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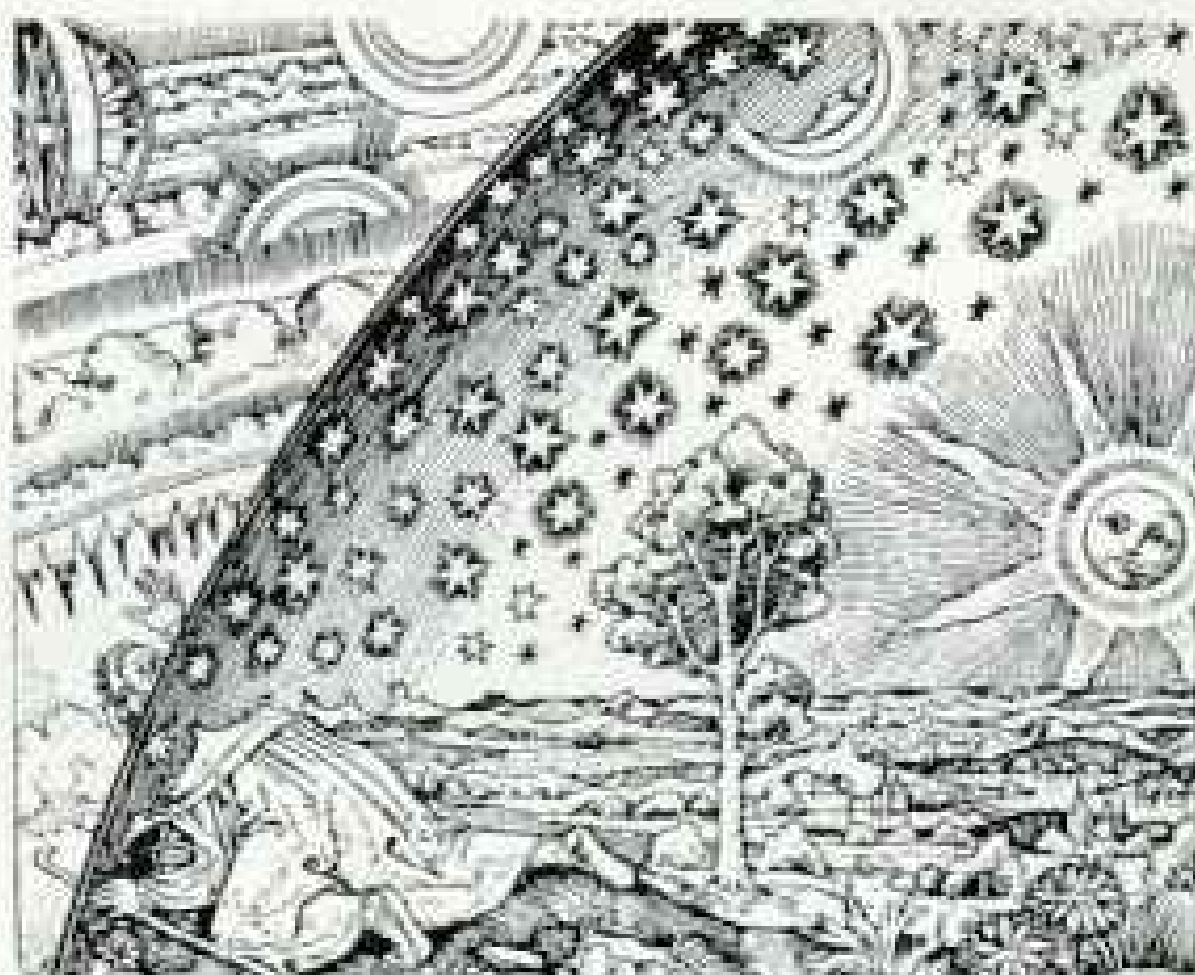
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SEE "BUSHMEN OF THE KALAHARI" FRIDAY, MAY 17, ON ABC TV (page 732A)

Venturing beyond heaven's vault, a medieval traveler discovers a fanciful universe. But even this seems tame beside the cosmos today's scientists explore.

Nursery of new stars, the awesome Trifid Nebula (following pages) billows with dust and fluorescing gas that ultimately will coalesce into suns.

ROBERT WOODCUT FROM THE BEUTMANN ARCHIVE (RIGHT), WILLIAM S. KERNERMAN, MIT PEAK NATIONAL OBSERVATORY



The Incredible Universe

By KENNETH F. WEAVER

ASSISTANT EDITOR

Photographs by JAMES P. BLAIR

NATIONAL GEOGRAPHIC PHOTOGRAPHER

FAR FROM THE LAND of everyday, out in the distant curves of the universe, lie strange and fantastic realms, unlike anything in our wildest dreams. Hidden by the barriers of time and space, they have lived forever beyond the reach of man, unknown and unexplored.

But now, just now, the cosmic barriers have begun to lift a little. Man has had his first glimpses of these once-secret domains, and their bizarre ways have left him stunned. They challenge his very notions of matter and energy. With Alice in Wonderland he says, "One *can't* believe impossible things."

And impossible, indeed, they seem to be.

In those far reaches of the universe, in those bewildering worlds, are places . . .

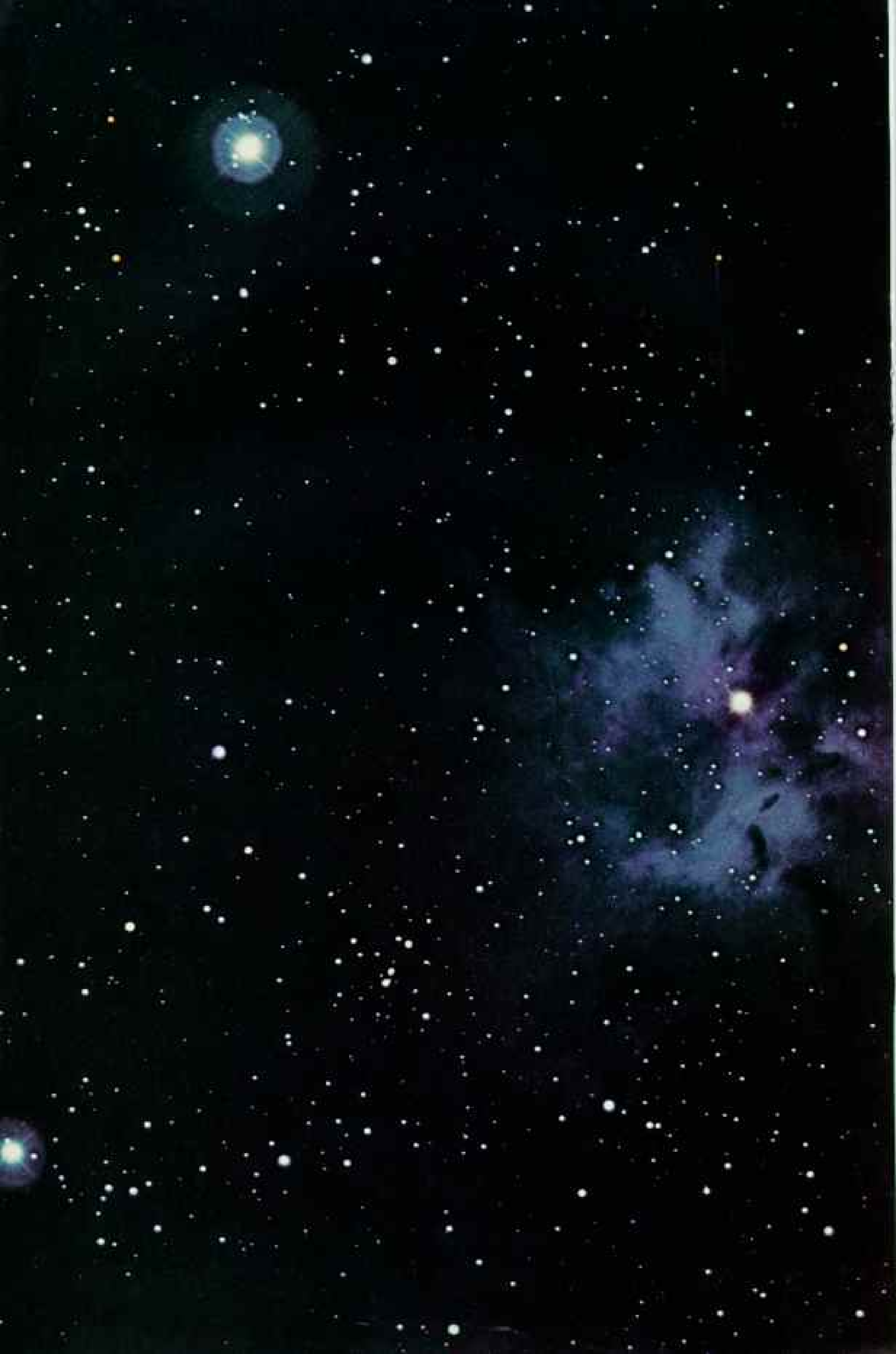
Where a teaspoon of matter weighs as much as 200 million elephants . . .

Where a tiny whirling star winks on and off thirty times a second . . .

Where a small mysterious object shines with the brilliance of ten trillion suns . . .

Where matter and light are continually sucked up by devouring black holes, never to be seen again.

Small wonder that the late British scientist J. B. S. Haldane could say, "...the universe is not only queerer than we suppose, but queerer than we *can* suppose."





The Galaxy, that Milky Way...

Powdered with stars.

—MILTON, "PARADISE LOST"

FROM EARLIEST TIMES man has marveled at the heavens. But much as he wondered, "What is the universe, and what makes it go?" he could learn nothing about the nature of the stars. He could only try to catalog those visible to the naked eye, some 6,000 of them. He had no way of knowing that the sun is a star, or that the stars blaze with intense radiation because of nuclear furnaces deep within their interiors. Nor could he tell that the planets, for all their brightness, are not stars but small dark objects that shine only by reflected sunlight.

In his innocence, man held his own special planet to be the center of the starry universe. Then Copernicus, whose five hundredth birthday the world celebrated just last year, dared to challenge this Church-approved dogma (pages 626-7). The earth moves around the sun, he said, not vice versa.

It was a profound and troubling idea; at least one man died at the stake for believing it. Yet it was still far from the whole truth, for it kept the sun at the center of things. And that misconception haunted man's thinking until the coming of photography and the large telescopes of the 20th century.

Then, just half a century ago, the American astronomer Edwin Hubble (page 633) confirmed that some of the fuzzy nebulosities on his photographic plates were not nearby clouds of gas, as most astronomers had assumed. Instead, they were galaxies, vast, slowly rotating congregations of stars, comparable to our own Milky Way galaxy. These stupendous "island universes" lay far beyond the bounds of our own great family of stars.

I recall vividly the thrill when Hubble's onetime student and assistant, Dr. Allan Sandage, took me into the plate vaults of the Hale Observatories, at Pasadena, California, and showed me those historic plates that Hubble had made with the 100-inch telescope on Mount Wilson, a few miles away.

Among the multitudes of stars, "cast like sand by handfuls," appeared a scattering of tiny spirals and irregular blobs. So inconsequential those faint smudges seemed! Yet their discovery as galaxies immeasurably extended our concept of the universe and forever destroyed the special position of the sun and of man's world in that universe.

Today we know that galaxies are as common as blades of grass in a meadow. They number perhaps a hundred billion. The huge 200-inch Hale reflector on Palomar Mountain—the world's largest optical telescope—can see as many as a million galaxies inside the bowl of the Big Dipper alone.

How does one comprehend the incredible size of this galaxy-filled universe? For such awesome distances astronomers think in terms of time, and use the telescope as a time machine. They measure space by a unit called the light-year, the distance light travels in one year at the rate of 186,282 miles a second—about six trillion miles.

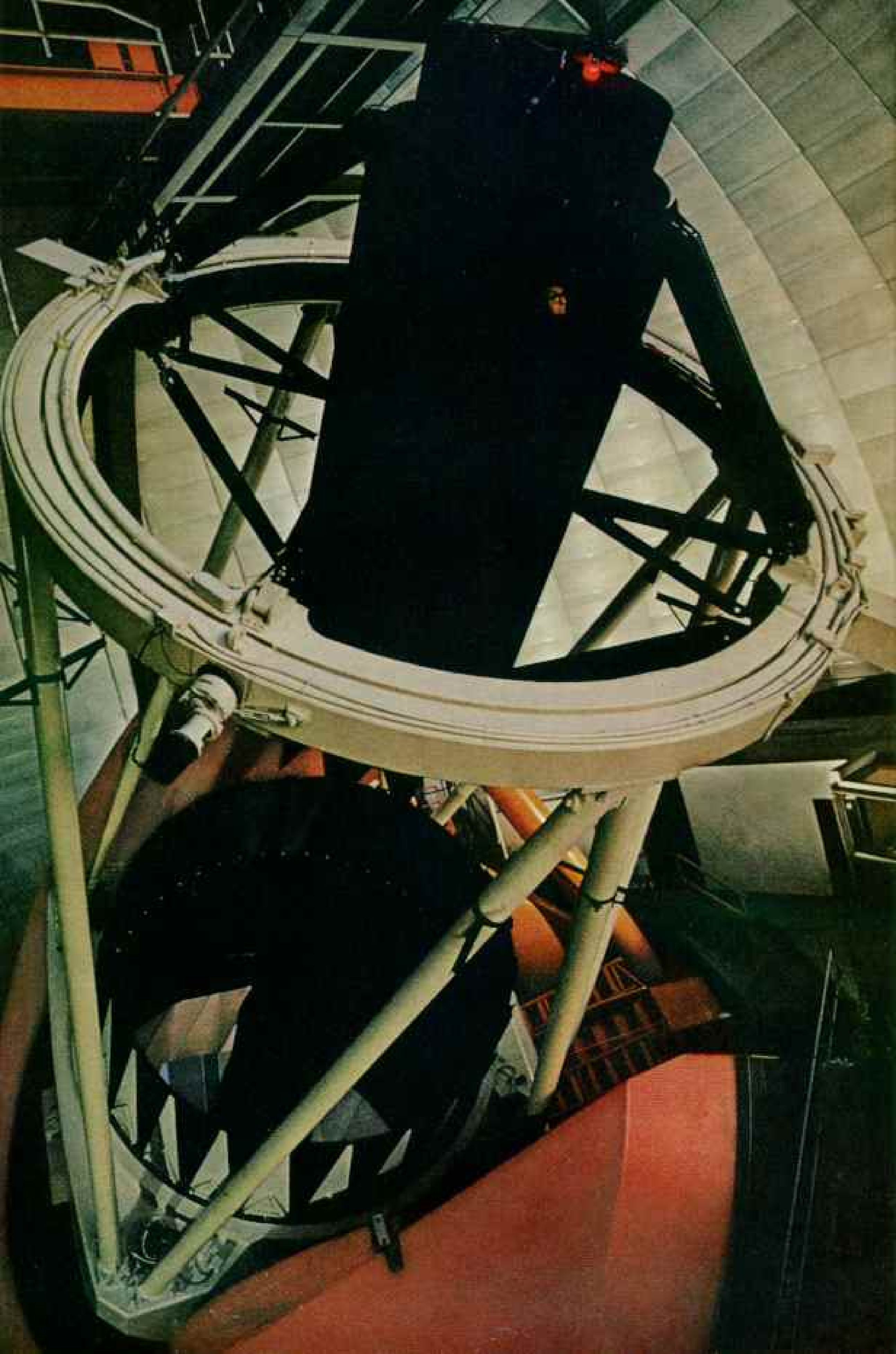
BUT EVEN THEN comprehension is difficult; how can the human mind deal with the knowledge that the farthest object we can see in the universe is perhaps ten billion light-years away? Imagine that the thickness of this page represents the distance from earth to sun (93,000,000 miles, or about eight light-minutes). Then the distance to the nearest star ($4\frac{1}{2}$ light-years) is a 71-foot-high sheaf of paper. And the diameter of our own galaxy (100,000 light-years) is a 310-mile stack, while the edge of the known universe is not reached until the pile of paper is 31 million miles high—a third of the way to the sun!

Not only did Hubble vastly extend the measure of the universe, but he also ended the notion that the heavens are constant and unchanging. In 1929 he proved that the universe is steadily expanding, like a balloon. He showed that the galaxies are all in motion, flying apart from each other at speeds proportional to their distances. This principle—the farther away a galaxy is the faster it moves—became established as Hubble's law.

With those all-important discoveries, the stage was set for a revolution in astronomy

Probe into the depths of space, the new 158-inch Mayall telescope—second largest optical instrument in the world—peers from its rotating dome at Kitt Peak National Observatory, near Tucson, Arizona. A viewer perches in the prime-focus cage, where he uses the instrument as a colossal camera.

JOHN F. BLAIR



that in just the past decade has taken on explosive proportions. Astronomy—or, more properly, astrophysics—is today in a golden age. Exciting new information now pouring forth in ceaseless torrents is shattering our ideas about the universe as surely as did Hubble's pioneering work in the 1920's.

Star to star vibrates light.

—TENNYSON, "AYLMER'S FIELD"

NOT MUCH MORE than a century ago the French philosopher Auguste Comte proclaimed that we could never know anything about the chemical composition of a star. But Comte did not understand the message of starlight, which we have since learned to decode. He did not know that with an optical instrument known as a spectroscope the astronomer would be able to split the vibrations of starlight into complex patterns that reveal such things as temperature, pressure, density, chemical makeup, magnetic field, and velocity of a star.

In fact, says Dr. Herbert Friedman, Chief Scientist of the Hulburt Center for Space

Research at the Naval Research Laboratory, "With optical astronomy alone we can tell far more about what is happening inside a star thousands of light-years away than we know about the interior of our own earth." It is all because of the message of starlight.

But stars send out information in forms other than ordinary visible light. In 1932 a Bell Laboratories engineer, Karl Jansky, was investigating radio reception for a transatlantic radiotelephone system. His wood-and-copper antenna, about 100 feet long and pivoted so the whole contraption could rotate, pinpointed a mysterious source of static.

To everyone's surprise, the radio noise came from nowhere on earth, but from the center of our galaxy, some 30,000 light-years away. The heavens were broadcasting, and the music of the spheres was not just a poetic notion after all!

Thus was born the science of radio astronomy. A new window had opened on the universe. Now scientists could analyze two kinds of energy beaming from stars and galaxies—light and radio—and each had its own amazing stories to tell. The vibrations of radio, captured *(Continued on page 599)*



To catch a distant star, opticians at Kitt Peak polish a 158-inch mirror (below), similar to the Mayall reflector. When completed in 1974 after two and a half years of grinding and polishing, the 17-ton mirror will study the skies from the Cerro Tololo Inter-American Observatory in Chile.

Seeking microscopic irregularities on the mirror surface, technicians flood it with a laser's ruby glow (right). Unevenness as slight as five millionths of an inch shows up as dark blotches.

Today's astronomers detect objects so far away that their light has taken perhaps ten billion years to reach us.



JAMES P. ELAIR AND NORMAN E. COLE, KITT PEAK NATIONAL OBSERVATORY; JAMES P. ELAIR (RECORD)





“A small...planet...of a minor star off at the edge of an inconsiderable galaxy”

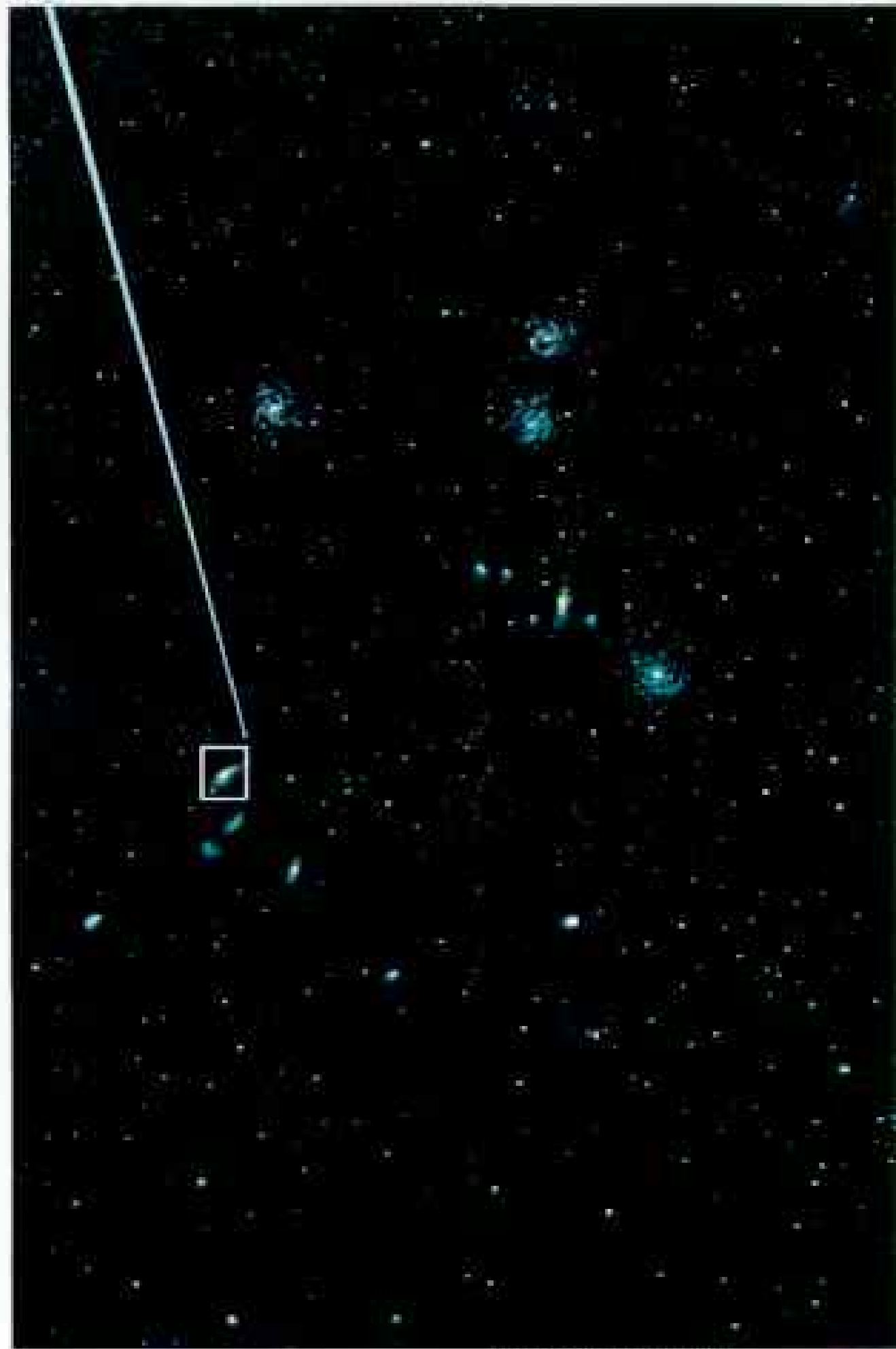
THE INSIGNIFICANCE of our earth in the immensity of the universe, so provocatively described by poet Archibald MacLeish, unfolds in this sequence of paintings. With each successive look the viewer stands vastly farther back, yet each larger scene still takes in but a fraction of the cosmos.

Gleaming among neighbor stars (left), the golden sun reigns over its planets: Earth on the left, Mercury, Venus, Mars, and Jupiter to the right, ranged along an imaginary line roughly indicating their planes of orbit.

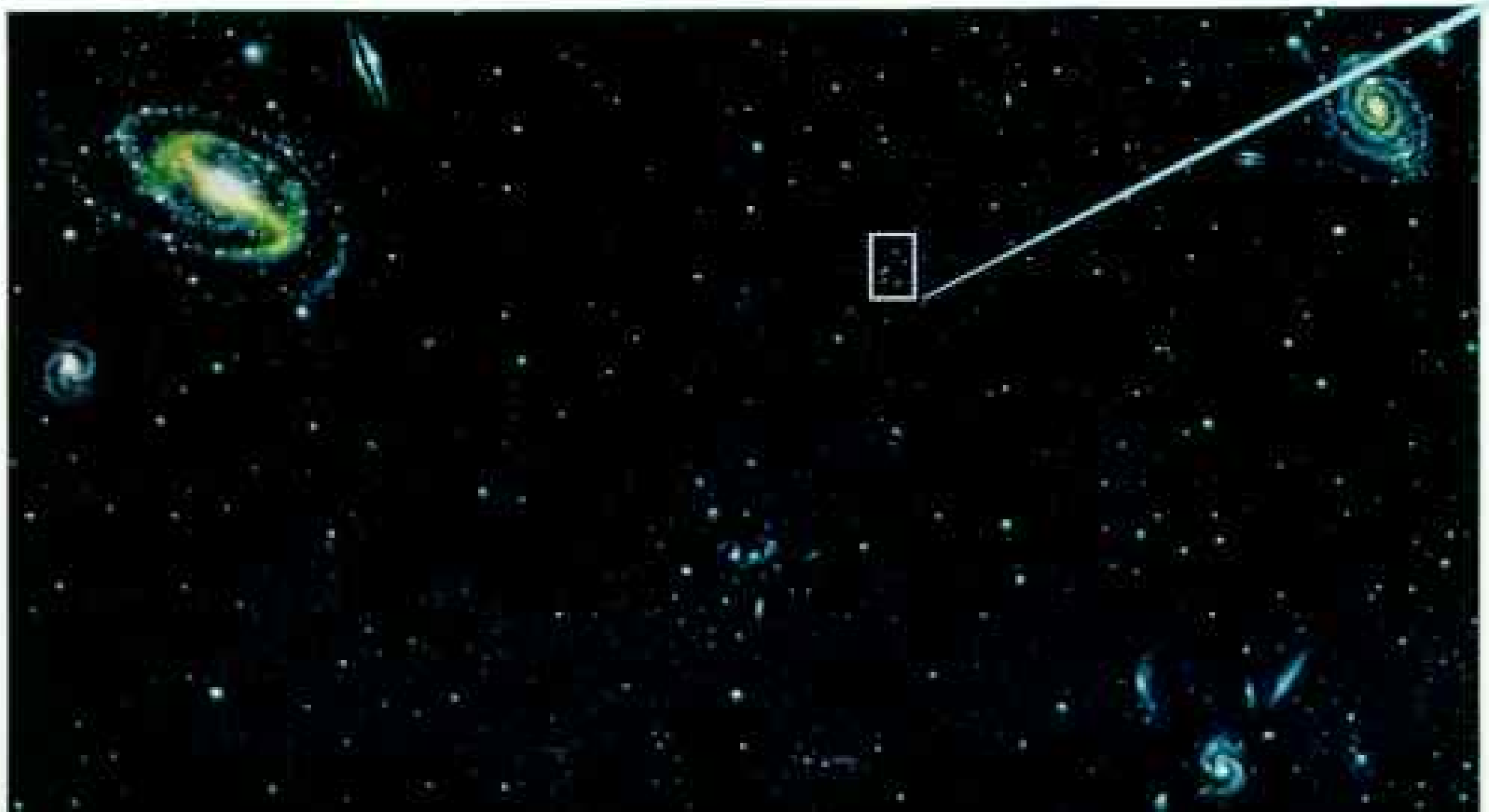
This solar realm, so enormous to the earthbound, shrinks dramatically when set in

its niche toward the rim of our Milky Way galaxy (above), home of a hundred *billion* stars.

The Milky Way itself seems to contract when viewed amid its cluster of sister galaxies (upper right). And even that cluster pales in a far wider view of space (right).



PAINTINGS BY IERONIM WALTERS





by metal dishes sometimes hundreds of feet in diameter, revealed a different kind of universe than we had ever seen, one in which the most frightfully violent events were taking place. These explosions and collapses released amounts of energy that make our sun look like a candle.

Still later another window was opened to the universe. It was discovered that a tiny crystal of germanium, cooled almost to absolute zero by liquid helium and sent to high altitudes by plane or rocket, could detect the whole range of infrared, or heat, emissions. So the message of the stars now came in three forms, all vibrations in the electromagnetic spectrum, which ranges all the way from radio to gamma rays (diagram, pages 604-605).

These vibrations differ only in their wavelengths and frequencies—radio being long wavelength and low frequency (that is, relatively few vibrations per second); infrared being somewhat shorter waves and higher frequency; and light waves being still shorter and still higher frequency.

As it happens, light and some of the radio waves from space come through earth's atmosphere with relative ease. In the case of infrared, much of the radiation is blocked by water vapor in the atmosphere, but significant wavelengths in infrared still get through.

But there are other portions of the electromagnetic spectrum—the high-frequency, high-energy radiations known as ultraviolet, X ray, and gamma ray—that cannot penetrate to earth. They cannot get through the molecules and charged particles of "the dirty basement window of the atmosphere." And fortunate it is for man that these extremely intense and dangerous radiations cannot reach him. The small amount of solar ultraviolet that does leak through causes painful sunburn and hints at the lethal qualities of high-energy radiations.

Lethal they may be, but ultraviolet, X rays, and gamma rays also carry from the stars messages that lower-frequency vibrations do not carry. And so astronomers in recent years have tapped these messages as well by using rockets, balloons, and spacecraft to get their instruments above the screening atmosphere.

X-ray observations have been made by a spacecraft called Uhuru. Another called Copernicus (one of the Orbiting Astronomical Observatory series) gathers ultraviolet. And a third, Small Astronomy Satellite B, has made substantial gamma-ray observations.

Holes in the heavens, yesterday's astronomers said of apparent rents in the canopy of stars. Then came the discovery that they result from obscuring clouds of dust known as dark nebulae. Barnard's S-Nebula (left) coils across the Ophiuchus region of the Milky Way.

This is only a small portion of one of the nearly 2,000 photographs that form the basic atlas of the heavens, produced during the 1950's at Palomar Observatory with support from the National Geographic Society.

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BY GIBBY (FACING PAGE)

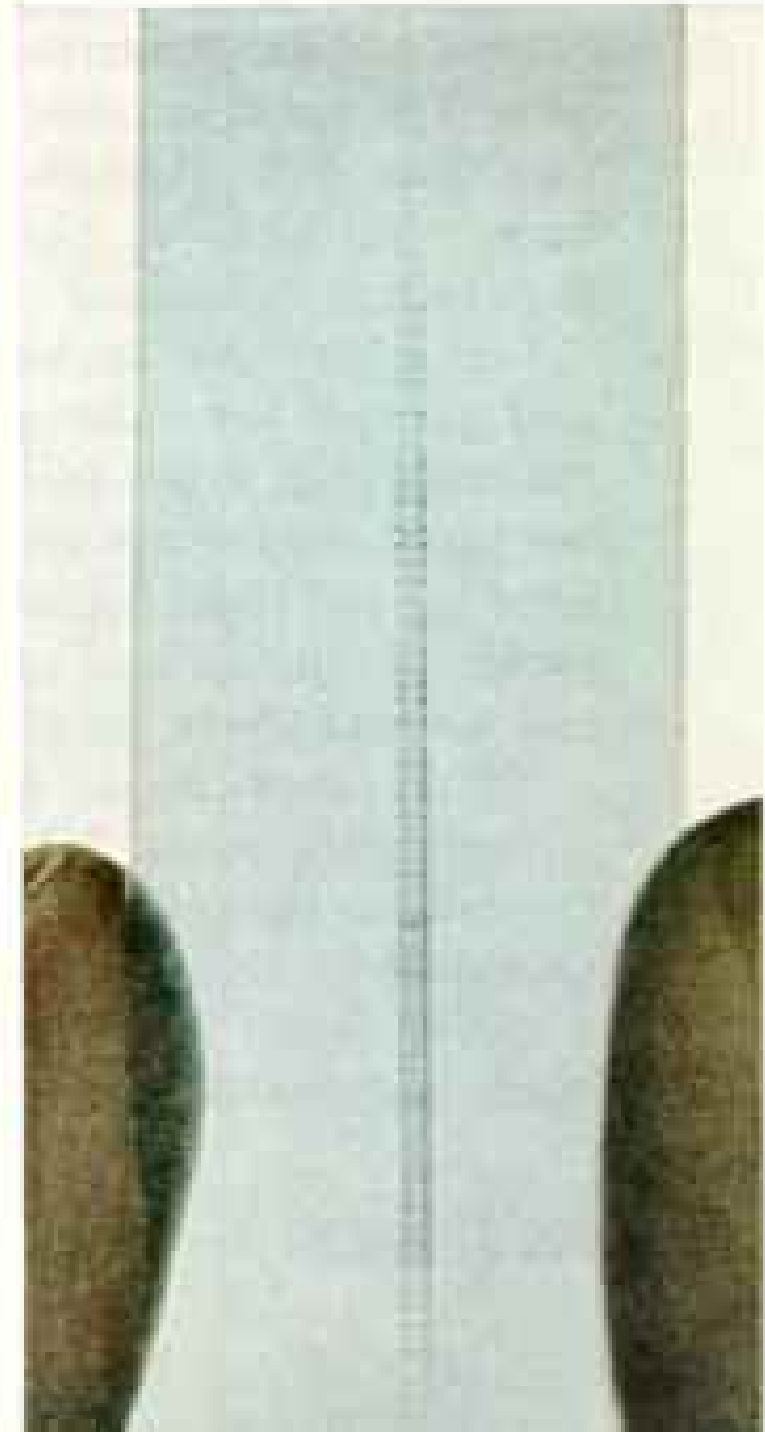


JAMES F. BLAIR

Roaming the cosmos, astronomer Allan Sandage of the Hale Observatories seeks to fathom the basic riddles of the universe: How fast is it expanding? At what rate is this expansion slowing? He works with the great 200-inch Hale telescope on California's Palomar Mountain.



JAMES P. BLAIR (TOP AND BOTTOM LEFT); JAY M. PASACHOFF (BOTTOM CENTER); HALE OBSERVATORIES (BOTTOM RIGHT)

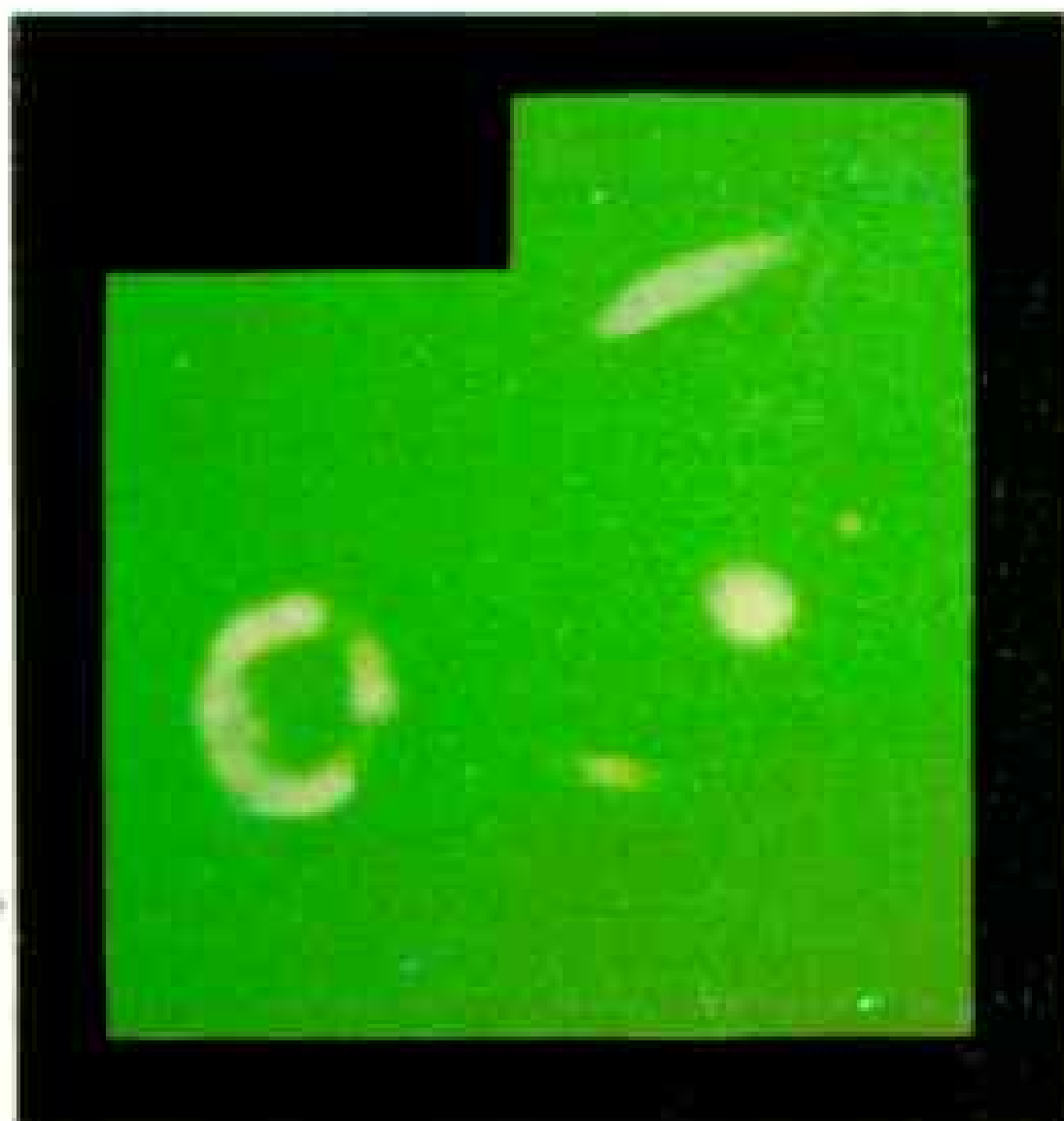


Riding an earthbound spaceship, Dr. Sandage (left) readies the Hale telescope for a night's viewing. Light entering the slit in the dome passes around his perch in the prime-focus cage to the 200-inch mirror shining 55 feet below.

Veteran of hundreds of chill vigils atop mile-high Palomar Mountain, Dr. Sandage now finds refuge in a heated viewing room (below left). Here he monitors the "Westphal magic machine," a light-measuring system developed by astronomers James A. Westphal, right, and Jerome Kristian. The device, linked with a computer, intensifies light a hundredfold.

Projected by the magic machine onto a cathode-ray tube (below), a ring galaxy a billion light-years away glows with startling clarity. Only a few such galaxies have been discovered.

Life stories of stars and galaxies unfold when their light is broken down into component wavelengths, or spectra (below center). Here the middle line, a star's spectrum, is flanked by twin spectra of iron for reference. Comparing the two can reveal the star's speed away from or toward the earth.



*Galaxies are to astronomy
what atoms are to physics.*

—ALLAN SANDAGE, AMERICAN ASTRONOMER

DO ALL THESE brand-new forms of astronomy mean the end of the old workhorse, optical astronomy? I spent a night observing with Dr. Sandage, one of the world's most distinguished astronomers, to learn the answer to that question. I drove up from the Pacific coast through orange groves, cedars, and ponderosa pines to the 5,570-foot plateau of Palomar Mountain in southern California. In the fading light of a January dusk, a series of silvery domes gleamed softly, each housing a separate telescope. Above them all towered the dome of the huge Hale telescope, an engineering marvel with a 200-inch mirror.

Inside the observatory building I found Dr. Sandage in the photographic darkroom. He was examining strips of film he had made the night before. They held only narrow, fuzzy bands called spectrograms.

Each spectrogram recorded the faint light from a distant galaxy, not as a bright point but as a spectrum, a band ranging from the longer to the shorter optical wavelengths, from red to blue and violet. Faint lines crossing this spectrum, some light, some dark, held the coded information from which he would later calculate the speed with which the galaxy is rushing outward toward the edge of space, and its distance from us.

Leaving the developing room, we walked out on the observatory floor. I was not prepared for the immensity of the instrument, a fretwork cylinder gracefully pivoted in its massive horseshoe yoke, nor for the impact of the spacious chamber itself. With its soaring dome in the dim light, this was a cathedral, a temple of science.

"Even though I have been privileged to observe here for 24 years," said Dr. Sandage, "every time I come into the dome I am terrified by the size and significance of this instrument. Here is where we find Absolute Reality."

We rode up in an elevator, crossed over a movable catwalk, and lowered ourselves into the very top of the telescope barrel. The observatory floor now lay 75 feet below, shrouded in darkness. Above our heads, stars glittered through the slit in the dome.

We were in the prime-focus cage (opposite),

a six-foot cylinder fixed at the point where starlight comes to a focus from the big mirror below. Here the astronomer can operate his cameras during a lonely night's vigil.

I shivered in the cold air. Dr. Sandage laughed. "I've spent a total of about a year and a half of 12-hour nights in this chilly cage. From now on, however, it will be easier. Tonight we'll be using a remote-control television system in a heated room."

In the control room, night assistant Gary Tuton maneuvered the huge telescope as Dr. Sandage called off the points in the sky he wanted to observe. His finding charts had been taken from the National Geographic Society-Palomar Observatory Sky Survey maps, made during the 1950's.

"Perhaps you don't realize," said Dr. Sandage, "what a supremely valuable gift to science the National Geographic Society made when it helped finance the mapping of the sky. These Sky Survey charts are used nightly at observatories all over the world."

FOR HIS FIRST OBSERVATION the astronomer asked the operator to target on a focus star, Gamma in the constellation Taurus. Gary Tuton punched buttons on his big console. We heard the metal dome rumbling and creaking like a freight train as it turned to bring the slit into position. Then a high-pitched whine filled our ears as the telescope, 500 tons of glass and steel floating on oil bearings, swung around on command, and Gamma Tauri appeared on our TV screen. Once aligned, the telescope could be moved to the area of the first observation.

Now Dr. Sandage took over the fine controls. He was searching for a galaxy whose catalog number is NGC 2844. Suddenly it swam into view—at first a fuzzy blob, then a delicate pinwheel with spiraling arms, a magnificent congeries of stars whose light began its long journey toward us a hundred million years ago, when dinosaurs walked the earth.

Gradually the astronomer made fine adjustments, until the galaxy was positioned directly on a line that represented the slit of the spectrograph, the instrument whose diffraction grating would spread the light into a spectral band. Then one more button was pressed, the camera mechanism clicked, and we relaxed while the exposure was made.

As we waited, Dr. Sandage told me of the enormous improvements in modern optical astronomy. "It may seem tedious to you," he

commented, "waiting for the spectrum to record on the film. But it takes a hundred to a thousand photons, or light units, to expose a grain on a photographic plate, and even with nearly 200 square feet of mirror we catch photons from very faint galaxies only one by one. We have to allow time for them to accumulate to get a picture. Even so, we can now get a spectrum in nine minutes that took 42 hours back in the 1920's. And we get better results."

He explained that the big telescope can photographically pick up objects ten million times fainter than those visible to the human eye. Electronic light amplifiers are now cutting down exposure time and permitting observation of even fainter objects.

Using improvements like these, astronomers probe farther and farther into space to learn how fast the universe is expanding and whether that expansion is slowing down. With such knowledge they hope to solve riddles of the universe that man has pondered since the time of the Babylonians.

I asked Dr. Sandage if the rapid flowering of so many new kinds of astronomy, opening up all parts of the electromagnetic spectrum, was driving the optical astronomer and his photographic plates out of the picture.

"On the contrary," he replied, "it's driving him crazy, because there is so much more to do. The radio and X-ray astronomers must have optical identification of what they are detecting to complete the picture. They come to us for that. The same is true of distances. After the radio astronomers discovered the incredible quasars, it was the optical astronomers who measured the red shifts and determined that quasars are the most distant objects known to man."

*There is nothing so far removed from us
as to be beyond our reach
or so hidden that we cannot discover it.*

—DESCARTES

TO UNDERSTAND the quasar, one of the most mystifying objects in the universe, it is necessary to go back a bit into history. In the early years of radio astronomy, after World War II, observers discovered many celestial objects that emitted radio frequencies but were apparently invisible in ordinary light. Eventually some of these sources were found to coincide with nebulae (gas and dust

clouds between the stars), with remnants of supernovae (exploding stars), or with galaxies. But until 1960 nothing as small as a star (outside our own solar system) was known to be a radio source.

Then came a bombshell. Allan Sandage and radio astronomer Thomas Matthews discovered a most unusual faint starlike object in the exact location of a radio source whose designation was 3C 48 (number 48 in the Third Cambridge Catalogue of Radio Sources). Immediately it became a phenomenon of intense interest to astronomers all over the world.

As the months went by, other radio sources were identified with optical objects of the same kind. In time they proved to be compact blue objects that emitted strongly in ultraviolet as well as the radio portion of the spectrum. And they tended to fluctuate in brightness over short periods of time.

They were named "quasi-stellar radio sources," or quasars for short. Nobody had the slightest idea what they were.

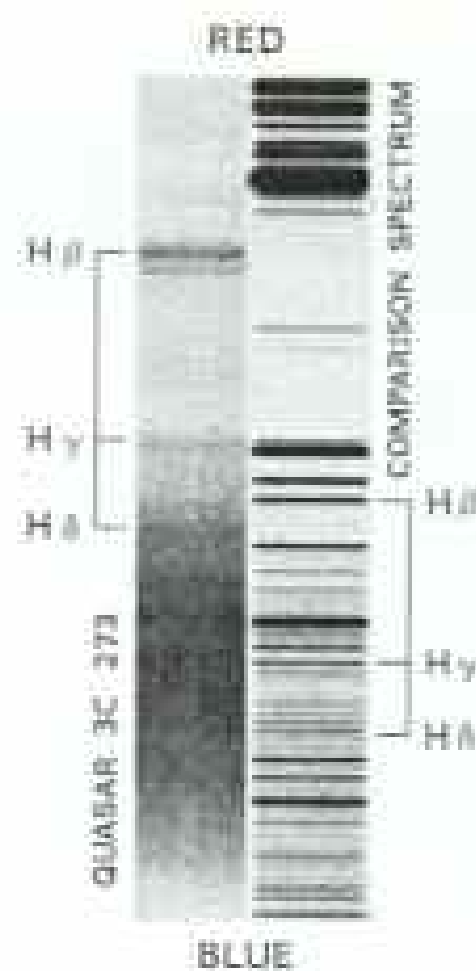
Then came the real shocker. One day early in 1963, at the California Institute of Technology in Pasadena, a Dutch-born astronomer named Maarten Schmidt was studying the spectrum of a newly discovered quasar known as 3C 273 (right). He was puzzled by the fact that the pattern of emission lines in the spectrum was not familiar.

Ordinarily, spectral patterns are well-understood fingerprints for identifying chemical elements in the stars. One set of lines, for example, is easily recognizable at certain wavelengths as indicating emissions from excited hydrogen atoms, another pattern signifies calcium atoms, and so on. But the lines in 3C 273 did not make sense.

Suddenly it dawned on Dr. Schmidt that the familiar pattern was there, but not in the expected place. It was shifted far down toward the red, or longer wavelength, end of the spectrum. This red shift was much more pronounced than those that astronomers were accustomed to seeing.

"That night," the astronomer recalls, "I went home in a state of disbelief. I said to my wife, 'Something really incredible happened to me today.'"

At first most scientists agreed that Dr. Schmidt's startling discovery was unbelievable. But when they examined the spectra of other quasars, they found even larger shifts. The original quasar, 3C 48, had a red

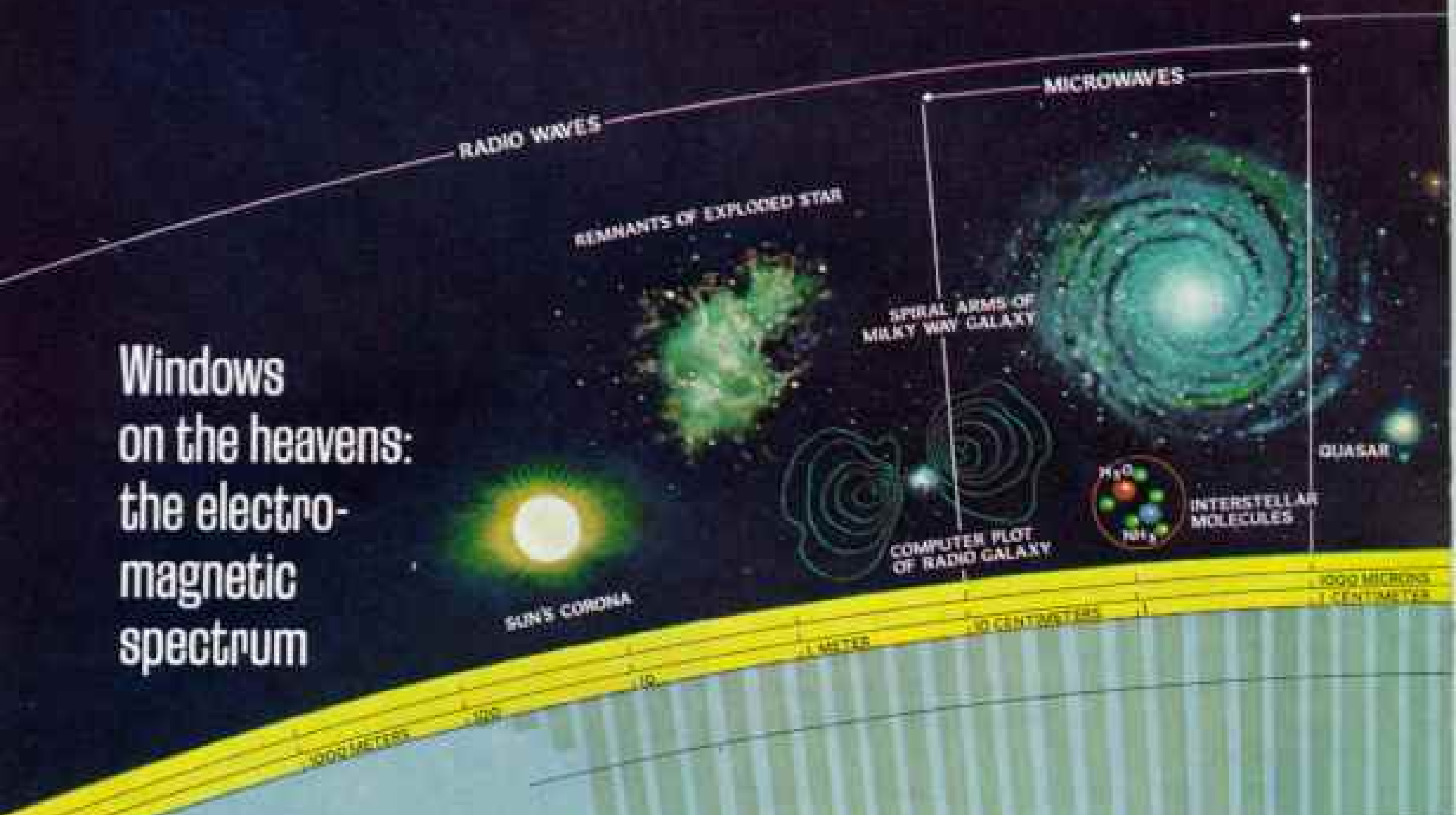


JAMES P. BLAIR (TOP); HALE OBSERVATORIES

Deciphering the cryptic quasars: These powerful radio sources each emit the fantastic energy of a hundred large galaxies. But for several years their spectra, instead of giving clues, defied interpretation.

Then Professor Maarten Schmidt (top) of the Hale Observatories and Caltech, studying a quasar labeled 3C 273 (right), cracked the code: Several lines of its spectrum, representing hydrogen, had shifted radically from the reference lines. This red shift (left) means that 273 lurks some two billion light-years away and is hurtling away at incredible speed. Astronomers have since detected a quasar some ten billion light-years away—most remote of all known objects.

Windows on the heavens: the electromagnetic spectrum



CELESTIAL OBJECTS constantly signal their presence. Voices emanate from the nuclear furnaces of stars, the rotation of interstellar molecules, and a host of other sources (top panel). Traveling at the speed of light in units of energy called photons, the signals vibrate in wavelengths (yellow band) that span the electromagnetic spectrum. At one end are the radio waves, thousands of meters long; at the other, gamma rays that vibrate in thousandths of angstroms (an angstrom is one-tenth-millionth of a millimeter).

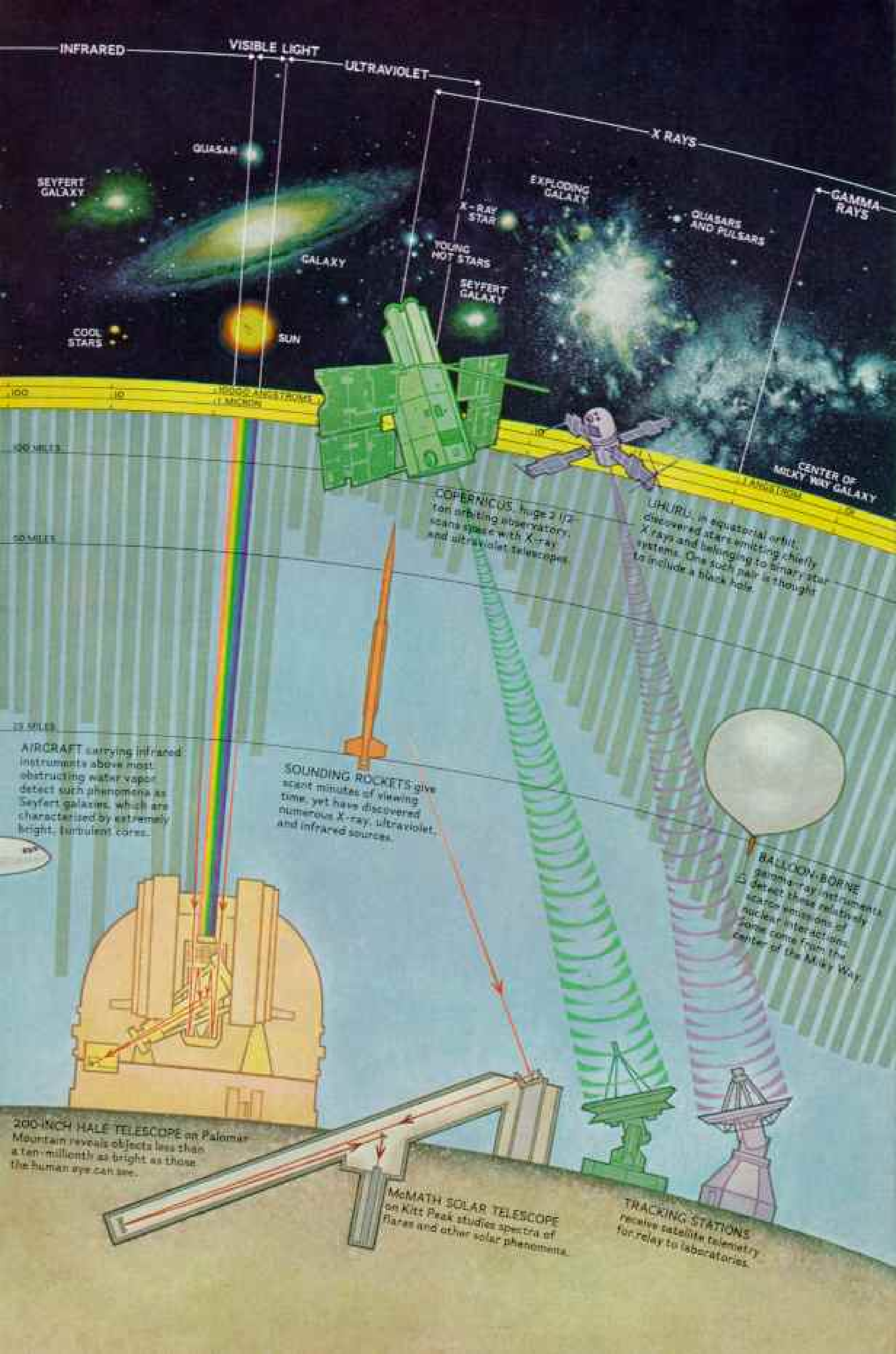
Each segment of the spectrum (labeled at top) opens an intriguing—though often elusive—window on the universe. Only the narrow peephole of visible light and some of the longer wavelengths come within reach of the ground-based astronomer. Most of the rest, stopped by atmospheric gases and charged particles, fail to reach earth's surface, as indicated by vertical gray shafts. To read their messages, scientists send electronic eyes aloft in balloons, planes, rockets, and satellites.

HIGH-ALTITUDE BALLOONS, lofting infrared instruments to vapor-free heights, help in the study of cool stars—those with temperatures about half the sun's.



RADIO TELESCOPES detect a wide range of signal sources, from exploding stars to interstellar molecules.

MICROWAVE ANTENNA at Holmdel, New Jersey, detected residual radiation from the "big bang" that probably spawned the universe some 13 billion years ago.



INFRARED

VISIBLE LIGHT

ULTRAVIOLET

X RAYS

GAMMA RAYS

SEYFERT GALAXY

QUASAR

GALAXY

COOL STARS

SUN

X-RAY STAR
YOUNG HOT STARS
SEYFERT GALAXY

EXPLODING GALAXY

QUASARS AND PULSARS

CENTER OF MILKY WAY GALAXY

100

10

10000 AIRBORNE (11 MICRONS)

100 MILES

50 MILES

25 MILES

AIRCRAFT carrying infrared instruments above most obstructing water vapor detect such phenomena as Seyfert galaxies, which are characterized by extremely bright, turbulent cores.

SOUNDING ROCKETS give scant minutes of viewing time, yet have discovered numerous X-ray, ultraviolet, and infrared sources.

COPERNICUS, 1400-ton orbiting observatory, scans space with X-ray and ultraviolet telescopes.

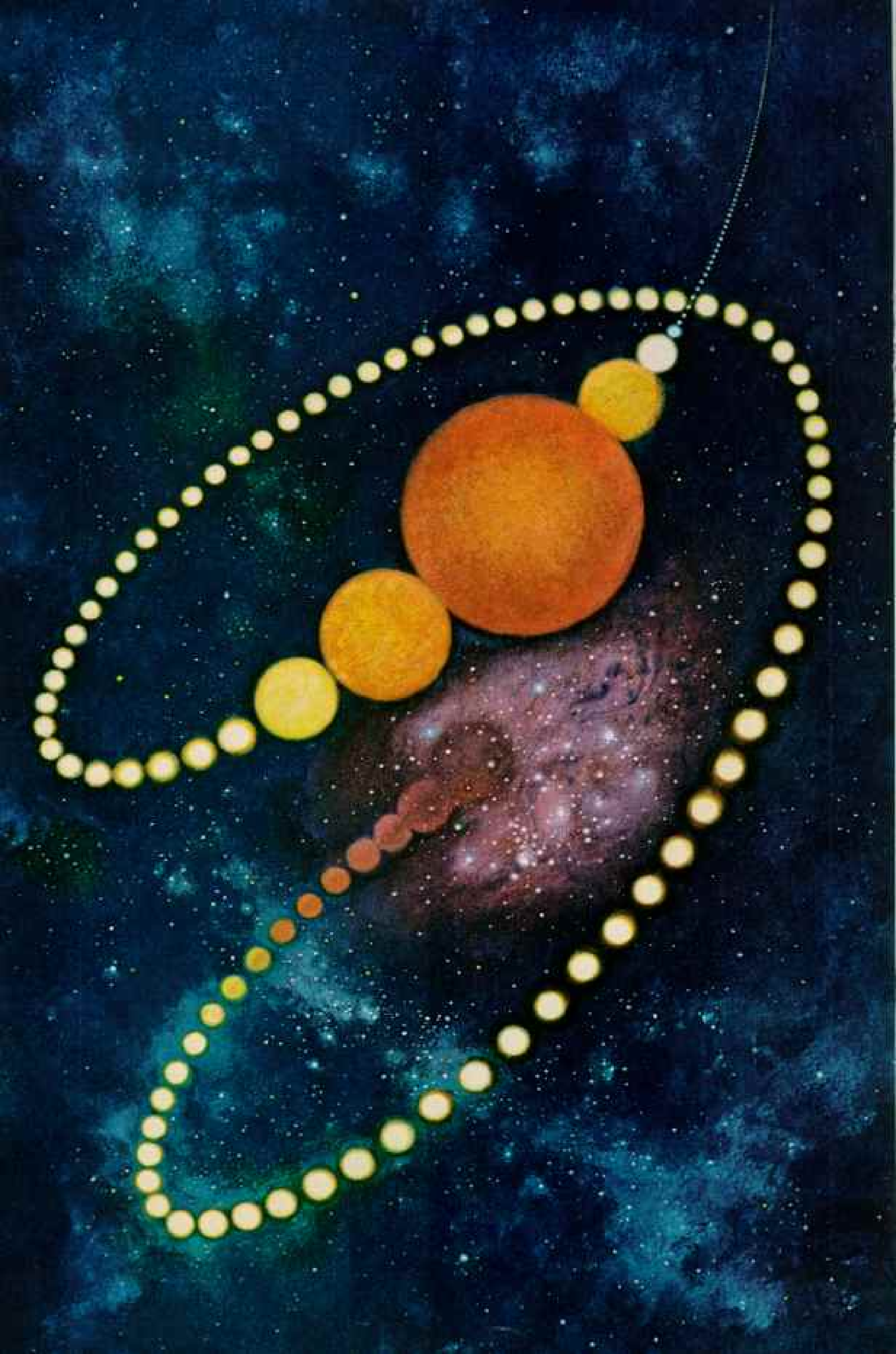
UHURU, in equatorial orbit, discovered stars emitting chiefly X-rays and belonging to binary star systems. One such pair is thought to include a black hole.

BALLOON-BORNE gamma-ray instruments detect these relatively scarce episodes of nuclear interaction, some come from the center of the Milky Way.

200-INCH HALE TELESCOPE on Palomar Mountain reveals objects less than a ten-millionth as bright as those the human eye can see.

McMATH SOLAR TELESCOPE on Kitt Peak studies spectra of flares and other solar phenomena.

TRACKING STATIONS receive satellite telemetry for relay to laboratories.



shift more than twice that of quasar 3C 273.

A red shift, as astronomers have known for more than a hundred years, means that the object is moving away from the observer. It is the same phenomenon—known as the Doppler effect—that makes the sound of a train whistle suddenly fall off in pitch as the train passes and rushes away into the distance. The sound waves are, in effect, lengthened and the frequency decreased as the source of the sound recedes. Similarly with a celestial object: The waves of light are lengthened (that is, become more red) as the source of light moves away from the observer. The faster it moves, the more the waves are lengthened.

Fortunately for astronomers, the red shift is an admirable yardstick. The amount of red shift tells how fast an object is receding, and by Hubble's law that in turn tells how far away the object is. So the relatively large red shift for 3C 273 put it some two billion light-years away (it is still the closest, as well as the brightest, of the known quasars). But the much larger red shift for 3C 48 put it at four billion light-years distant.

That was near the fringe of the known universe when Dr. Schmidt made his momentous discovery.

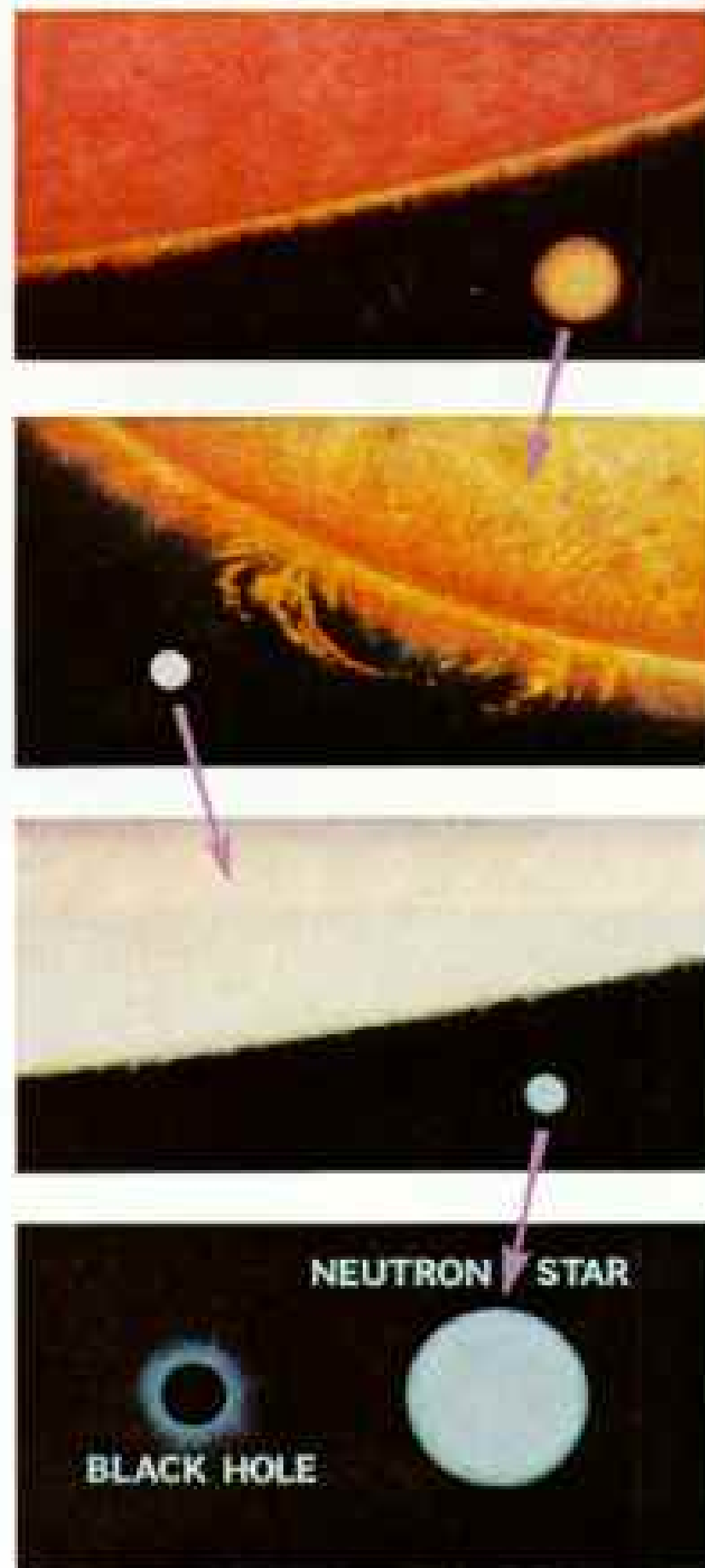
MORE QUASARS have been discovered in the years since then—some 350 have been confirmed—although surveys indicate that they are short-lived, cosmologically speaking, and that there were many more of them in the early history of the universe than there are today.

The most remote known object, and therefore the oldest known object, as this is written, is quasar OQ 172, discovered in 1973. Its furious rush into space at 91 percent of the speed of light puts it at an estimated ten billion light-years away. Thus quasars have doubled the horizons of the observable universe in just a decade.

As Professor John Wheeler, the distinguished theoretical physicist at Princeton, puts it, "Quasars are the beacons that light up the far away and long ago."

Inevitably this new class of heavenly bodies has aroused vigorous controversy as well as intriguing mystery. Quasars fluctuate rapidly in brightness, often within weeks or months, sometimes in only a few days. It is a principle well understood by astronomers that a celestial body does not change significantly

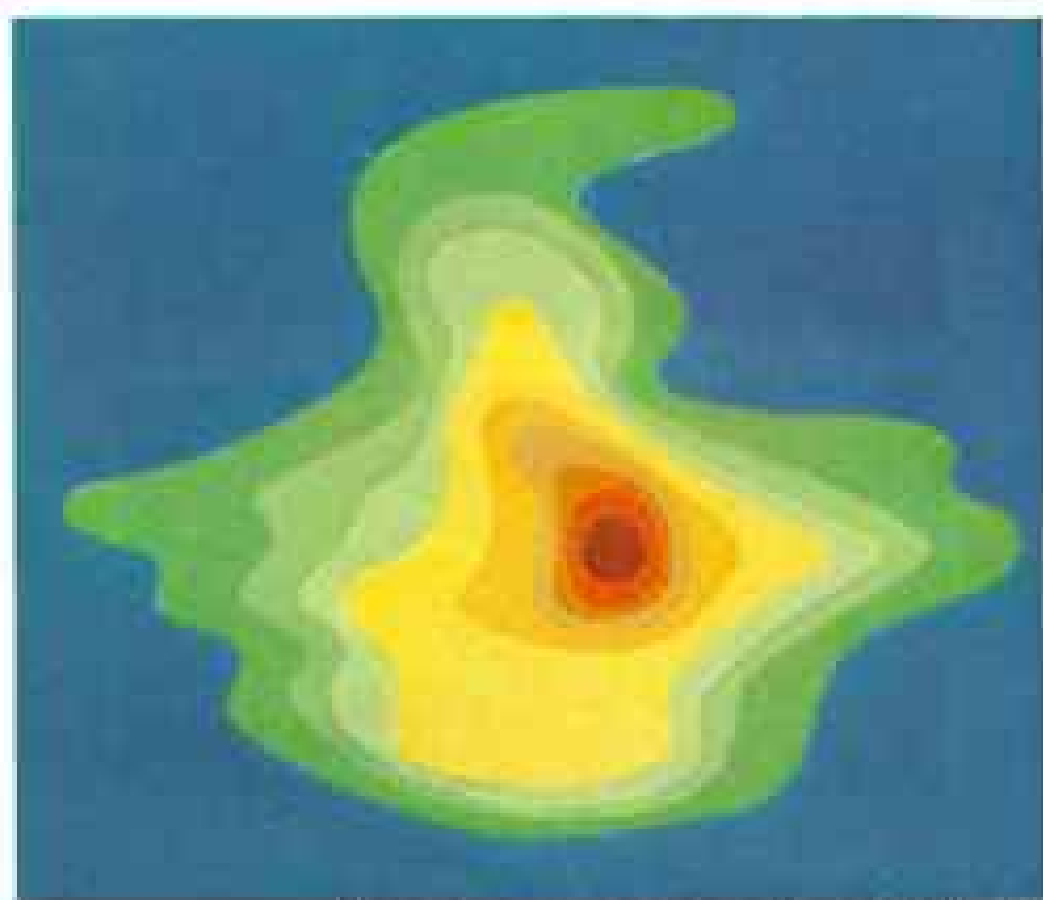
Fiery string of stellar beads depicts the life cycle of the medium-size star that is our sun (left). Five billion years ago gravity collapses a nebula, center, far too large to show in true scale. A star forms, its nuclear furnace ignites, and it quickly matures to today's yellow star. Five billion years from now, its inner fuel consumed, it expands into a red giant a hundred times its present size. Then it becomes a white dwarf and finally a cinder.



PAINTING BY DAVID WELTZER

Giants and dwarfs: stars in their death throes. A red giant (top panel) looms balloonlike over our sun, a typical medium-size star. The sun overwhelms a white dwarf (second).

A white dwarf appears huge beside a neutron star (third), the corpse of a star originally more massive than our sun. And the neutron star dwarfs a black hole (bottom), a collapsed star only a few miles across—so dense that even light cannot escape its gravity.



JAMES P. BLAIR (TOP), FRANK J. LOW AND GEORGE H. RIFE

Taking space's temperature . . . Arming his telescope with a sensor of supercooled germanium (in the gold-plated box above his hand), Professor Frank J. Low of the University of Arizona scans the heavens for slight temperature variations. Converting these infrared readings into a color-coded map, he obtains a picture of the Milky Way's center (lower). Great clouds of interstellar dust hide the center of the galaxy from optical astronomers. Dust and gas may constitute a significant part of the matter in the universe.

in brightness faster than the time it takes light to cross it. Therefore if a quasar is seen to change substantially within a week, it can be only a few times larger than our solar system, which light can cross in just about half a day. By contrast, light requires 100,000 years to traverse our galaxy.

So the quasars are remarkably small, celestially speaking. But if they are so small, and yet we can see them at such prodigious distances, they must be emitting energy at an unheard-of rate. In fact, some quasars produce more energy than a hundred large galaxies, totaling as many as ten thousand billion stars. In one second a typical quasar throws out enough energy to supply all earth's electrical needs for billions of years.

To account for such stupendous energies is difficult. Some scientists believe that even the nuclear processes in the atom are not sufficient, and suggest such extreme sources as massive gravitational collapse or even the annihilation caused by collision of matter and its counterpart, antimatter.

And that is one reason why a few scientists are loath to believe that the quasars are truly cosmological—that is, at the outer reaches of the universe. A small group of astronomers argue that the quasars are local, probably among nearby galaxies, and that the large red shifts are caused by gravitation or some other circumstance, not by swift recession at great distances. If this view is correct, then of course the quasars are not emitting phenomenal amounts of energy at all.

But the large majority of astrophysicists favor the cosmological theory. As the most eminent of Dutch astronomers, Professor Jan Oort of Leiden Observatory in the Netherlands, told me, "If the quasars are not cosmological, it would raise so many questions that I'm not willing to countenance them. I think the quasars are extremely important for cosmological research."

Maarten Schmidt himself leans toward this view: "I think of the quasar as the brilliant central core of some much larger object, perhaps the nucleus of a galaxy about to be born. But we know very little yet, and it is still very uncertain."

With philosophical humor he adds:

"When we look at a quasar over such enormous distances, we are looking back in time almost to the beginning. Are we therefore seeing now almost all the available universe? Will we get cosmic claustrophobia?"

Things fall apart; the center cannot hold.

—YEATS, "THE SECOND COMING"

WHILE QUASARS pour out their unprecedented energies at cosmological distances, startling and more readily observable events are taking place much nearer home. They involve the violent collapse of stars within our own galaxy.

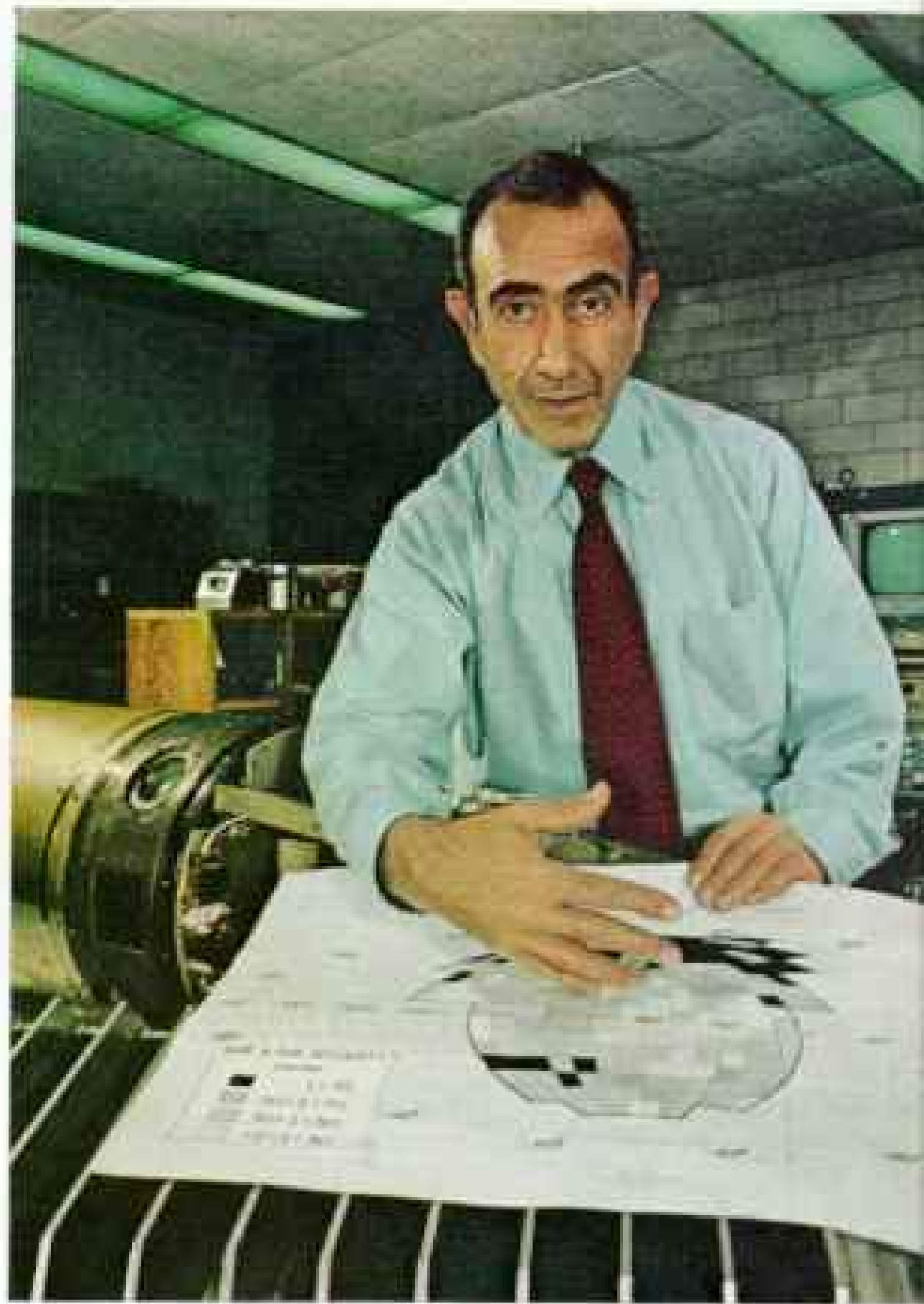
To mortal minds, which measure things on the time scale of human history, stars appear to be everlasting. But on a cosmic time scale, stars pass through a well-defined life cycle: They are born from clouds of dust and gas (chiefly hydrogen), live long and relatively uneventful lives pouring out energy, and then die (page 606). Their deaths are of special interest to astrophysicists, for stellar corpses become some of the strangest objects in the universe, and the explosions during stellar death throes fill space with stardust from which new stars and planets are born.

It may come as a shock to learn that nearly all the atoms in your body and in the earth were once part of a star that exploded and disintegrated. And probably those same atoms were once the debris of still an earlier star.

Our own sun was born, astronomers believe, about five billion years ago, the spawn of a gigantic swirling nebula of gas and dust. As the particles coalesced, gravitation pulled them swiftly together and they heated up. Within a few million years—a short time in cosmic terms—the new body developed within its deep interior a temperature of millions of degrees, enough to ignite the processes of nuclear fusion. Hydrogen atoms fused to form helium atoms, giving off energy in the process, and the sun began to shine.

Our star has changed little since then, and likely it will change little for the next five billion years. But at the end of that time the hydrogen at its center will near exhaustion, and the outer layers will begin to expand.

Then, according to well-developed theories of stellar evolution, a strange fate will confront any life on earth. The sun will begin to swell and redden. Eventually a bloated red sun will loom across some 25 percent of the sky. It will have expanded a hundred times in diameter and increased a thousand times in brightness. Its hot breath may have melted the inner planets, Mercury and Venus. The earth will be *(Continued on page 616)*



JAMES P. BLAIR (TOP); SOLAR PHYSICS GROUP, AMERICAN SCIENCE AND ENGINEERING AND NASA

... and reading space's X rays. Instruments lifted above the atmosphere discover a rich realm of X-ray radiations. Here Dr. Herbert Friedman of the Naval Research Laboratory, a noted pioneer in rocket astronomy, displays a chart of the universe locating sources of diffuse X rays, perhaps caused by hot intergalactic gas.

Huge loops of high-temperature gas arch above the sun's disk (lower) in an X-ray picture taken by the astronauts of Skylab I.



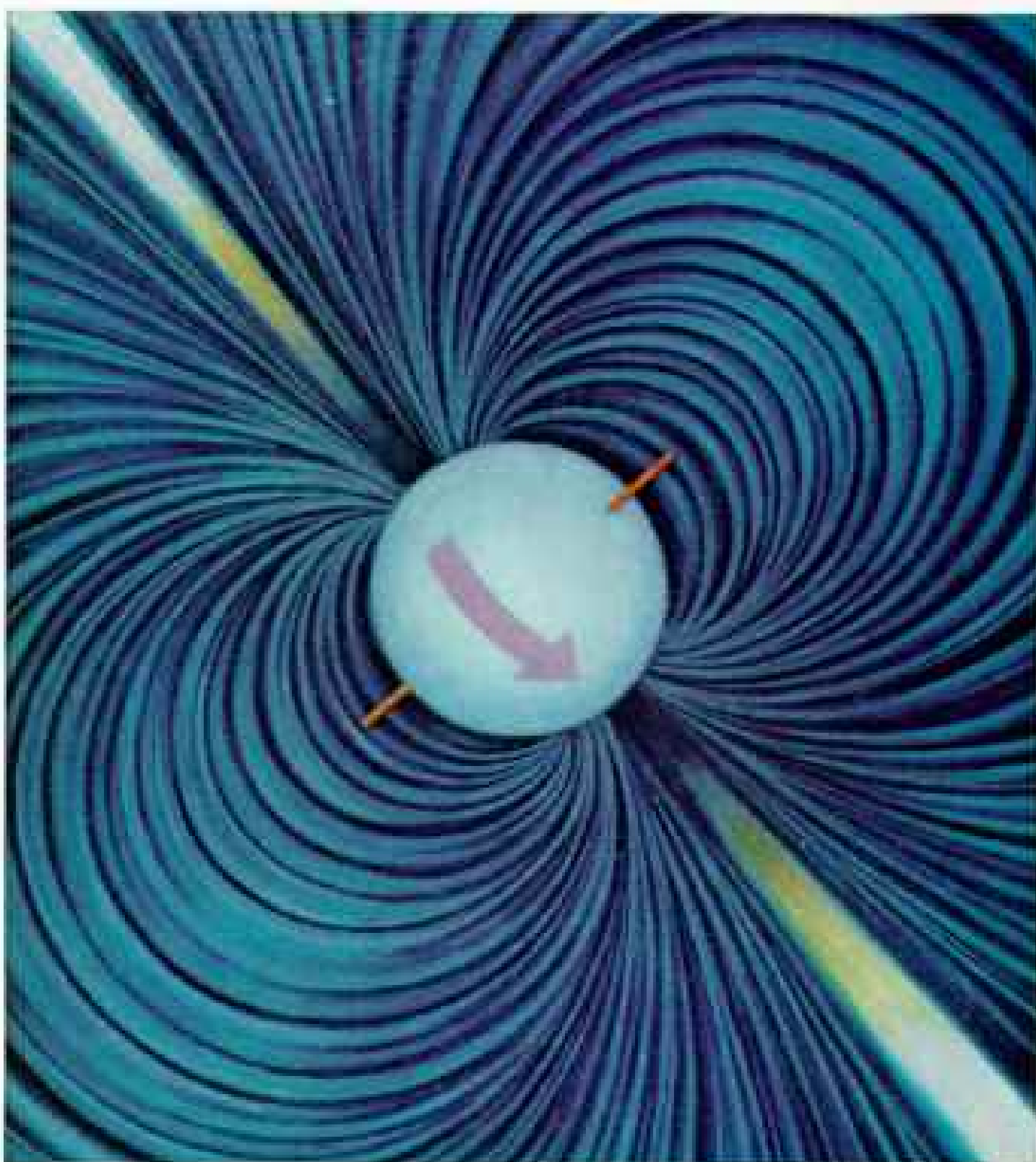
WALL OBSERVATORY (BOOVE AND BELINZ)

Exploding star, observed in 1937, gives scientists a grandstand view of an evolving supernova such as the one that created the Crab.

Its light dimmed after 15 months, the supernova wanes. Neighbor stars appear brighter in the longer exposure needed to film it.

Blacked out, the supernova is gone 4½ years after the blast. This exposure, twice as long as the previous one, brings out a dim galaxy.





LICK OBSERVATORY (TOP); PAINTING BY DAVID WELTZER

Belle of the Milky Way, the Crab Nebula fascinates scientists with a history that happily is known. In 1054 Oriental astronomers recorded the brief flaring of what they called a "guest star," an exploding large star now called a supernova. Today the remnant nebula, several light-years across (above, facing page), pours

forth a symphony of electromagnetic emissions.

Most exciting, the Crab harbors a pulsar, a flashing neutron star that formed in the explosion—the lower of two large stars near the cloud's center. It pulses 30 times a second (shown blinking on and off at upper right). Discoverers of the first pulsar kept it secret

for a time, thinking it might be a signal from another civilization.

Astronomers envision the pulsar as a rotating neutron star with an intense magnetic field (diagram). Energetic particles, guided by the magnetic field, radiate in a narrow beam that flashes like a lighthouse beacon as the neutron star rotates.

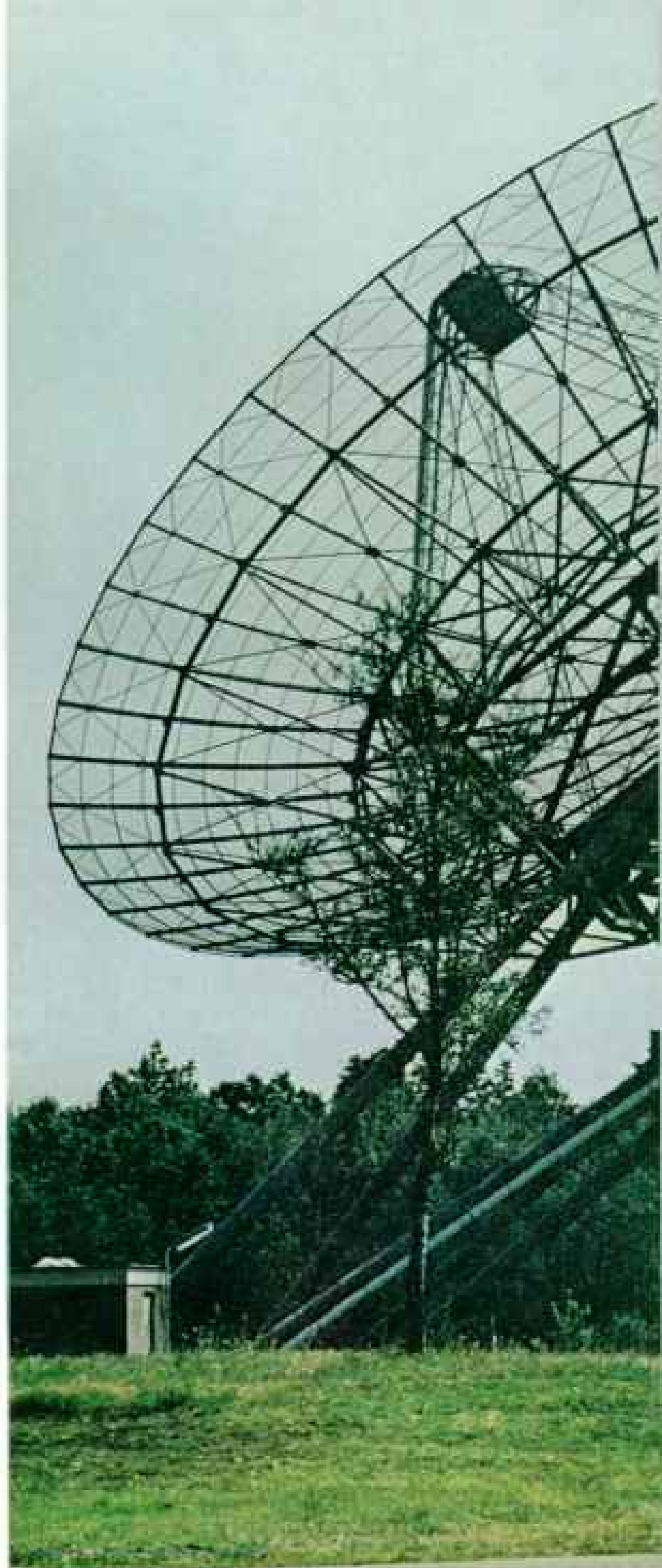
Cyclopean eye of the Arecibo radio telescope (following pages) fills a valley in Puerto Rico. It dwarfs two men inspecting new aluminum panels on the 1,000-foot-wide surface.

NATIONAL GEOGRAPHIC PHOTOGRAPHER ROBERT W. WOODEN



11





Larger and larger grow the bowls of radio telescopes as scientists strive to corral fainter and fainter incoming waves. Astronomers estimate that all the energy received by all the radio telescopes ever built equals only the impact of a few snowflakes on the ground. Yet these metallic eyes stand in the forefront of astronomy—discoverers of quasars, pulsars, and interstellar molecules.



JAMES P. BLAIR (LOWER AND FACING PAGES)

One of the men most responsible for radio astronomy's giant strides is Sir Martin Ryle (lower left), Britain's Astronomer Royal. Here he prepares a computer program for an eight-antenna array that stretches three miles near Cambridge.

Phalanx of five antennas stands sky watch near Westerbork in the Netherlands (above). Along with seven others, they form a mile-

long array that gives the image-resolving power of a single dish a mile across.

Gentle push of a button maneuvers the world's largest fully steerable telescope, at the Max Planck Institute observatory near Bonn, West Germany (upper left). A hundred meters (328 feet) in diameter, it is being turned to the study of interstellar molecules, among other mysteries.



U. S. NAVAL OBSERVATORY

Gem-studded brooch, the Whirlpool galaxy wheels majestically 15 million light-years away. Young blue stars, intensely hot, cause the two arms to fluoresce. One of these reaches out to a nearby small galaxy, also having a yellow nucleus.

reduced to a desolate rock, baked at temperatures that would melt lead, its oceans completely boiled away.

And earthlings? If they have survived, they will have fled to a moon of Jupiter, or perhaps to a more hospitable part of the galaxy.

For a hundred million more years the swollen sun, now called a red giant, will continue to deplete its nuclear fuel. Once the enormous outer envelope has dissipated, only a tiny core will remain. Then, to quote a recent report of the National Academy of Sciences, *Astronomy and Astrophysics for the 1970's*, "a frozen and presumably lifeless earth will swing bleakly around a faint white-dwarf sun appearing no larger in the sky than the tiny planet Mars."

Such white dwarfs may now make up 10 percent of the stars in our galaxy. Typically, they began as stars about the mass of our sun—perhaps a million miles in diameter. They end up about the size of the earth—8,000 miles across—with a density so great that a



LEWIS OBSERVATORY

Spider-web brocade of silvery contour lines, superimposed on a black-and-white photograph, charts the Whirlpool's radio emissions. Intense radiations, indicated by close contours, flow from the nuclei and the inside edges of the galactic arms.

teaspoon of white-dwarf material would weigh a ton.

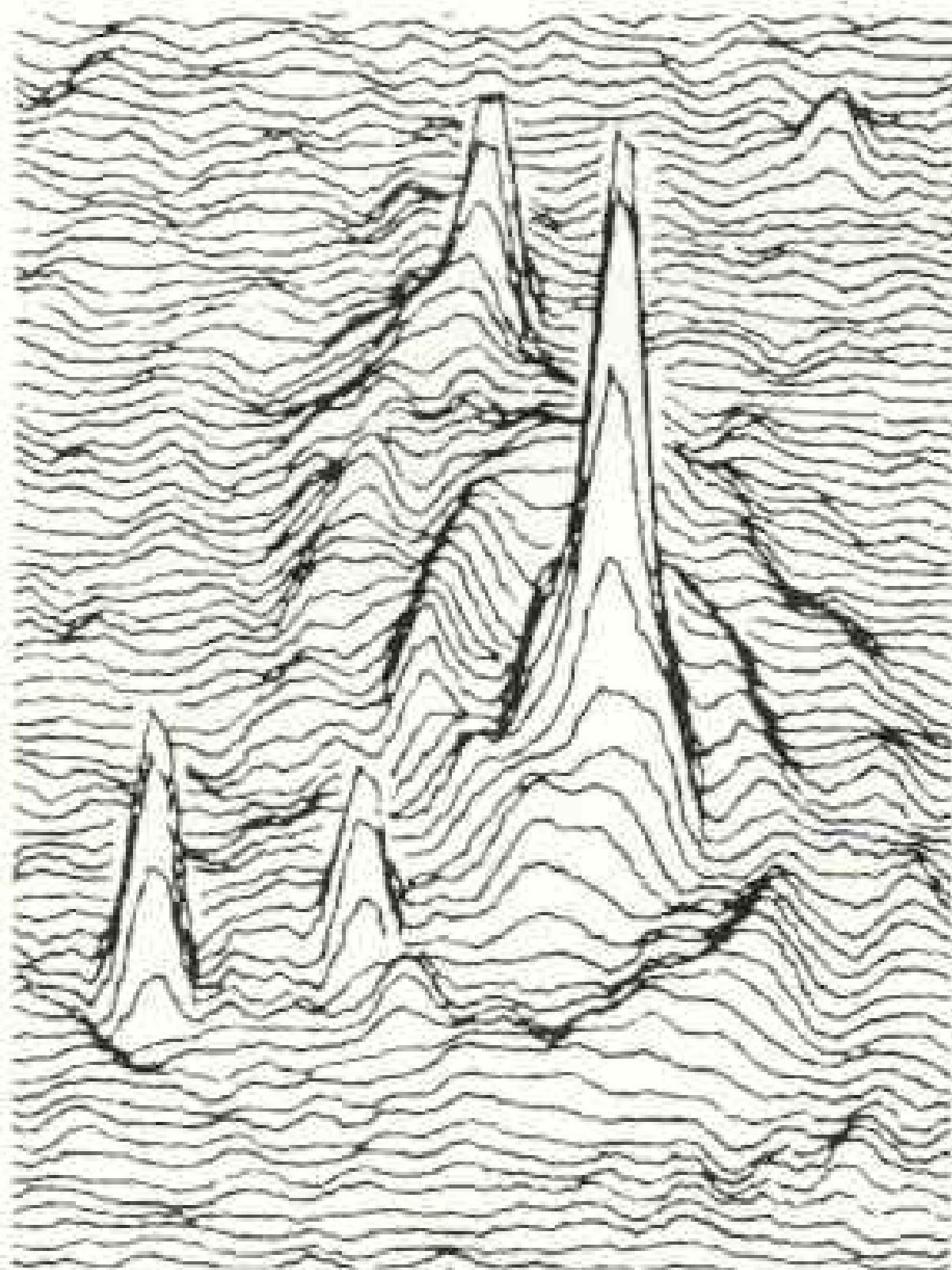
For some billions of years these squeezed-down stars continue to shine from the heat generated during their original formation. But they grow steadily colder, until white dwarfs become black dwarfs, cinders in the ash heaps of the universe.

*No doubt the cherubs earn their wage
Who wind each ticking star.*

—DON MARQUIS, "THE REBEL"

DYING STARS more massive than the sun do not ordinarily become white dwarfs; they suffer a more dramatic fate. The story of that fate is illuminated by two events more than nine centuries apart.

The first was a celestial spectacle that burst on the morning sky of July 4, A.D. 1054. On that day Chinese astronomers recorded a brilliant new star—today we call it a



LIDSEN OBSERVATORY

Alpine peaks pinpoint radio intensities in a third portrayal of the Whirlpool, by another computer plot. Such seemingly three-dimensional views permit instant identification of the location and relative strength of invisible energy sources.

supernova—that suddenly shone more brightly than Venus. For several weeks it was visible in daylight, and it did not fade from the night sky for more than a year.

The second event occurred in 1967 at the Mullard Radio Astronomy Observatory of the University of Cambridge in England. Astronomer Antony Hewish and a research student, Jocelyn Bell, were examining strip-chart recordings from a new antenna highly sensitive to fluctuating radio energy. They discovered mysterious signals, repeated on several occasions, when the antenna was pointed at a particular part of the sky. Closer inspections of the signals, made with a faster recorder, revealed a strange series of peaks spaced at precise intervals.

"It looked ridiculous," Professor Hewish told me later when he showed me the historic recording. "You just don't get pulses like that from the sky."

Thinking that the pulsing signals might carry a message from a civilization on the

planet of some distant star, the Cambridge scientists dubbed the source LGM, for "Little Green Men." Only when measurements disproved the idea of such signals was the discovery announced, in early 1968.

By then it was clear that the astronomers had come upon a new kind of star—"one of the most marvelous pieces of architecture in the universe," as X-ray astronomer Herbert Friedman called it. This belief was strongly supported by discovery of other pulsing stars, whose intense bursts of radiation came with clocklike precision at rates as slow as every four seconds and as fast as 30 times a second. Logically enough, they came to be called pulsars.

One of these stars held unusual significance. It was located about 6,000 light-years away, right in the middle of the Crab Nebula, which shows up in photographs as a beautiful glowing cloud of gas laced with a tangled web of filaments (page 610). That nebula is the debris from the supernova explosion seen by the Oriental astronomers in 1054. It has been expanding outward at velocities of about 900 miles a second, until today the cloud is some ten light-years across. It is one of the most glamorous and intensively studied objects beyond the solar system.

As long ago as the 1930's, Dr. Robert Oppenheimer and others had predicted that the collapse of a massive star, several times the mass of our sun, could lead to a stable object very much smaller than a white dwarf. In the end there would be a wildly improbable and incredibly dense object about ten miles in diameter. The immense gravitational force would crush the very atoms themselves, squeezing out all the space and leaving chiefly nuclear particles called neutrons. For such a strikingly imaginative body of ultra-dense matter, as yet undiscovered, they coined the term neutron star.

The discovery of a pulsar in the Crab in 1968 verified these exciting speculations. Very soon it became apparent that the pulsars must be rotating neutron stars. Only a body as small as a neutron star could rotate 30 times a second, as does the Crab pulsar, and not fly apart from centrifugal force.

Although the exact nature of a neutron star is still largely theoretical, the concept has been soundly worked out and is widely accepted. Here is the scientific consensus:

Collapse takes place within seconds. The outer layers of the gaseous envelope of the

star lag behind, and the shock wave of the collapse blasts them into space. So to an observer it appears to be an explosion, one of the greatest displays of fireworks in the universe. This is the supernova.

On the shrunken neutron star left behind, gravitational energy raises the temperature to many millions of degrees, yet the kilometer-thick crust is a fantastically solid and rigid crystalline material, 10^{15} times stiffer than steel (10^{15} is scientific shorthand for a number represented by 1 followed by 15 zeros). Inside, the neutrons form a superfluid with almost no viscosity.

Density of the neutron star, an extreme

state of matter, far exceeds anything known in our ordinary world—a million billion times the density of water. A teaspoon of neutron star material would weigh a billion tons—the equivalent of those 200 million elephants.

"If I could drop it on the floor," says radio astronomer Frank Drake of Cornell University in a flight of fancy, "it would have enough energy, this billion tons of stuff, to drive all the way through the earth, go out the other side, and then come back down through the hole and oscillate back and forth, till it finally came to rest at the center.

"If we collapsed the whole earth to neutron star density, it would be 100 meters [328 feet] in diameter," he adds.

As Dr. Malvin Ruderman of Columbia University puts it, "If you took all the human beings in the world and put them in one raindrop, you would have such density."

Calculations show that an object as dense as a neutron star must also have prodigiously concentrated gravity—a hundred billion times that of earth. So strong is the gravitational pull that a neutron-star mountain could rise no more than an inch, and to climb it would take more energy than your metabolism can create in a lifetime.

Suppose there were an earthquake—or more properly, a starquake—what would happen? Some astronomers believe they may have detected such events. They have seen pulsars suddenly spinning ever so slightly faster, in one case about a ten-millionth of a second faster per revolution. Such a speedup might mean that the rigid crust of the neutron star has cracked and the star has shrunk about half an inch. Trivial? Not at all. On earth that would be equivalent to the surface suddenly falling 40 feet. And the energy released by the neutron star's hiccup would equal the light of the sun for an entire year, says Frank Drake.

Except for such hiccups, the syncopated rhythm of the Crab pulsar seems fantastically precise, but ultrasensitive instruments detect an almost infinitesimal slowing down—about one part in 2,500 in a year. Thus the pulsar is slowly decaying as it uses up its energy. Meanwhile it pours out radiation all across the electromagnetic spectrum, with increasing intensity toward the X-ray range, and its total output year in and year out is more than 10,000 times that of the sun.

How the pulsar radiates its energy in such sharp pulses is not well understood, but one



JAMES F. BLAIR

Weird world of black holes intrigues two of astronomy's leading theoreticians, Professor John A. Wheeler, left, of Princeton, and Professor Peter Goldreich of Caltech. Dr. Wheeler, among others, suggested looking in binary star systems for black holes, such as Cygnus X-1 (opposite).

theory goes like this: As the star collapses, it spins faster and faster, like a skater pulling in her arms. At the same time its magnetic field, compressed as is the gravity, reaches a strength millions of times the strongest field we have ever created on earth.

In this field the spinning body becomes an enormously powerful electrical generator. It acts like a cosmic slingshot, accelerating electrons and perhaps protons to nearly the speed of light, until they radiate strong beams of radio and sometimes light and X rays. The particles may also become those baffling cosmic rays, charged particles of ultrahigh energy that travel at nearly the speed of light throughout space and bombard the earth from every direction. The magnetic field is believed to act as a funnel, channeling the particles and radiation into narrow beams. The effect is that of a rotating searchlight; hence the pulses (diagram, page 611).

More than a hundred pulsars, or neutron stars, have now been discovered, but no man will ever see one at close range. In the words of the National Academy report: "If an astronaut, more foolhardy than brave, were to venture sufficiently close that it [the neutron star] loomed as large as the moon in our sky, he would be irradiated (high-energy particles), burnt to a crisp (X rays), torn in shreds (tidal force), and blown away."

To survive his passage, the report continued, he would have to be traveling so fast that he would have only a thousandth of a second to glimpse the pulsar as he sped by.

The jaws of darkness do devour it up.

—SHAKESPEARE, "A MIDSUMMER NIGHT'S DREAM"

BIZARRE as the pulsar may be, it is only one of the newly discovered beasts in the wild menagerie of space. There is something still smaller, still denser, and still more mysterious: the so-called black hole. It is the end product of the catastrophic collapse of a really large star. It is the ultimate concentration of matter, predicted by the Einstein theory, accepted by scientists for years as a theoretical inevitability, but only recently confirmed as a near certainty.

Put simply, if a collapsing star is massive enough, its gravity is so strong that not even light can ever escape its boundaries. Thus the star simply winks out and is never seen again. Yet this astrophysical fantasy,

though permanently invisible, exerts a powerful influence, and for astronomers it is one of the most provocative objects in the universe.

"What is inside a black hole?" I asked Kip Thorne of the California Institute of Technology, one of the world's authorities on collapsed stars.

"It is impossible to tell," he answered. "You will never be able to see inside a black hole, and you can never know what has happened inside, since no energy in any form ever comes out to carry the information. We call it 'cosmic censorship.'"

"Yet," he added paradoxically, "it is easier to analyze the surface of a black hole than



PAINTING BY NATIONAL GEOGRAPHIC ARTIST VICTOR J. BELLEN

Slowly succumbing to an invisible foe, a giant blue star bleeds a stream of gases into the vortex of Cygnus X-1 as visualized by astronomers. A collapsed star whose powerful gravity prevents even the escape of light, the hole betrays its presence by bursts of X rays from the spiraling gases.

that of a star. We believe a black hole is an extremely smooth structure; it can never have ripples or mountains. Anything it traps can never escape. The black hole can neither split nor decrease in size; it can only grow, and nothing can prevent it from growing."

It is their enormous gravitational pull that permits indirect detection of black holes. Obviously, looking for a minuscule black dot in a black sky is futile. But some black holes are believed to be paired with visible stars. The members of each pair orbit about each other, and the black hole steadily attracts gases falling from its larger companion. As the gases spiral in toward the gravitational trap (but before they disappear), they collide, compress, and heat up to enormous temperatures. The resulting intense X rays become the clue that should signal the presence of the black hole.

In fact, the X-ray telescopes on rockets and satellites have helped produce the first evidence of the existence of a black hole. Intense emission is coming from a powerful but invisible X-ray object called Cygnus X-1, about 8,000 light-years away. It is estimated to be much greater than three times the mass of the sun, too massive for a neutron star. And it revolves with a supergiant star known as HDE 226868, from which gas clouds seem to be swirling around and disappearing into the invisible partner (painting, preceding page). So the black hole is no longer purely hypothetical!

SOME SCIENTISTS speculate about a large black hole at the center of our galaxy. Possible evidence comes from an important experiment by Dr. Joseph Weber at the University of Maryland that appears to show powerful gravitational waves, conceivably coming from the galactic center. Other scientists performing similar experiments have not been able to repeat Dr. Weber's findings, but it is generally recognized that gravitational waves should be emitted when lumps of matter fall into the gravitational well of a black hole.

"Ultimately," says Kip Thorne, "if the universe itself does not collapse and die first, the black holes will eat up all the matter in our galaxy. Already, as much as one ten-thousandth of the universe might be down black holes. We would like to sweep this fact under the rug, but occasionally we drag it out and look it in the face and shudder."

*Absence of evidence is not
evidence of absence.*

—ANONYMOUS

QUITE THE ODDEST TELESCOPE

I have ever seen is buried nearly a mile deep in a gold mine beneath Lead, South Dakota. It has no lenses or mirrors, none of the usual structure for looking at the heavens. Rather, it consists of a hundred-thousand-gallon tank full of cleaning fluid (opposite, below).

Its sole purpose is to look into the very heart of the sun, and it does this by trying to capture one of the most elusive particles known to man—the electron neutrino. This kind of neutrino is so elusive, in fact, that scientists have never seen it in nature, only in the laboratory. Yet such neutrinos are believed to be manufactured in prodigious quantities in the sun as a product of the nuclear reactions that give the sun its energy.

The neutrino is described as an extremely tiny nuclear particle having no mass and no electric charge, and it flies with the speed of light. It is not readily affected by other matter, and it could easily pass through a million miles of lead without being stopped. So it is well-nigh impossible to catch.

But Dr. Raymond Davis, Jr., and his colleagues from the Brookhaven National Laboratory have devised a clever trap with a tank of tetrachloroethylene cleaning fluid (C_2Cl_4). Shielded by nearly a mile of rock, the cleaning fluid is protected from cosmic rays and electromagnetic radiations at earth's surface. However, neutrinos penetrate the rock, and, as they fly through the cleaning fluid, an occasional one interacts with a chlorine atom, transmuting it into an atom of radioactive argon 37. The experimenters flush the tank periodically with helium to extract the argon 37, and by counting these radioactive atoms determine the number of neutrinos they have presumably detected.

Mysteriously, the neutrino count over a period of seven years has run far too low—less than a fifth of what careful calculations predict it should be. It raises the question of whether any neutrinos have actually been detected. But to some scientists this shortage carries the foreboding suggestion that the sun is temporarily slowing down, that nuclear processes at the center of the sun are less



JAMES P. BLAIR (PHOTO AND BELOW)

Elusive prey, ingenious traps: Does the nucleus of the Milky Way emit faint gravitational waves, indicating a possible black hole? Professor Joseph Weber (left) of the University of Maryland may have detected them with an aluminum-cylinder antenna, foreground. Crystal sensors on the surface translate minute gravitational vibrations into electrical impulses for recording.

Unlikeliest of telescopes is that developed by Dr. Raymond Davis, Jr., (below) to measure the sun's output of tiny massless neutrinos. Hoping to "catch" the particles, which can easily pass through the entire earth unaffected, Dr. Davis submerges a 100,000-gallon tank of cleaning fluid in water nearly a mile down in a South Dakota gold mine, where it is safe from bombardment by other radiation. A few of the neutrinos presumably collide with chlorine atoms in the fluid, changing them into atoms of radioactive argon 37 that can be separated and counted.



vigorous than they once were, and that neutrinos are not coming out as they once did.

If true, would we not already detect a cooling of the sun? Not necessarily, scientists say, for the radiant energy now at the sun's core will take a few million years to reach the sun's surface, after which it can come to earth in the form of light and heat. Neutrinos, on the other hand, fly out immediately, virtually unimpeded. So in minutes they can deliver a message of what is happening today at the sun's center.

If the sun is in fact in a temporarily cooler phase, how long ago did the cooling begin, and how soon will earth feel it? No man knows, but distant generations could face renewed ice ages.

*I know perfectly well that at this moment
the whole universe is listening to us.*

—JEAN GIRAUDOUX,
"THE MADWOMAN OF CHAILLOT"

IF INDEED someone elsewhere in the universe is listening to us via radio, that someone can be no more than fifty light-years away. Earthly radio broadcasting on any important scale began only about fifty years ago, so those pioneer broadcasts, expanding through space at the speed of light, are just now passing the fifty-light-year marker.

But there is compelling reason to believe

that faint radio signals from civilizations elsewhere in the universe may be coming our way. If astronomers can learn exactly how to tune in and in what direction to listen, we may eventually communicate with nonterrestrial beings.

Already we have tried. In 1960, at the National Radio Astronomy Observatory at Green Bank, West Virginia, Frank Drake listened daily for two months to the two nearest sunlike stars—Tau Ceti and Epsilon Eridani—both about 11 light-years from earth. He tuned his radio receivers to a fundamental wavelength in radio astronomy, the 21-centimeter line at which hydrogen, the most common chemical element in the universe, radiates most strongly. This attempt, called Project Ozma, detected no intelligible signals. Similar attempts currently going on in both the United States and the Soviet Union have so far been unsuccessful.

Dr. Drake hopes to try again soon with the largest telescope in the world, the 1,000-foot-diameter radio dish at Arecibo, Puerto Rico (pages 612-13). This instrument can send out powerful radar signals and also capture incoming radio signals. Says Dr. Drake, who directs the work at Arecibo, "This telescope could detect a duplicate of itself broadcasting anywhere in the galaxy. If the galactic community exists, we can now join it."

To be sure, no one can prove that life exists beyond earth. Moreover, as recently as two or



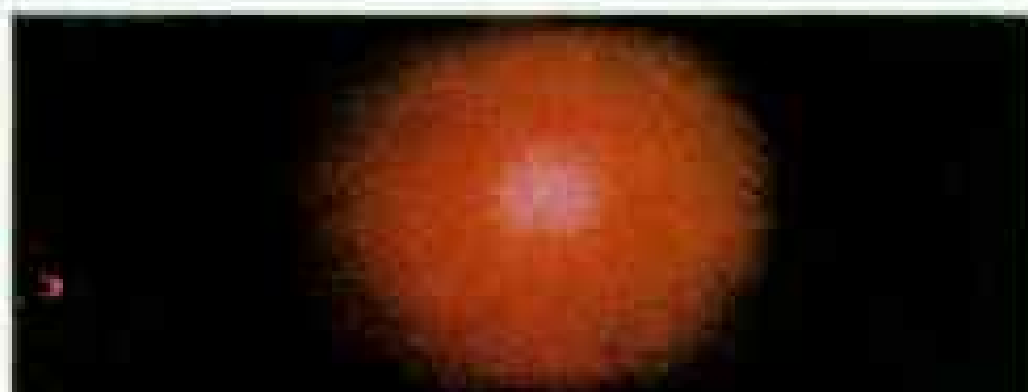
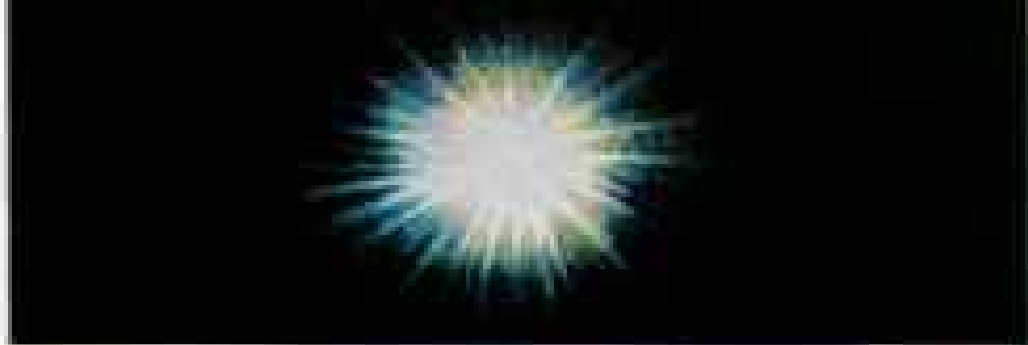
JAMES P. BLAIR (ABOVE); WALE OBSERVATORIES

Testing a stargazer's vision, a technician checks out the antenna system of the Radio Astronomy Explorer B satellite in a COMSAT laboratory. The test chamber's spongy, irregular walls absorb extraneous radio frequencies. Here a dummy antenna substitutes for four real ones, each of which will unfold to a spidery 750 feet.

RAE-B now orbits the moon free of earth's radio interference, recording galactic signals.

"Fireflies tangled in a silver braid," rhapsodized Tennyson about the Pleiades (right), in the constellation Taurus. Dust particles scatter the light of these hot blue stars, giving them their halos.





It all began with a "big bang," most astronomers agree. And it may end that way too.

Perhaps 13 billion years ago, when time begins, a primordial mass explodes in a titanic big bang (top). The fireball cools as it expands, and gas clouds begin to form into celestial bodies (second panel). Galaxies take shape, propelled outward by the initial cataclysm (third).

The world of the big-bang theory may expand forever, or it may collapse in on itself. After some 40 billion years, gravity may inexorably slow and halt the expansion (middle). Then begins an ever-accelerating rush inward (fifth panel). Perhaps 80 billion years after its birth, the universe slams back into itself (six). Then, under the oscillating-universe theory, comes another big bang (seven), and a new cosmos is born. PAINTING BY DAVID BELTZER

three decades ago it was pure speculation even to suggest the possibility. But that has changed. With our rapidly growing understanding of the universe has dawned the profound belief that we are not alone.

Not long ago at a symposium on this subject, Professor George Wald, Nobel laureate and professor of biology at Harvard, declared, "I think there is no question that we live in an inhabited universe that has life all over it."

His view was echoed by Professor Richard Berendzen, an astronomer from Boston University: "The question has become not so much one of *if* as of *where*. And many of these forms of life are probably far more technically advanced than ourselves."

Intelligent life elsewhere does not have to be like human beings. Scientists say, in fact, that it certainly will not have developed in forms just like us.

Whatever form it takes, life cannot exist in a fiery star; it needs a planet of appropriate size not too near and not too far away from a sun. We cannot see such planets outside our own solar system because they are too small and do not emit powerful radiations, but we can detect them by the way they disturb the motions of their parent stars. So we believe that a number of the stars closest to earth have small dark companions.

Suppose that only one in every hundred thousand of the stars in our galaxy has a planet with some kind of life—intelligent or

otherwise. That's only one thousandth of one percent of the hundred billion stars that are our galactic neighbors, yet it represents a million "populated" planets.

A growing number of scientists would say this is not an unreasonable estimate. Since other galaxies are believed to have, on the average, as many stars (and therefore planets) as the Milky Way, and since there are an estimated hundred billion galaxies, the number of extraterrestrial civilizations could be truly astronomical!

Estimates such as these take on added meaning from the recent discovery, chiefly through radio astronomy, of a rich variety of molecules in what was once thought to be barren space between the stars. Among these are molecules such as ammonia, hydrogen cyanide, formaldehyde, and water. They contain the basic chemical elements—carbon, hydrogen, nitrogen, and oxygen—that account for 99 percent of the living material we know. Some of these molecules are called "biological precursors"; when subjected to intense radiation or electrical discharges, they can produce the more complex amino acids that are the building blocks of life.

And so belief that life exists outside our own tiny corner of the cosmos is growing strongly. And we need not agree entirely with the cynical writer who said of the stars, "If they be inhabited, what a scope for misery and folly. If they be not inhabited, what a waste of space!"

This is the way the world ends

Not with a bang but a whimper.

—T. S. ELIOT, "THE HOLLOW MEN"

HOW IT ALL BEGAN and how it will all end—those are the cosmological questions that stir men's minds most deeply.

Only a few years ago the astronomical world was vigorously engaged in debate on origins. One school said the universe began in a single titanic explosion, the "big bang," and has been expanding ever since. The other said yes, there is expansion, but there was no big bang. New matter is constantly being created to replace that lost by expansion, so everything is in a steady state.

Today most astronomers regard the steady-state theory as dead. One of the nails in its coffin was a significant discovery by Dr. Arno Penzias and Dr. Robert Wilson at the Bell

Laboratories at Holmdel, New Jersey. Searching the heavens with an unusual horn-shaped antenna, they detected in the microwave region of the radio spectrum an unexpected faint radiation that came equally from every direction. It represents precisely the kind of radiation that would exist in space at a temperature of 2.7° Kelvin (about 455° below zero Fahrenheit).

Moreover, it is the kind of radiation that had been predicted on the theoretical grounds that a big bang had occurred long ago and that the primordial fireball had been expanding and cooling ever since. It is just about the temperature to be expected some thirteen billion years after such a big bang.

So the microwave background whisper found by Penzias and Wilson may be the dying echo of the big bang.

AND HOW WILL IT ALL END? Allan Sandage believes that the universe might collapse in on itself eventually. He has measured very carefully the rate at which the galaxies are expanding outward, and he finds that the rate is slowing ever so slightly. So, he suggests, if the slowdown is enough, gravity will eventually pull all the galaxies back in, just as a ball thrown into the air slows and falls back to earth.

It is not clear if the slowdown is enough, and Dr. Sandage does not know precisely how to interpret his observations of the ancient light that left the distant galaxies so long ago. But by one set of his calculations the expansion could go on for nearly 30 billion more years, and then the contraction would take another 40 billion.

A major mystery hangs over this hypothesis, however. Computations of the amount of visible matter in the universe do not show nearly enough mass to arrest the outward flight of the galaxies by gravitational pull. And so scientists are seeking additional invisible matter throughout the universe—in faint stars in galactic halos, perhaps in intergalactic gas and dust (not yet firmly detected), and in black holes.

If the missing matter is not really there, then the ultimate fate of the expanding, cooling, dying universe might best be expressed by the words of T. S. Eliot in his poem "East Coker":

"O dark dark dark. They all go into the dark,
The vacant interstellar spaces, the
vacant into the vacant." □



Huyens

CL. PTOLEMAEI



Pioneers in Man's Search for the Universe

COPERNICUS

"The earth ... lies right in the middle of the heavens," the Greek astronomer Ptolemy asserted. His concept helped shackle men's minds for more than a millennium. Then Nicolaus Copernicus, a scholarly and unassuming administrator in the Roman Catholic Church, triggered a revolution that dislodged earth—and man—from the center of the universe.

Born in what is now Poland in 1473, Copernicus pursued a Renaissance education that equipped him as physician, lawyer, economist, mathematician, and astronomer. While serving as a canon at the cathedral at Frauenburg (now Frombork), he quietly studied the movements of the planets and stars and compiled a massive work propounding his radical views. Word of them gradually spread across Europe, but for religious and political reasons the reluctant revolutionary delayed publication until the year of his death, 1543.

Then the world read the words that transformed the universe: "As if seated upon a royal throne," stated Copernicus, "the Sun rules the family of the planets as they circle round him." At the same time he explained the alternation of day and night by the earth's rotation on its axis.

"The fool wants to turn the whole science of astronomy upside down," Martin Luther is reputed to have warned. Copernicus did just that, and in doing so set astronomy free.

Paintings by JEAN-LEON HUENS

Text by THOMAS Y. CANBY

SENIOR EDITORIAL STAFF

WHEN TO SOW, and when to reap? How to predict the heavenly movements that signal religious rituals? To answer such questions, the ancients studied the awesome night sky—and thus gave birth to astronomy, man's first science.

This "science" bore strange fruits. Egyptians of 3,000 years ago envisioned the celestial vault as the star-spangled torso of the sky goddess Nut, arched over the earth. Each evening she swallowed the setting sun, which during the night journeyed through her body to be born anew the next morning.

Early Greeks thought that a spherical shield protected earth from distant fire; flames flickering through tiny holes in the shield explained the twinkling stars. And medieval writers constructed a cosmos in which a hierarchy of angels moved the celestial bodies.

Almost always earth reigned at the center of the universe—even though Aristarchus, a Greek of the third century B.C., suggested a system in which the earth revolved around the sun. But his notion faded in the face of contrary teachings of the revered Aristotle and Ptolemy, especially when the Church came to support the earth-centered belief. Not until the 16th century did Copernicus spark the intellectual explosion that liberated man from his misconception.

Not surprisingly, the challenge of astronomy—to fathom creation's grand design—lured the towering intellects of each era. As a skeleton key to unlock the heavens, they devised new forms of mathematics. Exploring the universe, they lifted the human spirit. "Astronomy," noted Plato, "compels the soul to look upward."

GALILEO

Wondrous vistas opened in 1609 to Galileo Galilei, first man to see the heavens through a telescope. Delightedly the Italian astronomer-physicist discovered mountains on the moon, the phases of Venus, the four "little stars" attending Jupiter. Scanning the Milky Way, he beheld countless stars never before seen. Observing sunspots traversing the solar disk, he deduced that the sun rotates.

With these discoveries Galileo became a convinced Copernican, and crusaded to gain Church acceptance of the theory. Attempting to convince skeptical prelates (right), he explains the lunar mountains and moons of Jupiter. When the Church proved unyielding, Galileo became abrasive; finally the Inquisition forced him to admit "errors" to avoid torture. But even that failed to still his questing mind. Before his death in 1642 Galileo explored a wide range of mechanics, from the movements of pendulums to those of falling bodies.

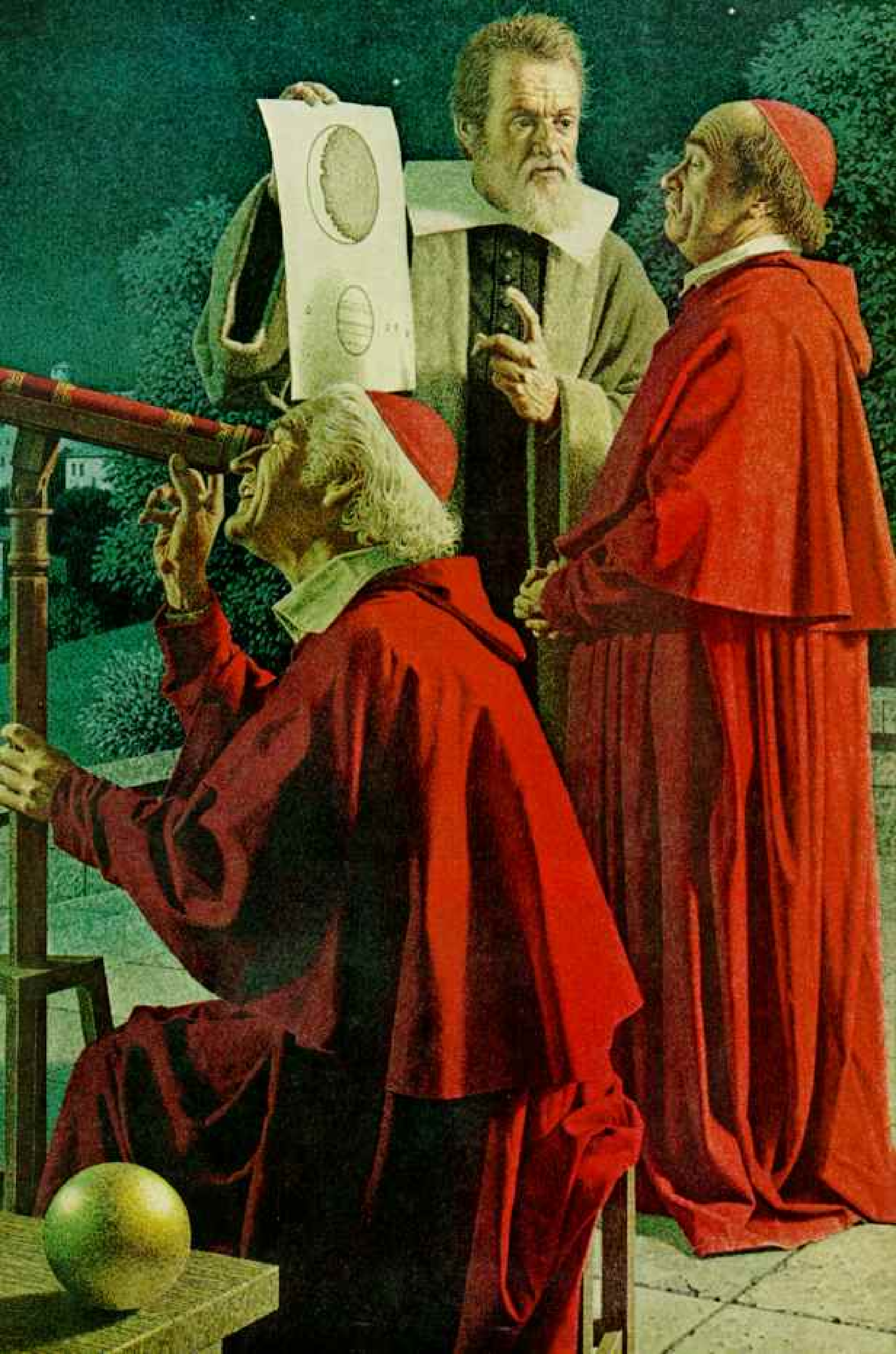


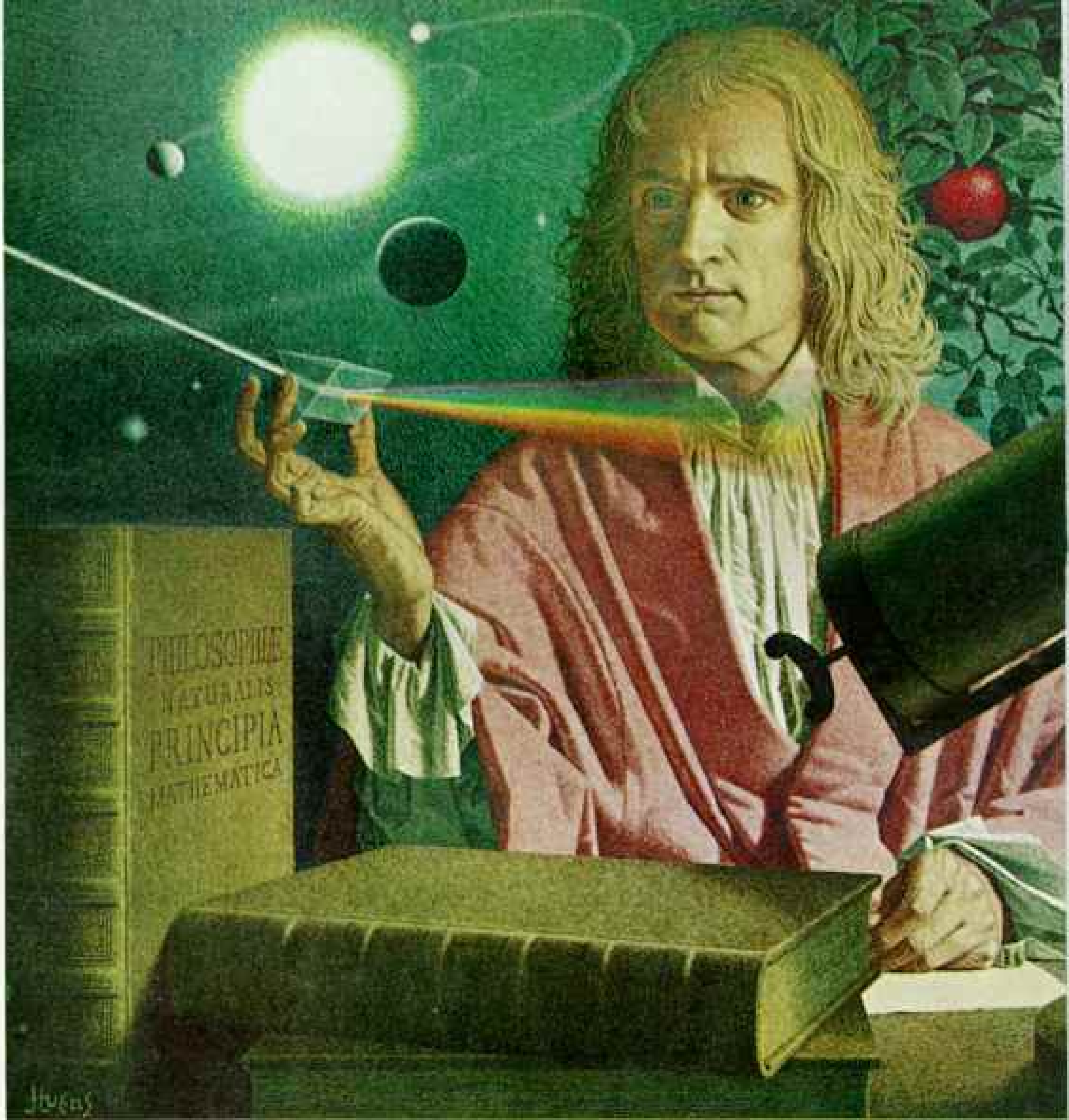
KEPLER

When a spacecraft orbits the earth, it follows a path based on laws discovered by Johannes Kepler (above), a versatile theoretician born in Germany in 1571.

Though not a frequent stargazer himself, Kepler worked with the great Danish astronomer Tycho Brahe. Using Tycho's observations of planetary movements, Kepler banished forever the pervasive notion—shared by Copernicus—that the planets move in circles. Instead, he discovered they move in ellipses, or oval orbits. Before a portrait of Tycho, he holds a diagram of his three laws of planetary motion.









NEWTON

When bubonic plague paralyzed England in 1665, Isaac Newton, then 22, left Cambridge University to carry on his studies at home. Eighteen months later, when the plague had subsided, Newton had determined basic principles of light and color, created integral and differential calculus, and begun to define the working of gravity.

Kepler before him had unlocked the secret of the planets' paths. But *why* did they swing elliptically around the sun? Supposedly inspired by the sight of an apple falling in his garden, Newton formulated the law of gravitation—that bodies attract each other with a force directly proportional to their masses and inversely proportional to their distance apart. Correlating this theory with his laws of motion, he employed his newly developed calculus to deduce the orbits of celestial objects. What Kepler had discovered from Tycho's observations, Newton could now explain and calculate for any heavenly body.

His findings appeared in one of the landmark books of all time, *Philosophiæ Naturalis Principia Mathematica*. It contained his laws of motion, including the familiar "to every action there is always an equal and opposite, or contrary, reaction." From his understanding of gravity he determined the moon's effect on the tides. He made the first reflecting telescopes, one of which is still a cherished possession of the prestigious Royal Society, to which it earned him membership. His discovery that a prism separates light into component colors led to the miracle of star study through spectral analysis.

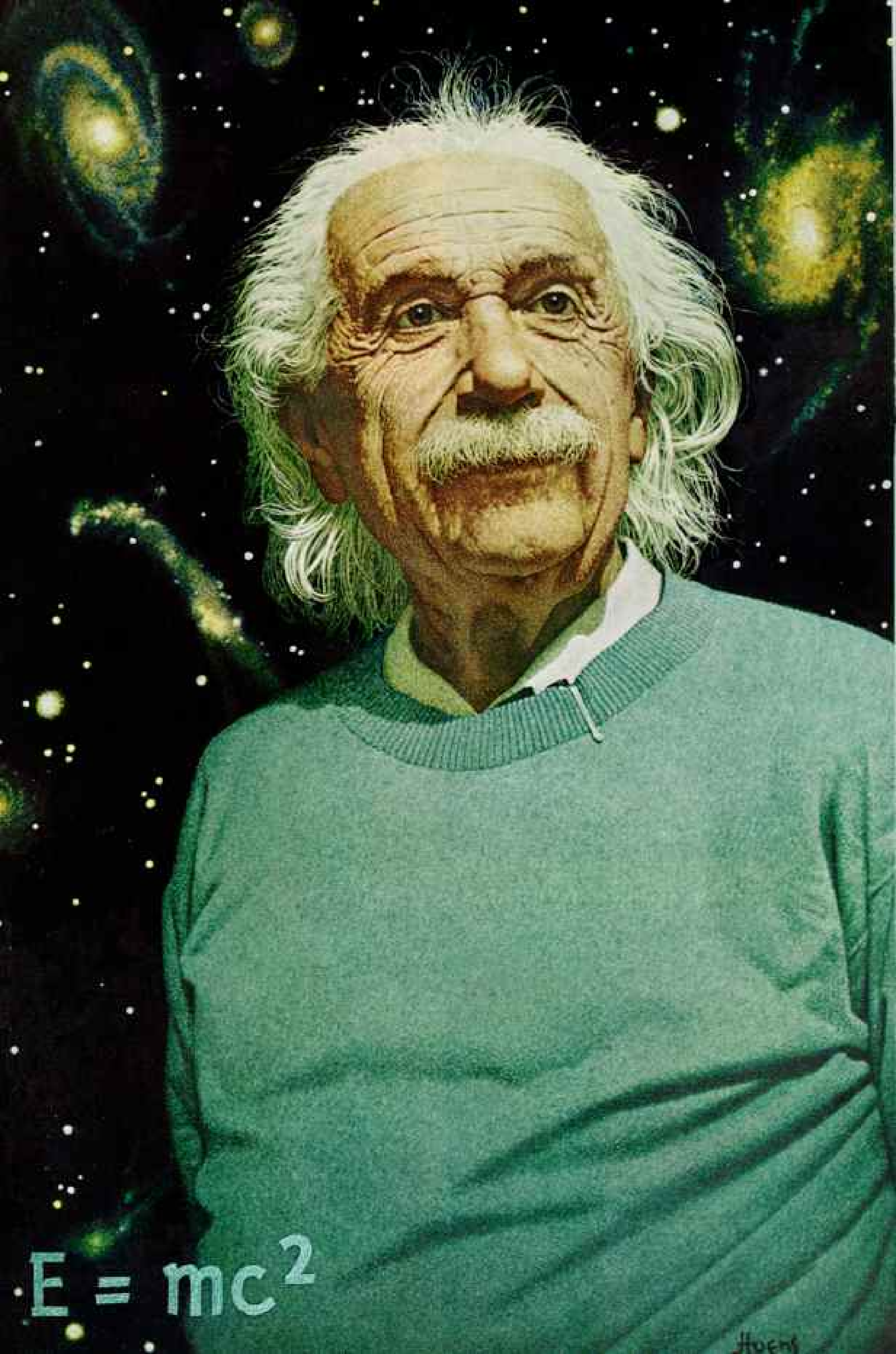
When Newton died at 84, his countrymen buried him in Westminster Abbey among kings and bishops, with a fitting epitaph: "Mortals, congratulate yourselves that so great a man has lived for the honor of the human race."



HERSCHEL

Settling in England at 19, German-born musician William Herschel acquired a small telescope that launched a life-long fascination with the heavens. Making ever-larger instruments, he methodically searched the skies for whatever he could find. Fame came in 1781 when, at age 42, he discovered the planet Uranus. He also detected double stars with interlocking orbits—proof that Newton's law of gravitation applied outside the solar system. He discovered the general shape of the Milky Way and the path the sun follows through space, carrying the planets with it.

Herschel's most ambitious telescope, 40 feet long, proved impracticable. Here he goes to observe with his sister Caroline, herself the discoverer of eight comets, and his son John, who also became an eminent astronomer.



$$E = mc^2$$

Huens

EINSTEIN

The news spread with lightning speed that spring of 1919: Scientists observing an eclipse of the sun had tested—and verified—Albert Einstein's revolutionary theory that gravitation bends light. Almost instantly "relativity" became an everyday term.

German-born Einstein was only 26 when he published his special theory of relativity in 1905. It held that motion, time, and distance are not absolute but relative to moving frames of reference. A later paper gave the equation $E=mc^2$ —energy equals mass times the speed of light squared. This brief formula opened to man the awesome power of the atom.

In 1916 Einstein published his second, or general, theory of relativity. Incorporating acceleration and gravitation into his concepts, it explained the universe in terms of curved space and time.

A 1921 Nobel Prize honored the physicist for discoveries involving light and electricity. In 1933, after Hitler had come to power in Germany, Einstein accepted a position with the Institute for Advanced Study in Princeton, New Jersey. Before his death in 1955, the gentle physicist-pacifist with the familiar tousled mane had won world reverence for having transformed man's understanding of the universe.

HUBBLE

At the dawn of the 20th century, "universe" meant the Milky Way; our galaxy, most astronomers believed, encompassed all celestial bodies. By the time Edwin Hubble died in 1953, man's concept of the cosmos was totally, bewilderingly changed.

Born in Missouri, Hubble spent his adult life in southern California's mountaintop observatories. Using the new 100-inch Mount Wilson telescope, shown behind him, he set about measuring the distances to mysterious spiral nebulae, long believed to be clouds of gas. Soon he established that they were actually other galaxies—star systems beyond our own.

This discovery dramatically demolished the accepted boundaries of the cosmos, yet it was only the start of an incredible voyage into space and time. Galaxies beyond remote galaxies appeared as Hubble systematically photographed the heavens. While he measured distances to the galaxies, a colleague named Milton Humason recorded their spectra. To Hubble, these told an exciting, almost frightening story: The cosmos was exploding wildly outward, with each more-distant galaxy hurtling away at proportionately greater speed. With discovery of the expanding cosmos, Hubble brought us a giant step closer to understanding the origins of the universe, and laid the foundation on which modern astronomy builds. □



Heart of the Bluegrass

By CHARLES McCARRY

Photographs by J. BRUCE BAUMANN
NATIONAL GEOGRAPHIC STAFF



Fast horses and gentle living still work their magic in a land of green-carpeted beauty. Thoroughbred yearlings (above) gambol across a Kentucky pasture at dawn. In the evening of his years, folk singer John Jacob Niles (right) hugs a dulcimer of his own making as he concludes "The Hangman," an old English ballad that he popularized.

IT WAS MIDNIGHT, and we were waiting in the heart of the Kentucky Bluegrass for a granddaughter of Native Dancer to be born. For three nights, as April rain beat a fidgety rhythm on the roof of Bill Hayes's stable near Lexington, we had breathed the sweet scent of hay and horses while keeping birth watch over a 20-year-old bay mare with the wondrous name of Golden Florin.

My companions were Nancy Hayes and her brother, Billy, who 11 months earlier had bred Golden Florin to Kanumera, son of the great gray Dancer. As a 3-year-old, Native Dancer won every race he ran except the Kentucky Derby. Billy, 21, and Nancy, 17, had a luckier ancestor: T. P. Hayes won the Derby in 1913 with a bay colt named Donerail, a 91-to-1 long shot. "That," said Nancy, "is just about the greatest dream a Kentuckian can have come true."

While the foal dreamed in her dam, we talked of the good life Billy and Nancy have led. Their parents, Bill and Jane Hayes, make a business of caring for other people's Thoroughbreds—midwifing foals, transporting

mares to breeding sheds and colts to Kentucky racetracks, nursing horses back to health after surgery or other treatment in a modern hospital the Hayes Haven Farm leases to a team of veterinarians.

Billy and Nancy have been helping their father in the maternity stalls since early childhood, and for both of them the experience is magical. "To me," said Billy, "watching a foal come into the world is just the most splendid sight the Lord has ever let me see."

In the marches of the morning I joined Billy in silent praise of the miracle of life. Golden Florin at last lay down and went into labor. Billy and Nancy, their young faces alight with sympathy and their hands quick with skill, knelt beside the mare, murmuring encouragement and giving gentle assistance. After a few painful moments the foal dived out of her long sleep, and into the life of speed and racing silks to which she had been bred.

Billy Hayes's love for horses and his bright optimism about them are as natural in a boy from the Bluegrass whose ancestor won the Derby with a long shot as are beauty and





Dreaming of the starter's bell, a pony boy leads a

fleetness in a Thoroughbred. The true Bluegrass—rolling countryside lovely in its fertility and resonant in its history, extending thirty miles or so in all directions from Lexington in central Kentucky (maps, page 642)—is noted for many things, such as bourbon whiskey, burley tobacco, noble architecture, and some of the most melodious English spoken on the planet. But it is famous, above all places in America, for blooded horses.

It is the bloodline of the Thoroughbred that

ties time together in the Bluegrass. Thoroughbreds punctuate the present—fortune on the hoof, hope on the wing, art on the gallop—behind white fences that flow like bridal lace to the horizons. The ancestors of this great-hearted breed carried the first settlers across the Alleghenies while the American Revolution blazed at their backs, and generations of Thoroughbreds have borne matching generations of Kentuckians into battle, into fame—and sometimes into penury—ever since.



stiff-stepping Thoroughbred through early-morning fog at Keeneland Race Course.

A stranger standing beside me at the rail of Lexington's lovely green Keeneland Race Course spoke a single sentence that captured the kinship between horse and man in the Bluegrass. It was just after dawn, and we were watching an exercise boy, joyously erect in the stirrups, as he breezed a fine Derby prospect called *Our Native*. In the silence of the sunburnt morning we could hear the rhythmic thud of the colt's hooves on the breast of the earth. My neighbor, white-haired,

kept his eyes fixed on the flying horse as he spoke. "Sounds like a man's heartbeat, don't it?" he said.

The heartbeat of the Bluegrass is never stronger than in the springtime weeks before the Kentucky Derby, and this was the time I chose for my visit. Foals were being born, mares were being bred, and the first warmth of the year was raising sweat on the flanks of the 3-year-olds who would carry the Bluegrass legend into the very center of

excitement on the first Saturday in May, at Churchill Downs in Louisville.

A special kind of electricity surrounded the 99th running of the Kentucky Derby in 1973, and a horseman named Tom Harbut told me why. I found Mr. Harbut running a curry-comb over about a million dollars' worth of horseflesh. He handles stallions at Lexington's Spendthrift Farm, where Nashua, Majestic Prince, Gallant Man, and other champions stand at stud. His father, the late Will Harbut, took care of Man o' War, and he was, like his son, a groom with the gift of poetry.

"My daddy was the one who called Man o' War 'the mostest horse,' and he was *right*," said Tom Harbut. "But that don't mean there won't be another Man o' War someday. That great blood just goes on pumpin' till it has to come together in one superhorse. Happens once in a lifetime, but it can happen any morning. That's what everyone is waiting for, and hoping for, all the time."

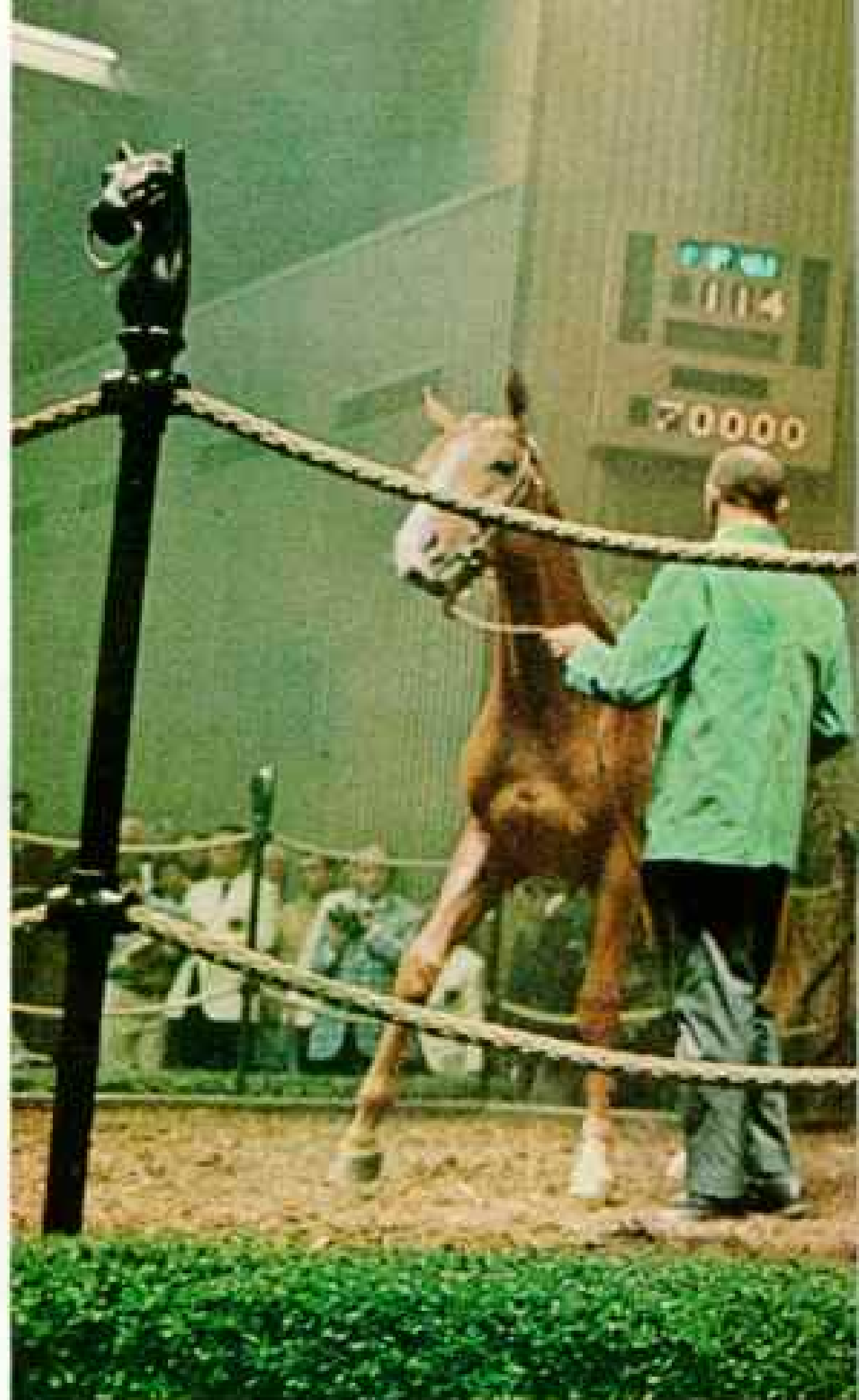
What? A Superhorse From Virginia?

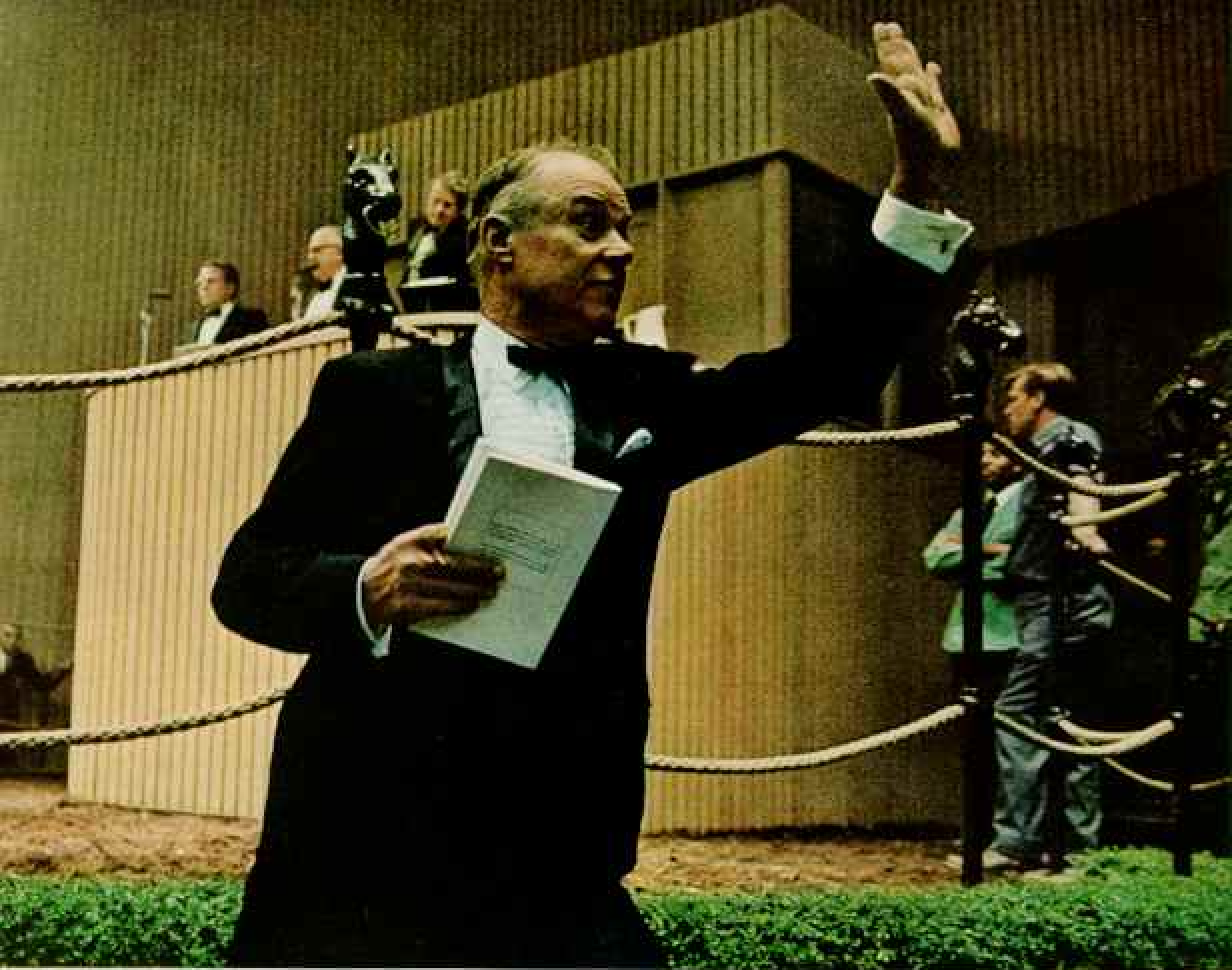
The Derby still lay in the future, but Tom Harbut, like most people in the racing world, had more than a suspicion that the long wait for a superhorse was over. At The Meadow farm in Virginia, the handlers of Secretariat were calling that magnificent chestnut colt by one of Man o' War's old nicknames—"Big Red." In *Virginia*—that was the rub!

I asked another Spendthrift groom, Clem Brooks, if it didn't sting that Secretariat—his breeding rights already sold to a syndicate of investors for \$6,080,000, or more than his weight in gold—should be the universal favorite to become the first winner of the Triple Crown (the Derby, the Preakness, and the Belmont Stakes) since Citation in 1948.

Mr. Brooks chuckled. "Secretariat may have grown up in Virginia, but his daddy is Bold Ruler of the Bluegrass," he said. "If that Virginia horse wins the Triple Crown, he'll be a Bluegrass horse by the first day of summer. *All* the great ones belong to Kentucky—we keep 'em going on forever down here, talking about 'em and talking about 'em until even we forget they didn't grow up chewing on bluegrass and drinking Bluegrass water."

And, indeed, after he had won the Triple Crown, Secretariat came to the Bluegrass to stand at stud at Claiborne Farm in Paris, where Bold Ruler begat him in the spring of 1969 from a mare named Somethingroyal.





BILL LUSTER (ABOVE) AND BECKWY

Pulses quicken as the bidding nears six figures at the Keeneland Summer Yearling Sale (above). Hoping to find another Citation (lower left)—first Thoroughbred to win a million dollars on the track—buyers from around the world throng the auction. Prices for pedigreed youngsters at Keeneland have run as high as

\$600,000, though the spirited colts and fillies have yet to sniff a starting gate.

Horse breeder Leslie Combs II of Spendthrift Farm (below center) watches the bidding on a smooth-muscled specimen as auctioneer George Swinebroad prepares to rap his gavel to close the yearling's sale (below).





Keen noses and tireless feet spell danger for foxes as the pack of the Iroquois Hunt searches for a fresh trail. Ever since James Harrod and Daniel Boone opened Kentucky's Great Meadow to settlers in the 1770's, the Bluegrass has been home to the hunter. Shawnees from north of the Ohio fought the Europeans' encroachment on their ancestral lands, but could not halt the flow of immigrants through the Cumberland Gap.

If he isn't careful, a traveler in the Bluegrass can spend all his time talking about Thoroughbreds. I would have been content to do so, but other matters stirred my curiosity. First things first: Is the bluegrass blue?

On this point I consulted W. Fauntleroy Pursley, squire of Cool Spring Farm near Winchester. "There's a week or so, when the grass is in bloom, when you can see a definite bluishness at twilight or in the very early morning," Mr. Pursley assured me. "Of course, those of us born in this part of Kentucky, and our fathers and grandfathers in front of us,



are a little more sensitive to that particular color than a stranger might be."

No Kentuckian will volunteer the information that there are bluegrass regions in Missouri, Virginia, Pennsylvania, and Tennessee as large as the one around Lexington. And if you want to discuss the theory that Kentucky bluegrass (*Poa pratensis*) is a European plant that grew in North America by accident after it was imported as padding for pottery used in the Indian trade, it's well to do so north of the Ohio River.

Whatever its botanical history, bluegrass is

the reason for Kentucky's civilization and the explanation for its fame. Through the long epoch of British rule in America, and for a generation afterward, Kentucky formed the western rump of the wilderness granted to Virginia under the royal charter of 1609. By 1729 hunters had visited the perilous eastern forests that became known as the Dark and Bloody Ground.

But it wasn't until later in the 18th century that explorers touched off a land rush with tales of the Great Meadow, a vast, grassy plain, teeming with buffalo and deer, pierced

by the virgin waters of Elkhorn Creek and the Kentucky and Licking Rivers.

The Great Meadow was a husbandman's paradise. The rich land was open from horizon to horizon, summers were long, winters were short but sharp enough to quicken the instincts of man and beast. The waters, rising from formations of limestone that underlie the region, were unlimited and pure, filled with minerals to build the light, strong bones needed by fast horses and reckless riders.

While the nation was still a-borning, Kentuckians were driving cattle and sheep and hogs to market through the Cumberland Gap, fattening the livestock along the way on lush wild grass. By 1830 a New England traveler named Timothy Flint reported on the abundance of the new lands and the self-confidence of its farmers. "Kentucky planters assert," he wrote, "that whatever article old Kentucky turns her chief attention to raising is sure to glut the market for that year."

The Kentuckian's attachment to the land

has hardly lessened with the turn of the centuries. Ira Massie, a tobacco specialist at the University of Kentucky in Lexington, told me of a Bluegrass farmer who was visited by a rich buyer from New York. "I'll write you a check for a million dollars if you'll walk off this land," said the Yankee.

"What in the world would I do with a million dollars?" rejoined the farmer—and stayed put. He is one of 137,819 tobacco farmers who grew 345 million dollars' worth of tobacco in 1972—a third of all Kentucky farm income.

Urban Expansion Threatens Farmland

If the land abides, the world changes. A hearty Kentuckian named Vic Jennings, master of 2,230 acres of fertile tobacco land and grazing country, gave me a capsule view of the farmer's present condition: "It's a good life, but it used to be better." Vic Jennings never thought he'd do anything except take over the farm from his father, as he did twenty years ago. Now he sees the growing city of Georgetown reaching toward his fields, and sometimes wonders if his son Dudley, 21, will have any land left to work.

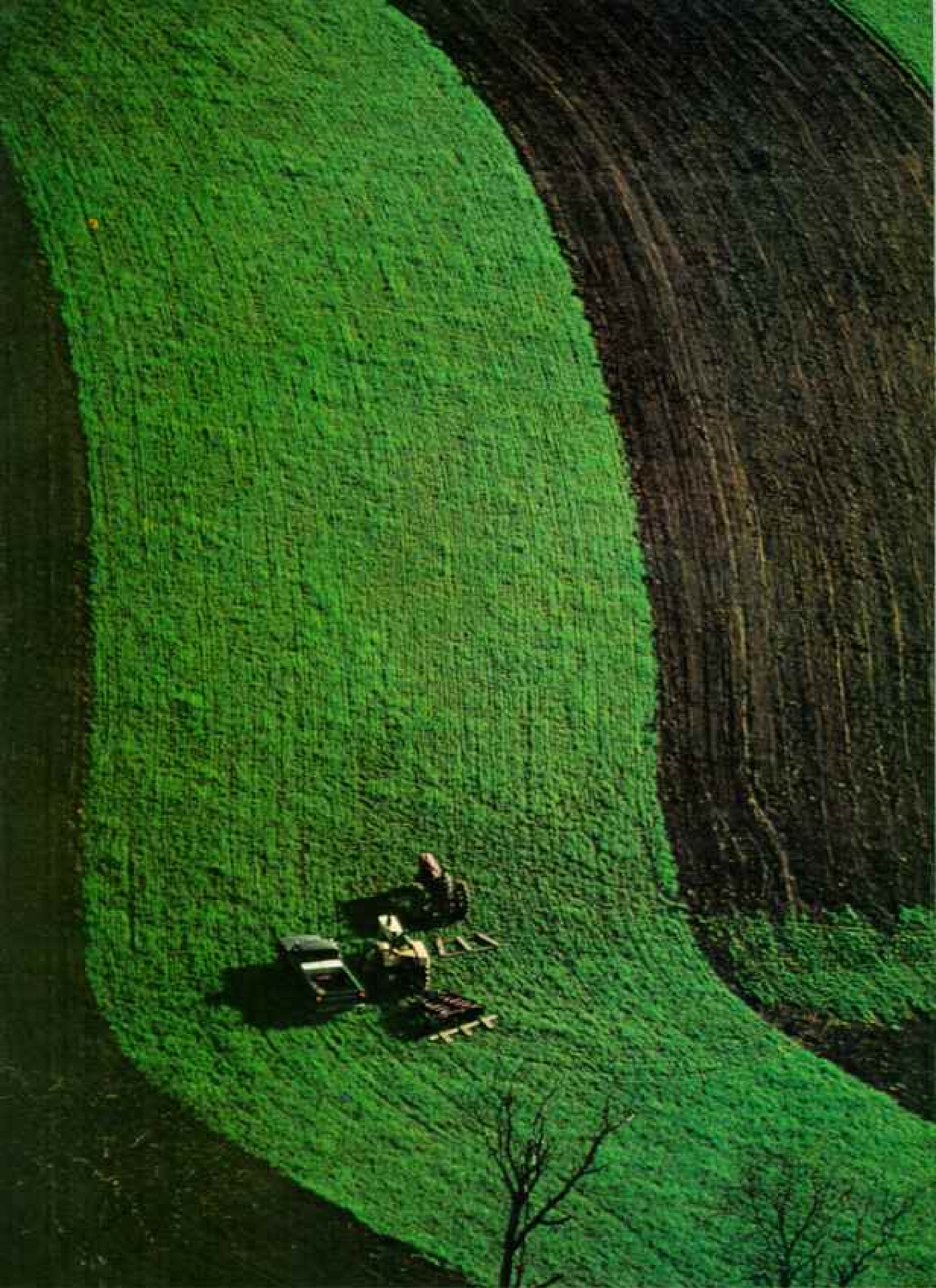
Mr. Jennings is an ardent collector of antiques. He led me through his house, laying an affectionate hand on the polished flanks of an oaken rolltop desk, a walnut cupboard, a cherry sideboard, a pie safe with sides of fancifully worked tin. He has a fine collection of tea-leaf-pattern china, another of mellow pewter, another of stone whiskey jugs. "I roam the auctions, and I'm proud that every one of these things was a bargain," he told me. "But it's not the trading that means something, it's the owning—a lot of old-time hands have handled these things, and that's why they're beautiful to me." *(Continued on page 647)*



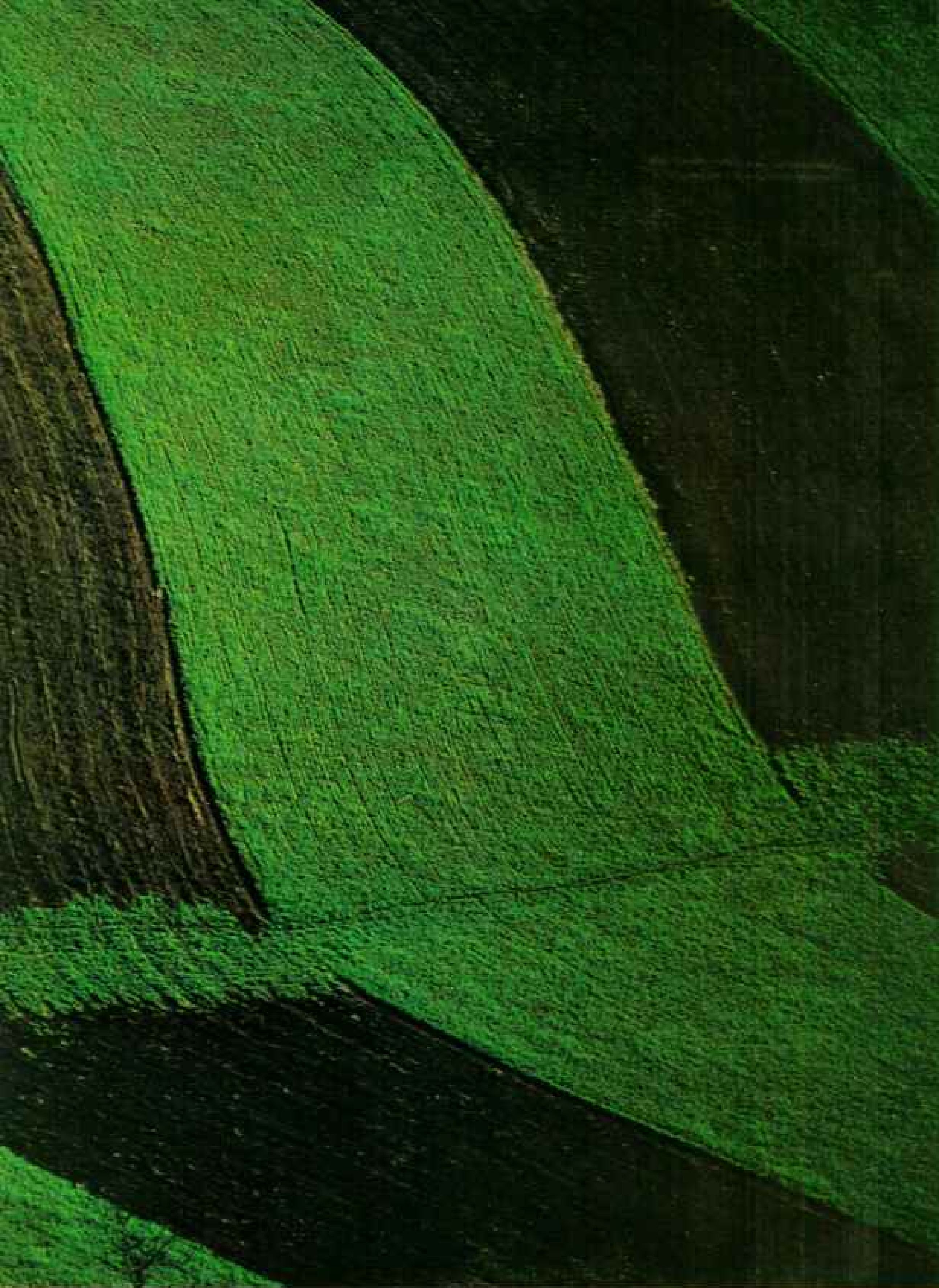
Like a bud in springtime, the Bluegrass unfolds its green fields in Kentucky's heartland (upper map). Spring waters seeping through beds of limestone sweeten the lush meadow grass that gives the region its name.

Upholding pillars of tradition, Sarah Buckner smiles from the columned portico of Rose Hill (right), her antebellum home in Lexington. Long the center of Bluegrass society and commerce, Lexington lies amid a galaxy of famous horse farms (lower map).

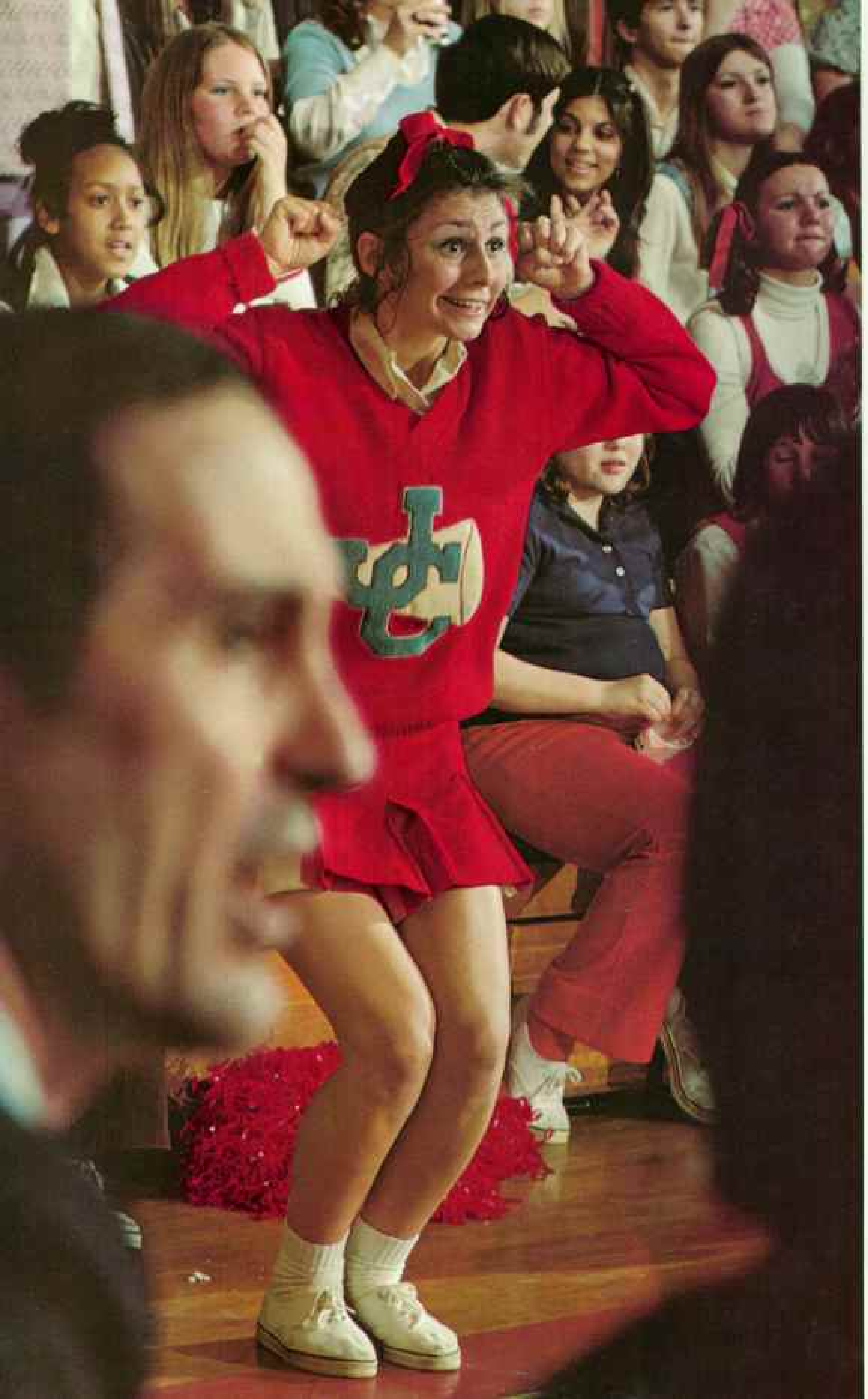




An earthen flag unfurled in the evening breeze, strip-plowed soil and



early-spring grass stream across a tobacco farmer's hillside.



Fauntleroy Pursley, who keeps 600 head of cattle and a lot of hogs, and grows tobacco as well on his six farms in Clark and Fayette Counties, implied that the land has other uses than making a living. He is joint master of the Iroquois Hunt (pages 640-41), and if he is a farmer by profession, he is a fox hunter by vocation. The hunt, first formed in 1881, was disbanded in 1912, but reincarnated in 1926. Ever since, Mr. Pursley has been galloping after the fox through upland fields and brambly coverts around his homestead. "When Daniel Boone first saw this country, he knew it was heaven for the hunter," Mr. Pursley told me, "and every time I hear a hound give voice, I leap to agree."

In this hunter's heaven the first permanent settlement was established 200 years ago by a Pennsylvanian named James Harrod; his rude log fort has been reconstructed in modern Harrodsburg. But Daniel Boone,

whose Boonesboro rose on the Kentucky River a year after Fort Harrod, was the first to build a myth. Naturally, it is Boone who lives in the hearts of Kentuckians; his life is regarded as the resolute model and the starting point of their destiny.

Dulcimer Strings Tie Past to Present

Boone's was the last ghost I expected to disturb when I knocked one rainy afternoon on the door of Boot Hill Farm—even though the place stands on the banks of Boone Creek. The door was opened by John Jacob Niles, the craftsman who had covered it from sill to lintel with a carved paean to his "gallant ancestors" and their balladry. Mr. Niles—"John Jacob" to all in the Bluegrass—was on the eve of his 81st birthday, and making no concession to the turn of the clock. Wearing a red tam-o'-shanter, chipper as a cricket, he informed me he was writing his autobiography and had filled more than 200 typewritten pages recounting his adventures up to the year 1907.

Mr. Niles is a famed folk singer and scholar of Anglo-American balladry (page 635). "When I first started collecting songs as a boy, my father told me I might take the music as far as Cincinnati," he said. "Well, I've sung the mountain songs, and played them on instruments I made myself, up and down the world, and I'm still doing it!" He darted from piano to dulcimer, singing in a supple tenor the ancient songs—"Barbara Allen," "Black Is the Color of My True Love's Hair," and others—that he rediscovered or composed and made famous.

I asked Mr. Niles how long his family had been in Kentucky. He struck a subtle chord on his dulcimer and replied: "I'll tell you how long the Nileses have been in Kentucky. A man named John Niles crossed the Alleghenies in the fresh tracks of Daniel Boone. He was confronted by an Indian brave on the edge of the great Bluegrass hunting ground. John raised his flintlock rifle, fired—and took



Eyes wide as basketball hoops, a frenzied cheerleader for Jessamine County High School (left) urges her team to another goal. Next to horse racing, basketball is the hottest sporting and social pastime in the Bluegrass, attracting thousands of spectators to high-school games and giving small towns a shot at stardom. In Harrodsburg the local team takes on Burgin under the bright lights (above).

Pristine elegance of Calumet Farm gleams in lazy summer sunlight (following pages); 23 miles of white fencing lace 850 acres of manicured pasture. Calumet's red-and-blue racing silks have captured the purse at the Kentucky Derby eight times, twice as often as any other stable has.







"We live on God's time around here," says 85-year-old tobacco farmer G. M. Watts, who disdains to set his watch by daylight saving time.

the Indian's arrow in his heart at the exact same instant. The two of them are buried in the same grave down around Harrodsburg. At least this is the legend I've always heard in my family."

In Woodford County, west of Lexington, where the Kentucky River elbows its way past limestone battlements and regiments of chestnuts, I called on a couple of Mr. Niles's contemporaries—G. M. Watts, 85 (left), and his 83-year-old brother, Bird. They live at the end of a grassy lane in a log house built by their grandfather in 1830 or thereabouts. They raise tobacco and a little corn, and sometimes drop a line into the cocoa depths of the river for channel catfish.

"I did some right smart fishing when I was a boy," said Bird Watts. "Catfish, big buffalo fish—all white, they were, and would go 35 to 40 pounds. But I haven't got the spare time I had back then."

The family has always owned the log house. "I guess maybe some of 'em sat right here and worried about the Shawnee," said G. M. Watts. Neither brother knows much about their forebears, though the family reaches back to pioneer times in only three long-lived generations. Those early Wattses moved in from Virginia. Some settled in Kentucky; others moved on west. "A lot of the family history got lost," Bird explained.

Kentucky, 15th state of the Union and first beyond the Alleghenies, was the place where the idea of the West began. But it was also the place where the cavalier culture of Virginia was transplanted and refined. The younger sons of patrician Virginia families, precluded from inheriting land by laws that settled a father's property on his eldest son, lost no time in reproducing the manor houses of their native state in the Bluegrass.

I had the good luck to be guided through some of these great houses by Richard and Patricia DeCamp of Lexington. Dick is executive director of the Bluegrass Trust for Historic Preservation, and Patricia is an enthusiastic partner in her husband's lifework of preserving the region's architectural treasure. I met the DeCamps on a Saturday morning in the flowering courtyard of the Hunt-Morgan House, ancestral home of the family that produced Gen. John Hunt Morgan, the heroic Confederate cavalry raider, and his nephew, Thomas Hunt Morgan, winner of a Nobel Prize in 1933 for his discoveries in genetics.

The Hunt-Morgan House, like many other historic houses in Lexington, faces Gratz Park, a jewel box with the stately buildings of Transylvania University at one end and the mellow houses of the old aristocracy sewn along its gray sidewalks like badges of rank on the tunic of one of Lee's lieutenants.

Unwelcome Glory at Welcome Hall

We drove into the country, where the De-Camps introduced me to Mrs. Louise Graddy, owner of Welcome Hall, in Woodford County near Versailles. Mrs. Graddy showed us the flawless dimensions of the old limestone house, and from its windows we glimpsed the gardens for which she is envied and admired.

"Welcome Hall was begun in the 1790's, before Kentucky was a state," said Mrs. Graddy, "and it has been a perfect home for many generations of our family—well, *almost* perfect. There's an old southern porch that shouldn't be there, but in 1828 there was a bride, and brides always like to glorify things!"

We stopped on the way back to Lexington at Hurricane Hall, so named at the end of the 18th century because it was inhabited by a family with many rambunctious children. Mrs. Stanley D. Petter, Jr., who lives in this splendid Federal house with her husband and their children, winced at the clatter of young feet on the grand staircase and allowed that the house was still earning its name.

Later in the day, spellbound by her stories, I followed Mrs. Sarah Buckner, widow of a relative of Confederate Gen. Simon Bolivar Buckner, through a delightful array of family keepsakes. Mrs. Buckner is mistress of Rose Hill (page 643), a great white mansion on Lexington's North Limestone Street, and though she lives there alone, her words filled the empty rooms with the dancing couples of her youth. Mrs. Buckner showed me musical instruments and faded fans, medals for valor and portraits of beautiful brides in beautiful gowns.

Fresh-killed Shroat and Burgoo, Too

John Hunt Morgan, who would have saddled a cannonball and kept his hat on, would have enjoyed the eighth annual race meeting of the High Hope Steeplechase, held at a farm near Versailles on the Sunday before the Derby. This day of amateur racing may be unmatched outside Afghanistan for the bravado of its horsemanship. Before the meet I encountered almost everyone I'd met in the

Bluegrass, and most of them put a mint julep or a piece of fried chicken in my hand.

The cuisine of the Bluegrass is, on the whole, nobler than the deep-fried drumstick. Mrs. Fauntleroy Pursley, famous among friends as a cook, gave me leg of fresh-killed shroat, sweet-potato fritters, and a dessert composed of lemon and a springtime zephyr during an evening at Cool Spring Farm that is as memorable for the Pursleys' hospitality as it is for Mrs. Pursley's culinary genius.

At Keeneland Race Course, and in many other places, I encountered the state dish, Kentucky burgoo, a stew made from chicken, beef, veal, onions, celery, parsley, carrots, turnips, tomatoes, okra, potatoes, cabbage, butter, black pepper, corn, and claret. Keeneland's clubhouse waiter assured me that burgoo "has got to be made for a hundred folks—and et by maybe twenty-five."

As to the mint julep, it is made with fresh mint, crushed ice, carefully dissolved sugar, and bourbon. The julep is absorbed, rather than drunk, from a foggy silver cup.

Bad Day at the Brush Jump

I had not been long at the High Hope Steeplechase before I came across Fauntleroy Pursley. He offered me a julep and put me into the care of his blond daughter, Mrs. Joan Mayer. We bounced over the infield in Mrs. Mayer's pickup truck, and took up our station near a murderous brush jump on the far turn of the two-mile course, where National Geographic's Bruce Baumann unlimbered his cameras. The six races that followed were a photographer's dream, and an orthopedist's nightmare.

On the first lap of the second race, six horses hit the jump like a volley of artillery shells. My widened eye registered a bay mare performing a lazy somersault in the noontime brilliance, with her rider—a slim youth in blue silks, his long blond hair blown by the wind of his fall—flying before her with the reins still gripped in his hands. Two more horses fell, sending their jockeys through the air like jackstraws. The bay mare landed on her back and skidded over the grass, all four hooves in the air, as the surviving horses landed all around her at an unbroken gallop. The blond rider uttered a loud "oof!" as a hoof daggered his ribs. The horses larruped on toward the shrieks of the crowd, half a mile away in the grandstand.

Bruce and I helped Joan Mayer repair the

broken jump while the blond rider walked around in a tight circle, clutching his bruises and cursing his luck. On the second lap two more horses fell, and the race finished with more empty saddles than full ones.

I spent a quieter day shortly afterward watching clay take shape under the sure hands of a Kentucky potter named Walter Cornelison. He is the owner and chief artisan of the Bybee Pottery, a long, low building in the tiny town of Bybee that has been tinted by many weathers to the hue of a clay pot.

I found Mr. Cornelison at his wheel, with the light from a smeared window falling on a lump of Kentucky clay. As we chatted, the clay spun and rose, and was transformed by his intelligent fingers into a tall and graceful pitcher.

"The deeds go back to 1809, the year Lincoln was born," he told me. "Just how old the pottery might be nobody knows—but I had a distant aunt who stood in the road outside and listened to the guns at the skirmish near Bighill in the Civil War, and these buildings were here then."

Clay Still Mystifies Longtime Potter

Mr. Cornelison was born 44 years ago within sight of the pottery, and has never left it; one of his sons plans to be a potter after college. Mr. Cornelison forestalled my question about the mystery of an occupation that has drawn five generations of his family to the potter's wheel. He lifted another perfect pitcher, smiled at its proportions, and remarked, "Even after all these years I wonder how it is that the clay takes shape."

Three 19th-century idealists—abolitionist Cassius M. Clay, minister John G. Fee, and educator J. A. R. Rogers—built a wheel to shape more precious clay in the town of Berea, which lies at the southern limit of the Bluegrass, within eyeshot of the Cumberland Mountains. In 1855 they founded Berea College "to promote the cause of Christ . . . under an influence . . . opposed to sectarianism, slaveholding, caste, and every other wrong institution or practice."

The idea was to provide tuition-free higher education for the youth of Appalachia, their living expenses to be met by a college-labor program. This idea still lives, as I discovered when I explored Berea's campus—trees, lawns, and mellow buildings all ashine in a spring rain—with Nora Lee Anglin, a sophomore who is earning her way to a degree



"Your move." Relaxing from the chores of running their farm, Silas and Hannah Stokes plot strategies in a game of checkers. Rising costs and urban growth have driven some small Kentucky farmers from the market, but the state's tobacco industry still centers on the Bluegrass. Annual production amounts to some 300 million pounds, second only to that of North Carolina.

Busy as bees, women and children ride a roofed wagon through the fields, cross-pollinating burley tobacco plants to produce hybrid seed (right). Careful cross-pollination will result in plants with uniform growth and disease-resistant characteristics. An ounce of the hybrid seed sells for \$48.



by acting as a student guide for visitors.

Nora Lee explained that 80 percent of Berea's 1,400 students are drawn from 230 counties in eight states of Appalachia. Each student works to help pay for such things as room, board, books, and laboratory fees. All must demonstrate financial need to be admitted, but Nora Lee drew an important distinction: "We may not have money, but we're not poor."

Indeed they're not. Nora Lee showed me workshops in which students, preserving the old-time crafts of the mountain folk, build furniture, weave cloth, make bread and many of the other things the college needs to carry on its daily life and its lively commerce in handicraft items. Nowhere on campus did I see an idle hand or an angry gesture.

"I feel that I'm going to be of some use in the world as a result of what I learn here," said Nora Lee. And I thought that the founders could hardly have hoped for a better message to come to them across the long years of their college's devotion to individual fortitude and Christian works.

Bourbon Invented by an Evangelist?

Not much nonpluses a Kentuckian, and it's taken in stride that a Baptist preacher should get the credit for first distilling bourbon whiskey. The pure limestone water of the Bluegrass is ideally suited to the making of spirits—each bottle of 100-proof bourbon is 50 percent water. In 1789, the year of Washington's inauguration, a frontier evangelist named Elijah Craig produced the first bourbon—fermented corn, barley malt, and rye, aged in a charred white-oak barrel—in the Bluegrass hamlet of Georgetown. His convivial invention has warmed the bones and enlivened the tongues of Kentuckians ever since.

Not that Kentuckians require bourbon or any other earthly agent to quicken their tongues. To hear an ordinary conversation in the Bluegrass is to believe oneself present at the rebirth of the English language, though it takes a while for a dull Yankee ear like mine to sort out the music and the sense in the local accent. Patricia DeCamp, after I'd asked her three times to repeat a sentence, advised me not to be embarrassed by my slowness. "Why, when I first went up to Vassar," she said, "I had to spell the numbers to the operator when I called home!"

At the Star Hill Distillery in Loretto, where the Samuels family distills a fine bourbon



called Maker's Mark, I ran into a young fellow who was ready to challenge the credentials of the Reverend Elijah Craig. "One of my ancestors, Robert Samuels, made whiskey in Kentucky in the 1770's, and in the family we believe he was the first to do it," said Taylor William Samuels, Jr. "The first Samuels to make bourbon *legally* was my great-great-grandfather, in 1840." Bill, Jr., (his father is president of the firm) showed me around the distillery, a group of timeworn buildings lying in a cup of bluegrass below a sparkling ten-acre lake that is the first secret of the gentle taste of the Samuels's whiskey.

The Samuels family concentrates on quality, producing only 18 barrels of Maker's Mark a day—as compared to 300 daily for the average Kentucky distiller and 11,000 for



Cat's cradle of telephone wires hangs above the main street of downtown Winchester (above). Far from the glamour of horse farm and hunt club, small towns like Winchester fill on weekends with the cars and pickups of tobacco and livestock farmers, in for the week's shopping or an evening's entertainment.

Tattooed cue jockey sends the balls flying in a pool hall at Harrodsburg.





Charging toward history, last year's Triple Crown winner Secretariat (above, third from right) bursts late from the starting gate in the Kentucky Derby. His number, 1A, indicates that his trainer, Lucien Laurin, has another horse in the same race. Giant 25-foot strides help Secretariat make up the lost yardage. Virginia-born but Bluegrass-sired, he blazed over the $1\frac{1}{4}$ -mile course in 1 minute, $59\frac{2}{5}$ seconds—a new Derby record.

Putting her money where her mouth is, a sun-splashed blonde tries to register a bet with a friend (left). Crowding the stands and the infield, 134,476 people filled Churchill Downs for the 1973 Derby; they wagered more than three million dollars on the event.

Racing colors garb a hopeful bettor at Keeneland (right). Scratch sheet in hand, he watches the Thoroughbreds enter the track, seeking a clue to the horses' fortunes—and his own.



the state as a whole. "We can't get all our ingredients in Kentucky, the way we'd like to," said Bill, Jr. "But we do buy our corn and barley from regions in Indiana and Minnesota that have limestone soil. We're a little bit mystical about limestone."

The grain is crushed in a slow roller mill to eliminate heat and odor; it ferments in ancient cypress vats because that wood is absolutely neutral; and it is aged six years in white-oak barrels, their insides charred for precisely 38½ seconds.

"It's the char that gives bourbon its color and some of its taste," Bill, Jr., explained. "We measure everything in fractions of fractions. Wine makers let nature take its course and hope for improvement. Bourbon makers strive for perfection, and reproduce it year after year. You want it to be the same. You just wait for the right moment."

D-Day at Churchill Downs

At last, on the fifth of May, the "rightest" of all Kentucky moments arrived. Derby Day burned brilliant, as it always does in the imagination of Kentuckians. A white sun, wheeling across the cloudless blue sky, produced a dazzling scene that was all color.

My wife, Nancy, who had joined me for the great day, drew in her breath in wonder when we stepped through the gates of

Churchill Downs. "The plumage!" she cried.

Ladies with parasols, gentlemen in stripes and checks, girls with shining hair falling from beneath airy summer hats, and boys in the boisterous rags that are the uniform of their generation, all blended into a rainbow of enjoyment. Laughter and shouted greetings, the singsong of the touts and the music of a regiment of bands rolled like surf over the crowd.

The bowstring of luck had been pulled tight by the most unexpected of events: Secretariat, the unbeatable colt, had been beaten in the Wood Memorial, a traditional tune-up for Derby contenders. At the Aqueduct Race Track on Long Island, New York, the burnished Virginian had been left behind by an outsider named Angle Light and a strapping bay called Sham. The three horses would meet again in the Derby.

Until post time the piquant doubt about Secretariat persisted. The Derby is the ninth race in a ten-race card, and the long day had coasted into a valley of ennui by five o'clock. Then the massed bands lifted their brasses in the diagonal light of afternoon, and played "My Old Kentucky Home." The flame of excitement sprang up again, and the voices of the crowd swelled with the words of the sentimental old anthem.

"Ladies and gentlemen, the horses are on



Friendly nuzzle warms a chill morning for a groom at Keeneland (left). Women have taken over many chores in the formerly all-male province of paddock and stable, rising before dawn to feed and curry their charges and clean the stalls.

Keeping fast company, a beady-eyed rooster, friend and stablemate of Keeneland racehorses, waits for his companions to cool off after the morning's workout (right). High-strung Thoroughbreds often adopt mascots to share their quarters as they train for their next race—never far away in the Bluegrass, where field and pasture echo to the steady pulsebeat of horses' hooves.

the track!" First out of the paddock was Angle Light, who had won his footnote in racing history in the Wood Memorial. Next, No. 1A, came the crown prince: Secretariat, keeper of all the great blood of all his great ancestors back to the swift stallions—the Godolphin Arabian, the Byerley Turk, the Darley Arabian—brought out of the desert in the time of kings to cover robust mares of England and found his quicksilver breed.

The field—bay, brown, chestnut, gray—blended with the jockeys' silks (more vivid in the Derby, it seemed, than in any other race). But the heart of light in this living canvas was Secretariat; he drew every eye, commanded every voice in the colossal cheer that greeted his appearance.

Winner Wears Victory With Poise

The last tone of the traditional bugle call fell on a murmuring crowd. The horses burst from the gate, drove past the grandstand (pages 656-7). With binoculars, I saw Secretariat well back. Ron Turcotte, Secretariat's jockey, laid the blue-and-white silk of his blouse along his mount's neck and let his colt match the fast pace being set by the blazing speedster Shecky Greene.

On the last turn all horses save one seemed suddenly to slow down. Secretariat, touched mostly by the whip of his ancestry, moved

around a clump of colts, and, with a stride that devoured the hearts of his rivals, sprang into the lead. He flashed through the tunnel of hysteria between the grandstand and the tote board, finishing two and a half lengths ahead of Sham in a Derby record: 1 minute, 59⁷/₈ seconds. Angle Light was tenth—and Our Native, eight lengths behind Sham in third place, doubled my \$2 bet.

Secretariat, with the faintest of sweat stains under his saddle, accepted the blanket of red roses in the winner's circle. He was the calmest creature at Churchill Downs. I thought I saw him give the world a cool sidelong glance, somewhat like a gentleman who had reasserted the honor he knew never to have been in doubt.

That evening Nancy and I toasted the champion in champagne and, after a night eddying with music and joyful strangers, boarded an early-morning plane. The pilot dipped a wing and swung us eastward over the Bluegrass. By first light I saw the emerald fields, silvered with dew, seamed by fences, adorned by grand houses, and set to music by the dance of the Thoroughbreds and the stories Kentuckians tell about them.

I knew Billy Hayes would be awake and doing. I wondered if he was leaning on a paddock fence, watching his filly with the wind in her tail and his dreams on her back. □



A LADY FROM CHINA'S PAST

A NOBLEWOMAN'S
LAST DAY, 2100
YEARS AGO, SEEMS
TO DAWN AGAIN
WITH THE DISCOVERY
OF HER RICHLY
FURNISHED TOMB

well they succeeded only now has become known, and the details are so rich that events of the lady's last day seem to unroll before our eyes.

The 20th century came to know the Chinese matron two years ago. Her 65-foot-high burial mound lay in the path of a hospital project outside Ch'angsha, capital of Hunan Province.

Archeologists dug down, pried open heavy outer coffins, and were incredulous at what they found. Before them lay a fantastic treasure of silks, lacquer ware, wooden statuettes, musical instruments, and paintings—a stunning array of perishable domestic wares of the Han period.

Finally, in silent awe, they opened the innermost casket. There, after removing 20 layers of silk, they came face-to-face with the dead woman, remarkably free of decay. For the first time a complete human body from ancient times had been unearthed in China.

Scholars initially believed the occupant of the tomb near Ch'angsha was the wife of the first *Tai hou*, or Marquis of Tai, a title instituted by Emperor Hui in 193 B.C. Recently, however, some experts suggest that the woman was of even higher status



Photographs from CHINA PICTORIAL

Text by ALICE J. HALL

NATIONAL GEOGRAPHIC STAFF

ONE soft summer morning she rose early, donned a silk gown, and strolled about the gardens, moving slowly with the aid of a walking stick. She had more than a little reason for happiness. Surrounded by all the trappings of wealth, she also basked in the esteem granted to older women of her class.

A servant offered her fresh melon on a lacquer plate. She ate and rested. Then a kernel of fire in her chest expanded into massive pain. Unconsciousness enveloped her, and she died.

Her story sounds contemporary but it is not. The world on which the noblewoman closed her eyes was that of China early in the Han Dynasty, more than 2,100 years ago. Her mourners believed that her immortality hinged on how well they observed funeral rituals and preserved her mortal form, and they went to extraordinary lengths. How

NATIONAL GEOGRAPHIC expresses appreciation to *China Pictorial*, a leading magazine of the People's Republic, for generously opening its photographic files to us, thus making possible this most comprehensive picture presentation of the tomb excavation yet to appear in a Western magazine.

—THE EDITOR

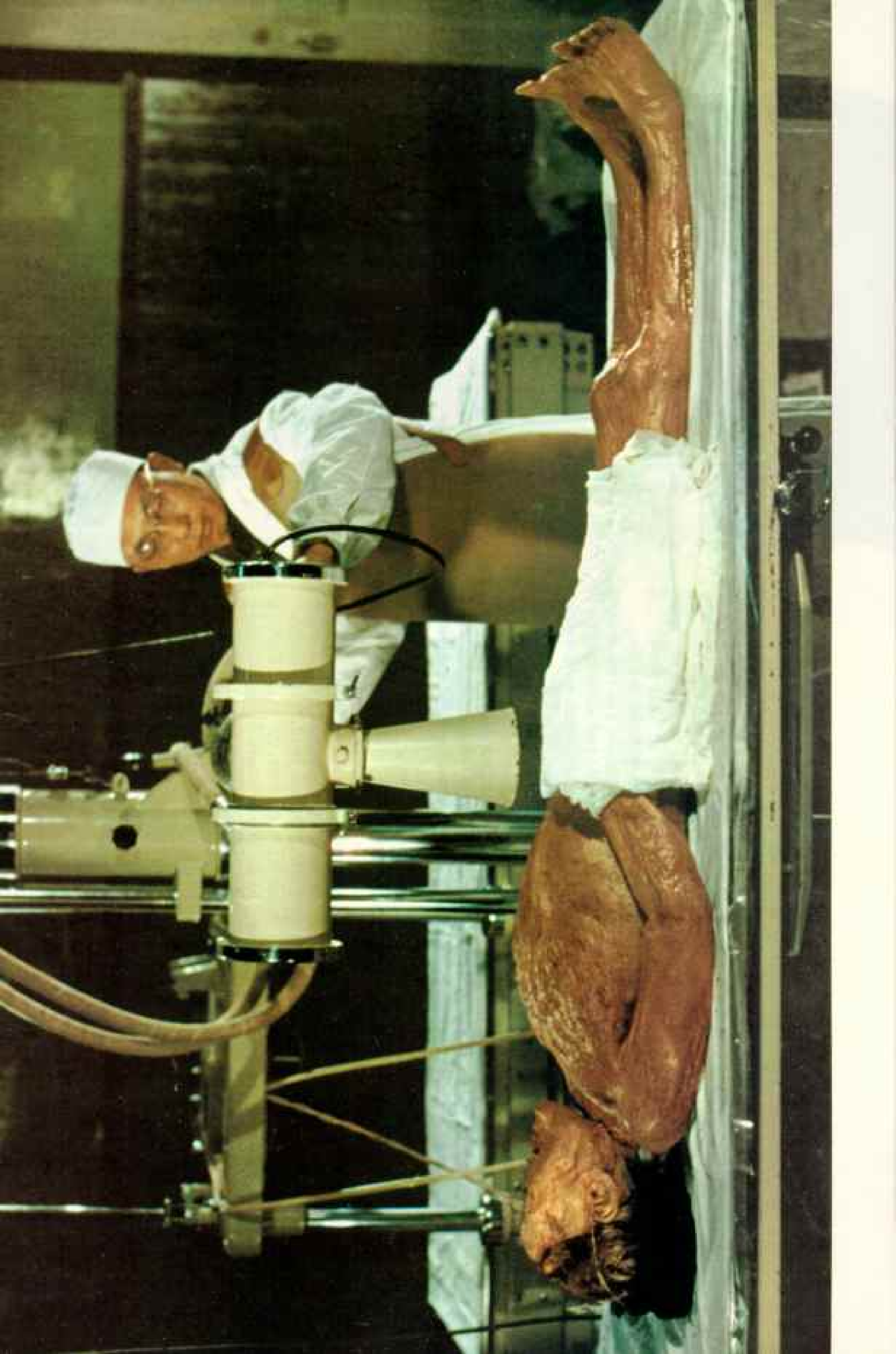
—Lady Ch'eng, a consort of Emperor Ching, who reigned from 156 to 141 B.C. Mother of three princes, Lady Ch'eng also figured in an intriguing story of substitution that appears in Han chronicles.

Once, when summoned to her lord's chamber, she sent her maid servant, Lady T'ang. The girl conceived and bore a son who became the prince of Ch'angsha. The two women remained friends and, according to a 1,000-year-old Chinese geography, both were buried near Ch'angsha.

Whoever the aristocratic woman was, she breathed the air of peace. During the second century B.C., Han emperors finally ended rebellions, and the unified nation entered a golden age. The Chinese could pause to take pride in their civilization, the most advanced in the Far East. They considered themselves "capable of honoring that which should be honored," in contrast to nomadic barbarians who gnawed at their borders. Following ancient teachings, they paid high honor to the family—both living and dead. And so the lady and her belongings were meticulously entombed according to the Chinese *Book of Rites*.

Ever in attendance, a carved wooden statue of a servant, 31 inches high, wears a silk costume little damaged by its 2,100-year interment.





A HOST OF ILLS, THEN A HEART ATTACK...

The exhumed body astonished scientists. The well-preserved skin was still elastic and the joints mobile; hair remained rooted when pulled. Cords around the head secured a hairpiece, which also survived in good condition.

To study the body, the government brought pathologists, anatomists, biochemists, and other medical specialists from all over China to Hunan Medical College. Their findings produced an amazingly

detailed biography. The lady was overweight, about 50 years old, had borne children, and possessed group A blood. She died suddenly, an hour or so after eating; 138 melon seeds (left) remained in the esophagus, stomach, and intestines.

Though death was quick, life may have been a trial. X-ray examination (above) showed tuberculosis scars, a poorly set fracture of her right forearm, as well as spinal problems that may have caused lumbago.

Internal organs contained gallstones and parasites: whipworms, pinworms, and schistosomes.

Most surprising, a severely occluded left coronary artery pointed to heart disease. "No doubt about it," says cardiologist Dr. Tsung O. Cheng, Professor of Medicine at George Washington University, who visited Hunan Medical College last year and studied the data. "My Chinese colleagues are correct; the lady died of a heart attack." The autopsy counters the notion that coronary

disease is a product of modern technological civilization.

Chinese doctors showed special interest in the packets of herbal medicines—cinnamon, magnolia bark, and peppercorns—found in the tomb. According to Han medical canons, these were prescribed for heart disease, just as they are by herb doctors in China today.

Chemists analyzed a reddish fluid that partly covered the body and some of the grave goods. It contained a mercurial compound and organic acids that could have retarded deterioration. Since the tomb had been made airtight, so that few decay-causing bacteria could live, many experts speculate that the lack of oxygen also aided the preservation.

Doctors treated the body with modern preservatives; it is now kept at Hunan Medical College. Motion pictures of the excavation and the autopsy are being shown in the United States.





HOW THE ANCIENT CHINESE BURIED A MATRON OF MEANS

More than 1,000 tombs have been found in the Ch'angsha area. Robbers plundered many of them in the 1930's and 1940's, and antique dealers sold the treasures throughout the world.

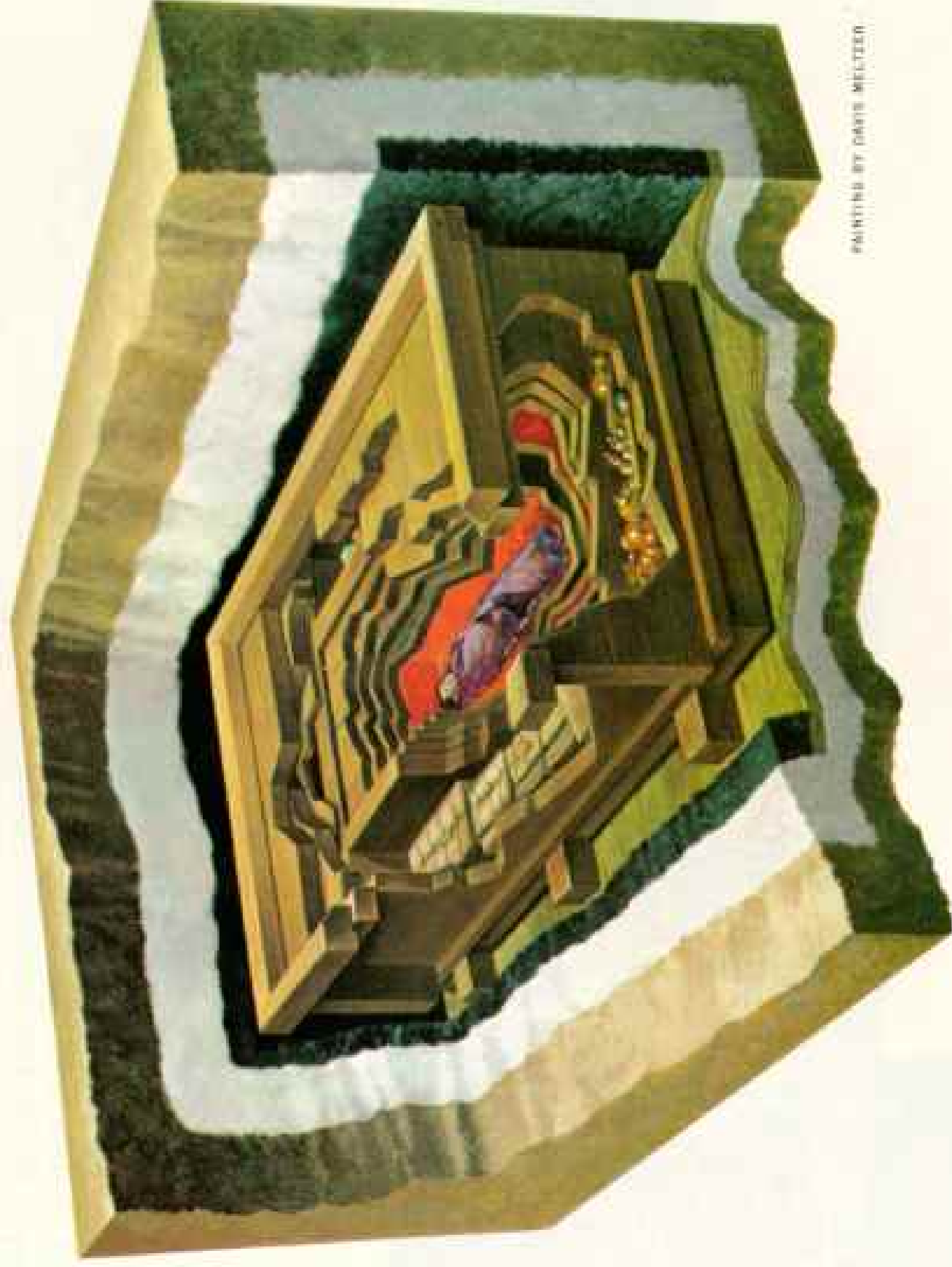
But no one tackled two immense companion mounds covered with trees, until modern construction threatened the easternmost burial site, traditionally the position of honor.

For four months archeologists carefully excavated a funnel-shaped pit. At the bottom, 52 feet down, on a carpet of 26 bamboo mats, stood a massive wooden box. Within, amid a trove of grave goods, rested a series of three

plain coffins and three ornate caskets. Covering the whole, five tons of charcoal absorbed any moisture that might permeate a

layer of white clay two to four feet thick.

Elsewhere in China, as the ancients sought to preserve and glorify mortal remains, they walled tomb entrances with iron and even enclosed bodies in jade suits. But nowhere have results been found that matched the Ch'angsha burial.



PAINTED BY DAVID MELTEEN

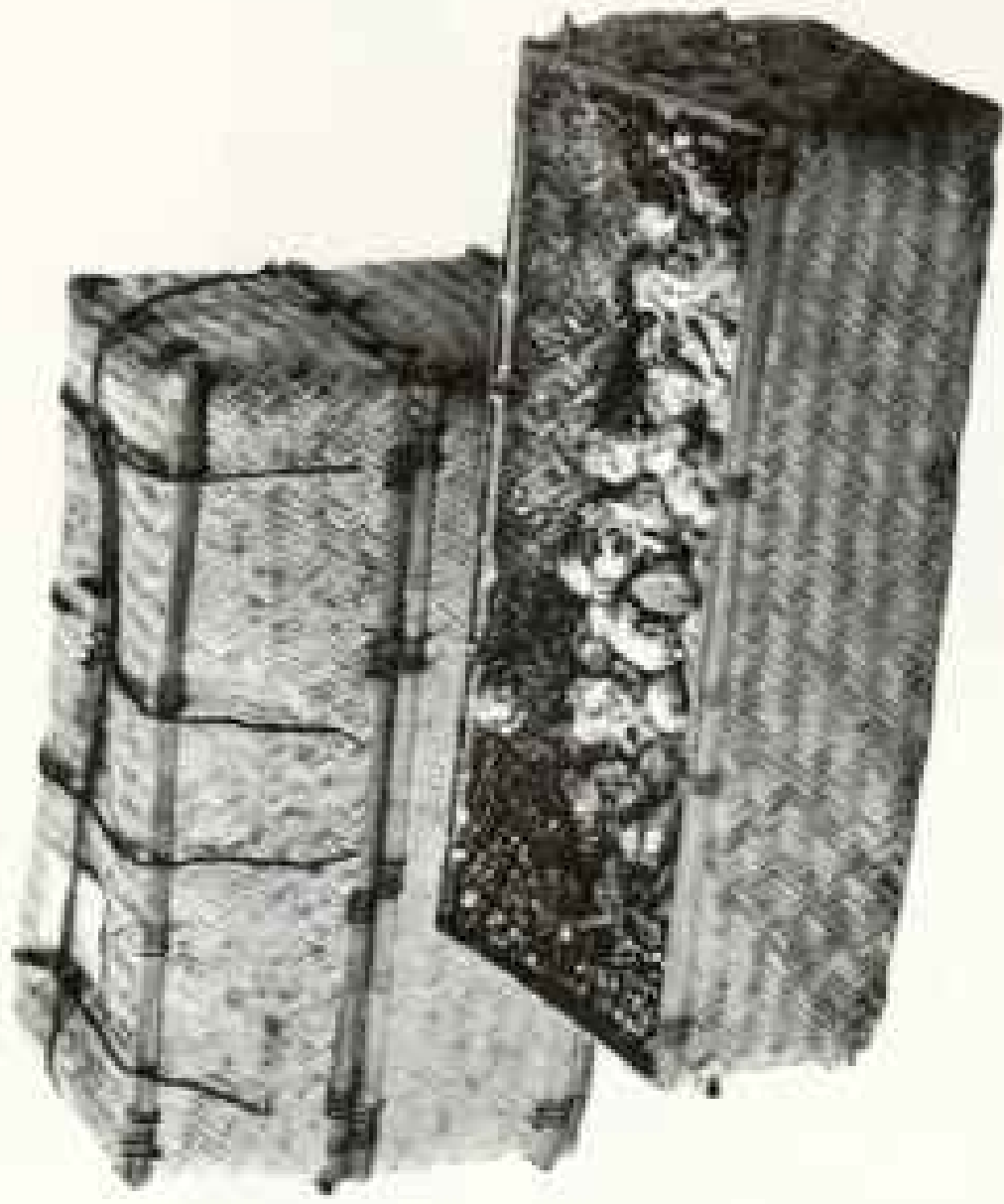


BOXES WITHIN BOXES: MORE WONDERS TO BEHOLD

Lavish decoration embellishes the three inner caskets. On the largest, 8½ feet long, upper left, painted swirls represent clouds, one of the oldest and most enduring of Chinese motifs. Amid the swirls gambol guardian figures—cranes, deer, and fantastic beasts on galloping horses.

Rearing unicorns, auspicious symbols, face each other on the end of the red-lacquered second casket.

Fine warp-patterned silk, appliquéd with real feathers, sheathes the top surface of the innermost casket. Within, neatly bundled in silk and tied from head to toe with nine silk cords, slept the great lady.



Bamboo cases, one containing the remains of 40 eggs (near left), bore clay seals that gave clues to the lady's identity. A seal inscribed "Majordomo of the Marquis of Tai" (far left), was at first thought to mean that the dead woman must be Lady Tai, but some experts later decided that it may merely identify the official in charge of the burial. The characters on another seal, interpreted as "Lady Hsin Chui," perhaps reveal the woman's given name.

To wait on the lady in death were 162 funeral statuettes of servants, a humane change from the custom of burying slain retainers. The smaller carvings wear painted clothes; several larger ones, in silk costumes, probably represented minor officials.

An inventory found in the burial made possible the positive identification of the grave goods. Known to the Chinese as a "Send-off Book," the compilation was written on 312 bamboo strips that were tied in bundles. Only a few objects itemized, such as 100 clay sheep, were not in the grave—perhaps because a laborer of 2,100 years ago was absentminded.





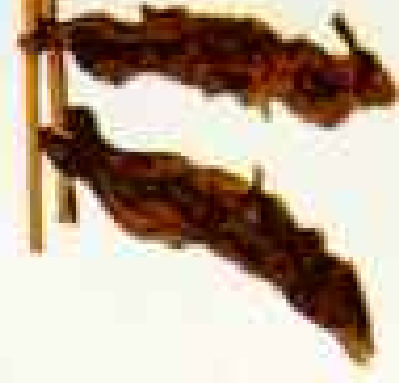
MUSIC TO GLADDEN THE WAY TO HEAVEN

Miniature musicians re-create a chamber ensemble that might have entertained the great lady during her lifetime. Three of the foot-high figures sit before zithers, while two companions play mouth organs.

Intact instruments (below) found in the tomb appear ready to sound a song. The 25 silk strings of the 46-inch-long zither arch over movable bridges and wind around four pegs. On the mouth organ,

22 bamboo pipes fit into a wooden mouthpiece with fingering holes. Both the mouth organ and zither are still played in the Orient.

Twelve bamboo pitch pipes lie beside their embroidered carrying case. Tradition says that 4,600 years ago an emperor sent his minister to the mountains to find a special bamboo that sounded a C note when cut into a nine-inch pipe. All other notes—and shorter pipes—derive mathematically from it.



COSMIC JOURNEY ON SILK

Acclaimed as the most valuable of the tomb's treasures, this *fei i*, or flying garment, weaves fantasy and reality to suggest the soul's ascension to heaven. The seven-foot banner was found atop the innermost casket.

Reading the design from the bottom, experts see first a netherworld of fantastic beasts. Entwining dragons slide past a jade circle symbolic of the sky and around red leopards. These guardians of heaven's gates flank a ramp leading to the most intriguing scene (**enlarged on the following pages**). Here stands the lady herself, most experts believe, in the earliest known portrait on silk. Bent with age and leaning on a walking stick, she leads handmaidens and receives servants' offerings of food.

Above her head, over the batlike wind god, a myth unfolds (**right**). On the left a legendary lady, Ch'ang O, who stole the elixir of immortality, flees to the moon on a dragon's wings (**enlargement, below**). To the right, a large sun with a crow calls to mind Ch'ang O's husband, who shot down false suns, leaving the only true one. The couple symbolize moon and sun; their story illustrates *yin* and *yang*, the principle of opposites that has long dominated Chinese philosophy.





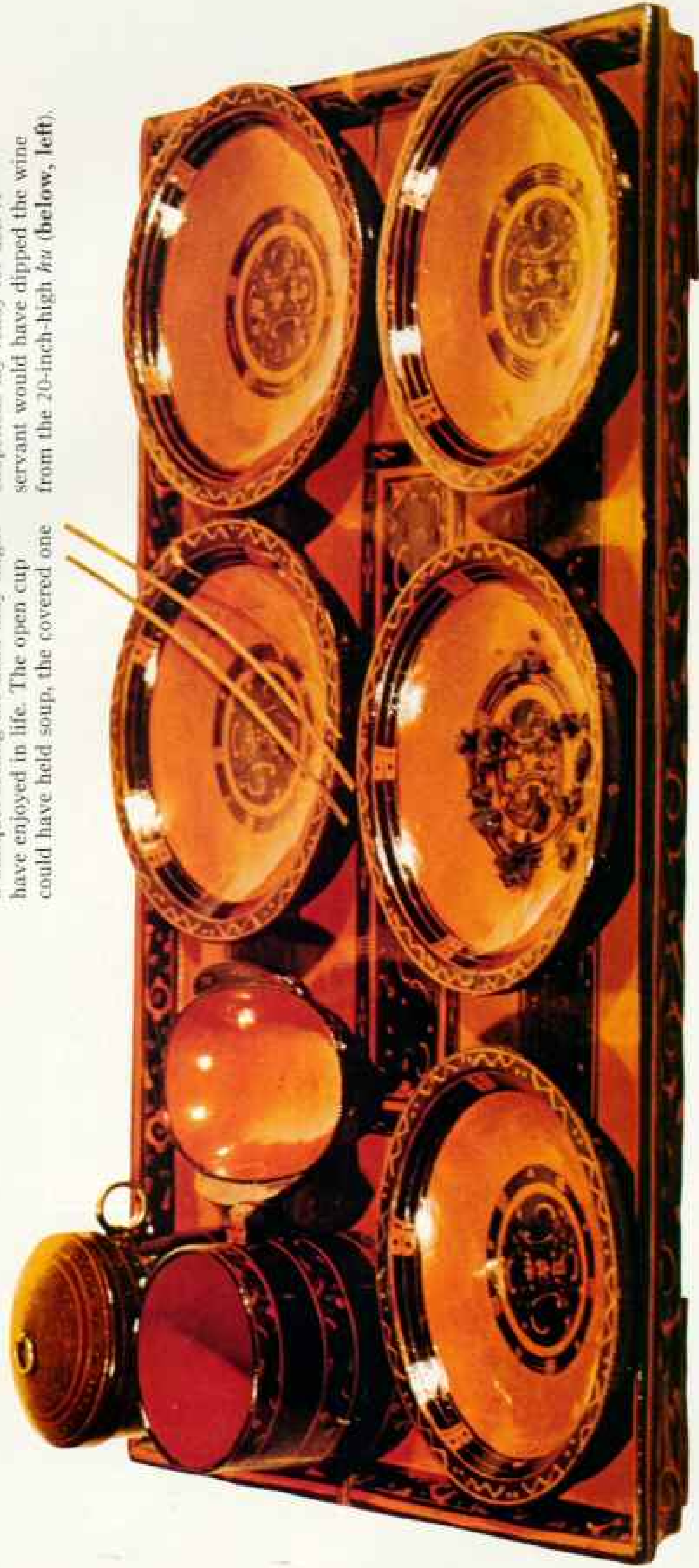




“SET OUT YOUR DISHES AND MEAT STANDS, DRINK WINE TO YOUR FILL”

So commanded a Chinese poet who lived long before the Han era. As if in response, a lustrous lacquer tray table was placed in the grave, duplicating a banquet setting the dead lady might have enjoyed in life. The open cup could have held soup, the covered one

a beverage, while the shallow wing-handled vessel offered wine. Some plates held 21-century-old morsels of chicken, spareribs, and fish; chopsticks lay ready for use. A servant would have dipped the wine from the 20-inch-high *hu* (below, left).

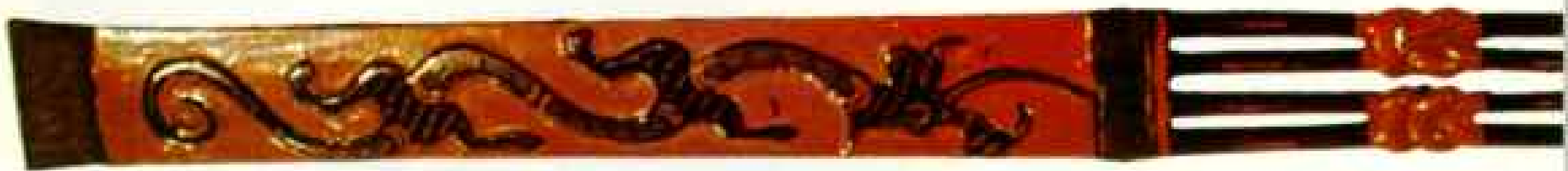




In Han times artisans in small factories produced the lacquer ware, one of China's superlative inventions. Over a thin base of carved wood or woven bamboo, they applied successive coats of lacquer, the resin of a native sumac tree, building up a hard, acid-resistant surface. Powdered minerals added to the lacquer created vibrant colors. With flowing brushstrokes, the craftsmen painted delicate flower petals,

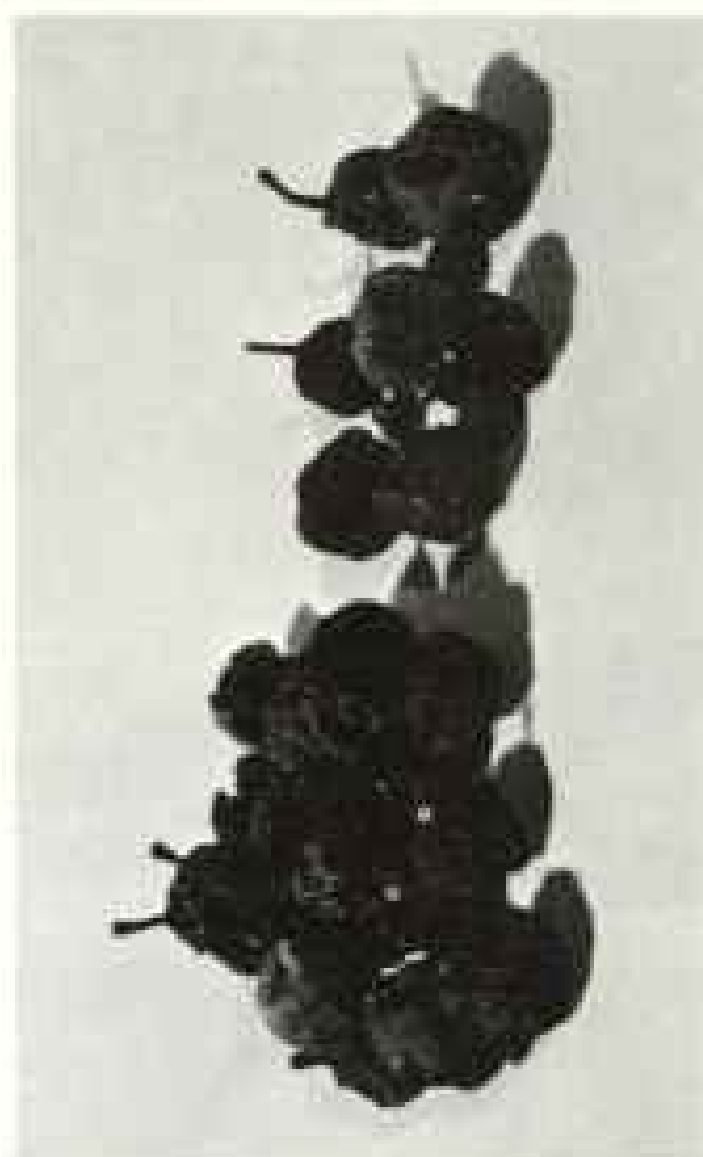
grass-blades, and clouds. The product, amazingly lightweight but durable, became a popular trade item. The tomb's 180 pieces of lacquer ware undergo inspection and cleaning (**below**) at the Hunan Provincial Museum in Ch'angsha, where many of the grave goods are exhibited.





SPREADING A TABLE FOR ETERNITY

Glistening lacquer ware reveals the refinement of early Han court life, with its attention to propriety and ritual. Winged cups that nestle in



their own covered container (above) bear the inscription "Please drink wine." The suggestion banished the chance of a social error, such as using them for water.

The 25-inch-long ladle (right) reached deep into a large jug for the last draft of wine. The utensils bring to life a third-century B.C. poem:

*Jadelike wine, honey-flavored, fills
the winged cups. . . .*

*Here are laid out the patterned
ladles, and here is sparkling wine.*

Funeral offerings of fruits and grains should be abundant, according to the *Book of Rites*, a collection of customs compiled by Han scholars. Mourners for the great lady complied, presenting containers filled with pears (upper left), plums, and strawberries. Burlap bags held rice, wheat, and millet.

Like a 20th-century cosmetics case, a toilet set (middle left) could store scarf and mitts in its upper compartment, while nine small boxes below held hairpiece, powder, rouge, comb, and brushes.

The squat tripod, or *ting*, for storing food, resembles ancient Chinese bronze vessels inlaid with silver. In the early Han period lacquer ware cost ten times more than bronze; emperors drank from solid jade cups.





WARDROBE FOR THE WEALTHY

Wraparound gowns, previously seen only in works of art, came to light at Ch'angsha for the first time. Wispy as a spirit's wing, this plain silk *p'ao*, weighing less than two ounces, probably served for summer wear.

Embroidered mitts (**left**)—which leave the fingers free—and silk shoes, stockings, and gowns lay neatly folded in bamboo cases.

Silk making began in ancient China. According to legend, an emperor's consort, by watching silkworms work their magic, learned to spin and weave fine cloth. Third-century B.C. literature mentions printing patterns on silk. Now two pieces of gauze are visible proof that the sophisticated process flourished in China more than 2,000 years ago. Multiple printings produced the stylized clouds and bird wings (**below**).





YESTERDAY'S CURRENCY, TODAY'S TREASURE

Some fifty lengths of silk, here inspected by museum technicians (above), comprise the most lavish



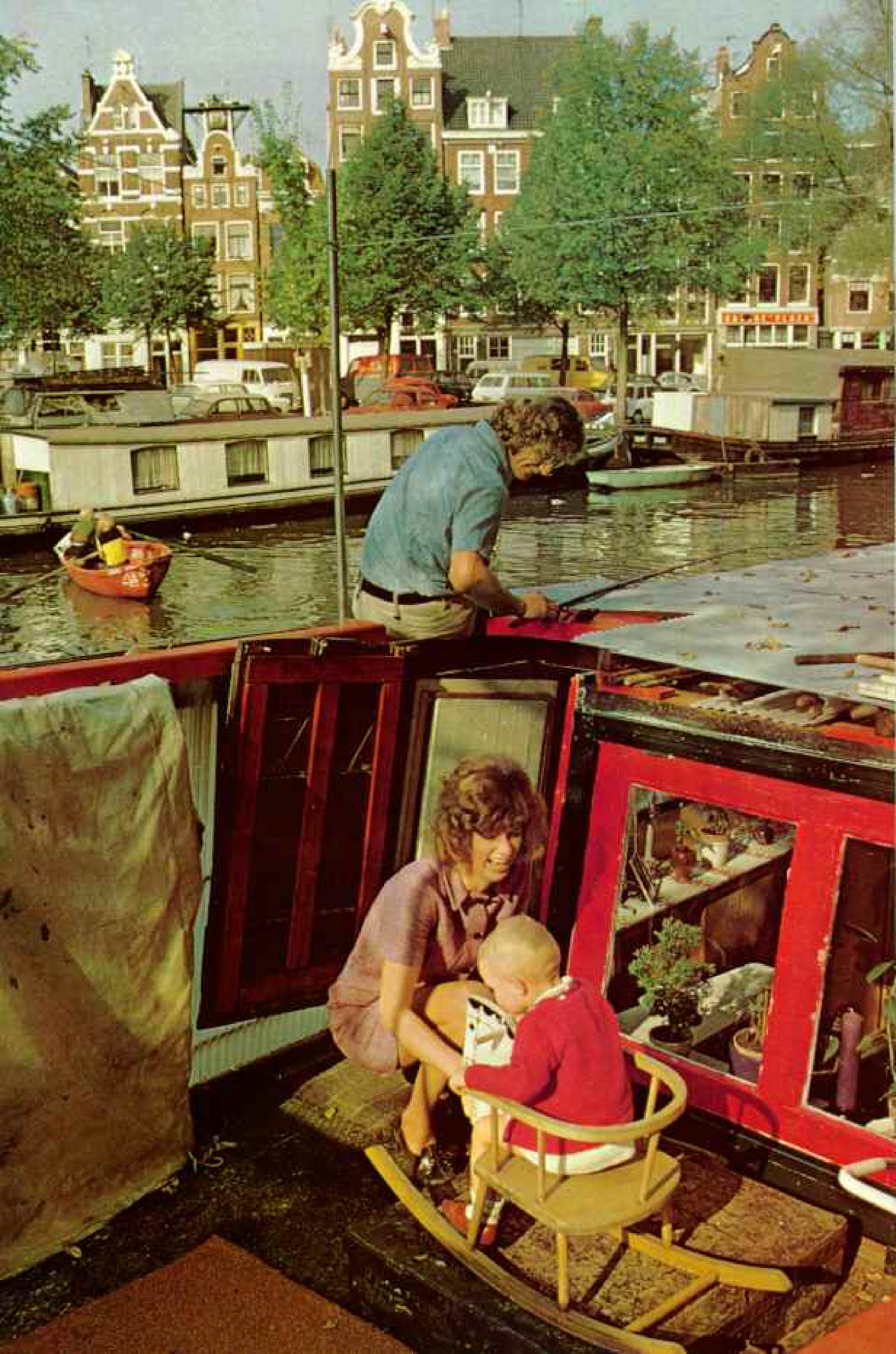
ancient cache of the fabric ever found in China. The designs so captivated modern Chinese that they have copied some of them on textiles sold in Peking department stores. In the Han era bolts of silk paid taxes, tribute, and bribes.

In the upper three textiles at right, clouds and bird wings are depicted in fine chain-stitch embroidery. The lozenge-patterned silk at bottom demonstrates superlative technical skill.

By the first century B.C. China had opened the great Silk Road to the West; demand for the fabric gradually spread to Rome, where matrons wearing fine Chinese gauzes were described as "dressed and yet naked."

Remarkable as this find is, Chinese archeologists hope for greater treasures. Once they have developed facilities for preserving such relics, they plan to open the companion mound. Will they find a man—the Marquis of Tai—or a woman—another consort of an emperor? □





Rockabye starboard, rockabye port, the stern's a backyard where housing is short. This young family (left) lives aboard a boat moored on one of Amsterdam's canals. The tolerant, easygoing capital of the Netherlands licenses less than half its 2,600 houseboats and now and then levies fines on the rest in a low-key campaign to control the fleet's size. Distinctive Amsterdam homes—one room wide, four stories high, and gable to gable—bob in the fun-house mirror of a canal (below).



Amiable Amsterdam

By
WILLIAM
DAVENPORT

Photographs
by
ADAM
WOOLFITT

THE NETHERLANDS WAS IN A TURMOIL, my morning paper assured me. I read this dire news in *Le Figaro* as I flew from Paris to Amsterdam to meet with a group of businessmen and professors in what our Pilgrim Fathers knew as a shining city of civil and religious liberty. The Dutch Government had announced a ban on Sunday driving, thanks to the Arab embargo on oil—a punishment for the Netherlands' pro-Israel stance in the Yom Kippur war. As a result, the French newspaper pronounced the economic situation "catastrophic."

But the Amsterdammers who met me when I landed at Schiphol Airport looked as solid and calm as always. And they hadn't lost their sense of humor.

"Not to worry," said Lukas, a young lawyer, as we drove into the city. "We're getting back at the sheiks with our own embargo on tulips and cheese."

The doughty citizens of Amsterdam, I decided, must be the most adaptable burghers in the world. They were out in force next day, turning gasless Sunday into a holiday on bicycles, roller skates, horseback, and shanks' mare.

Public transportation was jammed. Going to the Concertgebouw, I boarded a bus that streaked to the hall in record time. There



From a dam on the Amstel River, Amsterdam has spun its orderly web by dredging marshes to make canals and provide landfill for building sites. Today it is home to 800,000. The city sprang into full flower in Rembrandt's century, the 17th, when the



population doubled and redoubled to 200,000. It quickly became Europe's prime port, and from its quays sailed great merchant fleets and explorers charting the New World, including Henry Hudson in search of a new route to China.

wasn't a private car in sight. As *Le Figaro* pointed out, the Dutch are a disciplined people, stolid in the face of catastrophe.

"It's because we're so permissive in raising our children," a professor of psychology told me. "We make them self-reliant. We let them get the anarchy out of their systems when they're young. Then they acquire an adult sense of communal responsibility."

Explosive Greeting From a Namesake of Saint Nick

Dutch permissiveness, which scandalizes other Europeans, tends to be controlled by benevolent surveillance, however. I had observed this on an earlier trip to Amsterdam, when I saw thousands of children, half angel and half imp, lining the Damrak, the main street, awaiting the annual arrival of Saint Nicholas, better known by his nickname, Sinterklaas.

One flaxen-haired boy of 6 was clutching a red firecracker as big as his forearm. His mother, whose massive placidity recalled Vermeer's "Kitchen Maid," watched him with an indulgent eye. So did I, but more warily, as he lifted the lid of a well-filled ash can, calmly lighted the fuse of his firecracker, and dropped it inside.

"Klaas," said his mother (he was Saint Nick's namesake), "*doe die klep dicht*—put the lid back on."

Klaas complied. A split second later there was a most satisfying boom that blew the lid three feet into the air. It landed with a clang on the cobblestones. Klaas's delft-blue eyes shone with joy. Smiling down at her son, his mother handed him the lid—and another firecracker.

"*Dicht laten*," she said. "I tell him to keep the lid on," she explained to me. "Otherwise it is making a mess. Is it not?"

I nodded agreement as the lid blew off again.

Keep the lid on: This could be the motto of a city that has



JAMES L. ARNOLD, NATIONAL GEOGRAPHIC PHOTOGRAPHER (ABOVE)

Capturing the palette of Amsterdam's flower mart (above), a sidewalk artist could himself be a study for one of the worthy burghers portrayed by Rembrandt. In the city's Rijksmuseum (right), children gather to learn about "Night Watch," one of the master's best-known works. They may also visit the new National Vincent Van Gogh Museum, opened in 1973.





been clamping a lid on the sea ever since the first Amsterdammers built a dam on the Amstel back in the 1200's to keep their polders dry.

Seven centuries later they manage not only to keep the sea out of their polders, as they call their hundreds of thousands of acres of reclaimed land, but to keep the lid on the oil shortage and also on an explosive social situation that goes with being capital of one of the world's more densely populated countries: 950 people a square mile. With that density, the United States would have more than three billion inhabitants!

Yet, as my plane descended, I had seen a forest, thousands of little gardens, and green pastures full of cows. And the population pressure showed no signs of vitiating Dutch hospitality—certainly not in the case of Klaas's mother.

"Have some *speculaas*," she said. "It's a special cookie we make in honor of Sinterklaas."

I happily bit into a large, crisp, golden-brown spice cookie. In bas-relief on the cookie's surface, Saint Nicholas performed his most famous miracle, rescuing three little boys from a barrel of brine where they were being pickled by an evil innkeeper. This marvel, legend has it, took place in the fourth century, when Saint Nicholas was Bishop of Myra in Asia Minor. He thus became the Great Protector of Little Children. Since he also calmed tempests and assured ideal conditions for fishing and trade, he became the patron saint of Amsterdam.

"*Sinterklaas komt!*" shouted Klaas.

I was expecting a roly-poly department-store Santa Claus. But the official Sinterklaas of Amsterdam, architect Gerard de Klerk, is a truly majestic figure, six feet four inches tall. Astride a white horse and wearing a scarlet tabard and bishop's tall miter, he came riding down the Damrak accompanied by a cortege of mediievally costumed university students and 60 versions of Black Peter, his traditional attendant, all tossing candies to the cheering kids.

Like surplus parts for new Pentagons, the giant apartment buildings of Bijlmermeer squat on the outskirts of Amsterdam. Termed graceless by many, the angular complex will be served by a new subway system. The self-contained total community for moderate-income families follows the urban-planning tradition of its parent city, which is subsidizing construction. Following a basic scheme drawn in the early 1600's, Amsterdam spread like the growth rings of a tree (lower map, facing page).



I followed the parade to the Dam Square, the "forum" of the city, where stands the massive National Monument commemorating the Netherlands' war dead. Here Mr. de Klerk dismounted and was officially welcomed by Burgomaster Ivo Samkalden. A combination of city manager and lord mayor, the burgomaster of Amsterdam is selected by the national government and appointed by the Queen.

Chatting with Sinterklaas and Dr. Samkalden in front of the huge Royal Palace, I learned that this ponderous building was begun in 1648 and that it stands on 13,659 wooden pilings, as solid now as they were three hundred years ago.

"All Amsterdam is built this way," Gerard de Klerk told me. "The city is an inverted forest. We still build in the same manner, but now we often use concrete pilings."

Canals Commemorate Royalty – and the People

I left crowded Dam Square and walked down the Raadhuisstraat to the tranquillity of the city's center, with its concentric canals (map, below): the old, inner Singel, meaning belt or girdle; the Herengracht, canal of the gentlemen burghers; the Keizersgracht, named for the Habsburg Emperor Maximilian I; and the Prinsengracht, honoring the liberator, Prince William of Orange, whose descendant Juliana now reigns over the Kingdom of the Netherlands.

The quays of these pale-green canals, hand-paved with red bricks and lined with elm and poplar trees, are a compelling invitation to stroll. So, as hundreds of others do every day, I walked along the Prinsengracht, admiring the tall, narrow, gabled houses built by Dutch merchants in the 17th and 18th centuries. Moored to the quays were some of the 1,100 registered and 1,500 illegal houseboats of Amsterdam, picturesque evidence of the chronic housing shortage in this city of 800,000.

Boarding one of these tiny floating houses, I met Peter and Ina, and their 3-year-old daughter, Ingrid (page 682). Peter,

Though standing still, Amsterdam moves inland as the Dutch reclaim ever more acreage. The city once had direct access to salt water via the Zuiderzee, since dammed to make the freshwater IJsselmeer. Dashed line shows a new reclamation project that will add thousands of acres more between Amsterdam and the sea.





MICHAEL KUM (1982)

Glassy eye stares out over the Paradiso (above), a club supported by the city to gather and control the youth invasion. Here police ignore the common use of marijuana. But even Amsterdam's vaunted permissiveness has its limits; hard drugs are not allowed.

With gay abandon, a quartet has carried a couch onto a trams-only thoroughfare (facing page), posing for photographs to advertise a musical review. Amsterdammers take such antics in stride.

a draftsman, bought the barge three years ago for 8,000 guilders—roughly \$2,800—and pays the city about \$40 a year for mooring rights. The couple partitioned the hold into a living-dining room, a kitchenette, two bedrooms, and a study. They heat the house with oil stoves, cook with bottled gas, and bring their water aboard in jugs.

"We have electricity," Ina told me, "but only unofficially."

I saw a wire connecting the houseboat's bridge with a pole on the Prinsengracht. Peter winked.

"The police wink, too," he said. "They know there's a housing shortage."

Since then, the city has approved electrical hookups for houseboats that have been registered for more than two years.

Amsterdam, I decided, is a town of pragmatic tolerance. This impression was confirmed when I had lunch with two Dutch alumni of my university. Hans is a 45-year-old executive of a tobacco company, Mies, a left-wing professor of psychology at the University of Amsterdam. What they had in common, besides degrees from Columbia, was long hair. It seemed, sometimes, that just about all the males in Amsterdam, including soldiers, soccer players, and policemen, were coiffed in the style of the High Renaissance.

"It's because we don't want to be confused with the Germans," Mies said.

Left or Right, Politicians Respect Business Acumen

Over a rich Dutch dish, *Rodekool met Rolpens* (red cabbage with rolled meat and apples), Hans and Mies told me that Amsterdam is a "red city" controlled by radical elements of the Labor and Socialist Parties. Hans, a Catholic conservative, was not happy about it, but Mies, who described himself as a utopian socialist, approved. Poles apart politically, they remain good friends and play chess together once a week in an Amsterdam pub.

"It keeps us from underestimating each other," said Hans.

Mies was an ardent supporter of a fiery radical alderman on the city council whom Hans called the "*enfant terrible*" of Amsterdam politics and whom I will call Brinkers.

"Most intellectuals just sit around talking," said Mies, "but Brinkers gets into the arena and fights for higher wages and low-cost housing for the workers."

"Low-cost housing," snorted Hans. "What about the million-guilder [\$345,000] house he just bought for himself on the Leidsegracht?"

"It's the most expensive canal street in Amsterdam," he explained to me, "and guess who sold him the house? The leader of the conservative opposition!"

"You can't blame him for that," said Mies. "Who wouldn't like a canal house? He got a good deal. Business is business." Capitalism, it occurred to me as they talked, is not exactly moribund in "red" Amsterdam.

I found business booming the next morning as I strolled through the half-mile-long market of the Albert Cuypstraat. Baroque barrel organs cranked out their hurdy-gurdy tunes, and people were buying everything from gaily printed batik to baby eels, a delicacy Amsterdammers love. Red Amsterdam





JAMES L. SMITH (TOP PHOTO)

Radiant rebirth of the diamond trade owes much to expert Louis Asscher (top), who survived a Nazi concentration camp to return home to Amsterdam. Jews first found sanctuary here in the 16th century. Excluded from traditional guilds, many took to cutting diamonds. Father-to-son skills flash (above) from oval, brilliant (round), and marquise cut stones.

gave every appearance of being a pillar of the consuming society. It was a relief to leave the bustling marketplace for the silence of the placid canals.

Pausing on one of the 650 bridges that link the city's 90 islands, I gazed at the gabled houses, their long reflections suddenly fractured into splinters of rose and jade in the rippled wake of a passing motor launch. Those stately mansions and warehouses symbolize the flowering of the city's golden age.

Even During War, Dutch Commerce Flourished

The seeds of that golden age were sown in 1568, when the Low Countries, demanding autonomy and religious freedom, revolted against Catholic Spain, then the strongest power in Europe. Commercial Amsterdam held back at first, but when the Spanish closed the ports of Iberia and South America to Dutch shipping, Amsterdammers rallied to the standard of William of Orange. In Amsterdam religion is a question of conscience; trade is a matter of life or death.

It took the Eighty Years' War to get rid of the Spanish, but Amsterdam flourished despite the conflict, thanks to the Dutch East and West India Companies and the exploits of such explorers as the English navigator Henry Hudson, whom they employed to seek a new trade route to China. In 1609, 85 years before the Bank of England was created, the Bank of Amsterdam was founded.

In 1628 the naval commander Piet Hein captured the Spanish Silver Fleet off the coast of Cuba and brought the riches of the Americas to Amsterdam. But you can count on the Dutch to temper such glory with good housekeeping. When Piet Hein, the national hero, rushed across the family threshold to kiss his mother, he was promptly sent back to wipe his feet.

Proud of their spotless mansions and their handsome warehouses, the triumphant burghers of Amsterdam commissioned portraits by Rembrandt van Rijn, with whose profound and probing genius the golden age of Amsterdam reached its peak. The evidence glows on the walls of the Rijksmuseum, where each year a million and a half visitors stand transfixed before "Night Watch" (pages 686-7), "The Jewish Bride," "The Anatomy Lesson," and the most mysterious and introspective of self-portraits. Here also glow Dutch interiors by Jan Vermeer and Pieter de Hooch, which the Municipal House Improvement Agency, the *Stadsherstel*, uses as models in its meticulous restoration of the old houses of Amsterdam.

I dined in one of those houses in the Herenmarkt, overlooking the Brouwersgracht, the Brewers' Canal, as the guest of Mr. and Mrs. Edward Houtsma. Sanderijn Houtsma, a writer, was not too happy about the eggplant color that had been ordained for the beams of the living room ceiling.

"Maybe it will fade," she said hopefully.

The Houtsmas—Edward is a civil engineer—have done a beautiful job of furnishing their typical house, four stories high and one room wide, combining classical austerity with such amenities as an espresso machine and a splendid Spanish sherry keg to achieve the cozy atmosphere that the Dutch call *gezellig*.

"Amsterdam is a troublesome city," Sanderijn said, "where

old customs clash with new ideas and end in compromise. People, especially the young, are questioning the old Calvinist values. Catholic priests are marrying in defiance of the Vatican. All authority is being questioned.

"We are a people of principles," she went on, "and we have as many political parties as we have principles."

Amsterdam's 16 parties, Edward said, ranged from Maoist Communists to Calvinist conservatives.

"And don't forget the *Kabouters*," Sanderijn added.

The *Kabouters*, meaning pixies, dwarfs, or gnomes, are the latest addition to Amsterdam's contentious Municipal Council. A radical youth group, they called themselves "*Provos*," short for Provokers, back in 1966. Now they have decided to be less provocative and more playful.

"I want to release the medieval *kabouter* that has been locked up inside us for five centuries," wrote their leader, Roel van Duyn, in his book, *Message of a Wise Kabouter*.

In the last city election the *Kabouters* stunned Amsterdam by winning five of the 45 seats on the Municipal Council. *Kabouters* believe in practical help to the aged, whole-grain bread, organic farming, depollution of the environment, and the removal of automobiles from the congested city (a program unexpectedly boosted by the Arab oil embargo).

Serious Proposals—or Merely Tilting at Windmills?

In his two-room apartment in the *Jordaan*, Amsterdam's old working-class quarter, now becoming as chic as London's Chelsea, Mr. van Duyn outlined the *Kabouters*' goals.

"With one hand we must organize a counterculture to achieve utopia," he told me. "With the other we must infiltrate the establishment to humanize it.

"Step by step, we the people are ousting the cars from the *Jordaan* by placing flowers and trees in their way," he added. I had noticed potted trees and plants deployed in the street to prevent parking. The *Kabouters* want the city to supplant autos with free bicycles and small electric cars for communal use.

"How will you produce electricity?" I asked.

"The same way we reclaimed polders from the sea—with wind energy," van Duyn replied. "A small windmill on every house would produce enough power for the house and a car."

The gentle, persuasive "pixie" turned to another favorite *Kabouter* project. "People in towns are too alienated from nature and food production," he said. "We are teaching them to plant city farms. Would you like to see one?"

He led me down the *Leliestraat* to the "farm," a small city lot full of tall weeds and sunflowers, bounded by gabled houses and a brick wall bright with children's paintings.

I wish I could report that the town garden was a lush success. But the potatoes, carrots, turnips, and radishes I saw were pitifully small, deformed, and fibrous.

Elsewhere, Dutch farmers get one of the highest yields in Europe from their soil—with some crops, more than twice per acre what American farmers achieve. But Amsterdam has never lived on agriculture; it lives on international finance, trade, industry, and the port that made the city great.

"Twenty-five percent of the gross product of Amsterdam

Rising to the top as beer exporter to the United States, Alfred H. "Freddy" Heineken directs the firm's global operation. Modern equipment, shrewd marketing, and traditional Dutch business acumen have made Heineken beer a worldwide leader.





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Safe but sad scooternaut rides sidesaddle on mamma's *brommer* (left). Bikes and motorbikes, cars and trucks, all jockey for right-of-way on Amsterdam's crowded streets. Rush-hour traffic looks like an invitation to disaster, but commuters thread their way home with remarkably few accidents.

Problems of inflation are met with a bike and pump (right). Though a flat tire is a nuisance to a distraught girl, air is at least free. What flows from a gasoline hose comes much dearer, at \$1.35 a gallon. The half million Amsterdammers who regularly travel by bicycle are well prepared for the energy crisis. In a nearly flat city, multispeed bikes are unnecessary. Most have one gear, a warning bell, and a frame heavy enough to withstand constant use.



comes from the port," Capt. Cornelis van Eeghen, then Director of the Port Association, told me next morning as we boarded the harbor master's launch. "And 17 percent of the city's workers are connected with the port. We offer modern terminals for cargo and cruise ships, under all weather conditions, only 15 miles from the open sea, thanks to our tide-free North Sea Canal. And our Rhine canal links us with the heart of the Common Market and 200 million customers.

"It's true that Rotterdam, not Amsterdam, is the busiest port in the world," the captain admitted as we swung out onto the silver surface of The IJ, "but it concentrates too much on one thing—oil. We in Amsterdam are more diversified. To remain competitive with Rotterdam, we're planning a new marine port at IJmuiden, 15 miles west of here at the mouth of the North Sea Canal. Then we can handle ships up to 200,000 tons; 90,000 is our limit now.

Halfway Measure Saves Building Costs

"There's a first for Amsterdam," he said, as we chugged past a huge vessel that appeared to be cut in half, bow section at one pier, stern at another.

"To avoid the expense of a big slipway, an Amsterdam engineer invented a method of building a ship in two sections," Captain van Eeghen explained. "The two halves are welded together with 100 percent accuracy, thanks to laser beams."

Cormorants and gulls soared above Portuguese and Nicaraguan ships under repair in the dry docks. Lumberyards were stocked with Russian pine and African mahogany waiting for the Rhine journey to France, Germany, and Switzerland. We passed huge silos, each holding 8,000 tons of grain for transfer to railroads, trucks, coastal ships, and barges.

"We transfer maybe four million tons of grain a year, ten million tons of ore, five million tons of oil," the captain said.

The Arab oil boycott was not so total as the sheiks thought, I decided, as I watched Soviet tankers unloading.



Squared away for low bridges, a tjalk designed for shallow-water sailing makes



JAMES L. ANON

its way past a full-rigged stand of poplars on the Amstel just outside Amsterdam.



MICHAEL FOST (ABOVE PAGE)

Prodigal sons and daughters, wandering members of the youth movement gather in a secularized church building (facing page). Street people thronged the city's Dam Square in the early 1970's. After a melee with police, officials provided camping facilities in Vondelpark, where an American tootles his recorder (above). It's only a carnation confrontation for a policeman at a flower show (top).

"We're still the first port in Europe for tropical goods," he said, as we cruised past warehouses aromatic enough to inspire a sea-fever poem: nutmeg, pepper, cloves, vanilla, tea, and the cinnamon that goes into speculaas.

All the riches of this fragrant and bustling port seemed to be reflected in the fond proprietary gaze of the captain.

"Ever since 1275, when Count Floris V of Holland first gave us special customs privileges, Amsterdam has been the transfer point from large to small ships and vice versa," he told me, as we drank Brazilian coffee in the cabin of the launch.

"This is what we call promotion coffee," he said. "It's so strong it kills the captain, and the first mate gets promoted.

"The motto of our stock exchange is 'Bide your time,' " he went on. "With our duty-free entrepôts, we can buy at today's prices, unpack, store in bond, consign, disassemble, reassemble, repack, reship, and sell when the price is favorable. Our municipal bonded warehouse has one of the largest stocks of Oriental carpets in Europe. We have wines from everywhere, in casks, waiting to be bottled and reexported."

Wine Triggers Spirited Nationalism

I remembered his words that afternoon at a wine-tasting party at the home of American Consul and Mrs. Eugene Braderman. They had invited most of the resident diplomatic corps, too, and we sampled half a dozen varieties of California wine, accompanied by bland Dutch cheese.

"How did you like the wine?" I asked a Frenchman.

"Acceptable," he replied, "for a little California wine."

"What did you think of it?" I asked a German.

"It was a bit *stuffed*," he answered. "Have you ever tasted our Bernkasteler Doktor?"

When the Spaniards and Portuguese began touting their wines, I looked for a native Amsterdammer without an ax to grind. The flat Netherlands makes great beer, gin, and apricot brandy, but grapes grow best on hillsides.

I found a prosperous-looking local burgher.

"How did you like the wine?"

"I have four million bottles of wine in my warehouse," he replied. "California wines, Rhine wines, Burgundy, Bordeaux, anything you want. I can sell you Bordeaux cheaper than you can buy it in France. Prices were fluctuating so wildly we had to stock up to stabilize them. Would you like to place an order?"

Trade and finance are in the Amsterdammers' blood, I thought, and they have always known how to bide their time and hedge their risks. Eighteenth-century Amsterdam bankers helped finance and supply the American Revolution—and at the same time underwrote British government loans.

Pragmatic Amsterdam still thrives on trade, now augmented by the revenues of tourism.

"We're the fourth tourist city in Europe, after Paris, London, and Rome," architect Gerard de Klerk (whom I had met earlier as Saint Nicholas) told me in his office in the Warmoesstraat, the oldest street in Amsterdam. "We're expecting more than two million visitors next year.

"I'm doing a new hotel for the Sonesta chain," he said, showing me his drawings. "I have designed it to harmonize with



Horse and carriage go with love and marriage for this imaginative couple, who hired a coach-and-two to take them to their reception at the International Cultural Center in Vondelpark. Most Dutch couples still settle into sedate family life. The result is called *gezellig*, a cozy domestic intimacy. The word has also been used to describe the city's carefully regulated red-light district, giving a clue to a special kind of Dutch tolerance. Even vice has its place—if it's orderly.

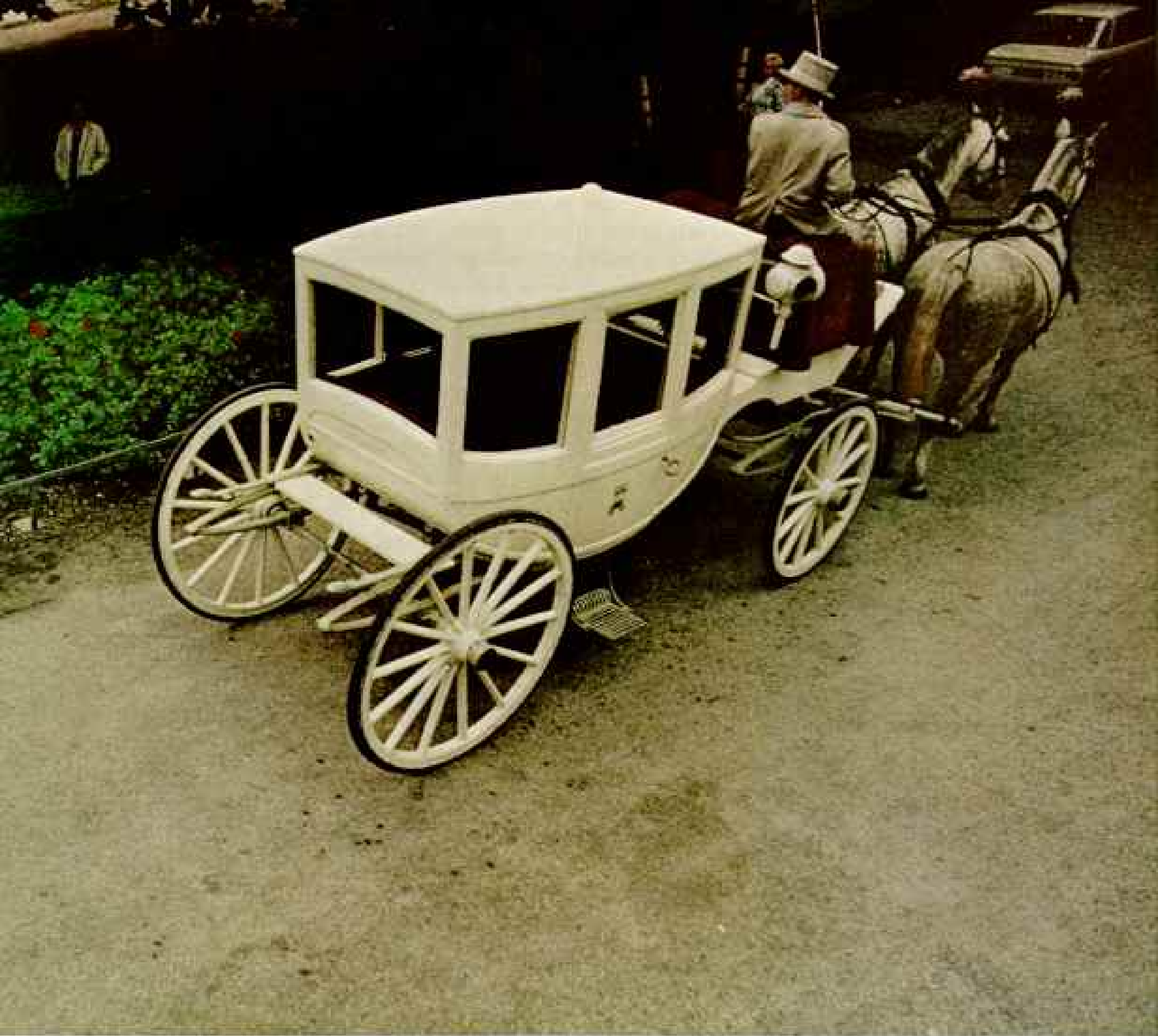


some nice old houses in the Straw Market that Sonesta owns. I persuaded Sonesta to sell them to Stadsherstel for one symbolic guilder. Now the agency is subsidizing the restoration. When finished, Stadsherstel will lease the renovated houses back to Sonesta as an annex to the new hotel."

At the construction site I saw the 60-foot concrete pilings being driven down through the soggy earth to a "bedrock" of hard sand. Amsterdam has been defying the Biblical injunction about building on sand for 700 years.

Across the street stood the oldest building in the neighborhood, the *Silveren Spiegel* (Silver Mirror) restaurant, built in 1614. I found the interior dark with paneled oak, bright with burnished brass, and decked out with checkered tablecloths and curtains. A sign behind the bar proclaimed, "A good drink now and then is what the heart requires." In short, the *Silveren Spiegel* is *gezellig*.

It was so *gezellig* that it became a favorite of the Gestapo during the Nazi occupation. Tante Wies, who owned it at the time, was a merry widow of 60, "a fat and jolly typical Amsterdam bar woman," the present manager told me. She was so



MICHAEL RUIJ

affable that it never occurred to her Gestapo clients to investigate the attic where she was harboring 17 Amsterdam Jews.

I climbed up a steep ladder to the attic refuge. I saw the tiny windowless kitchen with a concealed ventilator, where thousands of meals were cooked for Tante Wies's secret guests while the Gestapo hunted elsewhere. Unlike the tragic Anne Frank—whose home on the Prinsengracht is now a museum—Tante Wies's Jews escaped the holocaust.

Dutch Buy Diamonds, but Not to Wear

Only 15 percent of Amsterdam's hundred thousand Jews survived the nightmare of World War II. Among them was Louis Asscher (page 692).

When I visited his factory, the largest of its kind in Amsterdam, it was humming with the diamond-coated bronze saws that take an average of eight hours a carat to cut through the hardest mineral on earth. In 1970 Asscher and his brother Joseph were awarded the *Mercure de l'Élite Européenne*, the industrial Oscar of Europe, for their efforts in restoring the diamond industry wrecked by the Nazis.



JARCE L. ANCO

Moving day means rigging the roof beam to lower mattress and furniture too bulky for steep, narrow stairways. Most house facades on Thorbeckeplein and other Amsterdam streets tilt slightly outward, which makes hoisting easier. In this district students often live above cafés and night spots.

"The Dutch don't like to wear diamonds," Asscher told me, "because they don't like to show off, but they do like to buy them as an investment."

Benno Premisela, descendant of a Polish-Jewish family that found refuge in Amsterdam in the 17th century, survived the Nazi persecution by hiding out in his native city for four years. Now a noted interior and industrial designer and successful businessman, he is a utopian socialist who seeks to integrate all minorities, sexual, racial, and political.

"We are a progressive city," he told me. "We are experimenting, changing. Catholic priests are renouncing celibacy. I wish our rabbis were that open to change. Our TV stations are privately owned and very educational, the freest in Europe. Everything has been seen on TV in this country, even an abortion. Now we have just had a program on relations outside of marriage. The situation is wide open."

Famed Neighborhood Offers Sin and Salvation

Wide open is the phrase for Amsterdam's notorious red-light district, where the girls pose in picture windows in the lovely old canal houses of the Oude Zijds Voorburgwal, now garish with neon signs. In the midst of this neighborhood stands the headquarters of the Salvation Army.

Here, in a typical old Dutch interior with an Oriental rug on the table and with mullioned windows casting a mosaic of pale-green and amethyst light on the tile floor, I had tea with Lt. Col. A. M. Bosshardt. A strong-minded woman, she wore a badge that summed up her quality in a word: GOODWILL. Colonel Bosshardt has been ministering for 40 years to the sick, the homeless, the dispirited, the lonely, and the lost.

"There are about 3,000 girls in this district, selling love," she said. "What a delusion! Who can buy love? We know them all. They accept us, we accept them, they come to us for help. Most of the people who patronize these places are from out of town, provincials and tourists having a fling."

"Does it offend you that it's so blatant?"

"No. It's far better to have things out in the open. If you drive it underground, you can't control it. This way we can reach out to the girls. Tolerance is the best way."

A few yards from the Salvation Army I passed one of Amsterdam's 80 sex shops, where a handful of patrons with bored expressions leafed through pornographic magazines. By contrast there were 65,000 football fans that night at the Olympic Stadium. In Amsterdam, I concluded, pornography cannot compete with soccer.

The game, introduced from England in 1879, is a national mania, actively involving more than a third of the male population of the Netherlands. During my visit the Ajax team of Amsterdam held the championship not only of the Netherlands but also of Europe.

That night Ajax defended its title against an old enemy, Madrid. It was a resumption of the Eighty Years' War. The short, swarthy Spaniards in royal blue with close-cropped black hair; the Dutchmen, big and rangy in red-and-white-striped uniforms with their long blond locks floating in the breeze.

I sat squeezed in between an English film maker and an



Amsterdam fan. The crowd roared as its heroes appeared. "That's Keizer," the Dutch fan said. "That's Krol, that's Hulshoff with the beard."

When Ajax scored, I thought the stadium would fall down. Bombs burst in air and the spectators burst into song.

Ajax wint de Europa Cup!

Ajax wint de Wereld Cup!

Today Europe, tomorrow the world!

As Ajax proceeded toward a methodical 3 to 1 victory over the Spaniards, I saw nearly a score of Dutch boys and girls climb over a high fence that separated the cheap from the expensive seats. No one attempted to stop them, least of all the police, who simply watched indulgently. Most of the officers wore hair as long as the players'; a few patrolled the emerald-green turf with fierce-looking Doberman pinschers.

"That's just to keep people from attacking the referee," my Dutch companion explained. Almost anything else, I concluded, was allowed in this tolerant city.

Almost, but not quite. When permissive Amsterdam became the hippie capital of Europe a few summers back, the city's

Two in a cockleshell scull past the solid mansions of the Herengracht. Merchant Amsterdam expressed its values in the naming of three canals built in the 1600's. The outer and least fashionable was called the Prince's Canal. Next came the Emperor's Canal. The finest was the inner, the Herengracht—canal of the gentlemen burghers.



Tough sledding during the energy crisis finds a family strolling in the Sunday snow beside carless streets near Bijlmermeer (above). With little oil of their own, the Dutch quickly felt the effects of the Arab fuel boycott. Output and employment in oil-related industries have dropped sharply. Fortunately, huge reserves of natural gas discovered in 1960 in Groningen Province had already enabled much of the Netherlands to convert from petroleum for heating.

Dam Square was occupied by a couple of thousand of those leisurely world travelers. They sat on the steps of the National Monument all day and bedded down at night on the pavement. With no sanitary facilities, the young people got very messy. So did the Dam Square and the doorways of the nearby stores. The burghers of Amsterdam were appalled. The old Dutch Cleanser complex was soon at war with permissiveness.

"Sometimes tolerance ceases to be a virtue," a Concertgebouw cellist told me. "This was one of those times."

Dutch Practicality Creates a Hippie Haven

The city passed an ordinance: no more sleeping in the streets. The sanitation department was ordered to hose down the Dam Square at 6 a.m. This was not in harmony with hippie life-style.

"But you don't make new arrangements without offering alternatives," police officer Evert Jagerman told me. He wore his hair collar-length and looked more like a scoutmaster than a cop. "We were accused of acting like Fascists," he said. "No Amsterdammer wants to act like a Fascist. These youngsters had to sleep somewhere, so we set aside special areas for them all over town, especially in the Vondelpark. The city spent a million guilders. We built showers, toilets, laundry facilities, a dispensary, a workshop, even a market for hippie handcrafts.

"They are decent kids," Officer Jagerman continued. "Now they have discovered the adventure of sleeping under the trees and stars. I think our national poet, Joost van den Vondel, would be pleased. Three hundred years ago he wrote some verses that fit the hippie philosophy: 'Heaven is our roof; we do not work; we are as free as birds.'

"Sleeping capacity in the park depends on the weather, and how they want to arrange themselves. When it rains, they can



ERDGY KRISTOF, NATIONAL GEOGRAPHIC PHOTOGRAPHER

go to one of our inside 'sleep-ins' and have a mattress for three guilders a night."

"Are drugs a problem?" I asked.

"Our narcotics squad concentrates on hard-drug pushers," he replied. "That's one thing we *don't* tolerate. We don't bother much about 'pot,' although it's illegal too."

I had noticed a sign on a barge just across the canal from the police station: The Lowlands Weed Company, specializing in marijuana plants.

"It's legal to buy and sell the plants," Officer Jagerman explained. "It's only illegal to sell them dry. It became fashionable to plant your own hemp on your balcony. My own family did it. Now it's going out of style."

"The hippie fad is passing too," he said. "We had 3,000 in the Vondelpark last August. This summer we're down to 2,500. We still have about 50 parents coming to the police station every summer—Germans, Swiss, Italians, Americans—all looking for their 16-year-old son or daughter. We give them this map showing our sleep-ins and youth centers. They usually find their missing kids."

"This situation is under control," Mr. Jagerman concluded. "We Amsterdammers see things in perspective. If people aren't making trouble, let them alone. Live and let live. We have always been tolerant of minorities. We treat the hippies the same way."

The hippies killed with kindness! I talked to a group of them later in the Dam Square. They were seated cross-legged on an Oriental rug, drinking wine.

"Man, this *used* to be the place," one of them told me. "But it's getting too *structured* around here. We're thinking of going somewhere else, like maybe Copenhagen." □



J. VAN DER WOUDE

Never on Sunday: The rule was imposed when gasoline sources dried up last fall. Special permits were carefully examined by police (above). "We've had harder times," say the Dutch, recalling battles against the dike-breaching sea and the Nazi occupation, when Amsterdam earned the motto bestowed by the late Queen Wilhelmina: "Heroic, Resolute, Merciful."



Tanna Awaits

ON THE VOLCANO'S RIM looms a blood-red cross. Nearby, men with "U.S.A." daubed on their bodies shoulder make-believe rifles of bamboo. Soldiers of Christ? Hardly. On the New Hebridean island of Tanna, both cross and marchers herald a hoped-for messiah of material riches—a savior cryptically called John Frum.

Some followers of the mythical Frum consider him a beneficent spirit; others see him as a god come to earth, or as the "king of America." All believe he will someday usher in a prosperous, work-free millennium of unlimited "cargo"—pidgin English for Western material goods. Thus, anthropologists call the John Frum movement a "cargo cult," one of scores that have sprung up across Melanesia.

Stone Age ways ruled on Tanna when Capt. James Cook discovered the island in 1774. Traders' ships soon followed, disgorging trinkets and tools that seemed like manna from heaven. Surely, the Tannese reasoned, the god who gave the white foreigners sharp knives and bright cloth would not neglect them. Many adopted Christianity as a route to the strangers' wealth, but still the cargo failed to come.

Frustration grew, blossoming around 1940 into the John Frum cult. Prophets predicted Frum's arrival, and in 1942 World War II reached Tanna's shores. U.S. troops landed on nearby islands, bringing food, arms, prefabricated houses, jobs, and legions of jeeps. John Frum's long-awaited millennium was at hand!

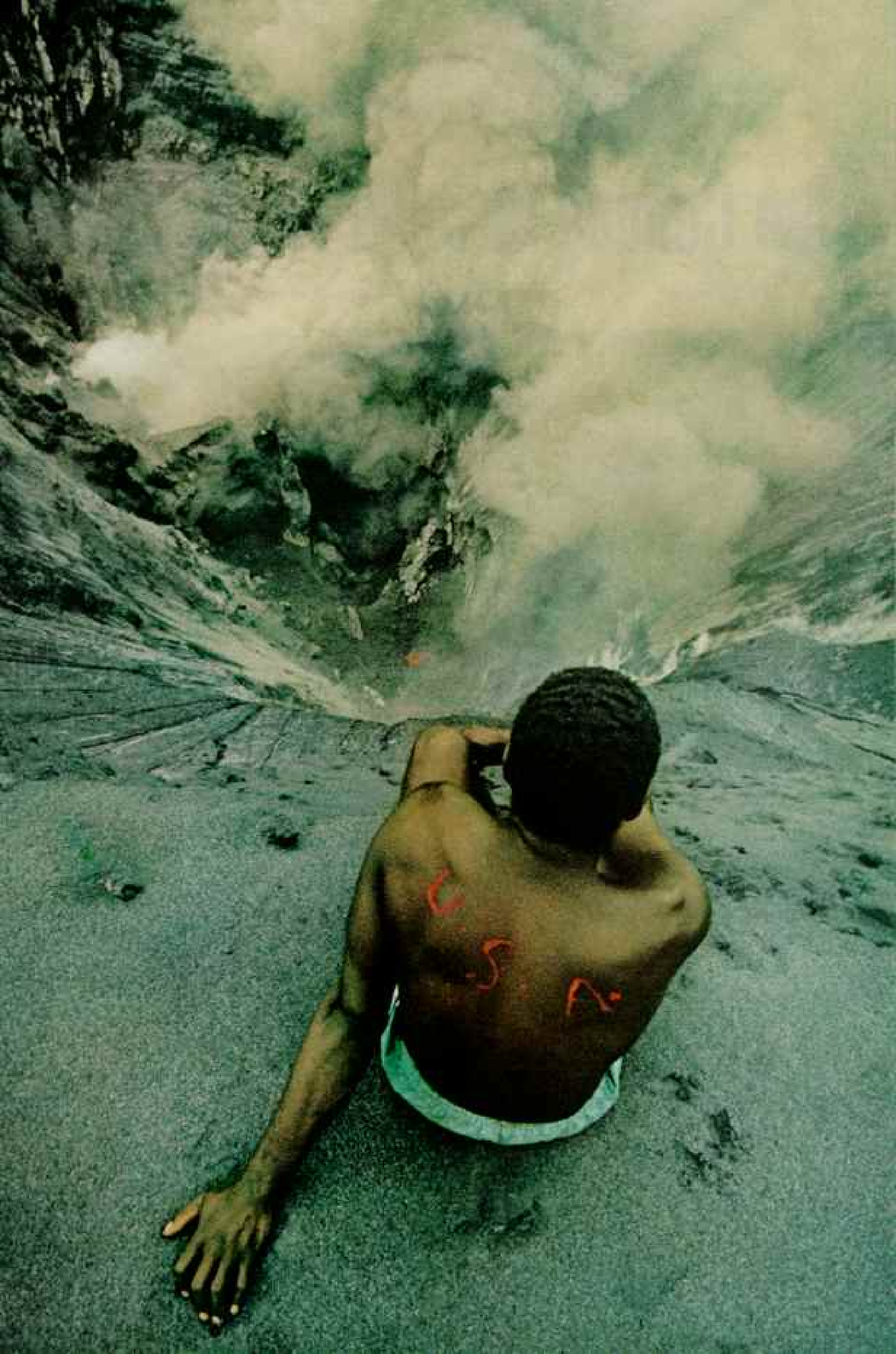
But with the war's end, the cargo disappeared, and islanders resumed their vigil. Some turned to mock military drills in the hope of luring GIs—and cargo-laden Liberty ships—back to Tanna.



ARTICLE AND PHOTOGRAPHS BY KAL MULLER, Ph.D.

the Coming of John Frum





INITIALS of the GIs' homeland emblazon a drill-team member who gazes into the smoky throat of Yasur Volcano. His forefathers revered the crater as a god's fire-filled abode. Islanders now believe Yasur's red-hot depths harbor some 50,000 of John Frum's soldiers, ready to emerge when their leader arrives. To hasten that glorious day, pious followers lavish prayers and flowers upon red Frum crosses (below). Nearly all the island's 12,000 people believe at least to some degree in John Frum.

Awash in the Coral Sea's eastern fringe, Tanna is one of about 80 lush

isles of the New Hebrides (map). A British-French condominium rules the once-remote archipelago, now a scant three hours from Sydney, Australia—so close that tourist agencies promote Yasur as "the world's most accessible active volcano."

Tannese guides permit tourists to scale Yasur's cone, but allow no souvenir pebble-snatching, for they believe the stones hold powerful magic. Every "taboo-man," or shaman, keeps a private cache of rocks, each credited with a specific everyday purpose, such as healing, ensuring a good yam harvest, or causing favorable winds to blow.

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BACK to the Stone Age: Convinced that Tanna's changing culture has enraged John Frum, some islanders seek a return to traditional costume and ritual. At the recently revived ceremony called *nekowiar*, once held on the island every year or so, Tannese feast, dance, and sing, then each guest selects a slain pig to take home (left).

During the revelry, Tannese men reminisce over a photo of a wartime friend and construction foreman they call "Tom Navy" (above), a U.S. serviceman who paid them and issued supplies, unknowingly acting out John Frum's role. Celebrants asked me to take a group portrait (below) to show Frum they have re-adopted old ways.







HUMAN WHIRLWIND swells and subsides during a dance at the nekowiar festival (above). Feet drumming out a thunderous rhythm, the men chant and slash the air with long, hooked "toka sticks." Later they will pair off to perform skits of everyday events—fishing, nailing wood, even using a jackhammer or playing tennis. Women and children proudly look on, and later take their turns.

In addition to dancing and giving up

Western dress, John Frum followers delight in returning to practices once banned by missionaries—magic and drinking narcotic kava, a root extract. But even these traditionalists tolerate the 20th century, and some own stock in the local airline, which they acquired in conventional capitalist fashion—with an outlay of cash. Two cultists wipe down one of "their" planes (left) as a third chats with the pilot, second from right, and Tanna's head of tourism.



TREASURED RELICS bring to mind Tanna's brief brush with plenty. One islander proudly wears a souvenir of World War II—a discarded helmet liner (left). Others unveil a community hoard of Army trousers, dog tags, keys, and even U. S. currency (left, below) acquired when they worked alongside Navy Seabees. Their fondness for America stems not only from its wealth, but also from the wartime presence of black U. S. servicemen, who seemed to possess as much cargo as did white soldiers.

Unfortunately, the islanders' devotion to John Frum carries a high price. Believing that their savior lives in the United States, they generally refuse cooperation with New Hebridean authorities for fear of compromising their fidelity to Frum. Widespread confidence in Frum's ability to replenish any shortage once moved Tannese to convulse the island's economy by slaughtering their pigs, eating up all available food, and casting hard-earned local currency into the sea.

Although Frum fails to materialize—as has been the case for 35 years—his followers remain devout, often attributing his absence to their own shortcomings or to governmental intervention.

Administrators' attempts to discourage the cult only reinforce a conviction that European rulers want to keep the islanders cargo-poor. And so cultists cling to Frum in hopes of a better life, while Western critics see the movement marching a downhill road to unfulfilled promises and inevitable disappointment. At the festive nekowiari, I watch a brightly painted, apprehensive youngster ride atop his grandfather's shoulders (right) and I wonder: Will Tanna's generation of tomorrow continue to ride on today's beliefs? □



NATURE'S AQUATIC ENGINEERS

Beavers

Article and photographs by
DES AND JEN BARTLETT

AS THE BEAVER APPROACHED, I lay motionless in the cold water. Through my face mask I could clearly see the transparent covering protecting each of the animal's eyes. It swam toward me with front feet held against its chest like tiny fists. Alternately thrusting with its large webbed hind feet—each as wide, when fully spread, as a ping-pong paddle—the animal glided so close it brushed against my camera housing. It showed no sign of alarm, but slowly expelled bubbles of air while rising gracefully to meet its own upside-down reflection. Then it broke through the surface and sighted my wife, Jen, and daughter, Julie, on the bank 35 yards away.

Crack! It slapped its tail down hard on the water and crash-dived in alarm, for man is the beaver's greatest enemy. Yet, in its underwater domain, this particular animal had shown no fear of me.

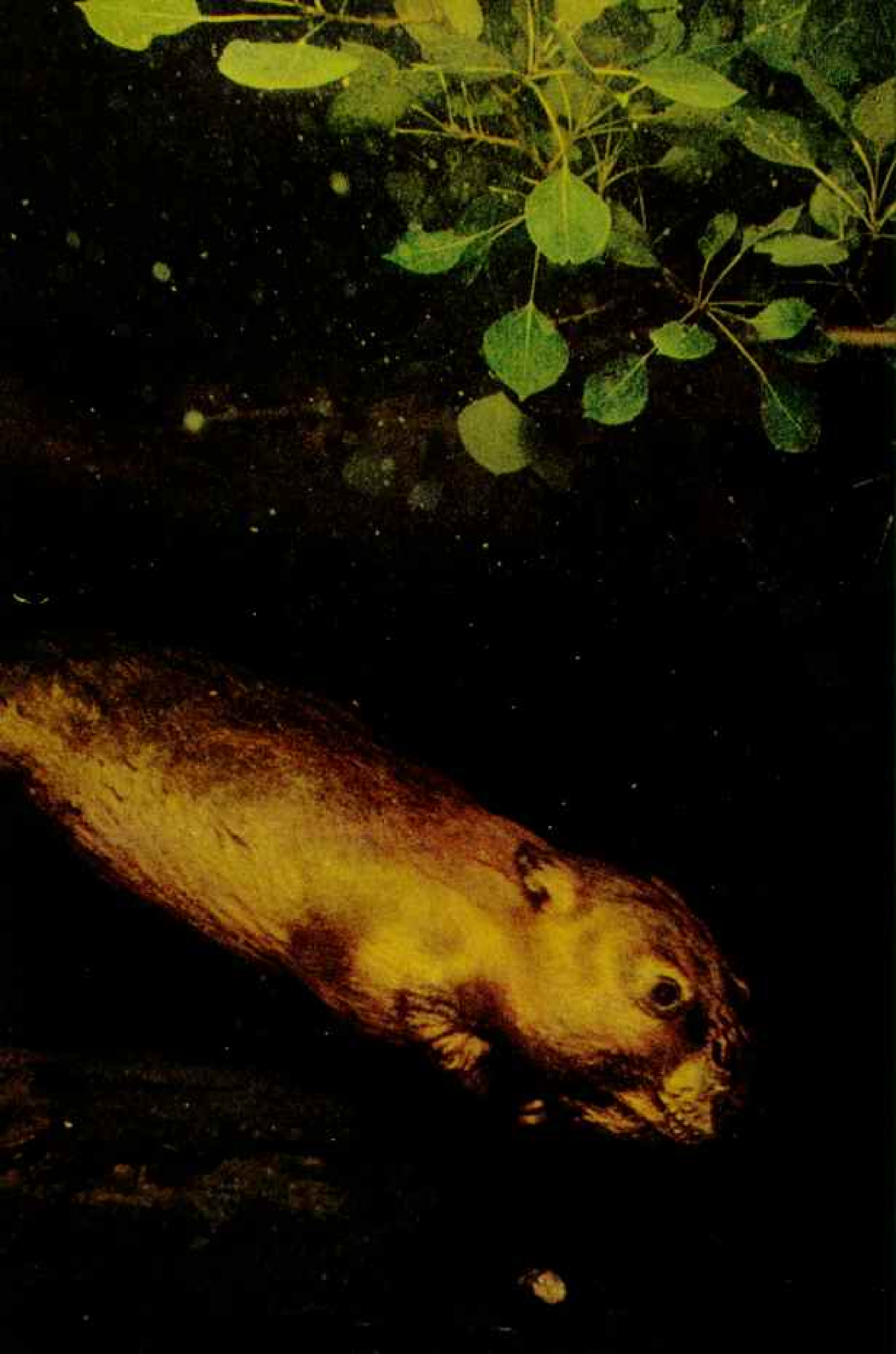
It was October and we were studying a beaver pond on Granite Creek in Wyoming. A thin film of ice was beginning to form, but below it was one of the most extensive winter caches of food we had seen—a 60-foot-long, 5-foot-high wall of willow branches, standing upright in the bottom mud, their tips barely poking through the ice.

We determined to stay for a while and make additional footage for our film *The*

Sleek submarine of the pond, a beaver dives for dinner. Once hunted almost to extinction, North America's *Castor canadensis* now stages a comeback, thanks to conservation and a change of fashion in hats and furs.

WILLIAM B. CURTIS







Magnificent bonus of the quest for beaver: the opening of the West. Trappers were the first to report Yellowstone's geysers and the first to trek many Rocky Mountain passes.

A beaver lodge (above), dwarfed by the massive Teton Range, rises from a Wyoming pond; a moose wades nearby for lush water plants. Serving as wildlife refuges, beaver-created ponds also benefit fish, waterfowl, and small mammals.

Not only fur, chiefly used in making felt hats, but also a musky glandular secretion—castoreum—made the beaver valuable to man. Indians and Europeans prescribed it for colic, epilepsy, frostbite, and hysteria. The animals exude another secretion that they curry into their coats (right) to make them waterproof.





World of the Beaver, a Survival Anglia Limited project that had taken us from Alaska to the Wyoming Rockies over a period of years.

No other animal has ever motivated exploration of an entire continent to the degree the beaver did in North America. From the early 1600's, trappers explored much of the vast domain in search of the animals' pelts for the European market. The Hudson's Bay Company, chartered in 1670 to trade in New World furs, marketed close to three million beaver pelts between 1853 and 1877. Profits were often enormous; one trapper earned \$50,000 in a single year.

As many as 250,000 skins were sold in Europe each year while the craze for the fur lasted. In Europe and Asia beavers were already close to extinction when Old World settlers reached North America. This resulted

not only from the demand for fur, but also from the even greater demand for the animal's musk glands and their secretion, castoreum. Regarded as a cure-all from the time of the early Greeks through at least the 18th century, castoreum contains salicylic acid, one of the main ingredients of aspirin. Castoreum also was—and still is—used as a fixative in perfumes.

The beaver vies with the capybara of South America for the title of largest rodent. Weighing about a pound at birth, it usually scales between 30 and 70 pounds as an adult, and, including a foot-long tail, may be four feet long. Beavers never stop growing, and some individuals may reach 100 pounds, about the weight of the largest capybaras.

The beaver complex we studied at Granite Creek, in Wyoming's Teton National Forest,

Lumberman,
architect,
engineer



WILLIAM R. CORTHOVEN (ELLOW RIGHT) AND KARL MACDONALD, PHOTO RESEARCHERS, INC. (ABOVE)



MOVER AND SHAPER, the beaver excels at transforming its domain to suit its needs. Feeling safe only in water, it creates its own pond—cutting logs, transporting them, and raising a barrier across a selected stream.

Aspens in an Arizona forest (**below left**) look as if Paul Bunyan had been at work. Actually, beavers standing atop four-foot-deep snow left the six-foot stumps. With powerful incisors, a beaver gnaws through a tree (**left**) as relentlessly as a chain saw.

After felling a tree, a beaver cuts it into

manageable pieces and hauls them to the damsite. It builds the dam base of logs and stones, then wedges sticks under the rocks with free ends leaning in the direction of the current. After weaving a latticework of brush, the animal scoops mud from the stream bed to plaster the dam face. Sediment and debris carried downstream help fill crevices.

Constant repairs keep the dam from washing away. The sound of rushing water seems to alert the beaver to breaks. Carrying a stick, a pond-sleeked repairman (**below**) sets out to plug a hole.

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Doing the beaver crawl, a pond dweller thrusts itself through the water with webbed hind feet and steers with its rudderlike tail. The animal can store enough oxygen to swim submerged for half a mile.

was the largest we had found. The snakily curving dam extended 1,104 feet.

Jen, Julie, and I soon found that we could almost set our watches by the beavers. They left their lodge within ten minutes either side of 6:15 each evening. In summer this was fine, allowing us some sunlight for filming. But by fall the animals were emerging well after sundown, and nothing we could think of would bring them out earlier.

Sabotaged Dam Tests Beavers' Response

One afternoon we made an eight-inch-wide gap in the top of the long dam with our bare hands, then concealed ourselves in the willows 50 feet downstream. Surely *this* would rouse the beavers.

The water cascaded over sticks protruding from the dam wall. Trout rose to feast on insects at the surface, and a family of mergansers fished for more than an hour before flying off downstream. But no beavers appeared.

Finally, at the usual hour of 6:15 p.m., a line of bubbles burst at the surface. "A beaver has left the lodge," Jen said, relief in her voice. Surfacing 30 yards away without noticing the break in the dam, it swam leisurely off to feed on willows.

Twenty minutes passed before it cruised slowly back, a V of ripples breaking the stillness of the pond. Nearing the break, it swam over to investigate the sound of rushing water, climbing partly out of the water to gauge the damage. Then it returned to the lodge and dived out of sight.

A few minutes later a beaver, perhaps the same one, surfaced with two willow sticks grasped crosswise in its mouth—discards from inside the lodge after the bark had been eaten. Reaching the dam, the beaver pushed the sticks forcefully into the mud at one side of the break.

We watched, fascinated. The animal then took a new grip on one stick, and pushed it in even deeper, only to pull it partially out again to embed its free end in the far side of the gap. After several trips to the lodge, the beaver completed a latticework of sticks.

As the first beaver worked, two others had left the lodge to feed, without helping with the dam repair. Now the dam repairer gathered a large clump of mud and grass from the dam's top and swam back clutching it firmly between front feet and chest. It pressed its soggy cargo against the sticks. A few more trips for mud and grass, and success:

The flow of escaping water was blocked.

Residents of the Granite Creek area told us that the lodge had been in continuous use for more than 30 years. Generations of beavers kept adding mud, gathered from the bottom of the pond, to the upstream dam wall. Now it rose four feet above the bottom and was ten feet thick at the base, making it impervious to the pressure of water impounded in the pond.

A network of canals reached out from the pond (following pages). Dug to extend the animals' food-gathering range, the outward-flowing canals were at least two feet wide and as much as three feet deep. Because of the sloping ground, the system had a series of locks, each about two feet high, to link upper and lower sections of each waterway. Across the middle of every banked-earth lock, the beavers had made a mud slide that served as a ramp. On reaching a lock, a beaver would climb the mud slide, willow branch in its mouth, and slip into the water of the upper canal.

A beaver can swim more than 700 feet along this canal system to reach the main beaver pond, coming out of the water briefly only when crossing locks.

Nimble Feet Speed Dining Time

One day in early fall we watched a beaver swim ashore and walk to a nearby clump of willows. Standing on its hind feet, broad tail serving as a prop, it cautiously sniffed the air; fortunately, we were downwind. It soon dropped onto all fours to snip off three willow stems with its sharp teeth.

Gripping the base of each stem firmly in its mouth, the animal ambled back to the safety of the pond and commenced its meal in the shallows. Using front feet as dexterously as we would use fingers to eat corn on the cob, the beaver held up foot-long sections of willow and nibbled the leaves one after the other. Then it devoured the bark with zest, turning the stick as it ate.

In spring beavers that have dined all winter from their underwater cupboard enjoy a change of diet: grass, herbs, leaves, buds, and shoots.

Like other rodents, beavers have four large, curved incisor teeth. They are bright orange on the front surfaces; they grow throughout life and are self-sharpening—the lower pair works against the upper. Thus equipped, beavers cut through tree trunks

with surprising speed. Two protective flaps of skin close off the mouth behind these chisel-edged incisors, keeping wood chips and water out of the animal's throat as it works below the pond surface.

We marveled to see a beaver bite through a submerged 2½-inch-thick aspen branch in less than 30 seconds. It then towed this big branch toward the lodge, only to stop swimming halfway there and snip it in two to lighten the load.

But do not believe those tales that beavers are expert lumberjacks, capable of felling a tree in any direction they desire. Many times we have come upon large trees beavers had cut that had ended up hanging uselessly in other trees. A beaver circles a tree as it cuts out chips; the tree falls on the side with the heaviest branches. Very often this is toward a nearby pond, where abundant sunlight produces the most growth.

Along the Snake River in Wyoming we found large cottonwood trees, 28 inches in diameter, cut down by beavers. But other standing trees nearby bore weathered tooth marks where beavers had ringed them six inches deep and then given up the effort.

For reasons yet unknown, beavers occasionally abandon trees before they're felled, and apparently never return to finish the job. Perhaps they are frightened off by predators—coyotes sometimes surprise and kill them—but they have few other enemies because of their watery environment.

Tough Part Comes After Tree Is Down

Tree felling is only the beginning of the beaver's work. The animal then must cut the tree into manageable lengths for transporting to the pond. It leaves telltale signs of its labor.

In the White Mountains of Arizona we came upon several neat heaps of chips, arranged in a straight line from an aspen stump. The three-foot spaces between piles indicated the length of the logs that the beaver had dragged to the pond.

Once a branch or log reaches the water, a beaver easily tows the freight across the pond. I had the good fortune to view this cargo shipment from underwater. The beaver's broad, paddle-shaped tail serves as a rudder, enabling it to steer a straight course.

Beavers are completely at home in the water. If danger threatens, they can remain submerged as long as 15 minutes, thanks to

specialized respiratory and cardiovascular systems that permit storage of large amounts of oxygen in the lungs, blood, and muscles.

Monogamous creatures, beavers mate for life and remain as a close family unit living within the same beaver house, or lodge. However, as each beaver reaches the age of two, it leaves, or is driven from, the home pond, ensuring the species' dispersal into new areas. Because of this behavior, a typical beaver colony usually numbers about five animals.

Young beavers may travel more than 30 miles before settling down; one marked animal in North Dakota went 148 miles before finding a suitable homesite.

Golden Leaves Trigger Annual Harvest

Through much of the year beavers lead a leisurely life, but in the fall the term "busy as a beaver" certainly applies. They wait to gather their winter food until the leaves turn golden, when a tree's sap and other nutrients are stored beneath the bark. Branches cut at this time will not rot during the long months in underwater storage, and their nutritive value remains at its peak.

The beaver shares man's ability to alter the

landscape to suit his life-style. But in doing so the animal, unlike man, does little harm to the natural environment. In fact, it often makes things better. Beaver-built dams help reduce erosion and can raise the water table, improving the surrounding habitat for a great variety of wildlife.

Dragonflies, mosquitoes, and many other insects lay their eggs in beaver ponds and their aquatic larvae flourish. Fish—including trout in cold mountain streams—find the aquatic insects a ready food supply; waterfowl and other birds nest around the shores of ponds; muskrats, themselves aquatic rodents, sometimes make their homes in the walls of beaver lodges.

Moose browse on tender young willows growing on shore and wade into the ponds to plunge their heads underwater for mouthfuls of succulent aquatic vegetation. Raccoons, otters, weasels, and mink are among the many smaller animals seen around a beaver pond.

Although beaver activities benefit these other creatures, man dislikes the flooding caused by the damming of culverts and irrigation ditches, and the downing of stands of



Watery kingdom amid the Rockies, the estate of a beaver family stairsteps down Granite Creek near Jackson, Wyoming. Generations of animals constructed the complex of main and secondary dams (marked in white), lodge (arrow), and canals (above), with their connecting locks. European beavers, hunted almost to extinction more than two hundred years ago, survived only in large rivers with high banks. With deep water making dams and lodges unnecessary, the animals dug inconspicuous bank burrows. Now protected, Europe's *Castor fiber* can again safely build dams and lodges in smaller streams.



commercial timber. But man and beaver can come to terms. Early one November on Vancouver Island, British Columbia, we accompanied Fisheries Service personnel as they dynamited beaver dams that blocked salmon swimming upstream to spawn. By the time the beavers rebuilt their dams, the salmon had passed through safely.

The lodge, or beaver house, helps assure survival during the long winter months. Constructed of branches and mud, it rises several feet above the water's surface. A typical lodge spreads 12 feet in diameter at water level, and the visible part of the house stands six feet high (diagram, page 728).

At Jackson Hole, Wyoming, we discovered a beaver lodge with seven underwater entrances, the most we had ever seen. Using a portable power saw, I cut a small hole through the thick wall of this lodge, causing no damage otherwise. Then I crawled through the hole and examined the lodge thoroughly with the aid of a flashlight.

The single chamber was 7½ feet across and a scant 12 to 18 inches high. The vast bulk of the lodge serves as protection against enemies such as grizzly bears and as winter insulation.

The lodge's seven outside entrances must have come together below water level, for only the usual two openings showed inside the lodge. Almost two feet in diameter, and located on either side of a central platform covered with shredded sticks, these doorways were only three inches lower than the flat inside floor.

After I finished my inspection, Jen and I used branches to cover the hole I had made. Next morning, we found that the beavers had done such an excellent repair job with sticks and mud that nothing looked amiss.

Beavers Adjust to Life on Camera

It was impossible for us to film while inside a natural beaver lodge; the central chamber's height was too low to accommodate lights. So we built our own lodge near Orem, Utah, raising the ceiling slightly. Then we waited quietly in a large dark plywood box attached to the lodge. A black cloth curtain hid us from the beavers that soon moved in.

We aimed the lens of our camera through a hole in the black cloth and watched the beavers through the camera's viewfinder. After they became accustomed to the lights being turned on and off, they seemed to behave quite naturally.



Family food gatherer tows an aspen limb (above) to a winter cache anchored in the pond floor. Beavers harvest trees in the fall, when the most nutrients are stored under the bark.



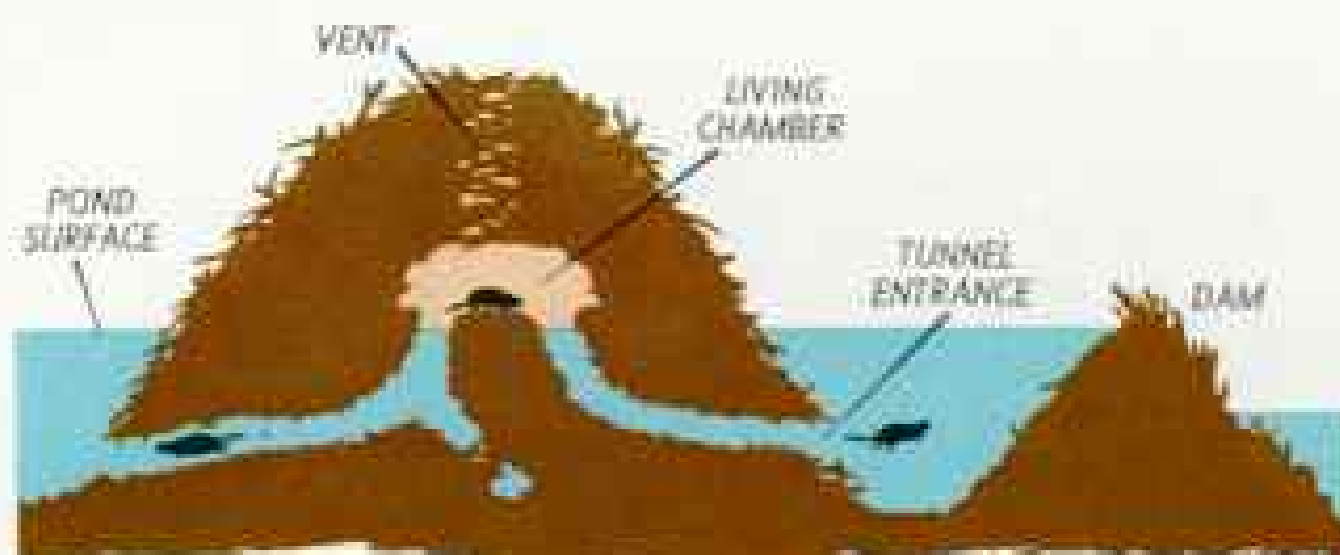


Banqueting underwater, a beaver hovers just beneath the surface. In summer the mammals dine on leaves, water plants, and herbs, as well as on bark. Beavers are specially equipped for work

underwater. Folds of skin behind the incisors seal the mouth, allowing them to cut branches without drowning. Clear membranes shield eyes, and valvelike ears and nostrils automatically close.

WILLIAM A. ZWEIFINGER (BELOW)





BEAVER LODGE AND DAM IN CROSS SECTION

High but not quite dry, a mother beaver and her three kits rest on the shelf inside their lodge. Father slips into a watery tunnel that gives access to the pond. Shredded wood chips on the chamber floor allow water to drain away. The interior of a lodge is only beaver-high, the authors discovered (*below*) when they crawled inside one. To take the photographs at right and on the following pages, they built a slightly larger chamber, attached a plywood blind, and focused their cameras through a hole in a black curtain.

Lodges usually have two interior doorways (*diagram above*) that may be connected with numerous outside tunnels; one that the Bartletts investigated had seven.

If beavers sense danger, they whack the surface of the water with their broad, scaly tails, signaling the rest of the family to seek hiding places. Then they dive (*bottom right*) to elude whatever frightened them.



Beaver kits, we learned, usually are born in May or June, but sometimes later. The infants arrive fully furred, with eyes open and teeth already cut.

With the mother tenderly caring for them, five newborn kits grew up inside the lodge as we watched. The mother would swim in with a branch, climb onto the platform, and drop the food for later consumption. Then, sitting up, she would carefully groom her fur, front feet simultaneously scratching her sides and copious belly.

Scratching with her right hind foot, she

used her inner toe, with its specially adapted split toenail, to comb the hair on the sides of her body. By bringing her tail up under her body to expose her groin, she was able to reach with her front claws a special oil exuded there from two abdominal glands. She thoroughly applied this to her fur, making it sleek and waterproof.

Grooming lasted perhaps half an hour—the usual maximum. The kits often slept through it, reposing at one side of the lodge. When the mother moved over to them, they greeted her with high-pitched cooing sounds,



all wanting to nurse at the same time. Since a female beaver has only four well-spaced nipples, one of the youngsters would impatiently wait its turn—often trying to shove another kit out of the way.

Rather than build a lodge, some beavers hollow out burrows in the banks of rivers and lakes. We came upon one such colony in the White Mountains of Arizona where, because of the steep terrain, the pond behind the four-foot-high dam was limited in size to 30 yards wide and 40 yards long.

Visiting the area after the spring melt, we could visualize the winter life of the beavers when ice and snow covered their pond. As a precaution against the pond's freezing too deeply or the underwater winter-food cache's

giving out before warm weather returned, a system of emergency tunnels had been dug from the den in the bank to two small access holes on dry land, 20 and 35 feet from the edge of the pond.

To get fresh food during severe winters, the beavers follow the tunnels and climb out on top of the snow. We found stumps of freshly cut aspens nearby, some reaching five and even six feet above the ground, indicating the beavers had worked on top of four-foot-deep snow in winter (page 720).

In Alaska one mid-September, we saw beavers going to unusual lengths to assure a winter food supply. It was snowing lightly as I donned a heavy wet suit and swam toward a lodge through a maze of drowned



alders, flooded when the beavers constructed their dam. To my surprise, I discovered deep ditches on the bottom—something I had never seen before. These Alaskan beavers, it seemed, had dug a canal system right on the bottom of their pond.

Radiating from the lodge like a river system, branches of the main canal led to holes under the banks. Even during a severe winter, when several feet of ice covered their pond, the beavers could navigate by following the canals and then climbing through access holes onto the snow. Air they had expelled during the previous dives would remain trapped under the ice, reoxygenated by the water and ready for reuse by the beavers on subsequent journeys from the lodge.

The more we studied the beaver in the wild, the more we wanted to know. Beaver farms have operated in the U.S. for many years. To supplement what we had learned from animals in the wild, we visited a farm near Orem, Utah. Manager Lloyd Rawlings has worked with captive beavers for twenty years. From him we learned that their gestation period runs between 100 and 110 days.

"Usually two to four kits are born," Lloyd said, "but we had one female successfully raise eight, while another female gave birth to nine but couldn't save them all."

Checking on a family with week-old kits, we found that two of the infants had been killed by the parents, an occasional happening for which scientists have no explanation.



Already an accomplished swimmer, a week-old kit needs help clambering onto the lodge shelf (left). Kits, born with fur, can float about in the access hole within hours of birth, but their buoyant bodies need more weight before they are able to dive. Females, who breed in winter and give birth $3\frac{1}{2}$ months later, often sit upright to nurse their young (above). At this time, the colony consists of the parents, new offspring, and yearlings. Two-year-olds, no longer welcome at home, wander in search of lifelong mates and suitable spots to raise their own families.



Never try to outswim a beaver, 11-year-old Julie Bartlett discovers as she romps underwater with Squirt, a pet she acquired as a week-old kit. Beavers with family responsibilities are busy most of their waking hours, but youngsters often spend time frolicking in the water—living proof of poet Arthur Guiterman's advice: "From Beavers, Bees should learn to mend their Ways; A Bee just Works; a Beaver Works and Plays."

The remaining one appeared unharmed. Lifting the lively ball of brown fur out of the den, Lloyd handed it to Julie.

"How would you like to raise a baby beaver?" he asked her.

So Squirt, as Julie named him, became a member of our family while we photographed beavers in the Jackson Hole area of Wyoming. At first on a diet of powdered baby formula, Squirt was nibbling playfully at willow twigs to supplement the milk by the time he was two weeks old. At the age of one month, he was expertly stripping and eating the bark from small branches.

He loved to swim in a bathtub half full of water when he was young, and soon graduated to much larger ponds outdoors, where Julie enjoyed swimming with him (above). When she dived, Squirt followed, often swimming much faster than she could. Reunited at the surface, Squirt climbed onto Julie's

shoulder for a free ride, while making high-pitched cooing sounds.

We enjoyed Squirt for nearly three months, but when we resumed traveling, we had to give him up. We found a good home for him with the director of the Arizona-Sonora Desert Museum near Tucson.

Species Returns to Former Haunts

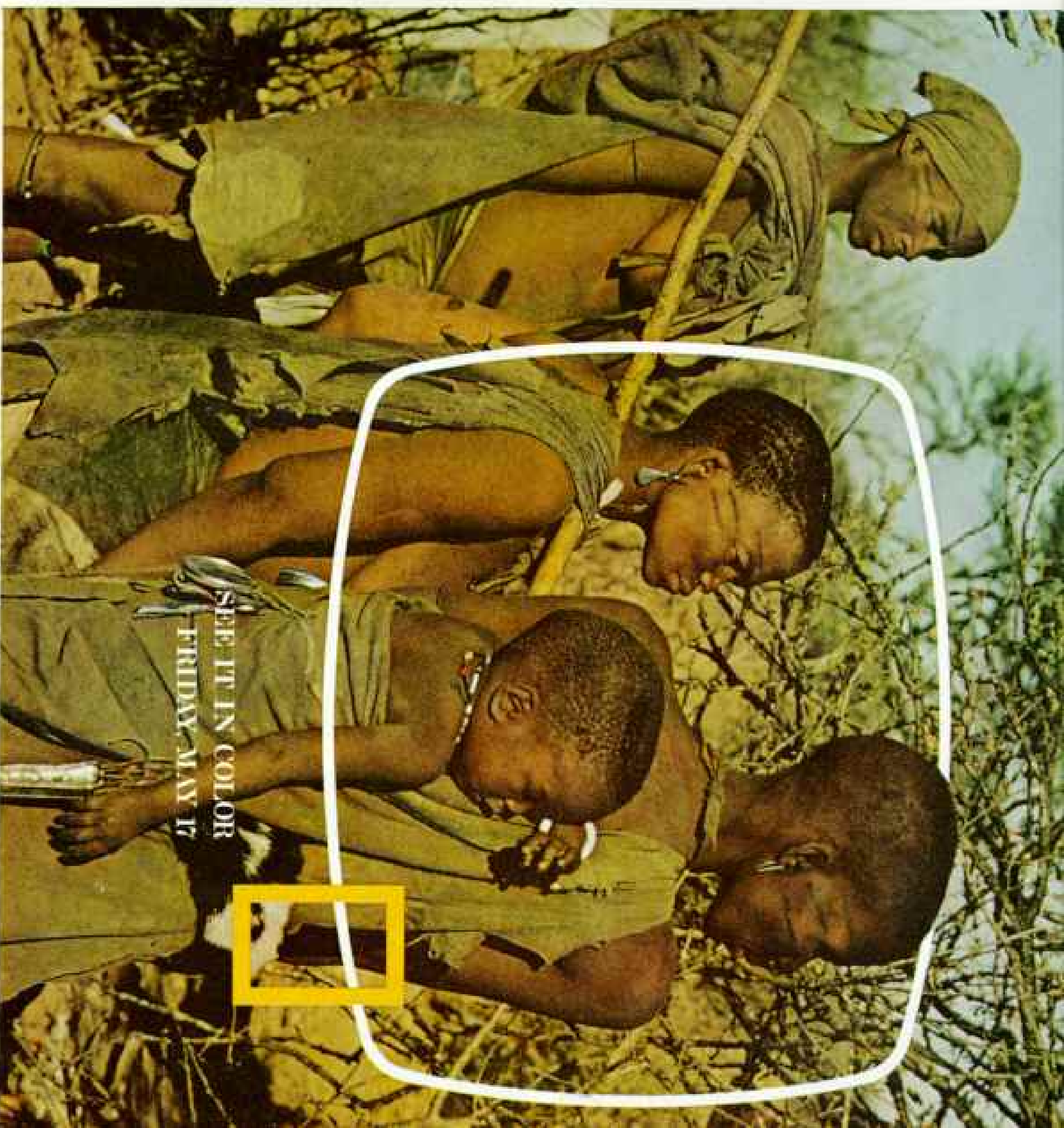
Good homes, in truth, once again are plentiful for beavers in the wild, thanks to successful conservation programs. Today the beaver has returned to most of its former territory in North America, from the Arctic Circle to northern Mexico and from the Atlantic to the Pacific.

It now seems certain that our descendants will be able to marvel, as we do, at the ingenious feats of aquatic engineering performed by these fascinating animals—the world's first dam builders. □

Bushmen of the Kalahari

Focusing on a fading culture, film maker John Marshall of the Kalahari Peoples Fund returns after 15 years to visit old Bushmen friends in southern Africa's great desert.

by [John Marshall](#)



SEE IT IN COLOR
FRIDAY, MAY 17

Clinging to life in a wasteland

IT'S A WORLD where home is a grass hut, a stick is a major tool, and the daily commandment is, "Find food and water." On ABC Television, Friday, May 17, the National Geographic Society presents "Bushmen of the Kalahari," final documentary of the 1973-74 season.

John Marshall chronicles the changing lives of African desert dwellers whose ancient hunting and gathering ways are disrupted as ranchers evict them from water holes and build fences across game trails. Mr. Marshall's friends return to their abandoned village by donkey (upper) after he fixes their water pump. A woman probes the sere earth for roots. But hardships are forgotten as youngsters mimic adults beating melon seeds and girls stamp out ancient rhythms around an evening fire.

You may recall that this program was announced in the magazine last year, but an unexpected strike kept it from TV screens. Now you can enjoy this extraordinary film, narrated by Leslie Nielsen, produced in association with Wolper Productions, and sponsored by St. Regis Paper Company and Western Electric.



MARSHALL PHOTOGRAPHY (LEFT, ABOVE) AND (TOP RIGHT)



Introducing a new small car from Dodge: Dart Special Edition.



The new Dart Special Edition is based on the premise that a small car can be a very luxurious car. As in some of the world's most expensive cars, high-backed seats covered in crushed velour are standard on the Dart Special Edition.

There are two body styles. The two-door hardtop and the four-door sedan. Either is available with the economical Slant Six or V8 engine. Comfort and convenience are the bywords for both models. Each door

is thickly padded on the top half and carpeted on the bottom half. There are assist handles and armrests on each door also. And the Dart Special Edition is finished throughout with plush cut-pile carpeting.

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And we at Allstate are delighted.

What General Motors is doing.

General Motors is offering air bags as an option on certain 1974 cars—Cadillacs, Buicks, and Oldsmobiles, in place of the currently mandatory seatbelt-ignition interlock system. Allstate commends GM's action, and hopes other car manufacturers will move to follow GM's example.

What Allstate is doing.

We've been urging and supporting the development of an automatic passive-restraint system like the air bag for years. Because we believe that a system like the air bag will do a great deal to save lives. Prevent serious injuries. And help hold the line on your insurance costs. And we make the following offer. *Allstate will provide a 30% discount on the medical coverage portion of the auto insurance for cars factory-equipped with air bags.*

What the air bag has been doing.

There have been 15 real-life crashes of air bag-equipped cars, and the air bag has never failed to inflate. Over 50,000,000 over-the-road miles have been logged with air bag-equipped cars. In every frontal-type crash at a speed high enough to cause serious injury, the air bag worked perfectly. Only once, in all this driving, has the air bag inflated inadvertently. (In that instance, the car was brought to a safe stop easily and without incident.) All this leads to a single conclusion: Air bags are the only road-tested and injury-criteria-tested passive-restraint system available today.

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Air bag discount available in most states.

Modern Magellans in orbit

SURELY Skylab was the ugly duckling of space, with one solar "wing" missing and a makeshift sunshade replacing a lost heat shield (below). But what a stately swan of science this 100-ton bird became. Keeping the vehicle in repair with daring space walks (right), Skylab crews dramatically launched the post-Apollo era by giving mankind its most significant studies of both sun and earth from space. Tens of thousands of unbelievably detailed photographs will yield information for a decade to come. Already scientists have found possible new oil and ore deposits and new water sources for drought-stricken West Africa.

This 70-million-mile odyssey will unfold in a future **GEOGRAPHIC**. Enable friends to share in the saga; nominate them for membership on the form below.



NASA



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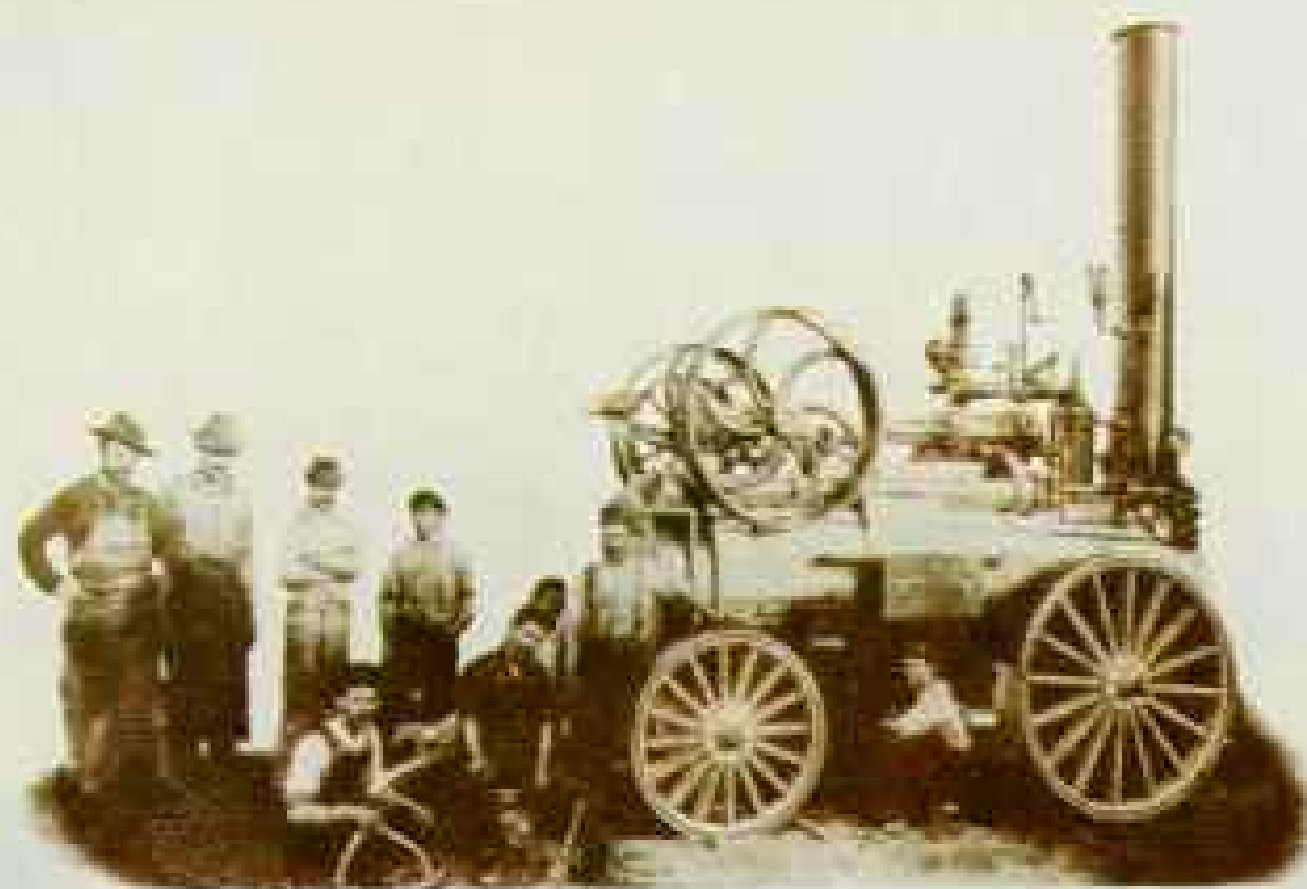
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Rowland Hansford may not look like your idea of a pioneer. And his field, commercial catalysis research, may not sound very exciting.

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Unicracking was, of course, the product of many scientists, engineers, and technicians at Union Oil, but it was Rowland Hansford who perfected the catalyst without which the chemical reactions that make up Unicracking wouldn't happen.

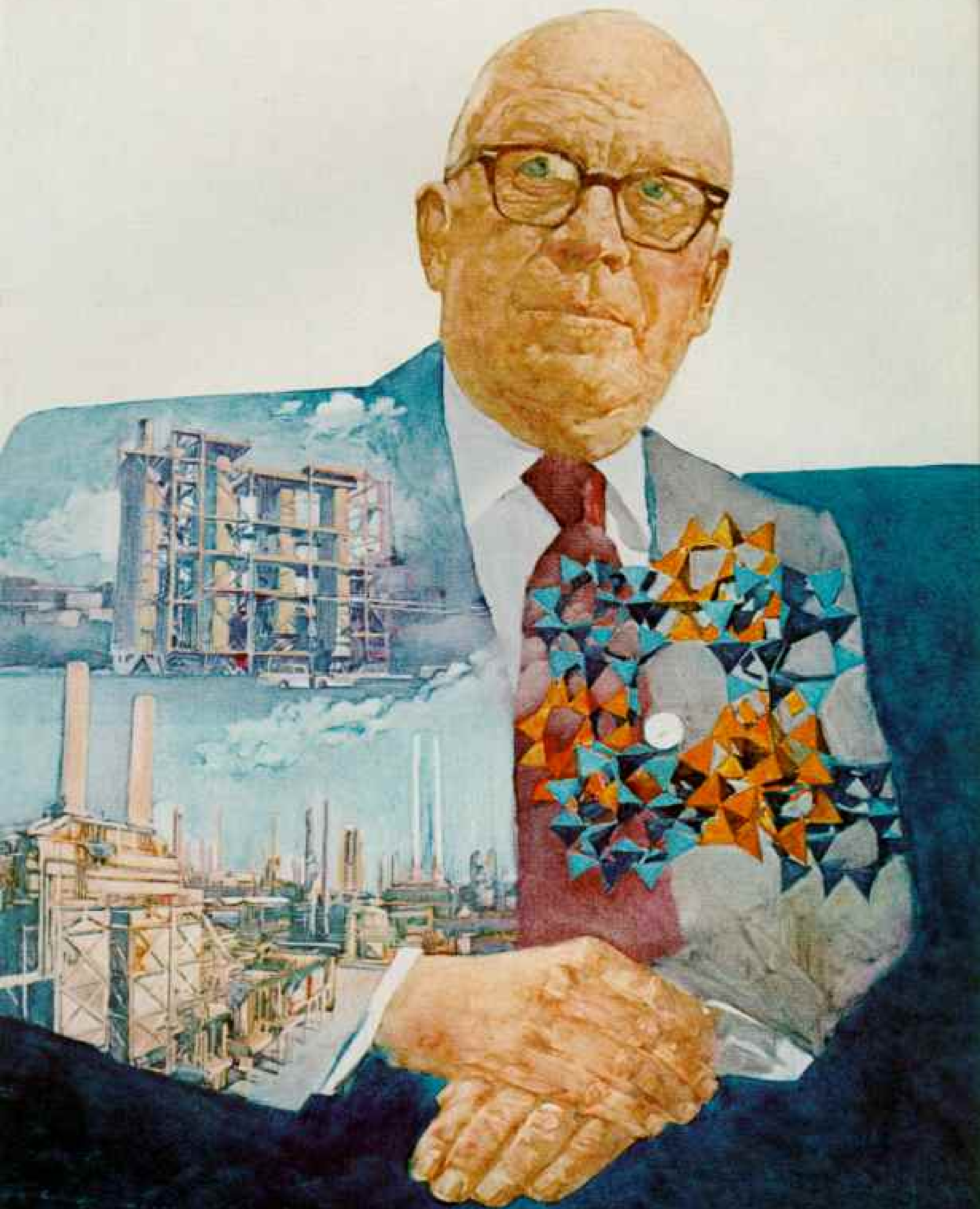
Union Oil is an acknowledged leader in developing refining techniques that give more, higher quality, and cleaner petroleum products.

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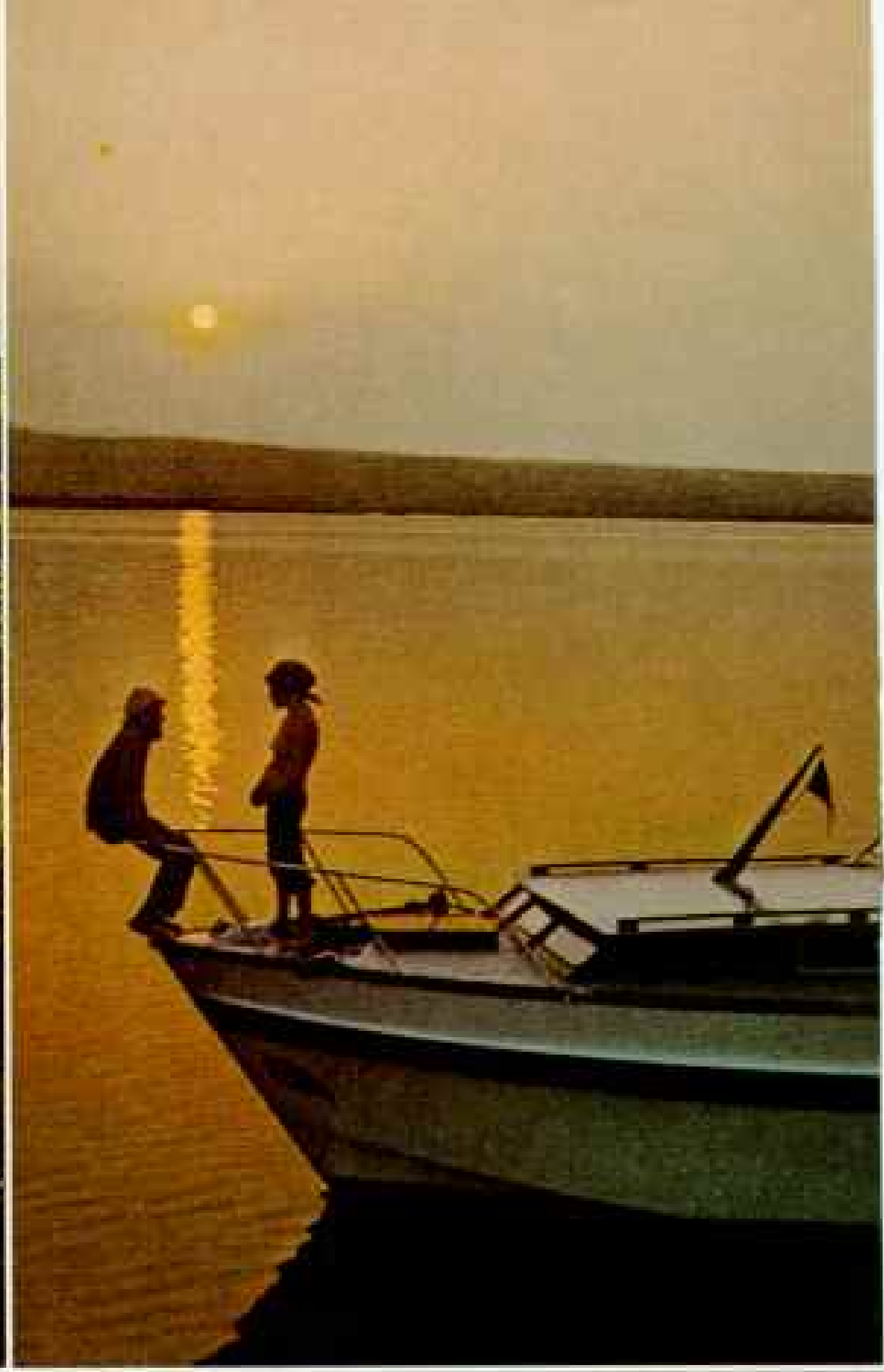
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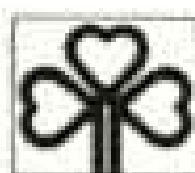
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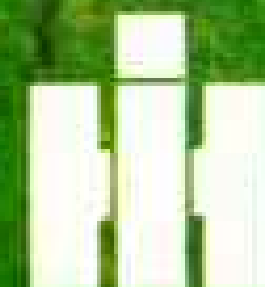
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To make a good recommendation on the type of tire that's best for you, your dealer

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New or old, your tires should be treated with special care. Leave the "torture tests" to the television commercials. To get the most out of your tires, take it easy. Avoid quick starts and panic stops. They help burn up tire tread. Fast turns on curves and around corners take their toll of the tread, too. As does driving at excessive speeds.

By far, the most important rule in tire safety, tire mileage and improved gasoline mileage, is proper inflation. Inflation pressure should be checked often...at least once a month. And if you do a lot of hard driving, the pressure should be checked once a week. For an accurate reading, tires should be checked when they're cold.

You'll get more mileage out of your tires if wear is equalized. Regular rotation, as recommended by the car manufacturer, goes a long way toward equal distribution of tire wear. If you have any doubts about when to rotate, ask your dealer.

When your tires are being rotated check for excessive or abnormal tread wear, fabric breaks, cuts or other damage. Because "reading tires" is a good way to head off trouble somewhere else. Tire wear can be a symptom of out-of-balance wheels. Or grabbing brakes. Or faulty shock absorbers. So be alert to the signs of trouble.

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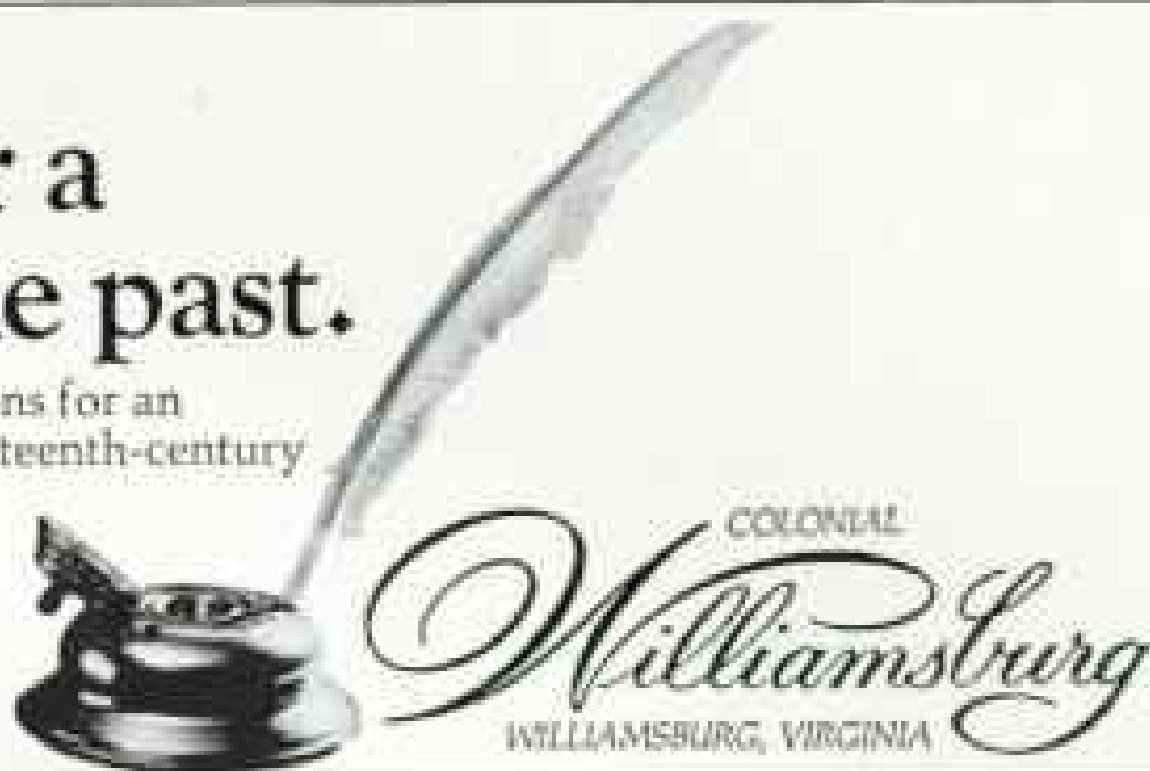
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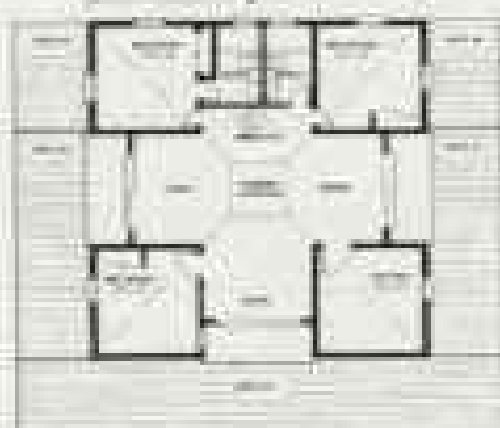
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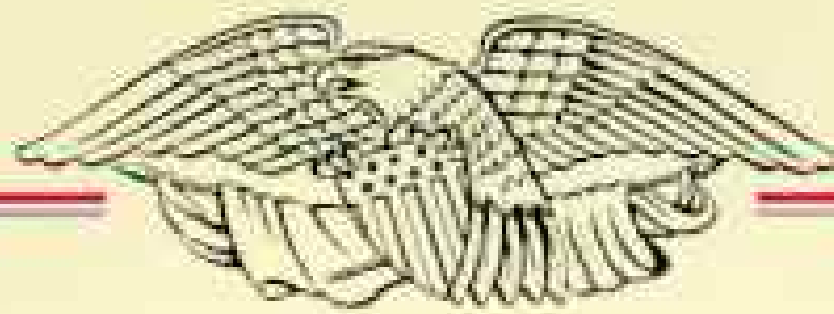
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THE 200TH ANNIVERSARY OF THE BIRTH OF OUR NATION—the Bicentennial of the United States of America—will be an event unequalled in our lifetime.

It is a milestone in the history of civilization. A time to be proud of our democratic society and all that it has accomplished. A time for meaningful rededication to the ideals that inspired our founding fathers. A time for jubilation, for reflection and for commemoration. A time to specially honor the fifty States that together have formed so perfect a Union.

To bestow this honor, The Franklin Mint—America's foremost private mint—is striking a special Bicentennial Medal for each of the fifty States of the Union. The complete collection of these fifty medals is certain to become one of the most esteemed and valuable heirlooms of the Bicentennial era.

Each Medal an Award-Winning Work of Art

The importance of these medals is attested by the manner in which the designs were selected. A Bicentennial Medal Design Competition was held in each of the fifty States, with a top prize of \$5,000 in each State.

To select the winning designs, a separate panel of judges was appointed in each State. Every State panel was made up of distinguished citizens of that

State—leaders in government, business, education and the arts. In many cases, the judging panel was personally appointed by the Governor. And in most cases, the prizes were awarded by the Governor at an official ceremony.

The fifty separate judging panels spent thousands of hours studying the entries of more than 13,000 artists before the final awards were made. By any measure, this was the largest and most exciting art competition in history.

Each medal in this collection is thus a singular work of art—featuring the design that was awarded top honors in the Bicentennial Medal Design Competition for that State.

Reflecting the Rich Diversity of America

Created by fifty different artists from fifty different States, these medals are representative of the many differences in heritage, in resources, in industry and in culture that constitute the richness of America. The complete collection truly reflects the unity in diversity that is America's strength.

The California medal, for example, depicts the discovery of gold, which provided the impetus for the great migration westward. Pennsylvania's medal commemorates the desperate winter at Valley Forge. The Maryland medal recalls the creation of our Na-



tional Anthem. Hawaii's medal, in a design based upon native art, symbolizes the fraternity of many different peoples. The Texas medal is a rugged representation of cattle and oil within the outlines of the Lone Star State. On New York's medal, the Statue of Liberty welcomes new arrivals, "yearning to breathe free."

Fifty different artists. From fifty different States. Together they have created a collection that expresses with force and feeling the essence of America. A collection that is the ultimate tribute to our nation's Bicentennial.

Prize Winning Designs in Solid Sterling Silver

The fifty first-prize winning designs have been painstakingly transformed into the lasting beauty of solid sterling silver by the skilled craftsmen of The Franklin Mint. The reverse of each medal is enhanced by an appropriate complementary design—in most cases, the Official State Seal.

Most of the States have already declared their medals to be the *Official State Bicentennial Medals*.

The Franklin Mint has reserved the *exclusive* right to issue complete sets of all fifty medals. These will be available to the general public in a strictly limited edition. Royalties on the sales of these sets will be paid to all fifty State Bicentennial Commissions.

An Important Opportunity

Now, for a very short period of time, you have the opportunity to acquire the most important series of medals issued in commemoration of the most important historic occasion of our lifetime—the 200th anniversary of the birth of our nation. The final date for entering a subscription is May 31, 1974. There is a strict limit of one collection per subscriber.

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ACKNOWLEDGMENTS

The Franklin Mint expresses special appreciation to the distinguished historians and art experts who served on the National Advisory Panel for the Bicentennial Medal Design Competition:

DR. WILLIAM ALDERSON
Director, American Association for State and Local History

DR. BRUCE CATTON
Senior Editor, American Heritage Magazine

DR. THOMAS C. COCHRAN
Former President, American Historical Association

DR. JOHN A. GARRATY
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DR. THOMAS B. HESS
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MR. GILROY ROBERTS
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MR. NORMAN ROCKWELL
Artist and Illustrator

Appreciation is also gratefully expressed to the Governors and other State officials who assisted in this program and to the 262 distinguished citizens who gave so generously of their time in serving on the judging panels in the fifty States.

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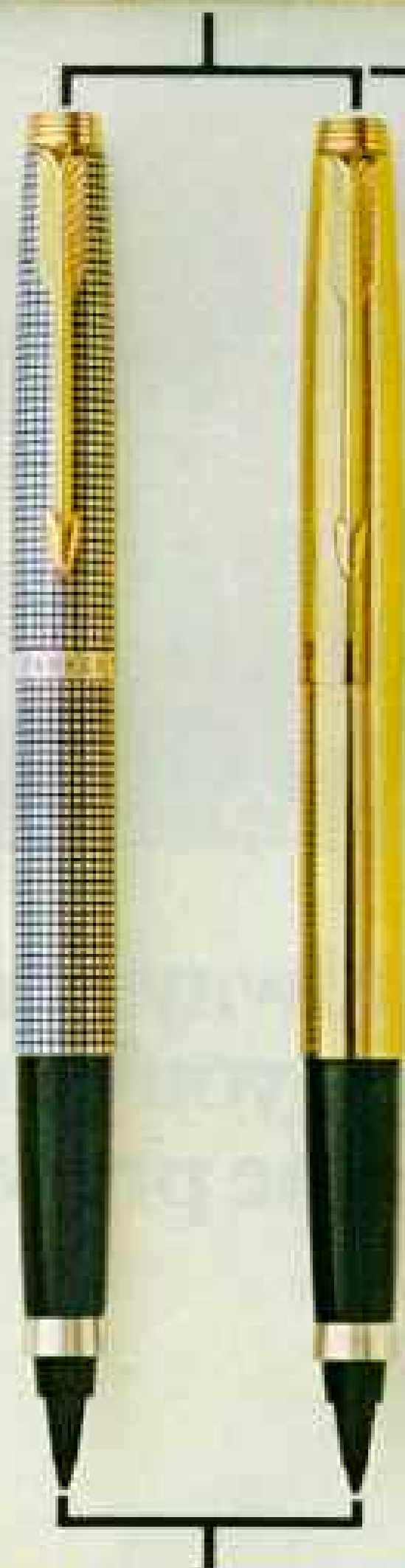
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3 Ask the Service Representative for a rundown on the specific rates and charges you can expect. Find out exactly what the regular monthly charges will be, and what the one-time-only payments are. Find out whether there are options in your area of paying on a monthly basis, or making a single one-time only payment, on certain items.

4 Are you going to be away from home for any extended period of time? A business office Service Representative can tell you, based on how long you plan to be away, whether you could save money by temporarily suspending your telephone service.

5 Moving to a new residence? Ask a Service Representative whether you are eligible for a credit on your bill if you take your present phones along with you to your new location.

6 If you've never had a phone in your name before, or have never established credit, you may be asked to pay a deposit when you order telephone service. But we don't like to keep deposits for long periods of time. In fact, if you establish good credit with us by paying on time, we'll return your deposit to you PLUS interest. Ask a Service Representative to explain the details which apply in your area.

7 If a coin phone swallows your money but doesn't give you your call, you're entitled to a refund. Find a phone that works, dial "Operator" and explain what happened. You'll get a refund in the mail. P.S. We'd appreciate it if you'd also tell the operator the telephone number and location of the phone that's out of order so we can get it fixed as soon as possible.

8 Reach a wrong number on a Long Distance call you just dialed? Don't just hang up. Ask for the area code and the number you reached in error. Then dial "Operator" and report what happened. The operator will have the charge removed.

9 Get a poor connection on a Long Distance call, or get cut off in the middle of your conversation? Don't just hang up and call back. The person who placed the call should report what happened to an operator. The operator will issue a credit for the time your call was interrupted.

10 Error on your bill, with a charge for a Long Distance call you didn't make? Call the business office. A Service Representative will arrange to get the charge removed.

11 Save on Long Distance charges by cutting down on person-to-person calls. It's true you may not be able to reach the person you want on your first try with a station-to-station call. But in many instances you can make two (or even three) out-of-state station-to-station calls for what it would cost you to make that one person-to-person call. This is particularly true if you dial your own calls instead of going through an operator.

12 Dialing your own out-of-state Long Distance calls is the least expensive way of all. If you don't know the number for a call you want to make to a distant city, you can obtain it at no charge to you by dialing the area code (when required) for that city, plus 555-1212, for Directory Assistance. Then dial direct and save. Save time

save money phone bill.

in the future by recording the number in your personal number book. A listing of all area codes can be found in the information pages at the front of your local telephone directory.

13 Make sure you know when dial-direct rates apply before you make your call. They apply on all out-of-state calls to anywhere in the United States (excluding Alaska) if they are completed from a residence or business phone without an operator's assistance. They also apply on calls placed with an operator from a residence or business phone when direct dialing facilities are not yet available.

14 But it's even more important to know the circumstances when direct-dial rates do NOT apply. They do not apply on person-to-person, hotel-guest, credit card or collect calls, or on calls charged to another number, because an operator must assist on such calls. Direct-dial rates do not apply on calls made from coin phones, even those from which you dial the complete number yourself before the operator comes on.

15 While operator-handled calls cost you more than those you dial yourself, there is one exception. If you run into equipment trouble completing a Long Distance call you're dialing yourself from a home or business phone, you're still eligible for the dial-direct rate even if you require an operator's assistance. Explain your problem to an operator. If you need help in getting the call through, or in making a satisfactory connection, confirm with the operator that it will be charged at the dial-direct rate.

16 Dial direct, but save even more by making your out-of-state Long Distance calls within the time periods when rates are lowest. The lower rates for out-of-state calls made in the evening, on the weekends or late at night are described for you in the call guide in the front of your local directory.

17 Don't get caught by surprise, or miss out on the money you can save on Long Distance calls you make within your state. The times when lower rates apply may be different than for your out-of-state calls. Check carefully in the call guide in the front of your local directory for a description of when to save on calls you make within your state.

18 If you're concerned about avoiding added charges on your Long Distance calls in general, don't guess how long you've been talking. Time yourself, so you can finish your call before overtime rates apply. To save even more time and money, jot down what you want to say before you dial.

19 Before you go ahead and place a Long Distance call to a business, check first to see if they have a toll-free number. You can recognize it because it has an 800 prefix instead of a regular area code. If they have one, it's usually displayed in their advertising, or you may find it listed in your own local telephone directory. If so, the call's on them, and you save.

20 The information pages at the front of your local telephone book are a good source for tips on how to place your calls and how to save time and money in using your telephone. Look in the book, and save.

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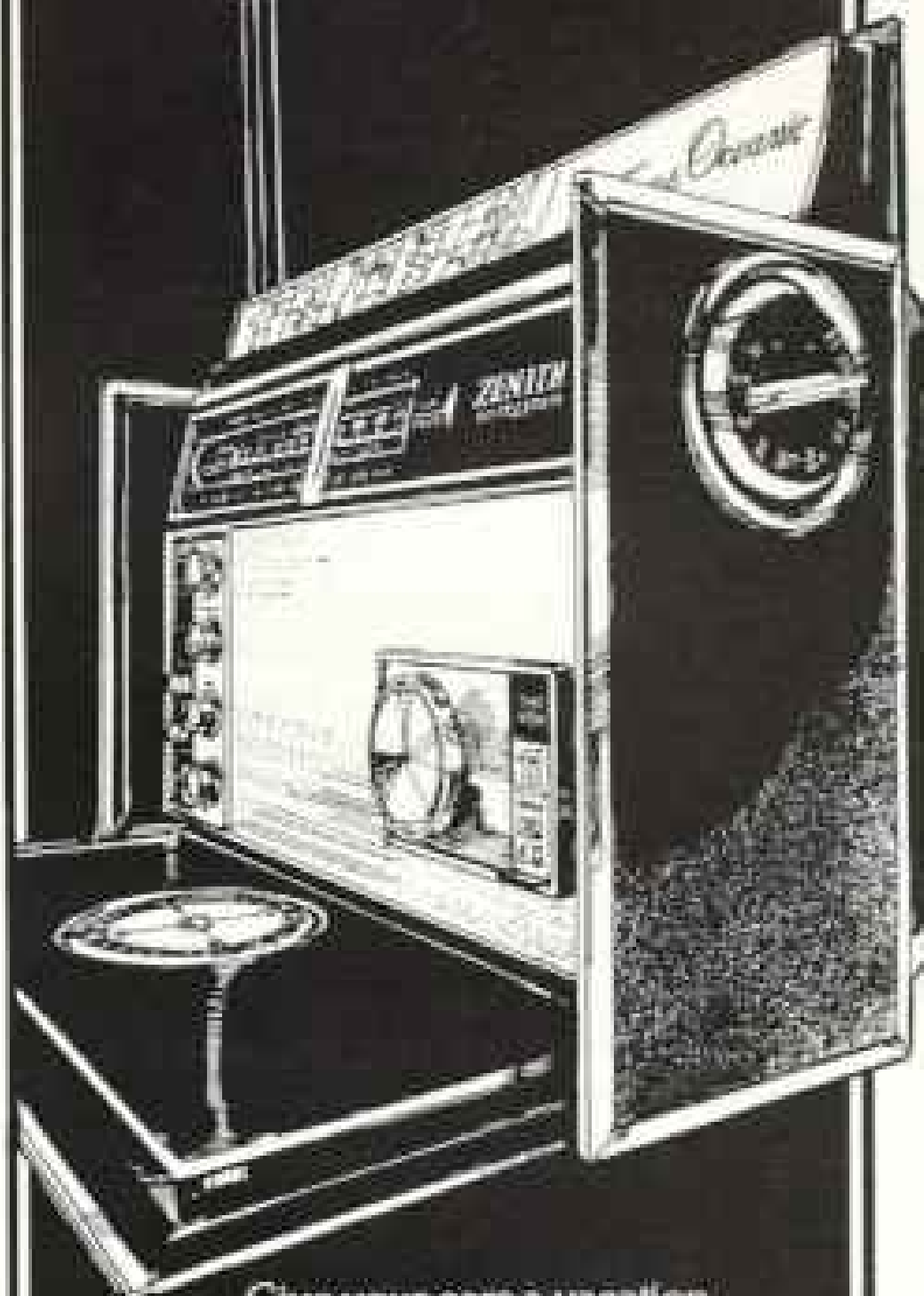
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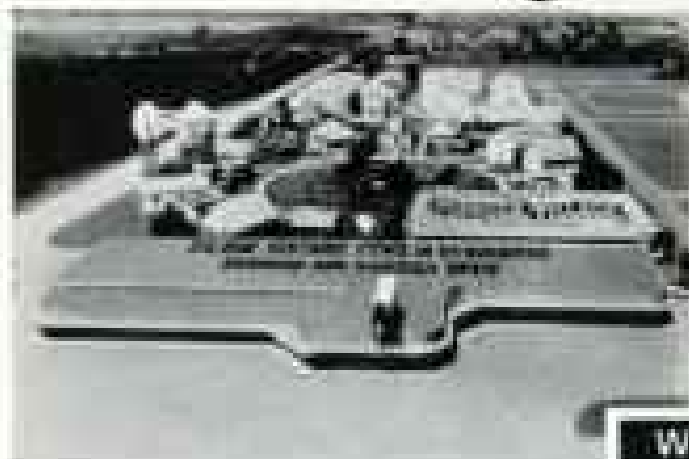
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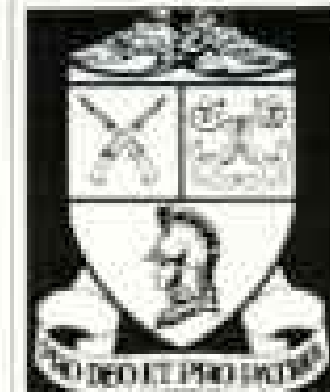
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In a city famous for its pretty girls, she's most beloved of all

Copenhagen's lovely Little Mermaid, perched gracefully on her rock at the harbor shore, was created in bronze by sculptor Edvard Eriksen. The fairy-tale heroine sent all of Copenhagen into mourning and nearly created an international furor when she was decapitated by vandals in 1964. Not until a new head was skillfully cast from the original 1913 mold and fitted to her slim figure was the city restored to its normal good appetite and spirits.

Copenhagen is indeed world famous for both food and fun. One Dane, a multimillionaire industrialist who commutes to work in his sailboat each day, told a NATIONAL GEOGRAPHIC staff writer that "if the warrior-bishop Absalon hadn't founded Copenhagen in the 12th century, the place would have been invented by Hans Christian Andersen or Walt Disney."

But a hard-working city it is, too. The Danes' centuries-old love affair with the sea has made Copenhagen a booming port. With its 25 miles of quays, its busy merchant fleet, and its great marine-engine and shipbuilding complex, it is first in Scandinavia.

Danish beer, meat, and dairy products whet

jaded appetites throughout the civilized world.

Danish craftsmen and designers, working in precious metals and rich teakwood, have become silversmiths and cabinet-makers to the world. Their clean, bold lines typify the best of 20th-century design.

But over all of this industry hover the lighthearted spirits of Hans Christian Andersen, immortal storyteller, and of good King Christian IV, 17th-century master-builder. From King Christian's vision came much of central Copenhagen's rich beauty—classic structures

with graceful arched doorways, elegant towers and spires soaring above wide plazas, and the Stock Exchange, with its fanciful tower formed by the entwined tails of four copper dragons.

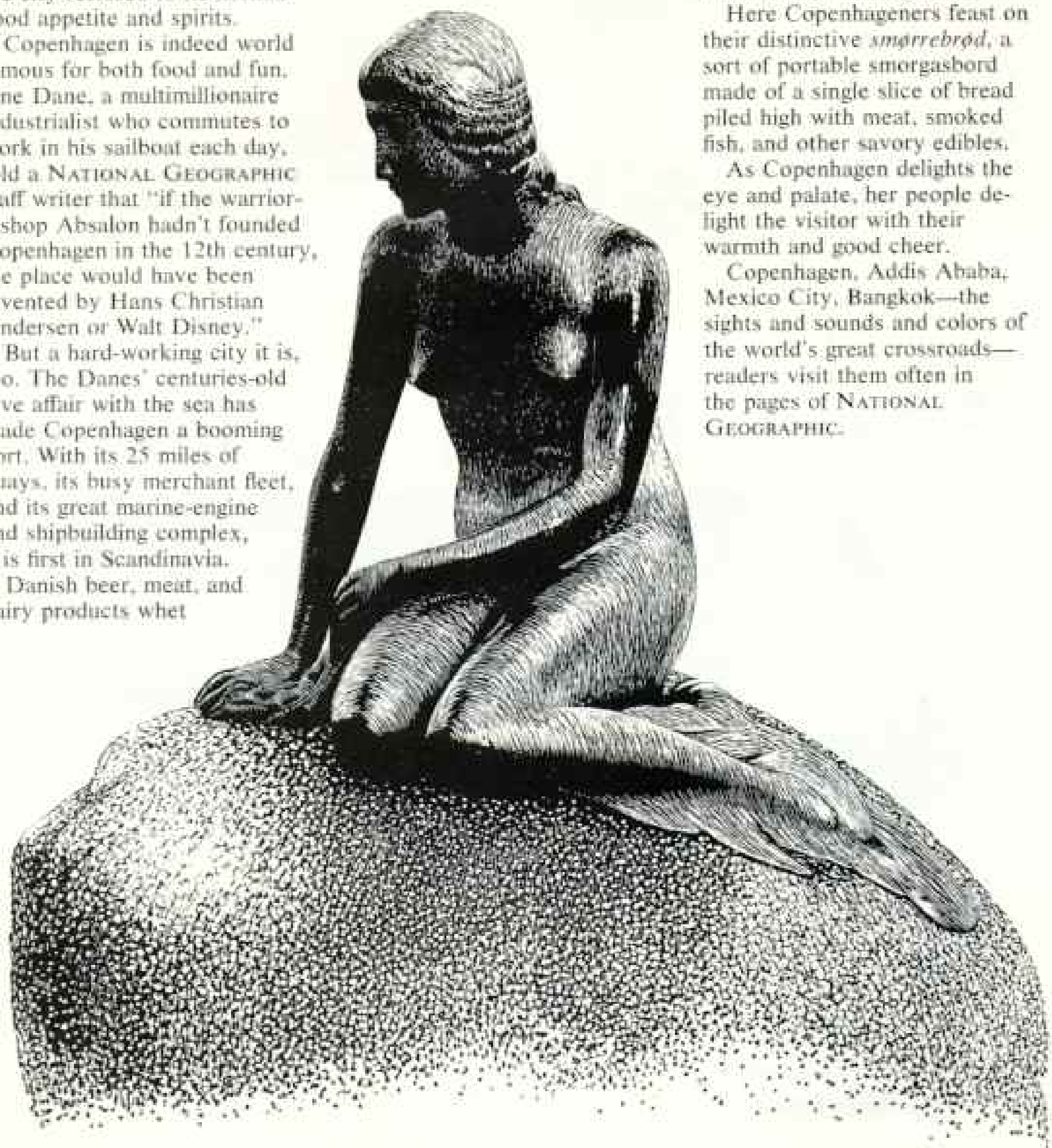
Tivoli, best known and very possibly best of Europe's amusement parks, is certainly in the spirit of the great king.

A glittering 20-acre fairyland of light, Tivoli is a mid-city magnet for gourmets and concert-goers, young or old, king or commoner. Its restaurants, theaters, concert halls, playgrounds, fun house, and fireworks displays have enchanted more than 150 million people in a century and a quarter.

Here Copenhageners feast on their distinctive *smørrebrød*, a sort of portable smorgasbord made of a single slice of bread piled high with meat, smoked fish, and other savory edibles.

As Copenhagen delights the eye and palate, her people delight the visitor with their warmth and good cheer.

Copenhagen, Addis Ababa, Mexico City, Bangkok—the sights and sounds and colors of the world's great crossroads—readers visit them often in the pages of NATIONAL GEOGRAPHIC.



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