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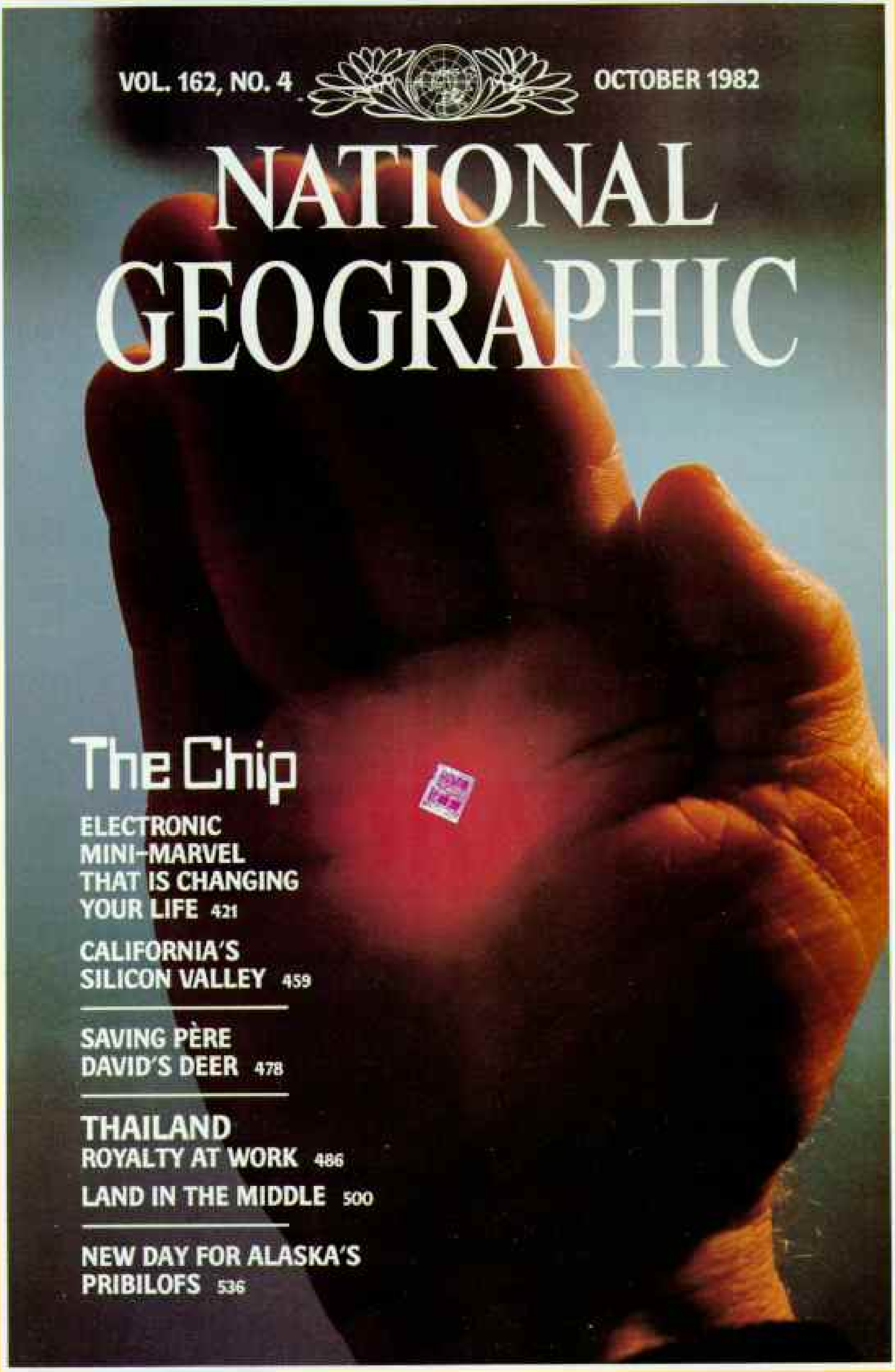

The Chip

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EVEN THROUGH the rose-colored glasses we're sometimes accused of using to view the world, it can be hard to find good news. All too often our evenhanded approach to stories casts us in the gloom-and-doom ranks. But not this month. In October we're happy to offer a varied collection of "good news" stories.

Not far from Sutter's mill, a modern California gold rush has been under way for some time, just as competitive but far more lucrative than the original. As before, vast wealth and power accrue to those who strike it rich, not with gold this time but with little flecks of silicon called chips—those electronic mini-marvels that are the nerve centers of the computer age. The John Sutter of this boom is William Shockley, co-inventor of the transistor. Scientists and technicians flocked to a valley south of San Francisco to be part of the world he began and stake their claims in the new industry.

Like camp followers, the usual mix of con men and crooks also gathered, their ranks spiced with industrial spies, both foreign and domestic. For not only national wealth and prestige but also military superiority ride on the high-tech chip. Photographer Charles O'Rear and writers Allen Boraiko and Moira Johnston unravel the mystery of the amazing little chip and tell us about the valley nicknamed Silicon, where it grew up.

From half a world away we bring two other success stories. First: Thailand—the domino that not only didn't fall when Communism prevailed in neighboring Vietnam, Kampuchea, and Laos, but whose thriving economy grows 6 to 8 percent a year. Regrettably, the growth is partly fueled by the opium that flourishes in Southeast Asia.

The parallel success story: an inside look at the Thai royal family, which this year celebrates 200 years of the Chakri Dynasty.

Even Alaska's Pribilof Islands, remote specks on the map of the Bering Sea, long cursed with economic problems and a deterioration of their Aleut culture, and condemned for their annual fur seal harvest, can see a better life ahead. The fur seal treaty extended by Congress through 1984 has the blessing of the Sierra Club and the National Audubon Society. The Indian Claims Commission has awarded the islanders an 8.5-million-dollar settlement of a 27-year-old claim.

Last, but not least, small herds of Père David's deer, long extinct in the wild in their native China, have prospered so well in England and the United States that some may soon be sent home to China to reestablish the species there.

We haven't thrown away the rose-colored glasses—who knows when we may want them.

Wilbur E. Garrett

EDITOR

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COVER: *Almost lost in the palm of a hand, a silicon chip is the heart and brain of the new computer age. Photograph by Charles O'Rear.*

ELECTRONIC MINI-MARVEL
THAT IS CHANGING YOUR LIFE

The Chip

By ALLEN A. BORAIKO

NATIONAL GEOGRAPHIC EDITORIAL STAFF

Photographs by CHARLES O'REAR

IT SEEMS TRIFLING, barely the size of a newborn's thumbnail and little thicker. The puff of air that extinguishes a candle would send it flying. In bright light it shimmers, but only with the fleeting iridescence of a soap bubble. It has a backbone of silicon, an ingredient of common beach sand, yet is less durable than a fragile glass sea sponge, largely made of the same material.

Still, less tangible things have given their names to an age, and the silver-gray fleck of silicon called the chip has ample power to create a new one. At its simplest the chip is electronic circuitry: Patterned in and on its silicon base are minuscule switches, joined by "wires" etched from exquisitely thin films of metal. Under a microscope the chip's intricate terrain often looks uncannily like the streets, plazas, and buildings of a great metropolis, viewed from miles up.

Even more incongruous, a silicon flake a quarter inch on a side can hold a million electronic components, ten times more than 30-ton ENIAC, the world's first electronic digital computer. ENIAC was dedicated in 1946, the ancestor of today's computers that calculate and store information, using memory and logic chips. But ENIAC's most spectacular successor is the microprocessor—a "computer on a chip." This prodigy is 30,000 times as cheap as ENIAC, draws the power of a night-light instead of a hundred lighthouses, and in some versions performs a million calculations a second, 200 times as many as ENIAC ever could.

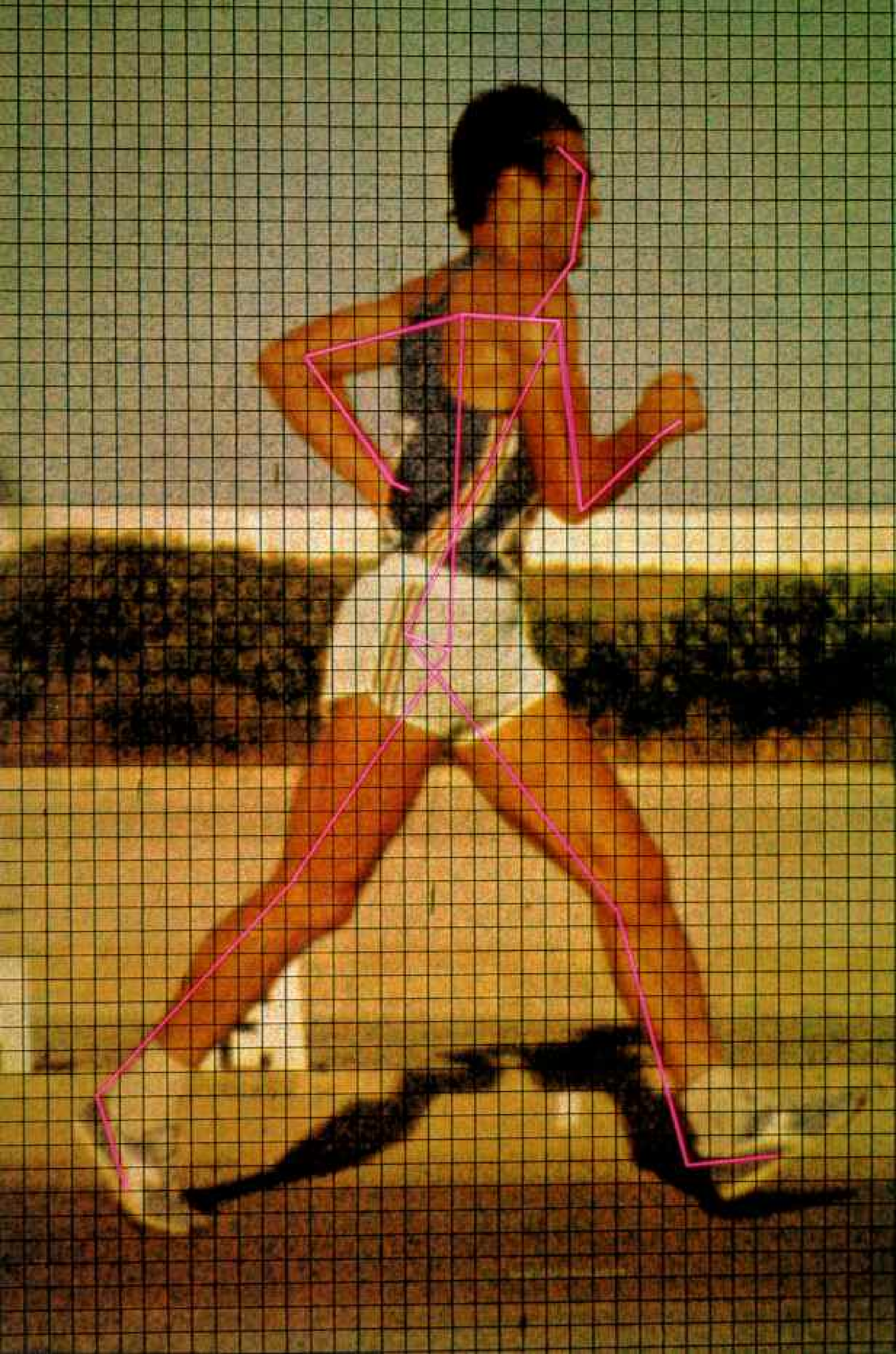
The chip would be extraordinary enough if it were only low-cost, compact electronics, but its ability to embody logic and memory also gives it the essence of human intellect. So, like the mind, the chip has virtually infinite application—and much the same potential to alter life fundamentally.

A microprocessor, for example, can endow a machine with decision-making ability, memory for instructions, and self-adjusting controls. In cash registers the miniature computer on a chip totals bills, posts sales, and updates inventories. In

***Polestar** of a new era, the chip explodes our horizons as its components shrink ever smaller. Nickname for the integrated circuit—a complex of electronic switches controlling electric current and fabricated on a fleck of silicon—the chip, since its introduction in 1959, has advanced technological capacity in quantum jumps. Some are colossal information storers called memory chips. Others, like this Motorola version **(facing page)**, combine memory with logic to produce a "computer on a chip," or microprocessor. Becoming cheaper and more powerful each year, chips are reaching into every area of modern life.*

***Armed by the might** of the miniature, medical prosthetics designers, like these at the University of Utah, are making bold advances with circuitry often as small as nerves and neurons. At the school's Center for Biomedical Design, Ken South of Seattle—victim of a power-line accident that claimed both arms and shoulders—tries out his new electronic limbs, activated by motion sensors and electrical signals from the skin.*

*At Stanford University, a team headed by Dr. Robert White is working on a "bio-ear" (**above**). Implanted behind the ear, it promises rudimentary hearing for the profoundly deaf.*



pacemakers it times heartbeats. It sets thermostats, tunes radios, pumps gas, controls car engines. Robots rely on it; so do scientific instruments such as gene synthesizers. Rather than simply slave harder than humans, machines can now work nearly as flexibly and intelligently, to begin priming a surge in productivity we may one day recall as the second industrial revolution.

The chip's condensed brainpower nourishes another phenomenon—personal computers. Last year more than 800,000 were sold, most to people who do not know how these first cousins of the pocket calculator work, nor need to know, because the chip makes them increasingly easy to use.

Piggybacking on personal computers are dozens of new services. Exotic now, computer conveniences such as electronic mail and newspapers and home banking and shopping could in time become as universal as telephone service.

Questions arise. If we can screen out all but the news that interests us most, will we grow parochial? If we shop and pay bills from home and carry less cash, will streets be safer? Must employees who work at home with company computers be electronically monitored? Will children stimulated by computers grow up to find effective cures for poverty, hunger, and war?

These questions were unimaginable in 1959, birth year of the chip, but in a decade they may be current. That would be no surprise, so broadly and swiftly has the chip penetrated our lives.

Recently I spent months gauging the progress and impact of the chip. In laboratories, scientists showed me that the chip, though complex, is understandable. At home a personal computer alternately enraged and enlightened me. And I learned that the chip's every advance incubates another, and that one another and another.

Eventually one billion transistors, or electronic switches, may crowd a single chip, 1,000 times more than possible today. A memory chip of such complexity could store the text of 200 long novels.

Chips refrigerated in ultracold liquid helium make feasible a supercomputer vastly more powerful than any yet built, with a central core as compact as a grapefruit.

Naval scientists envision semi-intelligent and autonomous robots that can pilot ships to evade enemy fire as well as rescue sailors and recover sensitive code books from sunken submarines.

Borrowing techniques from drug manufacturers, chemists hope to grow, not build, future computer circuits.

Farfetched? Then consider these coming innovations in light of some breakthroughs already achieved.

Unperfected but promising microelectronics implanted beneath the scalp can restore very rudimentary sight and hearing to some of the blind and deaf.

Robots that see, feel, and make simple judgments are entering factories, where less capable robots have been "reproducing" themselves for some time.

Within limits, computers can talk, heed our speech, or read. Some diagnose illness, model molecules, or prospect minerals with the reasoning and success of expert human doctors, chemists, and geologists.

The shock waves of the microelectronics explosion expand too far, in too many directions, to tally them all. But a few of the deeper tremors, recorded here, yield a sort of seismic profile of what lies beneath and beyond this first instant in the age of the chip.

"I WISH we'd had this chip when we were designing it." Dana Seccombe taps the tiny device in the palm of his hand as tenderly as if it were a rare seed, germ of some plant bred to fruit with money. Just so for his employer, the Hewlett-Packard Company, propagator of computers, calculators, and other electronic cash crops.

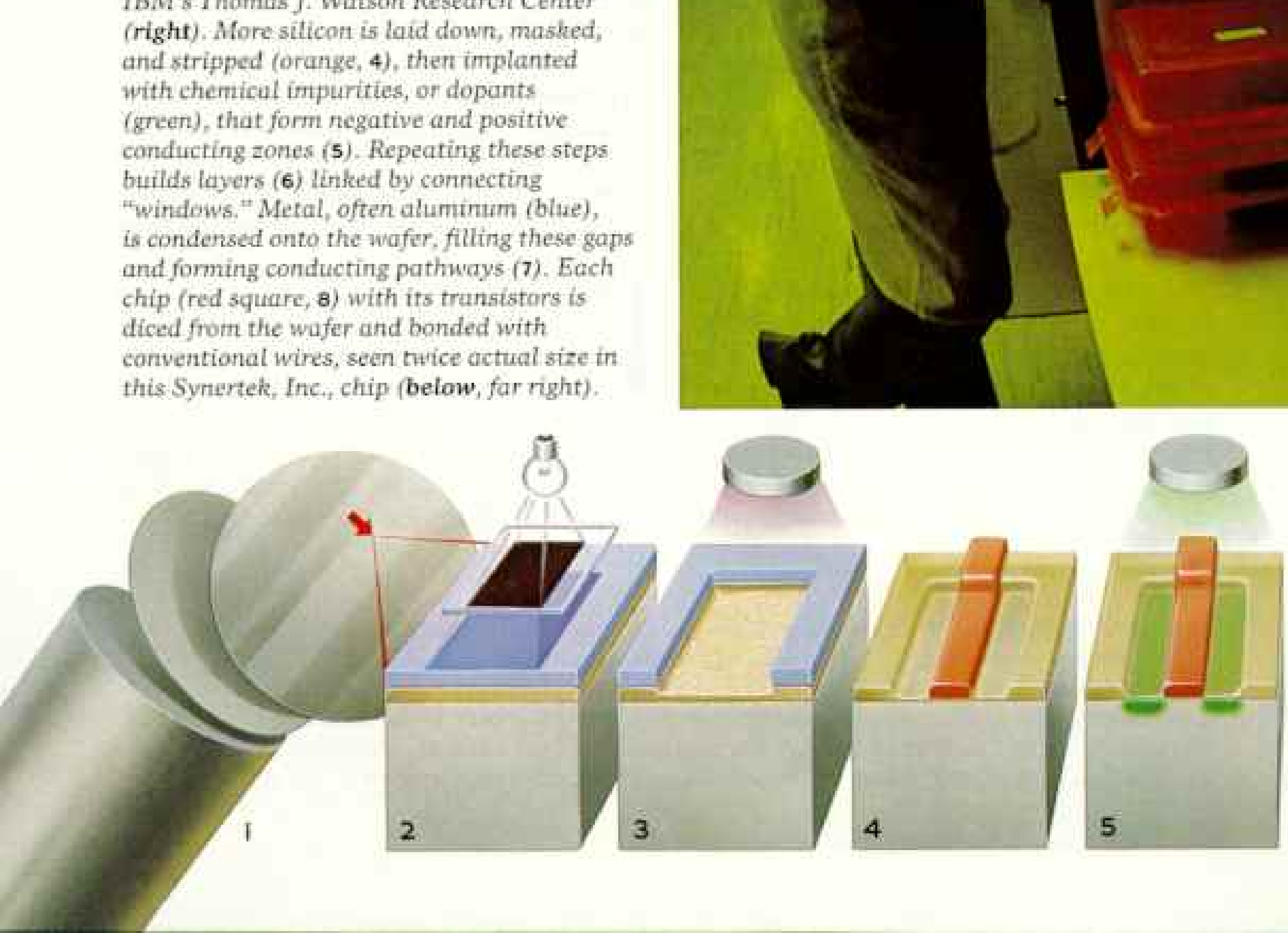
Racing to infinity, *the microprocessor achieves ever greater speed, with the number of calculations per second having leaped in 11 years from 50,000 to a million. Millions of data bits must be processed at high speeds to synthesize motion—a technology with applications ranging from rocket design to sports. Thus, at the Olympic Training Center in Colorado Springs, researchers use computer-produced stick figures, here superimposed, to analyze the performance of race walkers.*

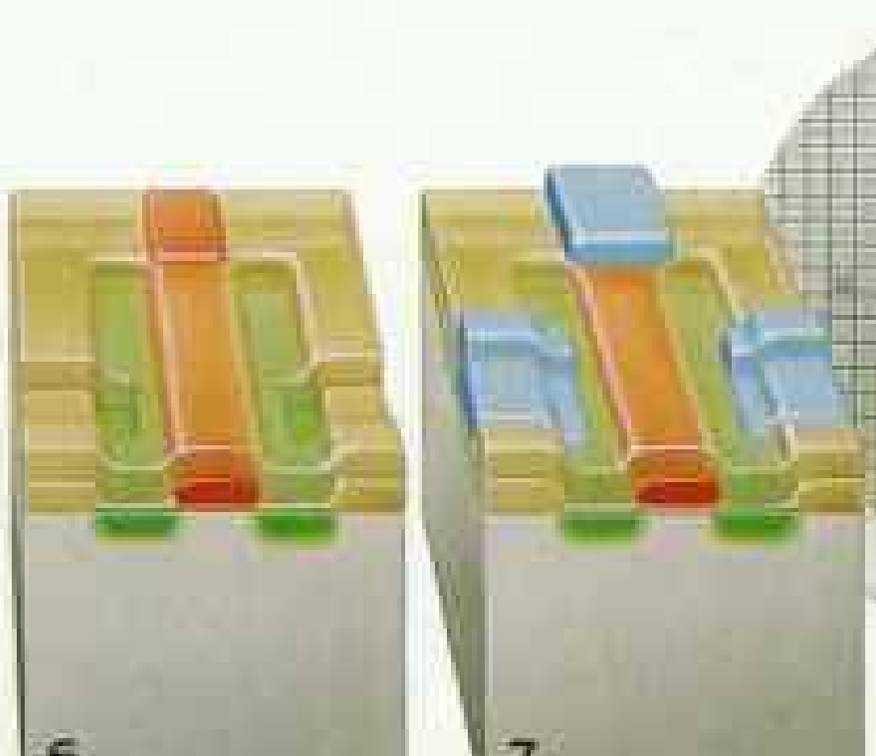
Making a chip

HUMBLE BASE of the chip, and earth's most abundant element after oxygen, silicon is refined from quartz rocks (**below**), *such as these in a North Carolina quarry. Silicon's properties can be altered to create electronic switches, or transistors, that control and amplify electrical signals. Cutaways below show major steps in transistor fabrication.*

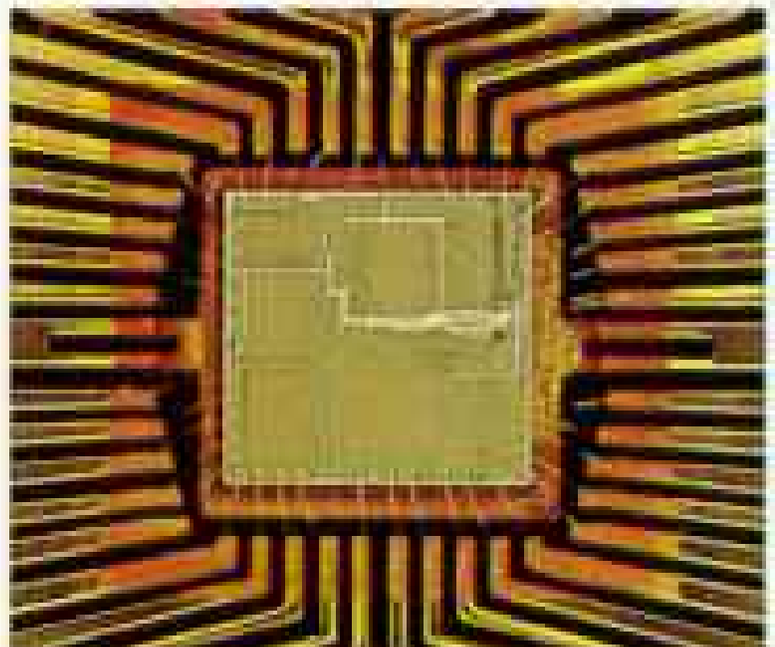
Melted and grown into long crystals, purified silicon is sliced into wafers (1) on which chips are made, hundreds at a time. Each may hold hundreds of thousands of microscopic transistors.

Wafers are insulated with a film of oxide (tan), then coated with soft light-sensitive plastic called photoresist (purple). Masked by a stencil and flooded with ultraviolet light (2), exposed photoresist hardens into the proper outline. Acids and solvents strip away unexposed photoresist and oxide, baring the patterned silicon to be etched by superhot gases (3), a technique used at IBM's Thomas J. Watson Research Center (**right**). *More silicon is laid down, masked, and stripped (orange, 4), then implanted with chemical impurities, or dopants (green), that form negative and positive conducting zones (5). Repeating these steps builds layers (6) linked by connecting "windows." Metal, often aluminum (blue), is condensed onto the wafer, filling these gaps and forming conducting pathways (7). Each chip (red square, 8) with its transistors is diced from the wafer and bonded with conventional wires, seen twice actual size in this Synertek, Inc., chip* (**below**, *far right*).





PAINTING BY DALE GUSTAFSON



Dana, head of chip design at an HP plant in Colorado, passes me the chip. It's a microprocessor and quite a handful, so to speak: 450,000 transistors, laced together by 20 meters of vapor-deposited tungsten "wire." Mapping every street and freeway of Los Angeles on the head of a pin would be an equivalent feat—and no harder. That is, in fact, the gist of Dana's complaint.

Every year for more than two decades now, engineers have roughly doubled the number of components on a chip, mainly by shrinking them. They began with soldered wires as thin as cat whiskers. These projected from silicon or germanium crystals sealed in pea-size metal cans. What resembled a three-legged stool was actually a simple electronic switch—a transistor.

The transistor was invented in 1947 at Bell Telephone Laboratories to replace the bulky glass tubes that controlled and amplified electric currents in early TVs and computers such as ENIAC. These vacuum tubes were energy hungry, gave off far more heat than transistors, and frequently burned out.

But the transistor too had a flaw. It often broke off circuit boards, plastic cards embossed with flat, snakelike wires. The remedy, hit on independently by Jack Kilby at Texas Instruments and Robert Noyce at Fairchild Semiconductor: Make the crystal in a transistor serve as its own circuit board. When the snake ate its tail, the integrated circuit—since dubbed the chip—was born.

Today engineers call it the crude oil of electronics, attesting that world dominance in technology rests substantially on the chip. It has strategic virtues indeed.

The chip lacks soldered wires, reducing failure points and making it ultrareliable. (A vacuum-tube computer as complex as Hewlett-Packard's microprocessor would fail in seconds.) Since the chip is tiny, electrical signals take short paths from switch to switch, saving time. Further, a chip carrying 1,000 transistors does more work, faster, than one with ten—at about the same cost.

Lured by this fairy-tale performance and economy, engineers raced to jam transistors on the chip: 5,000 produce a digital watch; 20,000 a pocket calculator; 100,000 a small computer equal to older ones as large as rooms. At 100,000 transistors, you enter "very large-scale integration," or VLSI. The

Clones of Pac-Man* *are begat by white-robed technicians in a scrupulously clean laboratory. Here* ***(facing page)****, chips designed for the popular video game cover silicon wafers at Advanced Micro Devices in Sunnyvale, California.*

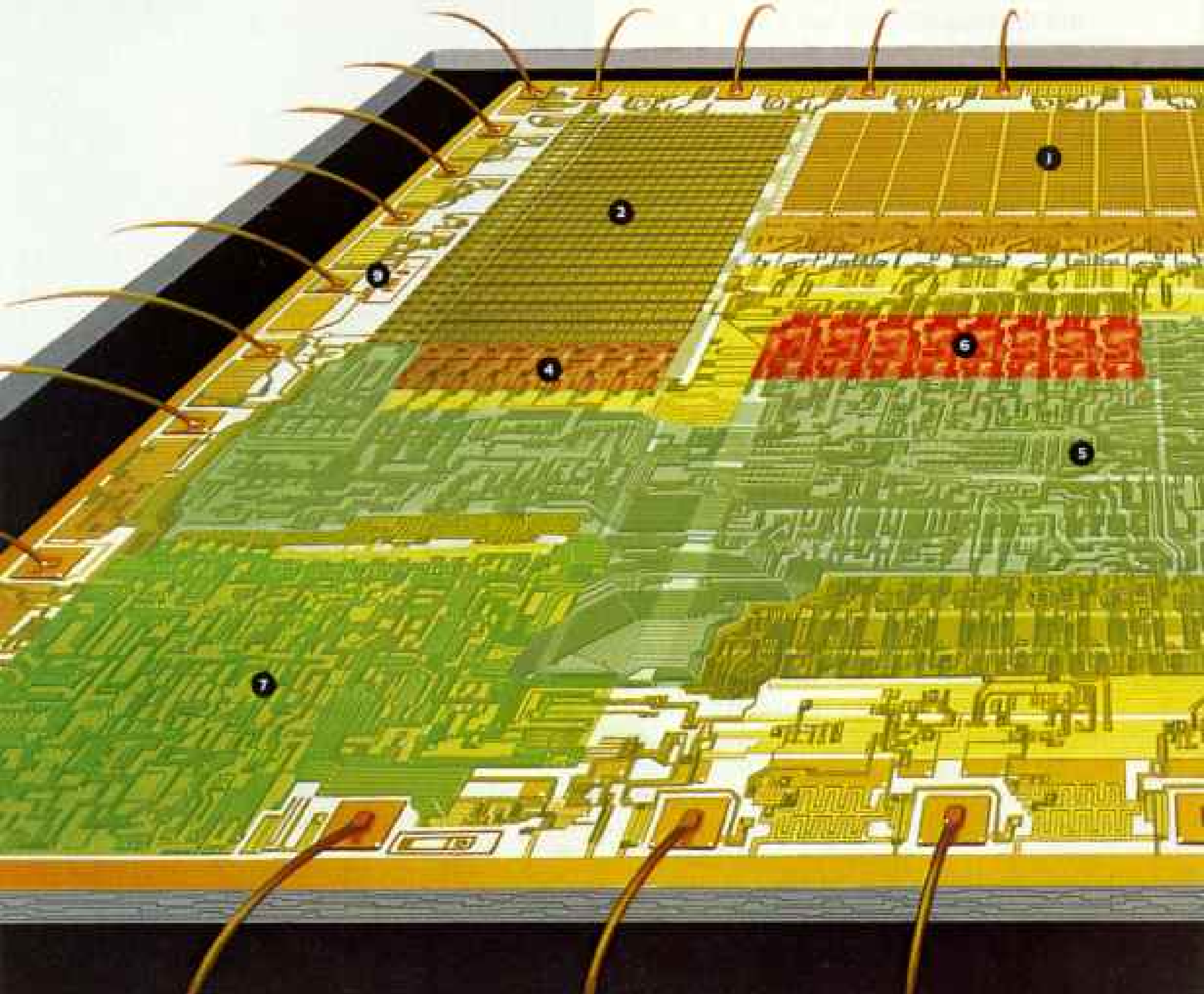
Taking chip design deeper into inner space is electron-beam lithography. At IBM's research center in Yorktown Heights, New York, an experimental electron-beam system ***(above)*** *patterns on each chip circuit features 1/100,000 of an inch wide—three to four times finer than those produced with photolithography.*

Mapping the "microsphere"

*THE GRIDIRON of a great city, seen from the air, would seem no more labyrinthine than the boldly patterned circuitry on the microprocessor depicted below. Small enough to be carted off by a large ant (**right**), this typical computer on a chip holds 30,000 transistors and is sealed in a protective ceramic case (**left**). Lifeblood of the chip, electricity flows in and out through wires of gold or aluminum, which are connected to the outside prongs for plug-in convenience. A window in this packaged chip allows ultraviolet flooding, which erases information. The chip's erasable programmable read-only memory, or EPROM (area 1, **below**), can then be reprogrammed.*

EPROM contains the basic program instructions for performing a specific task, such as running a microwave oven or controlling a car engine. More workaday, the random-access memory, or RAM (2), stores interim operational data. The storage capacities of chip memories are measured in K's, with each K representing 1,024 units of information. Most

ROBERT S. OAKES, NATIONAL GEOGRAPHIC PHOTOGRAPHER



microprocessors rely on auxiliary memory chips, sometimes hundreds, to perform their tasks.

Near each memory section, an addressing unit (3 and 4) selects and transmits instructions, which are dispatched as high- and low-voltage signals, traveling at near the speed of light. These are represented in the binary system, in which only two numbers, 0 and 1, convey information—in much the same way as the Morse code of our telegraph systems.

With things moving so fast, signals could easily get lost and data scrambled. To avoid confusion, signals are steered to the instruction unit (5), which interprets the program and breaks it down into extremely detailed steps for execution by the ALU, or arithmetic-logic unit (6). The ALU can add, multiply by successive addition, subtract, and divide by successive subtraction. Hundreds of thousands of calculations per second are possible with these simple methods.

PHILIPS SCIENCE AND INDUSTRY DIVISION (17X MAGNIFICATION)

The interrupt unit (7) allows—within a few millionths of a second—signals of higher priority to usurp control and begin operating a new program. Like a telephone switchboard, the off-chip-addressing unit (8) directs communications with outside sensors, displays, and other chips.

As in a book, the copyright mark (9) on this microprocessor protects the claim of its designer—the Intel Corporation, creator of the first such computer on a chip.

PAINTING BY DALE GUSTAFSON

Microscope eyes *get a break at Fujitsu Limited, the IBM of Japan. Here, at their semiconductor plant in Aizuwakamatsu, employees flood management with suggestions for improving*

chip, engineers joke, comes in grades like olives—large, jumbo, and colossal.

CONTEMPLATING the Hewlett-Packard chip—colossal grade—Dana says that to grasp its complexity I must scan its floor plan. He unfurls a roll of drafting paper. Four by eight feet, shingled edge to edge with thousands of squares and rectangles neatly inked in brown and black and green and blue, it's but one section of the chip.

"How wide a section, Dana?"

He thinks in microns; one equals thirty-nine millionths of an inch. "Fifteen hundred microns." That's the width of 20 hairs from my head; to spread out the rest of the chip's design would take a gymnasium.

Dana traces a red line from a black square to a green rectangle, symbols denoting transistors and their precisely mated connections. "It takes 100 calculations to position one of these rectangles properly. We mapped two million of them," he adds. Not

quality, adding substance to the boast that "Japan is number one!" Rivaling the U. S. in production of memory chips, the Japanese take dead aim on the computer market.

so odd, his wish for the computing power of a new chip even while still designing it.

Indirectly but obligingly, the chip goes to its own rescue in the guise of computer-aided design, or CAD. A computer built of earlier chips can store diagrams of transistors, rules on how to link them, and data on the intended function of new chips, information that enables the computer to design a chip circuit, display it on a screen, simulate its operation, and report its performance.

Besides plotting transistors, computers also route the interconnections among them. But no computer can yet calculate, in reasonable time, the optimum way to wire a VLSI chip: Possible wiring patterns number in the millions, so complex have chip designs become. Humans must still tediously debug them—hunt for errors, or bugs—and with video screens and attached electronic pens reroute connections or regroup transistors like building blocks.

By 1990 ambitious engineers expect to squeeze ten million transistors on the chip,

enlarging it slightly and making it as complex as a city nearly 1,000 miles square. How do you build a megalopolis almost twice the size of Alaska?

Manufacturing *any* chip is a painstaking, protracted process. Just south of San Francisco Bay, at the Intel Corporation in Silicon Valley, I found that it can take as long as three months to make a microprocessor (see the article about Silicon Valley beginning on page 459).

"Some magic's involved," engineer Ralph Leftwich said as I pulled on a baggy white nylon jump suit, cap, and bootees. *Voilà!* I was a conjurer's illusion in my bunny suit, required fashion in the "clean rooms" where Intel pioneered the microprocessor in 1971 and where filtered air holds fewer than 100 particles of dust or other contaminants per cubic foot. To a microscopic chip circuit, motes are as menacing as boulders.

In one clean room, trays held razor-thin silicon wafers, polished mirror smooth and racked like diminutive records. They were slices of a sausagelike crystal grown from molten silicon so pure that if contaminants were redheads, there would be but 15 of them on earth. Such crystals yield wafers as large as five inches across; each wafer becomes the base of hundreds of chips.

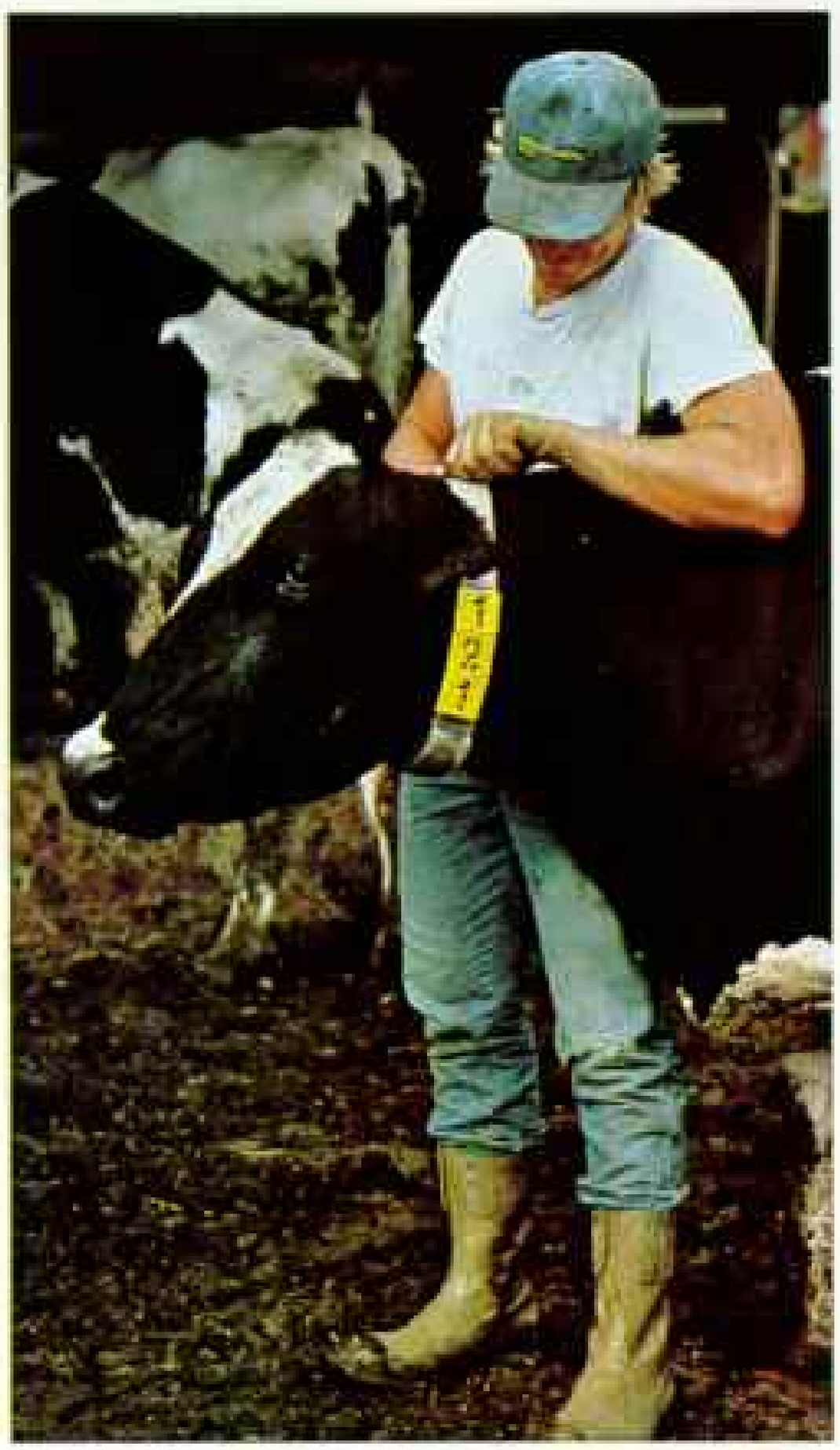
Two things make silicon, a semiconductor, the favored material for chips. Its ability to carry electricity can be precisely altered by ingraining its crystal structure with measured amounts of chemical impurities, or dopants. And silicon surfaces can be conveniently oxidized—rusted, in effect—into an electrically insulating glaze.

"Chips are sandwiches," Ralph said as I peered at a silvery oxidized wafer. He explained that techniques reminiscent of silk screening would stack and stencil the wafer with layers of insulation and crystal, the crystal doped with infinitesimal pockets of impurities laid out in some 300 identical chip-scale circuit patterns (pages 426-7).

"The impurities form conducting areas that overlap from top to bottom of a wafer. By etching 'windows' between them, we create transistors." At the end, with as many as 12 detailed levels demanding interconnection, a wafer receives an aluminum coating and a final etch that leaves conducting filaments invisible to the naked eye.

A new chip's ultrafine "wiring" offers so little entrée to its transistors that they defy individual quality testing. But their collective performance is judged as needlelike probes jab at metal pads on the rim of each chip on a wafer, running 10,000 electrical checks a second. Sound chips are diced from wafers by a diamond saw, then bonded and wired to gold frames and sealed in small ceramic cases propped on stubby plug-in prongs. Packaged, a wafer's worth of chips looks like a swarm of black caterpillars.

THIS ELECTRONIC SPECIES shelters by the dozens in a personal computer, and in their cocoon they might metamorphose into a journalist's tool as useful as pen or notebook.



Cows and computers *are a profitable combination for Missouri dairy farmer Tom Kessler. For 100 pounds of milk daily, his cows should eat exactly 35*

So I fancy at home one day, unpacking a personal computer the size of a portable typewriter. And "floppy discs": plastic platters about the diameter of 45-rpm records. Like cassette tapes, they're invisibly patterned with magnetic fields representing information. To make the computer receptive, there's a master disc. A shoe-box-shaped "disc drive" that I hook to the computer sends information back and forth between the disc and the computer's chips.

"Slip disc into drive," directs a manual. "Turn on power." The drive purrs, spinning the disc. It stops. Atop the computer, in the upper left of a TV screen—another attachment—there now hovers a small square of light. It blinks. That's all.

Minutes pass. "How's it going?" calls my wife from another room. Flustered, I tell her truthfully: "Nothing to it!"

That maddening, flashing marker on the screen insists on action, so I yank the computer's plug. A sullen scan of the manual discloses what's really needed: a concise chain of instructions—a program—telling the computer what to do, step by step. In my knotted brain a light goes on, followed by another on the screen.

Prompted by the blinking marker, or cursor, I type a practice game program on the computer's keyboard. Now the machine should display a dot, bouncing like a ball back and forth across the screen.

It beeps instead, heralding an error. I give the computer a very personal command not in any manual, then begin debugging.

pounds of grain, but often didn't. The diet of the cows, with electric eyes in their feed bins and transistorized sensors around their necks, can now be precisely monitored and controlled. Every day, farmers like Don Gloy of Grant, Nebraska ***(above)****—small businessmen all—are meeting the future in the shape of a home computer.*

CHOOSE A STARTING POSITION FOR DOT is up on the screen, good. So are the commands IF DOT ON SCREEN, PLOT NEW DOT POSITION and ERASE OLD POSITION. About two dozen other instructions look fine. Wait. I forgot to type: MOVE DOT AGAIN. Short one step of logic in its program, the computer simply quit. As might a dim-witted cook given a recipe that fails to instruct: "Bake cake in 350° oven for 50 minutes."

Frustrated and chastened by this machine that demands finicky precision, I can see why last year business and government paid an estimated four billion dollars for ready-made computer programs, or "software." Why by 1990 we may need 1.5 million programmers—more than three times as many as today—to write instructions for computers that issue paychecks, run factories, and target nuclear missiles. And why hundreds of programmers need months to debug 500,000 commands for flight computers aboard the space shuttle.

Fortunately, falling prices for personal computers help swell a rising tide of off-the-shelf programs that make the machines "user friendly." Once only an electronics hobbyist could master a personal computer—by building it. But as the chip reshapes computers into consumer items—some desk-top models cost no more than TV sets, pocket computers even less—they must be simple enough for anyone to use.

To budget money, for example. One program instantly shows a home buyer how changing interest rates affect house payments. Or savings. Programs teach, everything from arithmetic to zoology. Game programs—pinball and chess and monster mazes—may number in the thousands.

With a printer and a word-processing program, the computer I used to write this article shifts, copies, or erases a word, line, paragraph, or page of text, to print cleanly edited manuscripts or letters. It also keeps files and corrects mispellings. Misspellings. Misspellings.

IT'S THE NATURE of computers, of course, to do these things electronically, by switching, storing, and transforming pulses of electricity. But humans can't understand electrical signals; computers comprehend nothing else.

Last rites *for a great computer, ILLIAC IV, which cost NASA 30 million dollars in 1972, is disassembled for scrap* (**above**), *while a smaller, smarter, 11-million-dollar model waits in the wings at Ames Research Center in California. ILLIAC could perform millions of aerospace calculations per second—and simultaneously. But it consumed enough power to light a small city and needed a maintenance crew of 20.*

Spurred by the chip, racing obsolescence and falling prices are causing used-computer dealers, like Sonny Monosson (**right**), *to tear their hair. Co-owner of American Used Computer in Boston, Sonny gives the market only another year or two of survival.*

Yet we do communicate with computers—by translating our numbers, letters, and symbols into a *code* of electrical pulses. In computers, by custom, a high-voltage electrical pulse represents the digit 1; a low-voltage signal stands for 0. Because this system is binary (it contains only two digits), the electrical pulses in a computer are called bits, from binary digits.

Electrical pulses representing two digits may seem thin resource for expression, but Lincoln's eloquent Gettysburg Address was telegraphed across Civil War America with only a dot and a dash, the "bits" of Morse code. Similarly, ones and zeros can encode numbers, an alphabet, or even the information in photographs and music.

Many computers, including most personal ones, digest information in chains of eight electrical pulses. These pulse strings—called bytes—shuttle through a computer's chips something like trains in a railroad switchyard. Since a byte consists of eight bits that may stand for either 1 or 0, the "cars" in one of these "trains" can be arranged in 256 (2^8) different ways. That's more than enough combinations to represent uniquely each letter, number, and punctuation mark needed for this article. Or to write the instructions enabling a computer to express and print it.

To carry out instructions, a computer depends on its central processor; in personal computers this "brain" is a single chip—a microprocessor. If you scanned this silicon sliver by microscope, you would notice what might be railroad tracks. These conduct "1" and "0" electrical pulses, passing through the chip at nearly the speed of light.

Alone, a microprocessor cannot hold all the data it needs and creates when working. So memory chips help out. Magnified, they show transistors in intersecting rows and columns, recalling a city street map. This grid allows the microprocessor to assign a byte a unique "address" for instant storage

Relic of the fifties, *a 16K memory bank, spangled with vacuum tubes, makes an ungainly comparison with a 16K memory chip viewed through a microscope at the Computer Museum in Marlboro, Massachusetts.*

High-tech glossary

Bit *An abbreviation of binary digit, one of the two numbers—0 and 1—used to encode computer data. A bit is expressed by a high or low electrical voltage.*

Byte *A group of eight bits used to encode a single letter, number, or symbol.*

Chip *A small piece of silicon that is a complete semiconductor device, or integrated circuit.*

EPROM (erasable programmable read-only memory) *A type of memory in which stored information can be erased by ultraviolet light beamed in a window of the chip package. EPROMs can be reprogrammed repeatedly.*

Gate *This term has two distinct meanings in semiconductor technology: the controlling element of certain transistors, or a logic circuit that has two or more inputs that control one output.*

Integrated circuit *A semiconductor circuit combining many electronic components in a single substrate, usually silicon.*

K *Usually an abbreviation for kilo (1,000). A 1K memory chip, however, contains 1,024 bits because it is a binary device based on powers of 2. Thus a 64K memory can store 65,536 bits of information (64 x 1,024).*

LSI (large-scale integration) *This term is generally applied to integrated circuits containing from 500 to perhaps 20,000 logic gates, consisting of transistors, or 1,000 to 64,000 bits of memory.*

Logic *The fundamental principles and the connection of circuit elements for computation in computers.*

Mask *A glass photographic plate that contains the circuit pattern used in the silicon-chip fabrication process.*

Memory chip *A semiconductor device that stores information in the form of electrical charges.*

Microprocessor *An integrated circuit that provides in one chip functions equivalent to those contained in the central processing unit of a computer. A microprocessor interprets and executes instructions and usually incorporates arithmetic capabilities and some memory.*

RAM (random-access memory) *A memory in which any piece of information can be independently stored or retrieved. Its contents are only held temporarily.*

ROM (read-only memory) *A memory chip in which information is permanently stored during the manufacturing process.*

Semiconductor *An element whose electrical conductivity is less than that of a conductor, such as copper, and greater than that of an insulator, such as glass.*

Transistor *A semiconductor device that acts primarily either as an amplifier or as a current switch.*

VLSI (very large-scale integration) *Integrated circuits containing on the order of 20,000 logic gates, or more than 64,000 bits of memory.*

Wafer *A thin disk of semiconductor material on which many chips are fabricated at one time. The chips are subsequently separated and packaged individually.*

Lured into learning, *children at Sesame Place, an educational-play park near Philadelphia, sharpen their math and language skills on "user friendly" computers. The first generation to grow up with computers, children of the eighties are taking to them with a zeal and skill that often astounds their parents. More than just a powerful teaching aid, computers foster a technological literacy that will help prepare children for careers in a computer-based society. Noting the handwriting on the wall, governments around the world are committing themselves to computer education.*

and recall. Most often, a memory chip permits bytes to be retrieved individually, like the numbers in a telephone book. Some such random-access memory chips, or RAMs, can store the equivalent of four copies of the Declaration of Independence.

FOR JAPAN, the chip itself is a declaration of independence. In recent years Japanese electronics firms have adopted and refined U. S. technology to win a global lead in RAMs, the vital fuel of the computer industry. Japan's semiconductor samurai also have a reputation for quality and sharp pricing, keys to survival in a fiercely competitive 10-billion-dollar world market for chips. I glimpse part of it one day in Tokyo's Akihabara district.

This is no tranquil geisha quarter I'm wandering, but a garish electronics bazaar. If it holds a chip, you'll see it here, declares a shopkeeper. He sits nearly hidden in one of hundreds of stalls crammed with everything electronic from cassette players to pocket computers, ballyhooed by huge banners in hot pink and Day-Glo orange.

At many stalls loose chips tumble like jelly beans from bins and boxes. Hobbyists paw through them; so do engineers hunting competitors' chips to study. Keeping tabs on a rival's products isn't easy, for the Japanese output of electronic goods is huge: 16 million TVs, 16 million radios, and 55 million calculators in 1981 alone.

"We face far keener competition in Japan than in the U. S.," says Dr. Matami Yasufuku, executive director of Fujitsu Limited, Japan's largest computer company and a top chip producer. "We Japanese can't afford to dump discount-priced chips overseas."

U. S. competitors claim the Japanese have done just that, to capture 70 percent of the world market for 64K RAMs, chips able to store 65,536 bits of information. ("K" stands for 1,024). The Defense Department worries that U. S. computers, weapons, and telecommunications may grow dangerously dependent on the foreign memory chips. Anxious not to provoke import quotas, the Japanese have cut chip exports and shifted some production to U. S. plants.

Yet Japan's chip makers remain aggressive. Recently they unveiled a new generation of memory chip, with four times the

capacity of 64K RAMs. Their domestic chip plants expand relentlessly too: So many have opened on Kyushu in the past few years that this southernmost of Japan's main isles has been nicknamed Silicon Island.

U. S. rivals, trying themselves to gain or expand a Kyushu toehold, note that in the 1970s Japan's influential Ministry for International Trade and Industry sponsored a national drive to end U. S. dominance in chips. And they complain of Japan's tax breaks, research subsidies, and cheap loans for domestic firms, proof to them that the Japanese will tolerate no threat to a commodity as strategic as the chip.

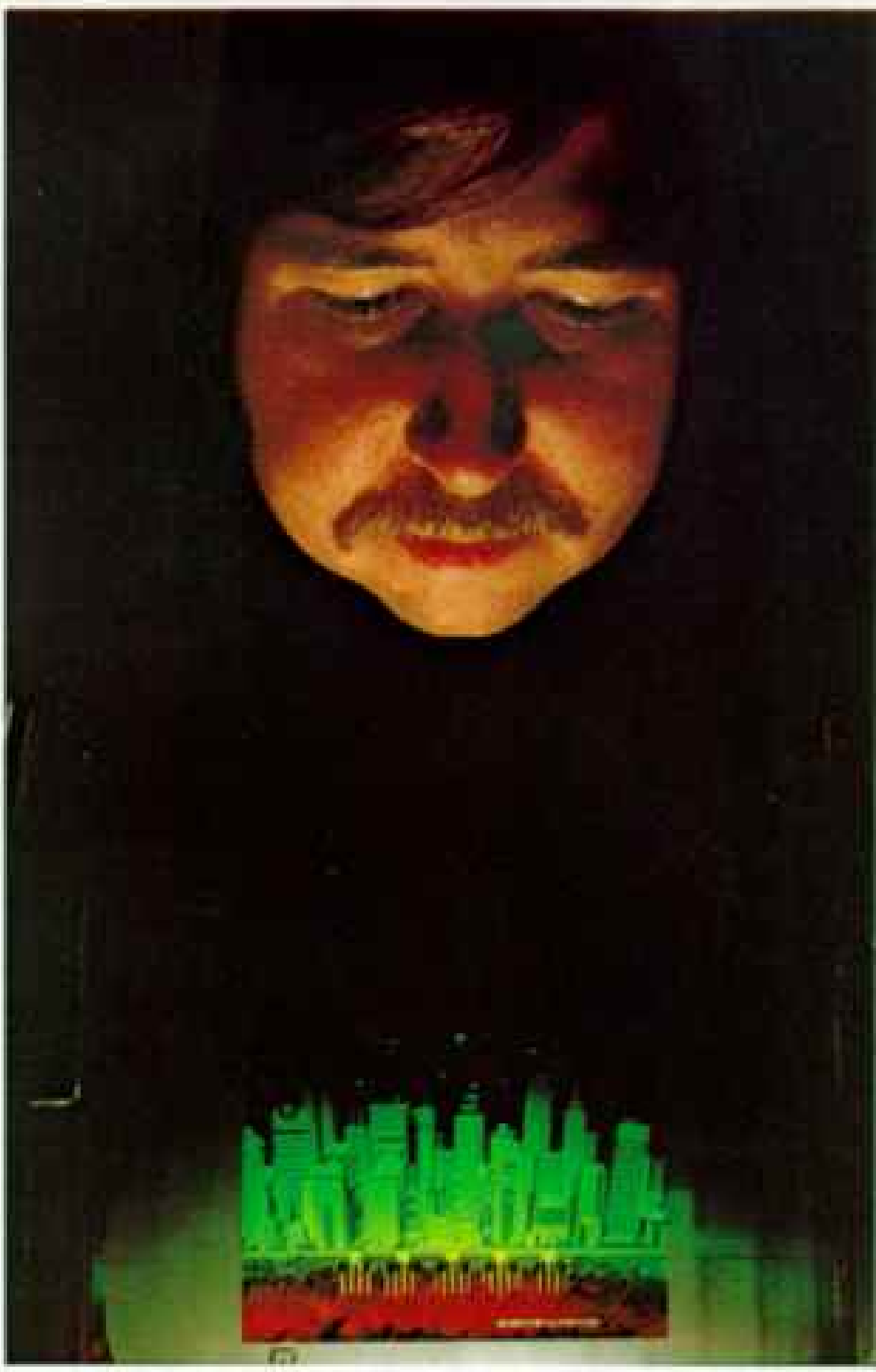
"We've got a few years of tough competition ahead," concedes Dr. Lewis M. Branscomb, vice president and chief scientist of the International Business Machines Corporation, "as the Japanese exploit the fact that they have given intense interest to manufacturing, productivity, and quality in the past 20 years while Americans were asleep at the wheel." Nonetheless: "I'm much surer of our ability to match them in production and productivity than of their ability to match us in innovation."

INNOVATION. Lately that word has taken on talismanic overtones in U. S. microelectronics research. Small wonder, considering some of the far-reaching changes brewing in the nature of the chip.

• Design: A squad of engineers needed 18 months to lay out Hewlett-Packard's microprocessor, but university students are now learning to plan complex chips in far less time, using new design principles devised by Professor Carver Mead of the California Institute of Technology and Lynn Conway of the Xerox Corporation.

Significantly, chips designed in this new fashion offer organizational insights that can simplify construction of "parallel processors," computers organized to do all steps of a task simultaneously, like a factory where everyone works at once.

Supercomputers operate somewhat like this now. In hours they run calculations—long-range weather forecasts, for example—that other computers take days to finish. Such speed is expensive; a super unit typically costs ten million dollars. But Dr. Mead believes that with new chip designs



Adding another dimension *to the video sorcery that already zaps millions, Atari Incorporated has acquired patents to mass-produce the hologram, a 3-D image produced with lasers. Though officials at the world's largest video-game maker say the idea still needs refinement, the combination of chip and laser has already resulted in military applications as well as computerized supermarket checkouts.*

Some seven million American homes now have video games hooked up to their TVs, the best place, many feel, for this activity. Pool halls of the new generation, quarter-gobbling video arcades raise fears of juvenile truancy and theft.

supercomputers could be built small and cheap enough to give one to every child.

"The consequences would be awesome," he predicts. "Kids could simulate with utter realism what it's like to pilot a jet, fly by the rings of Saturn, or be jostled by the atoms banging around in a fluid. Think how kids raised with such computers would transform society. There's nothing they wouldn't believe they could handle."

• Manufacture: Shrinking microcircuits put a premium on new tools to make chips with exquisite precision. At an IBM plant in eastern New York, beams of electrons transfer chip designs directly from computers to wafers. And they do it with an accuracy comparable to a skipper holding his ship within 525 feet of its course throughout a voyage from New York to New Orleans.

Such beams have unmatched potential to pattern wafers with incredibly fine circuits. At the National Research and Resource Facility for Submicron Structures at Cornell University, Dr. Michael Isaacson has carved into salt crystals letters so tiny that a 30-volume encyclopedia could be written on a chip the size of a half-dollar.

• Materials: Other scientists try building chip circuits, atom by atom, of chemicals beamed at wafers. The goal of such "molecular beam epitaxy" is more transistors on chips, packed in three-dimensional rather than flat arrays. The process can also sheet wafers with layers of gallium and arsenic compounds that conduct electricity ten times as fast as silicon.

The drive to cram more components on the chip may end in a test tube, says chemist Forrest L. Carter of the U. S. Naval Research Laboratory in Washington, D. C. Dr. Carter thinks that relatively soon molecule-size computer switches will be synthesized from inorganic chemicals, like some drugs. Then, within 30

Quantum leaps to the chip

VACUUM TUBE TRIODE

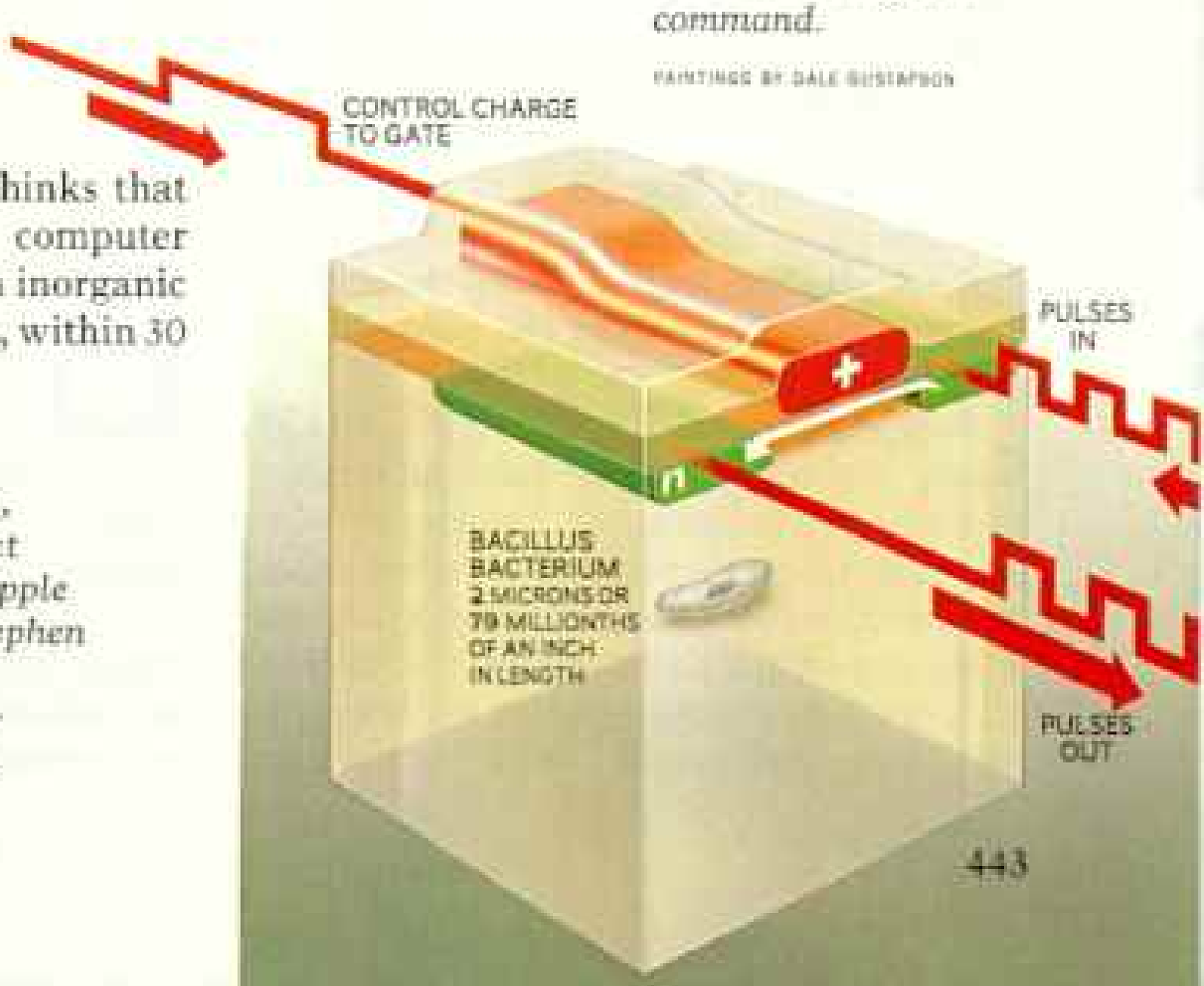
EARLY TRANSISTOR

THE VACUUM tube was the fragile glass controller and amplifier of electric signals in early electronic computers. But the bulky tube gave off vast amounts of heat and often burned out.

*Its cooler and more rugged successor, the transistor, was invented in 1947 at Bell Telephone Laboratories. Within a decade the device consisted of a speck of silicon or germanium crystal encased in a pea-size metal can (**middle**).*

*Still shrinking, transistors—some now smaller than a bacterium—can switch signals in billionths of a second and take virtually no power to run. This transistor (**below**) contains two regions treated with negative phosphorous atoms (green). A positive control charge (**left**) entering the polysilicon gate (red) attracts electrons from the phosphorous-treated areas to form a bridge across the gap (white arrow), allowing incoming pulses to pass and emerge on command.*

PAINTINGS BY DALE GUSTAFSON



***Designed in a garage** six years ago, Apple IIs roll off a production line at Carrollton, Texas. Co-founders of Apple Computer, Inc., Steven Jobs and Stephen Wozniak seized the moment when microelectronics opened the way for mass-produced personal computers.*

Chip on your wrist

THE CHIP has taken the tick out of the wristwatch and embellished it with calculators, calendars, and alarms. In the color-coded mechanical watch (1) the repetitive motion of a balance wheel (orange, uppermost) is turned into units of time through a gear train (purple) and a pacing

years, we could be jamming a cubic centimeter "with a million billion molecular switches, more, probably, than all transistors ever made."

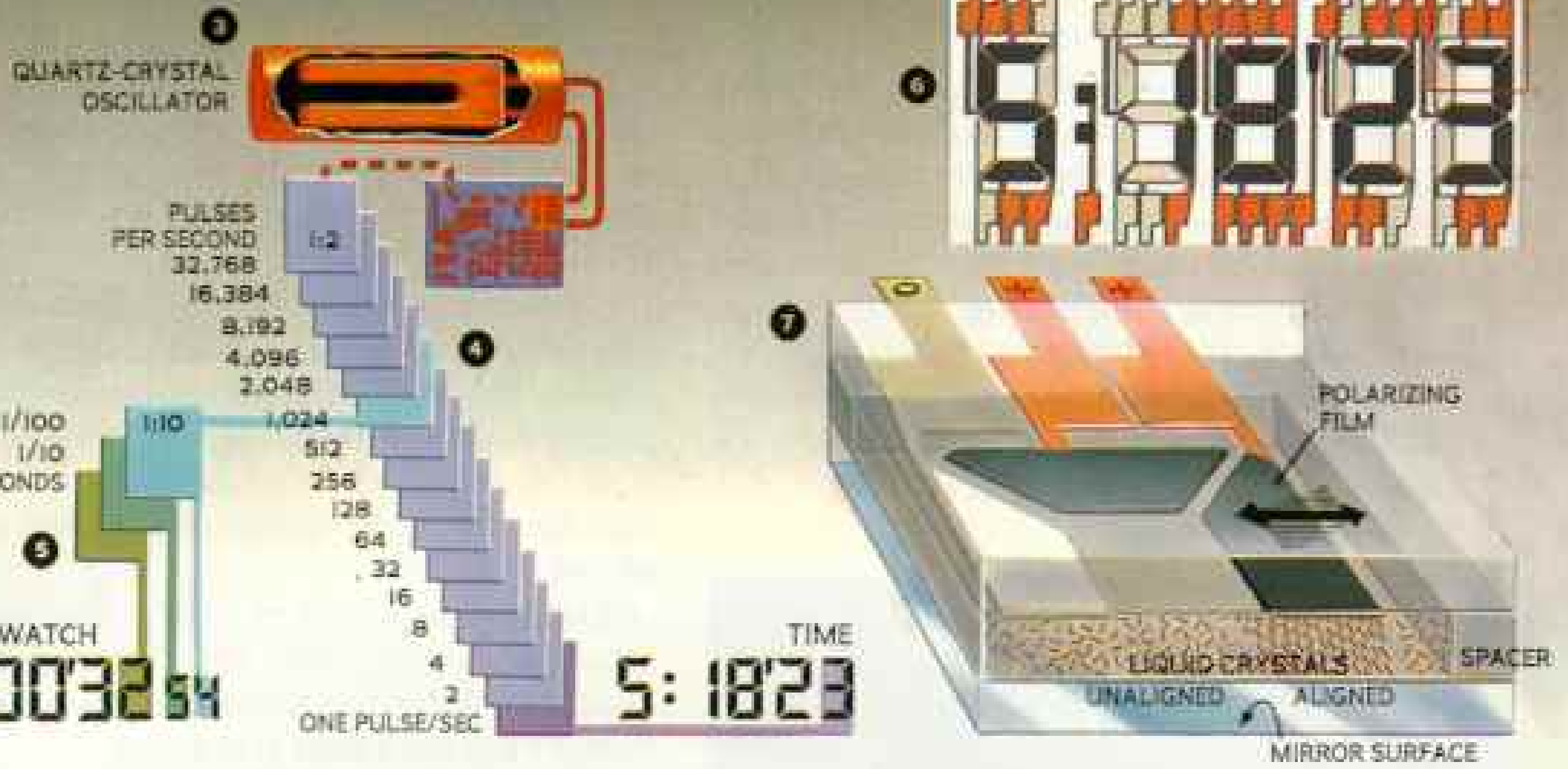
From Bell Telephone Laboratories scientist Andrew Bobeck has come the magnetic bubble memory. On this chip, bubble-shaped magnetic areas in a film of garnet crystal store such computerized messages as, "We're sorry, but the number you have reached has been changed to. . . ." One day, Bobeck told me, a bubble chip the size of a postage stamp will hold the contents of a small phone book.

Researchers at Bell Labs, IBM, and elsewhere are refining Josephson junctions—electronic switches made of metals that lose all resistance to electric current when chilled to near absolute zero. Chips with these devices can switch signals in seven-trillionths of a second, presaging ultrafast telephone switching equipment, or a refrigerated supercomputer. Its chilled circuits could be packed into the volume of a grapefruit, cutting travel time for signals and enabling the machine to carry out 60 million instructions a second, ten times as many as current high-performance computers.

IBM hopes to build a prototype in a few years. "Could it be of commercial significance?" IBM's Dr. Branscomb baited me. "I'll tell you in the 1990s."

BY THEN the Japanese may have created a thinking computer. Memory-chip successes have inspired the Ministry for International Trade and Industry to launch work on a machine that may win Japan command of the technological revolution being sparked by the chip.

In Tokyo, MITI official Sozaburo Okamatsu told me: "Because we have only limited natural resources, we need a Japanese technological lead to earn money for food,



PAINTING BY DALE GUSTAFSON

device called an escape wheel (also orange) that is powered by the stored energy of a mainspring (blue). These components have their counterparts—similarly colored—in the quartz-crystal watch (2). Batteries replace the mainspring as a power source. The escape and balance wheels are replaced by a quartz crystal (orange) (3), which oscillates at a frequency of 32,768 pulses per second. Circuits (4) halve the pulses 15 times to arrive at intervals of one second. In the stopwatch mode (5) pulses from the fifth circuit divide the frequency of 1,024 by tens, to arrive at approximate 10ths and 100ths of a second.

The chip also controls the digital display (6). Millions of microscopic liquid crystals float between a grid work of electrodes (7) that can form all numbers. When the electrodes are charged, creating an electric field, the crystals line up in opposition to the surface polarizing film to produce a display for a watch.

oil, and coal. Until recently, we chased foreign technology, but this time we'll pioneer a second computer revolution. If we don't, we won't survive."

MITI expects to have a prototype of the thinking computer by 1990, and a commercial product about five years later. "It will be easy to use," Okamatsu projected. "By recognizing natural speech and written language, it will translate and type documents automatically. All you'll have to do is speak a command. If the machine doesn't understand, it will talk—ask questions. It will draw inferences and make its own judgments, based on knowledge of meanings as well as of numbers. It will learn too, by recalling and studying its errors."

This vision of artificial intelligence—machines acting in ways humans regard as intelligent—unnerved me, so I sought out computer scientist Edward Feigenbaum at Stanford University. The Japanese, too, had asked his opinion of the thinking-computer project.

"I told them it was the right idea at the right time," he said. "Artificial intelligence is a great scientific challenge. The more people working on AI, the better."

Artificial intelligence is as much art as science. Under Dr. Feigenbaum, "knowledge engineers" tease from human experts factual knowledge and the sometimes unrecognized rules of thumb they use to apply it. Encoded in programs, such information already allows computers to plan genetics experiments, deduce the structure of molecules, and diagnose diseases.

Future "expert systems" may advise chip designers, soldiers who must troubleshoot complex weapons, even plant lovers, as the programs gradually become everyday consultants. "Imagine one helping you nurse your sick houseplants," suggested Dr. Feigenbaum.

At the University of Pittsburgh, computer scientist Harry Pople and internal-medicine specialist Jack D. Myers have created Caduceus, a program that catalogs more diseases than a doctor could possibly remember and that enables a computer to combine facts and judgment and make a multiple diagnosis. "Like your brain, it can shift gears from disease to disease," Dr. Myers told me. "I'll show you."

Into a computer went details about an elderly man rushed one night to the university hospital. He'd awakened panicky and short of breath. Heart attack? "My first guess," said Dr. Myers.

Considering the case—no chest pain, an earlier heart attack, blood pressure normal, a history of diabetes—the computer weighed and momentarily set aside more than a dozen diseases before flashing a message about a prime suspect. PURSUING: DIABETES MELLITUS.

The computer asked about the man's blood-sugar level. Quite high. It asked other questions to clinch matters, then announced CONCLUDE: DIABETES MELLITUS.

More questions probed breathing sounds, heart murmurs, chest X rays. . . . In minutes the computer also judged the patient a heart-attack victim. His doctor had taken several days to decide as much, with doubts.

In complex or unusual cases, Caduceus makes a sounder diagnosis than general practitioners, says Dr. Myers, and almost always agrees with the specialist who has time to study a patient's every symptom. After more testing, Caduceus could become a common doctor's adviser, and may even lower medical costs as physicians prescribe fewer but more suitable tests to answer a computer's questions about patients.

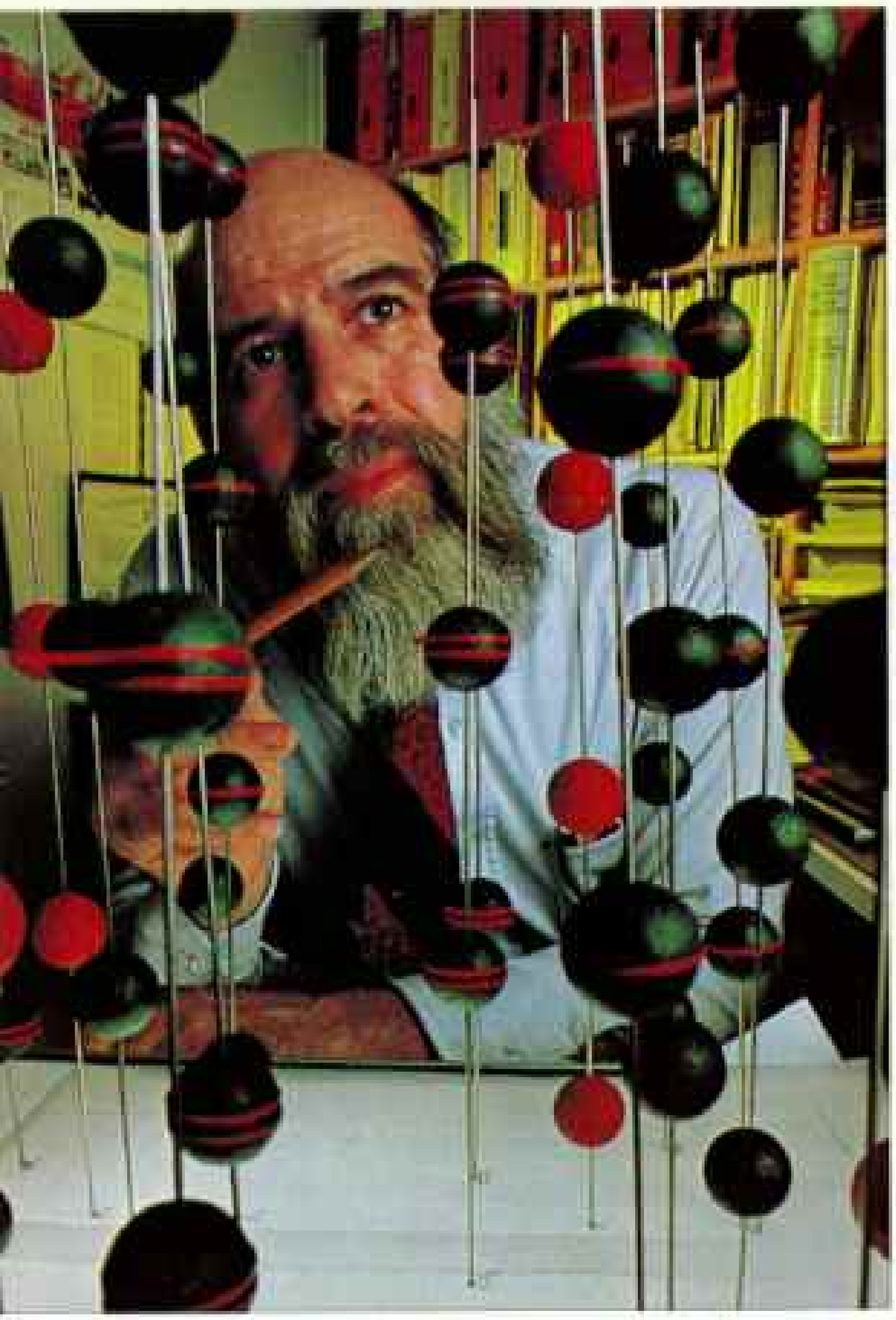
Also in Pittsburgh, Nobelist Herbert A. Simon teaches computers sweet reason with a program that seeks orderly patterns in irregular data and thereby hits on predictable laws of nature. This approximates the intuitive thinking of human scientists.

Named for Elizabethan philosopher and scientist Sir Francis Bacon, the program has independently rediscovered laws of planetary motion and electrical resistance, as well as the concept of atomic weight. Could Bacon discover an unknown natural law?

"Maybe, but the main goal is learning how the mind works," Dr. Simon told me at Carnegie-Mellon University. "I grew up in a computerless world," he said, "amid vague ideas about thought and the brain. Computers, when you try to program them to act like us, shed great light on such things."

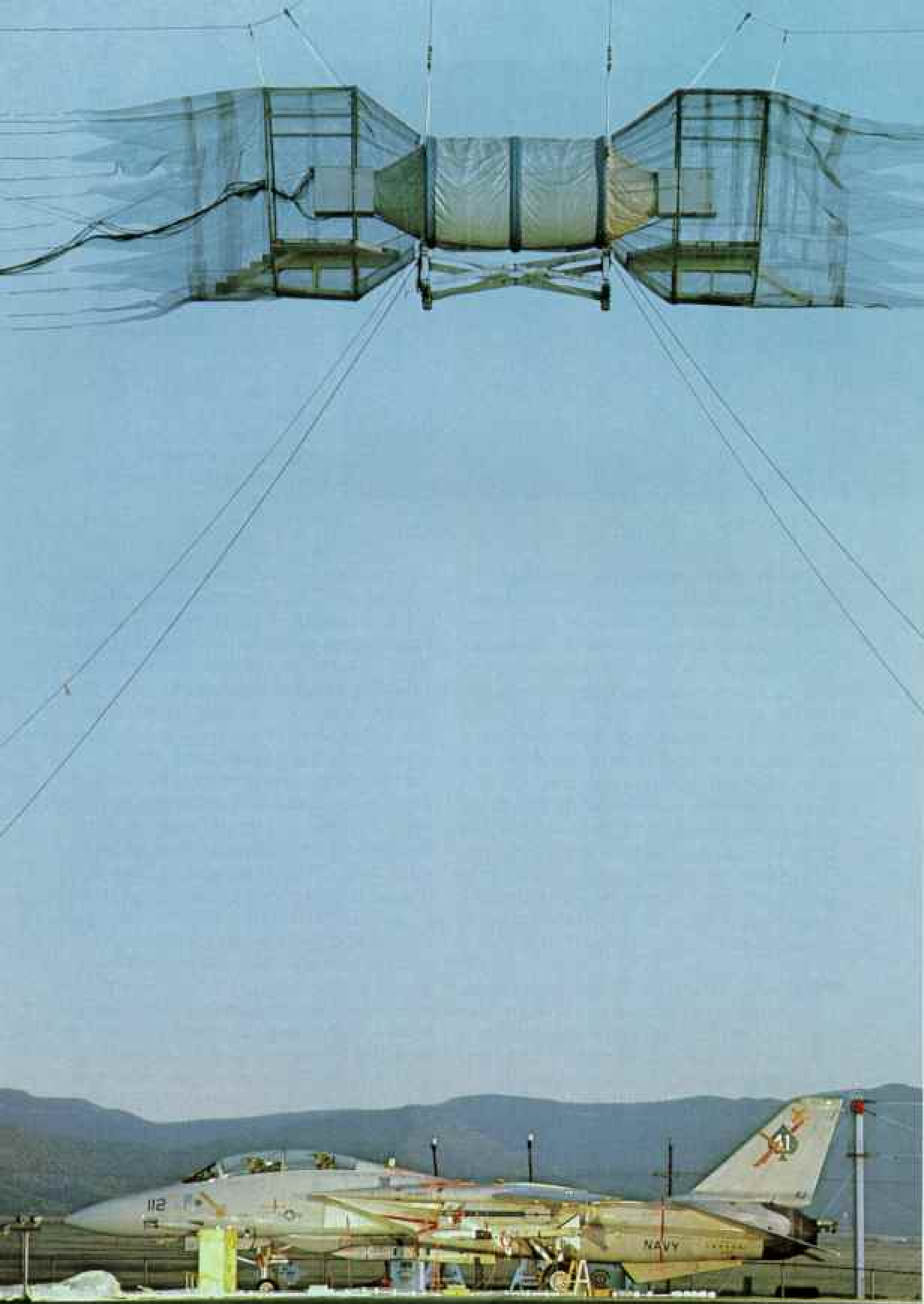
And could a computer, I asked, win a Nobel prize? "The Nobel Committee may yet have to think about that."

Wherever the discussion turns to thinking



Beyond silicon, *and into the realm of molecules—that is where scientists like Dr. Forrest Carter of the Naval Research Laboratory in Washington, D. C.* ***(above)****, expect to find the ultimate switching devices. Others feel synthetic proteins may even provide a framework for a "biochip."*

At Kirtland Air Force Base in New Mexico, planes are tested under a simulator for their vulnerability to EMP. An electromagnetic pulse emitted by a nuclear explosion could cripple electronics systems over a large area.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NAVY

State-of-the-art espionage *keeps U. S. Customs officials working overtime. At Los Angeles, agent Bob Olson* ***(left)*** *inspects an oxidation system—a vital component in chip production—that was bound for the Soviet Union with false papers.*

Strictly legal, a microphotography service in Silicon Valley films chips in sections with a photomicroscope. Tracing from the assembled enlargements ***(right)****, competing designers can understand and borrow engineering elements for their own chips.*

machines, the name Marvin Minsky comes up. Professor of computer science at Massachusetts Institute of Technology, he believes self-conscious and truly intelligent computers and robots are a distant certainty. They may be as inscrutable as humans, he adds:

"The notion that computers do only what they're told is misleading. If you can't tell a computer how best to do something, you program it to try many approaches. If someone later says the machine did as told, that's ambiguous—you didn't specify and couldn't know which approach it would choose. That doesn't necessarily mean we can't control an intelligent computer, just that we won't always know every detail of what it has in mind."

THAT PROSPECT may upset some adults, but children would likely take it in stride, as they have the more than 100,000 personal computers and computer terminals in U. S. classrooms.

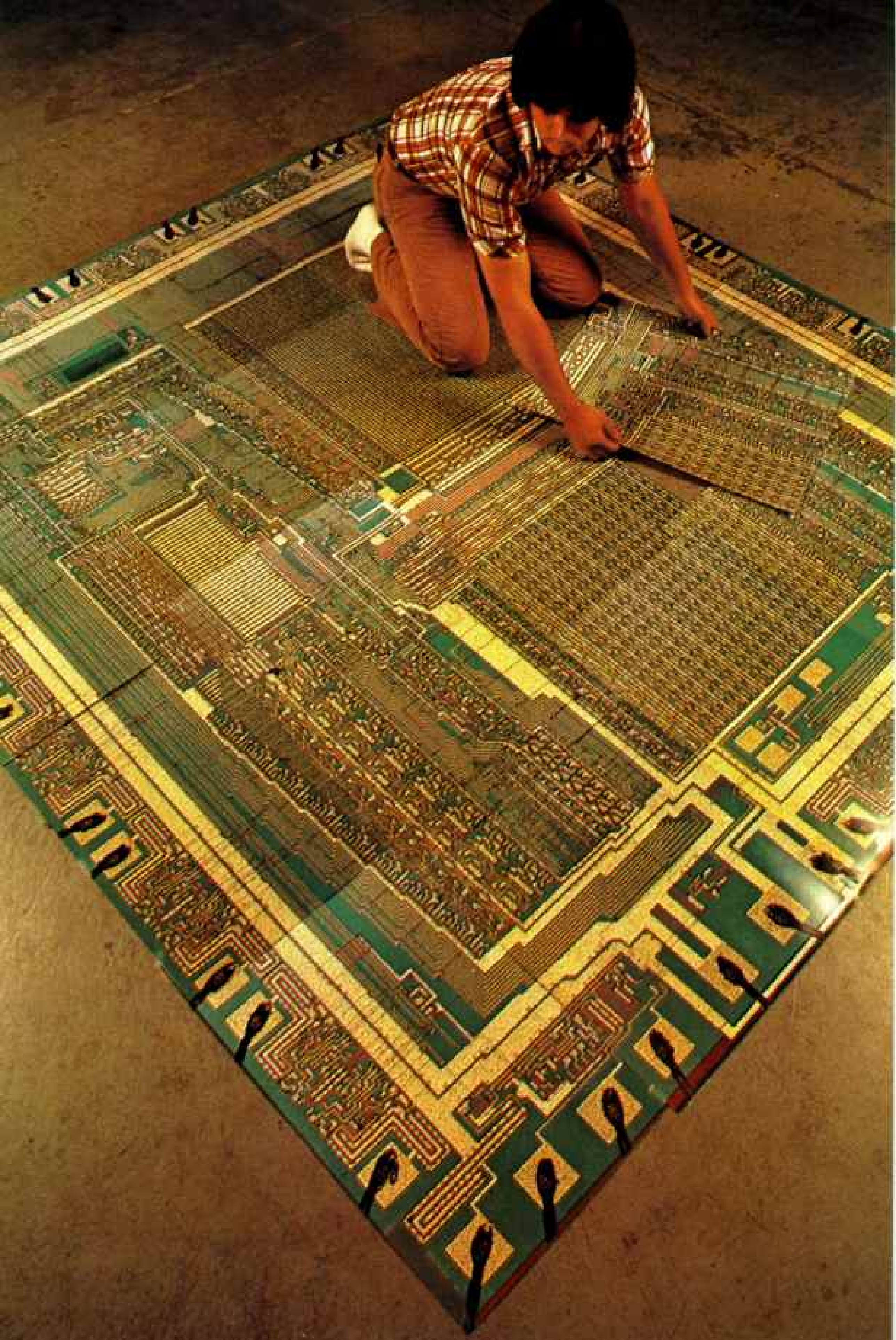
As the chip has cut their cost and advanced their use in schools, personal computers have refueled an old debate about the value and purpose of teaching machines. In Minnesota, where nearly all children 6 to 18 attend schools equipped with classroom computers, I saw third graders use one for rote grammar drill. The machine freed their teacher for true teaching, but it somehow seemed a costly alternative to flash cards.

Many education experts say the potential of school computers has been barely tapped, either to present subjects that boost analytic skills or to make children computer literate—able to run computers and grasp their impact on society. By that measure, most kids still grow up computer dropouts, possibly dooming them to be "know nots."

"The chip is remaking this into a world where information is literally wealth," says Peter Schwartz, former head of Future Studies at SRI International, a California think tank. "Without equal skill in using computers to get and employ information, people may divide into 'knows' and 'know nots' and suffer or prosper accordingly."

These cares have yet to burden Stacey, a second grader at P.S. 41 in New York City. I watched as she giggled and pecked at the keyboard of a personal computer loaned by the LOGO Computer Learning Center, also in New York. Soon the computer was drawing triangles within triangles, and Stacey was challenging a classmate to find them all.

Afterward, at the center, I confessed to associate director Dr. Robert W. Lawler my chagrin at seeing seven-year-olds juggle abstractions that had nearly bested me in high-school geometry. It's not uncommon, he assured me, for a child with a computer to learn more at a younger age.



"But the profoundest effect of computers on children," he went on, "may be to make them reflect on *how* they think." As Stacey had told me, nodding at her computer screen, "I try to make it like my head sees it."

On another front—a battlefront—children are dueling robots, blasting missiles, and zapping aliens in mock clashes programmed into video-game chips. Perhaps as many as 30 billion quarters are fed annually into coin-operated video games; that they tempt children to truancy or theft any more than other pastimes is, according to the industry, an unfounded fear.

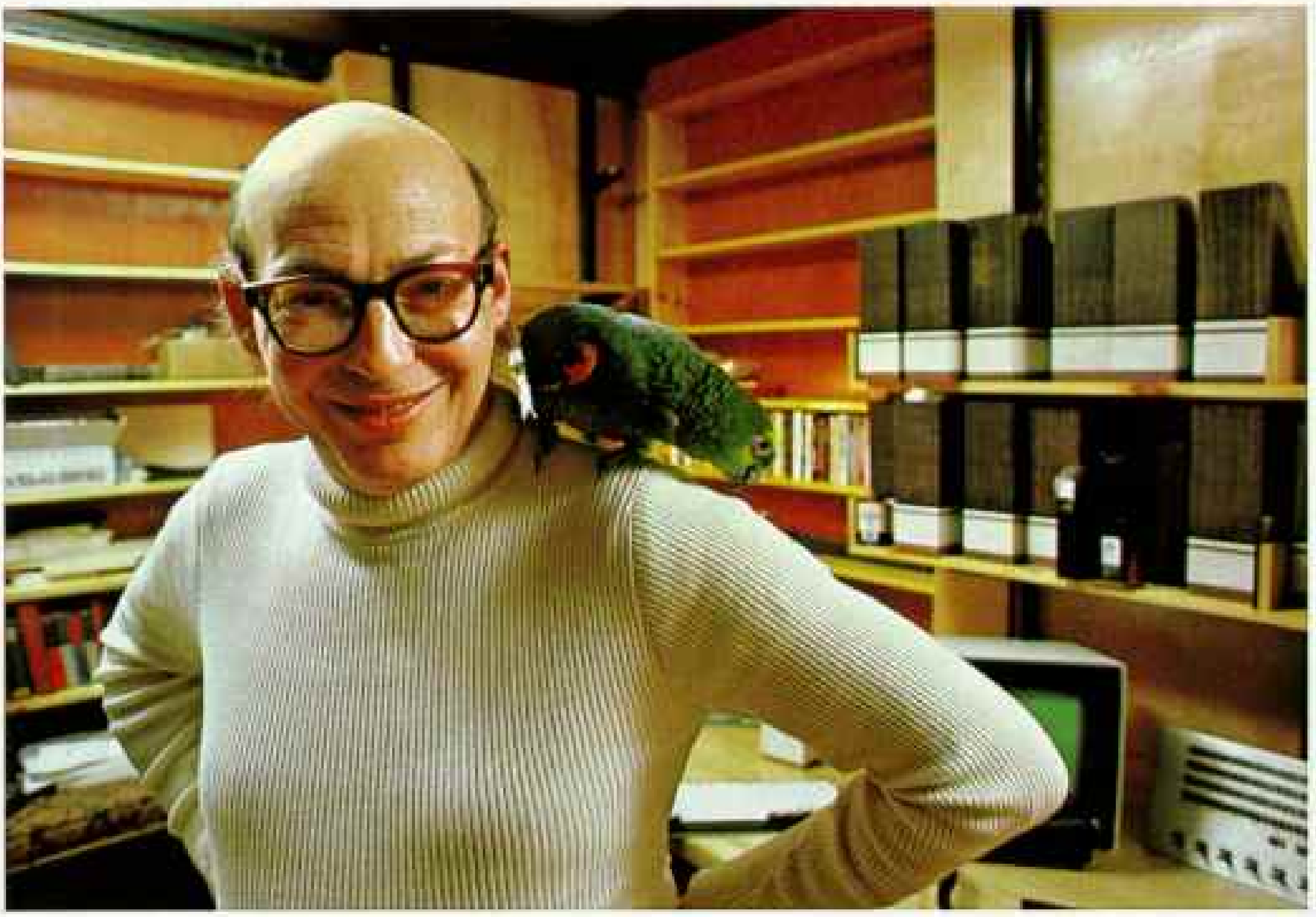
Versions for home TV and new emphasis on strategy over mayhem blunt most objections to video games. Some seven million U. S. households have them now, and Atari Incorporated, the world's largest maker of video games, expects that number to at least triple before finally peaking.

U. S. Army tank gun crews have also been toying with the chip, built into training simulators modeled on a video game. Like that diversion, the simulators stir aggressive impulses, and troops gladly practice more, without the peril and expense of real tank maneuvers.

ROBOT SOLDIERS have no place in Pentagon planning yet, but the Army will soon test a robot ammunition handler with chips for a "brain." A mechanical arm flexing hydraulic "muscles" and a pneumatic gripper "hand," it will hoist and arm 200-pound howitzer shells, duty that now fatigues and endangers four GIs.

Cosmetically, today's robots lag light-years behind the sleek androids of science fiction. Yet in dozens of industries chip-smart robots draw admiring looks for raising productivity as they tirelessly paint cars, weld ships, feed forges, and more. The hulking "steel collar workers" toiling in such jobs resemble counterbalanced beams set on boxes full of electronics. Other, smaller robot arms have shoulder, elbow, and wrist joints nimble enough to assemble electric motors or jiggle dainty light bulbs into automobile instrument panels. Some machines have more finesse, but none match the versatility of a robot: All it needs to switch jobs is a new tool at the end of its arm and a new program in its chips.

So an electrician tells me at a Chrysler assembly plant in Delaware. He oversees 30



robot welders and unselfconsciously calls them his. They crane and thrust like giant, long-necked vultures, made restive and quizzical by the skeletal car frames passing their perches. In two rows they seesaw over the steel bodies, diligently and fastidiously gripping them in C-shaped beaks. Air hoses hiss and convulse, the long necks shiver, and the snouts froth white sparks, wringing crackling arcs of heat and light from the clamped, welded steel.

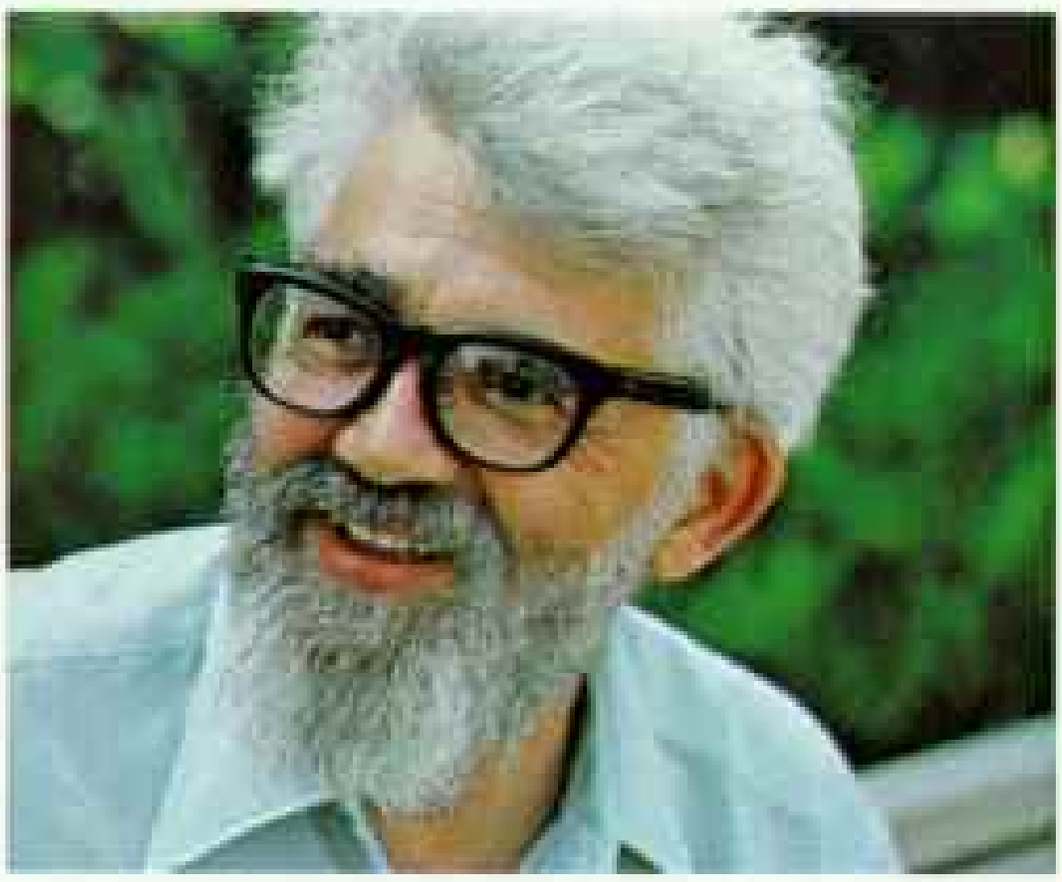
Where once 30 men sweated to weld 60 cars an hour, the faster robots now handle as many as 100, and the electrician has time to smoke his pipe. Waving it at the robots, he says they're more consistent too. "If they weld right the first time, they weld right every time, Mondays and Fridays included."

I heard more praise at a General Motors plant in Ohio: Robots work overtime without extra pay, cut defects and waste, never strike. . . . I also saw robots measure car-door openings with laser "eyes," one of many additions—tactile sensors, TV cameras, infrared probes—making robots increasingly productive. So much so that by 1990 GM hopes to be using ten times the 1,600 robots it has today.

Manufacturers and engineers talk more and more of fully automated factories, making computer-designed goods with mass-production economy and the distinction of custom detail. The Boeing Commercial Airplane Company is taking off that way now, lofted by the chip's cheap computing power. Filling orders for ten jets, each with unique seating, Boeing builds them all together, but to computer-customized blueprints. It's easy, because a robotlike device drills holes wherever wanted with just a change in program, dictated by a design computer.

Today's most advanced factory may be in Japan. In the Fanuc Ltd. plant near Mount Fuji, I saw unattended carts glide to automatic storage racks, accept metal blocks, and then roll to robots; they loaded the metal into unmanned drill presses and lathes to be shaped into parts for more computerized tools and robots. On a shop floor bigger than a football field I saw but 15 human workers.

Japan claims roughly half the world's 25,000 or so robots, and Dr. James S. Albus, a robotics expert at the U. S. National Bureau of Standards, likens that technological head start to an earlier one: "Japan has given us another Sputnik."



Machines that think? *"No reason we can't build them," says Stanford professor Dr. John McCarthy (**above**). Like MIT professor Dr. Marvin Minsky (**left**), he hopes one day to see robots programmed with common sense. Other artificial intelligence, or AI, experts include Drs. Allen Newell (**right,** at left) and Herbert Simon of Carnegie-Mellon University. Computer logic, they suggest, may help us better understand the workings of the human mind.*

The Chip: Electronic Mini-marvel

David and Goliath *of technology, the chip and the automobile have joined forces, more to the benefit of the ailing giant than the minuscule marvel that is similarly reshaping modern life.*

*Hot off the drawing boards at Honda, a navigation aid (***above***) enables drivers to negotiate complex cities like Tokyo with the aid of a cursor that traces the course on a map. But less conspicuous than the latest dashboard displays and gadgets are the microcomputers under the hoods of new cars, monitoring and controlling engine functions for greater fuel economy and emission control.*

*New muscle for the long arm of the law, in-car computer terminals (***right***) enable police in Vancouver, British Columbia, to query Ottawa with names and license plates for readouts—in seven seconds—about fugitives and stolen vehicles. The easy access to personal information that the chip allows worries many who fear an invasion of electronic snoops.*

Mulling the U. S. robot revolution coming in reply—and the jobs that will inevitably disappear—MIT automation researcher Harley Shaiken cautions that robots and the chip differ in a major way from previous waves of mechanization.

"This technology affects offices as well as factories," he told me. "It creates a potential economic vise: One jaw shoves people from the plant, and the other limits their shift to white-collar jobs." Shaiken concludes that without retraining programs and new jobs, we invite severe economic dislocations.

"We're creating jobs in the long run," responds Stanley Polcyn, president of the Robot Institute of America and senior vice president of Unimation, Inc., a major producer of robots. This nation has only about 6,000 now, he notes, adding that to meet demand for more, the robotics industry itself will hire great numbers of workers.

Then there are the new job markets robots will open, like deep-sea mining. Or repair of home robots. In five years, predicts Polcyn, the first modestly useful but very expensive ones should be housebroken.

ANOTHER FIXTURE of futuristic forecasts—the electronic newspaper—is already here. More than a dozen dailies now publish an edition without cutting a tree or inking a press.

"You can't give a kid separate editions for the lawyers, laborers, and housewives on his paper route," points out Elizabeth Loker, who helped develop an electronic edition of the *Washington Post*. It goes out over telephone lines to personal computers, and subscribers choose what they'll read from a menu on their screens, instead of hefting an entire paper off the front step. "Electronic delivery lets every reader assemble his own newspaper," says Loker.

Reading news on a computer screen for an hourly fee can tax the eyes and the wallet—an electronic version of a 25-cent paper could easily cost ten dollars. But publishers believe that shoppers will pay for up-to-the-minute advertising, a money-maker that also attracts the American Telephone and Telegraph Company. A possible future rival of newspapers, AT&T has already tested an electronic edition of the Yellow Pages.

At Bell Labs, the research arm of AT&T, I learned a primary cause of such changes. "Each time microelectronics cuts computing costs by a factor of ten," explained Dr. John S. Mayo, executive vice president for network systems, "it opens a vast array of things that were once uneconomic."

Like the teleterminal Dr. Mayo showed

Uncomplaining workers, *robots at a Chrysler plant in Newark, Delaware, cost $100,000 each. A single robot can perform a dozen or more different spot-welds with greater precision than a human. But many of the nation's 24 million industrial workers are wary of increasing automation.*

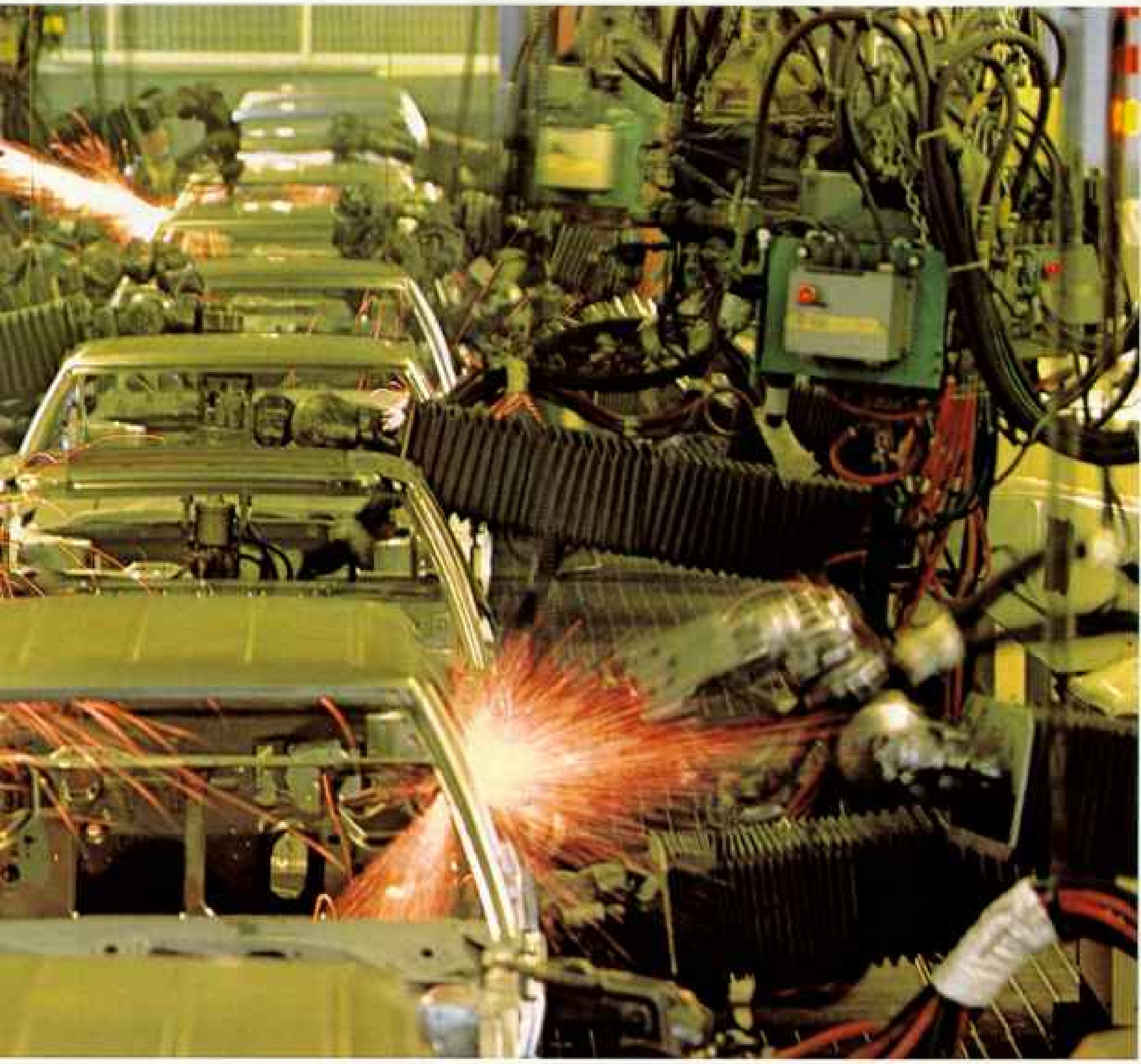
me: a combination telephone and computer terminal, with a compact keyboard and screen. The desk-top device logs his appointments, finds phone numbers, makes calls, sends and receives memos, and displays files—all at the tap of a few buttons.

Though experimental, Bell's teleterminal exemplifies the chip's power to alter the way we work, or even where we work.

"In 20 years a significant number of us—not just craftsmen or entrepreneurs—will work at home, using computers and dealing with our offices by electronic mail," says Dr. Margrethe H. Olson. The New York University professor advises corporations considering how to attract or keep workers who dislike commuting, have small children, or are homebound by handicaps.

Some bank and insurance company employees "telecommute" now, a trend, Dr. Olson told me, with subtle implications. "The nine-to-five workday will grow artificial. Sick leave, vacation, and pension policies will change. So will the separation of work and family and the concept of leisure time—what you do with it, and when."

At Columbia University, professor of public law and government Alan F. Westin spoke of a potentially worrisome aspect of working with the chip.



"Word processors and computer terminals can keep us under surveillance," he said. "A boss can know how many keystrokes a secretary makes in a minute, hour, or day. At insensitive companies new technology may be an opportunity to grip workers totally."

A decade ago Dr. Westin headed national studies of inquisitive centralized computer data banks, research that led to new federal privacy laws. He sees another challenge to our privacy in this decade.

"With personal computers and two-way TV," he said, "we'll create a wealth of personal information and scarcely notice it leaving the house. We'll bank at home, hook up to electronic security systems, and connect to automatic climate controllers. The TV will know what X-rated movies we watch. There will be tremendous incentive to record this information for market research or sale."

While some ponder how to shield sensitive information lodged in the ubiquitous chip, others contrive to tap it—for revenge, for fun, for profit. All three motives have figured in computer crimes.

Computers are woefully corruptible. Files can be altered, unauthorized commands can be added to programs, and legitimate ones misused, often without discovery. Nor does this take great skill: In tests, amateurs have penetrated the defenses of even classified military computers.

In recent years experts have put the cost of push-button capers at 100 million to 6.5 billion dollars annually. But undetected and unreported computer crimes make estimates suspect, cautions one authority, Donn B. Parker. He calculates that known computer frauds—a limited sample—typically cost their victims about half a million dollars. And the potential for plunder is sobering: Daily now, banks transfer more than 500 billion dollars around the U. S. by computer.

Electronic lawbreakers may hit harder and more often in the future, as personal computers multiply the means to penetrate computer systems and dramatically increase the number of people familiar with them. Drug runners and bookmakers already use personal computers, and other organized criminals will likely make them outright accomplices.

Teenagers, as easily as if vandalizing empty houses, have wrought long-distance havoc with their keyboards. Using telephone lines as a link, two California boys tampered with racehorse and greyhound pedigrees stored in a computer in Kentucky, and for a time the files of some Canadian corporations were an open book to youngsters at school computers in Manhattan.

CHILDREN OF THEIR TIME, you may lament, making mischief in a fashion ushered in with incredible rapidity by the chip. With such swiftness that you may conclude a revolution in our lives is well under way.

Yet it has hardly begun. In decades to come the technology of this age of the chip will surely seem minor, gradually dwarfed by its sweeping social effects.

Some will come as we put the chip to new uses. Chips aside, the latest artificial limbs and organs are not fundamentally new—unlike the microcircuits some scientists speculate we may one day implant in our heads to augment our intelligence.

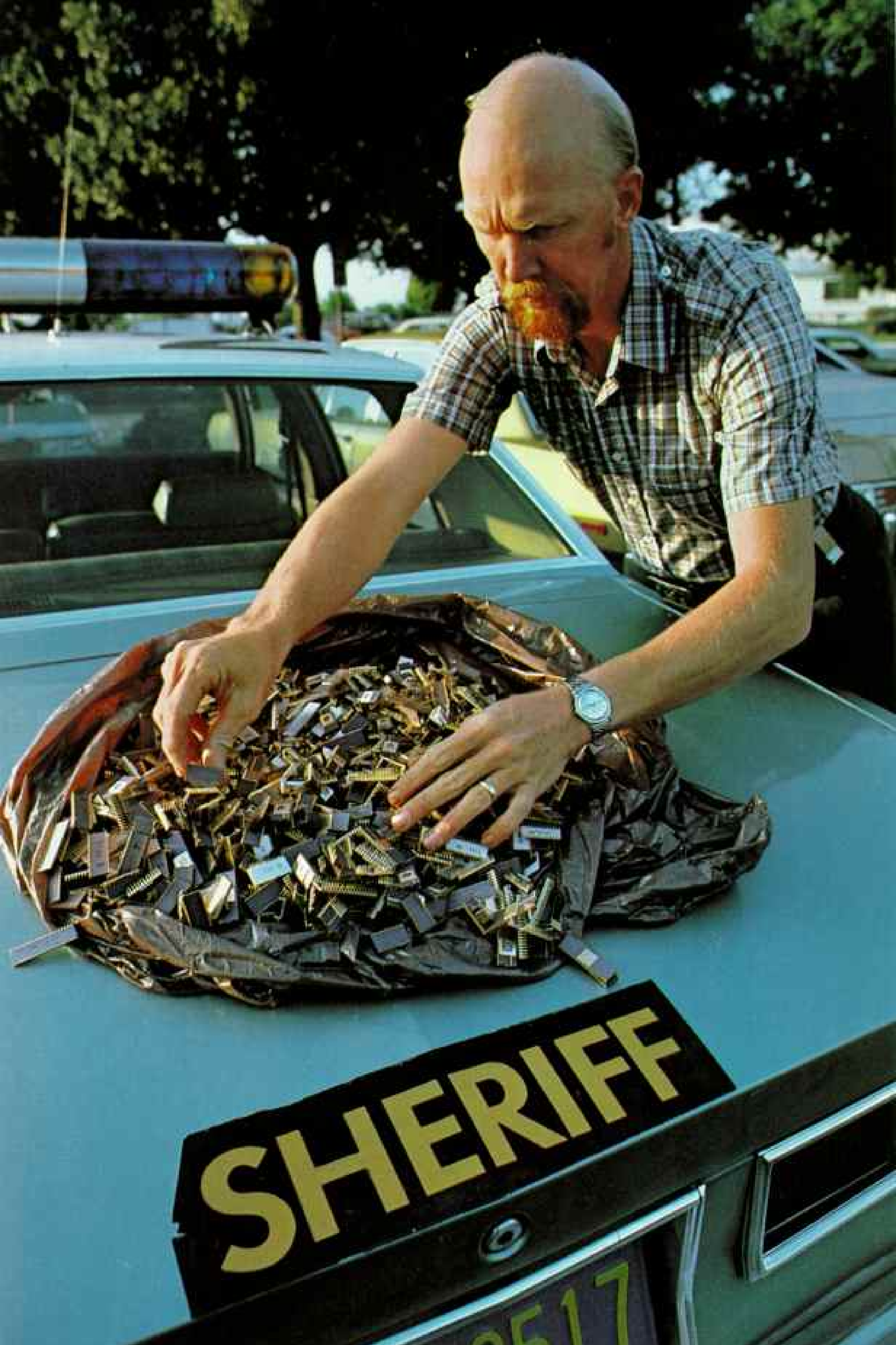
As well, the chip will add new dimensions to old social issues. In an economy based on robots, how will we share wealth, now commonly distributed in the form of jobs?

Deepest change of all, the chip will alter our self-image. Apes that master sign language and use tools have already shaken the idea that to *have* ideas is to be human, a view likely to decline even further if machines too begin thinking.

Such profound adjustments seem to be the unavoidable and unsettling price of living in the age of the chip. But not too great a price, for in paying it we stand to gain the benefit of exercising some of our best virtues: patience, flexibility, wisdom. □

Computer-human interface *finds literal expression in Berkeley, California, during a word-processing sales promotion. Computer-assisted accounting, marketing, and typing spell greater productivity in offices around the world—part of an electronics revolution still in its infancy.*


ROYAL
family
INTERNATIONAL
HOUSE


SHERIFF

HIGH TECH, HIGH RISK, AND HIGH LIFE IN Silicon Valley

By MOIRA JOHNSTON

Photographs by CHARLES O'REAR

SILICON VALLEY appears on no map, but this former California prune patch, an hour's drive south of San Francisco, is the heartland of an electronics revolution that may prove as far-reaching as the industrial revolution of the 19th century.

It is a place where fast fortunes are made, corporate head-hunting is profitable sport, and seven-day workweeks send cutting-edge technology tumbling over itself in its competitive rush to the marketplace.

Not surprisingly, flying—fast, challenging, and risky—is a sport that appeals powerfully to Silicon Valley men such as Bob Noyce, who snatches every chance to fly his twin-engine Turbo Commander to Aspen to ski, to his Intel plant in Phoenix, or just to wheel in the sky around Silicon Valley.

At age 54, he is one of the grand old men of an industry so young that its pioneers are scarcely in their 50s, yet so powerful that it is fast becoming known as the oil business of the eighties. Noyce had a key role in inventing the integrated circuit, the tiny computer chip that is the brains and basic building block of virtually all of today's electronic equipment, providing the quantum leap that created much of the wealth that spreads below his wings in a golden tide of purring Mercedes-Benzes and half-million-dollar homes in the hills. From the air the valley itself, with its grid of roads and rectangular buildings, has taken on the look of an integrated circuit.

Fifty years ago it was a landscape of orchards supplying half of the world's dried prunes. Even through the sixties, it bloomed with plums, pears, apricots, and cherries, one of the nation's most bountiful agricultural regions. Today only 13,000 acres of orchards survive out of an original 100,000. By the late 1960s, as industry surpassed agriculture as Santa Clara County's economic base, buildings of the valley's many semiconductor companies were beginning to fill the region from Palo Alto to San Jose, named in 1980 as the nation's fastest growing city.

Yet this dynamic growth happens behind a deceptively sedate facade. Driving through Silicon Valley, I am flanked by a monotone sprawl of low rectangular buildings, on which corporate nameplates

***Computer-age booty,** $50,000 worth of silicon semiconductors, or chips, were recovered from thieves bent on selling the meager gold built into these tiny devices that have revolutionized electronics.*

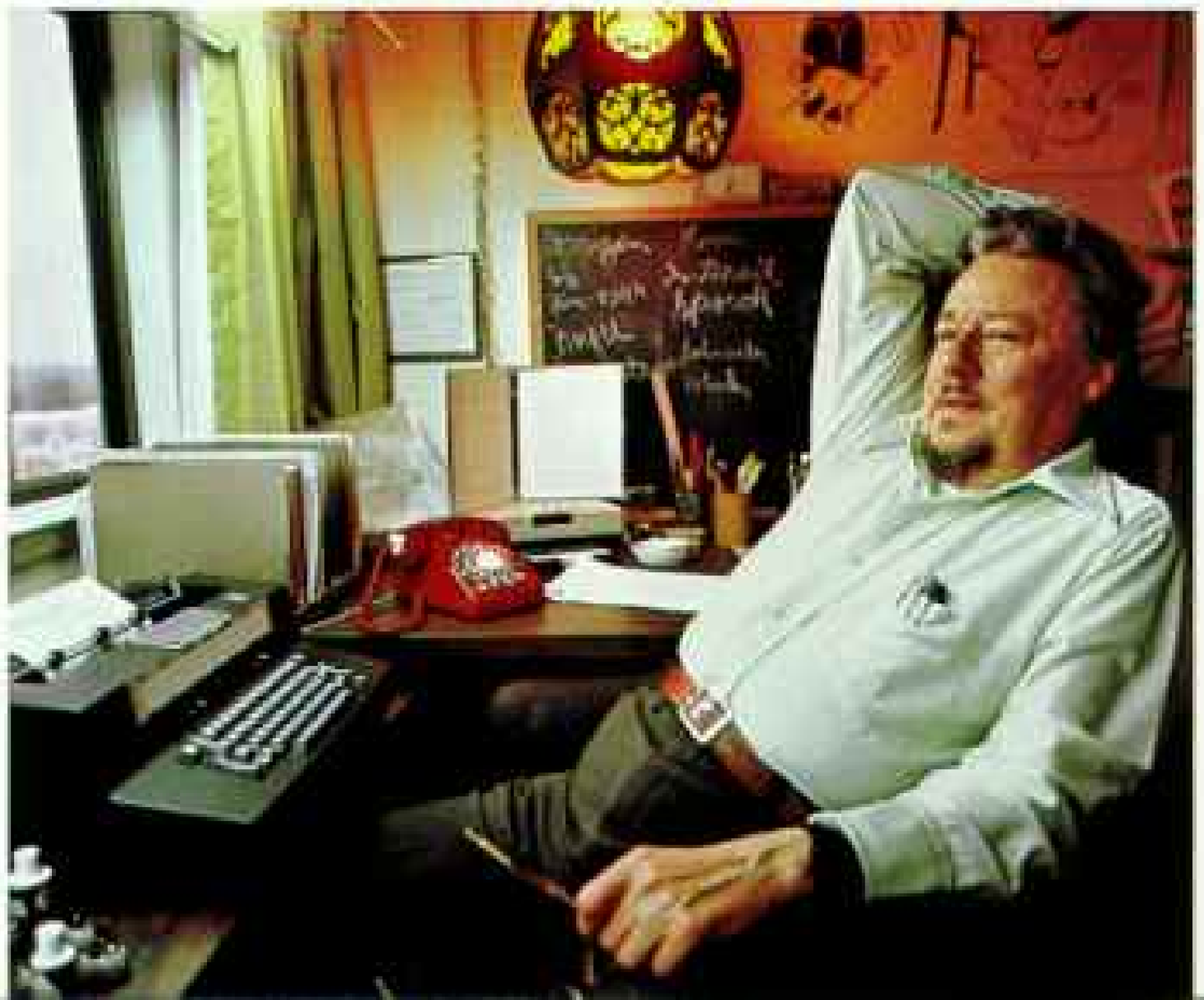
Industrial heists reaped perhaps 20 million dollars last year from firms in California's Silicon Valley, nickname for the high-tech empire reigning in the Santa Clara Valley south of San Francisco. Thriving in a heady swirl of engineering genius and entrepreneurial gambles, Silicon Valley now faces problems sired by wildfire success—and tough competition from Japan.

***Like a giant** integrated circuit, technological sprawl in Santa Clara (**above**) takes form in rows of prefabricated buildings called "tilt-ups," ideally suited to a business where ventures begin almost weekly—and even in aptly named streets (**left**). More than 80 chip manufacturers make Silicon Valley the world's semiconductor center. The chip—a sliver of silicon packed with*

hundreds of thousands of transistors—grew out of a simple prototype developed here little more than two decades ago, spawning not only chip makers but also firms that supply them or use their products.

The term Silicon Valley was insiders' slang until 1971 when Don Hoefler (**right**) *popularized it in a trade journal. An engineer, he now publishes the bulletin "Microelectronics News."*

California's Silicon Valley



display fusions of high-technology words that give few clues as to what goes on inside: Siltec, Avantek, Intersil, Signetics, Intel, Synertek. Inside, an intense concentration of brains, innovation, and enterprising zeal creates products that have captured one-fifth of the estimated 16-billion-dollar worldwide semiconductor market. And, despite recession, more of the aggressive little start-up companies that are the valley's backbone are constantly being born.

Befriending the computer, and putting it to work and play in daily life a decade before most of us found the courage to touch a keyboard, Silicon Valley and its families may well be a glimpse of a computer-and-communications culture that is the prototype of the future.

The freewheeling egalitarianism that has replaced the rural pace is nowhere more visible than at Intel, one of the valley's most innovative semiconductor companies. Leisure-time pilot Bob Noyce, a physicist, and Gordon Moore, a chemist, run Intel from modest cubicles separated from a surrounding sea of cubicles only by head-high movable partitions. Here, at the highest executive level, sport shirts and accessibility have replaced corporate pinstripes and wood-paneled boardrooms. Noyce says of his Spartan habitat, "It makes you feel as if you're in touch with what's going on."

The "Intel culture," as they call it, fanned with messianic zeal by co-founder Andy Grove, has produced the microprocessor, an all-purpose "computer on a chip" that can be adapted to infinite uses, the chip that opened the era of personal computers.

This innovative spirit not only is the lifeblood of Silicon Valley but also may be the key to its survival in an increasingly intense trade war with Japan, the competitor it perceives as a mortal threat in the international marketplace. Maintaining Silicon Valley's creative lead as chips grow so complex that computers increasingly help design them is one of Noyce's principal challenges. With a certain wistfulness for the days of the

Brains behind the boom *of Silicon Valley include one of the inventors of the integrated circuit, Bob Noyce* ***(left,*** *at right), vice-chairman and co-founder of Intel, and Ted Hoff, who created the microprocessor. President of ASK Computer Systems, Sandy Kurtzig* ***(top)*** *parlayed her ideas for computer software into a 75-million-dollar business. Co-founder of Apple Computer, 27-year-old Steven Jobs* ***(middle)*** *wheels as chairman of the fastest growing company in recent U. S. history. Aggressive salesmanship helped build the fortune of Advanced Micro Devices, headed by Jerry Sanders* ***(above).***

San Francisco-based free lance **Moira Johnston** gained national recognition in 1978 with a noted article about tire safety. She also authored the May 1979 NATIONAL GEOGRAPHIC article on California's Napa Valley.

Bright new cluster *in the constellation ringing San Francisco Bay, Silicon Valley (***above***, at left, from 25,000 feet) was lush with orchards a generation ago and praised as the Valley of Heart's Delight.*

The industry that renamed the valley developed around Palo Alto and spread

National Geographic, October 1982

some 20 miles to San Jose, the fastest growing city in the U. S. The Silicon Valley phenomenon touches 13 cities in this corridor, whose combined populations total more than 1.2 million. At $24,000 a year, per family income ranks among the highest in the nation, yet roof-raising real estate prices make affordable housing scarce. Smog settles over clogged roads, and stricter regulation has begun to limit industrial expansion. New companies find a foothold on the southern edge of the bay, but established firms are branching into other states and nations, where land and labor come cheaper.

individual breakthrough, he says, "Now it's a team effort. In 1970 Federico Faggin designed the 4004 microprocessor chip by himself at Intel in nine months; our 32-bit microprocessor took 100 man-years!"

But the individual can still star as an entrepreneur. Competitive energy vibrated from Sandy Kurtzig as she told me, "I have taken a bet that ASK Computer Systems will be doing 100 million dollars in annual sales in four years. We *will*." Sharing a quiet brunch after tennis with her husband, Arie, a research manager at Hewlett-Packard, and their two young sons, this lively brunette in slacks and sweater is president of ASK, which she founded with $2,000 in the back bedroom of her apartment in 1972. Since ASK went public last year, the worth of the company's stock has soared to more than 75 million dollars.

Sandy, 35, entered the industry with a mathematics-and-chemistry degree as well as a master's in aeronautical engineering. Aware of the nation's productivity crisis, she shrewdly saw that "the technology of the chip had far outstripped our capacity to put all that potential to work." Sandy targeted software, the programs that tell computers what to do. She developed software systems for minicomputers and sold them as easy-to-use packages to accomplish tasks such as inventory control and accounting in

Learning to speak electronics *along with English, Cambodian Samot Chheng* ***(right)****—with sleeping son—studies vocational English at a refugee center near San Jose, where classroom rules* ***(above)*** *also appear in Cambodian, Vietnamese, Laotian, and Chinese. Some 45,000 Southeast Asians live in the valley. Immigrant labor is sometimes exploited by bootleg circuit-board firms that show more concern for profit than quality work.*

"My hand skills have to be tops," says valley native Elizabeth Esparza ***(far right)****, a home-based specialist hired to assemble chips on prototype models of new circuit-board designs.*

manufacturers' factories and offices. Her strategies have been so successful that, while chip stocks plunged in 1981, ASK's rose to make the firm perhaps the nation's fastest growing public software company.

Yet Sandy, like most of Silicon Valley's successes, does not wallow in hedonistic excess. True, she recently purchased a baronial Tudor-style home, but says, "We didn't buy the house to show off. It was mainly to be on the flats where the kids could ride their bicycles."

But in a valley characterized by venture capitalist Don Valentine as "a pocket of entrepreneuring that attracts a breed of buccaneer capitalists and high-risk takers—an area barely big enough to contain the egos," there are some Silicon Valley winners who revel in flamboyant display.

"Money is life's report card," says a laughing Jerry Sanders, a street-wise kid from Chicago who parlayed an engineering degree and intuitive salesmanship to the presidency of Advanced Micro Devices (AMD) and to a reputation as the valley's highest flying businessman. Exuding brio and self-confidence, he measures his success in a string of homes, hand-tailored suits, a Rolls-Royce, and a Bentley. In good years he makes grand gestures to employees: a $350,000 Christmas party in San Francisco's Civic Auditorium; in a lean year he

served hot dogs and sauerkraut with panache that won cheers.

But for Sanders, as for Silicon Valley, work is the thing. The valley was born in 1955. Dr. William Shockley, Nobel Prize-winning co-inventor of the transistor at Bell Telephone Laboratories, sent out a call to a dozen handpicked young Ph.D.'s in physics and chemistry to join him in a warehouse in Mountain View, at Shockley Semiconductor Laboratory.

Noyce and Moore answered the call. There they would exploit the properties of silicon, a semiconductor of electricity whose conductivity could be modified by the addition of minute amounts of chemicals, allowing on-off electric signals—the very basis of computers—to occur at mind-boggling speeds. As transistors replaced vacuum tubes, the computing power of an unwieldy roomful of metal boxes ultimately could be contained in a hand-held calculator.

Ironically, Shockley's pioneering laboratory failed. "His ideas were too far ahead of the still primitive silicon technology, and he never produced a manufacturable product. What he did was to spawn Silicon Valley," says Shockley alumnus Harry Sello. Believing they had something—a better transistor—Noyce, Moore, and six others got financial backing from Fairchild Camera and Instrument to develop it. Since the founding of Fairchild Semiconductor in 1957, the valley's first viable semiconductor company, no fewer than two dozen companies have spun off from it, including the present leading triumvirate: Intel, Advanced Micro Devices, and National Semiconductor, all started by former Fairchild men.

The start-ups and spin-offs could never have flourished without infrastructure, the valley's vital support system that has built up south of Stanford University. Born before Silicon Valley, it began in 1939 with Hewlett-Packard, granddaddy of the area's electronics firms. Today it is an incestuous network of suppliers, customers, venture capitalists, brains, research institutes, computer and software companies, schools, and headhunters, the executive recruiters who move men around the valley at a dizzying rate in a tradition of musical jobs that is a key to the valley's contagious vitality.

With the convergence of infrastructure, innovative minds, and venture capital in the sixties, dramatic improvements in integrated circuitry (which basically masses many transistors on a single chip) brought prices plummeting. Noyce and Moore sold their first transistors to IBM for $150 apiece; today the price would be a fraction of a penny.

Toward a More "Personal" Computer

Steve Jobs is pleased with the falling prices. He hopes that his computer will become the Volkswagen of the industry, the computer every family can own. The 27-year-old co-founder of Apple Computer,

Electronics frontiersmen, *David Packard (**right**) and Bill Hewlett (**far right**) decided in a Palo Alto garage in 1939 to form Hewlett-Packard, today the world's largest maker of electronic measuring and testing devices. Inveterate tinkers, even on their vacation ranches, the two set Silicon Valley standards for casual, sharing management as well as precision engineering.*

*Radiant at 1200°C, a bell jar used in processing silicon wafers (**left**) emerges at U. S. Quartz, a firm drawn to Silicon Valley 12 years ago.*

whose typewriter-size instrument is pioneering the incorporation of the computer into daily life, bristles a little, too, as he reminds, "We'd rather call the Apple a personal than a home computer."

Although 1981 and 1982 have been the "years of the personal computer," with giants like IBM jumping into the market and about two million now in use in the United States, predictions that computers would be the nerve centers of our homes by the early 1980s have proved premature.

"It's no more difficult than learning to cook, but people are afraid they can't handle it," says Jobs's Silicon Valley neighbor Dan Fylstra, whose VisiCorp software packages are simple enough for use in the home. The machines are just not yet "user friendly" enough. Though research labs all over the valley are struggling to solve the elusive problem of speech recognition, we are a long way from marketing a computer that can respond to ordinary conversation—the ultimate friendliness.

So Jobs and his growing host of competitors have directed their sales efforts to office uses. But the Apple has inspired a dedicated cult of hard-core enthusiasts who trade new uses for the computer in the columns of Apple magazines; one engineer has programmed his Apple to activate a small motor that rocks the crib when his colicky baby cries or wriggles. And Jobs has become a potent role model for a new breed of bright kids who are writing and selling software programs and, with their arcane computer skills, gaining the prestige formerly tasted only by the high-school football team.

Over herb tea in a vegetarian restaurant, Jobs explained to me, "For us, computers have always been around. That's what separates us guys from you guys. You were born B.C.—Before Computers. And it's because of this place. I was born here. When I was 14, I was asking famous computer engineers here questions. Apple came out of the microprocessor, created in this valley just five miles from here."

Jobs's passion has paid off handsomely. With Steve Wozniak he built his first Apple in 1976 in his parents' Los Altos garage because they couldn't afford to buy a computer; now he owns Apple Computer stock worth 100 million dollars. While the chip companies suffered this spring, Apple's revenues soared 81 percent over last year's. Apple now occupies 22 buildings in Silicon Valley and plants in Texas, Singapore, and Ireland, which is bidding to become Europe's Silicon Valley.

Although Jobs drives the requisite Mercedes, success seems not to have spoiled the first folk hero of the computer age. In plaid shirt and jeans, he still prefers, as a friend said, "to drive his motorcycle to my place, sit around and drink wine, and talk about what we're going to do when we grow up."

The excitement of Apple's presence in

Cupertino has touched the district school system. Here children are introduced to computers as early as the first grade.

Bobby Goodson, the school district's computer specialist, believes computer literacy is going to be the next great crisis in education. "If kids don't understand computers, how can they handle the future?" she asked, as she restrained a class of seven-year-olds eager to get their hands on a computer for the first time.

A little girl with pigtails hunches over the keyboard, fiercely concentrating on following Mrs. Goodson's instructions. "Type in '10 PRINT "BARBARA."' Now type 'RUN.'" Her name pops up on the screen. Bouncing with delight, she rushes ahead to execute the next instruction. BARBARA fills the screen and begins repeating in relentless rows. Barbara looks up, awed by her own power. She has entered the computer age with the ease of skipping rope.

"The broad integration into society, though, is going to be a 10- or 15-year process," says Jobs. "But I believe we are already making a little ding in the universe."

Not All Share the Good Life

The social impact and the profits, Jobs notes, scarcely touch the lives of the 120,000 people who work on Silicon Valley's assembly lines. Most of those who live in ethnically mixed east San Jose—black, Hispanic, and about 18,000 Vietnamese and other Asian refugees—cannot afford to own a home.

But the opportunity that lures entrepreneurs gives some workers, too, a crack at the California dream. Secure in a comfortable home in Cupertino with her husband —Thanh, a computer engineer—Tien Nguyen, a gentle beauty with lush black hair pulled into a topknot, relives her escape from Vietnam in 1975.

"We left with nothing. I had just the slacks and blouse I had on. My father feared that when the Communists came, they would kill the whole family. The police put us—my parents, my three sisters, my younger brother—on a barge in the Saigon River with no shelter, no food, no drink. A tugboat pulled us to the open sea to an American ship we shared with 20,000 people. We slept on deck. My older sister, Dao, almost died of flu."

Brought to Silicon Valley by the pastor of a suburban church, Tien and Dao had assembly jobs within ten days. They found the route to upward mobility, the valley's electronics schools, and soon moved up to better jobs at Tandem Computer.

"We delivered papers after work and put our father through electronics school, and he has a job now with a valley electronics company," Tien says with pride.

The sisters have been upgraded again to office jobs at Tandem. But their smiles and chic clothes screen a deep homesickness. "But I feel strong," Tien says. "In my country I would stay home and cook. Over there I couldn't *interface* with all these people"—the local buzz word that reveals how well she has, well, interfaced.

Even Light Industry Brings Pollution

But the job growth that gives the Nguyen family a chance to prosper is compromising the sweetness of success. Straining from a small aircraft to see through the opaque veil of pink-brown smog that obscured the low mountains that flank Silicon Valley, county planner Eric Carruthers cracked to me, "On a clear day you can still see it's a valley."

Most of the smog is belched from automobiles. Below us, as rush hour began, rivers of red lights ran south, as Silicon Valley disgorged a quarter of a million people to housing tracts 10 and 20 miles away. "Jobs have grown faster than housing," Carruthers said. In 30 years San Jose has grown from 95,000 to nearly 660,000.

To deal with such growth, Santa Clara County has embraced a new program for systematic regional planning that it hopes will replace wanton expansion. And the need is urgent. The county recoiled this past winter when it was revealed that hazardous chemicals from 11 of the valley's major electronics firms had leaked from buried tanks and, in one instance, contaminated public water.

Voicing the shock shared by cities that had assumed the electronics industry was nonpolluting, San Jose's mayor, Janet Gray Hayes, said, "I remember thinking about smokestacks in other industries. I didn't expect this problem in my own backyard."

The county has proposed to have the cities use their powers to limit new jobs as a means

of curtailing housing expansion. As mayor of Sunnyvale, Dianne McKenna joined her city council in declaring a four-month moratorium on new industrial building, during which limits were voted on waste water and the number of employees per building for new plants.

Campaigning against the runaway growth that threatens the quality of life that once inspired the nickname Valley of Heart's Delight, Pulitzer Prize-winning novelist and 37-year Santa Clara County resident Wallace Stegner cautions, "It happens slyly. You see an orchard go next to you, but there are still a lot of orchards. Then it becomes catastrophic."

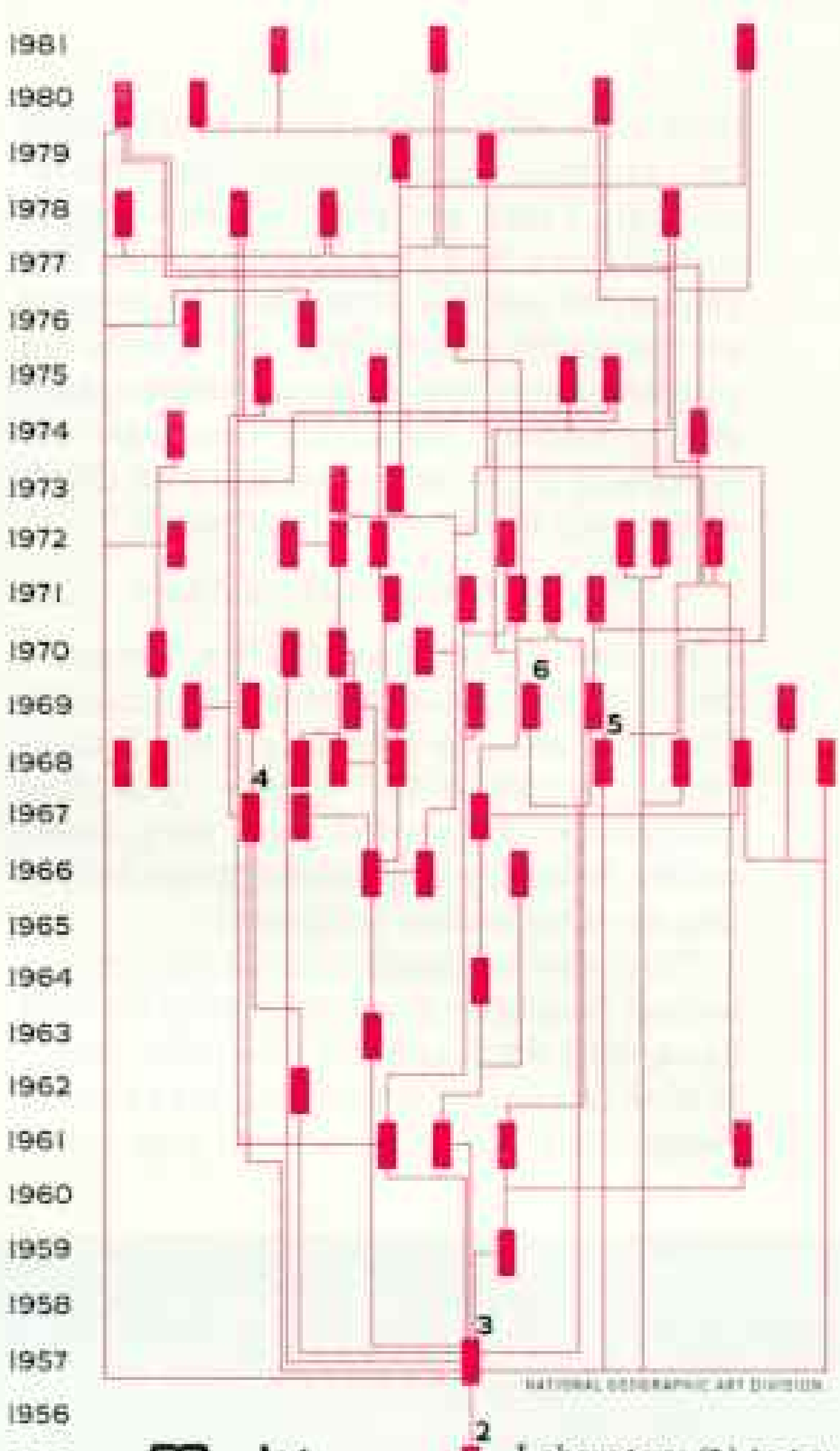
"The problems are the growing pains of any community that grew fast after World War II, plus the breakneck speed of change in Silicon Valley companies," says Bob Kirkwood, Hewlett-Packard's manager of government affairs. "The start-ups of the 1960s are just beginning to have the luxury of lifting their heads to look around."

As they do, some have gained a special view of the universe. Cherry Lorenzini, whose husband Bob's company, Siltec, produces the silicon wafers from which chips are made, says: "I can point out a satellite to my kids in the night sky and say, 'You know, there might be some of our silicon up there.'" Proud of her role, she says, "For a man to reach his moon, he needs a support team. Bob designed his first crystal-growing furnace on our dining-room table. We were the little guys going in and eating up the competing companies. His dream was to take Siltec from scratch to 50 million dollars; now the goal is 150 million. But for the men in this industry, it's total dedication," she adds. "I merged my dreams with his, but many women can't accept their limited roles in their husbands' lives."

There are other problems. "It's a tremendously striving, intellectually oriented population. They tend to be workaholics who can fall prey to alcoholism, divorce, and depression," says Dr. Rudolph Grziwok, director of the county's Fairoaks Mental Health Center in Sunnyvale. "Burn out" has become a common valley syndrome; for not all can maintain the winner profile.

In this environment, relationships can suffer. Driving home in his Mercedes-Benz

California's Silicon Valley



Multi-billion-dollar family

GENEALOGY of Silicon Valley chip companies charts the enterprise of engineers and executives who rose in firms, then spun off to develop their own companies. A new era in electronics grew from the invention of the transistor at Bell Telephone Labs (1). Co-inventor William Shockley came west and founded Shockley Semiconductor Laboratory (2) to try to develop silicon transistors. One of eight Shockley men who left to form Fairchild (3), Robert Noyce devised the chip—a simultaneous invention of Jack Kilby at Texas Instruments in Dallas, now the world's largest semiconductor company. Among Fairchild alumni are the valley's top three firms—National Semiconductor (4), Noyce's Intel (5), and Advanced Micro Devices (6). Silicon Valley companies now control 20 percent of the 16-billion-dollar world semiconductor market.

from his weekly dance class, one of the valley's brightest engineers said: "Stars are rewarded. There are stock options—you're riding in one! And my house is another. But you've just seen my social life. The projects are incredibly interesting, but they're on your mind seven days a week. Relationships get screwed up. Somebody who was very important to me met somebody who didn't work every weekend, and that was it."

Pressure Spawns Drug Abuse

For those on the assembly line, the stress shows in drug abuse. Marijane Esparza, an instructor at a San Jose drug rehabilitation center, described the vicious cycle that gripped her for several years as a board stuffer, soldering chips to the circuit boards that are inserted into computers.

"You start on drugs because the job's so boring, hour after hour, and you don't even know what the board is for. You take 'crank' [a methamphetamine] and you feel a flash of energy—zzt, zzt, zzt—and do you work! You do *twice* as many boards! Then, the technician standing behind you says, 'Hurry up, you did 100 boards last night.'" The pressure to maintain the drug-induced productivity rate, she and others fear, encourages the use of drugs.

Theft, an estimated third of it to support the drug habit, has been growing by leaps and bounds, according to Patrick Moore of the organized-crime section of the county sheriff's office. Greed has created an illicit market for the chips, as well as for the tapes and masks from which they can also be copied (page 458). A stolen chip design can save a corporation or nation ambitious for advanced technology millions of dollars and man-years in research and development.

"Integrated circuits are small, extremely valuable products," says Moore. "Someone can walk out with a fortune in his fist."

The largest haul yet occurred over the 1981 Thanksgiving weekend—3.5 million dollars in chips from Monolithic Memories. "Truckloads!" said an astonished Doug

Vanishing breed *in Silicon Valley, farmer Charlie Olson (**right**) checks the sun-dried apricots he produces along with prunes and cherries on 130 development-surrounded acres in Sunnyvale. Only one other farmer hangs on in the city. Exceptional soil and climate attracted fruit growers at the turn of the century, when Olson's grandfather planted the family business. New orchards opened elsewhere as available acreage shrank from 100,000 to today's 13,000. "But you don't get the quality that came out of this valley," says Olson.*

*Openhanded with open land, Frank Duveneck, 95 (**left**), preserves 1,800-acre Hidden Villa Ranch in the foothills of the Santa Cruz Mountains, where he and his late wife, Josephine, moved in 1929. Hikers wander the largely virgin tract, and city children come to learn about its working farm. The ranch also hosts an interracial summer camp and youth hostel. "I often hesitate to say we own this land," wrote Josephine. "We are only its custodians."*

National Geographic, October 1982

Southard, Santa Clara County's deputy district attorney, as he prepared his case against two men arrested. The spectacular recovery of the chips in South Lake Tahoe this past spring confirmed Southard's suspicions of a connection with the 1980 theft of 11,000 memory chips from Synertek. "It's organized crime—with a small 'o.' Not Mafia, but well-organized rings. The common thread is drugs and violence," he says.

International Duel Heats Up

Other thefts being investigated are increasingly casting the specter of international industrial espionage over Silicon Valley.

"The Japanese are coming awfully close to copying our chips," said Roger Borovoy, Intel's chief counsel. "They can buy them off the shelf and make detailed photographs of them without breaking any law. But if we get our hands on a copied chip, we'll sue!"

It was computer software, not chips, however, that made headlines this year, when the FBI in San Jose and San Francisco arrested nine people, most of them employees of Japan's Hitachi and Mitsubishi industrial giants. The nine and a dozen other Hitachi and Mitsubishi employees in Japan were charged with attempting to buy stolen data concerning IBM's new superfast 3081 computer from undercover FBI agents.

The power of the Japanese electronics industry had already been reflected in the tear-soaked balance sheets of Silicon Valley. In 1981, before Silicon Valley had one on the market, the Japanese cornered 70 percent of the world market for the 64K random-access memory (RAM) chip—most of the other 30 percent going to non-valley competitors Texas Instruments and Motorola. The 64K RAM—four times as powerful as the 16K RAM it supplanted—can handle 65,536 bits of information (1,024 per K). Minuscule though it is, the 64K chip, and the early Japanese domination of its sales, will be remembered in Silicon Valley as the technological equivalent of Pearl Harbor.

A conjunction of events—the 64K RAM,

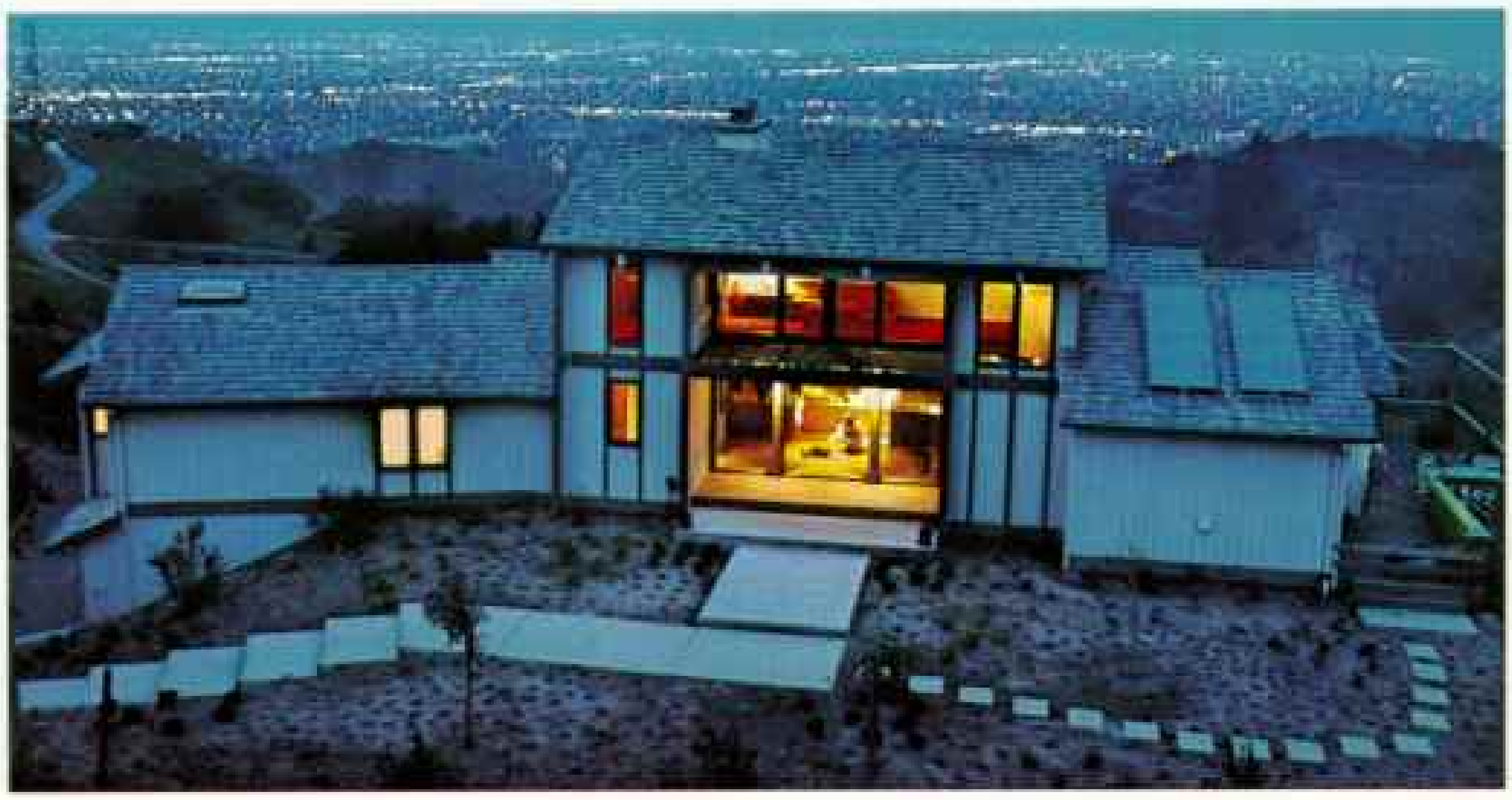
*"**It was a glorious high,**" says John Birkner when Monolithic Memories awarded new cars every four years to him and H. T. Chua (**right**) for designing a specialized chip called PAL. The friendly acronym stands for programmable array logic.*

Dangling state-of-the-art bonuses, salaries, and perks, Silicon Valley firms fiercely compete for talent in an industry characterized by job-hopping. "There is company loyalty," explains Birkner, "but higher loyalty to the individual."

*"High-energy people blossom in this industry," says manager Dave House (**bottom right**), relaxing with his wife, Nancy, after his standard 12-hour workday at Intel. "It attracts achievement-oriented people who are always trying to figure out how to do it better," he says.*

But the frenetic pace takes a toll: Divorces now outnumber marriages in Santa Clara County.

*Engineer Don Strandberg retreats to a view of the valley at his family's new half-million-dollar home (**below**) in a section of Cupertino where zoning allows only one house per four acres. "We feel as if we live in the country," says Strandberg—30 minutes from work during rush hour. "We see deer, quail, coyotes, and an occasional bobcat."*

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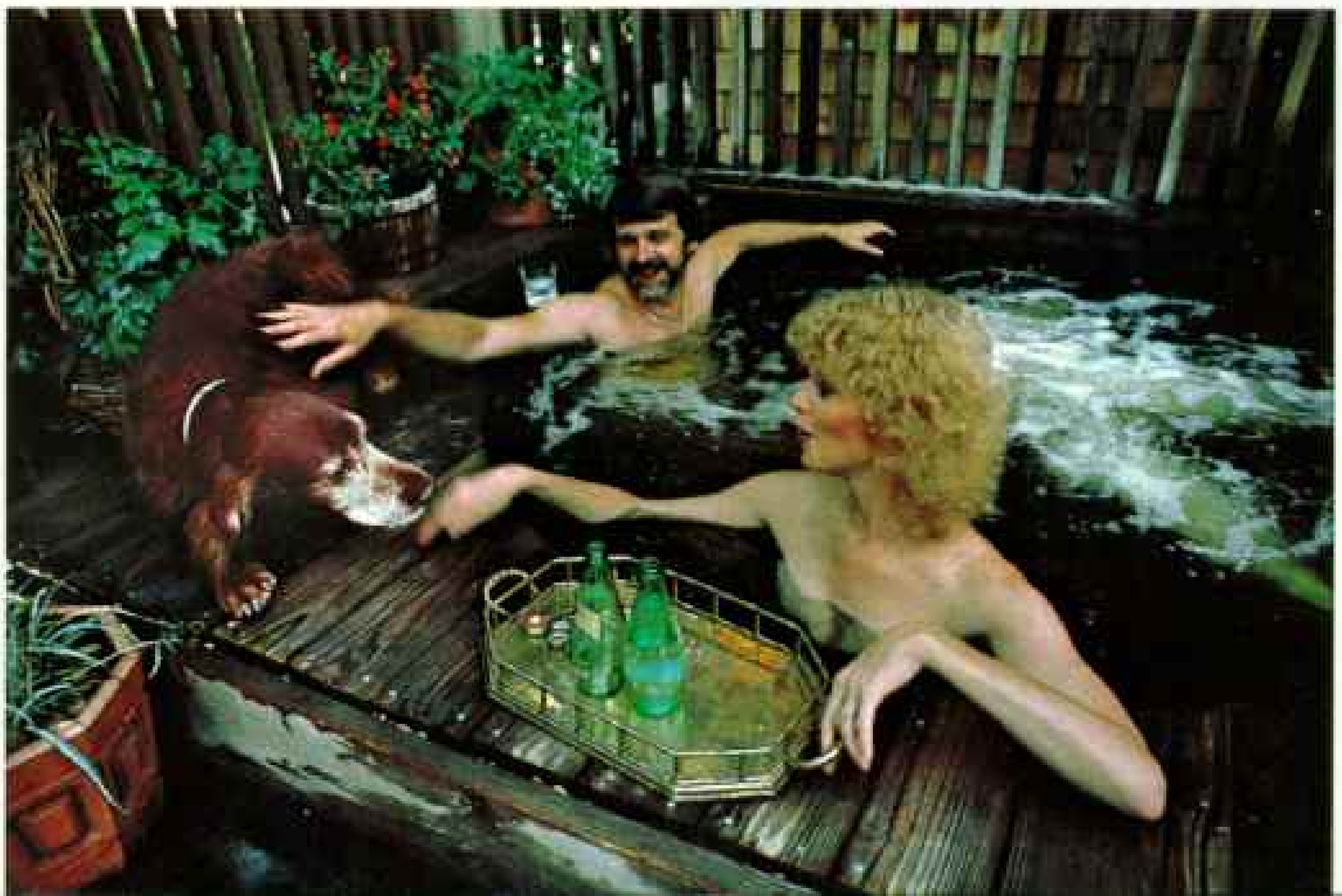


the international recession, corporate price wars—sent the valley's semiconductor profits plunging.

Frustrated but irrepressible, the valley responded with the esprit and determination of wartime.

Lobbying in Washington, Silicon Valley leaders bemoaned the lack in the United States of a national industrial policy similar to that of Japan, which throws its resources behind specific areas, such as chips.

AMD's Jerry Sanders fumed, "I just don't want to pretend I'm in a fair fight. I'm not. The Japanese pay 7 percent for capital; I pay 18 percent on a good day. They get hundreds of millions of dollars of free R and D [research and development] paid for by their government. Then their products arrive here in a flood."

As the trade war escalated into a critical test of the two cultures, Silicon Valley became a metaphor for the American way. "We'll outcompete the Japanese in the marketplace," asserted Harry Sello. "After all, we Yankees invented competition. Against the Japanese companies, we offer superiority in infrastructure, software, and, above all, innovation."

Carrying that confidence into the enemy camp, Intel aggressively launched an advanced new memory chip in Tokyo, breaching the Japanese market, and, this spring, fired its 64K RAM into the fray, announcing, "They've won the first skirmish, but we'll win the war."

***"We wanted to change** someone's life," said executives at Advanced Micro Devices when they offered a $240,000 company drawing. They succeeded with the winner, Jocelyn Lleno **(above)**.*

*Research in the valley affects the lives of all Americans. Physicists probe the atom at the Stanford Linear Accelerator Center **(right)** by shooting electrons at nearly the speed of light through a tube beneath this two-mile-long lab at Stanford University—a major fount of Silicon Valley talent.*

The Valley's Pulse Beats On

But Silicon Valley's power was being assaulted by other forces. The need for capital to sustain growth is forcing many of the smaller companies to sell out to major corporations, a move an industry financial specialist, Sal Accardo in New York City, believes may strip the valley of its "flair, drive, and creativity."

And by fouling its own nest with pollution, congestion, and soaring housing and labor costs, Silicon Valley is forcing industry out. Charles Sporck, president of National Semiconductor, flies regularly to Malaysia and Arizona to visit his assembly plants. Apple's Jobs flies to a June board meeting in Ireland.

Yet Apple and Intel are still headquartered here. Giants like IBM and Hewlett-Packard are committing themselves to expanded research facilities in Silicon Valley. And profit-driven investors are pouring capital into a buoyant new wave of chip, computer, and software companies, the definitive act of economic faith that, in the words of Sal Accardo: "Silicon Valley will continue to be the cerebrum, a magnet for creative minds." □

Père David's Deer Saved From Extinction

Text by LARRY KOHL Photographs by BATES LITTLEHALES
BOTH NATIONAL GEOGRAPHIC STAFF

THE ENGLISH DEER PARK, an aristocratic tradition begun in medieval times for the hunting pleasure of kings and nobles, today serves a higher purpose. At Woburn Abbey, 45 miles northwest of London, a rare species of deer has lived for all this century in idyllic exile from its native China. There, extinct in the wild for perhaps 1,700 years, it had long been protected in an imperial park. Now a familiar sight in zoos around the world, the animal was teetering on the brink of oblivion at the turn of the century when the 11th Duke of Bedford gathered at his Woburn estate the remnants of this imperiled species.

Named in the West after its first European observer, Père (Father) Armand David, the deer was known as *ssu-pu-hsiang*, the "four unlikes," to the Chinese, who saw in it the neck of a camel, the hooves of a cow, the tail of a donkey, and the antlers of a deer. The animal's fondness for water, well served by Woburn's several small lakes, supports the theory that its original habitat in China was swampy or riverine. If efforts of conservationists prove successful, the deer may one day be reintroduced into a natural environment in its native land.

ANCESTRAL HOME of the Dukes of Bedford for almost four centuries, Woburn Abbey makes an elegant backdrop for grazing Père David's deer. Woburn's brood of 420 animals, or about a third of the world population, owes its existence to two distinguished naturalists from a bygone era—a Frenchman and an Englishman whom fate had singled out to safeguard the species.

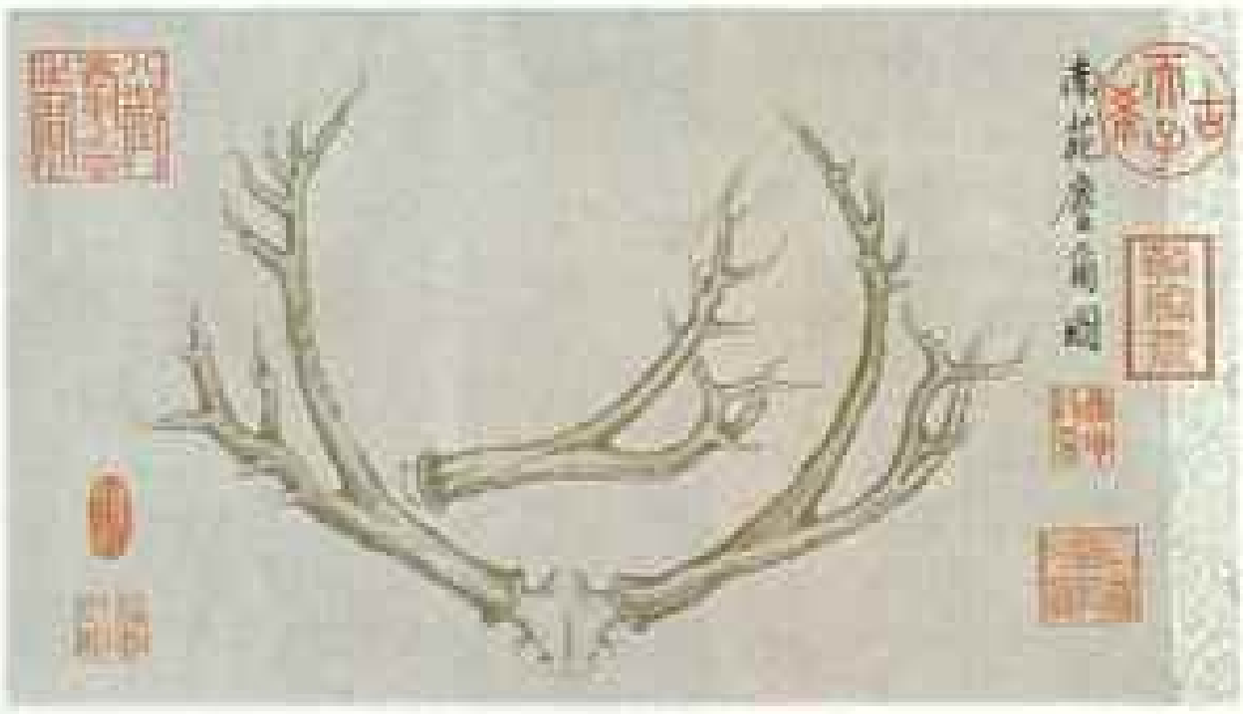
The saga began in 1865 when Père David looked over the wall of the imperial hunting park near Peking and beheld "a kind of reindeer." The stylized deer on a 16th-century porcelain (***right***) may represent such a scene. Though it was forbidden to enter the park, Père David managed to obtain two deer hides and some antlers, illustrated in a Chinese drawing (***below right***). These he sent to the National Museum of Natural History in Paris, where a new species was announced: *Elaphurus davidianus*.

In the years that followed, it was learned that the strange deer survived only in the emperor's game park, and Père David and others prevailed upon the emperor to send a few specimens to zoos in London and Berlin. But events soon conspired to push Père David's deer to the edge of extinction.

First, in 1894, a flood destroyed parts of the imperial park wall, allowing most of the deer to escape into the countryside, where hungry peasants ate them. Then, in 1900, what few breeding specimens remained were slaughtered by foreign troops during the Boxer Rebellion. When news of this filtered back to Europe, zoologists feared for the species' survival. They agreed to sell their animals to the European who had been most successful in breeding them, the 11th Duke of Bedford. In a 3,000-acre park on his vast estate, the immigrants thrived, and from an incredibly scant gene pool of only 18 animals has sprung today's world herd.

The Bedford estate has now turned commercial to survive taxes. The abbey, with its art treasures, and a drive-through zoo called Woburn Wild Animal Kingdom attract nearly a million paying visitors a year. Trails lead through the deer park, a sanctuary for several species. The Marquess of Tavistock, son of the present duke, manages the estate under a trust arrangement that will pass the deer park on to his eldest son.

METROPOLITAN MUSEUM OF ART, NEW YORK (BOTTOM LEFT); FREER GALLERY OF ART, WASHINGTON, D.C. (BELOW LEFT)



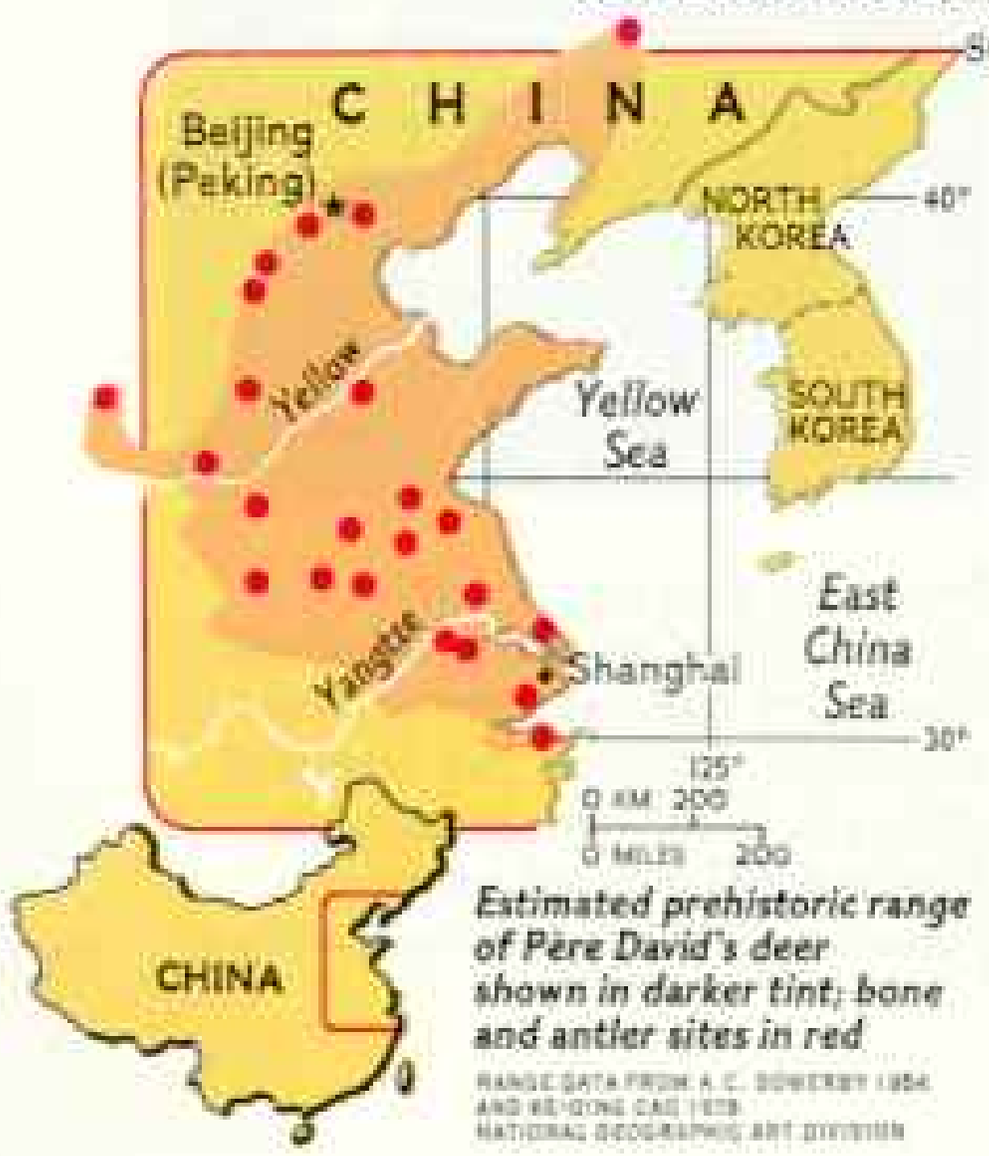
Saving Père David's Deer

COURTESY LAZARIST CONGREGATION, PARIS

***Seeker** of souls and species, Père Armand David was both a Lazarist missionary and a veteran explorer-naturalist. Traveling in China and Mongolia in the 19th century, the Basque scholar found scores of plants and animals new to the West.*

WHEN'S LUNCH? A three-day-old male (***above***) awaits his mother under a Woburn oak tree. Symbols of machismo, grass-tufted antlers—distinctively wide branched and backward pointing—identify a stag in rut (***right***). Emaciated by days of mating and caked with mud from a cooling wallow, he rests after yielding his harem to another male.

With fossilized antlers and other bones, scientists are gradually piecing together the Père David's original habitat in eastern China (***left***). Evidence to date indicates that its life in the wild probably ended after the Han Dynasty (206 B.C. to A.D. 220) as more land was cleared for cultivation.



Estimated prehistoric range of Père David's deer shown in darker tint; bone and antler sites in red

RANGE DATA FROM A.C. SOWERBY 1854 AND KE GONG CAO 1978
NATIONAL GEOGRAPHIC ART DIVISION

THE CALL OF THE WILD still stirs the species' collective bloodstream, despite many generations on Woburn's sheltered acres. This is especially evident during the summer rut, when the bellowing of amorous stags breaks the serenity of the English countryside. Antlers, freed of the blood-rich and sensitive velvet that peels off each May, become sparring instruments for contentious males (**bottom**). "Less violent rituals usually determine male dominance over the harem," says Maya Boyd, friend of Lord and Lady Tavistock and an Oxford student writing her Ph.D. thesis on the animal's ecology and behavior. "Injuries are rare in these infrequent contests." She concludes that males mark out their territory with fluid from a gland beneath their eyes (***above left***). During the six-week rutting season, a succession of males serve as harem masters, mating with dozens of females over a sleepless tenure of as long as two weeks. Calves arrive in April and May, after a ten-month gestation—among the longest of any deer species.

Because the world population of Père David's deer is so small, ways to minimize inbreeding were examined at a 1978 workshop co-sponsored by the Smithsonian Institution, which maintains a herd of around 60 at Front Royal, Virginia. Of some 1,100 specimens worldwide, nearly three-fourths exist in groups of six or fewer.

After the giant panda—an animal that Père David was also the first Westerner to record seeing—the deer may become the most important figure in Sino-Western wildlife diplomacy. Though there are a small number of the deer in Chinese zoos, many conservationists in China and the West want to see the species reintroduced to its homeland in large enough numbers to assure a viable population. A World Wildlife Fund plan would airlift a dozen or so deer to a site in eastern China yet to be determined.

"The Chinese have shown what they can do in conservation," says Lord Tavistock (***above right***), whose Woburn herd would be a major contributor to the effort. "But with China's human population pressures, a truly wild environment may be out of the question." A new home for the deer in China would help write a happy ending for a story that almost ended in tragedy. □

Thailand's Working Royalty

Photographs by
JOHN EVERINGHAM

THE 48 MILLION SUBJECTS of Thailand's King Bhumibol Adulyadej, Rama IX, regard the human summit of their realm with awesome Asian reverence. Courtiers approach the royal presence on their knees, offering gifts on ceremonial trays. They speak a special, elaborate language of the court, never addressing the King directly, but putting their questions to the "coarse visible dust, fine invisible dust" beneath His Majesty's feet. When a formal palace communiqué announced that Queen Sirikit had suffered a broken ankle, the staff had to offer a translation into modern Thai.

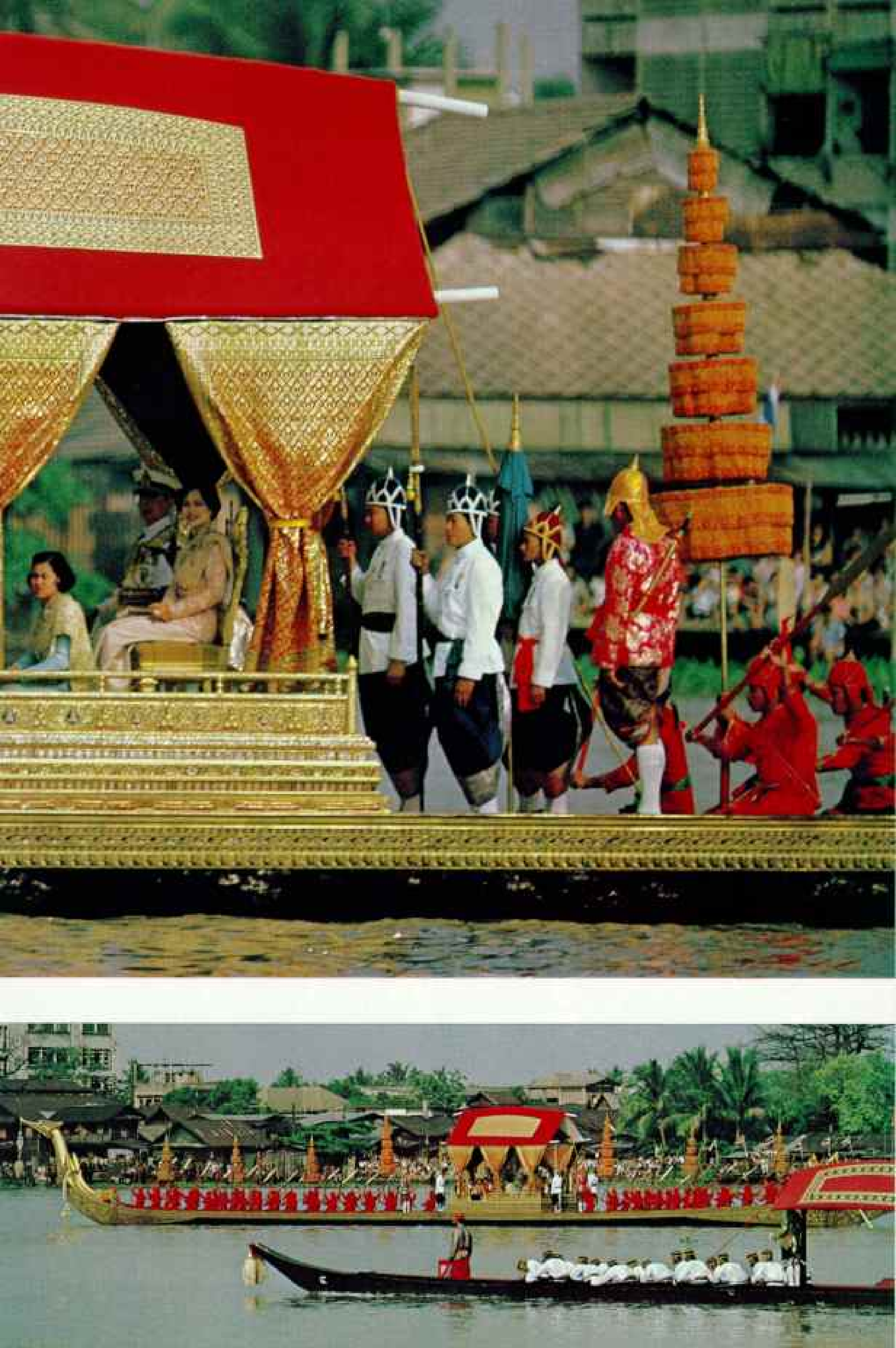
This year Thailand is celebrating the bicentennial of the reigning Chakri Dynasty with spectacular rituals that thread through seven centuries of history. Yet the pomp can obscure an important fact: Thailand has a strictly constitutional monarchy with perhaps the world's hardest working royal family. The King and Queen have a restless court: By car, by helicopter, and by foot, Their Majesties regularly travel to the 72 provinces of the realm.

On these pages readers can accompany the energetic court entourage through the photographs of Australian John Everingham and royal interviews by Denis Gray, Associated Press bureau chief in Bangkok, and NATIONAL GEOGRAPHIC Assistant Editor Bart McDowell.

In profound deference *to monarchy, a couple approach on hands and knees to be wed by King Bhumibol Adulyadej and Queen Sirikit in Bangkok's Chitralada Palace; an aide bears a royal gift at lower right. Beyond such ceremonial duty, Thailand's rulers have brought royalty out of the palace —into their people's lives and problems.*

A tradition revived: *Like those that have borne Thai rulers since the 17th century, more than 50 royal barges, retired for 15 years, were meticulously restored for this year's 200th anniversary of the reigning dynasty. Along the Chao Phraya River* ***(above)*** *the King and Queen ride beneath the canopy at right, with Princess Sirindhorn at their feet and Crown Prince Vajiralongkorn amidships. Royal guards in an accompanying vessel bow to stay beneath the rulers as they pass* ***(right)****; photographers, too, were denied higher vantage points.*

The barges echo smaller craft that have long carried travelers through riverine Bangkok, once known as the Venice of the East for its maze of klongs, or canals. Many, however, have been filled and paved over as roads during the city's explosive growth.



"I THINK that the Thai people understand the use of tradition," observes King Bhumibol Adulyadej. "Traditional doesn't mean old-fashioned. Even the most modern people have tradition.

"They say that a kingdom is like a pyramid: the king on top and the people below. But in this country, it's upside down. That's why I sometimes have this pain around here." The serious, scholarly face breaks into a smile as he points to his neck and shoulders.

A National Assembly enacts all laws, but the Royal Thai Army is the most powerful force in Thai politics. Changes in government have come with usually bloodless coups. National unity is achieved, Thais agree, through the Theravada Buddhist faith, a high sense of patriotism (the word Thai means "free"), and the monarchy. But over the centuries the king's role has changed greatly. Or as King Bhumibol puts it, "Monarchy in this country has always been on the move."

And the traditional man on the move who has reigned in Thailand since 1946 brings a singular perspective to his role.

He was born in 1927 in Cambridge, Massachusetts—the only monarch ever born on United States soil—while his father was studying medicine at Harvard University. Young Prince Bhumibol was schooled in Switzerland, where he studied both science and law and pursued such Western hobbies as fast cars and jazz clarinet. An automobile accident cost him his right eye, and it was during his convalescence that he fell in love with the daughter of a titled Thai diplomat, the present Queen Sirikit. The untimely deaths of his father and then of his older brother brought Prince Bhumibol to the throne of a nation occupied and exploited by the Japanese during World War II. Since the 1960s the king has rarely left Thailand. Patiently, he has served as a constitutional monarch through eight coups d'etat and 11 different constitutions. He has intervened only in moments of crisis, as in 1973 when student demonstrations left more than 70 dead; the King's compassion for the students

brought a quick change in government.

For NATIONAL GEOGRAPHIC, King Bhumibol recently reviewed the two centuries of the Chakri Dynasty, candidly characterizing the reign of each ruler: "Nine kings—I am the ninth. Each has a special characteristic. Rama I built the system of governing, of military security, of culture, et cetera. Rama II followed through, and as he got older he emphasized literature and art. He was himself an artist. Rama III set up the administration of the country.

"Rama IV was a philosopher and scientist and brought in modern technology. He blended modern science with a traditional religious outlook. Rama IV—King Mongkut, of *The King and I* fame—taught himself English and Latin. He calculated everything and predicted an eclipse that he went to see. He set up modern Thailand, but it was during the reign of his son Rama V, King Chulalongkorn, that it blossomed.

"King Chulalongkorn set up all the ministries and railroads and systems of education.

"King Rama VI continued with more emphasis on foreign relations. He, too, was an artist. The seventh reign was unfortunate, because there was an international depression. Rama VII was in a difficult position; the treasury was nearly drained. He set up democracy, but the ones who wanted the democracy cut him short. He would have set up a real democracy in a few years instead of the government that was not well devised, not well studied. We still have the effect of it.

"The eighth reign, my brother, had no time to do so many things—during and after World War II, a difficult time. But he set up, perhaps without knowing, the new kingship. The people had somebody to look on as a symbol. When he died he was 20, a young man with a good future. A new thing, because in the past kings were perhaps more sheltered. He was like raising a flag. But he also was cut short.

"So I came, when I was 18 years old. Now 36 years ago, quite a long time. When I came to this function in the palace, the chairs and carpets had holes. The floor creaked. The

Its splendor restored *with gold leaf and the polish of thousands of hands, the Grand Palace (**left**) sets the night ablaze during the bicentennial celebration last April. In 1782 the palace became the centerpiece of a new Thai capital called Krung Thep, "city of angels," known outside Thailand as Bangkok. Its founder, Rama I, established the Chakri Dynasty that still reigns through King Bhumibol, Rama IX.*

*Architect of Thailand's first foreign policy from 1851 to 1868, King Mongkut, or Rama IV (**right**), expanded trade with the West, but he held colonialism at bay. Thailand became a neutral buffer between British and French claims in Burma, Malaya, and Indochina. Mongkut pioneered close contact between the rulers and the ruled by traveling the country as a barefoot monk, until becoming king at age 47. He was romanticized by "The King and I," a musical now banned in Thailand for its historical liberties.*

BIBLIOTECA APOSTOLICA VATICANA

palace was crumbling down. It was just after the war, and nobody had taken care of things. I had to reconstruct. I don't demolish. I put things together piece by piece. Slowly. For 36 years. So this reign is perhaps characterized with going step by step. Evolution. Looking at the good things of the past. Traditions perpetuated and transformed. That is the lesson: We take old traditions and reconstruct them to be used in the present time and in the future."

FOR PUBLIC CEREMONIES in Bangkok, King Bhumibol is always dutiful and formal. Shaded by a purple umbrella, the King stands plumb-line straight, uniformed in white, sashed in gold as the symbol of his Chakri Dynasty. His expression is unsmilingly serious and his movements brisk and meticulous. He is not a glad-handing campaigner but the concerned father of his people, intense, iconic. In the tropical heat he moves among his subjects with complete control; only those close at hand can see that sweat drips from the King's chin and hands, unacknowledged by any gesture.

In this personal way the King himself hands each university graduate in the realm a diploma and each second lieutenant his commission.

Away from public view, the King's routine includes less pomp but no less concern with duty. Take, for example, the moated residential Chitralada Palace in Bangkok. The kilometer-square palace grounds project the King's interests, and seem more like an agriculture experiment station than a

Gritty reality holds court *when the King and his helicopter entourage clatter into an outpost on a problem-solving mission (**above left**). Villagers turn out en masse (**right**) to hear "Chao Pho Luang," their "royal father," here near Laos and Burma in the Golden Triangle. To counter widespread opium cultivation, the King encourages alternative crops such as kidney beans, potatoes, and coffee. He also has inaugurated more than 500 irrigation projects; an engineer at heart, he is seldom without topographical map and grease pencil to propose another dam or drainage canal (**above**). Such efforts, he believes, help thwart Communist insurgency in poor outlying areas—which is part of the reason he spends no less than eight months a year on the road within Thailand.*

royal preserve. Here His Majesty supervises rice crops and the building of storage bins and silos in metal, wood, and concrete. Ponds are stocked with varieties of fish from Japan. Technicians process milk products and demonstrate their skills for visitors. A forest project blends with landscaping; royal elephants, peacocks, and rabbits feed nearby. To fill a low spot in a roadbed, workers use the rubble from a remodeled temple. "Nothing is wasted," a palace workman notes proudly.

The King sums up his Chitralada activity: "Everything is experimental."

THE PALACE ITSELF seems less a monument than a family home. A children's playhouse sits near a pond in the front grounds. The palace's metal roof bristles with the King's ham radio antennas. Inside, furnishings are turn-of-the-century solid and bear the cipher of Rama V, king from 1868 to 1910. Rooms are decorated with heavy draperies, the tusks of long-dead elephants, ancestral portraits, and reproductions of favorite paintings like Sir Thomas Lawrence's "Pinkie." Attendants complain about mosquitoes that laze through open doors. The unpretentiousness of the palace reminds a visitor that descendants of a Thai monarch revert, after five generations, to the rank of commoner.

The King himself is a most uncommon man, and his conversation spans a Renaissance spectrum: irrigation systems, international balance of payments, minerals, even his own hobbies like photography and cartography—"but I have stopped painting; it takes too much time," he explains.

He still plays several instruments and composes music. In fact a privately printed book lists 41 of the King's compositions, among them "Hungry Men's Blues" ("You'll be hungry, too, if you're in this band—Don't you think that our music is grand?"), "Royal Guards March," "Love Over Again," and "Friday Night Rag."

Always the King's conversation returns to his visits with individual Thais.

"The Thai people are not military, but aware the country must be strong militarily. Once, in a province near Bangkok, a drunk man came up to me. The security people were not very happy about it, I understand. He said he had been a soldier. He had served the country. His son would be a soldier also, that without military people our country wouldn't be free like this. They say that drunk people do tell the truth.

"Just last month I went to the south, and in one village a man told me that he has one daughter and one son. And he asked me, 'Can Muslims go into the military school?' I said, 'Of course, if a boy is good, strong, and intelligent, he can apply to the military school.' And I asked the man, 'How old is your son?' He said, 'Six months old.'" The King laughs. "He wants his son to defend the country. He said, 'We Muslims are real Thais.'"

The King sees many forms of invasion: "The most modern way is to infiltrate and to take over the minds of the people. I call it mental warfare. To step into your head." To avoid mental invasions a government must show sensitivity and patience. Like the matter of opium:

"We don't deny that there is still opium

Royal images: *A floral arrangement catches the eye of King Bhumibol* (**above**), *long an avid photographer.*

grown in this country, but there's a very small quantity. The problem of opium is the traffic through the country. The people who cultivate the opium poppy don't get one-thousandth of the value. So we try to have a crop substitution. It takes many years just to begin. At first we went by car and by foot, then by helicopter, sometimes landing in the poppy fields. We must be careful because people don't understand what is bad.

"Once I walked for an hour to see one poppy field. The land looked bad, and the farmers said, 'Yes, the land is exhausted—no fertilizer.' We said we would give fertilizer if they would not grow opium but raise beans instead. The farmers asked time to take consultation, and after 15 minutes returned and said, 'All right, we'll take it.' Well, next year we went back—half beans, half opium. And better results from beans, so they asked for more beans. Next year they raised only 25 percent opium. It diminishes like that. We have to be patient. If we just destroy the poppy, the people will be hungry and wonder why we are against them. They could become insurgents. But it takes follow-up."

In their travels around Thailand, the King and Queen have faced danger from Muslim separatists as well as Communist insurgents. In 1977, for example, in the southern province of Yala, two bombs exploded near the royal couple.

"The danger?" muses the King. "The publicized danger is Communism. But the greed of our own people is more dangerous. If we clash too much among ourselves, we will become the slaves of what I call the new imperialism, be it Communist or dictatorship or whatever."

His faith in the Thai people remains firm. "Thais seem to be happy-go-lucky but are quite strong. Our people are relaxed, not high-strung or stiff. They are hospitable—to strangers and to new ideas. The majority are Buddhist—and the Buddhists have never had a holy war. They are polite. Honorable politeness. They have courage but are not harsh—strong but gentle."

HIS MAJESTY KING BHUMIBOL ADULYADEJ, RAMA IX

But his favorite subject for the camera is his queen, Sirikit, whose beauty has captivated him since their marriage in 1950. Their palace often echoes to jazz played on saxophone or clarinet, another of the creative King's talents.

WHILE KING BHUMIBOL performed his religious duties and meditations as a Buddhist monk in 1956, Queen Sirikit was named Regent of Thailand. Before the National Assembly she took an oath of allegiance echoing the King's own coronation pledge: "We will reign with righteousness, for the benefits and happiness of the Siamese people."

The Queen's active role fits into the historical traditions of Thai women, who "never had the feeling of being inferior to their menfolk," as the Queen herself has noted. Her own work schedule would dismay most males. Traveling with the King to remote areas, Queen Sirikit encourages traditional crafts to supplement the income of rural people. In Phet Buri Province she launched a project to make handbags and sandals from jute and palm leaves. In Prachuap Khiri Khan Province the Queen got women to make artificial flowers. She revived the old art of making *chao wang*, clay dolls, and sent instructors to teach Ayutthaya women to weave cotton. Embroidery, fern-vine basketry, tie-dyeing, silverwork—Queen Sirikit encourages both the crafts and their sale in special shops.

On frequent trips abroad representing the King as a goodwill ambassador, she promotes the export of handwoven Thai silk and at age 50, the arrestingly beautiful Queen Sirikit is herself an incomparable model for Thai fashions. She employs her organizational skills for the Thai Red Cross Society, for aid to refugee orphans, wounded soldiers, and flood victims.

Years ago, when an interviewer asked her favorite hobby, the Queen replied, "Looking after my children." The three princesses and one prince are now grown. And the Queen helps bring them into more of the royal concerns: opening exhibits, meeting diplomats, shaking endless rows of extended hands "for the benefits and happiness of the Siamese people."

The King's physician, Dr. Chinda Snidwongse, complains that "His Majesty works too hard." And though the 54-year-old King jogs and does push-ups almost every day, the doctor would "like for him to take a vacation each year." People still worry about the time seven years ago that he fell seriously ill after visiting a dusty hill-tribe village; others speculate about the possibility that His Majesty might have an ulcer.

Concern for the popular King reflects uncertainty over the royal succession. The eldest daughter, Princess Ubol Ratana, married an American while studying in the U. S. and currently lives in California. The youngest daughter, Princess Chulabhorn, this year married a Thai commoner. Crown Prince Maha Vajiralongkorn, now 30 years old, has enthusiastically studied military

science in Australia and the U.S.A. but has inspired controversy regarding his own suitability for or interest in acceding to the throne. Observers have noted that some Thais are disturbed by the crown prince's fascination with military matters and his seeming inattention to civilian pursuits. Others in the palace have described the prince's family life as "not so smooth."

If the prince should remove himself from succession, there is a popular alternative in

Humble before inner strength *that transcends tragedy, Queen Sirikit pays respect to a Buddhist monk who lost his limbs in an accident while drawing water from a well. She learned of the incident and quickly arranged a visit to the monastery while touring the rural north to promote development projects such as silkworm nurseries. The Queen also encourages cottage industries that include the weaving of distinctive fern-vine handbags.*

Rating a silver platter, *helmet and gloves are presented by aides to Crown Prince Vajiralongkorn, seated in the cockpit of an F-5E fighter* (**above**). *The prince, 30, ranks as a wing commander in the Royal Thai Air Force; duty in Australia and at Fort Bragg in the United States helped him develop proficiency in flying.*

Outside the Temple of the Emerald Buddha, eager hands donate funds to Princess Sirindhorn (**facing page**), *27, who organized the restoration of such shrines. The royal children include two other daughters, but of them all, Sirindhorn's charisma makes her the apple of the public's eye.*

the unmarried Princess Sirindhorn, a brilliant 27-year-old scholar who was years ago accorded a special dynastic title (Maha Chakri) by the National Assembly. More recently the parliament has revised royal law to permit, for the first time in Thai history, a woman monarch.

Princess Sirindhorn accompanies the King on numerous remote journeys, experiences that inspired her to write a poem that rhymes in both French and Thai. Its title—"The Footstep of My Father," seems portentous. At least, the princess makes a symbolic comment on the burdens of monarchy in Southeast Asia:

"Through the dark jungle, very dense,
Which stretches out interminably, somber and immense . . .
I follow without stopping the quick footstep of my Father.
Oh Father, I am dying of hunger and I am tired.
Look! The blood is running from my two wounded feet . . .
Father! Will we arrive at our destination?
—Child! . . . On the earth there exists no place
Full of pleasure and comfort for you.
Our road is not covered with pretty flowers.
Go! Always, even if it breaks your heart.
I see the thorns prick your tender skin.
Your blood: rubies on the grass, near the water.
On the green shrubbery, your tears dropped.
Diamonds on emerald, show their beauty.
For all the human race does not lose its courage
In the face of pain. Be tenacious and wise.
And be happy to have an ideal so dear.
Go! If you want to walk in the Footstep of your Father."

From its earliest days, the Thai monarch was defined in scripture as *Mahasammata*, or a king of righteousness, "elected by the people." Buddhist teachings of the ten kingly virtues were supplemented by a quartet of qualities for an ideal monarch: a knowledge of food production, a knowledge of men, the means of winning the people's hearts, and gentle words—all useful attributes for a Thai monarch in the late 20th century.

King Bhumibol Adulyadej defines the problem of his realm: "Our country is rich. And strategic. So that if there is any struggle in the world, people want to get this country. And there's always a struggle in the world.

"We still stand here. We stand here for the good of the whole world." □

Thailand: Luck of a

By BART McDOWELL
ASSISTANT EDITOR

Photographs by
STEVE RAYMER
NATIONAL GEOGRAPHIC PHOTOGRAPHER

MY FIRST and most lasting memory of Thailand, from the 1960s, is of six sprightly children beside a canal. They were dipping up water to pour over a playful baby elephant. The youngsters were laughing.

Those children now face the cares of adulthood, and the elephant is long in the tusk. Their homeland also has some larger problems. With Communist governments in neighboring Laos and Kampuchea and with Vietnamese troops on its borders, Thailand stands today as a front-line nation for the West. Yet this nearly Texas-size land of 48 million people remains a place of charm, spontaneity, and laughter.

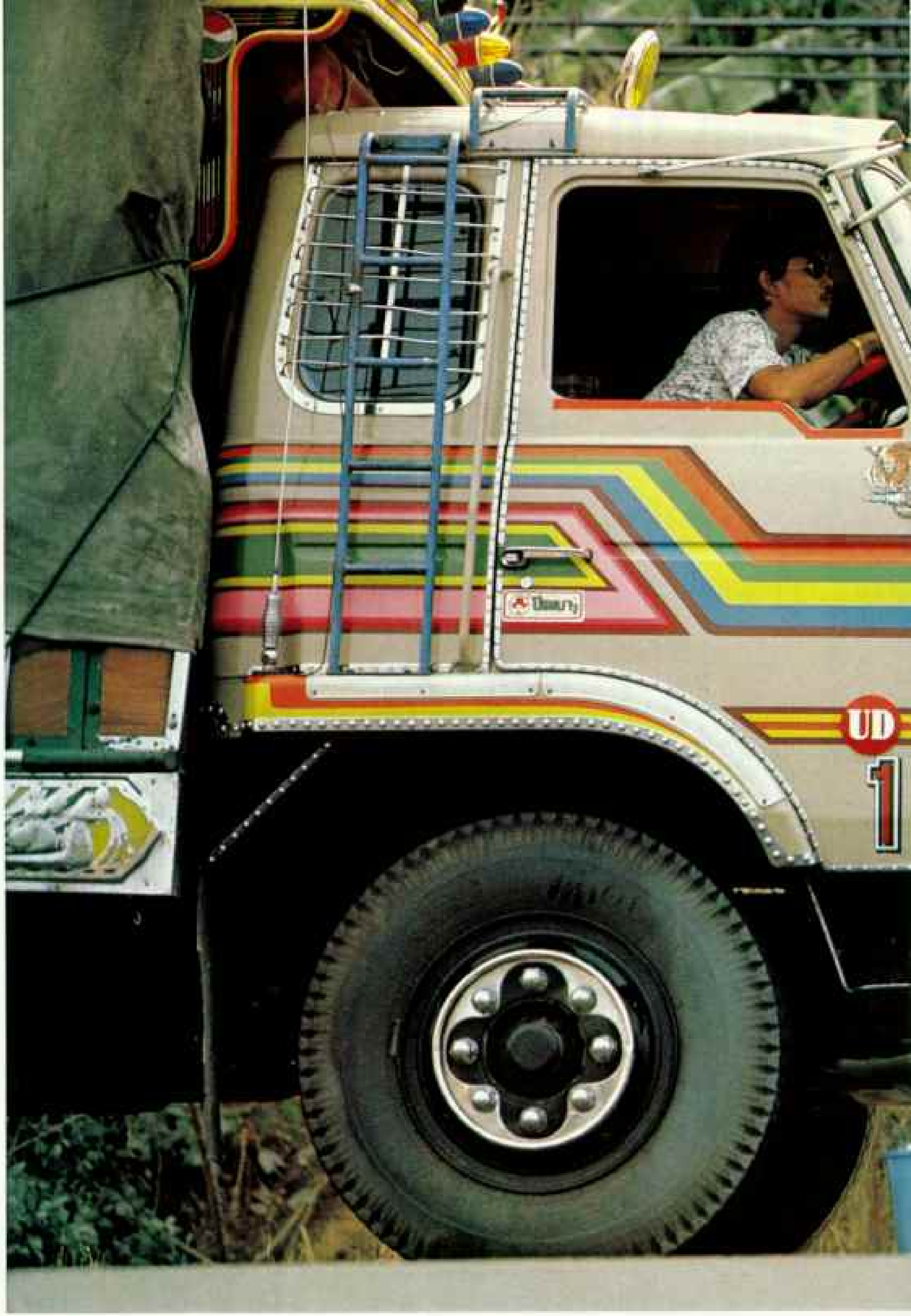
"We have not become a fallen domino," a university student told me, "because of the Lord Buddha and our holy King."

Buddhism pervades the kingdom, sometimes with startling effect, as I saw one hot noontime on Bangkok's Patpong Road. This is the neighborhood called the sex supermarket of Asia; a street sign in somewhat English exhorted visitors: "ROXY BAR . . . Girls Girls Girls . . . You Want em We Got em . . . spirits and hard waters served."

Inside, 26 go-go girls had covered their ivory skin with satin blouses, camouflage

***To earn merit** for their benefactors, Buddhist monks present alms bowls at Bangkok's Marble Temple. Like these young men, many of whom serve as monks for at least three months, Thailand honors tradition while striving to prosper in today's conflict-rife world.*

Land in the Middle



Slow moment in a fast life: *A truck driver naps in his hammock during a steamy midday wait to unload cassava near Chon Buri. With lax speed limits on a network of national highways, such drivers send their gaudy behemoths*

careering across the land at breakneck pace, frequently forcing cars to swerve off the road. Thailand owes its good roads in part to aid from the United States, which needed them to help supply air bases here during the Vietnam War.

suits, and T-shirts (one labeled Harvard). Their dither was domestic—arranging lotus blossoms, peeling oranges, and fetching bundles of joss sticks—for the Roxy was expecting nine Buddhist monks from the Kaewchamfah Monastery.

"Nine is auspicious number for well-wishing," one girl explained. "Sure, we wear clothings for monk. We cover pictures, also." She nodded toward a soft-core poster, now draped. "Monk see that and not want to be monk any more."

Punctually, in two station wagons, the monks arrived and filed silently into the bar. Then, adjusting their curry-colored robes, they sat cross-legged on a circle of cushions, closed their eyes, and began to chant mantras in perfect unison. The go-go girls knelt. And the Roxy Bar, marking a year of business profit, received a holy benediction.

In Thailand the prim and the prurient meet and merge. So do other trends and traditions. On the world's hungriest continent, Thailand is a net exporter of food, ranking sixth worldwide after the United States, Canada, Australia, Argentina, and France. Last year more oil was discovered in the north, and natural gas production began offshore in the Gulf of Thailand.

Tourists now bring a billion dollars a year to Thailand—only rice earns more foreign exchange (1.3 billion dollars). This year Bangkok's 12,000 luxury hotel rooms were in demand for the city's bicentennial celebration. No wonder. This capital city offers all kinds of textures and tastes from cool silk to hot peppers: palaces, floating markets, temple dancers, white elephants.

Thai currency, the baht, is freely convertible on world markets (23 to the U. S. dollar). The birthrate is falling and the rate of population increase is down to 2.1 percent. The economy grows 6 to 8 percent annually. U. S. government officials have discussed removing Thai handicrafts from the duty-free list, thus certifying Thailand's graduation from Third World poverty.

BUT THE GOOD NEWS has dark companions. Communist insurgents, though weaker than a few years ago, still shoot up trains and kill soldiers. The country has a nagging trade deficit, and soaring energy costs have dimmed TV sets and neon signs. Some 11 million people still earn less than $200 a year, the poverty level. And though Thai farmers increase their production 5 percent annually—a world record—they do it by chopping down once luxuriant forests. Thus soil erosion has become "perhaps our most severe geographic problem," in the words of geography professor Paitoon Pongsabutra.

Thais complain about public graft and even have an official Counter Corruption Commission. Last year that office received 4,813 complaints and reported saving five million dollars in graft ("tip of iceberg," according to a Thai newsman).

Political maps misleadingly show Thailand's borders precisely limned. But in Southeast Asia, borders blur for jewel smugglers, gunrunners, heroin dealers, guerrilla warriors, and refugees. On Thailand's perimeter, near Mae Sot on the western frontier, my driver, Weerapan Tarasarn, grew nervous as the afternoon waned. "We must leave before four o'clock," he insisted. "Bandits have twice robbed me of watch and money this year. The road is dangerous."

He was mortally right: Six bandits had murdered a guard on that road eight days earlier. Why so much crime? "Jade and rubies come from inside Burma," said Weerapan. "And money for arms." This is a major supply line for the 33-year-long civil war still being waged by the Karen people against the central government of Burma. Border areas and booty are up for grabs.

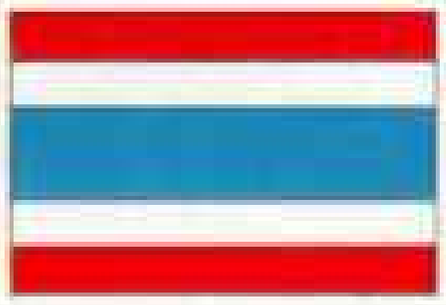
North, along the Mekong River, where Burma, Laos, and Thailand meet at the infamous Golden Triangle (map, page 506), photographer Steve Raymer and I traveled with some tough bodyguards—Thai Border Patrol Police armed with automatic rifles to

In a spirit *characteristic of the Thais, the smile scores during an exhibition soccer match between Manaschanok Klinsritsuk, a player from Thailand's TV and movie industry, left, and Trairong Suwankiri, a government official, during the Association of Southeast Asian Nations tournament in Bangkok. Delighting in the new, Thais have taken up a variety of international sports.*


HILL TRIBES
Government policies seek social integration of about half a million Karens, Hmongs, and other tribal groups scattered through rugged highlands.
GOLDEN TRIANGLE
To fight a deadly narcotics trade in Thailand, Burma, and Laos, Thai officials try to deter opium cultivation within their borders by substituting crops such as coffee and kidney beans.
KILOMETERS
200
STATUTE MILES
200
Mineral resources in red
Other products in blue
Refugee camp
DRAWN BY ROBERT W. CRONAN
COMPILED BY GRAHAM J. TRUSCOTT
NATIONAL GEOGRAPHIC ART DIVISION
Gulf of Tonkin
WATER PROJECTS
To mitigate water shortages in the northeast, catchments divert runoff into small holding tanks.
Hydroelectric plants fail to meet demand, and power must be bought from Laos.
REFUGEES
Thailand has strained to accommodate 380,000 people seeking sanctuary from upheaval in Vietnam, Laos, and Kampuchea (Cambodia). Some 200,000 others displaced from Kampuchea crowd camps along the border.
NATURAL GAS
Asia's longest undersea gas pipeline has begun to tap an enormous offshore field in the Gulf of Thailand, which may eventually generate half of the nation's electricity.
TOURISM
Second largest revenue source (after rice), tourism brings in a billion dollars a year. The southern peninsula draws 400,000 Malaysian visitors annually.
THAILAND
Chiang Saen
Chiang Rai
Tanen Range
Chiang Mai
TIN
Wang
Nan
FLUORITE
LIGNITE
Lampang
Yom
DAM
BURMA
Moei
COPPER LEAD ZINC
Sukhothai
Tak
Mae Sot
Phitsanulok
Ping
Moulmein
Viangchan (Vientiane)
Mekong
LAOS
VIETNAM
SALT
CASSAVA
Nong Khai
Nakhon Phanom
Udon Thani
SUGARCANE
1,571 m 5,154 ft
Phong
Pao
Khon Kaen
Chi
RICE
Khorat Plateau
Mun
Ubon Ratchathani
Warin Chamrap
RAILWAY
Three Pagodas Pass
Mae Klong (Kwai)
Nakhon Sawan
CASSAVA CORN
Chao Phraya River
Nakhon Ratchasima
ZINC
SRINAGARIND DAM
Lop Buri
CORN
Phra Nakhon Si Ayutthaya
1,328 m 4,357 ft
Dangrek Range
Nam Tok
Kanchanaburi
Tavoy
Bangkok (Krung Thep)
Thon Buri
Aranyaprathet
Angkor ruins
Samut Sakhon
Chon Buri
Andaman Sea
1,531 m 5,023 ft
Phet Buri
Bilauktaung Range
FISH
Ban Phatthaya
Tonle Sap
Rayong
1,675 m 5,510 ft
Hua Hin
Chanthaburi
RUBBER
Trat
KAMPUCHEA
Prachuap Khiri Khan
GAS PIPELINE
Phnom Penh
NATURAL GAS
Ho Chi Minh City
Chumphon
Ranong
Surat Thani
Gulf of Thailand
Phangnga
Phuket
Songkhla
Hat Yai
Yala
Sungai Kolok
MALAYSIA
THAILAND
Thailand's peoples
THAI
KHMER
KAREN
MALAY
VIETNAMESE
CHINESE
OTHER HILL TRIBES

"LAND OF THE FREE," as the nation's name translates, stirred in Asia more than a thousand years ago when the Thai people began spreading south from China. Their kingdom—known as Siam until 1939—took hold in the 13th century with its first capital of Sukhothai. The Thais absorbed Buddhism and other influences from earlier settlers whom they subdued. After expelling Burmese invaders in the 1770s, they rose to greatness under the Chakri Dynasty, which still reigns. Its kings welcomed Western commerce but staved off European colonialism. Today strongly backed by the United States, Thailand has witnessed Communist revolutions in Vietnam, Laos, and Kampuchea. With the monarchy's power limited, the military has effective control of the state.

AREA: 514,000 sq km (198,457 sq mi), three-fourths the size of Texas.



GEOGRAPHY: Foothills of the Himalayas in the north give way to a plain that dominates the northeast. The fertile alluvial valley of the Chao Phraya River covers the central portion, with rain forests along the southern peninsula. **POPULATION:** 48,000,000; minorities—Chinese, Malay, Lao, indigenous ethnic groups. **DENSITY:** 93 per sq km (242 per sq mi). **ANNUAL GROWTH:** About 2.1 percent. **CITIES:** Bangkok, capital, population 5,000,000; Chiang Mai, 110,000. **GOVERNMENT:** Constitutional monarchy. Head of state: King Bhumibol Adulyadej. Head of government: Prime Minister Prem Tinsulanonda. **RELIGION:** Theravada Buddhist 95 percent, Muslim 4 percent, small Christian minority. **LANGUAGE:** Thai, Chinese, various linguistic groups. **LITERACY:** 84 percent. **LIFE EXPECTANCY:** 62 years. **PER CAPITA INCOME:** $670. **ECONOMY:** Agriculture—rice, cassava, rubber, corn, sugar, livestock, tobacco, pineapples; Industry—tourism, textiles, transportation equipment, electrical goods. World's third largest producer of tin; significant natural gas.

use in case we flushed a warlord's army. Outlaws transport Burmese heroin here.

East, near Aranyaprathet, we heard distant bursts of gunfire inside Kampuchea, exchanged between occupying Vietnamese and Khmer resistance groups. A human tide of refugees from Communist lands has crossed this frontier—580,000 since the Vietnam War—and some 200,000, still not resettled, remain in austere camps today. Thailand so far has spent 1.2 billion baht on refugees, a government official told me, an expense viewed with mounting concern.

BOTH problems and progress are deeply rooted in the geography and folkways of these remarkable people. King Rama I, first monarch of the Chakri Dynasty, founded his capital, Bangkok, on the muddy banks of the Chao Phraya River in 1782 (see the preceding article). Bangkok grew organically, many of its canals turning to culverts roofed with pavement. This year, for the bicentennial, some 3,000 artisans have restored and dabbed acres of gold leaf upon Bangkok's monuments. Skyscrapers nudge the rain clouds; new bridges and expressways mitigate world-class traffic jams (pages 510-11). Agleam and abustle, Bangkok—population five million—seems the world's newest antique.

"I can remember when Bangkok was a sleepy river town," notes veteran foreign correspondent Keyes Beech. Now the city has insomnia. One night I made patrol-car rounds with Sublieutenant Somchart Sawangnetr, one of the 8,500 police officers serving the city. While his radio squawked, we looked for a hit-and-run driver on Sukumvit Road, then, siren shrieking, responded to a call east of the city where fire roared through a whiskey store and some apartments. Gradually the city quieted and dimmed down. The young officer talked about his six years on the force: "Many simple things I do—I killed a cobra last week in a woman's yard."

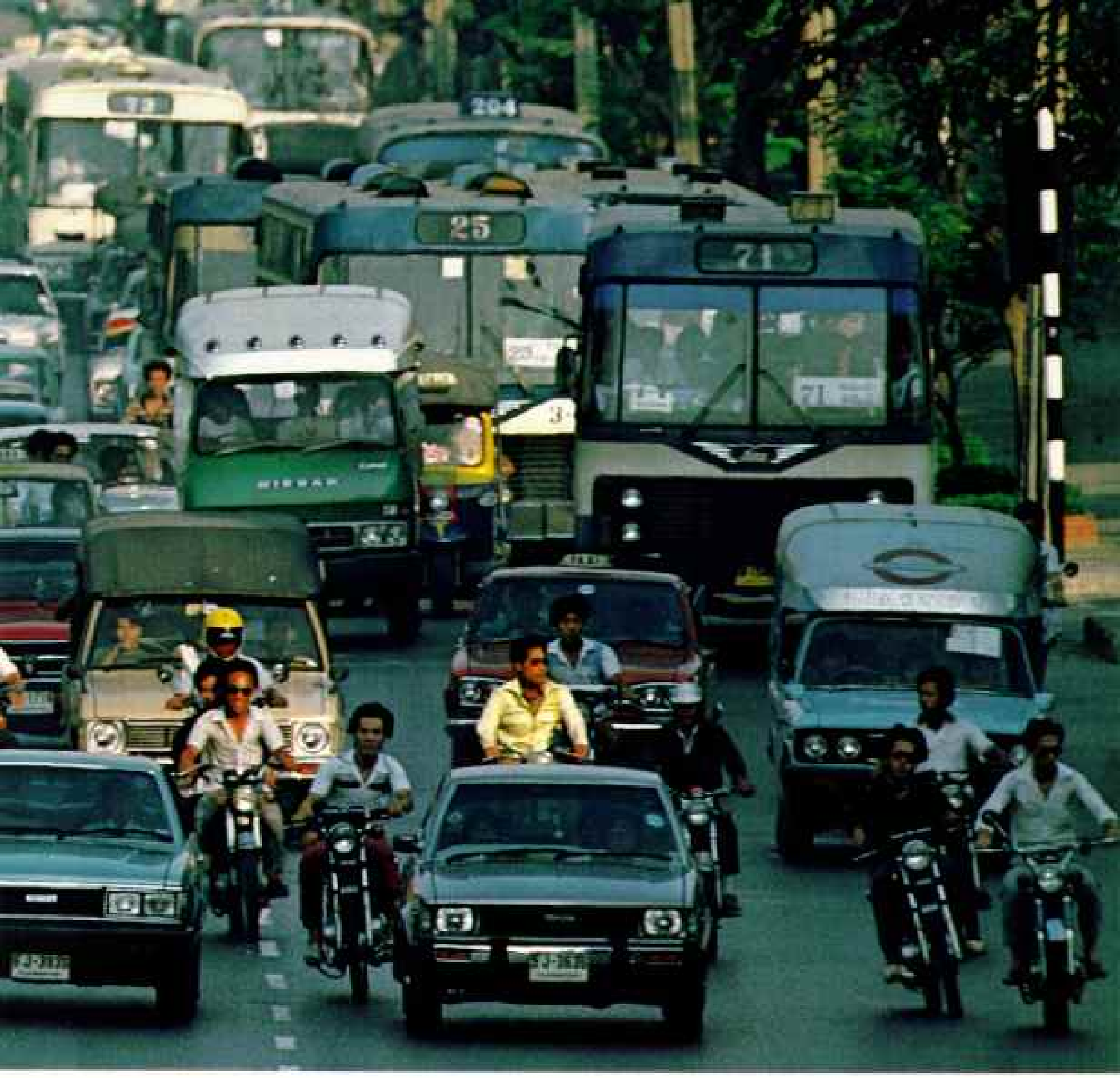
So far Somchart has missed handling sensational crimes like the two to three dozen homicides reported monthly in the city. Of the 69 police stations, four have jurisdiction on the klongs, those historic canals that still plait old parts of town. "Thieves sometimes use long-tail *(Continued on page 512)*

With the gift of incense, *fruits and flowers, and the grace of a classical dance, a young woman* ***(above)*** *seeks favor from the spirit of a Hindu god at Bangkok's Erawan shrine, built to bring good luck to workers who constructed the government-owned Erawan Hotel on whose grounds it stands.*

*To honor Buddhist precepts, the white-spired Temple of Dawn (****right,*** *upper right) rises beside the Chao Phraya River in Bangkok, which became the capital 200 years ago. The Royal Thai Navy Headquarters is in the foreground.*

In easygoing forbearance, Thais also make room in their hearts for a pantheon of local spirits while according respect to Christian and Muslim tenets as well.

Strangling a city, *cars, trucks, vans, buses, and motorcycles jam the streets of Bangkok, slowing movement to a crawl or full stop and creating some of the filthiest air in the world* **(above)**. *But traffic spells opportunity to a vendor hawking his flowers* **(left)**. *And it means tax revenues, since the government levels a 150 percent duty on imported cars. Parts imported for assembly in Thailand are taxed at lower rates. A new Japanese car so assembled goes on display in a Bangkok department store.*


204
25
71
NISSAN


พรีเมี่ยม

(Continued from page 507) boats driven and steered by long-shafted outboard motors, so police do too."

Somchart's colleagues at the police station add their comments. Homeowners, I learn, don't dare leave houses empty for fear of burglars. A hit man can be hired for less than $1,000 per murder. Yet during the Buddhist Lent all types of crime decrease dramatically ("even criminals are Buddhists").

The night wears thin. On Phetburi Road, the Pratunam market—open all night—glares with fierce fluorescence; late shoppers fill market baskets; and in sidewalk restaurants, diners order by inspecting live crabs and sniffing caldrons.

Stars fade, the dark sky goes pallid as dawn arrives over the Chao Phraya River. Barges bob toward docks with cargoes of sacked rice. A sleepy child brushes his teeth aboard a small barrel-top boat, his home.

A rising sun gilds monks trooping from their monastery, Wat Saket, carrying their empty bowls. Close-cropped hair and eyebrows give them strangely blank expressions, even when a station wagon stops and the pious driver ladles out rice for the monks' breakfast. Morning traffic begins to fog the atmosphere. Clamorous, glamorous Bangkok starts another day.

Last year half a million of the kingdom's poor sought new jobs in the capital. "The city cannot take any more people," one cabinet minister sighs. "We should move the capital to a new site."

Most Bangkok residents have no public access to drinking water. Even while girders go up, the city sinks into its own mud—as much as a handbreadth a year. Cracks in foundations open and yawn. Rainfall—more than a meter in the five-month rainy season—engulfs streets, and merchants build dams in front of their shops. With the jackhammer sounds of three-wheeled *tuk-tuks*, traffic noise pulses like a migraine.

Whatever its discomforts, I still like Bangkok as a city of secrets. Not far from the railroad station, for example, stands a temple of ordinary exterior, Wat Trimit, containing an image of the Lord Buddha three meters high; it weighs five and a half tons—and is made of gold. Jewel merchants in simple shops may cover a desk top with a fortune in sapphires; the salesman is one of the 500,000 Thais who earn their bread by mining, cutting, and selling gemstones. And behind the watery moat of the royal palace live the royal white elephants.

"White is not the color—it means auspiciously significant elephant," a member of the royal household explains, for the animals are pinkish brown or mottled.

EVERY DOOR OPENS onto a different human story. In a quiet residential area I walk shoeless across the teak-floored parlor of His Excellency Lt. Gen. Prayoon Bhamornmontri. At age 84, General Prayoon has known and served five of the nine Chakri kings and has influenced almost as much Thai history as he has witnessed. It was in his own Paris apartment in 1926 where seven young Thai officials began planning a constitutional monarchy for their country and a coup to bring it about. "Small things light a match," says the general.

In June of 1932 their coup succeeded, and the revolutionaries rode up to the palace with tanks and guns. King Rama VII was standing on the palace steps. "He welcomed us, but he said, 'The king cannot talk to you under tanks or machine guns.' So we pulled the tanks away and presented our new constitution. The king cleaned his glasses and began to read. . . ."

And thus royal absolutism ended and a new era of Thai history began. Different army factions have run the country practically ever since. From time to time students demonstrate, and citizens vote in free elections, but the military has maintained control. "I have taken part in five coups," says General Prayoon, adding with pride, "and none with bloodshed."

Elegance walks barefoot *after a downpour floods a courtyard in Bangkok, now reported sinking several centimeters a year. With 11,000 wells pumping groundwater, the city's foundation layers of sand and clay are compacting. If nothing is done, experts say, Bangkok will drop below sea level within 20 years and tidal water from the nearby Gulf of Thailand will invade and drown it.*

And does the constitution work today? "The king makes no deviation—a very correct monarchy. Of course, I have known the present king since he was eight years old."

The kingdom of Thailand—old Siam—began in the 13th century after the Thais migrated from southeast China to a spot on the River Yom, 370 kilometers north of Bangkok. There they founded the first capital, Sukhothai, meaning "dawn of happiness."

That Sukhothai dawn lasted 130 years and still represents a kind of Camelot in Thai legend. Artisans converged there, ceramists from China, teachers from India. Architects created a soaring style of temple with stupas of lotus-bud shape. Gentle Theravada Buddhists arrived from Sri Lanka, and sculptors fashioned images of the Lord Buddha, slender, serene, seraphic. King Ramkhamhaeng the Great then devised the decorative Thai alphabet that still celebrates, in stone inscription, the glory of his time and place.

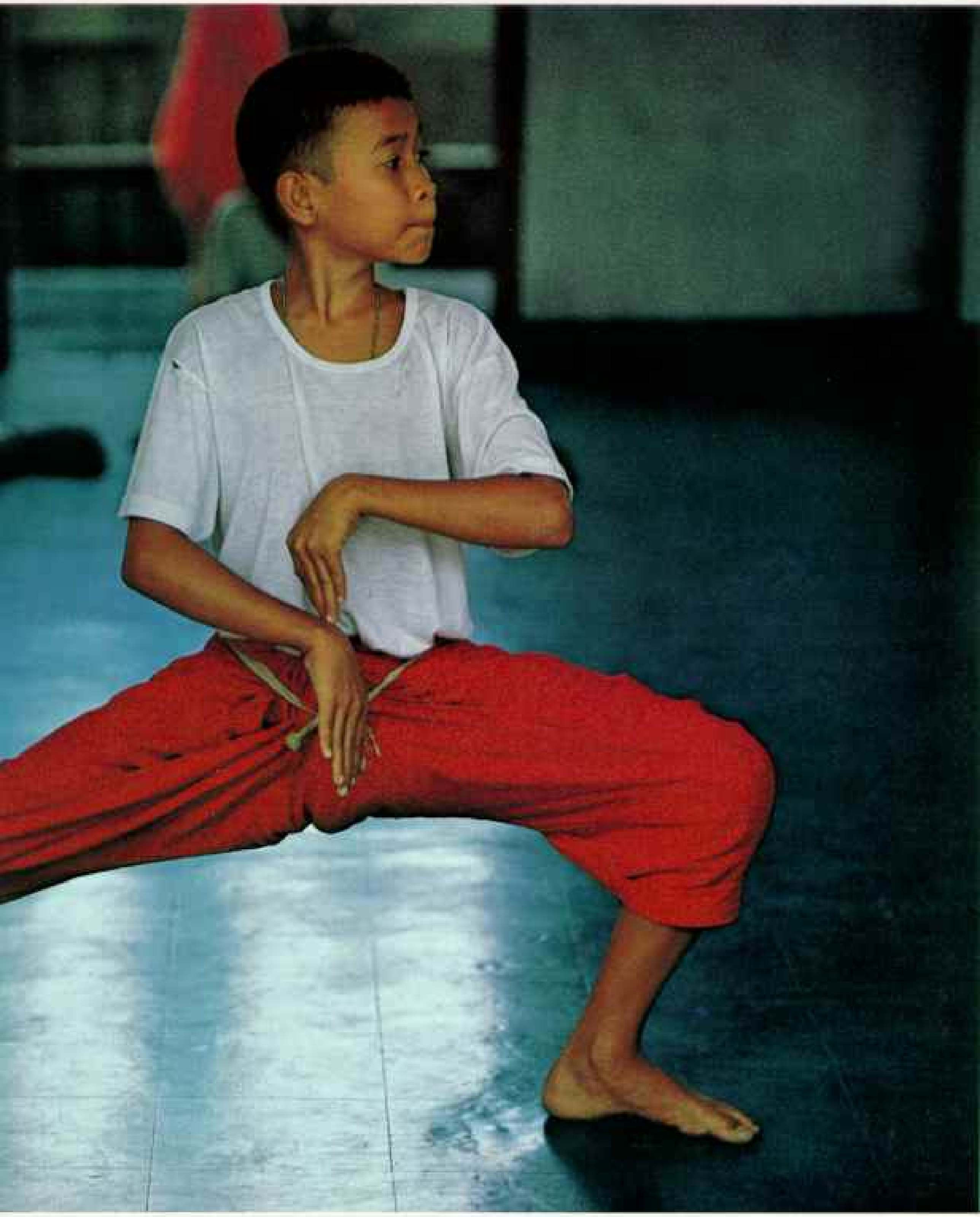
TODAY 30 monks live within the city walls, the sole residents of old Sukhothai, among some of the noblest ruins in Southeast Asia.

Archaeologist-landscaper Vira Rojpojchanarat showed me around the 126 surviving structures. With UNESCO help, the Thai Department of Fine Arts is excavating Sukhothai and restoring portions of the city. Beneath generous trees, visitors picnic in shaded clusters among the brick and stone ruins. Cheerful Buddhas sit upright once more, honored with incense, reflected in a newly restored royal pond.

With perhaps 100,000 modern Thais in this ghostly capital, I observed the festival of "Loy Krathong," a name meaning "floating the leaf cup." Under a full harvest moon in autumn, Thai families gather beside rivers and lakes to launch little boats laden with incense sticks and lighted candles. Inscriptions seven centuries old describe the way "crowds of people come to see the king light the candle and play the fireworks."

Modern Thais explain the custom variously as "apologizing to rivers for pollution" and "honoring the mother of water." Scholars find related practices in both China and India—unsurprisingly, since Thais have a tradition of importing and combining ideas.

Every little movement *has a meaning all its own, a youngster learns in studying the classical Thai dance at*



Bangkok's College of Dramatic Arts, where nearly 2,000 girls and boys are enrolled in a rigorous government-sponsored course. In this dance the boy depicts a monkey from the "Ramakien," the Thai version of the Hindu epic "Ramayana."

A motorized parade *comes with the noodles at a streetside café in Bangkok's Chinatown. Originally from China themselves, the Thais have a history of*

tolerance for Chinese immigrants, who make a living largely in commerce. Here a Mercedes-Benz, a fleet of motorbikes, and a crowded gold shop tell of their success.

Spirit houses, for instance: Thai residences and businesses have dollhouse-like shrines outdoors where flowers and bits of food are offered daily to the spirits. The practice is widespread in India. Thus Thais have added to their sincere Buddhist devotions an equally sincere belief in astrology, charms, and amulets (some called *hai-huang*, or worries-away).

A well-educated friend named Chaiyasith showed me the clanking arsenal of amulets he wore on a chain round his neck. "This one is rare, made by the hands of a most merited holy man. Millionaires pay 10,000 baht for one like it! Once during the Korean War when a Thai plane fell, the pilot was unharmed, for he wore such an amulet."

When I expressed admiration, Chaiyasith gave me a similar medal, made by another famous monk living near Three Pagodas Pass. "His name is Utama, meaning 'fortunate,'" Chaiyasith explained. "No, you must not carry it in trouser pocket—*higher*, shirt pocket or around your neck."

I put on the medal properly. And that afternoon my request was approved for interviews with His Holiness, the Supreme Patriarch of Thailand and, some days later, with His Majesty the King. Fortunate.

The Supreme Patriarch, spiritual leader for this Buddhist kingdom, receives visitors in a red-carpeted chapel of Wat Ratchabophit, near the realm's most venerated spot, the Temple of the Emerald Buddha.

His Holiness, born in 1897, seemed a man beyond the reach of time. His close-cropped hair was scarcely gray at all, his face softly creased with laugh lines. How, I asked, did the nonpolitical Buddhism of Thailand differ from the activist sort in Vietnam?

"His Majesty the King is the patron of Buddhism, defender of all religions," said His Holiness. The Supreme Patriarch cited the Vinaya, or monastic rules, and without mentioning Vietnam by name, added, "Monks in some other countries have no one to take care of them. No patrons or guides. So sometimes political actions take monks away from the Vinaya."

He spoke of mercy and his hopes that "no people would take advantage of another." Then His Holiness gave me good journalistic advice: "It is worthwhile to visit the refugee camps. *Difficult* life."

TO REACH a cluster of the camps, we drove northeast from Bangkok, traversing the heart of Asia's rice bowl. The year's second crop was almost ready for harvest. Yellowing rice plants were now collapsing with the weight of grain, turning the paddies into great tousled cowlicks. Along the Bang Pakong River, life is amphibious—oozing paddies, canoes, ducks, men with nets for seining fish, water buffalo wallowing in mud.

Farther along, the land is higher, drier, beyond the flow of irrigation. This is the province of Prachin Buri, cassava country, less prosperous. And soon we arrive at the border town of Aranyaprathet. A fading, out-of-date sign gives the distance—two miles—to the "Republic of Cambodia." It's a boomtown based on the one resource of human misery. Ministering to this need are International Red Cross doctors and nurses,

Mecca of pleasure, *Ban Phatthaya welcomes an American sailor who follows thousands of servicemen drawn here for R and R during the Vietnam War.*

United Nations officials—some 300 people from volunteer agencies—Thai soldiers, smugglers of people and treasure from Kampuchea, dealers in gold, swappers of bikes and motor scooters, gunrunners. Aranyaprathet thrives.

"The Vietnamese attacked Cambodians at two points on the border day before yesterday," a UN official told us, explaining tight security measures at Thai Army checkpoints. We drove past a low, hard mountain now denuded of trees; this is Khao-I-Dang, where a camp held 130,000 Khmer refugees two years ago; today 40,000 remain.

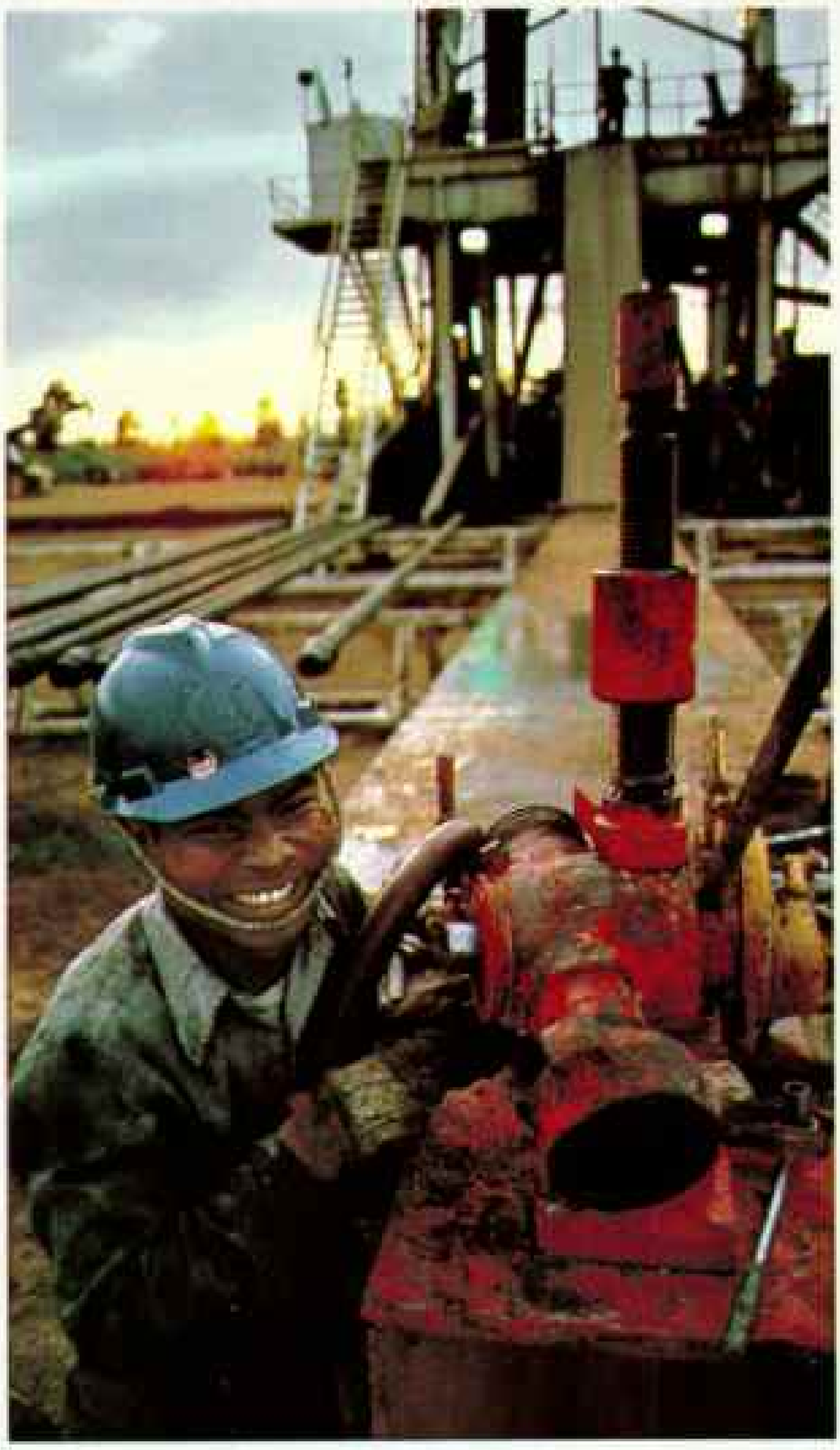
"To discourage other refugees from coming," one responsible Thai official told me, "we have designed holding camps that are decent but unattractive." Diets are monotonous and bare: 400 grams of rice a day, dried fish, and beans.

On the north horizon rose hills of the Khorat Plateau. A checkpoint sentry with an M-16 smiled and waved us on with, apparently, his total English vocabulary: "OK, bye-bye." We pulled into the camp of Ban Sangae. Temporary buildings were landscaped with flower beds and young banana plants. A naked toddler greeted us shyly; he wore only a tag reading "supplementary feeding."

"We have more than 13,000 people here now," explained Pol Ham, a local leader in the camp. "The females get three food rations each." Adult males get no food or direct help from UNICEF, since they often serve as resistance fighters and since UNICEF chiefly serves children. But women share food with their families. The military camp is half a kilometer away, well beyond the Thai-Kampuchean frontier.

Ban Sangae is a showcase camp, though the Vietnamese shelled it heavily in 1980.

Monument to misery, *the bridge over the River Kwai near Kanchanaburi appears under fire during a show simulating its bombing by the Allies during World War II. Then, 16,000 prisoners of the Japanese, and perhaps 100,000 Asian laborers, died building the bridge and the "death railway" that crossed it.*



Probing for pay dirt, *a Thai roughneck* ***(above)*** *works on an Esso rig drilling for oil in the scrubby northeast near Khon Kaen. Although natural gas was discovered here last year, no one yet knows if reserves will be developed commercially. Gas wells in the Gulf of Thailand, however, have recently gone into production—good news for a nation whose energy imports eat 40 percent of export earnings.*

Another kind of pay dirt, gemstones come from the mines near Chanthaburi and from smugglers crossing the borders of Kampuchea and Burma. Rubies ***(right)****, along with blue and black star sapphires, are offered at Chanthaburi's market to dealers from Bangkok, a major gem-cutting center.*

Like ponderous dancers, *elephants near Chiang Mai* ***(above)*** *lift legs in unison to show how they have been trained to roll logs in harvesting teak. But their days on such jobs may be numbered, since continued cutting could wipe out Thailand's hardwoods in a decade, some experts warn.*

Chin Sophonpanich ***(right)*** *parlayed his job as a coolie into one of Southeast Asia's largest business empires. As a founder and now chairman of the Bangkok Bank, he has investments in shipping, rice, and insurance.*

"At least it was not as bad as Non Mak Mun camp," said Pol Ham. "The Vietnamese Army invaded and occupied the camp for two days, then took some men back to Communist Kampuchea. Maybe a hundred of our people died, and 23 Thai soldiers. I saw bodies along the canals."

"In the forest we still exchange fire with the Vietnamese almost every night," said Gen. Dien Del of the moderate Khmer resistance group called KPNLF.

Along this border I visited other camps and settlements. In one I watched a surgeon treat a Khmer warrior who had lost a foot in a nearby minefield. Generally, though, I was impressed with the flexibility of the border and the easy way some people crossed it in both directions.

But not all people. "The last ten kilometers before the frontier were the worst," a 22-year-old Vietnamese Army deserter told me. "Our guide left us. We had paid him two taels of gold, but he vanished. Communist soldiers stole the few valuables we had."

THE NORTHEAST BORDER is harder to cross; the formidable Mekong River here separates Thailand from Communist Laos. At Chiang Saen, on the banks of the Mekong, I ate *pla taw*, a tender Mekong fish, in a riverside restaurant. "You can walk across the river here in dry season," said Col. Sawn Phongchawee, our police escort. Just now, after heavy rains, the Mekong was a good ten meters deep and perhaps 1,000 meters across.

Sea's boon to flavor, *salt rises in white mounds as harvesters work diked fields flooded with ocean water, which then evaporates in the sun. Extensive areas of the coast go to salt farming, productive during the November to May dry season. Crude windmills pump the seawater into ponds where crystallization takes place over a 10- to 30-day period.*

Upstream, where the Ruak River flows into the Mekong, three countries meet—Burma, Laos, and Thailand—within the Golden Triangle, opium center of the Far East. Bodyguards accompany us, for an opium warlord might mistake us for agents of the U. S. Drug Enforcement Administration; his army might kill us by regrettable mistake. A Thai journalist disappeared in these hills not long ago, murdered, some feared, by Shan opium traders. Twenty-six other journalists have met violent death in Thailand during recent years.

Our young Border Patrol Police hold guns at the ready. "Twenty of our own men were killed last year," the colonel observes. "But most were killed by Communists. . . .

"You've heard of Khun Sa?" our Thai friend asks. I have. His reputation is huge: By blood half Shan and half Chinese, Khun Sa is a warlord with a well-equipped 3,000-man army. He rules large portions of bordering Burma, say the gossips, enters Thailand at will, and controls most of the opium trade: 500 to 600 tons from Burma and perhaps 60 tons from Thailand. High stakes: an estimated traffic of billions of dollars. The *Bangkok Post* calls Khun Sa "the drug kingpin." ("But 60 percent of the opium comes from Burma and 25 percent from Laos," insists the colonel.)

Though our bodyguards watch closely, we see no sign of Khun Sa or his soldiers. In pickup trucks we view the countryside, climbing steep Doi Tung, a pagoda-crowned mountain revered for meditation. The forested slopes and valleys are as green as smuggled Burmese jade. Villages show Thailand's ethnic variety: This is hill-tribe country. Baca, a village of bamboo huts, is settled by the Akha tribe. Rice dries on reed mats ("high-quality rice—one crop a year"). Men chew betel, and women wear colorful headpieces adorned with coins—one, I notice, bears the profile of Queen Victoria.

In rural communities, the Border Patrol Police recruit informers to keep tabs on drug traffickers. But the patrol has also built nearly 200 schools for villagers. "It helps us keep friends," says the colonel.

All their work isn't friendly. Lt. Bai Simaphon recalls raiding a heroin refinery just 700 meters from the Burmese border: "Of course, a spy had reported on the location. We were 60 men, divided into three groups.

"We went by helicopter partway and walked in quietly. Heavy forest. When we were a hundred meters from their sentry, fighting broke out. They had 20 men firing at us. The engagement lasted 15 minutes, then they stopped firing and escaped across a stream into Burma. My men were not wounded, but we found the refiners had a machine gun and an M-72 rocket launcher —fortunately, no time to use them."

The colonel adds his appreciation. "The refiners had cut enough firewood to last six months. This was probably the largest heroin refinery in the country."

PEOPLE WAGE a different kind of anti-drug campaign north of Thailand's second city, Chiang Mai (pages 534-5). To reach the Hmong tribal village of Buak Chan, we climbed by four-wheel drive over a jolting trail with slimy ruts. This road is fairly new, terrible, and a godsend; before it was built, villagers had no way to bring produce to market. "Raw opium, of course, is portable and not perishable—you can keep it for years. It's a high-value, low-volume crop," said Richard Mann, UN administrator for a crop-substitution program. A farmer could make the equivalent of $2,500 an acre raising opium poppies. "But opium is a lot of work," Dick Mann explained.

The village of Buak Chan—54 Hmong families—sits in a trough among hills; its wooden houses have steep roofs to turn heavy rain.

"Four years ago they were planting opium poppies all over this hill," Dick said. "Now they raise only those poppies you see—all for local medical use."

We went to the headman's house, a place spacious but spare; on the porch, beneath caged parakeets, a woman was sewing on her treadle sewing machine, a sign of new prosperity. The headman, Yang Seu, greeted us; his features are strongly Chinese—unsurprisingly, since this community of Hmong emigrated from south China in the last century. Yang Seu himself speaks Yunnan-Chinese and Karen, in addition to Thai and his native Hmong. Hill tribes are not hillbillies.

Trailed by three of his sons, Yang escorted us on steep paths to his fields of kidney

Life-supporting bounty *of rice, here being sacked in a Bangkok mill (**above**), has fueled Thailand's progress and fed the hungry of Asia and Africa. The nation's last rice harvest—14 million tons—amounted to 18 percent of annual export earnings and accounted for 11 percent of the gross national product. Sacks of rice (**right**) being loaded on a barge at Bangkok, for example, are part of an 11,000-ton shipment to the Ivory Coast.*

Yet Thailand has one of the lowest rice yields per acre in Asia. In the past Thai farmers increased production mostly by clearing new land from jungle. To spare the forests, the government now encourages more intensive cultivation of cleared land by irrigation and improved farming methods.

beans, potatoes, and corn. "This was once all opium," Dick Mann recalled.

Walking briskly, Yang explained the use of homegrown opium: "We use for pains of childbirth and for stomach problems." Like paregoric.

"This corn matures a month earlier," our host continued, "so we can raise another crop." Laughter crinkled his Mongolian eyes. "Our income is now one-third greater than with opium."

Opium poppies thrive at elevations between 1,000 and 1,500 meters, and the northern Thai hills provide this limited range. "I've seen opium buyers come by horse and motorbike," said Dick Mann. Roads and new crops make the difference; so the governments of the Federal Republic of Germany, Australia, Japan, Canada, the U. S., and the U.K., and organizations like the Church of Norway as well as the UN are joining the Thais in this crop-substitution project. They give credit, seeds, and expert advice. Coffee is a lucrative alternative to opium. So are fruits, mushrooms, flowers, and flower seeds—Thailand now even exports tulip bulbs to the Netherlands.

These projects are working in 60 villages.

Out of the stuff *of dreams, limestone peaks thrust above Phangnga Bay: their fantastic shapes, the work of erosion; their veils of greenery, the legacy of rock-clinging trees. The region was a setting for the James Bond thriller "The Man With the Golden Gun."*

In predawn darkness on Phuket Island, a tapper cuts a rubber tree, starting the flow of latex into a waiting cup. The lucrative stream dwindles with the heat of the day.

Perhaps 250 other mountain villages still raise opium.

"If we moved police in and cut down all the opium plants," one high Thai official told me, "we would instantly turn those people into guerrilla insurgents. They must have some way to earn a living."

But along with the carrot, there has to be a stick. Last year, in a Hmong village northwest of Chiang Mai, after crop substitutions had begun, police made a token raid and destroyed about an acre of poppies. Days later, when project advisers tried to visit that community, they found logs across the road in 14 places. Each had a note in rustic Thai: "We want no more foreigners in our village."

CHANGE must come gradually, even with an industry like tourism. The governor of the Tourism Authority of Thailand, Col. Somchai Hiranyakit, analyzes one problem: "A few years ago we found Japanese wives did not want their husbands to come here. A bad image. So we invited Japanese lady magazine editors to come as our guests; we brought 600 Japanese women at low air fares. They visited Chiang Mai, saw hill tribes and arts of the people. They

bought silks and wood carvings—saw another side of Thailand. Now Japanese come for honeymoons. They photograph temples and elephants. Japanese are our prime overseas market for tourists."

THAILAND is still a tourist bargain and the scenery spectacular. What could exceed the beauty of Chiang Mai with its crumbling 700-year-old city walls and a moat full of red lotus blossoms? Well, perhaps the women. "The most beautiful women in Thailand," notes cinema producer Chalong Pakdivijit, "come from Chiang Mai." Lovelier than lotus.

In the south near Phuket, steep islands leap from the sea like flying fish. But can those limpid waters survive the pollution of expanding tin mines? And can the Thai tourist industry long survive the world's highest, most cumbersome hotel taxes? "We pay 12 different rates of taxes," a hotelman confided. "From 3 percent to 16.5 percent. Laundry and dry cleaning have different rates. Bookkeeping is terrible."

I am at least certain of Thailand's greatest tourist resource: the friendly Thai people and the famous Thai smile. A visiting American anthropologist notes that "the Thai smile is a warm, soft expression—as much with the eyes as with the lips."

Strangers passing on the street smile at each other. It's the first response. But, oddly, Thai boxers smile at each other before kicking each other on the chin. Why? "Maybe they're friends," a former Thai boxer told me. "Or maybe the smile is saying, 'See—you do not frighten me; I am confident.'" Others remind me that Thais avoid confrontations or any display of anger. They recall a favorite saying in the musical, five-toned Thai tongue: "*Jai yen yen*—literally, heart cool cool, or keep your cool."

Thais also smile at inconvenient laws—and thus make possible the tourist business on that elephant-trunk peninsula in the south. Typical is Hat Yai, a pleasantly modern city of 75,000 population without much local color. Yet each year 400,000 Malaysians come here by bus, train, and plane to shop. "Some products are legal," a local merchant admitted. "But these digital watches and tape recorders are smuggled in; they're cheaper here in Hat Yai than in the countries where they are made." His prices prove the point.

For all the tourist boom, southern Thais have their worries. Communist insurgents and Muslim separatists raid trains and rob trucks. "We face three groups of terrorists—perhaps a total of 3,000 people," police Lt. Kamron Liyawanich told me in Songkhla. "But fewer than in recent years."

Offshore pirate boats ply the waters of the Gulf of Thailand. But who are the pirates? "When their nets are in the water, they're fishermen," one foreign observer told me. "And when the nets are up, they're pirates." Not exactly.

"Honest Thai fishermen have also been robbed by pirates," a Thai friend insisted. "And the pirates are not just Thais—they come from other countries too." No doubt. The overfished gulf washes many impoverished shores.

Whatever their nationalities, gulf pirates are a tough bunch of cutthroats. A Roman Catholic priest, who prefers anonymity, was working with Vietnamese boat people and other refugees on the coast near Songkhla.

"One boat recently landed right in front of my bungalow," said the priest. "Eight refugees—seven men and one woman, all of them stabbed but still alive. We had to carry them to camp.

"There had been 44 people when that boat left Vietnam. Pirates hit them—robbed them of everything, even took the engine of their boat. Usually pirates rape the women, and then two or three weeks later drop them off on land. This time, though, the pirates stabbed all 44 people, rammed the boat, and left it to sink. But some of the wounded were able to bail it out, and they reached land."

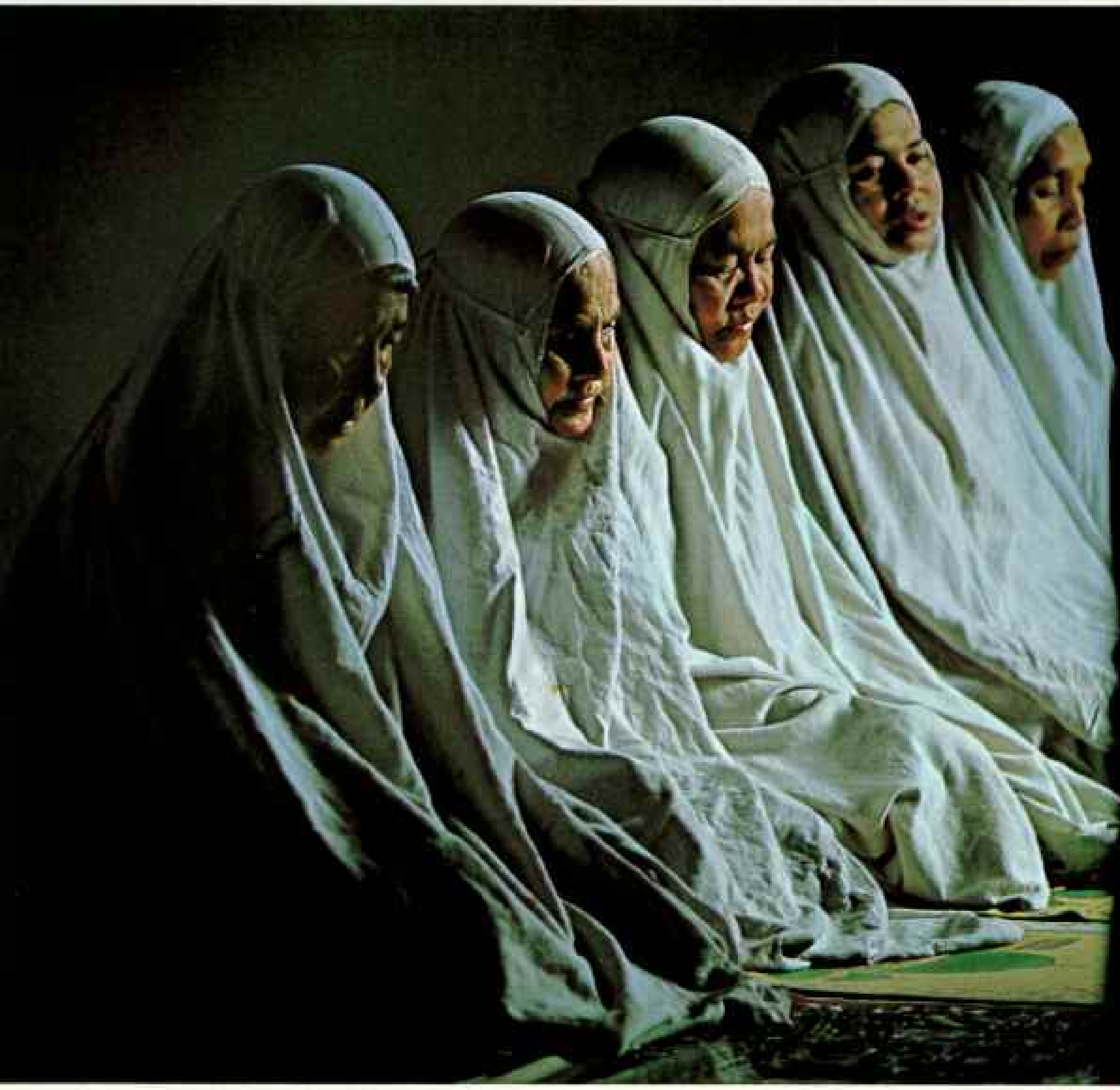
Fewer reach land these days, and fewer boats are sailing from Vietnam. Pirates no doubt are a deterrent. I strolled along the Songkhla waterfront after a storm. About 20 boats had been lost at sea. Now nets were drying, and fisher families were repairing the battered craft. These waters were dangerous, life was hard—and sometimes cheap. By definition, survivors are tough.

THE POOREST PART of Thailand is the northeast, where U. S. servicemen spent off-duty time and money during the Vietnam War.

The old U. S. Air Force base at Udon Thani has long been officially abandoned. And though Udon Thani has a VFW post of a few retired Americans, the Vietnam War seems as dim and rusty as the local sign reading Club B-29.

Still, 112 scrubby kilometers south lies Khon Kaen, a boomtown with a newer American presence—or at least a Western presence. This is oil-exploration country with a heady whiff of frontier. Oilmen wear tattoos and diamond rings and drawl the latest gossip about massage parlor shoot-outs. (With a population of 85,000, Khon Kaen can have a dozen murders a month.)

Both Esso and Phillips have people exploring northeast Thailand. It was from here that Communist guerrillas launched their low-grade war against the central government in 1965. The insurgents appealed to



Call to prayer *brings white-robed Muslim women to their mosque at Koh Panyi, a fishing village built on stilts in Phangnga Bay. Nearly 75 percent of the people in Thailand's southern tip profess the Islamic faith, and a separatist movement persists with bands of extremists terrorizing the countryside.*

Piteous procession *of the homeless, Kampuchean women with babes in arms or underfoot carry bags of rice at the Nong Chan refugee camp on the Thai-Kampuchean border. Some 40,000 lined up for the food, distributed by UNICEF; they will probably share it with their men, denied rations since many are part of a force fighting the Vietnamese occupying their country.*

*Besides the burden of caring for refugees, Thailand contends with Communist insurgents in the countryside. A soldier escorts a French visitor near Chiang Rai (**right**).*

honest grievances, for a citizen here earns only a small fraction of what one makes in Bangkok. Now there's a chance the northeast will strike it rich. Drillers have found gas beneath this brushy, eroded earth, and even oil to the west, though large-scale development is still years away.

Meanwhile, people are wary; Communist Laos is nearby. "If you spend 24 hours on this oil rig," says one American oil worker, "you're sure to hear gunfire."

I do not suggest the Laotians might invade soon or ever. Relations seem to be thawing between the two countries. Thailand even buys Laotian electricity, some 750 million kwh annually, generated by a

tributary of the Mekong River. "If we could ever find a way to develop the Mekong jointly with our neighbors," a Thai engineer mused, "we could solve a lot of our energy problems."

Oil accounts for almost a third of all imports, contributing to a three-billion-dollar trade deficit and generating most of the country's electric power. Last year only 17 percent came from hydro installations.

"Our main rivers are almost all developed," notes Swarng Champa, superintendent of the project for the new, 140-meter-high Srinagarind Dam, on the Mae Klong (Kwai) River, soon to be the largest single source of Thai hydroelectricity. "In the province of Tak there is still a *dream* of a site for a dam. But it's in a sensitive area." He refers to Communist guerrillas; Communist headquarters are rumored to be in the forests of Tak. And roadblocks of Thai soldiers on the highway confirm the sensitivity.

The hope for Thailand's immediate energy future lies in the south, where a new gas pipeline stretches 400 underwater kilometers beneath the Gulf of Thailand to gas fields of unusual promise. Union Oil of California has proved gas reserves here of more than 30 billion cubic meters. Texas Pacific has proved others.

We flew by Sikorsky S-76 helicopter out to a sturdy platform far from sight of land.

As the wheel turns, *coffee beans separate from the chaff at a Hmong village near Chiang Mai—a hopeful portent of a better future for a people long dependent on opium for a living. The Thai royal family, the UN, and several nations, including the U. S., have joined in crop-replacement programs here in the Golden Triangle. But the area remains a prime source of the drug, as a Black Lahu woman harvesting opium poppies verifies* (**left**). *One of a number of major tribes in the north known as the hill people—an estimated half million strong—the Black Lahu have arrived from Burma and Laos in recent decades. This youngster* (**right**), *casually bare bottomed, consults mother.*

Winds were rising, the sky was gray, and the radio shack crackled with weather reports about an approaching storm. This was LQ (Living Quarters) Station, hotel for 122 workers, though a kind of county seat for some 450 other men working on neighboring platforms and drilling rigs.

Gas production was already well under way. Eventually as much as 50 percent of Thailand's electricity will be generated from this gas.

"We've found abnormal temperatures—370°F [188°C] at the bottom of the hole," said production superintendent Les Boyer, an Oklahoman. "And the gas is about 15 percent carbon dioxide, which can cause corrosion. But boy, do we have gas!"

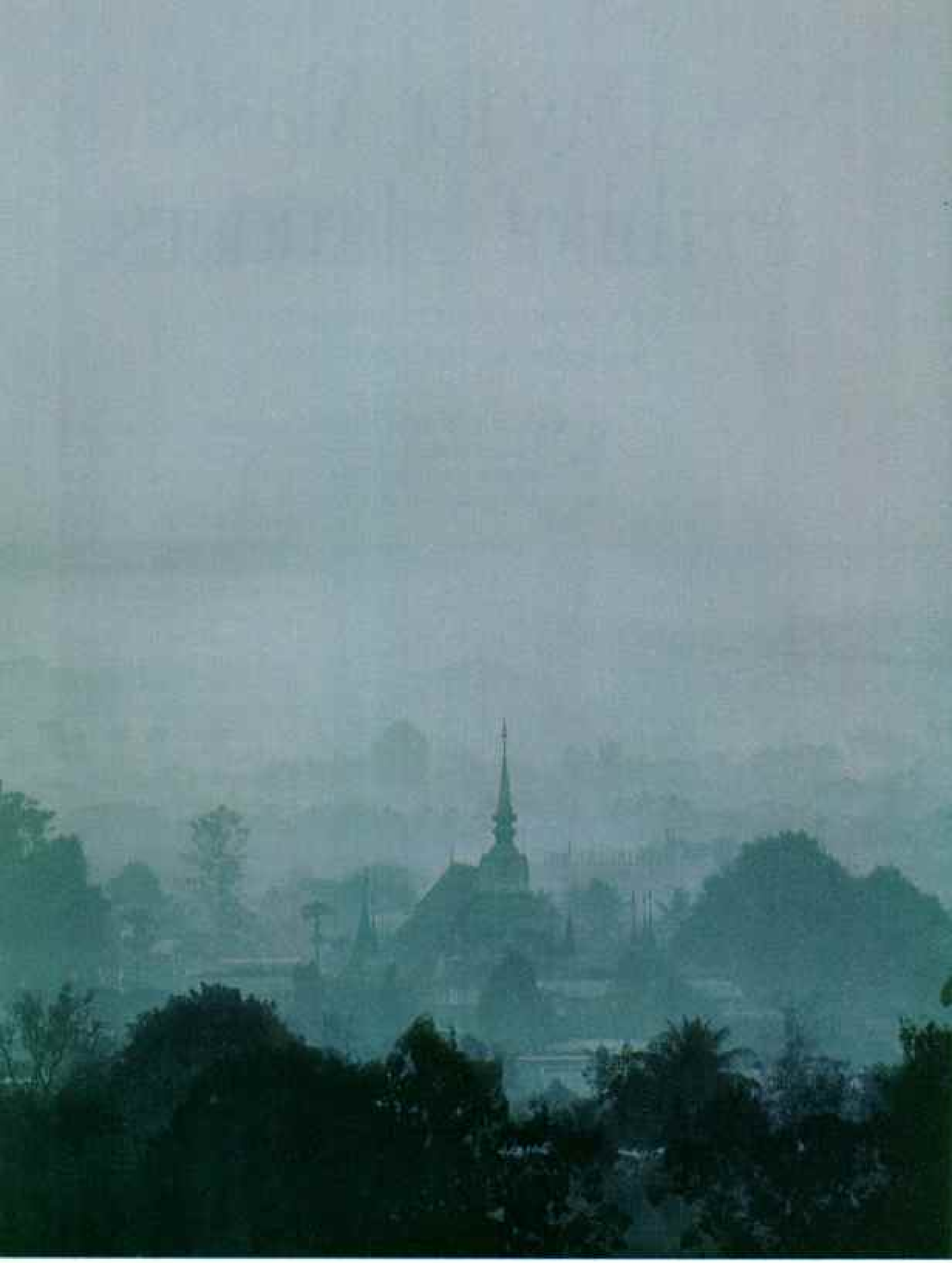
LQ Station, anchored against storms by pilings 100 meters into the seafloor, has four levels of living space, with a heliport on top. Nine evaporators turn seawater into fresh. And LQ offers beds, an exercise room with Ping-Pong and pool tables, one-hour laundry service ("there's nobody here who doesn't get dirty"), and a spirit house ("but no incense—it sets off our smoke detector"). Food is plentiful and good.

In the mess hall, talk buzzes in the languages of Babel. Ramadan alters the meal schedule for the Muslim Thais, who speak a Malay dialect. A 22-year-old busboy named Afisad has no eyebrows: He has just completed his duty as a Buddhist monk. But whatever the backgrounds, the working language is English: "For safety—if we say, 'Watch out,' people have got to duck. Our training program is good." And how do Thais compare with other Southeast Asian workers? "Better! Thais are the cream of the crop. As we train Thais, they take over."

SO THEY DO. For in spite of Thailand's problems, Thai energy—both human and mineral—portends a better future for this remarkable front-line Southeast Asian nation. I recall some 700-year-old words carved into the stone of old Sukhothai; they seem both past and prologue:

"Sukhothai is thriving. In the water there are fish; in the fields there is rice. The king does not tax his people. . . . Whoever wants to trade in gold and silver, trades. . . . Whoever wants to laugh, does so; whoever wants to sing, does so." □

Rose of the North, *Chiang Mai drowses on a summer's morn. As a thriving center for handicrafts—wood*



carving and paper umbrellas, silver and lacquer ware, silk and cotton weaving, and ceramics—this city does much to sustain the nation's cultural heritage, helping to maintain balance during a thrust for progress.

New Day for Alaska's Pribilof Islanders

By SUSAN HACKLEY JOHNSON
Photographs by TIM THOMPSON

FAR OUT IN THE BERING SEA on St. Paul, a rugged volcanic island, Larry Merculieff starts his Datsun pickup, waves good-bye to his wife and daughters, and drives half a mile to his office. He is an overworked, chain-smoking, 32-year-old college graduate, whose soft voice and easygoing manner belie the anxiety he is feeling these days.

As president of Tanadgusix (Our Land), which is St. Paul's native-owned profit-making corporation, Larry handles the business interests of St. Paul, and he is the best hope his people have of averting financial, social, and cultural disaster. Today not only St. Paul's sealing industry is under fire as a cruel and outmoded practice, but also the federal government, which operates the industry, is proposing to relieve its own budget problems by reducing financial support to the island.

***Steep-cliffed** St. George, one of five Pribilof Islands, rises from the Bering Sea (**above**). Isolated islanders face cuts in federal support and opposition to their sealskin industry—issues that raise a question: Is there a future here for Aleut natives such as St. Paul mayor John R. Merculief, Piama, his wife, and their children (**facing page**)?*

"The fur seal harvest has protected our culture and the island habitat. It is our economic mainstay," Larry said.

Larry is one of 550 Aleuts who live on St. Paul, which with 44 square miles is the largest of Alaska's five tiny Pribilof Islands. The Pribilofs are anchored in isolation 200 miles north of the Aleutian chain, 300 miles from mainland Alaska, 500 miles from Siberia; only one other in the group—St. George, 40 miles to the southeast—is inhabited (map, page 539).

When I first journeyed to St. Paul, it was late summer. The rocky beaches swarmed with life: countless seals shuffling about on rubbery flippers. It sounded and smelled like a barnyard metropolis. Some seals left the beaches to plunge into the dark sea. Soon all would be migrating south.

Nearly a million northern fur seals—70 percent of the world's total and the world's largest gathering of marine mammals—congregate every spring at Pribilof rookeries to breed and bear young, hauling up on the very beaches where they were born.

In 1786 Russian explorer Gerassim Pribylov, seeking a new source of furs, discovered the then uninhabited islands that now bear his name. To harvest the seal pelts, the Russians imported enforced native labor from the Aleutians, and most Pribilof people descend from these first reluctant settlers.

The United States took over management of the Pribilofs and their fur seals when it purchased Alaska from Russia in 1867. In recent years about 24,000 seals have been taken annually in a five-week summer season controlled by the U. S. National Marine Fisheries Service. Aleuts harvest and clean the skins. The government pays most of the bills for maintaining the Pribilof villages.

"St. Paul is a company town," said Maxim Lestenkof, the alcoholism counselor there, "and Uncle Sam owns the company."

Uncle Sam's "ownership" and support of the sealing industry have not safeguarded St. Paul's sealers from controversy. On one opening day of the sealing season, TV newscasters, film crews, reporters, photographers, a congressman, members of animal protection groups, a movie actor, biologists—all alighted on the Pribilofs to observe, record, denounce, or sanction.

Fur seals migrate through the waters of Canada, Japan, the United States, and the Soviet Union. The Interim Convention on Conservation of North Pacific Fur Seals, a treaty signed by these four countries, outlaws pelagic sealing but permits the U. S. and Soviet Union to harvest seals on islands in their possession. In exchange for not participating in open-water harvesting, both Canada and Japan receive from each of the others a 15 percent share of the furs. The treaty will be up for renewal in 1984.

Five a.m., and we could hear the seals long before we could see them through the morning fog. Only young males are taken, a plan with which nature seems to cooperate, because the nonbreeding bachelors gather in the periphery of the rookery.

Herders drove the young bulls inland, shooing away stray females and any males longer than the allowed maximum of 47 inches. Stunners, awaiting the bachelors at the killing ground, struck them with long hickory clubs, knocking the selects unconscious or killing them outright.

The stickers followed, severing each seal's thorax and puncturing its heart. Then came the rippers, who cut the skin around the belly and flippers, and the pullers, who peeled off the steaming pelts with heavy tongs. A skilled crew can stun, kill, and skin a seal in about one minute (pages 544-5).

After villagers take the meat they want—flippers, heart, and liver preferred—Tanadgusix tries to sell the carcasses for crab bait and sled dog food.

Tanadgusix also pays for each male sex organ collected. These "seal stix," when processed, find a ready market among Orientals, who consider them aphrodisiacs.

Seal Hunting: Necessary or Senseless?

To some observers the morning's work was the harvest of a renewable resource. Others would claim they had just witnessed a senseless slaughter. I felt sadness watching seals die, but I also felt concern for the Aleut people. What would become of them if sealing were outlawed on their islands?

Banning sealing would deprive Aleuts, 80 percent unemployed, of essential income. One sealing opponent, Jowanda Shelton, formerly of the Committee for Humane Legislation, proposed paying the Aleuts until they could find an alternative to sealing.

Mike Zacharof, a feisty St. Paul Aleut who represents the Aleuts on the North Pacific Fur Seal Commission, didn't like that idea. "It would be welfare, and we don't want it."

"Then why not make the islands a wildlife sanctuary and employ your people to guard the seals?" suggested Alice Herrington, president of the New York-based Friends of Animals, Inc. "You have the potential here for a fine summer resort."

"Being game wardens won't provide 80 different jobs as sealing does now," Mike replied. "Already nearly a thousand outsiders

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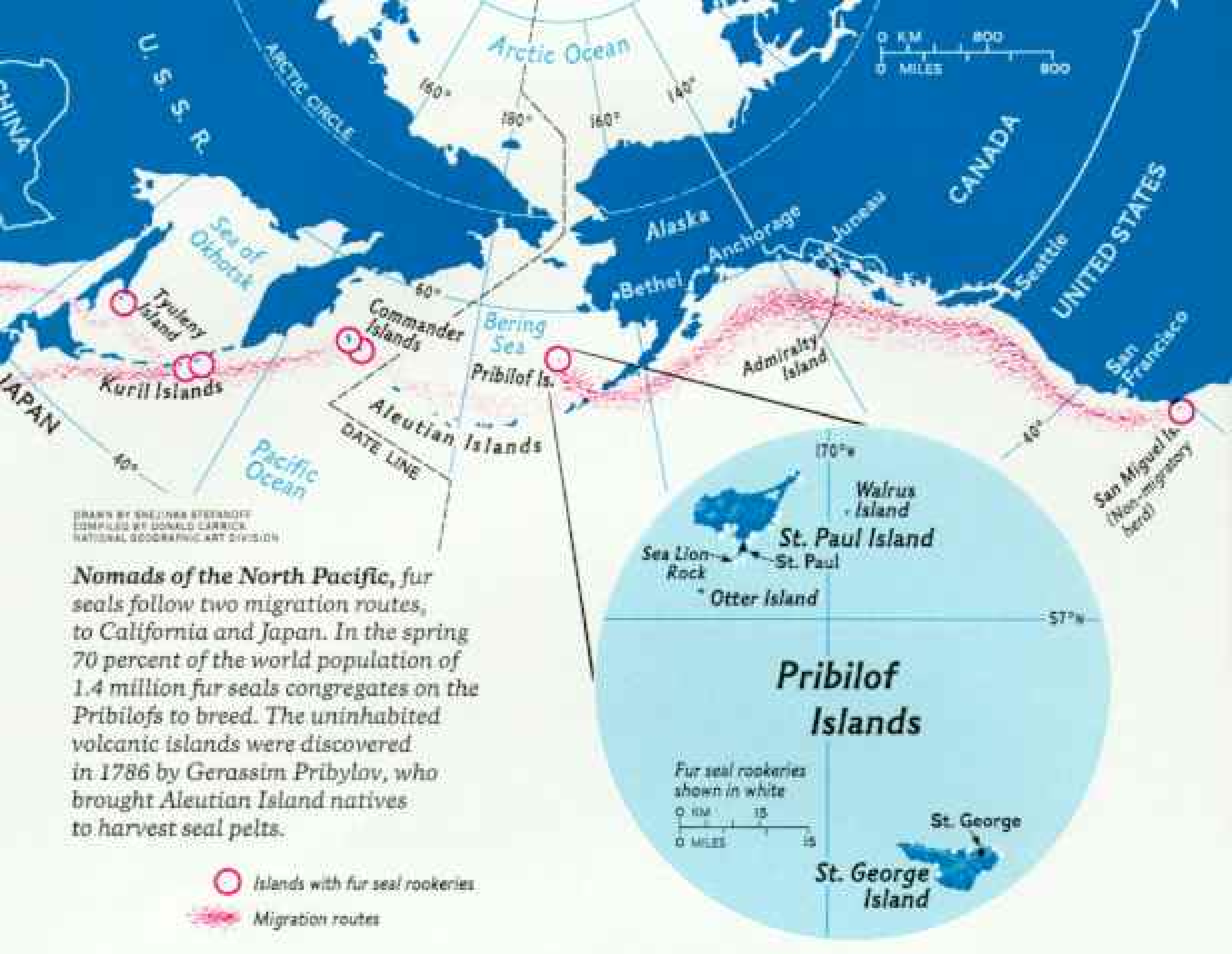
Susan Hackley Johnson, a free-lance writer and photographer, settled in Alaska ten years ago and now lives in an isolated mountain cabin 20 miles from Anchorage with her husband and youngson. **Tim Thompson,** a free-lance photographer, lives on Bainbridge Island, Washington.



DRAWN BY SHELVIA STEWART
COMPILED BY DONALD CARRICK
NATIONAL GEOGRAPHIC ART DIVISION

Nomads of the North Pacific, *fur seals follow two migration routes, to California and Japan. In the spring 70 percent of the world population of 1.4 million fur seals congregates on the Pribilofs to breed. The uninhabited volcanic islands were discovered in 1786 by Gerassim Pribylov, who brought Aleutian Island natives to harvest seal pelts.*

Islands with fur seal rookeries

Migration routes

visit St. Paul each summer. There's a limit to how many the island can handle."

The "humaniacs," as some Aleuts call the preservationists, concede that seals die most quickly and with the least trauma when killed by stunning and sticking. But they object to the harvest on grounds of unnecessary killing and the high cost to the government of the Pribilof program. The federal government spends 5.3 million dollars a year—75 percent of Pribilof income.

Walter Kirkness, director of the Pribilof Islands Program for the National Marine Fisheries Service, offers a rebuttal. "If we halt sealing, it would lead to abrogation of the treaty. As a result, we could easily see the return of free-for-all slaughter of seals at sea without any international controls at all. That would be devastating to the seals."

Mike Zacharof had an even more basic objection: "Instead of worrying about seals, which are in no danger of extinction, why not worry about an honest-to-goodness endangered species—the Aleut people?"

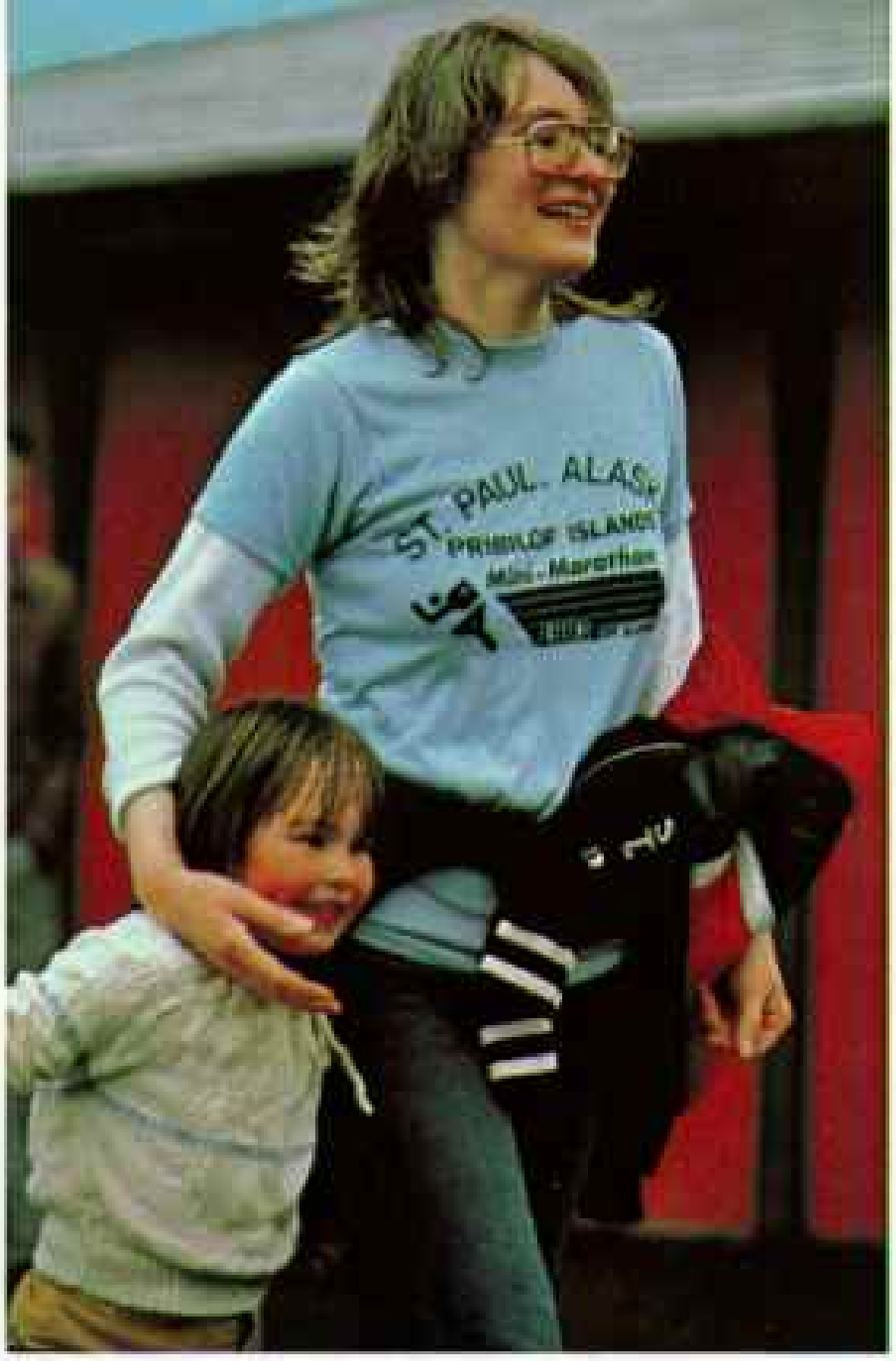
Since the Russians first gained sway over Alaska, Aleuts have decreased from an estimated 20,000 to a mere 3,200. White man's diseases wiped out many. So did a Russian disregard for native lives.

Under U. S. administration, a repressive bureaucracy brought little progress until, in 1971, the federal government settled aboriginal claims for land and compensation and gave Alaska's Aleuts, Eskimos, and Indians a means to control their lot. The settlement established profit-making corporations for each native village and region, with every villager a shareholder. For St. Paul's Tanadgusix, the chief profit makers are hotels and a restaurant.

Islanders won a reprieve for sealing when Congress extended the fur seal treaty through 1984. They were helped by the Sierra Club and National Audubon Society, which supported the treaty and looked upon it as a hallmark of wildlife conservation and management.

But a new threat to the islanders' economic well-being has suddenly loomed.

"It's called Reaganomics," said Agafon



On a lofty vigil, *rifle-bearing Aleuts* ***(facing page)*** *scan the waters off St. Paul for sea lions. Such hunting is supplemental for breadwinners of the only inhabited islands, St. George and St. Paul, the majority of whom earn their living from the annual fur seal harvest. Since income from the harvest can't support the islands' 700 residents, the U. S. government subsidizes the economy. Mindful of the Reagan Administration's plan to phase out the payments, Pribilof leaders press for development of commercial fishing and other self-sustaining enterprises.*

On the play side, Phyllis Merculieff and daughter Leatha ***(left)*** *walk after completing most of the course in a three-mile "mini-marathon." A sack race at St. Paul School* ***(below)*** *enlivens the Fourth of July holiday. Formal education extends through the tenth grade. Although islanders are entitled to their own high school, parents prefer to send their children to school on mainland Alaska to give them the experience of living off the islands.*

Krukoff, a St. Paul man who left the island to become president of the Aleut Corporation, the regional group that represents all Aleuts. "The government provides 75 percent of the employment on the islands, in sealing and public services. Because of proposed federal budget cutbacks, this support may be withdrawn within two to four years. Our people are scared."

No one knows what lies ahead, but not all regard the federal withdrawal as bad news. "It's a godsend," claimed Victor Lekanof, St. Paul's tribal officer. "If we have a lot of help during the transition, we can take care of ourselves."

Alaska may help out, although it is faced with plummeting oil revenue and budget rollbacks of its own. The Aleuts, under federal regulations, may assume management of the seal harvest, but to do so would require a heavy capital investment, which seems risky considering the uncertain long-term future of the fur seal treaty.

Most St. Paul people are pinning their hopes on their own village corporation and its president. "We can develop a world-class ocean fishery right here," Larry Merculieff said. "One fisheries expert described the Pribilofs as the only aircraft carrier in the middle of a strategic war zone—we're centrally located in one of the world's richest bottom-fishing grounds.

"But if we don't control development, it could mean destruction of village life. Big-time fishing would create more jobs, but it could bring in 1,500 or more transients—

and triple our present population. We could even lose control of our local government.

"We have two 24-foot fishing boats and plans to build a moderate-size harbor and facilities to handle crab, halibut, and other seafood. But it will take a generation till we have a cadre of knowledgeable fishermen."

New Bureaucracy, Old Problems

It has been more than a generation since islanders have allowed themselves to be this hopeful. When the United States took over from the Russians, hardships continued.

Government-provided houses were crowded and drafty. Officials from outside were not permitted to socialize with natives. Aleuts could not attend school beyond sixth grade. They were paid in store credit instead of in cash, which prevented travel and discretionary spending. There was no way to bargain for better conditions: If you complained, you could lose your job, and the government was the only employer.

Gabriel Stepetin, now in his 70s, has always been an Aleut spokesman. He remembers those days: "If I'd never left St. Paul, I would hate the white man today. I got over my bitterness when I went away and met good people."

When Japan invaded the Aleutians in World War II, the government evacuated the people on the Pribilofs on short notice.

"They told us to get ready immediately and take only one bag with us," St. George housewife Anfesia Galanin recalled. "So people put on *(Continued on page 548)*

Glowing streetlight *etches the silhouette of a lone pedestrian as summer fog envelops the village of St. Paul* ***(left)****. Though the islands lie at about the same latitude as Moscow, residents enjoy relatively moderate weather year round, thanks to prevailing ocean currents from the south. Come winter, the fog gives way to high winds, and ice floes dot the sea. To guide ships, the Coast Guard maintains a 625-foot loran (long-range navigation) tower on St. Paul* ***(above)****. The electric field created by the tower's 275,000-watt output causes hand-held fluorescent lamps to burn brightly.*

Swift and certain death *awaits seals driven from their rookery to a killing ground on St. George Island* (**above**). *Only young, nonbreeding males may be taken. With generations of experience, a team of Aleuts can stun, kill, and skin an animal in one minute. Within two hours a herd on St. Paul is reduced* (**right**) *to rows of carcasses (on the left) and pelts (right). The meat is eaten by islanders and is exported for animal feed; the annual yield of 24,000 pelts goes into the manufacture of fur seal coats.*

While the harvest is decried as cruel by some, others consider it humane since the killing is done quickly. Both the Sierra Club and National Audubon Society have agreed that the Pribilofs' seal management is among the most successful wildlife conservation programs. The world fur seal population rebounded dramatically after it dipped dangerously low from indiscriminate harvesting around the turn of the century. Under a treaty signed by the United States, Canada, Japan, and the Soviet Union, seal hunting on the open sea is prohibited. If the agreement is allowed to expire in 1984, island residents fear the devastation of the seal population, which would be a severe blow to an economy that is already suffering from more than 80 percent unemployment.

SUSAN HACKLEY JOHNSON (BELOW)

A remote haven for wildlife

*MILLIONS of seabirds breed on the rugged cliffs of the Pribilofs and feast in the food-rich Bering Sea, attracting bird lovers from around the world. Some species are native to the island; others are exotic migrants from places like Siberia. Flying in formation, murres dot the sky (**left**) as they return to St. Paul after a day of feeding at sea. Comical-looking parakeet auklets (**right**) bear white plumes behind their eyes only during breeding season. The red-legged kittiwake (**below right**) craftily builds its nest on the least accessible ledges.*

***Keenly aware** of the islands' wealth of fowl, a blue arctic fox (**left**) haunts the roosting areas to feast on eggs and birds and scavenges the beaches. Superbly adapted to the climate, the fox's body is well furred and compact, with a short snout and rounded ears to minimize heat loss.*

five or six sets of shirts and pants. When we came back two years later, nearly everything we valued was gone—our icons, antiques, furniture."

While the U. S. military occupied their islands, the Pribilof people were interned on Admiralty Island off southeast Alaska, in an old cannery and the dilapidated buildings of an abandoned gold mine. Uprooted and bewildered, they suffered misery and disease. One in four died.

But some found excitement in their new surroundings; there were rain forests, brown bears, mountains, and, in nearby Juneau, new friends and jobs that paid cash. Among these friends were members of the Alaska Native Brotherhood, founded by Tsimshian and Tlingit Indians to further native interests. After the war the islanders joined the organization and for the first time had access to legal assistance.

In 1951 they sued the federal government, claiming it had not treated the Pribilof people fairly and honorably. The Indian Claims Commission decided in their favor 27 years later, concluding that the "government was obligated to provide for 'comfort,' but 'wretchedness' and 'anguish' are the words that more accurately describe the condition of the Pribilof Aleuts."

The commission awarded the people of St. Paul and St. George 11.2 million dollars; eight months later, under threat of appeal by the U. S. Department of Justice, the Aleuts settled for 8.5 million. The money has not yet made its way through the bureaucracy, but when it does, 80 percent will be disbursed to individuals, 20 percent will go for community development.

"We call it our corned-beef money," Gabriel Stepetin told me, "because it seems like all the government ever gave us to eat was canned corned beef."

Like most islanders, Rufina Merculief's

***Youthful spirits** roar out of St. Paul and head for the open road on rented motorbikes (**above**). Come evening, they might be dancing to the music of former mayor Victor N. Merculief (**below,** at left), who rehearses with his brother Guy for a gig with their rock band. For others, national network television programs beamed from a satellite provide the major source of evening entertainment.*

family acquired its name when first baptized into the Russian Orthodox Church. Members of the Merculief/Merculieff families live on both islands; some spelled their name one way, some the other. The situation proved too confusing, so U. S. federal officials decreed that all St. Paul Merculieffs use two f's; those on St. George only one.

As a schoolgirl on St. George, Rufina Merculief, now the mother of grown children, was forced to learn English, forbidden to speak Aleut.

"They'd make us eat soap or tape our mouths shut," she recalled. "But I'd sneak off with my friends, and we'd talk it anyway. I loved the sound of our own language."

Today Aleut is taught in grade school. But feeling Aleut—treasuring that uniqueness—may be ever harder for new generations to achieve. "Our original culture was lost to us two centuries ago," Gabriel Stepetin said sadly, "and our children have discovered the American way."

Videotape Aids Community Spirit

Technology has made inevitable inroads. Citizens-band radios and telephones link virtually every vehicle and home. Friday nights people congregate for disco and rock dances in the recreation hall. Youngsters race about town on three-wheeled Hondas. Some homes have freezers and microwave ovens. The television set is ubiquitous. Programs bounced off a satellite circling the Equator bring villagers "Dallas" and Dan Rather. This cuts into the community spirit, but Larry Mercullieff has found a solution.

"When we want to notify villagers of important issues, we make a videotape. If we held a public meeting, few might show up. But everybody watches TV."

Most community functions—such as basketball games and bake sales—occur at school. St. Paul has a new school with the latest educational aids: an Apple computer, automotive repair shop, electronics lab, weight-lifting equipment. Beyond tenth grade, students are air-bused each fall for a semester or school year to schools in Anchorage, Bethel, and other mainland towns. Although the Pribilofs are entitled to a high school, parents on both islands voted no. Rufina explained: "Our kids know about the outside only through books and television, but that's not reality. They need to experience the world beyond our islands."

Some students who leave never return. Of those who come back, many find only chronic unemployment. Often they sink into alcoholism, an especially serious problem among adults.

"I worked sealing, went away to school, and now I'm back sealing," Phillip Lestenkof told me. "The name of the game is survival. You can't choose a career—you're lucky if you can just find a job."

Larry Mercullieff disagrees. The community needs new leaders to manage Tanadgusix's enterprises, but few have training. "Self-image is one of our problems," Larry explained. "Years ago the government treated us as inferior; we cannot allow this feeling of inadequacy to be passed on by each generation.

"More than our own village is at stake. St. Paul is the largest Aleut community in the world. If our young people leave, the village will die a slow death. It may be the death blow to the Aleut people's culture."

Perhaps the Aleuts' transformation from seafarers to landlubbers caused the most severe injury to their self-esteem. When the Russians brought enslaved Aleuts to the Pribilofs, they taught them to kill seals ashore. Until then, Aleuts were as comfortable at sea as the seals, whales, and sea lions they hunted. They paddled for days in oceangoing, kayak-like *baidarkas*. They subsisted on sea mammals, eating the meat, using the bladders for buckets, and burning the oil for heat and light. Bones were shaped into implements, seal gut into raincoats, sea lion flippers into shoe soles.

Islanders still fish in small boats for halibut in summer, go after reindeer in fall, hunt birds and gather eggs in spring.

Fleeing the bite *of a spring storm on St. Paul, a young girl heads for home near the Church of St. Peter and St. Paul. Men and women worship on separate sides of the Russian Orthodox chapel, and Mass is sometimes still read in Slavonic—traditions sown in the past and respected in the present on islands where the future is cloudy.*

One blustery winter afternoon I chanced upon Mike Zacharof on a high bluff near the village. Bundled in a warm parka against the wind, he was prepared, he said, to spend several hours scanning the sea, hoping to shoot a sea lion, now protected in American waters from all but aboriginal hunters.

"They poke out of water for air, then dive out of sight," he explained. "You have to be quick and sure, shooting them when their lungs are full so they'll float to shore.

"I come out here to get away from pressures," he confessed. "And when I really want to relax, I go away to St. George. It's even more peaceful there."

Quiet St. George Considers Its Course

I reached the island of St. George aboard a nine-passenger plane. Crouched by the sea, the only village, of the same name, shelters some 150 residents. Rows of uniform white houses cluster around the stately, onion-domed Russian Orthodox church, core of the island's spiritual and social life.

Offshore, lights from crab boats escaping a storm gleamed like low-hung stars. A stiff wind blew the wave foam back to sea and hustled a villager down the street, his parka billowing like a sail. A mother and daughter scurried into the church, arms laden with plastic Easter lilies. Nearby, a dozen scruffy foxes scavenged for scraps.

Ornithologists rate the Pribilofs, and especially St. George, as among the world's premier birding sites. Millions of birds gather here each summer. Almost 200 species have been sighted residing in or migrating through the Pribilofs.

In Nick Philemonoff's boat I visited a rookery. After a 20-minute ride Nick cut the engine. We drifted by a cliff soaring 900 feet above us like the facade of a Gothic cathedral. Nesting birds screamed and chattered from its ledges; tufted and horned puffins, cormorants, fulmars, kittiwakes, auklets, and murres flew about like confetti.

Nick said, "We watch St. Paul carefully to see if we want to grow along the same lines. They have a policeman now to handle problems. And I can see that people there don't share as much as they once did."

Sharing was once a simple matter: Divvy up the seal, the sea lion, the hardships. Now life is more complicated. There's the corned-beef fund to be fairly divided. St. George people wonder: Should we encourage tourism, a fishery, oil development?

All but subsistence sealing has been prohibited on St. George since 1973 to allow comparisons between an unharvested herd and a harvested one.

"St. George has all the problems of St. Paul—the impending federal withdrawal, the need to develop an alternative economy quickly—and no experience in dealing with them," Larry Merculieff told me.

But, more important, the islanders now have the right to choose—win or lose. After 200 years with little control over their lives, they have a chance to shape their destiny.

"If we all work together, we'll make it," Larry continued. "Our most pressing need is to create jobs for people on St. Paul. Fisheries, yes, but besides, Tanadgusix already owns St. Paul's King Eider Hotel and Restaurant. Tourists—mainly birders—come here in summer. A Danish marine architect is helping us design a fishing harbor and model community on corporation-owned land in the Aleutians. We've signed a contract with the Chinese to sell them seal stix. Oil companies are inquiring about a staging area for drilling in the Bering Sea. We are even moving outside the islands: Tanadgusix recently bought the controlling interest in an Anchorage hotel. We can become an economic powerhouse, but not overnight."

At St. George's Fourth of July dance, Larry's prophetic enthusiasm was given strong symbolic expression. The recreation hall was festooned with red, white, and blue streamers. A banner spanning the ceiling bore an especially appropriate message for the islanders: Let Freedom Ring.

Independence didn't occur for the Pribilof Aleuts in 1776. But it's coming now. □

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IVORY COAST

As a proud Ivoirian of the Baoulé tribe, I thank you for showing in "The Ivory Coast—African Success Story" (July 1982) that Africa has big cities and that not all Africans live in small villages with no electricity or running water. I feel the women (pages 94-5) are from Nigeria or Benin. Is there any way this could be verified?

St. Ambroise Azagoh-Kouadio
Winooski, Vermont

Some sources thought the women were Baoulé, others Sénoufo or Yorouba. The photograph was taken in Bouaké, a major city in the center of the country; most non-Ivoirians live in Abidjan.

NAMIBIA

I was somewhat surprised that your article on Namibia (June 1982) did not mention that the capital city of Windhoek was the first city to recycle its sewage for drinking water in a system with pipe-to-pipe connections. The waste-water treatment processes are among the most sophisticated used anywhere.

Herbert R. Pahren
Cincinnati, Ohio

As a world history teacher, I was captivated by your superb article on Namibia. On page 775 you mentioned that the Reverend Kalangula "would welcome American volunteers [teachers]." Do you have his address?

David Hersch
Manassas, Virginia

We have received many letters from teachers wishing to volunteer. The only address we have is the Reverend Kalangula, c/o Secretary, Administration for Ovambos, Private Bag X2001, Ondangwa 9000, South-West Africa/Namibia.

MOUNT EVEREST

The Sherpas' name for Mount Everest (June 1982) is Chomolungma, which would have been a more sensitive choice for the name of Nepal's national park. Sagarmatha is the name in Nepali. Perhaps the Sherpas would be more enthusiastic if the name of the park acknowledged the unique culture of their region.

David A. Berkowitz
Natick, Massachusetts

Is there such a thing as a Friends of Sagarmatha National Park organization that armchair adventurers can join and help contribute to such an interesting cause? Your article "Park at the Top of the World" stirred up childhood dreams about the Himalayas and the Sherpas.

Heather Miller
Layton, Utah

We know of no formal organization that accepts funds for the park. You might wish to write to Mr. Mingma Norbu, Park Warden, Headquarters, Sagarmatha National Park, Namche Bazar, Nepal. Mail delivery is slow, and you may not receive an answer for several months.

ARMADILLO

While squirrel hunting in Benton County, Arkansas, I had my first encounter with a live armadillo (June 1982). We gave each other a mutual start one warm October morning in 1966.

Wayland Holloway
Memphis, Tennessee

"The Astonishing Armadillo" is most interesting. I would suggest, however, that the range of the armadillo in the 1982 projection is too conservative. It should include more of Mississippi (maybe all of it), Alabama and Georgia, and a good-size chunk of South Carolina.

Thomas H. Stewart
Blue Mountain, Mississippi

The map was based on a study by Dr. Stephen Humphrey of the University of Florida. It does not reflect first sightings, since individuals may be found outside colonized areas. The dates represent surveys of breeding populations of armadillos over a period of time in a particular area.

Your excellent article on armadillos failed to mention a previously reported case of lepromatous leprosy diagnosed in a man from Texas who had killed and dressed many armadillos. As more contact between humans and "Texas turkeys" takes place, the increased risk for spread of this serious disease must be acknowledged.

Andre B. Whiteley, M.D.
San Antonio, Texas

TOLEDO

Your June 1982 article on El Greco and Toledo wrongly gave the impression that the Jews were just expelled in the 15th and 16th centuries. Thousands were forced into baptism against their will. In their hearts they remained true Jews, risking their lives and the lives of their families in an effort to secretly practice Judaism.

Helen Klein
Saddle Brook, New Jersey

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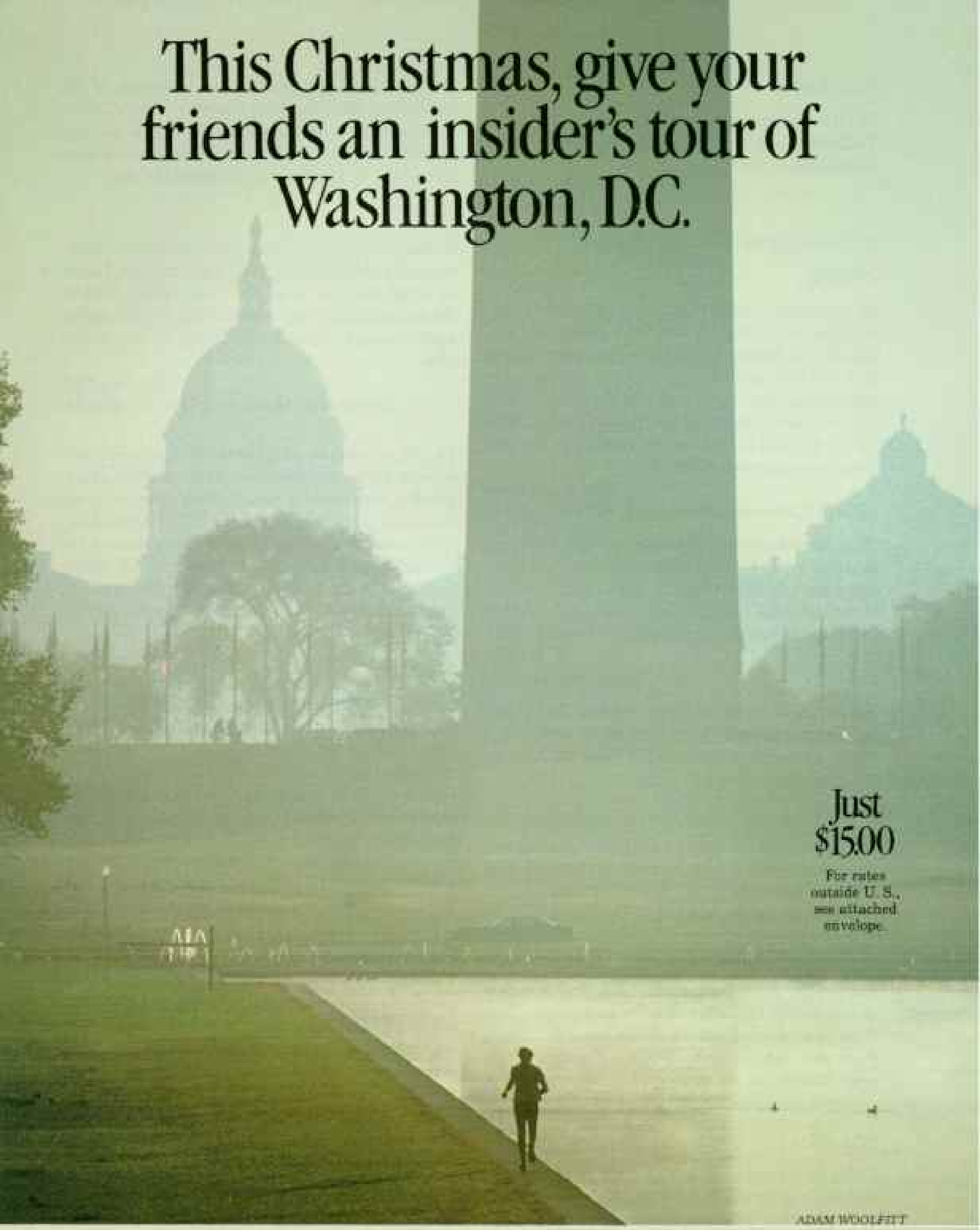

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Washington, D. C. 20036

EL GRECO

El Greco (June 1982) was born in the village of Fódhele, Crete, not Candia as your otherwise excellent article stated.

Roderick Dixon
Helsinki, Finland

El Greco said he was born in Candia.

PERTH

In your recent article on Perth (May 1982) you commented on the export of live sheep now taking place in Australia. There is a growing opinion in Australia against these exports. On any voyage as many as 5,000 sheep will die before reaching their destination. In fact a whole shipload of sheep was lost in 1981 as the result of a fire and the subsequent loss of the ship.

Harry J. Packer
North Richmond, New South Wales, Australia

The claim that Australian racing skiffs are capable of 35 knots is totally false. When two of these three-man skiffs entered the world sailing speed-record trials in Portland Harbour, the best they could do, in favorable conditions, was 14 knots.

K. R. May
Salisbury, England

Racing authorities in Perth confirm that a skiff has been unofficially clocked at 35 knots on a short run under spinnaker; top speeds of 20 knots are more the norm.

POTATO

Please tell your members that those tubers shown on page 670-671 ("The Incredible Potato," May 1982) are ocas, the South American wood sorrel, grown from northern Chile to Colombia.

Hans Hobt
Hannover, West Germany

Author Dr. Rhoades replies: "Few people realize the enormous variation in color and shape of Andean potatoes. All tubers shown were harvested from the International Potato Center's fields near Huancayo. No other root or tuber species is grown in the same fields."

POLAND

I was rather taken aback to learn in the special supplement to the April 1982 NATIONAL GEOGRAPHIC that Mikołaj Kopernik (Copernicus), "Established [the] theory that Earth orbits the sun." It was Aristarchus of Samos who first determined that the earth revolves around the sun and to state the causes of day and night and the change of seasons.

Angelo Dallas
Glenview, Illinois

Unfortunately for Aristarchus, scholars of his time refused to accept his theories. Thus, Copernicus gets the credit for establishing the theory, since he wrote a detailed mathematical explanation of the earth's movement about the sun.

SUDAN

In your article on "Sudan" (March 1982) the writer says the Nile is the world's longest river. I seem to recall that the National Geographic Society disclosed that the source of the Amazon extended approximately 50 miles farther than that of the Nile.

Jon Erickson
Deniliquin, New South Wales, Australia

The dispute lies in whether the Pará River is considered part of the Amazon system. National Geographic conducted a study of the Amazon, from source to mouth, in the early 1970s. Consulting with noted geographers and hydrologists in the United States and South America, we determined that the Amazon does not flow via the Pará, and therefore the Nile remains the world's longest river.

WHALES

It was a delightful surprise to find Dr. Roger Payne's essay on the humpback whales (April 1982). Those of us who have been fortunate enough to see a humpback break the water's surface in a leap of exuberance, or hear their haunting communications, know how important it is to ensure the future for these peaceful creatures.

Allen E. Smith, President
Defenders of Wildlife
Washington, D.C.

SINAI

The impressive photograph of the Bedouin lady on page 439 of your April issue has the right evidence of what the author says about their past. As an amateur numismatist, I could distinguish some Venetian and Ottoman gold coins probably not less than 300 years old. The very bottom silver coin belongs to Ottoman Sultan Abdul-Hamid II. One can read that it was minted in Istanbul in 1877.

Turhan Turgut
Istanbul, Turkey

Letters should be addressed to ***Members Forum****, National Geographic Magazine, Box 37448, Washington, D.C. 20013, and should include sender's address and telephone number. Not all letters can be used. Those that are will often be edited and excerpted.*

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It's analogous to having a movie theater screen in front of your easy chair. An appealing idea in a world of five-dollar movie tickets.

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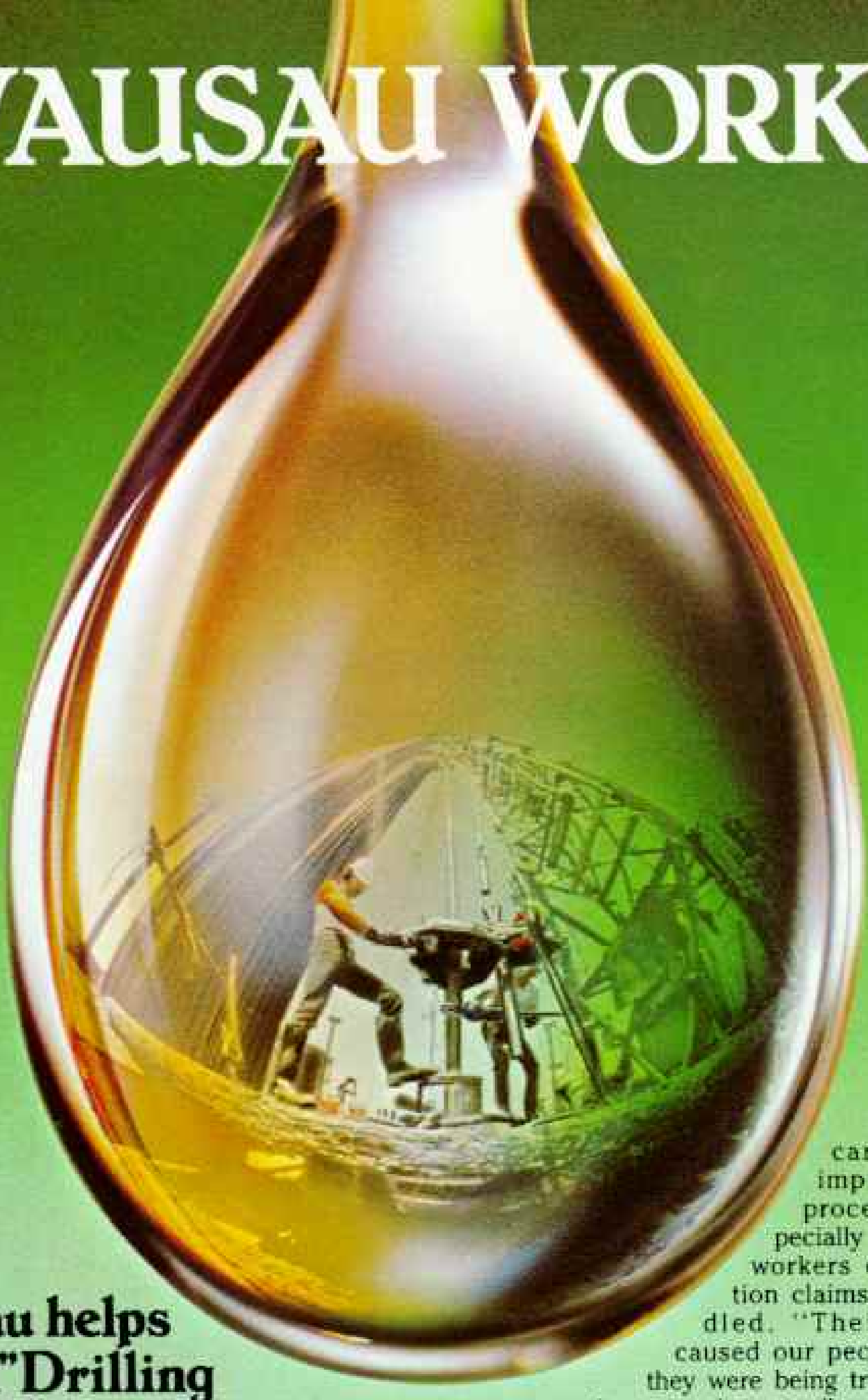

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Wausau, Wisconsin 54401

On Assignment

IN A CLOSE ENCOUNTER with chip technology, GEOGRAPHIC writer ***Allen Boraiko*** (below at left) and illustrations editor ***Bruce McElfresh*** "beam down" to a plate of three-inch-diameter silicon wafers. In this IBM ion etching chamber, electrically charged gas fluoresces red as it carves circuit patterns into the 180 chips on each wafer.

Boraiko, McElfresh, and free-lance photographer ***Chuck O'Rear*** (right) spent a year probing the world of the chip—the tiny powerhouse behind computers, robots, pocket calculators, and digital watches. They found the feat of packing hundreds of thousands of electrical transistors on a slice of silicon to be as fascinating as the computer-generated effects in films such as *Tron*.

To get the feel of computer technology, Boraiko held a bionic arm in his left hand and attached electrodes to his right arm. "I kept forgetting that what I did with my right arm affected the bionic limb," he recalls. "I was always hitting myself." He has written articles on silver, pesticides, and fiber optics.

A veteran of eight articles in the NATIONAL GEOGRAPHIC, O'Rear brought his latest subject close to home by investing in a personal computer. But only he could make the nearly 2,000 telephone calls needed to explore the picture possibilities and obtain permission to photograph companies and their closely guarded computer products. More than 18,700 photographs later, Bruce McElfresh began to select the illustrations for the chip article and a companion story on the Silicon Valley.

CHARLES O'REAR

O'Rear has dabbled in electronics since childhood, but reporting on the chip opened new doors. "At times," he says, "it was like stepping into the 21st century."

COMPOSITE BY STEVE JENKINS FROM PHOTOGRAPHS BY CHARLES O'REAR AND NATHAN BENN

If it's the best telecommunications system on earth, why on earth change it?

If you've ever tried to make a telephone call anyplace else on earth, you know what you've got in America. The best telecommunications system in the world.

But now you've heard the Bell System is on the verge of major changes. Changes in how we're organized. Changes in the way you can choose to do business with us.

Why change something that works?

There's a very good reason. The telecommunications business itself has changed.

For most of our history, the Bell System has had one overriding goal: universal service. Dependable telephone service at reasonable rates for everyone who wanted it.

Bolstering that goal were government policies determining that telephone companies would operate differently from most American companies. Within many areas of the country, we were to be the exclusive supplier of telecommunications services.
And since the Bell System didn't operate in a competitive market, its rates and profits were strictly regulated by the government. But today the goal of universal service has been achieved. Over 96% of American households have telephone service.

Now regulators and legislators in this country are looking more to the marketplace and competition, rather than to regulation, to decide who will provide competitive services and equipment and how they will be priced. In part, this stems from an increasing sentiment in this country for the deregulation of major industries.

But perhaps most important is the fact that technology has changed the future of telecommunications. We are about to enter a new era—the Information Age. The technology of communications gradually has merged with that of computers. The marriage of these two technologies offers the potential for an impressive array of new customer services. However, the blending of these two technologies has also blurred the boundaries between a traditionally regulated industry—communications—and the unregulated data-processing industry.

The combination of all these factors has led to a rethinking of public policies on telecommunications. These changes will require some changes in the Bell System. But we can assure you that your telephone service will still be the best telecommunications system on earth.

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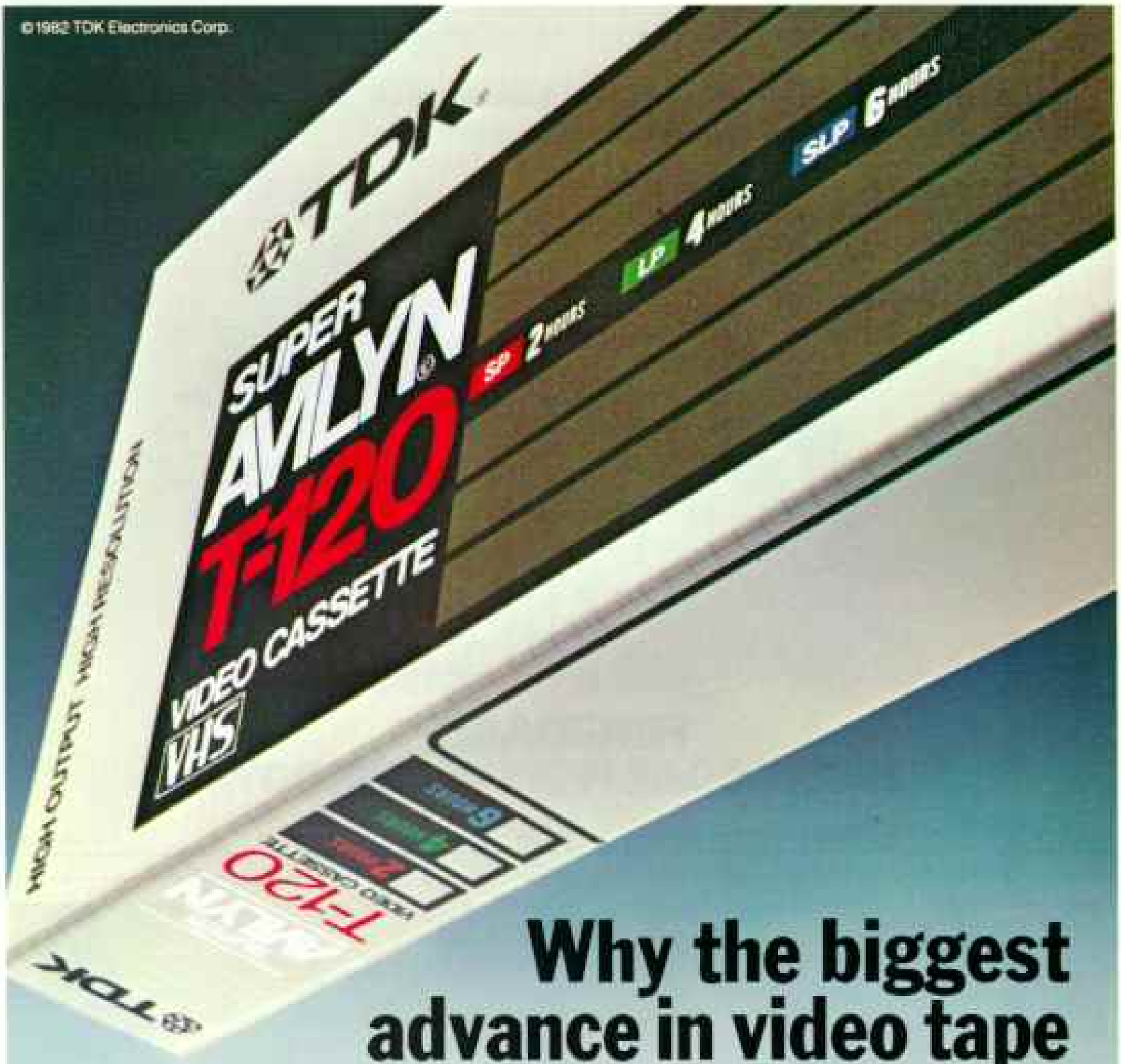

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