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Behold the Computer Revolution

By PETER T. WHITE National Geographic Staff

*Illustrations by National Geographic Photographers
BRUCE DALE and EMORY KRISTOF*

MY WIFE IS MAD AT COMPUTERS. "Those awful machines," she calls them. "How they mess up our credit card accounts! Imagine sending a bill for \$232.24 every month for four months after you've paid it!"

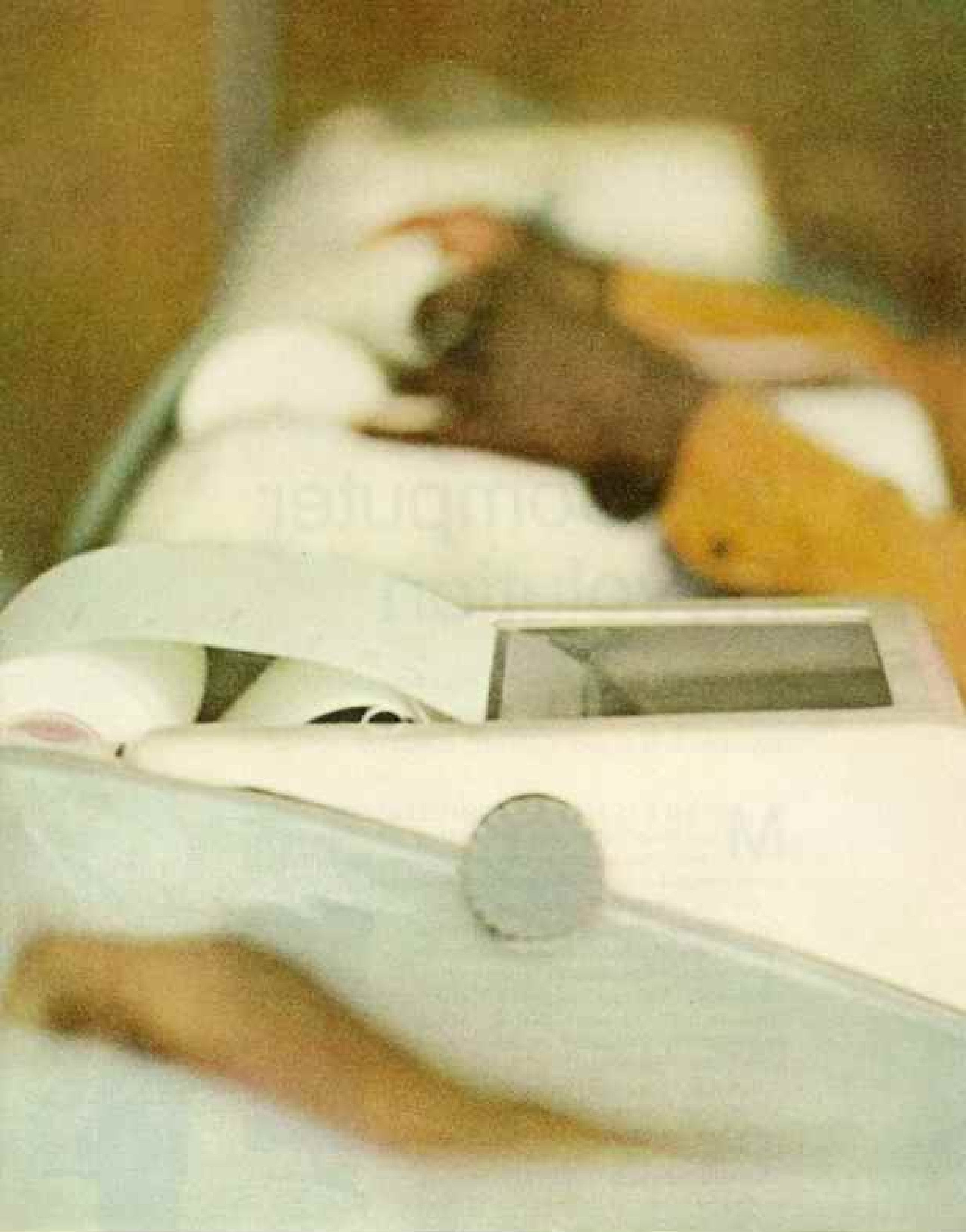
But I'm not mad. That mixup was settled after five months, and we never did feel as computer-harassed as some Americans, notably the Kansan repeatedly reminded that his department store bill was "overdue in the amount of \$00.00." At last he too managed to pacify the computer—with a check for \$00.00.

In a way, though, my wife is right. After a year of looking closely at computers—at what they are doing all over the country, what they are likely to do before long, and what their effects are expected to be upon us all and upon our descendants—I must say that these machines are indeed awful, in just about every sense the dictionaries assign to that word: inspiring dread, appalling, objectionable; solemnly impressive; commanding reverential fear or profound respect; sublimely majestic.

In the end I found my own ways of

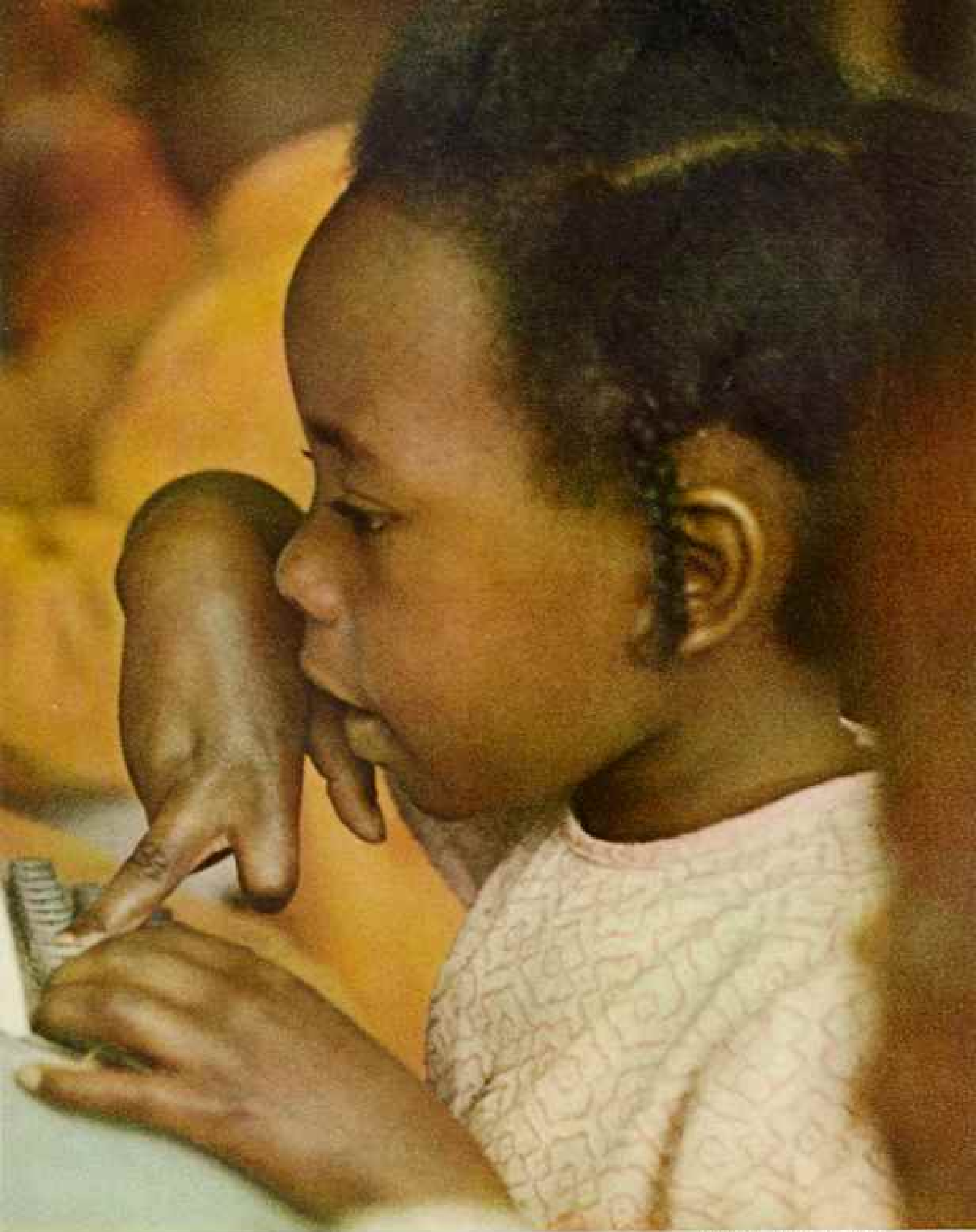


At the consoles of such electronic wonders as this IBM 370, man achieves the power to master information on a scale that profoundly influences the course of science, business, government—even the arts. © 1970



Bringing the blessing of education

Face to face with a classroom friend, six-year-old Shelia Brumfield raptly works her way through an arithmetic drill at a computer terminal in McComb, Mississippi. Taking turns with her classmates, Shelia identifies herself each day by pecking out her number and first name on the machine. Searching its electronic memory, the device



STYLING: BRUCE SALT © N.Y.C.

locates her file, reviews her performance, and picks up with the day's practice problems. Work done, it grades the assignment and bids a printed "GOOD-BYE, SHELLA." Computer practice not only speeds the rate of learning, but also frees the teacher to explain new concepts. Launched as an experiment by the Federal Government three years ago, computer instruction has been enthusiastically adopted by the McComb school system as part of its curriculum.



thinking fundamentally changed. It began with my first inkling of how significantly computers are embedded in our everyday life.

I take my salary check to the bank. The check is imprinted with sharp-cornered numbers in magnetic ink that can be read by computers. A computer credits my account, and sorts all the checks received at my bank, for forwarding to the banks on which they are drawn. Another computer will charge my employer's account in *his* bank.

In this way our commercial banks handled 20 billion checks in 1969. As the Bank of America, the Nation's biggest, puts it, "Had we not started to use computers years ago, we soon would have had to hire every adult in California to help with our bookkeeping."

Machine Keeps Track of New Numbers

I pick up my telephone and dial a number.

An operator's voice cuts in and says, "May I have the number you are calling, please?"

I say, "555-7170."

"Thank you," says the operator. Now another voice tells me: "The number you have called, 555-7170, has been changed. The new number is 555-7535. . . ."

That second voice came from a computer. While I was saying 555-7170, the operator punched those numbers on a keyboard. She thanked me, pressed a key marked "Start," and the computer took over.

It reached into its memory, or storage unit,

to match the old number with the new number. Then it fed the new number into an audio-response unit, which contains a vocabulary of prerecorded phrases and numbers from zero to nine, to assemble a message custom-made for me. That was the second voice I heard. The operator was through with me in seven seconds. She would have taken at least three times as long if she had had to do the whole job by herself.

Similarly, before the automatic dialing of long-distance calls, an operator had to write down the time and charges for each call. Now more and more computers keep track of that and send the bills, and the telephone companies get along with about 170,000 long-distance operators. To handle today's volume of long-distance calls in the old way would require nearly 750,000 operators—equivalent to all the unmarried women in their thirties now in the country's labor force.

At this point I paused to look into the nature of the computer itself.

Like all machines, it transforms things, as a lathe shapes a chunk of metal into a useful part, or a typewriter turns the touch of my fingers into words on paper.

The computer transforms information. This sounds simple, but it is in fact the basis of all its awesome power. How so? Because the information going in—in the form of numbers, letters, symbols, and even pictures—can be made to represent a tremendous variety of things. And the numbers, letters, and symbols coming out can be made to produce, often without human help, a tremendous variety of action, as we shall see.

One more thing to remember: The computer transforms information by electronic means. To enable the machine to do this, the information, or data, going in must first of all be put into a form the machine can come to grips with. For most computers in use today, the data is rendered into the so-called binary code, in which any number, or letter of the alphabet, can be expressed in terms of just two digits, 0 and 1. (For example, the binary equivalents of the decimal numbers one through ten are: 1, 10, 11, 100, 101, 110, 111, 1000, 1001, and 1010.)

Inside the machine, those binary digits—0 and 1—are represented by switches that may be either off (for 0) or on (for 1). The machine, in effect, consists of hundreds of thousands of tiny switches. They are grouped

The patient that always comes back

Lifelike in its apparent distress, a plastic-skinned manikin known as Sim One—for simulated patient No. 1—serves as a durable guinea pig for an anesthesia student and his instructor, right, at Aerojet-General Corporation's Electronics Division in Azusa, California. Driven by a computer, Sim reacts to their ministrations by sleeping, coughing, vomiting, changing his breathing rate, even temporarily dying. As the student tilts the head to insert a tube into the windpipe, the instructor stands near a console that permits him to vary Sim's reactions. From the monitoring of intensive-care patients to the sending out of hospital bills, computers have swiftly become medicine's newest partners.



EXTENSIONE (POSED) BY BRUCE BAILE; RIGACIONE BY EMURY KRISTOF © N.S.C.



They make computers work

◀ Texas tycoon H. Ross Perot eight years ago founded Electronic Data Systems, which specializes in computer work for other firms. Today, at 40, he is a four-hundredfold millionaire. Here, pressing buttons of a portable terminal that his firm designed, he transmits a coded message to a computer listening at the other end of a telephone line.

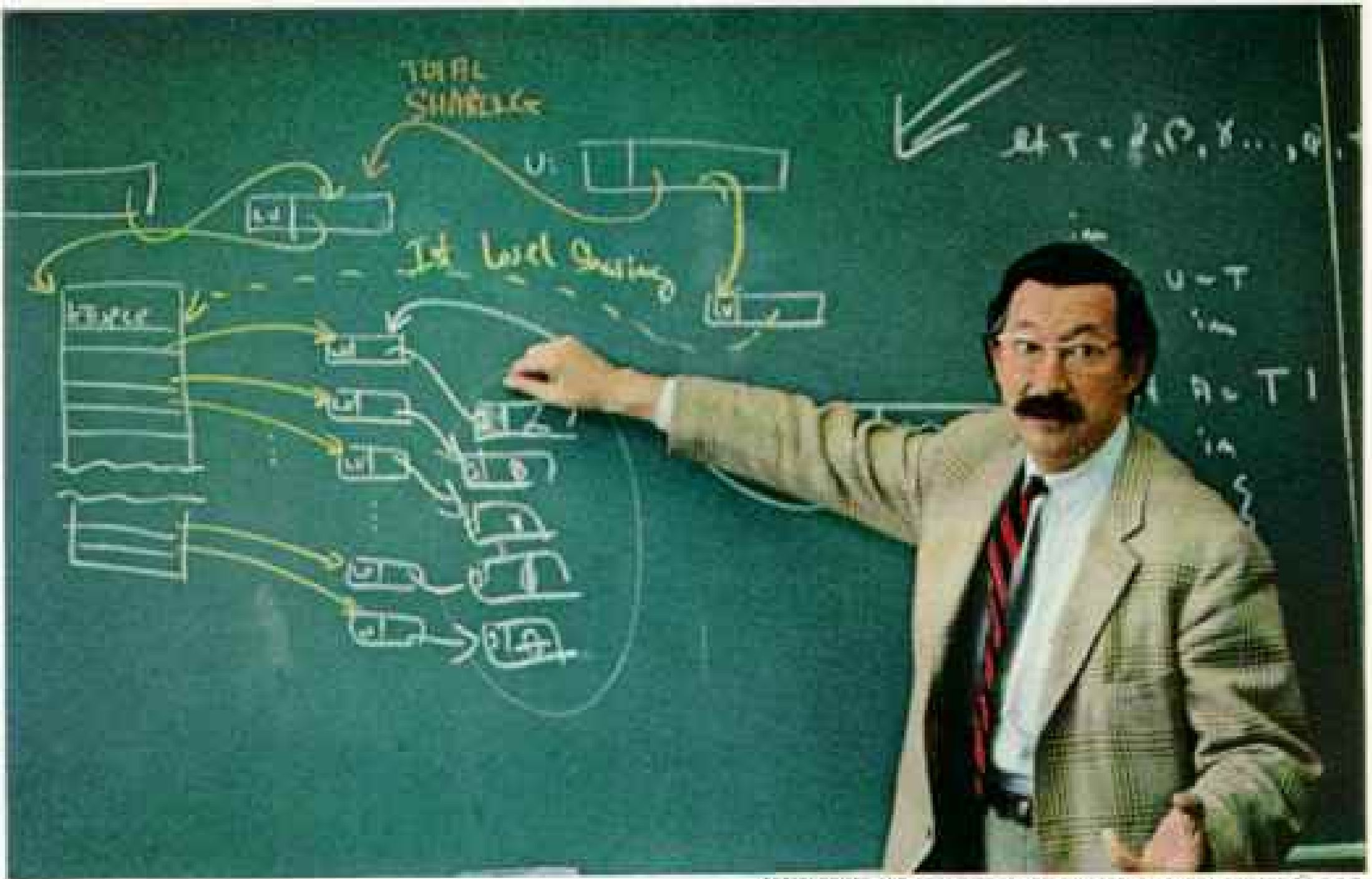
▶ Theoretician Joseph Weizenbaum conducts a class at Massachusetts Institute of Technology. Rejecting the notion that the computer will dehumanize society, the professor of computer science foresees its use in the personalization of many activities, such as teaching. Professor Weizenbaum envisions computers producing magazines and newspapers specifically tailored to individual subscribers' tastes.

▶ Man behind the memory, Professor Jay Forrester of MIT pioneered the data-storage system used in the majority of today's computers (close-up, page 602). He has also applied the computer to industrial organization and to the problems of today's cities.

Part of a core memory device lies on his desk. To implant information, electric impulses feed in data as combinations of 0 and 1—the two binary code values used in most computers.

◀ Time-sharing pioneer: Dr. John G. Kemeny helped develop the technique of having a single computer serve many masters at once, storing the data of each until called on to process it. President of Dartmouth College, he mans a terminal in his office tied in with the institution's Kiewit Computation Center (pages 632-3).

▶ Computer magnate Thomas J. Watson, Jr., serves as Chairman of the Board of International Business Machines, the world's leading computer manufacturer. He stands in front of an IBM 360.



DATAFLOW AND MICROFORMS (MIDDLE LEFT) BY SMURF PHOTO © W.A.S.

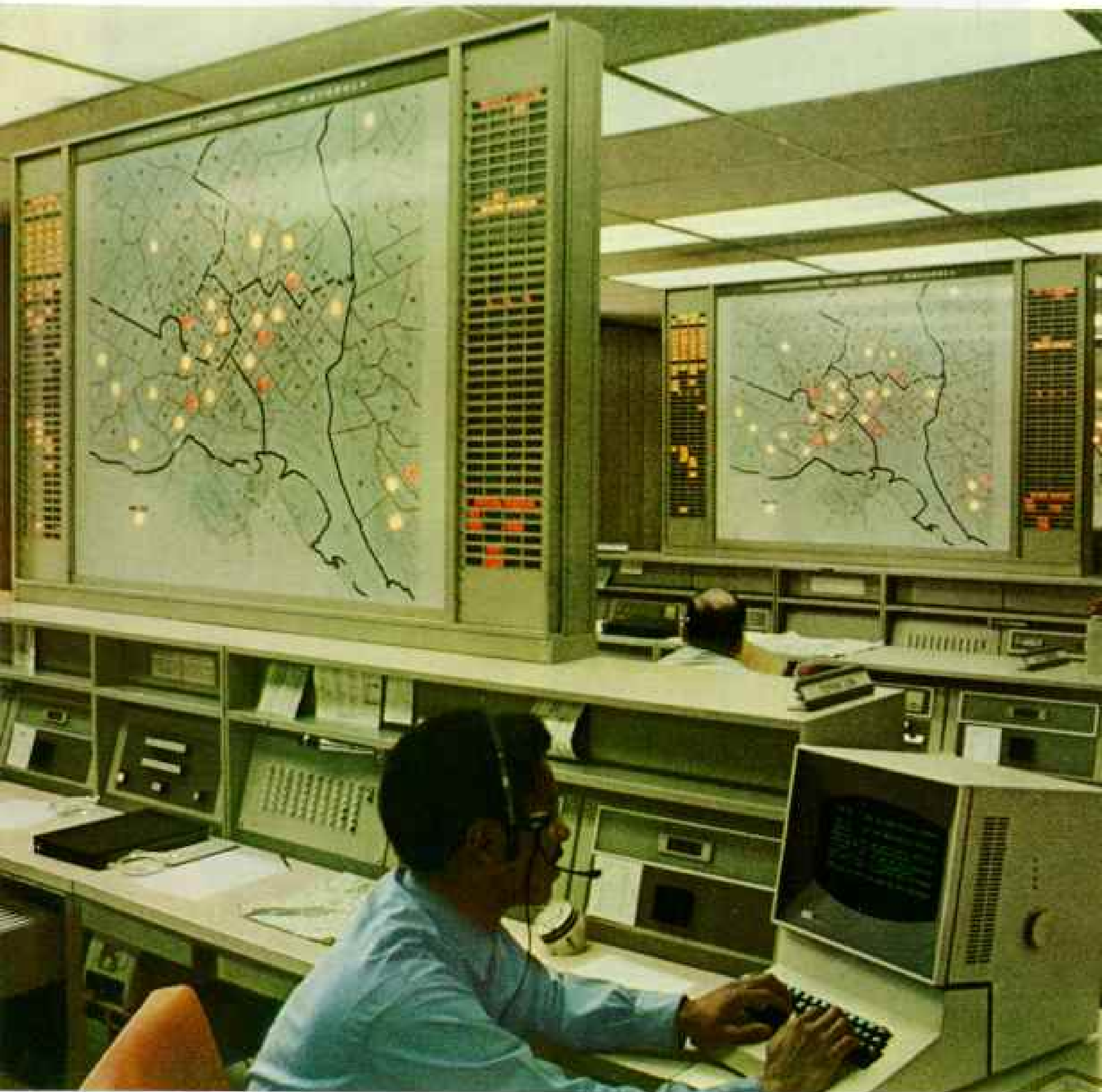




Computers against crime

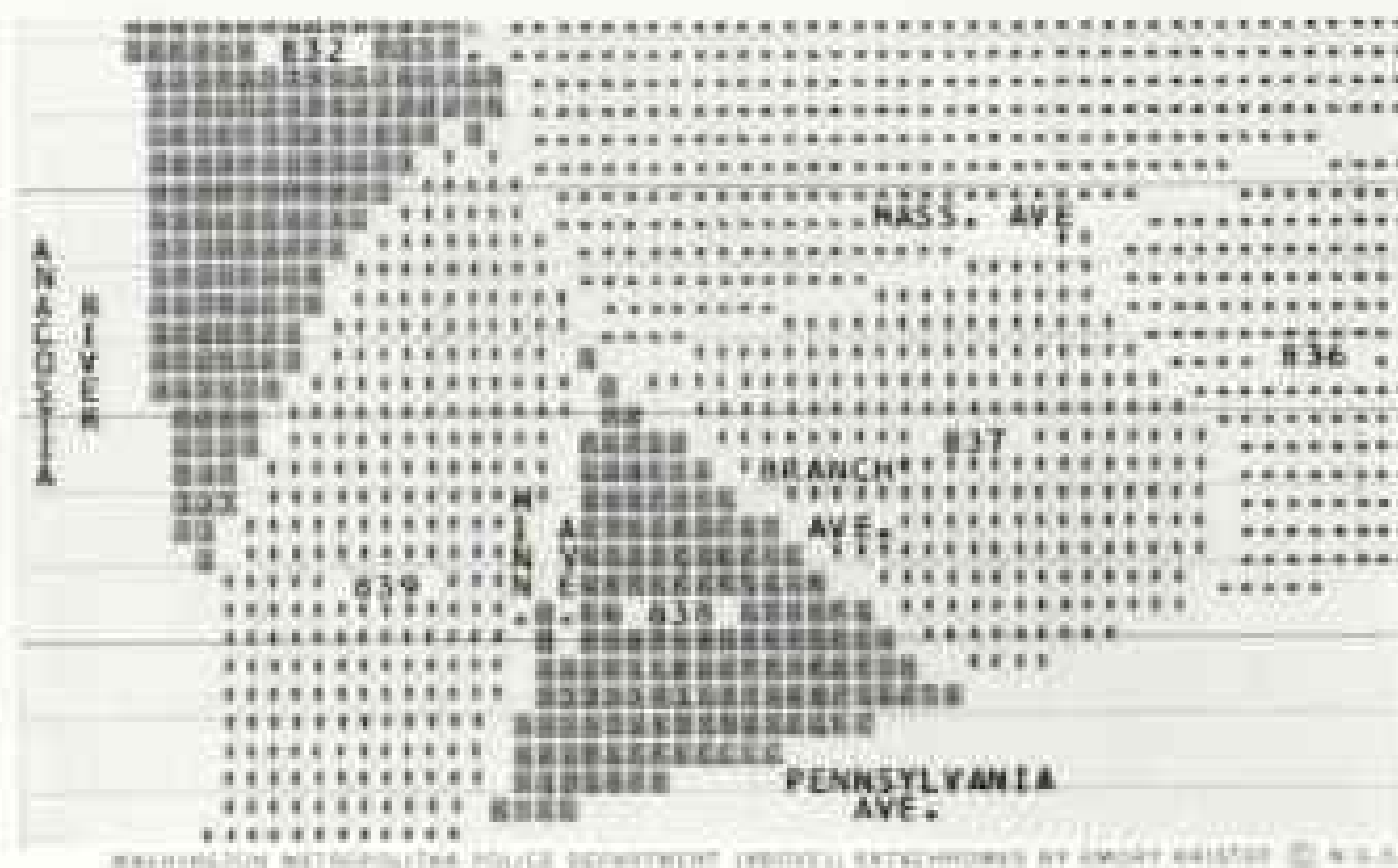
"Check D. C. license 999-398," radios a policeman in Washington, D. C., who spots a suspected stolen auto. His call goes to the city communication center, where lights on maps mark the patrol-car routes (below).

As an operator punches the license number on his keyboard, a computer instantaneously combs a vast criminal file on



objects and persons, constantly updated by Washington-area police units and courts and the D. C. motor vehicle department. The computer also queries the FBI's National Crime Information Center. Quickly it reports back on the display screen—in this case, no complaint.

As another anticrime aid, the computer prints monthly crime maps (right). Darkest shading shows high-crime areas, here within the Capital's 14th Precinct.



into five units: Input, Storage, or memory, Control, Processing, Output.

The input unit senses, or “reads,” data in binary code from various sources, such as:

- Punched cards, each with hundreds of spots in which a hole may be punched. A hole may represent 1, no hole may represent 0.
- Magnetic tape, with more than a thousand spots per inch—a spot magnetized in one direction represents 0; a spot magnetized in the other direction represents 1.
- A keyboard. When a key is pressed, the letter or number it represents is automatically encoded into electronic impulses corresponding to 0's and 1's.
- A radar antenna, or a TV camera. The data they gather is also turned into electronic impulses, representing binary 0's and 1's.

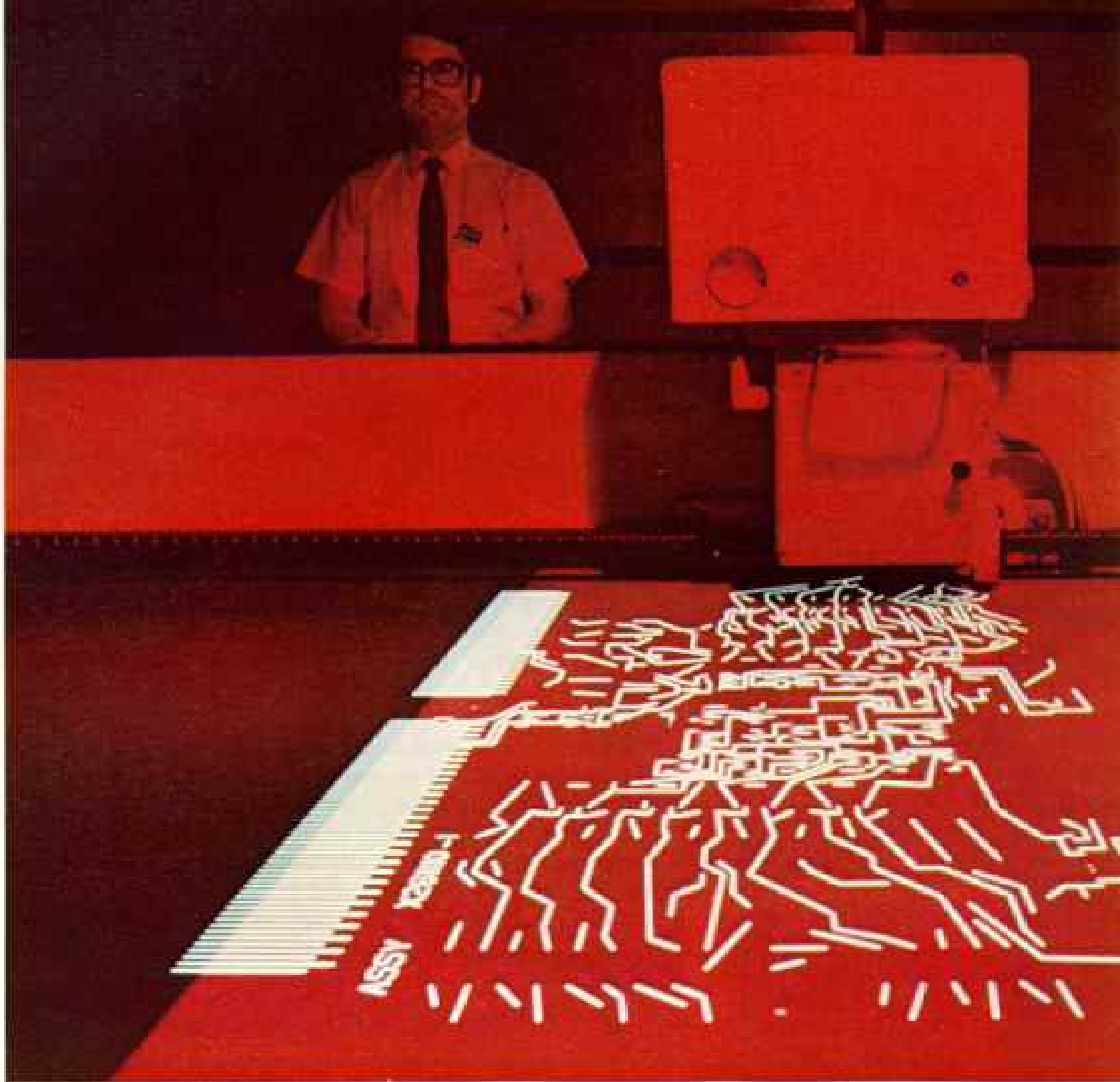
Output Appears in Varied Forms

Once sets of binary electronic impulses have been put into the machine, they are ready to be manipulated by the almost indescribably complex interactions of the memory, control, and processing units—that is, to be added together, or to be subtracted from others, or to be sorted or compared with each other; in short, to be processed. Then the output unit delivers the results, which can be made to appear in a variety of ways:

In binary code on punched cards or magnetic tape. Or decoded into decimal numbers and letters of the alphabet, and printed by an electric typewriter or other machine—such as the one turning out the mailing labels for 6,900,000 copies of this magazine. Or displayed on a cathode-ray tube similar to that of a TV set. Or put into words through an audio-response unit, such as the one I heard after dialing that telephone number that had been changed.

And because it's all done by what is basically the switching around of electronic impulses, the work of this most astonishing machine man ever built is known by the modest phrase “electronic data processing.”

For a modest but far-reaching example, I drive to a Jr. Hot Shoppe in northwest Washington to get a Royalburger. The girl at the checkout register punches a key marked RBG and out pops my check: 55 cents. Her punching



Anatomy of a computer

To create the computer's complex memory and nervous system, engineers turn to their indispensable assistants—other computers. Drawing with a beam of light, a computer-driven plotter traces the outline of a printed circuit on film at TRW Inc. in Los Angeles. The diagram will be reduced photo-

graphically to a 1/7-inch square, coated with conductive metals, and combined with other patterns to become an integrated circuit, or IC. These masterpieces of miniaturization, holding as many as 600 electronic components, give computers their compactness. They also reduce the distances electrical impulses must travel—a vital saving for a device performing a million operations a second.



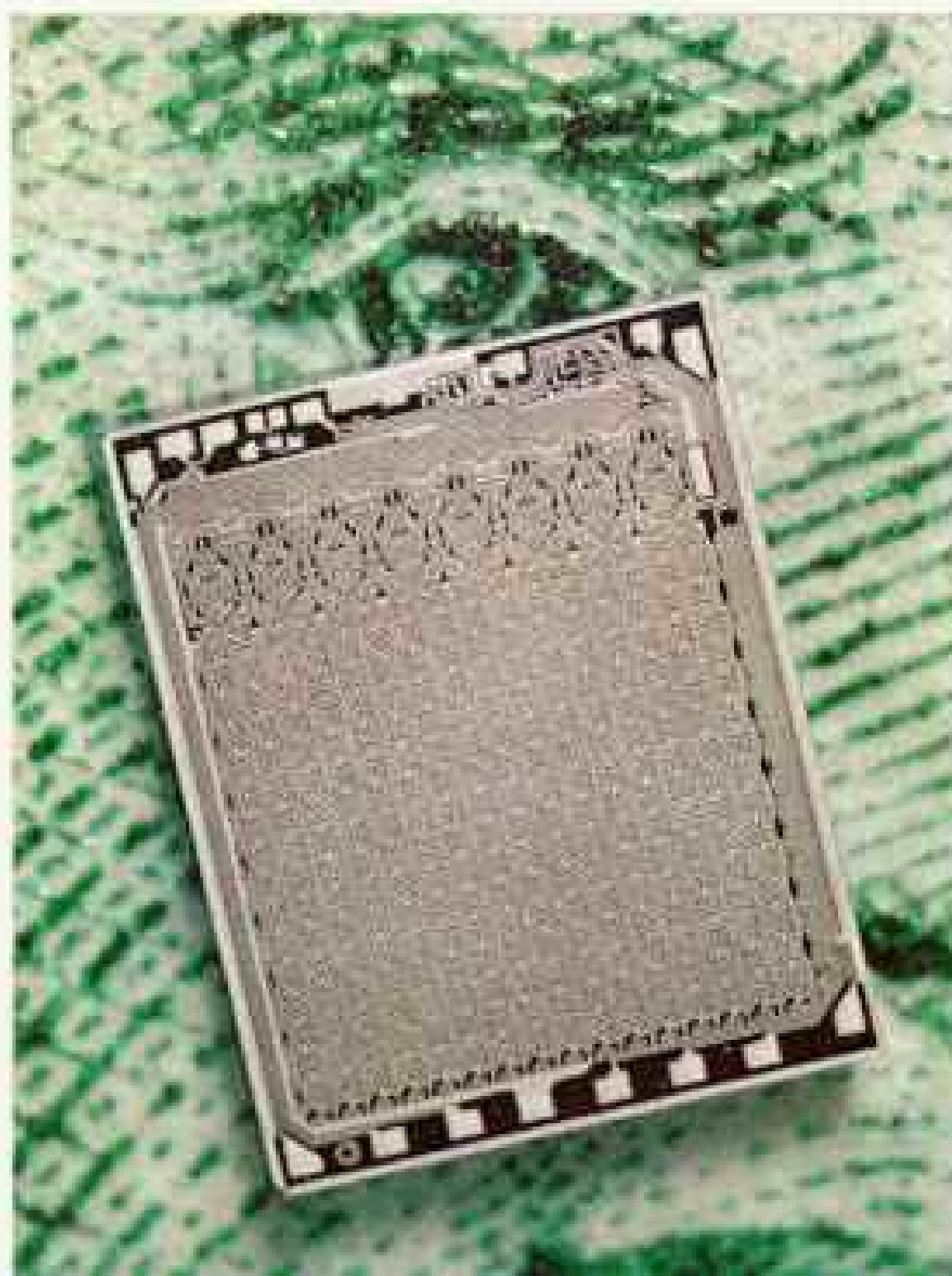
Electronic memory of most computers dwells in thousands of iron-oxide rings strung on wires, as in this IBM grid (left). Magnetized rings may represent the digit 1; nonmagnetized, the number 0.

Minuscule circuitry is dwarfed by Thomas Jefferson's face on a one-cent stamp; both appear greatly enlarged at far right. Lacelike "wiring" connects 2,500 microscopic transistors, resistors, and diodes in this memory "chip," made by Fairchild Semiconductor in Mountain View, California.





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automatically sends a series of electronic impulses to a computer memory.

Next morning, over a telephone line, a computer four miles away pulls in all the data stored the previous day, and the electronic data processing begins.

The computer adds the number of Royal-burger patties sold the day before in all the Jr. Hot Shoppes. It subtracts that number from the number of patties in the supply center. It compares the result with the number of patties estimated to be needed today, and prints an order for the right number of patties to be brought to the center. The computer also prints a list of how many patties are to be trucked to each Shoppe.

"How many buns, too," adds a senior official of Jr. Hot Shoppes. "It's quick, it's economical."

And it's characteristic of much data processing done by the biggest organizations nowadays. Thus do the automobile manufacturers keep from running out of parts. So do Boeing Aircraft and the U. S. Air Force.

Crime Data Converges at the FBI

Now I stand in a quiet room in the heart of Washington. An electric typewriter, unattended, clicks softly and rapidly, and stops. This is the FBI's National Crime Information Center—essentially a computer linked to police in all 50 states.

An FBI inspector says, "Watch the typewriter. If you see the word 'hit,' it means somebody has found something that somebody else is looking for." I see a timely cross section of crime and apprehension.

11:38 a.m. New Jersey State Police report a hit on a Vespa motor scooter with Arizona plates. It had been stolen in New York. . . .

11:56 Man wanted in Baltimore for unlawful flight. Computer acknowledges, adds that this man already is wanted in Virginia for breaking and entering. . . .

12:01 Inquiry from Utah, giving engine number of blue '67 Chevy pickup truck. It's another hit. The truck was stolen in Texas. . . .

The inspector explains that criminals have become disconcertingly mobile. "But as they rush across the country, a lot of them get caught in the middle, in Kansas, Nebraska, Texas. Say a trooper in North Platte, Nebraska, stops a man for making a left turn without signaling. Intuition tells him something's wrong; the man may be wanted, so he radios the information on the driver's license to his dispatcher, who types it on a keyboard, which



SHEPHERD of a steelworks, an unseen computer watches over an automated inferno at the Granite City Steel Company in Illinois. Controllers, sharing air conditioning with the pampered computer, monitor panels showing temperature, dimensions, and speed of the glowing strip of steel as it goes through powerful rolling mills at center. Hidden sensors constantly scrutinize the process. Should the product stray from programmed specifications, the computer automatically carries out proper adjustments.

ENTACHROME BY EMORY KRISTOF © N.G.S.



is connected to our computer here, and the trooper gets his answer within 90 seconds, before he has to let the man go.

"Or if he chases a car on the highway, he can check out the license plate while traveling only three miles. Could save his life, if he is told the man is armed and dangerous."

The anticrime computer's job is a matter of electronic matching. The Vespa hit at 11:38 was typed in thus: B505/AZ/67/MC. That stood for license plate B 505, Arizona, '67 motorcycle or motor scooter. Had there been nothing to match in the computer's storage, the machine would have typed back: NO RECORD. But the match was made, which triggered the outpouring of the stored information.

"We also put in stolen securities," the inspector said, "and boats, aircraft, snowmobiles. About two million records. By the way, Mr. White, what is your date of birth?"

I said May 11, 1925.

He typed DCFBIWA. NAM/WHITE, PETER. DOB/051125.

The machine typed NO RECORD, and the inspector bade me goodbye.

Computer Solves a Builder's Nightmare

I drove to the Potomac shore, to the Watergate complex—hotel, shops, offices, and apartments—four vast and unconventionally curvy buildings: a monument to computerization.

The reason is that so little is square about these buildings. All those curves, so harmonious to the eye, are far from symmetrical; an architect's dream but a construction man's nightmare. The project manager supervising the erection of two additional high-rise buildings says a computer is saving his sanity.

"Each concrete floor reaches out to a slightly different edge. Those glass walls are really hundreds of separate windows, set in hundreds of steel frames, each of slightly different breadth! To get the necessary specifications takes hundreds of thousands of calculations. Even if we could get enough engineers to do it, they'd each make little errors, and the pieces wouldn't fit properly.

"So—one computer figured it all. It sends specifications to the manufacturers for each window and frame. Each arrives labeled as to precise location. Excuse me."

He turns to a teletypewriter that spits out blocks of numbers.

"A lady who bought an apartment on the eleventh floor wants a wood-burning fire-

place," he says. "Now the computer tells us how we can put in a chimney for her without messing up the apartments higher up."

To learn how one operates computers, I entered a special school in Washington. The teacher said, "We don't just feed data into the machine; we must also put in instructions. First we analyze the problem. Then we write a solution as a logical flow of consecutive steps."

And so we drew up a flow chart, a sequence of concise instructions; in this case, the purpose was to turn out a factory payroll.

IF HOURS WORKED GREATER THAN 40, GO TO OVERTIME.

IF SOCIAL SECURITY AMOUNT IS LESS THAN SOCIAL SECURITY LIMIT, GO TO DEDUCTION.

IF BONDS EQUAL \$18.75, GO TO BOND—BUY.

And a lot more instructions. Finally: WRITE CHECK FOR NET PAY. And STOP RUN.

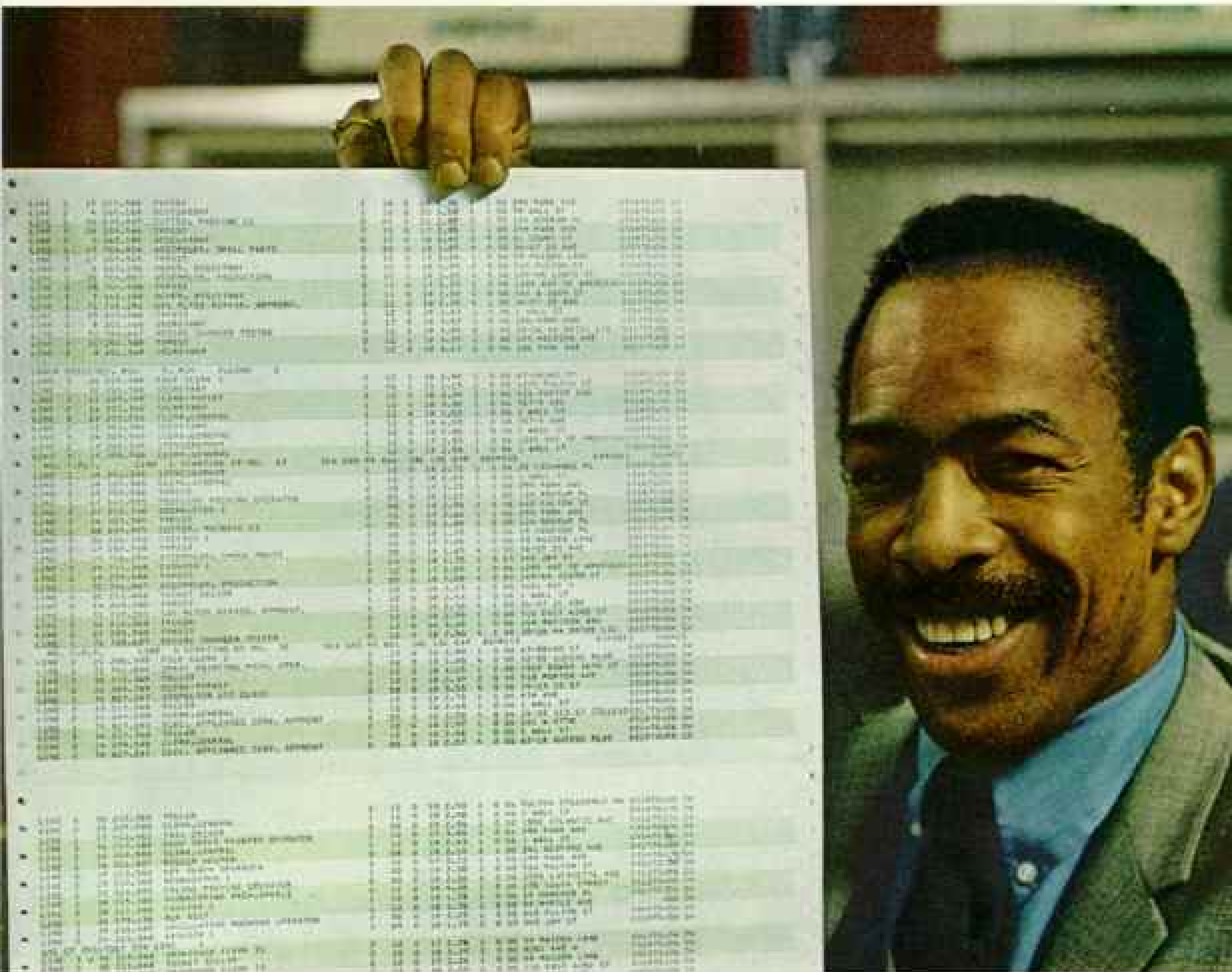
All these instructions would be encoded into series of electronic impulses and fed into the computer—to set a lot of the switches inside it, so to speak. Incredible, how much switching our instructions would unleash. To do the data processing necessary for the printing of each paycheck, circuits by the tens of thousands would be switched on and off, all within a single second!

And how marvelous that we didn't have to worry much about the inside of the machine: the mass of wiring linking masses of minuscule parts. But of course we weren't studying to become engineers. We were learning to write recipes for data processing; or, as the jargon has it, to write computer programs. I was becoming a programmer.

The teacher said, "Any well-defined procedure can be programmed." But how can one define the ever-changing factors in an industrial process well enough so that a computer can run an oil refinery? Or a steel plant?

The teacher said, "A properly programmed computer can control and modify its own operation." Many measuring devices keep watch on the process to be controlled. Their output is turned into electronic impulses. These are continuously fed back into the computer, which in turn sends out impulses of its own to continuously adjust the machinery necessary to refine crude oil into gasoline.

Or to mix the ingredients for steel in a furnace, and then flatten fat ingots into sheets thin enough to sheathe cars and refrigerators

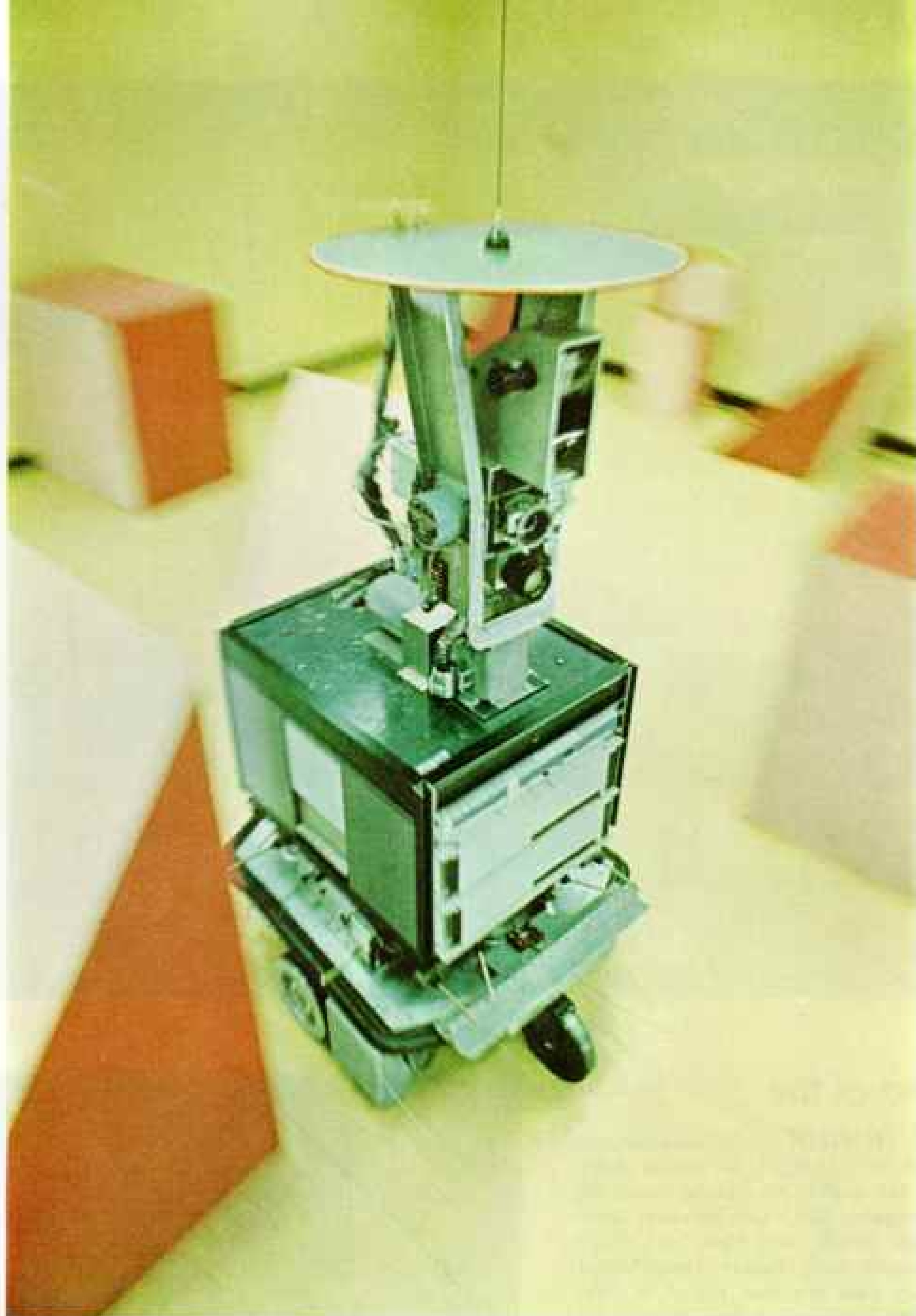


Friend of the job hunter

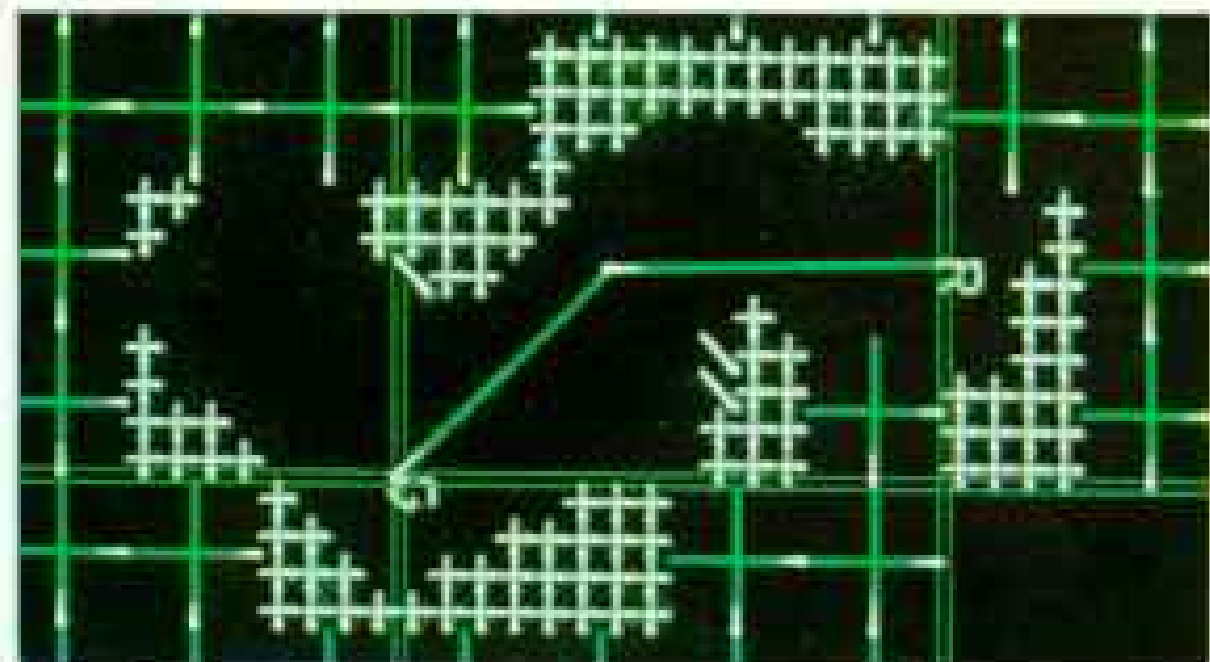
"If computers can match boys and girls for college dates, they can match job-seeking men with man-seeking jobs," said President Richard M. Nixon. And New York City's Manpower and Career Development Agency does just that. Robert W. McKinney, Jr. (above), a data manager for the Bedford-Stuyvesant area, displays a computer listing of available jobs. Applicants (right) will give counselors their requirements and qualifications. A counselor may then tell the computer that a 21-year-old male with a high-school diploma and a year's experience wants full-time work at \$2.25 an hour in accounting. The computer replies that such a job is open at \$2.41 on Court Street.



EXHIBITION (RIGHT) AND ASSEMBLING (TOP) BY EMORY NRIETOC © R.E.S.



EXTRACTOR (ABOVE) AND BIODRUMS BY BRUCE DALK © N.S.A.



(pages 604-5). Or to launch one of NASA's rockets into space. That process—requiring so many things to happen so fast and so accurately—could never be managed without computers.

Before such a rocket can be launched, hundreds of programs must be written, containing hundreds of thousands of steps. That requires hundreds of programmers, and a lot of programmers can make a lot of mistakes. Errors, or bugs, are eliminated as programs are run for testing, or debugging. Just the same, an undetected bug disabled the \$18,500,000 Mariner I, so that instead of flying to Venus it had to be destroyed barely five minutes after take-off from Florida.

Alas, how tricky it could be just to program a girl to cross a road! I had learned that from a film which, to illustrate the pitfalls of programming, shows her holding a walkie-talkie and doing only what she is told to do.

Take a step forward. Have you reached the curb? No.

Take a step forward. Have you reached the curb? Yes.

Stop. Look to the left. Is there a vehicle within 60 yards? Yes.

Is there a vehicle within 60 yards? Yes.

Is there a vehicle within 60 yards? Yes.

What went wrong? The girl was stuck because the programmer forgot that vehicles can be parked. He should have asked:

Is there a moving vehicle within 60 yards?

The reply would have been No, and the next instruction could have been *Cross the road.*

Something like this had happened in that department store's billing operation in Kansas, the one that produced bills for \$00.00, remember? Something was missing from the flow chart for that program, a step saying "Test for zero. If yes, send no bill."

Now that I knew how demanding it can be to work with computers, and how frustrating,

I could see why extra-bright programmers can earn \$20,000 a year at age 25. Why they sometimes chew their nails and pencils around the clock, and snap at their wives when they finally get home. And why one night a programmer fired two bullets into a computer. Unemployment checks were late that week in the vicinity of Spokane, Washington.

Machines Keep Track of Fashion Trends

To celebrate my escape from programming, my wife and I sent a lot of electronic impulses flying. We headed for a suburban Washington department store, and she chose a dress. The salesgirl tore off a portion of the price ticket that had a mass of holes in it (page 613).

That night many such stubs would go through a reading machine; it would transform the data on the stubs into holes in punch cards, ready for the computer.

Next morning the dress buyer would have a report from all the store's branches, showing just what dress styles were selling best, so she could reorder fast.

I stopped at the store's theater ticket counter. Any seats for the musical *1776* in New York tomorrow? The girl punched a keyboard, and the answer flashed right back on a little screen like that on a TV set: N101 and 102, fourteenth row, center. I said all right. The girl punched another key and our tickets were printed out then and there.

The morning after the show, I kissed my wife goodbye, picked up the phone, and asked an airline for a seat to Dallas. I couldn't see the reservations girl, but I knew what she was doing: punching keys, looking at a little TV screen, then punching in my flight number, date, destination, and name.

And something in addition. Did I want steak or lobster for my dinner? Steak! I was off to see H. Ross Perot, the celebrated computer tycoon, in Texas (page 598).

Mr. Perot had responded to a widespread

Shakey the robot

With a whirl and a wobble and a chirp from its radio transmitter, a man-high mechanism named Shakey prowls a room at Stanford Research Institute in Menlo Park, California. Challenged to discover a path through a maze of obstacles, Shakey starts out at the left side of the electronic map at far left. Following a dead-end path, it gropes forward, senses obstacles with its cat-whisker antennas, and ultimately zigzags to the goal. Asked to show how it would return, Shakey's computer intelligence—a PDP-10—recalls the obstacles encountered and draws for the robot a correct path, shown as R-to-G on the right-hand map. Scientists at the institute think machines like Shakey could someday explore dangerous environments such as those man might encounter on Mars.



need. Many a businessman eager to benefit from computers had learned the hard way that one can't simply buy the machines, plug them in, and expect them to do just what the salesman promised. A procedure might take only an hour to run, but the necessary programming might have taken a year.

Even little changes in a program consume much time and nervous energy. And a switch from one computer system to a newer one? Programmers quitting in a huff! Accounts mixed up by the thousands! Chaos! No wonder many corporations find it best to let somebody else do their data processing for them.

\$1,000 Check Turns Into Millions

Many men have discerned this need and scores have invested to profit by it, but none with the touch of Mr. Perot.

On his coffee table I saw a \$1,000 check framed in silver. "With that I started Electronic Data Systems," he said, "in 1962, when I was 32." Eventually his company issued shares to be sold to the public. These soon rose in value, to such an extent that the shares he had kept for himself were now worth several hundred million dollars.

The brightly lit hall where I watched his computers at work looked like any other computer center. False floors, to accommodate thick cables connecting those massive steel cabinets, in pale blue and pale gray. Reels of magnetic tape, spurring and stopping, quietly, behind plates of glass. Machinery printing out 1,100 lines a minute. For an insurance company, a bank, a brokerage house.

Mr. Perot said, "My secret is to hire men who are smarter than I am." Ten of his employees had become millionaires too.

Next to dazzle me with computer doings was a pigtailed first-grader named Shelia, in McComb, Mississippi (pages 594-5). I watched her at the keyboard of a Teletype machine as she hunted and pecked with slender fingers.

The machine typed: $6 - 5 = \underline{\quad}$

Shelia pecked in: 1

Machine: $4 + 3 = \underline{\quad}$

Shelia made it: 7

Then came the thing that impressed me so.

Machine: $5 + 2 = C + 3$

$C = \underline{\quad}$

Shelia, quickly: 4

I have since been assured that this is not an uncommon accomplishment for first-graders—that's the sort of math they are taught nowadays. But not many as yet are drilled daily by computers, as were all the pupils in the seven elementary schools of the McComb school district. It was an experiment then, piped in over telephone lines from Stanford University in California. Today the McComb schools have a mini-computer of their own.

The machine summed up: 16 PROBLEMS WITH 94 PERCENT CORRECT IN 168 SECONDS. GOOD-BYE, SHELIA. PLEASE TEAR OFF ON THE DOTTED LINE.

"The machine doesn't allow the mind to wander," said the district superintendent. "Some teachers were opposed. They thought it was just play. But our test results show significant improvements in the children's mathematical abilities. So what if it's fun?"

I noticed that among Shelia's classmates none got quite the same problems. A little boy named Ralph was given only the simplest additions. To $22 + 33 = \underline{\quad}$ he replied 6. The machine typed, NO, TRY AGAIN.

Ralph thought and thought.

TIME IS UP, ANSWER IS 55.

Ralph said, "It's a good thing; it tells you when you're wrong."

The machine does a lot more than that. As soon as a pupil types in his first name and identity number, it finds his file and provides a drill custom-made on the basis of his previous performances, geared to his own pace of learning. Teachers get daily summaries, reporting on each pupil's progress, and periodic print-outs of grades, saving paper work. If special counseling seems advisable, the child's file is instantly available for review. The teachers still teach. The machine provides drill.

Oh, oh, no more drills today. All the machines are out of order. A day later, they type out an explanation: STORMS HAVE BEEN RAGING IN CALIFORNIA . . . POWER FAILURES . . .

Quick tallies on the Big Board

As traders mill about, an official reporter of the New York Stock Exchange hastily jots on a computer card the details of a sale—the stock, its price, and the number of shares traded. Inserted in the electronic reader beside him, the information will flash almost instantly on 9,000 Exchange tickers and display boards around the world.

WEAKENED CIRCUITS WITHIN COMPONENTS THAT MAKE UP A COMPUTER . . . IT TAKES LONG HOURS AND CONSTANT PROBING TO TRACK DOWN AND REPAIR THEM ONE BY ONE

Those are the ills computers are heir to. There are more. Excessive humidity can make them go haywire. So can the vibration from heavy traffic. And particles of tobacco ash can mix up the impulses stored on magnetic tape and produce errors.

Exasperated Student Gets a Warning

As I traveled on, I was impressed by the variety of sophisticated programming done for the benefit of students nowadays. I sampled the computer-assisted instruction available to all the midshipmen at the U. S. Naval Academy—physics, electrical engineering, economics. And I took a geography lesson myself at Dartmouth College.

Please keep in mind that there is no human being at the other end of the line, just a well-programmed computer.

HI, I AM CALLED MISS TELETYPE—WHAT WOULD YOU LIKE ME TO CALL YOU?

PETER.

HELLO, PETER! TOGETHER WE WILL LEARN THE LOGIC OF LOCATING A SET OF CLIMATE DATA ON THE GLOBE . . .

I was given climatological definitions, plus information about average monthly temperature ranges and average rainfall for a real but unidentified place—interspersed with questions I was to answer in my own words.

Step by step I located the place in the Northern Hemisphere, in the upper mid-latitudes. I did fairly well but not for long.

BE SERIOUS, PETER.

I confess that I became unduly exasperated. I typed in an intemperate word. Miss Teletype reacted immediately.

GOODNESS—SHAME ON YOU!!! WATCH YOUR LANGUAGE OR I'LL CUSS BACK AT YOU.

I was ashamed. I buckled down.

VERY GOOD.

EXCELLENT, PETER.

PERFECT—THAT WASN'T HARD, WAS IT!

SO LONG FOR NOW, PLEASE GIVE ME A CALL AGAIN—SOON.

I paid my respects to the professor who had programmed Miss Teletype. "It's not all that hard," he said. "You know—you present things logically, you try to anticipate what might happen."

An even more graphic lesson awaited me at the Massachusetts Institute of Technology.

The associate dean of engineering took me to a desk equipped with a TV screen, a keyboard, and a so-called light pen all connected to the same computer.

"Take the pen and draw on the screen," he said. "Lines of light will appear on the screen, in the path of the pen. Please draw a child's set of building blocks. When you are satisfied, press this key—your drawing will be stored in the computer's memory."

I was creating a model, so to speak, of a set of blocks. It was in the form of information stored in the computer, representing algebraic formulas based upon lines and curves. No need to worry about the mathematics, though; the computer's program took care of that.

"Now watch," said the dean. "I can command your blocks to become larger or smaller. I can change their shapes. And rotate them, to view them in different perspectives. I can arrange them as I like; I can erase them." He did all that, moving the light pen, pressing keys. I had never seen a fancier toy.

Computer Models Help Decision Makers

"In the same way," said the dean, "we can create a model of something we really want to build. A school building perhaps, or a traffic interchange. Then we type in information on the physical site, on design requirements, and human considerations, on many factors affecting our project. The computer calculates these, and we can modify the model accordingly—add parts, delete parts, change some.

"We look at various stages of modification. We measure the effects and the costs. We are simulating things that might happen—to find the best choice, to make the best decision."

In other words, figuring out a lot of things a lot faster than many men could with pencils?

"I think your analogy is unfair to the computer," said the professor. "We have a brand-new capability here, to do things we couldn't do before, to explore so many possibilities. To let the truly creative man use his mind freely. An incomparable tool of exploration."

Modeling! Simulation! Much aircraft designing is done that way nowadays (page 615). An engineer with a light pen draws a cross section of a wing. Then, in effect, he turns his computer into a wind tunnel, subjecting the wing to simulated stresses.

He changes the shape and dimensions of the wing, and when the results look good to him, he presses a key. Thereupon a computer-controlled plotting machine will draw a

blueprint of what he designed. Then the computer could produce a tape, to control a machine to build that wing for a prototype.

Modeling and simulation get astronauts to the moon.* In training, they see the effects of their piloting simulated as they practice in a mockup.

For months the spacecraft's flight is mathematically simulated in computers; during the actual flight the model is corrected once every second. This freshly calculated navigational guidance can be beamed up, as needed, from NASA's central computers.

Never was space flight simulated more triumphantly than during the anxious hours of the Apollo 13 mission. While Astronauts

James Lovell, Fred Haise, and John Swigert hurtled through space in their damaged craft, other astronauts huddled inside the computerized command-module and lunar-module simulators in Houston, doggedly trying out procedures for returning Apollo 13 to earth under circumstances never before encountered and never really foreseen in complete detail. Finally the procedures thus checked and double-checked were radioed up to the real Apollo 13, and applied successfully.

I found less hectic varieties of simulation far and wide. Scientists in Connecticut observe

*See in NATIONAL GEOGRAPHIC: "The Flight of Apollo 11," December 1969; and "Tracking America's Man in Orbit," February 1962, both by Kenneth F. Weaver.



Helping tend the store

With typical male skepticism, the author and son Norby, 6, kibitz as Mrs. White shops for a dress at a suburban Washington, D. C., store. Should she buy, a salesclerk detaches the price tag, marked like those on bathing suits above. During processing that night, large holes will guide the card through a reading machine as small perforations reveal price, style, and other data. Noting this and some 12,000 other computer-recorded transactions for the day, a machine will print by next morning an accurate picture of sales, showing buyers what items to restock.

EXTRACTED BY EMORY BRISTOL © N.G.S.



ARTWORK: JACQUES AND BELOUS, BY CALCOMP, SAN DIEGO, CALIFORNIA

"The Fisherman": A computer, programmed to draw a human face, guided a plotter that turned out this portrait with Oriental features.



"Oscillating Wastebasket": A student at the University of Toronto programmed the computer that produced this abstract composition.

the spread of blight in a mathematically simulated field of tomatoes. From an analysis of rock data, a geologist at the University of Michigan simulates erosion, to show in successive computer-printed profiles how the Colorado River cut the Grand Canyon.

Scores of major companies use simulation. If car production drops, what's the effect on the steel industry? How high can copper prices rise before it is wise to switch to aluminum wire for winding transformers?

And how was the duck shooting last year? How is duck breeding coming along in Canada? From such information the U. S. Fish and Wildlife Service creates a model to simulate duck populations for the coming season, to decide how many hunting days to permit.

It would take all the pages the *GEOGRAPHIC* publishes in a year just to list all of today's computer applications.

Science Projects Stored for Reference

Back in Washington, I visited the Smithsonian Institution's computerized Science Information Exchange. Researchers send in brief summaries of their projects, to be stored on magnetic tape. Any scientist can order computer print-outs describing research underway in his field, so that he won't start to do what somebody else is already doing.

The director said he had about 100,000 active projects on tape, lots of them employing electronic data processing. "I suspect that using computers in research is becoming as common as using the microscope."

Computers monitor experiments. They analyze, tabulate, and sift findings, thus fostering the discovery of newly appreciated relationships and proving new theses. Not only in the physical sciences but also in biology, in archeology (see the article beginning on page 634), and in the humanities as well. Through analysis of the recurrence of certain words, a computer furnished convincing evidence that 11 Federalist Papers widely thought to have been written by Hamilton were by Madison.

By now I longed for a rest from computers. But I couldn't avoid the newspapers, with their daily diet of computer-related items:

- Computers in hospitals analyze electrocardiograms and brain waves; they monitor patients' progress by continuously measuring heart and respiratory functions, temperature, and blood pressure.
- Computers in state and municipal employment agencies match job applicants with job listings that are truly up to date, so that a

man won't go after a position that was filled two days before.

- Computers control traffic lights at city intersections, changing the signals in tune with the over-all traffic situation that very moment, as scanned by many sensors.

I also read that computer-made music is booming (pages 628-9). So is business in computer-written horoscopes. For \$20, one gets reams of advice and predictions—every bit as reliable, it seems, as any other horoscope. Computerized dating services flourish too. People love them, even though a computer once matched brother and sister.

And crime? Two bright young men from North Carolina are in jail now, but for a time they were riding high with an anti-poverty agency in New York City. They made a computer turn out thousands of checks to non-existent youths working at fictitious jobs. Then they had a lot of those checks cashed, collecting several hundred thousand dollars.

High Hopes for the "Beep-boom" System

I took to the road again, to discover what electronic data-processing is doing to warfare.

The general who heads the U. S. Army's Computer Systems Command gives me a glimpse of the automated battlefield of the future, where far-off detection devices, or sensors, feed data to tactical headquarters by radio.*

"Some sensors go 'beep.' The computer evaluates what set them off, say enemy tanks of a certain size. It picks out the right artillery pieces, orders the right fuses, aims, fires! No time wasted. We call it 'beep-boom.'"

This new system will soon be tested on maneuvers, and the general worries lest I jump to misleading conclusions.

"Remember, the decisions are still up to the commanders," he says. "A computer program has value judgments built into it—it says when certain conditions are met, go this way. But a commander can punch different criteria into the program. And he stays always in command because we put him either on-line, as we say, meaning the chain of action passes through him, or we put him off-line, meaning he acts as a monitor. If the commands coming out of the computer look good to him, he lets them be carried out. If not, he overrides them, with a button."

How can electronic data processing assist a commander under attack? During a Navy

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

demonstration at the Fleet Anti-Air Warfare Training Center in San Diego, I watch the weapons coordinator on an aircraft carrier make up his mind as enemy planes close in from different directions, faster than the speed of sound. Which of the enemy planes presents the greatest threat?

The coordinator sits at a console of the Navy Tactical Data System, which is fed by various sensors—the radars of friendly ships and planes. He presses a button and tiny pointed symbols jump onto a display screen: the hostile planes. Round symbols show friendly ones.



ILLUSTRATION BY BRUCE DALL © N.A.S.

Wielding a light pen, a console operator outlines aircraft parts on a computer-linked cathode-ray tube at Lockheed-California Company in Burbank. Striving to get the maximum number of parts out of a metal sheet, he uses his keyboards to maneuver the pictures and insert them in a computer memory. This information will guide a machine in cutting out the parts.

With his palm, he rolls a black rubber gadget protruding from the console like half a tennis ball. As he rolls it, a bright blip moves correspondingly on the screen; he rolls until the blip coincides with the closest hostile plane, presses another button, and the system "hooks on" to that plane.

He presses a third button. Rows of white digits appear in his read-out panel, giving information about that plane. Its present course. Altitude. Speed. Time to target, if it keeps going this way. A green digit flashes a computer-calculated "threat number" . . . 2 . . . 3 . . . 6 . . . The highest would be 7.

He checks on other enemy planes before making recommendations to the skipper. Other buttons will unleash the defense, the Phantom jets, the Terrier missiles. . .

In the future, should a real battle be in the offing, the admiral in another ship may be able to press buttons to cut in with commands of his own. So may the Chief of Naval Operations in Washington. So may the President of the United States, wherever he may be.

That's the idea of the World Wide Military Command and Control System. When completed, it will be the biggest computer network ever built. I saw something like that already in operation—inside Cheyenne Mountain, near Colorado Springs, Colorado. This is NORAD, the North American Air Defense Command, a most awesome electronic data processing complex, employing 15 computers and 34 generals.

President Himself Can Go "On-Line"

Information constantly feeds in from radars around the globe. Masses of intelligence and weather data are stored and constantly updated. The job, says a U. S. Air Force general in NORAD's Combat Operations Center, is to process all this data rapidly; to display the gist concisely; and, if necessary, to trigger nuclear weapons for air defense. Subject to decision from the President, of course. If necessary, the President would be right on-line.

"The only nation in the world that can launch an all-out nuclear strike on us is the Soviet Union," says the general. "And so our biggest radars look more than 3,000 miles over the horizon and into the Eurasian landmass, from England, Greenland, and Alaska. They pick up a rocket launch. Is it a test? Or a space shot? Or an attack on the North American Continent?"

"Within a minute the computers calculate the trajectory and display the answer. If it should be an attack, they predict the impact area. We'd get 15 to 25 minutes' warning. A target in the north would get less warning than one in the south."

The general goes home and a U. S. Army colonel takes over the operations console. "There are thousands of commercial planes in the air all the time, and we don't want to see those," the colonel says. "But if one isn't in a position where his flight plan says he should be, the computers pick him up. That's an 'Unknown.' A red light goes on, and if we can't identify him fast, we send up fighters to take a look.

Radar Watches Soviet Planes

"Of course," adds the colonel, "we routinely keep an eye on a few 'Specials' we're interested in." He lights a cigar and reclines in his swivel chair. Sixty-three buttons glow to the left of him, eighty to his right (page 626). He presses one.

On his screen appears an outline of eastern North America and part of the Atlantic. Near Newfoundland glow two dots with tiny tails. He presses again. Letters and numbers appear alongside the screen. "NN370, the Russian Aeroflot flight from Murmansk to Gander to Havana. NN245 is going the other way, Havana—Gander—Moscow." Another button brings up a little triangle off Cape Hatteras: VE01, a Russian fishing trawler.

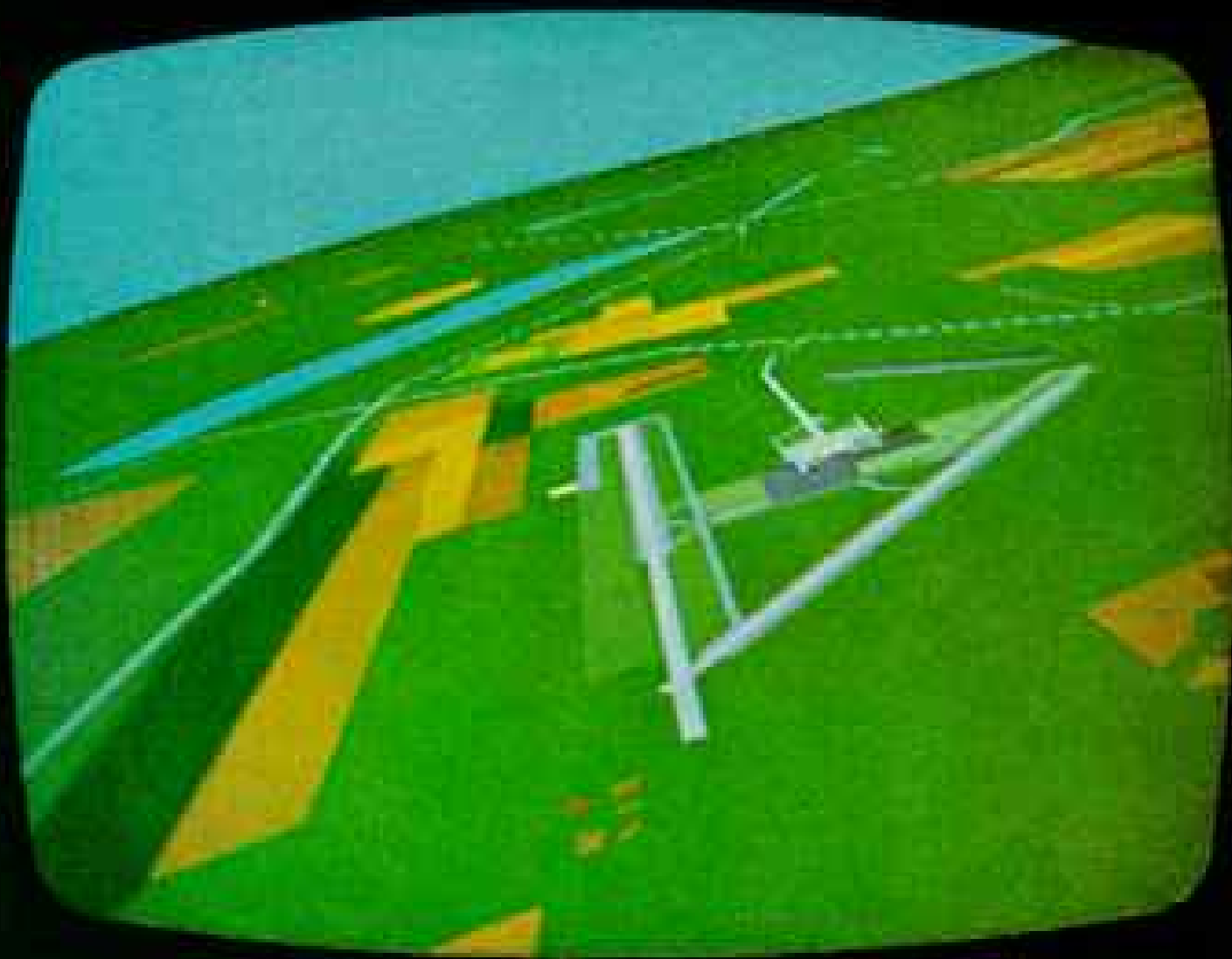
The colonel presses the button marked "World," and another button. I see the path of a Soviet Cosmos satellite. A blip marks the spot where it was a second ago. The colonel says, "We track every man-made thing in earth orbit."

It was an uneventful night. Cosmos 221 over New York. Cosmos 236 over Anchorage, Alaska. The airborne command post of the Strategic Air Command near Kansas City.

Then a red light went on. An Unknown popped up over California, going east.

It turned out to be United Airlines Flight 14, a DC-8 scheduled from Los Angeles to Kennedy Airport, New York, with 50 passengers and a crew of 7. It had been hijacked and was heading for Havana.

I headed back to MIT, whose researchers developed so much of today's computer gadgetry. What's in the future, for nonmilitary men like me?



AIRPORT THAT NEVER WAS:
As if seen from a cockpit, a computer-drawn runway looms realistically a mile and a half ahead (top left), at 600



ENTACHROMES BY BRUCE DALE. © N.G.S.

feet (center), then a mere 25 feet away (bottom). Finally the "plane" rolls smoothly to a stop—or crashes into black oblivion.



These vivid scenes flash on the screen of a new computerized flight simulator (above). General Electric engineers designed it to train pilots without the cost—or peril—of actual flight. Here a pilot veers the simulator as another jet appears to streak across the screen before him.

Keeping America on the wing

In this cavernous reservations center in Miami, Florida, Eastern Airlines ticket agents take bookings at 150 consoles. When an agent types a customer's travel inquiry to this or any of ten other regional centers, a computer flashes back flight schedules, seating, and meal service. The passenger makes his selection, and the computer subtracts a seat from Eastern's availability list. With this system Eastern keeps track of more than two million reservations simultaneously.

Confirming a reservation at Chicago's O'Hare International Airport, a United Air Lines agent types out the passenger's name and flight number. Instantly United's computer center near Denver, Colorado, responds, and the waiting line moves swiftly. Computerized ticketing spreads to new fields, from theaters and baseball games to campsite reservations.



"Computerized individualization," says Professor Joseph Weizenbaum (page 599). He gazes out his window, onto Technology Square.

"I am talking about techniques of mass production applied to produce things that are more or less custom-made. Do you care about skiing or coin collecting? Your weekly magazine will bring you a lot of ski and coin news, in addition to general news. But that same week your neighbor's copy of that same



FRANCHISES BY BRUCE DALE GARROD AND EMERY KRISTOF © N.A.E.

magazine will have a lot of news yours doesn't have—about stamp collecting and fishing, if that's what he cares about. For the computer that won't be much of a problem.

"You could have a rug made to your own design with a fault woven into it, for individuality, but made by machine on a production line with thousands of other rugs. A computer program can do that.

"Or a suit can be cut for you along with thousands of other suits, but to your measurements, fed in from a plastic card. You'll keep

the card, for other suits later on. You can see the beginnings of what I mean, right now, in the automobile industry. . . ."

Sure enough, at the Oldsmobile assembly plant in Lansing, Michigan, not one car coming down the line looks like the next. Sedan, convertible, hardtop, topless chassis for a hearse; Aspen Green, Sherwood Green, Burnished Gold, Galleon Gold, Azure Blue, Twilight Blue, Reef Turquoise—all mixed up, all ordered individually. Big engine, bigger engine, biggest; two-way power-adjustable

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1100

0300

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0600

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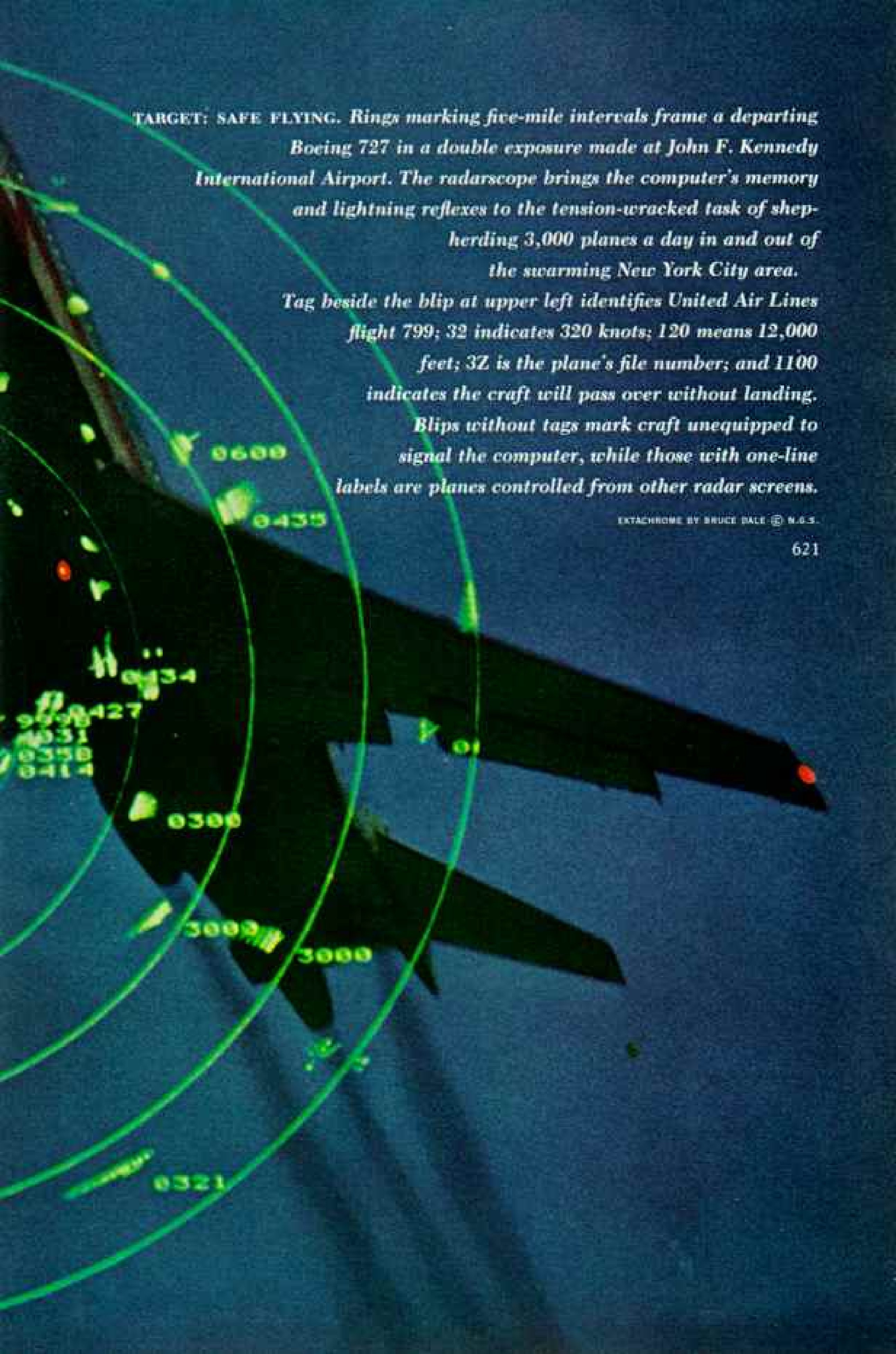
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A radar scope image showing a Boeing 727 and other aircraft tracks. The scope features concentric green circles representing five-mile intervals. A large black silhouette of a Boeing 727 is the central focus, with a red light at its tail. Other aircraft are represented by smaller green blips and tracks, some with numerical labels. The background is a dark blue gradient.

TARGET: SAFE FLYING. Rings marking five-mile intervals frame a departing Boeing 727 in a double exposure made at John F. Kennedy International Airport. The radarscope brings the computer's memory and lightning reflexes to the tension-wracked task of shepherding 3,000 planes a day in and out of the swarming New York City area.

Tag beside the blip at upper left identifies United Air Lines flight 799; 32 indicates 320 knots; 120 means 12,000 feet; 3Z is the plane's file number; and 1100 indicates the craft will pass over without landing.

Blips without tags mark craft unequipped to signal the computer, while those with one-line labels are planes controlled from other radar screens.

EXTACHROME BY BRUCE DALE © N.C.S.

seat, six-way power-adjustable seat; eight types of steering wheels. . . . The computer arranges for the right parts to reach the right assembly-line station at just the right moment.

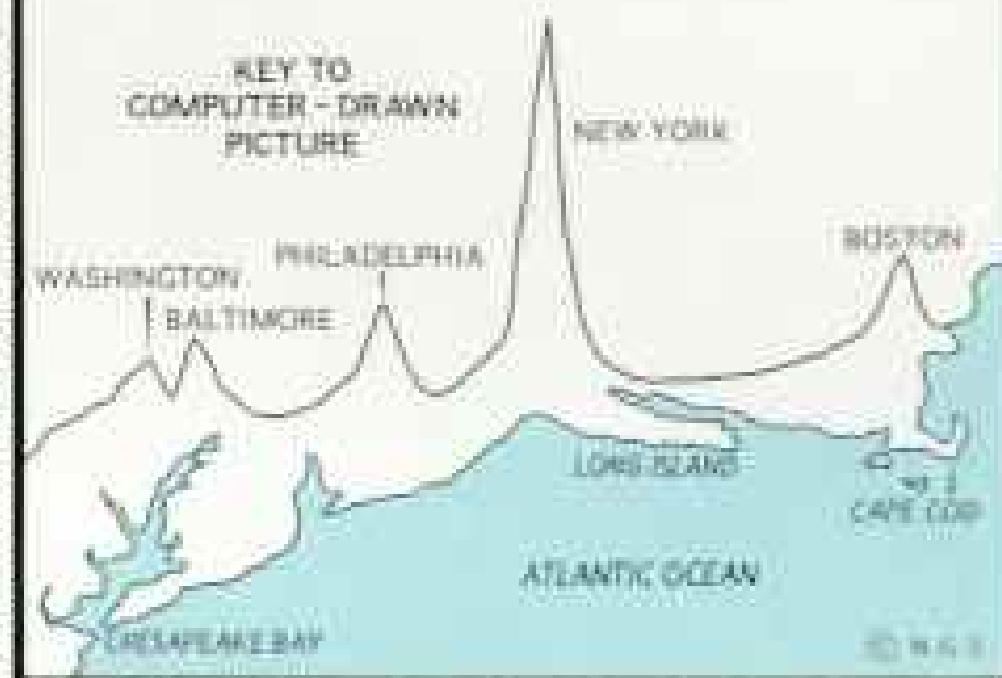
How many 1970 Oldsmobiles could conceivably be made here, without any being exactly like the other? The programmer winces; not every option can go into every model. He takes eight hours to prepare a program, and 18 seconds of computer time. The answer is 61,758,733,548,151,070,414.

What else lies ahead? A lot of computerized paying of bills. Say you keep an account in the bank and make a purchase in a shoe store. The clerk takes your bank credit card, inserts it into an attachment on his Touch-Tone telephone, and punches in the amount. The bank automatically deducts that from your account, and credits it to the account of the store.

Gas and electric meters will

People-picture of megalopolis

Fed a meal of geography and census figures, a computer prints out a diagram of the northeastern United States showing population densities as mountain peaks (identified in the inset sketch). The graph demonstrates how the computer can transform naked numbers into meaningful displays.



be linked to telephone lines, so that computers read the meters from afar and send out the bills. They could also be connected to banks; customers would then find utility charges on their monthly bank statements.

Your credit card will be truly theft-proof: it'll be your thumb. Computers will soon be programmed to recognize fingerprints rapidly. Eventually, when a state trooper stops a suspect, he may ask the man to put his thumb on a little screen in the patrol car—for instant scanning by the FBI computer in Washington.

Perhaps someday the desk worker fed up with traffic jams in the city will do his job at a computer input-output station at home: If he wants to see documents from company files, he punches his keyboard and they appear on his display screen. If he needs a copy, he presses a button and there it is, on paper.

If he wants to confer with colleagues, he presses buttons, and they appear on the screen too. To dictate a letter, he punches up his secretary, at her office desk or at her terminal in her home. She'll type it on her keyboard—and the text will emerge in the downtown office, to go into the files and into the mail. Or she'll send electronic impulses directly to the company addressed—into their computer.

How soon could computer use from home be upon us? Among 85 leading technical experts asked, the majority say within a decade. But it's not only a question of technology. It is

also a question of economic practicality, and I trust no predictions on that.

On the other hand, computer technology may yet outstrip the experts' expectations. Computer performance, in terms of capacity and operating speed, continues to grow by a factor of ten every two and a half to three years. Had the speed of manned flight increased at such a rate, an astronaut could have orbited the earth nine years after Orville Wright wobbled aloft at Kitty Hawk.

The fact is that the first "electronic digital computer, with a variable program stored in its memory"—to use a proper definition—was not in operation until 1950. At present some 70,000 are in use in the United States and another 20,000 abroad, chiefly in Europe and Japan. Technologically, 99 percent of these computers are obsolescent, and even engineers are awed by what is already being tested.

For data storage, not magnetic tape but holograms, or laser pictures.* For processing, not wires for electronic impulses to travel in, but laser beams. Not a million processing steps per second, but a billion per second.

Such advances permit vastly increased amounts of data storage. Such speeds will enable a computer to serve hundreds or thousands of users and still respond as rapidly as it now serves 30. Those machines might cost a lot more, but their output, unit by unit, will

*See "The Laser's Bright Magic," by Thomas Meloy, NATIONAL GEOGRAPHIC, December 1966.

become cheaper. Many new applications will be economically feasible.

And so I may yet have a chance to sit home and punch my push-button telephone to ask a computer for the best car route to the beach on Labor Day, and see the directions spelled out on my TV screen. Or see my wife pushing those buttons to order bargains from the department stores, with the charges automatically deducted from my bank balance—without mistakes! But to extend such services to millions of households might put such stress on the telephone network that it would have to be rebuilt, a matter of a decade at least.

Biggest Computer Grows in Pennsylvania

Architect of what may become the most powerful computer yet is Dr. Daniel L. Slotnick of the University of Illinois in Urbana. Here was brought forth one of the classic computers, the first ILLIAC, in 1952. Dr. Slotnick's baby is the ILLIAC IV, being built in Paoli, Pennsylvania (page 631). Would it really equal the capacity of all other computers in the world combined?

"That would be one hellish calculation," said Dr. Slotnick, "but it's probably not far from right."

Marvelous, 256 processing elements, a billion operations per second. Who needs all this computer power? The U. S. Atomic Energy Commission, for one. It seeks the biggest and most advanced computers, to design nuclear



EXTRACHROME (RIGHT) BY BRUCE DALE;
KODACHROMES BY EMERY KRISTOF © N.A.S.

Working on the railroad . . .

Golden strands in the glint of sunset, steel tracks of the Santa Fe railway lace an electronic switching yard in Kansas City, Kansas. The tracks fan

out from the hump, an incline that feeds cars onto the proper tracks for assembly into trains. Once the domain of the switchman, such yards today take orders from computers.

The machine stores in its memory a list of what cars to shunt where. After yard engines have pushed cars up the far side of the hump, the computer activates the proper switches, then brakes the cars for safe link-up.

Yardmaster (far left) will take over at his manual control panel if the computer fails, or if an unidentified car reaches the hump. Railroads also increasingly adopt ACI—Automatic Car Identification—in which a sensing beam reads a moving freight car's coded label (left).







RETRACED BY BRUCE SALT (ABOVE) AND JOHN LARSON, BLACK STAR © N.S.S.

... and for defense

Deep inside a Colorado mountain, an officer of NORAD—the North American Air Defense Command—scans the orbital path of a Russian Cosmos satellite. Glowing buttons offer an array of computer-generated displays. Here the United States and Canada sift reports from a worldwide network of sensors to track hundreds of aircraft simultaneously, along with every man-made object in earth orbit. Whenever a rocket is launched from the U.S.S.R., a NORAD computer calculates its course, to learn if an attack is imminent.



weapons and to make calculations for peaceful atomic uses. Could Dr. Slotnick cite a homelier application? He said: "Weather forecasts, one to two weeks ahead, accurate beyond anything now possible. Ideally we'd have readings taken at some 8,000 points around the globe, at 10 levels above each point, and 4 different measurements at each level. Altogether, more than 300,000 measurements. ILLIAC IV could digest all that, fast."

Bigger, faster, increasingly interesting. But as I toured the laboratories, what intrigued me most was the programming done to develop so-called artificial intelligence.

Robots Can "Learn" by Experience

At the Stanford Research Institute in Menlo Park, California, I watched a computerized robot moving about and making decisions on its own, "learning" as it went (page 608). Such machinery, I was told, might precede men in exploring the bottom of the sea, or the planets—their microphone ears hearing things in frequencies humans cannot hear, their television eyes seeing things in the infrared portion of the spectrum. . . .

How does a machine learn? By trial and error.

I had found that out at MIT too—from a 25-year-old Missourian, Richard Greenblatt. He had written a chess-playing program for a computer employed by MIT's artificial-intelligence team.

"In any given situation, some moves look more promising than others," he said. He drew me a "decision tree," showing various branches, or possible moves.

Having made a losing move, he explained, the program will clip off that branch. And so it will sooner or later wind up with the optimum path. "Now I don't feed in moves any more," he said, "I feed in principles. The learning process is already built in. While it's playing, I don't feed in anything, of course."

In 1967 this had become the first computer to win a tournament game. Now its official rating was close to the median for tournament players in the United States.

Could I play?

"Sure," said Richard. "We had a professor here the other day who said computers can't think. It beat him."

It beat me too, with its tenth move. Could I take my last move back, and play on?

We went to twenty moves, to thirty. More

and more young men gathered around. Forty moves, fifty. I got out of a trap rather elegantly, I thought. I looked around and was surprised. Why was everybody rooting against me?

Queen from Queen's Bishop 8 to King's Rook 8! The machine had nailed me with its fifty-ninth move. There was a great sigh of relief. Richard said, "You lasted longer than most people who come in here."

His program can be adjusted to look two moves ahead, or four, or six. It cannot possibly look ahead to the outcome of all possible moves—that would be a number with more than a hundred digits. No computer envisioned today would be capable of such a thing.

But the thought of things that computers may do before long gave me pause. Says Dr. Herbert Grosch, a senior researcher in the Center for Computer Sciences and Technology at the National Bureau of Standards:

"Many machines now can derive totally unexpected information through procedures the builder cannot fully predict. An advanced machine, programmed to evaluate its own performance by given criteria, may determine that some criteria are worthless and others more important than indicated in the initial programming. The human programmer has no way of knowing about these shifts in criteria values. He only knows that he gave the machine the capacity to make them."

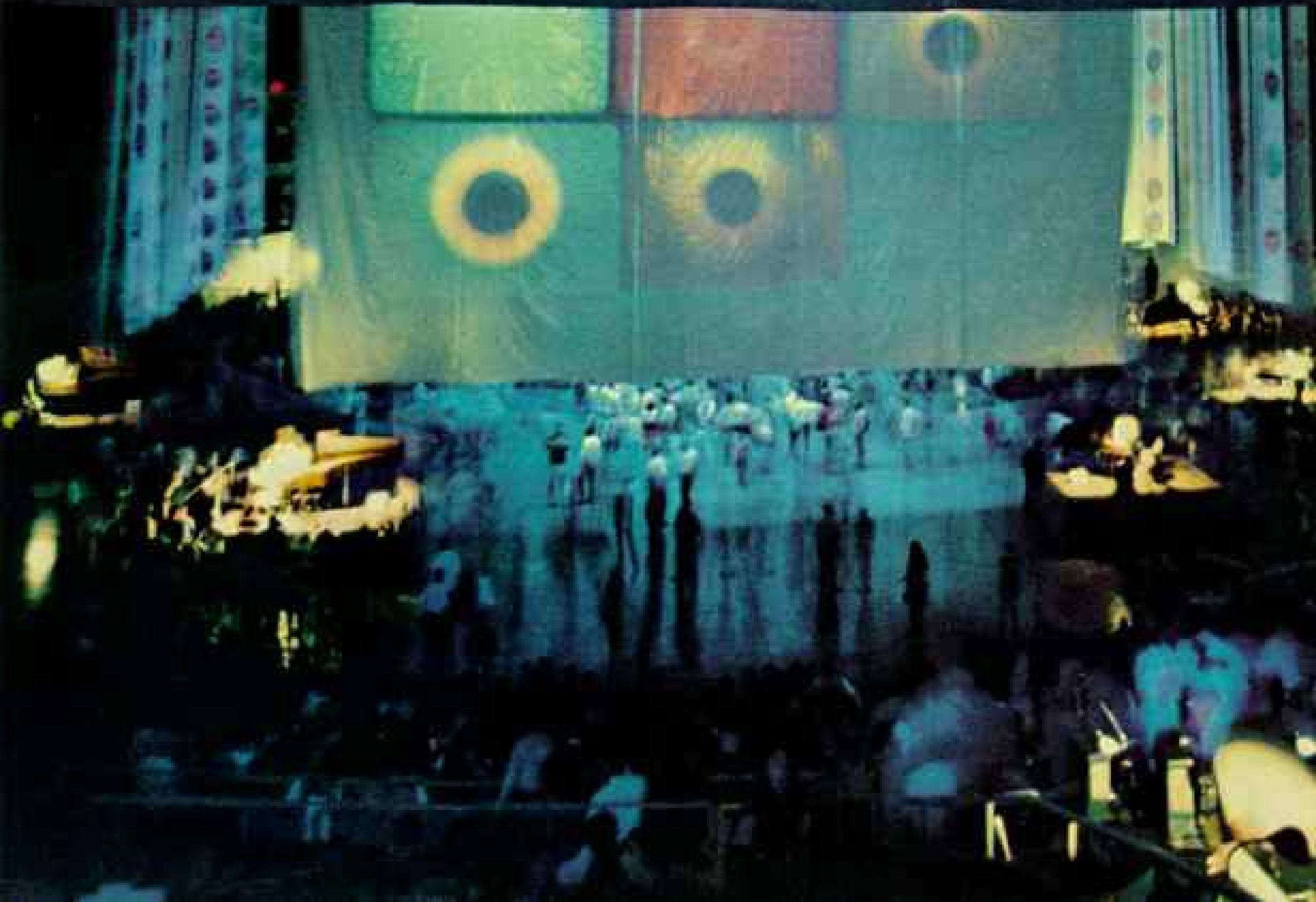
Computers May Act on Moral Values

Even today's computer technology—primitive in view of what is likely to come—permits the design of machines that adapt to a changing environment, repair themselves, and make new parts as needed. Moreover, serious men with impressive credentials in data processing do not think it at all unlikely that someday computers, supplied with feelings and even moral values, will make decisions based on those feelings and values, as well as on what their sensors perceive.

Right now there is growing concern that computer technology can damage individuals, and curtail the personal liberties of all.

U. S. Senator William Proxmire of Wisconsin warns that as credit-bureau files on some 120 million Americans are computerized, and linked into nationwide data banks, questionable information and data-processing errors are traveling faster and farther than ever.

"You could lose your credit, your insurance, even your job, because of such an error in a





EXTRACHROMES BY BRUCE DALE © N.G.S.

Students swing to machine-made sound

Like the inside of a gigantic jukebox (left), the University of Illinois Assembly Hall churns with garish lighting during a five-hour marathon of computer-created music. Presented by composers John Cage and Lejaren Hiller, the concert features the din of 51 loudspeakers pouring out notes that were both scored and taped by machines. Seven harpsichordists simultaneously played computer-written music.

One listener lies trancelike in a blur of swirling comrades (above); slide displays enthrall others (below).



The master file . . . A worker gathers reels of magnetic tape in the computer library of the Social Security Administration in Baltimore, Maryland. The tapes will go into one of the daily computer runs that calculate payments and keep up records on the 193,000,000

people who hold or have held Social Security numbers. Each capable of recording a maximum of 1,600 magnetized spots to the inch and stretching 2,400 feet, the agency's 170,000 tapes make up one of the world's largest collections of computerized information.



EXTRAORDINARY (ABOVE) AND ORDINARY (BY BRUCE DALL) © R.A.L.

credit-bureau file. You say, 'Not a chance in my case.' Don't be so sure; it has happened."

The National Academy of Sciences, mindful of computerized data banks being set up at every level of government, is sponsoring a nationwide study of the problems thus posed for individual privacy and due process of law.

How does a citizen know what information about him is going into a data bank? He doesn't know. Some is highly personal. Say you want to buy a house and apply to the Federal Housing Administration for a federally guaranteed loan. Your file will contain a credit-bureau investigator's report of whether your marriage is in trouble—because, says FHA, divorce is a leading cause for defaulting on housing loans, and what's wrong with weeding out the worst of the poor risks?

What if in the future FHA should exchange tapes with other agencies, as has been suggested? Then somebody else's idea of your

domestic life might be all over the place.

How could you correct inaccurate information about you once it was in the government data banks? As things stand now, you couldn't. An error in a personnel file, put in from some extraneous tape, could cost a civil servant a promotion. Or keep a man from getting a job. Chances are he would never know why.

Machines Hold Power for Evil and Good

Directing the Academy of Science's study is Alan F. Westin, Professor of Public Law and Government at Columbia University. He says: "Man has progressed over the centuries from the status of a subject of a ruler to that of a citizen in a constitutional state. We must be careful to avert a situation in which the press of government for systematic information and the powerful technology of computers reverse this historical process in the second half of the 20th century, making us 'subjects'

... and the "wizard"

ILLIAC IV, when completed, will perform a billion operations a second and may rival in capacity all other computers combined. Here an engineer checks function lights of a 60-foot-long section at the Burroughs Corporation in

Paoli, Pennsylvania, where three years have gone into its engineering. The 25-million-dollar machine may produce highly accurate long-range weather forecasts, a task involving torrents of data and variables that would overwhelm present-day computers.



again." He adds, "Perhaps the greatest legal device to facilitate the movement from subject to citizen in England was the writ of habeas corpus—the command issued by the courts to the Crown to produce the body of the person being held, and to justify his imprisonment.

"Perhaps what we need now is a kind of writ of 'habeas data'—commanding government and powerful private organizations to produce the data they have collected and are using to make judgments about an individual, and to justify their using it."

What if computer-equipped authority, insufficiently restrained, should turn hyper-inquisitive someday? If every purchase one makes, down to the last 10-cent newspaper, is recorded by a computer, showing where it was made and at what time; if millions of telephone conversations can not only be recorded daily but instantly scanned to pick

out key words considered alarming by the surveillance officers. . . . The implications surpass the horrors of George Orwell's *1984*.

Dr. Jerome B. Wiesner, Provost of MIT, has said that the computer's potential for good, and the danger inherent in its misuse, exceed our ability to imagine. Wouldn't that be the worst it could do—to become an instrument of tyranny, propelling mankind into a new Dark Age?

Flying north over the snowy fields of New England, I thought of the best it might do. It might induce men to take a fresh look at the world. Let's call this the systems view, and let me explain how it was explained to me.

To make a useful computer model of a complicated process at work, one must first gather a mass of facts about that process. About the life cycle of the lobster. About the growth and decay of the cities. About the dynamics of the American economy, for the

model now being built for the governors of the Federal Reserve System.

The finished model should help one decide what to do if one wants more lobsters, or healthier cities, or a healthier economy. But the greatest value of the model lies not in such specific guidance, but in the insight one gains in making the model, in what one learns while going after the factors that make up a complicated, ever-changing process.

In short, the common way of thinking in terms of simple cause and effect—the Newtonian, mechanistic view—is replaced by new awareness: of many causes, constantly producing varied effects, in what really are highly complicated and dynamic systems.

My little boy gets into trouble in kindergarten. There's rioting in Chicago, a coup d'etat in Cambodia. I used to have pretty

simple explanations for these occurrences. But no more.

It looks as if computers will become so common, so taken for granted, that we no longer will talk much about computers but rather about computing, in the sense that we no longer talk as much about automobiles as we talk about driving somewhere. When that day arrives, when we see the world in terms of systems, we may discover that an intellectual revolution has come, comparable to those wrought by Galileo and Darwin.

I landed at Hanover in New Hampshire, drove once more to Dartmouth, and found that this revolution may be closer at hand than I had thought.

Dr. John G. Kemeny (page 598), the mathematician who earlier this year became Dartmouth's thirteenth president, has a computer



Push-button

world Object of endless spoofing (right), the computer nevertheless stands secure as a shaper of the future. One glimpse ahead can be seen at the Kiewit Computation Center at Dartmouth College, where students fill computer terminal stalls. Because Dartmouth shares its facilities with other schools, the pupils represent all ages and confront the computer with questions involving everything from physics and mathematics to computerized checker games and the odds on the next football game. Thus youths acquire "hands-on" experience with the most amazing machines ever built.

ILLUSTRATION BY ENOCH KRISTOF © R.S.S.



"I have to leave the room. Which button do I press?"



terminal in his office, near a bust of Einstein, whose assistant he was. He told me:

"Nine out of ten of our undergraduates sit down at a computer terminal as naturally as they would go to the library to look up something in a book. Our freshmen start writing programs after two one-hour lectures. We don't teach them about computers, we teach habits of inquiry."

Snoopy Emerges From a Computer

That evening on campus, in the Kiewit Computation Center (left), ten of the sixteen terminals were occupied.

One sophomore had a girl with him. He was running a program printing out a picture made up of teletypewriter characters, a picture of the dog Snoopy.

"It snows your date," said a freshman. He was modeling a course for an Apollo flight.

Another worked on a Physics I problem, to see what would happen if another moon entered earth's orbit and crashed with the one already there. No, he didn't know much math, he was planning to major in English. But here he was, crashing moons around.

Said a professor, "Once the kids get their hands on the thing like that, they're no longer in awe of it. And they learn how enormously they can increase their powers."

Tens of thousands of kids, perhaps hundreds of thousands, will get their hands on the thing within one generation. I'll be awfully curious to see what they'll do with it.

THE END



Akhenaten basks in the benevolent rays of the Aten—the sun god—on a block from

Computer Helps Scholars

By RAY WINFIELD SMITH *Illustrations by*

THIRTY-THREE CENTURIES AGO, at Karnak on the east bank of the Nile, a great temple rose—a vast complex of structures that may have extended more than a mile into the desert.

Built by the revolutionary pharaoh Amenophis IV, who later changed his name to Akhenaten, the temple stood complete for little more than two decades. Then it vanished, razed and cannibalized as a source of stone for succeeding monuments, some of which are still standing.

My good fortune has been to direct an

intriguing research program that has succeeded in reconstructing on paper much of the actual appearance of this remarkable building. We have based our work upon more than 35,000 of the temple's decorated sandstone blocks, stacked away over the years in storehouses and in the open, after excavators and restorers retrieved them while working on other projects. Some were located as far away as Europe and even the United States.

Through photography of the relief-carved faces of these blocks, and with the aid of a computer, we have matched thousands of



RECREATED BY EMORY KRISTOF © N.G.S.

the Pharaoh's long-dismantled temple – “world's largest jigsaw puzzle” (pages 642-3).

Re-create an Egyptian Temple

National Geographic Photographer EMORY KRISTOF

stones and have seen superb works of art take form again after thousands of years. We have been able to re-create, on paper, a pillared courtyard sumptuously embellished and dedicated exclusively to Akhenaten's consort, the proud Queen Nefertiti, a woman who inspires worldwide fascination even in our day. Her courtyard is a ceremonial structure I believe to be unique in the history of Egyptology.

The inception of the Akhenaten Temple Project goes back to 1965, when the late Dr. William Stevenson Smith, a distinguished scholar from Boston, came to the United Arab

Republic. Bill wanted to examine a single block that had captured his interest years earlier, and I went along with him to Karnak.

The Nile that blazing day flowed blue and serene past Karnak's templed shore. Stepping down from the horse-drawn carriage that had brought us from Luxor, Bill and I walked past columns, pylons, and sculptured walls, some of the noblest relics of ancient Egypt's Age of Empire (pages 636-7 and 652).

There was nothing in that bright spring morning to hint that this royal seat of pharaohs was about to confront me with the

Rubble of yesteryear's glory lies in orderly ranks beside the still-splendid Temple of Luxor. More than 3,300 years ago many of these blocks were part of a temple built by Akhenaten to honor the Aten—the sun—proclaimed by him as the supreme god.

In 1965 the author determined to reconstruct this magnificent structure—on paper. Aided by your Society and the Smithsonian Institution, he and his Akhenaten Temple Project team have located and photographed 35,000 decorated blocks. Using a Space Age computer, they are re-creating pictorially much of this great monument—estimated to have approached a mile in length, with its interior walls, chambers, and enclosures decorated with a thousand scenes.

greatest challenge of my life—one that would lead me to startling conclusions about the age of Akhenaten (pronounced Ahk-en-AH-ten).

We stopped at the door of a low storehouse. Wiping his damp forehead with a sleeve, an Antiquities Department deputy used an iron spike to twist and break the seals.

The door swung open. From the dim interior, heat as from an oven blasted us.

Row upon row of blocks, neatly stacked nine high, reached into the gloom. Each block measured only about 2 feet long and 10 inches high and wide—small enough for a man to lift and carry. (Later, we found a special group of blocks that had been trimmed to a thickness of about seven inches.)

I scanned the relief-cut and paint-flecked fronts of the blocks. Much of the decoration was exquisite: parts of chariots, fragmentary scenes of animal sacrifice, hands strumming instruments, the proud tilt of a queen's head.

Computer the Key to a Challenging Task

"How many blocks are we looking at?" I asked, recovering from surprise.

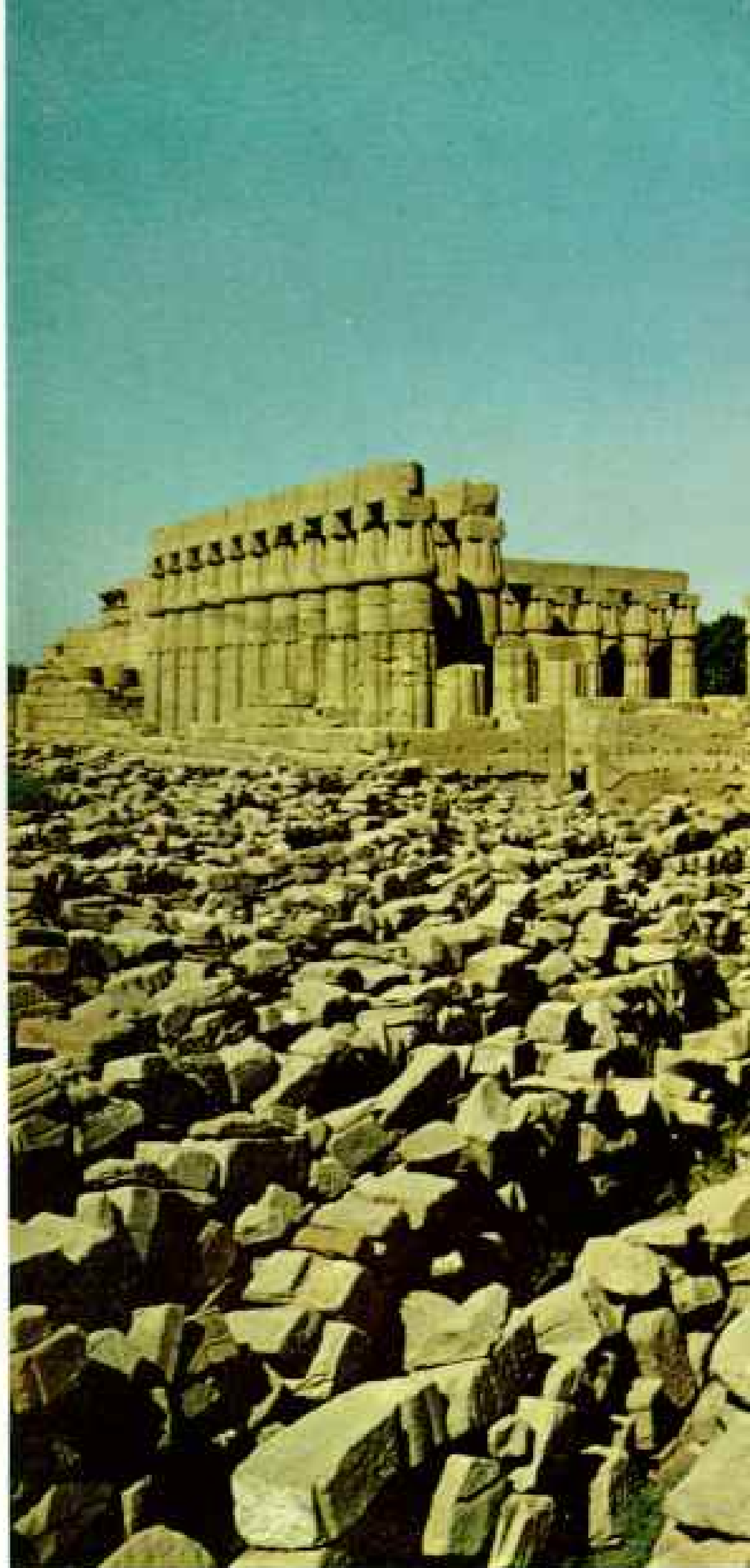
"About 16,000—some of the remains of the great temple built here by Amenophis IV to honor the Aten, the sun's disk," Bill replied.

"Isn't anything going to be done about them?" I asked incredulously.

"Nothing, as far as I know," Bill shrugged. "Oh, I suppose now and then people like me will study the odd block or two."

I was dumbfounded. That such a mine of beauty and historical lore should lie neglected seemed unthinkable.

Returning to Cairo, I sought out my friend Anwar Shoukry, who at the time was director general of the Antiquities Department, and asked him, "Shouldn't someone undertake



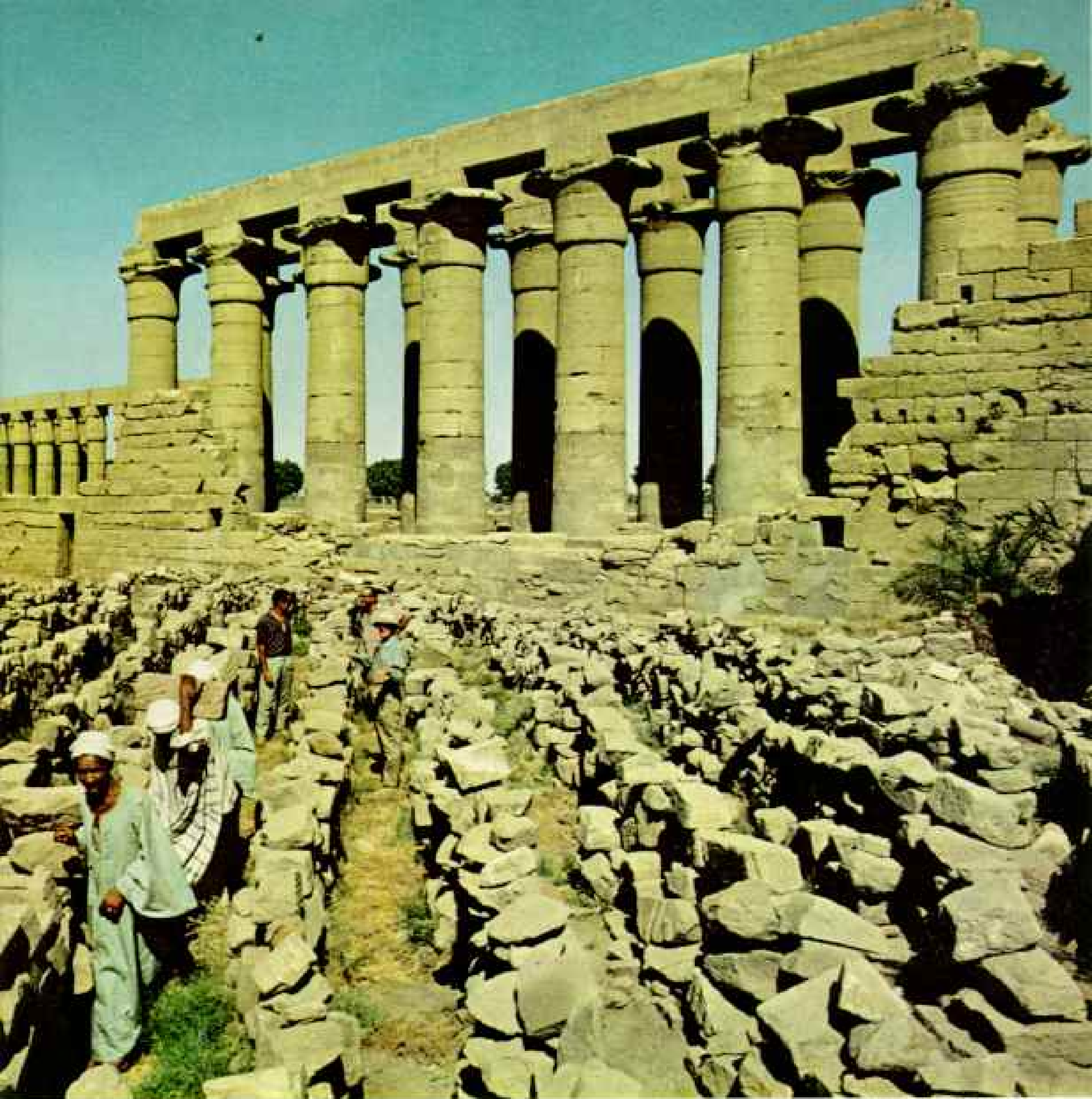
a proper study of those Aten Temple blocks?"

"Why don't you do it?" he suggested.

His confidence was flattering—but was there any practical way to go about the task? Those thousands of scrambled blocks composed the world's biggest and weightiest jigsaw puzzle. How could the pieces be put together again?

An idea struck me. What about photographing the sculptured sides of all those 16,000 stones? By sorting and matching the photographic prints, a great deal should be learned, not only about Akhenaten's long-dismantled temple to the Aten, but also about the strange and paradoxical Pharaoh himself.

I soon hit upon the only way my dream



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could be translated into reality—by enlisting that wizard tool, the electronic computer (see preceding article). A computer surely could “digest” our tally of the minutest details of carving and painting on every block, and on command give back the information to us in a form that would immeasurably speed up—in fact, make possible—matching the stones.

Fortunately a computer was available in Cairo. The International Business Machines Corporation maintains a data center there.

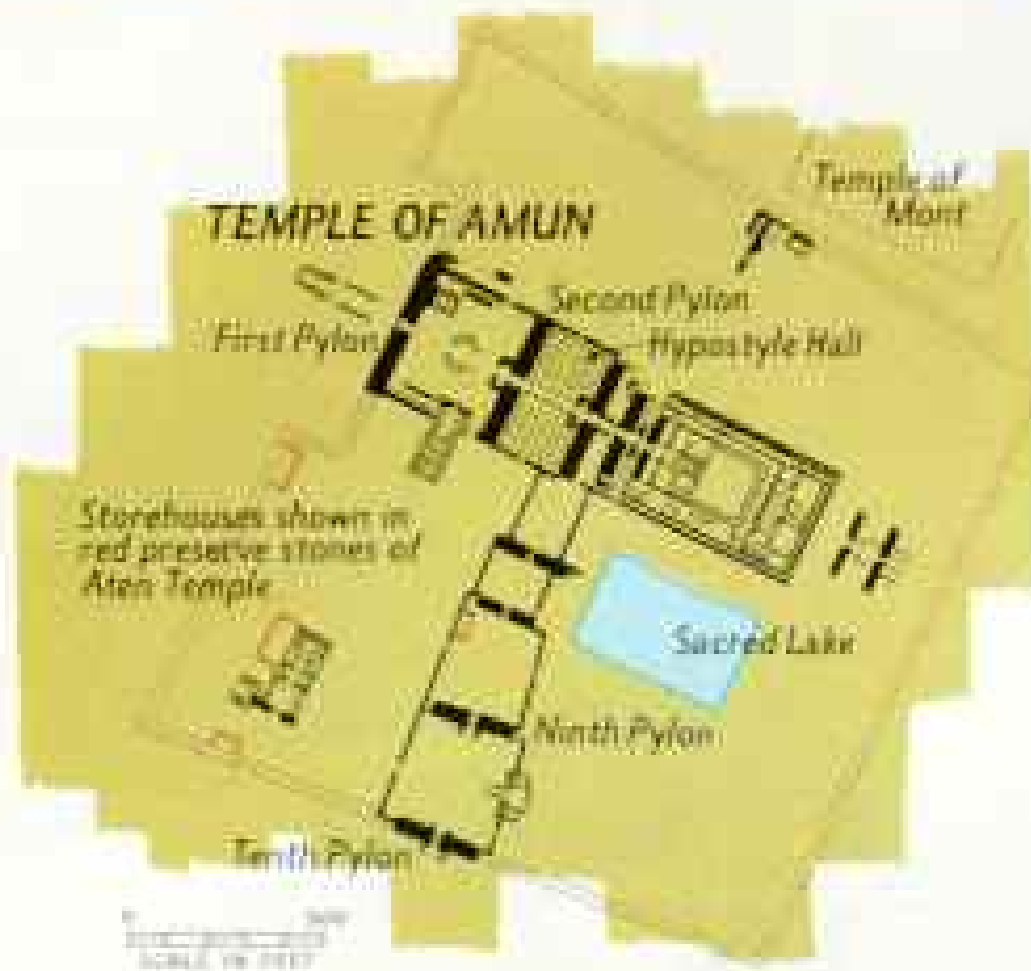
I discussed my plan with the IBM people, who freely offered their expertise. But first I had to find sponsorship and financial support. Fortunately, through my long interest in ancient glass, as student and collector alike, I

was friendly both with Cairo authorities and with American Egyptologists.*

Working funds came in due course from the Foreign Currency Program of the Smithsonian Institution. Payments were made through my institutional sponsor, the University Museum of the University of Pennsylvania, where I am a research fellow. Welcome added support came from the National Geographic Society.

I persuaded a Rome-based friend, James Delmege, to supervise photographing the blocks. From the start we had photographic counsel from National Geographic.

*See “History Revealed in Ancient Glass,” by Ray Winfield Smith, *Geographic*, September 1964.



Holy realm of ancient Egypt, the area now known as Thebes blossomed with monuments. The exact location of Akhenaten's temple remains unknown. Many of its stones were re-used for foundations and fill in the monuments of Karnak.



For simplicity and economy we used black-and-white film, but one of our staff always was on hand to record for each carved block the most minute details of colors still clinging to costumes, flesh, jewelry, flowers, animals.

For our analysis and matching program, I found a Cairo office and assembled a staff. Nearly all those enlisted were graduates in Egyptology from the University of Cairo.*

We set to work. James Delmege aimed his lenses first at blocks in Karnak's largest storehouse. On a good day, Jim and his helpers could photograph about 400.

None of us will ever forget the thrill when we achieved our first match of two Aten Temple blocks. I was in the office when Asmahan Shoucri (page 642), an attractive young woman with three school-age children, cried out with an exclamation of delight. She had seen that photoprints of two blocks fitted to form part of a scene showing sunrays and a hieroglyph. Most auspiciously, the inscription said, "The god's heart is pleased."

Akhenaten Challenged Even the Gods

What rewards warranted this elaborate effort to let these temple stones speak once more to men, after so many centuries of silence?

The challenge lay in the complex personality and unorthodox goals of Akhenaten, whom the American Egyptologist James H. Breasted termed "the world's first idealist . . . the earliest monotheist, and the first prophet of internationalism—the most remarkable figure of the Ancient World before the Hebrews."

Then, too, we shared the common curiosity about the eccentric king's marriage to Nefertiti, that symbol of queenly pride and beauty.

The Egyptian empire was still in its golden age in the 14th century B.C., when Amenophis III turned over control of Egypt to his son. The new ruler may well have been still in his teens.

Though the son, Amenophis IV, apparently possessed a brilliant and decisive mind, his

*An international group of Egyptologists collaborated in the Akhenaten Temple Project. Without the enthusiastic support of Dr. Sarwat Okasha, Minister of Culture in the United Arab Republic, and Dr. Gamal Mukhtar, Under-Secretary of Culture, the effort could not have succeeded. Dr. Charles F. Nims, Professor of Egyptology at the Oriental Institute of the University of Chicago, provided expert counsel as Resident Egyptologist. Prime consultants included John A. Wilson, Professor Emeritus at the Oriental Institute, Dr. Herbert Rieke, Director of the Swiss Archaeological Institute in Cairo, and Professor Abdel Moneim Abu-Bakr, former head of the Egyptology Department of the University of Cairo. Other distinguished scholars, too numerous to mention individually, afforded invaluable advice and assistance.

body may have been grossly misshapen, owing to some physical disorder. Reliefs and statues often give him a thin face and hatchet chin, thick lips, a large head, and heavy hips and thighs atop spindly legs (page 653). Other art depicts him as more normal in appearance.

About the time of his accession, perhaps when no older than 16, the future ruler married Nefertiti, whose name meant "The Beautiful One Is Come." One of the six daughters of this union would wed Tutankhamun, tenant after death of the fabulous tomb discovered in 1922 in the Valley of the Kings.*

Cautiously, even hesitantly at first, but then with swiftly surging authority, the new Pharaoh wielded his power to overthrow Amun, symbolic god-ruler of Egypt's pantheon. In

*See "Tutankhamun's Golden Trove," by Christiane Desmiches Noblecourt, *GEOGRAPHIC*, October 1963.

Amun's place he elevated the Aten, the sun's disk, to the rank of primary deity—and established a worship that was in effect the world's first single-god religion.

By the sixth year of his rule Amenophis IV took a second dramatic step—he changed his name to Akhenaten, probably meaning "He Who Serves the Aten."

Mystery Veils Pharaoh's Move to Amarna

Early in his reign the Pharaoh built the great temple complex at Karnak that yielded the blocks we are studying. But then, at about the time he changed his name, the god-king moved his residence from the ancient capital that included Karnak and Luxor.

With astonishing speed he erected a new city, complete with luxurious palaces, public buildings, and another Great Temple, 240

First step in assembling the gigantic puzzle—photographing the blocks. Man at left makes sure each one is recorded from precisely the same distance and angle to ensure uniform scale of the pictures. Despite the stifling heat in the Karnak storehouses (center map, opposite page), where most of the blocks are preserved, the team shot as many as 400 pictures a day. The author stands behind the cameraman.





Hodgepodge of figures, human and animal, rises tier upon tier. Several thousand of these blocks have been recovered from the core of the Ninth Pylon by the Franco-Egyptian Mission during its continuing restoration of Karnak (map, page 638). Some stones bear decorations on a long side, others on an end. The temple was built with alternating rows of these stretchers and headers.

miles down the Nile at Tell el-Amarna (lower map, page 638). He called the new imperial city Akhetaten, "The Horizon of the Aten," to honor his deity.

The reasons for this shift of the seat of power are still obscure. Perhaps it was the only way the new king could escape rigid antagonism from the wealthy and established Amun priesthood.

Absorbed in religious and cultural reforms,



REPRODUCTIONS BY EMURY KRISTOF © N.A.S.

Akhenaten neglected the affairs of empire. Clay tablets found at Amarna—a good part of the official files of the Pharaoh's foreign office at the time—give us many details. Within 15 years of his coronation, Akhenaten witnessed the virtual collapse of his empire. His death, perhaps in his early 30's, followed soon after. The Egyptian court reverted to its traditional polytheism, and the royal headquarters moved back to Thebes.

This was the man whose explosive, controversial career spurred me to comb Karnak and Luxor to find every last possible stone from his dismantled temple. Several storehouses at Karnak housed blocks, and there were thousands more stacked in the open at Luxor (pages 636-7). The Franco-Egyptian Mission at Karnak is still recovering Aten Temple blocks from the core, or interior, of the Ninth Pylon, one of the massive ceremonial gateways—there are ten of them—that add splendor to the Karnak scene.

Worldwide Search for *Talatat*

When the photographic work began, we knew of nearly 30,000 blocks. Karnak workmen traditionally have called them *talatat*, a puzzling designation, for the word is the Arabic collective meaning "threes."

Hundreds of additional blocks had vanished from Karnak and from Egypt as well, spirited out of the country in the illicit trade in antiquities. Following every lead, I have ferreted out many of them in museums and private ownership in Europe and America. I made a special trip to Europe to photograph these sandstone fugitives and to obtain, in some cases, photographs of blocks known to have been in Europe but now untraceable.

How was it possible to match blocks that had been photographed at different times in areas miles—or thousands of miles—apart?

This is where the computer proved its worth. To each block we assigned a nine-digit identification number, and photographed the block with its number. As developed prints poured into our Cairo office, the people there recorded on coding sheets every significant visual detail of every stone. Sent to the IBM center, this information was transferred to punch cards and then to magnetic tape.

From this memory bank, the computer at fantastic speed printed out hundreds of thousands of entries on sheets of paper. By letters and digits across many columns, these computer lists classified distinctive features for each stone.

We used 16 lists, one for each major type of block decoration. There is one list, for instance, for figures (subdivided under kings, queens, princesses, priests, and so forth), another for sunrays, and others for hieroglyphs, and for such categories as architectural details and defacements.

We immediately discovered that the Aten Temple masons had built the walls according to a rigid pattern. They laid up the stones in



ACKNOWLEDGED BY EMORY BRISTOL (ARROWS), JONATHAN S. BLANK (SQUARE), AND EMORY BRISTOL AND SAHED TAWFIK © N.S.S.

Putting the pieces back together



THE AUTHOR'S TEAM begins to match photographs of blocks—a virtually impossible job without a computer. Every conceivable detail—colors of remaining paint, sex, size, and other features of figures, angles of sunrays, hieroglyphs—was fed into an IBM computer in Cairo, which in turn prepared listings of stones with related characteristics.

Mrs. Asmahan Shoucri (above), cutting out blocks from a print, has already matched two stones on the glass plate before her; an enlargement of one rests on the stand. Dr. Sayed Tawfik checks a listing for additional blocks.

One of the first successful matchings, at left, grew into the scene at right,



which began with the header of Akhenaten's right elbow. Next step was to consult the computer list of all blocks with figures of Akhenaten in the proper scale. Possibilities were narrowed by checking for such characteristics as a profile facing left and a cutoff at shoulder height. Thus the numbers identifying one piece out of 35,000 (seen here in the slot of the double ruler at lower left) were located and the block matched to the elbow stone.



alternating rows of headers (small end facing outward) and stretchers (long side out). So we always knew which type of block we sought above or below the one to be matched. To this rule we found one notable exception. In Nefertiti's pillared courtyard, headers appeared only in alternate courses at the corners of the columns.

Actual matching is a painstaking procedure. In one instance, Said Gohary, one of my staff, wanted to find the match for a block showing Akhenaten's right elbow. He "asked" the computer for the numbers of all blocks with king figures in the required scale. This produced 218 print numbers. Knowing from earlier examples several other features that had to be present in the sought-after stone, Said scanned the column entries on the appropriate list, and quickly narrowed the choice to a single block (preceding pages).

Bringing the paired prints triumphantly to my office, Said was so excited he tripped over the threshold!

Where at Karnak had the Aten Temple stood? The question persistently arises, but as yet there is no definite answer.

Less than a hundred yards eastward from the eastern gate of the Temple of Amun, early explorers found the bases of 27 more-than-life-size statues of Akhenaten ranged around the southwest corner of an area presumed by some archeologists to have been within the Aten Temple. If so, part of the temple may have occupied the area north of the statues.

I suspect, instead, that the temple extended east of the statues (upper map, page 638). Perhaps remains of the foundation will be found sometime under a neighboring village and the fields beyond it.

After Akhenaten's death the Aten Temple at Karnak was cannibalized for new monuments. Smenkhkare may have reigned briefly after Akhenaten. Then, following the reigns of Tutankhamun and Ay,

the commoner Horemheb became king. He sought by every means to erase memories of the Aten and its royal sponsor.

Horemheb built the mighty Second Pylon, now partly restored to its ancient majesty. Such structures were favored monuments in ancient Egypt. Traditionally a pylon had two wings in the shape of massive truncated pyramids flanking a linteled gateway.

Horemheb used thousands of Aten blocks in foundations and for core stuffing of the Second Pylon. He took pains never to re-use any of the Aten Temple blocks where their decorations could be seen.

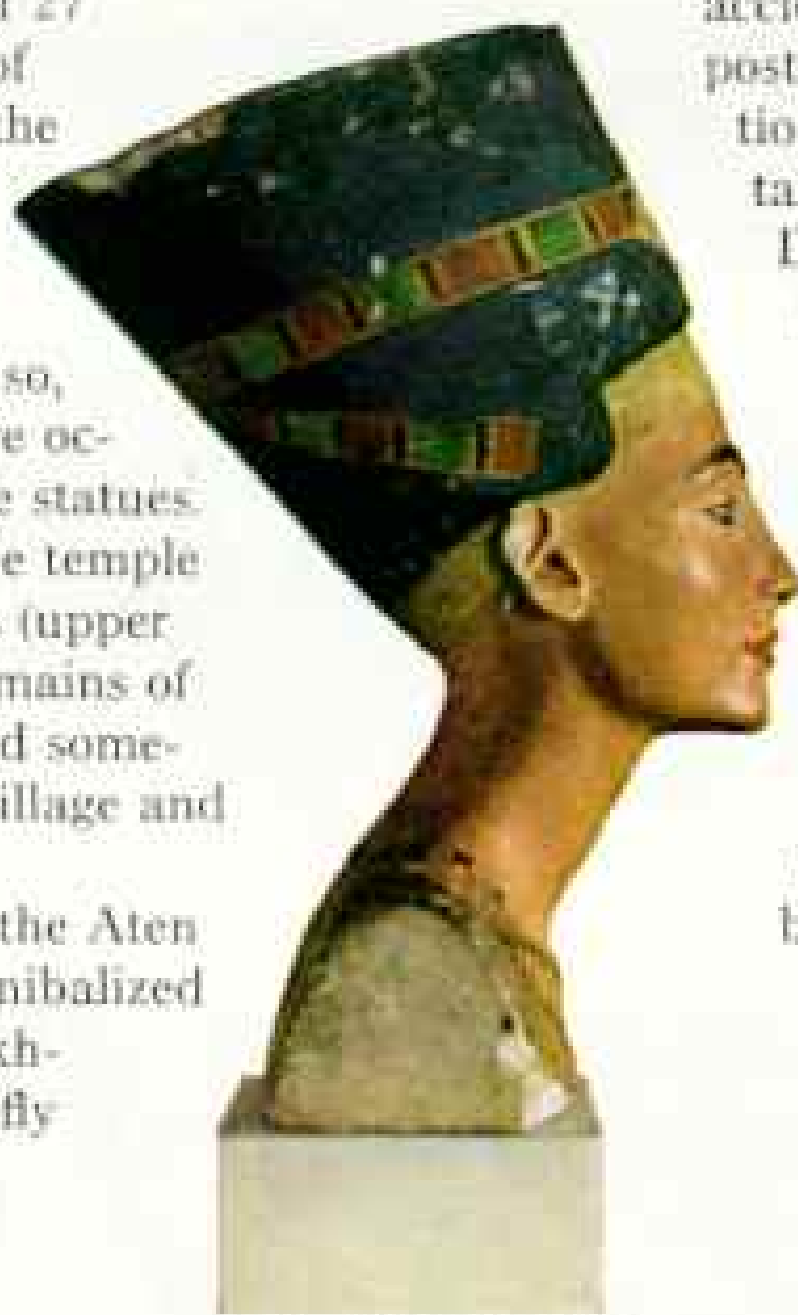
Nearly 33 centuries later, a Frenchman, Henri Chevrier, partly redressed the despoliation of the Aten Temple. The Egyptians in 1926 put Chevrier in charge of excavation and reconstruction at Karnak, and it was he who brought to light most of the Aten Temple blocks, as well as many fragments of the 27 statues.

Chevrier is still living, and I have the pleasure of his friendship. When I recently visited him in his Paris apartment, his eyes lit up on hearing of our present effort to reconstruct the Aten Temple through photographs.

Chevrier, to be sure, came upon the talatat accidentally. He found them in post-Akhenaten column foundations and in pylons he had undertaken to restore.

Dismantling the Second Pylon, grievously damaged by earthquake or ground subsidence, Chevrier found its great store of Aten Temple blocks. Some of them had been combined into seven puzzling structures which Chevrier called altars. Under our photographic analysis, they turned out not to be altars at all but parts of a unique ceremonial enclosure.

Several of the strange assemblages awaited our scrutiny in an outdoor storage area. They were square, almost six feet on a side, and as much



EGYPTIAN MUSEUM, WEST BERLIN

"The Beautiful One Is Come." Thus translates the name of the fascinating Nefertiti, Akhenaten's wife, who was worshiped as a goddess. The famous bust of the queen (above), breathtaking in its realism, proclaims her loveliness to the modern world. Distortion—virtual caricature—characterizes other art of the Pharaoh's time. The temple block at right and another shown on the cover exaggerate Nefertiti's delicate face and slender neck.



as three feet high. Their exterior blocks were distinctive in having been cut thinner than the other Aten Temple stones.

Chevrier recorded his perplexity at the manner in which Horemheb had buried these mysterious "altars" deep within the Second Pylon. Some came to light under the massive pylon walls. Others were interspersed amid the regular Aten Temple blocks, which filled the pylon core like dominoes in a box.

To Chevrier's amazement, some of the "altars" had been carefully turned upside down! He also discovered that the carved human figures—all of which were female—had been mutilated by having their facial features, bodies, and limbs hacked away. Strangest of all, somebody had cut deep slashes across the fingers of human hands with which Akhenaten's artists had terminated the sunrays on his temple reliefs.

Sunrays Help Solve a Puzzle

These sunrays proved the key to identifying the structures. When we followed the angle of convergence of the sunrays, we could pinpoint the position of the sun disks from which they descended, many yards above the still-standing courses of stone. The structures unearthed from the Second Pylon



RECREATING (ARTIST) BY LESLIE GREENER © N.Y.C.

Mortal turned goddess, Nefertiti inspects her monument as masons add finishing touches. Diligent detective work led to knowledge of this pillared courtyard—the most exciting discovery of the project. Careful matching of artistic and architectural elements of the blocks enabled the author to direct artist Leslie Greener in re-creating the colorful columns, decorated exclusively with female figures.

Scenes of Nefertiti facing herself across an offering table, endlessly repeated, embellish the outer faces. The other three sides portray the queen being blessed by the Aten's rays, each terminating in a hand.

The block above, showing one of the queen's daughters, may have been part of one of the multiple outer scenes.



LESLIE GREENER



could only be slices removed from soaring pillars.

Soon we found, scattered through our thousands of talatat photographs, numerous blocks identifiable as components of pillars. We now have matched hundreds of such stones, enough to confirm that at least 28 pillars must have stood in the courtyard of our temple.

Decorations on the pillars consisted exclusively of likenesses of Queen Nefertiti and her princesses. These figures—scores and scores of them—composed an extravagant and splendid exaltation of femininity. The pillars of this particular courtyard bore not a single figure of Akhenaten, nor even any inscriptional mention of him. In fact, nothing masculine—not a courtier, a fan-bearer, or even a male animal—appears on the pillar blocks.

Nefertiti a Power Behind the Throne?

Eventually we were able to establish the dimensions and placement of the pillars. Our Cairo team labored long and patiently to document the painting on the preceding pages. Artist Leslie Greener has re-created the moment when Nefertiti first visited the magnificent pillared courtyard that had been erected in her honor.

We are compelled to reappraise the stature of Nefertiti. We believe that, while still in her teens, she was recognized with a large courtyard dedicated exclusively to her person and containing no hint of the existence of her Pharaoh husband. Such a tribute, to our knowledge, was never accorded any other Egyptian queen, before or after Nefertiti.

There is strong evidence that Nefertiti held divine status at an early age. Prayers were addressed to her, indicating that people believed she had the power of granting human requests. Even her nurse, Tey, was called "the great nurse, the governess of the goddess."

With intellect to match her beauty, may not Nefertiti conceivably have been a power behind the throne? I am confident that our work will advance this speculation.

Studying the blocks from Nefertiti's courtyard, we noticed that defacements were concentrated on blocks in the Chevrier structures. Rarely did we find defacements on other pillar blocks.

As Akhenaten's army commander, Horemheb must have worshiped the Aten. Later, as ruler of all Egypt, he probably suffered embarrassment about this religious background. We believe that, to distract attention from his past, he staged in the Second Pylon an ostentatious demonstration of his contempt for the discarded order of things.

Well and good—but why Nefertiti as a victim? On the collapse of the Aten regime a special stigma quite possibly attached to Nefertiti, perhaps even more strongly than to Akhenaten. Some students



Frowning Pharaoh Horemheb (far right) directs the desecration of stones from Nefertiti's courtyard in this painting based on the author's studies. Scratching out the former queen's face and slashing the hands of the Aten, the sun god, precede the ignominious burial of sections from Nefertiti's columns inside the Second Pylon. Horemheb rose to power within 15 years of Akhenaten's death. As a military officer under Akhenaten, he doubtless once worshiped the Aten. Now, with the old gods again in vogue, he may have wished to erase the memory of his early devotion—and express his contempt for the dead queen.



PICTURES BY PETER BIANCHI, NATIONAL GEOGRAPHIC STAFF, AND LESLIE BRECHER © N.G.A.

suggest that Akhenaten weakened, toward the end, in his devotion to the Aten above other gods. Nefertiti perhaps tried to stiffen her husband's backbone.

Evidence of an Act of Revenge

Beyond these reasons, there may have been bad blood between the glamorous queen and lowly Horemheb. He may have suspected her of opposing his rise in influence.

Hence this act of degradation, to show his scorn for the former queen. Perhaps in full view of invited guests, Horemheb supervised his workmen as they obliterated Nefertiti's

likenesses and royal trappings on segments of pillars from her dismantled courtyard. Mutilation of the sunray hands symbolized rejection of the Aten's power (above).

Horemheb's minions thus concealed the blocks in the Second Pylon, perhaps intending to crush Nefertiti symbolically and to inflict on this beautiful creature the indignity of being turned upside down. She was expected to be lost forever from men's sight.

At Akhenaten's royal city at Amarna, archeologists have retrieved enough of palaces, temples, and noblemen's mansions to document the sumptuous scale of royal living.

Zoological gardens, pools, loggias, and sunken gardens, breweries, bakeries, and stables surrounded the god-king. Our temple blocks are confirming that similar luxury cradled Akhenaten and Nefertiti at Karnak.

Amarna, with its wealth of tomb art and inscribed stelae, has given its name to the distinctive style of exaggerated naturalism that is a cultural hallmark of Akhenaten's era. Yet the huge Akhenaten statues found at Karnak, and now the Aten Temple's human figures, prove that traditionalism had yielded to the

distorted "Amarna style" well before the new city was built.

In earlier reigns, Egyptian artists had often depicted other people with their pharaohs' features. However, the bizarre exaggerations of the Amarna style may have reflected Akhenaten's orders, or the artists' desire to flatter their ruler by making the canons of Egyptian art conform to his abnormalities.

The new fashion in sculpture and painting was not exclusive, however. Some craftsmen portrayed their figures in an idealized style,

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Battered blocks hint

Honoring the Aten, a worshiper pours a libation before an offering table; his other hand holds a gift of burning food. Flames arise from bowls of oil on a low table at right. Bases of such tables were found by the thousands at Amarna, the city built by Akhenaten 240 miles north of Thebes.



giving them features of flawless perfection.

As we put flesh on the ghost of a great temple, we are making steady progress toward visualizing as a whole the group of structures that composed this extraordinary edifice.

Thousands of Stones Still Undiscovered

Our photographic files now contain pictures of about 35,000 decorated blocks. A fair guess suggests that less than half the relief-cut talatat that adorned the Aten Temple ever will be available for photography and match-

ing, and that the total of decorated blocks in the temple may have approached 85,000.

Undecorated blocks, probably twice as numerous, we have usually passed by as uninformative. Very likely a quarter of a million decorated and undecorated stones composed the whole Aten Temple complex when first it stood, shining and complete.

Our Egyptologist advisers and I share the opinion that only the interior wall surfaces were decorated. Assuming that the walls generally stood 15 feet high over their total



Original paint still clings to the Pharaoh's face in this block found in the Ninth Pylon. Its location above the ground-water level helped preserve it.

Loping through a field, a female hyena appears in one of the temple's scenes from nature. The animal and her mate, whose haunches and tail can be seen at lower right, were carved by an artist of consummate skill.

REPRODUCED BY EGYPT SOCIETY © 1983

at vanished glories

Sinuuous hands probably belonged to the Pharaoh and his queen, the author believes. The female hand appears in yellow; most of the red paint usually applied to male flesh has vanished. The position of the hands seems to indicate a departure from the formal family portrayals of earlier periods.



length, simple arithmetic suggests a temple complex about a mile long, with more than two miles of sculptured scenes embellishing the pillars, walls of its courtyards, chambers, and sacred enclosures.

Wall scenes that we have reconstructed vary greatly in size, but they seem to have averaged about ten feet in width. Our tally of blocks thus allows us to conjure up an Aten Temple adorned with at least a thousand magnificent scenes!

Carvings Re-create an Eventful Era

The talatat we have already matched compose hundreds of groups, from isolated pairs of blocks up to dramatic photo-mosaics comprising 30 or more stones. As I pore over these exquisite reliefs, I imagine myself carried back to that colorful era.

A peak of pomp early in Akhenaten's reign was the royal jubilee he staged, probably in the fourth year of his rule. I am convinced that he never held another. The Pharaoh's

Aten Temple must have been under construction at the time, and a large number of our talatat are "cutouts" from scenes commemorating that sumptuous ceremony. Panels depicting religious homage are interspersed with carnival highlights—musicians, dancing girls, and wrestling matches.

Perhaps a year or two later, when Akhenaten and Queen Nefertiti made their first royal review of the completed Aten Temple, an air of festivity and loyal adulation must have greeted the couple. The scene surely was one of extravagant display. Elaborately prepared foods—fruit, ducks, haunches of game, rich confections—were laid out on row upon row of offering tables to honor the Aten and his earthly representative. Hordes of citizens of high and lowly rank must have cheered the god-king's progress.

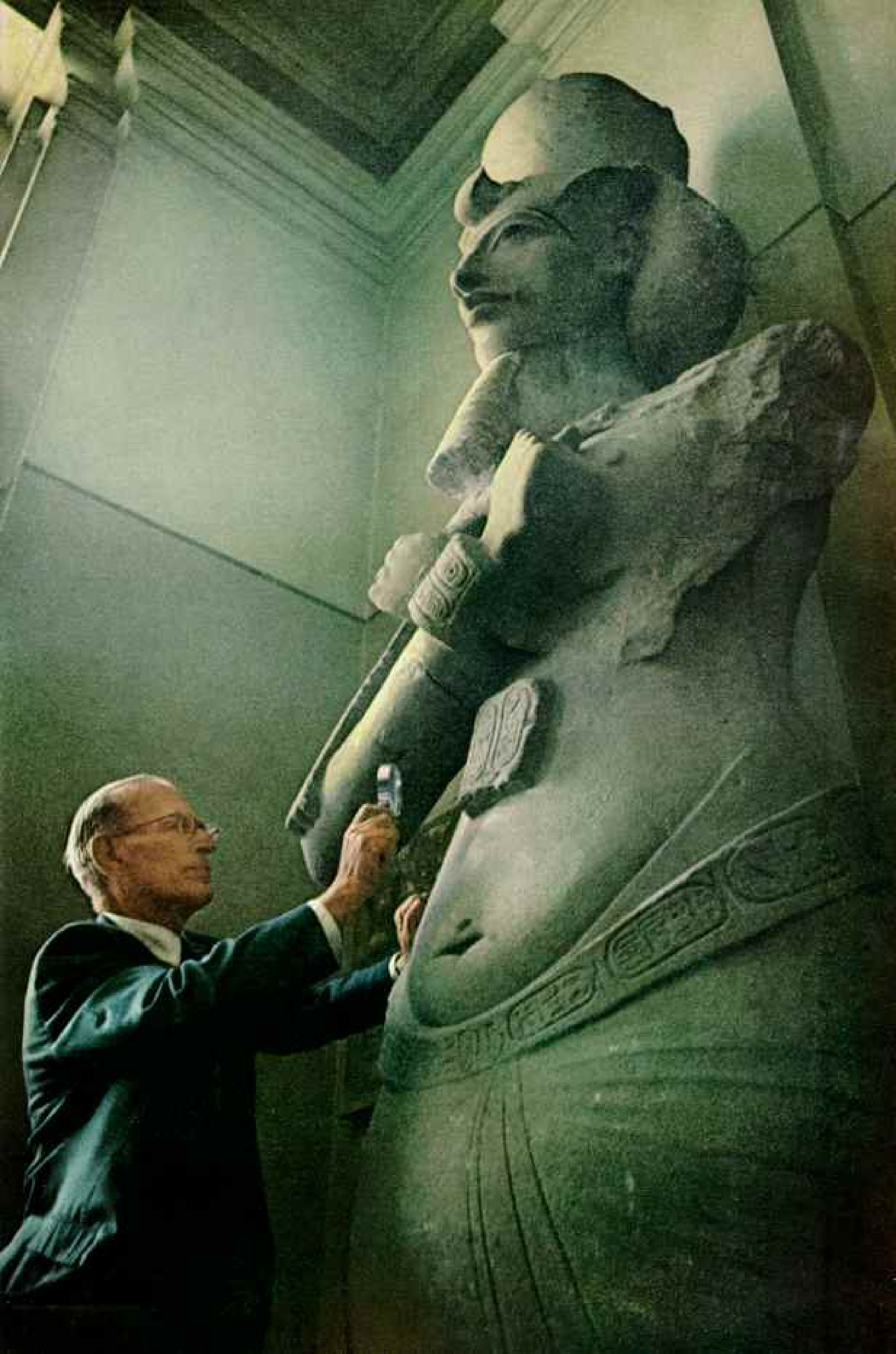
Everywhere resplendently decorated walls greeted the royal pair. They saw their own likenesses endlessly repeated. Akhenaten and his consort viewed scenes showing groups of



Ancient walkway of the mighty, the eastern access to the Temple of Amun at Karnak reverts to a footpath used by dark-robed Egyptian women. In 1925 two statues of Akhenaten came to light in this area. Henri Chevrier, Director of Works at Karnak for more than 20 years, wondered whether there had been others, and began a careful excavation. He discovered that 27 giant sculptures had once existed and concluded that they marked the site of Akhenaten's temple. The latest theory places it some 200 yards east of this still-standing gateway (upper map, page 638).

Colossus of Akhenaten (right) towers above the author, examining cartouches containing two of the sun god's appellations. It is preserved in the Egyptian Museum, Cairo.

Akhenaten directed his artists to portray him truthfully, some experts believe. Slight variations occur in the statues, but all depict the Pharaoh with peculiar physical characteristics—hatchet chin, slender neck, bulbous belly and thighs, and spindly lower legs—probably the outward signs of a glandular disorder.





PHOTOGRAPHS BY EMORY BRISTOL AND RICHARD TUBBS WITH RECONSTRUCTION BY LESLIE GREENER AND PETER BIANCHI © N.S.A.

"Thou appearest beautifully
on the horizon of heaven,
Thou living Aten,
the beginning of life!"

HYMN TO THE ATEN

Warm rays from the sun disk descend on the monarch. Akhenaten guides his royal chariot with his wife Nefertiti behind him, holding on for dear life; attendants follow, in one of the most nearly complete scenes yet assembled by the author's team. Artists Greener and Bianchi sketched in the remainder of the scene after studying similar temple reliefs.

Slowly, Akhenaten's temple emerges from oblivion. If funds become available for actual reassembly of the blocks, the author's identification numbers will reveal the precise location of each stone in a storehouse or a museum.

In the meantime, Egyptologists the world over will be able to study the photographic recreation of this great temple—and gain new knowledge of a royal couple who followed one god while the rest of the world still worshiped many.

clues to the elusive background of Akhenaten's theology. Did a revelation inspire him, as in the case of other prophets? Or was his tendency toward monotheism a reasoned ideal?

People ask me, "When will the Aten Temple be restored so that visitors can wander through its halls and courtyards?" It is impossible to surmise if this will ever be done. Physically, it would require the inclusion of tremendous quantities of new stone, and the task would be enormously costly.

I am confident, though, that many of the lovely scenes we have assembled will somehow

be re-erected for the world to admire. Perhaps selected assemblages of blocks can also be sent abroad as touring exhibits.

Whatever happens, we consider it a privilege to have laid a cornerstone for future research on the Karnak Aten Temple. The value of the computer as an archeological tool has been established without question.

Best of all is the satisfaction of having retrieved beauty and knowledge that seemed destined to oblivion when ancient Egypt nurtured and then destroyed the startling innovations of the god-king Akhenaten. THE END

Through

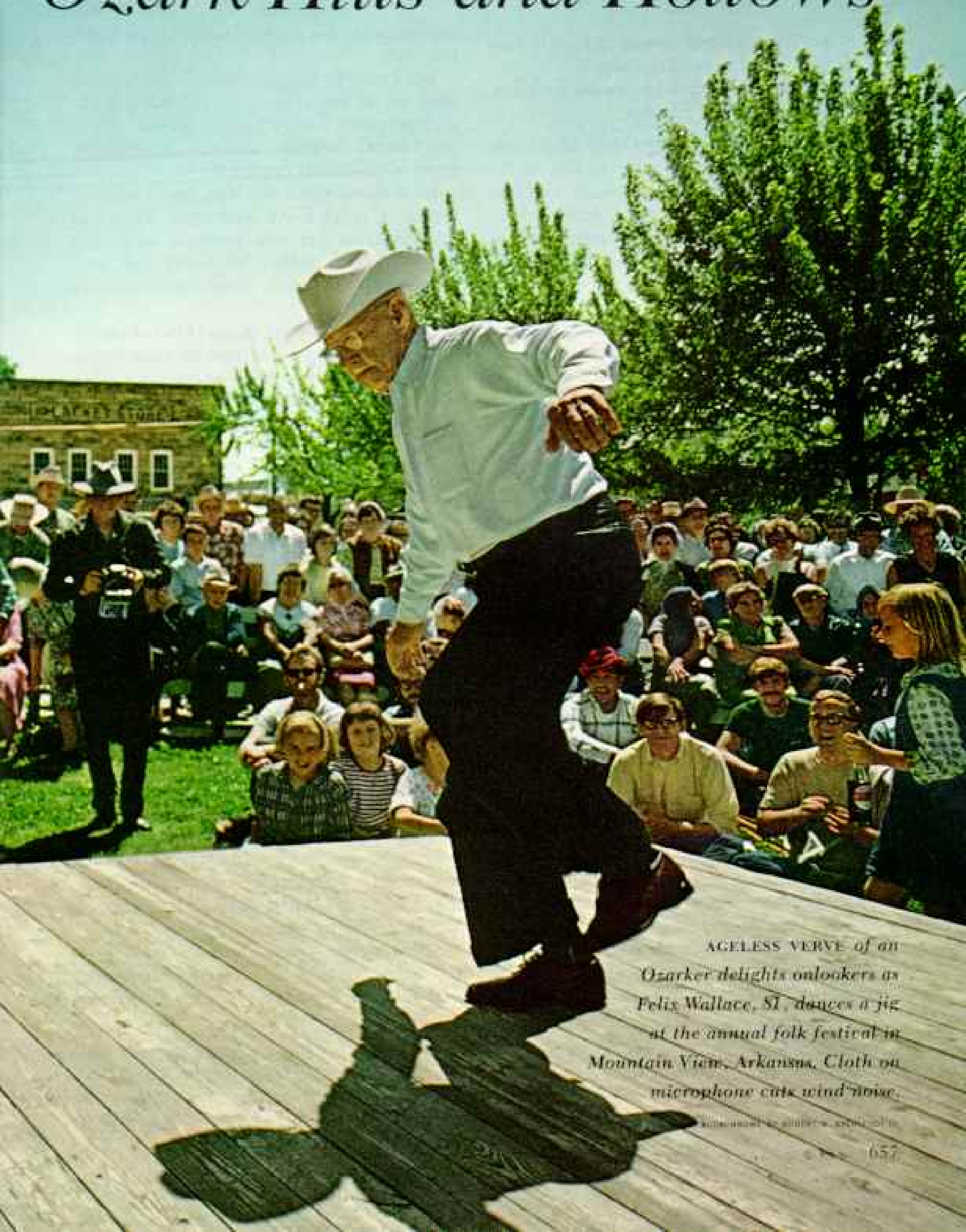


By MIKE W. EDWARDS

Photographs by BRUCE DALE

Both National Geographic Staff

Ozark Hills and Hollows



AGELESS VERVE of an Ozarker delights onlookers as Felix Wallace, 81, dances a jig at the annual folk festival in Mountain View, Arkansas. Cloth on microphone cuts wind noise.

DOWN FROM THE HILL, the old song drifted down through the pines and the hickories, down to where I sat with the men who had come to raise Lonnie Lee's house.

The words, bittersweet, told of a surcease of daily cares:

*There'll be no more sorrow or pain to bear
In that home beyond the sky;
A glorious thought when we all get there,
We never will say goodbye.*

Day breaks early in the Ozark Highlands in summer, and men rise with the sun. In the hamlet of Fox—a handful of houses scattered like broadcast wheat around a dusty Arkansas crossroads—neighbors, kin, and friends of Lonnie Lee had gathered before seven o'clock to begin building the new home.

Perspiring under the fierce sun, they had hauled stone for the foundation, nailed in floor joists, raised the framing of one wall.

At noon they had taken their well-earned leisure in the shade of a dell, enjoying the lunch their womenfolk had spread: chicken, dumplings, potato salad, pie. Then Tom Wilson and his brother James tuned up a banjo and guitar and climbed the hill to play and sing. We listened silently, squatting with our plates under the leafy boughs.

*O come, angel band,
Come and around me stand;
O bear me away on your snowy wings
To my immortal home.*

"My wife and I dreamed of a new house for 10 years," Lonnie Lee told me. Sawmiller and father of nine, he fixed me with blue eyes that sparkled like the clear stream I had fished the day before. "The first time I started it, a cyclone came along and blew it all down. So I cut a lot of new lumber and started over."

Then came another blow; an accident with his logging truck disabled him. When the word got around, neighbors decided to help. What neighbors! Never have I seen men work harder. They framed a second wall after lunch. Before packing their tools, they vowed to return as many days as necessary to finish the house. In a month the Lees moved in.

Through Ozark Hills and Hollows

This spirit, I found, is not unusual in the Ozarks, which cover a big slice of southern Missouri and northern Arkansas with saw-toothed ridges, wavy plateaus, and deep-cleft ravines (map, page 665). Long isolated from the American mainstream, the far-back hills

and hollows still nurture folkways of a century ago.

Yet I had to marvel, driving the twisting road out of Fox that night, that such a lifestyle survives. For no one can remain long in the Ozarks without also encountering the onset of enormous change.

Until recent years this was almost wholly a region of small towns and small farms, the pristine beauty of vast swatches of tousled terrain flawed neither by a city nor by a smokestack—in many areas, not even by a paved road.

The beauty—a wild, rugged kind of beauty—remains. I glimpsed it from the razor's edge of the ridgetops and from the narrow valleys with their willow-fringed streams—even in the vaulted caverns that honeycomb the depths. I often visited drowsy villages that the world seems to have forgotten.

But I also felt the rapid pulsebeat of towns grown big and busy with tourism and industry, providing jobs, paychecks, opportunities.

Economists say the Ozarks need them. One census study shows that between 1940 and 1966 the region's population shrank by 325,000—a tenth of the whole—as young people drifted away in search of work.

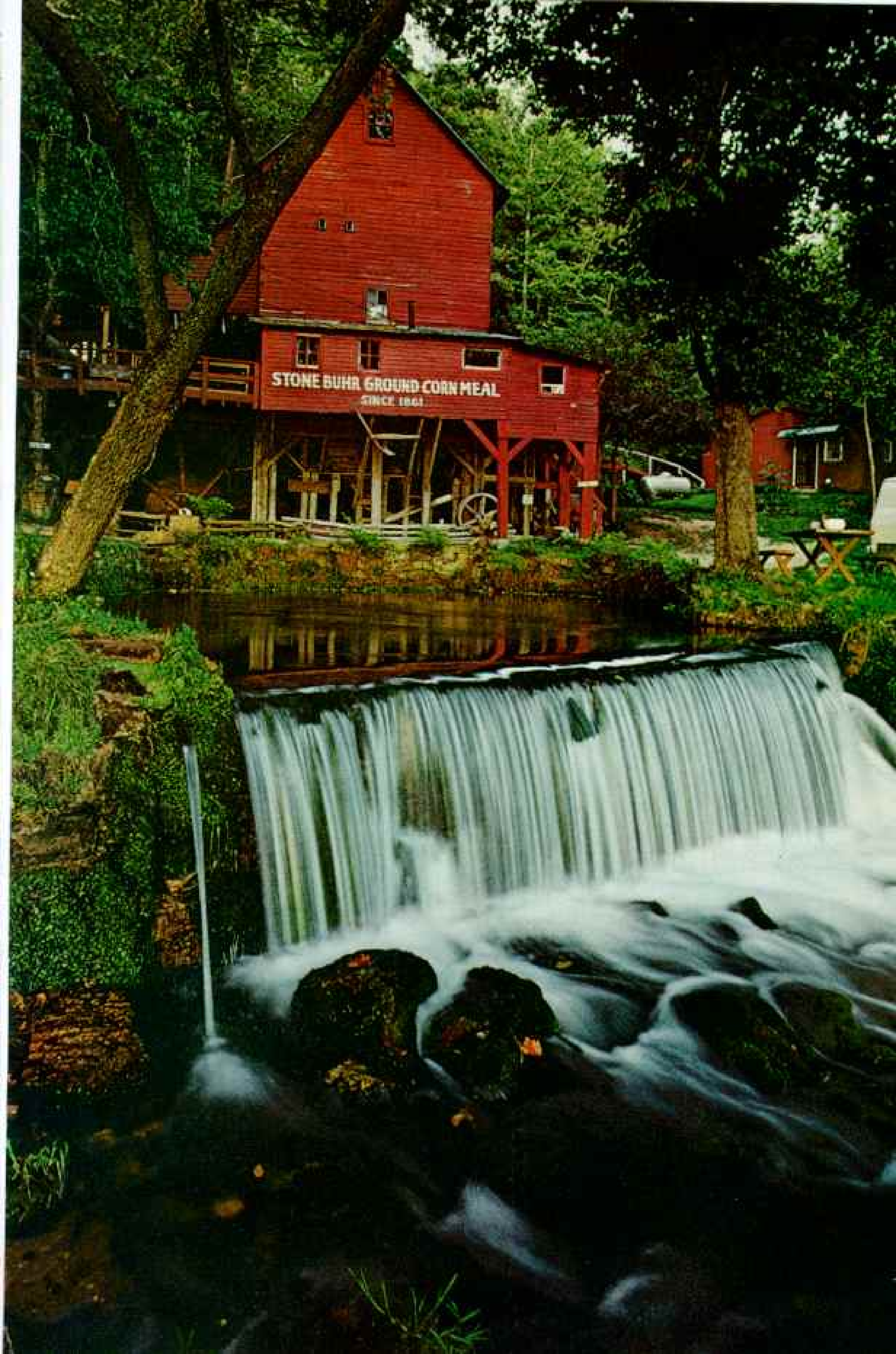
The average income remains low, more than \$1,000 a year below the national norm of \$3,687, making the Ozarks poorer even than Appalachia. But a new population study gave regional developers cause to cheer last year. It indicated that the people drain at last has ceased.

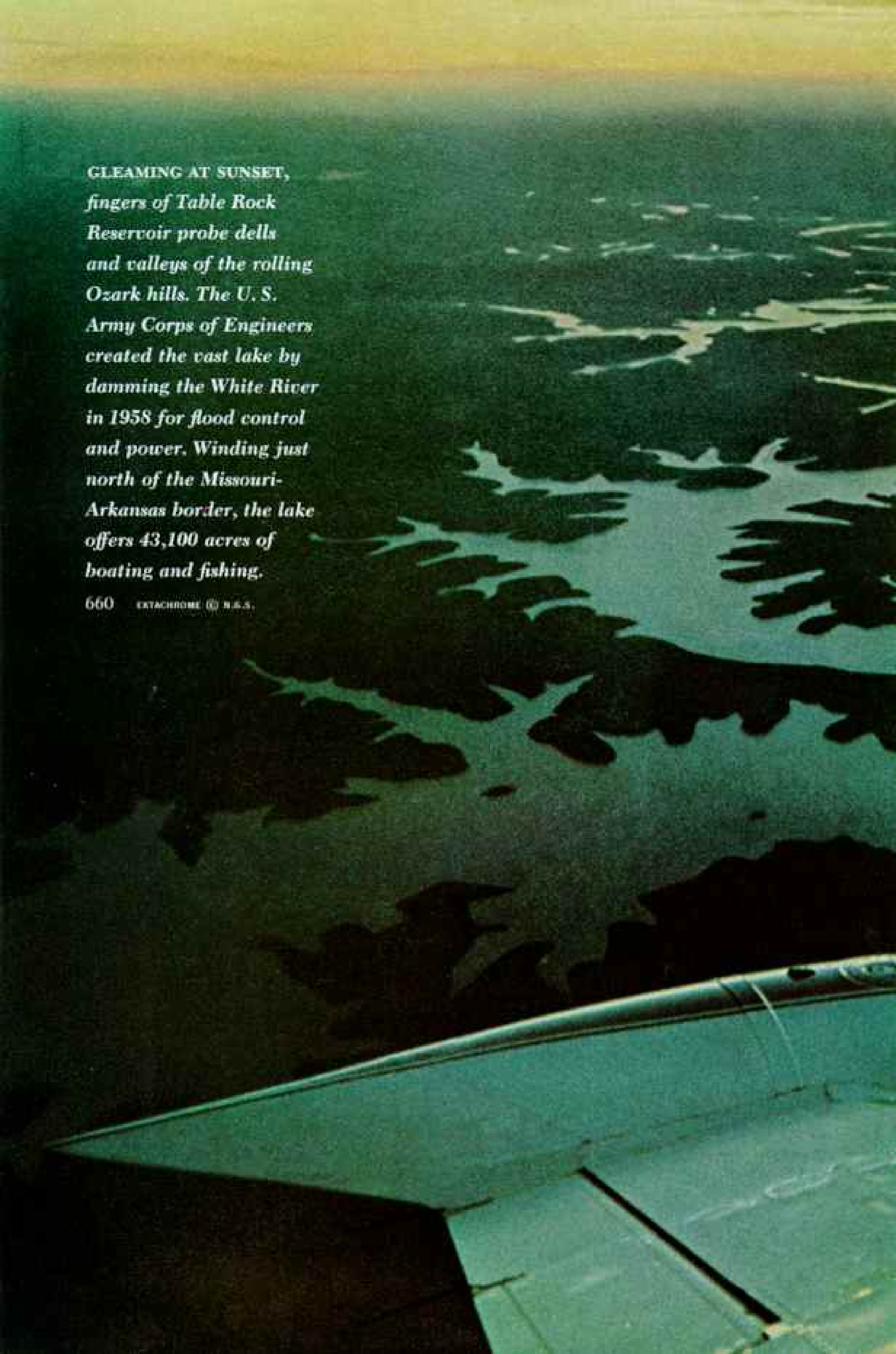
"City folks," as the Ozarker calls the outsiders who now flock into his land, fuel the new vitality. Vacationists stream in from Chicago, St. Louis, Little Rock, Memphis—20 million a year by some estimates.

Although most remain but a few days, skimming boats over lakes of shimmering emerald, perhaps 50,000 permanently traded

Music of the water mill survives in the Ozarks. The Hodgson Mill near Gainesville, Missouri, grinds meal and flour daily. Its 1,200,000-gallon-an-hour spring powers buhrstones brought from France more than a century ago. Although the land hums with new industry and tourism, Ozarkers cherish such reminders of the past.

RESEARCH BY BRUCE DALE © W.A.S.





*GLEAMING AT SUNSET,
fingers of Table Rock
Reservoir probe dells
and valleys of the rolling
Ozark hills. The U. S.
Army Corps of Engineers
created the vast lake by
damming the White River
in 1958 for flood control
and power. Winding just
north of the Missouri-
Arkansas border, the lake
offers 43,100 acres of
boating and fishing.*

660 EXTACHROME © N.E.S.





the tensions of the cities for the peace of the Ozarks last year. By all accounts, many more will do so in the future; the Ozarks seem destined to become a major retirement area as well as a popular resort.

Natives and Newcomers in Agreement

In the succinct style that often spices Ozark speech, an old-timer put this development in perspective. Confronting him on the town square in Berryville, Arkansas, a tourist inquired, "What's the main crop here?"

He replied in a single word, "Newcomers."

It may seem surprising, but natives and newcomers mix rather well. Cartoonists and humorists have long depicted the Ozarker as a barefoot, bearded rustic, lounging beside his still, "shootin' arn" across his lap. One can

hardly imagine such a man welcoming change and unfamiliar faces.

The fact is that the Ozarker neither resembles that stereotype nor—in my experience—exhibits hostility to outsiders. Moreover, he and his new neighbors agree on change: Neither wants too much of it.

"I'm not for progress if it means crowds and pollution," exclaimed a former Kansas City resident who retired to the Ozarks.

Echoed a shopkeeper in a small town, "We want just enough progress so our children can find jobs and stay at home."

To geologists and map makers, the Ozarks pose a problem of definition. "One of the perennial embarrassments in the life of your state geologist," Missouri's holder of that office wrote a few years ago, "is his inability



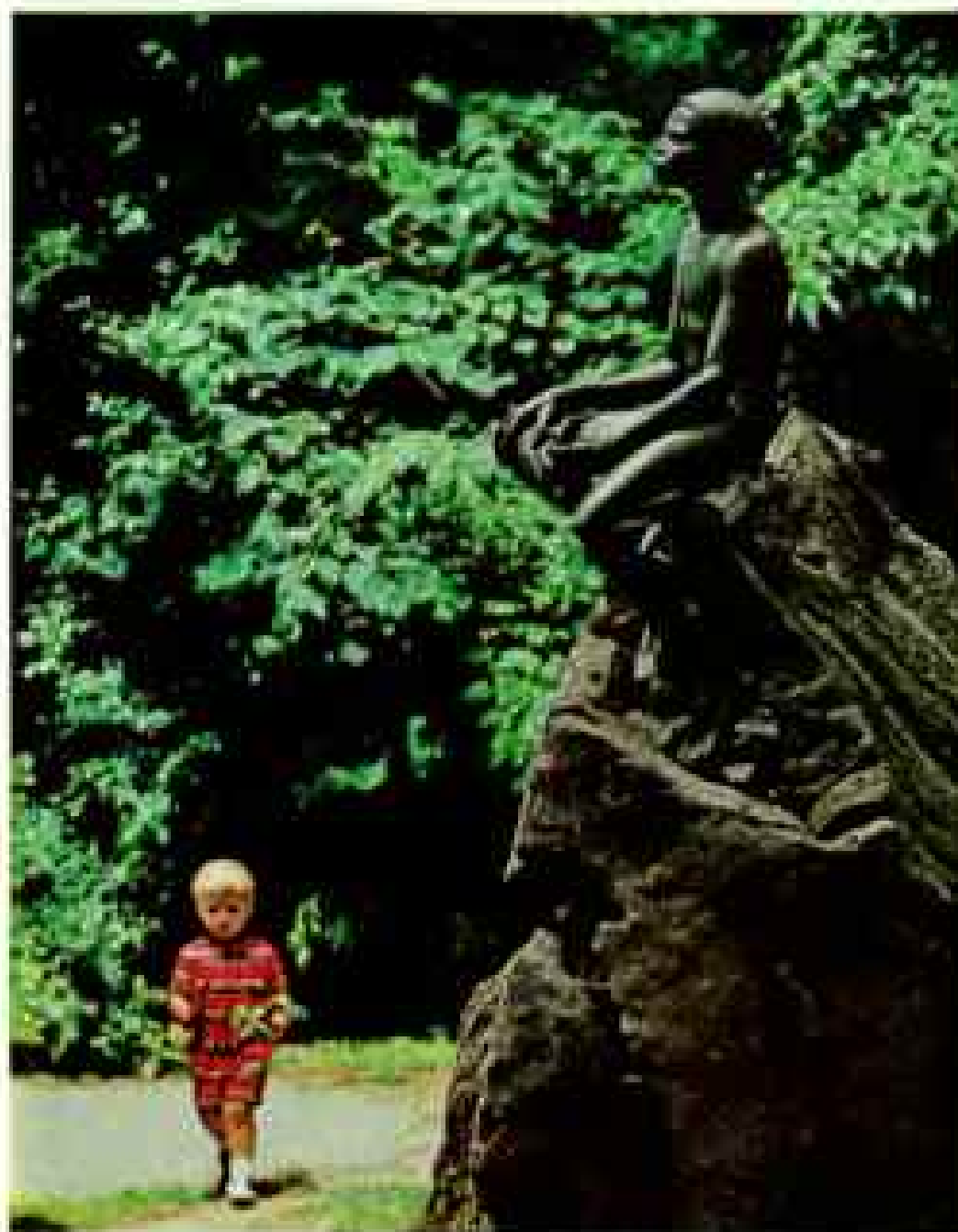
BOBACHOWICZ (ABOVE) AND ESTERHORN BY BRUCE DALE (2) W.A.C.L.

Luxury invades the Ozarks: Water volleyball takes over part of the pool at the Lodge of the Four Seasons, overlooking Missouri's Lake of the Ozarks. The complex includes convention facilities, health spa, skating rink, stables, and a second pool, partly indoors, heated, and dividable by a glass wall.

Evening cruise ahead, a motorboat takes on fuel at the docks of Tan-Tar-A, a Lake of the Ozarks resort that includes 80 private vacation homes.



The way of a boy with growing things earned young George Washington Carver the name "Plant Doctor." At his birthplace near Diamond, Missouri, now a national monument, a bronze likeness by Robert Amendola marks the hidden garden of the Negro youth who began life as a slave about 1860 and became a world-renowned botanist, agronomist, and humanitarian. He died in 1943.



to give a concise answer to a very simple question, "What are the Ozarks?"

If pressed, he continued, he would call them hills. Others say mountains. Still others, a plateau, a dome, or a highland.

Neither has accord been reached on how far the Ozarks stretch beyond Missouri and Arkansas into neighboring states.

If the present provokes disagreement, the past does not. Thick layers of sedimentary rock—limestone, dolomite, sandstone, shale—tell geologists that 400 to 500 million years ago the region was an ocean floor. Only a million years ago, the earth thrust the sea bed upward, forming a high plain. Then rivers sculptured it, chiseling valleys, smoothing plateaus, mining the layered stone with caverns and numberless springs.

"Our mountains ain't so high, but our valleys shore are deep," goes an Ozark expression. It fits; the Ozarks could boast no peaks—not even hills—were it not for the valleys the rivers gouged.

Elevations here seem unremarkable beside even the Appalachians, much less the Rockies.

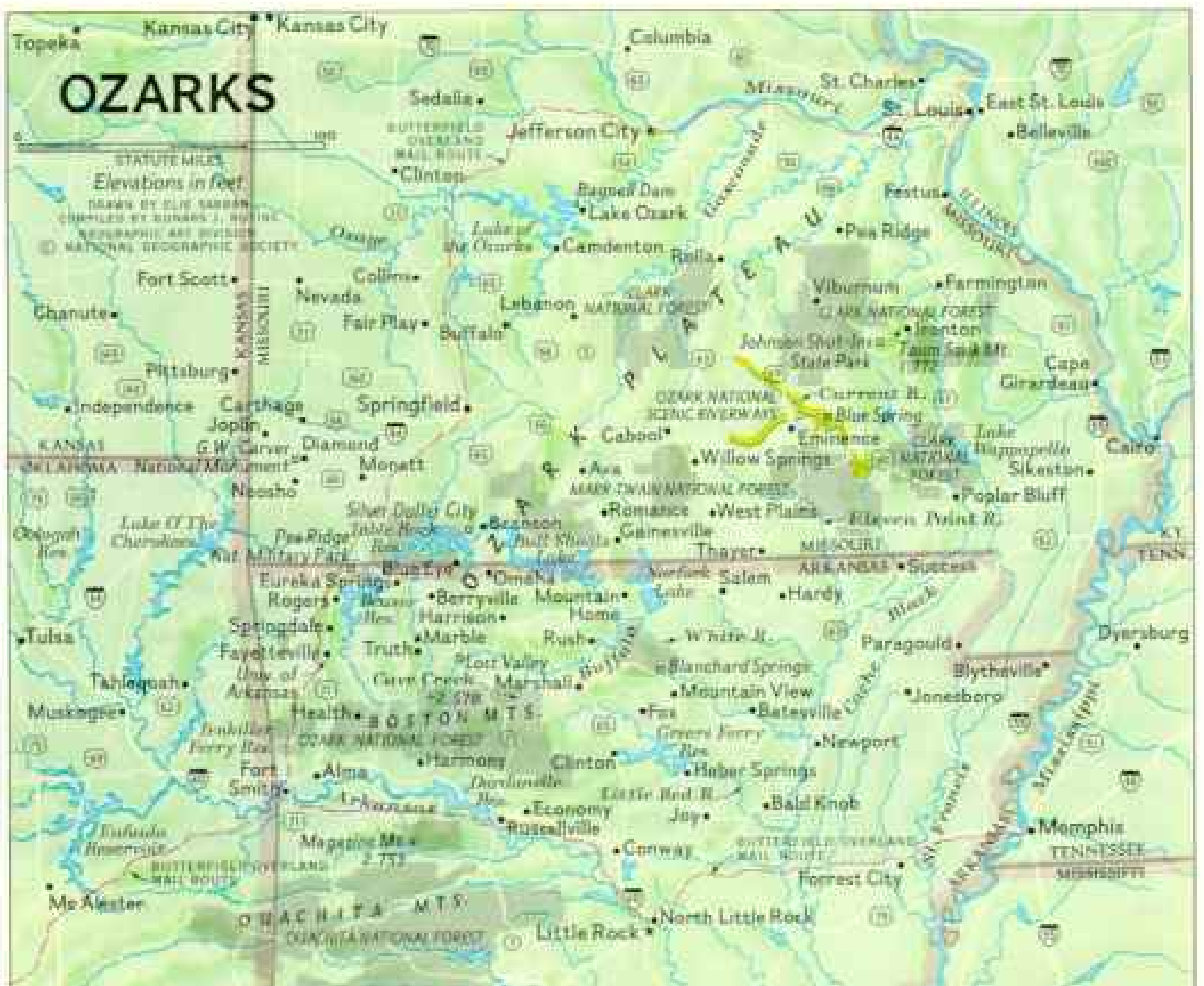
Timbered ridges roll to the horizon across northern Arkansas and southern Missouri. Here in Ozark National Forest a fire tower keeps watch over lush woodlands, touched by the first glow of autumn.



Rugged island of mountains, riddled by myriad caves, springs, and sparkling streams, the Ozark Plateau rose above the central plains about a million years ago. Frenchmen came to the region before 1700, seeking furs and mineral wealth. In the 19th century Anglo-Saxons from the Appalachians claimed the hills. Arkansas also boasts the deep-valleyed Ouachita Mountains.



STYLING: JEFFREY AND KATHERINE © NATIONAL GEOGRAPHIC SOCIETY



Hoisting semaphores of dogwood and redbud in spring, consumed in the hot flame of oaks and gums in autumn, a clutch of peaks called the Boston Mountains struggles up almost to 2,600 feet—the highest point in the Arkansas Ozarks (preceding page). Missouri's highest peak, Taum Sauk Mountain, rises to 1,772 feet.

The ruggedness of the Ozarks does not derive from grand extremes, but from the wrinkled landscape's affinity for the vertical. What the hills lack in height they make up for in steepness.

Civil War Brought Guerrilla Gangs

French trappers, traders, and miners ventured into the Ozarks from the Mississippi River in the 17th and 18th centuries, and some historians believe they contributed the root phrase of the region's name. Ozarks may be a corruption of "*Aux Arcs*," short for "in Arkansas country," or "*bois aux arcs*," referring to the wood which the Indians esteemed for "*arcs*," or bows.

Most of the Ozarkers I met are descended from families who came from the Appalachians, and especially the Tennessee Appalachians due east. This restless Anglo-Saxon yeomanry, with such names as Lancaster, Boyd, and Clark, ventured west over rutted trails, driving teams of lumbering oxen, beginning in the early 1800's.

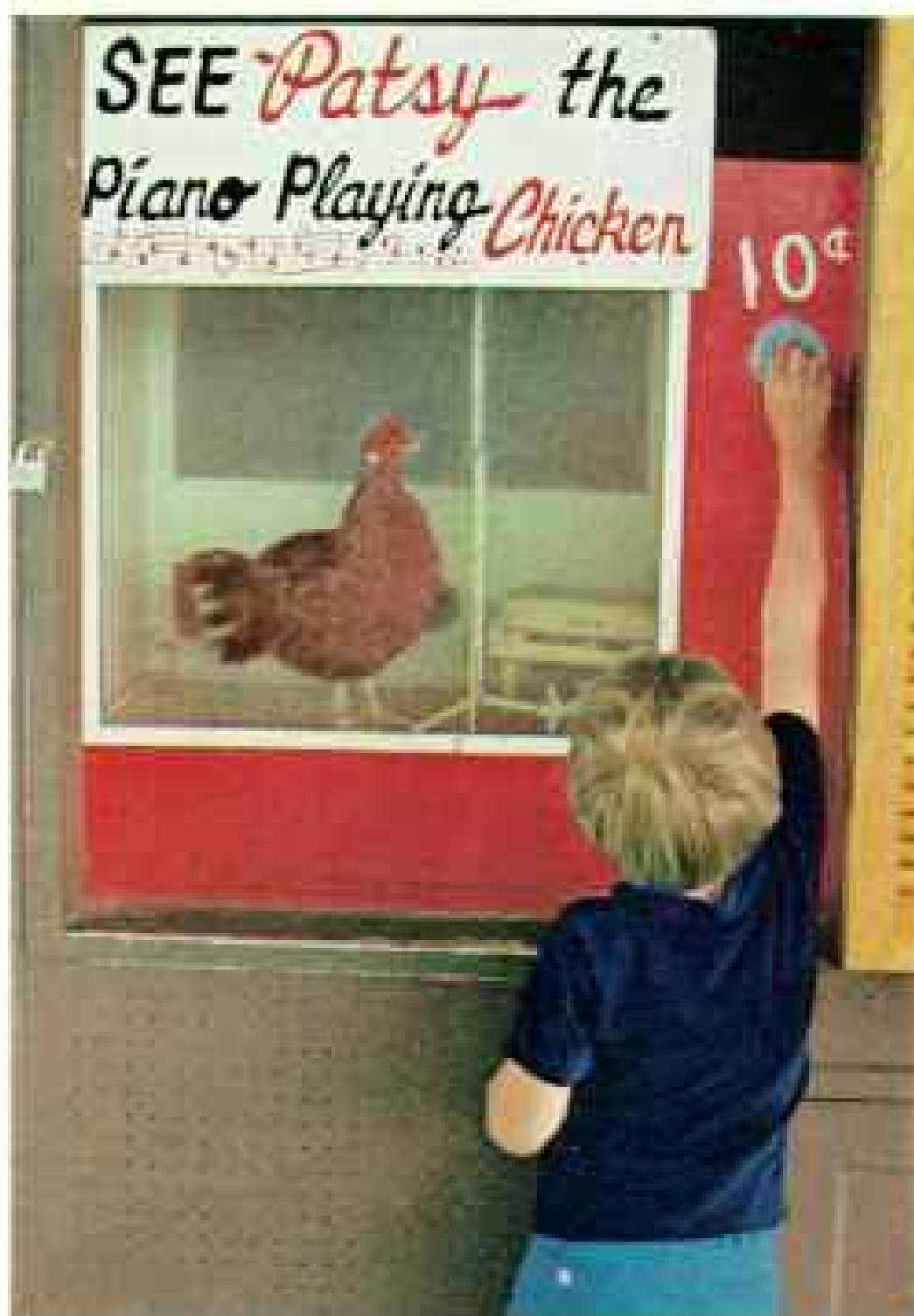
Slowed by the Civil War—in the Ozarks, a time when bands of vicious bushwhackers took advantage of the breakdown of law and order—the migration continued into the 20th century.

Though it served him poorly at times, the Ozark settler took his land, as in marriage, for better or for worse. And what he is, the land made him. Self-reliant, strong of heart and sinew, conservative in his beliefs, blessed with a sense of humor undimmed by hard times, eager to help a neighbor—this is the Ozarker, molded in the isolation of hill and hollow.

I think I got to know him best in the small Missouri town of Ava.

From Springfield, the Ozarks' largest city, I drove across roller-coaster hills to Ava on a somber day in dying autumn. Oaks that had glowed like hot coals two weeks before now delivered up brown leaves to a chill wind. Sycamores already raised bare white arms in surrender to winter's advance.

The friendly informality of Ava soon warmed me. A pedestrian waved a greeting on the town square. Seated on a curb, passing the time in conversation with his friends, 64-year-old Ed Thompson told me Avans rarely are in too much of a hurry to say hello. "If they should happen to get in a hurry," he added, "they just sit down and wait till that's over with."





"Coney Island," residents call the main street of Lake Ozark, crowded with cars in this view through a telephoto lens. Motels, restaurants, music halls, and amusement arcades cater to Lake of the Ozarks visitors. A youngster pays to watch Patsy (left) peck out a tune for a reward of corn, and blasé motorcyclists cruise through town, seemingly unaware of another traveler's stare.

The many arms of Lake of the Ozarks form behind 39-year-old Bagnell Dam, one of the last privately financed dams in the Nation. Owners of lake-front property hold title to the 1,375 miles of shoreline; in contrast, residents along lakes controlled by the U. S. Army Corps of Engineers merely have access to the water.





It's a rough life on the rodeo circuit, where intelligence and brawn are pitted against instinct and bulk. Leaping from his mount—a well-schooled quarter horse—the cowboy at right will try to throw and tie a 300-pound calf in record time at Camden-ton, Missouri.

Roughest events—bull riding, steer wrestling, and bronc riding—can lead to black eyes and bruises (above), or worse—broken ribs, sprained knees, dislocated shoulders.

A bronc might work as little as ten minutes a year. "Bucking stock is the most pampered bunch of hair-covered bandits around today," according to Randy Witte of the Rodeo Cowboys Association.

The Camden-ton rodeo has been discontinued, but other Ozark towns have adopted this popular Western sports event.



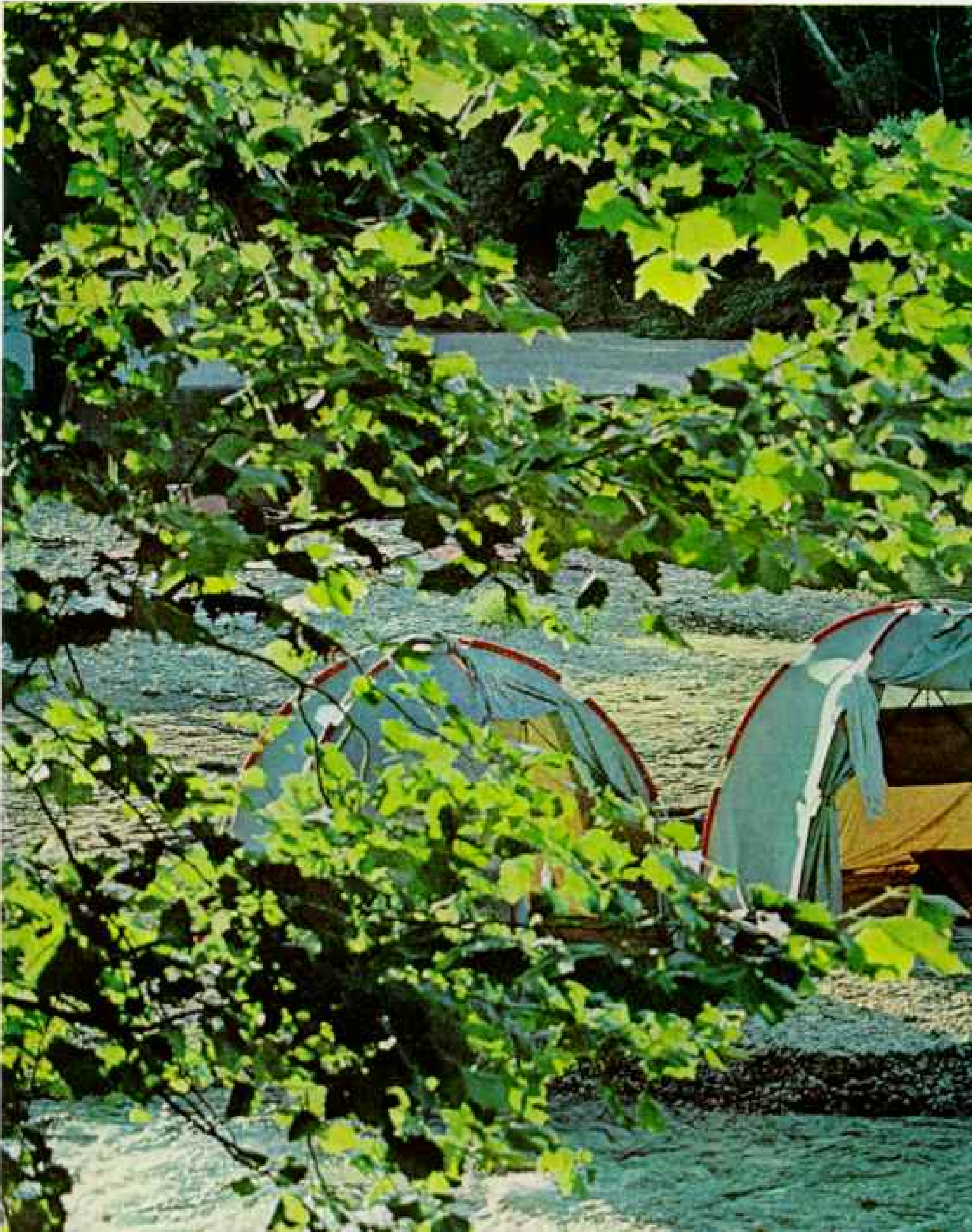


In the three-story red brick courthouse, I met Clarence Singleton, the county treasurer, a man refreshingly unencumbered by the protocol of office. "The old ways of the hills still are a-holdin' pretty good," Clarence told me. The next day, he added an exclamation point. Bringing his banjo to his office, he made the walls ring with two old square-dance tunes, "Buffalo Gals" and "Cripple Creek."

Though Ozarkers know how to enjoy their idle moments, they pride themselves on the work they've done—the strenuous work of taming the land and wresting a living from it. Lounging on the courthouse steps, now and again rolling cigarettes from papers and tobacco stashed in the bib pockets of their overalls, senior citizens talk about it.

Roy Cox's round, weathered face glowed

Aroma of bacon still hangs in the air as canoeists break camp on the Buffalo River. Proposed



warmly as he began such a conversation: "The first crop I ever tried to make, I was nine years old. Dad was sick and I was all there was to do 'er. Had an old thin wooden-beam turnin' plow. The team'd get that plow pulled in under a root and I'd get down and get a-hold of the crossbeam to pull it out.

"By the time I'd get it out, those horses'd start to pull it back under. And I'd just cuss

and cry. But I raised enough stuff to get through the winter on."

In time, the Ozark population grew too large for the tillable land available. Many then tried to work the precipitous hillsides—only to find the soil too thin and rocky. To a way of life that already demanded much, depression and drought added a greater burden in the 1930's.

for National Park Service protection, the stream winds for 148 miles through northern Arkansas.

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ADORNMENT BY BRUCE GALT © 1988



Yet I have never heard an Ozarker speak bitterly of his hard life. He jokes about the land that made life so. He tells strangers he uses a crowbar and a syringe to plant corn—the former to pry apart the rocks, the latter to shoot in the seeds. He says he grows potatoes on a hillside so steep that to harvest them he merely digs away the end of a furrow, allowing the crop to roll downhill to his wagon.

Not all his stories describe the niggardliness of his land; some credit it with amazing productivity. W. L. Turner of Ava told me about a pumpkin that grew so large that a sow, having eaten into its side, moved in to

farrow her pigs. "We wouldn't lie to you," he reassured me. "But we might tell you a big windy now and then."

Ozark humorist Bob Burns borrowed many "big windies" from the hills. He told of asking an uncle to send Ozark potatoes to California to be displayed at a fair.

"How many potatoes?" the uncle asked.

"Well, they only allow you to enter 100 pounds of any one thing."

The uncle answered: "I wouldn't cut one of my potatoes in two for anybody."

Now 78, Vance Randolph of Fayetteville, Arkansas, has devoted most of his life to collecting Ozark folkways and humor, and has written 22 books on the subject. His wife, Mary Parler Randolph, a collector too, teaches folklore at the University of Arkansas.

Depression Jokes Still Get Laughs

Much of the humor of the Ozarks, Mr. Randolph told me, can be traced to the British Isles—some of it to medieval times.

"I don't think people here appreciate a good story or an expression more than people anywhere else," Mrs. Randolph said. "But they do appreciate a different kind of joke. They like old sayings, such as the one about the Depression: 'We didn't have anything then—and we've still got it.'"

I asked why new humor hasn't taken root. "Ozarkers already have a good body of stories," Mrs. Randolph answered. "They're not especially sold on getting a new one."

The Ozarker's British heritage also shows in his love of fox hunting. Edwin Riley of Ava, now 52, told me his father took him fox hunting when he was 7. He has been dedicated to the sport ever since. Many Ozarkers agree with him that no music—not even the lively fiddle tunes that endure in the Ozarks—equals the music of hounds in the chase.

"I don't advocate killing the fox," he told me. "I just enjoy hearing the mouth of a dog and seeing the ability of one."

The Ozarker doesn't ride to hounds in a scarlet coat; he dons overalls and rides out in his pickup truck, hounds penned in back. Obliging, what Mr. Riley calls "a good-running red fox" leads the dogs in a circle perhaps two miles around. The hunter need only place himself in the center to hear the chase all night.

Starlight, pale and cold, silhouetted the ragged oaks of the ridge where Mr. Riley, his



STYACRIME © N.A.S.

Tired of fighting, a hooked rainbow trout still tries to avoid the net. In a flat-bottomed johnboat, the Ozark float fisherman's favorite craft, Mr. and Mrs. Jim Gaston ply Arkansas's Bruce Creek, a tributary of the White River. The camera was partly submerged to capture this unusual view.

neighbors, and I gathered one night a few miles from Ava. Frosty and Red Wing, Cricket and Roy Lee and Lad, a dozen dogs in all, went snuffing off into the darkness, sending back an occasional yelp. The men waited, listening, speaking in low voices.

Half a mile away, the pack came on a scent. Now the din grew. "There it goes! There it goes!" Mr. Riley shouted exuberantly. "Now boys, you're gonna hear a race. They'll be fairly hammerin' that fox pretty soon."

We built a fire when a cold wind stirred. As we warmed ourselves, the men discussed the qualities of the canine voices that drifted to us through the leaping shadows.

"That squawlin' dog's shore pretty, ain't she," declared George Proctor.

"Yeah," agreed Deward Henson. "She shore does be a mouth."

Raymond Freeman explained that the plaintive *oo-oor, oo-oor* I heard came from a "squawlin' dog." A dog he described as a "clear-mouth" seemed to be the tenor of the pack. Mr. Riley identified another as a "chop-mouth"; I judged that one to be a baritone.

Some fox hunters prefer one quality of voice, some another.

"But any kind sounds good if it's leadin' the pack," Mr. Freeman added.

Seeking Romance? It's in the Ozarks

One sunny autumn afternoon, deep in the Missouri Ozarks, I found Romance. A mere hamlet, Romance nestles in a leafy hollow at the end of a short ribbon of pavement.

An Ozark traveler also may discover Truth, know Joy, savor Harmony, salute Health, attain Success. Or save his money in Economy and buy with confidence in Fair Play. Such community names tell us much about the values of the early Ozarkers.

Sometimes the name givers indulged their insouciant humor. There is the story of a Missouri village called Smackout, because the proprietor of its general store always answered, "I'm smack out," when customers asked for goods he did not have.

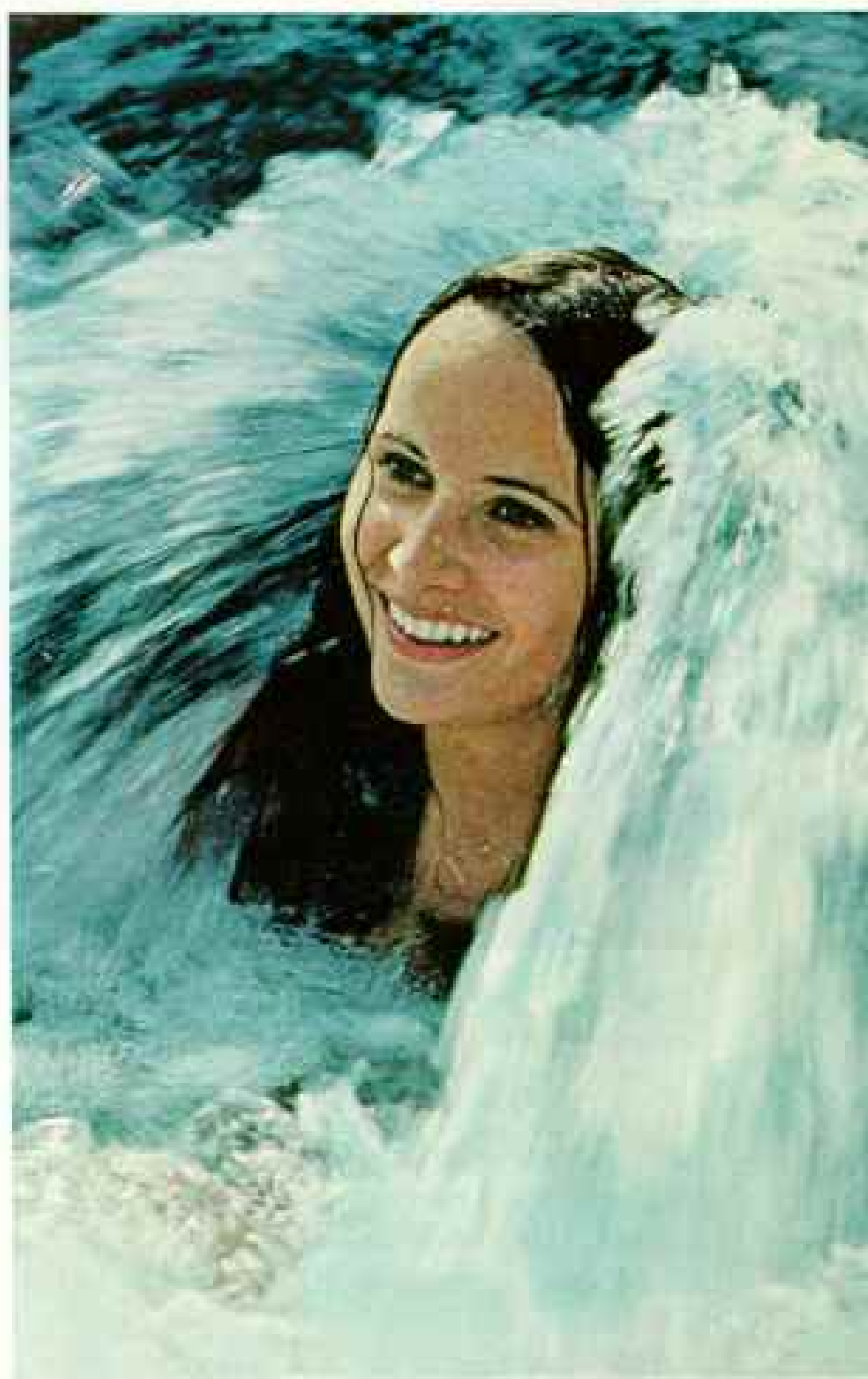
Another village that stands out in my memory is Blue Eye. Rather, I should say, two Blue Eyes stand out. The Arkansas-Missouri state line, passing across a high plateau where broom sedge glows coppery in the autumn sun, splits the community in twain. Blue Eye, Arkansas, home of 75 persons, boasts three gasoline stations. Blue Eye, Missouri, can top

that: 100 citizens, post office, school, general store, garage, liquor store.

Postmaster Cue Butler told me the name they share originated in 1870, when someone suggested that the community be named for the then-postmaster's deep-blue eyes.

Harassed big-city mayors would envy the nonchalance of municipal administration in the Blue Eyes. On the Arkansas side, Mayor Roy Hopper presides over a five-man council—when it meets. "That's generally just when something comes up," he said.

The council levies a modest property tax to pay for electricity for the streetlights and to



KIDCHURIE © W.A.S.

Robed in rapids, Karen Weinberger perches on a boulder in midstream at Johnson Shut-Ins State Park, near Ironton, Missouri. Water cutting through igneous rock formed the shut-ins, or narrow canyons, where deep, clear pools alternate with frothing cascades.



"Wooooo pig, sooey!" The piercing cry of University of Arkansas rooters fills the football

field in Fayetteville. "Razorback fans are what you might call rabid," says quarterback Bill Montgomery

keep the city park mowed. "That's what a fella gets bein' mayor here," Mr. Hopper explained. "He gets to mow the park. They pay me \$4 every time I do it. But I have to furnish the mower."

Although taxes do not cover expenses, neither Blue Eye goes into the red. Donations from citizens make up the deficits.

Games of horseshoes and marbles once occupied the idle hours of the citizens—adults as well as the young. Now eight trophies in the C. H. Badley & Son General Store attest

to the success of the Blue Eye baseball team in the Ozark League.

Lloyd Blevins told me that local youths develop rifle arms pegging rocks at squirrels. "Course, some boys have to throw at a squirrel a second time," he conceded.

I met Mr. Blevins in Tharp's service station, around the warmth of a gas heater. Old-timers gather there to swap yarns and humor out of the larder of the past.

As I took a seat to listen, John Matlock announced that this was his 83rd birthday.



ENTOURAGES BY BRUCE DRIS © N.A.A.

(right), who led his team to a Southwest Conference co-championship with Texas in 1968. Arkansas lost

to Texas in 1969 in a highly publicized home game attended by President Richard M. Nixon.

"I'd like to make a hundred 'fore I die," he added. "I used to devil my wife, tellin' her I was goin' to live to be a hundred or die tryin'." He added soberly: "I wasn't lyin'."

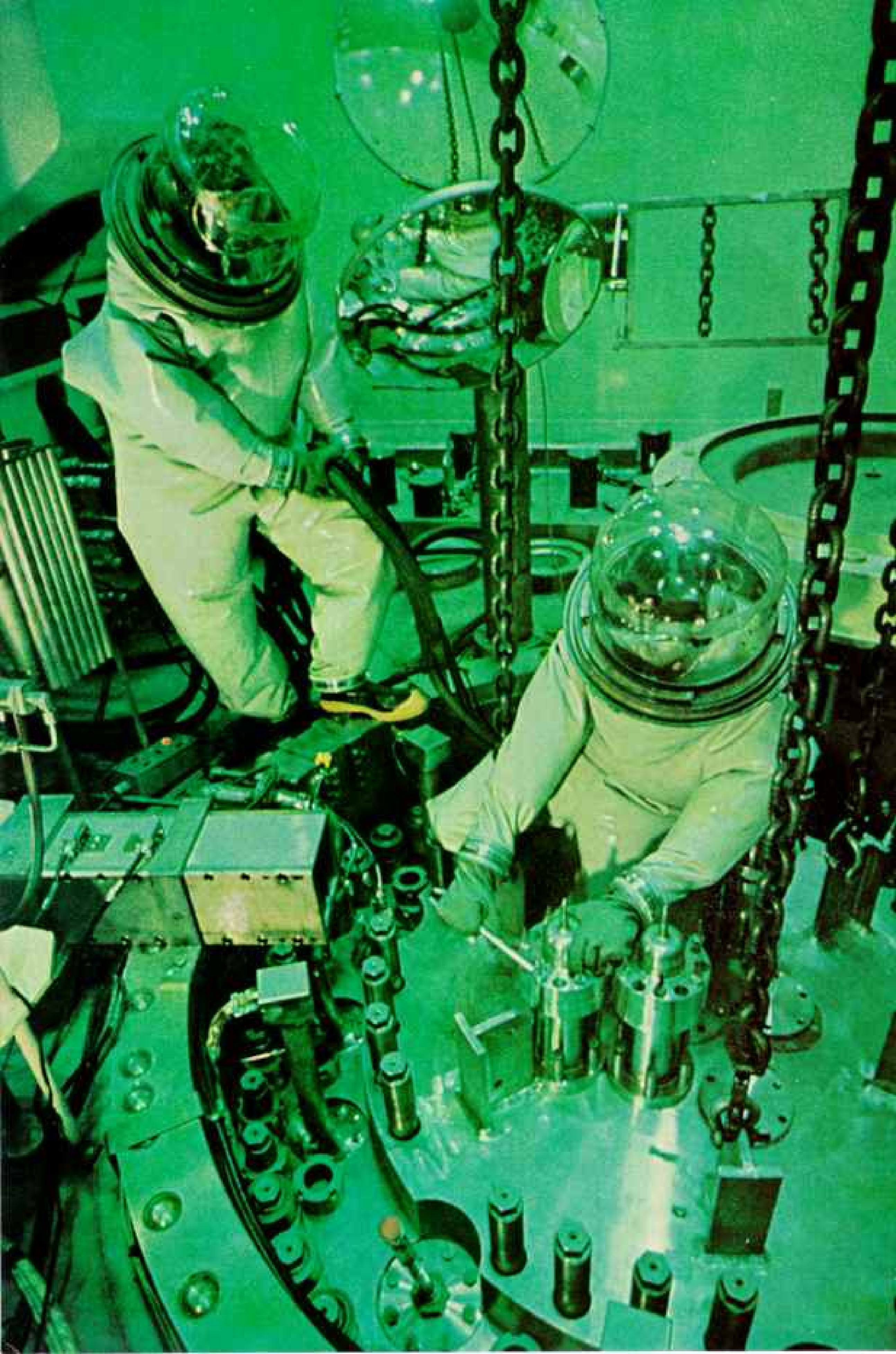
Old-time General Store Survives

Before asphalt and the automobile made Ozarkers mobile, the general store played a vital role in rural life.

"Back then, we carried a really large stock of goods," said Mrs. Eunice Holland, proprietor of Holland's General Store in Marble,

Arkansas. She stood behind a glass case that displayed jawbreakers and lollipops at moppet's-eye level. "Now there are big markets in the towns on all sides of us, so we carry less."

I wondered where more merchandise would fit. Assorted goods cascaded from the shelves and spread in mounds at my feet. There were boxes of nails and nuts and bolts; piles of percolator parts; shelves of crockery and cookware. My eye leaped from patent medicines to plow handles, from guitar strings and crochet needles to chimneys for kerosene lamps.



"People," Mrs. Holland said, "are always comin' in to hunt for some somethin' or other."

Often customers linger long around the wood stove that radiates warmth and welcome, just to the side of the canned goods.

I could not leave until I had rummaged again through the boxes and the shelves. I bought a globe for an old lamp cobwebbed into a corner of my basement at home, a long-spouted oil can for my workshop, and two large pairs of blacksmith's tongs. The bill came to \$2.65—including five jawbreakers.

Some of Holland's customers now are tourists. A tide of vacationists and retired city dwellers began to pour into the Ozarks after dam builders—chiefly the Army Corps of Engineers—started in the 1940's to remake the landscape (pages 660-61). More than a score of valleys vanished beneath sparkling reservoirs, created to generate power and control flooding.

Such practical purposes mean little to the visitors who school like minnows on the lakeside highways. Boats in tow, water skis fastened to car tops, fishing poles trailing from windows, they come to worship the water. Many build homes on lakeside bluffs.

I went to Heber Springs, Arkansas, to see in microcosm the changes wrought by the reservoirs.

Years ago, Heber, as local people call their town, enjoyed a reputation as a minor resort. Citizens ascribed curative powers to the

springs bubbling up in the town park, pungently smelling of sulphur.

"This one's the Black Sulphur Spring," explained R. C. (Doc) Johnson, an overalled septuagenarian who had come to fill a jug. "I like the taste of it a little the best."

He named the other springs nearby: Red Sulphur, White Sulphur, Iron, Arsenic, Eye. "That arsenic water—no harm to it," he assured me. (Another citizen vowed that it would cure dogs of mange.) Eye water not only soothes the eyes, Mr. Johnson added, "but I've heard two or three different ones say it'll clear up warts on your skin."

Recreation Brings a Business Boom

However miraculous their powers, the springs could not cure the economic ailments afflicting Heber only 15 years ago. Poverty stalked the small farms. No factory offered jobs. Young people drifted away.

Then the Army Engineers dammed the Little Red River near Heber. And as the construction crews departed in 1963—leaving behind the 40,500-acre Greers Ferry Lake—vacationists and home builders arrived.

Hundreds of new homes and 35 motels sprang from the hills. County real-estate tax collections quadrupled. An acre of land that sold for \$20 may now bring \$20,000.

New vitality, new industry, new people moving in—an economic revolution gathers momentum in many cities and towns.

Alien world of argon, an inert gas used as a fire preventive, calls for protective suits at SEFOR—Southwest Experimental Fast Oxide Reactor—near Fayetteville. The plant tests a process, utilizing uranium and plutonium, which produces more nuclear fuel than it consumes. The Atomic Energy Commission, General Electric, the West German Government, and 17 electric companies sponsor the quest for low-cost electricity.

Rainbow bands on a screen help testers check for distortion in new color television sets at the Zenith plant in Springfield, Missouri.



SILHOUETTES against the sky, skin-divers explore Blue Spring near Eminence, Missouri. Ghostly trees loom along the shore. The spring pours 67 million gallons a day into the Current, a swift stream designated in 1964 as part of the Ozark National Scenic Riverways.

Photographer Bruce Dale shot the picture from 73 feet down. Water caused the spots and flares when pressure broke the camera's protective case.

678 KODACHROME © R.S.S.







"What am I bid?" The call of the auctioneer rings out at a household auction in Alma, Arkansas. His assistant holds a kerosene lamp, likely to bring a good price from a collector of Americana. At a similar auction, an Arkansan told the author, the

And beneath them. Five hundred feet below Viburnum in southeast Missouri, I talked to miners blasting galena, the lustrous ore of lead, part of the mineral wealth for which Missouri has been known since the days of the French. In the 1950's, the discovery of vast new lead deposits around Viburnum and iron at nearby Pea Ridge spurred \$300,000,000 worth of mining investment.

A hamlet of a mere 25 souls a few years ago, Viburnum has a population of more than 600 now—and new stores, newly paved streets, and a new school. People expect the population to grow a lot more.

Mountain Home, Arkansas, tells one of the brightest success stories in the Ozarks. By the early 1950's, two new lakes were luring

many retired citizens from Midwestern cities. Young people also started to arrive, after the area launched a drive to attract industry and add paychecks. Plants that make apparel, hospital equipment, and aircraft parts have created 1,700 jobs since 1961.

New Buildings Rise on Bustling Campus

I heard the word "grow" often on the University of Arkansas campus at Fayetteville. The enrollment passed 11,000 last year—double the 1960 figure—and more than \$30,000,000 has been invested since then in construction.

Nowhere in the Ozarks did I find the impact of industrial growth greater than in Springfield, Missouri. "Queen City of the



lady of the house washed the breakfast dishes and then passed them out for sale.

Ozarks," Springfield calls herself, and rightly so. With 125,000 people, she's the biggest city in the region.

Springfield grew large in the remarkably short time of 20 years. A regional trade center and a college town—she boasts five institutions of higher learning—Springfield was discovered by industry in 1951. Ozarkers filed out of the hills to take jobs in the factories that sprang up.

The list of firms that have established branch plants is impressive: Kraft Foods, Owens-Illinois, Litton Industries, the 3M Company, North American Rockwell, Zenith Radio. Zenith's new 700,000-square-foot television assembly plant pumps \$20,000,000 a year into the economy (page 677).



KODACHROME BY BRUCE DALA © N.A.S.

Peace-keeping partners, the John J. Cowarts serve as marshal and deputy marshal of Omaha, Arkansas. "Local kids help police the town," they say, "so things are pretty quiet around here."

Fortunately, the Ozark industrial surge has been slow in reaching little Mountain View, Arkansas. Indeed, no paved road joined it to the outside world until the 1950's. But Mountain View's 1,500 citizens reckon their isolation an asset in a way. In this sheltered environment, father handed down to son the vibrant Ozark-style musicianship free of contaminating influences (pages 656-7 and 683).

Now townspeople intend to capitalize on the talents of the fiddlers, guitarists, banjoists, dulcimer and mandolin players, and gospel quartets abounding in the countryside. Surveying began last fall for a \$2,650,000 folk-cultural center at which musical entertainment will be a major attraction.

I visited a man who learned his music

at the family homestead—a lean, ambling, middle-aged man who usually wears a battered black felt hat and an infectious grin. James Morris is his real name. Folk-music fans around the world know him as Jimmy Driftwood (opposite).

"We'll sit in the back room," said Jim, ushering me into a combination kitchen, dining room, and den.

He could live in grander style if he chose. Besides recording fees, he earns royalties from his compositions. Johnny Horton's rendition of Jim's "The Battle of New Orleans" sold more than a million records. Eddy Arnold's recording of his "Tennessee Stud" sold more than half a million.

"I never heard the term 'folk music' when I was a boy," Jim said. "But all the people I knew lived folk music. Families would gather to sing old ballads like 'Barbara Allen' and 'When I Swim the Golden River.'"

When I said I'd never heard the last one, Jim fetched his well-worn guitar. His grandfather made it, and Jim prefers it to all other instruments. Rocking back in his chair, eyes half closed, he sang:

*Tell the girls to come and kiss me,
For I know they're going to miss me
When I swim the golden river in the mornin'.*

Seven years ago, Jim led local musicians in organizing the Rackensack Folklore Society, borrowing an old name for the Arkansas River and the state. Every Friday night Rackensackers gather at the courthouse to play.

Sometimes this free show attracts a thousand people, as it did the Friday I was there. An hour before dark, pickups brought the farm families to town—father at the wheel, grandmother in the middle, mother on the right side with an infant in her lap, two or three towheaded children bouncing in back.

In the courthouse I heard the squeal of fiddles and the twang of guitars as 25 musicians warmed up. David Morrison sawed a few notes on his fiddle, then listened as his 12-year-old grandson Rickie repeated them on his.

No professional-style fanfare ushered the performers to the platform. Rarely did a musician announce his number. The Rackensackers simply appeared and began to make music.

Roy Wrinkle picked his guitar and sang "The Wreck of Old 97." A family group offered two hymns. When Charlie Richardson fiddled a peppy tune called "Liberty," half a dozen spectators danced an impromptu jig.

Although a few Rackensackers have made

recordings, most do not aspire to the bright lights and big pay of popular musicianship. "I don't believe we'd enjoy our music as much if it was for sale," observed Bobby Blair, idly strumming his guitar. "If it's for sale, it's just different."

Nature Also Makes Music in the Ozarks

I spent two pleasant nights in a rough-board cabin in the Blanchard Springs campground, near Mountain View. Before breakfast I splashed in a cool stream, and under the stars I listened to nature's symphony—water cascading over stairs of stone, the rich bass of bullfrogs, the staccato rasp of crickets. No wonder Ozarkers are musical!

Early one morning I drove from the cabin to the White River, where Adrian Parks awaited me. He motioned me into a snub-nosed johnboat and set it adrift in the current, steering us over rocky spots where long experience as a guide told him trout might lurk.

He kept up a soft running commentary, talking to me, to any wildlife we saw, to the trout: "C'mon, fishie, get your breakfast. You on a diet or somethin'? . . . Don't be scared, old turtle. We won't hurt you. . . . There's lots of beaver around here. Always cuttin' trees, tryin' to make a dam to stop the river." He chuckled at the futility of that.

When my line tugged, I reeled in a 10-inch rainbow. "Not big enough to make a fuss about," Adrian said. "But it'll fry." In the next hour, I caught two more. But Adrian fretted. "You should've had your limit before now. Fishin's not so good this mornin'."

Rimming a high plateau, Arkansas Highway 7 led me south from Harrison into the tangled, rock-strewn hollows of the Boston Mountains, the most rugged part of the Ozarks and, to my mind, the most beautiful.

Beauty stirs deep controversy here.

Out of the crevices of the Bostons, past gnarled cedars clinging to sheer cliffs, wanders the Buffalo River, so unharmed by man that the National Park Service calls it "one of this country's last significant natural rivers" (pages 670-71). Conservationists are fighting to keep it that way by making it a national river. Segments of the Current River already enjoy this protected status as part of the Ozark National Scenic Riverways (pages 678-9).

The Army Engineers began planning in the 1950's to dam the Buffalo to prevent flooding, but called a halt in the face of fierce opposition. The appeal of the cash a lake resort might generate lingers, however, in the Buffalo

country—one of the least developed parts of the Ozarks.

One autumn evening I joined seven members of the Ozark Society, which helped carry the fight against the dam, to plan a canoe trip on the Buffalo.

As we sipped coffee beside a campfire, I asked Harold Hedges what makes the Buffalo special to him. A veteran of canoe trips on 81 rivers, he recently retired to a home near its headwaters.

"The bluffs," he answered. "Spectacular is the only word to describe the bluffs along the Buffalo. No other Ozark river offers anything that compares with them."

Next morning, we put the canoes into a glassy pool—and I, too, appreciated the majesty of the bluffs. Fortress-like, they rose to 400 feet, seeming to shut out the world.

In its deep V-shaped valley, the Buffalo slept beneath a coverlet of mist, awakening when the sun rose high enough to wash the bluffs in pale gold. Now vireos warbled and wrens chattered. A heron eyed us from a limb. Water snakes and turtles sunned on rocks.

We ate lunch on a gravel bar, then paddled on toward Rush. A ghost town now, Rush boomed from the 1890's through World War I, when its citizens extracted zinc ore from mines named Smuggler, Monte Cristo, Jackpot, Hawkeye, and Sam Hill.

Cave Yields Prehistoric Menagerie

Near Cave Creek, a Buffalo tributary, I sat in cool, dank Peccary Cave one afternoon as Jack McCutcheon probed a bank of clay with a trowel. Soon he handed me a small lump.

"Here," he said, "I'll let you have the joy of discovery."

When I rubbed away the clay, a fragment of what seemed to be yellowed ivory appeared. "Probably part of the tusk of a peccary," Jack ventured.

A balding, well-muscled man who puffs a pipe, Jack first explored the cave on his farm five years ago. His finds included the jawbone of a peccary.

A relative of the pig, the peccary still lives in the southwestern deserts. But the jawbone Jack found was of the genus and species *Platygonus compressus*, long extinct. When Dr. James H. Quinn,



EXHIBITION BY ROBERT M. LIGHTFOOT '11

Maestro of Arkansas folk music, Jimmy Driftwood (his real name is James Morris) enjoys his neighbors' artistry at the Friday-night musicale at Mountain View. A noted song writer, he organized the musicians of his home county into the Rackensack Folklore Society, which sponsors the Friday-night get-togethers.

Master of two arts, Violet Hensley both fashions fiddles and plays them. Here she saws out "Soldier's Joy," as daughter Sandy, one of nine children, and husband Adren strum accompaniment. Violet learned to carve the instruments from her father, and made her first at 15.

EXHIBITION BY BRUCE DALE © N. S. S.





Soft-shouldered Ozark hills enfold the 160-acre farm of Mr. and Mrs. Clarence Capps (below right), near Arkansas's Big Clifty Creek around the bend from Hogscald Hollow. Mrs. Capps, whose husband's family has lived in the region for generations, shyly confides

of the Geology Department at the University of Arkansas, learned of the discovery, he obtained grants for systematic trenching of the cave. It yielded an astonishing quantity and assortment of bones and a few artifacts.

The 30,000 specimens include fragments of mastodon and mammoth teeth, and bones of extinct species of wolf, deer, tapir, musk ox, armadillo, and an elklike animal called *Cervalces*. Jack also found 20 human teeth, 11 shell beads, and bits of charcoal, all presumably left by Indians of an unknown tribe.

Reservoir Drowns Unfinished Monument

I turned northwest from the Buffalo country to Eureka Springs, a town that seems to defy gravity. Its Victorian homes and stores cling to the steep flanks of two mountains. The streets twist through curves and switchbacks. There isn't enough level land for a grid.

The town sprang up in the 1880's, after word spread that numerous springs gurgling from the mountainsides had healing

powers. Eureka soon flourished as a resort.

People still fill jugs at the Little Eureka Spring. In the teasing way of mountain men, an elderly gentleman I met near the spring would not admit at first that he thought its water invigorating. "That old stuff ain't good for nothin'," he said. "I never touch it."

Then, eyes atwinkle, he added, "I got to be careful with it. Why, it'll put another 40 years on your life—and I couldn't stand to live 40 years more."

This area holds a peculiar appeal to crusaders. William Hope (Coin) Harvey, a turn-of-the-century free-silver advocate, started construction at nearby Mount Ne of a pyramid to house artifacts of our civilization, which he believed doomed. The site of his monument, never finished, lies beneath a reservoir now.

Carry A. Nation's last home, a Eureka Springs boardinghouse, still stands. The saloon smasher and prohibition crusader bought it in 1908, naming it Hatchet Hall



that "some folks call this Capps's Valley." The couple tend a mixed dairy herd of Holsteins, Jerseys, and Guernseys, as well as chickens and a small truck garden. Mrs. Capps preserves enough tomatoes, beans, peas, and other vegetables for their own use and sells the rest.



Miniature mountaineers—wry, relaxed, and wrinkled—attest a woodcarver's skill and humor at Silver Dollar City, Missouri, a colony that preserves and displays Ozark crafts. Artisans also tie brooms, blow glass, and weave baskets.

"How do you carve an Indian?" someone once asked Peter Engler. "You take a chisel, a mallet, and a tree trunk, and cut away anything that doesn't look like an Indian," he explained. Mr. Engler organized the Ozark Mountain Woodcarvers Guild with 11 masters and several apprentices, including his 15-year-old son Richard.



in celebration of her specialty. Louis Freund acquired it in 1939. "It was to be torn down to satisfy a \$100 debt," he told me. A muralist, Mr. Freund painted in Hatchet Hall's foyer a fine picture of Carry in action.

A part-time resident here is Gerald L. K. Smith, that durable advocate of the farthest right. Like Coin Harvey, Mr. Smith is monument minded. More than a million visitors a year view the 70-foot statue of Christ erected on a hill by the Elna M. Smith Foundation, named for his wife. Nearby, the foundation offers a controversial passion play in summer and maintains a gallery of 400 portraits of Christ in a variety of art forms.

West of Eureka Springs, I picked up the trail of the Butterfield Stage at the Elkhorn Tavern, now in Pea Ridge National Military Park. The stage bounced through this corner of Arkansas in the late 1850's, carrying the mail between St. Louis and San Francisco.

The fierce Civil War battle that swirled around the tavern in 1862—perhaps the most crucial engagement west of the Mississippi—blunted a Confederate invasion of Missouri.

A region of divided loyalties, the Ozarks furnished men to both armies and learned the terror of lawlessness. Guerrillas, plain bandits, even soldiers ravaged the countryside—killing, burning homes, looting barns.

"Inkstains, bloodstains, green grass, mildew, juice stains, and grease." Mrs. Ethel (Granny) Huffman swears by the removal powers of old-fashioned lye soap, which she makes by the barrelful at Silver Dollar City. Les Vining pours the hot soap into a form for Granny.





With local government mired in the chaos left by war, the siege of lawlessness continued long after the soldiers came home. Murderers so often went unpunished in southwest Missouri that a vigilante group sprang up, soon becoming known as the Bald Knobbers because its members met on a treeless hilltop.

"My grandfather was one of the organizers," Douglas Mahnkey of Forsyth told me. "Maybe they shouldn't have taken the law into their own hands, but they believed that only by vigilante action could they restore law and order."

As the Bald Knobbers avenged wrongs, an anti-Bald Knobber group began to ride the hills, taking revenge upon the avengers. By Mr. Mahnkey's count, 14 men died before the Bald Knobber episode passed. "It was," he said, "a long, terrible, bloody time."

I made Springfield, situated close to many interesting areas, the headquarters for much of my wandering. One day I drove west to a quiet hillside near Diamond, and tried to imagine there the boyhood of a freed slave a century ago (page 664).

"From a child, I had an inordinate desire for knowledge, and especially music, painting, flowers, and the sciences, algebra being one of my favorite subjects," George Washington Carver said in later life.

Standing at his birthplace, now a national monument, I could only guess at his struggle to nourish that curiosity. Born in a rude cabin about 1860, Carver had few opportunities to learn from books until well on the way to manhood. But the woods and the fields taught him nature's ways—a foundation for his efforts at Tuskegee Institute to encourage farmers to improve soil and diversify crops.

Old Ways Preserved—for Tourists

I found another counterpoint to Springfield's 20th-century bustle at Silver Dollar City, 40 miles south, near Branson. This recreated village of the 1880's keeps alive the old crafts of the Ozarks.

A blacksmith hammers on horseshoes. A housewife spins yarn. Basketmakers deftly weave strips of oak. Millers grind corn meal.

*See page 610, "Land of a Million Smiles," by Frederick Simpich, NATIONAL GEOGRAPHIC, May 1943.

"We work at keeping the authenticity," said Mrs. Mary Herschend, Silver Dollar City's energetic founder-administrator. "If we let this become just an amusement park, we've lost what we're trying to build."

She told me NATIONAL GEOGRAPHIC aided the quest for authenticity. In an old issue, the Herschends saw a photograph of a one-room log schoolhouse. They located it, bought it, and moved it log by log to Silver Dollar City.*

Lye Soap Kills Ticks, Lures Catfish

At a reconstructed pioneer home, I watched Mrs. Ethel (Granny) Huffman boil lard and lye to make soap (page 687). A novelty to most tourists, lye soap is prized by those who know its versatility. Peering from beneath her sunbonnet, Granny explained, "It's good for poison ivy, poison oak, ticks, chiggers, fleas, mosquito bites, athlete's foot, dandruff, dirty clothes, dirty-mouthed kids, and catfish bait."

"Lye soap stays on the washstand in our house," she said.

The Branson area enjoys special status in the Ozarks. Here steep hillside, there twisting valley, over yonder grassy plateau, its terrain has been a retreat for city dwellers since the early 1900's.

One of those who visited early—and came under the Ozark spell—was Harold Bell Wright. A minister in Kansas, he first entered the Ozarks to seek relief from tuberculosis. Returning, he wrote a novel, *The Shepherd of the Hills*, about the hardy mountain folk who showed him hospitality and the hills where he regained strength. First published in 1907, it became a best seller, the basis for movies and a play as well.

Visitors still buy his book at the Shepherd of the Hills Farm, where actors dramatize the story each summer. They need not read beyond the first page to know how the author felt about the Ozarks. For there he has Preachin' Bill say: "When God looked upon th' work of his hands an' called hit good, he war sure a lookin' at this here Ozark country."

All the others who have come under the Ozark spell—Ozarkers who love their land and tourists just discovering it—know Preachin' Bill was right. THE END

Reaching up to glory, worshipers lift hands and voices in praise of God at a tent revival led by evangelist E. L. Phillips at Branson, Missouri. In the Ozarks' rocky land, where life traditionally has been a day-to-day battle with the meager soil, faith tends to be fundamental, uncomplicated by doubt and dogma, and revivalists find responsive audiences.

The Wasp That Plays Cupid to a Fig

ARTICLE AND PHOTOGRAPHS BY
ROBERT F. SISSON

National Geographic Staff

I HAVE A CURE for that sometime feeling that you're getting nowhere: Spend a day in California's San Joaquin Valley with a lady wasp, whose frustrations will make yours look pale by comparison.

Shortly after dawn the little insect (*Blastophaga psenes*) matures from a larva hatched inside a male fig. She is wed immediately to a flightless husband who never leaves his birthplace.



Then the tiny bride—shown life-size at left—flies off to seek the only place on earth in which nature will let her lay her eggs, another male fig. But only one fig wasp in thousands ever finds that second male fruit. The others spend the rest of their short lives—usually about a day—wandering around inside a female fig, whose structure makes egg laying impossible.

Dusk descends. The lady wasp dies in frustration, and her unborn children with her. Yet her tiny life has not been fruitless, if I may be excused the pun.

For, as she made her way out of the natal male fig, her body picked up a cloak of its pollen (right). And as she wandered frantically through the heart of a female fig, she pollinated it, causing it to ripen. Her act gives

"Once upon a fig, there lived a she-wasp named *Blastophaga*..." Thus might a storyteller begin the wondrous tale of the minute female fig wasp. This stingless insect, searching for a place to deposit her eggs, unwittingly pollinates the *Calimyrna* fig, one of nature's delicacies.

Shown life-size (inset, above), a wasp dries her wings outside her birthplace, an inedible male fruit called a caprifig.

Magnified 48 times, another wasp (opposite) picks up a coat of pollen from male flowers as she makes her way out of a caprifig's interior. Flowers of the fig are imprisoned within the center of the fruit—a botanical rarity.

PHOTOGRAPHS BY NATIONAL GEOGRAPHIC SOCIETY





WHEN STAFF PHOTOGRAPHER ROBERT F. SISSON was asked to photograph the wasp that makes possible a multimillion-dollar fig crop each year, he came back from California shaking his head. "I'm afraid it's too small," he said, opening a tiny jewelry box lined with cotton. "I brought one to show you."

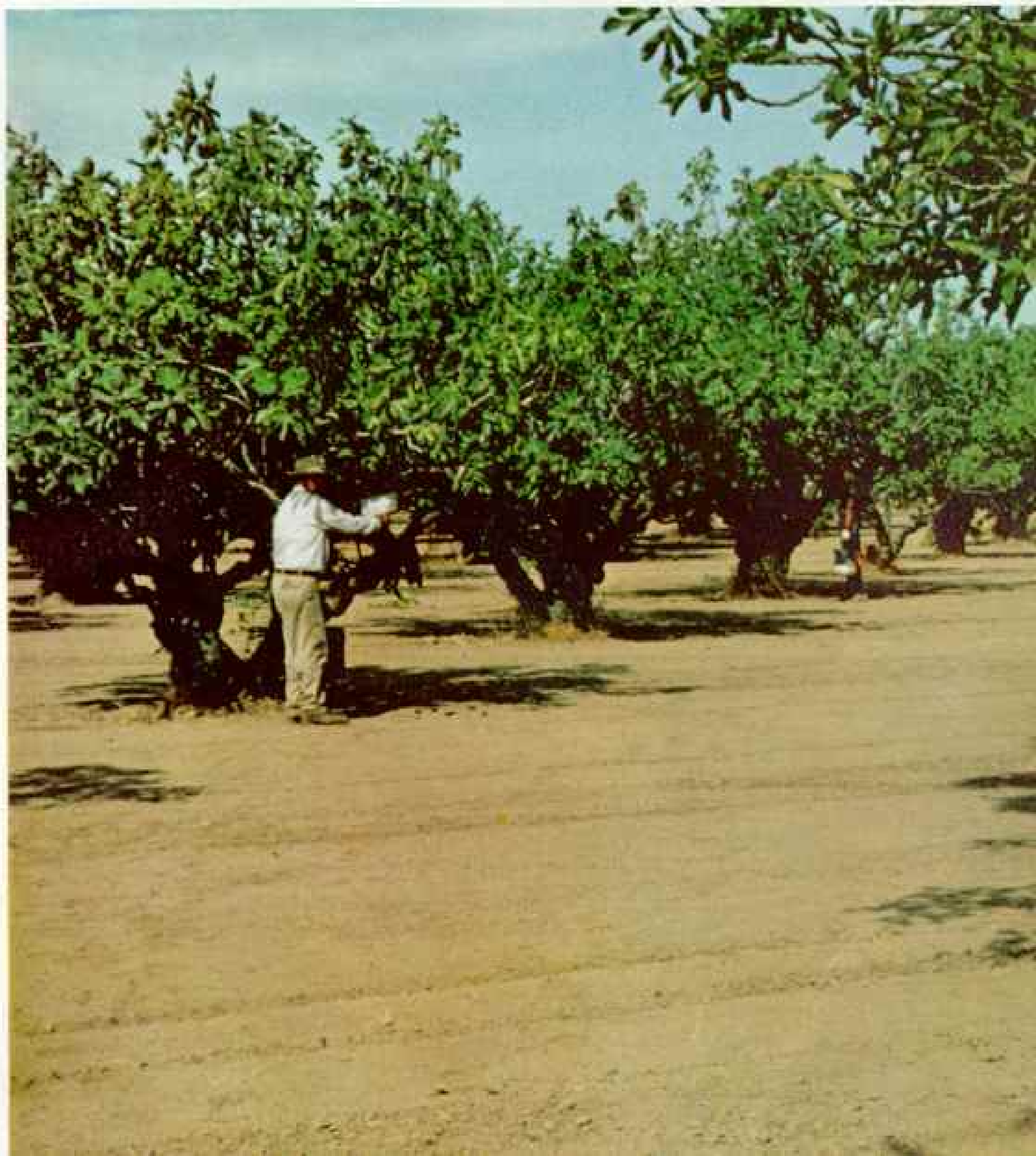
"Where is it?" asked the Editor, peering in vain.

"Right there," said Bob, pointing to a speck on the cotton. The Editor agreed that it was probably impossible to photograph this minuscule creature fertilizing a fig.

But the next time Bob Sisson returned from California, he had made this series of pictures—a feat at least equaling in difficulty his photographs of the railroad worm in the July *GEOGRAPHIC*, the ladybug in April, snowflakes in January, and walking catfish, grunion, salmon, squid, and shrimp in earlier issues.

Although Mr. Sisson here tells the story in light vein, his achievement is a notable contribution to knowledge, illuminating little-known details of one of Mother Nature's strangest ways. —THE EDITOR.

Giving nature an assist, guileful growers staple bags of wasp-filled caprifigs in female *Calimyrna* trees. The emerging wasps instinctively try to lay their eggs in the most convenient fig, and the relocation assures that they will fly to a commercially



mankind the Smyrna fig, a delicacy known since antiquity. No other insect is capable of doing this incredibly specialized job.

"Our first trees," said Ronald E. Klamm, managing director of the California Fig Institute at Fresno, "came from the Near East in the 1880's. They're called Calimyrna—for California and Smyrna, in Turkey.

"They grew well, but the fruit fell off before it ripened, because Calimyrnas, unlike the other fig varieties, won't mature without pollination. Horticulturist George Roeding tried to solve the problem by importing male trees

and pollinating the female fruit by hand—transferring the pollen with toothpicks. This worked, but it involved too much labor. Then the California growers learned the answer: The job in Turkey was done by the fig wasp.

"The first wasps were imported in the 1890's, but almost ten years passed before growers got a colony that matured at the right time to pollenate the figs. When they did, the fruit "set" and matured, and the state was on its way to a new crop that now brings our farmers two million dollars a year."

Ron guided me to the orchard of John E.

valuable Calimyrna rather than to a caprifig. By a quirk of nature, the wasps cannot deposit eggs in the Calimyrna's long-styled flowers (page 696). Frustrated, they die, but not before pollinating the Calimyrna, which could not otherwise mature.

RESEARCH BY NATIONAL GEOGRAPHIC PHOTOGRAPHER ROBERT F. ZISSEW © N.G.S.



Starting their maternal mission, female fig wasps swarm within a male fig, split open to reveal its inner world (below). Flowers on the stem side of the interior serve as hatchery and nursery for the insects. Pollen-producing flowers on the other side guard the opening, or eye, which the wasps must thread to reach the world outside. As they go, they pick up a cargo of pollen—bothersome stuff to them but precious to the *Calimyrna* fig. Once out, they hasten to find their way into another fig before their deaths, usually on the same day as their births.



LIFE SIZE

SCIENCE PHOTO LIBRARY © N. A. Z.



30 TIMES LIFE SIZE



Husband she never sees fertilizes a female wasp still inside the specially adapted flower she was born in (above, center). The author reports that the wingless amber male gnaws a hole in one side of it, then penetrates the other side for the act of fertilization. Duty done, he dies without leaving the caprifig.

Fertilized female (left) uses the first hole opened by her mate as an escape hatch. Females not found by males may chew their own way out of the casing, the author observed, by cutting around its equator (directly above). Though infertile, they go through all the motions of motherhood, pollenating figs as efficiently as their fertilized sisters.



DAVID H. HARRIS

Wheeler and his son, just outside Fresno, and helped unload my heavy cases of photo gear.

"You won't get stung," he told me. "Fig wasps don't have stingers."

He handed me a sharp knife as he left me to my work.

"Anything for science," he said. "Don't spare John's fruit."

I didn't, and during the next three weeks I reduced the Wheeler crop by several hundred figs, cut open in my search for wasps. I began where the wasps begin, inside the fruit of the male tree, called the caprifig (opposite, above).

What we know as a caprifig actually consists of a case enclosing fruit pulp and, at the center, two kinds of flowers, one male and one female. The size and shape of the female flower stimulate the wasp to deposit an egg; then the flower grows a protective covering, or "gall." One male fig may become the haven for as many as 600 eggs.

Male wasps hatch from the galls before the females. Inside my first sectioned fig a host of the amber males moved about in search of wives. Through the camera lens I watched one chew a hole in the top of a globular gall.



ROBERT HOGES © NATURAL HISTORY SOCIETY

Frustration . . . and fulfillment. Figs on a female Calimyrna tree (left) attract wasps, which cannot tell them from caprifigs of the male tree.

Inside a Calimyrna fig (below), a wasp finds only frustration as she tries to thrust her short ovipositor down to the ovary at the base of one of the long styles in the female fig's flower. Only in the male fig's short-styled flowers can she reach the base and deposit her eggs. Again and again she tries, all the while brushing male pollen onto female flowers. Finally the thwarted wasp dies of exhaustion and the June heat. Long before the fig matures, its enzymes completely assimilate the tiny insect.

Enough of her sisters remain in the male trees to lay their eggs and perpetuate the species. A female (right, from top) alights on a caprifig, seeks the tiny eye, and loses her wings—no longer needed—as she squeezes inside. Then, fulfilling her destiny, she at last deposits her eggs.



© TIM LEE/INCE



4 THRU LIFE SIZE



ILLUSTRATION © NATIONAL GEOGRAPHIC SOCIETY



Is this how he finds out if a lady, not a late-hatching brother, dwells within? I don't know, but the labor is not in vain, for the female wasp ultimately emerges through this hole. First, though, in the sequences I photographed, her mate cuts a second hole, through which he inserts his specially adapted abdomen to fertilize her (page 695).

Now I watch as the lady wasp climbs out of her gall. I follow her as she starts her journey to sunlight. Before her lies a thicket of pollen-producing flowers through which she must pass to reach the outside. On the way she acquires a heavy burden of white pollen.

Emerging into the June air, the tiny lady rests awhile. She tries to shed her pollen top-coat but cannot. Her wings lift her in flight.

Trick Causes Wasp to Work Overtime

My work with the male fruit is done. Following the tiny black insect, I find her about to disappear into a green female fig.

At this point, I should explain something. Fig growers are cunning. The Wheelers have loaded the odds against the wasp's finding another male fig: They have plucked most of the insect-laden male figs from adjoining plots and put them in open paper bags attached to the female trees (pages 692-3).

Using the knife again, I find the little female wasp at work for the Wheelers, trying to deposit an egg at the base of a flower part called a style. Ron Klamm arrives to see how I am getting along.

"Poor little girl. Watch her frustrations begin," he says over my shoulder. "The female fig style is long, the wasp's egg-layer, or ovipositor, is short.

"Instinct tells her she must place the egg at the very bottom of the style. She can't manage it. She tries another. Same story.

"For all I know, she may try every style in the fig before she gives up. In the process, bless her little soul, she and her sisters pollenate our figs."

As we watched a caprifig, a wasp came out. She shook herself in the sunlight, took off—and landed on a female fig.

Ron trapped her in his handkerchief.

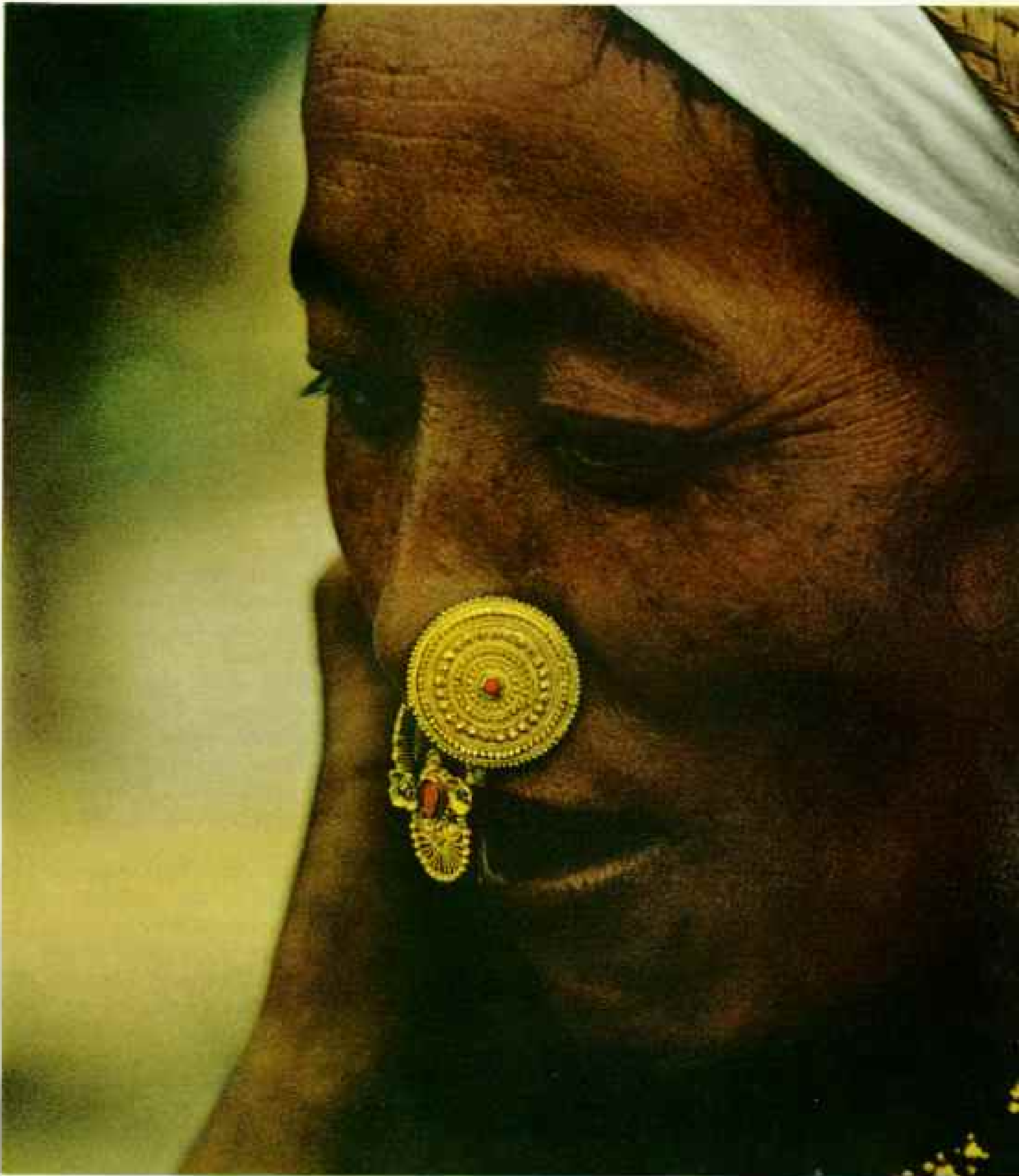
"If you ever tell anybody I turned sentimental over something I can hardly see, I'll hate you for life," he said.

We crossed the road. Deep in the foliage of a male fig tree, Ron opened his handkerchief. The little wasp flew away—to avoid the frustration that awaited so many of her sisters, I hoped, and lay her eggs. THE END

ganganagorak

CLOUD-WREATHED HIMALAYAN CAPITAL

ARTICLE AND PHOTOGRAPHS BY JOHN SCOFIELD ASSOCIATE EDITOR





FLOATING beyond serpentine rice terraces, the mile-high capital of Sikkim rides the mists of an early monsoon (above). The kingdom's steep mountains and hidden valleys favor the isolation of diverse ethnic strains, but in Gangtok—"the top of the hill"—they meld into one richly flavored Himalayan community.

BRIGHTENED by gold and coral, a Nepalese woman eases the woven bamboo headband holding her backpack. She sells her burden of bread at the Sunday market in Gangtok.

Nepalese of the Hindu faith form a majority in Sikkim, a land whose traditional culture and ruling family are Tibetan Buddhist. In the 19th century the British encouraged Nepalese farmers to immigrate to bring more land under cultivation. Today roughly two-thirds of Sikkim's 200,000 people are of Nepalese origin.



Colorful camaraderie of a mid-Asian market

EACH SUNDAY Gangtok's open-air Lall Bazaar rings with many tongues: Hindi, Nepali, half a dozen Tibetan dialects, and English, the official language. Dialect and dress give clues to each ethnic group. The flirtatious Lepcha girl above wears good-luck beads typical of Tibetans who subdued her spirit-worshipping, forest-dwelling ancestors in the 17th century and converted them to Buddhism.

Merchant from India, which lies only 10 miles to the south, offers hundreds of padlocks.

Boy with a Nepalese cap of embroidered cotton buys chickens for curry-flavored stews.

Shawl-draped Nepalese woman pays eager heed to a turbaned astrologer from India.



TIBET—that forbidding and forbidden borderland between China and India—has always fascinated me. I remember as a child an ornate *kapala*—a Tibetan ritual vessel made from a human skull—on our mantelpiece at home. Through my father's antique shop passed fearsome masks, sacred paintings framed in rich brocades, and gilded images of many-armed demons and serene Buddhas. My own home has never been without some of these symbols of the mysterious "Land of Snows."

The dream of seeing it for myself ended,

though, when Red Chinese armies in 1950 began systematically uprooting Tibetan society to make of this heartland of Himalayan culture merely another brick in the structure of Chairman Mao's New China. But the Tibetan way of life goes on, I discovered when the Indian Government allowed me to visit Gangtok, capital of the beguiling mountain kingdom of Sikkim (map, page 706).

The tiny protectorate is ruled by perhaps the world's most unusual royal couple. Scion of a noble Tibetan family, handsome Palden Thondup Namgyal, the Chogyal of Sikkim,



PHOTOGRAPHS BY JOHN SCOFFIELD © NATIONAL GEOGRAPHIC SOCIETY

steers his country into the modern world while carefully guarding its role as a sanctuary of the Tibetan form of Buddhism. His queen, the Gyalmo, is a slender, soft-voiced American girl educated at Sarah Lawrence College in Bronxville, New York (page 707).*

On my first morning in Gangtok, snow-capped Kanchenjunga—earth's third highest peak—reared crisply above monsoon clouds. The sight, rare at this time of year, seemed

*See "Wedding of Two Worlds" by Lee E. Buttoglia, in the NATIONAL GEOGRAPHIC for November 1963, and "Sikkim" by Desmond Dooz, March 1963.

a good omen; I found that I had arrived just in time for Rumtek Monastery's once-a-year lama dance (pages 702-5).

The performance had already begun when my friend Tse Ten Tashi led me through the monastery's dim passageways to the second-floor sanctum of Rumtek's abbot, the revered Karmapa Lama, who came from Tibet. We exchanged long white scarfs—the traditional mark of respect among Buddhists of Himalayan lands. The prelate himself draped a length of cloth about my shoulders as I knelt before him.

(Continued on page 712)





ESTACHONRE (LEFT) AND RONGCHONRE (2) N.I.S.

Evil spirits beware!

AS IF SWOOPING from the mouth of hell, a lama-dancer threatens demons with his own devilish demeanor. Baby-packing youngster (above) stands enthralled. In May the new monastery of Rumtek—a piece of old Tibet re-created in neighboring Sikkim—stages a day-long dance drama to honor Padma Sambhava, the eighth-century Indian pundit who established Buddhism in demon-worshiping Tibet. He banished most of the devils, but embraced those who agreed to defend his faith. Sikkimese believe Padma Sambhava also visited their country to consecrate its holy places.

As a fierce representation of the revered mystic, this dancer brandishes a bronze dagger to destroy unconverted demons. Artisans in neighboring Bhutan carved the mask; silk brocades reflect Chinese fashion; Tibetans sewed the felt boots.

Rumtek shelters 200 lamas, the spiritual guides who link worshipers to Lord Buddha. Customarily, each Tibetan and Sikkimese Buddhist family dedicates a son to the priesthood.



Masked deities, led by yellow-hatted lamas swinging censers, re-create an incident from Padma Sambhava's life. Unseen in the privacy of his quarters, the Karmapa Lama,



abbot of Rumtek Monastery, watches through a horizontal slit between the two balcony curtains at top, left of center. Banner depicts a dark Buddha flanked by disciples.

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REPRODUCED BY



Little buckle on the Himalayan belt, Sikkim, a protectorate of India, lies on the front line of that country's disputes with China. The roads to Nalu and Jelep Passes served as major trade routes into Tibet until Sikkim sealed the border in 1962.

INDONESIA



Storybook capital of a gentle kingdom

GANGTOK, population 12,000, tumbles over hills terraced for a crop of maize. The Chogyal, as Sikkimese call their king, and his American-born queen, the Gyalmo (below), live in a modest red-roofed palace on the crest of the hill at left, and worship in the yellow-and-white chapel beyond it. Prayer flags flutter from government buildings nearby.

Semitropical Sikkim—sometimes called the “Land of Fruit”—reaps a bountiful harvest of oranges and apples. The country exports them, as well as medicinal herbs, cardamom, and some copper. India provides aid for roads, hospitals, schools, and other development projects, while directing Sikkim’s communications, defense, and foreign affairs.



Royal trio: The former Hope Cooke of New York City acquired the title “Consort of Deities” in 1963 when she married Crown Prince Palden Thondup Namgyal. The wedding shattered tradition; past rulers selected brides from the noble families of Tibet.

Second son of the previous king—and a Rimpoche, or reincarnated saint—Palden Namgyal was studying for the priesthood when the death of his elder brother made him heir to the throne. He met Miss Cooke on a vacation in Darjeeling, India. Court astrologers set their wedding date as March 20, 1963. In December of that year,

the prince became king. His wife, who has adopted his nationality, actively encourages Sikkimese arts. Here their six-year-old son Palden joins the royal pair at palace ceremonies.



Last procession for a princess

UP THE CLOUD-VEILED ROAD leading toward Natu Pass winds the funeral of Princess Sonam Padaun, youngest sister of the Chogyal, to the royal cremation ground at Lukshiyama last May 15.

Behind the parasol, symbolic of royalty, a lama holds a white scarf of honor attached to the body within the canopied litter. Thus he guides the soul on "the right path—the white one" through the dreamlike realm, or Bardo, between death and rebirth. Prayers and offerings ease the way. The royal family mourned for 49 days—the maximum period that the spirit roams.

ILLUSTRATION BY JOHN SCOFFELE © R.C.C. 709





LOWING TRUMPETS express veneration as the body is placed on the pyre, circled by lamas (upper right). A small boy in monastic training holds the ten-foot instruments off the ground (above). The conch-shell trumpets at right, encrusted with gold, silver, turquoise, and coral, simulate wind moving through a forest. Solemn but joyful friends wish the departed a good future life.

Himalayan Buddhists believe that during the Bardo passage the soul, by right thinking, can liberate itself from base desire and seek a better rebirth, possibly even an end to rebirth—nirvana.

The 43-year-old princess had worked to aid Tibetan refugees made homeless by the Chinese occupation. Most exiles moved to India, but 4,000 settled in Sikkim. Many paid their last respects (page 712).



EXTRACT FROM 'BELOW' AND 'KODACHINDE' © N.S.S.





A soul is free

MARKING THE PASSING of her patron, a Tibetan-refugee girl in school uniform lifts her hands in prayer.

Butter offerings feed the leaping flames (right), and the spirit moves on toward its next incarnation. A shrine, or *chorten*, will be erected to mark the cremation site.

(Continued from page 701)
“Very lucky,” said Tse Ten. “His Holiness’s blessing will speed you to nirvana, shortening your journey through life’s many rebirths.”

Hours later, as I worked frantically to record the day-long spectacle, Tse Ten rushed up to me. He was chewing on a *momo*—a Tibetan pastry filled with meat—and thrust another into my hand. “Eat,” he commanded. “His Holiness has



been watching. He says you have been making pictures too long without food and sends you this."

Tragedy pulled aside the veil from another face of the venerable culture that Sikkim guards. The Chogyal's youngest sister died. Nearly a week later, on a day selected as auspicious by the astrologers of the royal chapel, Sikkim's beloved Sonam Padaun was cremated in a ceremony worthy of a Himalayan princess and rich in the pageantry of old Tibet.

Up from mile-high Gangtok moved the procession, led by red-robed lamas. At the lofty royal cremation ground, only a few

miles from the now-sealed Tibetan frontier, trumpets moaned as the body was placed atop a pyre. Smoke held down by the sweeping fog engulfed mourners and clergy alike as pans of consecrated oil were poured onto the fire. It was late afternoon when offerings molded of butter were added, creating a great billow of orange flame (below); with a final soft shudder the last fragments of the princess's bier slipped downward into the ashes.

"The storms of this life are over," said a Sikkimese beside me, "and our princess has not yet started another. She is at peace."

THE END







I STOOD AT THE EDGE of a shrunken lagoon in southern Paraguay. It was the peak of the dry season, and the water was low and mirror still, save for an expanding circle here and there caused by the touch of a dragonfly or the surfacing of a small fish.

Opening my fishing kit, I tied a steel leader to the end of a 20-pound-test line, then a hook. My knife sliced a cube of bait from a hunk of sinewy local beef. My rod was a branch trimmed from a nearby thicket.

Unseen in these sullen waters swam piranhas—hungry as are all fish, but allegedly a hundred times more rapacious, attracted to anything fleshy. I had read, like iron filings drawn to a magnet.

I had heard the proverbial horror stories: the canoeist suddenly minus a finger; the cow skeletonized while fording a stream; the swimmer disemboweled by sudden attack. Nineteenth-century naturalist Alexander von Humboldt referred to the piranha as one of South America's greatest scourges. The words of eminent ichthyologist Dr. George S. Myers also came to mind: "...teeth so sharp and jaws so strong that it can chop out a piece of flesh from a man or an alligator as neatly as a razor, or clip off a finger or toe, bone and all, with the dispatch of a meat cleaver."

On the other hand, during repeated visits

Seeking the Truth About the Feared Piranha

ARTICLE AND
PHOTOGRAPHS BY
PAUL A. ZAHL, Ph.D.
SENIOR NATURAL SCIENTIST



Rapacious killers or creatures much maligned? In an attempt to separate fact from fancy, the author journeyed across South America studying piranhas, including *Serrasalmus nattereri*, considered the most dangerous. These Brazilian specimens have red undersides (left), while a Paraguayan example inspected by Dr. Zahl (left, above), has a yellow belly.

to South American hinterlands, I had often watched Indian children splashing carefree and unharmed in piranha-inhabited waters (pages 720-21), their mothers waist-deep nearby rinsing laundry. Brazilian anthropologist Harald Schultz, after spending more than two decades in piranha country, could write, "In all these years I have never had a harmful experience with these greatly feared piranhas."

Unspectacular—Except for Its Teeth

Mindful of both sides of the story, I stitched the juicy bait onto my hook and swung the line out over the lagoon.

In a few seconds I felt a tug. I braced and whipped up the pole. It was disappointingly easy. Onto the bank flew a silvery fish scarcely larger than my hand—a little creature no more impressive than the trout of my boyhood days in the Sierra Nevada.

But the comparison stopped when I caught sight of jaws snapping wildly in their effort to dislodge the hook. Had my leader not been steel, it could have been severed instantly.

"Don't touch him!" warned my companion, Señor Juan Pío Rivaldi Blanco, chief of Paraguay's Fish, Game, and Fish Breeding Division. His boot came down, pinning the flapping piranha to the ground. Cautiously he removed the hook, seized the fish behind the gills, and held it up.

Latinized as *Serrasalmus nattereri*, this struggling specimen had silvery sides and a yellow belly—quite unspectacular, except for that mouthful of fiendish teeth. Each was a razor-keen triangle set so that when its cutting edges met those of opposing teeth, the shearing power would be all but irresistible (pages 722-3).

About a score of piranha species, differing in head shape, coloration, size, and temperament, but nearly all possessing that incisive bite, claim a habitat covering some four million square miles of tropical South America. They are found wherever fresh water flows or stands—from the lower eastern slopes of the Andes through Colombia, Venezuela, and the Guianas; south and eastward across the immense Amazon Basin; into Bolivia, parts of Peru, Paraguay, Uruguay, and northeastern Argentina (map, page 719).

Known as *perai* in parts of the Guianas and *caribes* in several other lands, they take their more common name from dialects of the Tupi linguistic group, in which *pira*

means "fish" and *ranha* "tooth." Virtually all piranhas belong to the genus *Serrasalmus* of the family Characidae, which also includes many a good-tempered aquarium fish.

One of the smaller piranhas, *Serrasalmus spilopleura*, reaches only about half the length of the big dark *Serrasalmus niger*, which may grow as long as 18 inches and weigh as much as five pounds. In my experience, the little one was not dangerous; I had encountered it everywhere in Paraguay, even in the smallest streams. *Serrasalmus niger* was another matter; while some of my informants declared it to be among the most harmless, others gave it a dangerous label. All my experts agreed as to the peril of dealing with *Serrasalmus nattereri*, the species that is probably most responsible for the piranha's fearsome reputation.

Some species have a tendency to gather in schools, while others are loners, except when lured into a group by the smell or taste of blood or raw flesh. Some are said to prefer deep habitats; others seem to frequent the shallows, either turbid or clear. Certain species appear to seek quiet waters, others the more rapid currents. Some seem savage; others are only moderately aggressive. Some seem to be omnivorous, but most are basically flesh eaters with cannibal tendencies.

Opinion Changes in a Split Second

To observe and photograph piranhas in their natural habitats, I planned trips that would sample the group's entire geographical range. I would begin along the Paraguay-Argentina border, then move northward into Brazil, proceeding eventually into the heartland and the delta islands of the Amazon, and as far north as Surinam.

After finding *Serrasalmus spilopleura*—the small innocent one—abundant in Paraguay, I was somewhat lulled in my estimate of the piranha potential. I had often picked this fellow from a net by hand, finding him no more hostile than a goldfish. Then one day an eyewitness experience changed my outlook.

Driving through Paraguay's picturesque cattle country a hundred miles south of the capital city of Asunción, Señor Rivaldi and I drew up to an isolated and brooding lagoon. Six or seven fishermen, hip-deep in the water, were setting a long seine.

I approached the net's onshore anchor man, clad like the others only in shorts and a straw



PHOTOGRAPH BY PAUL S. DILL © R.A.S.

Ravaged by its own kind, a piranha from Brazil's Rio das Mortes, River of Death, reflects the voracious side of the fish's nature. After this one-pound *sattereri* was hooked—and thus vulnerable—its rivermates attacked, biting out huge chunks in a few seconds. Piranha species may number around 20, but sparse data and identification problems preclude a specific total.





PHOTOGRAPHS BY LOREN MURTHIE © R.S.S.

hat. "Aren't you worried about piranhas?" I asked in my best schoolbook Spanish. He didn't bother to reply in words, but the answer came through loud and clear—a casual shrug of the shoulders, expressing anything but worry.

At a sign from one of the waders, my taciturn friend began tugging gently. Floats bobbed as the net was eased shoreward. The catch proved to be a modest one—several dozen common table fish, along with piranhas, including a number of the reputedly vicious *Serrasalmus nattereri*. No one registered the slightest apprehension as the fish were emptied into baskets.

Suddenly a *nattereri* flipped out of the net onto the bank. The nearest fisherman slapped his hand at the maverick—an instinctive "shoo" aimed only at the slightest contact, like that of a person trying to flip a glowing ember back into a fireplace. I saw no contact of hand and fish.

Then I noticed blood on the third finger of

Labyrinth of looping tributaries, the steamy reaches of the Amazon delta form an extensive haven for piranhas. At home in fresh water, both still and running, the fish can be found across some 4,000,000 square miles of South America (below). The author crisscrossed much of this territory on his five-month survey.

719



the man's right hand. During the preceding split second the creature's toothy scalpel had removed a piece of flesh the size of a dime, all but shearing the bone.

For a moment the victim seemed unaware of the wound. A piranha bite, like the cut of a razor, is said to be virtually painless at the instant it happens. Only when others noticed the blood did the fisherman see it too. His face blanched, but he made no sound.

Fish Bite Pouliticed With Tobacco

The attitude of the group was casual. I suggested that Rivaldi bind a handkerchief around the finger while I ran to the car for my first-aid kit. But before I could do so, one of the fishermen took a large pinch of smoking tobacco from a battered leather pouch, moistened it in the lagoon, molded it into a wad, and pushed it into the open wound. Then the finger, wad and all, was wrapped securely in a bit of dirty rag.

A few minutes later the man was back at work with his fellows. The wound would heal rapidly, I was assured, the tobacco acting as both an astringent and a disinfectant.

In Asunción I met missionaries Marvin

Cole and Roy Christopher, who ran a school in a village of Maká Indians on the west bank of the Rio Paraguay. The name NATIONAL GEOGRAPHIC was especially meaningful to these missionaries; during long months of breaking through linguistically to the Maká they had used back issues of the magazine to associate words with familiar objects in the photographs. The pictures had fascinated the Indians, and gradually they had been persuaded to reveal essential aspects of their difficult language.

My acquaintance with the missionaries led to a series of visits to the riverside Maká village. Aware of my interest in piranhas, the villagers invited me to join them on a fishing trip to a lake about two miles inland from their settlement. The lake turned out to be a soupy dry-season lagoon, scummed with algae and choked around the edges with marsh weeds. Under the scum were said to swim catfish, eels, rays—and piranhas.

My Indian friends, wearing old trousers or shorts or the briefest of loin cloths, splashed into the thigh-deep water. Their mood was carefree, almost jocular. Forming a loose line across the lagoon, some 25 men waded forward,

Oblivious to possible peril, children of Maká fishermen frolic in piranha-inhabited waters of the Rio Paraguay. In the shallows nearby, village women ignore the danger while doing their laundry. The author saw such scenes duplicated many times.

Scarred for life, a Brazilian on Marajó Island shows where piranhas sheared silver-dollar-size chunks of flesh from his leg. Despite such encounters, Amazonian fishermen display little fear of piranhas.



driving the aquatic population ahead for concentration at the far end. Each Indian carried his own net—two poles about seven feet long connected by a length of mesh. The trick was to plunge the net, spread open, into the water wherever fish might be, then to slap the poles together, creating a trap (pages 728-9).

Stingray More Feared Than the Piranha

That morning several Indians had shown me scars on their legs—mementos of earlier fishing forays. The scars were of three sorts: a vaguely discernible arc on the skin, an irregular blotch (opposite), or a network of localized marks and lines.

The arc-shaped scar derived from a piranha bite that had cut but not removed the skin, allowing the patch to be fitted back into place for healing. The irregular blotch resulted from the clean removal of skin and flesh, as in the case of the fisherman mentioned earlier. And the network of marks and lines was the work of a stingray's spine, with its attendant severe pain, infection, and slow healing.

In fact, native fishermen told me that they fear the stingray far more than the piranha—

more than snakes or caimans—for it wields its sawtoothed spine with great force and leaves a jagged wound. To avoid stingrays, which occur throughout South America's piranha area, the wading fisherman shuffles rather than treads through the water, on the more or less tested premise that a ray will not strike unless actually stepped upon.

Matching the Indians' slow forward pace, I moved along the bank. Finally a signal from the leader touched off a general outcry. With whacks and slaps, nets hit the water and in one swift motion were dipped, closed and hoisted, flapping with fish.

Most of the haul were catfish and large-headed *Hoplias*, but here and there I could

Like flashing razors, a piranha's triangular teeth, driven by powerful jaw muscles, can cut so cleanly that a fisherman sometimes does not realize he has been bitten until he sees the blood. Lower teeth of this *Serrasalminus nattereri*, bared by forceps, fit precisely into the serrated upper set. The author watched one Indian woman use a jaw, cleaned of flesh, in place of scissors to cut threads at her loom.

4 TIMES LIFE SIZE







spot *nattereri*. I watched the Indian nearest me. Cautiously he grabbed one just behind the gills—as Rivaldi had done—then quickly raised it to his mouth and bit fiercely down into the back of the head, instantly killing it. From time to time I could hear other such crunchings from along the line.

Within an hour each man was trailing a string of 50 to 100 assorted fish. During the entire operation no one had been bitten by a piranha or stabbed by a stingray. Apparently luck rode with the Indians that day.

On shore now there was new activity as men collected firewood and others trimmed wooden skewers with wicked-looking machetes. Soon half a dozen fires were blazing; around them the skewers were stuck in the ground and tilted toward the flames, each impaling fresh fish that nobody had bothered to behead (pages 728-9).

So far in my travels I had not tasted piranha. I tapped the shoulder of an ancient cheek-tattooed Maká who tended one of the fires. "*Wanaj*," I said, using the Maká word for piranha, and pointed to one browning and crackling on a skewer. The aroma was tantalizing.

Tough old hands pulled the fish from the stick and handed it to me. All I could do was toss it from hand to hand, blowing on it until it was cool enough for me to take a bite.

Imitating my friends, I sank my teeth into the dorsal flesh. To be sure, there were bones and scales to be wary of, but the meat had the texture of broiled bass and tasted just as good. Two or three of these eight-inch fish made an excellent meal.

That afternoon in the village I noticed a bead-laden matriarch dissecting the lower jaw from the remains of a piranha. Next morning I saw her at her loom. Hanging around her neck on a long loop of yarn was the toothed jawbone, which she used in place of scissors, neatly and swiftly cutting thread ends as she went along.

"Man of Faith" Swims the River

Three weeks later in central Brazil, along the Rio Araguaia bordering the State of Mato Grosso, I fished with a different group of Indians, the Karajá. With me on this new quest had come Heraldo Britski, an ichthyologist and museum curator from São Paulo. A Vasp Airlines DC-3, circling first to make sure there was no livestock on the grassy runway,

put us down in a field near the river village of Santa Teresinha.

Here, as in Paraguay, missionaries proved valuable informants. Summoned via a communications system difficult to fathom, Tom Pope, who works as a Protestant missionary on the far side of the Araguaia, met us before the sun went down.

"Piranhas? I respect them!" Tom admitted. He had been nipped once or twice while bathing in the river, he told me, but with no serious consequences.

"I still bathe in the river," he added, "and so does the Catholic padre on the opposite bank. He once swam the river to visit me. There's a man of faith!"

Roots and Vines Take Place of Hooks

Thanks to Tom, a fishing expedition soon took place. Early one morning four Karajá adults and half a dozen boys readied a slim dugout near the mission where Heraldo Britski and I had gone to meet them. There was no recognizable fishing gear in the canoe, but on the dank bottom lay a heap of carrot-size roots and a bale of vines. The juices of these plants, belonging to the families Sapindaceae, Euphorbiaceae, and Leguminosae, have long been used by South American aboriginals to stun fish. One of the effective ingredients is rotenone.

Tom, Heraldo, and I crowded in with the Indians and the plants. Within half an hour we stood on the banks of a large midstream island. Roots and vines were loaded into baskets or onto outstretched arms, and without palaver we filed behind Luiz, the lead Indian, across rolling stretches of soft white sand. Then, unexpectedly, we came to a depression in the sand—a lagoon 30 by 60 feet and not more than hip-deep. The water was pea-soupy with algae.

The boys squatted on the shore and began beating the roots to break the tough protective skins while two men waded into the pool. Each drove a heavy post into the bottom. The forked upper end would serve as an anvil for hammering juices from the vines. Accustomed by now to the Indians' indifference to the piranha hazard, I photographed these preparations, while Britski arranged collecting nets and jugs.

Now the boys packed the mashed roots into loosely woven baskets and waded with them into the lagoon. Back and forth they

shuffled, swishing their loads up and down in the water. Simultaneously the men bludgeoned vines on the post heads (page 727). Juices released by both operations spread in the water, appearing to form a soapy froth on the lagoon's surface.

Soon fish swirled madly here and there—small ones first, then larger ones. The juices were inhibiting oxygen absorption by the gills. Without a sustained supply of oxygen, any fish will quickly die. Such chemical substances, including rotenone, affect only the gills, and do not impair edibility.

After weeks in the field, I could easily spot surfacing piranhas. As usual, *nattereri* were the most abundant, but to my surprise their bellies were bright orange or red here rather

than yellow. Heraldo had no explanation.

We netted many a piranha minus a tail or seriously mutilated where flesh had been ripped from the body. It was obvious that when one fish begins to weaken from the effect of the chemicals, another as yet unaffected will rise to attack his disabled brother. Often when fishing for piranhas with hook and line, I have pulled up only a head, the body having been snatched away by fellows of the same ruthless species (page 717).

Baited Even With Fruit or Bread

What do piranhas normally eat? The ones we caught that day had dined on minnow-size characins. But these do not constitute the sole piranha diet. Years earlier in Venezuela



PHOTOGRAPH BY PAUL E. ZIMM © N.A.S.

Greedy gobblers at three months, piranhas hatched in the Fleischmann Memorial Aquarium at the Cincinnati Zoo gulp ground meat. These *nattereri* already try to nip the curator's fingers; when mature, they may measure 10 inches. U. S. aquarium stores sometimes sell piranhas, but several states, including Florida, ban imports. Floridians fear that the creatures might thrive in the state's subtropical waters, with disastrous effects on native fish—not to mention the effect on people.



FORNBERG © R.A.

I had successfully used fruit as piranha bait, and frequently I have seen fishermen stick wads of bread on their hooks.

While I photographed, Heraldo netted specimens for his museum collection, rattling off their tongue-twisting Latin names. The Indians basketed an abundant catch of their own. Any piranha still flapping they immobilized not with a bite, as had the Maká, but with the resolute whack of a club.

Breeding Time May Affect Behavior

A week after fishing with the Karajá, Heraldo Britski, laden with jars of preserved specimens, returned to São Paulo. I moved upstream to the village of Santa Isabel do Morro, into the John Kennedy Hotel, a traveler's lodge run by Senhor Roland Ubirajara Santos, hunter, fisherman, and a friend of river Indians.

Roland didn't like piranhas, but neither was he disposed to dwell on their savagery. And I was beginning to wonder about the tales of ferocity. After nearly two months in piranha country, with the guidance of knowledgeable experts, the only instances of aggression had been evoked by capture.

I was beginning even to doubt the authenticity of those photographs and movies I had seen showing piranhas boiling to the surface

Unpleasant companions: a piranha and an even more feared stingray. The rays lie on the bottom, often obscured by sand or mud. If a wader steps on one, it may whip its spine into foot or calf, inflicting an injury far more painful and slower to heal than a piranha bite. Both specimens were caught by the plant-juice method (right).

Plant juices replace fishhooks for Karajá Indians along Brazil's Rio Araguaia. From beaten vines and mashed roots, they obtain fluids that retard oxygen absorption by the fish and create a soapy froth on the water. Here they use forked posts as anvils to pound lianas and release juice into a quiet lagoon. Soon oxygen-starved fish will rise to the surface, to be speared or netted. When these fishermen capture still-active piranhas, they club them, in contrast to Paraguay's Maká, who dispatch them by biting into the backs of their heads.

in response to anything fleshy. Whenever I cited the classic story of the cattleman sacrificing a decrepit cow as a piranha lure some distance from the point where his herds must cross a river, I drew smiles. I met not a single cattleman in Paraguay or in the Mato Grosso who could verify that one.

On the other hand, I was reluctant to jump to conclusions. Piranha temperament might well be played upon by any number of variables: season, chemical content and temperature of the water, and, of course, availability of food. One ichthyologist has ventured the opinion that adult piranhas, like many another animal of land or sea, are particularly aggressive during the breeding period.

Roland knew of my preoccupation with piranhas. "I want to take you to the Rio das Mortes," he offered one day. "It's four hours upstream by motorboat, but there we will find fierce piranhas, I guarantee!"

Next morning, with a native boatman and a guide named Domingos Braga, we whined our way up the Araguaia. The River of Death, a tributary of the Araguaia, seems to have been named in grim remembrance of a massacre, but the details are fuzzy. Some say missionaries, others Brazilian soldiers, were the victims years ago of hostile Indians. That the name derives from the ferocity of the river's piranhas is an altogether different theory—one, I admit, I wanted to believe.

The sun had climbed high before we turned from the broad Araguaia onto the tributary with the sinister name. But there was nothing





Styx-like about the Rio das Mortes. My impression was one of shining, slow water, reflecting low lush jungle on both sides—a setting of perfect tranquility upon which the reverberating roar of our boat's motor seemed an intrusion.

Eventually the river widened and a huddle of thatched huts came into view. Domingos grinned, and we beached among several slender dugouts. Dogs barked as we jumped ashore; a woman appeared at a doorway, recognized Domingos, and shouted a welcome. Her menfolk were out tending the cattle, she explained.

Cattle Ford River Unmolested

While we talked, a man appeared on the bank across the river, leading two horses to the water's edge. In they waded, all three, and the horses drank. Still holding the reins, the man jumped into a canoe and paddled into midstream, his team swimming alongside. Our hostess caught my unspoken thoughts. "Ah, but they are harmless, the piranhas out there," she laughed, "or do you think we have tamed them? Every morning two hundred of our cattle swim across to grazing lands on the other side, and swim back at night."

She suggested we move upriver a mile or so to a particular lagoon she had heard was packed with treacherous piranhas. She spoke with authority, so we took to the river again. When a dugout paddled by two ranchmen appeared coming toward us, we met it bow to bow. Domingos talked to the canoeists, and one of the pair hopped aboard our canoe, agreeing to escort us.

Along the way we heard an uproar in the low trees along the bank, the kind of noisy fussing that a troupe of monkeys makes. Domingos abruptly beached the canoe and, before I could ask him questions, vanished into the jungle gloom, armed with his single-barrel shotgun.

Within minutes I heard a shot, and almost at





Nets at the ready, Paraguay's Maká Indians stride fearlessly through a piranha-infested lagoon. Each man wields a length of mesh hung between two seven-foot poles. Swiftly he plunges the net into shallow water and snaps the poles together, trapping the fish.

The catch is cooked over an open fire (below); bared teeth identify piranhas at upper right. A Maká (left) savors the sizzling dorsal flesh. "As good as broiled bass," reports the author.

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EXTRAORDINARY IMAGES BY HERBERT FISHER, RESEARCHER BY PAUL A. LEON. © N.A.S.



Piranhas' frenzied feast

A SLUGGISH brown stream turns into a roiling caldron as scores of piranhas devour the carcass of a capybara, a creature whose four-foot maximum length makes it the world's largest rodent. Within three minutes the hungry horde had stripped the flesh from the bones.

Underwater close-up at lower left reveals the fury of the feeding piranhas.

Theodore Roosevelt, in his 1914 book, *Through the Brazilian Wilderness*, widely publicized the piranha's ferocity. Since then, infrequent but horrifying tales of men being devoured have built the creature's image into that of a monster.

Some such stories may have been embellished in their retelling. Noted anthropologist Harald Schultz spent two decades roaming the Brazilian hinterland, and in that time met only seven persons who had been injured by piranhas.

once we were moving again, with a dead monkey in the bottom of the boat. Now I understood that he planned to use it to bait the piranhas, in place of the stale beef I had brought. Raised as a hunter, Domingos considered monkeys fair game, as hunters in other lands regard rabbits or squirrels.

We veered off the main river into a shallow tributary. Paddles took over from the outboard, and soon we came to a forced halt. A swamp lay between the tributary and the lagoon we were seeking, so we waded up onto the shore and dragged our boat across a stretch of quagmire to one of those by-now-familiar dry-season lagoons, its secrets hidden beneath a mucky green surface.

Monkey's Fate Demonstrates Peril

First we fished with hook and line, with instant results. Out came toothy, scarlet-bellied *nattereri* and some large dark piranhas. But this was nothing new. Then Domingos lassoed an overhanging branch with a length of rope and tied the free end to the monkey, which he lowered into the water.

We paddled off to watch. Suddenly there was a simmering at the surface, not impressive in itself, but all the hint we needed to know of the furious activity below. We watched for perhaps five minutes, until the trembling of the surface stopped. Then we paddled back. Domingos grabbed the rope and pulled up the monkey. Hardly more than bones remained.

Here in a quiet lagoon, a spillover of the Rio das Mortes, was undeniable evidence of what a school of hungry piranhas could do. I could easily understand the notoriety that had grown up, the body of lurid tales.

Yet, was this typical? On many an occasion I had poured beef blood into piranha waters or tossed in chunks of fresh meat, and had seen no reaction whatever. From river to river, from one landlocked lagoon to another, my experiences seemed inconsistent. Where one day children swam and women did their laundry only a few yards from where my hook caught any number of *nattereri*, the introduction of a new set of stimuli might produce a frenzy of piranha activity—or no response at all. Responses varied not only from one species to another, but within the same species. Unpredictability, I concluded, was the watchword in any situation involving piranhas.

My final experience with piranhas was on Marajó Island, in the Amazon delta. There for several days I lived on a *fazenda*, a ranch

Sun-bleached bones in muddy shallows on Marajó Island attest to the savagery of piranhas. Ranchers told the author that weak or wounded animals most often draw the killers. But Dr. Zahl's investigations proved that piranha attack is neither predictable nor inevitable. Much research is needed to understand the complex interplay of the triggering factors: voracity of the species, water level and temperature, time of year, availability of food.

STYLING BY PAUL A. ZHU © B.S.L.

just inland from the coast, where a winding stream rose and fell in accordance with nearby Atlantic tides. "Packed with piranhas," stated Carlos Pamplona, the *fazenda's* manager, as he waded waist-deep for a bath. "But they are nasty only when the tide shifts," he added, "after the ebb."

Next day Carlos made his point by tossing half a goat carcass into the water. Slowly it sank to the bottom, unmolested. "See? High water. The piranhas are quiet."

Hours later, after the ebb tide, when the stream began rising, Carlos dragged down the carcass of a young caiman as a lure. He tied it to a stake at the shore line. As we waited, water gradually covered the bait.

Suddenly a churning troubled the placid water around the carcass, building to a boil. In their frenzy some of the predators leaped into the air, then splashed back to renew the onslaught. Some worked their way through the caiman's softer underside and their thumping and thudding inside it could be seen as they tore and ripped the flesh with their teeth and incredibly powerful jaws.

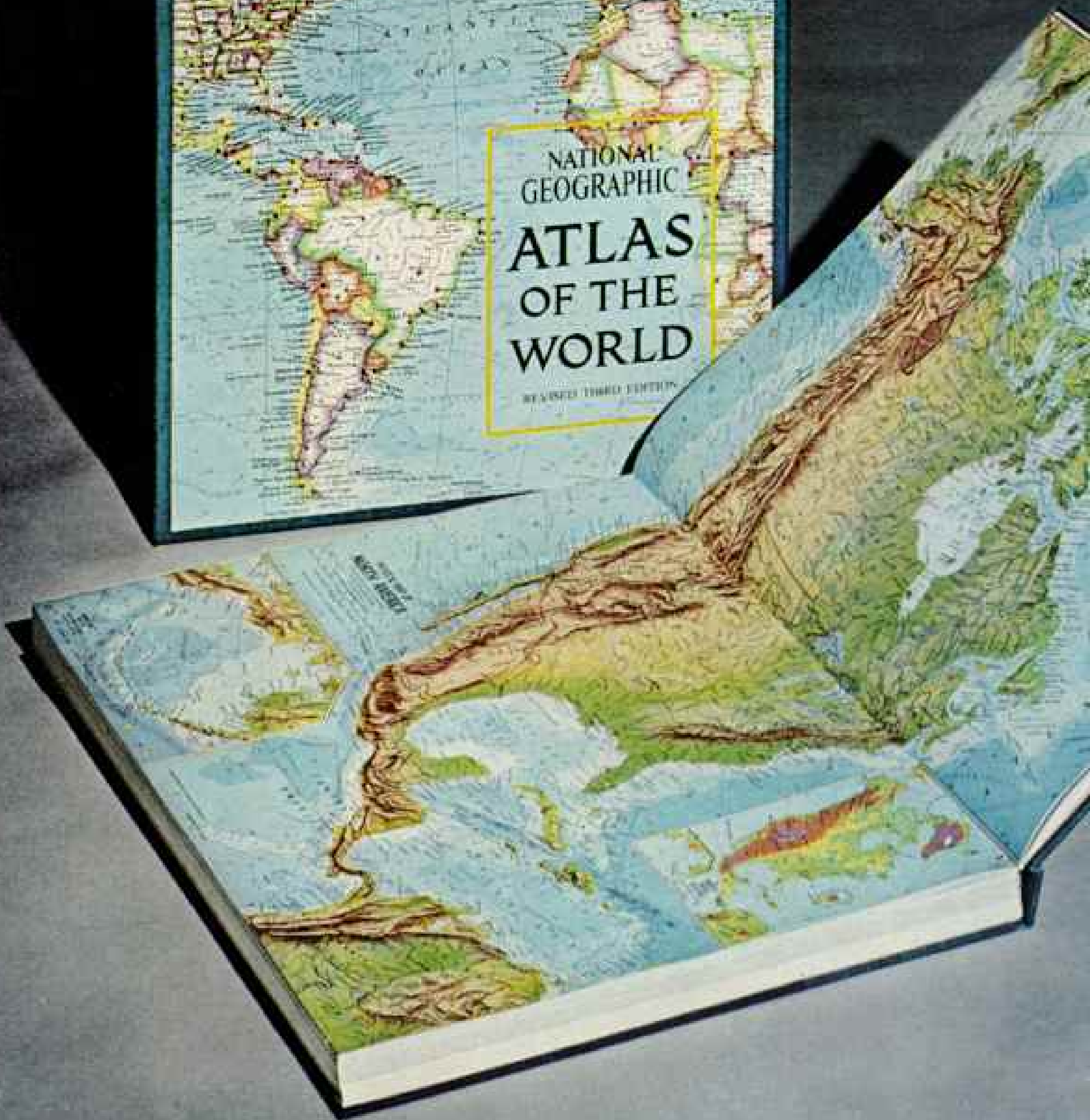
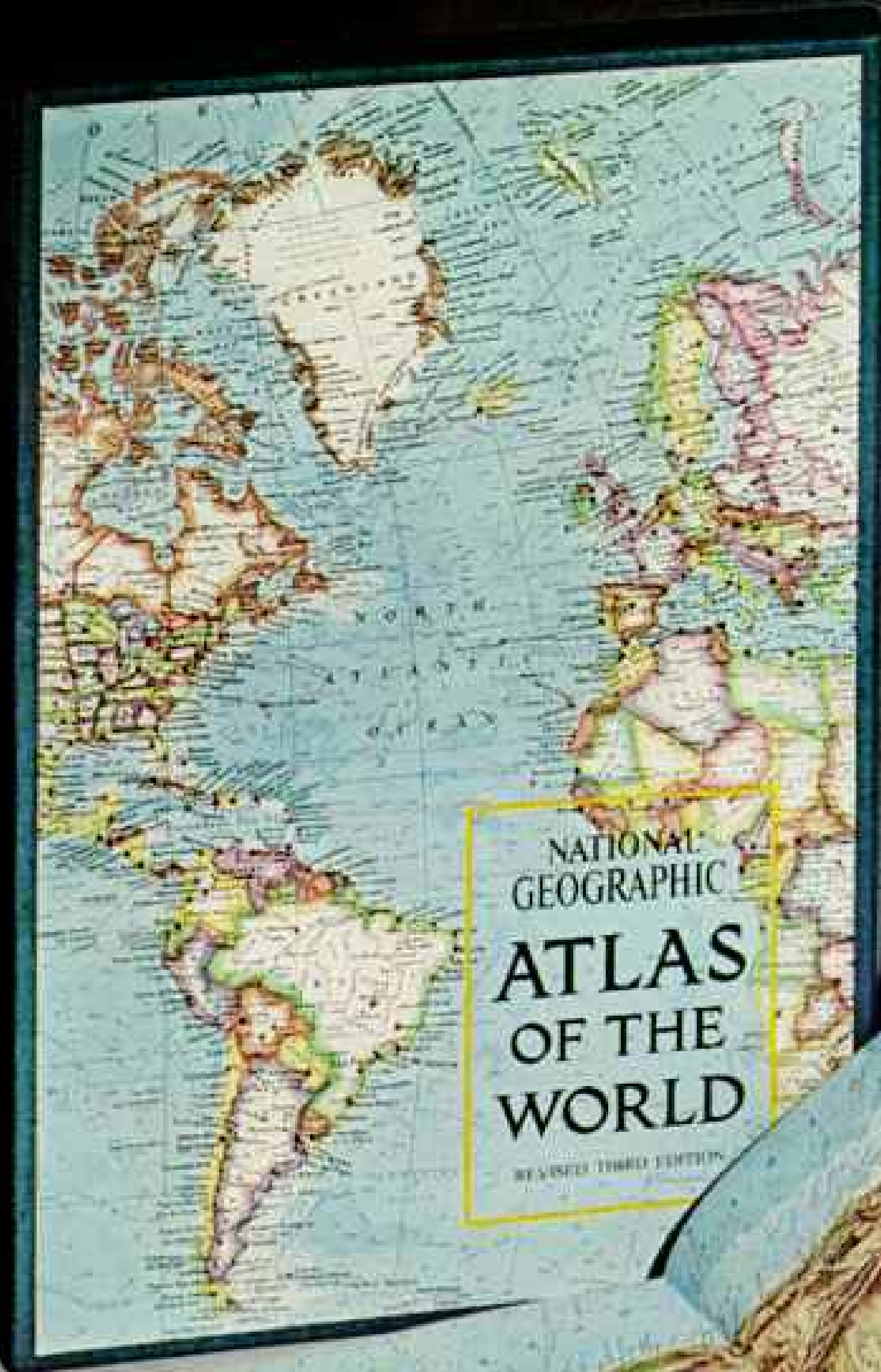
Stream Bathing Loses Its Appeal

No more than three minutes passed before the boiling ceased. Carlos untied the cord by which the caiman had been secured and pulled the remains ashore—bare white bones and fragments of tough hide.

Later that day, when the tide had shifted again, a group of dusty *vaqueiros* strolled down from the bunkhouse to bathe in the shallows. "Come on in," one of the cowboys waved to me. But one glimpse of the caiman skeleton sprawled there on the bank, and I shook my head. As long as I remained in piranha country, I dipped my bath water from a bucket on shore. For I had learned that piranhas are just like most fish in one respect: You never know when they will feel like biting.

THE END





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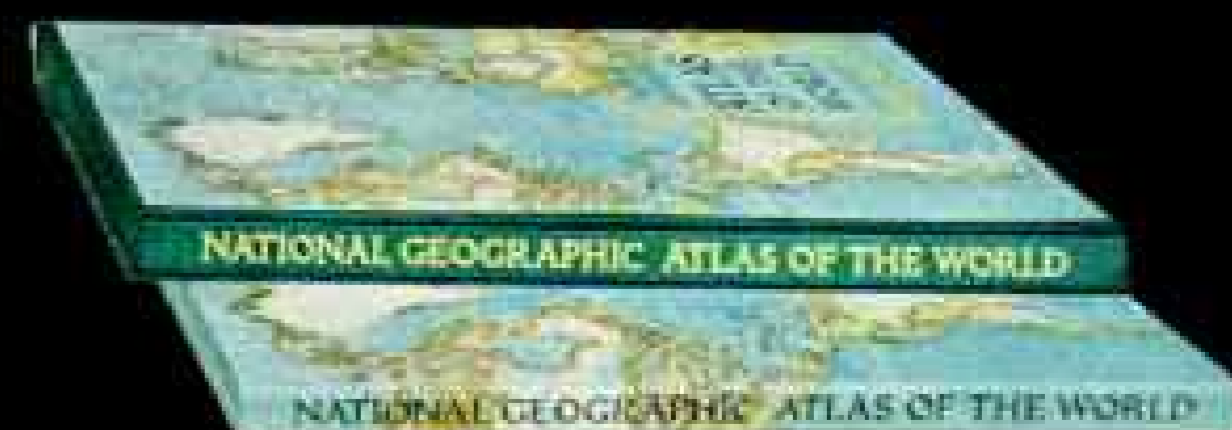
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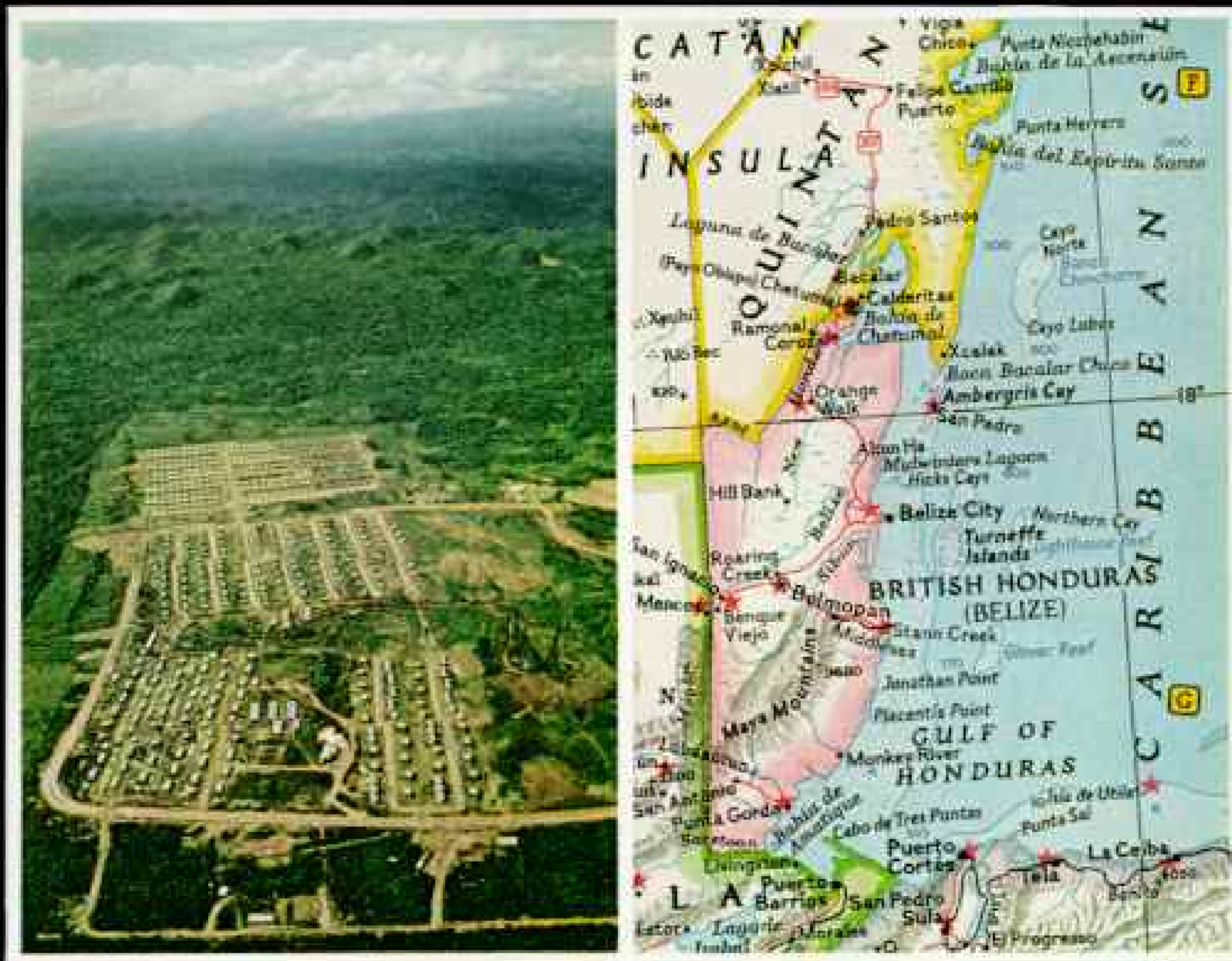
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RODACHROME BY MICHAEL E. LONG, NATIONAL GEOGRAPHIC STAFF © N.G.S.

Storm-spawned capital, the world's newest, rises on a lush plain in British Honduras, Central America. Because hurricanes periodically devastate Belize City, the old capital, this last British colony on the American mainland built Belmopan 50 miles inland and transferred the government there last August. The new city, one of many additions to the latest National Geographic atlas, heralds prospective independence, when British Honduras will change its name to Belize.

the highest standards of living among Pacific lands, and that in desert-dry Botswana the traditional tribal greeting, *pula*, means "let there be rain."

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Your revised, third edition keeps abreast of world name changes, too. Sukarnapura in Indonesia's province of West Irian (formerly Netherlands New Guinea) becomes Djajapura. Sihanoukville in Cambodia reverts to its former name, Kompong Som. By their sheer number, these changes could overwhelm a user of the atlas, but the new index has been carefully constructed to convert confusion to clarity: There you can find

a city or country under its old name, too, if you don't know—or don't remember—the new one.

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COVER: Regal profile of Nefertiti adorns a block of Akhenaten's temple (page 634). PHOTOGRAPH BY EMERY KRISTOF © N.G.S.

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Two other Corollas have left rear windows that are just as appealing. The spotty Corolla Fastback at \$1918*. The roomy Corolla Wagon at a mere \$1958*.

Yet, as inexpensive as it is, the Toyota Corolla doesn't rely on price alone. It has fully reclining bucket seats. It has

thick wall-to-wall nylon carpeting. It has an all-vinyl interior. To make it all the more beautiful.

But one of the most beautiful surprises in the Toyota Corolla is the amount of legroom. There's not an economy car around that comes close.

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Illustrated at left: Forget-me-not: Necklace \$15 Earrings \$13.50* and \$22 Brooch \$19 Grape motif: Earrings \$22* and \$25 Brooch \$36
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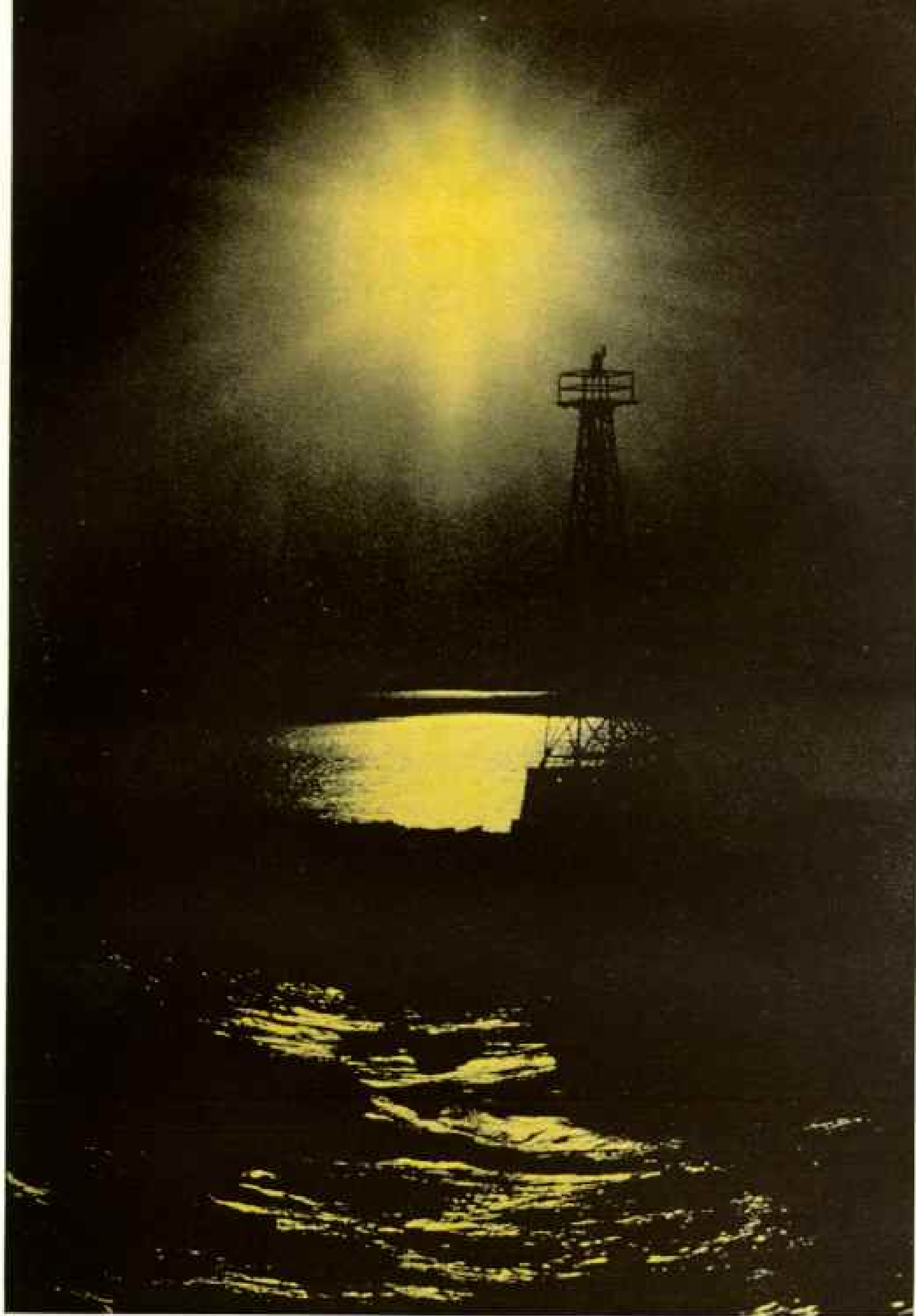
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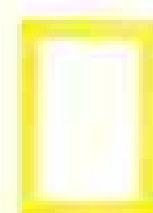
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The fishing is

When fishermen first saw oilmen drilling in the Gulf of Mexico some twenty years ago, they were shocked. "The fishing will never be the same," they said. And they were right.

Nearly a thousand oil-producing platforms now rise from gulf waters and the fishing is better than ever. Far better.

Not only are catches more abundant. The variety is more interesting. At least a dozen species of fish, which were seldom seen in the

area before, are turning up near the platforms. Among these are the aristocratic pompano.

And the big fellows seem to be moving closer too. The annual Tarpon Rodeo at Grand Isle, in the heart of Louisiana's offshore oil-fields, is now one of the largest fishing contests in the United States.

Jersey's affiliate, Humble Oil & Refining Company, operates many of the offshore wells. Here's how they explain the fish phenomenon.



better than ever.

When the legs of a platform are thrust into the ocean floor, they attract various forms of marine life, such as plankton, algae and barnacles. These attract small fish. And the small fish attract big fish. And so on and so on, in the fish-eat-fish rhythms of the sea.

For Jersey or Humble to claim credit for this natural process would clearly be absurd. We simply point out that it might not happen at all if we ran our oil platforms without caring

about the waters in which they stand.

By the way, commercial fishing in the gulf is going great guns too. Trawlers are now catching over four times the weight of fish they caught in 1940.

**Standard Oil Company
(New Jersey)**



See the art that turned on Picasso.



See the influence of African art in the portraits of Picasso's cubist phase.

See its colors and broad strokes in the work of Ferdinand Leger.

See the impact of it in those strange, marvelous long faces of Modigliani.

Take a look around South Africa.

Not far from Pretoria you can stop at the N'debele village, where masterly women artists create abstract, geometric murals on the walls of their houses.

While you're in Kimberley, visit the Bantu Museum. Here you can actually pick up fantastic masks, sculpture, pottery, and examine them at close range, feel their shape and weight.

You'll want to bring home examples of African art and artifacts. And you can. In the shops and the Indian Market you'll find masks. Pottery. Weaving. Stone sculpture. Wood sculpture. You can even take home a warrior's shield as tall as a man.

Prices are incredibly low. Walk

off with a Zulu axe for \$2. Or an African mask for 1/10th of what it would cost in the U.S.

Interestingly enough, these low prices apply not just to art, but to everything.

A tourist can live quite comfortably here for \$10 a day.

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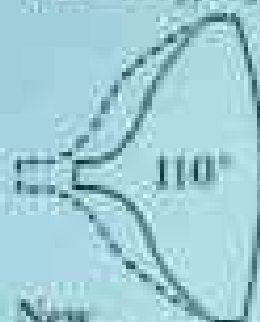
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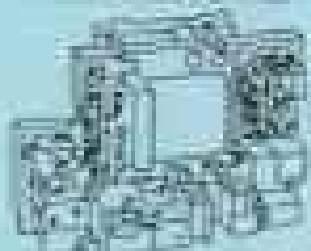
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Inside, the Argosy is a triumph of electronic engineering. The chassis is 100% solid state. Tubes that can deteriorate and cause colors to fade, shift or wash out have been replaced by advanced solid state components. The result: a reliable, cooler-running

power plant capable of much more consistent TV signal processing.

The modular design of the chassis, called "Trans Vista" 100, marks another dramatic advance. Most set functions have been grouped on 11 removable circuit boards—we call them AccuCircuits. Should an Accu-Circuit failure occur, the service technician simply locates the faulty board and snaps a fresh one in place. Simple as that.



This extraordinary television set comes with an extraordinary warranty, which we're proud to describe below. Basically, it's a full year's coverage on both parts and labor, plus two years on the picture tube at the service agency of your choice.

The Argosy: you can buy a cheaper color portable, but you can't buy a better one at any price. See for yourself at your RCA dealer's.

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SIMULATED TV RECEPTION

ARGOSY 1-YEAR PARTS AND LABOR COVERAGE—BASIC WARRANTY PROVISIONS RCA's new



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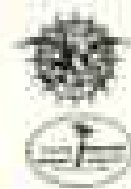
Mark Maxwell and his bride to be, Laura

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When a boy sees no future in education, how do you keep him from dropping out of school? Out of everything?

One answer came from a course at Louis D. Brandeis, an academic high school in New York City.

On paper it was Shell's Automotive Professional Training course, with Shell providing sophisticated electronic equipment and learning materials.

Actually it was a plan to introduce boys, many from underprivileged backgrounds, to a world they have never known or imagined. A world of scientific instruments, like the electronic Autosean. A world of scientific thinking, where using your head pays off better than using your fists.

The results were pretty tremendous.

The boys stuck to a strict code of behavior. There were few dropouts. No absenteeism.

Since the course began, over 100 have graduated.

And many of the graduates have gone on to good-paying jobs in automotive or aircraft repair.

But the big surprise was this: many of the boys went on to college.

After this initial success, Shell extended the course to 12 other schools, and 25 more will soon be added.

One thing we learned from the Brandeis experiment: if a boy can be encouraged to learn by shaping up a sick engine, he has a pretty good hope of shaping up his future.



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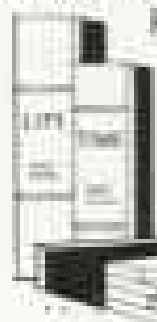
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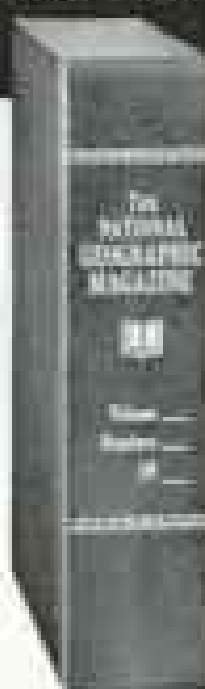
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BURLINGTON NORTHERN

Going places in the American West

The mother got over her rubella in three days. Unfortunately, her unborn child didn't.



To pregnant mothers, rubella (German measles) means a few days in bed, a sore throat, a runny nose, temperature, and a rash.

But if they're in their first month when they catch it, there's a 40% chance that to their unborn babies it can mean deafness, or a heart condition, or brain damage, or cataracts which cause at least partial blindness.

Only last year, an immunization against rubella became available. But when a pregnant mother

gets immunized, the prevention may be as harmful to her baby as the disease.

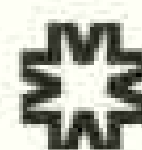
So if unborn babies are going to be protected, it will have to be by inoculating the kids who infect the mothers who in turn infect the fetuses.

And it will have to be done now.

You see, rubella epidemics break out every six to nine years. The last outbreak was in 1964. Which means the next one is due any day now.

In the last epidemic, 20,000 babies were deprived of a normal childhood — and 30,000 more deprived of any childhood at all — because no immunization existed.

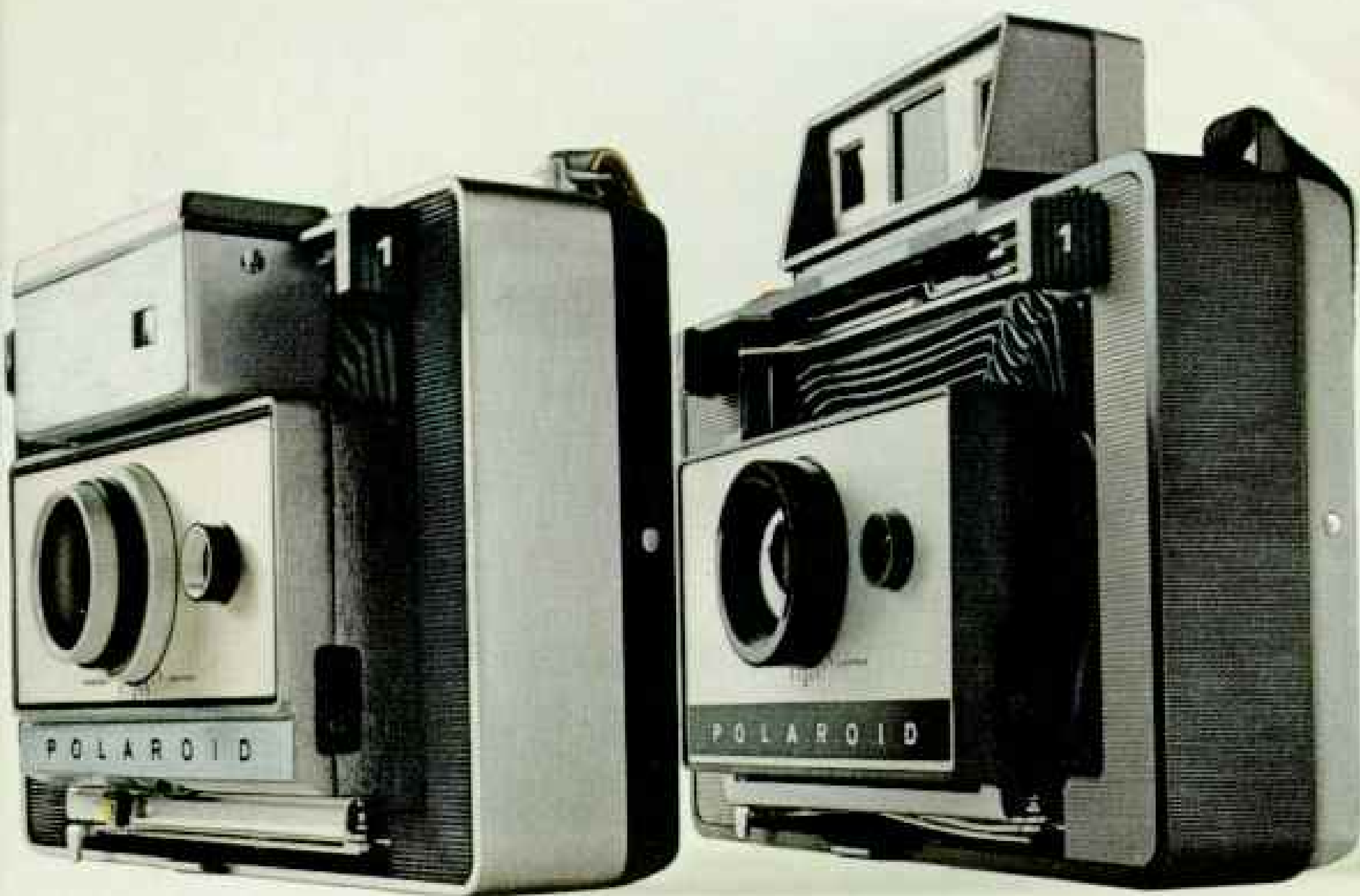
It would be unforgivable if the same thing happened again because an immunization existed and nobody used it.



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