

VOL. 154, NO. 5

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NATIONAL GEOGRAPHIC

**PILGRIMAGE
TO MECCA** 581

**YAKIMA, WASHINGTON'S
BOUNTIFUL VALLEY** 609

**NATURAL GAS—
HOW MUCH, HOW SOON?** 632

**WHERE THE RIVER
SHANNON FLOWS** 652

**MASTERWORK ON
THE MALL** 680

ART TREASURES OF DRESDEN 702

**FLASHLIGHT FISH OF
THE RED SEA** 719

NATIONAL GEOGRAPHIC

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IN THE NORTHERN LATITUDES the gold has gone out of the maples, and millions begin wondering where the snow shovel went and whether they have enough firewood stacked. Once again we are at the mercy of the elements—and once again the winter is further darkened by concern over energy supplies and prices.

This will be the sixth winter since the oil embargo and those long lines at the gasoline pumps. We have become conditioned to far higher gasoline prices, to home-heating and electricity bills inflated by soaring production costs passed along to the consumer, and to coalfield strikes that add fuel to the fire in only a figurative sense.

Meanwhile, despite the creation of a new Department of Energy, we have failed to come to grips with the problems. So many dollars have flown overseas to purchase oil that their value as international currency has been affected. The bright prospect of nuclear energy has been dimmed by the questions of radioactive-waste disposal and plant safety. And Congress has struggled for 18 months in search of a national energy policy, disagreeing chiefly over deregulation of natural gas.

In this issue, author Bryan Hodgson takes up the natural-gas industry, with surprising results. Expecting a shortage situation, Bryan traveled the country—and kept finding people who are finding gas, with promise of great quantities, and using unusual means to obtain that gas. A story of possible crisis became one of probable opportunity.

Bryan's article on natural gas follows others on oil, coal, wind power, solar power, and geothermal energy that have appeared in NATIONAL GEOGRAPHIC in the past few years. Still to come is science editor Kenneth F. Weaver's status report on nuclear power, literally the most explosive of all energy issues, surrounded by the most questions.

For Ken this is familiar ground. Six years ago he anticipated the energy problems of today and wrote a masterful summary, "The Search for Tomorrow's Power," which we published in November 1972.

We expect that our writers will be covering energy assignments for a long time to come. Since energy is a subject of great importance to every reader of this magazine, we intend to keep you informed.

Silbert Brown

Pilgrimage to Mecca 581

Fulfilling a basic Muslim duty, Islamic scholar Muhammad Abdul-Rauf joins the annual hajj to the spiritual center of one-fifth of earth's peoples. Photographs by Mehmet Biber.

Washington's Bountiful Yakima Valley 609

Migrant Mexicans and enterprising Indians help make this one of the world's richest agricultural regions, roamed by Mark Miller and photographer Sisse Brimberg.

Natural Gas: The Search Goes On 632

Trillions of cubic feet of yet untapped energy lies within the planet's crust. Bryan Hodgson and Lowell Georgia show unconventional new ways it is being unlocked.

Where the River Shannon Flows 652

Allan C. Fisher, Jr., and Adam Woolfit follow Ireland's longest stream from gentle lakes to wide Atlantic estuary.

Masterwork on the Mall 680

The National Gallery of Art's spectacular new building was born as a sketch on the back of an envelope. Director J. Carter Brown tells the story of architect I. M. Pei's double-triangle tour de force. Photographs by James A. Sugar.

Treasures of Dresden 702

Ravaged by war and fire storm, East Germany's "Florence on the Elbe" miraculously safeguarded a priceless trove of art. John Eliot and Victor R. Boswell, Jr., detail its wonders, some now on tour in the United States.

Flashlight Fish of the Red Sea 719

Zoologist Eugenie Clark and photographer David Doubilet dive by night to study the ethereal Photoblepharon—"eyelid of light."

COVER: *Pilgrims kneel before the Sacred Mosque at Mecca, goal of all Muslims at least once in their lives. Photograph by Mehmet Biber.*





pilgrimage to mecca

By MUHAMMAD ABDUL-RAUF, Ph.D.

DIRECTOR, THE ISLAMIC CENTER, WASHINGTON, D. C.

Photographs by MEHMET BIBER



"And proclaim unto mankind a pilgrimage." With this command from Allah to Abraham, later revealed to the Prophet Muhammad, one of the most remarkable religious phenomena in the world came into being: the hajj, or annual pilgrimage to Mecca. For more than 13 centuries, Muslims have journeyed to this sacred region in Arabia to pray (left) and to fulfill a lifetime duty of Islam. The Plain of Arafat blooms with believers as the multitude halts and bows toward Mecca for the midday prayer (overleaf).

*Here we come, O Allah, here we come!
Here we come. No partner have You.
Here we come! Praise indeed, and
blessings, are Yours—the Kingdom too!
No partner have You!*

THIS TALBIYAH, recited by more than a million Muslim pilgrims one recent December, marked the formal beginning of our pilgrimage. Etched in memory is the scene at the airport in Beirut, where we waited all night for our flight to Jidda in Saudi Arabia. My son Faisal and I, each clad in two pieces of seamless white cotton terry cloth, bareheaded and wearing sandals, and my daughter

Aisha, with only her face and hands exposed, were among hundreds similarly clad.

How spoiled we were! The thought of the African herdsman who had walked much of the way, and the Indonesian peasant who had invested his life savings in making this pilgrimage by sea, shamed us into thanking God for the ease with which we were performing our hajj.

At dawn we boarded: "First-class passengers, then tourist class. . . ." How awkward that there should be such a distinction on this journey. Trappings of class here were more a cause of embarrassment. I remembered savoring the feeling of equality on my first pilgrimage

25 years earlier, when I rode from Kuwait in the back of a truck.

Now in a state of *ihram* (restriction)—forbidden to clip our nails, cut our hair, hunt, argue, or engage in sexual activity—we were eager to join our brethren converging on Mecca from all over the world. There we would perform a major duty in our religion: the pilgrimage to the Kaaba, originally built, Muslims believe, for the worship of God by Abraham and his son Ishmael, ancestors of our Prophet Muhammad.

The annual pilgrimage, instituted by Abraham, was continued by succeeding Arab generations, for it brought wealth and prestige to Mecca. Pagan practices, however, were gradually introduced until the religion of Islam, with its dedication and submission to God, came in the seventh century A.D., restored the hajj to its purity, and made it a deeply spiritual journey.

IN TWO HOURS we were in Jidda, and by late morning we began the 45-mile drive to Mecca. Busloads of pilgrims were around us, and what a variety of features—Oriental, Negroid, Caucasian, and all the blends brought by generations of intermarriage.

On the way we stopped at the Mosque of Hudaybiyah, site of a treaty marking the political turning point of Islam in its battle for survival in the seventh century. Here Muhammad concluded a truce with the Quraysh, the polytheistic inhabitants of Mecca among whom he was reared and to whom he first delivered his message: God is One.

The Quraysh had responded with unrelenting persecution, forcing Muhammad to emigrate from Mecca—the Hegira, A.D. 622, which begins the Muslim era.* The treaty halted the battles waged against the Prophet and his new town, Medina, more than 200 miles north, allowing him and his community to practice their faith in peace.

Continuing on our way, we passed a white pillar that marked our entry into the sacred territory, a circle around Mecca in which no wild animal may be hunted. Chanting the talbiyah, our excitement mounting, we came to the city's outskirts. In

*Thomas J. Abercrombie examined Islam and its world in "The Sword and the Sermon" in the July 1972 NATIONAL GEOGRAPHIC.

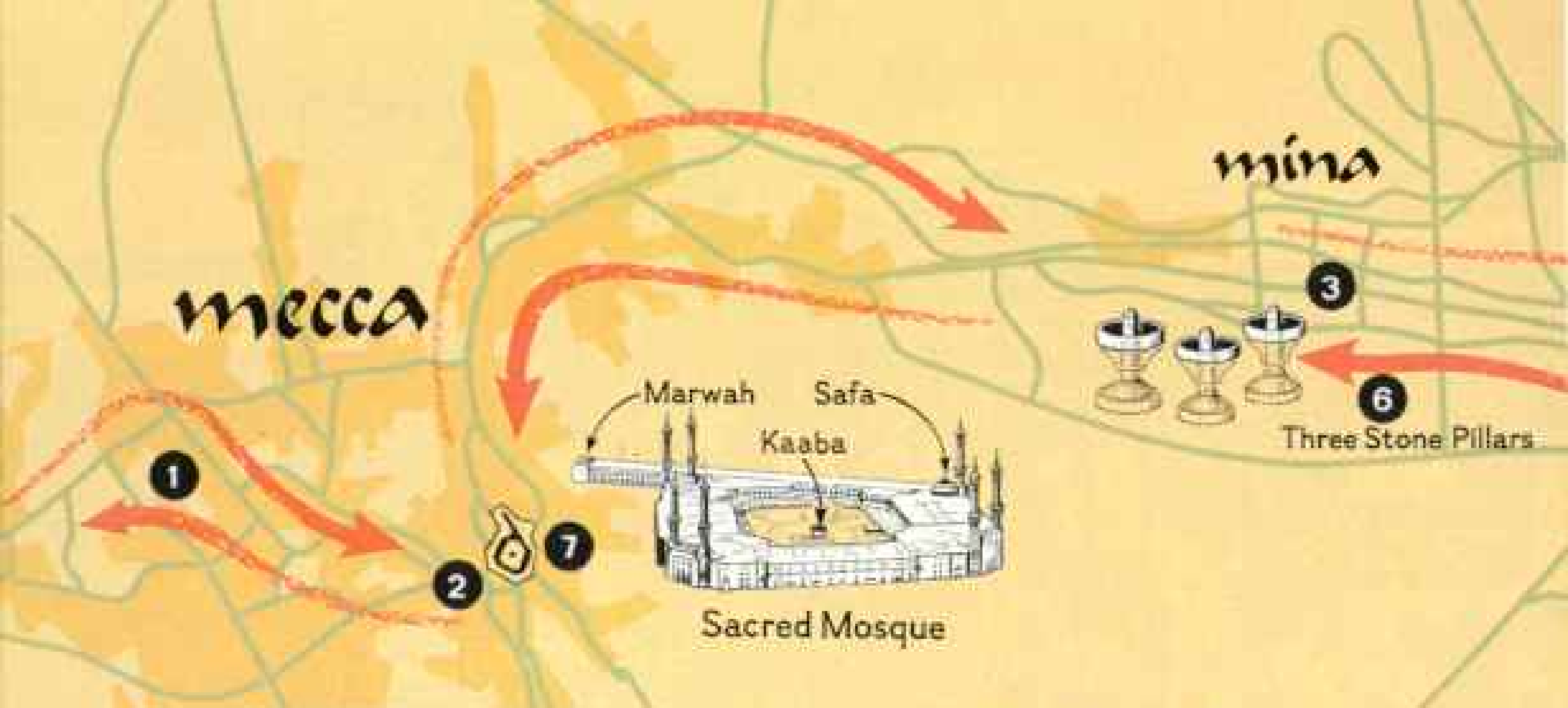


Swelling the tide of believers, another plane-load of pilgrims arrives at Jidda, 45 miles from Mecca. Last year 1.6 million Muslims made the pilgrimage, many



MOHAMMED AMIN

having invested their life's savings to take the holy trip. Before arriving in Mecca, pilgrims don the simple *ihram* costume: Men dress in two pieces of unsewn white cloth; women wear simple gowns and keep their faces unveiled. The humble garb signifies that whatever their station in life, all Muslims are equal in the eyes of Allah.



pilgrims' progress:

1 Before entering Mecca—open only to Muslims—pilgrims don the garments of ihram and are forbidden to hunt, argue, cut their hair or nails, or engage in sexual relations. **2** At the Sacred Mosque, pilgrims make a greeting *tawaf*—circling the Kaaba seven times. They then perform the *sa'y*—making seven trips between

one of these buildings the *kiswa*, the embroidered black cloth covering the Kaaba, is made anew each year.

Finally we were in Mecca, Islam's holiest city, crowding a barren valley walled by harsh hills (pages 586-7). Accompanied by Adeb Tilmissan, a courteous young Saudi student assigned to us by our host, the Muslim World League, we drove through teeming shop-lined streets to the Sacred Mosque to perform the *tawaf*, the prescribed seven counterclockwise circumambulations of the Kaaba. Entering through the Gate of Peace, we were met by a hum of chanting. In the middle of the mosque's large open court our eyes fell on the Kaaba, majestically towering over a sea of humanity.

It is impossible for any pilgrim to forget that first sight of the black-draped shrine. Five times daily in our prayers, from whatever part of the world we are in, we face toward the Kaaba, longing for the moment we can cast our eyes on it and touch it.

Each pilgrim reacts to seeing the Kaaba in his own way. In my first experience I became suddenly dazed. My wife clung to my arm, trembling and sobbing. This time my

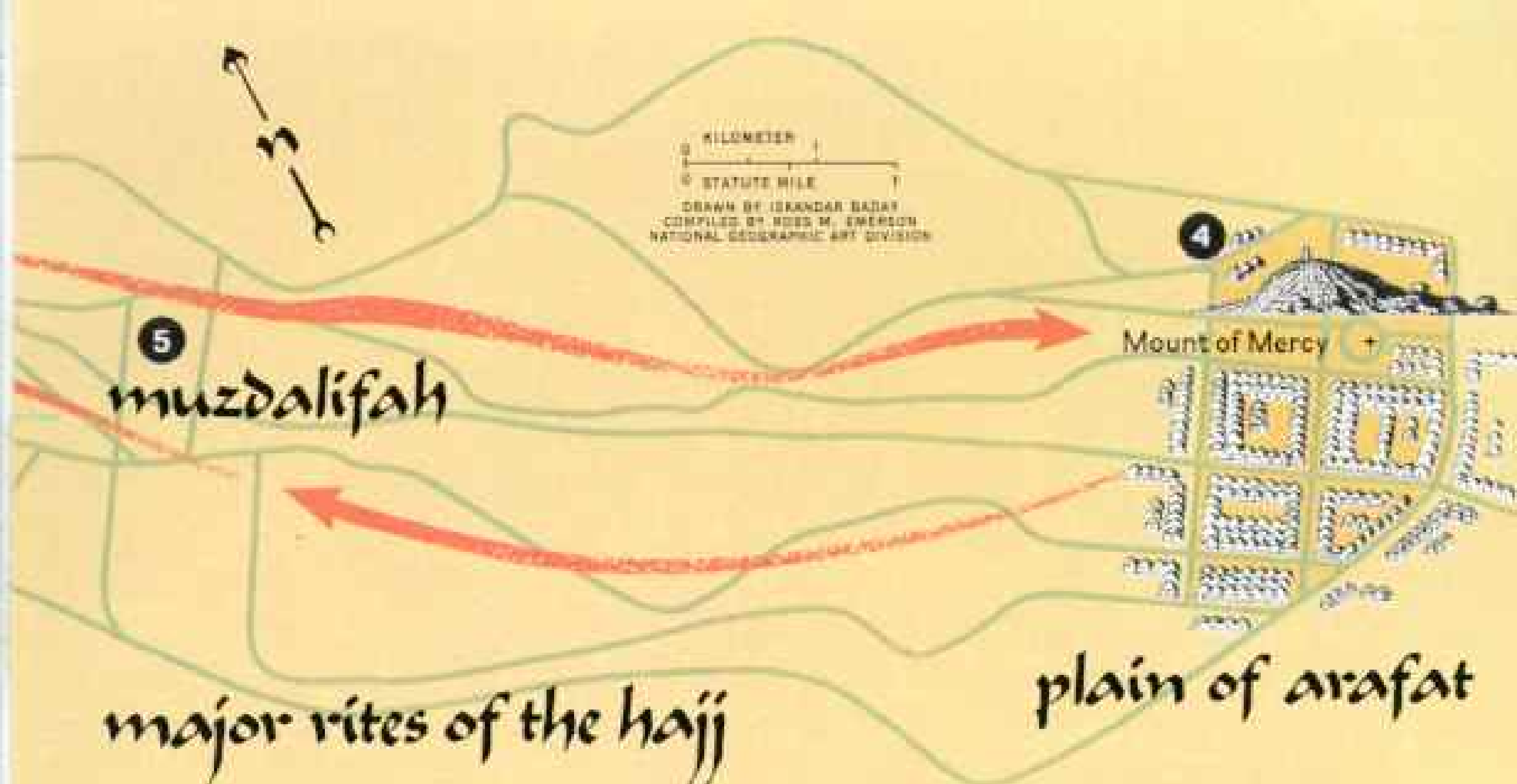
daughter shuddered as if an electric current had shot through her, and my son was speechless. He later told me he was struck by deep feelings of sweet tranquillity.

Caught up in the ecstasy of devotion around us, we recited together:

O Lord! Grant this house greater honor, veneration, and awe; and grant those who venerate it and make pilgrimage to it peace and forgiveness. O Lord! Thou art the peace. Peace is from Thee. So greet us [on the Day of Judgment] with the greeting of peace.



WHY THIS VENERATION of a stark cubelike building of gray stone? It is not a striking piece of art, nor is it adorned with precious stones. And no Muslim endows it with power to benefit or to hurt. The Kaaba is the House of God, dedicated to His worship by Abraham. Near it the Prophet Muhammad was born about A.D. 570. Forty years later the archangel Gabriel descended with the revelation of the truth—that there is but one God—calling Muhammad to cleanse the Kaaba of idols.



major rites of the hajj

the hills of Safa and Marwah, enclosed in a long gallery. **3** On the eighth day of *Dhu'l-Hijjah*, the twelfth and final month of the Muslim lunar calendar, pilgrims move to Mina for the essential final days of the hajj. **4** Next morning they travel to Arafat for the pilgrimage's central ritual: the "standing." From noon until sunset

Muslims pray near the site of Muhammad's farewell sermon. **5** At sundown they go to Muzdalifah for the night. **6** Returning to Mina for three days, pilgrims stone three pillars representing the devil. The sacrifice of animals and a post-Arafat tawaf complete the hajj. **7** Before leaving Mecca, pilgrims again circle the Kaaba.

And here, eight years after his emigration from Mecca, the Prophet triumphantly yet humbly returned to see those idols toppled at his beckoning and the purified Kaaba rededicated to the worship of the one God.

We plowed through the crowded court toward the Black Stone. This sacred rock, 12 inches in diameter, is set in silver in the east corner of the Kaaba (page 592). The only remaining relic from the original building of Abraham, it is the starting and end point of the tawaf. Pilgrims are eager to touch or kiss it, as if it represents the right hand of God, with whom they are renewing their covenant. Reading the golden Koranic lettering embroidered on the Kaaba's black cover reminds us of its original builders, Abraham and Ishmael, and their prayers to God to raise from that area a messenger of peace, learning, and wisdom.

At last we came close, but the crowd was too thick for us to touch the stone, except Aisha, aided by the police officer in charge. Swept along by the human tide, we kept chanting prayers, struggling to touch the stone or the Kaaba whenever possible.

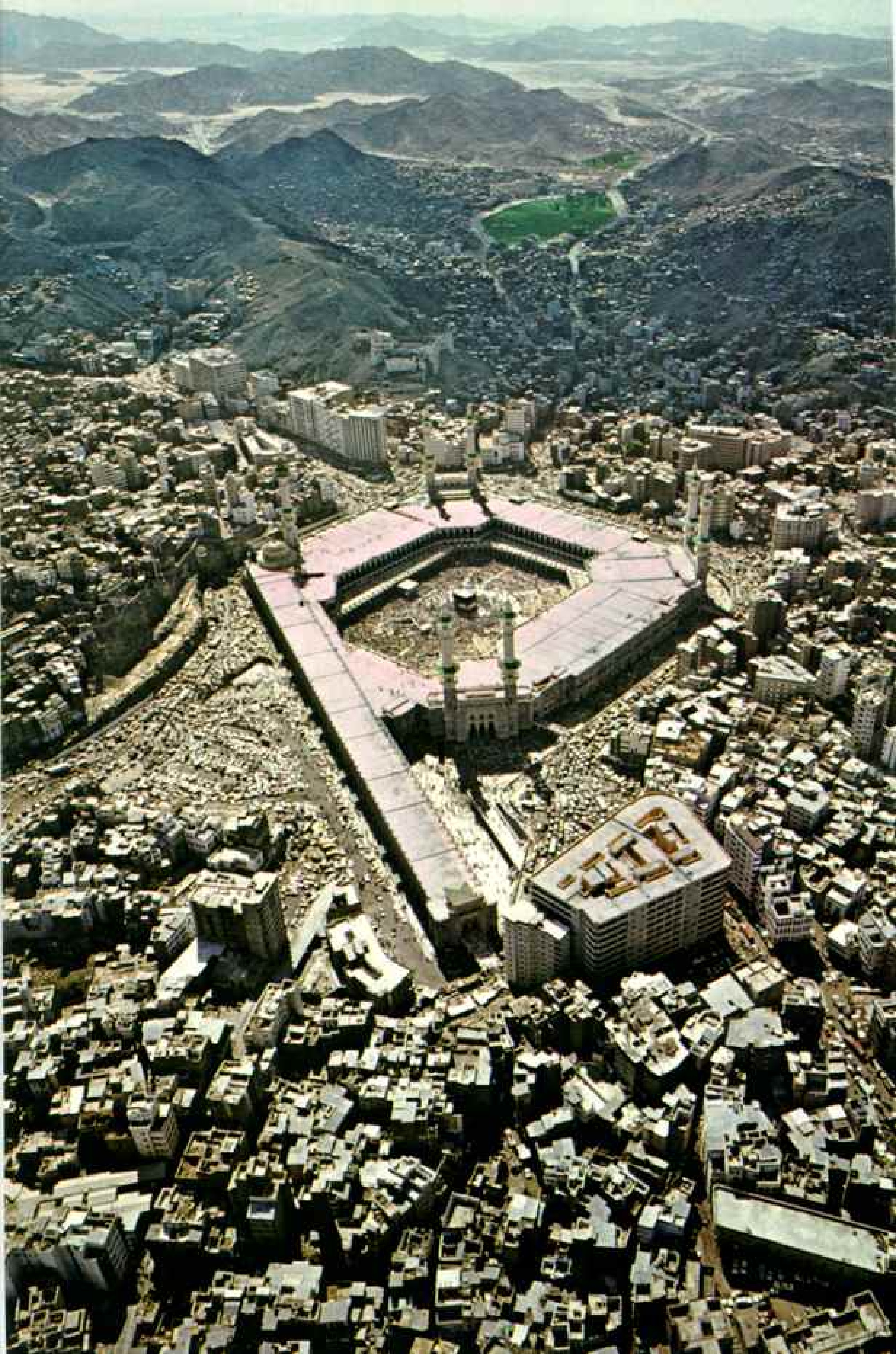
Coming opposite the Black Stone on each

circuit, we raised our right hands to it and recited: "In the name of God; God is most great!" The Kaaba loomed over us as if it were an ear of God absorbing the earnest prayers of His human creatures. Like subjects appealing for their sovereign's favors at the foot of his throne, we circled our Lord's House, shedding tears, seeking blessings and mercy, and yearning for His company in paradise.

On completing the tawaf rituals, we went to drink from the Well of Zamzam, with its rich mineral water with which Ishmael and Muhammad had quenched their thirst.

Ishmael and his mother, Hagar, the tradition goes, were left alone in a desolate valley by Abraham with only some dates and water, which were soon exhausted. Seeing her infant writhing with thirst, Hagar desperately searched everywhere for water. She had asked the departing Abraham, "Has your Lord instructed you to leave us here alone?" When Abraham answered affirmatively, she said, "Then God will not abandon us."

God did not abandon them. Zamzam was revealed to them, and beside it Abraham



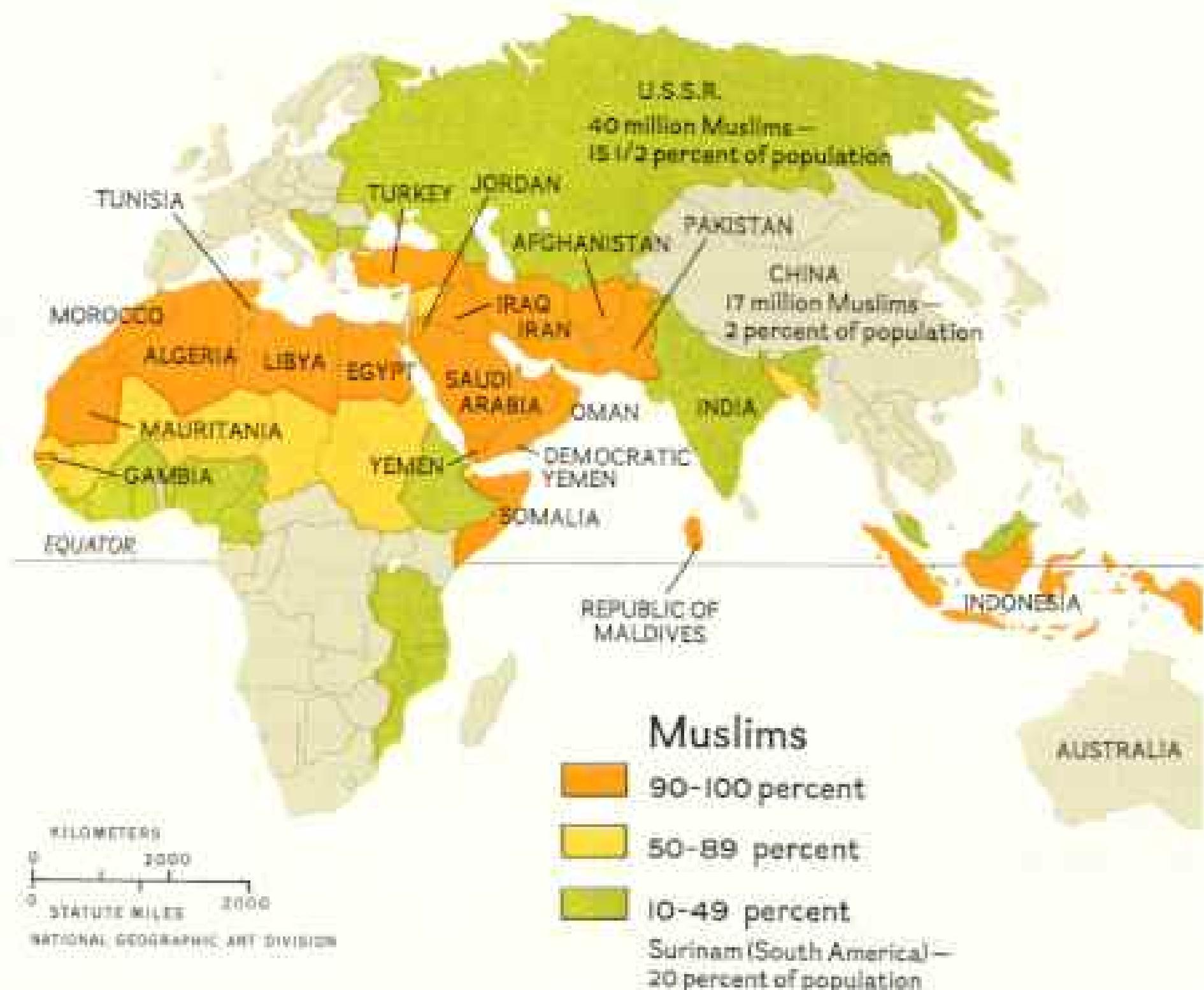
CENTERPIECE of the Muslim world, the Sacred Mosque at Mecca (left) burgeons with life at the height of the pilgrimage season. Situated in an arid valley near the birthplace of Muhammad, the revered mosque, al-Masjid al-Haram, features seven minarets. At its center stands a 50-foot-high, cubelike stone structure called the Kaaba, which, according to Islamic tradition, is the shrine erected to God by Abraham. Some 800 million Muslims—a fifth of mankind—turn toward this structure five times each day in prayer. The world's second largest religion, after Christianity, Islam is the dominant belief in some forty nations, all of them in Asia and Africa (below).

The 70-day pilgrimage season in 1978 climaxes November 8 to 14, when most of the important hajj rites take place. The hajj season advances 11 days annually because the Muslim lunar calendar has only 354 days.

Arriving pilgrims employ *mutawwifs*, or guides (right), who handle passports, arrange transportation and housing, and lead the faithful through the series of rites.



RIGHT BY MOHAMED AMIN



and Ishmael in time built the House of God, and the town of Mecca grew up around it.

After the greeting tawaf, performed on arrival in Mecca at any time of the year, pilgrims proceed to the ceremony of the sa'y, making seven trips between the hills of Safa and Marwah, now inside the mosque. This ritual reenacts Hagar's search for water before she was led by an angel to Zamzam. During the seven journeys of the sa'y, a pilgrim recites prayers, his heart closely in communion with God.



WHETHER they arrive early or late during the 70-day pilgrimage season (which begins annually with the start of the tenth month of the Muslim lunar calendar), pilgrims spend the eve of the ninth day of the twelfth month in the village of Mina, four miles east of Mecca. Following the practice of the Prophet, they rest there before the day of the "standing." During this high point of all hajj rituals, pilgrims stand on the Plain of Arafat and pray from noon until sundown.

By the time of our arrival Mina had become a crowded tent city (pages 598-9). After dawn prayers, we joined the rush of one-way traffic flowing to the Plain of Arafat, eight miles farther east, greeted by the bright colors of sunrise.

Pilgrims crammed cars, buses, and trucks and rode on the backs of camels and donkeys. Often those on foot seemed to make the fastest passage. By noon all would make it to the hot desert plain, all clad in the same simple attire, rulers and subjects, rich and poor, men and women, black and white.

It was a scene to last in memory: a million and a half people assembled for the day on this barren, rocky plain (page 594-5), leaving all wealth and fame behind, praying for salvation and for our brethren's deliverance. Thus we reinforced the sense of equality before the Lord and reminded ourselves of the day to come when all will be raised and gathered for accountability, leading to eternal bliss or affliction.

Some pilgrims climbed to the spot where the Prophet, from the back of his camel, delivered his farewell sermon. In it he reiterated some of the basic teachings of Islam and bore witness to his companions that he had

given his message and fulfilled his burden of prophethood. Three months later, in Medina, A.D. 632, he died.

Shortly after sunset the reverse rush toward Mecca began. On the way back to Mina pilgrims halt for the night at Muzdalifah. There they offer prayers, as the Prophet did. And there they collect pebbles to throw at the three "Satan's stoning points" in Mina during the following days. These pillars symbolize the forces of evil, and casting stones at them symbolizes our lifelong struggle against evil (pages 600-601).

On the tenth day of the month pilgrims celebrate the 'Id al-Adha (Festival of Sacrifice)—which marks the end of the pilgrimage season—by sacrificing an animal, thus commemorating Ishmael's deliverance.

We drove from Muzdalifah to Mecca soon after midnight, halting briefly at Mina for the first part of the stone-throwing ceremony. Then we returned to the Sacred Mosque to perform the post-Arafat tawaf in the same way we had made the greeting tawaf, followed by the sa'y ceremony. Then each of us had a lock of hair clipped, symbolizing the end of ihram.

Afterward we could have returned to our room, had a shower, and resumed our regular clothes, but we decided to stay in the Sacred Mosque until dawn, then join the 'Id prayer congregation.

We stationed ourselves on the balcony overlooking the Kaaba as throngs began to fill the vast court of the Sacred Mosque. I sat by the railing, reciting the Koran as the rapidly increasing crowd of pilgrims flowed under the bluish glow of light. I could not discern faces or heads, only a sea of human waves revolving around the gracefully draped House of God.

Hypnotized by the scene, my mind floated over the immense influence of the humble man behind this spiritual fervor, whose teaching has molded the daily lives of these multitudes, giving them spiritual and moral guidance, certainty, and comfort and drawing them here from all corners of the globe.

I pictured the Prophet kneeling in prayer inside the Kaaba, cleared of the idols that had desecrated it. I felt as if my eyes penetrated those very walls before me, surveying the empty expanse within, gold-and-silver lamps hanging from a ceiling resting on

three wooden columns. Would that I had the privilege of praying under that roof, prostrating myself on that marble floor. Only on rare occasions is the Kaaba opened, notably for its ceremonial washing, which is attended annually by the king of Saudi Arabia himself (page 592).

What is it that impels the Muslim to make this journey involving great sacrifice, hardship, and cost, yet doing so ardently and lovingly? What meaning do the rituals have?

We each carry within our hearts a divine element. Torn from the womb of existence and ushered, crying, into this world, we spend all our energies in the pursuit of a state of happiness. This restless, incessant drive is no more than that divine element within us seeking its origin.

The joy of Islam lies in its recognition and fulfillment of man's various needs. Unburdened by and innocent of the sin of any other, we are encouraged to pursue our material, emotional, and intellectual urges and are rewarded by God for fulfilling them. Yet we must not forget our origin, God our Creator, unto whom will be our return. Toward this end we perform ritual obligations called the Five Pillars of Islam: belief, prayer, almsgiving, fasting, pilgrimage.

These embrace the recitation of *shahadah*, confirming our belief in God and His angels; in resurrection for final judgment; in God's messengers, beginning with Adam and concluding with Muhammad; and in His sacred books, including the Torah, the Psalms, the Gospel, and the Koran, the word of God revealed to Muhammad through the archangel Gabriel.

They also include prayers five times daily in which we face the Kaaba wherever we may be and, without intermediary, pray directly to God, kneeling and prostrating in humility; the giving of alms, 2½ percent of our income and savings, as an expression of sympathy to the poor and a sharing in God's blessings; fasting during Ramadan, the ninth month of the lunar calendar; and making this pilgrimage in which the Kaaba, focal point of Islam and symbol of our unity, becomes immediate and touchable.

In these common beliefs and observances, simple and clear, a Muslim feels united with his brethren in faith, now more than three-quarters of a billion worldwide.

He is also conscious of a common religious heritage with Judaism and Christianity, the other great monotheistic faiths that rose amid the deserts of the Middle East. For to a Muslim, Islam is God's revelation made to Adam and Noah; the religion revealed to Abraham and Moses; the religion of David and the Prophets of Israel, and of Jesus and the Twelve Apostles. For the final time, in its purity, the true religion was revealed to the Prophet Muhammad.

A Muslim yearns to escape, at least once in a lifetime, from the conflicts and vagaries of daily life to the birthplace of his Prophet and the House of his Lord. There he seeks, with his brethren, spiritual nourishment and deliverance. The pilgrimage symbolizes the return to our origin. We taste the joy of this return, and that drive within our hearts is somewhat contented and fulfilled.

DIVINE wisdom selected the arid region of Mecca, stripped of all botanic luxuriance, purely as a focus of faith. God commanded Abraham to take his infant son Ishmael and leave him with his mother in this desert valley. On a later visit, the Koran tells us, Abraham was commanded to sacrifice him, and here Ishmael was saved at the last moment, a sacrificial ram being substituted. Here Abraham and Ishmael raised the first Kaaba. The rituals of pilgrimage recall these events, and the austerity of this site underlies its sacredness.

We cannot go on pilgrimage and expect to enjoy a comfortable vacation, pleasant scenery, good food, and entertainment. We are never far from God wherever we may be. But God chose this point purely for His worship, and we are excited to have transported ourselves to this point purely for His sake.

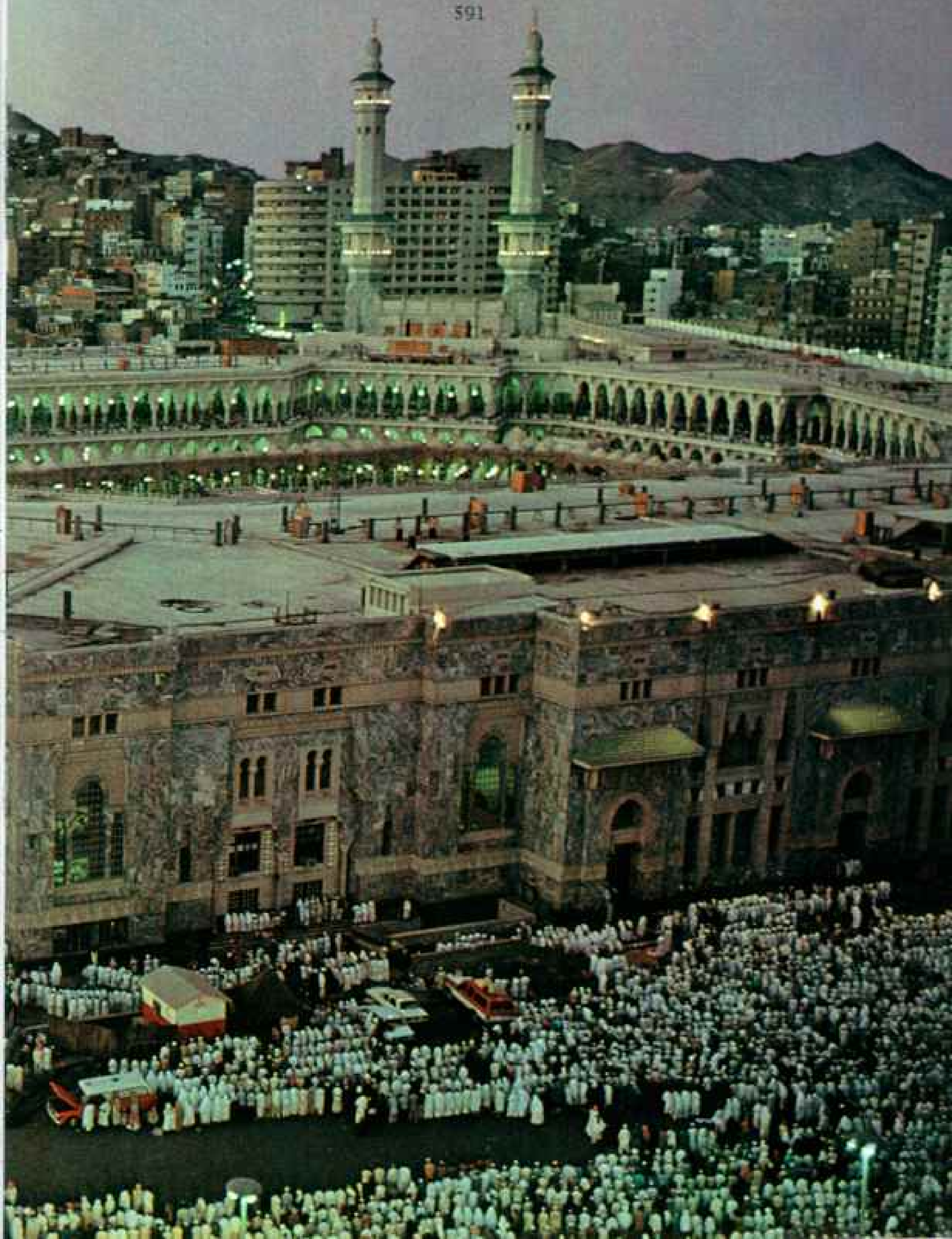
Soon there was no more space in the mosque. "*Allahu akbar!*—God is most great!"—came the call to prayer. The flow around the Kaaba ebbed to a stop. The human particles formed concentric circles around it, and the hum of chanting melted into silence. All I could hear was the distinct voice of the imam leading the dawn prayer, the rustle of clothes as we performed our prostrations, and the echo in my heart:

"O God! Let this not be the last time we pray before the Kaaba!" * * *



"ALLAHU AKBAR! – God is most great!" – rings the muezzin's call. Pilgrims cluster at the Gate of King Abdul-Aziz al-Saud, named for the tribal leader who founded modern Saudi Arabia in 1932.

591



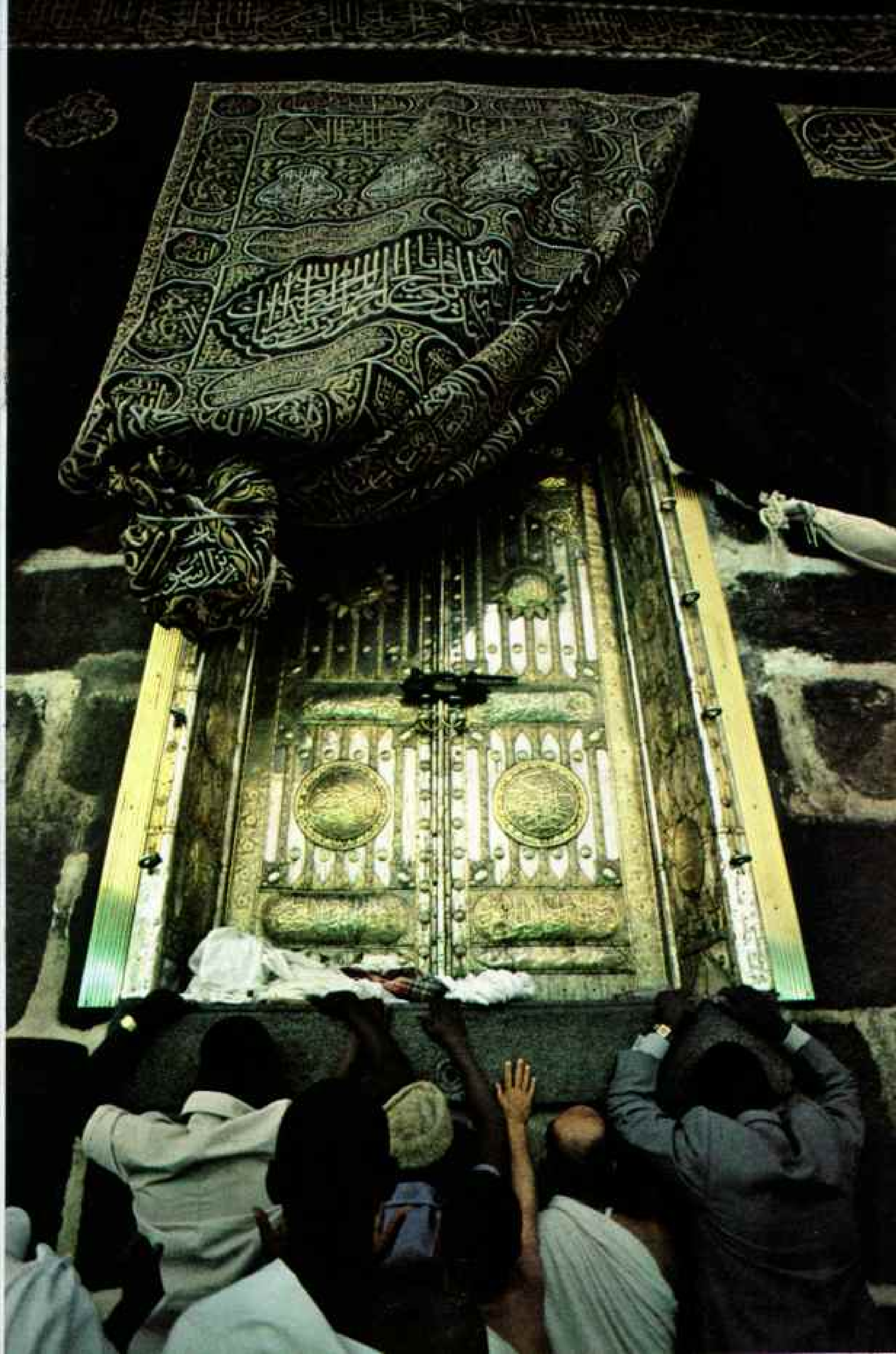


OPENING HIS HEART to Allah, King Khalid of Saudi Arabia (below, center) prays before the ceremony of washing the Kaaba's interior. The shrine's gold-and-silver door (facing page) is opened annually for the event during the hajj season. Ministers and bodyguards stay near. Muslim dignitaries take this opportunity to perform a tawaf and kiss the Black Stone (right), encased in silver. Embedded in a corner of the Kaaba, the Black Stone is believed to be the only extant piece of Abraham's original shrine. The Kaaba itself has remained empty since A. D. 630, when Muhammad cleansed it of idols and reaffirmed Islam as a one-God faith.



MOHAMED AMIN (ELOWE)





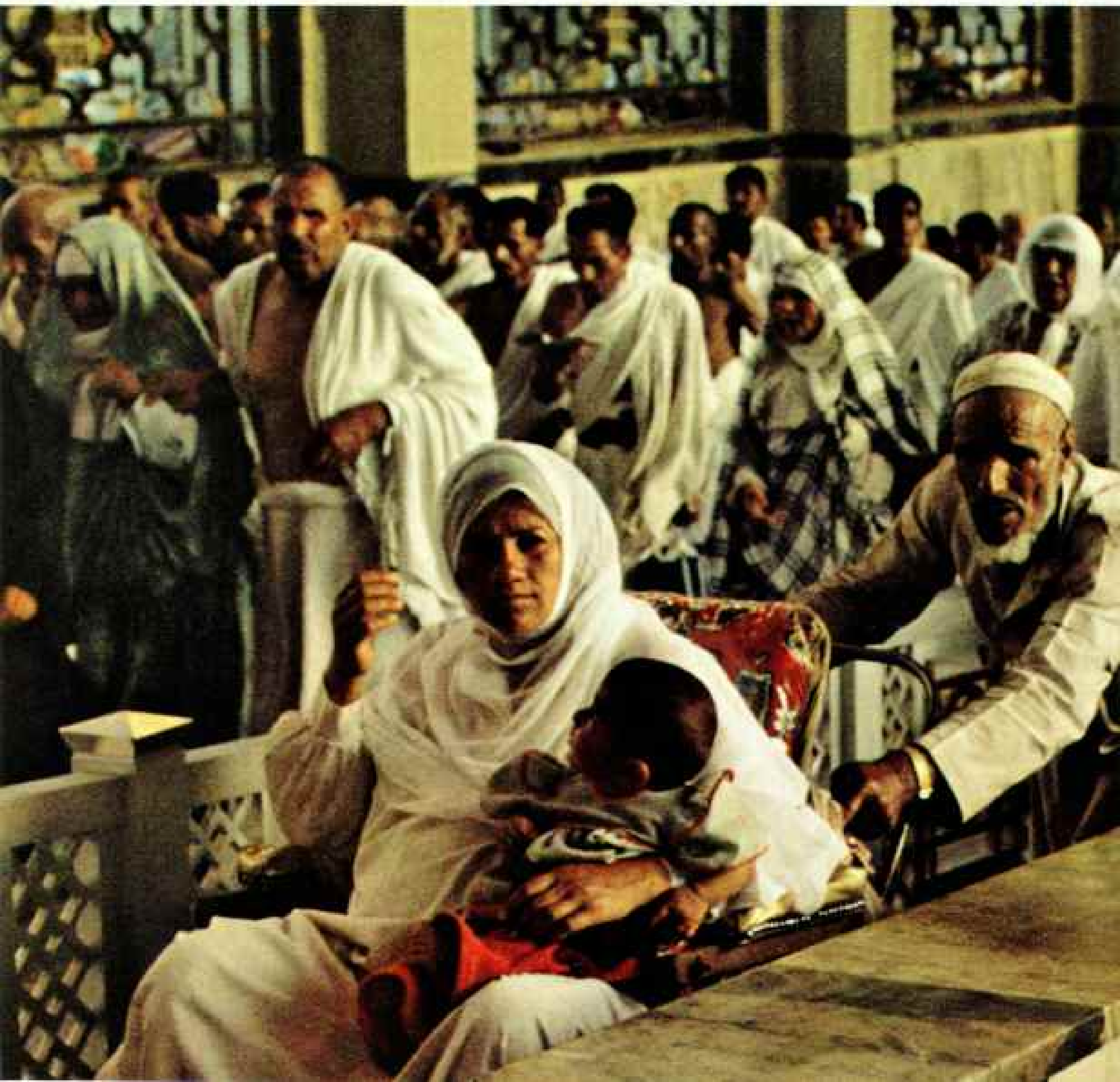




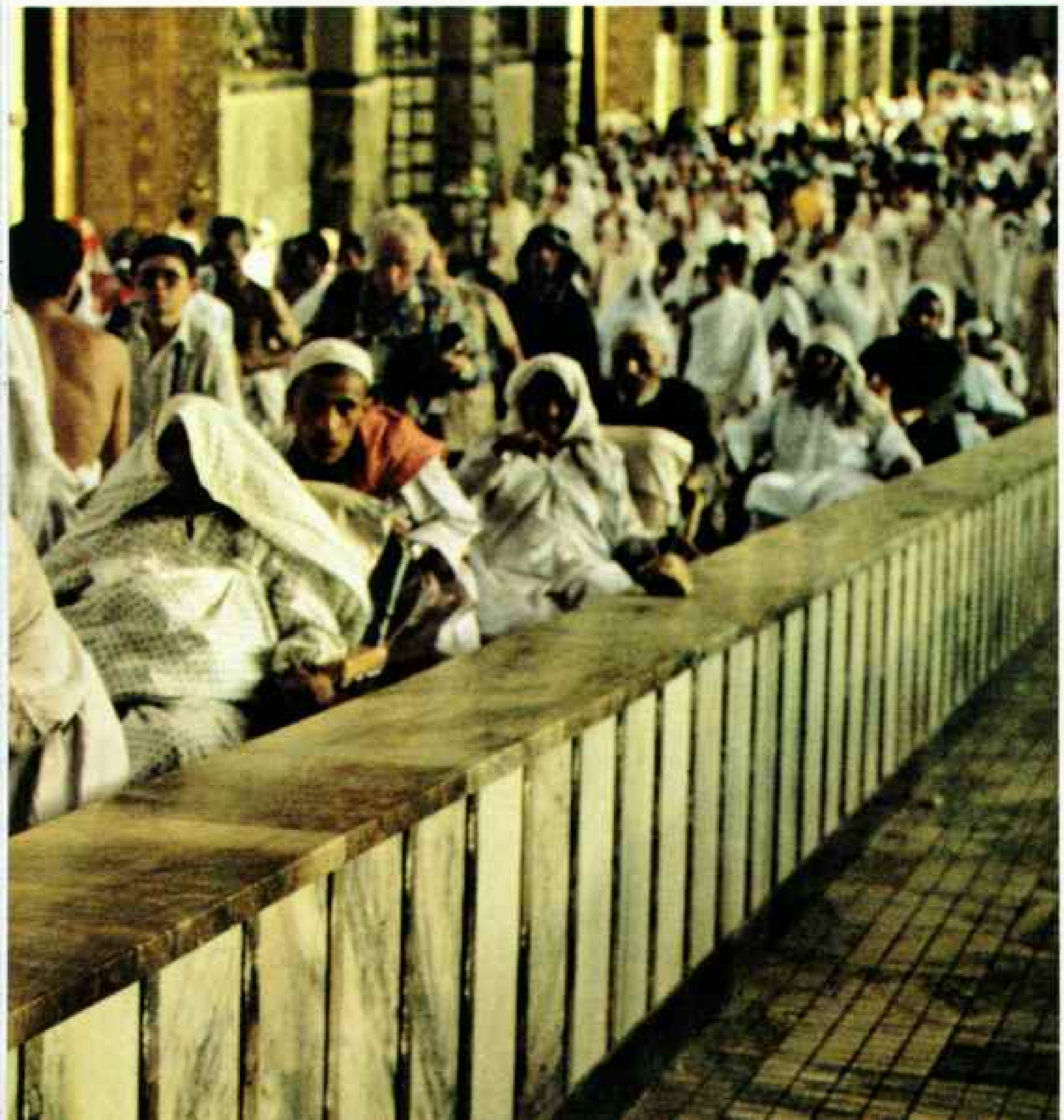
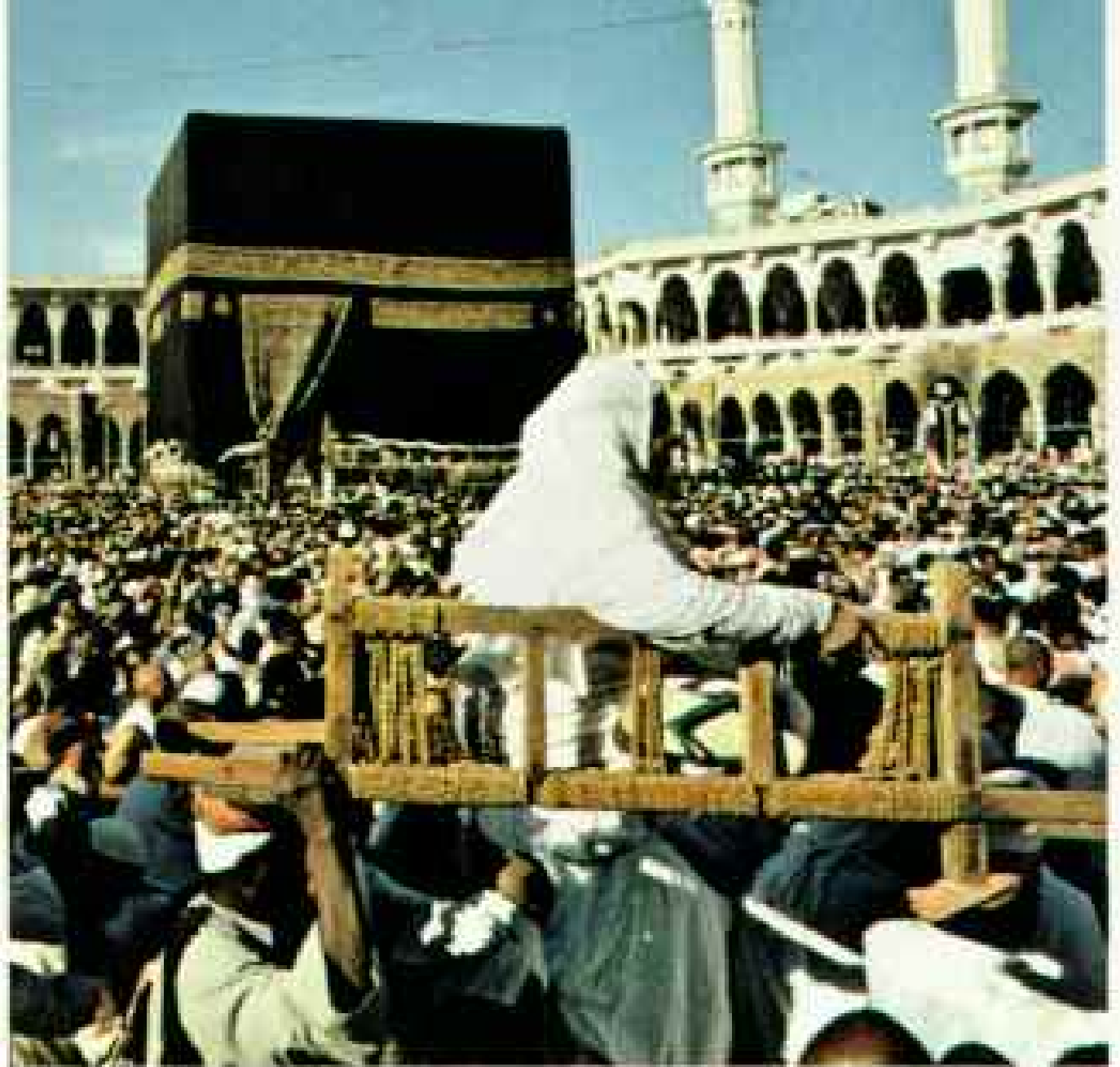
MUHAMMAD AMIN (LEFT)

CHORUS OF PRAYERS recited by more than a million voices fills the air over the Plain of Arafat (left). Crowding into an immense city of tents, 12 miles east of Mecca, the throng gathers to perform the *wuquf*, or the "standing." From noon until sundown on the ninth day of the final hajj month, Muslims converge on the Mount of Mercy, center, where, standing under the scorching sun, they pray and recite verses of the Koran (above), hoping that their sins will be forgiven. If this all-important ritual is missed, a pilgrim fails to complete his hajj. It was on the Mount of Mercy that Muhammad delivered his farewell sermon in A.D. 632, confirming the rules of pilgrimage and imparting the last of his revelations:

This day have I . . . completed my favor upon you, and have chosen for you Islam as your religion.



THE FLOW of humanity rarely ceases inside the Sacred Mosque as pilgrims exercise body and soul during hajj rites. As believers circle the Kaaba seven times, the old and crippled are borne on litters (right). Pilgrims next perform the sa'y, reenacting the search for water by Hagar, mother of Abraham's oldest son, Ishmael. Seven times pilgrims stream between the hills of Safa and Marwah (left); a passage is open for those unable to walk (below). The Kaaba was built beside the Well of Zamzam, which, in Muslim tradition, was revealed to Hagar by an angel.







A VILLAGE becomes a city as thousands upon thousands of pilgrims pour into Mina (left) for the stoning of the "devil" pillars. Once the gathering place for desert tribes, Mina today exists almost solely for the hajj. The multitude spends three nights here after arriving from Arafat, eight miles to the east. For the rest of the year Mina is left mainly to caretakers. During the crush, accommodations can cost more than a hundred dollars a night. Most of the pilgrims pitch tents on the barren hills or curl up in blankets and prayer rugs on the dusty streets.

Faced with a sevenfold increase in foreign pilgrims since 1950, the oil-rich Saudi Government has embarked on a massive building program. More than a hundred million dollars went into enlarging the Sacred Mosque. New multilane roads link Mecca and Arafat; a new airport has been built in Jidda. By scanning a bank of recently installed closed-circuit televisions (above), a Saudi soldier can monitor the crowds and call in helicopters for traffic or ambulance duties. Other cameras televise the hajj events via satellite to more than forty countries; on radio the prayers go out in seven tongues.



SATAN IS THE TARGET when pilgrims flood the streets of Mina for the stoning of the pillars (above). According to Islamic tradition, Abraham was ordered by Allah to sacrifice his son Ishmael (not, Muslims say, the younger son, Isaac, as the Bible relates it). Thrice Satan tempted the boy to flee and Abraham to desist, and each time, at the

sites marked by pillars, the devil was answered with stones. Satisfied with this display of faith, Allah provided a ram for the sacrifice.

Testifying to their struggle against evil, pilgrims reenact the event (top, right). Each must cast at least 49 pebbles at the three pillars during the three-day rite. To make the pillars accessible to more people,



MICHAEL ARYH

an upper level was added around each. Pebbles, as well as sandals and turbans, begin to pile up at one pillar (above, right).

While at Mina, most Muslims also arrange for an animal sacrifice. Bedouin tribesmen lead large herds of sheep and goats from the arid hills to sell to pilgrims, who can wield the knife themselves or else pay a butcher to perform the sacrifice.



According to the Koran, meat must be given to the poor. Now, because of the large quantities involved, meat not distributed fresh is frozen at a recently built plant and distributed later.

As a sign that most of the restrictions of ihram have ended, pilgrims at Mina or later at Mecca clip a lock of hair or, as preferred by men, shave the head.



OASIS OF COMFORT in the midst of an implacable desert, the Mecca Inter-Continental Hotel (left) caters to the more affluent pilgrims, some of whom enjoy a sumptuous buffet (below) following one of the hajj rites. Since entry into Mecca is forbidden to non-Muslims, German and French technicians had to supervise construction of the hotel over closed-circuit television, relaying instructions to Muslim foremen by radio and walkie-talkie. The new complex includes a mosque and conference center, and on each of the marble balconies, markings indicate where a guest

should stand to face the Kaaba during the five daily prayers.

Pilgrims on a more Spartan regimen use one of the many washing facilities (below) the Saudi Government has installed to combat contagious disease. Formerly the hajj was beset by a high mortality rate: Epidemics of smallpox, cholera, and malaria would sweep the crowded and unsanitary pilgrim camps. Now, because of mobile hospitals, portable toilets, disinfectant spraying, abundant pure water, and a modern quarantine center at Jidda, the World Health Organization no longer regularly monitors the hajj.



THE RETURN TRIP is hot and crowded as the pilgrim army swarms through Mina (following pages) on its way back to Mecca and thence homeward. Vehicles must pick their way through a dense current of pedestrians, many of whom carry belongings wrapped in blankets and prayer rugs. Passengers atop a bus sprout umbrellas to shield against a sun that can heat the valley to 110°F. Pilgrims usually spend about two weeks in the region of Mecca.









fAREWELL TO MECCA: All visitors circle the Kaaba before leaving the holy city. On a fragrant Arabian night, under the bluish lights of the mosque, worshipers are transformed by a time exposure into a blur, as if they make up a whirlpool drawing them inexorably to the core of their faith. Other pilgrims anoint themselves in the holy water of Zamzam, lower right. Before departing the country, most pilgrims also visit Medina, the second city of Islam, more than 200 miles north of Mecca. There they offer prayers at the mosque in which Muhammad is entombed.

Having completed the rites of pilgrimage, a Muslim returns home with the esteemed title of hajji. An increasing number of Muslims observe, however, that the recent reliance on easy charter flights to Mecca has devalued the title and diminished the stature of the pilgrim. To restore the worth, they advocate a return to an ascetic tradition, arguing that the more arduous and challenging the pilgrim's journey to Mecca, the greater the mental and spiritual benefits.

Yet, whether a pilgrim spends several years walking from Nigeria or a few hours flying from Iran, there is little question that the pilgrimage has provided him with the spiritual climax of his life, as well as a profound appreciation of the unity of Islam. Prayer resounds as the pilgrims leave the gates of Mecca:

Repentant and devoted to the service of God, we now return home and bow in humility and gratitude to Him. □

MOHAMMED AMIN



LONG BEFORE DAWN they came along the gravel road in run-down pickup trucks and battered sedans pulling dilapidated house trailers and pushing cones of yellow light through the dust of those ahead, trailing plumes of blue smoke and lurching up the grade with the desperate whine of disintegrating transmissions. Some even came on foot.

In the gloom babies cried, dogs barked, and couples argued while children slept fitfully under blankets spread out on the dewy grass. At length trailers went dark, and the windows of parked cars misted over. Along the edge of the orchard a few small fires flickered, and in the chill crystalline stillness the desultory conversations of weary men carried far with a startling clarity.

The orchard ran to a wire fence beyond which a desert commenced to rise up into low rolling hills. At dawn the sky above the hills glowed a vivid blue. Aroused by the first light, coyotes filled the dim rocky coulees with mad laughter to frighten rabbits from hiding beneath the twisted gray limbs of sage.

I stood at the fence with field glasses, scanned a canyon still in shadow, and saw a rabbit dart through a pale brittle garden of Russian thistle and wild grass in doomed flight. A foreman wearing a fifty-dollar stetson arrived in a pickup and parked on a rise above the orchard. Sleepy men emerged from cars and trailers and from bedrolls in the orchard and, hands in pockets, walked stiffly up the hill to ask for work.

So this ragtag army of migrant laborers had come to the end of their yearly odyssey—to the beginning of the autumn apple harvest in Washington State's bounteous Yakima Valley.

Part of Washington's inland empire, the Yakima Valley lies between the Columbia River and the Cascade Range. The valley is actually two adjacent basins in Yakima County connected by the Yakima River, a 215-mile tributary of the Columbia (map, page 614). Fed by the Cascades' snowfields,

NORTHWEST OASIS

Washington's Yakima Valley

By MARK MILLER

Photographs by SISSE BRIMBERG



Frozen assets in one of the nation's most prolific fruit-growing regions, porcelainlike pear blossoms weather a subfreezing night under sprayed-on coatings of ice. In full flush of spring, Yakima Valley orchards hug an irrigation canal (above) brimming with mountain runoff, lifeblood of Washington's dry but fertile interior.

the Yakima supplies a 2,000-mile system of irrigation canals to water half a million acres and more than seventy crops.

The Cascades shelter the valley from moist Pacific winds, hold yearly precipitation to about eight inches, and create a greenhouse effect, with three hundred sunny days annually. The valley's semiarid setting, amid sagebrush steppe and sparse timberlands of pine and fir, belies its agricultural fertility. Soils rich in volcanic ash combine with the sun and water to produce yields twice those of average farmlands. This natural alchemy makes Yakima County the nation's leading producer of apples, hops, and mint, and consistently among the leading counties in the value of all its crops. Where irrigation does not reach, bunchgrass flourishes, making the valley Washington's livestock center.

Verdant Valley Draws All Types

To this abundant oasis the migrant comes to earn his daily bread from the hardworking local farmers, on lands once the domain of the Yakima Indians, and here the interests of all three are combined in a colorful, but often troublesome, way. The Yakimas on their 1,300,000-acre reservation in the lower basin have only recently begun a program of agricultural development to help the tribe escape what one member called "this second-class limbo into which we've been pushed." A state labor official told me, "There are about 30,000 workers in the valley during peak season. Two-thirds of them are true migrants, another 3,000 migrate within Washington, and the rest are local people." A controversial work force, they include an unknown number of illegal Mexican immigrants.

Nearly a third of the valley's 164,000 people live in the city of Yakima, where

Fruit of hard labor, each 25-bushel bin of apples will bring seven dollars for migrant pickers Alfredo and Manuela Regalado. Aided by their older children, they may fill 25 bins a day. At fall harvest, a flood of migrants from Texas, Arkansas, and California arrive in the valley. Of the many illegal aliens in their ranks, growers claim "the valley wouldn't get picked without them."

processing plants in the sprawling Produce Row district fill an endless stream of railroad cars and truck trailers with meat, dairy products, and almost every kind of agricultural produce.

The apple, however, remains the valley's chief emissary. Last year 15,000 pickers harvested 25 million bushels of apples from the valley's 42,000 acres of orchard—half of Washington's crop and about a sixth of the nation's supply.

After the harvest, nearly half of the apples



are stored in a controlled atmosphere of 31°F with reduced oxygen, where the fruit's ripening process, or respiration, is slowed. The technique ensures a year-round supply of "fresh" fruit and stabilizes market prices.

Pre-waxed Apples Head to Market

At the Eakin Fruit Company in Yakima I stood at the end of a conveyor belt as an endless column of processed apples wiggled toward a platoon of box packers. The fruit was blood red, lustrous, and perfectly

shaped. "We wax them," said Bob Eakin, "to replace natural wax lost in washing. So they keep better."

Eighteen million of the apples shipped from the Yakima Valley are grown by Peter Hanke, whose 160-acre orchard lies at the base of the lower valley's Rattlesnake Hills (pages 630-31). Peter and his wife, Susan, came to the valley in the early 1960's to take over a faltering family farm. Through eight long years of unproductive growth, they financed their *(Continued on page 615)*

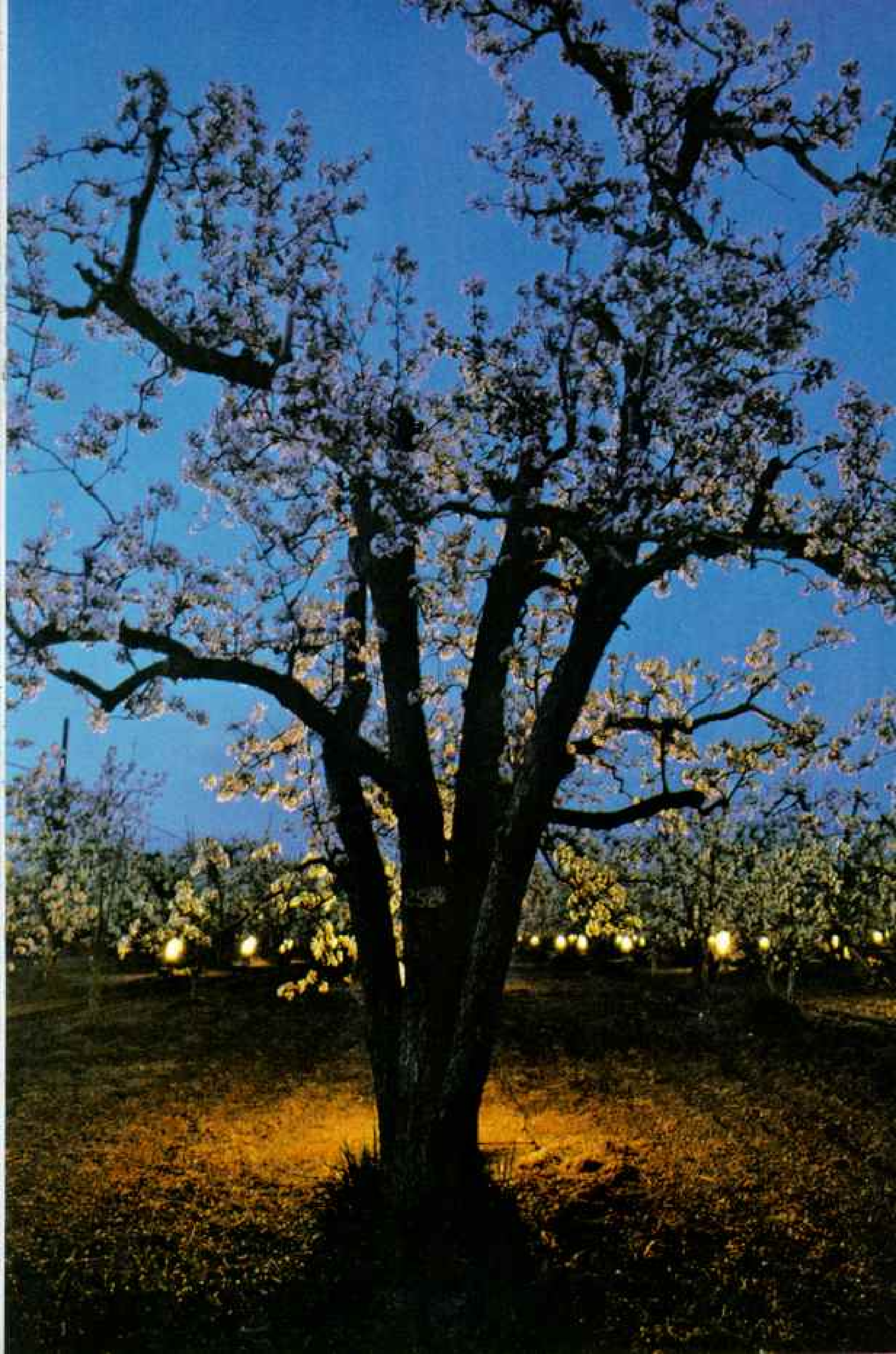




After a battle with Jack Frost, workers for apple orchardist Peter Hanke warm up around one of the 3,000 smudge pots (below) they lighted with flamethrowers from moving tractors. Pear orchards too are protected this way (right), as well as with

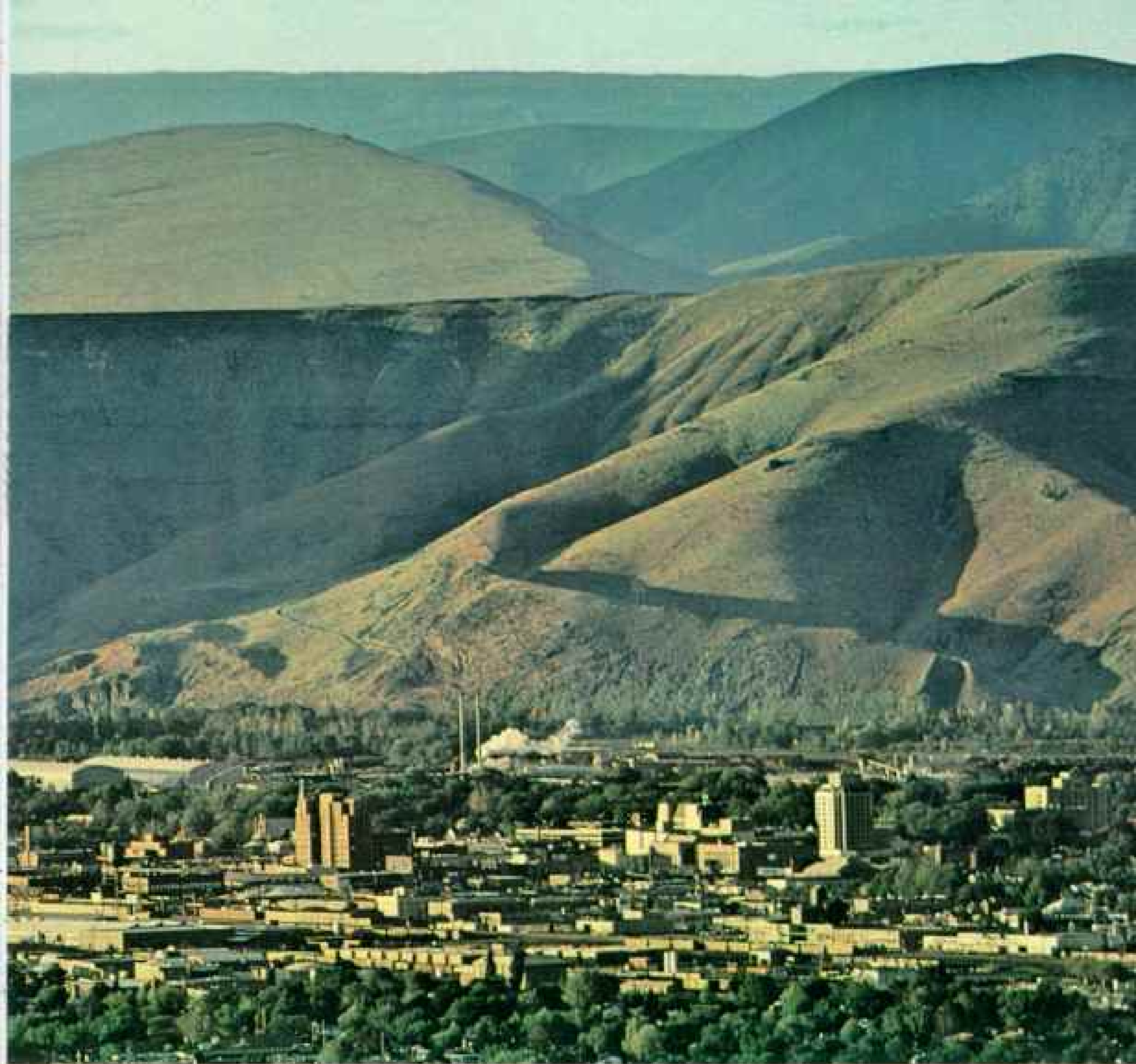
elevated, rotating wind machines that return rising warm air to the orchard floor. To cut costs, some growers use the riskier method of spraying their trees with irrigation water, which, when frozen (above), may keep them safe at the freezing point.







Her Honors meet: Dixy Lee Ray (top, far left), Governor of Washington, is welcomed to Yakima by Mayor Betty L. Edmondson. Only Chicago and New York boast greater concentrations of fruit storage and packing facilities than this city of 52,250 (above) and its environs. The valley's half a million irrigated acres produce more than seventy crops. The Yakima Indian Reservation (map) is one of the country's most prosperous.



newly planted fruit trees by growing alfalfa seed, hay, and mint. Worth about \$1,000 an acre before cultivation, the land, with improvements, is now worth from \$5,000 to \$12,500 an acre.

"But a frost during the blossom season can wipe you out," Peter told me. "Half a million dollars gone in an hour." When low temperatures threaten, bells that are set off by frost alarms ring in the house and barnyard. Positioned throughout the orchard are more than 3,000 diesel-oil smudge pots—essentially louvered chimneys whose voracious drafts heat enormous volumes of air (pages 612-13).

"We burn until the freeze lifts," Peter explained. "About a thousand bucks an

hour literally going up in smoke. If you hesitate, though, hoping the thermometer won't fall—and then it does—you can have your crop disastrously thinned out."

Consumers Look for Color and Shape

Barring killing spring frosts or sudden violent winds able to strip trees bare, the Hanke crop rolls to Yakima City in October. More than 40 percent of the apples are sold fresh; the rest are kept in storage. Besides the Red Delicious, the valley's apple crop includes the Golden Delicious, Wine-sap, Rome Beauty, Jonathan, and Granny Smith. The Red Delicious tree is favored for its high yields as well as for the popularity of its fruit. "When people think apple," one



processor told me, "they usually think red."

They also think oblong. In the daily wide temperature swings of the Pacific Northwest the Red Delicious assumes a tapered shape that consumers have come to prefer. Its silhouette is the trademark of Washington's State Apple Commission, which represents more than 5,000 growers. After the introduction last year of a "chemical girdle" that causes reds to grow into the favored "Washington" shape—regardless of origin—some growers in the Yakima Valley yelled foul, but to no avail.

Mint Growers Fought Back

Low blows are something Yakima Valley mint growers also live with. In 1970 the valley's mint farmers sued major mint-oil buyers for price-fixing and won an out-of-court settlement of 14 million dollars.

Driving across the lonely Toppenish Plain, I found the evening air east of White Swan saturated with the cloying aroma of a mint-oil distillery. The scent led me down a dirt road to a rumbling iron shed. Through a window I saw the mint grower stretched out on a broken-down recliner, gazing thoughtfully at a roaring boiler. Curled beside him on the floor was an enormous gray dog that studied me with baleful eyes.

"That's Wolf," said the grower, Wiley Cordell. Hearing his name, Wolf growled

appropriately. "He's supposed to be half wolf." (Another growl.) "He earns his keep by guarding my product." Wiley pointed to a row of thirteen 55-gallon drums. "You see there \$52,000 worth of peppermint oil. I told Wolf ["growl"] it's half his so he'll pay attention if anybody tries to rustle it."

The extraction of mint oil begins in September when the mature plants are mowed and deposited in steel hoppers through which boilers force superheated steam. The oily essence is vaporized, drawn off, and condensed. Primarily a flavoring, peppermint oil, when refined, yields menthol. Spearmint farmers consider themselves responsible for chewing gums, dental preparations, and scented soaps.

"I do just fine," said 31-year-old Wiley. "I sweat, though. I eat dust. No gentleman farmer. I try to do everything myself, rent equipment I can't afford, do my own repairs. You couldn't pay a man to work like I do. The Lone Ranger. I never even got a high-school diploma until I joined the Navy, where I learned to weld. I welded on the Alaska pipeline for four years. These eighty acres are the fruit of my labors."

It was Wiley who introduced me to the annual Moxee Hop Festival, a miniature Oktoberfest in early August that celebrates in advance the Yakima Valley's 38-million-pound harvest. Wiley went off in search of

Hands of time spin back when two vintage electric trolleys trundle through the countryside around Yakima on rails used for transporting fruit-laden boxcars. On one, trolley master Jack Wimer shows off his watch to a load of conventioners (left). He has taken to the rails in his spare time "just for the fun of it." So too has Yakima Valley College instructor Hazel Leland—here helping Wimer clear dirt from a crossing (right). Of the same model as those used in Yakima early in the century, the two cars were found in Portugal and brought back as a Bicentennial project and tourist attraction.



Pond monkey for a moment, 71-year-old Maurice Hitchcock (below), head of the family-owned White Swan Lumber Company, feeds logs into his mill on the Yakima Indian Reservation. A major buyer of the Yakima Nation's greatest asset—an estimated 700 million dollars' worth of fir and pine—he flies around the country in his Gates Learjet (right) to drum up business. At 69, his wife and copilot, Kathleen, was one of the oldest women on record to obtain an instrument rating for the plane.



the Hop Queen. I ducked into a tent filled with raucous song. A dozen men seated at a long wooden table raised a beery chorus:

*A hop farmer's wife
Leads a hell of a life
Of poverty, hunger, and fear.*

*Her man sweats away youth
At labor uncouth,
So the rest of the world can drink
beer.*

At least part of the song is true. Hops, the flowerlike cones of the female vine, are used mostly in the brewing of beer to impart to the beverage its aromatic bitterness. The United States is the leading producer of hops after West Germany, exporting 50 percent of its 55-million-pound crop, 70 percent of which comes from the Yakima Valley's 21,000 acres of vines (pages 620-21).

Like most of the valley's growers, hop farmers depend largely on hand labor. To

get it, they can telephone the Job Service Center in Yakima, funded by the U. S. Department of Labor. Jesse Farias is manager of the center. A Chicano, 33 years old, Jesse spent his youth in migrant labor.

"My brothers and sisters still do it," he told me. "Some people like it, others can't escape it. Education is the exit, but for that, kids need a stable home. Otherwise they never settle out of the migrant stream.

"Wages and working conditions for farm workers have remained pretty much the same over the years," Jesse pointed out. I recalled that new legislation has increased the minimum wage by only 45 cents, to \$2.65 an hour. "It's still one hell of a way to make a living."

Migrants Hope to Keep Dignity

Late one September afternoon I sat on the sandy banks of the Naches River and enjoyed the melancholy harmonica serenades of Harvell Pond. Migrants from Arkansas'



Ozark Plateau, Harvell and Arlene, his wife, had parked their battered pickup and house trailer in a grove of poplars off the highway. While Arlene washed clothes in the river, Harvell watched over their two sons and discoursed on a life of transient toil.

"The hardest thing is to keep your dignity. It seems like more and more people don't respect manual labor. Growers are happy as hell to see us at the start of harvest, but once it's over, they don't want us around."

That evening I sat in the yellow light of a hissing lantern above the trailer's folding table and waited for Arlene to say grace. "We thank Thee," she concluded, "for good health and our safe trip to Washington. And we pray for those in need. Amen."

On another evening I found Harvell slumped in a camp chair with his shirt off after ten hours of picking apples. He was soaking his feet in the river and sipping cider. Arms brown and torso pale, his leanness testified to 35 years of toil. Harvell is 42.

"Let's face it," he told me. "I can't read, can't hardly write my name. Arlene handles the writing. I grew up on the road, can't remember being inside a school. My folks were good to us, but we all had to work to get by. My daddy passed away on the road in California. In onions."

Fields in Summer, School in Fall

A sturdy and perpetually smiling woman, Arlene was leafing through a dog-eared notebook filled with the addresses of farms and foremen. Sons Harvell Junior and James, 7 and 9, sat in a pebbly shallows to escape the heat.

"The boys summer with us," Arlene explained. "We pick cotton, vegetables, and citrus in the Rio Grande Valley. We work the Imperial Valley vegetables, then apricots and peaches in the San Joaquin Valley. We pick cherries in Oregon and Washington, and then we pick the apples. When school starts, *(Continued on page 623)*



High and dry above irrigated trenches, mildew-prone hop plants find a perfect environment in the Yakima Valley, where rainfall averages eight inches a year. In April nimble-handed workers string two lengths of vine support at a time (above)

from 18-foot trellises. Around them the young perennial herbs may coil upward a foot or more a day. Come harvest, the vine-laden twine will be cut and separated from the cones (bottom right)—wherein lies the substance that both preserves and imparts



the distinctive flavor to beer. Then on to a drying kiln (top right), where hot air blown through the floor removes most of the moisture from the cones. Perched atop a roll of burlap, a kiln operator finds time for a little televised diversion.



we put the boys on a bus and send them home to their grandmother."

The Ponds enjoy a Thanksgiving reunion in Arkansas; then Harvell and Arlene depart for two months of citrus picking in Florida. After a Christmas holiday together, the family splits up again for six months.

Last year the Ponds arrived in Florida to find their jobs erased by severe frosts. It meant a three-thousand-dollar loss in earnings for them—about one-third of their average income. Such calamities fall on the shoulders of migrant children, who must go to work to supplement their parents' wages. One result is that many migrant youngsters achieve only a slapdash education and are virtually illiterate.

"Times Do Get Hard"

In 1975 the American Friends Service Committee surveyed Yakima Valley asparagus fields and reported that children were being unlawfully exploited, compelled to work alongside their parents to supplement family earnings.

Harvell is philosophic. "It's true, but now and then the kids have to help out when times get hard. In this line of work, times do get hard."

Times have indeed become harder for American migrant farm workers, who increasingly complain of competition from illegal Mexican immigrants. The Yakima Valley, with perhaps 11,000 illegals, is the Immigration and Naturalization Service's biggest headache in the Northwest.

Last autumn arrests were running 80 a week, an insignificant reduction of the valley's labor force, but enough to anger apple growers who needed 1,200 extra pickers when September and October cloudbursts and an early winter hastened ripening.

One grower told me, "Without illegals, I'd be out of business. If the Feds raided me tomorrow, I'd hand them picking bags and say, 'You pick my crop; nobody else will!'"

Half of Mexico's farm workers earn less than 15 dollars a month. In the valley an

apple picker can earn more than 50 dollars a day. In 20 days his earnings will exceed Mexico's per capita annual income. Couples can make as much as a hundred dollars in a day, and adolescent children can generate up to 75 percent of an adult's earnings. Such figures often lure otherwise law-abiding people into the United States in defiance of immigration quotas.

Officially called "undocumented aliens," illegals are tempting prey to unscrupulous labor contractors, who may withhold spurious "deductions" from paychecks. Those who complain risk betrayal. "I've heard stories about guys who put illegals to work, then tip off the Feds, who come in and arrest them," a grower told me. "That way, the contractor doesn't have to pay for the labor and sometimes collects an award to boot."

As Mexico's population and inflation increase, so does the number of illegals competing for jobs on American farms. "I used to count on two months' work up here," complained Elmer Paar, whose three decades as a migrant show in his gaunt suntanned face. "Now I'm lucky to get 30 days. Growers don't hold no loyalties for Americans."

"We're not cops," said a foreman who admitted that at least half his picking crew were illegals. "We're in business. Illegals pick well and they work hard. The faster the fruit gets picked, the better off we are."

New Ways Changed Yakimas' Lives

The valley's tribe of migrant laborers shares its economic lifeboat with another tribe, a real one that once roamed from northern Oregon to Canada and from the Cascades to the Bitterroots of Montana. Today the 6,350-member Yakima Indian Nation, the legal descendant of 14 nomadic tribes and bands whose archeology dates from 14,000 years ago, looks restively to the future from the relative confines of a 2,000-square-mile reservation, slightly larger than the State of Delaware.

"That may sound like a lot of land," said Robert Pace, media representative for the

Though his hands tell the story of an unsettled youth, Steve Oldcoyote, a Sioux cowboy from South Dakota, has planted roots in the Yakima Indian Reservation's rich cattle range. Now working for rancher Bill Northover, a Yakima, Steve is one of many non-Yakima Indians drawn to the reservation by its job opportunities.

tribe, “but the old Yakimas required nearly ten times that. They fished a hundred miles from where they dug wild roots. They rode into Montana for buffalo. They were hunters and food-gatherers, not farmers.”

Pressured by white settlement, the tribe gave up nine-tenths of its land by treaty in 1855. Unused to agriculture and cut off from traditional food supplies, the Yakimas fell prey to ennui, abeyant despair, and alcoholism—classic ills of cultural disruption that linger today. Bereft of spirit, the tribe sank into abject poverty.

“Many old people here just waited to die,” remembers Marjorie Russell. A Cherokee,

Marjorie married a Yakima she met near an Army base in Oklahoma during World War II. “When I came to the reservation,” she told me, “I was struck by the sadness among the elderly, who felt that life wasn’t worth living anymore.”

The Allotment Act of 1887 ended common ownership of reservation land. Freed of trust restrictions on their parcels, many of the impoverished Yakimas sold the tribe’s most fertile lands to whites, 22,000 of whom reside within the boundaries of the reservation today.

“It was an attempt to undermine the 1855 treaty, but luckily it didn’t entirely work,”

Covert for coyotes, Ahtanum Ridge cuts the 175-mile-long Yakima Valley into



said Bill Northover, a cattle rancher who has served on the tribe's 14-member council, the Yakima's chief legislative body.

Water Rights Bring Confrontation

Ironically it is the 1855 treaty, which relinquished so much, from which the tribe's strength flows today. Under its terms, tribal lawyers assert claims to water and fish and seek greater control over reservation affairs.

Citing a 1908 Supreme Court holding that reservation Indians have first claim to water passing through or by their lands, the tribe is suing the Bureau of Reclamation for an increase in its allotment of two acre-feet of

water annually for each acre of irrigable land and for maintenance of water flows to protect fish runs. Fearful that the reservation's needs could eventually monopolize irrigation water, local governments have raised vigorous legal opposition. Fishing rights are also at issue. Entitled by law to half the fish that migrate through traditional fishing grounds, the Yakimas have found recent runs severely reduced and charge state officials with failure to curb excessive offshore harvests. At stake is the success of the Yakimas' seafood plant, nucleus of a 35-million-dollar processing facility for many kinds of food that, when it is

two basins. Seen in the background of the upper valley are Yakima's outskirts.

625





Around his grandfather's shack, artist Leo Adams (above), a Yakima Indian, is building a studio-home as reflective of the reservation landscape as of his success as

a painter. At the tribe's headquarters in Toppenish, an eye-catching vehicle of pop art (below) also bespeaks the Yakima Nation's kinship with the here and now.



completed, will employ some 1,500 people.

Inevitably, despite formal expressions of goodwill, such problems create friction between the tribe and the 158,000 non-Indians in the valley. "People lash out viciously at the tribe from misunderstanding," said Jim Normandeau, the nation's administrative director. "They believe us to be welfare wards of the government, which is untrue—we earn and spend our own money."

"The Miracle Will Come"

A Lincolnesque Montana Flathead Indian, recruited for his financial experience, Jim monitors a 20-million-dollar cash flow from tribal operations. The Yakimas' chief asset and income source is their 493,000-acre stand of timber—most productive of any American Indian reservation. The tribe has also invested its money in farming, furniture manufacturing, and an aircraft sales and charter service. The Yakimas' seafood-processing facility is in a 114-acre industrial park near the tribe's Toppenish headquarters. On the same tract are its furniture factory and tobacco warehouse.

Despite increasing earnings, some tribal businesses demand heavy reinvestments. As a result, though the tribe's assets are valued at about 800 million dollars, yearly allotments to each Yakima from tribal coffers currently total only \$450. The low sum rangles many Yakimas, who complain of poor management. Sighed one veteran councilman: "They see all the buildings and expect an instant miracle. The miracle will come, but with time."

Watson Totus, the 73-year-old chairman of the tribal council, believes in it. "I hope to see all Yakimas eventually living on the reservation, living well. This is where we belong; this is home."

This heartfelt wish of a traditionalist has so far been denied by unemployment. In winter, when agricultural and fishing operations slacken, the unemployment rate on the reservation soars to 30 percent. Of the tribe's membership, about 1,550 live elsewhere. "They leave to find work," said Elizabeth Williams, who tends the tribal enrollment list.

"It's hard for an Indian to get started," said Bill Northover, whose Medicine Valley cattle ranch I visited during a rain-soaked

roundup. Starting with a few head, Bill slowly built up a herd of Herefords, the financial mainstay of his 1,200-acre spread, lying within the reservation boundaries.

"Even today, an Indian has a hard time getting a bank loan," he told me, scraping muddy boots against a fence board. "It has stopped a lot of good people from farming and ranching, and they ended up bums."

"The difficulty arises," said Jim Normandeau, "because a reservation Indian can't mortgage his trust-held land without Government approval. It becomes a cumbersome process, and consequently we spend much time trying to build lines of credit for the individual."

Lack of credit has handicapped other tribes as well; this was a primary reason for the founding in 1973 of the American Indian National Bank of Washington, D. C., in which the Yakima Nation now holds a controlling interest. With the infusion of a million dollars (plus ten dollars more to get the controlling interest) from Yakima tribal funds, the bank ended 1977 with more than 20 million dollars in demand deposits. Councilman Bill Yallup is a director.

"The national examiners found all kinds of faults," he told me. "They said we had no prior knowledge of many tribes' ability to repay—that they weren't really qualified for loans. Well, that was the prime reason for establishing the bank, and they understand that now."

New Projects Mean More Jobs

Foremost among tribal priorities is the creation of jobs and reservation enterprises that will eventually provide year-round employment not only for the Yakimas but also for many non-Indians. Though economic development is a top priority, education is a major concern.

"Our people haven't been very successful in public schools," said Violet Rau, who designs cross-cultural study programs for the tribe's school system.

Believing that local school boards were unresponsive to cultural barriers that impeded Indian students, the Yakima Nation established its own model programs as a supplement to public schools, with emphasis on parental involvement.

"Indian children are confounded by the

Patience runs deep as Yakima tribal-police chief Joseph Young and his brother, Gary, dipnet for Chinook salmon in the Yakima River below Horn Rapids Dam. Time was when they might net hundreds during the spring run. This year, after laboring three weekends on a scaffold that will wash away with winter rains, they caught only a couple of dozen salmon and a few steelhead trout. Disruptions by the Columbia River's many dams and heavy offshore Pacific harvests share the blame. Though most of today's meager catches go to the freezer, some are grilled fresh to celebrate the season's run (below).







competition and regimentation commonly found in conventional schoolrooms," Mrs. Rau explained. "But in our schools, the people bloom."

Like most reservation Indians, Yakimas straddle two worlds, a cultural dichotomy most evident among the young.

For the Yakimas, a Strange Reality

Such contradictions haunt the reservation. Defeated in war, the Yakimas found solace in their conquerors' religions; where tepees once serrated the rolling horizon, the steeples of lonely clapboard churches spike pious silhouettes into the sky. Old men recall fathers who battled the U. S. Cavalry, and in the cemetery of an Indian Shaker church small American flags mark the graves of Yakima servicemen killed in action.

"We must look forward," a tribal elder told me. "We must also look back. We are now in two places at once, and that can be the same as being nowhere at all."

"When I fish the salmon runs," said Leonard Olney, beside the tumbling Klickitat, "I feel like an Indian. When I drive a truck in Toppenish, I don't feel like anything."

As he opened a gunnysack to show me his catch, three large steelheads he would sell to the reservation processing plant for 85 cents a pound, we came under the impassive scrutiny of an alert old Yakima draped in a rain-slicked poncho. Told he was 91, I knew he had lived his youth in the twilight years of traditional tribal culture.

"We had a peace not possible anymore," he said hoarsely. Raising an arthritic hand, he pointed toward the fishing place, a gorge



Backyard desert, the Rattlesnake Hills offer a world in total contrast to the lush orchards young Pete Hanke (left) works with his father. Like many valley farmwives, his mother, Susan (below), tends a flock of sheep for her personal income.



of columnar basalt smoothed by eons of rushing water and now littered with refuse. "The earth does not know us anymore," he intoned. "Too many people don't remember who they are."

Meeting Place for Many Cultures

I had said my farewells to Harvell and Arlene Pond several days earlier, and was preparing to leave the valley myself when autumn colors, already vivid, flared with a final brilliance under a cerulean November sky. I stood again at the edge of the orchard where two months before I had walked, in the predawn hours, past the sleeping forms of migrant workers.

With me was a young African agronomist who had come to the Yakima Valley to conduct research on high-protein grains.

Clad in a black suit, white shirt, and tie, he stood in six inches of powdery soil and scribbled in a tiny notebook. From out of the trees, looking a bit lost, emerged a Saudi Arabian food buyer in robe and headdress. Stooping under a nearby tree, an old Yakima Indian was gathering apples dropped by the pickers.

The African and the Arab regarded one another in briefly speechless wonder.

"This must be the place," said the Arab, laughing.

"It must certainly be the place," replied the African, whose English was as Oxfordtinged as the Saudi's. The Yakima, a stout, flannel-shirted man with long silver hair tied back in a bandanna, drew himself up and announced sternly, "This has *always* been the place." □

NATURAL GAS: THE

NATURAL GAS? We could have it running out our ears," says Dr. Paul Jones. "But first we've got to accept some new ideas about petroleum geology."

He stabs a finger at a map of the Texas-Louisiana coastal region, which is barely recognizable beneath a crazy-quilt pattern of subsurface contour lines.

"Those lines could lead us to more gas than we've ever dreamed of, enough for centuries," says Paul. "They mark the geopressure systems—150,000 square miles of porous shale and sandstone saturated with hot brine at abnormally high pressures. There's good scientific evidence that this brine could contain as much as 50,000 trillion cubic feet of gas. That's equal to 2,500 times our present yearly production."

As a hydrologist, Paul has spent thirty years—most of them with the U. S. Geological Survey—studying the critical role of underground water in the earth's geological history. Some of his ideas are still sheer heresy to many petroleum experts. But he is one of a growing band of scientists, engineers, and hard-nosed production men who reject the dire predictions that United States gas resources will soon be exhausted.

Instead, they want to rewrite the petroleum-geology textbooks to include six "unconventional" gas sources (pages 645-7) long dismissed as too difficult or too costly to exploit:

- **Geopressure zones.** Interest is focused on the Gulf Coast region, but researchers have identified several other U. S. regions that also may contain significant resources.
- **Deep basins.** Today drillers are finding unheralded quantities of gas at depths between 15,000 and 30,000 feet.
- **Western "tight sands."** In the Rockies

drillers have learned how to extract gas from concrete-hard sandstones estimated to contain some 800 trillion cubic feet (TCF).

- **Coal seams.** An estimated 850 TCF of gas exists in the nation's coal seams at depths as great as 6,000 feet.

- **Devonian shales.** More than 1,000 TCF is believed trapped in dense rock underlying 90,000 square miles of Appalachia.

- **Methane hydrates.** At certain pressures and temperatures, methane and water form an icelike substance beneath permafrost and in deep-ocean bottoms. Undetected in nature until the mid-1960's, hydrates may have captured enormous quantities of gas thought to have dissipated millennia ago.

"If we recover only a small percentage of all this gas, we'd more than quadruple our present estimates of potential resources," says one government researcher. "But this is scarcely mentioned as a possibility in our energy plans."

He's right. In April 1977 federal policymakers wrote a virtual obituary for natural gas. A 14 percent production drop by 1985 would compound already critical shortages. Industry and government reserve estimates were almost identical: about 208 TCF, barely a ten-year supply at today's consumption rate of some 19 TCF annually.

That spelled trouble. Today natural gas supplies 41 percent of our nontransportation energy, serving 41 million homes and providing 40 percent of industrial needs. It is our cleanest fossil fuel, and also the cheapest, with interstate prices rigidly controlled since 1954. In early 1978, residential consumers paid an average of \$2.34 per thousand cubic feet, compared to \$11 for an equivalent amount of electricity.

But with gas price deregulation on the horizon, higher fuel bills are a certainty.

By BRYAN HODGSON

SENIOR EDITORIAL STAFF

Photographs by LOWELL GEORGIA

SEARCH GOES ON



NATIONAL GEOGRAPHIC PHOTOGRAPHER JAMES L. AMOS

Ping-Pong ball in the game of natural-gas shortages, a container for transporting liquefied natural gas (LNG) moves out from a manufacturing facility in Charleston, South Carolina. Installed aboard ship, such containers will bring gas at minus 260°F from abroad for regasification and distribution. The high cost, as well as the risk of a catastrophic accident, may be unnecessary. Some experts and hardworking drillers believe there's still plenty of gas to be found at home.

The planners are turning to massive engineering projects for new gas supplies. Liquefied natural gas (LNG), chilled to minus 260°F and imported by tanker from Algeria or Indonesia, may cost five dollars per thousand cubic feet delivered to U. S. pipelines by 1985—more than double the controlled price of new domestic gas. The 4,800-mile Alaska gas pipeline also will require a five-dollar price, as would synthetic gas produced from coal in a series of proposed 1.6-billion-dollar plants backed by the government.

"But we could drill a thousand exploration wells for the cost of one coal-gas plant," says my government friend. "If we're wrong about unconventional resources, we'd soon find out. If we're right, we'd find huge new energy supplies in our own backyard—with a very good chance that they'd be cheaper than the alternatives, and reduce our dependency on imported fuels."

Methane Pervasive in Nature

Nature's gas isn't hard to find. Cows belch it. Swamps bubble with it. You can make your own by mixing organic waste with water in an airtight tank. Anaerobic bacteria digest the waste and produce methane, the principal ingredient of natural gas. They've been doing it for four billion years, helping make methane the world's most pervasive hydrocarbon.

Finding petroleum hydrocarbons—gas and oil—is more complex. It's a gambler's game, and nature has stacked the deck.

Petroleum was formed in organically rich sediments laid down over millions of years on the margins of long-vanished oceans. Partially decayed by bacteria, the organic matter was "cooked" into oil and gas by heat, pressure, and chemical reactions as

layer after layer of sediment pressed down to create deep basins in the earth's crust.

Nature shuffled and reshuffled the cards, alternating rich layers of fine silt and chalk with beds of salt, sand, or clay. And the hydrocarbons were restless. Often dissolved in underground waters, they migrated upward or laterally to create giant reservoirs in porous sandstone or limestone layers trapped beneath impermeable rock. Where no traps existed, they often escaped to the surface and were lost.

Finally, there was a joker in the deck. In deep, hot regions, the cooking process continued until the hydrocarbons were reduced from liquid oil to molecules of gas.

For decades oilmen treated gas as a necessary evil. It provided most of the pressure that caused oil to flow to the surface. But it caused deadly blowouts. There was no market for it. Since 1859, night skies have glared hellishly over the world's oil fields as trillions of cubic feet of natural gas flared uselessly away (below). Not until the 1930's was the first major U. S. pipeline built to carry gas as a lowly by-product of oil.

Things have changed. In the U. S., laws severely restrict flaring. Today gas travels through a million-mile, 50-billion-dollar pipeline network. Eighty percent of our supply comes from the gas-only reservoirs disdained by the oil pioneers.

The legacy of that disdain lives on. For years gas price controls were based on its by-product status. Researchers concentrated relatively little effort outside the areas where oil, vastly more profitable, might be found. Unconventional gas resources were largely ignored and poorly understood.

Now that, too, is changing. A new breed of pioneers, armed with new technology and new ideas, has entered the gambler's game.



Hot liquid spurts furiously from the high-pressure valve. Dr. Denton Wieland fills a beaker and holds it to the light with a connoisseur's eye. "Good, clean stuff," he says, and offers it to me.

I take it reverently. It's a very special vintage—hot, salty water, aged for millions of years and foaming with natural gas like warm champagne (page 639). It is an actual sample of geopressurized methane, the most exciting unconventional gas source of all.

Government Probes Geopressure Zone

We're sweltering on a barge moored in Tigre Lagoon, deep in the humid coastal marsh of southern Louisiana. Dr. Wieland, a veteran petroleum engineer, is working on the U. S. Department of Energy's first geopressure test well, Edna Delcambre #1. It is producing as much as 10,000 barrels of water a day from a sandstone aquifer 12,600 feet below, where pressure is almost 11,000 pounds per square inch and the temperature is 240°F. The gas is collected by an elaborate manifold system, and the water is forced by its own pressure down another well bore for disposal 2,500 feet underground.

Major oil companies have made similar tests in utmost secrecy. But Edna Delcambre #1 is in the public domain. And the results are dramatic. Gas production is 150 percent higher than originally predicted.

"We expected 20 cubic feet per 42-gallon barrel of water," Dr. Wieland says. "But we're getting 50 cubic feet."

The new data delights Dr. Paul Jones, reinforcing theories he's held for years.

"We know that enormous quantities of gas are dissolved in geopressure waters. The reasons are complicated [illustration, page 647], but basically here's what happens:

"The amount varies with temperature,

Great sunbursts of flaring gas spangle the Persian Gulf in a midnight satellite image made in 1974. Though the practice is restricted in the U. S., some seven trillion cubic feet of oil-field gas went up in smoke last year worldwide—an energy equivalent of two years of Alaskan North Slope oil production. Oil economics being what they are, "waste" gas often remains cheaper to burn than to transport.

pressure, and salinity. Recent research indicates that water may dissolve as much as 1,000 cubic feet of gas per barrel at 30,000 feet. Near the 20,000-foot level, with lower pressures, its saturation capacity is about 100 cubic feet. Now, over geologic time, these waters have been forced upward. As they encounter lower pressures, gas comes out of solution in tiny bubbles. As more water passes through the pressure-drop zone, the number of bubbles increases. They move upward with the water. When they collect beneath geologic traps, free-gas reservoirs are formed. Today, many such reservoirs in the Gulf Coast geopressure zones are producing trillions of cubic feet a year.

"But the aquifers are vastly more extensive than the free-gas pockets. Virtually all the water is gas saturated. That is the gas we must learn to recover."

Paul published his theories in 1975, not long after ending his career with the U. S. Geological Survey. His research was a key factor in a USGS study estimating that sandstone and shale in Gulf geopressure areas contain some 60,000 TCF of dissolved gas. Since then he has endured much skepticism from oilmen and energy planners alike.

Rock Pores Hide Treasure

Edna Delcambre #1 is changing all that. In November 1977, Dr. Philip Randolph of the Institute of Gas Technology in Chicago analyzed the well's behavior, and announced that the unexpectedly high production could be explained if only 6.5 percent of the rock's pore space, once thought to contain only water, actually was occupied by tiny trapped gas bubbles.

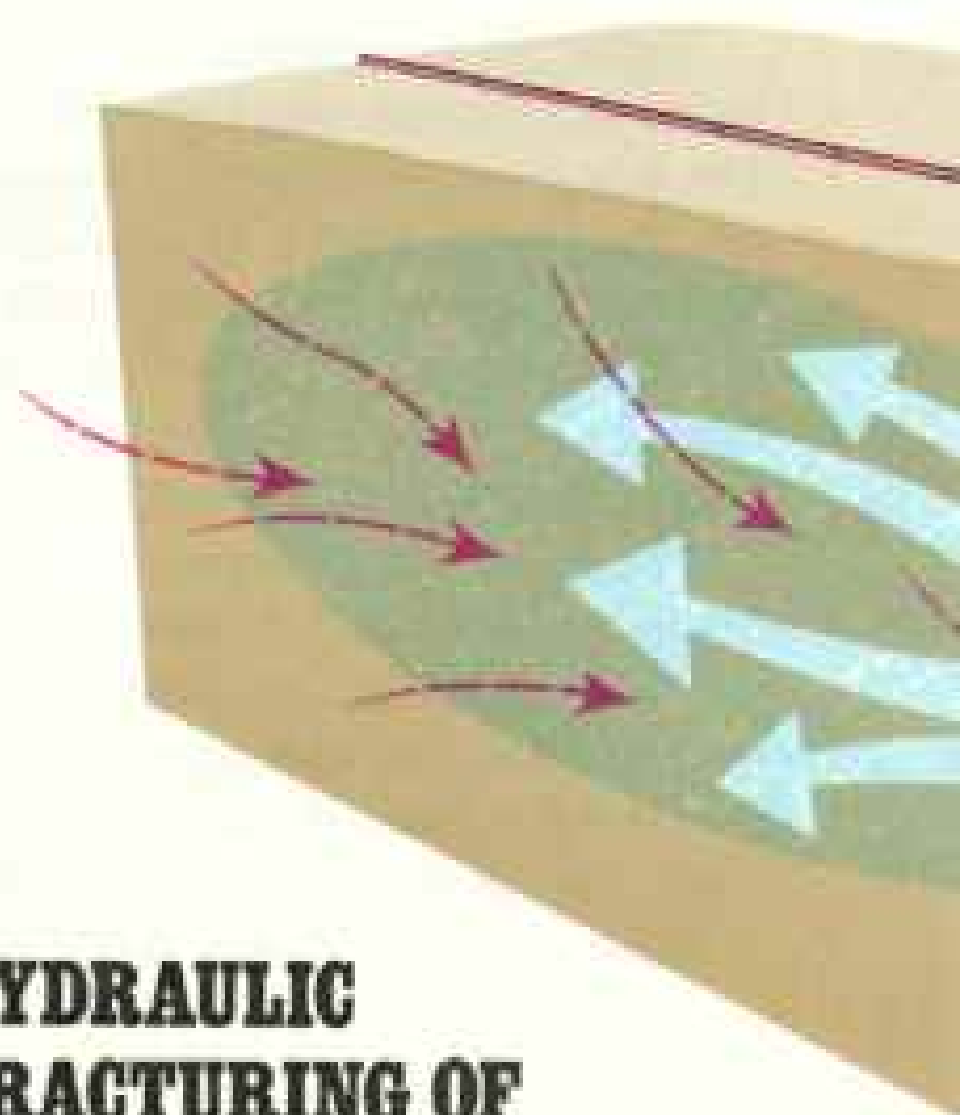
According to Dr. Randolph's theory, allowing water to rush upward through the well bore reduces the pressure; in turn, that allows the gas bubbles in the aquifer to expand, pop free of their traps, and join the water flow. If that phenomenon is true of geopressure aquifers in general, he said, they could contain five times more gas than estimated for dissolved gas alone.

But he provides a hardheaded note:

"I'd urge at this point that we stop worrying about whether we have a thousand trillion or ten thousand trillion cubic feet of geopressure gas. We know there's a *bunch!* But only by drilling, by developing solid



SEM, DOWELL DIVISION OF DOW CHEMICAL, U.S.A. (ABOVE AND BELOW)



HYDRAULIC FRACTURING OF "TIGHT" SANDSTONE

A blender truck ① draws water from storage tanks ② to mix with sand from a silo ③, a polymer, and other chemicals. Here directed from a remote control center ④, the mixture (blue arrows) is injected under great pressure by pump trucks ⑤ deep into the perforated well casing to fracture surrounding rock ⑥. The polymerized liquid is later drawn off, leaving the sand in place to prop open the fracture ⑦. Gas (red arrows) then flows through the fracture to the well bore and into the pipeline for distribution ⑧.

Tough as concrete, tightly packed sandstone in the Rocky Mountains imprisons gas that can be released by fracturing the rock with a mixture of water, special sand, and a jellylike polymer (left), here held by a Dowell chemist in Tulsa. A hard, round, large-grain sand (photomicrograph, left, middle) is used. Ordinary sand (left, bottom) is too fine and fragile to keep fractures propped wide enough for maximum gas flow.

At Amoco Production Company's Wattenberg field in Colorado, Halliburton Services technicians stand by as fracturing sand pours from a conveyor (right).

Drillers are using several agents other than sand, including glass beads and—probably most important because of its relative abundance—bauxite, which is sintered, or heated, into superhard pellets.

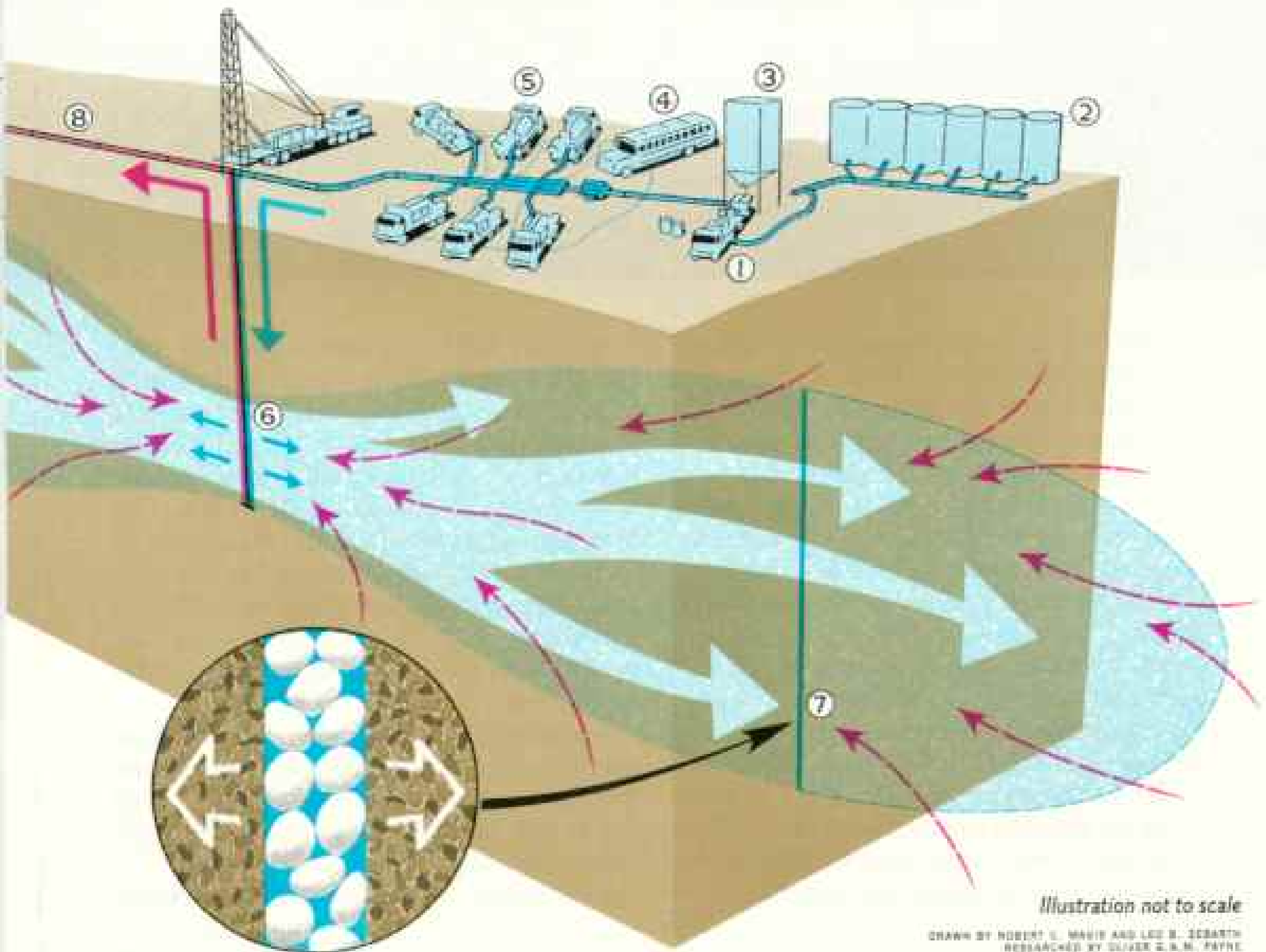


Illustration not to scale

DRAWN BY ROBERT C. MAWY AND LEE B. DEBARTH
 RESEARCHED BY OLIVER G. B. M. PAYNE
 NATIONAL GEOGRAPHIC ART DIVISION



engineering data and lab research are we going to solve the gut issue: How much gas can we produce, and at what price?"

Some experts reject these theories.

"The best reason to drill geopressure test wells is to lay this thing to rest," says Charles Matthews, a consulting petroleum engineer for Shell Oil Company, citing its experience with geopressure aquifers broken in blocks too small for adequate water flow.

But recently Amoco Production Company reported a gas-to-water ratio 140 percent higher than anticipated from normally pressured shallow brine wells in Oklahoma. As for geopressure: "We think it's close to flying on solution gas alone, given continuity of reservoirs," says Michael Waller, the company's vice president for research.

And in 1977 a 20,000-foot well near Baton Rouge, Louisiana, produced as much as 496 cubic feet per barrel—five times the dissolved-gas ratio. Later, a nearby Chevron U.S.A. well blew out while probing at 21,346 feet (above). Before killing the blowout, Chevron initially measured an incredible daily production of 142 million cubic feet, and sold 3.6 billion cubic feet—a year's supply for 31,000 homes—to recoup in 29 days the well's five-million-dollar drilling cost.

Although the company denied that geopressure water played any part in the spectacular production, the accident served notice that unexplored geopressure regions shelter impressive amounts of free gas.

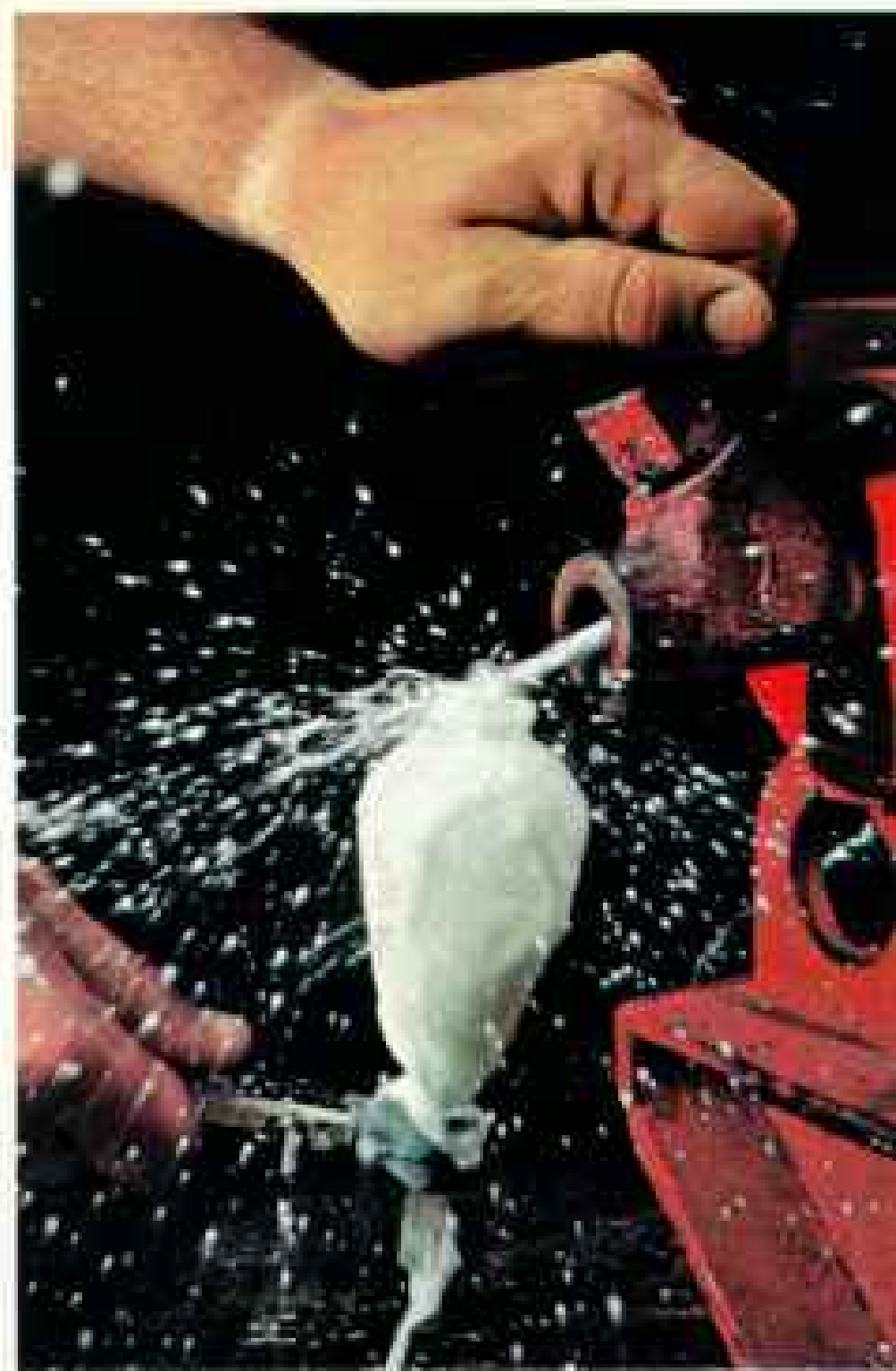
In Houston, Ernie Geer and Harold Cook



CHUCK FISHMAN, CONTACT

Blowing its top, a 21,346-foot-deep Chevron well near Baton Rouge, Louisiana, belches a cloud of steam after penetrating a geopressure zone. Billions of cubic feet of methane followed. Such geopressure zones, relatively unexplored, may contain incredible amounts of gas.

At a Department of Energy test well, water containing geopressure gas foams like seltzer (below).



NATIONAL GEOGRAPHIC PHOTOGRAPHER JAMES P. BLAIR

believe the industry has overlooked vast geopressure-gas potential by abandoning wells that are invaded by water. They work for Transco Companies Inc., investigating unconventional gas resources. Their research turned up a study, published in the early 1950's by engineers of the Stanolind Oil and Gas Company of Tulsa, demonstrating that the pores of "watered-out" gas reservoirs still contain between 15 and 50 percent of the original free gas, which had been bypassed by invading water.

Computer studies, plus their own knowledge of reservoir behavior, led them to a startling conclusion: Producing 50,000 barrels of water a day from each of two specific waterlogged wells would release enough trapped gas to permit recovery of some 30

million cubic feet daily—equal to the wells' original water-free production.

"At first people thought we were nuts," Ernie recalls. "But Transco patented the process, and we're negotiating with several owners of abandoned wells. I think we could get them back in production by late 1979."

DOE's Role Increases

Meanwhile, enthusiasm for geopressure gas is growing. Since 1976 the Department of Energy has quadrupled its research budget, and hopes to complete at least three geopressure wells by late 1979. At least two major oil companies are reported to be planning privately financed projects.

Paul Jones sums it up like this:

"There's too much evidence to ignore," he



says. "I think we could be producing two trillion cubic feet a year from this resource by 1985—at considerably less cost than importing liquefied natural gas.

"All we need are people unafraid of new ideas—or taking an old-fashioned chance."

Drillers Go Ever Deeper

New ideas are an old story to Robert A. Hefner III. He has already told NATIONAL GEOGRAPHIC readers about some of them:*

"We expect to discover gas between 24,000 and 28,000 feet. We're shooting for man's deepest penetration of the earth."

Therein lies another untapped major source of natural gas: deep basins.

Bob Hefner made his predictions stick. His company has drilled more than thirty successful deep wells in western Oklahoma's Anadarko Basin and participated in many others, two of them below 30,000 feet.

Now he's ready for more.

"We think we'll find between 70 and 360 trillion cubic feet of gas in the Anadarko between 15,000 and 40,000 feet," he says. "We're as sure as 150 million dollars in research and exploration can make us. We're even predicting gas production below 50,000 feet, with better technology."

The Anadarko is already one of the nation's most productive basins, with conventional reserves of 130 TCF—more than that of the Gulf Coast States.

"But this basin has 22,000 cubic miles of sediments below 15,000 feet—and only one percent of it has ever been touched by a drill," Bob Hefner says.

It's no business for the fainthearted. In 1972 Bob's company discovered a field containing an estimated 100 billion cubic feet of gas. But unexpected technical problems with seven wells swallowed 20 million dollars; the eighth, completed last May, produces 20 million cubic feet a day (page 650). Bob declared a company holiday.

"We won't recover our investment for three or four years," he says. "But now we've learned how to overcome the problems, such as pressures so high they crush ordinary well casings, and hydrogen sulfide that can cause drilling pipe to crumble."

Bob classifies his new success as a "super well," one whose production exceeds the energy of one million barrels of oil a year.

Riding high, dual 30-inch pipelines of Transcontinental Gas Pipe Line Corporation soar above cows cooling in Louisiana's Atchafalaya River (facing page).

At the company's Johnsons Bayou processing plant, workmen roll a 1,500-pound urethane "pig" from the mouth of a 42-inch pipe. Gas moving through the pipe pushes the pig before it, scouring out liquids and sediment.



"Just 165 wells like that will produce more energy each year than the Tennessee Valley Authority's system and the U. S. nuclear-power industry combined!"

"They're not just gas wells. They're national energy institutions."

Recently a committee of independent gas producers from around the country echoed Bob's feelings about deep exploration. Gas may lie as deep as 30,000 feet in the Appalachian Basin, they said. Other promising areas include the Arkoma Basin in Oklahoma and Arkansas, the Mississippi Embayment in the South, and the Delaware Basin in Texas, already boasting more than 70 super wells. (Continued on page 648)

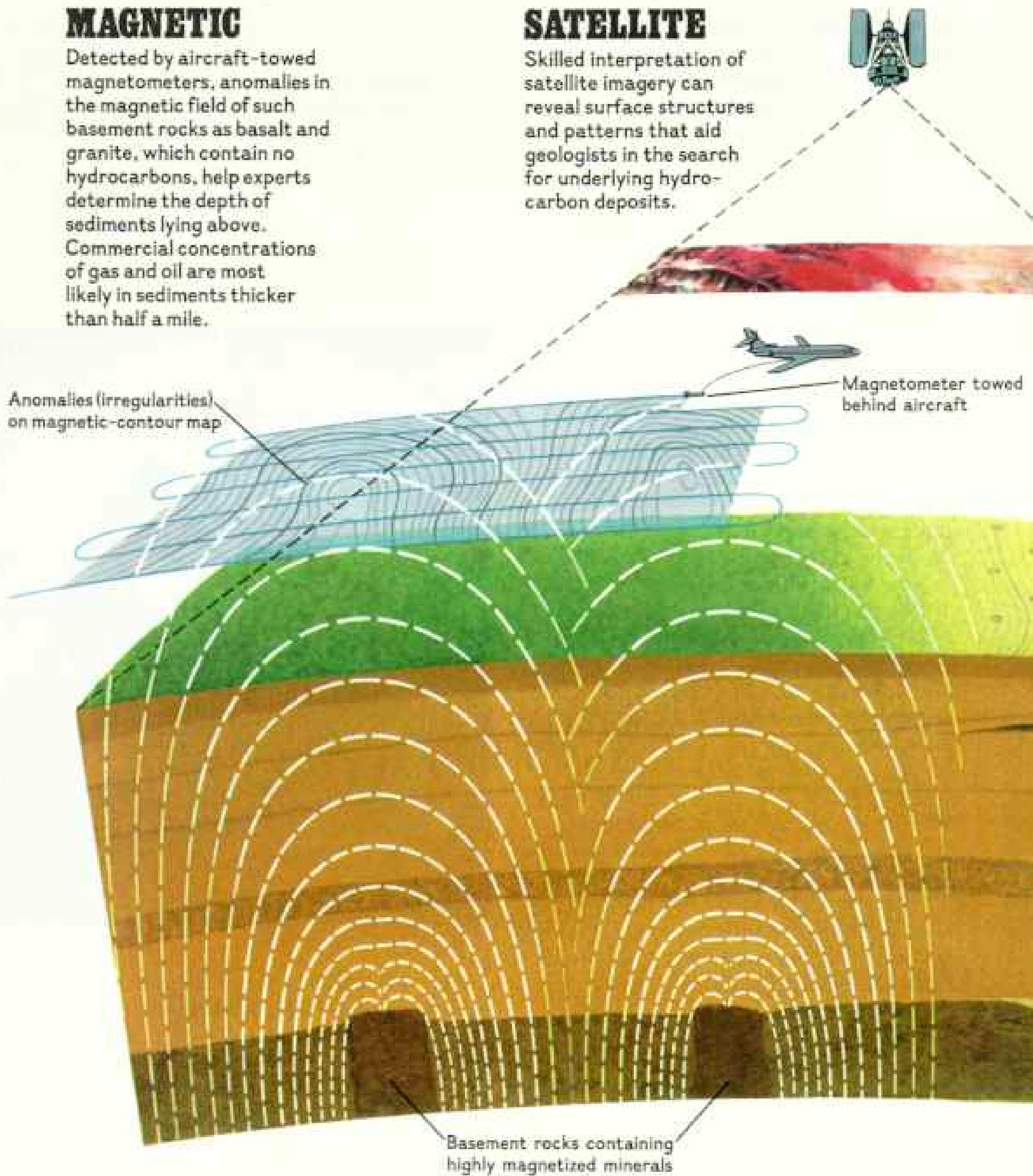
*See "Oklahoma, the Adventurous One," by Robert Paul Jordan, NATIONAL GEOGRAPHIC, August 1971.

MAGNETIC

Detected by aircraft-towed magnetometers, anomalies in the magnetic field of such basement rocks as basalt and granite, which contain no hydrocarbons, help experts determine the depth of sediments lying above. Commercial concentrations of gas and oil are most likely in sediments thicker than half a mile.

SATELLITE

Skilled interpretation of satellite imagery can reveal surface structures and patterns that aid geologists in the search for underlying hydrocarbon deposits.



THE SCIENTIFIC SEARCH FOR GAS

Like a physician examining a patient, exploration geophysicists use a variety of means to probe the earth for gas. Yet today's methods can only indicate areas where gas might be found.

With refinements in digital computers

and survey techniques, it may be possible in future data analyses not only to identify hitherto undetectable gas sites but also to determine how much gas is present, and to estimate the cost of drilling and the potential profitability.

GRAVITY

The mapping of variations in gravitational pull can help locate major features associated with hydrocarbons. For example, a salt dome, often associated with trapped gas and oil, exerts a lower gravitational pull than does denser surrounding rock.

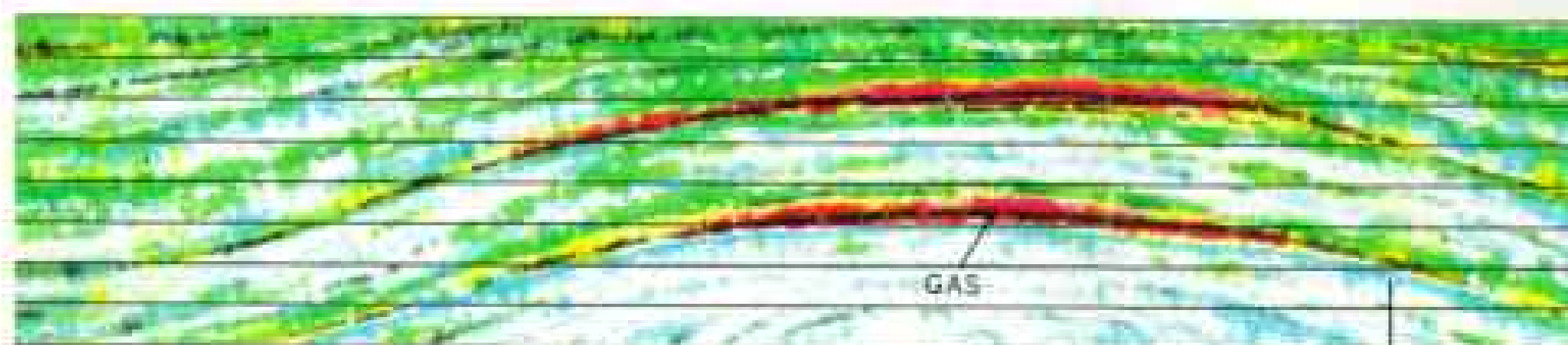
Gravimeter measures differences in the force of gravity.

Gravity map

Huge vibrating plates on trucks send sound waves into the earth's crust.

Recording truck registers information picked up by geophones.

Seismic profile may be color coded to show possible gas accumulations as "bright spots."

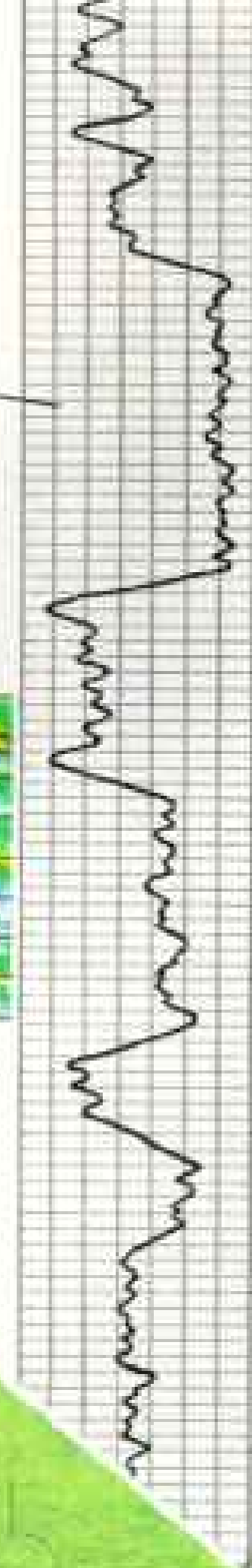


As sediment accumulates, a layer of salt from an ancient seabed is forced up through rock strata, forming a dome.

SEISMIC

Sound waves reflected off layers of rock of different properties yield data for a subsurface map that may indicate likely locations of gas and oil. More than 95 percent of all pre-drilling exploration effort is by this method.

Log readout



Borehole

Sonic generator

Energy path

Receivers

DATA LOGGING

To measure the physical properties of rock strata around a borehole, an acoustic logging tool — one of several types of logging devices — is slowly raised through the hole. This tool records the time it takes for a sonic impulse to travel through a given thickness of rock, which helps determine porosity.

FOSSILS

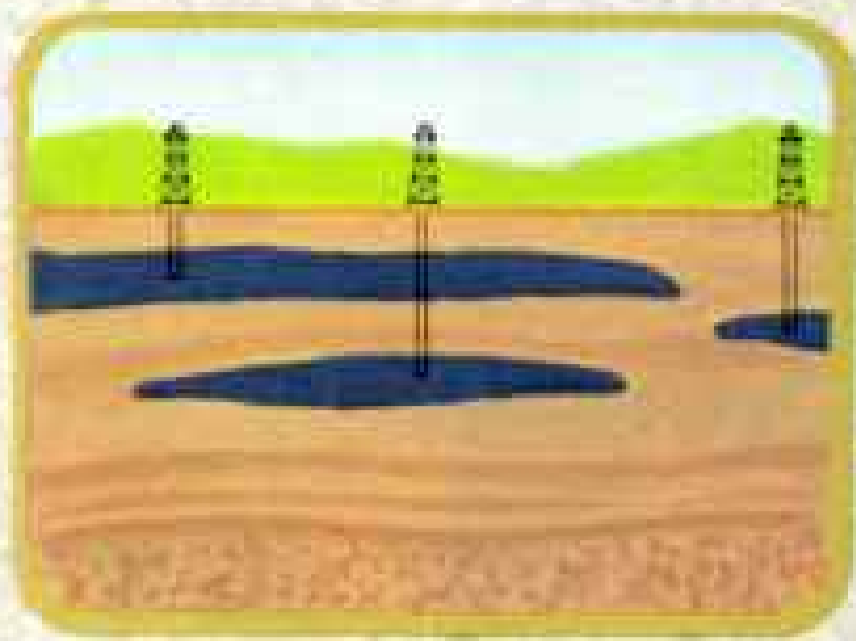
Shale samples taken from a well bore may contain microfossils that help determine age, and whose color indicates the heat and pressure at which they were "cooked" in the earth. They aid in the accurate dating of sedimentary layers and help to locate likely deposits of gas.

Threshold for oil and gas generation in shales (40°C to 60°C)

Peak generation for oil (60°C to 120°C) and gas (60°C to 200°C)

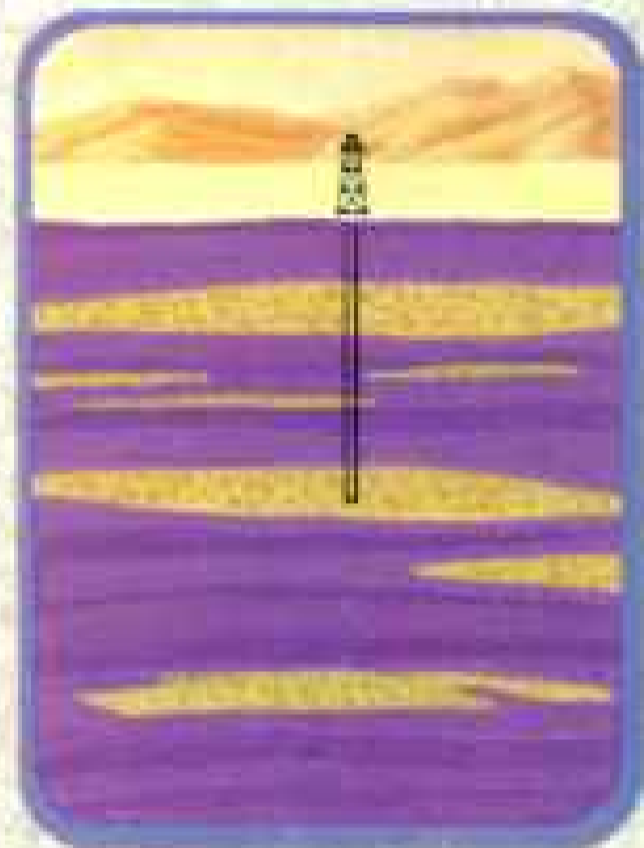
Cutoff for gas production (250°C)





COAL SEAMS

The miner's bane, methane lurks in the nation's seams of coal — as much as 850 trillion cubic feet (TCF), 44 times the total U. S. gas production in 1977. Significant amounts of the coal-seam methane are readily recoverable.



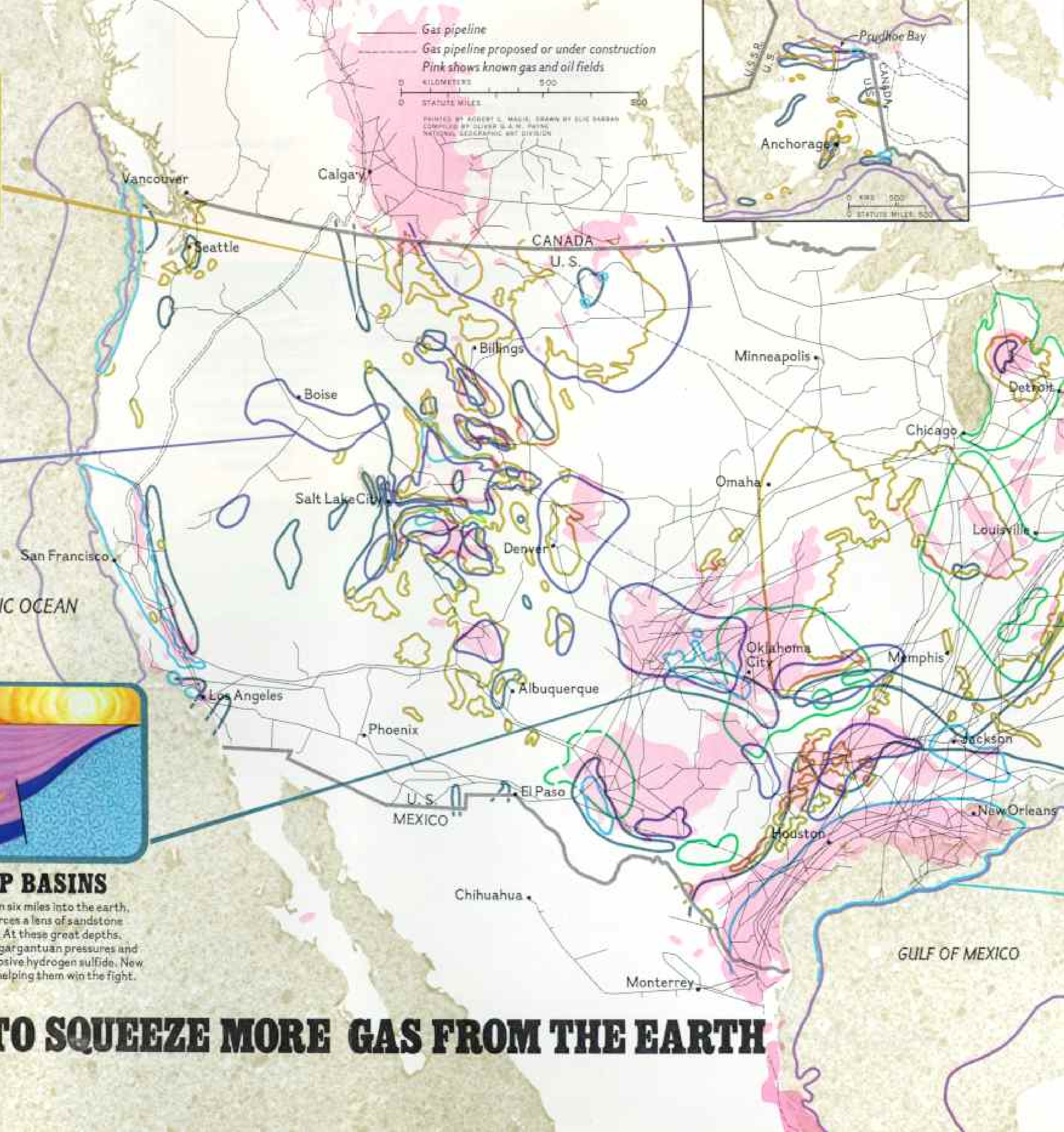
TIGHT SANDS

Tightly compacted beds of sandstone in the western U. S. — remnants of stream and marine deposits — trap an estimated 800 TCF of gas. Since 1973 drillers, using such new technology as massive hydraulic fracturing (pages 636-7), have recovered an additional 191 billion cubic feet of gas in the Rocky Mountains alone.



DEEP BASINS

Punching down six miles into the earth, a well bore pierces a lens of sandstone to release gas. At these great depths, drillers battle gargantuan pressures and searingly corrosive hydrogen sulfide. New technology is helping them win the fight.



Gas pipeline
 Gas pipeline proposed or under construction
 Pink shows known gas and oil fields

0 500
 KILOMETERS
 0 500
 STATUTE MILES

PRINTED BY ARTHUR S. MAGIS, DRAWN BY SUE BARBAN
 COMPILED BY OLIVER S.A.M. PAINE
 NATIONAL GEOGRAPHIC MAP DIVISION



SIX WAYS TO SQUEEZE MORE GAS FROM THE EARTH

HYDRATES

At certain temperatures and pressures, gas and water solidify and may form vast hydrate layers beneath thick permafrost and also beneath the seafloors. Regions where conditions are favorable to the formation of hydrates and where sediment thickness generally exceeds half a mile – the usual minimum for gas and oil exploration – are outlined; stippled areas identify sites with strong seismic indications of hydrates. Sediments underlying the hydrates may also contain gas.



DEVONIAN SHALES

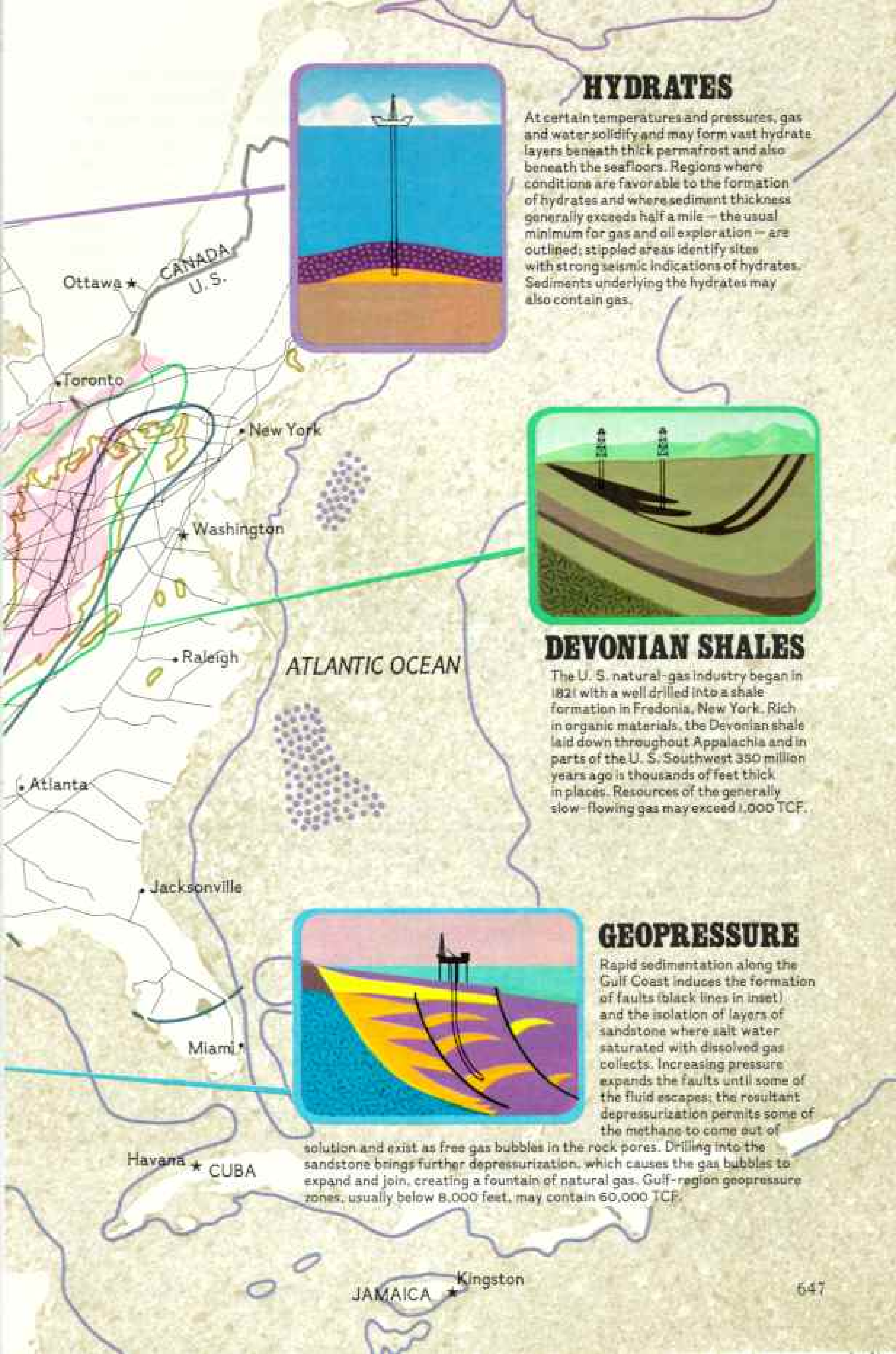
The U. S. natural-gas industry began in 1821 with a well drilled into a shale formation in Fredonia, New York. Rich in organic materials, the Devonian shale laid down throughout Appalachia and in parts of the U. S. Southwest 350 million years ago is thousands of feet thick in places. Resources of the generally slow-flowing gas may exceed 1,000 TCF.

GEOPRESSURE

Rapid sedimentation along the Gulf Coast induces the formation of faults (black lines in inset) and the isolation of layers of sandstone where salt water saturated with dissolved gas collects. Increasing pressure expands the faults until some of the fluid escapes; the resultant depressurization permits some of the methane to come out of



solution and exist as free gas bubbles in the rock pores. Drilling into the sandstone brings further depressurization, which causes the gas bubbles to expand and join, creating a fountain of natural gas. Gulf-region geopressure zones, usually below 8,000 feet, may contain 60,000 TCF.



(Continued from page 641)

"If you doubt their judgment, just remember that the nation's 5,000 independent operators made 90 percent of the onshore oil- and gas-field discoveries in 1976-77—and they drilled more than 50 percent of the deep wells," Bob says.

Meanwhile, there's the Anadarko—and a new set of predictions.

"We want to organize a 12-year program to drill 5,000 deep wells. We predict production of a trillion cubic feet by 1982, four trillion by 1991, with more reserves discovered as we go. That'll cost about 16 billion dollars. At today's higher gas prices, I think we'll be able to smoke out the investors."

Long-term Gamble Pays Off

"Got a match?" Jim Tocher asks. He lights a kerosene torch and touches it to the hissing vent pipe. Gas blooms into a twenty-foot flame, banishing the mountain chill. It's my first glimpse of another major potential gas source: western tight sands.

"That's what 250,000 cubic feet a day looks like," Jim says, gazing at the flare. "Pretty good production from a tight-sand reservoir. The well isn't hooked to a pipeline yet, so we have to vent now and then to keep the borehole clear of water."

Jim, president of Taiga Energy Inc., relishes the warmth. For him, it marks the end of a long financial chill.

"We laid out a million bucks to tie up 200,000 acres in 1974," he says, eyeing the sweep of mesas and valleys of the Douglas Creek area on the Colorado-Utah border.

"The gas is in tight formations—meaning you get small production. But we figured that new methods, plus a price increase, would let us make some money."

The increase was delayed for two years. Investors hibernated. Jim mortgaged his home to help finance the first well and keep his company afloat.

"But they finally boosted the controlled price from 42 cents to \$1.42 per thousand cubic feet, enough to get started. We've raised four million dollars and completed 18 wells. We'll at least triple that this year. Other companies are moving in, and a pipeline is on the way. I'm guessing this area will be producing a billion cubic feet a day from wells like this in five to ten years."

Today thousands of men like Jim Tocher are turning the Rocky Mountain states of Wyoming, Montana, Utah, Colorado, and New Mexico into the nation's hottest energy frontier. In five years they have punched nearly 20,000 wells into the region's many sedimentary basins.

"Here's what we're up against," says Paul Mathias, youthful chief engineer for Chorney Oil Company, one of hundreds of petroleum firms based in Denver.

He tosses me a photomicrograph showing jagged sand particles locked together with fine silt and clay.

"Those are tight sands. They're more dense than concrete. A few years ago nobody thought they were worth drilling. But we've found a way."

The way, called massive hydraulic fracturing, involves forcing fluids at high pressure down wells to create underground cracks as much as a mile long in the tight-sand beds. Sand grains carried by the fluid lodge in the cracks, propping them open, allowing from five to twenty times more gas to reach the well than with conventional techniques.

Today such "frac jobs," costing as much as \$200,000 each, are the key to the Rocky Mountain gas boom. Without them, Colorado's largest gas field, the Wattenberg, wouldn't exist.

"Nobody would touch this area ten years ago," says Bill Delap of Panhandle Eastern Pipe Line Company as we fly over green pastureland twenty miles north of Denver. "Now there are 650 wells, producing 125 million cubic feet a day. With massive fracturing techniques, we get about 200,000 cubic feet per well. Without it, we wouldn't even get enough to pay the drilling costs. We're planning 350 additional wells. We think we'll recover a trillion cubic feet before the field runs dry."

Can Gas and Wilderness Mix?

Amoco is now exploring a 1.5-million-acre tight-sand region in Wyoming, where individual test wells have produced more than four million cubic feet a day from reserves estimated in the trillions.

That is only a fraction of the petroleum resource around the so-called Overthrust Belt, an extensive, complex geologic area

that includes not only tight sands but also deep gas deposits and rich oil reservoirs. Today it is a paradise for Rocky Mountain wildcatters. Federal agencies, however, ponder closing much of this wilderness area to exploration.

"The government giveth an energy crisis—and taketh away part of the solution," sighs a Denver independent. "I wonder if they've talked to those other government people who want to increase strip-mining of western coal?"

Coal Hides Cleaner Fuel

"Digging isn't the only way to get energy from coal," says Harvey Price. "By drilling into seams for methane, we think production could reach a trillion cubic feet a year by 1985, the equivalent of 40 million tons of coal—with no environmental problems."

Price is an executive with a Houston petroleum-engineering firm that has made a specialty of unconventional gas. Already he has ten coal-seam drilling projects across the U. S. Recent core samples from Pennsylvania coal beds indicate gas resources of seven to nine billion cubic feet per square mile, half of which Price thinks is recoverable.

"This isn't potential gas—it's here today," says Price.

Resource estimates are huge—850 trillion cubic feet, according to a 1977 Federal Power Commission study. "We think it's closer to 1,000 trillion," Price says. "They left out several basins."

Coal-seam methane is nothing new. Miners have feared and fought it for years, and thousands have died in methane-triggered explosions. In 1964 the U. S. Bureau of Mines began a research program designed to remove the deadly hazard and cut ventilation costs by drilling into coal seams before they were mined.

"We've produced more than two billion cubic feet since 1972 in just one West Virginia seam," says Maurice Deul, who started the project. "And just last year a small horizontal borehole produced between 60 and 70 million cubic feet from a Utah seam. We're planning a full-scale program there."

Degassing can permit a 10 to 20 percent coal-production increase, but horizontal drilling is not the most economical way to tap the huge gas resource.

"The gas flows slowly, with very little pressure," says Ed Talone, who worked on the Bureau of Mines program before joining Price in 1976. "So we fracture the seams with liquids. That can increase the flow eight- to twentyfold."

Coal companies fiercely resist this idea, claiming that fracturing can create cracks in overlying rock, endangering mining operations. But Bureau of Mines studies of three fractured seams that were later mined showed no such damage, and one major company has already drilled and fractured more than a dozen sites on its coal leases.

"That's not the main issue," says Talone. "Coal companies own the coal, but in the East few of them have clear title to the gas. Until that's resolved, it will be a bigger roadblock than the technology. Meanwhile, we're starting another program. We think there's a lot of gas in Devonian shale."

Eye in Space Aids Shale Probe

"But it's hard to get," says Dick McClish, an energy specialist for Ohio's Department of Energy. "We're looking for help from out in space."

He unrolls a large map overlay covered with lines like scattered dry spaghetti.

"This is Ohio's share of the Devonian sediments. The lines are surface faults, plotted from satellite pictures. We think they'll lead us to underground fault systems where shale-gas production is best."

Devonian shale contains an estimated 1,000 trillion cubic feet of gas beneath 90,000 square miles of seven Appalachian states. Ten percent of the gas can be recovered by modern methods, according to the U. S. Department of Energy's Technology Center in Morgantown, West Virginia.

Shale gave birth to the U. S. gas industry in 1821, when the first well was sunk at Fredonia, New York. It produced only a few thousand cubic feet a day for 35 years. Low productivity and long life are typical of Appalachia's 10,000 shale wells. But the Big Sandy field of eastern Kentucky has produced three trillion cubic feet since 1914.

"We'd like to find some more fields like that," says Dick McClish. "The space survey has given us some promising sites. The state is putting up 1.3 million dollars for drilling in Ohio this year, and private

investors another 1.7 million. They'll get the gas—and we'll get the most sophisticated Ohio Devonian core sampling ever. A real challenge—and every 5,600 cubic feet of gas means one less barrel of oil imported.”

Shale isn't the only gas “play” these days in Appalachia. Recently, with state help, a private firm probed unexplored strata. The well tested at 1.6 million cubic feet a day—phenomenal for Ohio. In central Pennsylvania, an Amoco well tested at 20 million cubic feet daily from a previously unexplored basin. In West Virginia, Consolidated Gas Supply Corporation drilled into a shallow formation near Clarksburg and reported 7.5 million cubic feet a day.

“We don't really know *what* we've got in Appalachia,” says J. Pasini III, a senior engineer at the Morgantown Energy Technology Center. “The big companies pulled out years ago, and there's been almost no real exploration for fifty years. They're starting to come back now—and not just for fun.”

Soviets Predict 300-century Supply

For sheer optimism about the future of natural gas, Soviet scientists win hands down. They estimate that a 30,000-year world supply lies trapped in layers that most petroleum geologists hadn't dreamed of.

These layers, called methane hydrates, are made of water and gas, which solidify

naturally underground at certain temperatures and pressures. Extensive hydrate deposits were discovered beneath Siberian permafrost in 1969. Drilling through them, the Russians discovered that huge volumes of free gas were trapped underneath.

The implications are staggering.

For years geologists believed that most of the world's natural gas escaped millions of years ago from areas that lacked traps of impermeable rock.

But hydrates are also impermeable. And the proper temperature-pressure conditions occur not only in permafrost regions, but in gas-rich deep ocean sediments as well. If hydrate layers exist there, the Russians said, they may contain *1.7 million trillion* cubic feet of gas.

Evidence is growing. A U. S. Geological Survey team headed by Dr. Arthur Grantz has found seismic evidence that thousands of square miles of hydrate layers may exist beneath the Beaufort Sea north of Alaska. Others have found hydrate indications off the Atlantic coast of North and South America. And they believe hydrates may explain the large quantities of methane found in hundreds of locations by the National Science Foundation's Deep Sea Drilling Project since 1968.

“We're virtually certain that they exist,” says Dr. George Bryan of Lamont-Doherty



Geological Observatory. "We've checked the seismic data against tests we've conducted on hydrates made in the laboratory, and the results agree."

In 1970 Soviet scientists stirred up another hydrate debate. They announced production of significant quantities of methane from two test wells—from three to nineteen million cubic feet a day—by injecting methanol into the formations to break up the gas-water solids.

Industry spokesmen dismiss the feat as a costly, impractical experiment. But Richard D. McIver has another idea. As a researcher for Exxon Corporation, he studied hydrate samples recovered at Prudhoe Bay in 1969; now he is a leading expert for an independent research firm.

"It's quite possible that the Russians were producing from the boundary zone between a hydrate layer and an underlying free-gas zone. Producing the free gas would cause a pressure drop—and that, in turn, would cause the hydrates to melt. We know that a hydrate reservoir can hold up to six times more gas in the same volume than a normal reservoir. So the melting process would add large quantities to the flow."

McIver believes the first commercial hydrate production will come from the shallow and accessible permafrost regions onshore—but not until conventional Arctic gas

has been fully developed. Deep-sea hydrates must await much research and major new offshore drilling technology.

Is Barnyard Gas Next?

Technology. Economics. Statistics. At first it seemed to me that natural gas was nothing else. Now I've traveled the land to meet men who are cheerfully testing ideas against the earth's endless mystery.

I must confess their optimism has rubbed off. And if they're wrong, I know some other optimists, with some quite different ideas.

Jim Samis, for instance. In Oklahoma he shows me around his three-million-dollar plant, which makes more than a million cubic feet of methane each day from cow manure and recycles the residue into high-quality cattle feed and fertilizer. "This isn't a pilot plant," he says. "We're in business."

Or Dr. Joseph Katz. In a basement workshop at Argonne National Laboratory in Illinois, he has bred thousands of generations of algae, and has learned to simulate aspects of photosynthesis—the means by which green plants convert sunlight into energy.

"That energy, electron by electron, drives the chemistry on which all organic life is based," he says. "Someday we will learn to use this principle to make fuel and food as nature does—quietly, and without any fuss." □

Deep driller, managing partner Robert A. Hefner III (right) of GHK Company took the plunge into Oklahoma's Anadarko Basin in 1969. It wasn't smooth. The drill pipes encountered supercorrosive hydrogen sulfide and pressures as great as 19,000 pounds per square inch. Last May, Hefner scored big when his #1 Watkins well spewed gas from 17,000 feet below the ground. His employees and their guests gathered for a party while the well was flared for cleanup (left).

Hefner predicts that gas will be produced here at depths of 50,000 feet. By 1991 he estimates the deep basin's output at four trillion cubic feet a year. "That's equal to the energy in 720 million barrels of oil," he adds. "Oil that we won't have to import."



Where the River Shannon Flows

By ALLAN C. FISHER, JR.

ASSISTANT EDITOR

Photographs by ADAM WOOLFITT

Erin's ancient highway, the River Shannon winds across Ireland's verdant splendor as well as through the legends of its vibrant past. Longest river in the British Isles, it meanders for 214 miles, swelling and narrowing into a chain of lakes before yawning into the Atlantic. The river glimmers with reflections of castle towers and monastic ruins. Sailors delight in its wide open waters; anglers extol its teeming depths. The Shannon is home to John Weaving, who explores a tributary by motorboat while shipmates Brocky and Twiggy stand watch over the port and starboard sides. Weaving quit a career in banking to become a river nomad, living aboard a 60-foot barge and working as a navigational consultant and free-lance handyman.

Ní h-aitheantas go h-aointíos.

To know beauty, one must live with it.

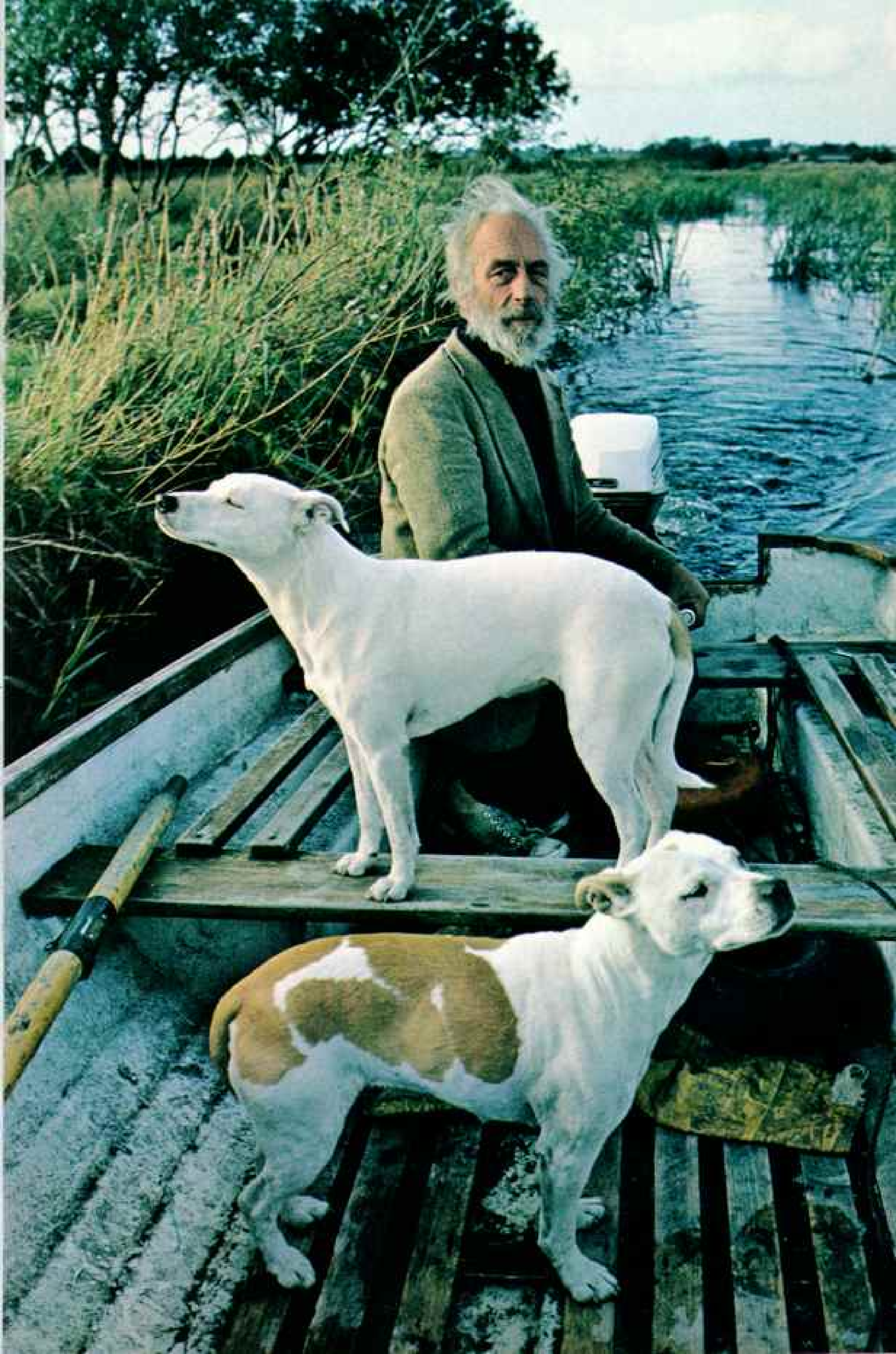
—IRISH PROVERB

FOR EVERY MILE of Ireland's River Shannon, for every bend, there are legends, stories as old as the tumbled ruins of castles and churches that stand like brooding Stonehenges along the Shannon's shores. My favorite I heard from an old pensioner who fished for bream from the riverbank near Battlebridge. He gave his name only as Sean. Though still lively of eye and tongue, he was so small and frail that a stranger might think him one of the wee people. Sean said he had heard the story from his father's father:

Near the headwaters of the Shannon, where it is but a brawling stream, lived in solitude a young monk of the utmost piety and goodness. He spent his days in fasting and prayer for others. Never did he ask of God anything for himself, though he dwelt in a dank cave near the river and was blind. The Shannon gave him his only pleasures: cool, sweet water to drink and bathe in and a burbling, merry passage to hear.

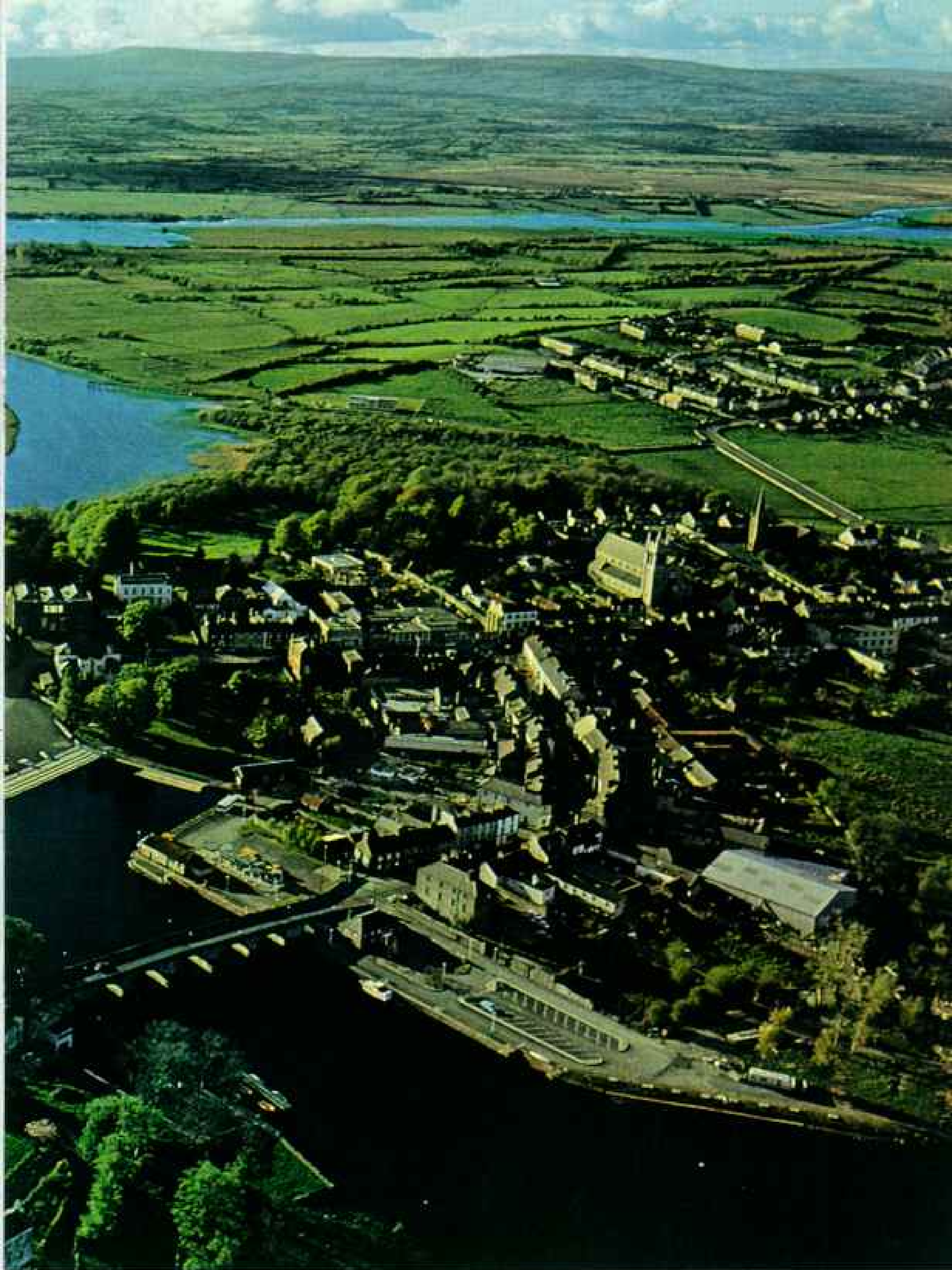
The great bards, travelers of the Shannon, learned of the monk's goodness, and all visited with him, determined that he should see the beautiful river in song and story. They sang of its source, the mysterious Shannon Pot, a dark, brush-girt highland tarn always full to overflowing—though no stream ran into it. In its waters no man or animal could drown. And the bards described the river's passage through meadows aglow with the purple, white, and yellow of wild flowers. They sang of a succession of blue lakes formed by the Shannon, dotted with islands and rimmed by mountains splashed with molten gold spilled through towering clouds. And they told him of an inland sea, an estuary whose sparkling waters flowed westward into the ocean tempests.

Though enchanted with these beauties, never once did the selfless monk pray to see them. Then one day, as he laved his eyes at the water's edge, the dark veil lifted, and he saw. God had decided a man so good should not be denied a river so lovely. And the monk joyously journeyed downstream, seeing all and praising God. It is said he sailed





Curling blue ribbon on a mottled green carpet, the River Shannon loops around the town of Carrick on Shannon. With a flotilla of small craft,



MARTIN ROGERS

Carrick is the center of the Shannon's small but growing hire-boat business, offering river adventurers anything from a rowboat to a cabin cruiser.

the marches of the sun into the red west, where he joined St. Brendan the Navigator in many good works in lands unknown.*

I heard that tale before I had seen much of the Shannon. But the bards did not exaggerate; the beauty is still there. Change has touched the storied river very gently. Traveling its entire length from headwaters to the sea, I saw it much as the monk did with his newly opened eyes.

The Shannon lies wholly within the Republic of Ireland and flows through the heartland of the country for 214 miles, making it the longest river in the British Isles (maps, below and right). With its 32 tributaries, it drains a fifth of all Ireland.

John Weaving, bearded, patriarchal-looking, knows the river as well as any man (page 653). For 15 years he pursued a banking career, then shed it like a hair shirt for a life on his beloved Shannon. Now, with his dogs, Brocky and Twiggy, he lives aboard a 60-foot work barge and repairs jetties, piers, or whatever needs fixing. It sounded disloyal, but one day John confided to me, "The Shannon is a very odd river. In fact it's a river for only about a third of its length."

Indeed, for two-thirds of its length it doesn't fit the conventional image of a river. As fresh water it flows into and out of three major lakes and many lesser ones, stringing them together like blue gems on Ireland's central plain. Then it joins the estuary that stretches sixty miles from Limerick to the Atlantic.

Measurements show the Shannon discharges far more fresh water than can be accounted for by the flow of its tributaries. Myriad underground rivulets and streams, percolating through limestone, feed the river and its lakes—and, incidentally, account for the almost constant level of the Pot.

The Shannon remains surprisingly undeveloped and virtually pollution free. At the head of the estuary a hydroelectric plant straddles the river, and downstream the traveler passes another power station, a cement plant, oil depots, and marine

terminals. A plant for processing bauxite into alumina is being built. But vast stretches remain much as they have for centuries.

Above tidewater, aside from several widely spaced power plants, there is no heavy industry, not even waterborne commercial traffic. Until 1960 Guinness Brewery barges, loaded with barrels of porter and stout to slake the Irish thirst, plied the river, but today rail and trucks do the job.

The Shannon ranks in my mind as the most unspoiled vacation spot in all Europe. The lonely Pot sleeps as in time long past, the meadows still riot with color, the lakes remain as sweet and untouched as a maiden, and the estuary still flows serenely along the marches of the westering sun.

If the freshwater Shannon can be said to have an industry, it is boating. About 21,000 visitors a year—mostly Germans—rent 22-to-42-foot cabin cruisers from ten companies scattered along the river from Killaloe, just above the estuary, to Carrick on Shannon, near the head of navigation.

I traveled the Shannon afoot, by car, and in various kinds of boats. But on the upper Shannon I went first-class: a 32-foot triple-cabin cruiser with twin diesels and a pleasant 18-year-old lad, Paddy McCormack, as guide, cook, and agile line handler for an aging sailor. Our boat's name, *Agricola*, Latin for "farmer," seemed apt, for the Shannon is essentially a rural river.

On the upper reaches one repeatedly sees cattle in the blossoming, scented meadows, and occasionally they even gather at the unfenced locks that bypass rapids. Indeed, cattle seemed intent on boarding us in our cruise from Carrick to Battlebridge, a tiny village beneath a musical rapids where river navigation ends. Cooling their undersides, cows waded amid yellow water lilies almost in midstream, while others lounged on the embankments, half hidden by rushes. Swans lifted

(Continued on page 661)

*See "The Voyage of Brendan," by Timothy Severin, NATIONAL GEOGRAPHIC, December 1977.





NORTHERN IRELAND

0 KILOMETERS 20
0 STATUTE MILES 20

— Canal ◁ Lock
▲ Power station △ Ruin

Elevations in meters (black) feet (red)

Stairsteps on the waterway, a series of locks lift and lower boats traveling the Shannon. Pleasure craft can cruise the Grand Canal all the way to Dublin.

Speaking in stony silence, the remains of once mighty kingdoms and centers of piety — such as the monastic ruins at Clonmacnoise — tell their stories to the unhurried visitor.

Northernmost power station on the Shannon burns soft coal mined in the area. Other facilities use imported oil or native peat or tap river power directly.

Springing to life from the Shannon Pot, a tiny pool nestled in an upland meadow, the Shannon flows through the heart of the Emerald Isle. Remarkably free of commercial traffic or industrial development, the river wanders past bucolic countryside and storybook villages — a haven for boaters and sightseers.

River Shannon

MAP BY DEWEY G. HERRICK JR.
COMPILED BY PATRICIA J. HARRISON
NATIONAL GEOGRAPHIC ART DIVISION



"Don't stay too long in this country or it will capture you." That's the gentle warning Matt Leyden gives visitors to his home overlooking Lough Allen (above). To live on a small Irish farm may sound idyllic, but Leyden, his wife, Ann, and their three sons know it means hard work, such as the backbreaking task of potato digging (below).

While being weaned, their calves lap a gruel of milk, cereals, and additives, a

cheaper feed than milk alone. Teaching a calf to drink from a bucket is a tedious two-week process. Mrs. Leyden dips her fingers into a calf's mouth, as if to prime the pump (below).

After the morning milking, Ann and Matt tote a ten-gallon can to a cart; with Sally on his lap, Matt lets Jackie pull him (right) for the quarter-mile trip to the milk-truck stop. Despite the toil, the Leydens savor the beauty and freedom of their life.







Looking tired and tattered, 22-year-old Vincent Gilhooly emerges from the Arigna Collieries mine, producers of coal for power plants and institutional heating. Such industrial installations are so scarce along the Shannon that, in the words of one farmer, "You can stick your kettle down here and make your tea with the water. It's that pure."

(Continued from page 656) question-mark necks above the high grasses, and querulous ducks scooted away uneasily from our bow.

A friend told me of a Belgian boat renter he met at one lock. Showily tattooed, a real blue-water sailor, the Belgian shook his head and rolled his eyes. "Incredible! Too much!" he said. "We have cow dung on our dock lines!"

THE SHANNON'S SOURCE: Log na Sionna, the Hollow or Hole of the Shannon. That's the Pot's proper name. At first glance it's not impressive, merely a pond about 25 feet wide in a highland meadow, fringed by hawthorn and a rather ugly, almost stunted form of willow called sally. But the mood of the place soon grips one. Lichens cover the bark of the sally trees, and from a distance they look like scabrous apparitions peering into a dark mirror. If you see that strange tarn on a day of gray gloom and fitful rain, as I did, it seems an eerie, haunted place.

On the meadow's edge sag the roofless ruins of a stone cottage and outbuilding. Everywhere on the Shannon one finds such derelicts, many so old that only their stones know the truth of it. Prowling about, I found a touching "Home Sweet Home" inscribed above a broken lintel of the fireplace. But the wind moaned in pain through breached walls, and cattle had churned the dirt floor into a quagmire that reeked of excrement.

Legend persists that no man or beast can drown in the Pot. I heard it several times from local people. All seemed to know someone who knew someone who had fallen in and been miraculously supported. But the Pot is not the bottomless hole popularly believed. It's been plumbed and found only 25 feet deep.

From the Pot to Lough Allen, a seven-mile distance, the river tumbles more than 300 feet. To see these strange headwaters, strewn with rocks and deadfalls, you must go by car and afoot.

Many mountains, beautiful but virtually treeless, encircle Lough Allen, eight miles long and the third largest of the Shannon lakes. Again I marveled at the lack of development, aside from a power plant fueled by coal from nearby hills. Otherwise, nothing but farms and a scenic road ring the lake.

Farmers here speak proudly of Turlough O'Carolan (1670-1738), last of the great Irish bards, who is buried nearby. A prodigious drinker, O'Carolan came to his deathbed unable to swallow, legend tells, but put lips to his favorite cup, saying two such old friends should not part without a kiss.

Years ago boats from downstream could reach Lough Allen by a canal. Lough Allen now serves as a storage reservoir for the hydroelectric plant at Ardnacrusha, far down the river.

Boats cruise easily from Carrick to Lough Key, a smaller lake but also a place of idyllic beauty. You motor up the Boyle, a Shannon tributary, threading a reedy way through minor loughs until suddenly the Curlew Mountains loom to the west, and you are in island-studded Key, made even more beautiful on clear days by Ireland's limpid air, pollution free almost everywhere.

Entering and leaving Lough Key, you pass through Clarendon Lock, which has the Shannon's only woman lockkeeper, Mai Conlon. Clarendon, like the other locks, is a convivial place. Boatmen, their craft tied up while awaiting an opening, stroll about, visit other boats, swap yarns, sing and strum guitars. Each lock becomes a clearinghouse for messages and gossip.

GEORGE McARDLE, an Englishman who prefers to live among the friendly Irish, told me about his first tie-up at Clarendon. Workmen were doing some repairs, so George took that as excuse enough to leave his boat and seek a pub. He asked if there were one nearby.

"I didn't believe my ears," said George, "when a workman pointed at a little dog and said, 'Manfred will take you.' The dog led me down a path, and several times we passed people who nodded to me and said, 'Good evening, Manfred.' Finally we reached a crossroads with two pubs. Manfred went straight to the one on the right, stood at the bar on his hind legs, with his front paws against it, and looked expectantly at the pub owner's wife.

"Being properly grateful to Manfred, I said, 'What will he have to drink?' The lady said, 'Oh, Manfred doesn't drink. He'll be having a dog biscuit.' And she gave him one. I asked, 'Why did he head straight for this





Field day for the horsey set, the Great October Fair at Ballinasloe—one of the oldest horse fairs in Europe—began where travelers to the king's castle at Tara stopped to trade in their tired mounts. Generals equipped their armies with hardy Ballinasloe steeds, prized for superior bone structure strengthened by calcium-rich grasses from the limestone plain. The fair waned when the tractor replaced the horse on farms, but local boosters revived it. Last year's fair brought 2,000 hunting and riding horses to the sale. After dicker-ing, a slap of hands seals a deal (left).

pub instead of the one on the left?' The lady smiled a bit smugly and replied, 'It doesn't have dog biscuits.'"

I took this yarn with a grain of salt on the biscuits, but Mrs. Conlon swears it's true. Manfred is dead now, but, as Pied Piper for thirsty boatmen, he wore a path to that pub. "He snarled at anyone who came in a car," says Mrs. Conlon, "but he would almost hug and kiss anyone off a boat."

Carrick, with several marinas and boat-hire companies, ranks as the busiest boating center on the Shannon. One Saturday morning I watched purposeful bedlam and ordered chaos as 47 families arrived, claimed their boats, and shipped out.

Donnaca Kennedy, who takes people on cruises out of Carrick, said, "The main thing we have to offer here is peace and quiet. On the Continent it's almost impossible to find someplace to be alone."

Kennedy operates one of the self-propelled 60-foot barges that used to carry Guinness stout on the river. Indeed, a number of boatmen bought the metal barges and converted them into cruising vessels. Sean Fitzsimons, a pub owner at Athlone, calls his *De Iron Lung* and says she's haunted. "There is a ghost who walks about her at night," he told me. "My wife has heard it. And a friend of mine one night heard foot-steps and, though he saw nothing, was sure a man entered his cabin and stood beside him. I did some research and found that a man had fallen off my barge and drowned while it was still used by Guinness."

SOUTH OF CARRICK, after taking *Agricola* through a series of small lakes and a canal, Paddy and I decided to get off the beaten channel, so to speak, and venture into a remarkable wilderness of backwaters. We sought Grange Lough, but to get there we had to push our bow through a maze of courses winding among rushes and reeds. On the main Shannon, boats easily follow red and black markers, but here we had to ferret them out among the vegetation.

We persisted, slowly feeling our way through magnificent stretches of yellow water lilies and growth as high as our cabin top. Finally the green wall parted, and we found ourselves slowly cruising the Shannon's inner sanctums, Carranadoe Lough

and narrow Grange Lough. Amid rolling farmland we anchored, the inevitable stone ruin on one side of us, a farmhouse on the other, cattle grazing in the fields.

I am a night person, soothed by shadow, my spirits lifted by stars. While Paddy swam, I watched a long twilight envelop the lake. A man came down from the farmhouse to the water's edge and bathed. Swallows and martins coursed all about *Agricola*, and the lonely call of a curlew sounded overhead. The land's soft exhalation brought us

the smell of mown meadows and cattle. A planet burned on the horizon, and the first stars appeared. Then a line of purple dusk stole across the waters, and it was night.

At Lanesborough stands a riverside power station unusual in but one respect: Peat, not coal or oil, fires its boilers. With Paddy Mooney, a cheerful, encyclopedic fount from Ireland's Bord na Móna, or Peat Board, I watched huge elevators lift railroad cars full of bricklike peat turf to the top of the plant, then dump the contents into



an open maw leading to furnaces below.

Bord na Móna, government owned, harvests some four million tons of peat annually. Irish hearths consume much of it, and peat-fired plants generate about a quarter of the nation's electricity. Years ago, when coal and oil still were cheap, the government decided to burn peat in some power plants to encourage a home industry. Now that decision looks prescient, for peat costs Ireland far less than conventional fuels.

Peat bogs lie on both sides of the upper

Shannon. Paddy Mooney gave me a real bog trotter's view of them. I had expected quagmires; to my surprise I walked dry-shod through vast fields, all a uniform brown. That's what a good bog looks like after it has been drained and the overburden removed. It yielded underfoot with a curious sponginess, as though I were intruding in someone's new garden.

Huge machines cut turfs, about the size and shape of bread loaves, while other machines scratched and scraped the surface to make milled peat.

LOUGH REE, second largest of the Shannon's lakes, can be brutal in high wind, but we found it so placid *Agri-cola's* passage seemed intrusive. With great fidelity, the water reflected each cloud, even a gull that glided silently but persistently alongside us. We passed emerald isles with grazing beef cattle but no habitation, and I wondered how the cattle got there. Paddy explained that their owners made them swim over in spring and back in fall.

Between Athlone and Portumna the river valley broadens and the land stretches away in a patchwork quilt of fields, hedges, and distant hills, all in varying hues of green. An Irish friend told me his countrymen recognize at least ten different shades of green, and some people say as many as forty. In winter months the Shannon floods low-lying land, renewing farmers' fields. One, however, told me he didn't like the annual flood. With a straight face belied by merry blue eyes, he explained, "Sure and it's those fish now; they eat my asparagus."

*In a quiet watered land, a land of roses,
Stands St. Ciarán's city fair,
And the warriors of Erin in their
famous generations
Slumber there.*

That bit of old verse refers to one of the most hallowed places in all Ireland.

Things start jumping when the horses show their form to potential buyers at the Ballinasloe fair. The stakes are high: Top show and jumping horses fetch the equivalent of \$7,000 and more. At night business gives way to merrymaking as acrobats, jugglers, and Gypsies entertain.





Up a lazy river by the Lough Derg shore, wafts of song drift out over the water, as if in celebration of a sun that too seldom shows its face in this misty land. When the

big top comes to town, the Irish step right up. But a girl at Fossett's Circus in Limerick hacks off when a cheeky camel gets a bit too forward (below).



Approach it by boat, just nine miles south of Athlone, and you might think its hilltop array of stone towers and walls still a "city fair." But when nearer, you see that these are ruins, the remains of Clonmacnoise, a monastery founded by St. Ciarán about 548. It became one of the great ecclesiastical centers of Europe.

Remnants of eight churches, two round towers, three high crosses, and 400 early gravestones still survive. It's amazing anything remains. By one historian's count, fire ravaged Clonmacnoise 13 times between 722 and 1205. Vikings plundered it eight times between 832 and 1163. In that same period Irishmen attacked it 27 times, and the English six times between 1178 and 1204. After each sack the monks rebuilt, but the English garrison at Athlone reduced it to final ruin in 1552.

I don't think anyone can wander about that holy hill without being moved by the tangible evidence of a people's enduring faith. Perhaps I lingered longest at the impressive Cross of the Scriptures, erected in memory of a high king who died about 914, and the little temple on the site where St. Ciarán himself may be buried.

OF ALL THE BLUE GEMS strung together by the Shannon, Lough Derg, largest of the lakes, became my favorite. Twenty-five miles long, and nearly ten miles wide at its southern end, it has fewer shallows than Ree and provides excellent cruising for deep-draft boats. Here *Agricola* joined other boats in the week-long Lough Derg Rally. Races, rendezvous, contests, a ball—participants in this annual movable feast enjoyed them all while cruising to such picturesque harbors as Mountshannon, Dromineer, and Garrykennedy.

Near the tiny, buttonhook-shaped harbor at Garrykennedy I sought out a living Irish legend, violin maker Jerry Martin (page 673). Jerry, a self-taught craftsman, has been making fiddles, as he calls them, since 1922, and long ago they became collectors' items. But Jerry is 81 now, frail, arthritic, and alone; no longer can he make many fiddles, and he lives Spartanly in a crude, dirt-floored cottage, warmed by a peat fire and crowded with his tools, wood, and a few pieces of old furniture. I found him huddled

by the fire, sucking on a cup of steaming tea with a wall sign behind him that said:

NO CURSING
NO FILTHY TALK
NO WASTE OF GOD'S NAME
ALLOWED HERE

—Jerry Martin

Jerry was always small, but age has diminished him and hunched him over. Yet his craggy face takes on youth when he talks of his craft. How many fiddles had he made? "Seventy-four," he said. "But that's nothing. Stradivari made hundreds."

He showed me his tools, woodpiles, and the back of an unfinished fiddle. "We call that wood sycamore, and you call it maple," he said. "The belly I make from pine. I buy strings and bow. Can't get the right kind of wood for the bow."

Then he brought out his treasure, a finished fiddle made years ago on which he had lavished extra care and love. "I wouldn't take a thousand pounds for it," he said. It was indeed lovely, lustrous with a French polish endlessly rubbed and with a thin inlay all around the perimeter of the top. "That inlay's what made me famous," Jerry said. "It's no fiddle without an inlay. I cut it by handsaw to a sixteenth of an inch thick, measuring by eye. You must bring in a fiddle to an eighth of an inch at the ends and three-sixteenths in the very middle."

He said he had sold his last three fiddles for fifty pounds (87 dollars) each, which I thought too little. "I could sell twenty a day," he said. "I used to make one in three weeks. Sometimes I would work 14 hours straight." He gazed at his gnarled hands. "I'm not able to do that anymore. Now it takes months."

I asked him to play his treasure, and he replied shyly: "I know nothing about music meself. I cannot read it. But I play. It's not so easy . . . the fingers . . . hands. . . ."

He put bow to strings and the notes of "Over the Waves" danced about the dark little room. He followed with "Londonderry Air." I thought the tone of the instrument hauntingly beautiful. Closing my eyes, I imagined myself listening to a child who played charmingly but with slight hesitancy. Then I said good-bye, leaving Jerry sitting by the glowing peat, his arthritic hands held out to the warmth as if in supplication.



WHEN THE SHANNON leaves Lough Derg, it flows between mountains that rise almost at the water's edge, creating a reach like a Norwegian fjord. Irish weather, compensating for the often fleeting nature of the sunlight, gilded those mountains for us with shafts of purest gold. Irish sunlight can be as special as Irish green. At the end of this passage lay Killaloe, a town of such charm that I made it my headquarters while exploring the estuary.

Near Killaloe I did some serious fishing with Hugh Gough, a man who may have the world's best job. Hugh is the coarse-angling officer for the Inland Fisheries Trust, which means he goes fishing or takes people fishing just about every day (page 675). The Irish distinguish the pursuit of coarse fish—pike, bream, rudd, perch, tench—from the classic quest for salmon and trout. Hugh and I sat on the riverbank with every intention of depleting the Shannon's bream population.

The evening before, Hugh had baited the bottom off our riverbank with bread and maize meal. Bream, bottom feeders, would be attracted to the bait, then to our hooks, now skulking in the area with nice fat maggots on them. So much for theory.

We sat and we waited . . . and waited. Hugh got a bite. I didn't. Hugh caught a small perch. I caught a cramp in my leg. Hugh queried the fish and himself: "What are you doing, Mr. Fish? Where are you? Must I wait another day for you? What is the water temperature? Is my hook too big? Should I use one maggot or two?"

Hugh fashioned balls of bread and meal and threw them out as more bottom bait. "They have to go down with a 'plop' instead of a 'plip' or they break up and wash away," he said. All went in with a gratifying plop, but no bites ensued. Hugh scattered maggots on the water with a slingshot. They attracted only a little brown bird.

I was devouring a chocolate bar when Hugh told me how to raise maggots. Open up a sheep's heart and let blue flies lay their

eggs in it. When the heart is alive with squirming maggots, feed them rancid butter. And then—but perhaps that's all you want to know about raising maggots. It was enough for me.

To Hugh Gough's embarrassment, we caught nothing. But just upstream a lone Englishman pulled in seven big ones.

IN 1929 the government's Electricity Supply Board completed a hydroelectric dam at Ardnacrusha, creating a barrier for salmon running upriver to spawn. So the government made ESB responsible for keeping not only the salmon happy but other fish as well.

And it has. Fish ladders and passes help the salmon around the dam and various weirs, and at Parteen the ESB maintains a large hatchery that raises salmon and trout.

Hatchery workers remove the adipose fin from the backs of salmon before releasing them; this distinguishes them from fish raised in the wild. On the day I visited a fishing weir, hatchery-bred fish numbered more than half those caught, reflecting an ominous trend. Marine biologist Noel Roycroft of the ESB commented, "The daily catch used to average 2 percent hatchery fish; now it's almost 20 percent. The wild population steadily decreases."

Meanwhile, illegal Irish trawlers work back and forth across the mouth of the Shannon, taking great netfuls of salmon. Roycroft and John Costelloe, a conservation officer, told me about the trawlers one day as we cruised the estuary, talking to fishermen. "Those poachers have denuded the south coast of fish, and now they're moving here from Kerry," Costelloe said. "One of those boats rammed me, and when I went back with two other officers, they held shotguns on us and drove us off."

For generations licensed fishermen have worked the estuary for salmon with drift nets, using homemade rowboats called *ganloes*. On a morning gravid with the threat of

A shepherd of the church draws a faithful flock to a venerable place of worship on the Shannon—the ruins of the Clonmacnoise monastery. Founded 1,400 years ago, the monastery repeatedly rose phoenixlike from the ravages of fire and invasion. Grasping a crozier, Anglican Bishop Donald Caird of the Church of Ireland helps conduct a service that commemorates Clonmacnoise as a great medieval center of holiness and scholarship.



Like tiny white boats on a deep-green sea, farmhouses dot a vale near Lough



Derg. Some natives insist that a true Irishman can distinguish 40 shades of green.

rain we pulled alongside the ganlow of Peter Burns, a strongly built block of a man, and his son Eamon. When I asked Peter how long he had been a fisherman, he replied wryly, "By the looks of it, too long." They had one salmon to show for five hours' work. "On a good run years ago, we would take 20 or 30 a day," Peter added. "In a good year we made up to £6,000 [\$10,950]."

But the Irish can find humor in almost anything. Fishermen up and down the river were telling a story about the legendary Hush Hogan, a fishing guide who could always find salmon for his clients. An English angler, on the river all day with Hogan but with only one fish to show for it, confronted the guide angrily.

"I figure this one salmon cost me a hundred pounds," the Englishman fumed.

"Then aren't you glad you didn't catch two?" said Hogan.

ARDNACRUSHA'S 85-megawatt hydroelectric plant creates a barrier not only for migrating salmon but also for boats, and the fish get through easier. Boats must use two dark locks with a total drop of more than a hundred feet. Bound downstream, you feel like you're sinking to the bottom of the River Styx; tricky currents make Ardnacrusha off limits for rental boats.

Below the dam lies Limerick, the Shannon's largest city, an ancient place (pages 676-7). It may be the city of Regia mentioned in the *Geography* of Ptolemy. The Norse founded a settlement there about 920. A century later Ireland's foremost hero, Brian Boru, made himself king of all Ireland and ousted the Norse. His fortress, Kincora, stood on the Shannon's banks somewhere in the Killaloe area.

Oceangoing vessels of 12,000 tons tie up at Limerick's docks, and an island terminal off Foynes, farther downstream, can take 60,000-ton ships. Foynes serves as the base for oil exploration off the northwest coast of

Ireland. The Irish, intent on developing the long-slumbering Shannon estuary, offer attractive subsidies and tax incentives to new industries. The new alumina plant near Foynes will provide jobs for 800.

But you can still make a peaceful, lovely passage down the estuary, as I did aboard a Limerick Harbour Commissioners launch. A cement plant with two huge stacks yielded to rolling meadows and a succession of dramatic old castle ruins: Cratloe; Carrigunnel, feudal seat of the O'Briens; and Dromore, built for an earl of Limerick. The Westropp estate and its Georgian mansion slipped by on our left, Shannon Airport on our right.

Shannon Airport, once seemingly doomed to a slow death, has become a showplace of modern Ireland. It started the first duty-free airport shop and flourished after World War II, when transatlantic aircraft stopped there to refuel. Then came jetliners, with greater range. Shannon declined. An imaginative entrepreneur, Brendan O'Regan, suggested making Shannon a duty-free industrial park to attract companies that could ship supplies and products by air.

This idea succeeded so well that the airport now houses some eighty international businesses, forty of them manufacturers that make everything from fur hats to industrial diamonds. More than eight thousand people live there.

DOWNSTREAM from the airport, near the Shannon's mouth, our port launch put into the town of Kilrush, headquarters of the eight pilots who guide some eight hundred ships a year up the river. Harbor pilots are among the proudest and most dedicated and independent of men. Such a man is Michael Scanlan, large of frame but soft of speech, who has plied the Shannon for more than thirty years.

In Ireland, as in many countries, piloting has long been a job handed down from father to son. As we walked the quay, Michael

"I live for music," says fiddle maker Jerry Martin, who for 48 years has worked in the same cottage in the lakeside village of Garrykennedy. Martin spun out tunes at dances before discovering he enjoyed making instruments more than playing them. Now his creations are played by several traditional Irish music bands. At 81, Martin figures he'll finish only one more violin, his 75th. "The energy is gone," he says.





Sleek high jumper of the Shannon, a salmon leaps up the falls at Annacotty on its way to spawn at its birthplace.

pointed to Scattery Island, which now has only two people living on it. "For generations the pilots and their families dwelt there," he said. "But in the 1960's we came ashore. The desire for closer relationships, only possible ashore, became too strong, and for years we hadn't had a government teacher on the island for the children.

"We on Scattery were always prepared to walk alone. We never had a woman die in childbirth, or a stillborn baby. Yet we never had a doctor or nurse. Help came from within and from one's neighbors and friends."

We talked about piloting. Was fog the worst problem? "Fog is never difficult because you take all precautions," said Michael. "It's the only time you're working 100 percent. Accidents are the result of familiarity, not the unusual."

No piloted ship on the Shannon had suffered a serious accident within Michael's memory. When I attributed that to experience, he gave a reply typical of his proud profession: "Experience is only polish. The right thing has to be in you."

MUCH OF THE ESTUARY can be enjoyed by car, on scenic roads that invite one to stop for dramatic views of the broad, blue river. I often passed big enclosed wagons, gaily painted, each pulled by a hulking draft horse. Vacationists rent these wagons, resembling prairie schooners, and drive them along designated routes, stopping each night at communal spots where the horses can be pastured.

A mosaic of tiny fields covers Kerry Head, with cottages scattered about like random rocks. I pushed on to the end of the land, to the very last little farm above the Shannon's juncture with the sea. There the brothers Thomas and Michael Gaynor live on flinty, hardscrabble land that commands a magnificent view of the river's mouth far below. I found Thomas walking along the road with a mound of hay that moved with him. You had to look quite closely to see the little donkey bearing the load.

While the taciturn Michael stowed hay, Thomas and I stood in a sky-high field and regarded the river. "I fish down there for bream," said Thomas, "and I set pots to catch lobsters. Not much salmon now."

(Continued on page 679)



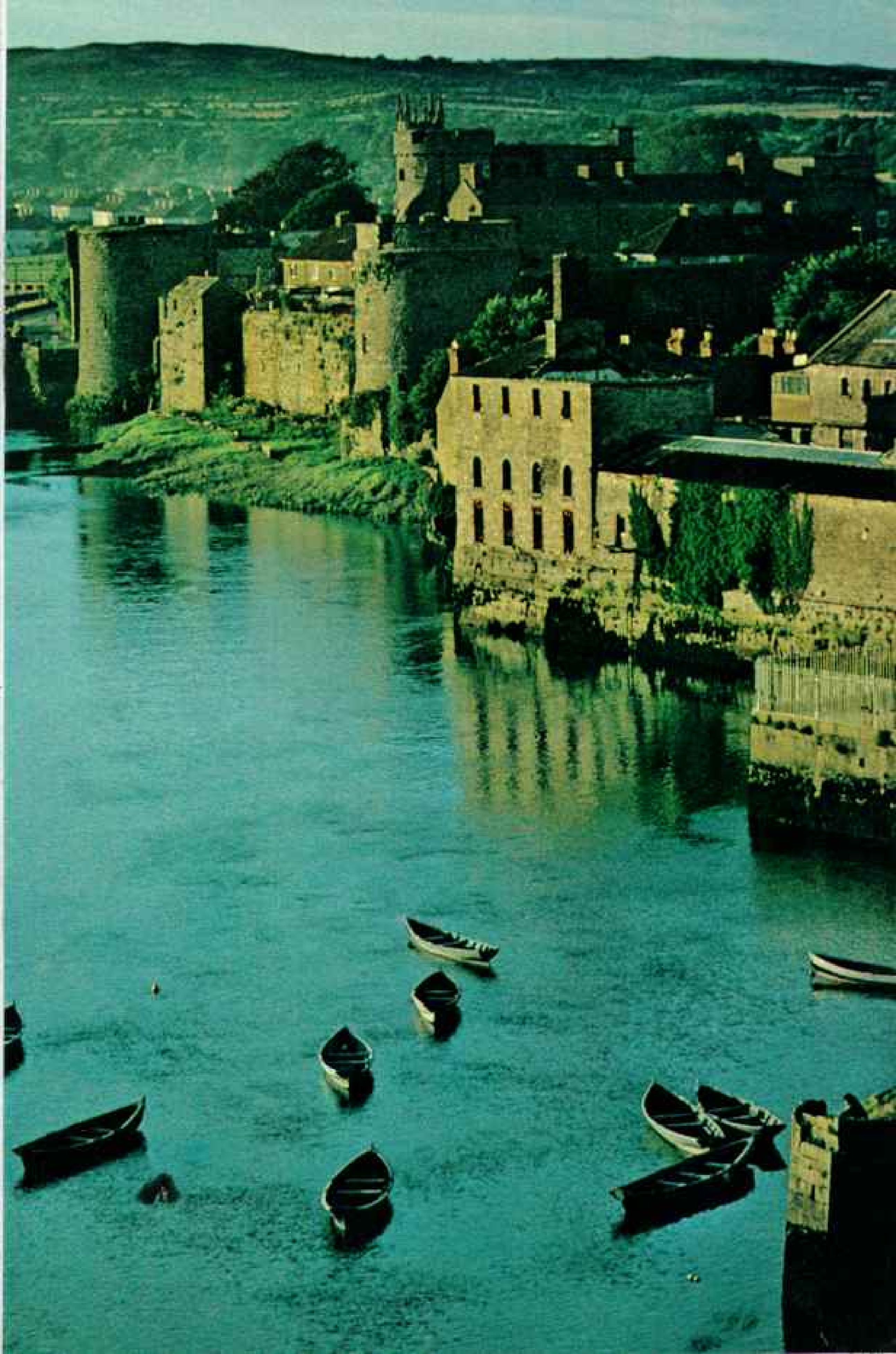
Fear of frying shouldn't worry this tench, plucked from a Shannon tributary by angling officer Hugh Gough, since many consider such coarse fish as tench and bream unpalatable. They are caught mainly for sport and released when the day's fishing is done.



City of sieges, Limerick looks back on a history less mirthful than the type of humorous rhyme that, for reasons unknown, shares its name. Founded by Vikings about 920, the city withstood repeated attacks before Irish hero Brian Boru finally ousted the Norse. The English took Limerick in 1174 and built King John's Castle, which still commands Thomond Bridge (right). When William III of England was repelled in 1690, the Siege of Limerick became a symbol of Irish resistance. Today Limerick—the largest city on the Shannon—is an important dairy, salmon-fishing, and industrial center.

With rosy cheeks and twinkling blue eyes, a dark-tressed lass at the Ballinasloe fair epitomizes Irish feminine beauty (above).







Stacking ammunition against winter's attack, John Crotty, 83, piles peat next to his cottage in Ross. The hamlet stands where the Shannon meets a sea that has scat-



tered Ireland's children to lands more prosperous. But seldom more lovely.

(Continued from page 674)

When I exclaimed over the incomparable vista, Thomas shrugged, then commented: "I did come home one day and found two men sitting in this field in chairs, just looking. One said, 'I could stay here forever.'"

Anyone who visits Thomas Gaynor knows how that man felt.

Far across the river mouth, on the road to Loop Head, I stopped at a farm owned by John Cleary and his aged mother, Margaret Cleary. Below us emerald fields met the blue of the estuary, where islands lay scattered like anchored dreadnoughts.

"Ah, we see that view so often we pay no attention," said Mrs. Cleary.

And John said, "It means nothing because we were born and raised here."

John told me that a group, including actors Cary Grant and Jack Lemmon, had planned a luxury resort on the bottomland below the Cleary farm, but the project never matured. Indeed, lack of such development on the Shannon often puzzled me.

NOT MANY PEOPLE live on Loop Head, and you can drive miles with only the wind for companion, past hedgerows and stone fences, the Atlantic on one side, the Shannon on the other. Partway to the headland, I stopped, climbed a windy knoll, and gazed a long time at the river, my soul refreshed by that long, glittering sweep of water. Somewhere below lay the shoal called Kilstiffin Bank, and I recalled a tale pilot Michael Scanlan had told me.

"I believe there is basic truth in legend," he said. "Kilstiffin Bank probably once was part of the mainland, and old Irish annals say that in the ninth century a great storm ravaged that area. Many people lost their lives, and scores of houses disappeared beneath the sea.

"When I was a kid, I used to hear old people say that if a sailing ship dropped anchor on Kilstiffin Bank, during the night a little man would climb the anchor cable and say, 'Take up your cable; it's gone down the chimney of my house.'"

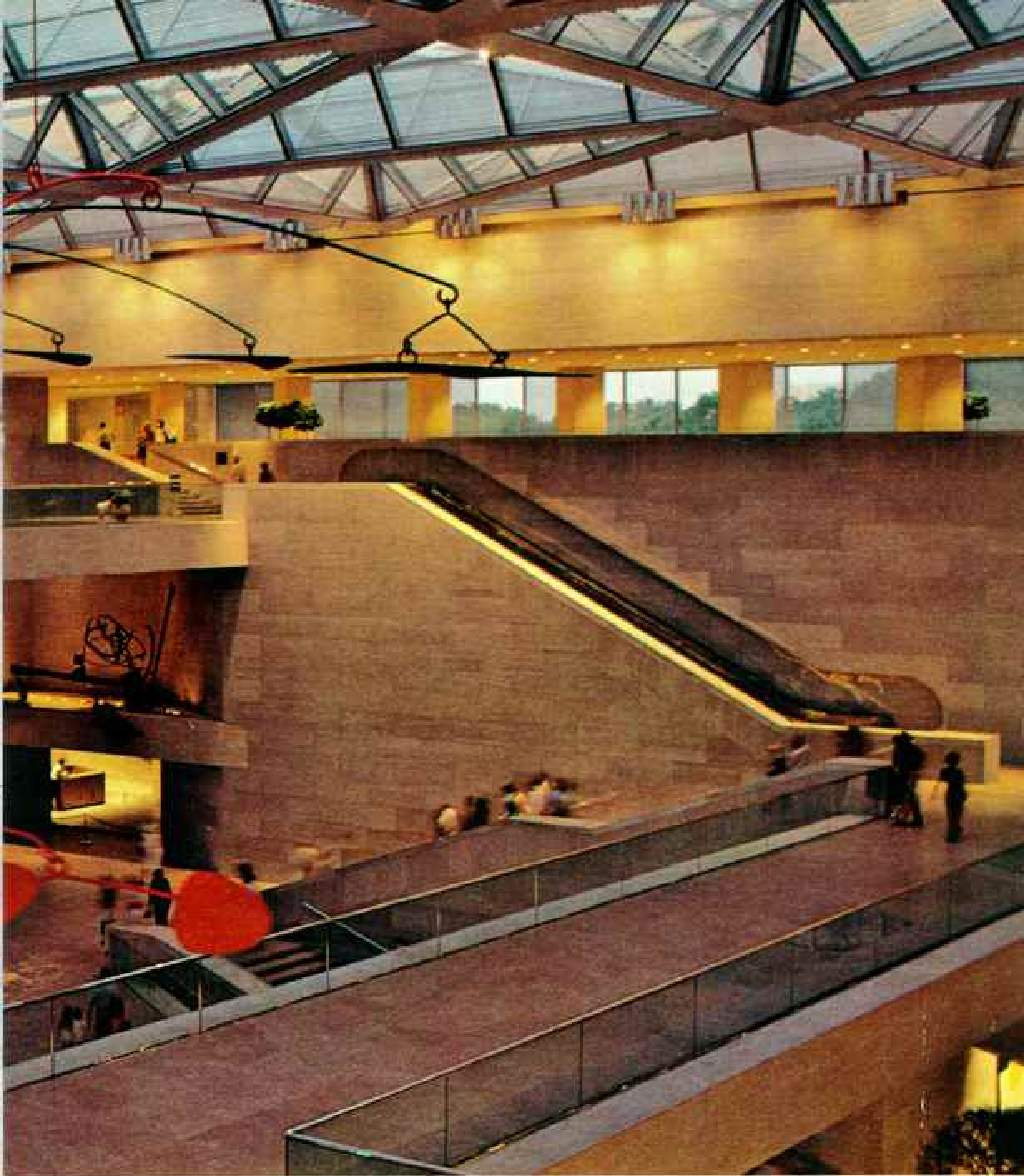
For every mile of Ireland's Shannon, for every bend, there are legends. . . . But the sheer beauty of the river, that is reality, as true today as it was when the brave penants of Brian Boru flew over Kincora. □



THE NATIONAL GALLERY'S NEW

MASTERWORK ON

By J. CARTER BROWN DIRECTOR, NATIONAL GALLERY OF ART



THE MALL

Photographs by JAMES A. SUGAR

Celebrating genius in art, and itself a dazzling flare of inspiration, the East Building of the National Gallery of Art opens in Washington, D. C., after a decade of design and construction. An Alexander Calder mobile glides above the airy central court.





Cast from dreams, a journey in perspective, Henry Moore's bronze "Knife Edge Mirror Two Piece" stands sentry as dusk encloses the East Building entrance (above). Slight shifts in light or viewing angle reveal subtleties of form in both sculpture and structure. With exquisite attention to detail, stonemasons carved from marble blocks the building's sharp corners, and cabinetmakers handcrafted the wooden forms used to mold its coffered concrete ceilings. Designed by China-born I. M. Pei, the addition is the 94.4-million-dollar gift of Paul Mellon, his late sister, Ailsa Mellon Bruce, and the Andrew W. Mellon Foundation. Opening day, June 1, draws 22,000 visitors (left).

ONE OF THE greatest pleasures I have as a museum director these days is to watch the faces of our visitors as they come into the National Gallery's new East Building.

I suppose if I had to find one word to sum up the atmosphere there, it would be "joy."

Little wonder. Sunshine floods through the building's mammoth skylight, which floats like a cloud overhead. Ever changing patterns of light and shadow splash on pink marble floors and walls. A great mobile by Alexander Calder turns lazily in the air currents. And everywhere there are people enjoying themselves—strolling across concrete bridges that echo each other at different heights, flowing up the main escalator that seems carved out of marble, lingering at a café with spectacular views, and, most important, exploring galleries filled with art that ranges over two thousand years of mankind's achievement.

The East Building, a gift to the nation from Paul Mellon, his late sister, Ailsa Mellon Bruce, and the Andrew W. Mellon Foundation, is both an architectural delight and the culmination of many people's dreams. It is also the result of chance-taking decisions and painstaking craftsmanship, of radical but rational approaches, and throughout, an insistence on excellence.

Radical approaches? Chancy decisions? Let me describe what called them forth.

In 1937, when Congress accepted Andrew W. Mellon's offer of his spectacular art collection and funds to build the original National Gallery, it set aside for future use an adjacent plot of land on the Mall at the foot of Capitol Hill. Though certainly prime real estate, the site was an awkward shape—a would-be rectangle except that one long side tapered in toward the other to form a trapezoid (following pages).

This trapezoidal shape posed immense design problems. Placing a square or rectangular building inside it would have thrown away a lot of area. Also, the axis of such a building would have been jarringly out of alignment with the original gallery.

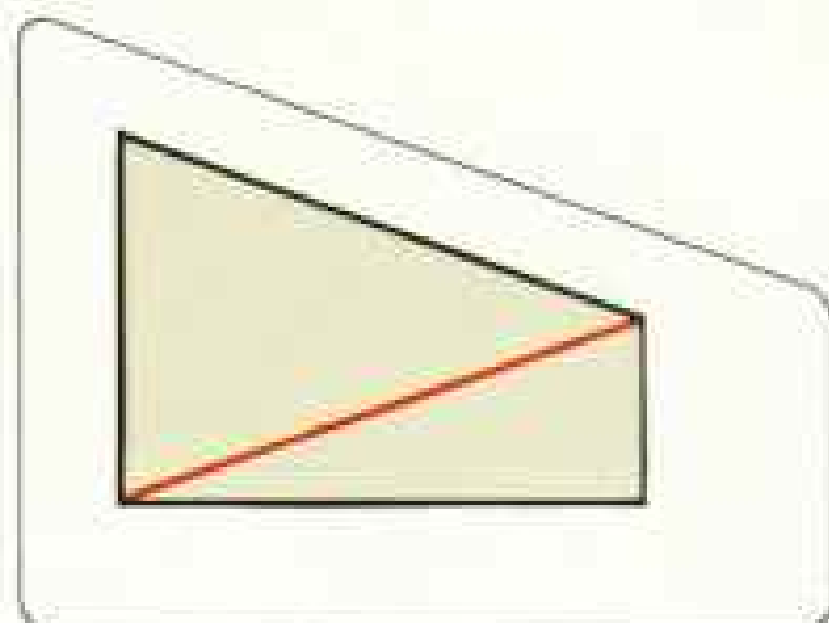
The location of the trapezoid also posed a challenge. It lies at the confluence of two primary elements in Pierre Charles L'Enfant's 18th-century plan of Washington—the sweeping (Continued on page 692)



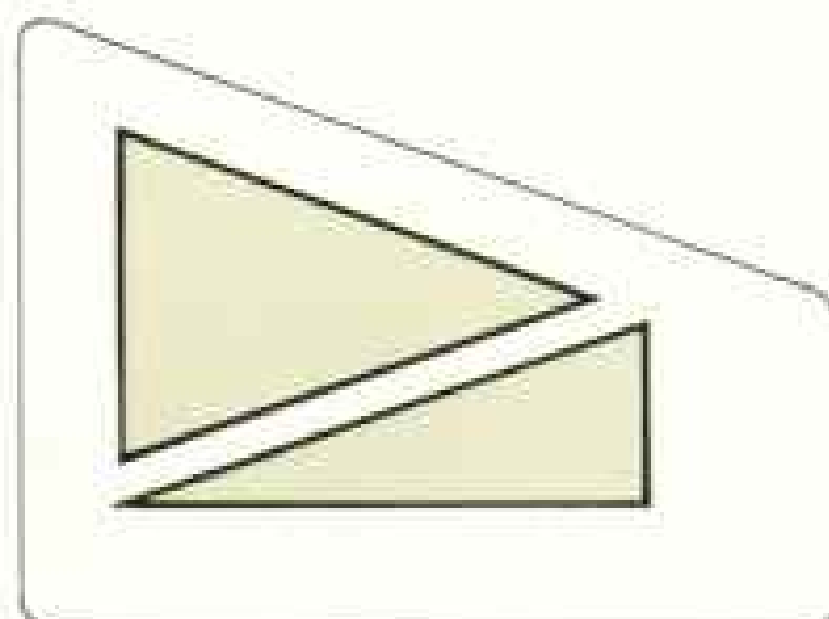
THE GALLERY'S TRIUMPH IN TRIANGLES

As classic as Euclid's geometry but contemporary in style, the new East Building wedges between broad Pennsylvania Avenue and the green sweep of the Mall. "It was the most difficult piece of land I've ever worked with," recalls architect Pei. The land—shaped like an ill-folded handkerchief—had been earmarked for the National Gallery's expansion in 1937, when, as a condition of his gift of artworks and the original building, philanthropist Andrew W. Mellon asked Congress to reserve the adjacent plot. By dividing the trapezoid, Pei created a two-part building: one triangular segment for a study center, the other for exhibitions. A spacious area containing the Concourse was carved below ground, roofed by the granite cobblestones of National Gallery Plaza and punctuated by crystal-like tetrahedral skylights and a fountain. It houses a café-buffet and a moving sidewalk that runs partway between the new and old buildings.

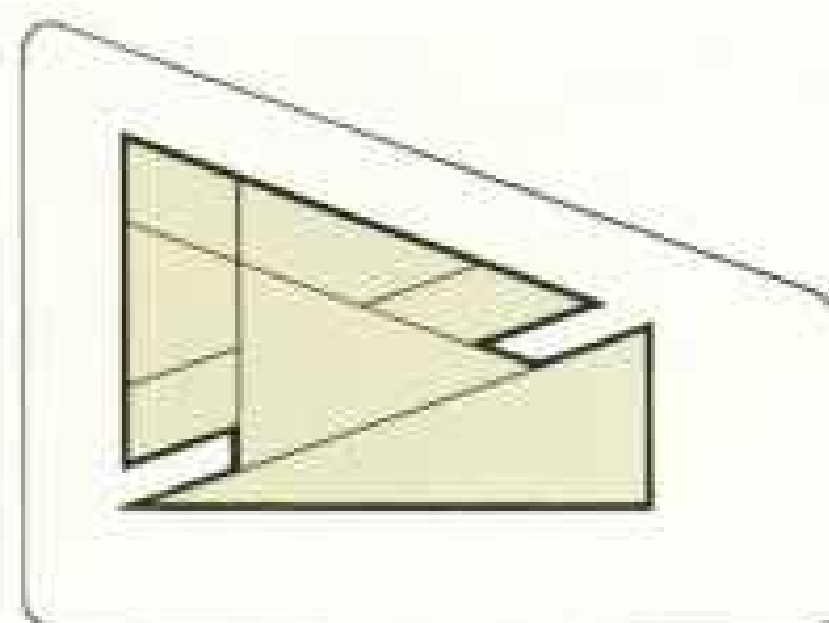
Pei's ingenious bisecting stroke permits the major axis of the new building to line up with the axis of the original West Building (below). The overhead view underscores how the convergence of streets and the shape of the land are echoed in the design. The orchestrated parry and thrust of angles has garnered widespread acclaim for what *Washington Post* architecture critic Wolf Von Eckardt calls "the exhilarating beauty of good geometry." *New York Times* critic Ada Louise Huxtable praises it as "a genuine contemporary classic." Says award-winning American architect Philip Johnson: "It is a miracle of understanding in modern museum design."



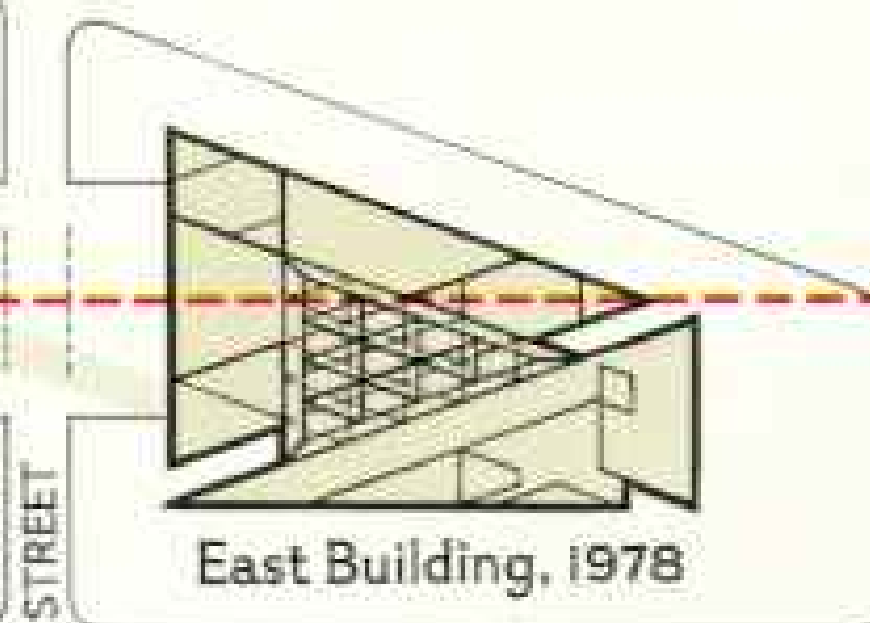
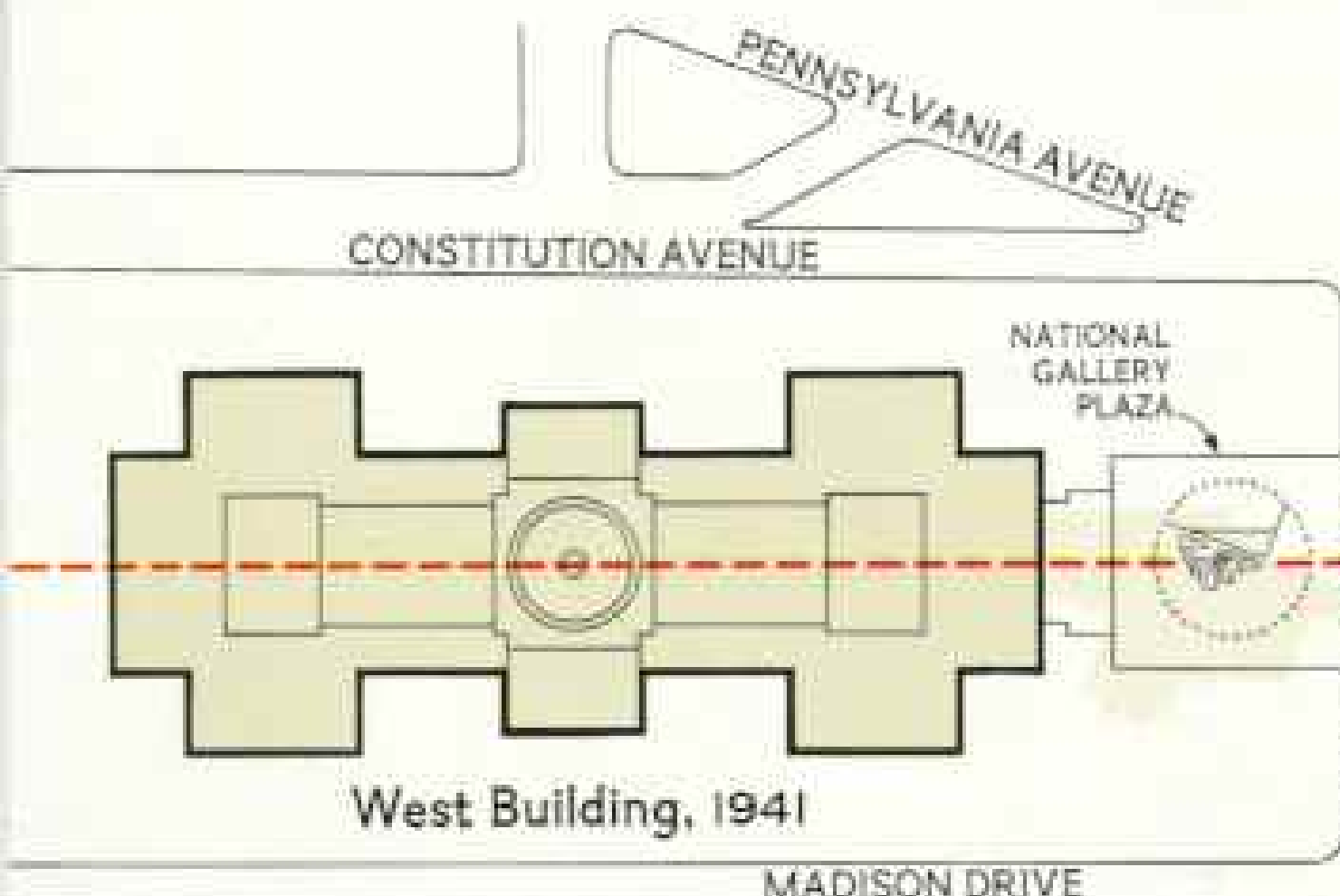
With a single, inspired stroke Pei sheared the trapezoidal building site in two. The awkward plot demanded a brilliant design solution to achieve maximum aesthetic impact and space usage.



Two triangles result, coaxing optimum space from the site. The larger isosceles triangle houses exhibition areas; the smaller, a right triangle, allows space for a study center.



A third triangle becomes a huge skylight over a multilevel court. Diamond-shaped towers contain galleries and reiterate the building's angular motif.





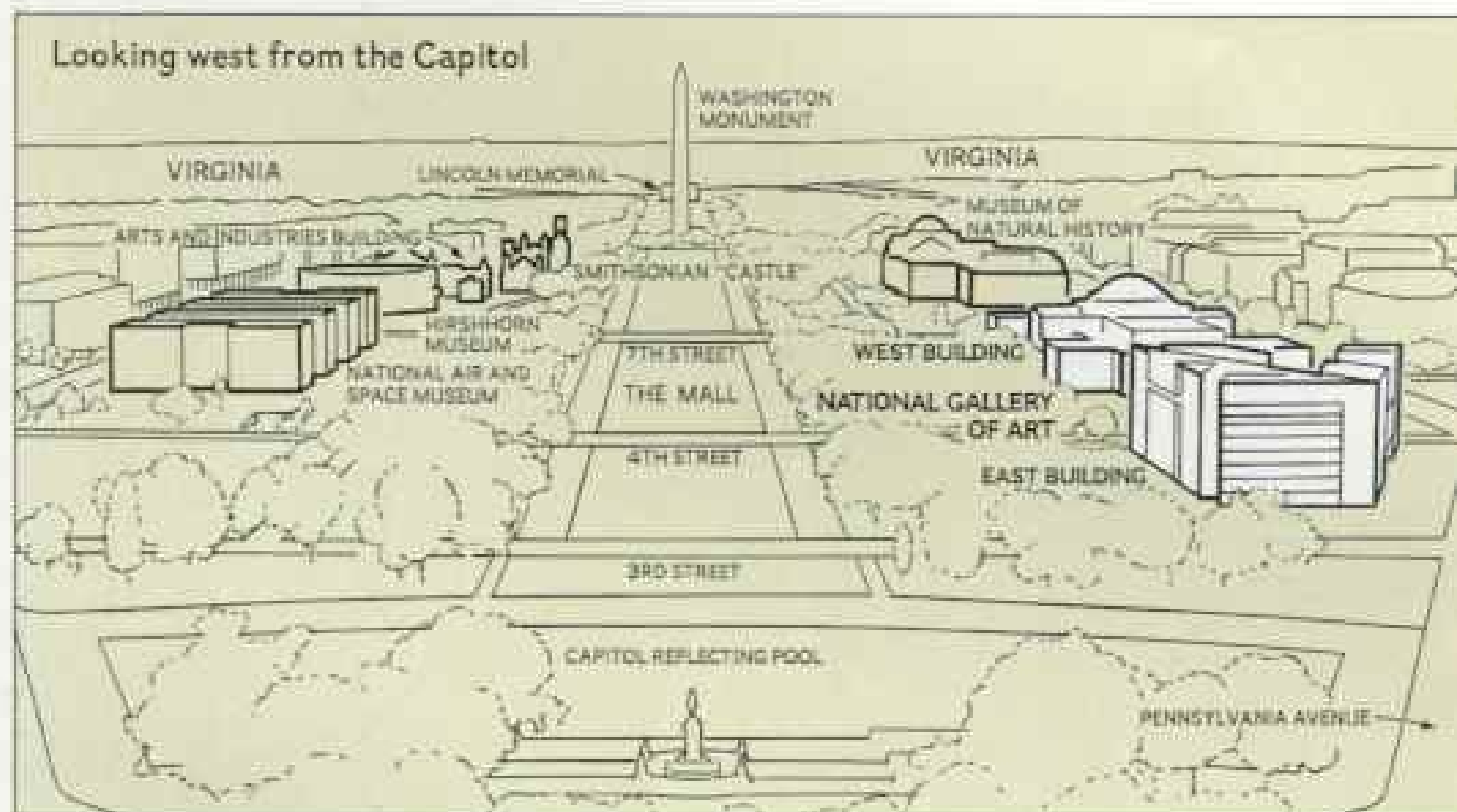


Masterminds behind the masterpiece: architect Pei, National Gallery director J. Carter Brown, and gallery president and benefactor Paul Mellon, son of Andrew W. Mellon. They stand in the main reading room of the then-under-construction 300,000-volume library of the East Building's Center for Advanced Study in the Visual Arts (above).

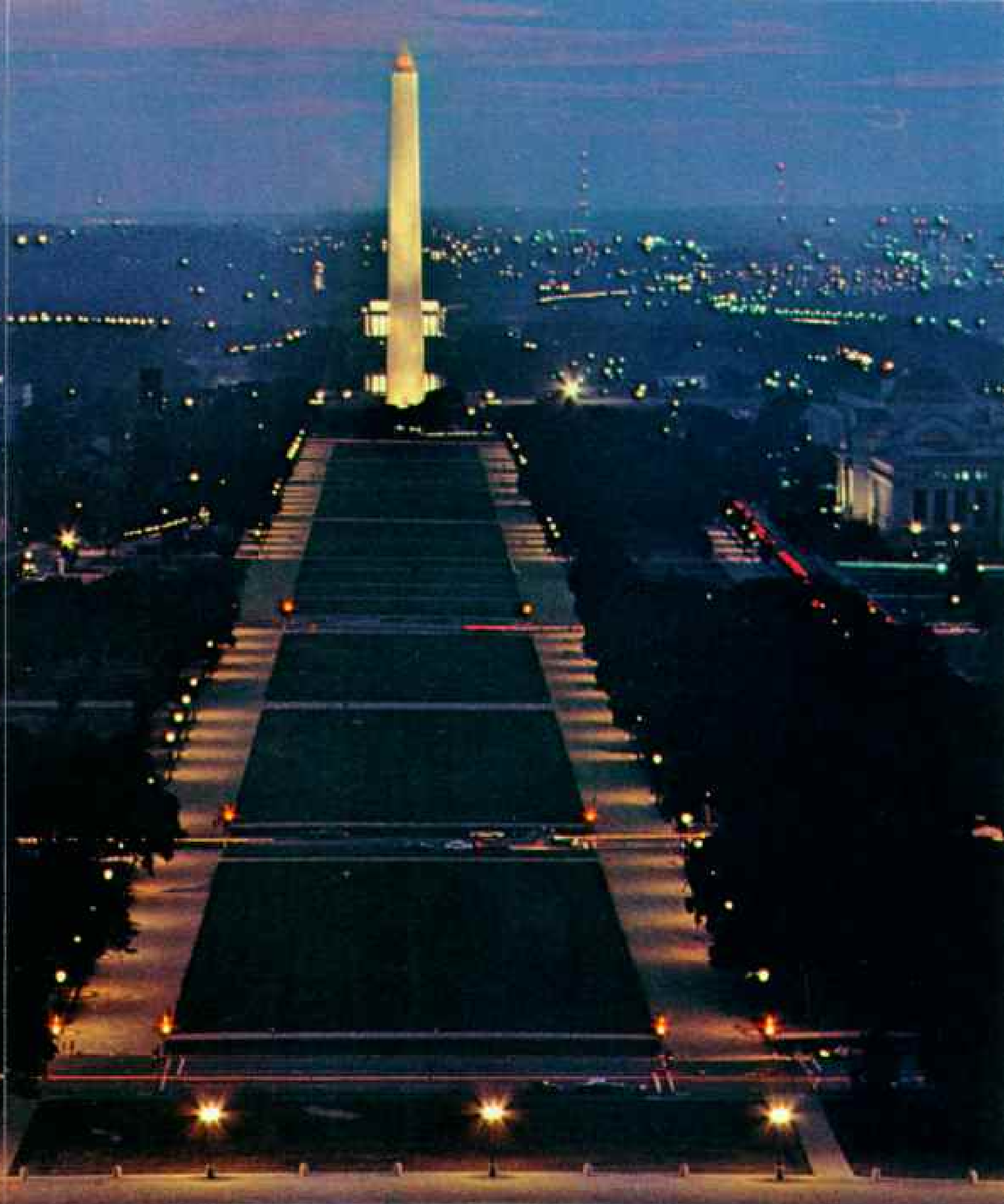
Before the new building opened last June, Mellon and his wife gave a central-

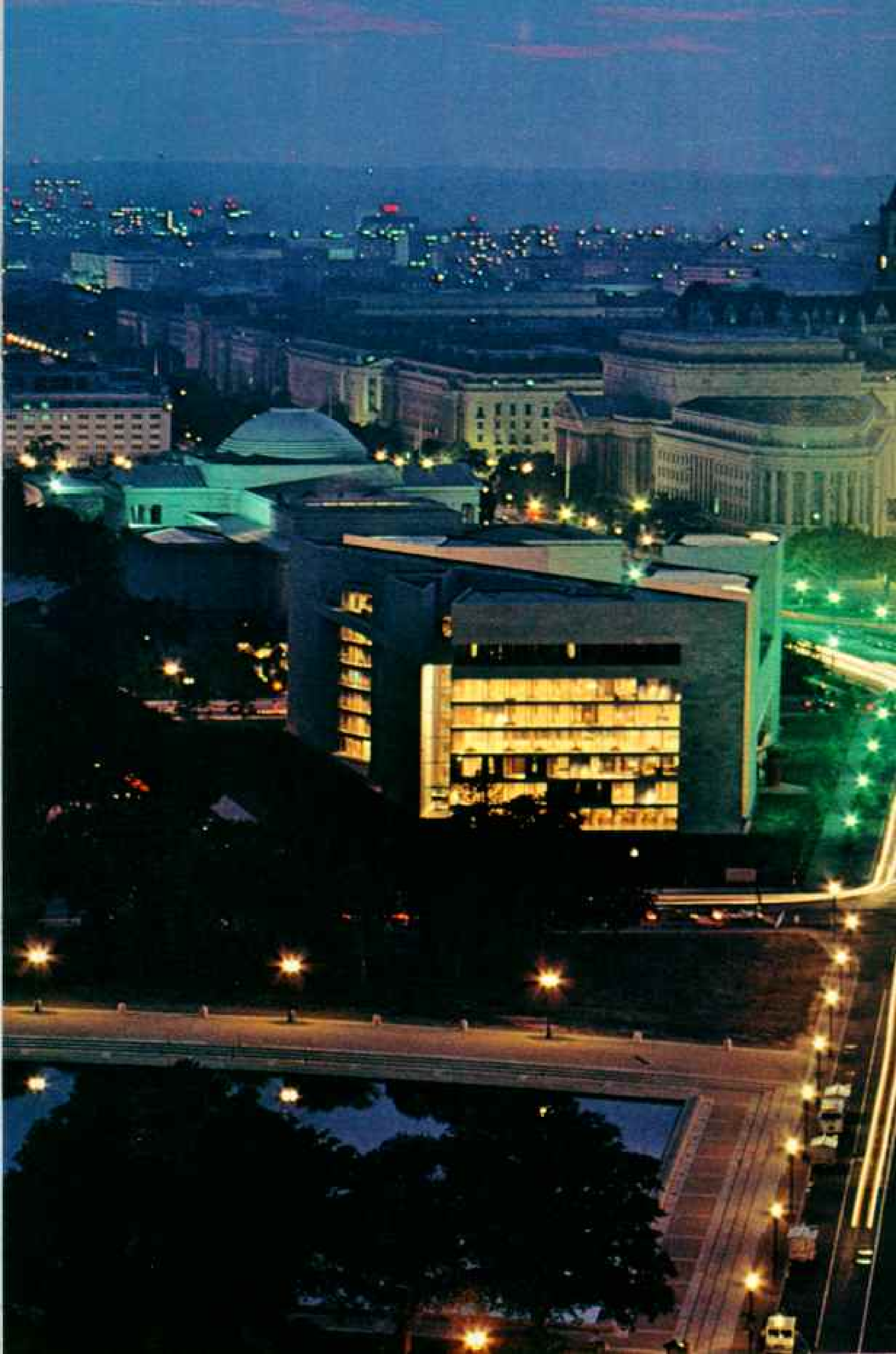
court dinner (preceding pages) for lenders and donors, in elegant recognition of the fact that all National Gallery acquisitions are privately funded or are outright gifts. The government underwrites only operating expenses and maintenance.

The drawing (below) shows how the new Mall monument helps fulfill Washington city planner Pierre Charles L'Enfant's vision of the Mall as "unparalleled for beauty" (overleaf).



NATIONAL GEOGRAPHIC ART DIVISION





(Continued from page 683) greensward of the Mall, stretching as it does today from the Lincoln Memorial to the Capitol, and the broad thrust of Pennsylvania Avenue, key artery in the city's monumental core.

With impressive museums already lining both sides of the Mall and with lofty government structures defining Pennsylvania Avenue, the building placed at the end of this march of titanic architecture had to possess a definite presence.

"Fitting In" a Dual Problem

There were other demands. It had to be in harmony with the exquisite neoclassical design of the original gallery, now called the West Building. And it had to meet the pressing needs of a national gallery that was truly bursting at the seams.

From the initial Andrew W. Mellon gift of 133 artworks, our collection has grown to more than 40,000 pieces, and attendance has soared beyond three million people a year. We needed room for temporary exhibitions, such as *The Splendor of Dresden: Five Centuries of Art Collecting*, with which we opened the new building (pages 702-17).^{*} And we needed study space for art scholars, for a library, photographic archives, and staff area, and for the National Gallery's rapidly expanding educational enterprises that serve more than 4,000 communities in all 50 states.

Our building had to meet one more demanding, and seemingly contradictory, condition. While our strategic location on the Mall called for bigness, I hoped for smallness. The exhibition galleries must be on a human scale—intimate rooms in which visitors could absorb art without visual indigestion, where they would not be overwhelmed by architecture or suffer "museum fatigue" from walking down endless corridors. There must also be a large central open area to which visitors could retreat and reorient themselves between excursions among the galleries.

To resolve these many problems, museum trustees chose architect I. M. Pei. As

^{*}Before returning to Dresden, the exhibition will be shown in New York City at the Metropolitan Museum of Art, October 21, 1978, to January 13, 1979, and in San Francisco at the California Palace of the Legion of Honor, February 18 to May 26.



Even the young at art appreciate the childlike joy of the vivid Matisse cutouts in the Tower Gallery (above). Throughout the new building, walls can be tailored for any display. Large-scale spaces showcase





JAMES A. SUGAR AND LARRY D. KINSEY, NATIONAL GEOGRAPHIC STAFF (ABOVE) AND JAMES A. SUGAR AND NELSON H. BROWN, NATIONAL GEOGRAPHIC STAFF

abstract and expressionist works, such as those in the “Aspects of Twentieth Century Art” exhibition, where Wilhelm Lehmbruck’s “Seated Youth” reposes (below). Intimate galleries display a collection of diminutive impressionist paintings. “They are sensitive little things. You have to bring the environment around them, like pulling a comforter around your ears on a winter night,” says the author.



head of I. M. Pei and Partners in New York City, Pei enjoyed a great reputation. He could design an art museum, as proved by his stunning gallery at Syracuse, New York. He could add a museum onto an existing building, as witness a sensitive addition in Des Moines, Iowa. And he could design a center for study that dramatized the excitement of scholarship, as he did beautifully in Boulder, Colorado. On top of all this, he possessed a keen interest in the problems of cities as well as individual buildings.

Pei grasped at once the importance of our trapezoid as a legacy of L'Enfant's plan, the need for harmony with the existing building, and our peculiar requirements for exhibition space and a study center. We awaited his solution expectantly.

"I Drew a Diagonal Line...."

"I was returning to New York after a gallery meeting in 1968," the architect recalls, "trying to find a solution to that difficult site. I sketched a trapezoid on the back of an envelope. I drew a diagonal line across the trapezoid and produced two triangles: one for the museum, the other for the study center. This was the beginning."

A two-part building whose shape would be formed in triangles resulted (page 685). This simple, brilliant plan, developed and refined and painstakingly executed over a decade, ultimately accommodated our diverse demands.

The larger of the two triangular segments, adjoining Pennsylvania Avenue, would hold exhibition areas. Tall diamond-shaped towers would rise at its points, matching the heights of the federal buildings along Pennsylvania Avenue. Its major axis and entryway would align exactly with the axis of the original building.

The smaller triangle, with one side facing the Capitol, would contain a study area. One of its corners would be a knife-edge

19-degree angle, giving the new building one of its most striking features (page 698).

As plans progressed, the two triangles came to share a common room, the central court. Above this, binding the two parts, would perch a triangular glass roof, itself made up of a cluster of triangles.

For me, the onset of this mammoth undertaking also launched a rewarding relationship with I. M. Pei. To acquaint ourselves with the problems we would face, we visited museums in North America and Europe to study varying approaches to the housing of art. I learned that art is close to Pei's heart; he proved sensitive to the relationship of art and architecture.

We assembled an effective team to help us. By good fortune David W. Scott joined us as planning consultant. He had served as the director of the National Collection of Fine Arts during its expansion. Construction manager Hurley Offenbacher came from a similar post with the National Air and Space Museum, which was completed ahead of schedule and under budget.* Overseeing every detail was the building committee of the board of trustees, whose chairman, Paul Mellon, missed none of its 68 meetings. Like his father before him, he would not permit his name to be part of the National Gallery's official name.

Seven years of exacting toil and 94.4 million dollars (all of it a gift of the Mellons) went into this masterwork on the Mall.

The new building's marble walls glow with the same warm pink as the old, and indeed the stone for both came from the same Tennessee quarries, some of which had to be reopened for the new project.

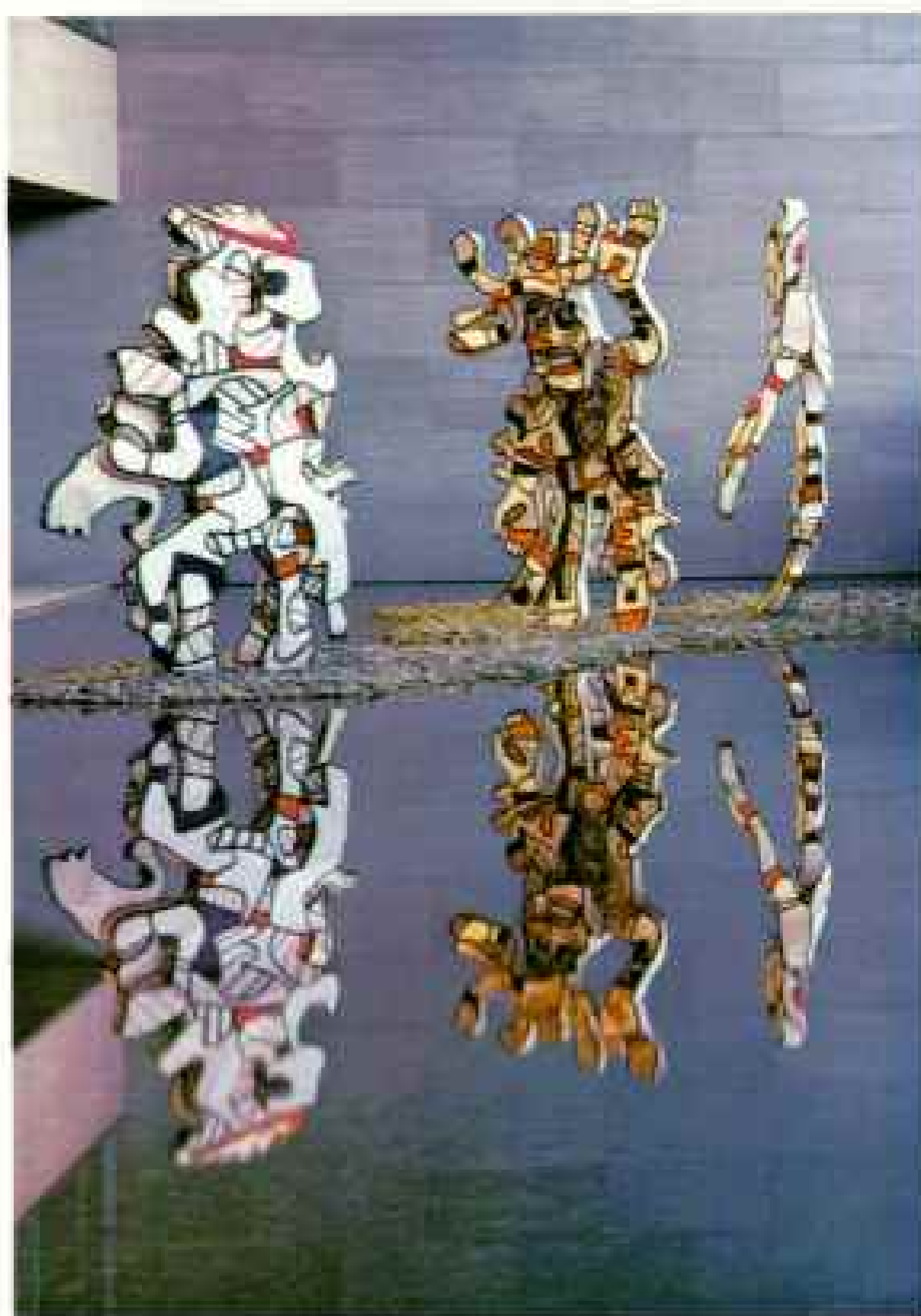
A carpet of pink Oklahoma granite cobbles, bordered on each side by plantings of oaks and magnolias, spreads between the East and West Buildings. In the center,

*See "Of Air and Space," by Michael Collins, NATIONAL GEOGRAPHIC, June 1978.

Miró, Miró on the wall—bright and buoyant as balloons and as whimsical as the fairy tale—reflects Spanish artist Joan Miró's fanciful vision of woman. Titled "Femme," the tapestry woven by Josep Royo spills 31 feet down the court's south wall. Sculptor Isamu Noguchi's monolithic "Great Rock of Inner Seeking" stands in the triangle's apex; in the distance, the Robert A. Taft Memorial Carillon rises on the Capitol grounds. Seven works were commissioned for the new building, including the tapestry, Calder's mobile, and Moore's bronze.

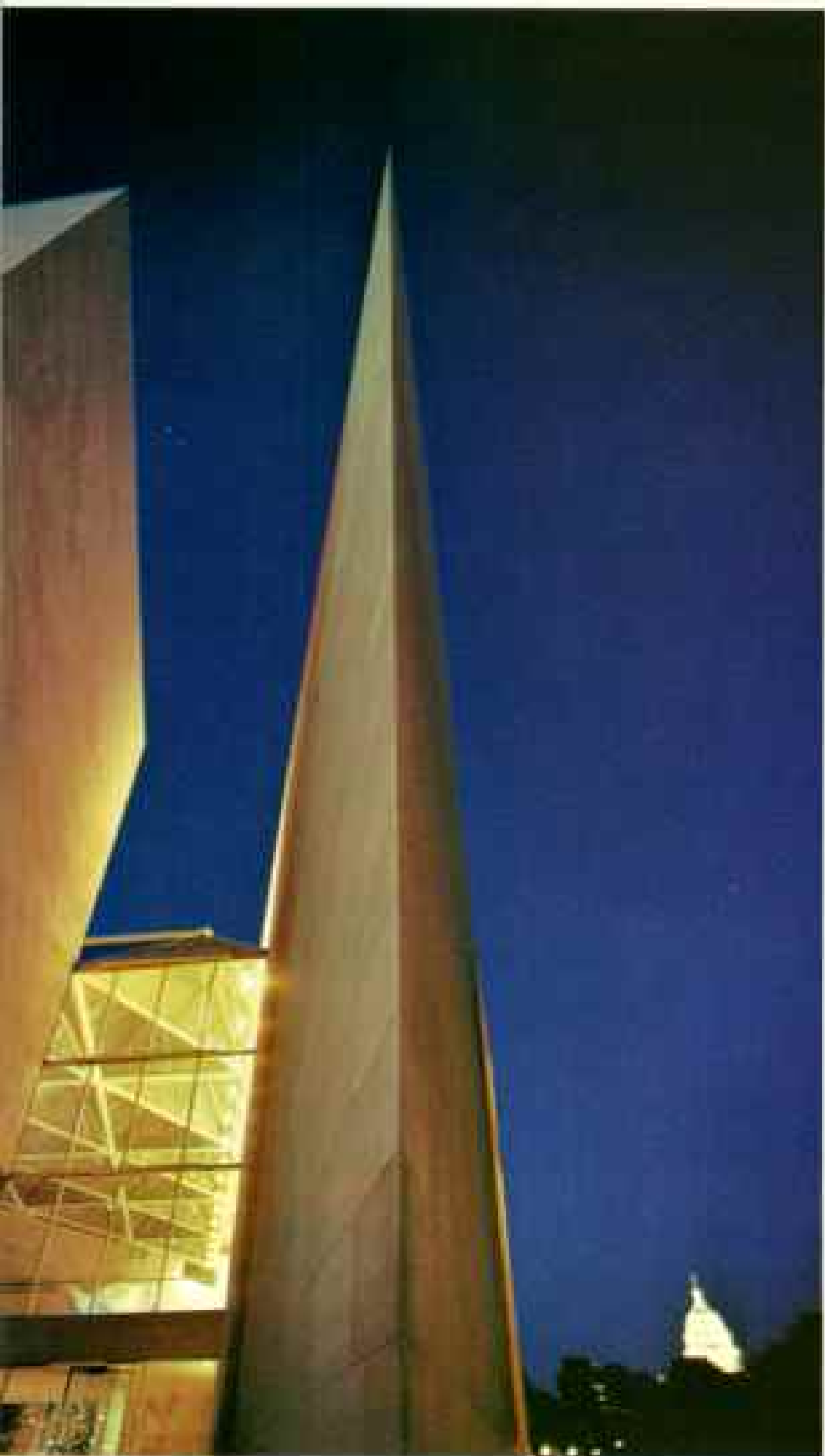






Stark solemnity of steel or whimsy of cast acrylic, two vastly different kinds of sculpture find settings eminently suited to each. David Smith's Voltri sculptures (left), commissioned for the 1962 Spoleto Festival and shown in a Roman amphitheater there, find a re-created amphitheater under an adjustable skylighted ceiling that can be hoisted to a maximum height of 37 feet. Working from raw steel and scrap metal at an abandoned steel factory in Voltri, Italy, Smith created 26 of these powerful images in less than a month.

The jigsaw-style figures of Jean Dubuffet's "La Députation" (above) cavort on a black-stone island in the image-doubling mirror of a sculpture pool. Although the new building presents a core collection of contemporary art, exhibitions cut across the centuries.



Blade sharp, the 19-degree angle (above) exhilarates and compels visitors to feel the edge; constant touching discolored the bottom two blocks. "The angle was inevitable," says Pei, who insisted on its sharpness despite suggestions that it be blunted. Some Tennessee quarries that supplied pink marble for the National Gallery's older building were reopened to furnish stone for the new.

Reflection of a spotlight sets ablaze the stainless-steel Jean Arp "Oriforme" sculpture on the south lawn (facing page).

fountains play against seven glass tetrahedrons that lie like scattered crystals. These serve as sculptural elements and as skylights for the restaurant below. Framed by the trees and gallery buildings, this area becomes a great outdoor room, or plaza, linking the old and new structures.

Visitors enter the new building beneath a coffered concrete mezzanine whose low overhang has a deliberate compressing effect. Inside awaits an explosion of space and light. The eyes skip up graceful marble staircases, follow along flying bridges busy with visitors, climb a petaled branch of the great Calder mobile; and soar to the topmost facets of the vast skylight floating 67 feet above.

Daylight floods through, bathing the court in the changing moods of sun and clouds. More light surges in through glass window walls and cascades over ficus trees growing in huge marble planters whose rims double as seats for visitors. With these links to the outside, the massive chamber becomes a continuation of the outdoors—an extension of the Mall itself.

Curators' Delight: Movable Ceilings

Exhibition spaces—totaling some 75,000 square feet—bank the north and west sides of the larger triangle and fill the three towers. Much to our curators' delight, the architects left the interiors open and designed some of the ceilings to move up and down. By erecting temporary partitions, we can create the proper environment for each exhibition.

The building's concrete work offers one of its most beautiful features. To obtain harmony with the pink stone, builders blended marble dust with white cement, sand, and aggregate to obtain a soft tint. Concrete forms were crafted by cabinetmakers so that each cast would be perfect, each joint invisible. Some pours took many months to form, prepare, and cure—a long time to agonize over flaws that happily never occurred.

The elegant marble staircases play a double role. The riser of each step hides a slot through which air flows for heating and cooling. Such design care is everywhere evident in this uncluttered building. All its myriad ducts, pipes, and wires have been painstakingly concealed within the walls, in leftover angles, even in the planters that hold the ficus grove.



On the lower level, life-size figures of jousting knights announce *The Splendor of Dresden* exhibition. Nearby are two auditoriums, photographic archives, audiovisual studios, and a computer room.

A moving sidewalk hums within the Concourse, part of a two-story structure that extends beneath the plaza to the West Building. Ahead gleams an oasis of daylight, pouring down from the plaza's tetrahedral skylights. An underground waterfall reflects light on the 700-seat café-buffet and publications center. Beginning operations before the gallery opened, the restaurant served a million people its first year. The immense subterranean area, housing maintenance and support facilities as well as the Concourse, contains fully one-third as much space as the entire new building.

The building is, in itself, a work of art, a sculpture on the Mall. It is also an engineering feat that blazed new trails in the construction industry, and in so doing gave all of us a few gray hairs.

For example: Pei's design called for sweeping facades of unornamented marble. This meant that there were no places to hide expansion joints that relieve pressures when changing temperatures cause the rock to expand and contract. I entertained unpleasant visions of stones pushing each other right off the ends of their courses.

Refusing to clutter their pristine design, the architects devised a remedy: They padded the edges of each block with a gasket of neoprene, allowing them to expand and contract independently.

Building Needed "Ballast"

The foundations posed larger problems. Our trapezoid sits atop the ancient bed of Tiber Creek, long since buried by urban paving and grading. Once or twice a year heavy rains raise the water table almost to the surface. Our building had to be waterproof and well anchored; we couldn't have it floating down Pennsylvania Avenue like a ship!

To cope, builders planted a forest of 40-foot steel cables, casting and anchoring them in concrete. Around the cable tops they poured ponderous concrete slabs six feet thick—ballast for our boat. The hardened cables support the building in dry times and moor it during wet.

The trickiest problem by far was the great glass roof over the central court. Spanning 225 feet on two sides and 150 feet on the third, this ethereal-looking triangle weighs a staggering 660 tons. Not only did it have to support its own weight, but also a maximum snow load of 30 pounds a square foot, or about 250 tons more.

Changing Temperature Also a Problem

Computers whirred as engineers calculated the complex angles of the "space frame," the mosaic of steel tetrahedrons that supports the actual glass-and-aluminum skylight. Project architect Leonard Jacobson explains our problems here, or at least the iceberg tip of them, this way:

"Not only do we have the weight load. Steel is affected by temperature changes and will shrink and expand. We've got to let all the individual frames move—yet keep them in place. Similarly, the *entire* space frame will shrink and expand, and it, too, has to be movable yet fixed. And while everything's moving around this way, it must remain waterproof."

Although the steel structure was to be self-supporting, it could not hold itself up until all the pieces were in place. So during the months of creation it rested on a scaffold.

As completion neared, our curiosity increased: What would happen when we removed the supports? Finally the last prop came down. The structure sank—precisely as planned, coming to rest within a quarter of an inch of calculations.

The glass situation was as complex. We were using double-thick thermal glass, with an inner pane that was actually two thicknesses laminated together to form safety glass. To the laminate we added a chemical to block ultraviolet radiation, which can irreparably harm paintings. The panes themselves had to assume countless shapes and, because they were double thickness, had to be preformed in the factory. Each pane had to fit into the aluminum framework with proper clearance. It was slow work.

A measure of the pride and workmanship that went into the East Building can be found in 23 awards given by the Washington Building Congress to individual craftsmen. This is more than three times the number earned by any other Washington building

since the awards originated nearly a quarter of a century ago.

Alexander Calder's huge mobile, so restful to watch in its skylight nest, also caused its share of consternation. After a maquette of the artist's original design was approved in 1973, Calder turned it over to his fabricator, a factory near his studio in France. Shortly thereafter, a delegation from the museum visited the factory and found that the piece would weigh more than 5,000 pounds! Although the space frame could take the weight, it was clear that so heavy a mobile would be static—not even a gale could have budged it.

We sought the aid of artist-inventor Paul Matisse, grandson of the painter Henri Matisse. Paul suggested that we substitute honeycomb aluminum for the steel. Placed in charge of fabrication, Paul slimmed down the mobile's weight to 920 pounds. Three stories high and spanning 76 feet, it now turns majestically in the building's air currents, sometimes going faster when crowds stir the air, but occasionally stopping even

then as if to take a rest (pages 680-81).

Interestingly, Calder, who saw the completed work one week before he died, never referred to it as a mobile. Paul told me the artist simply called it "my object."

What will the new building show? It will not be solely for contemporary art. Instead it will help the National Gallery fulfill its two-fold role: to house exhibitions of art from all periods and to serve as an anthology of paintings, sculpture, and graphic arts from medieval times to the present.

Kids Catch on Fast

The National Gallery will continue to evolve, providing opportunities for learning and delight. Already the East Building is developing in that direction. Crowds are enormous, and guards tell us that people are reluctant to leave when the doors close at night. I particularly like the comment a guard heard from three children who unanimously endorsed the building over other museums because, they told their parents, they didn't get as tired. *They* got the point! □



Head-on charge of two Saxon knights re-creates a 16th-century joust for *The Splendor of Dresden*, an inaugural exhibit. On loan from the German Democratic Republic, more than 700 artworks—paintings, porcelain sculptures, bronzes,

and bejeweled artifacts—highlight a legacy that has survived war's destruction (following pages). But the most dramatic work of all—the new East Building—not only exhibits but exalts the riches of civilizations past and present.

TREASURES

By JOHN L. ELIOT

Photographs by VICTOR R. BOSWELL, JR.

BOTH NATIONAL GEOGRAPHIC STAFF

FEW CITIES have produced such joys of creation as Dresden, and few have been so lashed by repeated Wagnerian storms. A fire burned the town nearly to the ground in 1491. During the Seven Years' War in the mid-18th century, two-thirds of the city was destroyed. War struck again in 1813 when Napoleon Bonaparte commandeered Dresden and there won his last major battle.

And on February 13 and 14, 1945, three waves of U. S. and British bombers delivered an incinerating blitzkrieg that lasted 14 hours and 10 minutes. A hideous fire storm, generating winds of tornadic intensity, engulfed 6 square miles (15 square kilometers) of the city, destroying 75,000 homes and apartments and killing tens of thousands of people.

Yet, miraculously, most of Dresden's art treasures—repeatedly spirited out of the path of destruction—have survived its convulsive past.

Nestled astride the Elbe River 110 miles (177 kilometers) south of Berlin in the German Democratic Republic (East Germany), the city today

welcomes some four million visitors a year, eight times its population. They flock to see thousands of paintings, prints, porcelain sculptures, curious scientific devices, ornamented weapons, and bejeweled artifacts. In an unprecedented exhibition, more than seven hundred of those treasures are now touring the United States.

Art is the lifeblood that courses through Dresden. Known to have existed in 1206 as a German settlement, the city eventually became famous as the "Florence on the Elbe."

Saxony's wealthy 16th-, 17th-, and 18th-century rulers were voracious collectors who stimulated a stunning explosion of painting, architecture, music, and literature.

Dresden's galleries became filled with the masterpieces of Jan van Eyck, Dürer, Rubens, Rembrandt, Vermeer, and many more, including Raphael's famous "Sistine Madonna." The city rang with the works of Bach, Handel, Telemann, von Weber, and Wagner.



OF DRESDEN



Collector's prize, gilded steel armor for man and horse was bought by a Saxon ruler in the early 1600's from the king of Denmark. An insatiable thirst for art governed the sovereigns of the German duchy of Saxony from the 16th through the 18th centuries. They filled Dresden, their capital, with treasures from around the world.



E. HORN (ABOVE); NATIONAL GEOGRAPHIC PHOTOGRAPHER GORDON W. SAHAN (BELOW)



Apocalyptic brush of Dresden artist Hans Grundig prophesied the havoc brought by Nazism in "Vision" (right), a 1936 painting.

Nine years later British and U. S. bombers made his nightmare real, igniting a fire storm that charred much of the city (left,





upper). Today reconstruction continues around the restored roof of the Katholische Hofkirche, or Catholic Court Church (left,

lower). Artworks stored outside the city were recovered by Soviet troops and art experts and returned in the 1950's.



Hither came Goethe, Schiller, Ibsen, and Dostoevski to live and write for part of their careers.

Dresdeners are justly proud of that legacy and keenly aware of the tragedy laced through it. Amid the magnificent showcase called the Green Vault, now installed in the Albertinum museum, I stared in awe at "The Court of the Great Mogul," a spectacular ensemble of gem-studded figurines (pages 712-13). Mrs. Herta Reichel, a museum guide whose eyes sparkled with excitement, brought to life the goldsmith who created it, Johann Melchior Dinglinger.

"It took him, his two brothers, and 14 students seven years—from 1701 to 1708—to complete this masterwork for their sovereign, Augustus II, Elector of Saxony and King of Poland," she said.

"But when it was finished," she added with a chuckle, "Augustus told Dinglinger,

"We shall gratefully accept this. But we are not able to pay for it.' So they settled on a sort of loan and installment plan. Meanwhile, Dinglinger had to keep some cash coming in, so he somehow managed to do these other smaller things." She gestured to a galaxy of Dinglinger pieces in other cases.

"I am a native Dresdener. I am married to the Green Vault—it's the loveliest marriage anyone could have," she said. "And I suppose I am happiest about the fact that these treasures have survived so many wars."

Mrs. Reichel had been home with her mother that February night in 1945.

"We were lucky. No bombs fell where we lived, near the stadium," she said. "But it's almost impossible to describe that night. There was so much light that ten kilometers away from Dresden you could read a newspaper in the middle of the street. The city was one big torch.



"After the war ended, I worked as a tour guide. I will never forget the first visitors that I had to show around the ruins. They were British, from Coventry."

Her eyes grew moist. "To destroy so much beauty . . . it is impossible to forget. It keeps hurting whenever you remember it. Our young people love the city today, but we older people will never forget how Dresden once was."

I thanked Mrs. Reichel for her help and walked slowly outside into the gray January chill. Ahead of me loomed the blackened silhouette of the Frauenkirche, the Church of Our Lady, a heap of rubble with parts of a wall curving against the sky. It will remain the way the bombs left it, a somber memorial.

Suddenly a west wind delivered the muffled roar of explosives. Blasting for construction. Or reconstruction. In my mind

Dresden's passion for porcelain, here displayed at the National Gallery, brought a flood of Oriental imports. The six-inch-high coffeepot (below) resulted from experiments by Johann F. Böttger, who in 1708 first made porcelain in Europe.





the bombs went off all over again. I took a direct hit.

No one is sure, even 33 years later, how many people died. The official GDR figure is 35,000. Other estimates of the death toll have varied substantially.

Fortunately most of the artworks had been removed from the city early in the war and secreted in Saxon castles and estates, as well as in abandoned mines and tunnels. Nonetheless, some of the paintings were all but ruined.

Russians Recovered Collections

When Soviet troops entered the city in May 1945, they were dispatched to help art specialists search for and recover the collections. Many artworks were taken to the U.S.S.R., where experts repaired the damaged pieces. All were returned between 1955 and 1958, although Dresden had just started to rebuild its museums.

And with all deliberate speed Dresden continues to rebuild.* With a population of 510,000, the city spreads over 87 square miles (226 square kilometers) in a slightly disconcerting montage of modern, generally attractive office and apartment buildings, which contrast with the stately grande dames of the Baroque and other eras.

They include the spectacular Zwinger, an assemblage of six museums crowned by scores of fanciful statues, and the towering monument of the Kreuzkirche, or Church of the Cross. Both have been completely restored. The grace of Semper's Opera House, completed in 1878, is returning slowly under the diligent ministrations of hammer and chisel.

For 17 years the *Oberbürgermeister* (mayor), Gerhard Schill, has directed the painstaking reconstruction. "It took nearly ten years after the bombing to clear some 18 million cubic meters of rubble," he said. A massive effort to restore many historic buildings and monuments goes on.

Dresden's role as a center of the arts masks the fact that it is also a hub of science and

electronics technology. "We are now producing goods worth more than 13 billion marks [6.2 billion dollars] a year," Mr. Schill noted. "Dresden enterprises export their goods to more than 90 countries around the world."

Though dedicated to Dresden's future, Mr. Schill also treasures its past. "The most beautiful building for me will always be the Zwinger," he said. "You should see it in the summertime. Often there are queues hundreds of people long in front of the entrance to every collection. It's worth the wait."

It is. Art lovers come in droves—from elsewhere in the GDR and from scores of other nations, including the United States and the Soviet Union.

And what they come to see is largely the result of the extravagant genius of Saxony's most colorful ruler, Augustus II, or Augustus the Strong.

"He was a very complicated character. He was ambitious and he wasn't terribly honorable. But he was absolutely curious about everything in the world, an incurable romantic and incredibly liberal for the age in which he lived."

Dr. Joachim Menzhausen, the curator of the Green Vault, paused and took a bite of pastry in the museum's coffee shop as he spoke of the flamboyant Augustus's background.

From Playboy to Saxon Ruler

"He had quite a career as a playboy before he was crowned in 1694 at the age of 24," Dr. Menzhausen said, "although as ruler he had only 10 or 12 mistresses. Compared to the kingly possibilities at the time, that was rather modest."

"He was the second-born son of the family. When his older brother died, Augustus became elector. And he wasn't quite ready for it." The Saxon rulers were known as electors because they, together with the rulers in

*See "East Germany: The Struggle to Succeed," by John J. Putman, NATIONAL GEOGRAPHIC, September 1974.

Offering New World riches, a bejeweled blackamoor bears a stone studded with emeralds. The two-foot-tall statue was commissioned about 1724 by Saxony's most famous ruler, Augustus the Strong, probably for the opening of Dresden's Green Vault, the treasury he turned into Europe's first public museum of precious objects.



Ornate weapons delighted the nobility of Saxony. Wheel-lock rifle inlaid with deer-horn was made in the 17th century.



Grenade launcher from the 18th century also shot fireworks from its bell-shaped muzzle to light up court festivals.



Inlays of silver wire and appliques of gilded brass embellish a flintlock pistol made around 1750.

other princely states, elected the Holy Roman Emperor.

As Dr. Menzhausen spoke, the charisma of Augustus emerged with the intricacy of a Bach fugue. It was he who opened the world of art to the Saxon public for the first time. It was he who unlocked all the accumulated treasures of his predecessors and created a museum of precious objects, the first of its kind, from the Green Vault, originally called the "Secret Depository" because it served as Saxony's treasury.

"Augustus was a fantastic exception to the other electors, but he wasn't truly a great man," Dr. Menzhausen added. "A great prince has to be a great politician, and that Augustus was not. In his early years he got involved in a war to the north and was badly beaten by Sweden.

"Augustus died ten years too soon, in 1733; there were so many projects he left unfinished. But he truly opened a window on the world for his people. He commissioned the best artists in Europe to create works

based on his own vast knowledge of faraway lands—Japan, China, India, Egypt, and the New World."

Inside the Green Vault Dr. Menzhausen displayed a fascinating example of a New World connection: an exquisite statue of a blackamoor carved from pearwood and bearing a stone matrix embedded with Colombian emeralds the size of ice cubes (page 708).

Court sculptor Balthasar Permoser carved the statue itself, while Dinglinger did the goldwork. "Wilhelm Krüger probably crafted the tortoiseshell tray holding the emeralds. It's difficult to see, but if you look carefully underneath the tray. . . ."

I peered and saw a delicate filigree, barely visible. "He did it to make the piece absolutely perfect," the curator explained. "He knew that probably no one would notice it. It's like a signature."

From 13 miles northwest of Dresden comes another signature that certifies such perfection: crossed swords. They are the

Baroque pageantry of a ladies' jousting tournament fills the Amphitheater, built especially for such events in the late 17th century. It was a forerunner of the Zwinger, which by 1728 housed a fabulous ensemble of museums for Dresden's art collections.



hallmark of perhaps the world's finest porcelain, made by a factory in the town of Meissen. There I watched skilled artists and craftsmen create works long prized as Dresden china.

Alchemist's Result Good as Gold

Joachim Schulz, a director of the Meissen factory, described the freak invention of European porcelain. "In 1701 an alchemist named Johann Friedrich Böttger came to Saxony. Hearing that Böttger could create gold from base metals, Augustus put him under guard and told him to produce. When Böttger failed, Augustus imprisoned him. But eventually Augustus allowed him to go back to work in a laboratory, where in 1708 he became the first person in Europe to discover the Chinese secret of porcelain making. Augustus later forgave Böttger when delicate Meissen porcelain came to be called 'white gold.'"

Böttger had been working with native clay, which first yielded a brown ceramic.

"He kept looking for something to turn it white, and what he used was kaolin. That's an erosion product, a white clay," Mr. Schulz said. "It was fashionable back then for powdering wigs."

Augustus, determined to keep the process from his royal rivals, directed that workshops be set up in 1710 in Meissen's castle, the Albrechtsburg, where they remained until 1865. Production had by then outgrown the castle's primitive facilities, so they were relocated in a new factory, where today 1,200 full-time artists and about 200 apprentices carry on a 250-year-old tradition of excellence.

Perched at his worktable, one craftsman, Klaus Henker, meticulously shaped an unglazed figurine. Another worker swept past with about twenty ceramic pieces on a board balanced on one hand, like a waiter carrying a tray of coffee cups.

"This is going to be a monkey playing a bass viol," Mr. Henker said. "It's part of a set called the 'Monkey Band,' which is an



Oriental opulence shimmers in "The Court of the Great Mogul," depicting Indian ruler Aureng-Zeb receiving presents.

Augustus the Strong's goldsmith, Johann M. Dinglinger, labored seven years on the extravaganza, four and a half feet across.



It features 132 enameled figurines and 33 gifts, the whole encrusted with 4,909 diamonds, 164 emeralds, and 160 rubies.

orchestra of 21 monkeys. The whole set costs about 18,000 marks [\$8,500].

"According to one legend, Augustus III—Augustus the Strong's son and successor—was disgusted with his orchestra. 'This is not a court concert, it's a monkey concert!' he said. And Johann Joachim Kändler, the most famous of the court's porcelain artists, got wind of the story—and got busy.

"The next time the orchestra went to rehearse, each musician found on his stand a porcelain monkey playing his instrument."

Meissen artists today strive to remain faithful to the legacy handed down by Kändler and his colleagues while imparting their own style and mark to each piece. Virtually all their works are exported, most to the West.

Towering Castle, Towering Collection

Sitting high on a hill above Meissen, the Albrechtsburg no longer turns out beautiful porcelain, but the stately castle is filled with magnificent works of art. In one room I skated across a gleaming parquet floor on felt slippers provided to protect the wood. The walls held early sketches by Albrecht Dürer, one of Germany's greatest artists, whose works bridged the gap from the medieval age to the more realistic style of the 16th century.

Sketches by Lucas Cranach the Elder also drew my eye. Cranach was a friend of Martin Luther and the chief artistic exponent of Lutheranism. "Luther worked much of his life in Saxony," Dr. Menzhausen had told me earlier, "and therefore there was a strong cultural and spiritual reaction here against the other Catholic parts of Europe. In the 16th century, during the Reformation, Saxony served as the center of northern and middle European Protestantism."

Adjoining the castle is the 700-year-old Meissen Cathedral. Its 14 sandstone pillars create a curtainlike effect when one views the main altar.

"Try to estimate the height from the floor to the ceiling," challenged a cathedral guide.

I guessed about 150 feet. "Sixty feet," he corrected, grinning. "That's what Gothic architecture does to you."

Back in Dresden, I visited the Zwinger's porcelain collection, which enshrines the masterpieces of the Meissen men—Kändler,

his colleague Johann Gottlob Kirchner, and Johann Gregorius Höroldt, who developed the distinctive Meissen colors that eventually equaled the richness of porcelain made in the Orient.

In the far end of the gallery rests what must have been Kändler's most ambitious undertaking in porcelain. A large sculpture of Augustus III rides a magnificent rearing steed whose hooves are poised above the reclining figure of an old man. And this was merely a model for the finished product, which was intended to be life-size but was never completed.

Like Father, Like Son

"Augustus III was just like his father, a fantastic influence on the arts but a terrible politician," said Dr. Menzhausen's wife, Ingelore, the collection's curator. "That's the way the Saxons have always been."

We examined porcelain animals about two feet tall: a stately heron, a grimacing gargoyle, an ape clutching her young, and a trumpeting elephant with a strangely twisted face.

"That was done by Kirchner," she said of the elephant. "You can see how the sculpture cracked badly and was later glued back together. They had terrible problems with the firing process for these large figures in the 18th century. They're so fragile that I was nervous about allowing any of them to travel to America for your exhibition."

"But I couldn't say no," she added with a gentle smile.

The artistic tradition that put Dresden on the map remains as strong as ever. Dresden *breathes* culture. The city trains hundreds of carefully selected students in art and music academies and a prestigious school of dance. The art galleries that attract throngs of tourists are frequented by Dresdeners as well. They flock to the concerts of the city's two symphony orchestras. Tickets to the opera are especially scarce when a favorite son comes home to sing—Peter Schreier, one of the world's best tenors.

Mr. Schreier invited me to his country house in Lungkwitz, seven miles south of town. A slender moon shone over the hills as he emerged from his porch, an overcoat flung on his shoulders, and walked down the long driveway to greet me, the evening wind tousling his hair.

"I have professional ties all over the world," Mr. Schreier said inside over glasses of dry Meissen white wine, "and it's a little illogical that I still live in Dresden. But this will always be my home."

He was born in Gauernitz, a village just outside Dresden, and moved into the city when he was 8 to enter the *Kreuzchor*, the 700-year-old boys choir of the Kreuzkirche. "With the necessary discipline in the choir, and all of us living in dormitories together, the choir became a second mother to me. I still can't seem to tear myself away from it all." This despite the fact that Mr. Schreier sings about 120 nights a year in concert halls from Tokyo to Washington. His fame has earned him the freedom to travel to Western countries, unlike most citizens of the GDR.

"Each February," he said, "there is a special Requiem performed by the choir. It was written by a past director of the choir who witnessed the air raid. The text is based on Biblical references. There's one passage that goes, 'How devastated do I see this city before me?', symbolizing Dresden."

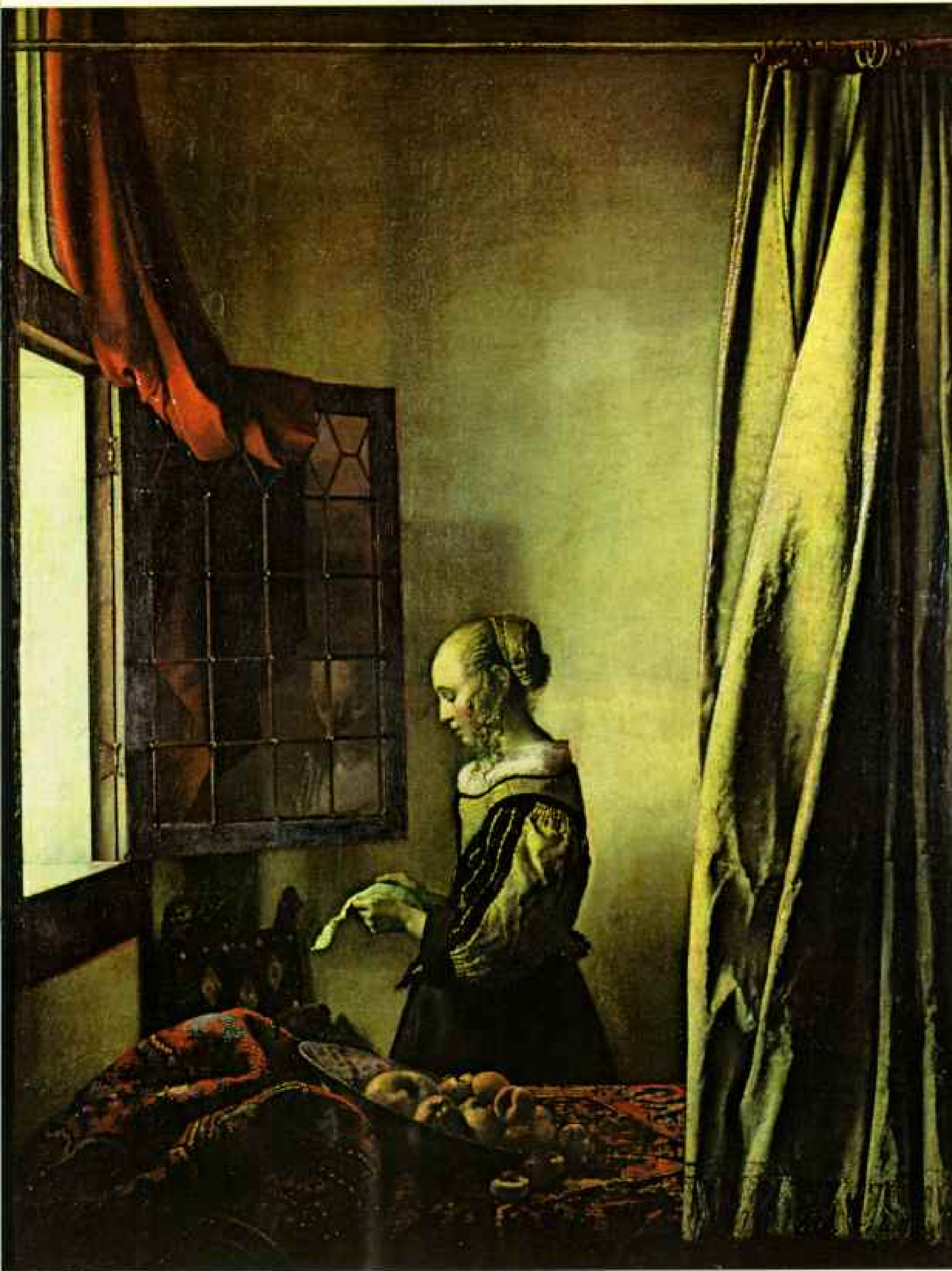
"The choir is divided into four groups standing in the north, south, east, and west parts of the church. The intent is to commemorate the sorrows of war everywhere."

The Requiem is performed on February 13. "The raid also killed 11 members of the Kreuzchor," Mr. Schreier said.

I heard the choir one evening at vespers, surrounded by children and their parents in a section above the nave of the church. The little ones hung over a railing, peering at the 140 angels below who were pouring their hearts into their singing.

A blond boy of about 4 pointed to the organ towering from the rear wall of the church. "Is that where the music

Hailed as the "Florence on the Elbe," Dresden once boasted a collection of more than 3,000 canvases carefully chosen to represent Italian, French, German, and Dutch schools. Paintings were the penchant of Augustus the Strong's son, Augustus III, who in 1742 bought Vermeer's "Girl at a Window Reading a Letter" (right).





comes from?" he asked his mother.

"Hush, my child," she murmured, as she listened.

Soon the organ spoke. Herbert Collum played Bach's "Toccatina in E Major." Powerful tones flowed from the pipes through the church. The restoration of Dresden's ruined Kreuzkirche had been faithful and meticulous. The acoustics are incredible.

In a church a few blocks away, the Katholische Hofkirche, or Catholic Court Church (page 704), there is another organ, a



Timepieces cosmic and comic: Gold, silver, and enamel gleam in a four-foot-high planetary clock and perpetual calendar completed in 1567 (left). Its dials calculate moon phases and the positions of six planets. Astral clocks notwithstanding, a ruler still had to get up in the morning. The cub-size "Drumming Bear" (above) served as a royal alarm clock and a delightful example of Dresden humor.

beautiful instrument completed by Gottfried Silbermann in 1753. It was dismantled and stored safely outside Dresden in 1944. During the bombing the Hofkirche was almost completely destroyed. Restoration of the church is nearly complete; the organ was reinstalled in 1971.

I heard it one morning with Professor Hans Nadler, director of the Institute for Monument Preservation. An organist was practicing and treated us to a recital.

Later we entered the Chapel of the Sacrament, where an artist was perched atop scaffolding, restoring the face of an angel. Matthias Schulz had been working in the chapel for seven months and at that moment was engaged in a labor of love.

"There is no record of exactly how this angel looked," he said. "So I can do it freehand. Actually I have a 10-year-old son, Markus, and the angel is resembling him more and more," he added with a twinkle in his eye.

Outside, Professor Nadler unlocked a door in a fence that led into a courtyard. All around us were skeletons of brick, black and burned. "This was the Dresden Royal Castle that contained the original Green Vault," he said. "Three years after the bombing, I went into a cellar far below ground. The heat had been so intense that even down there it had melted a bottle into a twisted mass." And the booms of reconstruction blasting again floated in from the distance.

In the Green Vault of today, my interpreter, Heide Milinski, has a favorite object, a sphere carved from a solid piece of rock crystal in the 16th century. It was thought to be magical because everything reflected in it appeared reversed.

"It's so beautiful and simple and uncomplicated," she said to me. "After looking at all these baroque things for so long, it's such a nice change."

"It isn't hard to understand why people thought it could foretell the future," Dr. Menzhausen observed.

Dresdeners hope their future will be as clear and simple and uncomplicated. In the Hofkirche there is a brief history of the church printed in six languages. It closes: "A few hours in a night sufficed to destroy what was done in years of work. Hence this cathedral makes us continually aware of the necessity to safeguard peace." □



Flashlight Fish of the Red Sea

By EUGENIE CLARK, Ph.D.

Photographs by
DAVID DOUBILET



PHOTOBLEPHARON PALPERRATUS, FOUR TIMES LIFE-SIZE

Eerie constellations of the shallows, goldfish-size *Photoblepharon* feed at night along Red Sea reefs in a 40-minute time exposure. Like many of the thousand-odd species of bioluminescent fish, *Photoblepharon* glow because they host light-emitting bacteria, an estimated ten billion to the milliliter packed in a special organ, the photophore, below each eye. As these microbes consume sugar and oxygen supplied by the fish's blood, they give off light, even hours after their host dies.

THROUGH A SHADOWY NIGHT sea the phantom lights glow before us—blue-green, cold, unearthly. Slowly we fin toward them as though drifting through space into a realm of unexplored galaxies.

At our approach the galaxies resolve into glowing fragments, pairs of tiny half-moons that blink together. Amid the pale light I recognize the moons as patches of luminescence beneath the eyes of myriad small fish.

With my partners, photographer David Doubilet and marine naturalist David Fridman, I hang motionless in the water, surrounded by ethereal light. At any abrupt movement the fish stream toward the refuge of the coral below. As they nestle, still glowing, among fissures and crevices, the reef seems to catch fire, pulsing like some giant bed of coals.

Such bizarre creatures suggest the abyssal depths of the sea, yet the reef lies only a few feet below the surface. For an hour we explore the surrounding waters, constantly bathed in the ghostly light of tiny dancing moons.

Toward the end of the dive David Fridman suddenly turns on his powerful electric torch to stun several of the fish, then slips them unharmed into a hand net (page 723). Switching off the torch, he leads the way back to shore by the glow of his tiny captives. On the beach we transfer the specimens to a plastic jug that begins to gleam softly.

"Beautiful," remarks David Doubilet. "Another jug or two, and we'd have the makings of a lighthouse."

Our encounter with the "flashlight fish," as it is sometimes called, took place

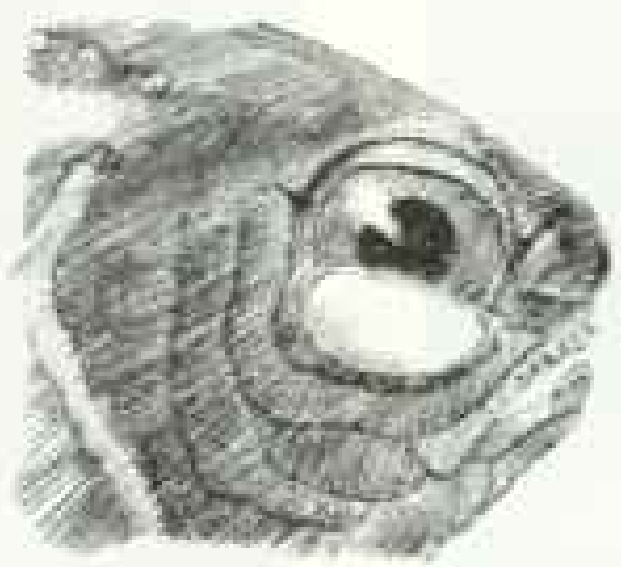
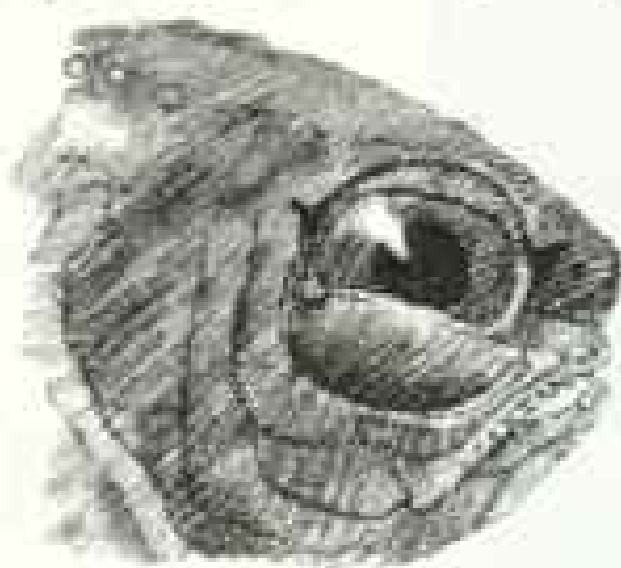
a year ago last summer in the Gulf of Aqaba at the head of the Red Sea (map, page 723). It was not my first view of the fish. During decades of research into the extraordinary marine life of the Red Sea, I had encountered it before, though rarely in such numbers. Now the NATIONAL GEOGRAPHIC had assigned David Doubilet and me to observe and photograph this fascinating species.

My companions were no strangers to the flashlight fish. David Fridman was the first to discover the species in the Red Sea, while diving in 1964, and David Doubilet had encountered the fish on our previous research projects together.*

Scientists call the three-inch-long inhabitant of the Red Sea *Photoblepharon*—a combination of Greek terms roughly meaning "eyelid of light." French divers in the Comoro Islands of the western Indian Ocean nicknamed the fish "*le petit Peugeot*," for the luminescent patches' resemblance to automobile headlights.

Photoblepharon is only one of some thousand species of luminescent fishes, most of them residents of ocean depths ranging from a few hundred feet to thousands of feet. *Photoblepharon*, however, is one of the most spectacular of these "night fishes," for its light organs are among the largest and brightest of any creature, either on land or in the sea.

Like many other luminescent fishes, *Photoblepharon* depends on bacteria for its



DIAGRAMS BY RICHARD SCHLECHT

The fish that winks, the *Photoblepharon* can raise or lower a fold of skin over the photophore at will (above). The organ's black lining guards the eye against glare. The fish uses its light to locate food and apparently blinks to communicate.

Cruising a reef (right), a pair of fish blink normally about every 20 seconds. When startled by the photographer's flash, they flee in agitation, blinking as many as 75 times a minute.

*The author has described other unusual marine creatures in the following GEOGRAPHIC articles: "The Strangest Sea," September 1975; "Into the Lairs of 'Sleeping' Sharks," April 1975; "The Red Sea's Sharkproof Fish," November 1974; and "The Red Sea's Gardens of Eels," November 1972.



source of light. Billions of the microorganisms exist in each luminescent patch, called a photophore. By a chemical reaction similar to that in fireflies, the bacteria convert energy from food and oxygen in the fish's blood into a continuous supply of light.*

Aquarium Glows With Living Light

Despite its name, *Photoblepharon* has no real eyelid. The photophore, however, has a fold of black skin on its underside that can be raised to cover the patch. Inside the photophore a layer of silvery crystals intensifies the light emitted by the bacteria, as a telescope's mirror concentrates starlight. A film of black pigment lines the inner wall of the photophore, preventing the fish from

being blinded by its own luminescence.

After our dive the two Davids and I took our specimens back to the coastal city of Eilat. Here David Fridman helps direct a public aquarium known as Coral World, next to Israel's highly regarded Heinz Steinitz Marine Biology Laboratory. Dr. Moshe Shilo, director of the laboratory and an expert on marine bioluminescence, had welcomed our further study of *Photoblepharon*.

As we released the captives into one of David Fridman's holding tanks, we were bathed once again in blue-green light, like a trio of witches stirring a luminescent brew.

*See "Nature's Night Lights," NATIONAL GEOGRAPHIC, July 1971, and "Wing-borne Lamps of the Summer Night," July 1962, both by Dr. Paul A. Zahl.



David Doubilet suggested, "Bring your desk in here and work, Genie. You'll cut down on Fridman's electric bill."

During the following weeks I made a series of night dives in the northern reaches of the Red Sea to study *Photoblepharon* in its natural surroundings. Le petit Peugeot has an astonishing range. With minor local variations the species is found from Indonesia on the east to the Comoro Islands and the north end of the Red Sea on the west, a distance of more than 6,000 miles.

No one has yet managed to breed *Photoblepharon* in captivity, though a pair apparently spawned soon after they were taken in Indonesia. None of the eggs hatched, but some were found hours later clinging to

strands of artificial eelgrass. The discovery suggests that, even though *Photoblepharon* has such a wide range, its eggs remain only briefly in the free-floating state.

Moving Clouds of Fireballs

During an evening field trip to Ras Muhammad, the southern tip of the Sinai peninsula, I noted another characteristic of *Photoblepharon*: Like a number of other gregarious fishes, it does not form a true school. Instead of aligning themselves in formation, the members of a group swim at varying angles in a roughly spherical mass of from twelve to sixty individuals.

Standing at the water's edge beside Ras Muhammad's great fringing reef, I watched



Honeycombed corals of the Red Sea, here explored by the author, shelter *Photoblepharon* during the day. The fish shun all light but their own, hiding during moonshine and at daybreak. David Fridman, curator of Coral World aquarium in Eilat, Israel, collects specimens momentarily stunned by his torch (above). He discovered Red Sea *Photoblepharon* in 1964; the species ranges as far as Indonesia.



NATIONAL GEOGRAPHIC MAP DIVISION



"It's like floating among the stars," says author Clark of the sensation—impossible to capture on film—of skin diving in total darkness among an aggregation of twinkling *Photoblepharon*. She found she could read her watch by the light of a single fish, one of the brightest glows in the bioluminescent realm. Why do the fish gather near the surface on moonless nights and beam their collective lights? Probably to look for tiny crustaceans and



ILLUSTRATION BY STANLEY MELTZOFF

worms attracted by the radiance. While the eye-opening galaxy may attract predators, it confuses them as well. When threatened, a single fish can close its lids, dart away, and light up again in an unexpected spot, a disconcerting maneuver researchers call "blink-and-run." Other times it turns its lights off, swims up to an intruder, and flashes. Such behavior makes *Photoblepharon* one of the most versatile of bioluminescent creatures.

as groups of flashlight fish foraged beneath the surface, looking like clusters of undersea fireballs. "I've seen them gather in groups of as many as 200 individuals," David Fridman remarked. "Probably the concentrated mass of light attracts a great deal of food, such as small crustaceans.

"I've caught a good many live *Photoblepharon* since I first found them in the Red Sea," he added. "I used to take specimens home and put them in an aquarium with plenty of rocks for them to hide among in the daytime. Then at night I'd turn out the lights, so that the whole family could watch them in action.

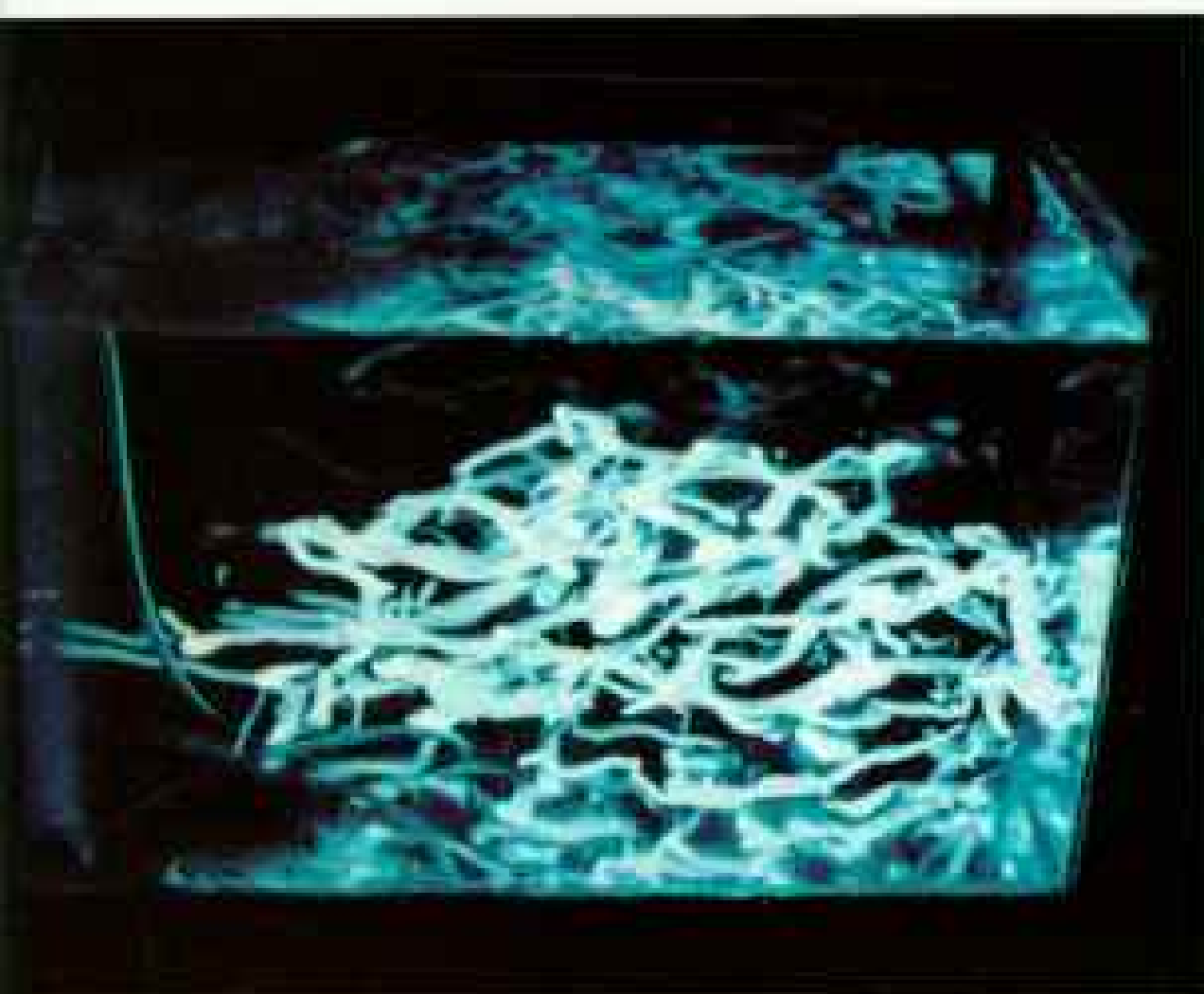
"Once I had an overnight guest in the room where I keep the aquarium. During the day, of course, he thought the tank was empty. When he turned off the lights to go to sleep, the room suddenly began to glow an unearthly blue-green.

"You could hear the man a block away!"

The same concentrated mass of light that attracts food may also draw larger fishes to prey on *Photoblepharon*. Yet the small fish uses its luminescence in an ingenious way to confuse enemies.

"It involves swimming in a zigzag fashion with lights on during the zig and lights off during the zag," says my friend Dr. J. Woodland Hastings, an authority on bioluminescence at Harvard University and an adviser to the Heinz Steinitz Marine Biology Laboratory. With a team of other scientists headed by Dr. James Morin at the University of California at Los Angeles, Woody Hastings has published valuable reports on *Photoblepharon* behavior.

"When disturbed," Woody explains, "the fish behaves in a way that would certainly confuse would-be predators. *Photoblepharon* swims slowly during the zig, leaving its light on, then abruptly turns its light off and swims rapidly in some other direction.



Filmed by their own light, a dozen *Photoblepharon* weave a tangled web during a three-minute exposure in a darkened laboratory at Coral World. A weak red light (right) reveals the fish's outlines without disturbing them. In nature, *Photoblepharon* are dependent on their bacterial light; without it, they cannot locate their food. Science has learned much about the relationship between fish and bacteria, but mysteries abound. When and how do the bacteria get into the photophore? And what turns them on?



When the light goes back on moments later, the fish is in some unpredictable location. Then the sequence is repeated.

"At night," Woody adds, "*Photoblepharon's* normal blink rate is about two or three times a minute. But when the fish is disturbed, it goes into the zigzag behavior and the rate increases to as many as 75 times a minute. Can you imagine the effect when twenty or thirty fish are doing a blink-and-run at the same time? If you were a predator, you might look for dinner somewhere else."

Anglers With Lighted Lures

Photoblepharon's flashlights are an irresistible lure. Natives of Indonesia's Banda Islands bait their hooks with photophores taken from live fish; the light organs keep glowing for hours.

Other luminous fish of the deep sea, the ceratioid anglers, waste little energy swimming after prey. Instead they hang like

dirigibles, each with a light called an "esca" at the end of a long angling rod. One angler can slide its lighted fishing rod backward on its head to guide prey into its huge mouth.

Although harmless itself, *Photoblepharon* shares the Red Sea with some rather hazardous company. The shallow waters contain several types of poisonous fishes, such as the lionfish and other scorpionfishes, whose dorsal spines can inflict agonizing, though generally not fatal, wounds. Another troublesome but less toxic inhabitant is *Diadema*, a long-spined sea urchin that moves largely by night.

One evening at Sharm el Sheikh, on the lower Sinai peninsula, the two Davids and I were diving "blind"—that is, without lights—on a reef particularly rich in life. As I made my way slowly along the reef, I felt something large brush past me to seaward. I swung toward it, wondering if the disturbance of the plankton might create enough



luminescence to identify the creature. I hoped it was not the large hammerhead shark we had seen there earlier in the day.

As I backed against the reef, I felt the stinging thrust of needles through the seat of my wet suit and deep into my skin.

"That's it!" I thought. "After more than thirty years of diving, I have to go and make a beginner's mistake."

As the pain began to sharpen, I wondered grimly if I had encountered a lionfish. If so, the pain would soon become agonizing, and I might well have to exchange my wet suit for a hospital gown. Fortunately the pain leveled off after a time, and I continued the dive. My attacker—or rather my attackee—had been a *Diadema*. The only damage was a seatful of painfully embedded spines and a case of slightly injured pride.

Do These Fish "Talk" by Blinking?

During another night dive I took along a pocket mirror to see how *Photoblepharon* would react to the sight of its own blinking. I managed to lure one specimen away from its group, and it followed the mirror some distance along a reef. As it chased its own image, the blink pattern seemed to change, but I couldn't put my finger on it.

Later I spoke with Woody Hastings about *Photoblepharon's* blinking pattern as a possible means of communication.

"We just don't know whether blinking represents an actual 'language,'" Woody answered. "Jim Morin and his team have established that blinking rates change when two fish meet, or when one sees its mirror image, as you discovered on your dive. We also know that a female *Photoblepharon's* blink rate changes when she defends her personal territory, and that the rate changes radically when a fish is disturbed. But whether this represents communication remains a question."

In an attempt to answer the question, scientists at the Hebrew University laboratory in Eilat are currently experimenting with specimens, using an ingenious dummy flashlight fish whose rate and pattern of blinking can be varied to imitate live fish. After searching for a name to bestow on the decoy, the researchers finally hit on a unanimous choice—"Photobluffaron."

Whatever its functions, *Photoblepharon's*

luminescence is highly efficient. It involves a direct conversion of biochemical energy into light. In contrast, light from our household incandescent or fluorescent lamps requires several energy conversions, from the initial powerhouse fuel or waterpower into electricity and thence into light.

New data on other types of flashlight fish continue to come in. Only this year Dr. John McCosker, director of Steinhart Aquarium in San Francisco, brought back the first live specimens of a Caribbean species and placed them on display. Further study of the fish may provide clues not only to its fascinating behavior but also to the role of bioluminescence throughout the entire undersea world.

Like David Fridman, at times I transported my glowing captives ashore like fireflies in a Japanese lantern. On one of my last dives in the Red Sea, near the tip of the Sinai, I set out at night with a friend, Howard Rosenstein, to capture *Photoblepharon* for David Doubilet to photograph. Near a deep cleft in the seafloor known locally as the "Canyon," we captured a single fish and imprisoned it in a plastic bag. After a time I signaled Howard to continue the search while I took the first specimen ashore.

Turning Off an Undersea Lamp

I turned then and headed back through the dark sea, with only the single *Photoblepharon* to light my way. I swam out across the Canyon to avoid the fringing reef and suddenly felt myself isolated from the entire world. But the light from the tiny fish, blinking inside the bag, was bright and comforting. I held the bag at arm's length in front of me and imagined myself as Diogenes with his lamp, looking for an honest man.

Then another thought struck me: I was far out over the Canyon, with what amounted to an esca in my hand. I realized I wasn't prepared to face just any creature the lure might draw from the depths of the Canyon.

Squeezing some water out of the bag, I tied it securely. Then I opened the front of my wet suit, tucked the bag inside, and closed the suit again. As I did so, I wondered if I were the only creature beneath the sea ever to turn off a photophore with a zipper.

The rest of the long, lonely swim back to shore that night I made with no lamp to guide me. □

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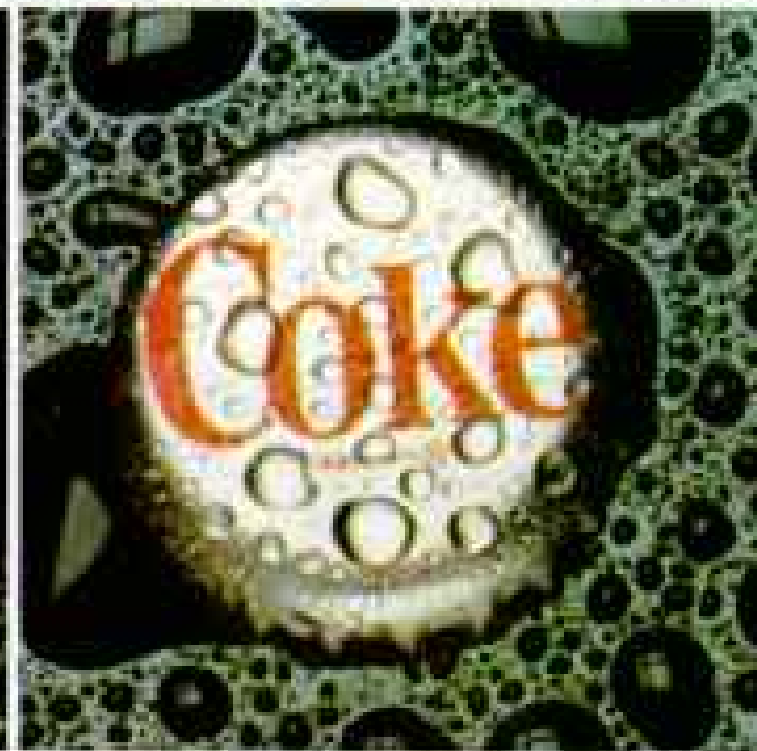
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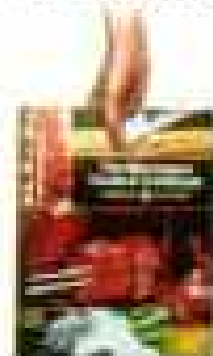
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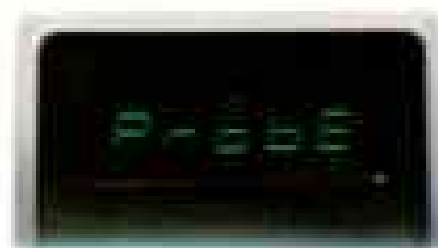


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"And would you believe it even tells me when I make a mistake!"

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instance, forget the Micro-Thermometer™ it displays 'use probe.' And it gets your attention when it's done, by beeping!"

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-Mrs. Miller-



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Before we mine the land we study it. What we learn helps us to restore it properly.



Subsoil is stockpiled and used to refill mined-out areas.

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Refilled area.

From 20 to 200 feet of earth must be moved to uncover the 110-foot-thick coal seam.



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Continuous Reclamation Mining often leaves the land more productive, easier to farm and ranch, and more supportive of wildlife.



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Science helps create a new Marquis standard of driving comfort.

The most scientifically engineered Marquis in history.

Science contributed extensively to the new Marquis' development. Result: a new Marquis standard of driving comfort.

Read how it compares to the '78.

Not just more beautiful.

More aerodynamic.

Lines and proportions evolved for practical as well as aesthetic reasons. They're wind tunnel-tested and refined.

More spacious in almost every dimension.

Computer analysis helped give Marquis more headroom, leg room and shoulder room—even more front seat hip room.

New Command Seating Position for driver.

The driver's seating position has been re-engineered. New lower hood and redesigned glass areas. New controls within convenient reach.



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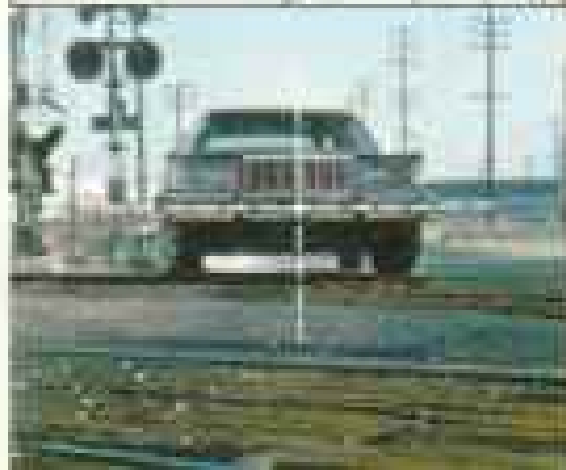
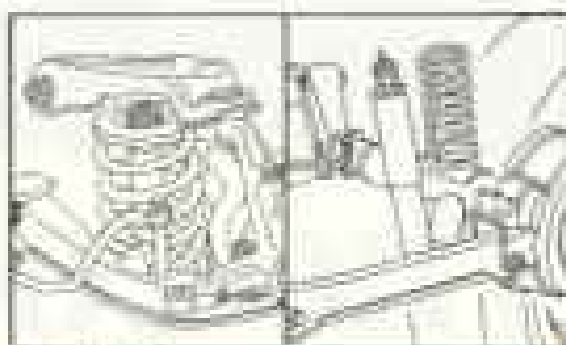
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Ride re-engineered with all-new suspension geometry.

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Corners flatter, takes bumps and dips with increased stability.

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forward mount shock absorbers. All contribute to Marquis' ride and handling characteristics.

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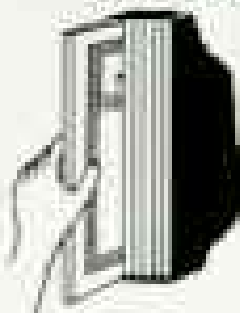
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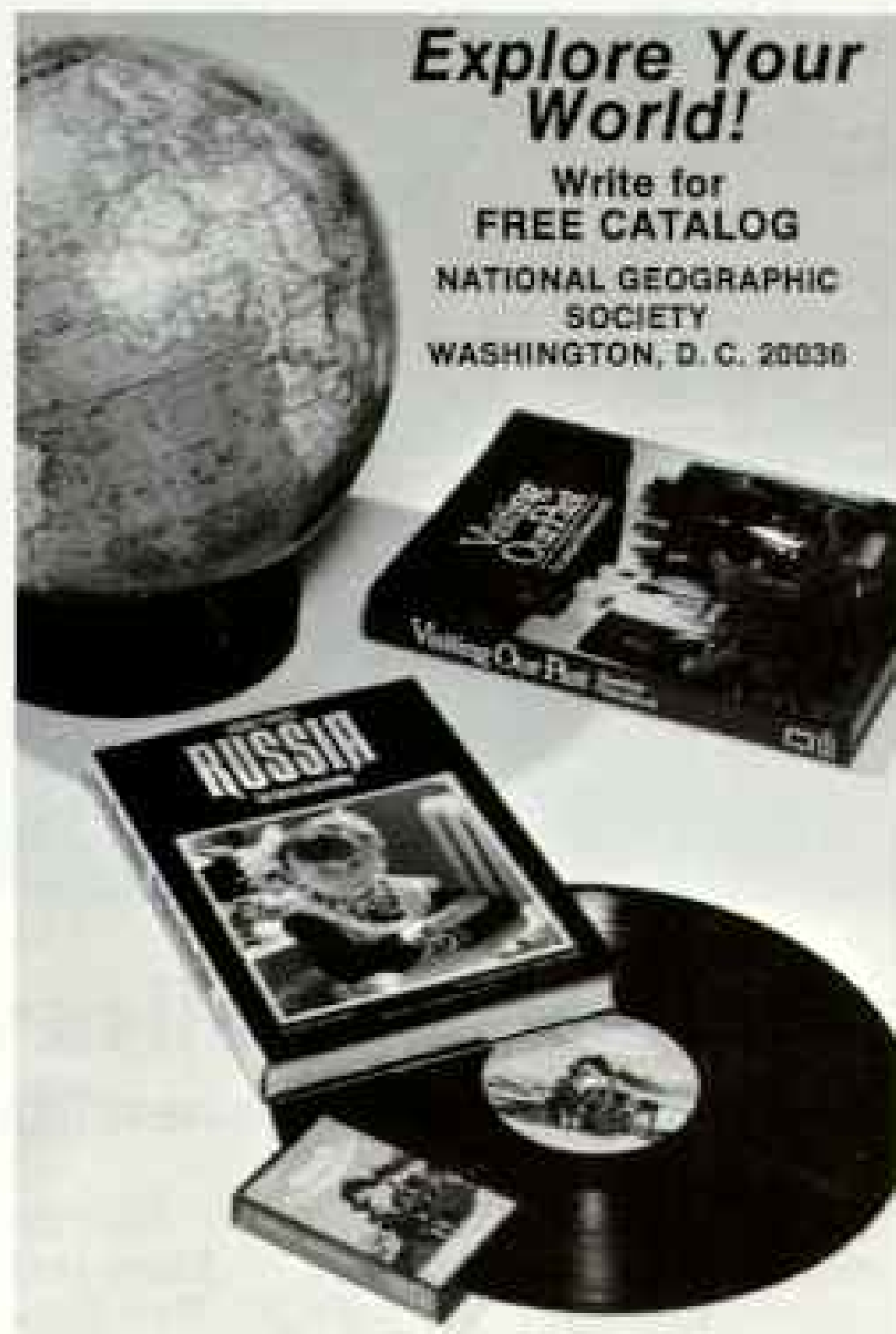
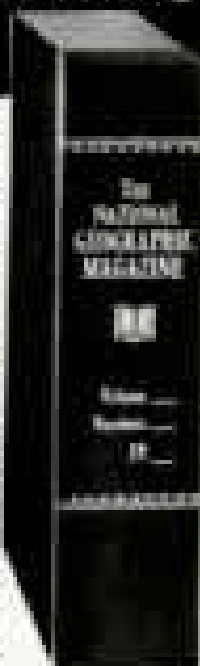
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"choice" land beyond and called it Vinland. On the present-day Island of Newfoundland, Norsemen stepped ashore five centuries before Columbus.

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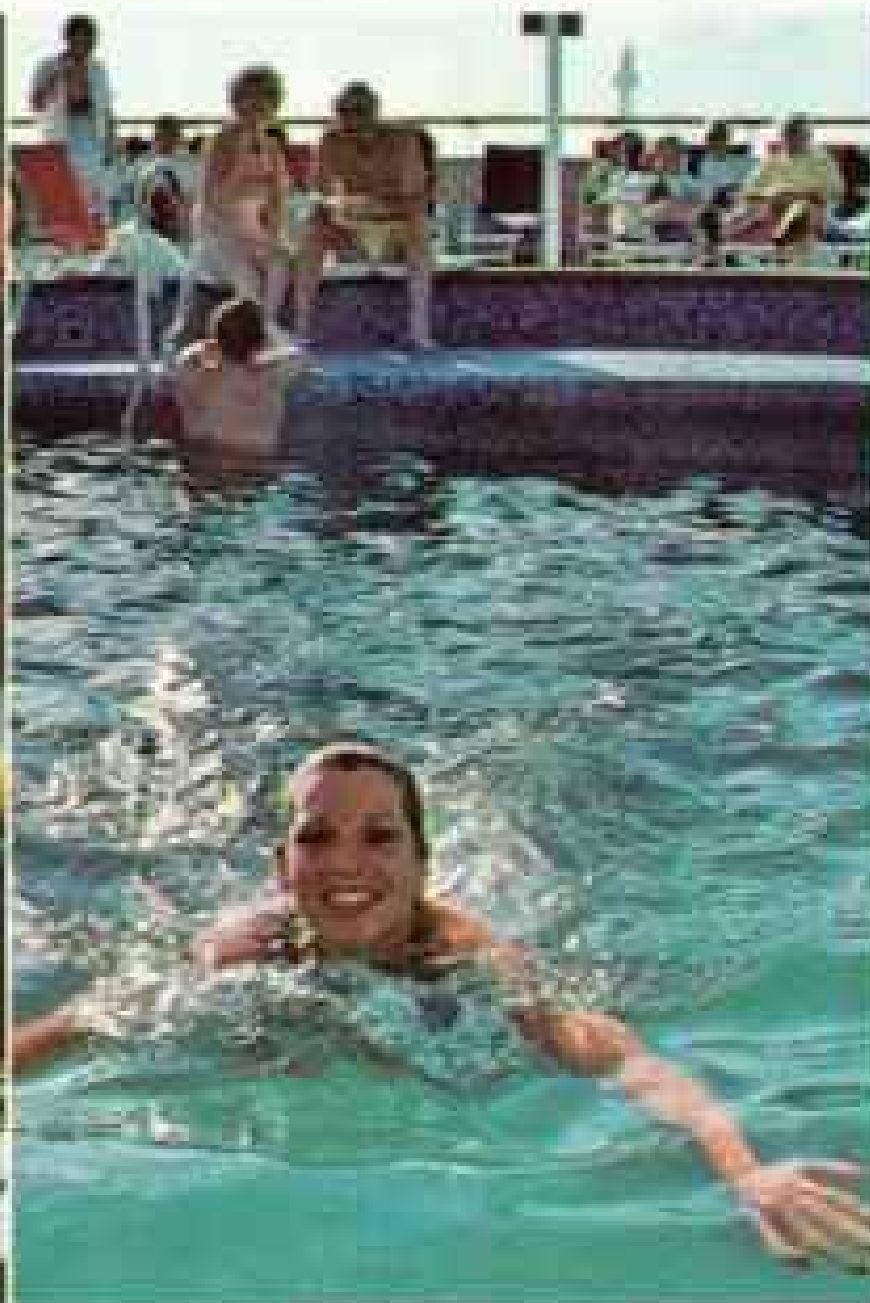
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LTD Landau 2-Door Sedan

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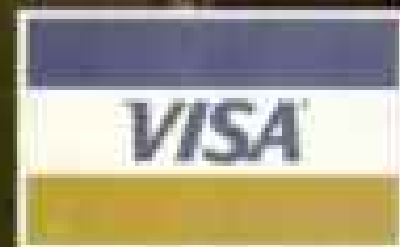
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Hellmann's® also **BAKES!**

(The Real Mayonnaise
is the shortening.)

BUBBLE BUNS

(Quick and easy pull-apart buns)

- | | |
|--------------------------------|--------------------------------------|
| 1/2 cup finely chopped walnuts | 1 package (10) refrigerated biscuits |
| 1/3 cup sugar | 1/3 cup HELLMANN'S |
| 1/2 teaspoon ground cinnamon | Real Mayonnaise |

Grease ten 2 1/2-inch muffin pan cups. In small bowl combine first 3 ingredients. Separate biscuits. Cut into quarters; shape into balls. Coat each with Real Mayonnaise, then roll in walnut mixture. Place 4 in each muffin pan cup. Bake in 400°F oven 15 to 17 minutes or until browned. Serve warm. Makes 10.

PECAN JUMBLES

(Crispy drop cookies with a nutty taste)

- | | |
|---|--------------------------|
| 1 1/2 cups firmly packed dark brown sugar | 1/2 teaspoon baking soda |
| 1 cup HELLMANN'S Real Mayonnaise | 1/4 teaspoon salt |
| 2 eggs | 1 cup chopped pecans |
| 1 teaspoon vanilla | 1 cup pecan halves, |
| 2 3/4 cups unsifted flour | optional |

In large bowl beat first 4 ingredients until smooth. Stir in next 4 ingredients. Drop by level tablespoonfuls 2 inches apart on greased cookie sheets. Top each with pecan half. Bake in 375°F oven 8 to 10 minutes or until lightly browned. Immediately transfer cookies to wire racks. Makes about 4 dozen.

CHOCOLATE MUNCHIN' CAKE

(The lacy look makes this moist cake beautiful)

- | | |
|--------------------------------|----------------------|
| 1 1/2 cups unsifted flour | 1/3 cup chocolate |
| 3/4 cup sugar | flavored syrup |
| 1 teaspoon baking soda | 1 tablespoon vinegar |
| 2/3 cup strong coffee or water | 1 teaspoon vanilla |
| 1/2 cup HELLMANN'S | 1/4 teaspoon salt |
| Real Mayonnaise | Confectioners sugar |

In 8 x 8 x 2-inch baking pan stir together first 3 ingredients. Add next 6 ingredients. Stir with fork, scraping corners and sides of pan, until mixture is uniform. Bake in 350°F oven 30 to 35 minutes or until top springs back when touched lightly. Cool on wire rack. Place paper doily on top; sprinkle with confectioners sugar. Remove carefully.



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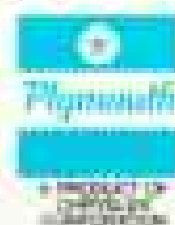
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CAPERCAILLIE

Shown much smaller than actual size (9" diameter)

Announcing a most important
new porcelain plate collection...

GAME BIRDS OF THE WORLD

by Basil Ede

An extraordinary series of twelve collector's plates
by Europe's foremost wild bird portraitist...
his *first* works of art in porcelain.

Each plate bears a new and original work
created by Basil Ede
exclusively for this limited edition.

Available by subscription only.

Advance subscription deadline: November 30, 1978.

THE ARTIST. Basil Ede, of Sussex, England, has been called "the outstanding wild bird portraitist of his generation, and perhaps of his century." He is widely regarded as Europe's most distinguished bird artist. Indeed, the authority of his style and the distinction of his work have profoundly influenced the way birds are portrayed by artists throughout the world.

After notable exhibitions in London and other major European cities, Basil Ede was honored by a one-man show at the Smithsonian Institution's National Collection of Fine Arts in Washington, D.C. This was followed, during recent years, by important exhibitions at New York's famous Kennedy Galleries.

His paintings have been commissioned by the National Audubon Society and the World Wildlife Fund, among others. And he is represented in many prominent public and private collections, including the collection of HRH Prince Philip, Duke of Edinburgh.

Now, at the height of his career, Basil Ede has created his *first* works of art in fine porcelain—*Game Birds of the World*. A series of twelve collector's plates portraying the beauty and grace of game birds in precise, authentic detail and with his own inimitable flair for color and composition.

Each of these twelve plates is, in itself, a masterful work of art. Together, they form an incomparable collection that will be a proud acquisition for every subscriber...a focus for conversation and admiration when displayed in the home.

THE GAME BIRD PLATES. The plates will be crafted in France, by the world-renowned firm of Haviland of Limoges. The exceptional translucence and whiteness of Limoges porcelain are ideally suited to bring out the subtle colors of Basil Ede's art.

And the plates will be large in size—9 inches in diameter—to provide full scope for Ede's finely detailed portrayal of game birds in their natural habitat.

The jewel-like quality Ede brings to the birds' plumage...the delicate hues of each bird's protective coloration...the wonderfully natural colors of its environment...all will be captured *exactly*.

Franklin Porcelain has devoted more than two

years to meticulous preparation for the issuance of these plates, and every detail will be of the highest quality. For example, each plate will be hand-decorated with a border of pure 24 karat gold, perfectly proportioned both to the size of the plate and to the scale of Basil Ede's art. And each plate will incorporate as many as sixteen separate ceramic colors. Only through such perfection of detail could the standards of Basil Ede and of Franklin Porcelain be satisfied.

Ede's very beautiful and marvelously accurate works of art—created especially for this issue and available only on these fine porcelain plates—make this a collection that will be enjoyed and prized by all who love the beauty of birds, of art, and of porcelain.

And, as the *first* works in porcelain by Europe's leading painter of birds, this is a collection clearly destined to have lasting importance.

THE LIMITS OF EDITION. The Game Birds of the World porcelain plate collection will be produced only once and in strictly limited edition. The plates will be crafted exclusively for individual subscribers. And the limit of one collection of Game Bird Plates per subscriber will be enforced without exception.

Thus, the total number of sets to be issued will be forever limited to the exact number of original subscriptions entered during a rather brief offering period, plus one set for Basil Ede and one for the archives of Franklin Porcelain.

Since the plates will not be sold separately and will not be made available for original sale through dealers, the original subscribers and the artist will be the only people in the entire world who can acquire this collection. In the future, any dealer who may wish to offer these plates to a client, or any collector who may wish to acquire these plates at that time, can only hope to obtain them from one of the original subscribers.

ADVANCE SUBSCRIPTION DEADLINE: November 30, 1978. The collection will be issued to subscribers at the convenient rate of one plate every other month. The original issue price is \$55 per plate, payable in two equal installments of \$27.50 per month. Each plate will be accompanied by specially written reference material and a special display stand, and a Certificate of Authenticity will accompany each collection.

To enter your subscription, complete and mail the Advance Subscription Application at right in time for it to be postmarked by the advance subscription deadline of November 30, 1978. A final announcement will be made in January, and the subscription rolls will then be closed forever.



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A Limited Edition

Must be postmarked by November 30, 1978.
Limit: One collection per subscriber.

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I need send no payment now. The twelve plates are to be sent to me at the rate of one plate every two months. The issue price of \$55,* per plate will be billed to me in two equal monthly installments of \$27.50,* with the first installment due in advance of shipment. *Plus my state sales tax.

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But in the "voluntary" parts of your car insurance—collision and comprehensive (fire and theft)—that cover physical damage to your own car, there are some things you can do to lower your insurance bill.

Safe drivers pay lower premiums for both liability and collision coverage. Insurance rates are set that way because drivers with a good past history are less likely to have accidents in the future. Many insurance companies define "safe drivers" as those with two or less

moving traffic violations and no "chargeable, at fault" accidents within the past three years. Their premiums may be as much as 25% lower.

You can often cut your premiums for collision and comprehensive by 25% to 50% by raising your deductible. Many people still choose full-coverage comprehensive and \$100 deductible collision

value of your car on the used-car market, and your own financial situation. If your car is more than five years old, it may not pay to buy any collision insurance. If you do have an accident, casualty losses over \$100 that are not reimbursed by insurance coverage are tax deductible, in many instances, providing you itemize your tax return.

TYPICAL INSURANCE PREMIUMS FOR A FULL-SIZE 1978 MODEL GM CAR*

	Full-coverage comprehensive and \$100 deductible collision		\$200 deductible comprehensive and \$500 deductible collision
	Standard	Safe Driver	Safe Driver
ATLANTA	\$267	\$201	\$111
CHICAGO	\$947	\$711	\$395
LOS ANGELES	\$476	\$358	\$197
SANTA FE	\$412	\$311	\$172
WINNETKA, ILL. (suburb of Chicago)	\$372	\$280	\$154

*Insurance premiums are based on many factors, including your age, the kind of car you own and where you live. Rates vary from company to company. The figures above do not include liability coverage.

coverage. That means they pay the first \$100 on collision-related damages and the insurance company pays the rest. But just look what happens when you increase the deductibles to \$200 on comprehensive and \$500 on collision: In Los Angeles, for example, the typical annual premium for a safe driver will drop from \$358 to \$197. The higher the deductible, the lower the premium. (See the chart for more examples.)

Of course, you assume more of the risk by choosing higher deductibles. It's a personal decision that should be based on a thorough evaluation of the age of your car, the

We believe that if you have enough information you won't have to spend as much money to own and maintain a car. And that'll be good for you and good for us.

This advertisement is part of our continuing effort to give customers useful information about their cars and trucks and the company that builds them.

General Motors

People building transportation to serve people



Arizona

Has anybody ever seen it all?

Imagine lush green high-country forests. Startling red cliffs. And sky-blue swimming pools, enjoyed year round.

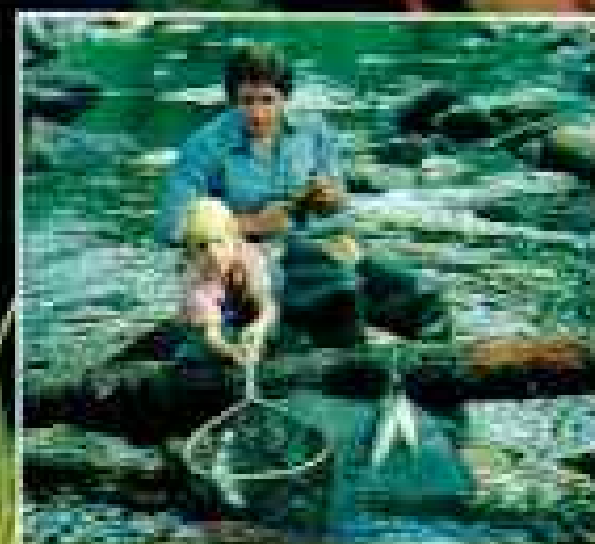
Imagine the stillness of a centuries-old Spanish mission. The bustle of a high-fashion shopping center. The fascination of an Indian crafts shop.

Fairways in the foothills. Tennis with a "city lights" view. Five-star dining, and cowboy cook-outs. Accommodations that make you welcome, rates that make sense.

Casual cities like Phoenix and Tucson. "Old West" towns like Tombstone and Pioneer. Speedboats on the Colorado River.

Imagine all this and more, in one place. Under a golden sun that paints the evening sky with colors that even life-long residents come out to see.

The place is Arizona, and maybe nobody will ever see it all. But we'd like to help you get started.



Arizona Office of Tourism
1700 West Washington
Dept. 230
Phoenix, AZ 85007

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and a free record of "Arizona...
Has anybody ever seen it all?"

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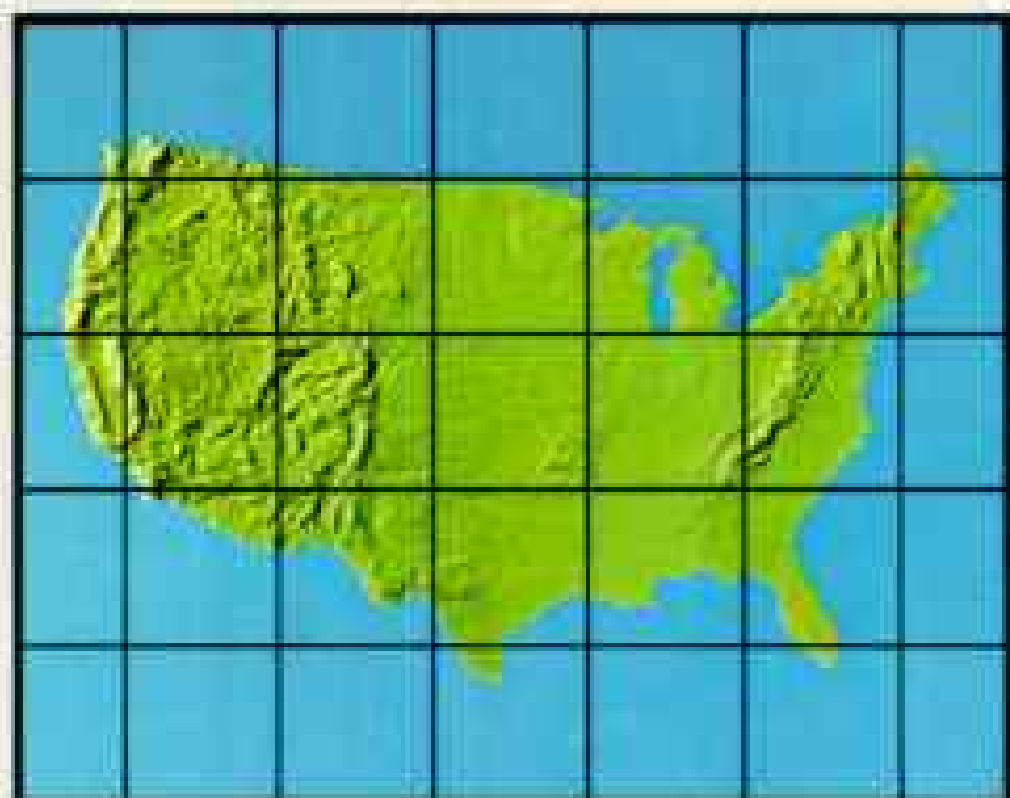
FREE RECORD





In Wyoming, Amoco is using computer technology to drill wells and develop American energy faster.

That's energy that can't be shut off by foreign countries.



All over America, Amoco is working to make our country less dependent on foreign oil.

Today, almost half the oil America uses is imported. The time has come to use more American ingenuity to expand America's energy supplies.

Amoco is helping to reduce our country's dependence on foreign oil by finding petroleum deposits here at home. New-found reserves of domestic energy will make America more secure and reduce the impact of any future embargo.

Working toward this goal, Amoco is using new thinking to find oil reserves in America that will help keep American dollars from going abroad.

In Wyoming, we're using computers to drill wells and develop energy faster. Working with a remote terminal, a drilling crew can send facts on field conditions to a central computer that sends

back specific instructions on drilling speeds, mud mixtures and bit sizes and weights, right to the drilling site.

This enables the crew to drill wells in less time, move rigs to new sites sooner and open more producing wells each year.

Amoco's leadership in developing new technologies like computer-assisted drilling is one of the reasons why we were able to help open up 81 new oil and natural gas fields in America last year.

Exploration and production of new American fossil fuel reserves are important, because these fuels will be relied on heavily until solar and other new forms of energy come of age.

Until these new sources of energy are practical on a large scale, Amoco will keep up the search for petroleum deposits throughout America.

You expect more from a leader.



Standard Oil Company (Indiana)

*Discover
The Ritz:
your elegant
breakfast
is just the
beginning.*



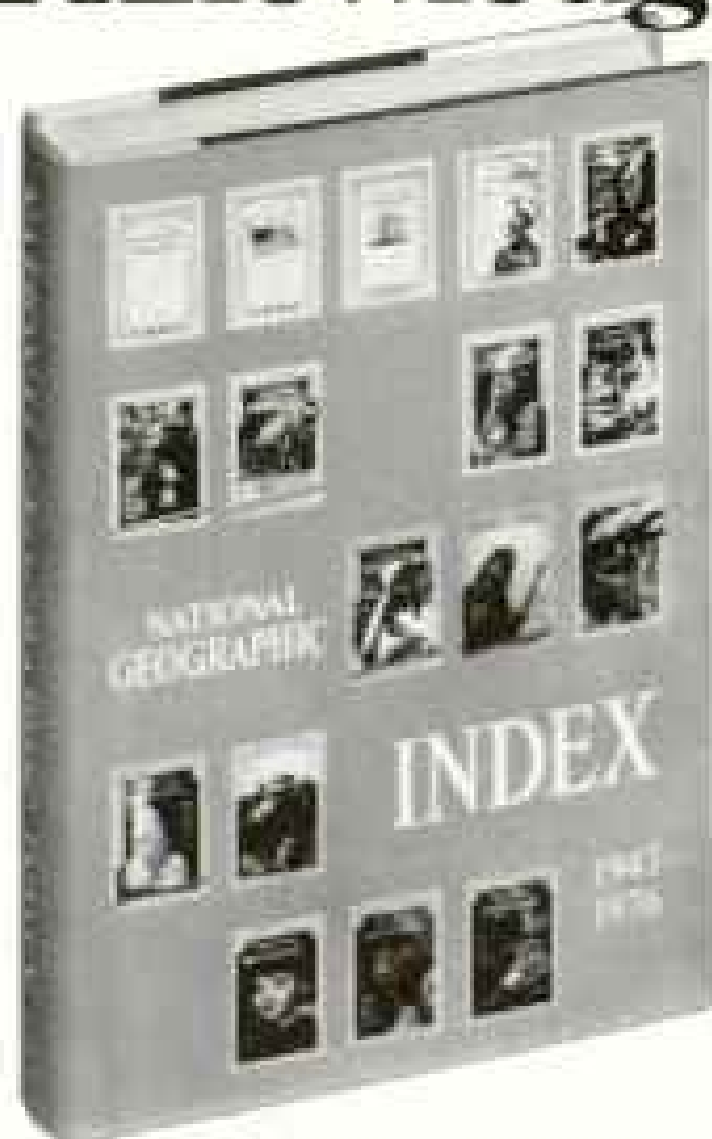
When your spouse joins you on a business trip, one of the first things you'll discover at The Ritz in Chicago is the large, comfortable room. And there's shopping — seven floors of it right there in Water Tower Place. And a modern Health Spa. And dancing and entertainment in The Bar. There's no end to the pleasant discoveries you'll make at The Ritz!



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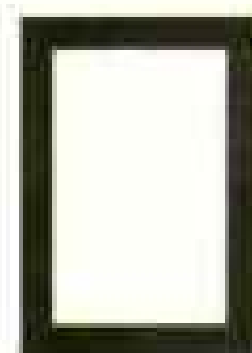


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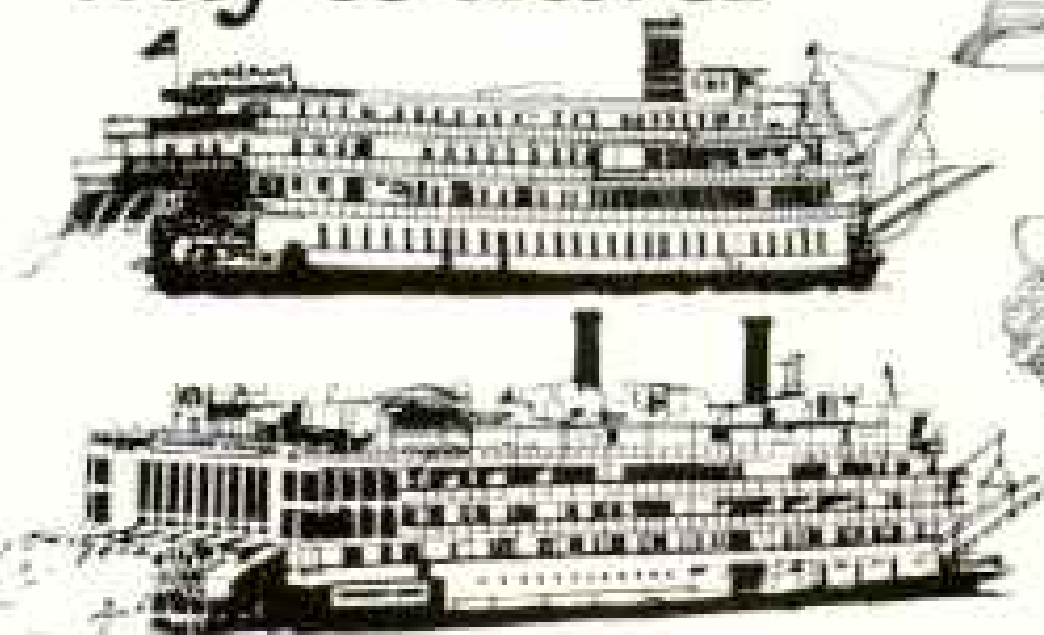
He called the Buffalo, calmed the waters and healed the sick. Beaverhead, a dealer in magical spells, the Medicine Man of the Blackfeet, captured in porcelain by the artists of Cybis.

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THE WINGS OF MAN

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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.

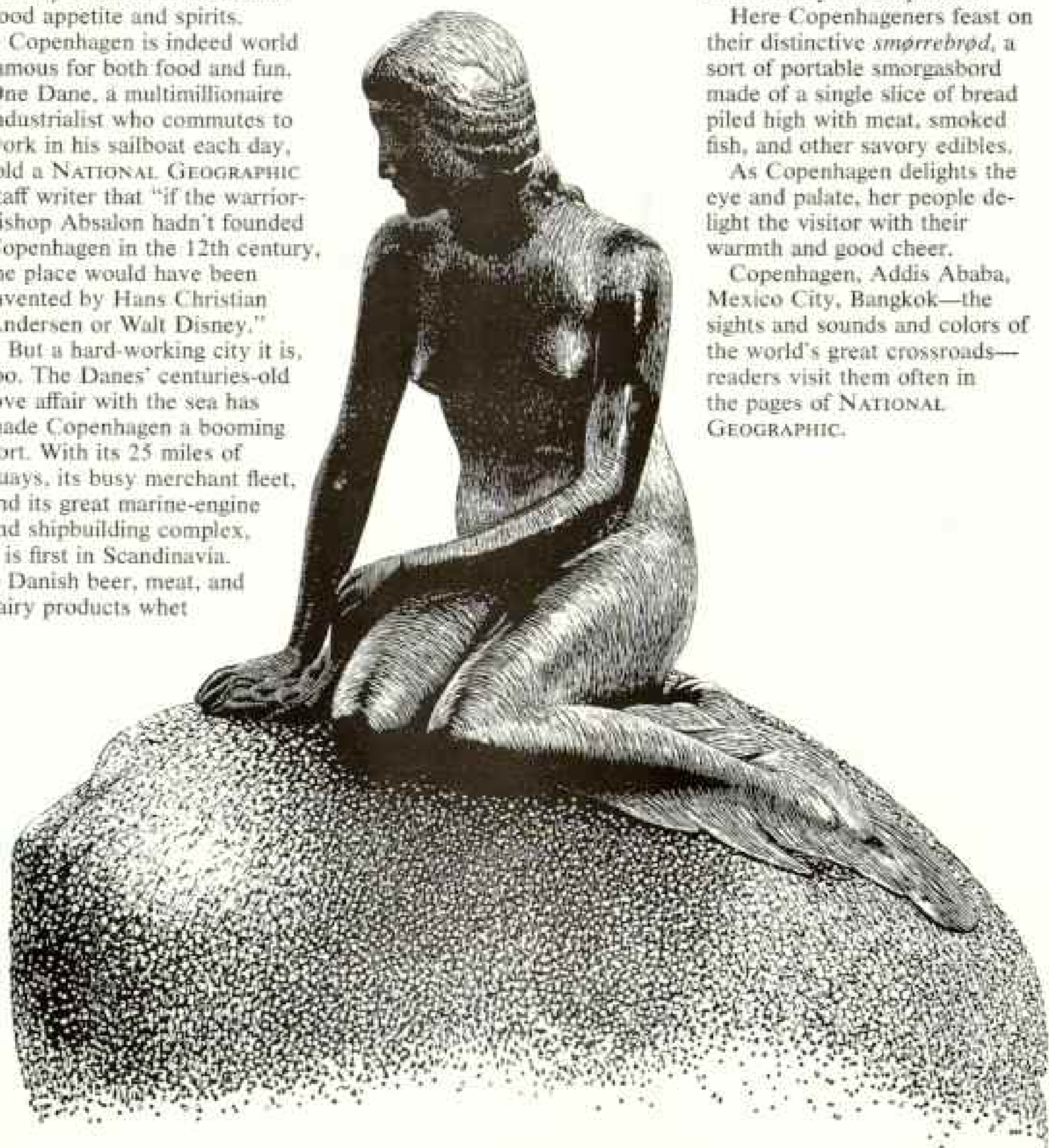
Tivoli, best known and very possibly best of Europe's amusement parks, is certainly in the spirit of the great king.

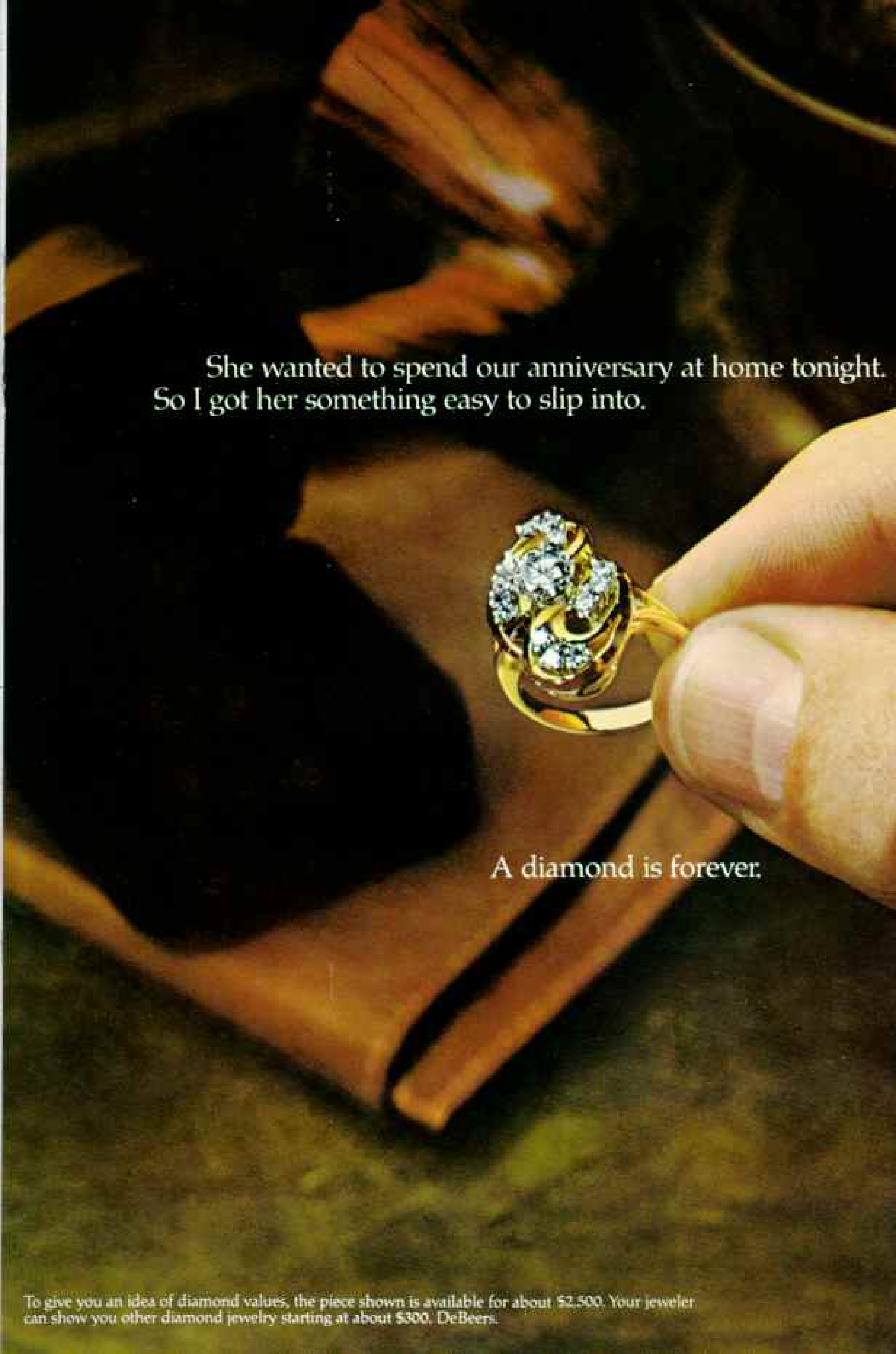
A glittering 20-acre fairyland of light, Tivoli is a mid-city magnet for gourmets and concert-goers, young or old, king or commoner. Its restaurants, theaters, concert halls, playgrounds, fun house, and fireworks displays have enchanted more than 150 million people in a century and a quarter.

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.



A close-up photograph of a hand holding a diamond ring. The ring features a large central diamond surrounded by smaller diamonds in a halo setting, all set in a yellow gold band. The background is a dark, textured surface with several cinnamon sticks, suggesting a warm, homey atmosphere. The lighting is soft, highlighting the facets of the diamonds and the texture of the hand and cinnamon sticks.

She wanted to spend our anniversary at home tonight.
So I got her something easy to slip into.

A diamond is forever.

To give you an idea of diamond values, the piece shown is available for about \$2,500. Your jeweler can show you other diamond jewelry starting at about \$300. DeBeers.



NORTH



EXPRESSWAY



NORTH

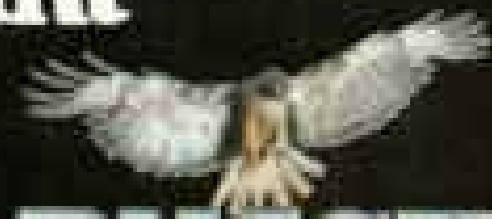


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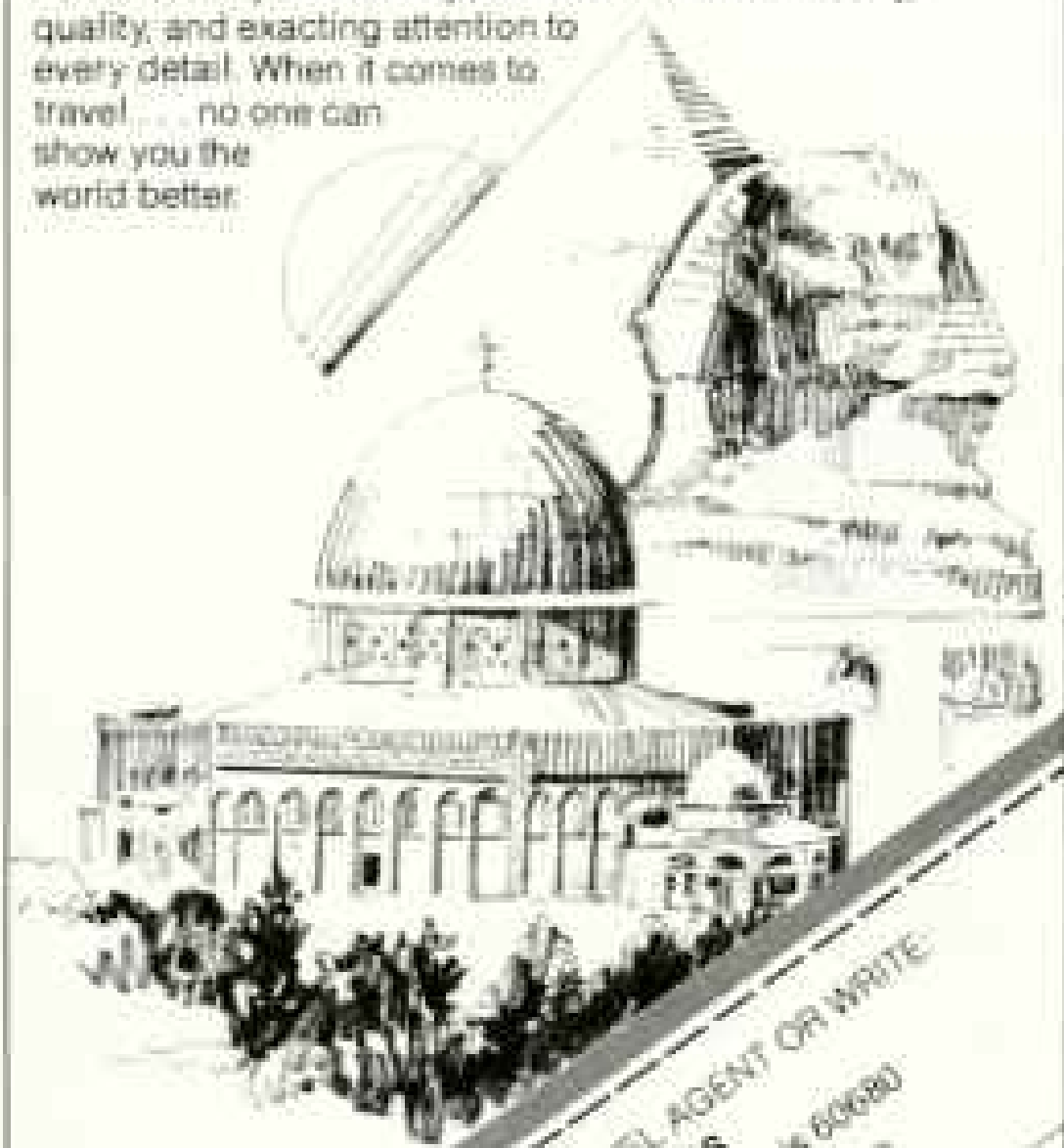
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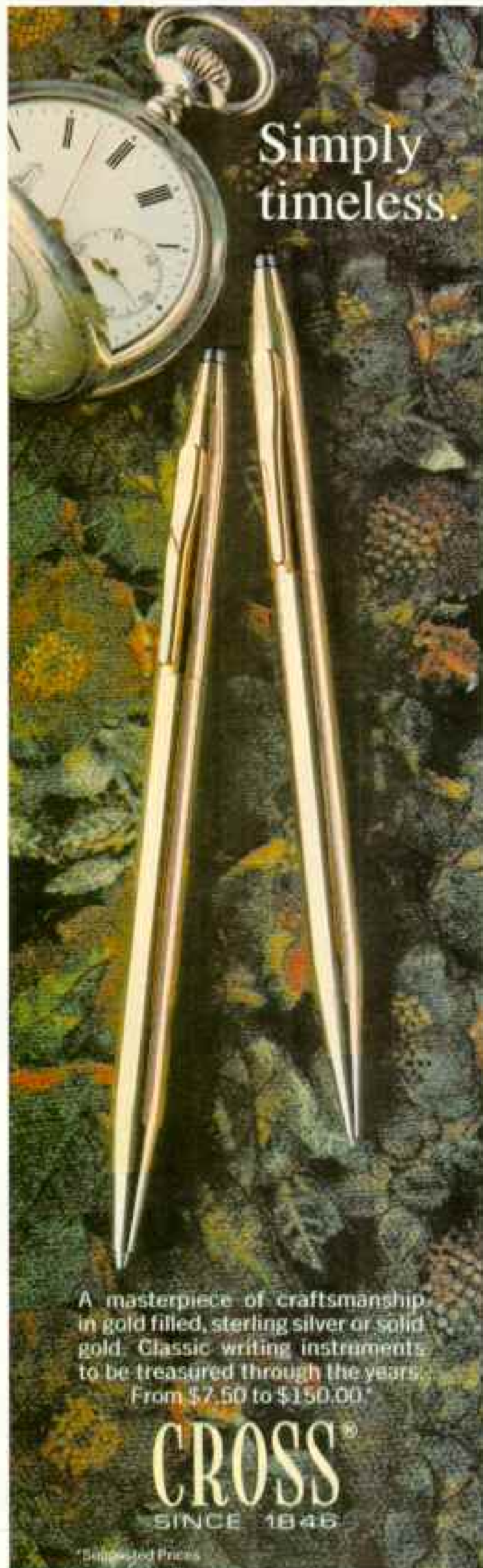
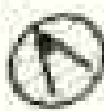
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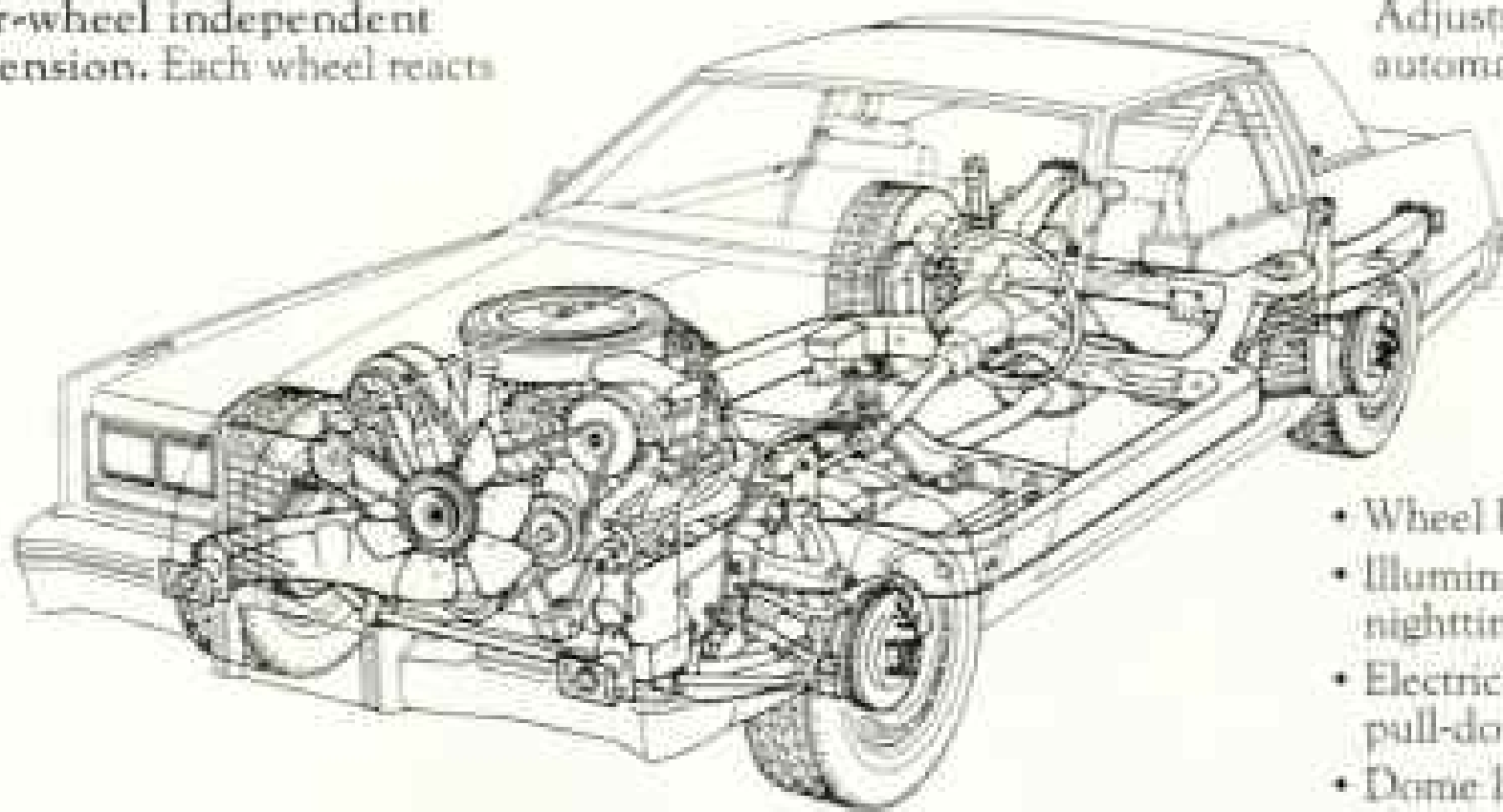
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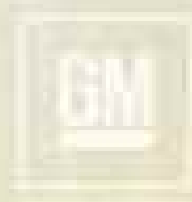
- Side window defoggers for added convenience.
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- Automatic Climate Control.
- Quick-ratio power steering for easy parking and cornering.
- Dual Comfort front seats (seat two people).
- Lamp Monitors, front and rear.
- Chimes that courteously urge you to buckle up.

- Flush-mounted windshield as on custom cars to reduce wind noise.
- More headroom and legroom—front and rear—than '78 counterpart.
- Reduced turning circle for more maneuverability in city traffic.
- Right side rearview convex mirror contributes to field of view.
- Steel-belted, wide whitewall radial tires.
- Six-way power seat adjuster for driver.
- Column-mounted headlight dimmer control.

- Wheel bearings sealed for life.
- Illuminated Entry System for nighttime convenience.
- Electric trunk release and power pull-down.
- Dome light, dual spot map lamps.
- Impressive mileage. EPA estimates are 22 mpg highway, 14 city and 17 composite for the standard EFI engine. California figures are lower.

EPA estimates are 29 highway, 21 city and 24 composite for the '79 Eldorado with the available diesel engine. With either engine, your mileage will vary depending on how and where you drive, your car's condition and available equipment. Eldorados are equipped with GM-built engines produced by various divisions. See your dealer for details.

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GENERAL ELECTRIC TELEVISION TECHNOLOGY IS CHANGING THE WAY AMERICA ADJUSTS COLOR.



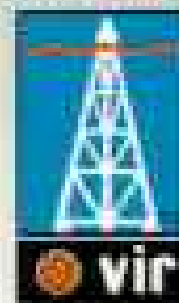
In 1977 General Electric won an Emmy for being the first to use the broadcaster's VIR color signal in home television. The GE VIR set uses the signal, broadcast with many programs, to adjust color distortions which may occur as the color signal passes from the broadcaster, through TV communication systems, to your home.

Flesh tones, backgrounds, blue skies and green grass are automatically adjusted for you by the computer-like circuitry in your GE VIR set.

An incredible sixty times a second, giving you vivid lifelike colors.

And all GE VIR sets have a 100% solid-state modular chassis and the In-Line picture tube system pioneered by GE.

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Excellent Performance.

Performance is what Ford Fiesta is all about. With front wheel drive and Michelin steel-belted radials to help take you up hills, through mud and over ice and snow.

Rack and pinion steering for precise handling. And acceleration that will absolutely move you. In Ford tests, 1978 Fiestas accelerated from 0 to 50 MPH in an average of about 9 seconds. And their front disc brakes brought them from 50 to 0 MPH in an average of 3.3 seconds.

High EPA Gas Mileage Ratings.

Fiesta not only gives you great performance, but also high fuel economy ratings. 1979 EPA gas mileage estimates were unavailable at the time this ad was pub-

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At Over 5,000 Ford Dealers.

Fiesta is sold and serviced at over 5,000 Ford Dealers and backed by Ford Motor Company, Dearborn, Mich. Test-drive a Fiesta and see why we call it Wundercar.



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And now National Geographic offers you a breathtaking look at that civilization—in *Ancient Egypt: Discovering its Splendors*, with the largest picture format of any book ever published by National Geographic.

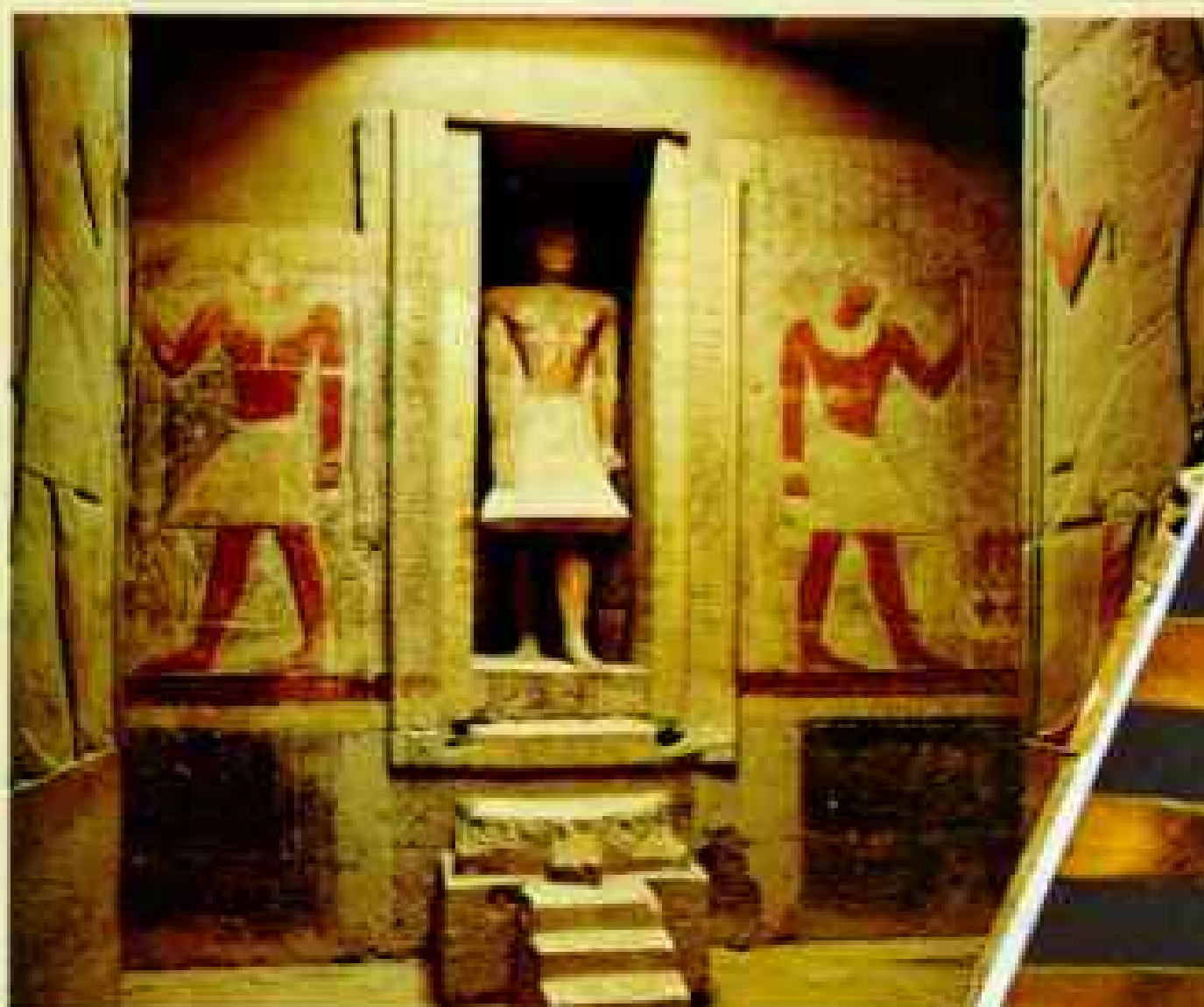
Brilliant color photography captures the essence—the marvelous heritage—of ancient Egypt. Its remarkable artifacts and statuary. Its exquisite necklaces, rings, gem-studded jewelry. Its fashions, coiffures, cosmetics, and furniture. You see also tools and methods of working . . . games and pleasurable pastimes . . .

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Hippopotamus, made of faience nearly 4,000 years ago. CAIRO MUSEUM



Ornate burial chambers symbolize entry into the afterlife.

Ancient Egypt's page spreads are nearly two feet wide. See the mask of Tutankhamun larger than its actual size.

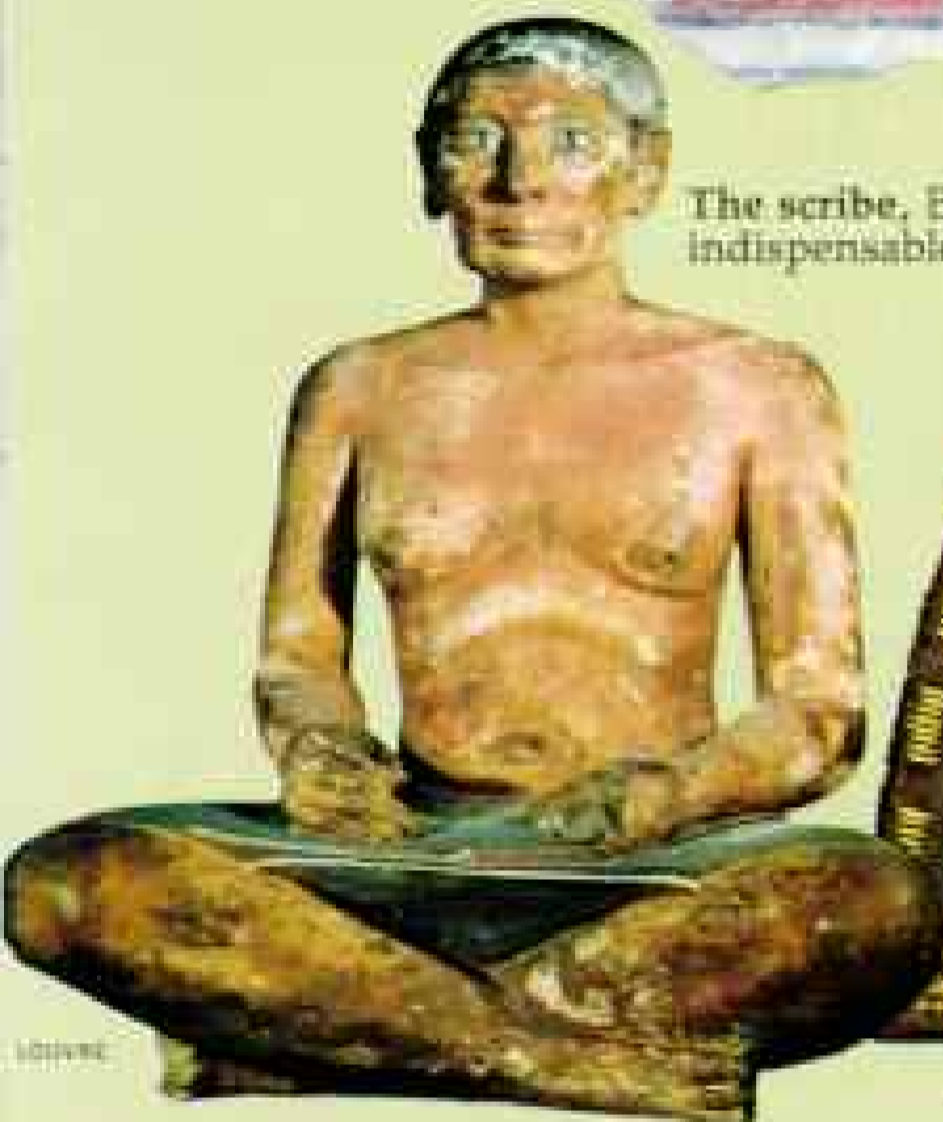


Bounty from the Nile Valley provides this sumptuous feast.

BRITISH MUSEUM



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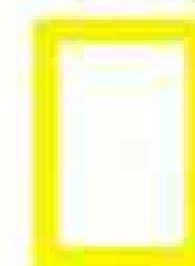
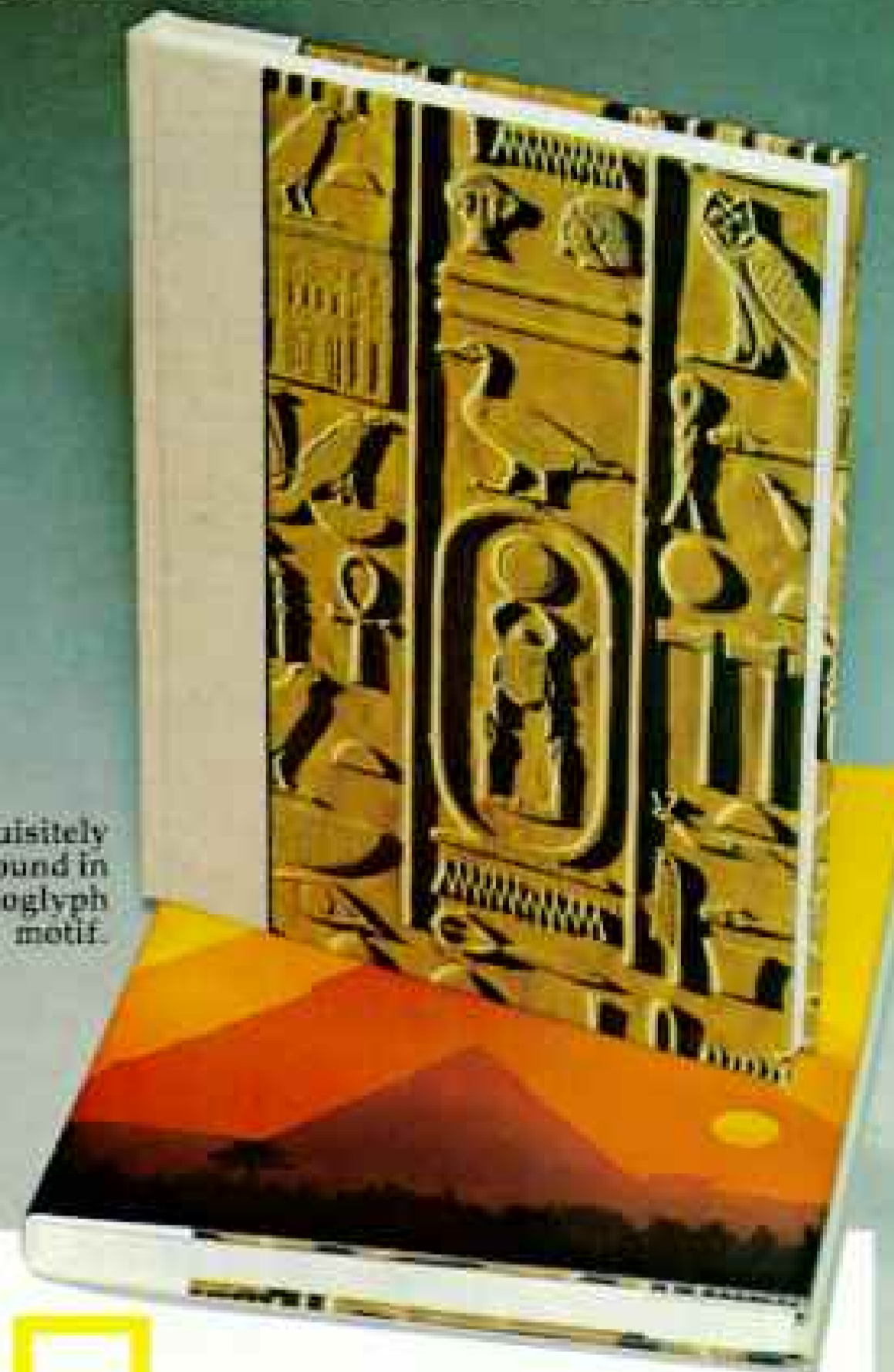


A golden fan, once rimmed by ostrich feathers, depicts a royal hunt.



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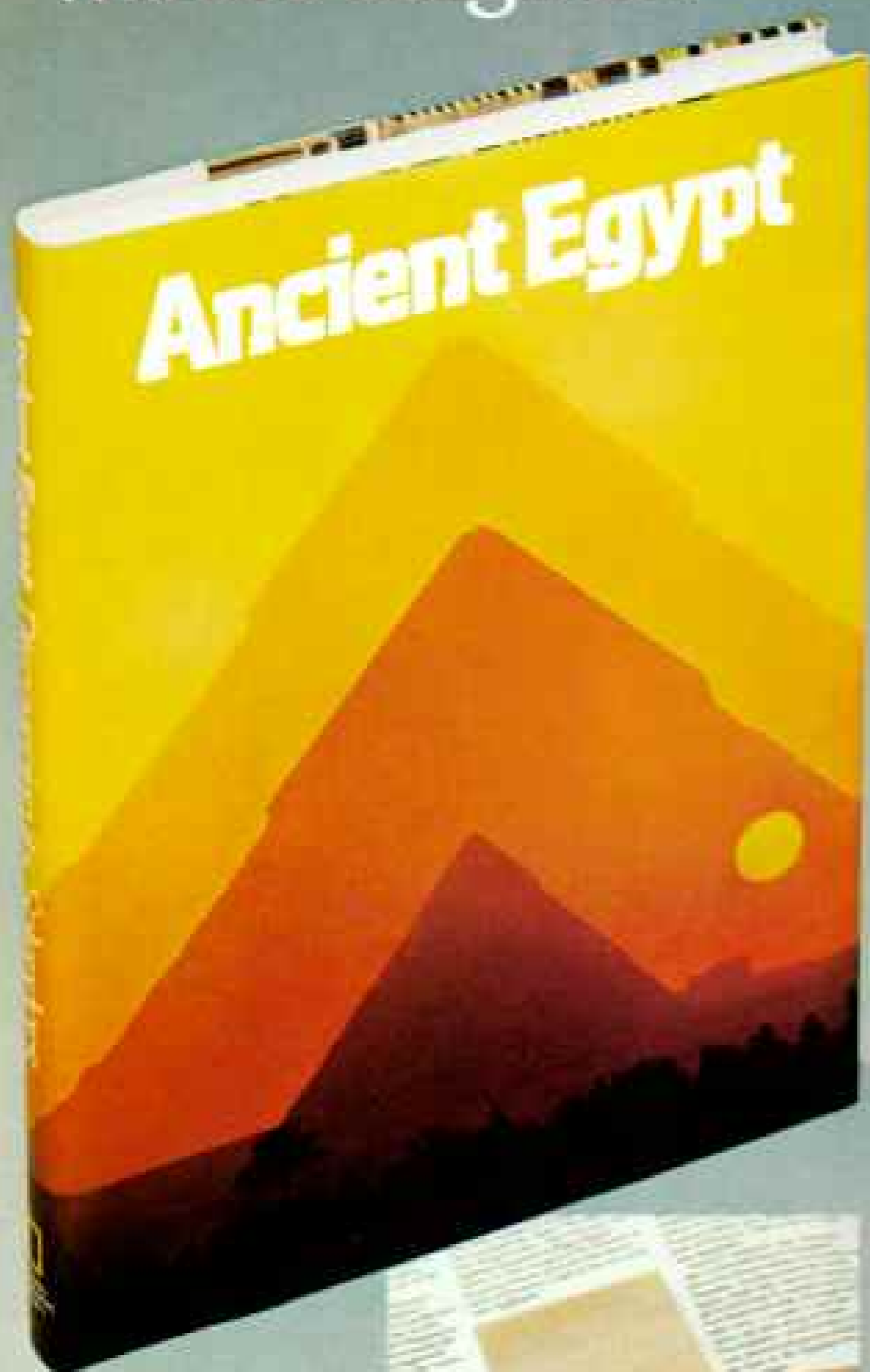
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NATIONAL GEOGRAPHIC

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This is good news for the railroads, but it's better news for the consumer and the nation. Many piggyback trains move their cargo with about half the fuel that would be required by trucks to move the same goods.

Usually there's a cost saving in piggyback shipments, too, with the advantage of fast, long-distance travel and expedited door-to-door delivery service.

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Association of American Railroads,
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Impact absorbing guard rails already in place across 25 states use a *patented* shatter-proof plastic, developed by Phillips Petroleum, to help save lives and reduce crash damage on our highways.

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