to recognize" because of "marginal visual cues" resulting from the low ceiling and poor visibility in the final-approach zone. The safety board stated that Calderón was just three seconds too late in taking corrective action.

Opinions Vary on Study Cancellation

Who gives serious answers to serious questions about serious business? Researchers can, but the researchers tell me their work has never been carried to conclusions that compel. At Wright-Patterson Air Force Base a few years ago the FAA and the Air Force launched the most scientifically thorough investigation of the low-visibility landing ever attempted, beginning with a simulator.

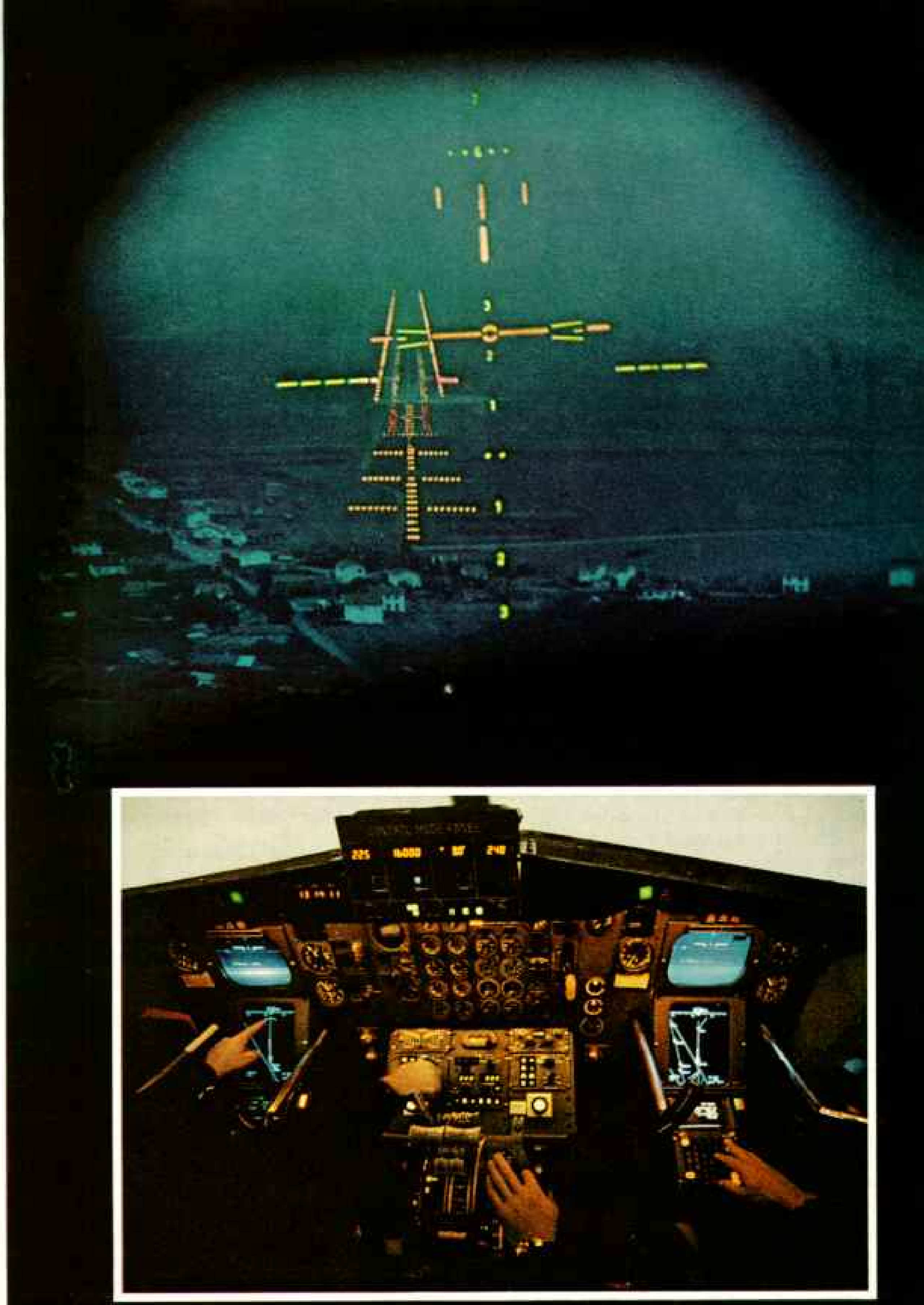
"For the first time, pilot performance was being tested under the most trying conditions," said Aer Lingus Capt. St. John McCloskey, chairman of the All Weather Operations Study Group, International Federation of Air Line Pilots Associations.

Before actual flights were undertaken, the program was stopped by FAA, at the recommendation of the Air Transport Association of America, the organization that represents most U.S. scheduled airlines. The ATA felt that the program had proceeded without their consultation, and was being conducted with military hardware that might not be applicable to the needs of civil aviation.

An FAA official told me that his agency considered the simulator "inadequate."

Reducing transition time from instrument to visual flight, an electronic display superimposes flight-path information on the lighted runway and approach-light system at Toulouse, France (**top**). The Head-Up Display, mounted on a pane of glass near the windshield, is directly in front of the pilot's eyes; here the captain of an Air Inter airliner maneuvers against a strong crosswind.

Near the top of the instrument panel of a Boeing 737 (**right**) at NASA Langley, two cathode-ray tubes present similar information. Pilots generally prefer the head-up version, but NASA is evaluating both for airline operations.



A researcher on the program agreed that "the simulator was not adequate, nor was the study intended, to address safety issues from the regulatory point of view." But, he added, "The simulator was entirely adequate to examine the study's basic question: What must the pilot see, and for how long, to land an airplane in low visibility? This question has never been answered."

A representative of the U. S. Air Line Pilots Association told me that the study promised to "cast doubt on the safety of present landing minimums."

In their report the researchers commented that the problem of approaches and landings in poor visibility remained "extensive and ill-defined," and that the part of the problem they had looked at was like "the tip of an iceberg."

Toward a Safer Tomorrow

The low-visibility "iceberg" is a rare berg indeed in the ocean of landings, and pilots are doing a good job of steering over it. How can they do a better job in the future? The practical answer: better gadgets.

One possibility is the Head-Up Display, which projects crucial flight-path information on a glass in front of the pilot's eyes, showing him what to do to stay on the approach path (preceding page). There's been a fuss for years over this gadget. Finally, at FAA's request, NASA is evaluating HUD for airline operations.

The inevitable trend, however, is automation. Someday a jetliner will be built that will fly itself from takeoff to touchdown; pilots will merely monitor its performance. They're monitoring certain landings now.

In 1976, the second year of British Airways European Division's operations in Category III, "the blind landing," their jetliners autolanded at Heathrow Airport in runway visibilities as little as 100 meters. That's a bit longer than a football field, the distance a jet traverses in 1.3 seconds.

On November 18, 1976, a TWA crew penetrated the "Cat III" bastion with an autoland at 1,000-foot runway visibility in a Lockheed TriStar at San Francisco. This is the wave of the future, but don't hold your breath until it reaches the Altoona airport.

Unlike an autopilot, an autoland system goes all the way. Latched onto the radio altimeter during the final moments of the approach, computers land the airplane. Pilots merely monitor the instruments.

From the flight deck I have viewed half a dozen clear-day autolands by the TriStar and the Boeing 747. They possess systems that are the peak of the engineer's art—as does the McDonnell Douglas DC-10. Autoland can deliver you where you want to go, and when, with little regard to weather. But there is some question whether these systems are providing enough information to the pilots who have to monitor them.

"Approaching the runway in the Category III environment, man and machine are out of time," said William F. Swartz, one of the "iceberg" researchers at Wright-Patterson. "Better instruments or displays are crucial for the crew to perform their monitoring task, and to alert them to take over in the remote event of system failure close to the ground."

Thomas G. Foxworth, a veteran Pan Am pilot and an aeronautical engineer, comments: "In the flight deck of the future, we may as well put the pilots behind glass and give the flight attendant an ax, with instructions to break the glass in case of emergency."

There's another fuss brewing here.

Relax and Enjoy It

Listen, though, to an Air Force officer recently retired from "Wright-Pat." He has made scores of landings in visibilities that would immobilize a snail. He has shared his findings with many airline pilots. He's not a loud man.

"Tell your readers," Lt. Col. Larry Hadley suggested, "that their pilots are tremendously experienced. They know that the problems exist, but the record shows that passengers are in doggone good hands."

When the rain slants across your window on final approach, remember that. □

Who's afraid of flying? Not the traveling public, who throng aboard jetliners in ever increasing numbers. In a passenger lounge at Dallas/Fort Worth Airport, the mood is casual, and rightly so. These people will be about ten times safer during their flights than if they were to drive their own automobiles the same distance. BOB KELLER


11 To 16
Commuter Airlines
Gate 16

Penguins and Their Neighbors

By ROGER TORY PETERSON

Photographs by
DES and JEN BARTLETT

WE COULD HEAR the penguins long before we saw them—myriads of clamorous rockhoppers trumpeting "Hurrah-hurrah-hurrah," swarming where the island sloped jaggedly into the South Atlantic. Porpoises played there, and fleets of the red-eyed little gnomes zipped among them. Coming in to land, each penguin swam the final stretch underwater and then popped out onto the shelf of rock like a jack-in-the-box.

Long files of rockhoppers, still dripping, hopped up the slanting ledges. They bounced from boulder to boulder like midgets in a sack race. When the rocks became too steep or slippery, they dug their sharp nails into grooves gouged by their ancestors over the years.

Charmed by these deceptively doll-like birds, my companions were tempted to pick them up—they weigh only six pounds and stand scarcely two feet high. "Don't try it," I warned. "There is nothing cuddly about them. The cutting edge

Abandoning an Antarctic iceberg, a file of Adélie penguins heads for the open sea. In the world's lonely southernmost reaches, a noted ornithologist and his shipmates find the wildlife population spectacular and varied.

of the rockhopper's beak is knife sharp."

We had traveled thousands of miles to witness this spectacle on Westpoint Island, one of the Falklands, off the southern tip of South America. It was our first port of call in the M.S. *Lindblad Explorer*'s latest wildlife odyssey to the latitudes of the Antarctic. As an expedition naturalist, I had during ten such voyages become enamored of the natives—the penguins—those unbirdlike birds whose behavior at times seems so much like ours. But my fellow passengers and I would also observe the other creatures that abound in the subpolar seas: albatrosses, petrels, shags, seals, as well as the now scarce whales. The lonely Falklands are one of the richest areas for seabirds and marine mammals on the fringes of the South Atlantic.

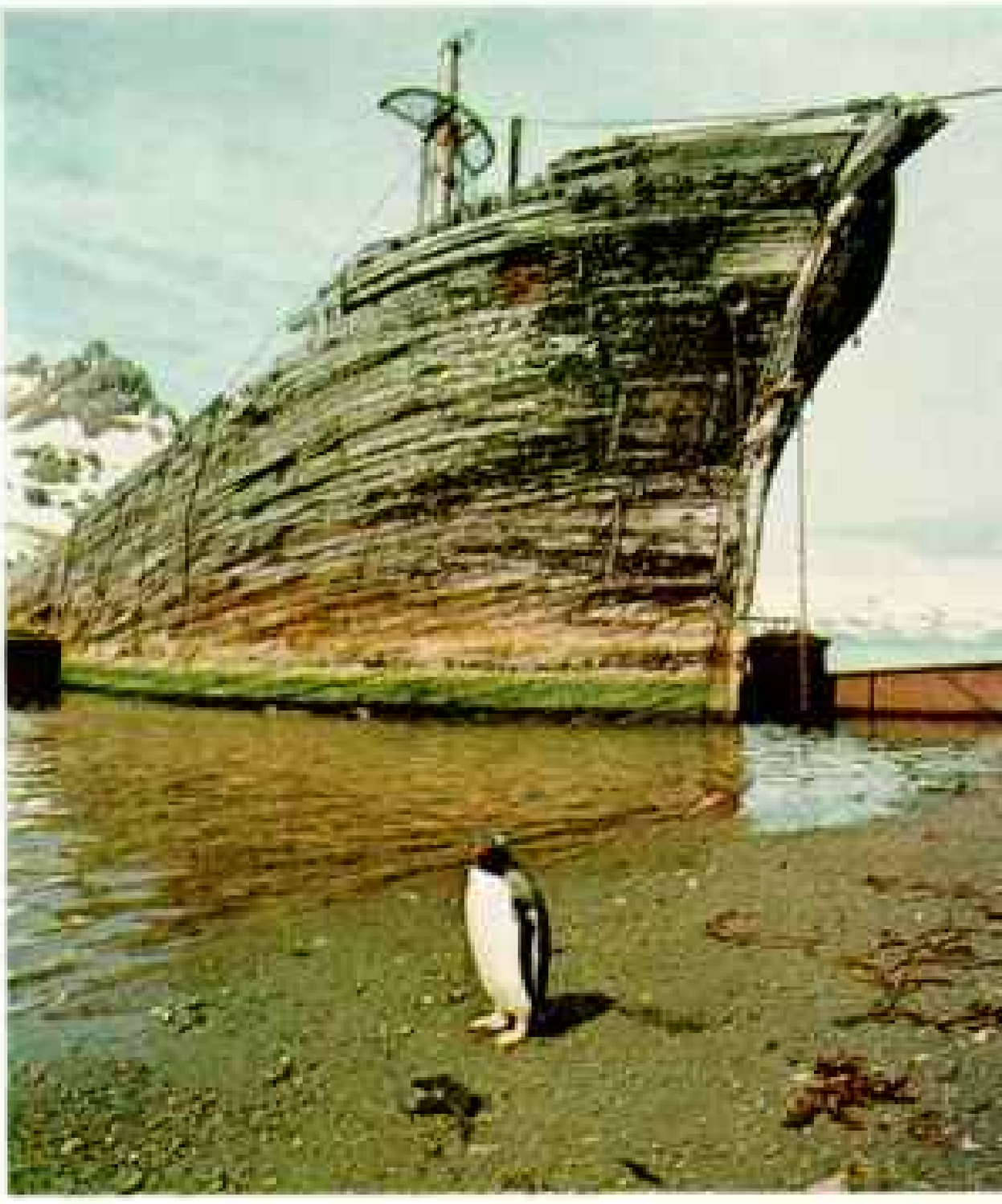
Congregating by the thousands, the rockhoppers poked, jabbed, and jostled one another. They were rude to us too. Several went out of their way to nip at us and flail our shins with their stiff flippers. While we surveyed the unruly multitude, a dark hawklike bird swooped in and grabbed a fuzzy chick. It was a striated caracara, one of the world's rarest birds of prey.

A far worse predator once riddled penguin populations. During the 1800's men killed millions of penguins in the Falkland Islands and boiled the carcasses in iron pots to render their oil. Today the penguins here are government protected, and rockhoppers alone must number close to five million.

There are some 17 species of penguins. In my travels I have seen and photographed them all. Only three—the emperor, the Adélie, and the chinstrap—are strictly Antarctic. The others range from the more temperate subantarctic islands to the tropics. One, the Galapagos penguin, even reaches the Equator.

The common denominator in their environment is a cool or cold ocean current. But imagine swimming about in icy seas in a thick waterproof suit, then landing on a rocky shore to spend days in a crowded colony with the sun beating down. How does a penguin

More than a holiday on ice, the journey between subpolar islands and the Antarctic Peninsula (**above**) on the M.S. *Lindblad Explorer* offered passengers an intensive course in natural history. At an abandoned whaling station on South Georgia island, a lone gentoo penguin saunters past a rotting hulk (**below**). Awaiting return to their ship (**facing page**), passengers toast Christmas Eve with spice cookies and hot wine punch. In a world of white, their red parkas help guides keep track of them.



The Author: A world-renowned ornithologist, artist, and nature writer, Roger Tory Peterson is perhaps best known as editor of more than 20 natural history field guides. Bird lovers have followed his simple identification methods for 43 years, since the first edition of *A Field Guide to the Birds* appeared in 1934.

adjust to such extremes of environment?

Its heating and air-conditioning system is superb. When it is swimming, innumerable small hard feathers overlap like tiny shingles to form a shell that effectively shuts out the cold water. Thick down next to the skin acts as a kind of thermal underwear. For added insulation there are subcutaneous layers of fat on the body.

To avoid heat prostration when ashore, a penguin can fluff its feathers to allow warm air trapped close to its body to escape. It may also pant, stand with its flippers well out from its body, or lie down with its feet extended, so that capillaries close to the surface of the underwing or the feet can release heat.

Underwater, penguins are as clean-lined as porpoises; their heads, pulled back to the shoulders, contribute to a torpedolike contour. While the bones of most airborne birds

are hollow for lightness, penguins are endowed with solid bones for ballast when they dive, sometimes to 850 feet or more.

Their wings, reduced to flippers, are propelled by powerful pectoral muscles, which enable them to hit speeds of 15 miles an hour. Penguins are the only birds that have developed the trick of porpoising. Time and again I have watched them leap clear of the water and then slip back in again (pages 248-9).

Barely a peek apart, a colony of 10,000 king penguins on South Georgia remains unperturbed by a crimson-clad photographer. Each nesting bird incubates a single egg atop its feet, covered by a fold of skin and feathers. Hatched the previous year, brown downy chicks take as long as 13 months to mature, overlapping the next mating season. Thus parents can raise only two chicks every three years.

Can this be love? Wandering albatrosses spread wings, clack bills, and shake heads in a ritual dance (**right**); bonds between courting birds may last the whole of a 50-year lifetime. Equally impressive, their wingspan may exceed 11 feet. Riding the wind, they can circumnavigate the world in far southern latitudes without ever touching land. A smaller black-browed albatross (**below**) nests placidly as a pair of macaroni penguins waddle past.

Here among the rockhoppers on Westpoint Island, I pondered the vast differences between the penguins and the black-browed albatrosses with which they were sharing the sea and the rocky slopes above it. Scientists suggest that both may have diverged millions of years ago from the same ancestral stock, the penguin to become an avian submarine, the albatross the supreme sailplane.

When I returned to the house of Roddy Napier, owner of Westpoint Island, I found a barbecue in full swing, with a long line of my shipmates savoring the repast.

Until the mid-1960's, visiting the seventh continent was generally possible only for scientists and support personnel. Then Lars-Eric Lindblad, a Swedish-American entrepreneur, began taking tourists there.

The *Lindblad Explorer* is a 250-foot, 2,500-ton ship, strengthened against ice, with a cruising speed of 15 knots and a capacity of 92 passengers. It is more a floating seminar than a cruise ship. Passengers attend lectures on Antarctic exploration, marine biology, icebergs, whales, and other topics.

Food Abounds Where Waters Meet

On this latest expedition our plan was to sail from the Falklands to the island of South Georgia, 900 miles southeast, and then double back to the Antarctic Peninsula, following the Scotia Ridge (map, page 239). This great underwater arc, a horseshoe-shaped extension of the Andes, joins the southern tip of South America to Antarctica, emerging above the sea at intervals to form islands. The voyage in Antarctic and subantarctic waters would take us three and a half weeks.

Between the Falklands and South Georgia the sea grew rougher, grayer, and colder; we

had reached the Antarctic Convergence, which corresponds, in a sense, to the tree line in the Arctic. Here, icy Antarctic currents meet more temperate oceanic waters from the north, and immense concentrations of the microscopic plant life called phytoplankton occur. This rich sea pasturage supports vast populations of zooplankton, small floating animals ranging up to shrimp-size krill, on which seabirds, seals, and whales feed.

Wandering albatrosses with wingspans of 11 feet or more and smaller black-browed albatrosses wove a crisscross pattern across our wake. Fulmars, storm petrels, skuas followed us. Capt. Hasse Nilsson, a trim, energetic Swede who runs the ship like a fine watch, would occasionally make a compelling announcement from the bridge: "There is a whale off the starboard bow!"

Low clouds hung on the mountains of South Georgia as they came into view. Now, plowing through the waves along the north shore, accompanied by hundreds of Cape pigeons, prions, and a few albatrosses, we entered Cumberland Bay's protected waters.

Not long ago hundreds of men lived on South Georgia; today its only residents are 20 to 40 members of the British Antarctic Survey. A supply ship lay at the BAS dock, so we glided on to Grytviken, which has known few ships in recent years. Once the whaling stations of Grytviken, Leith, Stromness, Husvik, and Prince Olav resounded with activity. Now all are ghost towns.

Grytviken stands as a silent, grim, and ugly memorial to the relentless destruction of earth's largest living creatures.* Tens of thousands of whales—blue, humpback, fin,

*William Graves discussed the plight of "The Imperiled Giants" in the December 1976 GEOGRAPHIC.

As if walking on water, a Wilson's storm petrel searches for tiny squid and crustaceans (**above**). Seven inches long, this is the smallest bird to breed on the Antarctic Continent.

A mixed menagerie crowds a South Georgia beach (**facing page**): king and gentoo penguins, corpulent elephant seals, and southern fur seals and their coal-black pups. Fur seals, once hunted nearly to extinction, today are making a comeback.

sei, and others—once were harpooned far at sea and towed here and to the other settlements where they were flensed and their blubber rendered into oil. Eventually the great factory ships and declining catches made such shore stations competitively impractical. These days we see few whales on our Antarctic cruises, except for killers and seis.

I have never set foot in a more disturbing place than Grytviken. The great platform on which the whales were cut up has not known blood and guts for years, but the aura of death is pervasive. The beach is a mortuary strewn as far as the eye can see with the whitened bones of countless whales. Yet lying among the debris were dozens of elephant seal pups, wide-eyed and innocent. Near one of the abandoned buildings a pod of molting elephant seals sprawled over the rusting machinery. These huge mammals suffered the same decimation as the whales but have made more of a comeback.

Until recently the elephant seals of South Georgia were harvested for their blubber under license from the Falklands, and up to 6,000 of the largest bulls were taken yearly. In 1964 the killing stopped.

A big bull elephant seal, largest of the seals, may measure more than 20 feet long and weigh three or four tons. Cow seals are about half as long. The big fellows contest for their harems in September, October, and November. Now, in December, they had returned to the ocean to feed on squid and fish. Pups conceived the year before were about two months old and newly weaned; they were living on their fat before going to sea themselves.

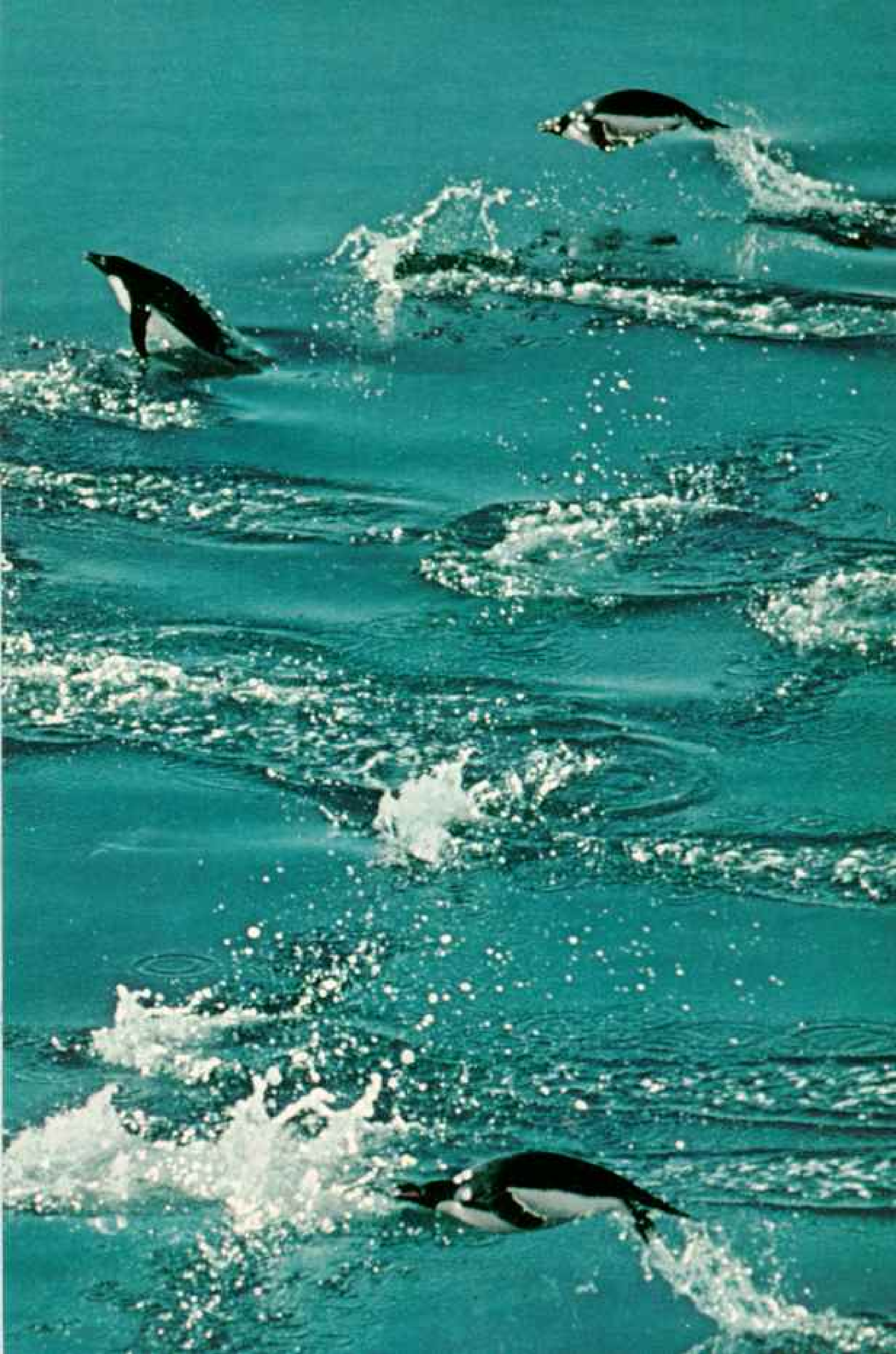
Before leaving the desolate whaling station, several of us joined Keith Shackleton, a veteran *Explorer* staff member, on a short pilgrimage. We followed a footpath to a little picket-fenced cemetery, where among the wooden crosses marking the graves of whalers and sealers stood a granite shaft. These words were inscribed on it:

TO THE DEAR MEMORY OF
ERNEST HENRY SHACKLETON
EXPLORER

In 1909 Sir Ernest Shackleton came within 111 statute miles of the South Pole, three years before Roald Amundsen and Robert F. Scott succeeded in reaching it. In 1915, on his third South Polar expedition, Shackleton's ship was crushed by the *(Continued on page 250)*

The fickle Antarctic: Passengers share the glacial calm of Paradise Harbor on the Antarctic Peninsula (**left**)—but on a similar day not far away, a 50-mile-an-hour gale springs out of nowhere. The crew rushes to ferry travelers from shore to ship (**top**). As the last rubber boat was hauled up (**middle**), lines broke loose, sending the expedition leader crashing into icy waves (**lower**). Rescue took five anxious minutes.

WITH THE GREATEST OF EASE *they fly through the seas—these porpoising Adélie penguins. Propelled as fast as 15 miles an hour by their flippers, they snatch a breath as they leap clear.*



A family epic draws wildlife artist Keith Shackleton to circle Elephant Island. In 1916, months after ice crushed *Endurance*, the ship of explorer Sir Ernest Shackleton, his expedition reached the island. From there, Keith's remote kinsman and five crewmen sailed to South Georgia. The 22 who remained survived 128 hellish days until his return. "A grisly place," says Keith; his painting of leopard seals (**below**) embellishes a page of the *Explorer*'s log.

(Continued from page 244)

ice of the Weddell Sea. He and his men set up camp on a drifting floe, eventually reaching Elephant Island, where he ordered 22 of his men to remain. Then the explorer and five picked companions sailed a lifeboat more than 800 miles to South Georgia. There they found help, and after several months all his men were saved.

The great explorer died on South Georgia of heart failure on January 5, 1922, the day after he arrived on another voyage. Now, Keith, his distant relative, placed a wreath on the simple grave.

Expedition Gets a Royal Reception

One of the best areas in South Georgia for the naturalist is the Bay of Isles. When we nosed our Zodiacs—rubber landing boats seating a dozen or so people—onto the long shingle beach, we were met by a large welcoming committee of king penguins. Standing shoulder to shoulder, they looked us over regally, then shuffled away in a body.

Reaching a height of three feet, kings are the most colorful of all penguins in their blue-gray jackets, bright orange collars, and silvery white shirtfronts. I can think of few other sights in the bird world more spectacular than a vast wall-to-wall carpet of king penguins. This colony of 10,000 birds rested near the foot of a small melting glacier.

From a nearby slope I could see virtually every penguin in the colony. Each incubating bird was holding a single, greenish white, pear-shaped egg on top of its thick feet, keeping it warm under a bulging apron of skin and feathers (pages 240-41).

The birds were evenly spaced, keeping one another in place with a jab of the beak or a slap of a flipper. When a homecoming king ambled through the colony, it was assailed on all sides. Here and there, wounded flippers bloodied the white breasts of combatants.

Weighing 30 to 40 pounds, the king penguin is second in size only to the emperor, which may weigh twice as much and stand four feet tall. But unlike the emperor, which spends its life on the sea ice of the polar coasts, the king inhabits the barren, muddy flats and beaches of subantarctic islands.

Its life cycle is unlike that of any other penguin. The chicks take as long as 13 months to become self-sufficient; a pair of adults can

successfully rear only two chicks during a three-year period. Most birds, we observed, were incubating eggs, while a few adults tended offspring as large as themselves. Some youngsters, looking like long-nosed dwarfs wearing brown fur coats, were shedding their youthful fuzz. Presently they would look not unlike their parents, and would put out to sea to run the gantlet of predatory leopard seals while learning to catch fish and squid.

Leaving the nesting penguins, we crossed to Albatross Island, still in the Bay of Isles, to see the nest of the wandering albatross, one of the largest of 13 species (pages 242-3). Airborne, it is a champion glider, but it must paddle and flap laboriously into the wind when taking off from water.

Using ropes, we scaled the bluff above the beach to the grassy plateau where the birds lived and were now beginning their breeding cycle. A few of the previous year's young still sat about; they would soon be flying. Incoming arrivals greeted each other with bill clacking and wing spreading. They walked about like old salts, swaying from side to side.

As many as nine years may pass before a wandering albatross produces its first egg. It apparently takes that long to become efficient enough at gleaning the sea to feed another mouth. A pair raises one young every second year; thus only about half the breeding population is nesting during any one year. But the life span is long; some may live 50 years.

Even the immature wandering albatross that returns to its natal home after three or four years at sea may engage in ritual dancing and wing spreading with other young birds. Although no eggs are laid, the courting birds eventually form partnerships that may endure for life.

Unwilling Matador Faces Bullish Charge

To become more familiar with other albatrosses, we beached our Zodiacs one morning at the head of a deep bay at Elsehul, near the western extremity of South Georgia. On the way to the slopes where the birds were nesting, we had to avoid inert elephant seals, piled against one another like gargantuan slugs, and several bull fur seals belligerently guarding their harems. One of our party, John Dornan, bearing tripod and cinecamera on his shoulder, was charged by an angry 350-pound bull. Because of a stiff leg, Dornan had to stand his ground. "Stop where you are!" he shouted. The astonished fur seal, recognizing a really dominant male, halted in its tracks.

How different from the feisty bulls were the nesting light-mantled sooty albatrosses. Innocent of the ways of humans, they let us come near them as they brooded their large single eggs. One gently nibbled my fingers. Its mate swept past to look me over, riding the updrafts. This small albatross is perhaps the most perfect gliding machine of all: the stronger the gale, the more effortless its flight.

On a neighboring cliff overhanging the bay, we discovered a small colony of gray-headed albatrosses. With their pearly heads and black bills with yellow piping, they seemed to me the handsomest of all albatrosses. If a pair of gray-heads successfully manage to raise their single chick, they do not breed the next year, but take an albatross vacation, riding the westerlies.

Macaronis: Dandies of the Antarctic

That afternoon, on the other side of the bay, we investigated a huge mixed colony of black-browed albatrosses and macaroni penguins. The name macaroni, which in earlier centuries meant a "fop," derives from the drooping golden plumes that adorn the birds' caps. They lay two eggs, one smaller than the other, but, though both may hatch, only one chick is raised.

Untold thousands of macaronis occupied their boulder-strewn metropolis on a hill. Many were trumpeting noisily and showing readiness to mate, with head and bill stretched forward and flippers waving rhythmically. Their associates, the albatrosses, sat in dignified silence on their tall cones of mud and turf.

Leaving South Georgia in our wake, Captain Nilsson pointed the *Explorer* toward the South Orkneys. There, on Signy Island, site of another British Antarctic Survey station, snow petrels were flying about the cliffs. When I came upon a pair incubating their single white egg in a crevice, I edged closer with camera to my eye. Pfft! One of the birds ejected a jet of viscous orange oil over my lens, a disagreeable habit all petrels have.

The snow petrel nests on mountain crags as much as 200 miles inland on the Antarctic Continent, ranking it among the birds that live farthest south. Concealed beneath its

Lightning snap of a leopard seal's jaws dooms an Adélie penguin (**above**), as its companions huddle on an ice floe; a pair of black-backed gulls and a hovering storm petrel await scraps. Meanwhile, other terrified Adélies were leaping from the water into the photographers' rubber boat. With a flick of its head, the seal begins tearing its meal into bite-size chunks (**lower right**). Yet the penguins

blithely ignore another leopard as it snoozes on the ice (**lower left**), knowing that here they can easily outmaneuver their ten-foot-long enemy. Although leopard seals may claim as many as one out of twenty of a penguin rookery's adults, predatory birds such as skuas, together with exposure to storms and desertion by parents, often take a much higher toll of eggs and chicks.

JULIE BARTLETT

white plumage is a dark-gray down that gives warmth by retaining body heat.

Leaving Signy, we headed for Hope Bay near the tip of the Antarctic Peninsula. There Argentina has a far-south research station, Esperanza. As we reached the jetty, loudspeakers were blaring tango music.

Esperanza is one of the few stations that still use sled dogs. We found the huskies chained in a line not far from a colony of Adélie penguins—100,000 or more—extending from the station for at least a mile to the foot of a great glacier.

While we were making friends with the dogs, an Adélie waddled up to one and was met with a lethal snap of the jaws. Adélies—the little chaps in the tuxedos—have never known wolves or other endemic land-based mammals; thus they have no fear of dogs. I have sometimes wondered whether they regard humans as just another kind of penguin.

Walking through the colony, we came upon a group of Adélies that a leopard seal had forced to seek refuge on a ragged block of ice. Two of the birds were mutilated and bloody. The predatory seal, lurking under the lip of the ice, surfaced two or three times, watching us. Then an incautious penguin plunged in and swam for shore. Quick as a flash the leopard seal grabbed the Adélie, and thrashing it this way and that, literally shook the body out of its skin (preceding page). A leopard seal will feed on krill, but when near a penguin colony it likes its krill pre-processed.

Penguin Behavior Seems Almost Human

Captain Nilsson steered next for the Chilean and Russian scientific stations which lie only five minutes apart on King George Island.* I spent most of my time there at a peninsula where three species of penguins live together in enclaves—gentoos, Adélies, and chinstraps. These three closely related penguins belong to the same genus, *Pygoscelis*, which, loosely translated from the Greek, means "rump-legged." All have long spiky tails but differ in head patterns: The gentoo has a white patch over the eye, the chinstrap a narrow black line across its white throat, and the Adélie a solid black head and white eye-ring. The Adélie, which bears the name of French explorer Dumont d'Urville's wife, is the most strictly Antarctic of the three and the most plentiful, numbering in the millions.

A penguin community may be the size of a small town or a large city, and as I watched the Adélies, chinstraps, and gentoos going about their daily business, I thought that many of their activities seemed strikingly human. There is constant bickering—constant greeting, protest, and challenge. There is love (but no privacy). There is thievery, as when one penguin steals another's stones to build a nest, and even juvenile delinquency when unmated two- or three-year-olds clumsily take over unguarded nests and chicks, which they may not properly care for.

Natural Antifreeze Protects Icefish

The *Explorer* glided on from King George Island to Anvers Island and the United States' Palmer Station, the most comfortable base in the Antarctic. The recreation room's expansive glass windows look out on a bulkhead jetty where the *Hero*, research vessel of the National Science Foundation, is moored. This wooden ship, built in Bristol, Maine, was named after the sloop whose young captain, Nathaniel Palmer, may have been the first man to sight the Antarctic Continent.

As a naturalist, I was particularly interested in the station's laboratory research on the strange, colorless, almost transparent icefish, which have no hemoglobin, or red pigment, in their blood. I wondered how these fish are able to live among ice floes and icy caverns without freezing solid. A scientist explained that their blood contains a special protein—an antifreeze—that prevents ice crystals from forming in their bodies.

Swarms of Adélies nest near Palmer. Watching them, I thought how exactly alike to our eyes each Adélie looks. Yet a penguin instantly recognizes its own mate and chick by the sound of their voices—as experimental work with tape recorders has shown us.

Penguins, albatrosses, skuas, seals, and whales are other nations, responding to life rhythms quite alien to our own. To the naturalist, the Antarctic is a tremendous experience. Because of the simplified ecosystem and the great numbers of individuals of very few species, he can more readily observe cause and effect; he can understand more clearly some of the basic principles of survival—and life. □

*See "Antarctica's Nearer Side," by Samuel W. Matthews, in the November 1971 NATIONAL GEOGRAPHIC.

The awkward age: Bulging baby fat and a raggedy down jacket mark a young king penguin. At rookeries all around the Antarctic, men once killed penguins by the millions for their oil. Today, for this fledgling, only natural predators wait.

Nyet! Ne fotografirovat! A self-appointed censor blocks Dean Conger's picture of potatoes being sold at Tashkent in Central Asia. Photographic restrictions became commonplace to the author over the years he covered the Soviet Union for magazine articles and the upcoming National Geographic book *Journey Across Russia: The Soviet Union Today*. Objections to his camera work often sprang from ordinary citizens as well as from officials. "This woman, proud of her city, probably thought I was trying to depict something substandard," said Dean. In front of St. Basil's Cathedral on Moscow's Red Square, he relaxes on the other side of the lens (**above**).

A veteran photojournalist recalls the frustrations and delights of covering the Soviet Union, largest country on earth

FIVE TIMES TO YAKUTSK

ARTICLE AND PHOTOGRAPHS BY DEAN CONGER NATIONAL GEOGRAPHIC STAFF

EVEN BY THE STANDARDS of an itinerant photographer, Yakutsk is a long way from anywhere. Over the North Pole lies Greenland; far to the south, the Philippine Sea. Both are closer than Moscow. This rough, tough frontier city in Siberia is 14 time zones east of Washington, D. C. It is rarely in the itinerary of Westerners who have no special reason for going there, such as visiting the Permafrost Institute. Yet somehow I have managed to pass through Yakutsk no fewer than five times!

A good part of my life over the past 16 years has been spent photographing the fascinating, incredibly varied people and places inside the U.S.S.R.—or making arrangements to do so.

In the company of other National Geographic writers and editors, but often alone, I have crossed the Soviet borders on one assignment or another 26 times since 1961, covering nearly 100,000 miles. This labor has entailed great frustrations—and rewards.

Among the satisfactions, I count the more

Bedrock hospitality marked most Soviet dealings with the author. At Lake Teletskoye—a source of the Ob River—a picnic host offers the ubiquitous vodka, bane of journalistic concentration. Staff writer Robert Paul Jordan, background, offers cigarettes to the local game warden.

Age differences often reflected changing attitudes. After photographing a family that took him skiing (**right**), Dean learned that the older woman had viewed him with distrust. The children, innocent of earlier cold wars, eagerly sought his return.

than 340 illustrations appearing in *Journey Across Russia: The Soviet Union Today*. For this volume alone—produced by the Society's Special Publications Division—Assistant Editor Bart McDowell and I crisscrossed that sprawling nation for some 30,000 miles over a period of two years.

What is it like to work as a photographer in the Soviet Union?

To a journalist accustomed to freedom of movement, open access to all segments of society, and the right to follow a lead wherever it goes, the task can be near maddening. To accomplish anything at all, one must learn to live with the Soviet view that journalism is an instrument for the promulgation of state policy. The idea of a free press, as we know it, is foreign, mysterious, even repugnant.

It is small wonder that I was often thought of as a kind of spy—why else would I be there? I have been watched. I have had plainclothes police in my hotel rooms, pleasant but firm about not photographing from the window. I have been placed under citizen's arrest twice while taking pictures (and quickly released twice), and while I do not enjoy being suspect, I understand it. Russians have been suspicious of foreigners for centuries.

At times, if I tried to photograph a picturesque horse-drawn sleigh, or even a queue outside a shop, a bystander would object, demanding, "Why don't you photograph our monuments or our museums?" Pointing a camera at a rural oxcart, many Russians feel, constitutes malicious propaganda, demeaning their country's great industrial achievements.

But then, just try to photograph those industries!

Once I flew to the town of Mirnyy, deep in Siberia, 2,500 miles from Moscow. My official hosts graciously allowed me to photograph the schools, shops, streets, hospital—almost everything except the mining and processing of diamonds, which was my sole reason for going to Mirnyy.

There is a list of rules—both written and implied—stating what one can and cannot photograph. At times such rules are not enforced, but one is always aware that they *might* be.

Ordinary People Hard to Meet

It is a perpetual challenge to reach beyond the permissible, to seek simple meetings with average citizens, to observe and photograph significant situations not in the "program" prepared by your official hosts.

I recall the thought expressed by George F. Kennan in his memoirs, about returning to Moscow as U. S. Ambassador in 1952:

"Never did I long more for the privilege of

Journey through a colossus

THE AUTHOR'S ODYSSEY covered 100,000 miles, crisscrossing a nation that stretches nearly halfway around the Northern Hemisphere. Two watches were needed to keep him on schedule, since throughout 11 time zones trains and planes run only on Moscow time.

"I liked Siberia," said Dean, "though the name brings prison camps to the minds of most Americans. They are there somewhere, of course, but the rest is frontierlike. You can fly all day and see nothing but forests."

being, if only for a time, a part of these people, of talking with them, of sharing their life. . . . But this was not to be."

Our problems were not identical, but I find the ambassador's words still pertinent 25 years later. I know the gnawing worry about inadvertently causing problems to those who are friendly to you. And I have often felt discouraged by the constant effort to cross what Mr. Kennan called that "invisible and insuperable barrier."

Yet, with patience and luck, it does happen. I remember an evening in a Tyumen restaurant. It is common practice in Soviet restaurants to join others at tables with empty seats. However, foreigners are often segregated from ordinary diners. So when

three young people, two girls and one man, asked if they could sit with us, we welcomed the opportunity and said, "*Pozhaluista, sadites*—Please, sit down."

Only at that instant did they realize we weren't Russian. They looked flustered, and blushed. The lady manager of the restaurant, knowing that we were foreigners, rushed over and told our new friends in very brusque Russian that the table was *zaniat*—reserved. In Russian I protested that these were our friends; we wanted them to join us. Fortunately the manager relented.

These young people were from small Siberian villages farther to the north, and they were in Tyumen to compete in a cross-country ski race. This was their first visit to the "big city." We could tell by their expressions that to sit with foreigners was "blowing their minds."

Often Soviet restaurants have live music. And so it was on this night in Tyumen—loud, pseudo rock music. We danced with the girls, and they talked freely of their life in the village, of sports, and particularly about the skiing event they were to participate in.

With the help of our interpreter we told them about our families and life in the United States. One of the girls was very striking, with dark hair and flashing eyes. When we bade one another good night, she said with a new confidence, "I didn't know it could be so easy to talk with Americans."

Journalists Buffeted by Political Winds

In a way, I have thought of my work as a "people to people" project, and my lens as one small peephole through which others may gaze into a world not often seen. I have mentally contrasted it with the secret, massive, expensive, and highly technological observation that goes on between the Soviet Union and the West all the time. Probably never before in history have governments known so much about each other, and their peoples so little.

That is why I keep at it, even though I know the result is almost guaranteed to be less than complete—that, by the rules imposed by my hosts, much will be left out.

Sometimes the most carefully arranged trips are canceled without warning or reason. If relations between Washington and Moscow become strained—the spirit of détente cools—there is a ripple effect. The winds of international relations blow even the smallest blade of grass in the Soviet Union.

But times and men change. And some communication is preferable to none. Through the photographs and text brought out of the U.S.S.R. over the past 16 years, literally millions of our members have gained in their knowledge of that vast power on the other side of its self-erected wall. So long as an exchange is maintained, so long as communication continues, we are all better and not worse off.

In the last analysis, I believe in the intelligence of the free mind to understand the context of what is reported from nations like the Soviet Union.


MO

If children were soldiers and wars were but games, all encounters could be as congenial as this youngster's salute to Dean aboard a Soviet train. Two generous and easygoing Soviet soldiers, one the owner of the military hat, were among those who shared the long hours with the photographer on this part of his journey.

Through a cold glass, warmly (**below**), two children peek from the window of their train en route from Vladivostok to Moscow on the Trans-Siberian Railroad. "Temperatures of minus 40 degrees F. often left train windows opaque," said Dean, "but the atmosphere inside made up for it. Meeting people was one of the joys of train travel."

In spite of the problems, I have photographed young men being inducted into the armed forces; the ritual of the Russian *banya*, or bath; the funeral of an engineer in Moscow; newborn babies in Moscow; life in very rural villages (on the shores of Lake Baikal, along the Ob River, north of Moscow, far to the north in Siberia). I have also recorded church services—Russian Orthodox in Moscow; Roman Catholic in Vilnius, Lithuania; Baptist in Odessa.

On my film as well as in my memory are vignettes—elderly women enjoying taking off their shoes and wading in the Baltic; skiing in the Caucasus, Siberia, and Murmansk; exciting medical experiments in Sukhumi on the Black Sea and at Science City in Siberia; the spontaneity of song in Tbilisi; the beauty of folk singers and dancers in Azerbaijan and Central Asia; the marvelous faces in a Central Asian market; the timeless beauty of Islamic architecture in fabled Samarkand, Khiva, and Bukhara.

Yakutsk Offers Horse and Hare Fare

And good old Yakutsk, a city in the middle of nowhere, built on permafrost a thousand feet thick. Winter temperatures here often reach minus 50 degrees F., and people begin to generate their own fog. (Yet I found it not so cold as Verkhoyansk or Oymyakon, where nighttime temperatures sometimes plummet to 90 below!)

The frozen remains of mammoths have been found in this region, and now gas, gold, and diamonds. High-quality furs also come from the area. In the early 1600's—about the time the Pilgrims arrived in America—Yakutsk was a fort and staging area for cossack explorers. More recently it may have been a transfer point for luckless convicts on their way to labor camps.

Not the least of the city's fascinations is the exotic food you can find there: braised horse ribs, for example; roasted hare; *stroganina*.

Stroganina? The natives fish through ice, and their catch promptly freezes. In days gone by they simply shattered a fish against a rock and chewed the frozen shards with salt. Today the fish is shaved wafer thin and eaten frozen with salt, mustard, or various sauces.

Remembering stroganina fondly from a winter trip to *(Continued on page 267)*

Liberated for labor, lovely at play: Dean's camera interrupts the work of two paint-splattered construction workers in Yakutsk, in eastern Siberia. On the beach at Yalta warm sun spotlights a bather named Larisa (right). The three contrasting faces exemplify the Soviet Union's amalgam of more than a hundred ethnic groups. The involvement of women covers a broad range of the country's work force, the author observed, perhaps because of the enormous manpower losses of World War II. "Women are highly visible in manual labor," said Dean. "On the other hand, they also constitute 70 percent of Soviet doctors."

Cautious hand of friendship braves the chill air at Murmansk above the Arctic Circle, as a little girl signals her age to the photographer. Nursery-school youngsters circle an ultraviolet lamp (**right**) for a winter dose of vitamin D in this ice-free but sun-scarce port. "Russians dote on their children," said Dean, "and although discipline is strict, horseplay remains."

Yakutsk, I asked for it once during a summer visit. In July, however, stroganina is not too popular. Finally Viktor Yakovlev, a Novosti Press Agency photographer, located a frozen fish someone had stored in an underground permafrost cooler.

Somehow it didn't taste as delicious as it had before. Not wanting to offend Viktor, I wrapped most of the fish in plastic and tucked it in my shoulder bag, along with my sweater and other gear, and departed for the airport. I forgot the fish. In a couple of days, I discovered, stroganina can undergo a dramatic—perhaps the word is overpowering—change!

Materially, Soviet Life Improves

Although village life proceeds with a sameness that seems eternal, I have witnessed many changes in Soviet cities over the past decade and a half. Yakutsk has doubled in population, to 140,000. The environs of Moscow and countless other cities have spawned vast blocks of look-alike apartments to help house the country's 255 million people.

I have seen many new factories and power plants, and more automobiles and consumer goods. Shopping queues have grown shorter, clothes more stylish, TV sets and luxury items more readily available. Materially, at least, life seems to have improved somewhat for the average Soviet citizen.

When I first went to Russia, dissident voices were silent. Today there are a few that are outspoken, and others that are not. Most of these dissidents have a genuine love of their motherland that I admire. Not all are doctrinaire opponents of the political system. Some are artists, writers, and poets who resent dictated canons of art. Others wish their religion to be no deterrent to their participation in Soviet life. They only want to exercise the rights supposedly granted them by their own constitution. But even many who are unhappy are dedicated Communists. In general, they have received me warmly and treated me generously.

I have spent many a pleasant evening discussing life, love, schools, work, capitalism—many things. And the stylized diatribes in *Pravda* seem irrelevant when that day's paper is spread over a table and covered with smoked fish, tongue, sausage, and tins of sardines, or borscht, cucumbers, cheese, cakes, and that marvelous bread, as rich and dark as Russian earth. And ice-cold vodka served with hot boiled potatoes!

It is difficult *not* to bridge an ideological gulf when laughter and music fill a room.

Toylike herd, elfin rider: Reindeer course through a Siberian valley, a scene of crystal beauty highlighting the photographer's travels.

In warmer surroundings Dean bends low as a companion in a Leningrad *banya* swirls birch branches about him. "The object is to bring the heat to you," he said. "The Russian bath is a social event, one of the opportunities I had to mingle with the people."

Friend to friend. But most of these hearty informal feasts could not be photographed.

Some of my friends and co-workers within Novosti have extended themselves beyond their official duties to help Geographic projects. And I know full well that without their help and the official assistance of Novosti, I could not have worked there at all.

Many other persons, both official and not so official, have gone out of their way to lend encouragement, a helping hand, to take care of a current need. One young girl I shall never forget. After a very trying day of climbing to the 14,000-foot level of Mount Elbrus, she offered me a drink of warm fruit juice. I readily accepted. Only after I had downed it did I stop to think that she had carried the tin of juice up the mountain on her own back—and now she had none to drink for herself. Yet she smiled warmly as she watched the liquid bring life back to my battered limbs.

On another occasion, riding a train, a soldier noticed that the band on my wristwatch was broken. Immediately he offered me his own. I knew he would be offended if I did not accept.

The names linger in my mind . . . Natasha, Vasily, Lena, Nina, Boris, Valentin, Igor, Ibragim, Anna. . . . Some I hear from occasionally. Often the letter is posted from another country. Most of them I shall never see nor hear from again. The Russians I knew left their mark on me. Perhaps I left something with them. □

PURDAH IN INDIA

Life Behind the Veil

ARTICLE AND PHOTOGRAPHS BY
DORANNE WILSON JACOBSON, Ph.D.

"THAT SHORT THING lets your legs stick out. And surely you must have jewelry for those naked ankles!"

Motibai, an old woman of strong character, made it clear at our first meeting that my American clothes were as inappropriate in her village in central India as a topless bathing suit would be on Fifth Avenue.

I hadn't thought of my somewhat dowdy knee-length skirts as immodest. But, out of deference to Motibai and local fashion, I switched to full-length saris and silver ankle ornaments. "Ah, now you look nice," she said. "And decent."

By Motibai's rules, I was still underdressed: My face should also have been covered, especially in the presence of certain men. For she, like millions of Hindus and Muslims of northern and central India, practices purdah, following complex rules of veiling and seclusion that have been heeded by women in much of India for nearly a thousand years.

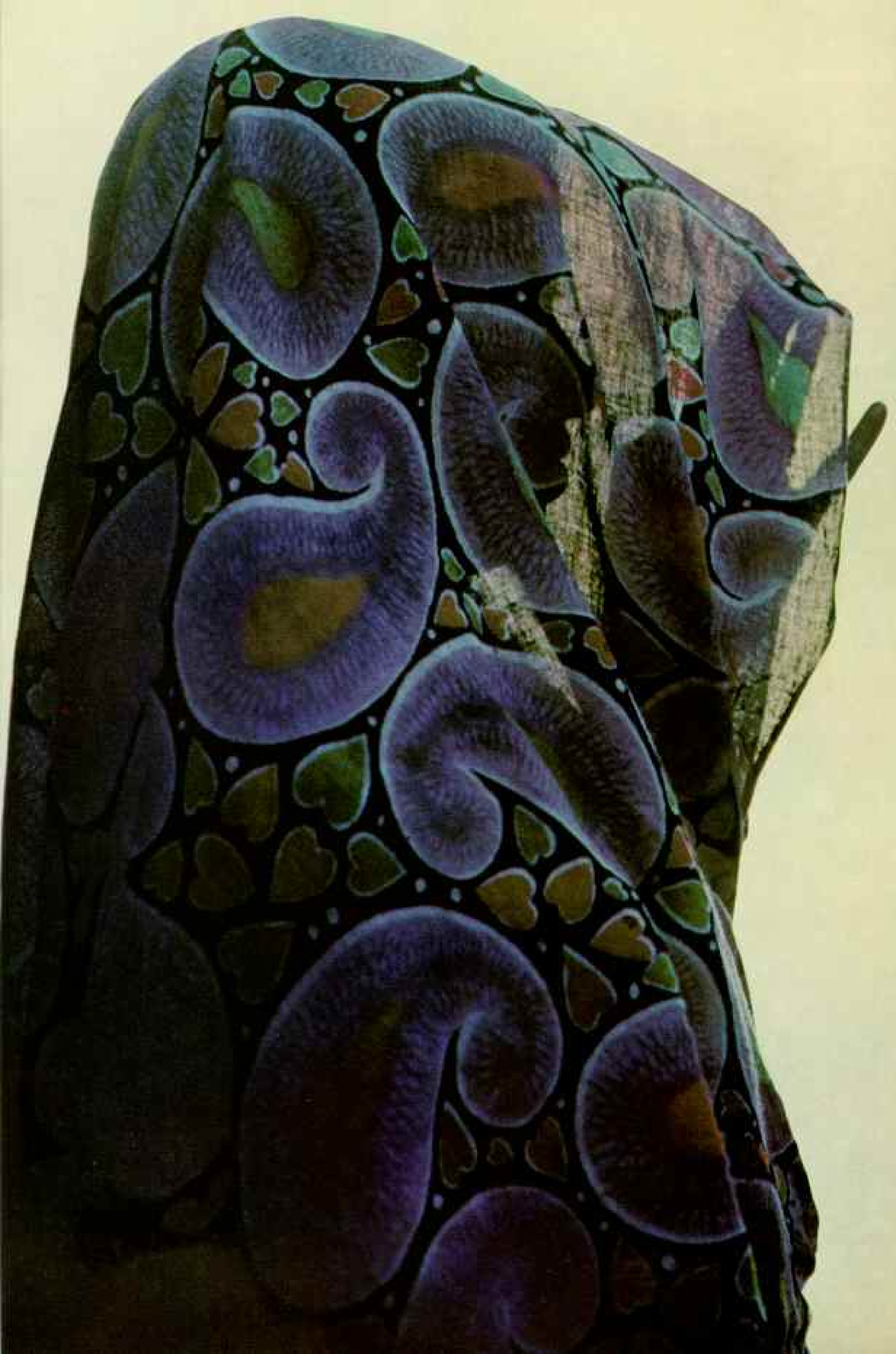
An ancient custom, purdah (meaning "curtain" in Persian) remains strong in many Muslim lands as well as in India, where, paradoxically, a woman prime minister until recently governed one-sixth of the world's people. While most educated women there consider its strictures outmoded, purdah seems to survive—especially in the countryside—because it aids the smooth functioning of a family-oriented society.

A typical rural community of central India, Motibai's village of Nimkhera lies some 40 miles east of Bhopal, capital of Madhya Pradesh, India's largest state (map, page 273). Its earth-and-stone houses, with whitewashed walls and tiled roofs, cluster on a wooded hillside overlooking a fertile plain. Temple, shrines, and mosque proclaim the spiritual allegiance of some 630 residents: Four-fifths of the population is Hindu; the rest Muslim. Members of both faiths practice purdah—but with certain differences.

Since the surrounding fields usually produce a surplus of wheat and pulse, these people are—by their country's standards—reasonably prosperous. And here, despite recent changes, basic features of age-old castes and customs endure.

I had settled in Nimkhera—socially complex for a small village—to explore the hidden world of purdah. For three years I enjoyed a close view of life behind the veil rarely seen by Westerners. Purdah, I found, requires both men and women to conform to exacting disciplines. *(Continued on page 274)*

Withdrawn as a shadow before new in-laws, a young bride veils her face. For her and millions of other women of rural India, life is ordered according to purdah—the centuries-old custom of secluding women. Under strict rules adopted at marriage, a Hindu woman veils before all older people of her in-laws' village, and even before her husband in the presence of other people. Although purdah may seem outmoded in our modern world, the author found it to be, in fact, a strong support of family life.



Her "indecent" Western skirt abandoned for a sari, anthropologist Doranne Jacobson trades stories in Hindi with women of the weaver caste (**left**). A new bride sits shrouded and apart in deference to her mother-in-law, who as head of the household may live more openly. To understand the intricate ways of purdah, the author, her archeologist husband, and their daughter lived three years in the farming village of Nimkhera (**above**). Accepted into village life, Doranne accomplished the difficult task of photographing women with faces unveiled and at ease.

PAMELA WILSON SARTORELLI (LEFT)

In fact my husband, Jerry, who was working on an archeological project nearby, had to make as many adjustments as I to win approval. With most neighbors he could not properly ask a husband about his wife, mention my name, or enter a courtyard unannounced for fear of surprising an unveiled woman. During our entire Nimkhera stay he never saw the faces of some of my best friends.

Our 4-year-old daughter, Laurie, quickly learned where she could go and where her father could not. She learned, too, to recognize veiled women by the babies they carried.

For Jerry, speaking directly to most women was taboo—in public, even to me.

Jerry found that idea difficult to accept: "You mean we can't walk or talk with each other outside the house? But what if I want to tell you something?"

"Ask a child to deliver the message."

"That doesn't do much for togetherness."

Purdah Strengthens Family Ties

Actually, one of the practical aspects of purdah is that it permits enforced togetherness to operate without too much friction. For in crowded India, where three or four generations may live under one roof, a man who seldom communicates with another's wife or sees much more than her toes is not very apt to change partners. And lines of authority within the family are clearly understood.

Traditionally, wives move in with their husbands and in-laws, and thus the family grows. In this part of India, Hindu marriages for the most part are arranged by parents of the same caste but of different villages, between young people who have never met.

Such was the case with Prembai, a charming high-caste Brahman girl of 14 who, according to Indian law at the time, should not have been wed before age 15. (The age has now been raised to 18.) Many villagers ignore this rule. I had been invited to participate in the preparations that preceded her marriage to Shiv Prasad, a handsome youth who lived some 40 miles away. For several days we anointed Prembai with purifying turmeric paste and serenaded her with wedding songs (pages 280-81).

On a date deemed favorable by astrological calculations, Shiv Prasad and his party arrived, heralded by a brass band and a dazzling display of fireworks. Veiled completely, Prembai sat among the visitors, receiving gifts of jewelry, clothing, cosmetics, and sweets. Then, in a predawn ceremony led by a Hindu priest, the couple walked seven times (an auspicious number) around a sacred fire to seal their union.

Women Have Their Day—Colorfully

On another day drums beckoned me to a lively celebration following the Hindu wedding of 12-year-old Bhuri.

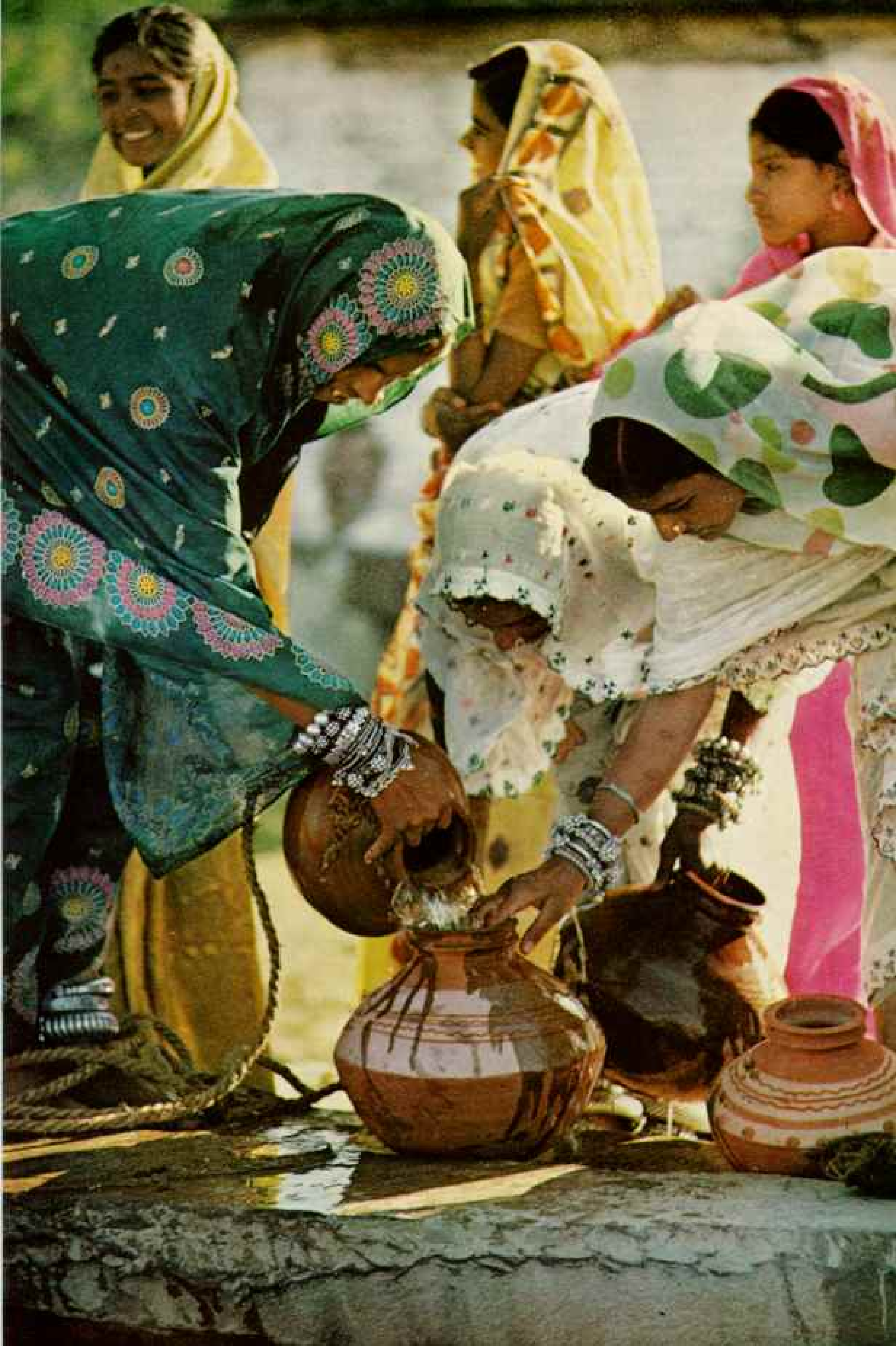
I had known the women of Bhuri's weaver-caste family as seemingly shy and subservient, almost more shadow than substance in the presence of strange men. But not that day. With obvious enjoyment they dashed potfuls of scarlet and indigo dye into the faces of the men who had accompanied the groom. Not content with this mess, they smeared the bright goo into the ears and noses of their dripping but docile victims (page 276).

After tying a cowbell around the neck of the groom's father, who, under the usual rules of purdah etiquette, would hardly be a figure of fun, the women burst forth with a medley of raucous and risqué songs. Such antics are a good-humored expression of the tensions that inevitably exist between in-laws.

Bhuri did not participate; she was hiding inside the house, from which she would not emerge until her husband and his entourage departed. In several years, after she had attained maturity, they would be reunited at his family's home to begin their married life. Prembai, too, would follow this course.

Jerry accompanied Hari Narayan, a Brahman youth of 18, on his *gauna*—bringing home the bride. Parting from her family, the girl Andolwali wept piteously; on the ride back to Nimkhera in our jeep, veil and silence

Veils fall away and conversation flows at the village well, where richly dressed Hindu girls, away from their elders, happily collect water for a wedding. Going to the well and attending religious festivals are among the few times young women escape the family cloister. Seclusion does not mean idleness, however. Women in purdah lead busy lives taking care of children, cooking, and working in the fields.



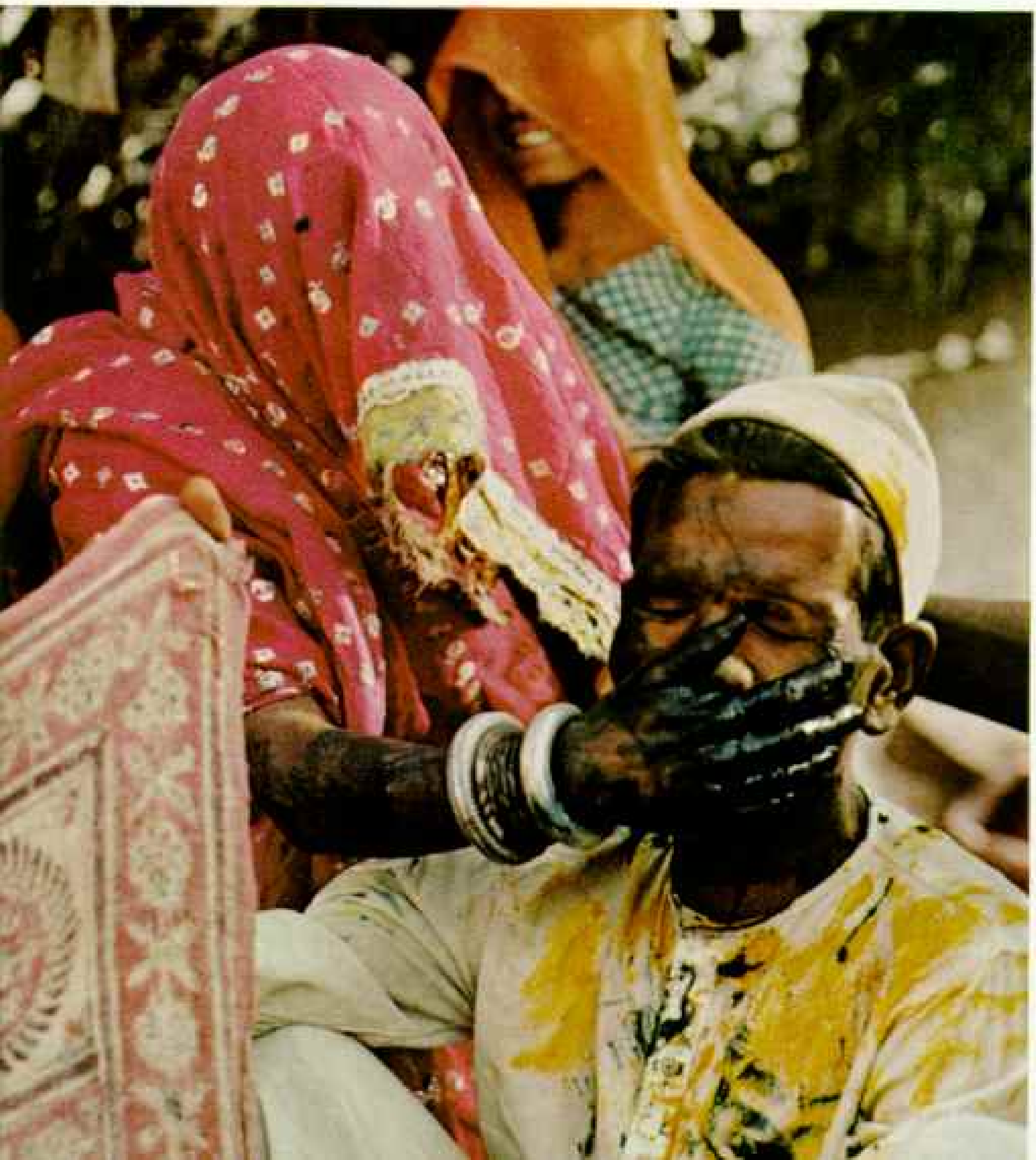
Outrageous for a day, female relatives of a new bride conclude wedding festivities by ritually abusing male kinsmen of the groom. In an act symbolic of the rivalry between in-laws, the women good-humoredly smear dye on the men (**below**).

Most village women accept purdah's tenets, which, though confining, provide security and clearly define duties and roles. Tension can erupt, though, when a young bride moves in with a husband and begins taking orders from in-laws. One wife, accused of stealing money, became "possessed" by an alleged demon and began swearing at her elders. An exorcist (**right**) yanks her hair and scolds the demon, while a brother-in-law painfully pinches her finger to drive out the evil spirit. Cured, the bride returned demurely to her husband.

concealed her feelings. Later she proved her spirit had survived the separation. As part of every gauna, man and wife grab for a piece of jewelry in a platter of turmeric water—a symbolic contest for power. Supposedly, the more agile one will rule the marriage. Andolwali won five out of seven rounds.

Families as well as faiths differ in the ways they uphold purdah; Hindus of the high-ranking Brahman caste like middle-aged Kesarbai favor a strict interpretation. I sat in the corner of her courtyard with Priya and Kamla, who as young *bahus*—daughters-in-law—must remain in virtual seclusion.

Kesarbai, ranking woman of the joint family, feels the practice of purdah is becoming too lax. "In the old days a bahu was almost never seen; it was as if she were plastered to the wall beside the stove. Nowadays you can



see all kinds of things, even bahus talking to their fathers-in-law."

As we chatted, we heard a man cough. Instantly, the young women covered their faces and fell silent.

Unseen and Unheard by Male In-laws

Shivji Maharaj, their old grandfather-in-law, appeared, addressing no one in particular: "I need my little water pot." Still veiled and voiceless, Priya fetched the pot, filled it with fresh water, and set it down beside him. He picked it up and, without a word, returned to his resting place on the veranda outside.

"Why did you cover your faces?" I asked. "And why didn't you just hand him the pot?"

Kamla answered. "We feel shy here in our *susral*, our husbands' home, especially among older men. To sit before them barefaced would be improper. So would handing anything directly to them, even to our husbands."

Later I saw that Priya and Kamla enjoyed unveiled, warm friendships with their husbands' younger brothers. Although the bahu's lot may seem a dreary one, it is not a dead end. True, she arrives at her husband's home a meek-acting, veiled creature in a state of subservience. But as she grows older and the senior women fade away, her privileges and position improve until she has considerable freedom as female head of the household.

In the meantime life might be difficult to tolerate if Kamla, Priya, and others like them had no reprieve. Fortunately Hindu purdah permits them to slip their shackles for long visits to their own *maikas*—parental homes—where they need not veil and may move about freely among friends and relatives.

Priya's brother had come to get her and her children for one such vacation.

"When are you coming back?" I asked her.

"In three, perhaps four, months," she answered happily.

"But surely you'll miss someone from here?"

"No one at all." We both knew it was improper to refer to her husband, who, quite rightly, was absent from the farewells and would not see her again until she returned. Modesty prevented husband and wife from openly admitting affection for each other.

Holidays Bring War Between the Sexes

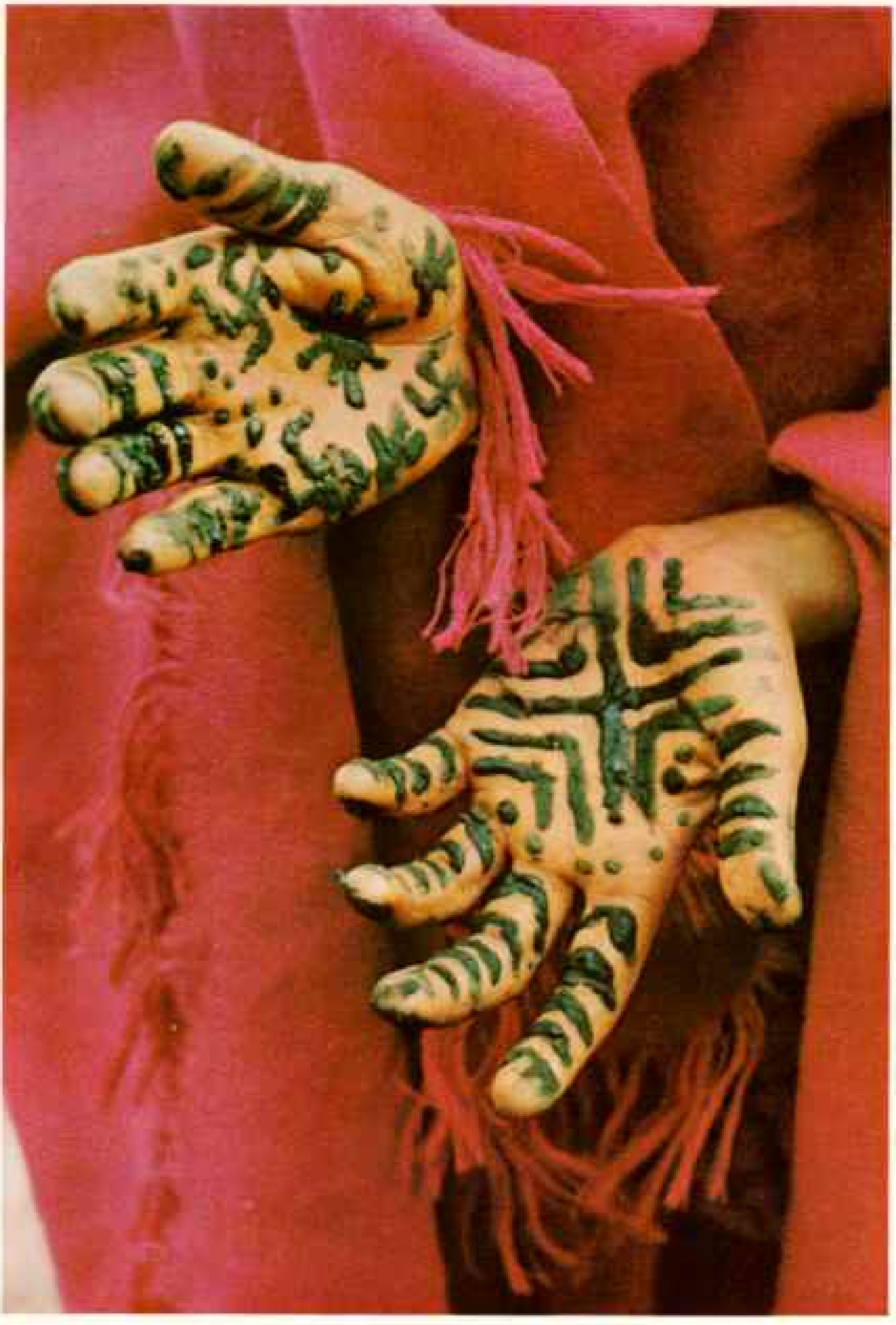
Two annual spring festivals—Holi and Jhanda Torna—permit some Hindu women further release from the conventions of purdah. Holi begins with the men splashing each other with colored water, and boys hurling mud and cow dung at the village houses. Then, as the men move from house to house singing ribald songs, some of the lower-caste women race out to flail them with long sticks.

A few nights later, on Jhanda Torna, the battle of the sexes gains momentum. After fortifying themselves with a marijuana-laced drink, veiled stick-wielding women defend a tall pole topped with a bag of brown sugar. The men, lightly protected with wooden shields, inevitably capture this prize, but only after suffering many bruises. This raucous contest may symbolize real but usually repressed tensions between men and women. Hostilities end with a professional dancing girl spinning through the night to the delight of all men and women assembled.

The Muslim minority in Nimkhera observes purdah much as Hindus do—with variations. The traditional badge of Muslim womanhood—married and single alike—is the burka, a veiled cloak originally designed to conceal both face and ankle-length clothes. In the past gloves and stockings were worn as well, so that not an inch of feminine skin appeared. Today many wearers have shortened burka hemlines to the knee, while some women have discarded the veil altogether.

But Muslim traditionalists still wear the burka, even during visits to the parental village. "There is no vacation from veiling except within the family," I was told by elderly Saida Begam. "Not even in death. At my funeral, my face can be seen only by those who saw it in life." In her case the approved list

Changing face of purdah appears within the Muslim household of Birjis Jahan. In 1967, carrying a daughter, she appeared in a shroudlike burka (**above**). With exposure to modern city life, her veil has now given way to dark glasses (**below**). Another daughter, Sultana (beside her and **opposite**), leaves the house with face entirely uncovered.



Painted and pampered, bride and groom at a Hindu wedding undergo elaborate preparations at the hands of their families. In rural central India parents still arrange marriages, with the partners coming from the same caste but usually from different villages. Before his wedding the groom is decorated with henna-leaf paste (**above**), which when washed off will leave bright orange designs.

Before 14-year-old Prembai's marriage, relatives anoint her with turmeric (**right**), associated with fertility. Like most village girls in this area, Prembai is wed young, but she will remain with her family for a year before joining her husband's household. Even then, as a reprieve from such an early marriage, she will return often to her village, where, unveiled, she will enjoy long visits

Joy is muted as Hari Narayan claims his bride of a year, who at 15 is judged ready to pay an introductory visit to his home and consummate the marriage. Their shawls have been tied together, and a brother touches the bride's foot in loving farewell. Back home, Hari Narayan smiles at a dancer welcoming him and his shy mate (**opposite**).

includes many male in-laws, for most Muslim women do not mask themselves from their own or their husband's close relatives.

Among Muslims, seclusion may also be a lifetime commitment. Saida Begam, for all her age, seldom ventures beyond her courtyard; in her fifty years in Nimkhera she has seen few of its lanes and houses.

Some women embrace purdah because it implies relatively high status. But not all of them can afford the luxury of seclusion. For many, limited means necessitate working as laborers, at menial tasks in others' fields and houses, as basket weavers and potmakers. In farming, veiled women do equal duty with men, weeding muddy rice paddies, sowing grain, and harvesting heavy bundles of golden wheat with sickles under a blazing sun.

Laurie and I often visited women at home as they cleaned grain and ground it into flour, made steaming flat breads called *rotis*, or plastered their homes with mud, painting them with whitewash and bright earth colors. And always there were children to care for. Rich or poor, Nimkhera's women in purdah have little time for leisure.

With but few exceptions there is no place in village society for an unwed woman. Of those unfortunately widowed young, most remarry, since women are in short supply in this region, and a man without a wife finds himself very overworked. But for a high-caste Brahman widow, custom prohibits remarriage. She forever gives up the toe rings, glass bangles, and *tika*—forehead decoration—that adorn married women. For her, religious devotions may be especially fulfilling.

Women May Rule Home and Purse

Although purdah appears to work to the overwhelming advantage of men, limits on free association apply to both sexes. Boys have no more right to select their mates than do girls. Obviously, men enjoy more privileges outside the home, but with them come extra responsibilities and worries. Many women have greater influence within the home and feel secure in having men bring them the necessities of life. And through control of inherited property and ownership of precious jewelry, women sometimes have a significant amount of financial independence.

"We love our daughters and sons the same," Keotiwali, a middle-aged mother, told me. "We bear the burden of both for nine months, and there is no difference in the birth pangs. Sadly, our daughters must leave us to become part of another family. But then, our sons bring home someone else's daughters to carry on *our* lineage and care for our aging."

Among Hindus, women play vital roles in religious matters. They pray to Lakshmi, goddess of wealth, for prosperity and to the goddess Gan Gaur to give their husbands long life. From powerful mother-goddess Matabai they ask the blessing of children, paying her special homage at the Havan, a nine-day sacred-fire ceremony in December,

attended by even the most sequestered bahus.

At this unique celebration, important men of the village wait upon and worship nine little girls selected to represent all their kind. "Young girls, *kanyas*, are just like goddesses," a Brahman priest explained. "We give them sweets, saris, and money; we touch their feet and garland them with flowers as a symbol of our respect for chaste womanhood. It pleases Matabai to see us honor them so."

In this region women have had political as well as religious power: Nimkhera was once part of Bhopal State, ruled for more than eighty years by veiled Muslim queens called begams. The last one abdicated in 1926 in favor of her son, Nawab Hamidullah Khan; his reign ended after Bhopal State in 1949 became a part of independent India, and later merged with Madhya Pradesh.

Her Highness Shahbano Maimoona Sultan, widow of Hamidullah Kahn, still lives in the Bhopal palace they once shared. Over tea she described the purdah world of her youth.

"When I was married in 1905, I was only 5 years old; my husband was 11. I spent the rest of my childhood in this palace observing purdah in its strictest sense. My husband and his older brothers and their sons were the only males I met with; the only man outside the family I saw was the old, white-bearded cook. I went to school here but always behind a curtain. The teacher sat on the other side, and we never saw each other.

"My mother-in-law showed that you can do

Shielded from sun and onlookers, a veiled woman joins her husband in harvesting a landlord's wheat field (**above**); they receive for their toil one-sixteenth of the grain. Discussion of the day's events must await time alone in a private chamber; public conversation between husband and wife is disapproved.

Purdah also affects the lives of men. They may never get to know the wives of younger friends or even of brothers younger than they are, nor should they enter even their own courtyards unannounced.

On the farm of Rafika, both the clatter of an engine and words of instruction crack the silence as the well-to-do landowner learns from her husband how to run a tractor (**left**). A modern Indian woman, she married for love and disavows the veil.

For all eyes to see, a little girl grins impishly in the cradle of her grandfather's arms. Revered as symbols of purity, girls remind adults of the honor and family strength they hope purdah will preserve.

anything, even rule a state, from behind purdah. But after my husband became ruler, she decided purdah should yield to modern trends, and we both gave up the veil."

Today young women of Bhopal's former royal family wear blue jeans and drive sports cars like others of their age elsewhere.

However, in villages like Nimkhera, old ways change more slowly. One of the first to break down purdah barriers there was Birjis Jahan, of a high-status, conservative Pathan Muslim family.

"Until recently I seldom went out, and I never visited the bazaar," Birjis Jahan told me. "On trips to my maika, I wore a burka, rode a bus owned by a relative, then was driven the last mile in a horse-drawn carriage completely enclosed with a curtain."

Birjis Jahan now travels about pretty much as she pleases, wearing dark glasses but no burka (page 279). "My eyes are burka enough," she said. "If I don't lift them to look at anyone, who can call me immodest?

"Yes, I still have an escort, usually one of my sons. But otherwise, for me, purdah is a thing of the past. I gave it up because I want to know what goes on outside my own four walls. Few upper-class Muslim women of Bhopal now wear burkas."

None of Birjis Jahan's five daughters intend to keep strict purdah, but they have not rejected it altogether. Her oldest son, Akhtar, married a cousin who never veils, yet has spent most of her years within the home.

Daughter Sultana, now 20, shuns the burka, but she remains highly decorous in her behavior, never venturing outside without a chaperone. She was privately tutored (without a curtain) and recently wed a cousin of her choice.

For Muslims, matchmaking between cousins is not uncommon, since, according to Muslim law, women share in the family inheritance. Joining kin in matrimony keeps property within the family.

Purdah Wanes as Education Spreads

Schooling is nothing new to India's city girls; many go on to higher education. This trend is beginning to take hold in villages like Nimkhera. "But what good does it do," a village matron asked, "if housework is our goal? I've passed tests in water fetching, cooking, and childbearing without attending a single class."

Prembai and Motibai realize that purdah's popularity is waning, but they accept its conditions as vital to the continuance of rural family life with its built-in work force and security for all ages.

Watching Kamla and Priya clean grain as they chatted, it was clear to me that when duties and roles are clearly assigned, there is no doubt about responsibility, and essential tasks are completed without argument. Restraints remind youths and elders alike that their own needs come second to those of the family, so vital to survival in village India.

Male voices echoed in the courtyard. Kamla and Priya pulled their veils down over their faces and silently continued cleaning their platters of grain. □

How Soon Will We Measure In Metric?

By KENNETH F. WEAVER
ASSISTANT EDITOR

Drawings by DONALD A. MACKAY

"Thou shalt not have in thine house divers measures, a great and a small. But thou shalt have a perfect and just weight, a perfect and just measure shalt thou have...."

DEUTERONOMY 25: 14-15

EACH DAY in the United States an estimated 20 billion measurements are made. The scientist, for his measuring, uses the metric system—logical, simple, and unified. But for most of us, what an antiquated, crazy-quilt hodgepodge we customarily employ!

We have, for example, a dry quart that is larger than a liquid quart; both are smaller than a British quart. An ounce for measuring fluids is not the same as an ounce used for weighing; moreover, the avoirdupois ounce is lighter than the troy ounce and the apothecaries' ounce.

Or consider tons. There's a long ton and a short ton, a register ton and a measurement ton, a wheat ton and a metric ton—all different.

Our barrel ranges from 31 to 42 gallons. We divide the gallon into four quarts, eight pints, or 16 gills—to say nothing of five fifths.

We split the mile into eight furlongs, 80 chains, 320 rods, 880 fathoms, 1,760 yards, and 5,280 feet. Then we divide the foot by 12 to get inches.

Actually the United States has three kinds of miles. Our survey mile, used in land measurements, is roughly one-eighth of an inch longer than the international mile. Confusingly, both are known as statute miles, and both are shorter than the nautical mile.

We deal with hands and cords, drams and scruples, pecks and carats, grains and points, firkins and hogsheads—all part of a gloriously illogical mingle-mangle of some 80 separate measures.

Yet we count by tens, by the decimal system, because ten is the only number that creates multiples of itself by simply changing the first digit. Then why not measure by tens?

How we got into this muddle is a story that goes back to the Babylonians and Egyptians, to the Romans and Vikings, and to assorted English monarchs of centuries ago.

In Egyptian papyrus texts, thousands of years old, there appears the figure of a forearm, symbol for the cubit. This earliest recorded unit of measurement was based on the length of the arm from elbow to fingertip—roughly 18 inches. The Great Pyramid of Cheops was built to cubits. And so, according to Genesis, was Noah's Ark—300 cubits long.

Even in Noah's time the measurement confusion had already begun. Forearms, after all, vary in length. Moreover, there were different cubits. Legend has it that the Egyptian King Menes decreed a royal

or sacred cubit 14 percent larger than the common cubit. This oversize measure was used in building his own palace but was forbidden to others. The original meaning of "pharaoh," incidentally, was "great house."

For measuring weight, the ancients used grains of wheat or barleycorns; the grain to this day is one of the smallest units of weight, 1/7,000 of a pound. The carat, used in weighing gems, was derived from the tiny carob seed.

The mile came to us from the Romans via Britain. In Caesar's day the mile was the *mille passus*, 1,000 double steps by a Roman legionary. It was 5,000 Roman feet. Queen Bess, in the late 16th

century, added 280 feet so the mile would be exactly eight "furrow-longs," or furlongs.

No one knows just how the yard got started, although it may be no coincidence that it is a double cubit. In any case, it is a fundamental unit of English measurement. The word itself comes from the Old English word *gierd*, rod, the staff used for measuring. Henry I established the yard as the distance from the tip of his royal nose to his fingertips.

As for the inch, in the tenth century it was the span of the knuckles on King Edgar's thumb. And the foot was decreed by Charlemagne to be the length of his own foot—about 12.7 present-day inches. But the English statute books of 1305 standardized the foot as 36 barleycorns "taken from the middle of the ear" and laid end to end.

Still another definition of the foot comes from a 16th-century German regulation:

"Stand at the door of a church on Sunday, bid 16 men to stop, tall ones and short ones as they happen to pass out as the service is finished, then make them put their left feet one behind the other and the length obtained shall be a right and lawful rod, and the 16th shall be a right and lawful foot."

The six-foot fathom, used by seafaring men, equaled the span of a Viking's outstretched arms. The acre was the amount of land plowed by a yoke of oxen in one day. And the gallon (the one in use in the United States today) was Queen Anne's wine gallon. It was much smaller than the ale gallon of her day and different from the imperial gallon eventually adopted for British use.

The confusion resulting from such an unwieldy makeshift of measures led to a desire for a more sensible system. Thomas Jefferson, in 1790, proposed a decimal system, based on units of 10, just like our money. In

his plan, for example, 10 feet would be a decad, 10 decads a rood, 10 roods a furlong, and 10 furlongs a mile.

Congress did not buy Jefferson's ideas, but at that same time the ferment of the French Revolution and the upsurge of interest in science produced another system based on 10's—the metric system. It was the most remarkable plan for measurement ever devised.

Its keystone was the meter, from the Greek *metron*, meaning "a measure." This new basic unit was not derived

from the variables of human anatomy; rather, it was to spring from the universe itself. The *mètre*, as approved by the French National Convention in 1795, was to be one ten-millionth of the length of earth's meridian between the Equator and the North Pole.

To determine this distance, a team of surveyors had set out to measure an arc of the meridian between Dunkirk in France and Barcelona in Spain. Despite many difficulties—they were plagued by the hostility of peasants and by arrests for treason—the surveyors finally succeeded. The meter was established at approximately 39.37 inches.

From this unit of length, a unit of volume was derived by

cubing a tenth of a meter to produce the liter. And a liter of water produced a basic unit of mass, the kilogram.

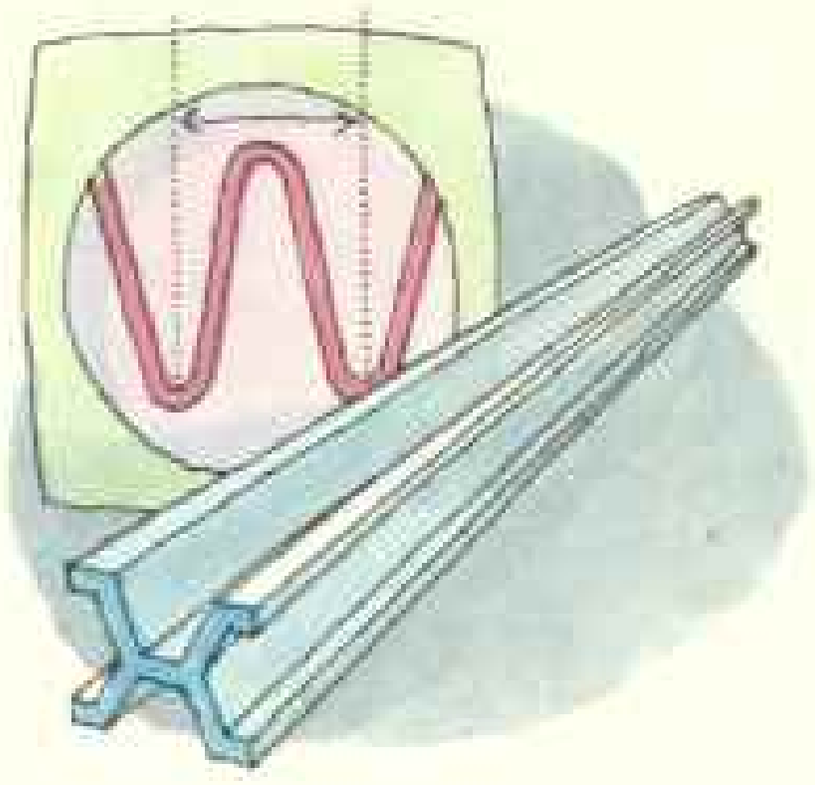
For larger units, multiples on the basis of 10 were eventually provided, with Greek prefixes: thus dekameter for 10 meters, hectometer for 100, kilometer for 1,000, megameter for a million, and so on. For subdivisions, Latin prefixes were used: decimeter for a tenth of a meter, centimeter for a 100th, millimeter for a 1,000th, and micrometer for a millionth.

Thus all the units were intimately and uniformly related. For the first time the world had available a consistent, unified measurement system in which calculations would be easy—no more unwieldy fractions, no more memorizing a host of conversion factors.

"Never has anything more grand and simple, more coherent in all its parts, issued from the hand of man," wrote Antoine Lavoisier, the most famous French scientist of the time.

Over the decades the metric system has been modified and expanded into what is known today as SI, *Le Système International d'Unités*. SI provides five other basic units besides the meter and the kilogram. For example, the unit for time is the second; the ampere is the basic unit for electricity; and for temperature the degree Celsius (formerly centigrade). For scientific use, temperatures are measured in kelvins starting with absolute zero (−273.15 °C). A kelvin is equal to a degree Celsius. In addition, the meter has been redefined, for even greater accuracy, as 1,650,763.73 wavelengths of orange-red light emitted by the krypton-86 atom.

Gradually at first, then ever more rapidly, the metric system



took root in Europe in the 19th century. It spread to other continents until, today, 95 percent of the world's inhabitants speak its language. Only in the United States (and in Brunei, Burma, Liberia, and Yemen) is it not yet the system generally in use.

Repeatedly our nation has approached metrication, but it has always backed away from full embrace. Nevertheless, by act of Congress, metric has been "legal" in the United States since 1866.

Metric (SI) prefixes

Multiplication factor	Prefix	Symbol	Meaning (in USA)	In other countries
$1\,000\,000\,000\,000\,000\,000 = 10^{18}$	exa	E	one quintillion times	trillion
$1\,000\,000\,000\,000\,000 = 10^{15}$	peta	P	one quadrillion times	thousand billion
$1\,000\,000\,000\,000 = 10^{12}$	tera	T	one trillion times	billion
$1\,000\,000\,000 = 10^{9}$	giga	G	one billion times	milliard
$1\,000\,000 = 10^{6}$	mega	M	one million times	
$1\,000 = 10^{3}$	kilo	k	one thousand times	
$100 = 10^{2}$	hecto	h*	one hundred times	
$10 = 10$	deka	da*	ten times	
$0.1 = 10^{-1}$	deci	d*	one tenth of	
$0.01 = 10^{-2}$	centi	c*	one hundredth of	
$0.001 = 10^{-3}$	milli	m	one thousandth of	
$0.000\,001 = 10^{-6}$	micro	μ	one millionth of	
$0.000\,000\,001 = 10^{-9}$	nano	n	one billionth of	milliardth
$0.000\,000\,000\,001 = 10^{-12}$	pico	p	one trillionth of	billionth
$0.000\,000\,000\,000\,001 = 10^{-15}$	femto	f	one quadrillionth of	thousand billionth
$0.000\,000\,000\,000\,000\,001 = 10^{-18}$	atto	a	one quintillionth of	trillionth

*While hecto, deka, deci, and centi are SI prefixes, their use should generally be avoided except for the SI unit-multiples for area and volume and nontechnical use of centimeters, as for body and clothing measurement. The prefix hecto should be avoided also because the longhand symbol h may be confused with k.

Moreover, our representative signed the Treaty of the Meter in Paris in 1875. Thus we joined the other major nations of the world in endorsing the metric system as the internationally preferred system. We also gave backing to a permanent International Bureau of Weights and Measures.

Further, in 1893 the United States became an "officially" metric nation. Three years earlier we had received from the International Bureau new and refined meter bars and kilogram weights. These were declared to be the nation's "fundamental standards" of length and mass. The pound, the foot, and other customary units were redefined as fractions of the metric units.

And yet we did not give up the welter of customary units. Bitter opposition from both labor and business met every attempt to get a metric bill through Congress. As recently as 1920 pamphlets were published with titles such as "What Real He-Men Think of the Compulsory Metric System."

Earlier, anti-metric forces had published as their theme song a ditty entitled "A Pint's a Pound the World Around," with this ringing stanza:

Then down with every
"metric" scheme
Taught by the foreign
school,
We'll worship still our
Father's *God!*
And keep our Father's
"rule"!
A perfect inch, a perfect
pint,
The Anglo's honest
pound,
Shall hold their place
upon the earth,
Till Time's last trump
shall sound!

But thoughtful citizens continued to point out the merits of the metric system. As Alexander Graham Bell testified before Congress (his statement was printed in the March 1906 GEOGRAPHIC):

"It is safe to say that, after the metric system has been adopted by the United States and our people have become accustomed to its use, we would no more dream of going back to the present system of weights and measures than we would think of carrying on the processes of arithmetic through the medium of the old Roman letters in place of the Arabic numerals we now employ."

Eventually the anti-metric agitation died away. Great Britain began conversion to the metric system in 1965. Australia followed in 1970, Canada in 1971. The United States was isolated—an island in a metric sea. Our huge multinational corporations, with many branches abroad, found themselves forced to use metric as well as customary units. Quite naturally they favored conversion to a single system.

Many began converting on their own, spurred by a decision from the nine Common Market countries that after April 21, 1978, they would accept no imports unless labeled in metric dimensions.

Finally, on December 23, 1975, President Gerald R. Ford signed the Metric Conversion Act of 1975, calling for voluntary conversion to the metric system and establishing a U. S. Metric Board to coordinate that conversion.

Even though Congress and the President did not go so far as to require mandatory conversion, most observers see the changeover coming with increasing rapidity anyway. Officials and businessmen to whom I have talked give varying estimates: some see a predominantly metric United States by the early '80's. More pessimistic forecasts suggest 1990. But all agree we are moving fast on the metric road.

Even without metric legislation we have already gone a considerable distance down that road. Scientists use metric measurements exclusively. So do many of our engineers.

Most of us are familiar with 35-millimeter cameras and film, 500-milligram vitamin pills, skis labeled in centimeters, hypodermics measured in cubic centimeters (the same as milliliters), and cars with engine displacement stated in liters. The airlines have long weighed our luggage in kilograms on overseas flights. We have

Metric (SI) units

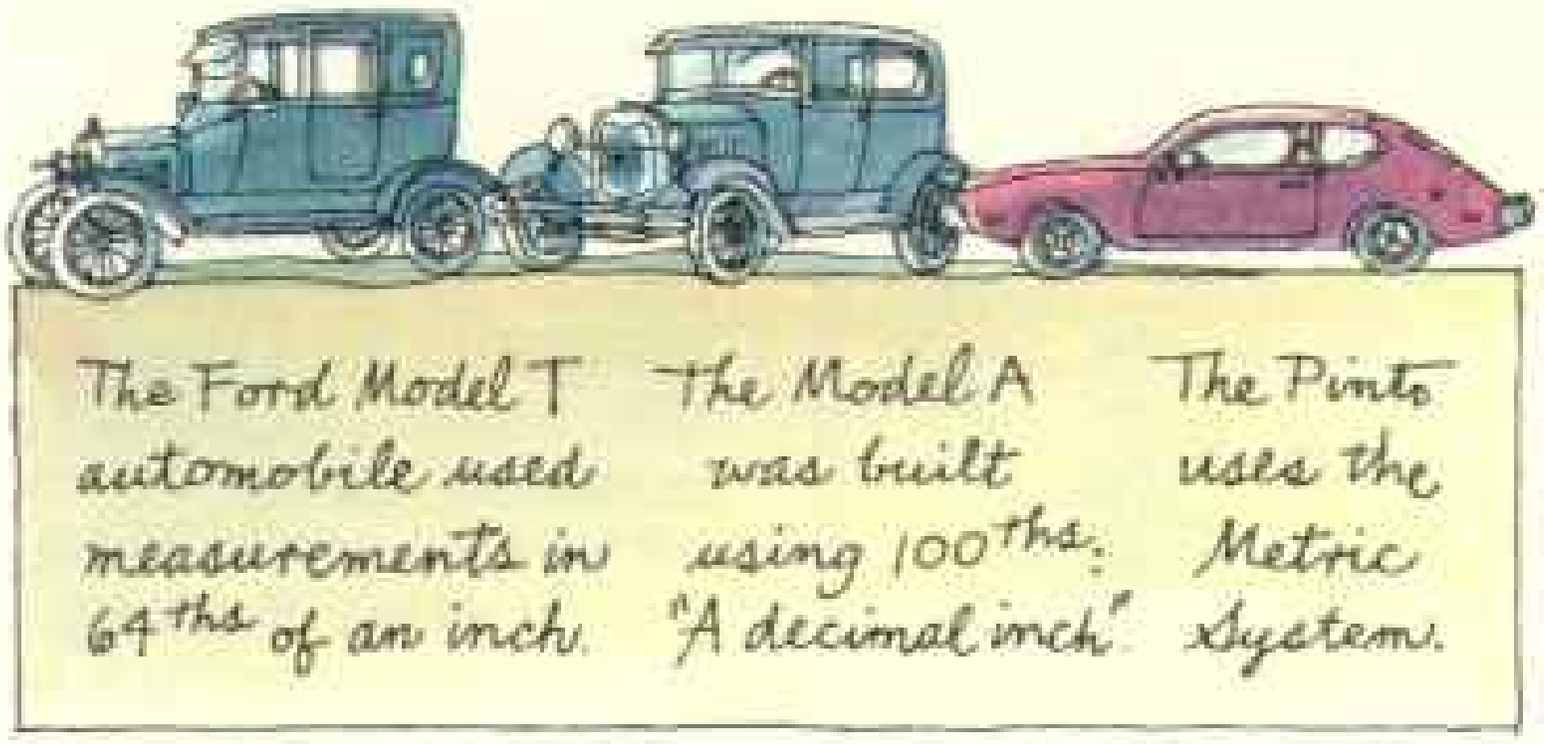
Quantity	Common units	Symbol	Acceptable equivalent	Symbol
length	kilometer	km		
	meter	m		
	centimeter	cm		
	millimeter	mm		
	micrometer	μm		
area	square kilometer	km^2		
	square hectometer	hm^2	hectare	ha
	square meter	m^2		
	square centimeter	cm^2		
	square millimeter	mm^2		
volume	cubic meter	m^3		
	cubic decimeter	dm^3	liter*	L
	cubic centimeter	cm^3	milliliter*	mL
velocity	meter per second	m/s		
	kilometer per hour	km/h		
acceleration	meter per second squared	m/s^2		
frequency	megahertz	MHz		
	kilohertz	kHz		
	hertz	Hz		
mass	megagram	Mg	metric ton	t
	kilogram	kg		
	gram	g		
	milligram	mg		
density	kilogram per cubic meter	kg/m^3	gram per liter	g/L
force	kilonewton	kN		
	newton	N		
pressure	kilopascal	kPa		
energy, work, or quantity of heat	megajoule	MJ		
	kilojoule	kJ		
	joule	J		
	kilowatt-hour	kW·h		
power or heat flow rate	kilowatt	kW		
	watt	W		
temperature	kelvin	K		
	degree Celsius	°C		
electric current	ampere	A		
quantity of electricity	coulomb	C		
	ampere-hour	A·h		
electromotive force	volt	V		
electric resistance	ohm	Ω		
luminous intensity	candela	cd		

*To be used only for fluids (both gases and liquids) and for dry ingredients in recipes. Do not use any prefix with "liter" except "milli."

Common metric (SI) conversions

If you know		Multiply by	To find
length			
inches	×	25.4	= millimeters
feet	×	0.305	= meters
yards	×	0.914	= meters
miles	×	1.609	= kilometers
area			
square yards	×	0.836	= square meters
acres	×	0.405	= hectares
volume			
quarts (lq)	×	0.946	= liters
cubic yards	×	0.765	= cubic meters
mass			
ounces (avdp)	×	28.35	= grams
pounds (avdp)	×	0.454	= kilograms
temperature			
degrees Fahrenheit	×	5/9 (after subtracting 32)	= degrees Celsius

If you know		Multiply by	To find
length			
millimeters	×	0.039	= inches
meters	×	3.281	= feet
meters	×	1.094	= yards
kilometers	×	0.621	= miles
area			
square meters	×	1.196	= square yards
hectares	×	2.471	= acres
volume			
liters	×	1.057	= quarts (lq)
cubic meters	×	1.308	= cubic yards
mass			
grams	×	0.035	= ounces (avdp)
kilograms	×	2.205	= pounds (avdp)
temperature			
degrees Celsius	×	9/5 (then add 32)	= degrees Fahrenheit



watched races in the Olympic games—all in metric.

In at least 14 states some road signs show both mile and kilometer distances or speed limits. The same is now true of signs in some national parks. A few months ago the Department of Transportation proposed that all speed-limit signs be changed to metric beginning in July 1978. Coca-Cola, 7-Up, Pepsi-Cola, Dr Pepper, and Shasta are now marketed in liter containers. By the end of 1979, all wines and spirits must be bottled in metric sizes. The familiar fifth will become 750 milliliters—about one percent less.

Federal agencies increasingly use metric measurements. The Department of Agriculture publishes crop yields and grain shipments in metric tons. All NASA reports give metric, with customary figures added. The Patent and Trademark Office now requires that patent applications include metric dimensions of items.

Of the top 1,000 major manufacturing and industrial concerns in the United States, more than 60 percent are estimated to be metric or in transition.

All four major motor companies are converting. Ford began ten years ago and pioneered with the designing of the metric Pinto engine. General Motors followed in 1975 with the largely metric Chevette. Since 1973, GM has designed all new parts in metric.

Has conversion posed an onerous burden on industry? I asked this question of a number of industry representatives. Their answer is uniformly no.

"The worry is greatly overstressed," says P. E. Burke of American Motors. "It turns out to be a myth that it would cost enormous sums." Everett Baugh of General Motors says, "Going metric in the Chevette caused no more than a ripple."

And George Nassauer of Procter and Gamble puts it even more succinctly:

"Going metric is no big deal!"

Perhaps not for business and industry. But how will it affect ordinary people, who now have to learn to think in a different measurement language?

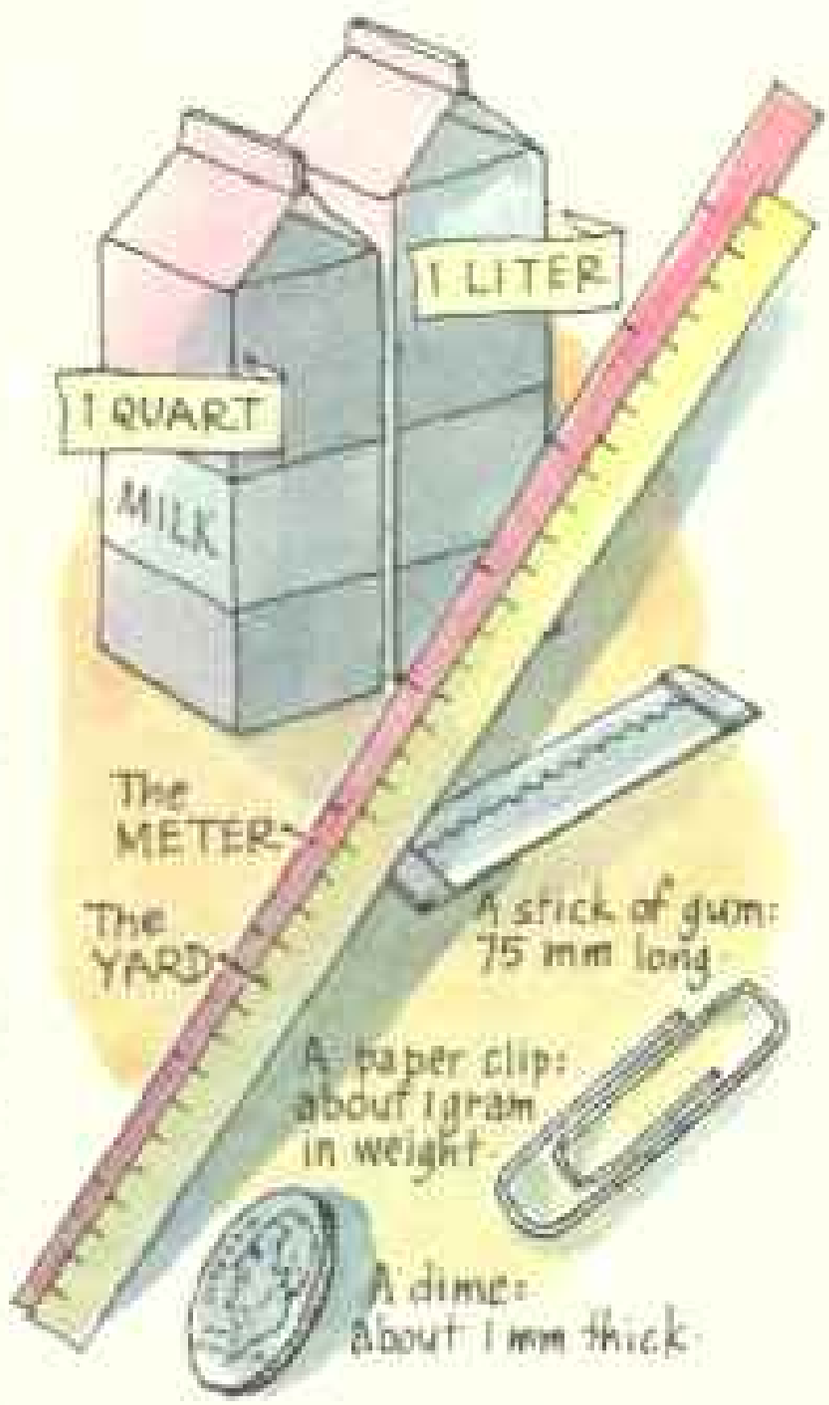
For youngsters, at least, it is no problem. The other day my 9-year-old granddaughter, who is excited about collecting insects, was describing her latest find. "It's just about a centimeter long," she said.

The metric system will hold no terrors for her. Like most children in the U.S., she is learning metric measurements in school. Some school systems, in fact, are phasing out instruction in customary units. Some states now require that all new textbooks use the metric system exclusively.

For older generations, conversion will mean more effort. But manufacturers are helping to ease the transition. Levi Strauss is putting dual labeling on its boys' pants. Dress patterns for years have given both measurements. Metric recipes are appearing in women's magazines.

And grocery stores are full of dual-labeled packages. Recently I found rice, 16 oz (454 g); canned beans, 15 oz (425 g); pineapple juice, 36 fluid oz (1.06 L); cream by the pint (473 mL); and chocolate bars, 4 oz (113.4 g). And by contrast, mustard, 1 kg (35¼ oz).

While conversions like these help at first, the advice of other



countries now successfully making the transition is to avoid translating as much as possible. "Learn to think metric from the beginning," they counsel. "Then the changeover goes smoothly."

A few tips help one get a feel for metric dimensions

and quantities. For example:

. . . a meter is only a little longer than a yard;

. . . a kilogram is only a little heavier than two pounds;

. . . a liter is only slightly more than a quart.

A teaspoon is five milliliters; a tablespoon 15. A 21-gallon tank holds about 80 liters of gasoline. A dollar bill or a paper clip each weighs about one gram. A golf ball weighs 46 grams, a year's NATIONAL GEOGRAPHICS fall just under five kilograms, and an average man weighs 75 kilograms.

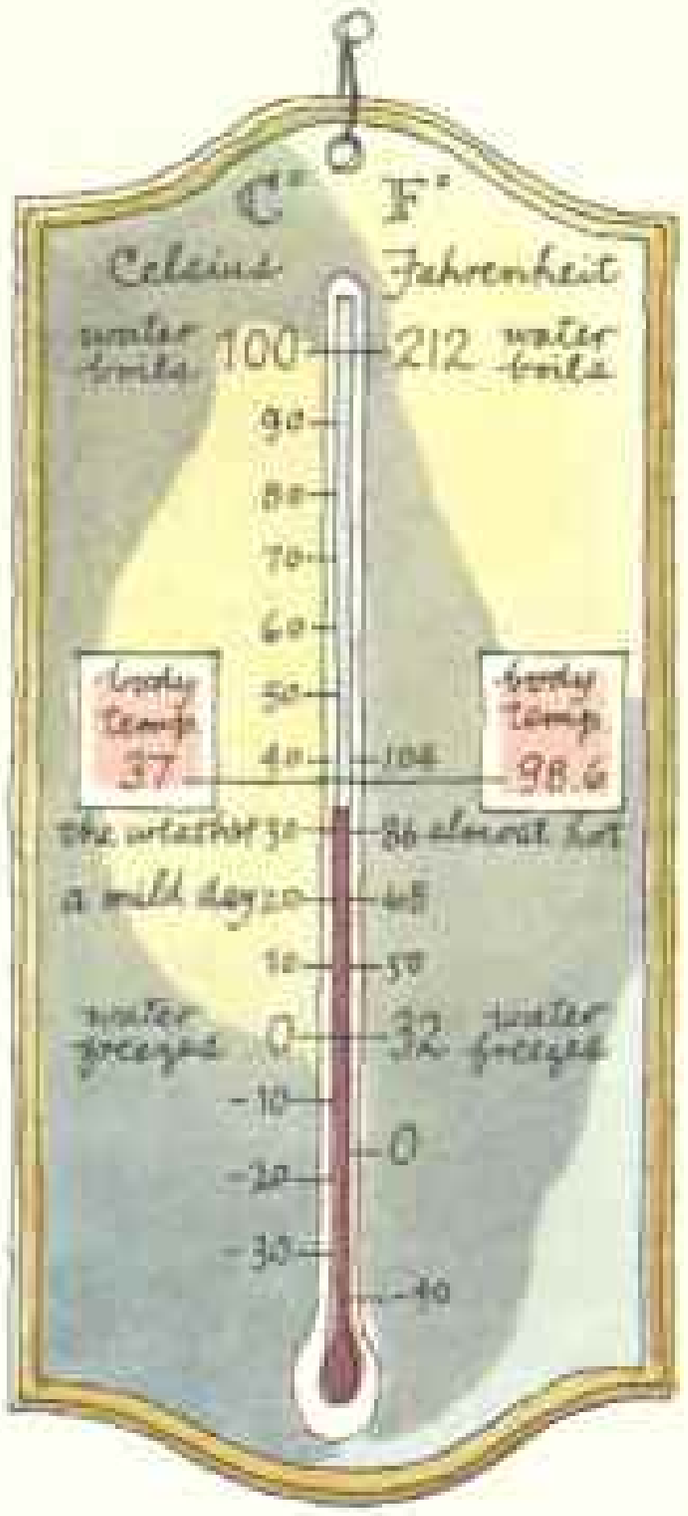
A dime weighs two grams and is one millimeter thick. A stick of gum is 75 millimeters long, a pencil 190. The long dimension of a standard manila folder is 300 millimeters.

The ordinary chair seat is about 450 millimeters high; a doorknob is usually about a meter from the floor. The Washington Monument is 170 meters tall, the Empire State Building 380 meters, and Mount Everest 8,848.

Chicago to New York City is 1,200 kilometers. The earth is 40,000 kilometers around, and the moon is 400,000 kilometers away.

And the national 55-mile-per-hour speed limit comes to about 90 kilometers per hour.

Temperatures in Celsius will not be difficult if one remembers that at 0° water freezes and at 100° it boils; 18° is recommended room temperature for saving energy, 22° to



26° is comfortable; 35° is a hot day; 37° is body temperature. For cooks, 185° is a moderate oven and 215° is hot.

All in all, switching gradually to metric should cause no serious inconveniences or expense to the average person, according to the experience of such countries as Australia and Canada. With effective public education, people discover most of their fears about metrication are unfounded.

For example, as the American National Metric Council points out, cooks will not need to throw away favorite cookbooks or recipes; they will continue using them as they do now. For metric recipes now becoming available, metric measuring spoons cost only a few cents. Measuring cups already on the market are conveniently marked in both milliliters and ounces as well as in fractions of a cup.

Mechanics will need metric tools, of course. But many of them have long since made the investment because of the need to work on foreign cars.

Will new packaging sizes substantially raise food costs? Food producers say not. It's simply a matter of adjusting machinery, not of making entirely new machinery.

Some things won't change even after we are predominantly a metric country. Our money system will remain unchanged; so will units of time. Twelve will still make a dozen, 20 a score. Drivers will continue to say, "Fill 'er up!" or "Five dollars' worth!" We'll still talk about "first down and ten yards to go." And we will retain such expressions as milestone, ten-gallon hat, and inchworm.

We will not likely switch to saying "28.35 grams of prevention are worth 0.4535 kilogram of cure," or "Give him 2.54 centimeters and he'll take 1,609 meters."

With a little time, we'll all find that switching to metric is indeed no big deal—except, perhaps, for the worried farm wife who said she wasn't sure she could get her hens to lay eggs in metric sizes! □

Meter or metre? The French, of course, spell it with an *-re*, as do all the English-speaking countries except the United States. One argument for that spelling is that it distinguishes between the word MI-cro-metre, a measurement, and mi-CROM-eter, a tool for measuring. In the United States, both spellings are officially recognized. Some federal agencies use one form, some the other. The American National Metric Council prefers *-er*, while the American Society for Testing and Materials stands by the *-re* form. Until the question is resolved, the GEOGRAPHIC will continue to use *meter*.

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One remarkable picture appears on the cover; another, a time exposure of 23 seconds (pages 206-208), leads our air-safety article. Share these creative efforts. Nominate a friend for membership today.

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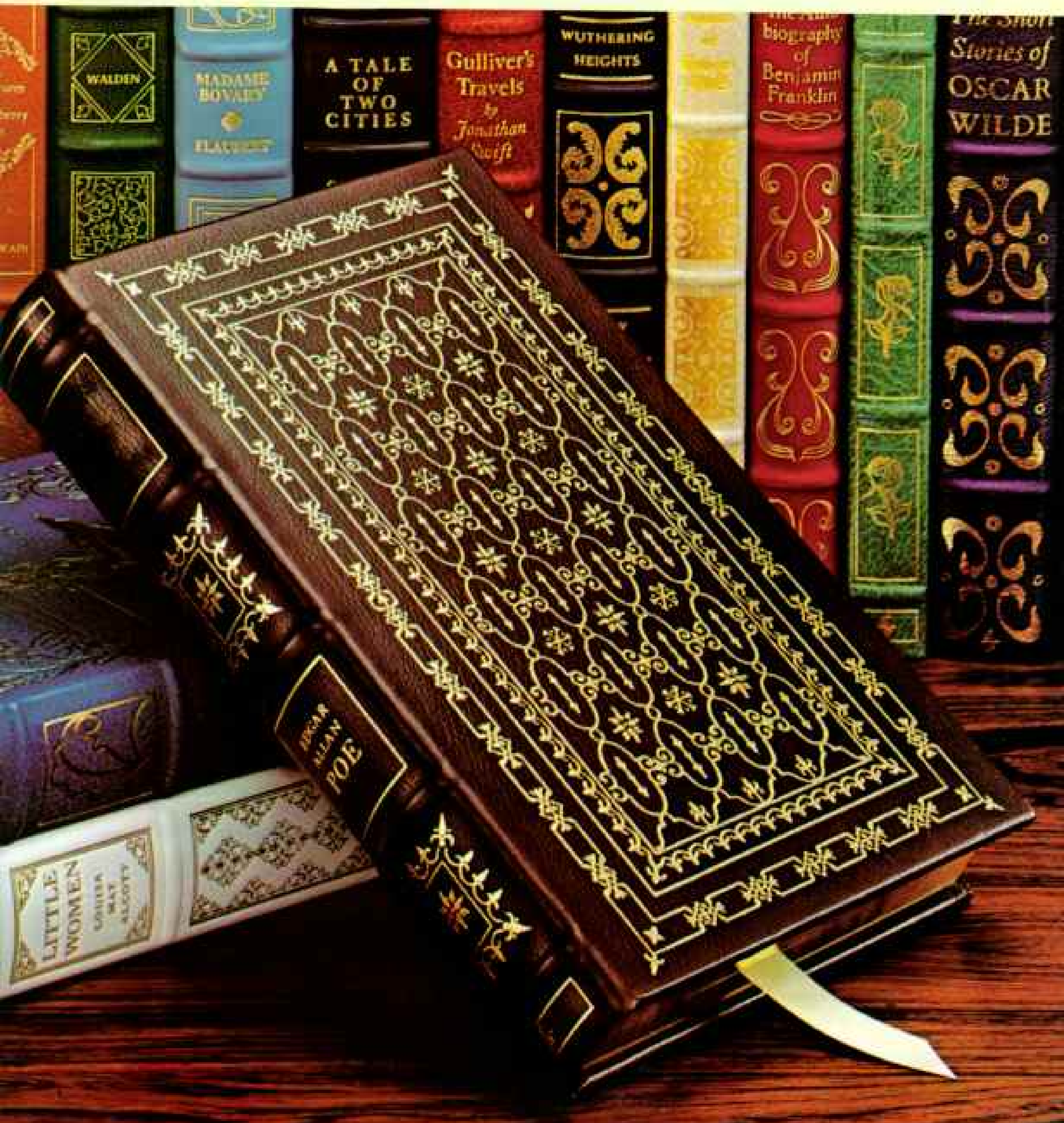

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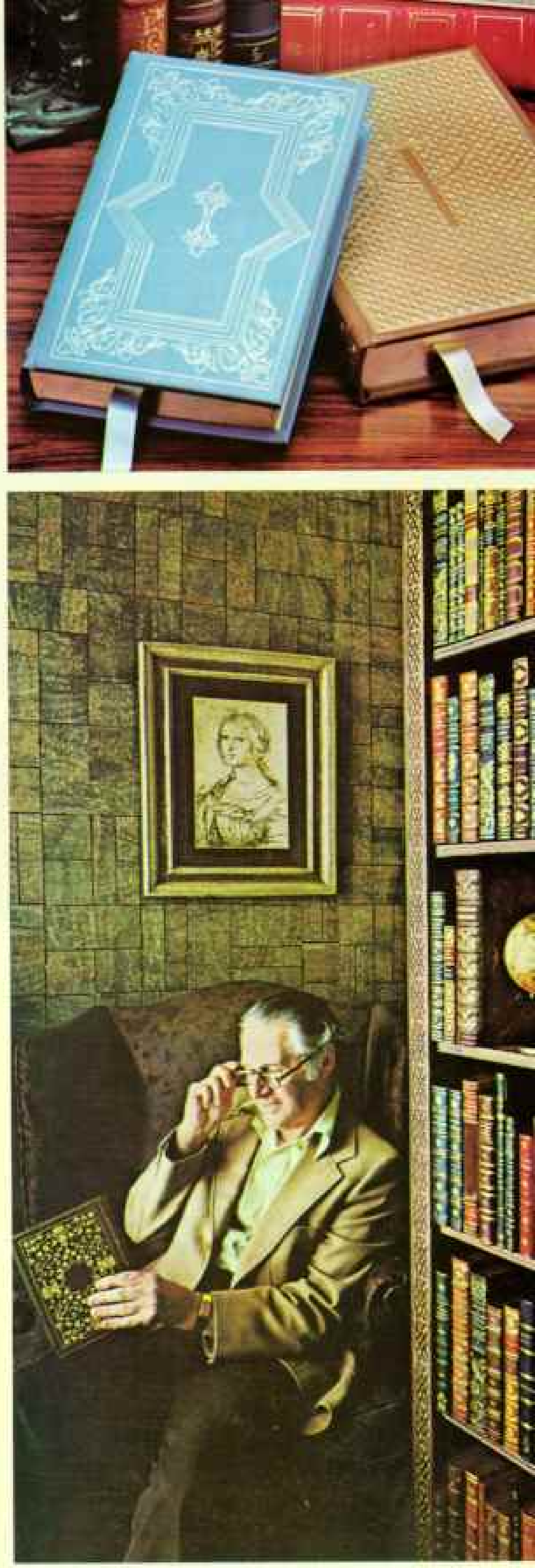

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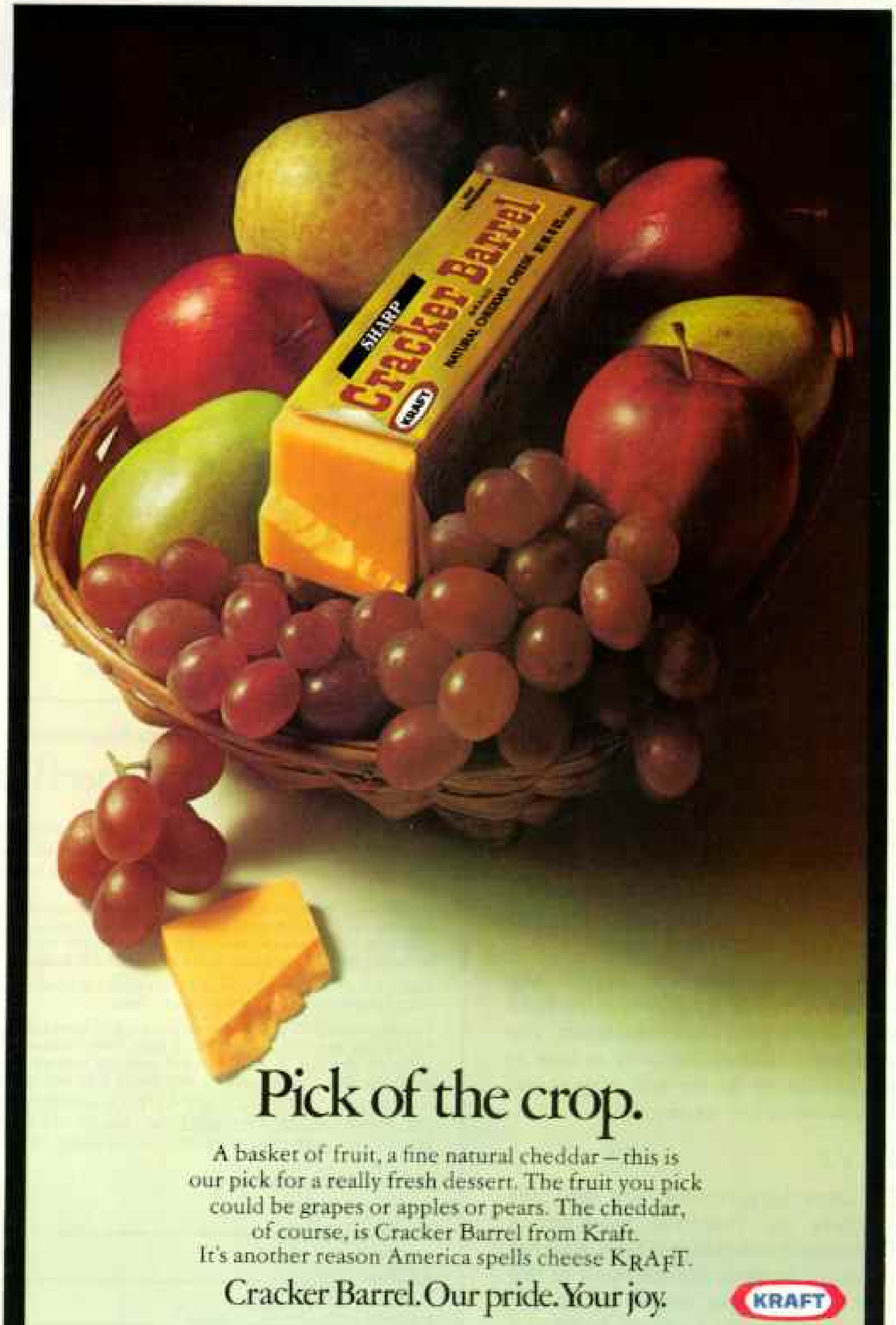

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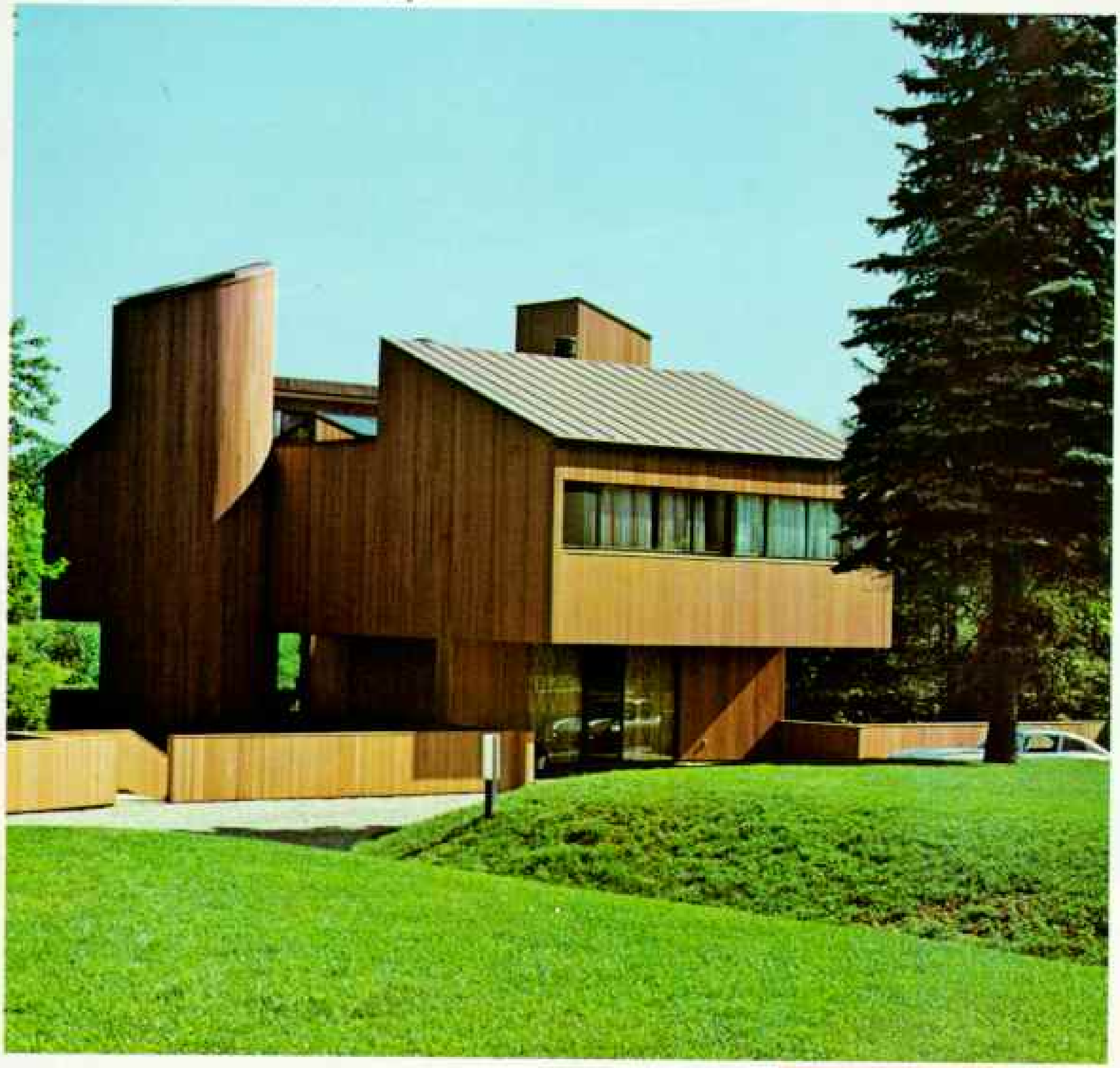

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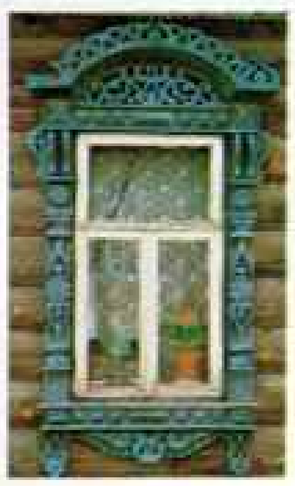

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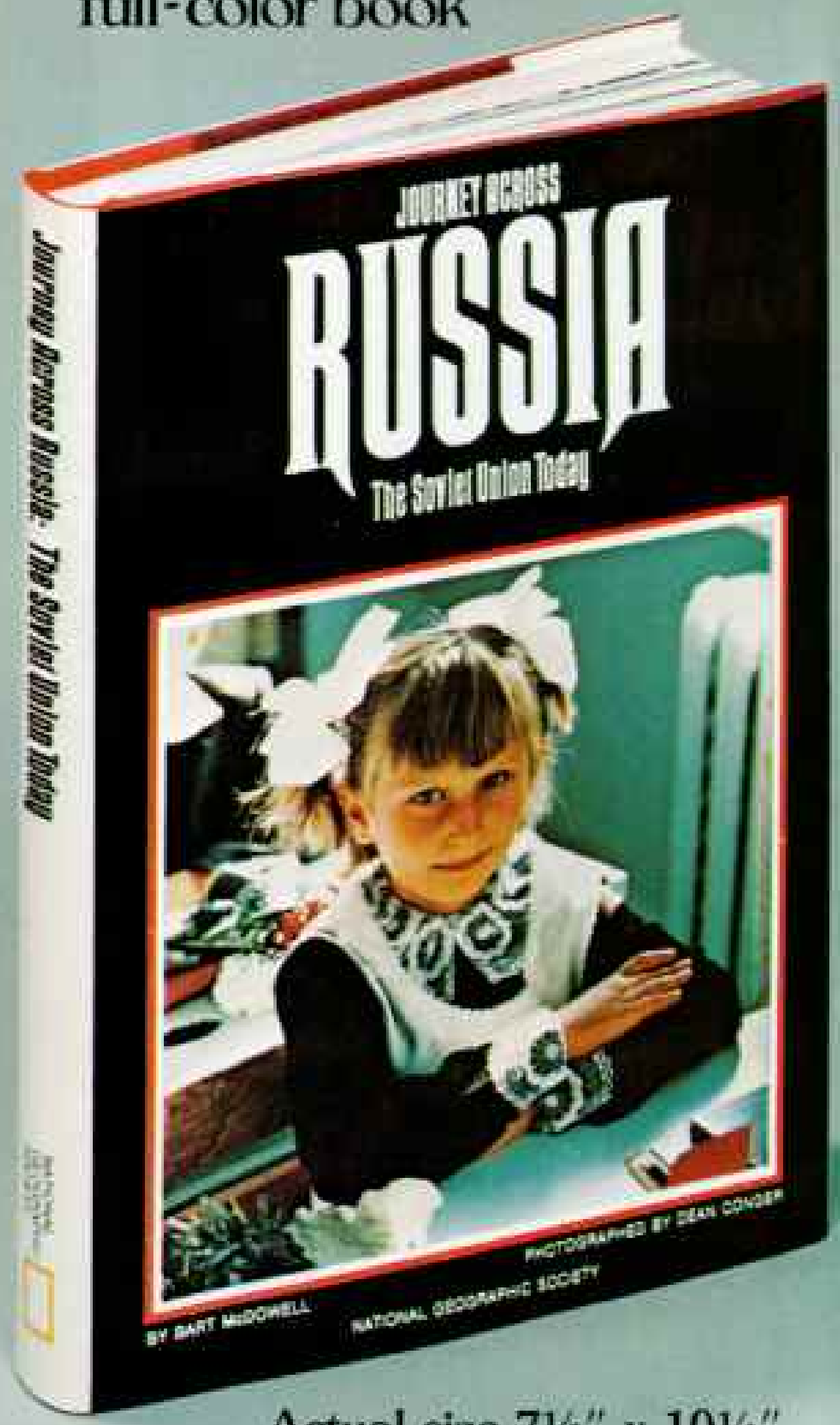

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