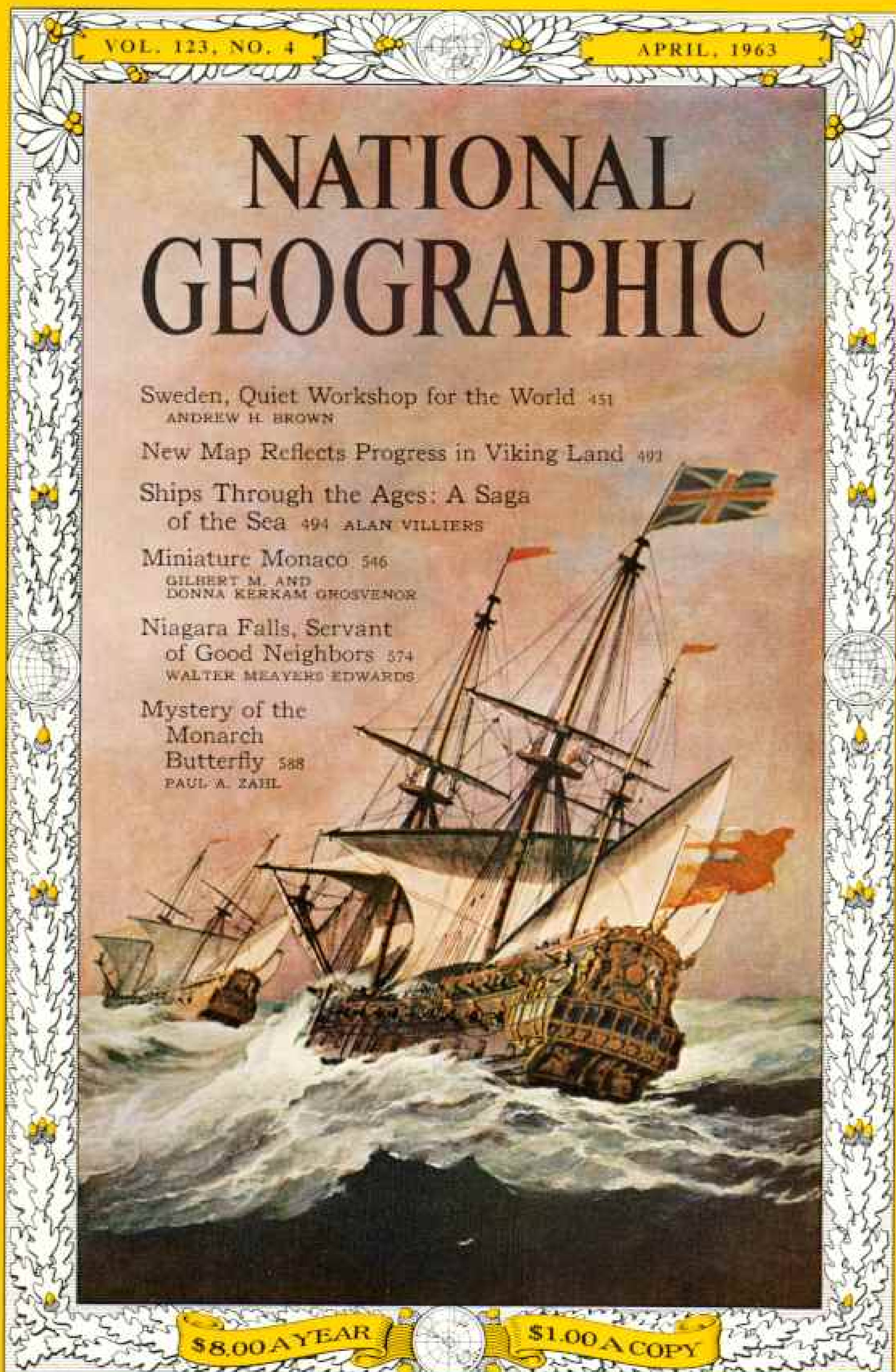
ATLAS MAP: SCANDINAVIA



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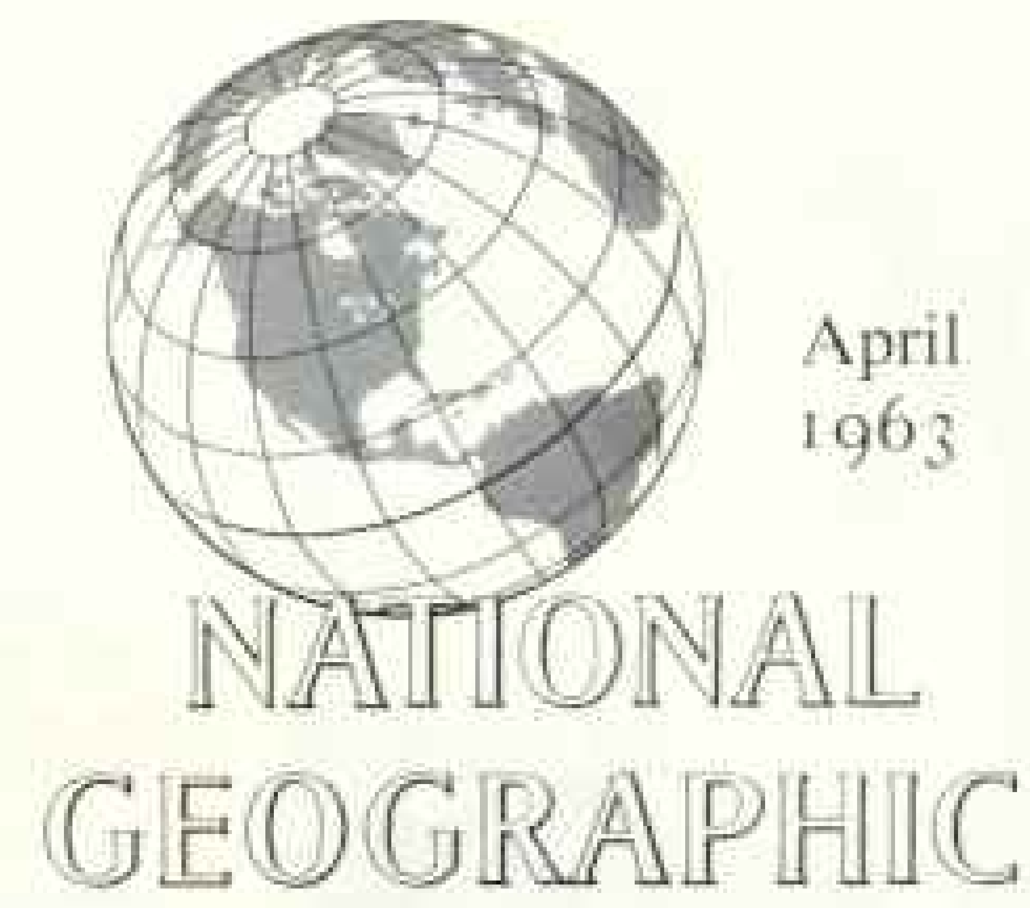

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Sweden, Quiet Workshop for the World

By ANDREW H. BROWN

National Geographic Senior Editorial Staff

MY HOST leaned across the luncheon table in the company dining room and handed me his business card: "Dr. Tryggve Angel, The Sandvik Steel Works Co., Ltd."

It was printed on a paper-thin rectangle of gleaming stainless steel.

"Carpenters all over the world use Sandvik saws," he said in fluent English. "Every day more than 100 million men shave with razor blades made from Sandvik steel. Many years it has taken us, and much testing, to make steel that will do exactly what we want it to do. This, for example."

From a well-tailored pocket Dr. Angel fished out a swatch of shiny fabric, woven from hairlike steel wire.

"This is a cloth made for special filtering processes. It has a thousand holes per square millimeter, an area about as big as one hole in that pepper shaker. And this." He dropped a tiny watch spring into my hand; it quivered delicately, like a ladybug testing its wings.

"Our finest steel—$100 a pound! But one pound makes 11,000 such springs."

KODACHROME BY THOMAS NEBBIA © N.G.S.

Sunny cloud of hair and blue eyes epitomize the Swedish look of a Stockholm beauty.

Swedes Strive for Excellence

There was a note of quiet pride in Dr. Angel's voice as I learned about world-famous Swedish steel from this courtly businessman. And as he spoke, I realized that I was learning more than a little about Sweden itself.

In this country, "good" is never quite good enough. In my 5,000-mile journey through Sweden, I found its people striving always for refinement, for excellence. And everywhere I saw the results of this determination: an air of confident prosperity, like the faultless cut of Dr. Angel's suit.

I saw much more, of course. One carries away from this biggest and richest of Scandinavian lands certain indelible impressions: A sail slanting across a rocky bay. Mushroom pickers wandering through woodland, eyes to the ground. Reindeer flowing like a brown landslide down a barren hill. The reflection of fairy-tale turrets trembling among water lilies in a chateau moat. A fountain splashing beside an outdoor cafe where diners feast on the August crayfish catch.

But one looking for the strength and sinews of Sweden sees other things too: Gaunt transmission towers slinging power lines across a river jammed with logs. A mile of freight cars, laden with blue-gray iron ore, thundering through a mountain pass. Flame spurting from a tapped furnace of molten steel. An artist painting flowers on shapely pottery.

Workers in antiseptic white assembling wafers of glass into precision lenses.

These are a few of the reasons why, in all Europe, only Switzerland equals Swedish living standards. Today Swedes enjoy the highest individual income of all European peoples.

Sweden has no slums. She has far more hospital beds per capita than the United States, one of the lowest infant mortality rates, and the world's healthiest children. Her technical and professional skills match the best of any nation's. (Swedes found 20 of the 103 elements in the atomic table.) Her stylistic taste and flair for design set standards around the globe.

Blithe angels dance as the hand of God lifts man toward heaven from the garden of the late Swedish-American sculptor Carl Milles. Now a public park, Millesgården crowns cliffs of Lidingö Island; a finger of the Baltic Sea separates it from distant Stockholm.

A spiritualist, Milles liked to humanize angels; once he carved them ice skating. For this angelic ballet, one dancer wears a wrist watch. The sculptor, a U. S. citizen, left many notable works in his adopted land.

Fathers Baby-sit as Mothers Explore a Shopping Center

Pools and potted plants adorn the plaza of Vällingby Center, a self-contained community on the outskirts of Stockholm. Designed for the balanced life, the center combines factories and theaters, stores and apartments.

Sweden has achieved these quiet miracles despite a frugal natural heritage.

"Forests cover half of Sweden," a government land-use specialist told me soon after I arrived in Stockholm. "And 100,000 lakes take up as much area as our farms. One-seventh of our land lies above the Arctic Circle, frozen half the year. Ice Age glaciers scraped off most of the topsoil and dumped it in the Baltic and Middle Europe." (See the new Atlas Map, **Scandinavia,** with this issue.)

Yet the Swedes love their moody, lonely countryside. Even in Stockholm—Sweden's only "big" city—water, cliff, and woodland frame almost every vista.

I first drove into Stockholm from the south, on a sunny June morning. Apartments in garden settings yielded to old buildings in stone and stucco, with carved doorways and weathered tile. The aroma of roasting coffee (Swedes drink more of it per capita than Americans) drifted through the streets. The road swept down in wide curves from the heights, offering glimpses of tugs and ferries chuffing in the harbor. I shot out into the concrete cloverleaf of Slussen.

KODACHROMES BY NATIONAL GEOGRAPHIC PHOTOGRAPHER THOMAS NEBBIA © N.G.S.

KODACHROME (ABOVE) AND NG EKTACHROME

Before me were ranged the pastel fronts and copper roofs of the medieval Old Town, "the town between the bridges" (above). Soaring church spires spiked the skyline. Traffic jockeyed for running room along Skeppsbron (Ships' Quay), where white ships in the Finnish trade lay moored.

There on the left, the 700-room Royal Palace unwound its neoclassic façade. Fishermen raised and lowered their round dip nets beside the North Bridge. Then I was in the heart of town at Gustav Adolfs Square, where lovely girls fill the benches in summertime, faces turned to the strengthening sun.

Since Birger Jarl, an early Swedish ruler, built a fortress here 700 years ago, Stockholm has swarmed over 12 islands that lie like giant stepping stones where the Mälar Lake meets the brackish Baltic. (The Swedish *ä* is pronounced like the *e* in "men," *å* like *a* in "raw,"

ö like o in "worm.") Now more than a million people live in and around "the city that floats on the water," as Swedish novelist Selma Lagerlöf described it.

You are not long in Stockholm before you comprehend that what Sweden is *not* helps to reveal the true national character.

This is not a country of violent politics or fierce public emotions. Politically neutral since 1814, the Swedes are good at minding their own business. To the average foreigner, only the world's acknowledgment of a statesman like the late Dag Hammarskjöld, a movie maker like Ingmar Bergman, or a heavyweight boxer like Ingemar Johansson gives notice of the varied talents that flourish in this far-north setting.

Dynamite Inventor Left Nobel Prizes

Stockholm's red-brick Town Hall was acclaimed an architectural classic virtually from the day in 1923 when it was completed. Individual citizens bought more than 3,000 copper shingles for the roof.

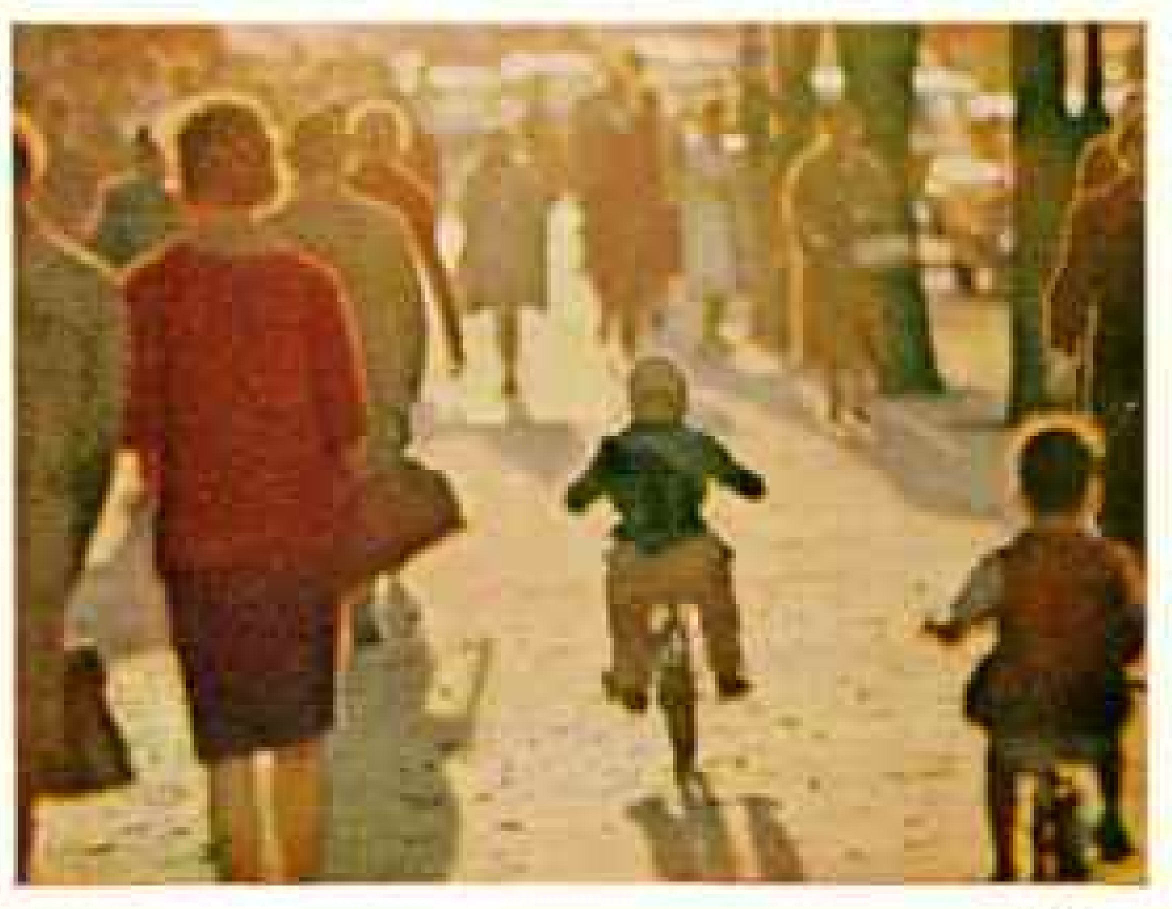
In the Town Hall's Golden Chamber, Nobel Prize laureates are banqueted each year. It seems a nice irony that a nation which rejects war as an instrument of policy should have given the world dynamite.

But Swedish industrialist Alfred Nobel, who invented dynamite and other explosives quickly adapted for military use, made amends when he died in 1896. He left 28 million kronor (about $5,000,000) to finance the Nobel Prizes for achievements in physics, chemistry, medicine or physiology, literature, and the furtherance of world peace.

Since Viking days, Sweden has drawn strength from the sea. Now the nation commemorates its maritime past with the ill-fated wooden warship *Vasa*, salvaged from the bottom of Stockholm Harbor. The 64-

BY NATIONAL GEOGRAPHIC PHOTOGRAPHER THOMAS NEBBIA © N.G.S.

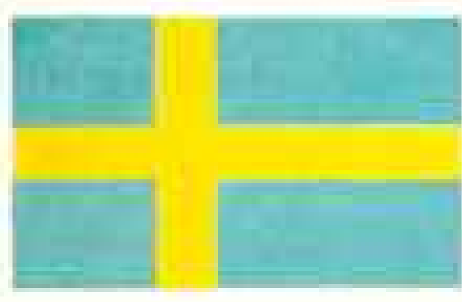
Historic heart of Stockholm endures behind a moat of waters from Lake Mälar (foreground) and an arm of the Baltic (center). Riddarholm Church stands behind twin domes of the Court of Appeals. Round tower in foreground houses part of the State Archives. Shadow half hides columned House of Nobility (left). Star surmounts the Town Hall tower.



Autumn's early dusk, filtering gold, finds young cyclists pedaling among homegoers.

SWEDEN

SWEDES HAVE PLENTY of living space. Although Europe's third largest country—after France and Spain—Sweden has a smaller population than New York City. Bigger than California, Sweden shares something of that state's Christmas-stocking shape. One-seventh of it lies in the Arctic, which helps to explain why 80 percent of the people live in the southern third of the land. Only 14 Swedish cities count more than 50,000 residents.



Within the past century, lack of individual opportunity cost Sweden a fifth of its population by emigration. But the industrial revolution, late to reach Sweden, reinvigorated the country. Raw materials—vast forests, rushing rivers, minerals—were at hand to spur swift industrial growth. Now the nation shares with Switzerland the highest standard of living in Europe and a policy of military neutrality which, in Sweden's case, has given the land nearly 150 years of peace.

The Swedes' name for their country, Sverige, is ancient. Early ruling tribes took the name *Svea*, literally "we, ourselves"; *-rige (rike)* means "kingdom." Hence Sverige, "our own kingdom." Racially, Swedes are remarkably homogeneous; there has been little infusion of outside blood. Ten thousand Lapps live in the north.

OFFICIAL NAME: Sverige. **GOVERNMENT:** Constitutional monarchy. **AREA:** 173,649 square miles. **POPULATION:** 7,500,000. **LANGUAGE:** Swedish. **RELIGION:** Predominantly Lutheran. **ECONOMY:** Only 15 percent of working population in agriculture (dairy products, grain, potatoes, sugar beets, vegetables, fruits); 60 percent in industry and commerce (chief manufactures: forest products—wood pulp, cellulose, and newsprint; also automobiles, ships, ball bearings, machine tools, electrical equipment, glassware). Sweden has scarcely any oil and little coal, but abounds in wood, waterpower, and iron ore. **MAJOR CITIES:** Stockholm, capital, industrial center (pop. 808,484); Göteborg, leading port (pop. 404,349); Malmö, trading and shipbuilding center (pop. 228,878); Uppsala, cultural center (pop. 77,400). **CLIMATE:** Mild in summer (Stockholm average high 70° F.); long winters, extremely cold in north, temperate in south (Stockholm average low 22° F.). Rainfall, mainly in autumn, moderate in south, low in north.

gun vessel foundered on her maiden voyage in 1628. Under roof in an exhibition building on Djurgården Island, *Vasa* today stands high and dry amid displays of her decorative carvings and relics of her armament and rigging.*

Against the sea wall at Skeppsholmen lies another ship that sails no more—the immaculate white square-rigger *Af Chapman*. The three-master, named for a famous Swedish admiral, now serves as one of the world's most popular youth hostels.

"Captain" Ruth Johansson, the hostel manager, welcomed me to her shipshape command with a jingling of the 20 keys on her big brass key ring. We had tea on deck.

"*Af Chapman* was a Swedish naval training ship when the city of Stockholm bought her," said Miss Johansson. "The purchase price was only $1,000, but it cost $100,000 to refit her as a hostel."

Young people from all the world swarmed over the *Chapman*. 'Tweendecks, the ship can sleep 130 guests at the equivalent of only 80 cents a night.

I bunked that night in what once had been the second mate's cabin. A porthole gave me a morning view of drifting gulls and white cruise ships. Pleasure craft carrying fishermen and water skiers sped out toward the Skärgård (Skerry Yard, or "yard of rocky islets")—the web of waterways east of the city.

Old Town Preserves Stockholm's Past

I stepped ashore from the *Af Chapman* to wander the narrow streets of Stockholm's fascinating Old Town.

Sweden's capital has glass-faced skyscrapers and a shiny, 23-mile subway system running out to new apartment suburbs. Already, the country's first industrial atomic reactor, at the Ågesta Nuclear Power Station, has been installed to provide heat and light for a residential district. Still, Stockholm clings to the Middle Ages in the Old Town.

Here carved doorways and scrollwork iron lamp brackets lend enduring elegance to tall, soot-stained house fronts. Along the main shopping street, Västerlånggatan, sidewalks are too narrow for walking; vehicles seldom attempt this thoroughfare. Pedestrians stroll

*See "Ghost From the Depths: the Warship *Vasa*," by Anders Franzén, NATIONAL GEOGRAPHIC, January, 1962.

Gleaming glass towers of office buildings rise near fruit and vegetable stalls in Haymarket Square, Stockholm. Signs advertise peaches, plums, and pears. Prices refer to kronor; 2.50 equals 48 cents. Fractional weights are in kilograms.

KODACHROME BY NATIONAL GEOGRAPHIC PHOTOGRAPHER WINFIELD PARKS © N.G.S.

1.50
3.50
2.50
1.75
2.25

KODACHROMES BY NATIONAL GEOGRAPHIC PHOTOGRAPHE

WINFIELD PARKS (ABOVE) AND THOMAS NEBBIA © N.G.S.

Theater in the round diverts visitors to the Hallwylska Museum, Stockholm. Actors in knee breeches and periwigs perform an 18th-century drama on the courtyard stage.

in the middle of the street, shopping for pastries, flowers, jewelry, antiques, or television sets. Even narrower is the Mårten Trotzigs Gränd—only 40 inches across!

One can read most of Sweden's history here among the cobbled squares and church spires of the Old Town. In the cool hush of the Riddarholm Church, I stood beneath tattered standards and honored war trophies. Tomb slabs of hero kings paved the floors; since 1632 every Swedish monarch except the one queen, Christina, has been laid to rest here. She lies in Vatican City.

Sweden Fights Way to Nationhood

Nearby in the Stortorget (Great Square), Danish rulers executed fourscore Swedish nobles in 1520. But a year later young Gustavus Vasa, son of one of those slain, began an uprising that won the independence Sweden has never since relinquished.

Gustavus Vasa, the "George Washington of Sweden," was elected to the throne in 1523 at the age of 27. Before his death in 1560, he had freed his country from foreign economic domination and united jealous provinces into a strong national state (page 463).

His grandson, Gustavus Adolphus, took Sweden into battles in Russia, Poland, and Germany during his reign from 1611 to 1632. With neat strategy he picked off one enemy force at a time, winning extraordinary victories. He died on the battlefield, but not before he had made the Baltic Sea virtually a Swedish lake.

A brilliant warrior, Gustavus Adolphus recruited a disciplined national army at a time when other countries relied on mercenaries. He gave his troops new flexibility and striking power, equipping small, fast-moving units with light, quick-firing rifles and fieldpieces. (Swedish industry got its start turning out armaments.)

The country was to know one more era of military greatness. In 1699, when only 17,

Heads Appear to Sprout From Bushes in Kungsträdgården (King's Garden)

Facing a long winter with short daylight hours, Stockholm bench warmers treasure an October interlude. Telephoto lens records the Swedish ritual of sun soaking.

King Charles XII led Swedes against a coalition of Russia, Poland, Saxony, and Denmark. At Narva in Estonia, Charles crushed Russian forces that outnumbered his five to one, and went on to other triumphs. His death while fighting the Norwegians ended Sweden's imperial ambitions in 1718. But how bright the flame of glory had burned!

Smörgåsbord Challenges Appetite

During my stay in Stockholm I sampled the capital's fine cuisine—much of it French, with many fish specialties—in settings that ranged from the continental elegance of the Restaurant Riche and the Arms of Bacchus (Bacchi Wapen) to the barrel-vaulted stonework of the Golden Peace (Gyldene Freden).

Then Halvar Sehlin, secretary general of the Swedish Touring Club, invited me to a typical Swedish smörgåsbord at Stallmästaregården (Stable Master's Place), a famous restaurant on the northern edge of the city.

Sehlin guided my uncertain hand.

"First, always, at a Swedish smörgåsbord you take some herring and perhaps some anchovies. Try these home-pickled herring and the herring au gratin."

I obeyed.

"Now some smoked eel, a couple of those steamed prawns, and a bit of salmon."

We returned to our table, cleaned plate number one, and went back to the smörgåsbord for round two.

Sehlin served us both with slices of beef and ham, and piled pyramids of small bright-red shrimp on our plates. We pinched the shrimp out of their shells and popped the sweet, white meat into our mouths.

Now we rose more slowly and helped ourselves to

EKTACHROMES BY NATIONAL GEOGRAPHIC PHOTOGRAPHER THOMAS NEBBIA © N.G.S.

Galaxy of Lamps Welcomes Stockholm Shoppers to NK

Sweden's biggest department store displays some 300,000 items. The initials NK, pronounced "enn-ko," stand for Nordiska Kompaniet (the Nordic Company). Long known for its promotion of Swedish art and handicraft, the mart serves as a showcase of industrial design. Delegates at the United Nations General Assembly sit on NK-made chairs. King Gustaf VI Adolf and the royal family visit the store regularly. This view shows the high-ceilinged entrance court of the downtown shop.

Spiral of sausage towers above an NK food display. Casseroles in foreground contain balls of fish and meat. Cold cuts surround the sausage. Other trays hold spreads and relishes. NK chefs once prepared a full-course meal for 70 and flew it to Kenya.

Ermine-robed Gustav Opens Parliament in the Throne Room of His Palace

Pioneering in a partnership between king and people, Sweden saw its first parliament convened in 1435 with representatives from four estates—nobles, clergy, burghers, and peasants. In an 1866 reform, the Riksdag became a two-chamber body, with members of the First Chamber elected by provincial assemblies and city councils, and the Second chosen by universal suffrage. The Constitution of 1809 gives the king "sole power to govern the country," but he does so through his Cabinet, whose members hold seats in the Riksdag.

Here the monarch, who is never admitted to Riksdag sessions in the Parliament building, reads his annual message to the representatives. Court officials stand behind him, and members of the royal family gather in the balcony at right. The diplomatic corps occupies flanking stalls.

Aura of power envelops King Gustavus Vasa, who united Sweden in 1523. Carved in oak and enameled, this work by Carl Milles stands in the Nordiska Museum on Djurgården, an island of parks and exhibition halls in Stockholm.

NG EKTACHROME BY K. W. GULLERS, PAPPO GUILLUMETTE (LEFT), AND KODACHROME BY ANDREW H. BROWN © N.G.S.

three kinds of cheese and tomato aspic on a curl of lettuce. These consumed, Sehlin said, "The hot dish is next. I hope the smörgåsbord has sharpened your appetite."

Sharpened it! My appetite lay prostrate. Yet somehow I found room for loin of pork stuffed with prunes, and *äppelkaka med vaniljsås*—apple cake with vanilla sauce. Plus coffee and cognac.

Swedes Sought Opportunity in U. S.

The next day I paid a visit to the Swedish Foreign Ministry, housed in a rococo mansion built between 1783 and 1794. In his high-ceilinged office looking across the North Stream to the Riksdag (Parliament), Sten Sundfeldt spoke to me of Sweden's extraordinary century of progress.

"In a few generations," the Information Chief of Sweden's Foreign Ministry told me, "we have advanced from an old-oaken-bucket economy to automated industry and broad social benefits."

Less than a century ago, Swedish productivity lagged behind a soaring birth rate. Between 1865 and 1914, a million and a quarter Swedes, unable to make an adequate living at home, emigrated to the United States. But the factories and machines of the industrial revolution, reaching Sweden late, came at last like rain to a drought-seared garden. Today, Sweden ranks among the world's most highly industrialized nations.

"We are a leading exporting country," Sundfeldt said. "Each year we sell abroad goods worth more than two and a half billion dollars—iron ore, wood pulp, paper, automobiles, specialty steels, and manufactures of all kinds."

"Swedish modern" has become a synonym for useful things designed to be good looking, be it an adding machine or a crystal vase, a dining table or a handmade rug. Swedish products are familiar the world over: Orrefors and Kosta glass, Gense stainless-steel tableware, SKF ball and roller bearings, L. M. Ericsson telephones, AGA (Svenska Aktiebolaget Gasaccumulator) marine beacons, and Electrolux refrigerators.

Later I spoke of these things in an interview with Sweden's shrewd, lanky Prime Minister, Mr. Tage Erlander. And he pointed out to me a basic dilemma facing his country, so dependent upon foreign commerce.

"Politics and trade—they are always tangled up together," he said, with a gesture of stirring a pot. "You must remember, our biggest exchange of goods is with Germany and Great Britain. Germany is a founding member of the European Economic Community—the Common Market—and now Britain is negotiating to become a full member, too.

"Since World War II, Sweden has worked continuously for an integrated European market," Mr. Erlander went on. "Like our partners in the European Free Trade Association—the so-called Outer Seven—we've always regarded EFTA as a step toward that goal.

"The Common Market carries with it strong political overtones. Sweden is firmly determined to continue her policy of neutrality. This is why Sweden cannot apply for full membership but must rather seek a nonpolitical association with the Market."

By trade, travel, and tastes, Swedes always have linked themselves with Western Europe. Yet, lying between the Western union of NATO (North Atlantic Treaty Organization) states and the shadow of the Russian bear, Sweden is wary. All too conscious of their exposed position, Swedes have embarked on a major civil-defense program.

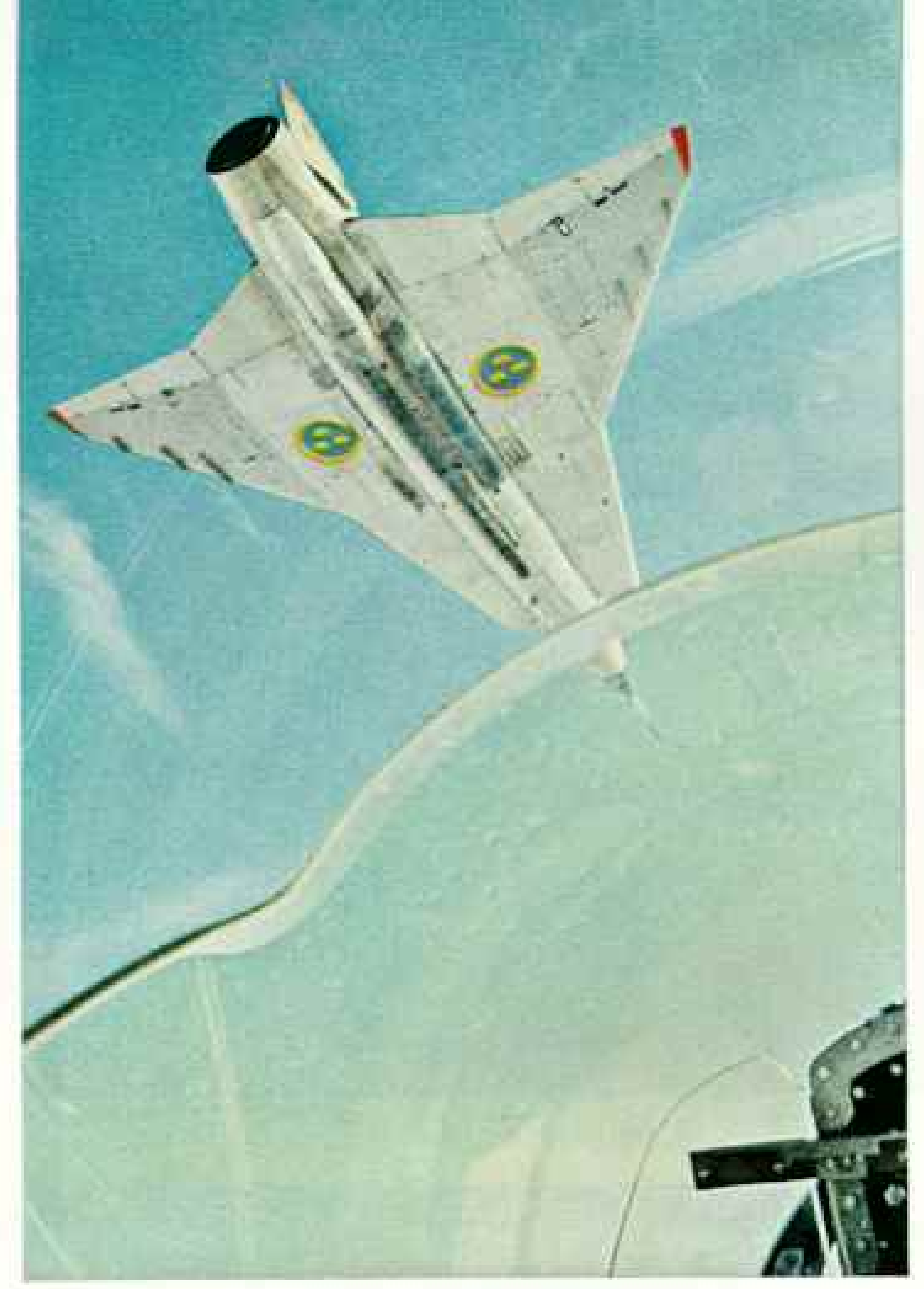
Often, in Stockholm, I drove my Swedish-built Volvo into Katarinaberget—a huge excavation in solid rock that serves as a parking garage for 500 cars in peacetime. In the event of nuclear attack, it could shelter 17,000 people temporarily, or 6,200 to sleep and stay (opposite).

Fourteen such massive shelters, equipped with power plants and air-filtering systems, have been constructed in nine Swedish cities. In addition, 30,000 standard shelters (required by law in new factories and apartments) would shield some 1,600,000 citizens.

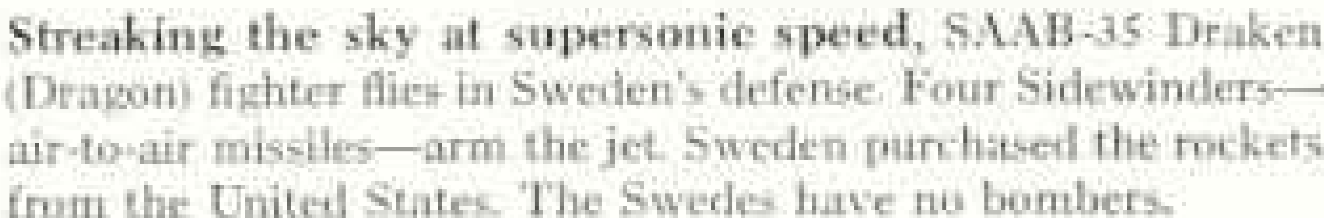
Nuclear Shelter Houses Elegant Theater

An hour's drive west of Stockholm, in the city of Västerås, I visited the plants of ASEA (Allmänna Svenska Elektriska Aktiebolaget), one of the world's leading electrical equipment manufacturers. Leaving the factory, I walked across a park to another nuclear shelter hidden in the granite heart of a green hillock. Railings divided the wide access steps, marked with luminous paint, into queue lines to channel the 5,500 people the place would receive in case of attack.

The Västerås community shelter, however, serves surprising peacetime uses. Engineer Ivar Ritzen led me through an elegant theater with cushioned seats, indirect lighting, and



Swinging for health, gymnasts play in an underground shelter in Västerås. The installation serves as part of Sweden's large-scale civil-defense program against atomic attack.

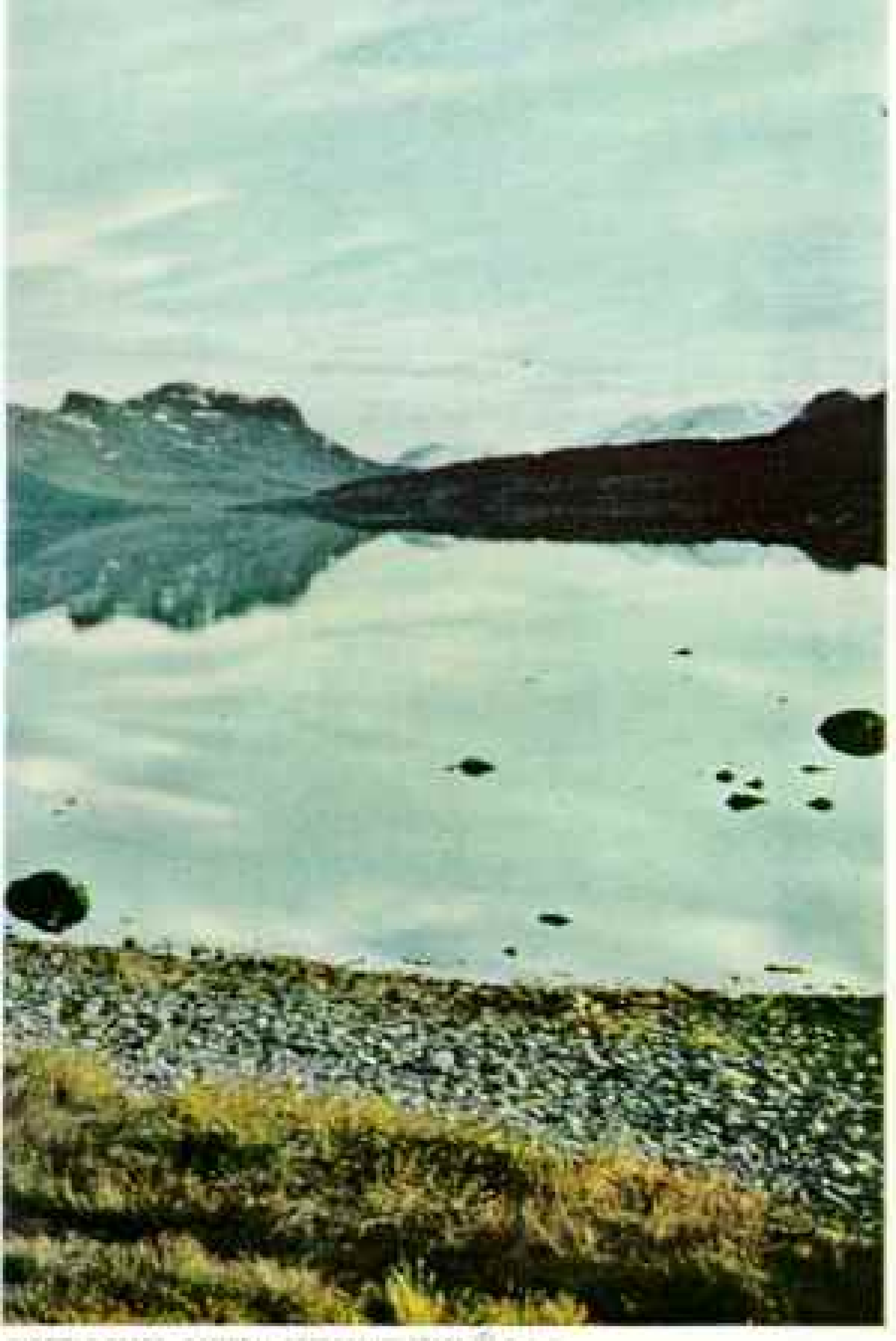


Streaking the sky at supersonic speed, SAAB-35 Draken (Dragon) fighter flies in Sweden's defense. Four Sidewinders—air-to-air missiles—arm the jet. Sweden purchased the rockets from the United States. The Swedes have no bombers.

Largest atom bomb shelter in the world, Stockholm's Katarinaberget can hold 17,000 people in an emergency. Today cars use it as a garage. Drive-in bank at far left and gasoline station offer extra services.

ANSCOCHROME (ABOVE) BY WINFIELD PARKS AND EKTACHROMES BY THOMAS NEBBIA, NATIONAL GEOGRAPHIC PHOTOGRAPHERS © N.G.S.

KODACHROMES BY ANDREW H. BROWN (ABOVE) A



WINFIELD PARKS, NATIONAL GEOGRAPHIC STAFF © N.G.S.

modern stage equipment. In a hobby shop we watched men building a full-scale glider that soon would spread its wings. We watched girls on parallel bars, tumbling mats, and trapezes in a windowless gymnasium (page 465). We ate soup and sandwiches in the shelter's cafeteria, and I gassed up my car in the underground service station.

Having shown me these grim precautions against nuclear destruction, Sweden turned to me her most joyous face.

After three weeks of June, the warmth and sun of summer gain the upper hand over the usually taciturn Swede. During the long daylight of the "white nights" he explodes with merriment that rises to fortissimo on Midsummer Eve (pages 470-71).

The gaiety finds its sentimental Mecca in Dalarna, the "land of dales." This Vermont-like midland province (Dalecarlia in English) cherishes old-time customs and costumes. Here a young girl can dream of the man she

Illuminated by the midnight sun, campers warm their hands over a fire beside Lake Langas. Lying in Lapland, north of the Arctic Circle, the mountain lake enjoys perpetual daylight in early summer.

Defying an ominous sky, racing sloops beat to windward off Sandhamn, a sailing center in the Stockholm Archipelago. Countless islands and broken coastline lure Swedes to the sea. In winter they launch iceboats.

Summer sailor, proud of her Viking heritage, takes the tiller of a Sandhamn racer.

EKTACHROMES BY THOMAS NEBBIA (ABOVE) AND WINFIELD PARKS © N.G.S.

Acetylene flashers for buoys and beacon lights undergo testing in the plant of AGA (Svenska Aktiebolaget Gasaccumulator) near Stockholm. Each unit releases intermittent puffs of gas that flash when ignited by a pilot flame. A quart of acetylene gas provides enough fuel for 10,000 flashes.

Tanker takes shape at the shipyard of Kockums Mekaniska Verkstads AB in Malmö. Masked welder in foreground works on a subassembly. A pioneer in welded ship construction, Kockums can build vessels of 120,000 deadweight tons. Sweden ranks as the world's fourth largest shipbuilder, after Japan, the United Kingdom, and West Germany. The United States is seventh.

will marry—if she keeps one each of nine different flowers under her pillow.

Every visitor to Dalarna knows Leksand, where summer campers are so thick they share tent pegs, and where an open-air allegorical play, *The Road to Heaven*, presents Biblical events in a Swedish-village setting. He knows Rättvik, with its outdoor museum of farmhouses centuries old, and Mora, where famous artist Anders Zorn colored his earliest sketches with crushed lingonberries because he was too poor to buy paints.

These are only the best known of the towns ringing 25-mile-long Lake Siljan, "the eye of Dalarna."

Dalarna Cradled Country's Freedom

I went to Dalarna with Gustaf Lidén, a friend from Sweden's Foreign Ministry. We first called on a college mate of Gustaf's, Rudolf Aldskogius, who teaches religious history at an Uppsala high school. Aldskogius's cottage lay high on a hillside at Tällberg, facing the wide sweep of Lake Siljan and the blue hills that pile up toward the Norwegian border.

Aldskogius stood with us at his picture window. "This is our country's New England," he said. "Dalarna's people were our patriots, like your Lexington and Concord minutemen. Our fight for freedom was the earlier, by two and a half centuries, and it started right here around this lake.

"In the 16th century, our Danish overlords ruled us with a heavy hand. Under Gustavus Vasa, the sturdy yeomen here rose up to head the rebellion that threw the Danes back where they came from."

Gustaf and I left Tällberg in pursuit of modern history—the elaborate spectacle at Leksand, where 20,000 people converge each year on a grassy natural amphitheater to witness the raising of a 70-foot Maypole.

In a lower, friendlier key was the Maypole raising at the old, old town of Färnäs, north of Lake Siljan. Little girls offered us garlands woven from clover blossoms as we threaded our way among barns and homes built of hand-hewn timbers.

Women in finely pleated skirts, colored aprons, and white caps wound the Maypole with birch twigs and peonies. Men dressed in pale yellow tights of buckskin, green waistcoats, leather aprons, white jackets, and curled-brim hats raised it erect with long poles. Musicians sawed at their violins,

Memory of summers past haunts a matron. She watches Midsummer Eve dancers rejoicing in the sun.

Dancers Pay Tribute to Summer's Longest Day

Summer breathes magic for the Swedes.

"When the woods and fields are green and flowers are in bloom," wrote Olaus Magnus in 1555, "the people assemble . . . to dance." And so they do today.

Here, in folk costume, youths and maids of Dalarna cavort around the Maypole in the festival of Midsummer Eve in June. Fiddlers saw out old-time melodies. Wreaths on the pole symbolize prosperity and fruitfulness.

Similar folk dances have taken place for generations in Stockholm's famous Skansen park (below).

Flouncing her apron and beaming a smile, a dancer faces her partner at Midsummer festivities in Skansen, Stockholm's folk park. He wears chamois breeches.

KODACHROME (ABOVE) BY TORE JOHNSON, TIO, AND
NG EKTACHROMES BY W. D. VAUGHN © N.G.S.

and their music drew song from scores of throats as dancing couples whirled around the Maypole.

Raising the Maypole is the Christianized holdover of a fertility rite rooted in Norse tradition. For centuries June 23d was the merrymaking date. Now the national holiday comes on the Friday nearest that date, to allow three unbroken days of festivity.

Worshipers Row to Church

On the Sunday after Midsummer Day, we watched three great 20-oared church boats speed toward the Lake Siljan shore at Rättvik's white church, called *Den knäböjande bruden vid Siljan*, "the bride who is kneeling at Siljan's edge."

The wooden craft glistened with fresh varnish. Leafy garlands sprouted from the gunwales. At the quay, a grizzled helmsman smilingly refused my hand; he hopped out spry as a cricket with a cordial *"God dag!"* and a finger touching his black felt hat. The costumed crew paraded into church as crowds on the banks sang:

"Through the fair worldly kingdoms,
We go to Paradise with songs."

For hundreds of years, the villagers from all around Siljan have come by water to attend summer services at Rättvik, as Miss Britt Arpi, proprietor of the Hotel Siljansborg, explained.

"It is a pleasant tradition, coming to church this way," said Miss Arpi. "But the only remaining builder of church boats on Lake

Violin's joyous song satisfies a young musician at the Midsummer Eve festival in Dalarna. She may play on through the night, but at this time of year dawn comes by 2 a.m.

Siljan has made his last one. Yet we hope that with care the present boats will last another hundred years."

Dalarna rejoices in these festive midsummer days, then returns to work in the factories and forests that have made this province a primary wellspring of Swedish wealth.

At Falun, Gustaf and I peered into the pit—it would easily hold Yankee Stadium—that was the cradle of Swedish mining.

The hollow shell of the Copper Mountain, resembling a giant bomb crater since a spectacular 1687 cave-in, was the source of metal that in the mid-17th century gave Sweden first rank in world copper output.

"The greatness of the realm stands and falls with the Copper Mountain," said Sweden's Queen Christina during a visit to the Falun mine in 1646.

One Copper Coin Weighs 44 Pounds

More than 600 years ago a Swedish king gave privileges to mine Falun copper to the Stora Kopparbergs Bergslags Aktiebolag (Big Copper Mountain and Mining Area Company). Later the mine became an important source of silver, zinc, and lead. SKBA still owns it, as well as iron mines, steel mills, pulp and paper works, and power plants all over Dalarna and adjacent provinces.

In the mine museum beside the Falun pit, I saw a copy cast in copper of the biggest metal coin ever made anywhere: It was the 24-inch-long, 1644 copper "X-Daler" (ten-dollar) piece, and it weighed 44 pounds. When first issued, it would buy one horse and 70 kilograms of butter. Of 26,000 struck, only three such coins are known to survive.

"I wish we owned one of them," Sven Ryd-

Carved Ships Sail an Ocean of Stone Near Norrköping

Relics of a Nordic culture that flourished some three thousand years ago, the vessels conjure up visions of exploration and seafaring adventure. Color added in modern times makes the carvings show up better.

KODACHROME BY THOMAS NEBBIA © N.G.S.

Bastion of the Baltic, Kalmar Castle won renown as the key to Sweden because of its impregnability and strategic position. Besieged 23 times but never taken, the 12th-century fortress blocked invaders from the south. Once a royal residence, later a distillery, it is now a museum. Here in 1397 Queen Margaret of the Danes formed the Kalmar Union of Sweden, Denmark, and Norway, which was dissolved in 1523.

berg of SKBA commented wistfully. "Each one is priceless."

From Dalarna I drove southeast to the university town of Uppsala, where I found the tomb of the man who is perhaps Sweden's most illustrious son, Carolus Linnaeus.

"God created; Linnaeus put things in order," the saying goes about the founder of modern botany. Son of a clergyman, the boy was wonder-struck by the perfection of the growing things in his father's garden.

Between 1728 and 1730 Linnaeus attended Uppsala University, where he patched his shoes with birchbark. He then earned a medical degree in Holland, publishing there his *Systema Naturae.*

This work first presented Linnaeus's system of plant classification. His arrangement put all plants into 24 classes and then into orders. Later, in his *Species Plantarum,* the botanist set forth his two-name system of plant identification, soon adopted for the scientific nomenclature of all living things.

Uppsala University, nestled between a castle-crowned hill and the murmuring Fyrisån River, turns out 600 well-trained minds a year. It has been educating Swedes and scholars of many nations since 1477.

KODACHROME BY ANDREW H. BROWN, NATIONAL GEOGRAPHIC STAFF © N.G.S.

KODACHROME BY THOMAS NEBBIA © N.G.S.

Rector Magnificus: Prof. Torgny Segersted bears this title as head of the University of Uppsala. Founded in 1477, the university produced such world greats as mystic-philosopher Emanuel Swedenborg, botanist Carolus Linnaeus, and Dag Hammarskjöld of the U.N. Towers of Uppsala's 14th-century cathedral rise beyond the window.

A couple dallies on a Stockholm park bench.

KODACHROME BY WINFIELD PARKS © N.G.S.

I strolled through the main university library, the largest in Sweden, housing more than a million volumes on 18 miles of shelf space. But I had come to see one particular book: the famous fourth-century *Codex Argenteus*, or Silver Bible.

This rare treasure, a fragmentary translation of the New Testament, is inscribed in sumptuous silver and gold lettering on rich purple parchment. Written in the Gothic language, it is a sort of European Rosetta Stone, providing a key to old forms of Germanic and, by extension, to the roots of English words. Many regard the Silver Bible as the world's most valuable single book.

Skåne's Farms Help Feed Europe

I turned my lively little Volvo southward and headed for Sweden's farm belt, the province of Skåne (pronounced skaw-neh). Here I drove through miles of low, flat, fertile landscape that contrasted markedly with the rough, wild look of most of rural Sweden.

Many of the people of Skåne trace descent from Danish forebears; this most southerly district belonged to Denmark until 1658. In that year Sweden's King Charles X defeated Denmark by an "impossible" ice crossing over the narrow straits of the Great and Little Belts, thus besieging Copenhagen from the rear. Charles claimed Skåne and two adjacent provinces as war prizes—and rich prizes they proved to be.

"This is our country's granary," a guide told me at the Swedish Findus food plant near the city of Hälsingborg. "Here in Skåne we grow a quarter of Sweden's wheat and nine-tenths of its sugar beets."

At Bjuv, I saw the Findus freezers and canneries that each year turn out 50,000 tons—about 2,000 truckloads—of vegetables, berries, and poultry, cereals, baby foods, and cake mixes.

I drove south to Malmö, a port city that is a major gateway to Sweden from Central Europe. It ranks third among Swedish cities, after Stockholm and Göteborg.

Here is one of Sweden's four big shipyards, Kockums Mekaniska Verkstads AB (page 469), where I climbed aboard the 41,400-ton tanker *Texaco Alaska* at her fitting-out quay. The 700-foot, all-welded vessel neared readiness for her sea trials, prior to delivery to her owner, Texaco Panama Inc. The cool salt air off the Öre Sund was blend-

ed with the aromas of red lead, oil, sanded wood, new rope, and the metallic pungency of iron and steel.

Capt. Anders Hellner of Kockums led me from stem to stern of *Texaco Alaska.*

"A great ship like this combines the efforts of workers in many lands," Captain Hellner pointed out. "Yet she carries to sea much evidence of Swedish manufacturing skill. *Texaco Alaska*'s turbines and boilers were built here in our plant. Electric motors and alternators came from ASEA in Västerås. Electrolux provided freezer boxes and Swedish mills a lot of her plates."

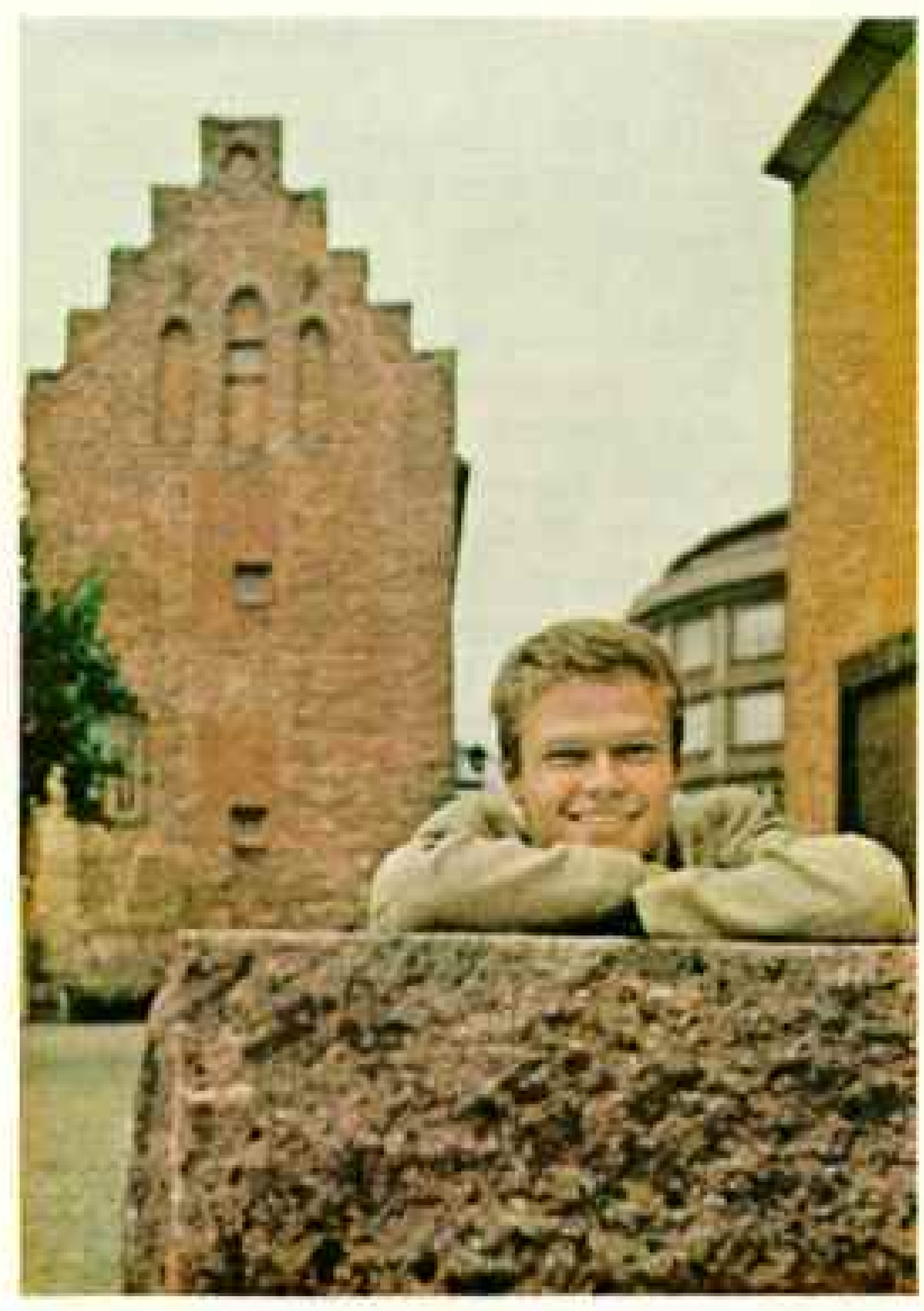
Hellner paused, then went on, "There's one big thing we can't put in the *Alaska*, or any other ship, from Swedish sources."

"What's that?"

"The fuel to drive her. Sweden has almost no petroleum. What little coal we have is too low-grade to fire ships' boilers, even if coal were not outdated for this purpose."

Even though neutral in World War II, Sweden lost more than a third of her merchant fleet. But she has rebuilt it to twice prewar size. Apart from "flag-of-convenience" countries like Liberia and Panama, only Norway has a larger per capita ship tonnage.

My tour of Malmö's venerable Town Hall led through the paneled council hall of the



Age-worn halls of Lund University, established in 1668, surround student Jan Svante Sundvik.

Loveliness among the leaves: A maple tree's golden foliage frames Berit Nystrand of Linköping.

KODACHROME (UPPER) BY WINFIELD PARKS AND EKTACHROME BY THOMAS NEBBIA, NATIONAL GEOGRAPHIC PHOTOGRAPHERS © N.G.S.

Guild of St. Knut (Canute), a medieval forerunner of today's Rotary, Elks, Masons, and other fraternal orders.

The Guild of St. Knut, which still meets in the Knutssalen, has an 800-year history. One legend tells that anciently the brethren of St. Knut were pledged to assist the escape of brothers who committed the mild indiscretion of murder. If, however, a St. Knut member was foolish enough to kill a club fellow, he was fined 18 pounds of honey—enough, apparently, for the brotherhood to brew a batch of mead to forget the incident.

Central Heat Warmed Old Castle

Castles, chateaus, and manor houses, dating from Danish days, stud Skåne. At evening, the liquid voices of nightingales sound across beech groves where medieval Danes once sharpened steel behind thick walls against the peril of Swedish attack.

I stopped at one such fortress, the castle of Glimmingehus, close to the Baltic Sea. Narrow gunports slash the flat, grim walls of this moated stronghold. Slits even in the stairwells allowed defenders to pour bullets, boiling water, melted lead, and fierce threats of mayhem against any attackers.

Glimmingehus had 16th-century central heating. In the basement, I saw the huge wood-burning furnace that once warmed the castle through a maze of chimney shafts.

Heading north out of Skåne, I plunged back into the "true" Swedish landscape of pine woods and blue lakes, of red farmhouses in narrow fields folded among granite hills and hogbacks.

Deep in the rough heart of Småland province thrives a rural industry of utmost delicacy. It always has been true in Sweden that where farming was poor, craft skills blossomed. Even today, almost half of Sweden's 25,000 factories and workshops employ fewer than a dozen workers each.

Between Kalmar and Växjö, exquisite crystal and stylish utilityware pour from some 14 glassworks. These are the modest, often antiquated-looking plants that give Sweden a great name everywhere for fine stemware and decorative glass. Places like Orrefors, Kosta, and Strömbergshyttan are bywords for peerless art crystal (pages 480-81).

Walking into the furnace hall at Kosta was like stumbling on a workshop of fairy-tale gnomes. In a drab, shadowy setting, the glassmakers did a kind of slow ballet around the dome-shaped ovens. They seemed to be playing with the glowing globes that adhered to the tips of their blowpipes. The molten, yellow-orange plastic globes were never still as the men rolled, blew, spun, swung, shaped the glass. Here and there a face would suddenly light up in the oven glare.

Kosta has built glass houses for its master glassblowers. The homes are as attractive as they are practical. Outside light filters through translucent turquoise glass walls. Handsome glass-mosaic floors are warmed by radiant heat from built-in coils.

Another handcraft, weaving, led me northward to the Södermanland hamlet of Ripsa (population 260). There a big white pointer bounded out in welcome from the manor house of Sandvik. I had an invitation to visit vivacious Countess Ebba von Eckermann and her husband Erik. I had heard how the von Eckermanns rescued their village when Ripsa was hurt by the surge of its young people to the towns.

"Mechanization of farming and forestry in this region took away work our townsfolk depended on," said Erik von Eckermann. "Today power saws cut my timber, and trucks haul it to the mill."

Women Weave in Converted Stable

Thirteen years ago Countess Ebba von Eckermann revived the weaving skill once traditional in this region. She laid out geometric designs that the farm wives of Ripsa could translate into pure wool fabrics.

The Countess led me to a converted stable, where pedal looms turn out handwoven material patterned in green, purple, and rust, red, yellow, and blue. In cutting and stitching rooms, we saw the woven fabric take shape in fashionable skirts and coats, suits and scarves and robes.

Now shops in Paris, New York, and other cities offer the gay and stylish garments.

Island of elegance, the manor house of Edeby at Ripsa dates from the 1650's. Its owner, Prof. Harry von Eckermann (left), entertains his son Erik, granddaughter Margaretha (center), and a neighbor, Mrs. Olle Nyman. Erik and his wife, Countess Ebba, have brought new prosperity to Ripsa villagers by sponsoring a hand-weaving industry.

KODACHROME BY ANDREW H. BROWN, NATIONAL GEOGRAPHIC STAFF © N.G.S.

KODACHROMES BY ANDREW H. BROWN (ABOVE AND BELOW) AND WINFIELD PA

"It is a miracle," said the Countess's chief weaver to me. "Again we have pride to do good work!"

Sandvik is a spacious but simple house, with plank exterior and heavy framed windows. After a fish-soufflé supper, we had coffee on the terrace, with a view between urns of geraniums across a lawn to Båven Lake, enfolded by forest. A whisper of breeze moved the leaves and made a far-off light flicker. The evening ripple flattened to black calm. Erik squeezed music from an accordion. In these surroundings I could appreciate the profound affection of the Swede for his barely tamed homeland.

Sweden has put to work hundreds of her rivers to provide the tremendous power her industry consumes. To see one of them, the Indal, a major stream of middle Sweden, Gustaf Lidén and I headed north to his home province of Jämtland. Two days later we were catching trout where the Indal gathers its headstreams along the Norwegian border.

Gustaf and I stopped at the mountain resort town of Åre, and rode the cableway that lifts summer view-seekers and winter skiers high on 4,659-foot Mount Åreskutan. Far below, the slack ribbon of the Indal River cut through ancient hills.

Beside a farmhouse west of Åre, I was startled to see a sign, "Dam Bad   Camping." Gustaf chuckled and pointed out the extra space between "Bad" and "Camping." What the Swedish words offered, he explained, was a camping place that had a bathhouse for women, for *Dam Bad* translates "women's bath."

As we drove 260 miles down the full length

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Thunderheads Pile Up Over Grästorp; Tractor and Reaper Head for Cover

Only nine percent of Sweden's land is arable, but farmers produce enough to make the nation self-sufficient. Small farms in the south achieve the efficiency of vast estates, using up-to-date machinery, scientific methods, and cooperative buying and selling. These golden fields yield oats.

Farmwomen generate good humor. They work in Skåne, the granary of Sweden.

Living afloat, these British yachtsmen see Sweden in slow motion as their sloop chugs along the Göta Canal, a crosscut of the nation. At some points the canal rides a ridge and surveys the land from an elevated lookout, or climbs water stairways, tiers of locks.

Elegance of simplicity distinguishes two long-necked vases made by the Orrefors glass works, among Sweden's foremost.

Dancers' joyous abandon, frozen in crystal and photographed against a furnace, enlivens a work of art at the Kosta factory.

Poems in glass: Swedish crystal

A HERD of giraffes in full flight, the grace of curved lines frosting gemlike colors, the vitality of varying shapes: Such elements, seen here in the Kosta exhibition hall, make Swedish crystal world famous.

Vicke Lindstrand, who designed the giraffe vase and other items with it, strives to make each work a masterpiece. He considers his art a combination of painting, drawing, and sculpture. "But glass is quite sufficient in itself," he says, "and the artist should only enhance its natural beauty."

Blobs of molten glass, impaled on blow pipes, await the breath of artisans in a workroom at Kosta. Soon the glowing droplets will blossom into bowls of beauty. Men who assist must spend 15 years as apprentices before qualifying as master blowers. The trade is a family affair and skills pass down from generation to generation.

KODACHROMES BY ANDREW H. BROWN (ABOVE) AND THOMAS NEBBIA © N.G.S.

of the Indal, the river demonstrated Sweden's dependence on forests and falling water. Between the outlet of Stor Sjön Lake and the river's mouth, the stream falls 958 feet. All but a few feet of this drop is strait-jacketed by 13 hydroelectric dams and their backed-up storage lakes.

Halfway downriver we stopped at Stugun powerhouse. Superintendent Åke Rudin explained that Sweden leads the world (with Russia a close second) in long-distance transmission of electricity. At Stugun, power from several Indal plants surges into Sweden's transmission network, pushed at superhigh voltages from Lapland as far as the shipyards of Malmö, 800 miles south.

Driving on downriver, we saw the Indal vanish under a carpet of floating logs. Tugs strained to shove the timber along. Sweden's 51 billion trees, I learned, produce more than one and a half billion cubic feet of new wood each year, enough to fill an empty Pentagon building 21 times (page 485).

The Indal empties out near Sundsvall, on the "Gold Coast" of the Gulf of Bothnia. We watched logs feed endlessly into the big Skönvik paper plant. This is one of scores of lumber, pulp, and paper mills along these shores that make the product of her forests Sweden's most lucrative export.

Midnight Sun Warms Kiruna

In the Scandinavian Airlines plane, 300 miles north of Stockholm bound for Sweden's iron-rich Lapland attic, the stewardess had her little joke: "See that dotted line through the pine woods? That's the Arctic Circle." There was no line, of course, but we could see the tiny hamlet of Polcirkeln (Polar Circle) passing below us.

As we let down to Kiruna, tundra began to replace forest. More lakes appeared. Then the mesalike iron mountain of Kiirunavaara hove in sight, and we landed.

During the few July days I spent in the far-north town of Kiruna, the sun burned ceaselessly out of a turquoise sky. The thermometer topped 80° F., and the sunshine felt little

AN EKTACHROME BY NATIONAL GEOGRAPHIC PHOTOGRAPHER THOMAS NEBBIA © N.G.S.

KODACHROMES BY WINFIELD PARKS (ABOVE

cooler at midnight than at noon. The radio reported Kiruna that day the warmest town in all Sweden.

From Kiruna and from Gällivare, 60 miles southeast, about 400,000 carloads of iron ore—16,400,000 tons—roll away each year to the steel mills of the world. Kiruna by itself furnishes about three-fourths of the iron ore mined in Sweden. (And Sweden has more than nine-tenths of Europe's high-grade ore—50 percent iron or better.)

Arctic Dwellers Bask on Beach

I found Kiruna bustling with building activity, trying to keep pace with its rising population of more than 26,000. Across the town lake, swimmers and sun-bathers crowded a sand beach; it might have been a scene from the French Riviera, but for the Lapps who strolled the steep streets in brightly embroidered tunics and tasseled caps.

This was Kiruna in summer. But for several weeks each winter, the city's 3,800 miners emerge to a sunless world of moonlit snow.

Kiruna Center nestles between two mountains of iron ore, Kiirunavaara and Luossavaara (page 488). With a young engineer, Åke Janson, I wandered through the heart of Kiirunavaara, a mountain drilled as full of holes as an anthill. The sound of dripping water was spasmodically drowned out by the roar of drills. We pressed against the walls to let squat ore cars trundle past, carrying the heavy blue-gray rock to the crushers.

Kiruna and Gällivare iron travels a long way to market. More than three-fourths of it goes by rail to the year-round port of Narvik, on the coast of Norway, for shipment mostly to German, Belgian, and British steel mills. West Germany buys nearly half of Sweden's iron ore exports. Through occupied Narvik, during World War II, the Swedes grudgingly supplied the Germans with Kiruna ore.

Electric locomotives pull the trains on all Sweden's main-line railroads. From Narvik a continuous electrified rail line reaches south 1,355 miles to Trelleborg, far away at the southern tip of Sweden (see supplement map).

AND ANDREW H. BROWN, NATIONAL GEOGRAPHIC STAFF © N.G.S.

Beauty as well as efficiency is a concern of the Swedish State Railways. The system owns thousands of acres of flower plots at 2,000 stations throughout the country. Since World War II, the railroads have employed a staff of 50 or more trained gardeners to supervise the planting of millions of flower seedlings—larkspur, pansies, petunias, snapdragons—as well as shrubs, fruit trees, and rose bushes.

I rode a train from Kiruna to Narvik, following the foreign-bound ore from mine to ship. The rails led westward, uphill, alongside 40-mile-long Torne Lake. Close to the Swedish border, the thundering cars flushed a reindeer herd with ragged pelts and antlers still in the velvet. The train braked to a sudden stop. A reindeer had been struck. The

Lights come to life along broad Stortorget as dusk falls over Hälsingborg. Sightseers greet the night from the lofty keep, all that remains of a medieval fortress. Clock tower marks the town hall. Denmark's shoreline twinkles across the Öre Sund.

Harvesters of the sea clean and crate herring on a crowded wharf in Smögen, a typical fishing village near the Norwegian border. Vessels from villages such as this sail as far as Iceland in search of fish.

trainman jumped down with a fire ax to dispatch the wounded creature.

"Are you going to leave it there?" I asked.

"Yes, the Lapp herdsman will find it before evening. He'll make a claim against the railway. That deer is worth 140 kronor to him—about $27 in your money."

Trains and automobiles—a far greater menace than wolves and bears—kill more than 2,000 reindeer yearly in northern Sweden.

Slow Boat on a Quiet Canal

I flew back to southern Sweden for a more peaceful ride aboard a slow boat on the Göta Canal. A hundred and fifty years ago, in a day of water-borne commerce, Sweden built this famous waterway to link Stockholm and Göteborg (Gothenburg). The canal still has some commercial use, especially for hauling lumber, but it now mostly serves cruising tourists and wandering yachtsmen (page 479).

I joined the narrow-beamed ship *Götaland* for a voyage from Töreboda to Ljungsbro. Oaks, lindens, and maples leaned over the canal banks. Farmers and their wives cocked the hay in golden fields. Tenders emerged unhurriedly from red and yellow cottages to roll back the ingenious bridges that project iron fingers across the channel.

Capt. Hans Johansson left the bridge to join me for a glass of wine.

"We have today a quiet ship," he said in English. "Twenty-five American schoolteachers had the idea of coming, but they were not arriving at the quay."

The *Götaland* slipped by a pasture dotted with brown cattle grazing amid wildflowers.

"Here you can just putting your hand out and have a flowers or squeeze a cow's milk," said the bouncy skipper, laughing and running fingers through his black hair.

The ship paused at Vadstena on Lake Vättern. I had time to visit the exquisite Convent Church with its star vaults that suggest crowns of palm trees. It was built from plans laid out in the 14th century by Birgitta, one of Sweden's most illustrious saints.

The lovely church is overshadowed by the nearby Vasa Castle, a splendid but grim stronghold with salt-shaker towers. The castle was ordered built by King Gustavus Vasa, whose anti-Papist purge sent Catholicism in Sweden into decline. Most Swedes now belong to the Lutheran State Church.

KODACHROME (ABOVE) BY JOHN COCHRAN AND EKTACHROME BY HANS MALMBERG, TIO © N.G.S.

International class studies botany on the Åland Islands, formerly Swedish but now owned by Finland. English Harriet Debenham (left), American Susie Cochran, and Swedish Katrin Halvers pick mushrooms.

Colonized by Swedes in the 12th century, the islands were ceded with Finland to Russia in 1809. They became a part of independent Finland in 1917.

Piled Like Matchsticks, Logs Await Trucks

Spruce and pine in vast forests enrich Sweden's Norrland, and in winter loggers fan out to make the cuttings. From depots like this, trucks haul loads to frozen rivers. Spring thaws tumble the timbers to saw and pulp mills on the coast.

My Volvo now bore me west to where the Göta River spills into the Kattegat at Göteborg, Sweden's second city and leading port.

King Gustavus Adolphus founded Göteborg in 1619, calling in Dutch builders to lay out a fortress city along the lower Göta River. They stamped their trademark on the place with a web of canals.

Göteborg flourished in its rocky rivermouth. Merchant adventurers moved into the city from Holland, Germany, England, and Scotland. When Napoleon blockaded English ports, Göteborg welcomed British merchants. Englishmen and Scots poured into the Swedish city and hung out their trading shingles. Today the city telephone directory is thick with names like Wilson, Carnegie, Stuart, Chalmers, Gibson, and MacFie.

Göteborg's string-bean harbor, really the dredged and widened river estuary, brings in 25 percent of Sweden's foreign purchases and ships out more than a fifth of her exports. A big part of the 10,000,000 tons of oil Sweden buys each year (her No. 1 import) comes by tanker to Göteborg.

In the company of soft-spoken Åke Hall, reporter of *Göteborgs Posten* (the Gothenburg *Post*), I watched ships being welded together in shipyards which launch three of every five Swedish-built vessels (below).

At the Volvo automobile plants, we walked beside assembly lines that hatch two family cars common in America. One is the tough, swift 544, the model that carried me thousands of miles through Sweden; the other, the sportier-looking 122S, called "Amazon" in Europe. More than half of Volvo's cars are exported (13,950 to the U. S. in 1962).

KODACHROMES BY ANDREW H. BROWN (BELOW) AND THOMAS

Sweden builds only two makes of cars, the Volvo (Latin for "I roll") and the smaller three-cylinder SAAB (Svenska Aeroplan Aktiebolaget—Swedish Airplane Company). With some pride, a Volvo official pointed out to me that his firm gives Swedish buyers free repair of accident damage, within Scandinavia, for the first five years of a car's life.

Viking Sailors Scoff at Gales

On a day that turned wild with wind and rain, Åke Hall and I drove with Niels Hjorth, the *Post's* yachting editor, to a regatta at the Royal Göteborg Yacht Club. The mooring basin lies where the Göta River meets the ocean among knobs of surf-scoured rock.

Gray scud blanked out blue sky, and girls who had been sun-bathing picked up their towels and headed indoors.

"The baked beans are cold," Hjorth said.

"How's that?" I asked.

"In Swedish slang, girls are called 'beans.' Along this shore, we call a sun-bathing girl *brun böna*—'baked bean'!"

Scores of boats bobbed at moorings as crews struggled to get sail up. By now a heavy wind boomed out of a black sky. The dinghy races were canceled.

"Can't let the kids out in that," said Hjorth.

But Dragons, Star Boats, Folk-boats, and R-boats (Regelbåtar) would still run.

"*Hej!*" Hjorth gave the familiar Swedish salutation to two young men in white ducks and blue sweaters on the Folk-boat *Inga Lisa*. We grabbed the dinghy that came downwind to us on the end of a line. Then *Inga Lisa's* owner, Bertil Engberg, pulled us aboard.

"The wind's stiffening," shouted Engberg,

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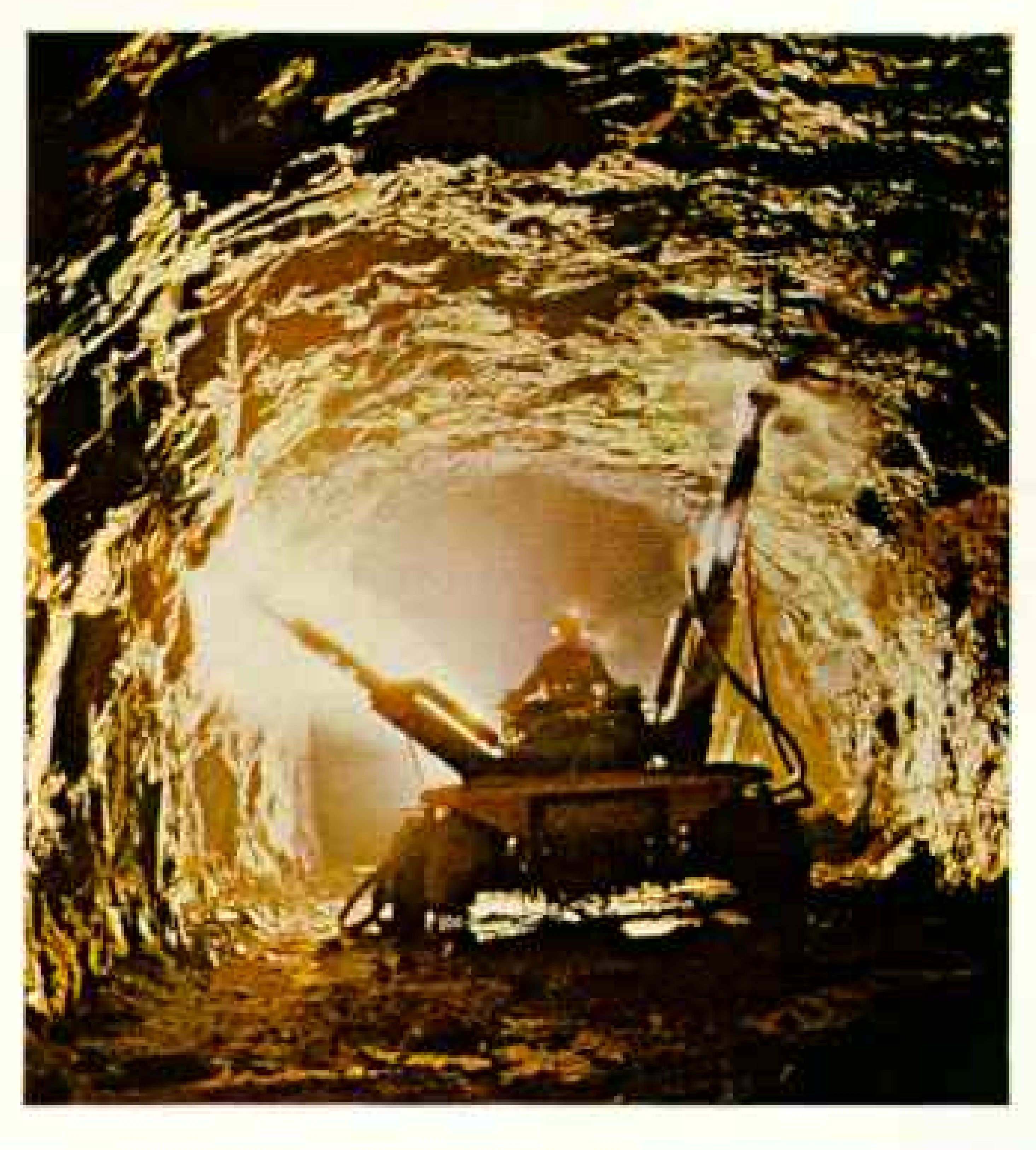
Forest of Cranes Shadows Göteborg, Sweden's First Port and Second City

Established in 1619, Göteborg found its destiny as a door to the world. In the 18th century, ships of the East India Company loaded Swedish iron and wood to trade for Chinese spices, silks, and porcelain.

Today Göteborg's port moves more than a third of Sweden's overseas commerce, builds more than half her ships, and markets an annual sixty thousand tons of fish.

Sign in the rear window of a Volvo will advertise the car in the United States. Just off the assembly line in Göteborg, the automobile will board ship in the nearby harbor (left). Last year Americans bought 13,950 passenger cars from the firm, which exported more than half of its output of 96,000. A compact, the Volvo has won many international road tests in its class.



Twin drills bite iron ore at Kiruna

RELENTLESSLY, the machine moves along a mine passage, boring hole after hole for the blasters. Kiruna, a settlement far north of the Arctic Circle, annually produces some 13 million tons of high-grade ore.

Cleft and scarred with old open-pit mining, Luossavaara Mountain yields ore that contains up to 68 percent iron. Today miners work underground. Railroad crossing frozen Lake Luossajärvi at left carries ore to Norway's ice-free port of Narvik.

Shaft of light in darkness outlines a Kiruna miner exhaling a cloud of vapor in chill air.

coming about with a snap of nylon to slip out the narrow harbor entrance. The skipper had us lean flat to windward as he rounded a couple of buoys to get the feel of wind and sea chop.

Then, with the races about to start, our host put us off at the jetty. *Inga Lisa* sprang away. We stumbled along the sea wall, bright with yellow oilskins and sou'wester hats. Pistol cracks started successive heats. Boats heeled wickedly, rain-drenched canvas slow to lift.

Two Dragons were dismasted; through glasses we saw them dragging sail across the rough water like winged ducks.

An hour later, Engberg came in to receive a second-place red ribbon.

Swedes Vote for Welfare Programs

I lunched one day with Åke Hall at an open-air restaurant in Göteborg's lovely downtown park called Trädgårdsföreningen. The unwieldy name means simply "Garden Society." The talk turned to an aspect of

KODACHROME (BELOW) AND EKTACHROMES BY NATIONAL GEOGRAPHIC PHOTOGRAPHER THOMAS NEBBIA © N.G.S.

Swedish life that I had glimpsed everywhere in the country, but did not yet fully comprehend: the so-called welfare state.

"Many foreigners think of us as rabid socialists," said Åke with a smile. "They are alarmed at the extent of 'free' care our government gives us. Of course it isn't free—everyone pays for it. But we think it is worth it. And it has all been voted for by a series of public referendums.

Students Pay No Tuition

"Say one of my children gets sick," Åke Hall continued. "I'll call any doctor I want. I pay his bill, and then the government pays me back three-fourths of the cost. It's much the same for our medicines and hospital care.

"When our children were young, we got a yearly cash award for each of them until they reached 16. This grant amounts to 550 kronor per child now—about $106. Our public schools charge no tuition; not even the big universities, like Uppsala, Lund, and Stockholm. And college students can get government loans, without interest, to cover their living expenses.

"As for me, when I'm 67, I'll get the basic annual pension of $855 plus a supplementary payment equal to two-thirds of my average income during my 15 best earning years."

The cost of all these welfare programs, Åke agreed, is high. Swedes pay stiff taxes,

Helicopter whirls in with a nurse to serve Lapps living north of the Arctic Circle. Carrying books, she acts as a librarian, too. Swedish Lapps, or Samelats, number about 10,000.

Furry sea, spiked with antlers, swirls around a Lapp reindeer herder. With his lasso he cuts out beasts for branding and butchering. He and his family follow the herd in summer.

and almost a third of the national budget is earmarked for social benefits.

Free enterprise, however, dominates the Swedish economy. The state controls railroads, communications, almost half of the power stations, and the Kiruna-Gällivare iron ore. These, in the Swedish view, are public services and strategic resources rightfully operated by the government. But most of Sweden's forests, farms, industries, and trade are privately owned.

Åke Hall summed up Sweden's economy as "free-enterprise capitalism moderated by social aims and standards."

Sweden's people are by instinct and training proud and law-abiding. They are jealous of privacy and individual rights. Conscientious and eager to get ahead, they are nonetheless ready at the drop of a time card to take to the hills, or shore, or mountains.

Nation Aims at Self-improvement

Yet the zest for outdoor play and the preoccupation with the market place and social stability really are only two facets of a Sweden that warmly cherishes the traditions of a proud past. Here is a nation with its own distinctive Nordic spirit of ardent, but not obsessive, self-improvement. It is a quality that seems rooted in the quiet conviction that a thing worth doing is worth doing well.

THE END

Progress in Viking Land: New Map of Scandinavia

IN NORWAY men carve out a road to North Cape on the Barents Sea—and now a car can reach Europe's northernmost point, although it must travel 40 of the last 64 miles by ferry.

In Sweden the atom goes peacefully to work—creating light and heat for a section of Stockholm.

In Denmark, where there is a saying that "the pig hangs onto the cow's tail," some seven million pigs annually fatten on skim milk to become the bacon and other fine pork products for which the nation is famous. But today industrial products—machinery, textiles, metals, and chemicals—account for the majority of exports.

To show the changing, prospering land of the Viking, the National Geographic Society's latest Atlas Series Map, **Scandinavia,*** supplements this issue of the magazine, which also features a comprehensive article on Sweden (preceding pages).

From Iceland to a Red Frontier

The 11-color map includes Norway, Sweden, Denmark, Finland—all in the northern tier of free Europe. Technically "Scandinavia," a name of obscure Nordic origin, applies only to Norway and Sweden. By language and culture, however, Denmark, Iceland (Inset A), the Faeröe Islands (Inset B), and part of Finland are considered Scandinavian.

To the east and southeast the pink-shaded border of the Soviet Union curves like a jagged scimitar, enclosing the once-free lands of Lithuania, Latvia, and Estonia. The 1938 boundary of the U.S.S.R. also appears. Norway today faces 112 miles of Soviet border, while Finland shares 788 miles.

On the map Norway appears almost as one great mountain, culminating in 8,097-foot Galdhøpiggen. Barren rock, laced with racing streams and crowned with numerous glaciers, covers three-fourths of the country. Cultivation occupies a scant three percent of the land.

But Norway produces and uses more hydroelectric power per capita than any other nation—8,000 kilowatt hours per year; Canada ranks second with 5,000 kwh. Linking the iron-rich north and industrial south, a recently completed 452-mile railway snakes from Bodø to Trondheim.

Sweden and Finland, mantled by forests, together provide two-fifths of Europe's newsprint. Profiting from geography, the Finns have interwoven their 55,000 lakes with canals to float timber from forest to mill. After World War II Finland industrialized rapidly, and now exports lift trucks, cranes, and other heavy machinery throughout the world.

Iceland, a former Danish colony that became an independent republic in 1944, nudges the Arctic Circle 650 miles west of Norway. It lives mainly by fishing. Glaciers, sand, and lava cover its uninhabited central plateau. Hot springs puddle the land, heating homes and enabling greenhouses to grow such tropical plants as bananas. Geysir, which gave its name to all other geysers, erupts near Thingvalla Lake.

The Danish Faeroe Islands lie 400 miles west of Norway. Of the small archipelago's 35,000 inhabitants—mostly fishermen and shepherds—many descend from Norse settlers of a thousand years ago.

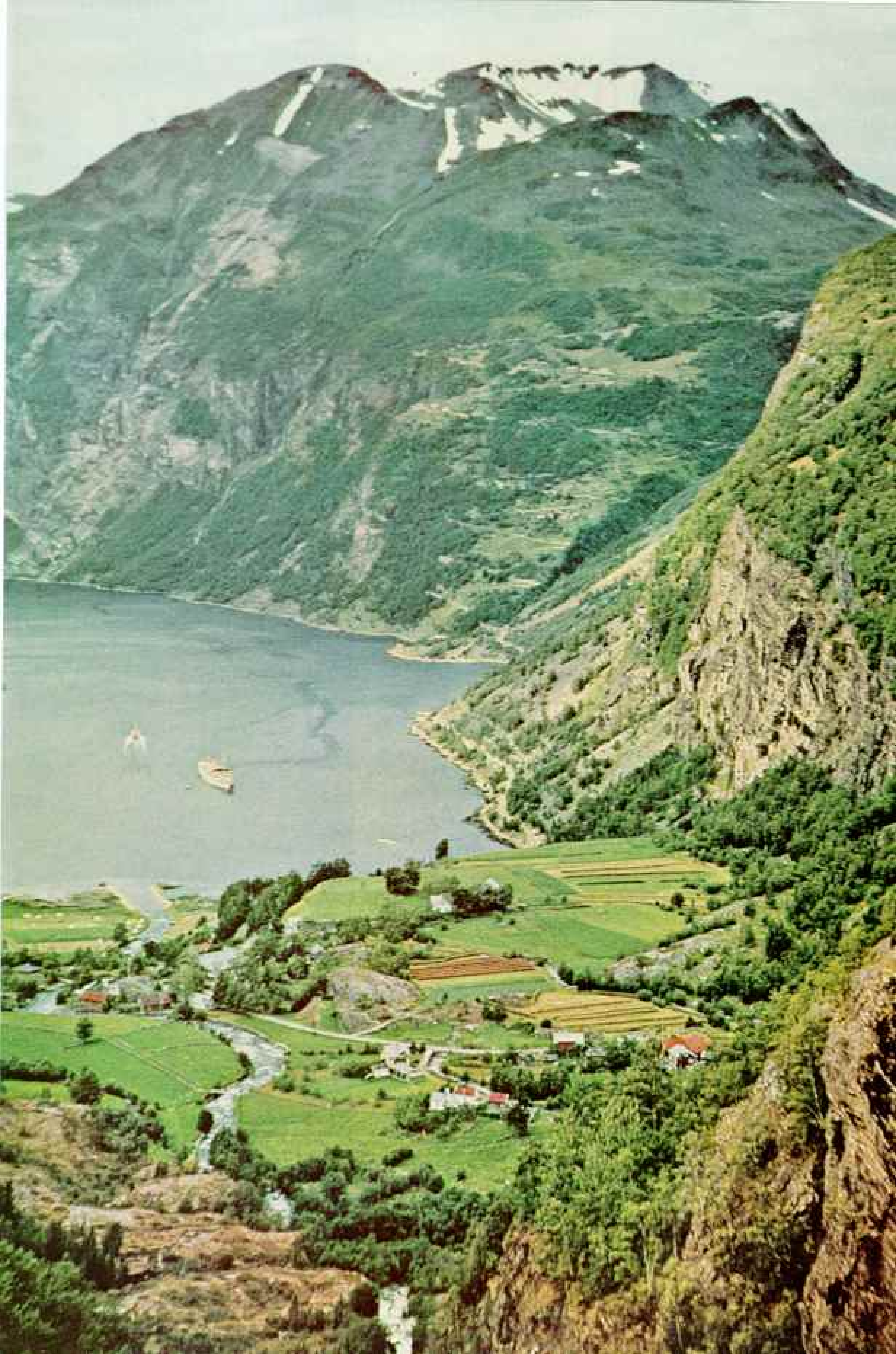
Only a handful of technicians at a weather station people Norway's Jan Mayen Island (Inset C), 350 miles northeast of Iceland. Almost as far north, on the mainland, some 30,000 Lapps emulate their nomadic ancestors, herding reindeer and fishing.

In Scandinavia crops of barley, rye, and potatoes grow north of the Arctic Circle, thanks to the Gulf Stream system that warms the shores and tempers the winds sweeping across northernmost Europe.

*__Scandinavia__ is the 37th uniform-size map issued by the Society in the past five years; it becomes Plate 34 in the Atlas Series. A convenient Folio binds the maps; it may be ordered from the National Geographic Society, Dept. 68, Washington 6, D. C., at $4.85. Single maps, 50 cents each; a packet of the 35 maps issued from 1958 through 1962, $10.50; the 35 maps and Folio, $14.00.

Farmhouses cling to the slopes of Geiranger Fjord reaching 57 miles into southern Norway. Mothers tether children to keep them from tumbling down cliffs. Ice Age glaciers carved Scandinavia's coastline. This arm of the sea gives its name to the village at its head.

KODACHROME BY LOUIS RENAULT, PHOTO RESEARCHERS, INC. © N.G.S.



Ships Through the Ages: A Saga of the Sea

By ALAN VILLIERS

From drifting log to nuclear freighter, from tribal catamaran to transatlantic liner and 100,000-ton tanker—this is the story of the evolution of the ship

THERE I WAS, sailing the beautiful full-rigged ship *Joseph Conrad*, bound down-Channel and round the world. Forward, the sea turned to white at the graceful bow. Aloft, the three high masts bore pyramids of sails, graceful, perfect for their work, and under control. The wind sang in taut rigging, efficiently designed to give strength and support just where it was required, and to control the yards and the 20 sails. Aft, a young seaman at the wheel was steering competently, just with a touch of the spokes.

How come? I asked myself. How had all this evolved? And the steamships and the motorships, coasters and deepwatermen, liners, tankers, every sort of ship upon the sea routes of the world, many of them crowding up through the Strait of Dover that day and every day?

The sailing ship was not just the loveliest but also, in her way, the most nearly perfect of man's sea-borne creations. How had man learned to sail big ships at sea?

How had he learned to balance so many sails with such complete effectiveness, to direct so vagrant a power as the wind and make it work efficiently for him, to hang a small rudder on some pintles and make that turn a ship at sea the way he wanted to go?

I had often wondered about such things, and studied them. One has the time at sea, and can make the opportunity. I had studied the story of the ship all over the world, in a practical way—by sailing with the Arabs in their dhows upon the Indian Ocean, with the Bihari far up the Brahmaputra in a single-masted country-craft, with the Trobriand Islanders off New Guinea in a dugout, off Brazil in a balsa raft, off the Horn in many a powerful steel square-rigger, off Singapore in a junk.

I'd read the books, too, and visited the museums. The outlines of the story seemed plain enough.

Early Sails Made of Matted Leaves

Logs float. Bark floats. Inflated hides float. Early man noted these things, and used them. He began to hollow the logs, shape the bark, cling to the hides. He learned to lash a few logs together with thongs of vine or twisted leather, and had then a raft. He made wickerwork baskets watertight, and sat in them. He poled himself along, or traveled at the current's whim. He made crude paddles and used these. He developed the thole pin as a fulcrum for oars, and then he could row.

He saw the drifting leaves catch the wind with their upturned edges. He contrived sails out of matted leaves, and let his frail craft blow along with them. He fished and he hunted, venturing in his primitive craft along rivers and in estuaries, and from quiet Asian beaches facing summer seas.

Slowly he learned to build up planks on edge upon a dugout base, either upon a single large hollowed tree, or two trunks joined. He learned to stretch skins upon a frame, to bore holes in light planks and sew them together in boat form, to use cloth for sails, to steer with a steering oar.

In time, he built bigger rafts, putting shelters upon them, and stumpy masts. He developed lithe, long boats. He studied the stars, and ventured on voyages. He traded and he raided on the highway of the sea.

And slowly, slowly, down the dark ages man has sailed himself to light. Slowly, he evolved the ship, that great instrument of progress—discoverer of continents, agent of commerce and of good international relations, mightiest mobile creation the world has known. The sea is still the cheapest highway, and the safest.

The most primitive craft, serving their purpose, still survive. Through much of the Pacific and Indian Oceans' remoter islands, along the rivers of Brazil and East Pakistan, the dugout canoe is today a form of local transport of the first importance. The Greenland Eskimo still finds the sealskin kayak a hunting craft well suited to his needs. Chinese junks, Arab dhows, Malay proas, Brazilian jangadas, Greek caiques, West Indies and Grand Banks schooners, northern full-rigged ships still sail, and I have seen them all and sailed in many of them. This living pageant of all our histories presented upon great rivers and the sea has always fascinated me.

Today's seaman, wandering the seven seas in cargo liner or huge carrier, may still come upon homely reminders of the seaman's ageless past. To him sea history is a vivid and a living thing.

Egypt Pioneers in Shipbuilding

A felucca, or gaiassa, sailing in the Suez Canal or down the Nile today is a very odd vessel. Close to, it looks a feeble old rattletrap—a ramshackle affair of bits of wood, a very light mast, and the lightest of canvas. That thing the origin of all ships? What a crazy idea.

But it very well might be. At any rate, boats of a sort have been sailing in Egypt for perhaps seven thousand years, and records of them go back a good five thousand.

The Author: For this article, his 18th sea story in the NATIONAL GEOGRAPHIC, Alan Villiers draws on more than 40 years of sailing experience—in Arab dhows, windjammers, World War II landing craft, and the Nuclear Ship *Savannah*. One of the greatest nautical writers of our time, Australian-born Captain Villiers now lives in England.

◀ **Golden Sails Catch the Breeze as Henry VIII's Flagship Puts to Sea**

Father of the fighting navy, Henry built dockyards, established an admiralty, and encouraged construction of vessels specifically designed for combat. To augment the small man-killing weapons that crowded poops and forecastles, he had hulls pierced for gunports and mounted broadside batteries of ship-killing cannon on the lower decks, a step that revolutionized naval warfare. His *Henry Grâce à Dieu*, a wonder of her day, bristled with some 385 guns and carried 700 soldiers and seamen. The King himself, legs apart, stands proudly in her waist as the English fleet departs Dover for France in 1520.

PAINTING BY FRIEDRICH SOUTERMEK, AFTER AN UNKNOWN CONTEMPORARY, FROM MUSÉE DE LA MARINE, PARIS © N.G.S.

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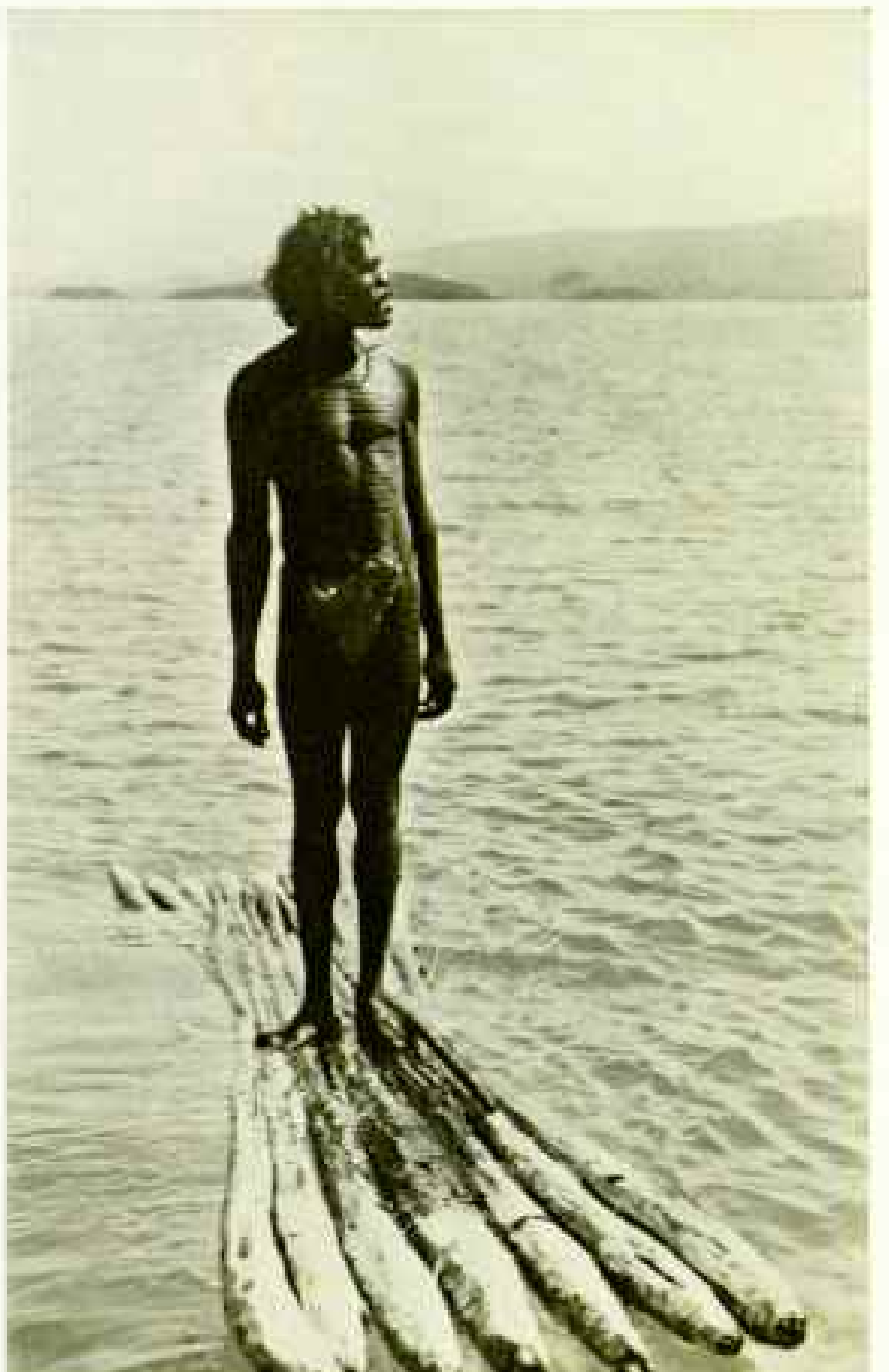
UNDERWOOD & UNDERWOOD

Inflated hides form a raft on the Sutlej River in the Himalayas. Returning upstream, the men deflate the skins and pack them on their backs.



WILLIAM JACKSON

Crude raft of mangrove logs carries an aborigine on Camden Sound, Western Australia. He can propel himself by paddling with hands and feet.

When the ancient Egyptians were pleased with anything, they made a record of it in stone. They were often pleased with what their ships did for them. So they carved pictures of their nautical history on rocks.

They were well placed for developing shipping. The Nile was a great waterway, and ships were the trucks of that long, useful, and inexpensive road. The Egyptian coastline fronted both the Mediterranean and the Red Sea, in both of which the sailing weather was good for much of the year.

Voyages Began Far Inland

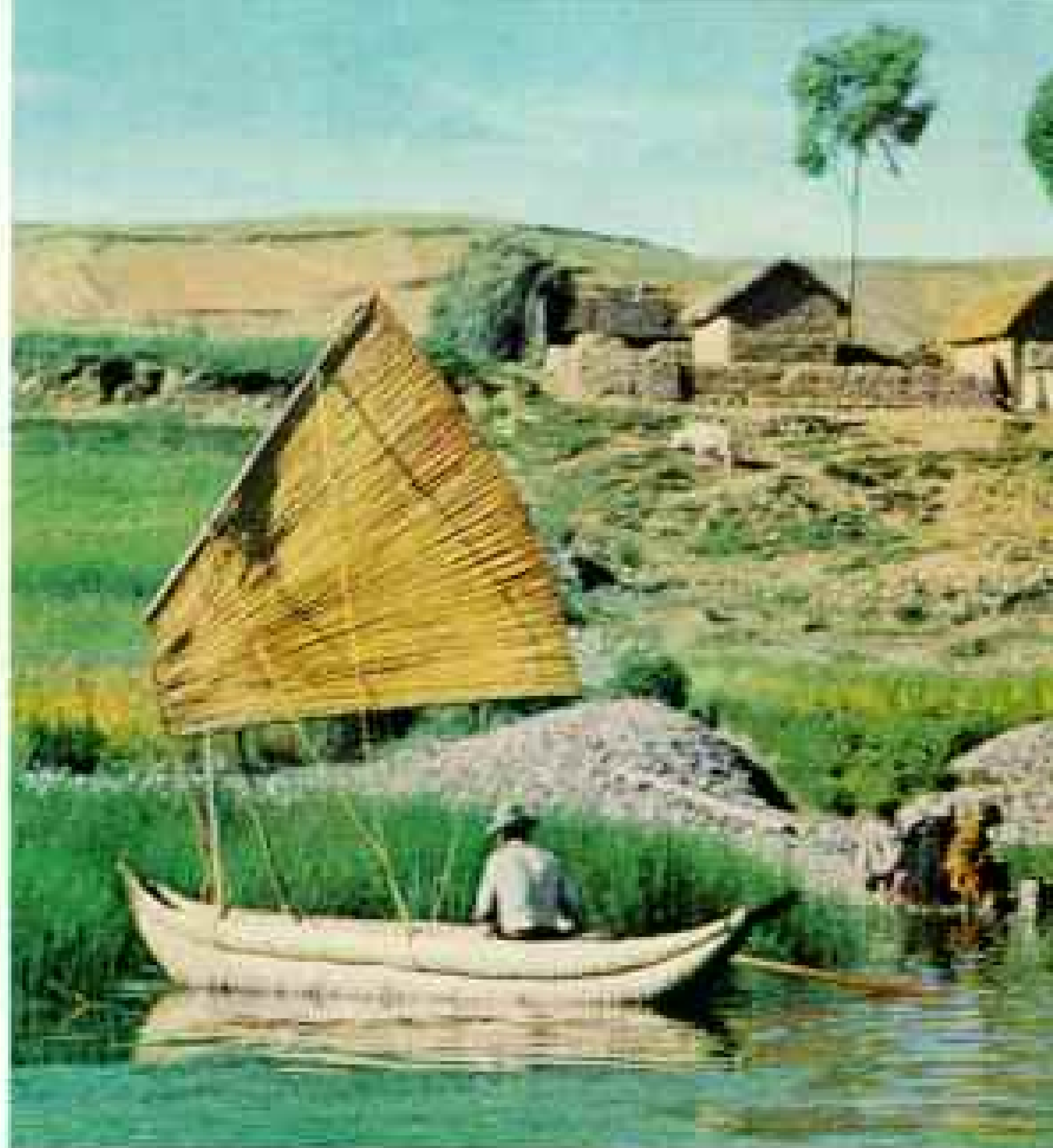
The best part of 5,000 years ago, the Egyptians were building large ships which could go places. Huge blocks of granite were shipped downstream from Aswân, 525 miles above Cairo, and some of these blocks weighed 60 tons. This was river sailing, but some Egyptian vessels went outside too.

Far inland, in the Valley of Hammamat, a rock inscription tells of a seafaring expedition to the "Land of Punt," probably Somaliland, made about 2000 B.C.

Why are the records so far inland? Because the valley was on the route to the Red Sea port of Quseir (Kosseir), which was the setting-out place for these voyages to Punt. A forgotten backwater now, Quseir was a great place in its day, a few thousand years ago. If Punt were Somaliland, making a voyage there

KODACHROMES BY J. BAYLOR ROBERTS, NATIONAL GEOGRAPHIC STAFF (LEFT), AND CARL S. BELL © N.G.S.

Bamboo basket boat in South Viet Nam lacks bow or stern but makes headway. Calking with cow dung and coconut oil waterproofs the craft.



Bundled bulrushes and a sail of reeds serve the Andean fisherman on 2-mile-high Lake Titicaca. Cellular air spaces make the rushes unsinkable.

was no great undertaking. Primitive vessels could have made it all right. I have made much of it myself in a very small Red Sea dhow not much improved over the ancient Egyptians' ships.

Temple Walls Record Ancient Vessels

A later record tells of a venture by that strong-minded, tireless woman, the famous Queen Hatshepsut. Her archivists chipped away a great deal of good stone to record the voyage, about 1500 B.C., 200 years or so before the Exodus. To this day, her sculptured ships still sail and load their incense upon the timeless stones of her temple of Deir el Bahri, near Thebes.

"The loading of the ships very heavily with marvels of the country of Punt," an inscription reads, "all goodly fragrant woods of God's Land, heaps of myrrh-resin, with fresh myrrh trees, with ebony and pure ivory, with green gold of Emu, with cinnamon wood, khesyt wood, with ihmut-incense, sonter-incense, eye-cosmetic, with apes, monkeys, dogs, and with skins of the southern panther, with natives and their children. . . ."

If this seems a big freight for a small ship, remember that the Queen sent five ships. They were shallow-draught vessels, to sail the reef-strewn inshore channels of the Red Sea, but they were beamy and at least 70 feet long. Their overhanging ends facilitated cargo working, and were more convenient for embarkation of people and animals.

I saw the same overhanging ends in 70-foot fishing canoes on the Brahmaputra in 1960. When the fishermen landed to sell their catch, the canoe headed in and swung her high bows over the bank for the crew to jump ashore, while the hull remained afloat.

These Egyptian ships are usually shown with a sail and oars, or paddles. They have one big sail, sometimes on a bipod mast, sometimes on a single pole, but the sail is set between a long, slim yard at its head and often a boom of the same length at its foot. To the modern eye, there is a superfluity of gear, but the long boom required a great deal of support.

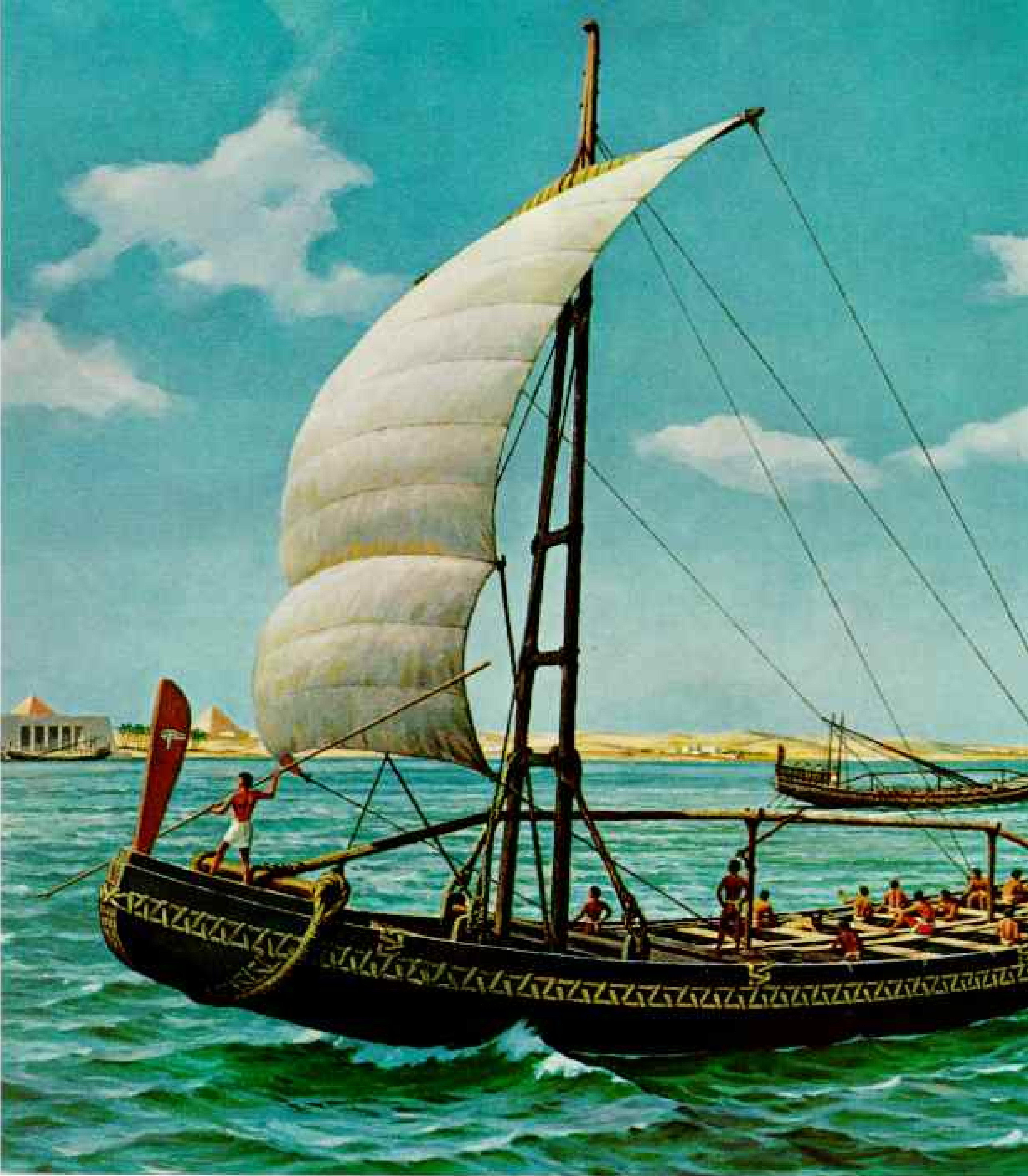
Craft Rely on Oars in Calm Waters

Wood was scarce in Egypt and ships weak-built. To strengthen them, a truss of heavy rope was passed from bow to stern. It was set taut by a tourniquet.

Red Sea waters were calm, particularly inshore where such craft would have to sail. Hence the need for oars and oarsmen.

Such ships might look odd today. But make no mistake, they could sail; and they could make considerable good-weather voyages.

From Quseir to Somaliland is a coasting passage. Red Sea dhows, some of them 60 and 70 feet long, make similar passages today



(pages 512-13). Many still have only one mast and one big sail, but they handle well.

I ought to know. I have been in them—once on a six-week passage that nearly killed me. We sailed only by day, and the captain's knowledge was the store of his personal experience from childhood. We had no charts. Our rudder hung precariously on a single primitive bolt, and the helmsman used a tiller.

We got our water from wayside stops at village wells, and the resulting infections nearly wrote me off. Our food was fish with a bit of rice. Now and again we bought a few fresh vegetables at a bazaar. We had coffee from Al Mukhā (Mocha), and Persian tea, and cloves from Zanzibar. A bit of unleavened bread was baked now and again in the ashes, when we had a fire.*

*See "Sailing With Sindbad's Sons," by Alan Villiers, NATIONAL GEOGRAPHIC, November, 1948.

PAINTING BY HARVEY GARNETT SMITH © NATIONAL GEOGRAPHIC SOCIETY

Breasting the Nile, an Egyptian ship of the third millennium B.C. sails past the pyramids of Abusir. Pole-wielding sailor takes soundings, while three helmsmen man the steering oars. Two-legged mast mounts a slender square sail. Short planks pinned to one another, rather than to a framework of ribs, form the fragile hull. Rope truss stretched over forked uprights supports the bow and stern. With mast lowered, the ship beyond uses its oars to move downstream against the prevailing wind.

Egyptian boatbuilders use chisel and adz on a panel in the tomb of Ti, Saqqara. Other Nile Valley sculptures provide man's earliest picture of seagoing ships.

LEHNERT AND LANDROCK, CAIRO

We had 70 tons of cargo, and passengers as well. The dhow was about 60 feet long. We sailed the best part of 700 miles. What that little dhow could do in 1938, so could the ancient Egyptians on a voyage to Punt.

Among the great maritime peoples of the Mediterranean were the Phoenicians, an able race of adventurous merchant seamen. They had the timber to build better ships than the Egyptians, and they were inveterate traders. They were open-sea sailors, with genuine seagoing vessels, and they cruised not only about the Mediterranean but to northwestern Europe, as far as England.

The Phoenicians, a tight-lipped lot, regarded seafaring knowledge as a priceless trade secret, learned the hard way; so we know little about their ships.

The Bible, in the 27th chapter of Ezekiel, sheds some light on Phoenician ships: "They

BAS-RELIEF FROM PRAENESTE (PALESTRINA), ITALY, C. 30 B.C.; NOW IN THE VATICAN MUSEUM. ANDERSON-ALINARI

Ship in stone commemorates Rome's rule of *mare nostrum*—"our sea," as Romans proudly called the Mediterranean. Fighting galleys such as this fought the Battle of Actium in 31 B.C. Archers and stone throwers occupied the tower near the prow. Carved crocodile rides ahead of the oars.

Powerful ram in the shape of a fighting boar's head, a figure typical of the period, juts from the bow of a sixth-century B.C. galley. The stern ladder served as a gangplank. This ship was originally portrayed on a Greek cup found in Tuscany and now preserved in the British Museum.

have taken cedars from Lebanon to make masts for thee. Of the oaks of Bashan have they made thine oars. . . . Fine linen with broidered work from Egypt was that which thou spreadest forth to be thy sail. . . ." [5-7]

Phoenician shipmasters were crafty, too. There is a story of one, sailing to the mysterious Isles of Tin somewhere north of the Bay of Biscay, who was followed by a Roman merchantman. He deliberately led the Roman onto rocks, perhaps near Ushant (Île d'Ouessant, off the west coast of France). Both ships were lost. A system of insurance covered the Phoenician losses; not so the Roman.

Phoenician trading ships were big double-enders with high prows. Like the Egyptians, they used a single mast and sail. When the Egyptian King Necho wanted to send an expedition by sea right around Africa, about 600 B.C., he chose Phoenicians to do the job. The voyage, tradition says, took at least three years.

Some scholars doubt that the voyage was ever made. To me, however, it makes sense.

In King Solomon's time, his ships and Phoenician fleets were sailing from the Gulf of Suez round the coast of Arabia to Persia and Baluchistan—quite likely also to India. Runs down the coast of East Africa were commonplace, in the favorable monsoon.

This is the kind of voyaging which I found Arab, Persian, and Indian dhows carrying on in 1938. In the early 1960's some still do so.

Ancient Navies Fought With Galleys

But it was Greeks and Romans who carried the development of the ship forward, for both war and peace. The Greeks developed the war galley, a long, fast vessel manned by oarsmen, who were the "engines" in quiet Mediterranean seas—the more oars, the more powerful the ship. The Phoenicians were using double-banked galleys (biremes) for inshore work by 700 B.C., and the Greeks had triple-bankers—triremes—not long afterward, with outriggers to accommodate the third bank of oarsmen.

Such vessels were exclusively fighting ships, with underwater rams on strengthened bows and light upper decks for the fighting men. Not designed for long voyages, they were usually hauled ashore at night, where the crews cooked, ate, and slept.

In battle the galleys rowed full speed at one another, trying first to ram and then to board. Soldiers hurled stones and javelins and sought to close with spears and swords. Before long they were using what they called "engines," too—missile launchers that used sprung wooden levers held back with twisted ropes to lob large rocks or fire oversize arrows upon enemy decks.

These fighting galleys must have been fantastic vessels. They must have made a brave sight, rowing along in the blue Mediterranean among the fabulous Greek islands, oar blades flashing wet in the golden sunshine, spray curling white above the powerful rams, or with large single sails (often in beautiful colors) swelling in the soft, warm breeze.

Persia Assembled 1,000 Galleys

They were known as long ships to distinguish them from the slow-sailing cargo carriers called round ships (following pages). At any of the great Mediterranean battles between 600 and 200 B.C., rival long ships covered the sea by hundreds. During its campaign against Greece in 480 B.C., Persia assembled more than 1,000 galleys, which fought at the Battle of Salamis; their crews numbered some 200,000.

Inventories of the Athenian dockyard still exist, inscribed on stone slabs later used as lining for drains. These, dating some 300 years before Christ was born, give exact details of the gear issued to each ship and exact figures for the ships in service. The oarsmen were recruited by rich citizens responsible for providing and manning such ships of war. The richer the citizen, the larger the number of galleys he might provide. Fair enough, since war galleys existed for the protection of the state.

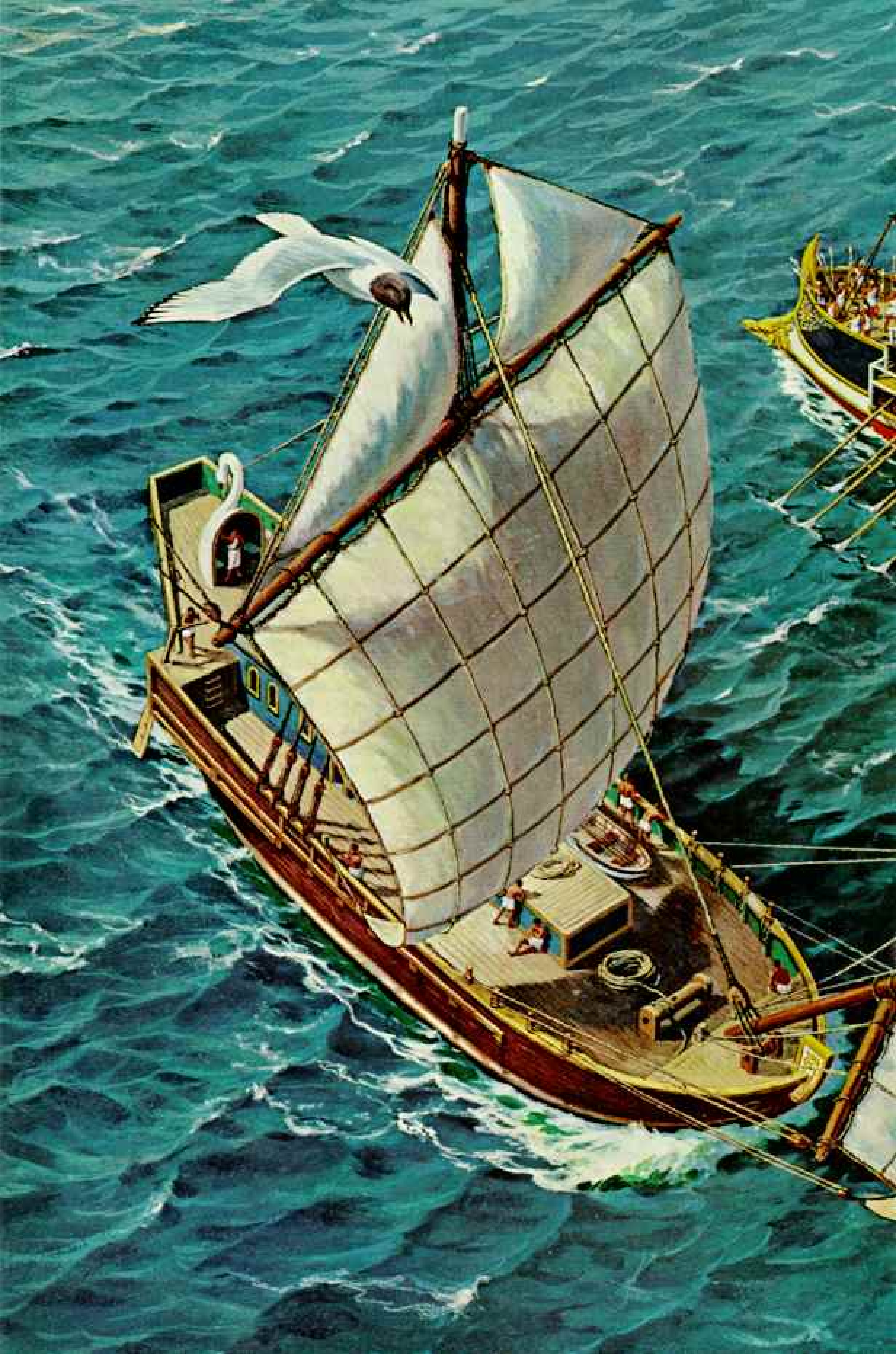
The ancient round ship developed into a short, fat merchantman, a wooden vessel with a deck and two masts. The shorter mast, leaning forward, stood up from the bows. It was more like a high-angled bowsprit and it car-

Two Banks of Oars Propel a Bireme Past a Beamy Roman Merchantman ▶

Battleship of its day, the bireme suggests a centipede striding across the sea. Outboard platforms make room for one bank of rowers; another bank sits below. A flutist sets the tempo as oarsmen pull against the wind. When the craft goes into action, marines crowd the catwalks; the mast comes down.

Roman round ship plows along peacefully with sails set. Brails, the vertical lines on the mainsail, allow easy handling. Twin topsails add power. *Artemon*, the sail at bow, helps balance the freighter before the wind. Goose head embellishes the stern.

PAINTING BY ROBERT GARRETT SMITH © N.G.S.



HERVEY GARRETT SMITH

COURTESY MUNICIPALITÉ DE BAYEUX

Flagship ***Mora*** of William the Conqueror spreads its sail across the Bayeux Tapestry. Dragon prow, massed shields, and side rudder suggest a Viking longship. Signal lantern and a cross surmount the masthead. A 231-foot-long strip of embroidered linen dating probably from the 11th century, the Bayeux Tapestry records the Norman Conquest of England. Latin inscriptions tell the story. A museum in Bayeux, France, preserves the relic.

ried a small square sail named the *artemon*.

Such a sail was useful for maneuvering. The replica of the 17th-century *Mayflower*, which sailed across the Atlantic in 1957, carried one. We called it the spritsail. It helped to keep the ship before the wind, and was essential for balance.*

The ship in which St. Paul was wrecked had such a sail. It was set in the last extremity to help run the ship ashore on the island of Malta. St. Paul's ship was big enough to carry 276 passengers and a cargo of wheat as well. The Bible tells us so.

*See "How We Sailed the New *Mayflower* to America," by Alan Villiers, NATIONAL GEOGRAPHIC, November, 1957.

William's fleet crosses the Channel after sailing from St. Valéry sur Somme, France, in 1066. Horses leap ashore at Pevensey as mariners unstep a mast. Knights gallop off toward Hastings and ultimate victory.

Wealthy kings or government officials sometimes went in for a life of luxury afloat as well as ashore. There is a third-century account of a ship that was fitted out like a floating pleasure palace. The deck of the bathroom and of the saloon was done in mosaic. Outside were gardens and a covered promenade shaded by rows of grape vines and ivy growing from casks of earth.

Stout Craft Survived Storms

Tough northerners who had no use for flowerpots or mosaic baths also made notable contributions to the development of the seagoing ship.

The north was a place of many islands and long coasts indented with bays, where the only means of transport was by water. These stern coasts took a savage beating from the fierce North Atlantic. Storms could blow up at almost any time, and for miles there was no place to beach or haven to run for. In such waters ships had to be able to stay at sea and survive bad weather.

When Julius Caesar campaigned in Gaul in 56 B.C., he was impressed by the strength and seaworthiness of the ships he saw in what is now Brittany. He describes them as stout craft of solid oak, with strong masts and sails of leather. They had beams a foot through, and their hulls were built with a sea-kindly sheer. Their anchor cables were of iron chain, and they traded to England.

Vessels such as the Nydam ship—a strongly built double-ender dug up at Nydam, in Schleswig, a hundred years ago—may have traded across the North Sea early in the Christian Era. Thought to belong to the first half of the fourth century, she is a roomy ship, 75 feet long with a beam of 11. Her stem and sternposts rise nearly 10 feet above her keel. Her hull is clinker-built (overlapping planks) and well calked. Coins found aboard date from A.D. 69 to 217.

Tough waters bred tough people. While fleets of Mediterranean galleys fought in wonderfully marshaled actions, a race of northerners called Vikings overran northwestern Europe. Before long they were in the Mediterranean, too. Vikings discovered Greenland, colonized Iceland, seized much of Ireland, Scotland, and England, took part of western France, and sailed to America. Their ships were so important to them that great chiefs were buried in them.

Two such ships, discovered under mounds of blue clay in Norway and now preserved in Oslo, give us a good idea of the Viking ship's development. A queen was found buried in the 70-foot Oseberg boat (1904); a man, probably a king, about six feet tall, in the 76-foot Gokstad vessel (1880).

Both ships carried a single large square sail set from a yard on a very strong mast. Household and shipboard requirements of all sorts had been placed aboard. Found with the vessels were the bones of horses and dogs, as well as sledges, chests, even a complete cart. The ships also carried land tents for shelter in harbor at night, ornamental shields along the sides, big cooking pots, and ample stowage space for water and stores.

Vikings Sailed Tight Ships

An exact copy of the Gokstad ship sailed across the Atlantic in 1893. Skippered by Magnus Andersen, she took 27 days from Marstein, near Bergen, Norway, to St. John's, Newfoundland. She made the passage unescorted, under sail alone, and behaved very well. She logged as much as 11 knots.

Captain Andersen reported that the ship proved remarkably tight, even in storms. As in the original Gokstad ship, her planks were secured to the ribs only by lashings of roots. In a big sea, the whole bottom worked, frequently rising nearly an inch, and the gunwale could twist half a foot out of line. The ship's elasticity was alarming at first, but the planking allowed no sea in.

16th-century Caravel Fires a Salute as It Drops Anchor off Malacca

Exotic cargoes pile up in this crossroads of the Orient, an outpost of empire established in the wake of Portuguese explorers. Junks with battened sails bring silks from China, short-masted dhows

PAINTING BY HERBERT BARNETT SMITH © NATIONAL GEOGRAPHIC SOCIETY

unload cloves from Zanzibar, and sampans with painted eyes shuttle from ship to ship. Into this Malayan roadstead glides the caravel with pennants streaming. Triangular lateen sails allow her to work close to the wind. Square-rigged foremast drives her before a breeze. Her canvas displays the Cross of Christ, emblem of a religious order that helped finance the search for new sea routes.

This vessel went on to the World's Columbian Exposition in Chicago and was preserved there. Not long ago I was looking at her where she stands, a shapely and able vessel, in Chicago's Lincoln Park. I was glad I was not around when such craft were raiding the coasts of Ireland, and the Vikings were flaying people alive.

"From the fury of the Norsemen may the good God deliver us!" the poor people prayed. In retaliation they flayed the Norsemen alive, too, if they got the chance.

Oars Useless in Heavy Seas

By 1066, English ships and Norman ships alike were simple single-masters, very like the Viking vessels. Pictures of them appear on the famous Bayeux Tapestry (pages 506-7). Seals from French, German, and English ports show similar one-masted sailers.

Development of the stern rudder and the deep-draught hull improved sailing qualities. In such rough places as the North Sea, the Bay of Biscay, and the Atlantic off Portugal, oars would not do as a reliable means of propulsion. Calms were usually of short duration. There was plenty of wind. If ships wanted to get anywhere, they had to sail. And so hulls deepened, masts were strengthened and made more rigid, rigging was added to support the mast from sideways stresses in beam winds. Fore- and aftercastles grew.

Sailors lived forward, officers aft. This was a natural outcome since it was from aft the ship was worked. The rudder and tiller were there, and the controlling rigging of the sail. The aftercastle, or poop, was also farthest from the stinking bilge water that swirled in the ship's belly. It was the logical place of command and was readily defended.

When fighting was to be done, knights and soldiers were embarked. The knights hung their shields, emblazoned with their arms, around the aftercastle and camped and fought from there. It was like a castle's keep. Large platforms, big enough for eight or ten archers, were built at the masthead.

Such big platforms, called tops, lasted a long time. You can see them aboard U.S.S. *Constitution* in the U. S. Naval Shipyard at Boston, or at the lower mastheads of *Mayflower II* at Plymouth, Massachusetts.

These one-masted ships carried English Crusaders to the Mediterranean. There were many one-masters in that sea, too, but they were usually not square-riggers. The northerners liked one big square sail on a rigidly supported mast. The southerners used numerous ships rigged with the lateen sail—a large triangular sail set from a flexible yard that was slung from a comparatively low mast.

Both rigs had their advantages, but the development of the strongly built north European ship from one to three masts in the 15th century made her pre-eminent.

The single mast was stepped slightly forward of the ship's center. There was room ahead of and behind it for other masts. Bright shipowners added a foremast, with another smaller sail, as the Chinese had done in Asian waters centuries earlier. The high-angled bowsprit, with its spritsail, followed.

Then they needed something aft to balance the ship; so they added a small mast with a lateen sail, or, later, perhaps a single square sail set from a crossed yard.

Thus, the full-rigged ship arrived. In an improved form she is still with us, after 800 years, but in ever diminishing numbers; there are only a few school ships now.

Ocean's Immensity Poses Problem

As man improved his ships, slowly another and even more difficult problem loomed—the immensity of the ocean. He didn't know it then, but something like three-fourths of the earth he lived on was water.

Coasting might suffice for long Asian voyages, but the European had to find his way across the trackless sea. If Europe's seamen had been restricted to coasting, America might still be undiscovered!

The advance of the science of transoceanic navigation was a slow, cumulative process. Chinese pilots had the compass a thousand years ago. With it a pilot might strike out for short passages across the open sea, if he knew where he was going and knew the coasts at the other end. This the Asians did on their monsoonal voyages.

When I sailed in a Persian Gulf dhow in 1938-39 on an 8,000-mile voyage that lasted eight months, we were out of sight of land only one day, and the captain-pilot knew every headland, every feature of the coasts of all Arabia and of East Africa as far south as Mozambique.

He had a book aboard, in manuscript, handed down for generations, in which were drawings of all the prominent hills and headlands of both coasts, with compass courses and distances and other matters of direct importance.

If the Asians had been as good navigators as they were shipbuilders and sailors, they might have discovered America centuries be-

ROBERT MOORE, NATIONAL GEOGRAPHIC STAFF; EKTACHROME (BELOW) BY LLOYD A. SMITH © N.G.S.

Temple carving of about A.D. 1200 in Angkor Thom, Cambodia, shows a ship with the high overhanging stern still seen in Hong Kong Harbor (left). Sailors in the relief trim the sheets, while two passengers play chess. Down goes the anchor at left. Fishermen below cast nets. River boats dodge crocodiles.

Tousled youngsters play at the tiller of a timber-laden Chinese junk.

Barefoot Sindbads haul on halyards after sheeting home a lateen sail aboard a Kuwaiti boom. They hoist the sail and swing the yard by hand.

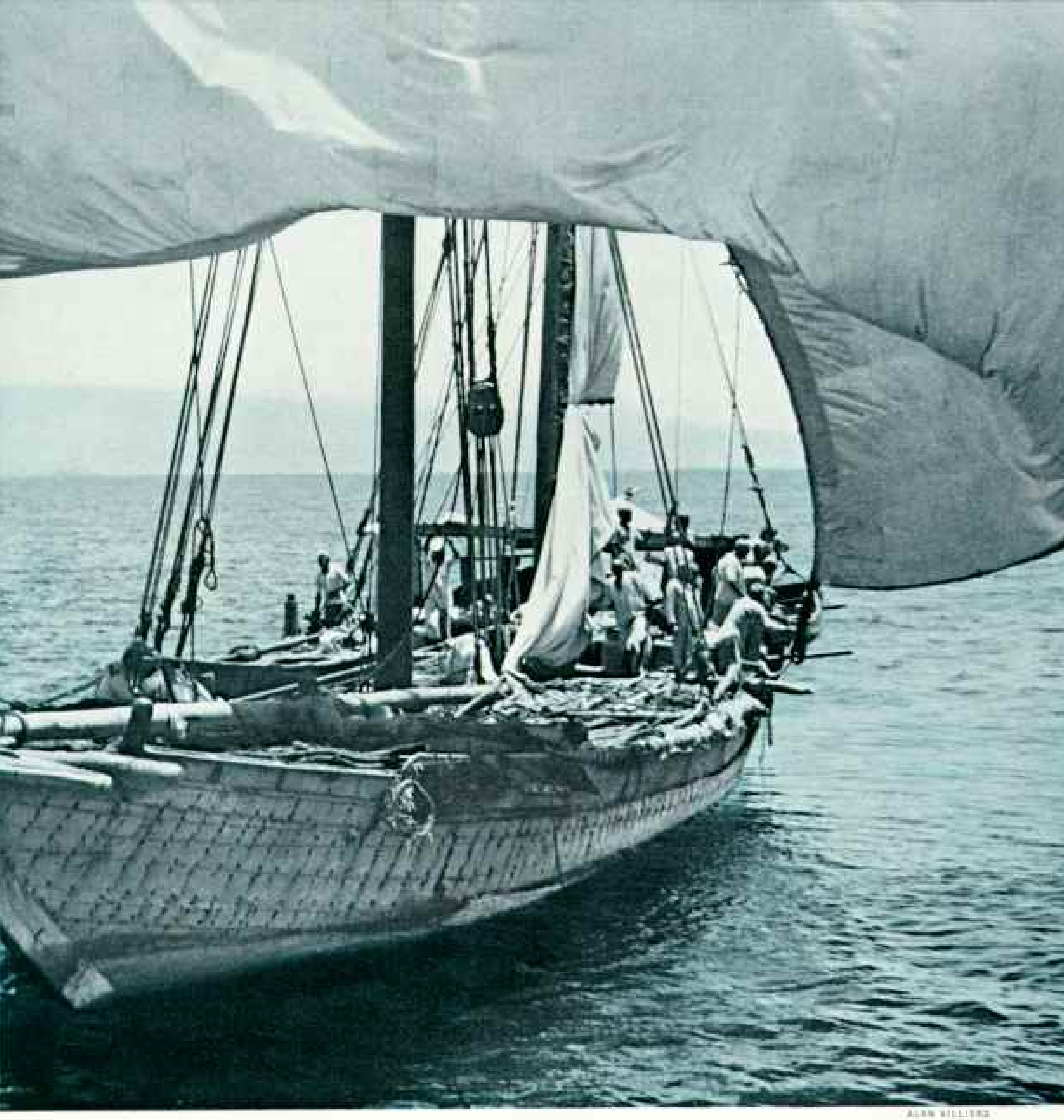
Canvas bellies in the breeze as a nail-fastened Arab dhow gets under way. Long teak nose marks her as a Kuwaiti boom. Vessels such as this show little change from Bible days. Crewmen eat and sleep in open.

fore the Europeans. But they were content with the sailing they knew.

Many were accomplished mathematicians and understood the movement of the major stars. Arabs of the Middle East perfected the astrolabe, a complicated instrument of great value in land surveying. They knew that on long desert journeys he who understood the stars and their movements would arrive where he was bound. Follow the star? It was not as easy as that, for most stars appear to move. It was their regular and predictable movement that had to be comprehended by travelers upon sand or water. In deserts, the navigator had the advantage of a stable element. He could use more effectively the delicate, finely adjusted astrolabe to establish his position because he could keep it still. At sea there was no such stability.

"The Admiral was unable to take the altitude, either with the astrolabe or with the quadrant, because the rolling caused by the waves prevented it," Columbus's journal records on Sunday, February 3, 1493.

What Columbus needed was knowledge of his latitude through the noon height of the sun. With that, and a carefully kept reckoning of the distance he sailed west to estimate his longitude, he had a good enough idea of where he was. To work out his latitude was a comparatively simple problem of figuring how far his ship was north or south of the place


ALAN VILLIERS

where the sun was directly overhead, at ship's noon. The astrolabe measured the angle of the sun above the horizon at noon; his books told him where the sun was then overhead, for this was predictable. The "back-room boys" had tabulated that knowledge—and they still do, in nautical almanacs.

British Aid Navigation

Not until the English mathematician John Hadley introduced his quadrant in 1731 did good observations of the sun's altitude become possible at sea. Hadley's instrument, employing mirrors, permitted observations by reflection, avoiding the sun's glare that was so destructive of accuracy. In time the quadrant developed into the sextant, still in use.

Knowledge of the means of working out a ship's longitude came later. Latitude could be worked by simple mathematics, once noon altitude was known, but to establish longitude called for solution of a complicated problem in spherical trigonometry in which one factor was precise measurement of time.

For this, a perfect clock was necessary. This was the chronometer, and its perfection had to wait until late in the 18th century. The English explorer James Cook was the first to make real use of the accurate marine chronometer developed by another Englishman, John Harrison.

Before Cook's time, many famous voyages

SAILS VANQUISH OARS *off the Flemish coast in 1602 as a Dutch man-of-war grinds a Spanish galley underfoot. Oared vessels offered mobility in calms, but proved no match for square-riggers in a breeze. Unable to bring her fixed bow guns to bear, the Spanish craft took a fatal blow amidships. Doomed rowers now struggle in the splintered wreckage. High Dutch hull thwarts boarders. Artist Hendrik Cornelisz Vroom left his name and date on the white bar of the victor's ensign. Dutch ship shows the evolution of the strong European three-master, able to go anywhere.*

PAINTING BY SEYMOUR LUCAS, LEICESTER ART GALLE

had been made with no better means of navigation than reckoned distance, an approximate knowledge of latitude most of the time, and well-kept compass courses. With these went a sharp lookout, frequent stops by night, and soundings by lead line when possible.

In the days of sail, such navigation methods were satisfactory, but for powered vessels precise methods were required.

Even when I first went to sea more than 40 years ago, old sailors were still taking ships on voyages by the "three L's"—log, lead, lookout—with a fourth L for latitude when necessary. In coastwise schooners, knocking about the Mediterranean or the Caribbean, personal know-how still counts. I was in a Tasmanian lumber schooner once that navigated only by the three L's.

"We only load wood, don't we? We'll float," said her captain, filling the hollow bottom of the lead with a piece of galley fat to see what sort of sand, mud, or broken shells might be

ANS MUSEUM © NATIONAL GEOGRAPHIC SOCIETY

PAINTING BY WILLEM VAN DE VELDE THE YOUNGER, NATIONAL MARITIME MUSEUM, GREENWICH, ENGLAND

Storm-tossed *Resolution* reels under the onslaught of wind and wave. Commercial rivalry plunged England into three wars with Holland between 1652 and 1674. The need for larger all-weather warships produced this tall-masted 70-gunner of increased firepower.

Lords of the Admiralty study a scale model of an English man-of-war that incorporates scientific advances. Designer with quill extolls this 17th-century model; it served as a guide to the builder. Samuel Pepys, famed diarist and secretary of the Admiralty, sits at the far end of table.

found sticking there when he hauled it up again. He said the nature of the bottom would tell him where he was.

But one day after I left her, that schooner loaded a cargo of benzine and sailed for Port Adelaide, South Australia. She has been missing for more than 30 years.

I think the Chinese were the greatest of all Asian seamen, and their junk the most wonderful ship. Hundreds of years ago, the seagoing junk embodied improvements only relatively recently thought out in European ships—watertight bulkheads to isolate hull damage and so keep the ship afloat; the balanced rudder which makes steering easier; and sails extended with battens.

Marco Polo, who visited China in the 13th century, tells of junks that had 60 cabins, as well as other accommodations for a crew of three hundred. The lower hold of the largest vessels had 13 watertight compartments, and such ships made voyages of several thou-

sand miles. Some junks traded, at times, to the Persian Gulf, the Bay of Bengal, and the coast of East Africa.

The influence of the junk was immense in the East. In the 1960's the type is still to be seen sailing out of Chittagong in East Pakistan. Chinese junks may have sailed eastward to California. There is a tradition of one such voyage made about the year 200 B.C. to a land called Fu-Sang, possibly California; the captain's name was Hee Li.

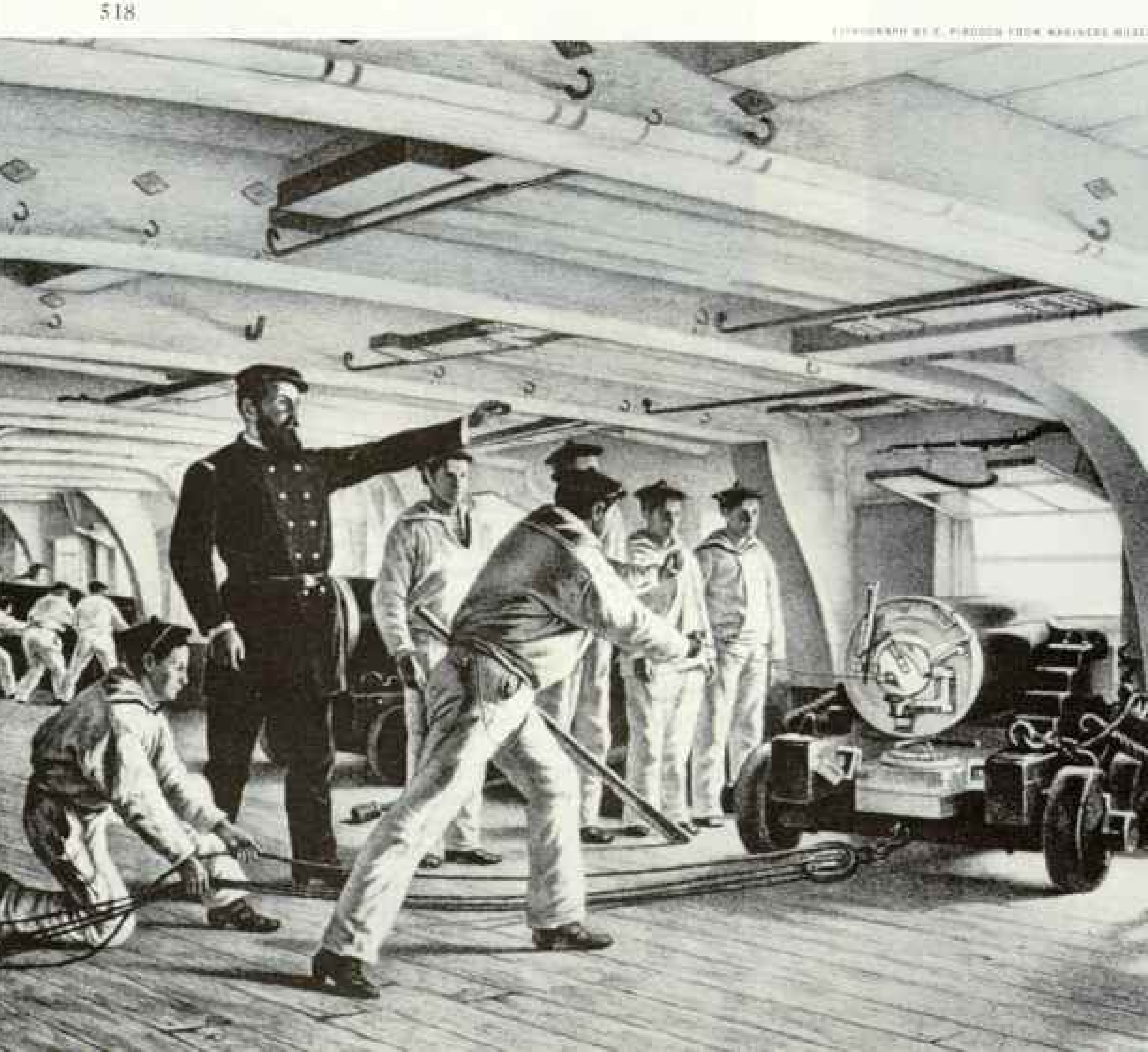
Big ships are no new idea. Vikings built long vessels. The late 15th and early 16th centuries saw several huge ships.

Henry VIII's giant *Henry Grâce à Dieu* was a four-master with eight decks in the stern, 385 guns, and two mizzenmasts, each carrying one lateen sail. Each of the many upper decks was stoutly secured and could be cut off from the others, in case of boarders. The only point where such a ship could be boarded was in the waist. But here the invaders could be promptly blown to pieces by swivel guns, mounted on the castles and known as "murdering guns" (pages 494-96).

There were many other sorts of big ships besides odd enormities like *Henry Grâce à Dieu*. There were carracks, galleons, and round ships called naus—a confusing nomenclature. The famous treasure galleons of Spain were massively built and heavily armed—the battleships of their day, with tremendous freight capacity. But they were as slow as time.

Carracks Carried Heavy Cargoes

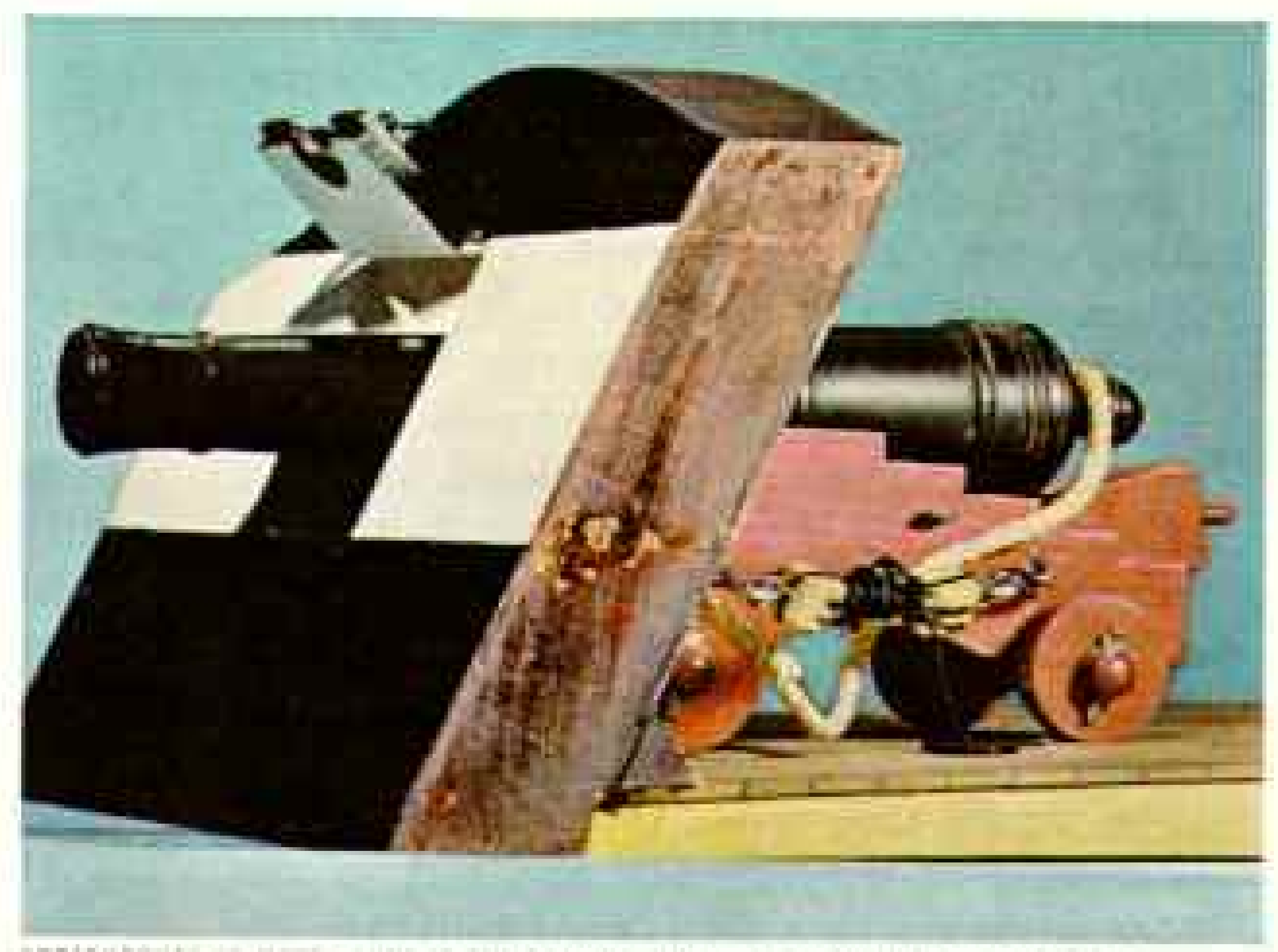
When Portuguese enterprise opened the trade of India to European exploitation, in the 15th century, small caravels and barks were insufficient to handle the merchandise. So the carrack was produced. A vast barrel of a ship, she could scarcely sail out of her own way. Her beam was half her waterline length; her castles soared to amazing heights.



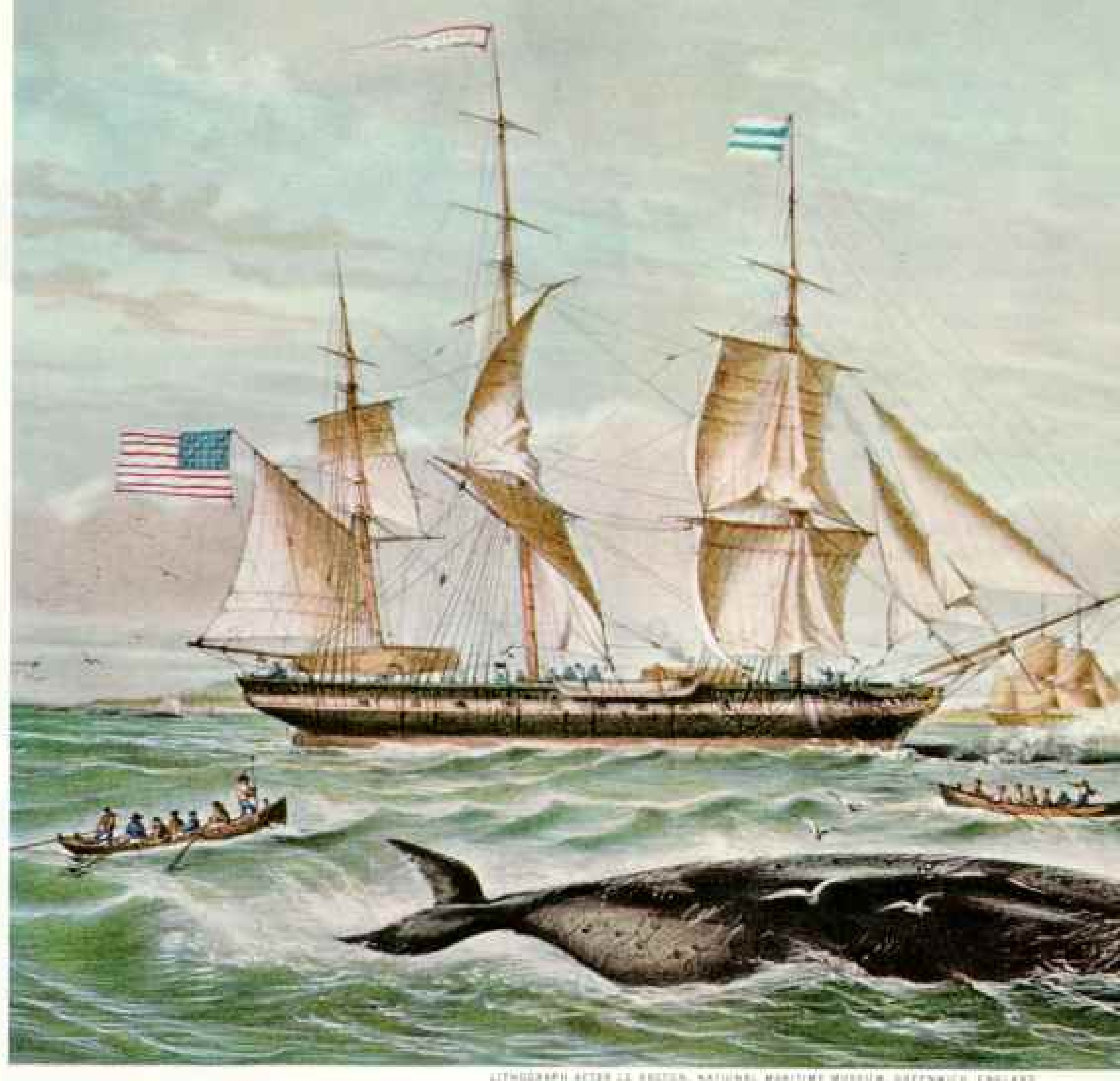
Ship-borne guns, introduced in the 14th century, grew steadily bigger and more deadly. Swivel-mounted "murderer" at top blasted boarders. Welded iron bars and hoops formed the barrel of the lombard (second from top). Four-wheeled saker (third), which went to sea in the 17th century, threw a nine-pound ball 4,000 yards. Ship-killing 24-pounder armed the U. S. frigate *Constitution* and survived until the Civil War spawned rifled guns and armor plate.

Ready to fire. French seamen snap to attention in an artist's conception of 19th-century gun drill aboard the training ship *Austerlitz.* With firing lanyard in hand, the gunner's mate awaits the instructor's hand signal.

NEWPORT NEWS, VIRGINIA © NATIONAL GEOGRAPHIC SOCIETY



KODACHROMES OF MODEL GUNS IN THE NATIONAL MUSEUM, SMITHSONIAN INSTITUTION, BY ROBERT S. OAKES, NATIONAL GEOGRAPHIC STAFF © N.G.S.



LITHOGRAPH AFTER [illegible], NATIONAL MARITIME MUSEUM, GREENWICH, ENGLAND

The largest carracks could carry a thousand tons of cargo and hundreds of troops. They were expected to make only one voyage annually, but profits were high. If they stayed clear of rocks and shoals and were not dismasted, and if they arrived with their rich cargoes in good order, and perhaps half their crews alive, that was enough. No more was asked of the sea freighter of those days.

By this time, the common ship had three masts. Sailors worked on the yards without footropes. Sailors were expendable, anyway. If one or two fell from the rigging, death only came more swiftly. Actually, few fell. In all my sailing ship experience, I never saw a man fall from the rigging. Nervous characters did not go to sea as sailors.

In waters that suited them, smaller ships continued to flourish. For instance, in the Mediterranean the galley lasted until the 19th century. In such a sea, oars were the auxiliaries, and they did that duty until steam engines put them out of business.

Captives Provided Manpower

Big sailing ships could not work oars. For such power to be of use, ships had to be shallow-draught, slim, long, low. Hence the galley, which was all these things. Manpower came from captures in warfare or piracy, or plain slavery.

Despite their great oar power, it is doubtful that galleys ever moved at the speed of a Harvard or Oxford eight, except for rare bursts to drive home the underwater ram into an enemy's side. Men could not sustain such heavy work for long.

After the era of the Crusades, Venetian and Genoese galleys were still sailing the Mediterranean, carrying ever increasing car-

goes of valuable merchandise. In the early 14th century the Venetians organized a fleet of great galleys, which sailed to England and Flanders. Others traded to the Levant.

Venice paid tribute to her ships in the *Sposalizio del Mare*—Wedding of the Sea—held annually on Ascension Day, when gilded galleys and gondolas followed the Doge in a parade.

Fighting galleys were still armed with a heavy ram forward, below the surface, and also, from the 15th century, a battery of guns lined up abreast on the foredeck; one of them was as heavy as possible. Rowing up on a ship, the galley gave her a burst with these guns just before boarding. Her deck could accommodate large numbers of soldiers—or pirates.

Long after they ceased to be of much

Whaler takes aim as his boat draws close. Lying off the Cape of Good Hope, *Uncas* backs sails to launch more boats after a pod of whales.

Whale strikes back! One flick of its giant flukes shatters a boat and hurls the hunters into the foam.

use for warfare, galleys remained the favored vessels of Turkish and Algerian pirates. Then rigged with two masts carrying huge lateen sails, they could really move under sail as well as with oars.

But they were very vulnerable. Once the big guns were fired, they were difficult to reload. They could be aimed, like the ram, only by pointing the whole ship.

The famous Knights of Malta maintained a fleet of galleys for centuries, to fight the infidel. At the Battle of Lepanto in 1571, when the Turks were decisively beaten in one of the most famous naval encounters in history, the combined fleets of Spain, Italian city-states, Sicily, Malta, and the Pope numbered more than 200 large galleys, and the Turks had more.

After Lepanto, when oared fighting ships began to disappear from the Mediterranean, both Sweden and Russia introduced them into the Baltic, where rocks and shoals imperiled the pure sailing craft. At first these Baltic vessels were galleys, but they soon became small sailing ships, resembling more the northern square-rigger than the Mediterranean galley. Their auxiliary power was usually 18 to 20-odd pairs of long oars worked from the gun deck. Such ships were built in the Baltic as late as 1809.

Francis Drake Leads the Way

In 1577-1580, the Englishman Francis Drake took a small three-master, *Golden Hind*, around the world without a base anywhere. And she was not even as large as a small modern tug. One leg of that circumnavigation was from Java to Sierra Leone—9,700 miles—without a port of call or a stop for maintenance.

Drake's circumnavigation demonstrated seaworthiness and seamanship as never before. By the end of the 16th century European sailing ships could go anywhere there was water to float them.

Merchantmen developed lower hulls and greater cargo capacity. They still had to be prepared to fight, but with the introduction of gunports cut into their hulls, naval ships could battle each other anywhere at sea.

Warships went down the ways beautified like pampered queens—their upper gunports ringed with gracious carving, their aftercastles carved and windowed. Angels, cupids, lions, sculptured kings adorned them.

But these lovely ships were no pampered dolls; they were the ships that fought. When they came to grips, it was a real roughhouse. First they hammered one another with broadsides and then, if possible, clashed and boarded.

They flung more than simple balls of iron. They used slung shot to cut the rigging and bring down masts, grapeshot to kill as many men as possible, heated shot to start fires. They went for each other hell-for-leather, and battles were bloody and sometimes long. In fact, blood ran so freely on decks and in the scuppers that it was the practice to paint the bulwarks inboard a bright blood-red, on the principle that they would soon become that color anyway.

Sovereign Fights in Splendor

In the 17th century shipbuilding began to depend more on mathematics and science than on tradition. King James I of England hired a Cambridge M.A., Phineas Pett, as his naval architect to produce finer fighting vessels. Pett produced such outstanding ships as the 96-gun *Prince Royal*, 1,400 tons, and the *Sovereign of the Seas*, most powerful man-of-war in the world when launched in 1637, and never defeated.

The *Sovereign* was a full three-decker carrying a complete tier of big guns on each deck. She had royals set above her topgallant sails, and a real mizzen carrying square sails as well as a large lateen. She steered by tackles, which must have been very heavy. Wheel steering was introduced about half a century later.

She was gilded, painted most lavishly, varnished, polished, carved, and embellished with figures, scrollwork, and circling laurel leaves. The bill for her decoration came to a sixth of her total cost.

But she was a tough ship, all the same, and magnificently built. Cut down to a two-decker in 1652, she fought in just about all her country's naval engagements, which were more than a few, and she gave a pretty good account of herself until 1696, when she burned at dockside.

Such ships could stand bad weather. They had to or they were of little use in the narrow, stormy seas of the English Channel and its western approaches, or the gray old North Sea. During peaceful periods they may have spent most of their time in port but, once war began, they had to be able to keep the sea for long periods.

Development of the anchor and rudder

TO ANCHOR his craft, the early mariner tied a stone on a line and tossed it overboard. But stones, no matter how heavy, could slide. So sailors added grapnel-like teeth to bite into the bottom.

Traditional anchor shape evolved by the time of Christ. Barges of the Roman Emperor Caligula carried anchors of wood and iron. Vertical shanks had horizontal stocks that prevented the arms from twisting free.

Arrowhead-shaped flukes of the 18th-century anchor gave a firmer grip. Hinged flukes make the modern stockless anchor easy to carry and burrow in when it drags along the sea floor.

Steering gear shows a similar evolution. Egyptians used two or more oars worked by tillerlike levers. Vikings mounted a steering oar on the starboard (steer-board) side. The stern rudder, hinged on the center line and presenting a larger surface, deflected water better, turned the ship faster, and was more seaworthy.

When added decks buried the helmsman, the whipstaff enabled him to swing his tiller by remote control. Block-and-tackle rig smoothed the action, multiplied power, and allowed wheel steering from an upper deck. Big ships still use steering wheels, but power turns their rudders.

DRAWINGS BY DONALD BRETT © N.G.S.

Phoenician anchor

Egyptian steering oars

Primitive grapnel

Viking steering oar

Roman (wooden with lead stock)

Roman (iron)

Medieval stern rudder

18th century

Modern stockless

16th century whipstaff

18th century steering wheel

Men such as Pett were helped by the enterprising and able Samuel Pepys, the famous diarist who served for years as secretary of the Admiralty of England (page 516).

After Pett and Pepys, warships remained much the same for 200 years. Great monopolies in merchant shipping, such as the East India Company, were good for profits, but they froze merchant ship development.

In essence the sailing ship of the line remained little changed until the reluctant acceptance of power put an end to her, in the middle of the 19th century. A sailor from *Henry Grâce à Dieu* could easily have jumped three centuries and fought aboard *Victory* at Trafalgar, in 1805; or with John Paul

Twin girls in wood decorated the bow of a now-forgotten square-rigger some 130 years ago. A vessel's name often dictated the woodcarver's design. These dainty blondes, possibly the shipowner's daughters, may have graced a brig with a name like *Twin Sisters* or *Ann and Eliza*. Marine Historical Association, Mystic, Connecticut, preserves the figurehead.

Top-hatted effigy takes a sight with a quadrant, clumsy forerunner of the sextant. New York Historical Association, Cooperstown, displays the relic, which may have identified an instrument maker's shop. As shipbuilding declined, carvers turned to cigar-store Indians and circus-wagon ornaments.

Clippers and down-Easters

Jones aboard *Bonhomme Richard* against *Serapis* in 1779. The boatswain of 1580's *Golden Hind* would have been an excellent man aboard *Constitution* during the War of 1812. Wheel-steering, though strange at first, would not have bothered him, for it was a simple and obvious improvement.

The wheel was introduced, apparently, early in the 18th century, at least into English ships; but, like so much else in the story of the ship, no one can say who invented or developed it, or even which country. Probably some bright watchkeeping officer, fed up with whipstaffs and their awkwardness and kicks from steering tackles and clumsy windlasses, came up with the idea. Once demonstrated, it was so obvious that everyone accepted it, and forgot where it came from (page 525).

Sailing ships of war were built as late as the 1850's, with the same old rigging plan and sides pierced with gunports. But the English had a steam naval sloop by 1843. The French *Napoléon* (1850) and the British *Agamemnon* (1852) were the first real steam line-of-battle ships with screw propellers.

The sailing navy was ended. It was great while it lasted, and it lasted a wonderfully long time.

Today at least two sailing warships survive in a restored and properly rigged condition, to show us what once was general. The U.S.S. *Constitution* is preserved in the

nuzzle the New York waterfront. Steeving jib booms salute shops along South Street

NATIONAL GEOGRAPHIC STAFF, AND EKTACHROME BY W. D. VAUGHN. PAINTING BY CHARLES ROBERT PATTERSON FROM THE BERWIND-WHITE COAL MINING CO., NEW YORK © N.G.S.

U.S. Naval Shipyard at Boston, and H.M.S. *Victory* still acts as flagship of the commander in chief at Portsmouth, England.

The old "wooden walls" were finished by the mid-19th century, but the big sailing merchantman lasted another 100 years. Here the American contribution was immense and magnificent. In Europe development was often held back by undue conservatism. In the United States after the Revolution, man was free. So was enterprise.

Privateers Win China Trade

There was no American Navy when the Revolutionary War began, so privateers were used. A privateer was any armed merchantman with guts enough to fight under her country's flag, and there were hundreds. One of the best was the ship *Grand Turk*. By 1785, her war work finished, she was sailing around the Cape of Good Hope to Mauritius and on to China, making wonderful profits from her enterprise and sailing skill. Before long, American ships had won a practical monopoly of the China trade.

The *Grand Turk*'s owner, Elias Hasket Derby of Salem, is rated as one of America's first millionaires. He sent ships wherever he could find trade—to India, Java, China, Mauritius, the Philippines. They were small ships and their cargoes were minute, by later standards. But the teas, spices, and so forth which they carried brought high prices in a rich and growing market. The little ships paid well.

Fast ships were needed for such Yankee enterprise. The Baltimore clipper brigs and schooners led the way. Know-how in tough ocean sailing, gained from the splendid square-riggers of the North Atlantic passenger trade, led to the development of the big clipper ships. Soon these swift, stately, and glorious vessels were racing over the sea routes, under their clouds of white cotton canvas, as cargo-carrying ships never had been raced before.

No wonder they continue to inspire artists and writers! Storming out to Australia from England, full of emigrants and cargo, or fighting the savage, ceaseless gales off fierce Cape Horn, California-bound for gold, the swift, lean, racing clippers were glorious, unrivaled, almost incredible. Theirs was the most marvelous era the sea had ever known, and they were unquestionably the most wonderful ships.

Outstanding among the clipper builders was Donald McKay, born in Nova Scotia, of Scots descent, New Englander by adoption. He designed and built a succession of beautiful and highly successful ships whose names are still household words. His glorious *Lightning* streaked like lightning across the seaways of the world. His *Champion of the Seas* was just that, and his beautiful *Flying Cloud* flew like a white cloud of grace and strength and beauty over the sea as ships had never done before. *Lightning* was only one of his creations to exceed a 400-mile day, hitherto unknown. His *Sovereign of the Seas* once sped 6,200 miles in 22 days; his *Flying Cloud* raced around the Horn to San Francisco in less than 90 days.

These ships still stir men's hearts in a way no other ships did, or can. In the Hamburg office of a German shipowner friend of mine—the man whose father, F. Laeisz, owned the renowned Flying "P" line of great four- and five-masters—pride of place goes not to the massive, powerful, gale-slugging Cape Horners of those later days. The only model in his room is the graceful little *Flying Cloud*. The perfection of her lines and the memory of her sailing deeds are balm in a worrying world.

She could make 19 knots. This was sailing! Drive, drive, drive, men and ship—that was the way of it.

Steamers Edge Out Sailers

But the clippers' day was brief. They were evolved too late. When the clippers were in their prime in the 19th century, the steam engine was already steadily advancing, mainly in Britain.

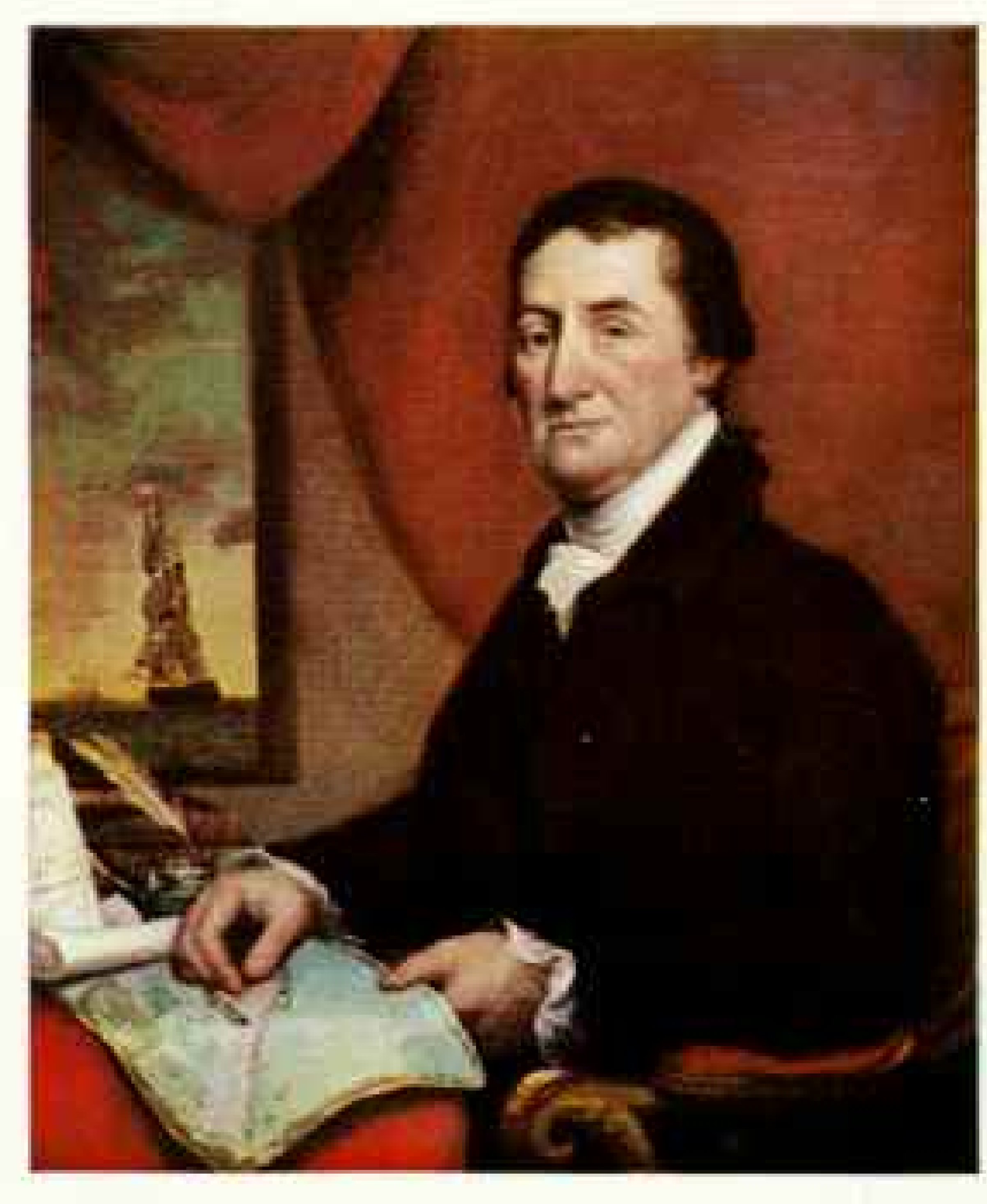
Here cheap coal, iron ore, and abundant labor, combined with an island's dependence on shipping, gave Britain a lead which she grasped with both hands. Plodding iron ships, their screw propellers ever thrusting them forward while black smoke belched from their thin, high funnels, were marching over the oceans of the world in increasing numbers, carrying everything.

The clippers were wooden ships. Hard driving wore them out swiftly. The opening of the Suez Canal in 1869 gave even the comparatively inefficient steamships of that day too great an edge on the ships of sail. Britain, which started late with clippers and built some beauties, concentrated on steam. Before the end of the 19th century, Britain

WATER COLOR (ABOVE) BY ANTOINE ROUX AND OIL PAINTING BY JAMES FROTHINGHAM, PEABODY MUSEUM OF SALEM © NATIONAL GEOGRAPHIC SOCIETY

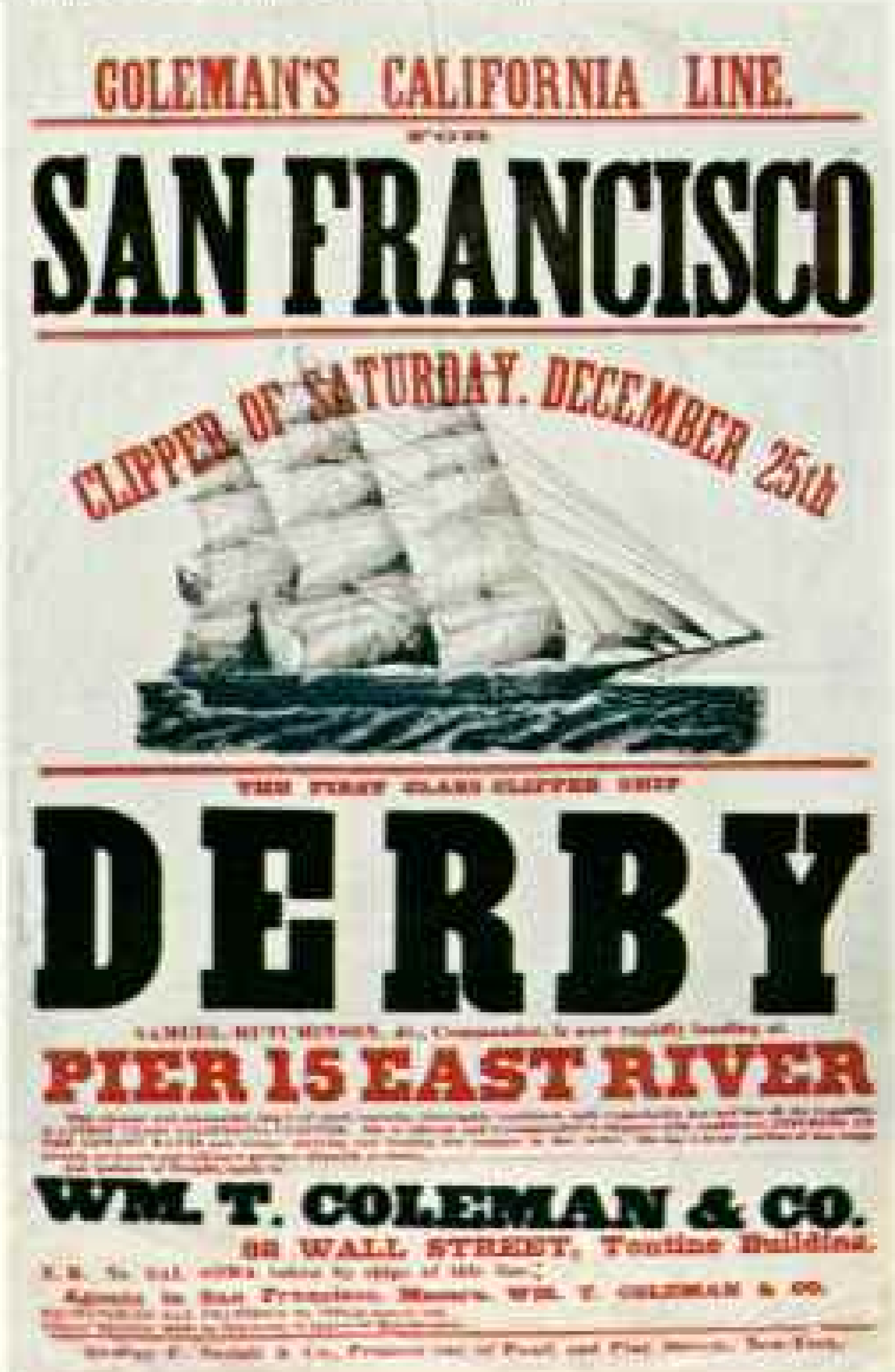
Profitable privateer, the brig *Grand Turk* fires a salute to Marseille, France. In five cruises during the War of 1812, the doughty 18-gunner took 31 English prizes.

Elias Hasket Derby prospered from privateering during the American Revolution. Voyages of two earlier *Grand Turks* helped make him one of the Nation's first millionaires.



For readers seeking further information on man's nautical progress through the ages, the Society proudly recommends its most recent book, *Men, Ships, and the Sea,* to which Capt. Alan Villiers and other noted maritime authorities have contributed. This beautifully illustrated volume of 436 pages, with 259 color plates and 27 maps, is available at $9.85, postpaid. It can be ordered only from the National Geographic Society, Dept. 70, Washington 6, D. C. Specify later billing if desired.

PAINTING BY MONTAGUE DAWSON, COLLECTION OF NELSON MOORE © FROST & REED, LTD., LONDON



FROM PEABODY MUSEUM OF SALEM, MASSACHUSETTS

Calling all forty-niners! Determined to cash in on the scramble for gold in California, a clipper owner appeals for freight and fares. Cost of a New York-to-San Francisco passage ranged as high as $1,000.

Tall-sparred and built for speed, the clipper ship was so called because it raced along at such a good clip. The swift square-riggers set the world's first permanent sailing records: In 1854 *Flying Cloud* raced from New York to California in 89 days 8 hours. Slow ships needed as much as 240 days.

Racing Neck and Neck, Tea Clippers Drive for London With All Sails Set

Nearing the finish of the tea race of 1866, *Ariel* and *Taeping* set every possible stitch in one of sailing history's most famous tests of speed. They compete for a bonus of 10 shillings a ton for the first tea to reach London and £100 for the winning skipper.

Loading together at Foochow, China, the clippers crossed the bars of the Min River the same day. They sighted each other briefly in the South China Sea, then split tacks and lost contact. Drawing together again 15,000 miles from Foochow, they piled on pyramids of sail for the sprint up the English Channel. They docked on the same tide, 99 days out. *Taeping* led by 20 minutes, but the captains split the prize money.

PAINTING FROM ADDISON GALLERY OF AMERICAN ART, PHILLIPS ACADEMY, ANDOVER, MASSACHUSETTS

As sun breaks through clouds after a storm, a Yankee schooner captain grabs a quick noon sight. When sun reaches its zenith, he shouts, "Eight bells!" His mate checks by making a similar observation. The artist, Winslow Homer, settled on the Maine coast and went to sea with the fishing fleet. He said he painted his subjects "exactly as they appear."

Lovely lady ghosts past a channel-marking buoy. Unlike the square-riggers, the schooner spreads her sails abaft the masts and takes the breeze on either side of the canvas. This fore-and-aft rig enables her to beat against contrary winds and makes her easy to handle—"one mast, one man," as sea dogs tell it.

owned nearly 11,000 ships of some 14 million tons, or half the world score of 28 million tons.

As to the American sailing ships, their very excellence was, in part, their undoing. They were so good they were retained too long, while the tramp steamer and cargo liner steadily took a greater and greater share of the world's trade. Yankee businessmen found better outlets for their resources and their enterprise than ships. Go West, young man! was the cry; and he could go West by land.

Deserted Ships Deteriorate

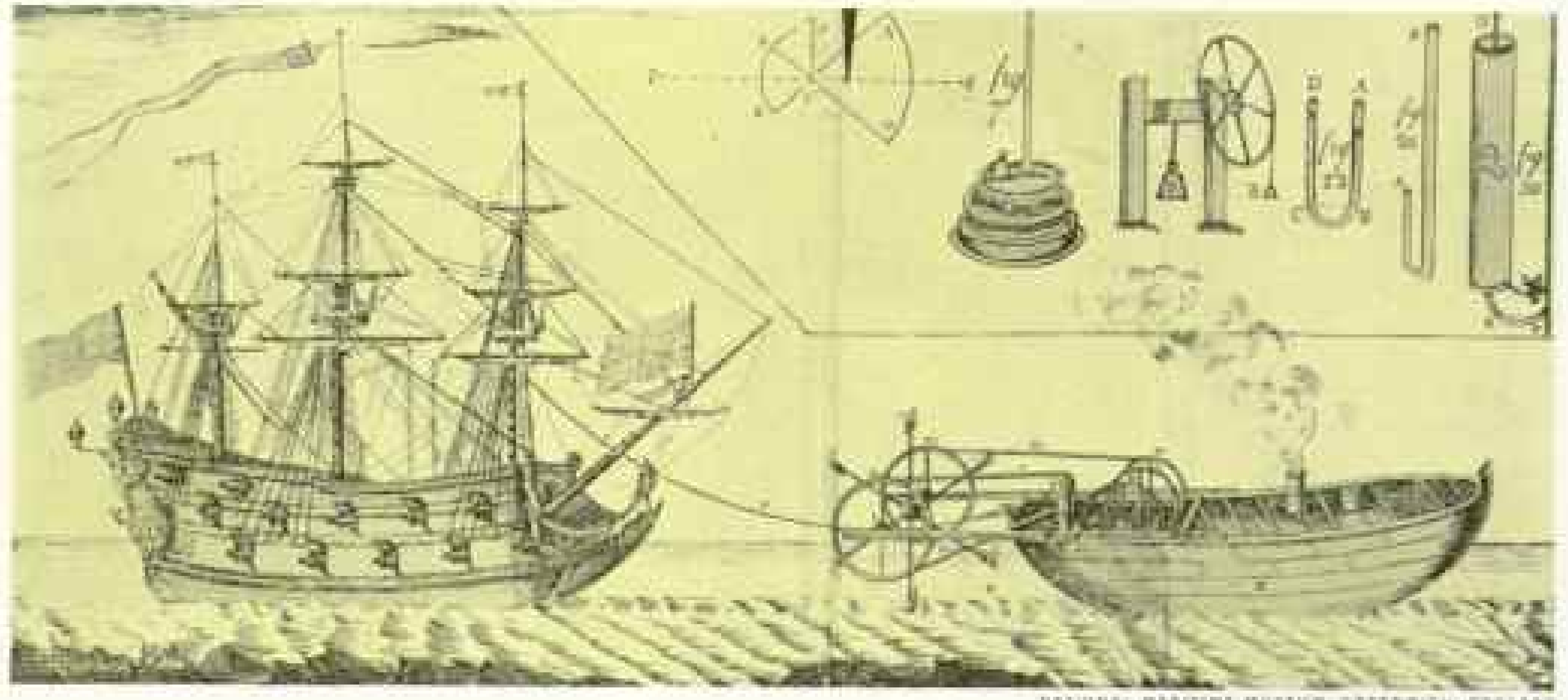
Enterprising American seamen moved ashore. When their clippers reached San Francisco in the gold rush of '49, the sailors rushed off too. They were free men, and the adventurous land had need of them. So the ships languished, rotting at moorings.

For months and sometimes years, graceful wooden sailing ships lay in San Francisco Bay cheek by jowl, packed so tightly you could almost walk across them. Not a crew could be found to man any of them.

Ships deteriorate when not used. Some were berthed close inshore and used for accommodation ships. Others were hauled up to become foundations for waterfront reclamation. Piers were built up on them. The land rolled over them. Sometimes today excavation on the San Francisco waterfront turns up their massive, shapely old ribs.

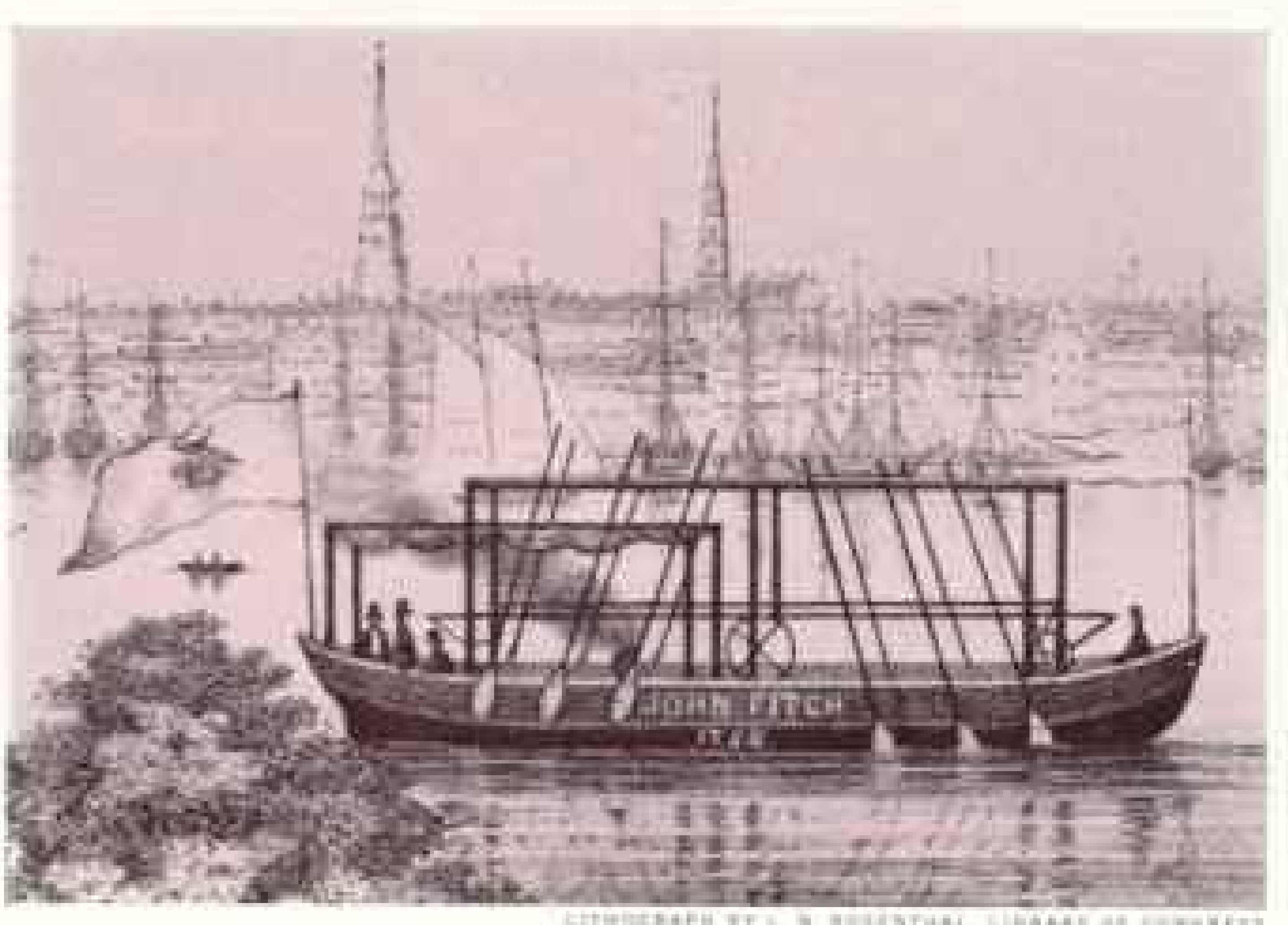
Schooners in dry dock await repairs at Newport News, Virginia, in 1906. This unusual photograph shows the three-master *Sallie I'on*, four-master *Malcolm Baxter, Jr.*, five-master *Jennie French Potter*, six-master *Eleanor A. Percy*, and the only seven-master ever built, the *Thomas W. Lawson*.

PAINTING BY HERBERT GARNETT SMITH; PHOTOGRAPH FROM MARINERS MUSEUM, NEWPORT NEWS, VIRGINIA © N.G.S.



NATIONAL MARITIME MUSEUM, GREENWICH, ENGLAND

Dawn of steam. Jonathan Hulls of London patented a tugboat in 1736. This patent was the first real step in the development of steam navigation. In the drawing, Hulls's boat tows a British warship.



LITHOGRAPH BY L. N. ROSENTHAL, LIBRARY OF CONGRESS

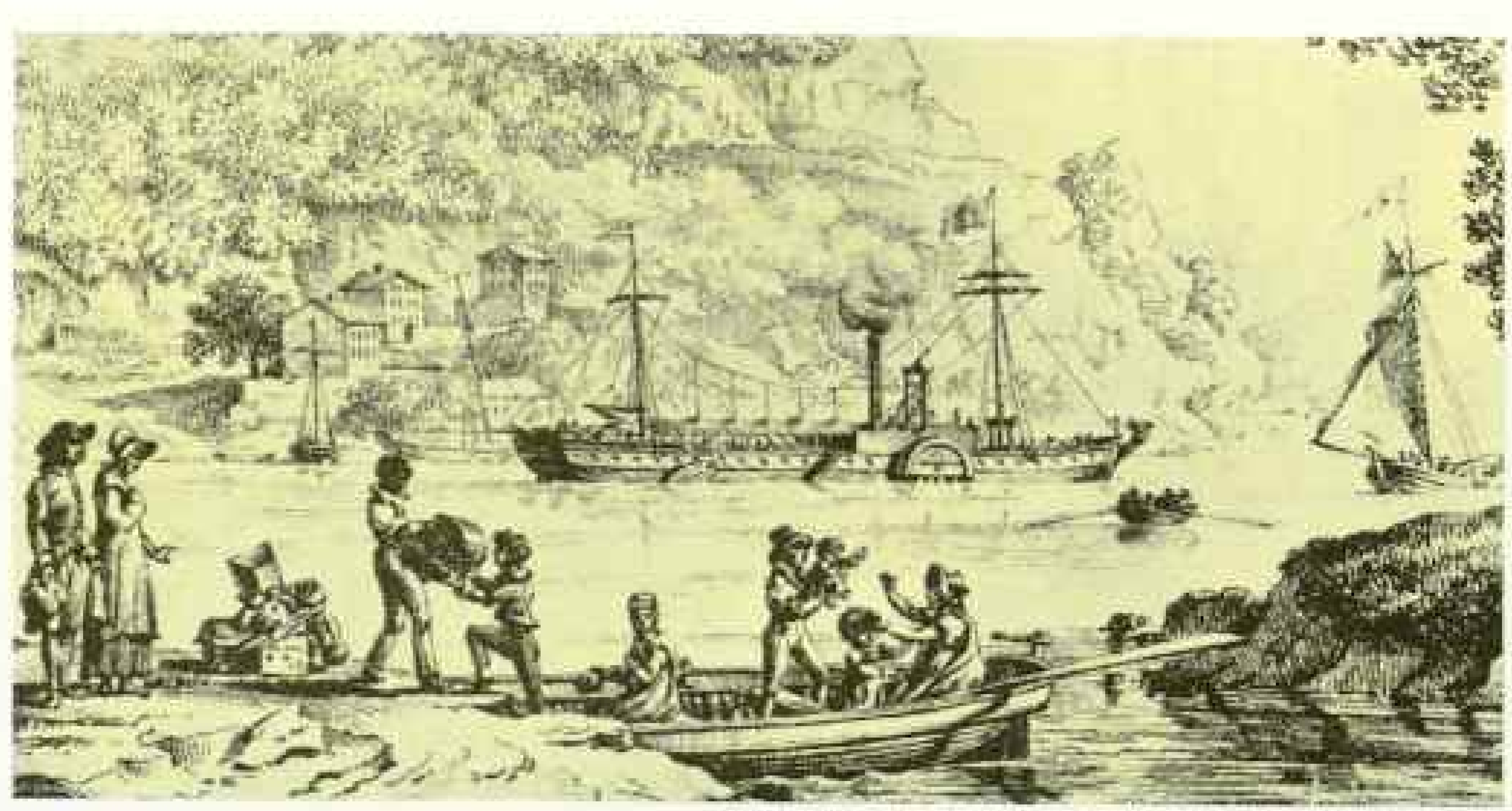
Propelled by upright paddles, a steamer built by John Fitch of Connecticut took its inspiration from Indian war canoes. His craft worked, but rowboats could outrace it.

Savannah Puts to Sea With Paddles and Sails

First vessel to cross the Atlantic with the help of steam, *Savannah* made history in 1819.

This view shows sailors setting the sails to take advantage of the wind, for the 100-foot ship carried little fuel. In a moment paddles will stop, and the crew will fold and stow them on deck. Smoke will fade from the angled funnel that guides sparks away from the rigging.

"Fulton's Folly"—Robert Fulton's *Clermont*—turned jeers to cheers in 1807. She churned up the Hudson River from New York to Albany in 32 hours. Sloops averaged four days.



LITHOGRAPH BY DE F. BERTHAUX, STOKES COLLECTION, NEW YORK PUBLIC LIBRARY

PAINTING BY HERBERT GARRETT SMITH © NATIONAL GEOGRAPHIC SOCIETY

The wonderful red-blooded races of the beautiful clippers were a stirring and romantic spectacle, a rush of romance across the bosom of the rolling sea. But when Suez plus power served the markets better, they were done. Steamships could carry bigger cargoes more efficiently, and regularly.

Chests of tea became just another commodity to be crowded into their ever increasing holds. Spices, silks, pepper, ivory, and other desirable wares were moved now by the ever more reliable steamer, and the merchant knew when they could be expected, to the very day.

The sailing ship found herself left with cheap bulk cargoes such as coal, nitrates, grain, and lumber. With these she could serve as warehouse as well as carrier. Such cargoes, loaded slowly at outlandish ports not considered worth the steamships' while, offered poor profits on long, hard hauls.

The clipper fattened to become the down-Easter, mostly from Maine. She was still sailed hard, but with small crews. No longer did the sea road offer the way to Yankee fortune.

Big iron and steel windjammers continued to be built in numbers in Britain, France, and Germany until after 1900. They tramped about the world under many flags, and some of them were magnificent vessels. With masts and rigging of steel and great, strong steel hulls, they could sail well and shift enormous cargoes with the utmost economy.

Five-master Speeds to Death

Greatest of all was the German *Preussen*, built in 1902. The only five-masted full-rigged ship in the world, she was 433 feet long by 54 feet beam, registering more than 5,000 tons and displacing 11,000. *Preussen* was the quintessence of everything seamen had learned down the centuries. The area of sail on her high steel masts was 60,000 square feet. Steel made her building and rigging possible; the

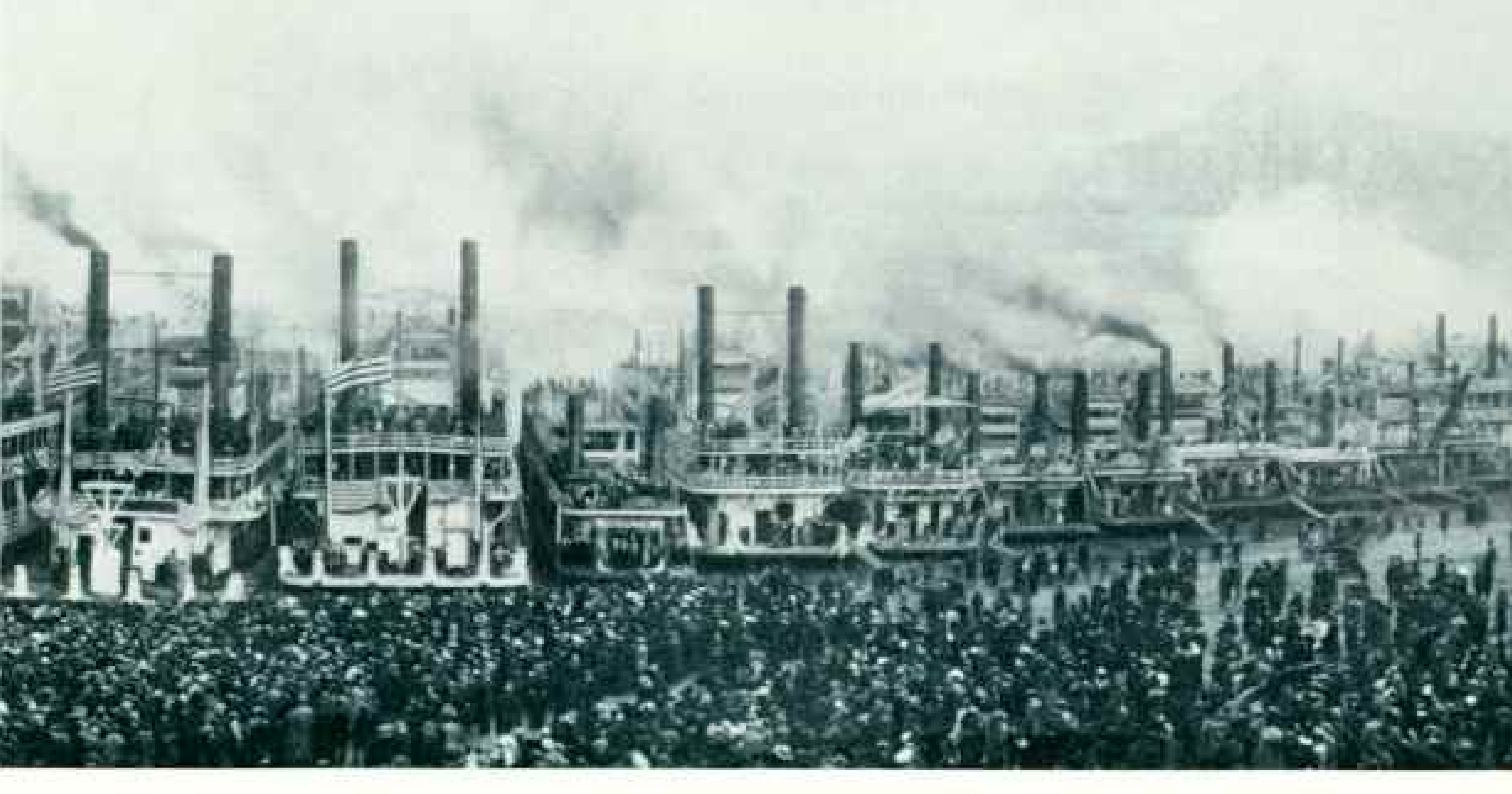
tradition of all her ancestors from Nile boat and Roman to iron ship and clipper contributed to her sailing. And, like the clippers but without their big crews—she carried 42—she was *sailed!*

The *Preussen* lasted only eight years. She averaged 7½ knots on tough voyages to Chile and back, always deeply laden, always having to fight her way each outward passage westward around Cape Horn. She could log better than 17 knots. One day in 1910 a steamer, misjudging *Preussen*'s speed, tried to cross her bows, smashed into her, and forced her ashore in the Strait of Dover. Some of her rusted bones still lie there.

Big four-masters built of steel and often manned by boys continued to sail for 40 years after that, growing fewer and fewer until at last, with the loss of Germany's *Pamir* in a North Atlantic hurricane in 1957, there were no more.

Today there is no longer a sizable pure square-rigged ship sailing anywhere, only some auxiliary square-rigged school ships.

World's largest stern-wheeler, *Sprague* pushed Mississippi tows from 1902 to 1948 and won



Proud boats at Pittsburgh, Pennsylvania, in 1911 celebrate a century of steam on western rivers.

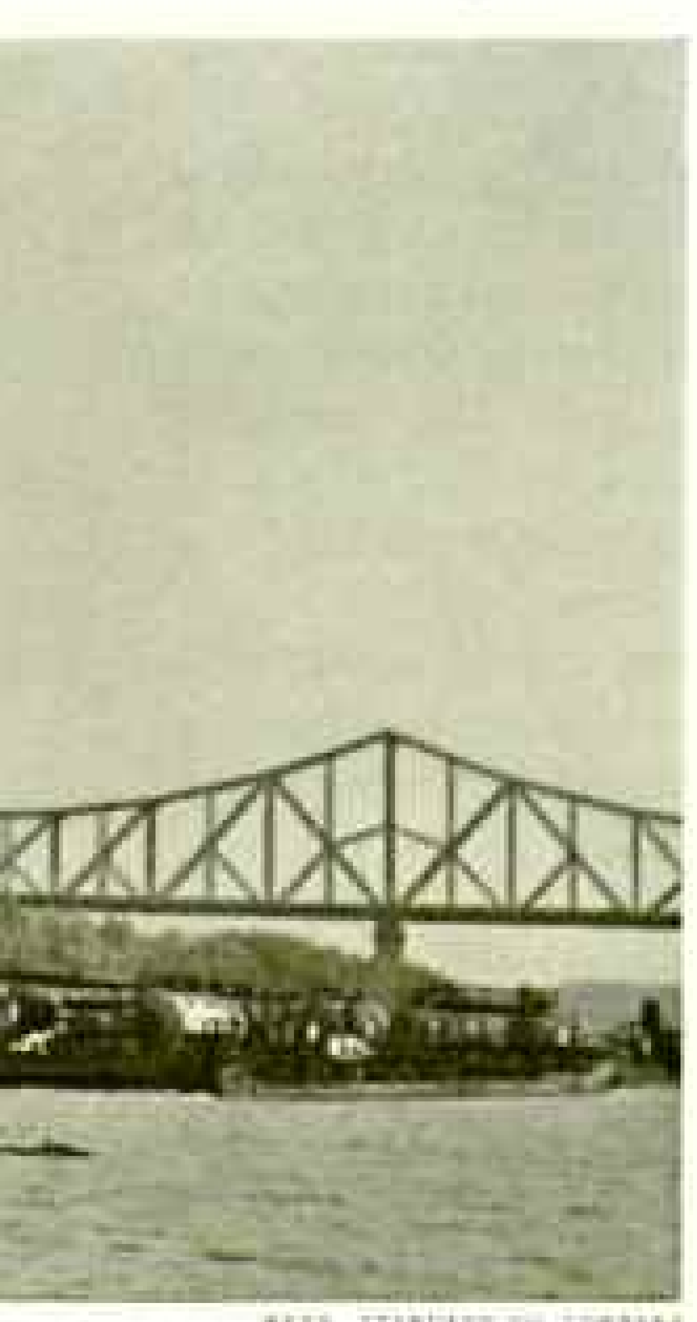
Nicholas J. Roosevelt launched the *New Orleans* at Pittsburgh in 1811. She puffed into the Crescent City 3½ months later.

R. W. Johnston mounted his panoramic camera on a telephone pole to make this centennial picture. Small white-hulled craft is a copy of the *New Orleans*.

Historic 1870 photograph shows palatial saloon of the *Great Republic*. Victorian chandeliers and gingerbread woodwork lured passengers. Flanking the saloon were 54 staterooms. Early U. S. river boats named cabins for states along western rivers.

FROM THE COLLECTION OF LEONARD V. HUBER

renown as "Big Mama"



WEBB, STANDARD OIL COMPANY

Unlike square-riggers, schooners carried their sails *behind* the mast and could accept the wind on either side of the canvas. For that reason they were easier to handle. Schooners, the most economical ships ever developed, reached great size in the United States, with many masts. The only seven-sticker was the steel *Thomas W. Lawson*, which wrecked herself on the Isles of Scilly in 1907 after only five years of life (page 531).

A big fleet of schooners was built toward the end of World War I, mainly on America's northwest coast. Others fished the Grand Banks off Newfoundland. Many of these sailed out of Gloucester, Massachusetts. The schooner rig was ideal for the hard-worked dory fishermen, and Gloucester schooners were fast, able, and handsome ships. But only a dozen big schooners, all Portuguese and mostly built of steel, fish the Grand Banks today. The convenience of trucking, and big towed barges, finished big American coastwise schooners. Diesel draggers drove them from the Banks.

Watched Pot Boils Indeed

A boy named Watt watched a kettle boil, and—in adult life—put sailing ships out of business. The Scot James Watt's production of an effective steam engine in 1765 made the steamship possible. Paddle to screw propeller, wood to iron, bigger and bigger ships, better and better engines—steam piston, steam turbine, diesel, gas turbine. And now engines driven by nuclear power—that is the story.

At first, progress was slow. Seamen were against power, didn't believe in it. What, smut up the clean white sails and the varnished spars, and go against the wind? The idea was satanic to the old sea dog.

One of the first steamers, the small tug *Charlotte Dundas*, operated on the Forth and Clyde Canal in 1802. The *Dundas* towed barges at three miles an hour, but Scots said the wash from her paddles would destroy the canal's banks and hounded her off the water.

A Connecticut Yankee named John Fitch preceded Robert Fulton with river steamers that ran on the Delaware around 1790 (page 532). But Fitch lost his backing. He tried France when the United States failed him, but did no good there either. Fitch's inventiveness merely impoverished him, and he died at Bardstown, Kentucky, his steamship derelict and derided.

Robert Fulton, a Pennsylvanian of Irish parentage, developed the successful steamer *Clermont*. Earlier, he had experimented in France with a minute submarine he called the *Nautilus*. A commission appointed by Napoleon watched Fulton's *Nautilus* blow up a sloop under Brest Harbor in 1801, but did not buy. It was a good thing for Britain. If the French had had *Nautilus*, the outcome at Trafalgar might have been different. Napoleon did not understand sea power.

With one of James Watt's English engines, built in Birmingham, Fulton's *Clermont* was doing nearly five miles an hour on the Hudson River in 1807. She took 32 hours between New York and Albany, but she got there, and kept on doing it. *Clermont* was the first power-driven vessel to carry on a successful commercial traffic.

First Steamer at Sea: *Savannah*

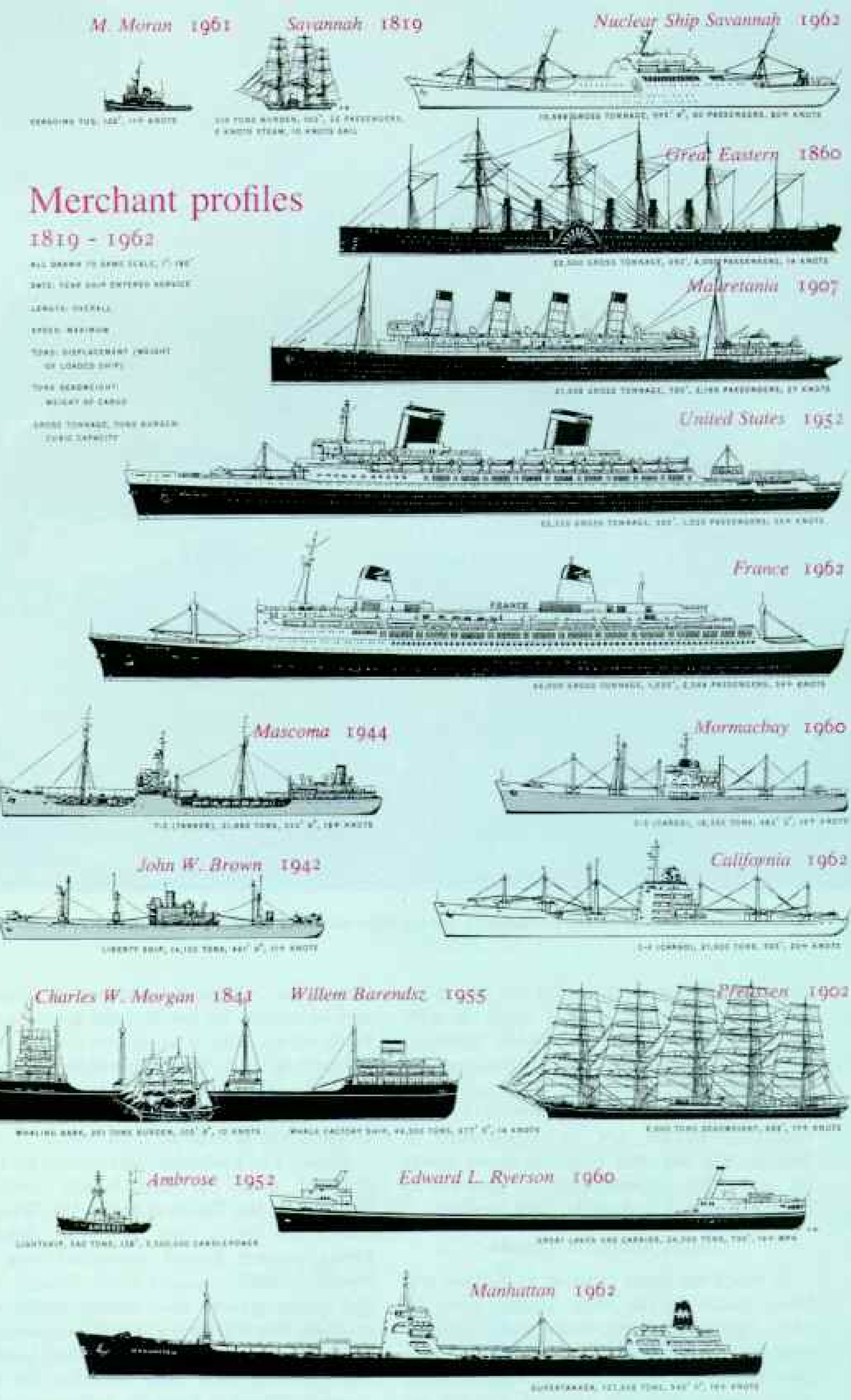
By 1823, more than 300 steamers were at work on American inland waterways, where there was plenty of firewood to keep their boilers going. Here they did so well that it was thought the best place for them—steamships for rivers, steam tugs for canals and harbor work, but schooners for the coast and big sailing ships for ocean voyages.

Nevertheless an American ship was first to use steam on an Atlantic crossing. This was the *Savannah*, an auxiliary ship built by Fickett & Crockett at New York City in 1818. Only 100 feet long, *Savannah* had, besides full sailing rig, a 90-horsepower steam engine to drive paddles that could be taken down and stowed inboard (page 533).

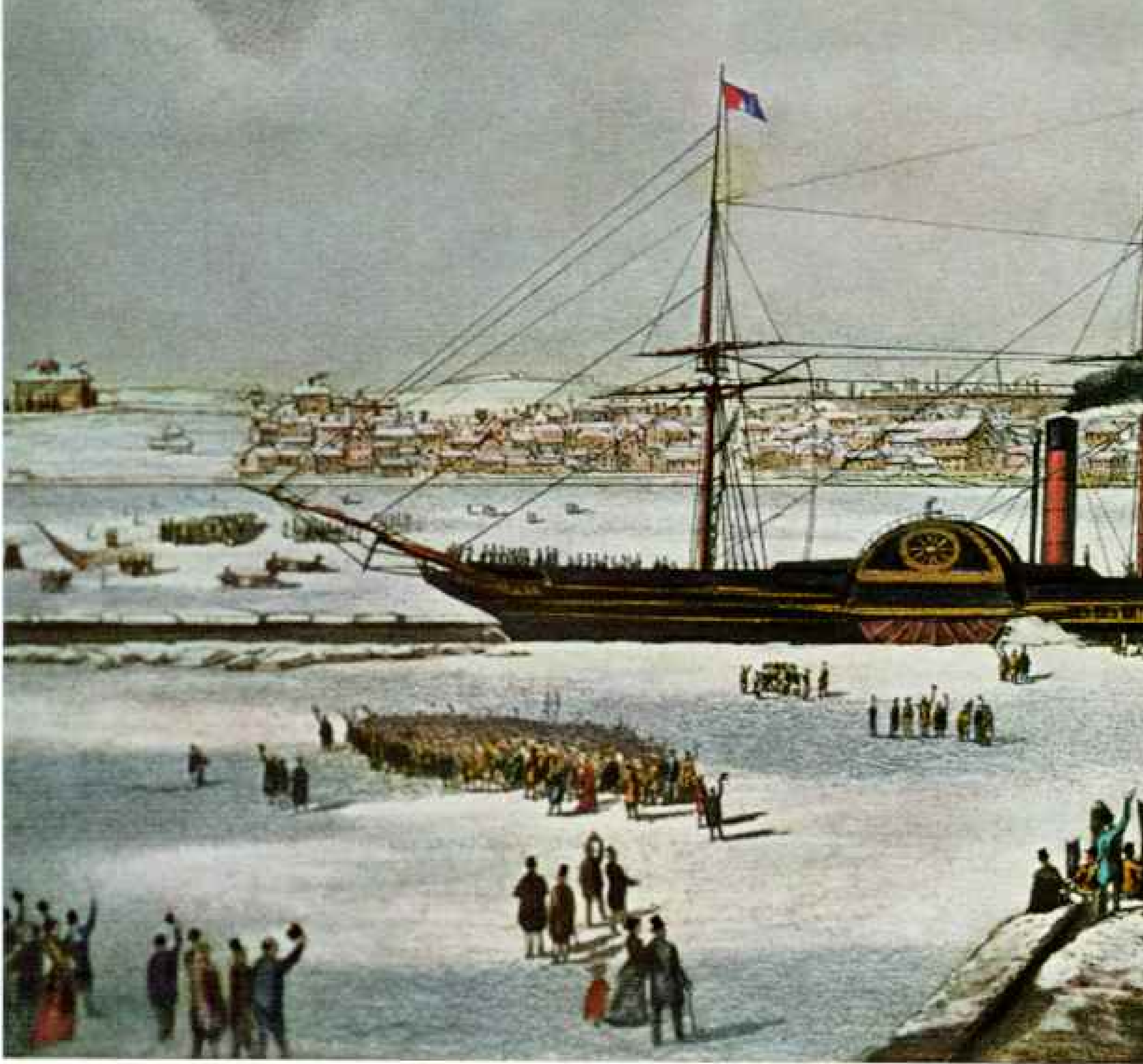
Few regarded *Savannah* as a practical proposition, so in 1819 she crossed the Atlantic to see if her backers could find interest there. From Savannah, Georgia, she made Liverpool in 29 days, but she attracted neither charterers nor buyers. After trying St. Petersburg in Russia, also fruitlessly, she went back to America under sail.

Savannah's best speed under power was five knots. On her transatlantic passage she carried only 60 tons of coal and some cordwood. With this, she could steam for little more than three and a half days. Off the coast of Ireland she was mistaken for a sailing ship afire. Her engine was removed on return to the United States, and she became a plain sailing ship. She was wrecked on Long Island in 1821.

Fifteen years later, some "experts" were



Merchant profiles
1819 - 1962
M. Moran 1961
Savannah 1819
Nuclear Ship Savannah 1962
Great Eastern 1860
Mauretania 1907
United States 1952
France 1962
Mascoma 1944
Mormacbay 1960
John W. Brown 1942
California 1962
Charles W. Morgan 1841
Willem Barendsz 1955
Preussen 1902
Ambrose 1952
Edward L. Ryerson 1960
Manhattan 1962



Cheering Bostonians chopped a seven-mile channel from dock to open sea in 1844 to free

still arguing that steamers on the North Atlantic were impossible. You might as well, they said, try to send a ship to the moon.

While American development was restricted to lakes and rivers, the evolution of the ocean-going steamship was left to Europe, especially Britain. On an island such as Britain, the sea and ships mattered above all else. The opportunities in speeded-up communications and trade were obvious.

Cunard Started in Canada

In much the same position as Britain was Nova Scotia in the early 1800's. Here, by 1830, Samuel Cunard was already contemplating a transatlantic service. Three years later the *Royal William* crossed the Atlantic under steam, and Mr. Cunard was not far behind her. Obtaining support in Glasgow and Liverpool, he founded the great Cunard Line, which was in operation on the North Atlantic by 1840 with dependable passenger steamers, and has remained so ever since. Payment for carrying the mails helped, but Cunard had to earn such payments.

France had a successful steamship by 1823. Holland used the British-built auxiliary *Curaçao* in the Dutch trade to the West Indies a few years later. By 1838, Britain's *Sirius* pushed herself westward over the North Atlantic, against Gulf Stream drift and the permanent wind system, under power alone. She was only 178 feet long, designed for the short run between Cork and London. She reached New York burning her own wooden fittings to keep the boilers going.

FROM A DRAWING BY J. S. KING, MARINERS MUSEUM, NEWPORT NEWS, VIRGINIA

the transatlantic steamer *Britannia*, the first regular Cunarder, from their icebound harbor

To keep *Sirius*'s engines developing 320 nominal horsepower, her boilers took 24 tons of coal every 24 hours to supply her with steam at 15 pounds pressure to the square inch. No wonder she ran out of fuel!

Great Western: First True Liner

The Brunel-designed steamship *Great Western* arrived a few hours after her. They had raced, and *Sirius* won. This same Isambard Kingdom Brunel, who created the successful *Great Western*, designed the fabulous *Great Eastern* years later (pages 540-41).*

Great Western, the first real Atlantic liner, could carry 800 tons of coal, though she registered little more than 1,300 tons gross. She could also carry about 100 passengers, and cross the Atlantic at nearly nine knots.

By 1840 the Cunard Line was in business with four Scots-built auxiliary paddle-wheel sister ships, each 207 feet long and displacing 2,000 tons. *Britannia*, like the others, had paddles of 28 feet diameter driven at 16 revolutions per minute by side-lever engines of 740 horsepower. A crew of 90 handled sails, engines, cargo, mails, and the wants of 115 passengers. A shelter was provided for cows to produce fresh milk for the passengers.

Charles Dickens, however, didn't think much of *Britannia* when he crossed in her in 1842. Getting there, for him, was no fun at all. The saloon, he said, was "not unlike a gigantic hearse with windows in the sides"; his stateroom was an "utterly impracticable,

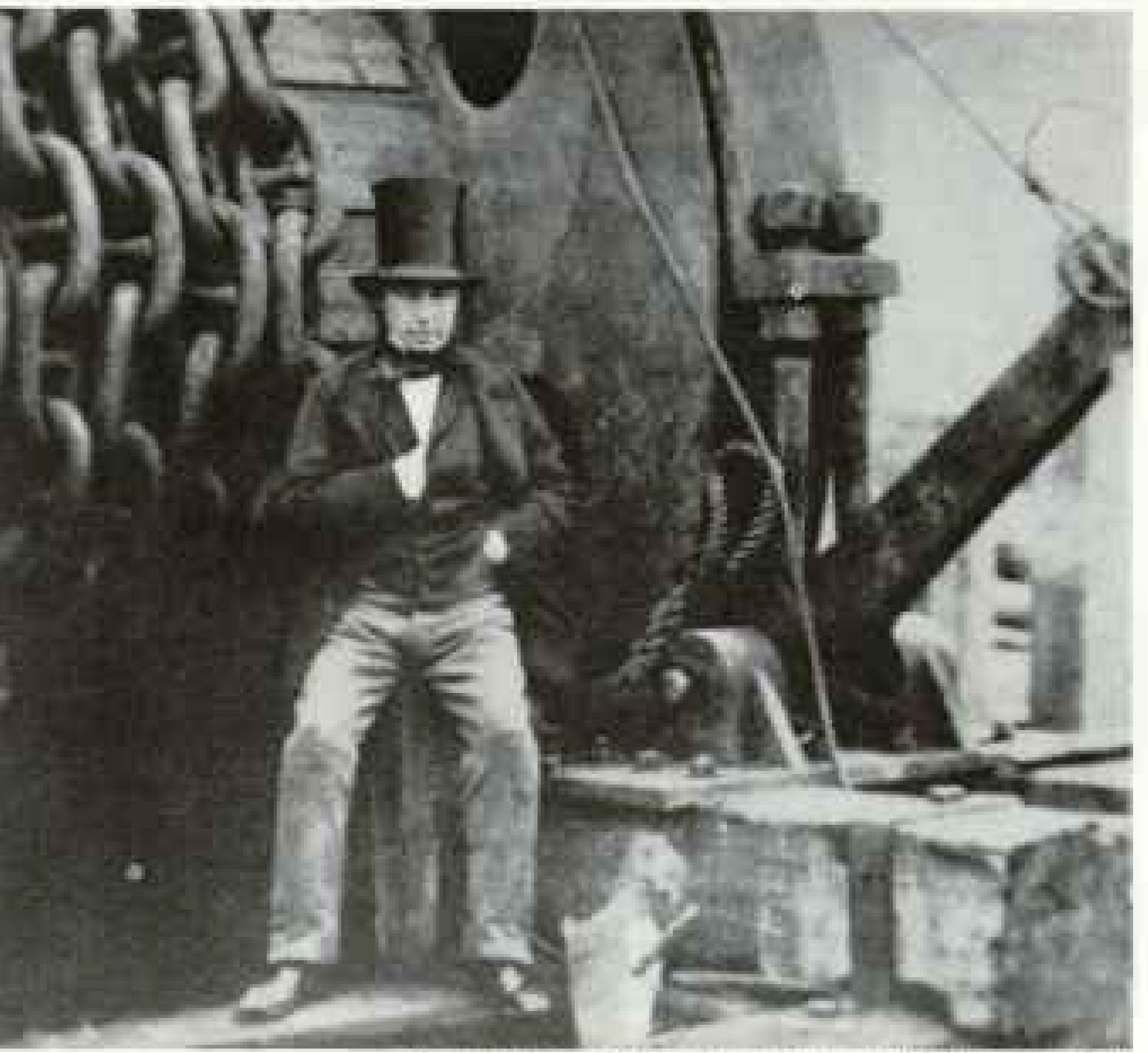
*James Dugan tells the story of *Great Eastern* in "The Great Iron Ship," Harper & Brothers, 1953.

Great Eastern Inches Down the Ways Side-first as Windlasses Check the Monster's Momentum

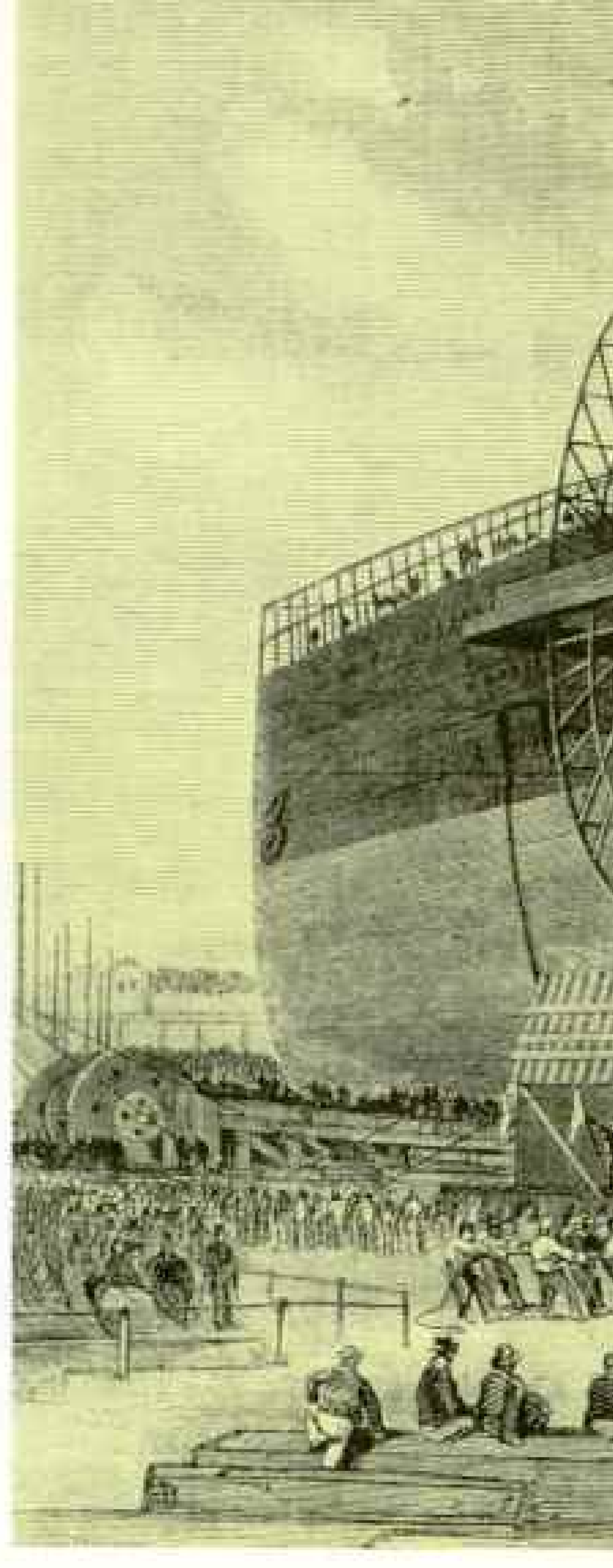
Several times the size of any contemporary, *Great Eastern* was too large to launch stern-first. Workers spent the winter of 1857-58 easing her into the Thames.

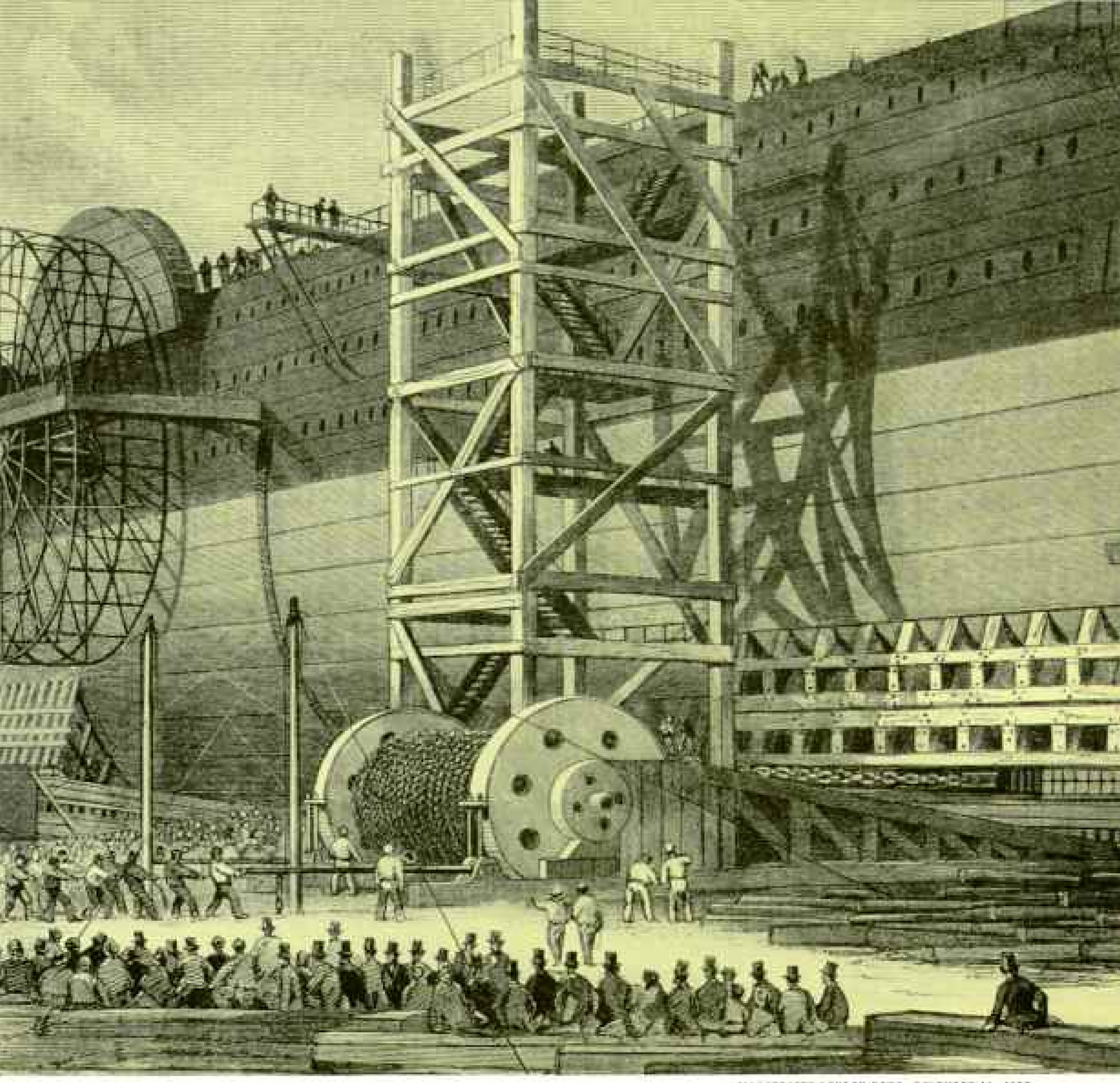
Great Eastern was driven by paddle wheels and a 24-foot propeller. Six masts carried 58,500 square feet of canvas (below). A white elephant until time came to lay transoceanic telegraph cables, she never lived up to expectations. When wreckers broke up her double hull in 1889, they found the skeleton of a riveter who, old salts swore, jinxed the vessel for all her 31 years.

Napoleonic pose characterizes Isambard Kingdom Brunel, odd genius who designed *Great Eastern*. Worry over setbacks to his giant creation hastened his death.



NAUTICAL PHOTO AGENCY (ABOVE) AND SCIENCE MUSEUM, LONDON





ILLUSTRATED LONDON NEWS, NOVEMBER 14, 1857

thoroughly hopeless, and profoundly preposterous box." But Mr. Dickens was no seaman.

While Cunard prospered on the North Atlantic and Europe raced to produce the biggest, fastest transatlantic liner, America's inland waterway traffic was flourishing.

The Mississippi, reaching from the Gulf of Mexico into the heart of America, soon became an expressway full of side- and sternwheelers, some of them immense, all picturesque, many dangerous. Nearly 200 had blown up on western rivers by 1850. An explosion aboard *Sultana* in 1865 killed some 1,500 men, mostly Union soldiers.

Picturesque river steamers, built up with tiers of comfortable cabins over enormous flat hulls, plied from St. Louis, Pittsburgh, Cincinnati, Nashville, Memphis, Louisville to New Orleans. High natural-draft funnels belching flames and smoke, huge paddles belting the water, galleys full of the aroma of luscious Southern food, opulent cabins and saloons thick-carpeted like a movie palace of the 1930's—plush, gilt, music, dancing, gambling—the great shoal-draught ships raced along.

"Steamboat a'comin'!" was a shout then to raise all men's eyes. She might be the famous *Natchez* or the rival *Robert E. Lee*, which raced like China clippers.

Screw Propellers Get a Grip

The Archimedean screw is more than 2,000 years old, but it was 1836 before its principle was adapted to a propeller and was used successfully to push a sizable ship. In 1839

World's longest liner, the 1,035-foot *France* ends her maiden passage to the welcoming geysers

the seagoing screw steamer *Archimedes* showed its real worth. On one of her test runs she made ten miles an hour.

By the early 1860's, all the great Atlantic lines were using screw-propelled steamers. America had the *Massachusetts,* a ship-rigged steamer that used a screw in 1845. But *Massachusetts* was still essentially a sailing ship. The idea was that she would outsail the liners eastbound, with the aid of the Atlantic's strong west winds. Then she would return under power westward.

Yankee Ships Cling to Canvas

The scheme did not work, for the good reason that ships with auxiliary power could not compete with full-powered vessels. Weak engines were just not good enough. They took up space, employed many men, used up coal, water, and oil, and interfered with the ship's sailing qualities. Engineer Isambard Kingdom Brunel's 322-foot *Great Britain* was, in 1845, the first successful big propeller-driven ship to cross the Atlantic.

Thus sails were outmoded, but most Yankee shipowners did not appreciate that. Their sail tradition was too strong and their packet ships so good, of their kind, that they were unwilling to give them up. So they continued to operate sailing packets across the North Atlantic for years after all such ships were doomed. Many Irish and other European immigrants crossed the Atlantic under sail at the middle of the 19th century. Passage was cheaper, but it was grim in steerage.

During the Civil War America produced the iron-clad warships *Monitor* and *Merrimack,* the shape of things to come. But the cream of the greatest ferry service in the world was left for years to others—British, French,

EKTACHROME BY RALPH AMDURSKY © NATIONAL GEOGRAPHIC SOCIETY

of New York fireboats. A tugboat flotilla escorts the ship to her berth on February 8, 1962

Germans, Italians, Dutch, Scandinavians.

The story of the ship became more and more one of marine engineering. In 1884 Charles A. Parsons invented a practical turbine, which applied steam directly to fixed blades mounted on drive shafts. The turbine increased speeds and reduced inertia inherent in the reciprocating engine, which used steam to drive pistons connected to propeller shafts. Parsons' marine turbine was first demonstrated in a vessel, *Turbinia*, at Queen Victoria's Diamond Jubilee review in 1897.

Oil Replaces Coal in Liners

The Cunard liners *Mauretania* and *Lusitania* were fitted with Parsons turbines in 1906. And these fast four-funnelers led to the development of such superships as France's *Normandie*, America's *United States*, Italy's *Rex*, Germany's *Bremen*, Cunard's *Queens*. The 27-knot *Mauretania* held the Blue Riband of the Atlantic for 22 years. She could cross in less than five days. Now the *United States* can do it, if necessary, in less than four. Oil-fired boilers provide steam to power the turbines; few coal-burners remain at sea these days.

The diesel engine, invented by a German engineer named Rudolf Diesel, drives many of the world's freighters today. Its chief advantage is saving boiler space, but the really big fast ships are still steam. Tankers of 80,000 to 100,000 dead-weight tons steam at 18 knots from the Persian Gulf with crude oil for the refineries of California. On the Great Lakes, the old wooden schooners have grown to vessels like the 710-foot *George M. Humphrey*, which carries 24,000 tons of iron ore at better than 15 knots.

Sailing whalers like the *Charles W. Mor-*

gan have become 20,000-ton factory ships, specialized tankers with 'tweendecks full of machinery and modern tryworks, and ramps cut in their sterns through which 90-ton whales are hauled bodily aboard. The diesel engine and fuel oil, instead of coal, give greater flexibility and tremendous range.

A fifth of the world's merchant ships today are tankers of one sort and another.

And Now Nuclear Power

The nuclear-powered merchant ship *Savannah* may look like her predecessors outwardly, but her power plant could revolutionize the economy of the sea. Launched at Camden, New Jersey, in July, 1959, the new *Savannah*—595 feet long and able to carry 9,500 tons at better than 20 knots—was part of President Eisenhower's "Atoms-for-Peace" program. Early in 1962, the *Savannah* ran successful trials under nuclear power. Even earlier, atomic-powered submarines were able to circumnavigate the globe under water at phenomenal speeds.*

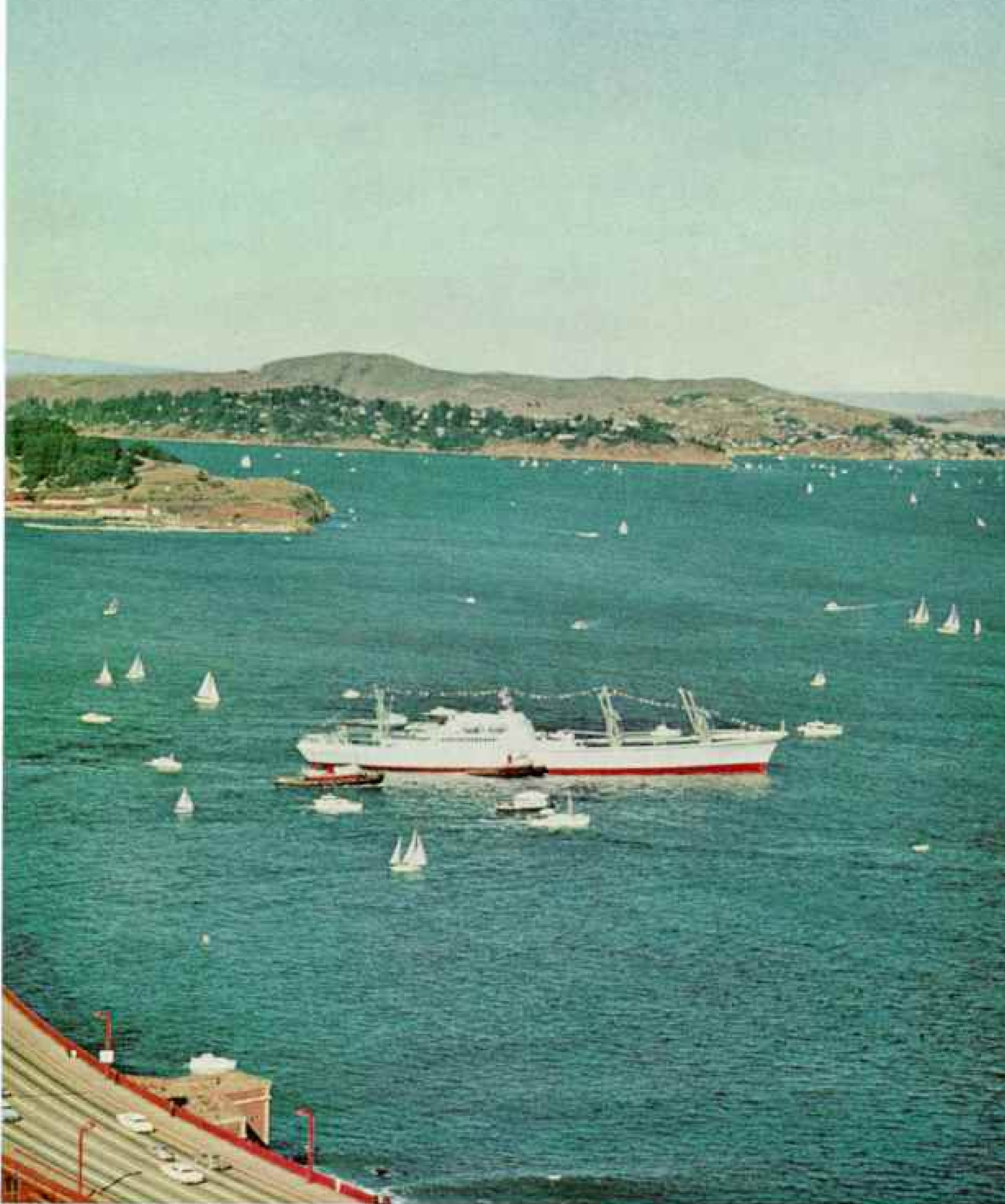
So man continues to strive toward better, safer, larger, more economical ships—with the gas-turbine engine, the nuclear plant, the crewless ship run by automation.

We still, however, have to come up with the ocean-going jet-propelled ship—a good idea patented by an English inventor, John Allen, in 1729. His craft was to make headway "by forcing water through the stern or hinder part, at a convenient distance under the surface of the water, into the sea, by means of proper engines placed within the ships." But the process of evolution goes on—upon the sea, under the sea, over the sea.

We have the skim-dish called the hovercraft, a sort of cross between an aircraft and a ship, which propels itself upon a cushion of air, racing over the water at 50 knots and floating up over the sand to land its passengers on the beach; the experimental dracone, a seagoing "sausage" of neoprene-coated nylon to be towed with its cargo of oil or other liquids; the Grumman hydrofoil ship *Denison*, which can cruise at 60 knots.

So ships come—all shapes, all sizes, some (to a seaman) very odd indeed, but all in direct line of man's endless endeavor to perfect his means of communication by sea, to control the sea as his great highway. We have come a mighty long way, but the quest for perfection is not ended yet. THE END

*For articles on nuclear-powered vessels, consult recent supplements to the two-volume Index to the National Geographic Magazine.



KODACHROME (ABOVE) BY JOE MUNROE, LENSGROUP, AND EKTACHROME FROM GRUMMAN AIRCRAFT ENGINEERING CORPORATION © N.G.S.

Ships of the future take to the sea

FLYING on winglike hydrofoils, the Grumman-built *Denison*, designed as an ocean-going vessel, skims five feet above Long Island Sound (left). As *Denison* revs up her gas turbine and picks up speed, foils lift the hull above the waves and permit a top speed of more than 60 knots. Alexander Graham Bell experimented with hydrofoils; they worked like small wings in the water.

SWEPT-BACK superstructure gleaming in the sun, the N.S. *Savannah*, world's first nuclear-powered merchantman, glides beneath San Francisco's Golden Gate Bridge. Soot-free and funnel-less, she draws her power from a reactor fueled with uranium. Capable of circling the world nearly 14 times without refueling, *Savannah* inaugurates the Atomic Age of merchant shipping.

Miniature Monaco

ARTICLE AND PHOTOGRAPHS

BY GILBERT M. AND DONNA KERKAM GROSVENOR

THE HILLS OF FRANCE *squeeze 370-acre Monaco around its harbor. Oceanographic Museum faces the sea at left.*

KODACHROME FROM HELICOPTER BY GILBERT M. GROSVENOR © N.G.S.

All winter long my wife Donna and I had thought about visiting Monaco. We would swim in the blue Mediterranean, bask in Europe's finest climate, rub elbows with royalty in glamorous Monte Carlo, and savor life in one of the world's smallest and strangest countries.

Besides, Monaco was making news by arguing with its powerful neighbor, France, 368,125 times its size. After seven centuries of self-rule, this toy Riviera principality was teetering on the edge of political disaster.

By treaty, Monaco had agreed to conform with French political, military, and economic interests. Now France wanted Monaco to impose taxes on businesses based in the principality. If foreign as well as French firms were to be taxed, the carefree little country, with its air of musical-comedy charm, might never be the same again.

22,000 Residents, 2,000,000 Visitors a Year

Coming by car from Italy, we first sighted Monaco from one of the world's most beautiful mountain drives, La Grande Corniche. From our high vantage point we beheld the entire principality, cupped between the foothills of the French Alps and the sea.

We could take it all in at a single glance, for 370-acre Monaco is less than half the size of Central Park in New York City. It reaches only three miles along the Mediterranean shore and 200 to 1,200 yards inland.

Monaco's permanent population consists of 3,400 native Monegasques and 18,600 foreigners with residential privileges. Yet to this tiny principality, pressed on three sides by France, come two million pleasure-seeking visitors each year.

Directly below us spread Monte Carlo, most famous of Monaco's three districts. The huge baroque casino stood out among pastel-hued hotels and apartment houses crowded against the sea.

Fronting the pocket-size harbor lies Monaco's next district, La Condamine, a residential and business section. Here international firms operate happily, sheltered by Monaco's liberal tax laws, and wealthy or retired people clip their coupons with never a worry about Monegasque income tax.

Beyond the square stone-jettied harbor, atop a headland, sits the third district and capital, Monaco-Ville—the Rock—crowned by the fortress palace of Prince Rainier III. Monaco's renowned Oceanographic Museum,

 A sovereign nation less than half the size of New York's Central Park, Monaco has its own flag,

a temple of the sea, is built into the Rock's sheer cliff (page 546).

Farthest west lies Fontvieille, an industrial section, not an official district. It turns out such varied products as pharmaceuticals, plastics, tobacco, precision instruments, ceramics, glass, and cosmetics.

Conqueror Comes in Friar's Garb

Donna pointed to the Rock. "That's where it all started," she said. "Do you remember the story of how the early Grimaldis took that fortress in the 13th century?"

It was quite a coup. On a night in 1297, drowsy soldiers inside the fortress on the Rock were shaken awake by a knock on the gate and a friar's plea for a night's lodging. Once admitted, the intruder drew a sword and slew the guards. He hailed companions, and they captured the Rock. The bold adventurer was François (the Spiteful) Grimaldi, scion of aristocratic seafarers from Genoa.

Now, more than six and a half centuries later, a Grimaldi, Prince Rainier III, still ruled the Rock and the principality lying below us.

Like a giant amphitheater facing the sea, Monaco's crowded, sun-splashed buildings rose above the harbor, a stage where luxurious yachts rode side by side (pages 546-47).

The magnetism of the setting reached out to us. We descended to the sea.

The glistening yachts, like competing starlets, vied for top billing. Multicolored standards waving from their sterns reminded me of the parade of flags fronting the United Nations headquarters in New York. Donna counted the flags of 12 nations.

On board, professional crews polished brass or varnished brightwork. Although hailing from scattered ports, the crews sported identical blue-denim trousers and white T-shirts with their yacht's name emblazoned in blue across the front. The uniform, I learned later, is adopted by virtually all boats visiting Monte Carlo.

At the quay's end I looked up and across to the Rock and Monaco-Ville clinging to it. Atop the palace flagstaff fluttered a white standard bearing the crest of Grimaldi. It signified the Prince was in residence.

It seemed incredible to me that one family could control the principality so long. How could the Grimaldis hold off the Spanish, Genoese, Venetians, the Austro-Hungarian Empire, and survive two world wars?

diplomats, stamps, and National Council

MONACO

MONACO'S THREE DISTRICTS and many tourist attractions, including a famous oceanographic museum, a casino, and fine hotels and shops, jam a Mediterranean Sea coastal area on the French Riviera that embraces scarcely half a square mile.

Prince Rainier III, the thirty-second Grimaldi to reign, rules Monaco. His Princess is the former actress Grace Kelly of the United States. Under a new constitution, adopted last December and hailed as a "Coup de Grace," women now have full voting rights and are eligible to hold office in the National Council.

OFFICIAL NAME: Principality of Monaco. **GOVERNMENT:** Constitutional monarchy. **AREA:** 370 acres. **POPULATION:** 22,000. **LANGUAGE:** French. **RELIGION:** Roman Catholic. **ECONOMY:** Tourism, stamps, beer, tobacco, pottery, glass, perfume; also pharmaceuticals, plastics, precision instruments, ceramics, printing. **CLIMATE:** Mediterranean—mild winters (average January low 37° F.) and warm summers (average July high 83° F.).

KODACHROME © NATIONAL GEOGRAPHIC SOCIETY

Sou'westered Prince Albert I, the great-grandfather of Rainier III, looks out to sea near the Oceanographic Museum he founded. He went to sea on more than 30 scientific explorations.

Donna had a theory that seemed likely: The Grimaldis had cleverly kept pace with their times; they never let tradition interfere with progress.

In the 14th century, the wealthy Grimaldis ruled the waters off Monaco and increased their fortunes by levying a *droit de mer*, or sea tribute, on all goods carried by vessels passing within sight of the Rock.

For the next three centuries, even though outgunned by larger fleets, the Grimaldis held on to their tiny fief by negotiating protective treaties with both France and Spain, and by marrying their offspring into the wealthy and influential families of Europe.

In the 1860's when Monaco's treasury ran low, Prince Charles III—Prince Rainier's ancestor—sold the rights to his country's struggling casino. A shrewd businessman named François Blanc (White) obtained a 50-year operating concession. He guaranteed Monaco a substantial share of profits from the casino.

François Blanc transformed the pumpkin-size principality into a Riviera playground. Grand dukes arrived in special trains to try their luck. Monegasque fishermen beached their boats, exchanged fish for chips, and became nimble-fingered croupiers.

Blanc's casino profits ran high; the saying still lives that "whether you bet red or black, White will win." The House of Grimaldi won, too. In 1869, Prince Charles III abolished taxes in Monaco.

Albert I Founded Museum of the Sea

Science, ballet, and international conclaves were introduced to Monaco by Charles's son, Prince Albert I (left). He inherited the early Grimaldis' love for the sea and was fascinated by marine biology, making 30 scientific voyages. In 1910 he opened the Oceanographic Museum to exhibit his astounding collection of specimens. Jacques-Yves Cousteau, renowned undersea explorer, now directs the museum, which last year attracted more than 850,000 visitors and scientists (pages 566-67).

Prince Albert, noting that Monaco's climate suited subtropical plants, also started the Exotic Garden. Today it ranks with the finest cactus gardens in the world (pages 562-63).

The present Prince, Rainier III, has inherited his ancestors' business sense as well as their flair. He has sparked a fantastic economic boom and a 200-million-dollar, five-year expansion project, which includes adding 100 acres of land to Monaco. And he has given his principality a beautiful Princess, the former Grace Kelly of Philadelphia and Hollywood.

Wedding Crowds Jam Monaco

As the days passed into weeks, we explored the principality on foot. Most charming to us was the antique district of Monaco-Ville, which remains unblemished by 20th-century architecture. Its buildings run together like a jigsaw puzzle (opposite), and the narrow, crooked streets, forbidden to automobiles, lead to secluded garden restaurants crammed into small courtyards.

In stark contrast is Monaco-Ville's main square, which bursts with tourist buses and foreign-licensed autos. A good part of the palace's 100-man, whistle-blowing guard—the *carabiniers*—struggle frantically in the square for control.

At a sidewalk cafe I asked the proprietor what caused the tremendous crowds that day.

"The big wedding," he replied simply.

"What wedding?" Donna inquired.

KODACHROME BY DONNA K. AND GILBERT M. GROSVENOR © NATIONAL GEOGRAPHIC SOCIETY

Art displays and cafe chairs barricade sidewalks of a medieval lane in Monaco-Ville. Red-and-white sign forbids motor traffic. Boys with bathing trunks march to the seashore.

In his Ferrari, Phil Hill of California, a former world champion, awaits the beginning of Le Grand Prix, Monaco's "Race through the Streets." Drivers must circle the two-mile course 100 times. Crash bar guards Hill if his car upsets.

Kerchiefed race fan clocks a driver during a prerace trial run.

KODACHROMES © NATIONAL GEOGRAPHIC SOCIETY

Roaring racers approach a hairpin turn (top). One of the cars at center skidded into two others, causing a runaway wheel to bounce toward author Grosvenor, who dived from its path. A less-fortunate Monegasque was knocked unconscious. Three cars crashed into protective hay at left.

"Madame, Prince Rainier's wedding, of course," he answered, annoyed.

"But that was in 1956," I protested.

"Quite true, and ever since we've had the crowds," he retorted.

Not many days later, Monaco exploded with excitement. It was Grand Prix week. Europeans jammed the principality in early June for one of several Grand Prix races to determine world auto-racing supremacy.

Monaco's Grand Prix is the most famous auto race through city streets. Stands line the course. Spectators hang from apartment and hotel balconies.

"We reserve race-view rooms years in advance," a hotel manager told me.

Yachts flock to the harbor and anchor close to the breakwater. The owners are hoisted to the masthead in bosun chairs for a bird's-eye view. Helicopters churn overhead; light planes circle endlessly.

At race time the loudspeaker crackles, "Ladies and gentlemen, their Serene Highnesses the Prince and Princess of Monaco."

In his red Porsche, Prince Rainier speeds through the traditional *ouverture du circuit*. Beside him sits the Prin-

Postage stamps: big business in a little country

STAMP ISSUES bring more to Monaco's treasury than its casino. To collectors the stamps are not only beautiful but storytelling.

A series portraying Prince Rainier III and Princess Grace was sold only on their wedding day. Eager to buy, collectors lined up with sleeping bags.

cess, in a Kelly green dress and white turban.

The racers line up for the start. The red-and-white flag dips, drivers clutch out, the machines scream, shudder, then leap forward trailing streaks of burned rubber and dense exhaust clouds.

I stand atop protective hay bales at the first turn. Donna remains behind a wall near the track on the Avenue de Monte-Carlo.

Red, green, blue, and metallic blurs of machines and drivers merge into a maelstrom of color as the cars roar toward me at 60 miles an hour. Squinting through the telephoto lens, I sense a dangerous squeezing pattern forming in the heavy traffic (page 553).

Suddenly one car nudges another, triggering a chain reaction. Three entangled cars fishtail badly, practically into my lap. A viciously spinning wheel shears loose from its axle. In my range finder, I see it coming.

The wheel bounces, gathers momentum, and sails directly at me. Forgetting pictures, I flip backward, cameras flying, and hit the pavement flat out.

An elderly Monegasque track official, standing but three feet away, remains frozen, and the wheel plows into him like a steamroller. He is knocked unconscious. An alert Red Cross stretcher team speeds him away to Monaco Hospital. My enthusiasm for close-up pictures vanishes.

After 82 minutes the lead cars have toured 50 laps—the halfway mark. The field narrows as drivers and machines fail—the three-car crack-up, broken fuel pumps, sheared drive shafts, fractured gear boxes.

At 94 laps a New Zealander, Bruce McLaren, leads the Ferrari team's Phil Hill, an American, by 30 seconds; at 98 laps the lead narrows to 12 seconds; the checkered flag drops as McLaren finishes a scant two seconds ahead of Hill, 1961 world champion.

High Fashions Bring High Prices

After Le Grand Prix, the Monte Carlo summer season shifts into high gear. The small, fashionable dress shops display the newest creations from Paris, Milan, and Rome. Leotardlike outfits of stretch silk by Pucci, the rage of the Riviera, sell for $100 and up, and matching silk shoes and purse for another $50. Antique shops are willing to sacrifice authentic Louis XIV chairs for only a few thousand dollars each.

Monte Carlo's hotels begin to fill up. Of them all, only the Hôtel de Paris is really

The 25-franc denomination honoring Jules Verne shows how Captain Nemo's *Nautilus* foretold the modern bathyscaph. One-franc stamp depicts Alexander the Great's mythical dive in a crystal sphere and, 23 centuries later, Dr. William Beebe's bathysphere descent. Capt. Jacques-Yves Cousteau's diving saucer, financed in part by the National Geographic Society, appears on the 50-centime stamp.

Postal official looks at an enlarged 10-franc design. It commemorates establishment of a laboratory at the Oceanographic Museum to study the effects of radioactive waste material deposited in the seas.

Monaco's interest in oceanography began with Prince Rainier's great-grandfather, Albert I, who built research ships, lowered fish traps 3½ miles, and also took geological samples at the same depth. In 1910 he inaugurated the Oceanographic Museum now directed by Cousteau.

KODACHROMES © NATIONAL GEOGRAPHIC SOCIETY

plush. Moreover, it is really expensive—three-room suites can cost $120 a day.

As one Monegasque put it, "If the Hôtel de Paris were cheaper, the status seekers would avoid it."

At our hotel the furniture was only almost antique. Our bathroom was twice the size of our bedroom, and wooden steps led up to the tub—four feet above the concrete floor.

One morning I ordered orange juice for breakfast, and the incident provided an amusing sidelight on Monegasque hotel thinking. The menu listed the beverage for sixty cents, and so when the bill exceeded three dollars, I inquired about this small mistake.

The manager apologized profusely and telephoned the chef. After a lengthy conversation he reported, "No mistake, monsieur. The oranges were very small today. It took more than usual to fill your glass."

We were learning how Monaco keeps its economy in the black. Tourists and the commerce they generate provide some 40 percent of the Monegasque income.

Anything bought in Monaco carries a sales tax of about 3 percent. All services—hotels, restaurants, entertainment—are taxed 9 percent. The principality also runs a tobacco monopoly and operates highly profitable radio and television stations, among the most powerful in Europe.

In 1885 Monaco issued its first stamp, and unwittingly struck another rich vein of national revenue. No one could have predicted the 20th-century popularity of philately, or that Monaco's stamps would eventually contribute 8 percent of its budget.

Strangely, while it is still Monte Carlo with its casino and glamorous life that draws visitors, gambling profits now bring in only about half as much as Monaco's stamps.

Home of 600 "Presidents"

So successful is this Monegasque economy that the country levies no personal income tax and no property tax; corporate taxes are modest. Yet it is probably the only country left in the world with no national debt.

This economic lure has helped spark the prosperity. Foreign firms need pay only a moderate fee to incorporate in Monaco, but their activities must be real. Holding companies and letter-drop corporations are not allowed.

Monaco presently has 600 corporations. *Directeurs* (presidents) outnumber croupiers—although the croupiers' tips alone exceed

Princess Caroline Tosses Floral "Bombs" at Friends

As mule-drawn floats passed the reviewing stand in Monaco's Battle of Flowers last June, Prince Rainier launched floral fusillades at his subjects. He laughed heartily when a small boy returned a barrage of carnations. Here Princess Caroline, then five years old, fires a flowery missile. Her mother, Princess Grace, holds a movie camera.

Hungry mule steals a tasty flower on a teammate's bridle.

Young lady chooses peasant costume for the floral pageant.

KODACHROMES © NATIONAL GEOGRAPHIC SOCIETY

the average annual "fee" of 10,000 French francs ($2,046) paid the directeurs.

Ironically, Monaco's very success had threatened to bring about her downfall. Her tax inducements figured in the rift between President de Gaulle of France and Prince Rainier.

Paris argued that it was unfair for French businessmen to incorporate in Monaco and thus avoid paying taxes to France.

However, Monegasques countered that France must approve all applications from both French and foreign firms desiring to transfer their activities to Monaco. If France did not wish her citizens to set up business there, she could deny them incorporation.

"Surely, the true source of the French-Monegasque dispute must be obscured," a Monegasque told me. "Taxation would help France so little, but hurt Monaco so much."

An Italian businessman put it more bluntly: "If the French clamp down, I'll move my offices to Geneva within the month."

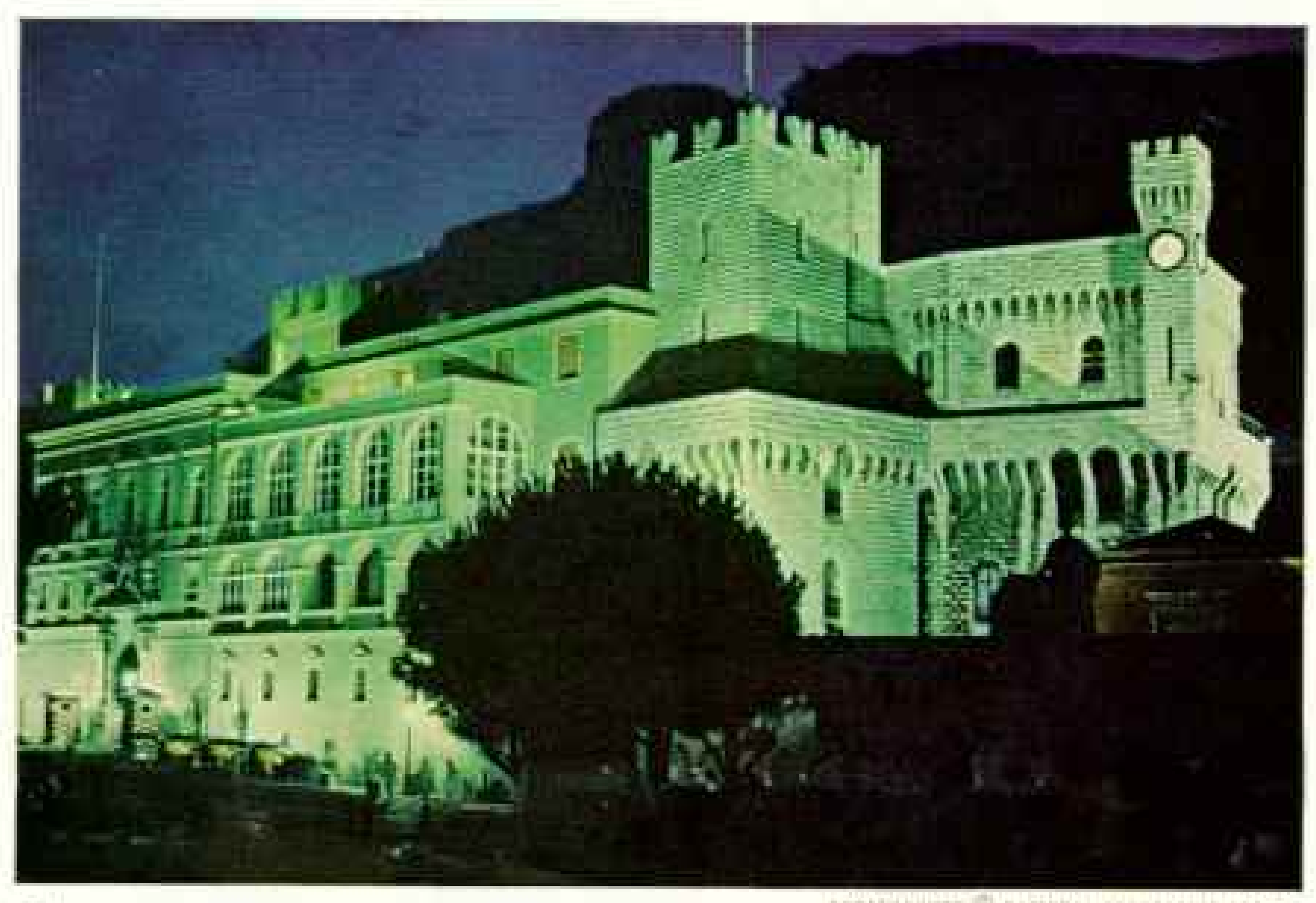
We were eager to interview Prince Rainier about his plans, as well as to photograph the princely family. Finally approval came from Georges Lukomski, palace photographer and assistant press attaché.

Powdered wig and cocked hat call to mind the once-fashionable dress of the 17th-century French court. These young ladies and gentlemen of five or six years parade as nobles at the Battle of Flowers.

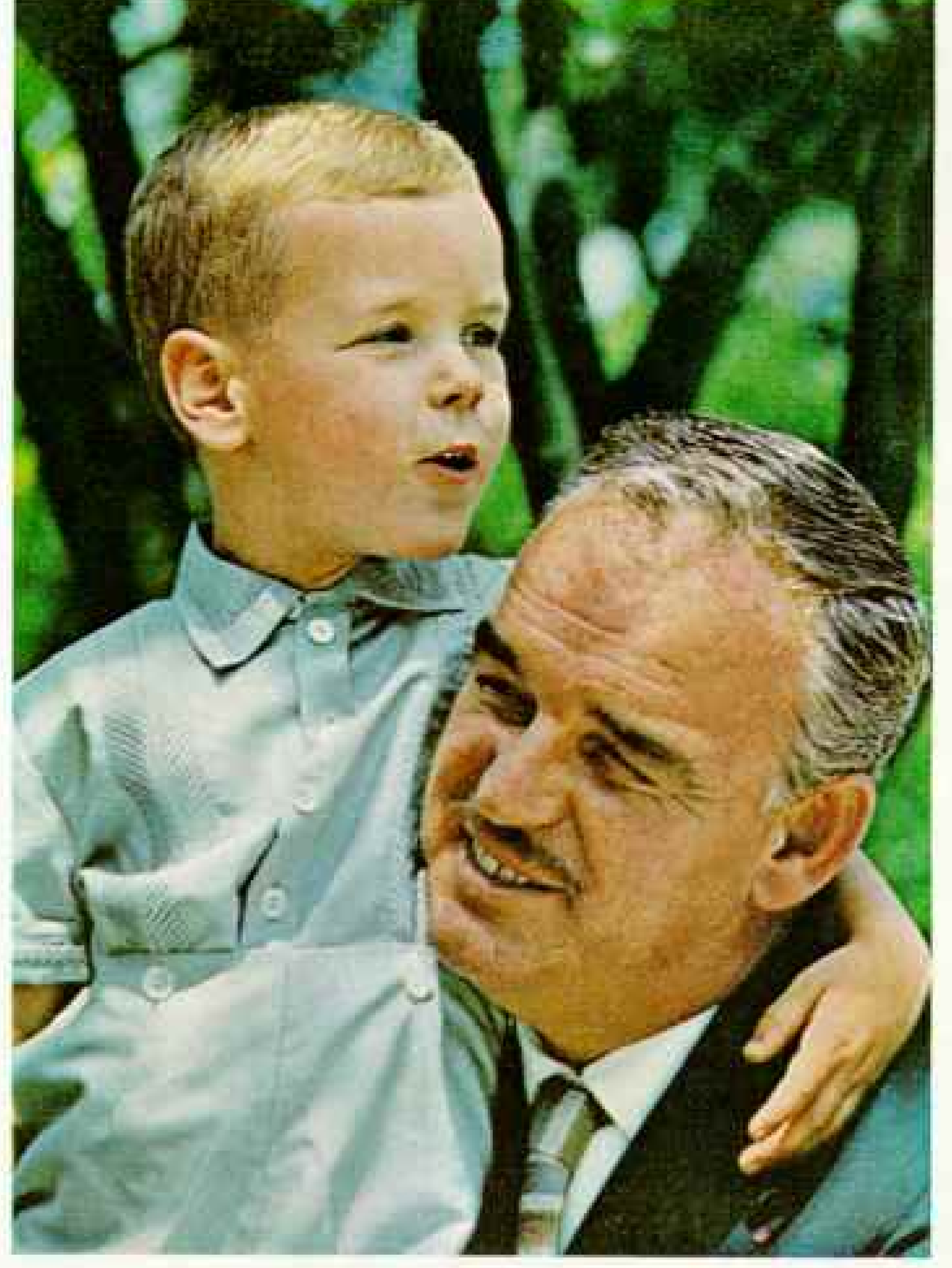
Sightseers blaze away with cameras as the guard changes at the Palace of Monaco—a daily ceremony. These five *carabiniers* are part of the palace's 100-man guard. They wear tropical helmets and red-and-white epaulets.

Floodlighted, the Prince's palace reveals crenellated towers. Some date from the 13th century. Formal *salons* occupy this wing, which faces a large square. Sentry boxes bear chevrons of red and white, Monaco's national colors.

Palace's red roof, courtyard, and swimming pool stand out in aerial view. Brilliant white Oceanographic Museum perches on rocks where early men lived in caves before Phoenicians established Monaco as a Mediterranean port.



KODACHROMES © NATIONAL GEOGRAPHIC SOCIETY



Yacht rigging frames Prince Rainier and Princess Grace for a NATIONAL GEOGRAPHIC portrait. Later the Prince hung a copy of the picture in his office. Yacht's bowsprit points across Monaco to the French hills.

Princess Caroline nestles next to her mother, while Prince Albert, Marquis des Baux, puts an arm around his father. Albert is heir apparent to the throne of the Grimaldis, oldest European dynasty still in power. The Grimaldi rule began in the year 1297.

KODACHROMES BY NATIONAL GEOGRAPHIC PHOTOGRAPHER BATES LITTLEHALES (ABOVE) AND DONNA K. AND GILBERT M. GROSVENOR © N.G.S.

Arriving early, we asked Georges to show us around the Palace of Monaco. We started in the inner courtyard which separates the offices, formal reception rooms, and visiting-royalty suites from the private living quarters.

"We'll take the back way; it's quicker," Georges announced as we mounted a dark, musty stairway—little changed since the 15th century.

The ornate rooms we passed through were predictably antique, richly leafed in gold and dressed in velvets. Although George Washington never slept there, Georges assured us that numerous popes, cardinals, emperors, and kings had.

Through the labyrinth of halls and stairways we twisted, glimpsing paintings and relics of the early Grimaldis.

Back on the ground floor we passed what appeared to be a naval torpedo with a seat and controls to guide it.

"That's the Prince's skin-diving submarine," Georges said casually. "He uses it sometimes when he collects specimens for the Oceanographic Museum."

We emerged into a sunlit garden where children's swings and sandboxes shared space with the flowers. Balls, tricycles, and toy trucks lined the gravel path. An inflated swan, plastic raft, and two tiny paddles drifted in a blue-tiled swimming pool.

Prince Rainier and Princess Grace entered the garden. Prince Albert, then four, and Princess Caroline, five, skipped behind them.

They were so informal that Donna momentarily forgot her much-practiced curtsy.

"Welcome to Monaco," the Prince said.

(Continued on page 568)

Delicate white cranesbill *(Pelargonium tetragonum)* comes from South Africa.

Exotic Garden brings the subtropics to Europe

LIKE MANY Monaco projects, the Exotic Garden traces its history to the eager curiosity of Prince Albert I. While watching construction of the Oceanographic Museum, Albert observed that subtropical plants had started growing in his principality. In 1913 he ordered work to begin on the Exotic Garden. Soil was carried up a mountain, and many plants were anchored with metal rings. The result: a magnificent subtropical garden at the foot of the French Alps. The latitude is that of Portland, Maine.

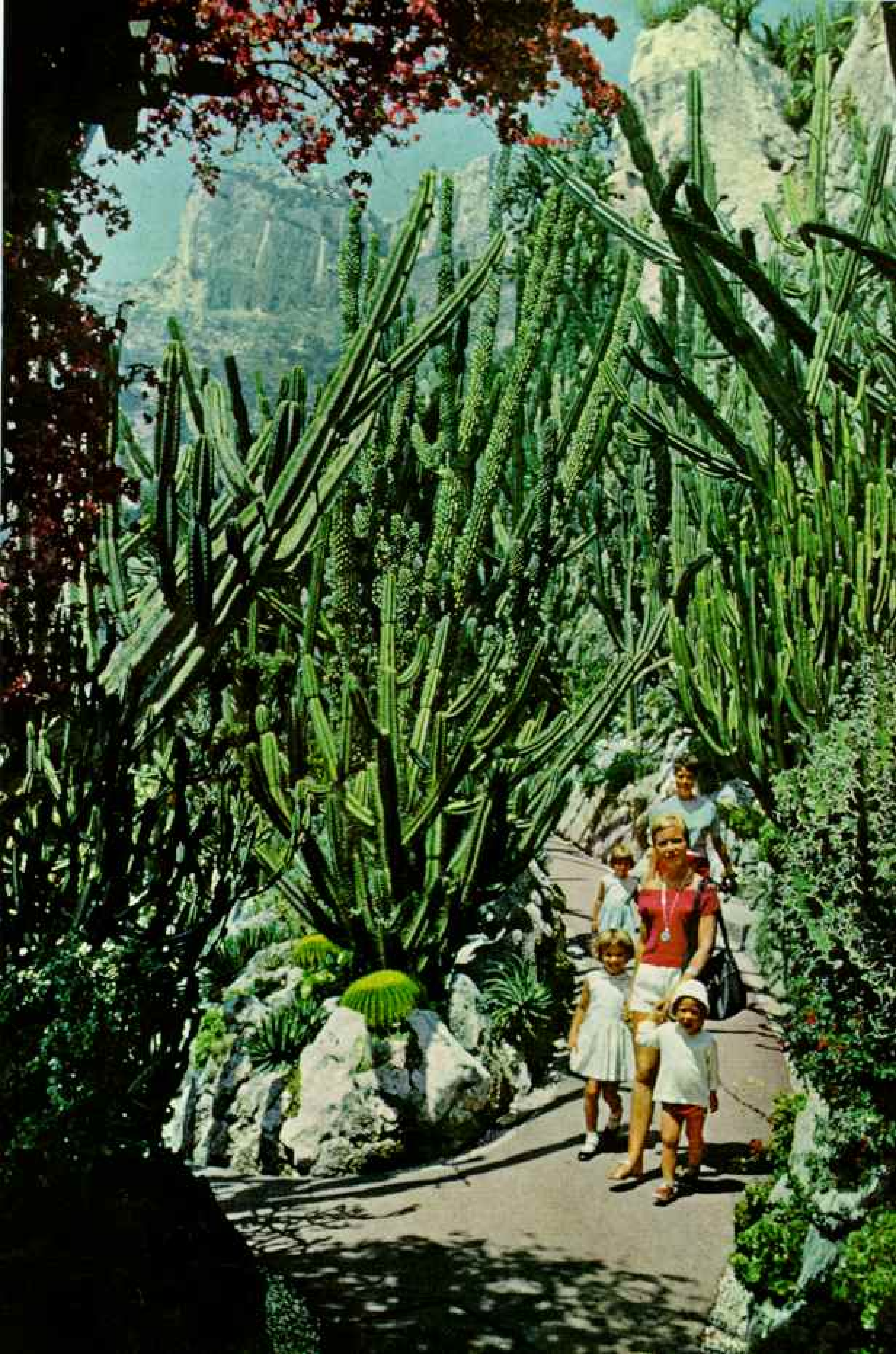
Orange-spired aloe: one of the colorful African succulents (below).

Mobile stamens of a prickly pear flower (above, left) bend forward to coat bees with pollen. When the visitors leave, the stamens will swing back to an outspread position.

Cactus forest from the Americas interests garden visitors. Treelike plants are *Cereus.*

Green "rose" *(Greenovia dodrantalis)* hails from the Canary Islands. Pink flower *(Carpobrotus acinaciformis)* is planted along railroad tracks near the Mediterranean. It holds so much moisture that sparks cannot set it afire.

KODACHROMES © NATIONAL GEOGRAPHIC SOCIETY



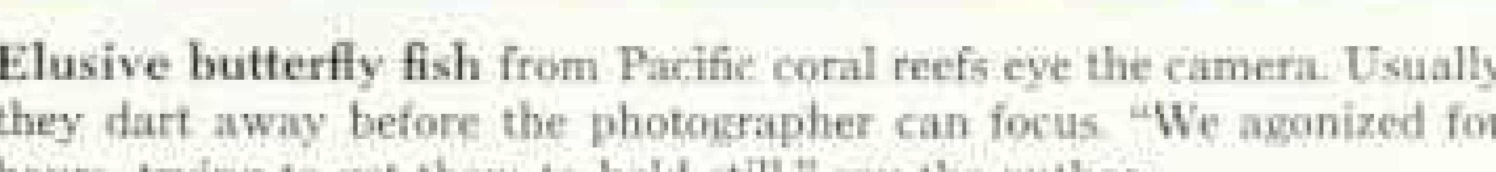
KODACHROMES BY DONNA K. AND GILBERT M. GROSVENOR © N.G.S.

KODACHROMES © NATIONAL GEOGRAPHIC SOCIETY

Cologne in Eiffel Tower bottle is a new item of the Lancaster Beauty Products. Owner Georges Würz and his son discuss business on the balcony of their factory overlooking the harbor. The French border bisects their property. By law, the Würzes can store goods on the French side but must keep production in Monaco. "If France should shut her frontier," says Würz, "our French and Italian workers would be jobless and I would be bankrupt."

Lipsticks pass inspection in the Würz factory, which the owner calls a "woman's kingdom." Some of his products go to the Common Market countries.

Terrace of the Exotic Garden surveys the Rock. Visitors take refreshment here after inspecting the cacti and aloes. Small bridge at upper left carries a path across a gap in the cliffside.



Elusive butterfly fish from Pacific coral reefs eye the camera. Usually they dart away before the photographer can focus. "We agonized for hours, trying to get them to hold still," say the authors.

Gorgeous spines of a turkey fish hold fever and anguish. After the stonefish, its ugly rela-

The underwater world of Captain Cousteau

FOUNDED by the scientist-prince Albert I to house treasures brought back by his deep-sea surveys, the Oceanographic Museum is forging ahead under the famed Capt. Jacques-Yves Cousteau, leader of a continuing series of National Geographic Society–*Calypso* expeditions.

Established as a French foundation, this temple of the sea has laboratories devoted to oceanographic research. The relics of Prince Albert's marine exploration and an aquarium attract 850,000 visitors a year.

Under a princely decree, the museum administers a three-and-a-half-mile stretch of sea floor as a preserve. Here Cousteau plans to experiment with sea farming. Phosphates will be sprayed on fish pastures. Farmhands will work with Aqua-Lungs, while supervisors cruise in diving saucers.

Cousteau points to a model of future construction. A five-story parking garage is planned to accommodate 600 cars and 40 buses. Cantilevered grandstand built over the water will seat 1,500 visitors watching seals and porpoises playing in tanks.

Skeletons of marine mammals fill a museum hall. Long-jawed sperm whale dwarfs the killer whale on the uprights beside it. Walrus at lower left displays ivory tusks.

tive, *Pterois volitans* may be the most poisonous in the world. Even a slight prick is painful.

Little porcupine fish calmly eats crab as a savage moray eel watches. When the porcupine inflates to balloonlike shape, sharp spines protect it from predators such as the moray.

EKTACHROME (BELOW) AND KODACHROMES © NATIONAL GEOGRAPHIC SOCIETY

The fresh, natural beauty of the Princess surpassed her familiar photographic image. But it was the Prince who surprised me. His portraits fail to express fully his youthful exuberance and dynamic personality.

"Does your GEOGRAPHIC article include all the Riviera?" Princess Grace inquired.

"No, your Highness," I replied. "We're photographing only the Principality of Monaco."

"That's wonderful!" the Prince exclaimed in flawless English. He studied in British schools and served as a French liaison officer with a Texas division in World War II.

"I trust you're interested in seeing more than just the casino," the Prince commented.

"We're exploring all the principality this summer," I assured him, "even the blueprints for land expansion."

The Prince lit up. "Good. Then you know of the new land we're gaining both from the railroad and from the sea.

"Next time you visit Monaco," he said, "the trains will run underground—not along the waterfront as they do today." (I could vouch for the latter: Our hotel room overlooked not only the harbor, but the more than 50 trains a day that rumbled through the principality.)

"You know, don't you," the Prince asked, "that we're using the rock from the rail tunnel to create new land along the shore? We badly need the new industrial sites in Fontvieille and space for new hotels, offices, and apartments in Monte Carlo."

Although the Prince did not mention it, Monaco's growing acres come from an additional source: French soil bought as earth-fill from the owners of nearby hillsides.

"Don't forget to visit our industries in Fontvieille," the Prince said, bidding us farewell.

Welcome to a Woman's Kingdom

So, next day, Donna and I called on the flourishing Lancaster Beauty Products factory. It further emphasized the puzzling relationship between France and Monaco.

Monsieur Georges Würz, the owner, welcomed us into his "woman's kingdom" (page 565).

"Our lipsticks, facial creams, and extracts for problem skin are sold mostly to the Common Market countries," he told us. "In order to meet the demand for our products, we employ workers from the French towns of Beausoleil and Menton."

"And what would happen if France blocks her roads leading into Monaco?" I asked, recalling newspaper speculation.

"The workers would be jobless, and I would be bankrupt," M. Würz replied.

He opened a door, stepped across the threshold, and announced, "I am now in France. The frontier divides my factory. Under French law I can only store goods here; but where you stand, in Monaco, I produce our *produits de beauté!*"

This brought to mind the Monte Carlo apartment building

The yawl *Agneta* sweeps gracefully toward the entrance of Monaco's harbor. Yachts ride the water near the spot where Julius Caesar embarked for Greece to fight Pompey in 48 B.C. Rocks of the breakwater attract throngs of sun-bathers at lunchtime (page 570).

KODACHROME © NATIONAL GEOGRAPHIC SOCIETY

KODACHROME © NATIONAL GEOGRAPHIC SOCIETY

Beauty on the rocks: a frequent sight in Monaco's harbor. Secretaries use a two-hour lunch period to picnic, swim, and sun-bathe on concrete blocks along the mole. Girls carry bathing suits in baskets and adroitly change with little loss of modesty.

where tenants in the front reside in Monaco and pay no taxes, while those in back live in France—among them a French tax collector.

The noon whistle blew, and people scurried from their offices. We left the factory to join throngs headed beachward for a two-hour lunch in the sun.

At the popular Calypso restaurant, on the water, we sat amid bikini-clad patrons who ate pizza and *salade niçoise* or did the twist to a blaring jukebox.

It was here we observed a most remarkable feat of legerdemain, which revealed, among other things, why Monegasque working girls carry bulky handbags. Each bag contains at least a lunch, beach towel, bathing cap, and bikini. Magicianlike, out in the open, the girls shed dresses and underclothes and skillfully don bikinis with a minimum loss of motion or modesty. The execution was brilliant, if devious.

Donna confessed that her admiration failed to spark the necessary courage for emulation. "This is no place for a novice," she said.

Syndicate Controls the Casino

We left until last a visit to the casino that brought reigning royalty to Monaco for a century. We had already been briefed by Monsieur A. G. Bernard, the casino's public relations manager.

© NATIONAL GEOGRAPHIC SOCIETY

Happy couple test the Riviera surf. These lunch-hour bathers step across the French border to Monte Carlo Beach. A concrete walk fronts the pebbly strand.

While few non-Monegasques know this clever, philosophical gentleman, everyone knows the syndicate he represents: Société des Bains de Mer et du Cercle des Etrangers de Monaco—the Monaco Sea Bathing Society and Foreigners Club.

SBM controls the Casino of Monte Carlo, the Hôtel de Paris, Monte Carlo Beach, the high-stakes Casino d'Eté, modern bowling alleys, and even a jet-helicopter passenger service. A fabulously wealthy Greek shipowner, Aristotle Socrates Onassis, is a large stockholder in SBM. He lives aboard his luxurious Monaco-based yacht, the *Christina*.

As the short, wiry M. Bernard ushered us into his office, I immediately asked, "How can I expect to win at your casino?"

"Ah! Winning depends upon how you play," he responded. "But winning is not really the primary motivation of our patrons. For some, it is relaxation or release from worry or loneliness; for the system players, it is a study in mathematics; for the tourists, the casino is a novelty; and for a few, gambling is a disease, as destructive as any on medical record."

I asked permission to photograph the casino.

"This is possible, but only if you bring your own models. We must respect the privacy of our patrons who may wish to remain without names or faces—you understand?"

With that he handed me a pass. "To eliminate temptation for madame, I have issued you a joint card for the casino, monsieur." He smiled. "She cannot go without you."

"That's fine," I said, "but you still haven't told me how I should play to win."

"Ah, yes, there is one foolproof way," M. Bernard began. "You pass through the *salons ordinaires* into the *salons privés*. Select a heavy bettor, station yourself behind his chair, keep your hands in your pockets . . ." he paused ever so slightly, "and watch. If you gamble in this way, you will always win."

With that advice we entered another world, another era. Nothing had been spared in creating this dazzling monument to French baroque architecture and design. Gold-faced moldings, pastel frescoes, and muraled ceilings are interrupted only by crystals drip-

ping from huge chandeliers suspended above the array of green-felt tables.

We followed M. Bernard's instructions and walked through the salons ordinaires. The attendant bowed as we stepped from wooden floors onto plush-piled carpet and into the hushed salons privés. These are private only in that an extra payment is required, and guests must be properly attired for the privilege of wagering higher stakes.

Voices intermingled with the crisp clicking of chips, the metallic tick of spinning balls in roulette wheels, and the tinkle of the jewel-encrusted wrists reaching to place bets.

At the center table a small group gathered around a tall, slender Italian, his deep suntan accentuating graying sideburns. Only his eyes hinted of nervousness as he tossed out four-thousand-dollar *plaques*. In fifteen minutes he won 125,000 francs, more than $25,000. Then he turned and scooped up his winnings. Dropping a $100 tip on the table for the croupiers, he strode briskly away.

This was a night we would not soon forget. Thanks to M. Bernard's foolproof method, we had won a vicarious fortune.

Happy Land of Make-believe

We have come to know Monaco as many things. She is well ruled by one of the oldest and shrewdest dynasties in Europe. She enjoys a booming economy. Since our visit the tiny fief and France have worked out a settlement of their fraternal spat. In the future, French businessmen who settle in Monaco must pay taxes. For those who have already acquired residency, however, the favorable economic climate remains unmarred.

But Monaco emerges, ultimately, as a land of make-believe. She suits the fairy tale, even to the handsome Prince who marries the beautiful Princess and lives in a palace overlooking the sea, hopefully, happily ever after.

As long as enough people want to believe in fairy tales come true, there will always be a Monaco somewhere. THE END

KODACHROME (ABOVE) AND HG EKTACHROME © NATIONAL GEOGRAPHIC SOCIETY

Skyrockets shower stars into the Mediterranean as the Casino d'Été climaxes a Friday night gala. Street lights bejewel Monte Carlo behind the brightly lighted casino.

Monte Carlo croupiers and guests of the authors pose in the casino. Rules forbid the photographing of visitors, but employees set up a realistic scene around a roulette table.

SERVANT OF GOOD NEIGHBORS

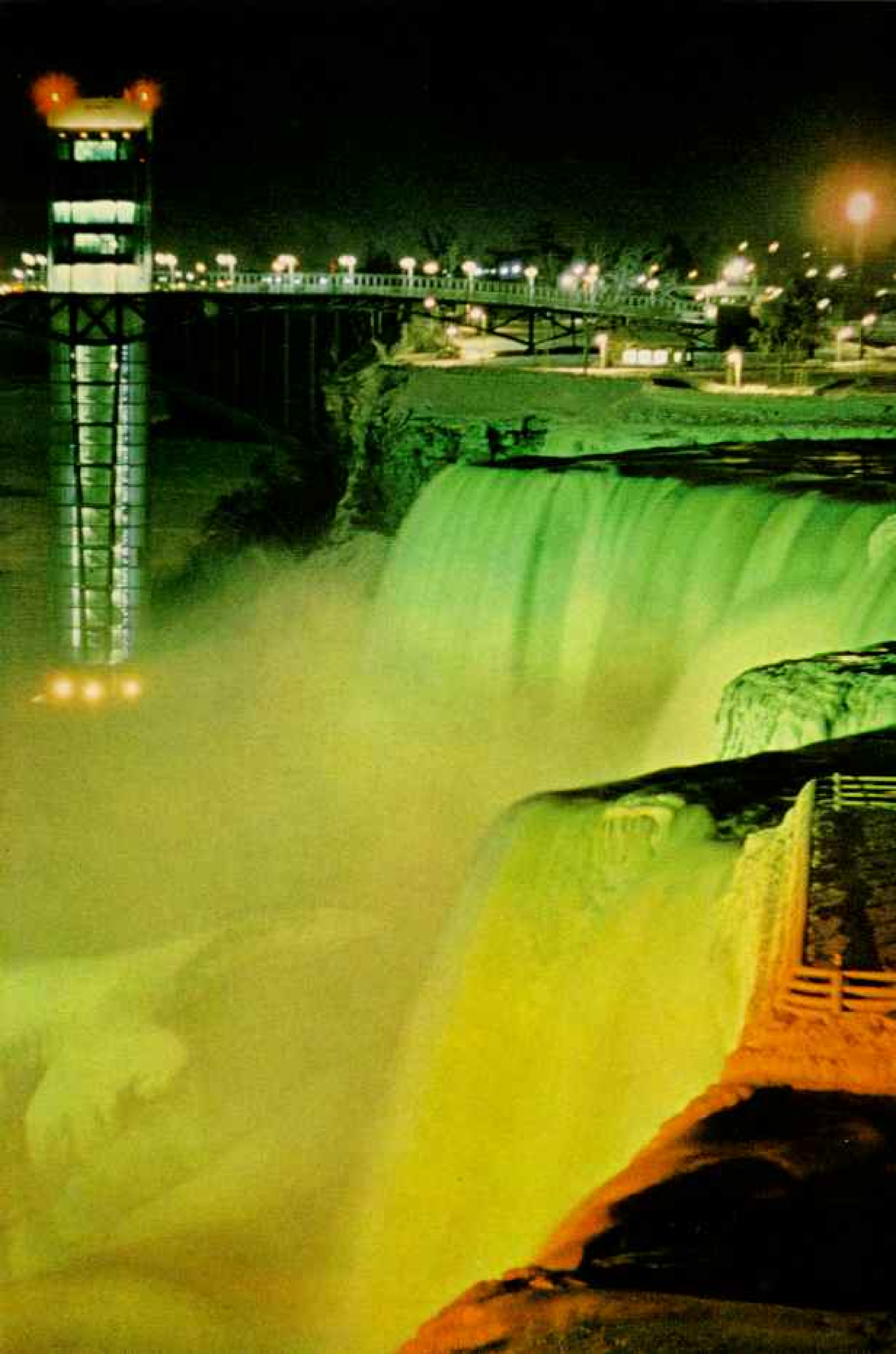
Niagara Falls

PHOTOGRAPHS BY WALTER MEAYERS EDWARDS
National Geographic Staff

SEARCHLIGHTS of more than four billion candle power radiate splendor over Niagara Falls, a breathtaking spectacle on the United States-Canadian border. Rainbow hues flash across the lip of shadowed Luna Falls (lower right) and bathe 1,000-foot-wide American Falls beyond the guardrail enclosing Luna Island. Observation tower at Prospect Point rises from ice-choked Niagara Gorge.

KODACHROME © NATIONAL GEOGRAPHIC SOCIETY

Peace rules the border. Stars and Stripes and the Canadian ensign fly side by side on Rainbow Bridge; its 960-foot steel span above turbulent Niagara Gorge links New York State with Ontario. Two of the Falls' five million annual visitors step across the painted boundary marker. Sheraton-Brock Hotel and 55-bell carillon tower rise on the Canadian shore. Not one soldier stands guard along the 3,987-mile U. S.-Canadian frontier.



 Clouds of mist billow beneath the ceaseless avalanche that roars over the half-mile sweep of

KODACHROME © NATIONAL GEOGRAPHIC SOCIETY

Horseshoe Falls, 186 feet high. *Maid of the Mist* cruises below Ontario's Queen Victoria Park

KODACHROMES BY WALTER MEAYERS EDWARDS

EKTACHROME BY NATIONAL GEOGRAPHIC PHOTOGRAPHER WINFIELD PARKS

Maid of the Mist Noses Into the Maelstrom

Slicker-clad sightseers ride the diesel vessel as she pitches and rolls below Horseshoe Falls (see also page 576). *Maid of the Mist* has carried countless visitors into the caldron. Her name perpetuates the legend that Indians each year sent their fairest maiden over the Falls in a canoe to appease the Thunder God living below.

Blizzard of spray lashes the *Maid*'s deck passengers.

Aero car swings above The Whirlpool at a sharp right bend of Niagara Gorge 3 miles below the Falls. Here the river, churning down the 300-foot-wide passage at 25 miles an hour, flings its savage current against the Canadian bank (left) and forms a giant swirl. This tramway stretches 1,708 feet between two stations in Canada, dipping to 150 feet above the water.

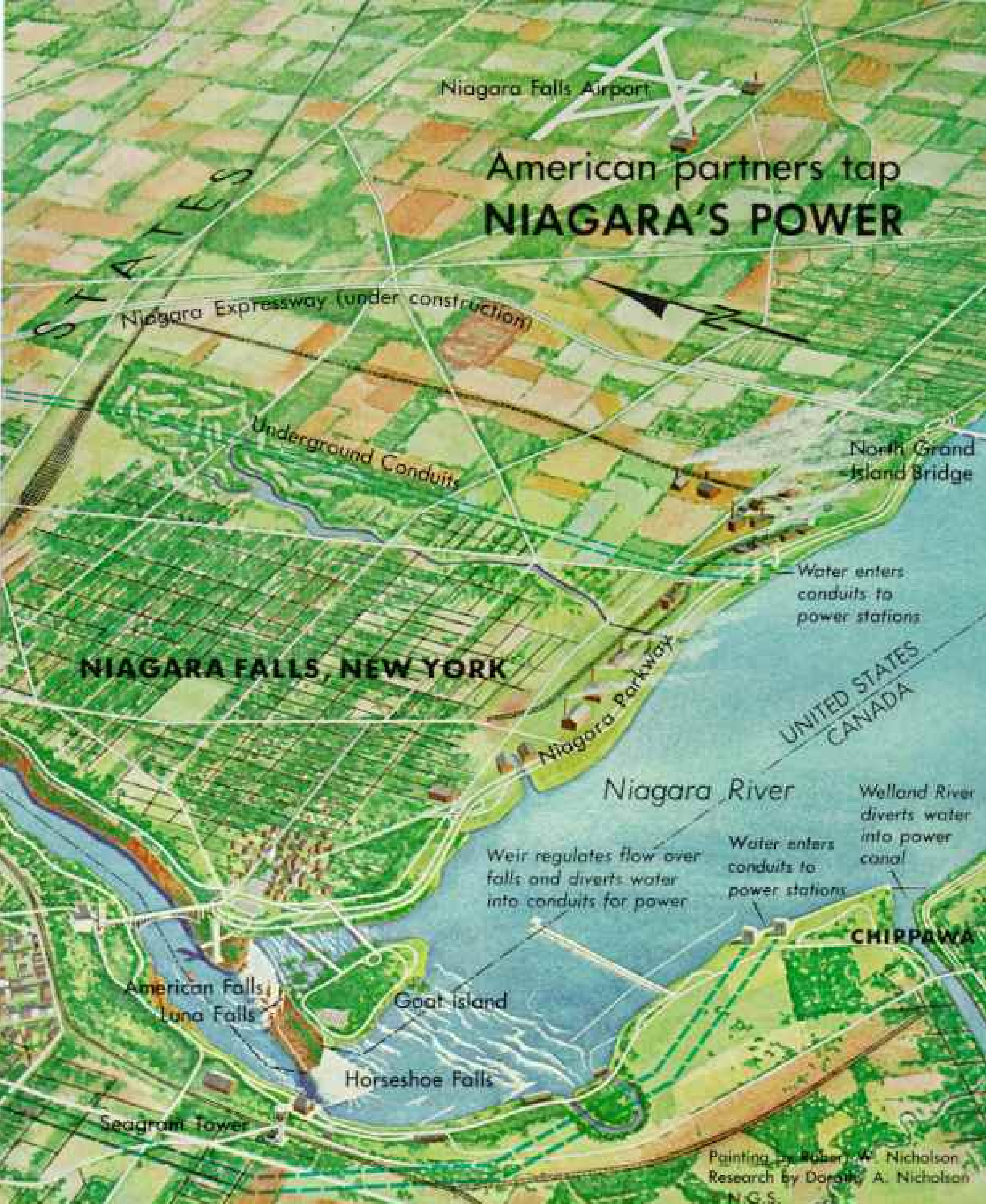
Translucent waters of Luna Falls spray visitors on Hurricane Deck near the former Cave of the Winds. No tourists have been permitted behind the water curtain since 1920, when falling rock killed three persons. The cave no longer exists.

NATIONAL GEOGRAPHIC STAFF © N.G.S.

Niagara Parkway (under construction)
Niagara Escarpment
Pumped Storage Reservoir
Lewiston Pump Generating Plant
LEWISTON
Lewiston-Queenston Bridge
Forebay
Switchyard
Robert Moses Niagara Power Plant
QUEENSTON
Sir Adam Beck-Niagara Generating Stations
Switchyard
Pumping-Generating Station
Pumped Storage Reservoir
Power Canal
Power Canal
The Whirlpool
UNITED
CANADA
NIAGARA FALLS, ONTARIO
Power Canal
Underground Conduits

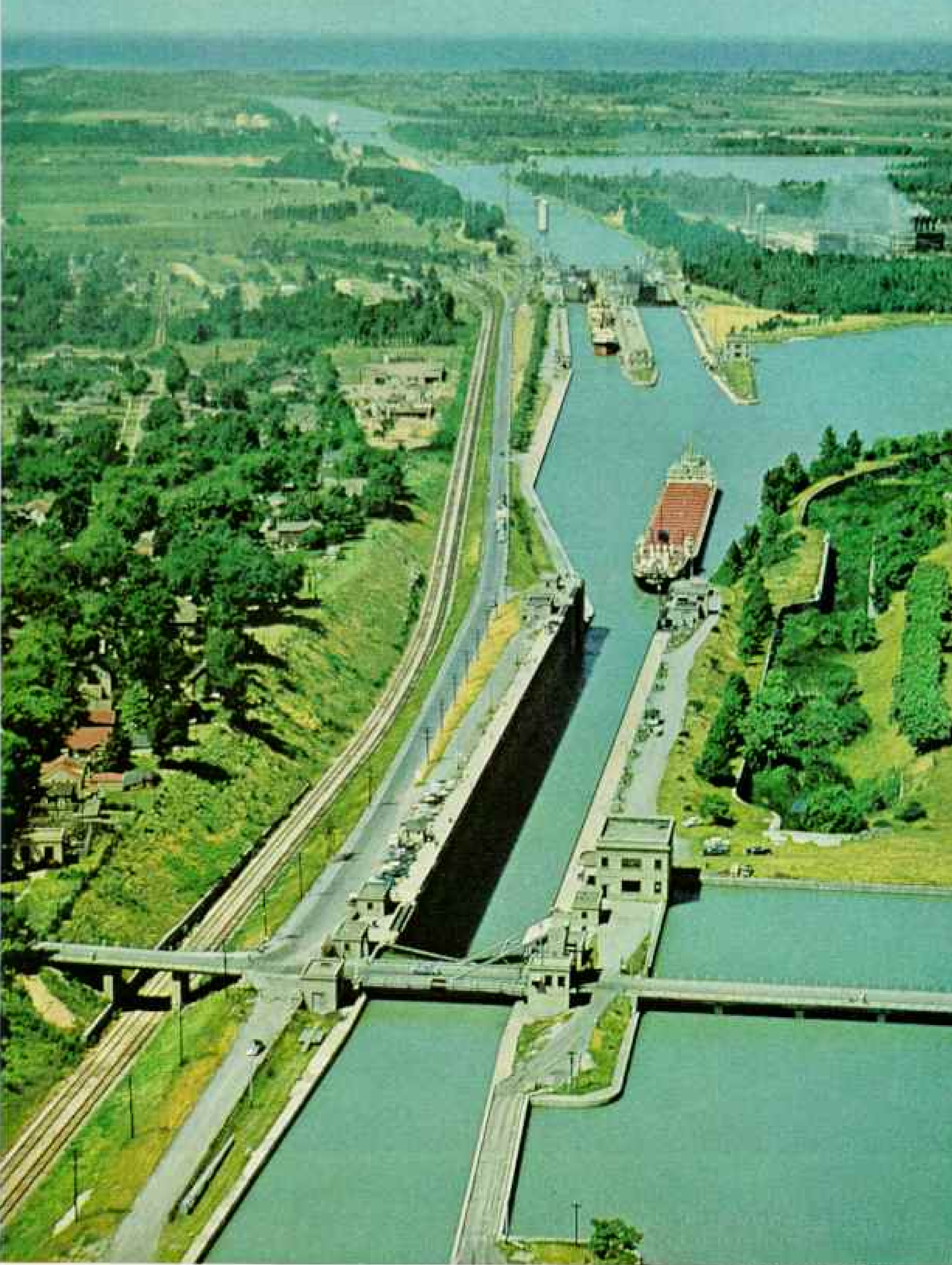
Niagara's power capacity ranks the Falls as the Western World's largest hydroelectric complex

EVERY SECOND some 200,000 cubic feet—the combined flood of Lakes Superior, Michigan, Huron, and Erie—flow down the Niagara River to the Falls. A 1950 hands-across-the-Niagara treaty gives Canada and the United States equal shares of the plunging water for generation of power, some four million kilowatts. It prescribes a minimum flow over the Falls of 50,000 cubic feet a second except in



daylight during the tourist season, when it is increased to 100,000 for esthetic reasons. Twin conduits, each larger than four double-track railroad tunnels, channel part of the water to the newly finished Robert Moses plant. Likewise, two mammoth 5½-mile tubes beneath Niagara Falls, Ontario, feed the Sir Adam Beck-Niagara Generating Station No. 2, across the river from the Moses plant. At night when power demand is low, Niagara-powered electric pumps store water in reservoirs. During the day's peak demand, the stored water flows out through the same pumps, which become turbogenerators producing more electricity.

The diversion reduces erosion that has gnawed back the Falls from the Niagara Escarpment at upper left about seven miles since the Ice Age.



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Ships Plying Canada's Welland Canal Bypass Niagara Falls

Eight massive locks overcome the 326-foot drop between Lakes Erie and Ontario (top). Bushes and earth at right center fill a trenchlike remnant of the last of three previous Welland Canals. The Falls lie 10 miles east of here, to the right of the picture.

Fire-retarding Foams Suggest Giant Cupcakes

Cheap, abundant water power and rich deposits of rock salt made Niagara Falls the cradle of the U.S. electrochemical industry.

Here in the Hooker Chemical Corporation's plant, research engineers have produced buoyant Hetrofoam, a polyurethane plastic designed for insulation at high and low temperatures.

This laboratory technician lathes samples into hourglass-shaped cores that will be machine-tested for tensile strength.

KODACHROMES BY WALTER MEAYERS EDWARDS © N.G.S.

Not even a blowtorch can sear Fiberfrax, a ceramic insulation that stands up under intense heat—2,300° F. Manufactured by the Carborundum Company in its Niagara Falls, New York, plant, cottonlike fibers 25 times finer than human hair are processed into blanket, yarn, rope, cloth, and sheet form.

Molten stream of aluminum silicate (lower left) pours from a furnace heated by a postlike electrode. A jet of steam converts the liquid into fluffy Fiberfrax.

KODACHROME BY NATIONAL GEOGRAPHIC PHOTOGRAPHER WINFIELD PARKS © N.G.S.

Spectacular panorama surrounds diners in the sky atop the new Seagram Tower in Ontario (page 586).

Martial music and cannon salute Flag Day in June at Old Fort Niagara, where the river meets Lake Ontario, 15 miles north of the Falls. Riflemen costumed as British redcoats present arms at the raising of historic French, U. S., and British banners. Frenchmen built the Castle, now part of a New York State park, in 1726 to strengthen their hold on the Niagara frontier. Behind the façade of an innocent chateau, massive walls hid cannon emplacements, powder magazine, and a well to ensure water during attack.

Fringe-topped carriage rolls through Queen Victoria Park. Riders peer at American and Luna Falls.

KODACHROMES AND AN EKTACHROME (OPPOSITE, LOWER) BY WALTER MEAYERS EDWARDS, NATIONAL GEOGRAPHIC STAFF

Floral clock on the Canadian side, inspired by a similar timepiece in Edinburgh's Princes Street Gardens, is three times larger than its Scottish counterpart. Stainless-steel hour and minute hands weigh 500 pounds each. Some 24,000 plants, different in each season, make up the design. Power transmission towers rise above Canada's Sir Adam Beck-Niagara Generating Station No. 1.

Seagram Tower Gives Sightseers an Eagle's-eye View of Falls and Gorge

Visitors to the eight-level crow's nest atop the 325-foot structure see the bridge-linked cities of Niagara Falls, Ontario (left), and Niagara Falls, New

KODACHROME BY NATIONAL GEOGRAPHIC PHOTOGRAPHER WINFIELD PARKS © N.G.S.

York. Nearby roars the world's most famous waterfall. "Niagara" has become synonymous with a mighty, overwhelming flood, not by height or volume alone—nearly 100 falls are higher, and at least two carry greater flow—but because of the 186-foot leap of a tremendous amount of water.

Mystery of

Orange-and-black monarch flits

Millions of monarchs stream south each fall, deserting breeding grounds in Canada and the northern United States to winter in Florida, Texas, California, and Mexico. Mysteriously, new generations find the same communities, even the same trees, which year after year harbor clouds of wintering butterflies.

THE BUTTERFLIES had come, monarch butterflies beyond number. I watched with delight as clouds of them, tens of thousands of them, fluttered, darted, and dipped in the sunlit coastal city of Pacific Grove, California.

They had arrived on schedule, in October, but not like waves of wintering birds. Instead they winged in singly, so that I had scarcely realized what an incredible migration this was.

Some of these fragile insects had flown only a fewscore miles, from birthplaces in the San Joaquin Valley. Others had fluttered from as far as Oregon, Washington, or southern Canada. But all had come, by some mysterious instinct, to this and other coastal wintering places—without ever having seen them before. By tagging, scientists are learning the story of these remarkable migrations.

One afternoon the monarchs performed an enchanting ballet, silhouetted

the Monarch Butterfly

ARTICLE AND PHOTOGRAPHS BY PAUL A. ZAHL, Ph.D.
National Geographic Senior Staff (Natural Sciences)

KODACHROME © NATIONAL GEOGRAPHIC SOCIETY

across ice plant and aloe at its wintering ground beside Monterey Bay, California

against my window curtains. In shifting myriads they danced through shafts of sunlight. Then, suddenly, the ballet became a rout; shadows streamed up the curtains like rivulets of smoke. I threw open the door.

Smoke itself was the assailant—blue clouds of it from a leaf fire down the block—and monarchs by the thousands were erupting from the grove of trees across the way.

Massed Monarchs Weigh Down Foliage

Edna Milar, owner of the motor lodge at which I was staying, hurried past me, worried that the smoke might permanently disperse this special pride of the town.

"Are they coming down?" I asked, joining her beside a giant eucalyptus tree. The butterflies were wheeling high overhead.

As the smoke lifted, they began alighting cautiously. Soon twigs were bending under the weight of massed monarchs—even though 100 butterflies weigh scarcely one ounce.

"Thank heaven," whispered Mrs. Milar—and I marked one more example of the regard that Pacific Grove's residents have for the butterflies. Mrs. Milar lowers her voice while in the grove, so as not to disturb them, and asks visitors to do the same.

No one knows how long the monarch hordes have been visiting Pacific Grove, although residents recall them as long ago as the turn of the century. Today the community calls itself "Butterfly Town, U. S. A.," and Ordinance No. 352 makes it illegal "to molest or interfere with in any way the peaceful occupancy of the Monarch Butterflies on their annual visit to the City. . . ."

Many species of butterflies migrate, and other towns in other lands see the far-flying wanderers.* But Pacific Grove is justifiably famous for its monarchs.

I could see them clinging motionless now to their perches. They resembled countless dead leaves, having folded their wings to

*See "Butterfly Travelers," by C. B. Williams, NATIONAL GEOGRAPHIC, May, 1937.

KODACHROMES BY PAUL A. ZAHL, NATIONAL GEOGRAPHIC STAFF © N.G.S.

Warmed by morning sun after a cool night, California monarchs unfold the brilliant upper surfaces of their wings. Lighter underwings mark a few still too chilled to stretch. Adults live on nectar from flowers; flightless larvae feed on milkweed (page 592).

Clinging by hundreds to eucalyptus leaves, comatose monarchs keep wings closed, hiding the bright upper surfaces. A visitor to Pacific Grove, California, on a gray day may look directly at 10,000 monarchs in trees and say, "I see the dead leaves. Where are the butterflies?" A few hardy individuals spread their wings in this early-morning view.

show only the drab undersides (opposite).

During the cooler hours of the day, these butterflies rest in a state of semisleep. Only when they feel the reviving warmth of the sun do they rouse and flutter off in search of the nectar and water that constitute the adult monarch's exclusive diet.

This orange-golden multitude lodged in a dozen or so eucalyptus and pine trees in Mrs. Milar's grove. At a couple of other sites in town, and a few other select places on the California coast, they were also roosting.

The great smoke crisis over, the abiding mystery of the monarch came to mind: How are new generations able to arrive at the precise place and even the same trees used by monarchs year after year as wintering sites?

Some of them come 1,000 miles or more through wind and rain, over mountains and plains and high over cities, resting only at night on trees and shrubs along the way. And their flying speed is astonishing; the monarch cruises at about 10 miles an hour, and may sprint as fast as 30!

Larvae Thrive on Milkweed Diet

I began my study of *Danaus plexippus* on the opposite side of the continent last summer, on an egg-collecting expedition with monarch admirer Robert T. Mitchell, of the U.S. Fish and Wildlife Service's Patuxent Research Center. An open field near Beltsville, Maryland, verdant with milkweed, was our hunting ground. The hunting was good.

Scientists long have been intrigued by the monarch. At least two distinct populations exist in North America—one in the western states, the other throughout the Midwest and East. Separating them lie the great ridge of the Rocky Mountains and the western deserts. The eastern contingent winters in Florida, along the Gulf Coast of Texas, and in Mexico.

Like migratory birds, wintering monarchs fly north in the spring to lay eggs and begin the life cycle anew. But a bird feeds its offspring many kinds of food; larvae of the monarch dine only on milkweed of the genus *Asclepias*, which is why the monarch is often called the milkweed butterfly.

Using a hand lens, Bob Mitchell and I discovered numerous tiny jade-green, bullet-shaped eggs, most of them cemented to the undersides of milkweed leaves (left).

All around us flew the adult monarchs. Some few were faded with age, their wings torn. These old butterflies probably had wintered in Florida. With the approach of spring in the north and the promise of fresh milkweed there, they had set out on their long return trip northward.

Monarch egg, 36 times life-size, lies glued to a downy milkweed leaf. Dark head of the developing larva shows within the pinhead-size shell. A monarch female may lay more than 400 eggs, which hatch in 3 to 12 days, according to the temperature. Most are laid on the undersides of leaves; the author turned this leaf over.

Newly hatched caterpillar (above), also 36 times life-size, turns its black-knobbed head and devours the transparent eggshell from which it came. Soon it will start nibbling the milkweed leaf, its regular diet.

Monarch Caterpillar Begins a Magical Metamorphosis

Hanging head down from a twig in a figure J, a two-inch larva prepares to shed its skin for the fifth time and change into a pupa, or chrysalis. A six-pound human baby that grew at the same rate would weigh eight tons in two weeks. As caterpillar or butterfly, the boldly marked monarch needs no camouflage; for unknown reasons, parasites or predators seldom attack it.

KODACHROMES BY PAUL A. ZAHL, NATIONAL GEOGRAPHIC STAFF © N.G.S.

Mating had occurred before or during the flight. By the time they reached the first milkweed fields on their way north, some of the females, already gravid with eggs, began laying. Others, not yet ready, journeyed on.

"Those fresh and bright monarchs are the offspring of migrants," said Bob. "They were probably born here in Maryland."

Some of these, in turn, would proceed northward. Ultimately a wave of monarchs reaches southern Canada. There, too, eggs are laid, hatch, and in about five weeks the larvae metamorphose into adult butterflies.

Voyager Lives Less Than a Year

During early summer many monarchs, having mated and laid eggs and thus met the specifications of nature's blueprint, grow old and bedraggled, and presently they die. But those that reach adulthood toward the end of summer make the great return southward.

Unlike some species that live a matter of only days, a monarch may live nine months. But a marked monarch has never been recaptured at the same place the next year.

Well-stocked with egg-laden milkweed leaves, I returned to my Washington, D. C., laboratory. I arranged some of the leaves in a glass terrarium, and soon the monarch's life cycle began to unfold (left and below).

I had collected newly laid eggs. Five days later they hatched. After gorging on milkweed leaves for 15 days, shedding its skin four times as it grew, each larva was a chubby caterpillar about two inches long.

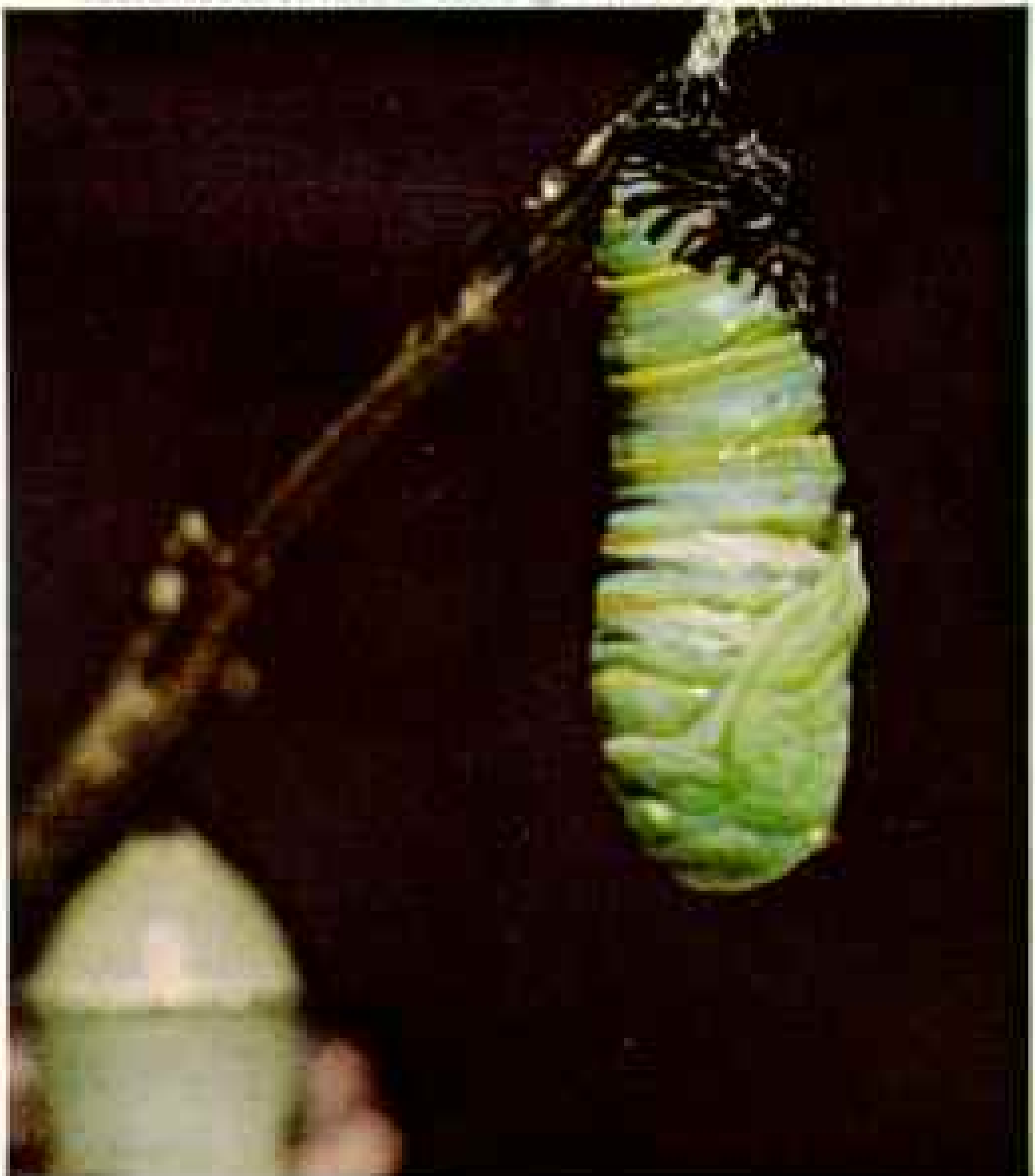
Then the caterpillar crawled away from the leaf and attached its tail end to a twig I had provided. Hanging head down, it squirmed and contorted. Within hours it had shed its tough outer hide, transforming itself into the stately chrysalis—a resplendent cask bejeweled with gold dots (next page).

Another two weeks ensued. As the days passed, I saw the outlines of the adult butterfly taking shape inside the chrysalis, pressed tightly like a mummy inside a burial urn. Then a crack appeared at the lower end of the shell. A large rupture followed, and the beautiful mature lepidopteron (Greek for "one-with-scaly-wings") emerged.

At this close range I could readily distinguish the sex: Males alone display a tiny black spot—a scent gland—on one of the veins of the upper surface of each hind wing.

KODACHROMES BY PAUL A. ZAHL © NATIONAL GEOGRAPHIC SOCIETY

Starting to unzip, the skin splits, and the milky-green pupa bulges forth behind the head. Squirming within its loosened striped jacket, the pulpy mass ripples with wavelike pulses that tear open the skin like a plastic bag. Monarchs never spin cocoons but do weave the little silk buttons from which the larvae hang.



Five minutes later, the pupa quiets down and hangs in the last folds of its old garment. Soon it will withdraw a hooked stem from the tip of the skin and embed it firmly in the silk button. Then the pupa gyrates until the old skin sheds. At this point a fall of even an inch would kill or maim the fragile pupa.

KODACHROMES © NATIONAL GEOGRAPHIC SOCIETY

Strand of golden beads studs a pupa. Sealed against evaporation in a waxy jade envelope, the erstwhile caterpillar awaits transformation into the winged beauty opposite.

Developing wings show through the transparent case two weeks later. The snugly packaged pupa is about to begin the miracle of rebirth into an imago, the mature insect.

Newborn monarch, hanging from the shattered walls of its discarded house, expands its soft, fleshy wings by pumping a clear green fluid into them from its contracting body. When the wings stiffen and dry, the insect will fly away to carry on the species.

Instinctively, as soon as the adult had gathered strength, it would begin fulfilling the basic needs: nectar and water, in time a mate, and not long thereafter, if a female, milkweed plants on which to deposit eggs. I released my terrarium-reared monarchs and watched them flutter into an autumn sky.

Soon the monarch migration would begin. One by one, for they are individualistic flyers, they would take off for their winter homes: to Florida and Texas and Mexico, or in the case of the western group, to the warm California coast or Mexico.

Record Flight: Ontario to Mexico

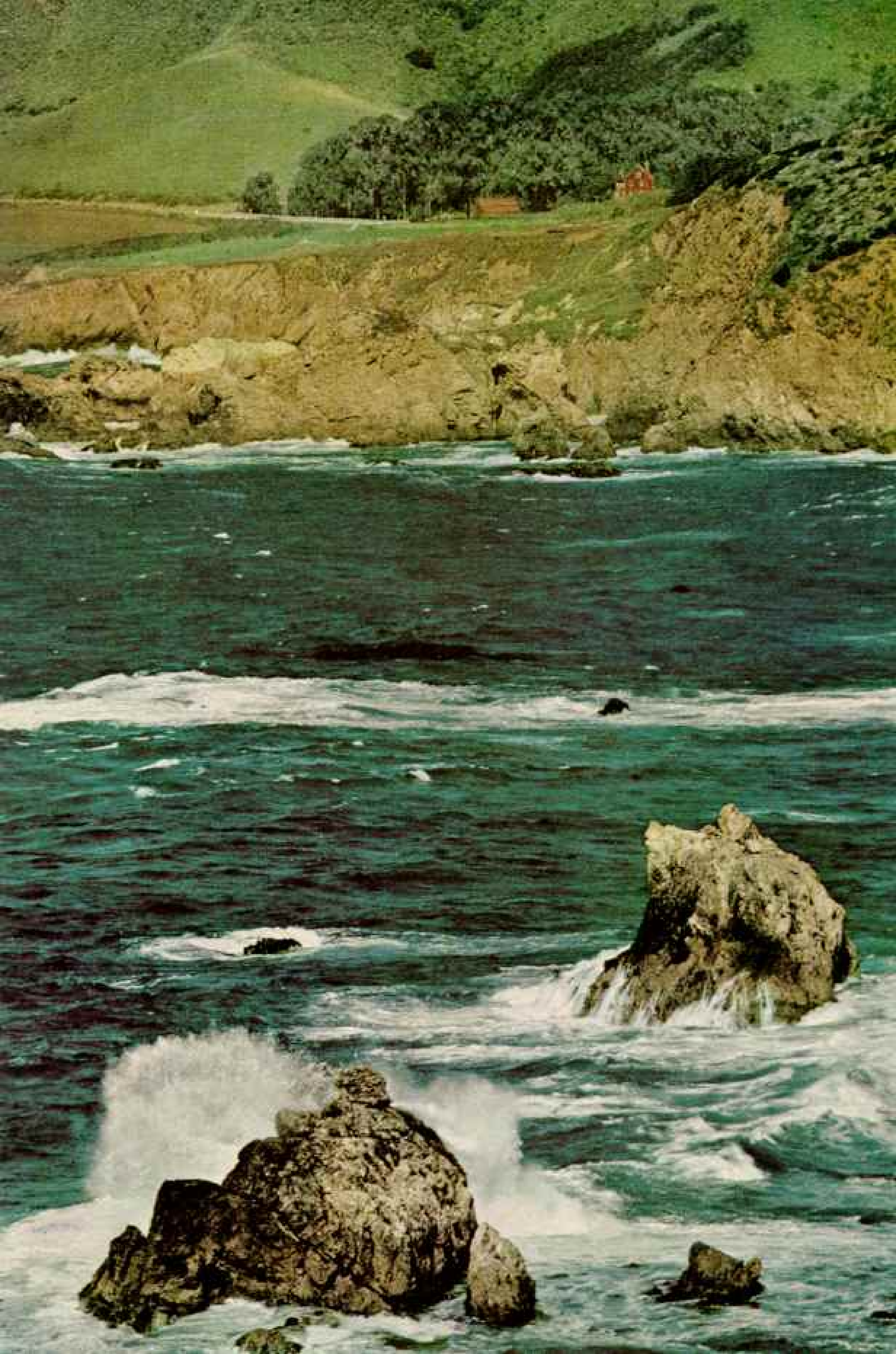
I visited Pacific Grove because it is the best known monarch wintering site in the United States. Concentrations in California also have been reported as far north as Bodega Bay, above San Francisco, and as far south as Riverside, inland from Los Angeles.

For years, lepidopterists have marked these insects in the hope of learning more about their migrations and guidance systems. Methods have included dyeing the wings, rubber-stamping them, and labeling them.

I discussed monarch-tagging with Paul W. Beard, a Monterey schoolteacher who has stuck gummed paper labels to thousands of butterfly wings (page 598). Thanks to him and hundreds of other monarch fanciers across the continent, many flights have been recorded. The longest spanned 1,870 miles, from the vicinity of Toronto, Ontario, to the town of Catorce in San Luis Potosi, Mexico.

"This is all the more remarkable because of the odds against recovering a tagged specimen," Paul told me. Of the 4,000-odd monarchs he has labeled, he said only six had been recovered, all in the Sierra Nevada foothills within 150 miles of his home.

One cloudy November day, Paul and I drove 17 miles south of Pacific Grove to Palo Colorado Canyon. There, deep in a grove be-



KODACHROMES © NATIONAL GEOGRAPHIC SOCIETY

Make-believe butterflies welcome the monarchs back to Pacific Grove with a parade. Each fall elementary school children salute the returning insects, which winter in several groves within city limits.

Prettiest monarch of them all, Gerri Stewart leads the parade.

White Surf Marks Trail's End for Migrating Monarchs

Tens of thousands winter in the eucalyptus trees across this arm of the Pacific at the mouth of Palo Colorado Canyon. Passengers in cars on State Highway No. 1 flash by unaware of the clustering wonders deep within the grove.

World's best known butterfly, big-winged *Danaus plexippus* flies far. In the past century this native North American butterfly has been reported in the Azores and western Europe and across the Pacific as far as Hawaii, Australia, and Java. Gravid females borne by ships or planes have aided this spread, although monarchs in flight have been sighted 500 miles at sea, perhaps blown there by strong winds.

HS EKTACHROME BY PAUL A. ZAHL, NATIONAL GEOGRAPHIC STAFF © N.G.S.

Netful of ghostly monarchs will tell the ratio of males to females in Palo Colorado Canyon. Schoolteacher Paul Beard helps survey butterfly habits.

Fingers fold a paper tag over a wing; adhesive surfaces meet through a hole punched in the wing. "Send to Museum Toronto Canada," the numbered tag asks, in a continent-wide cooperative study. Newer tags stick tighter and resist rain. A monarch took one 1,870 miles from Canada to Mexico.

KODACHROME BY PAUL W. BEARD © N.G.S.

side the pounding ocean, he led me to several trees festooned with insects, all semidormant in the faintly chilly air.

"Watch this," Paul said.

Using a net with a 16-foot handle, he reached up and with a quick sweep captured perhaps 75 specimens, harming none. But there were thousands and thousands more in the eucalyptus trees around us. If a labeled monarch were among them, no one would guess it.

I looked up at the quiescent clumps. With wings folded as usual, the butterflies were hard to distinguish. But then shafts of sunlight filtered through, and the trees came to life. Immediately the monarchs spread their wings to the sun's warmth, revealing upper surfaces agleam with gold, orange, and black.

The trees were in bloom, or so it seemed.

As the morning rays bore down, some of the awakened beauties abandoned their perches to search for nectar-bearing blossoms. By early evening, though, every butterfly was back at home base, squeezing and jostling for a bit of parking space. There they would rest until revived by the next day's sun.

Back in town, a friend told me that he'd watered his lawn that day—and then a flying carpet of monarchs had come to drink their fill from the wet grass. He was enchanted.

Monarch Flights Still Baffle Scientists

But the question remains: How can a frail butterfly find its way to these wintering grounds from a summer birthplace half a continent away? Hardly from "memory." As I have said, there is no record of a monarch long-lived enough to *return* to its wintering place the following year.

Might each new generation rely on celestial navigation—possibly the polarized rays of the sun—to guide its flight?

Perhaps. We can surmise only that a dim instinct and built-in biochemical forces urge the monarch on and guide it.

Until science offers answers, citizens of "Butterfly Town, U.S.A." are grateful simply that this beautiful enigma reappears yearly to puzzle and delight them. THE END

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WASHINGTON, D. C.

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COVER: Battered by wind and wave, 70-gun *Resolution* rides out a storm. English men-of-war fought three wars with Holland between 1652 and 1674 (page 517).

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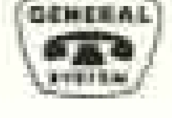

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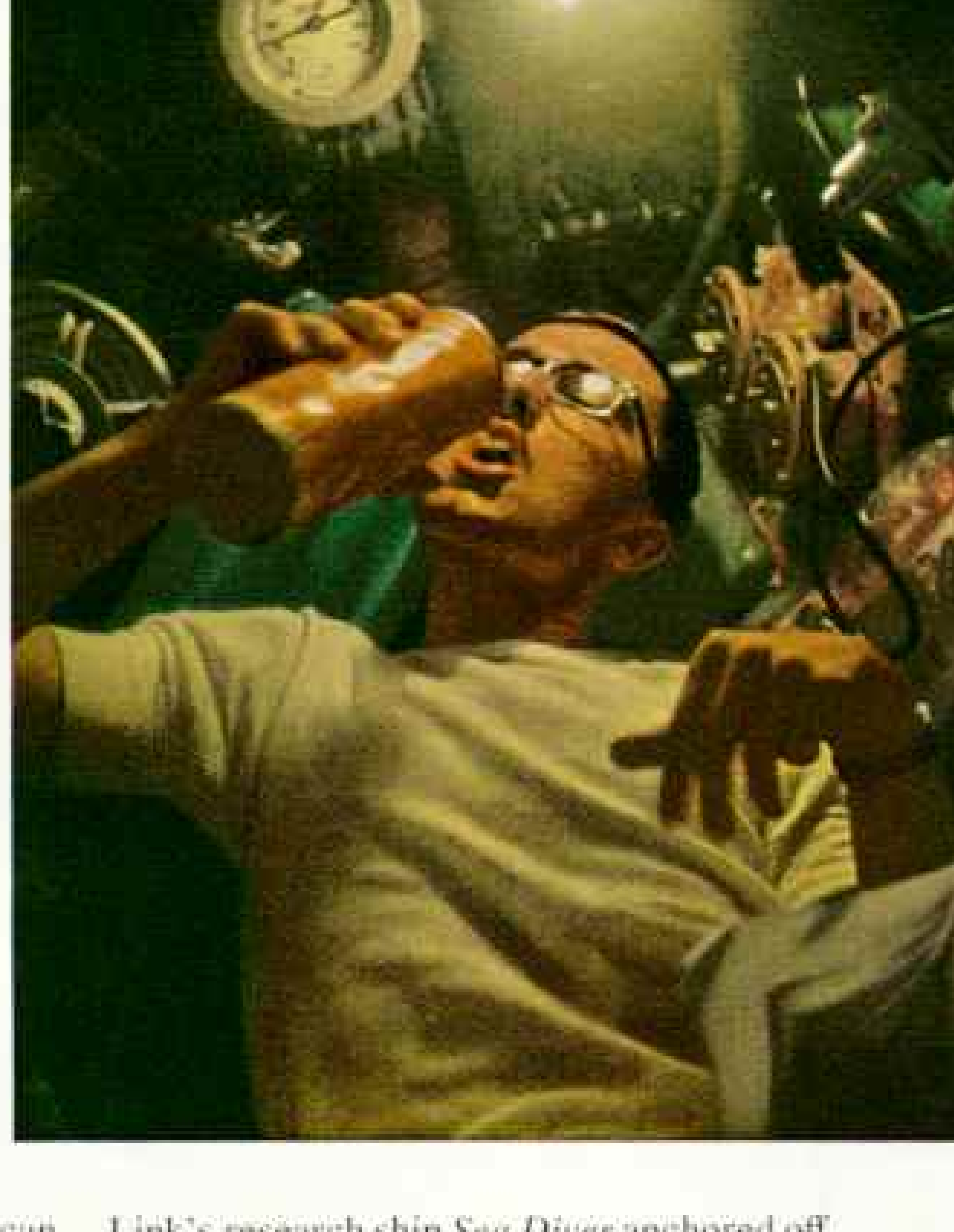

Daring pioneer rests after a historic underwater conquest

AT LAST a diver has shown that men can work, eat, and sleep comfortably while submerged 200 feet in the sea. A remarkable aluminum pressure chamber designed by Edwin A. Link made possible Belgian underwater specialist Robert Stenuit's night and day beneath the waves. Thus success marked the first trials of the ingenious Man-in-Sea Project conceived by Mr. Link and supported by your National Geographic Society.

Here the cylinder lies on the afterdeck of Link's research ship *Sea Diver* anchored off southern France. M. Stenuit's young wife peers at her husband through a porthole as he completes 65½ hours of decompression necessary before he can step out.

In next month's GEOGRAPHIC the inventor and Lord Kilbracken, British peer who rode aboard *Sea Diver*, recount the drama of this milestone in man's conquest of the ocean. Share their fascinating narratives with your friends. Use the form below to nominate them for membership in the Society.

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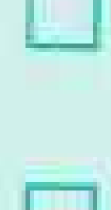

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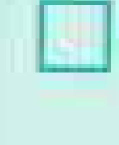

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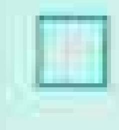

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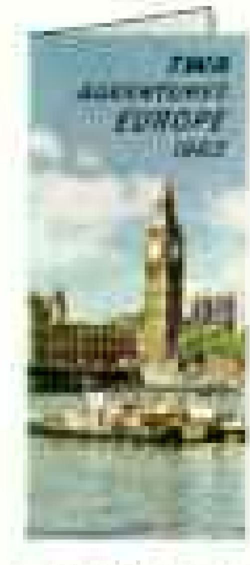

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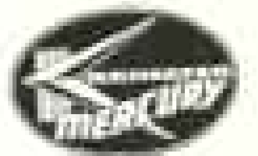

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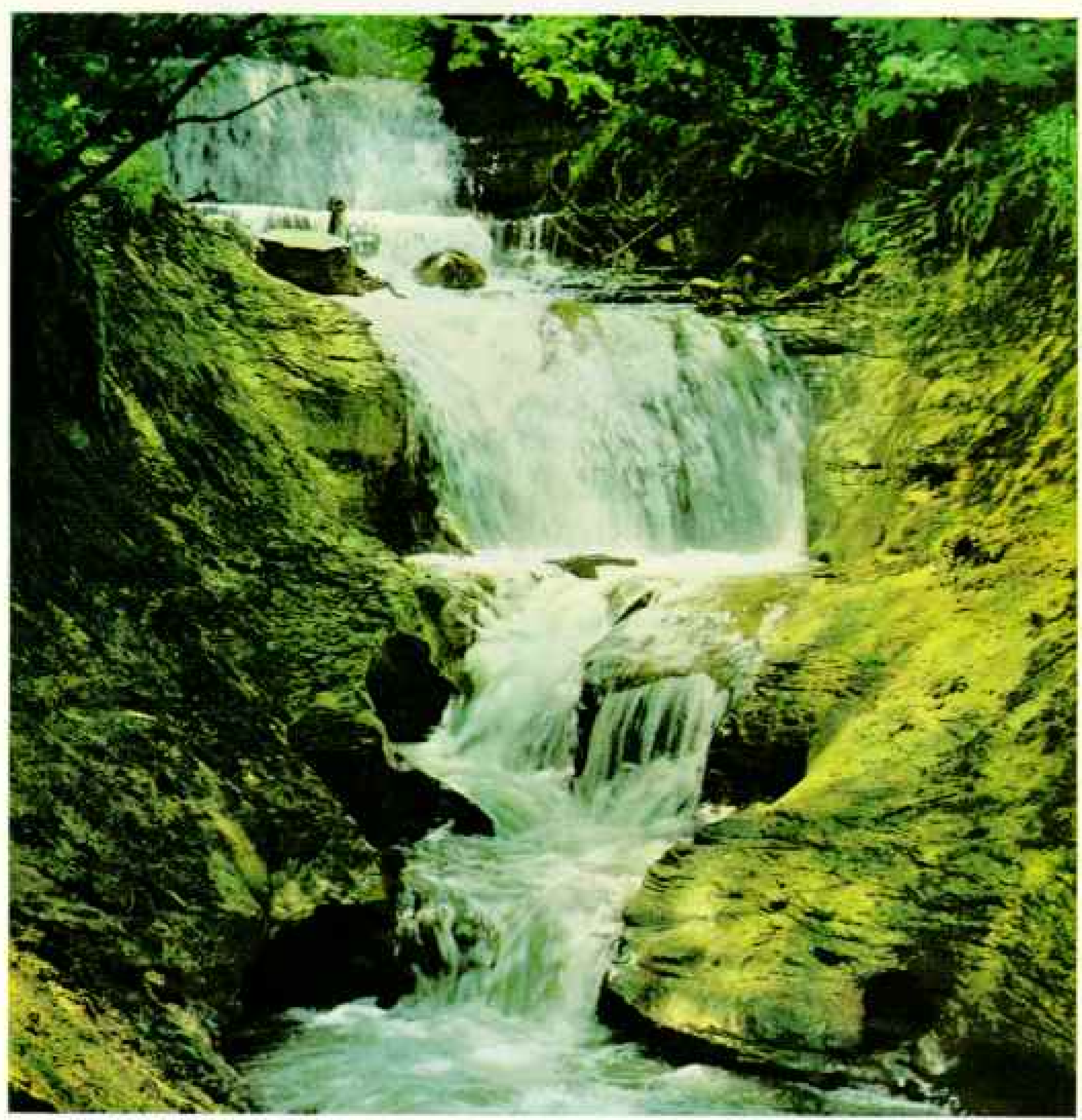

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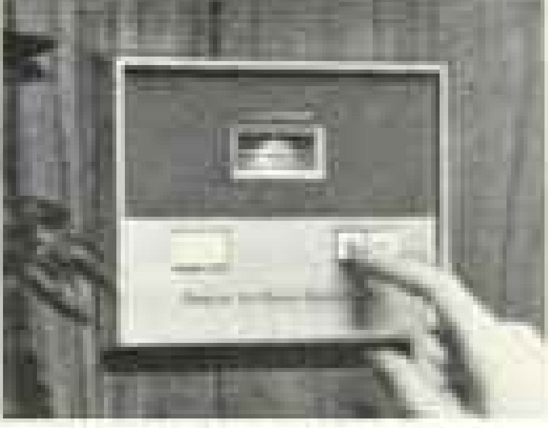

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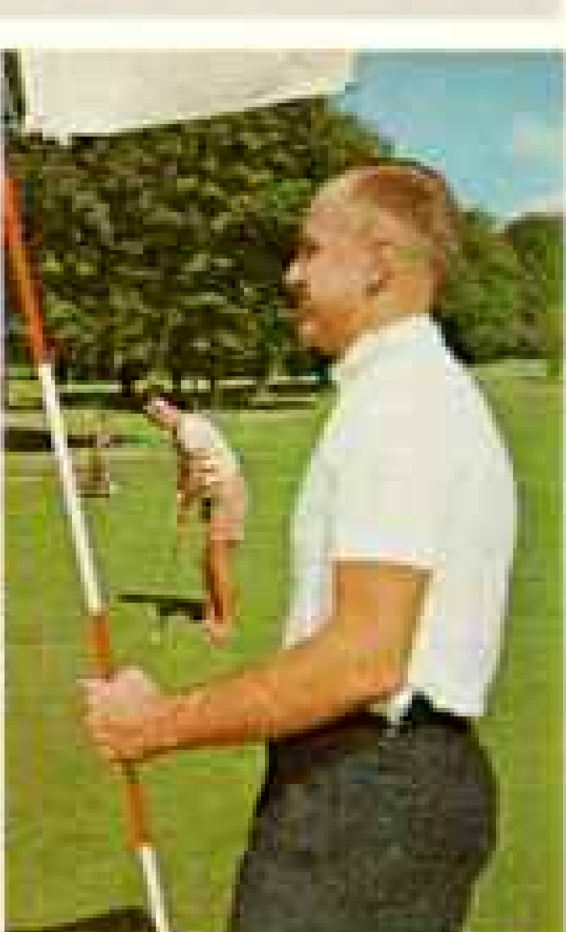

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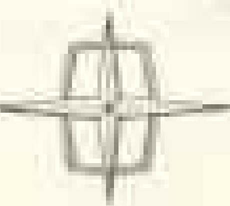

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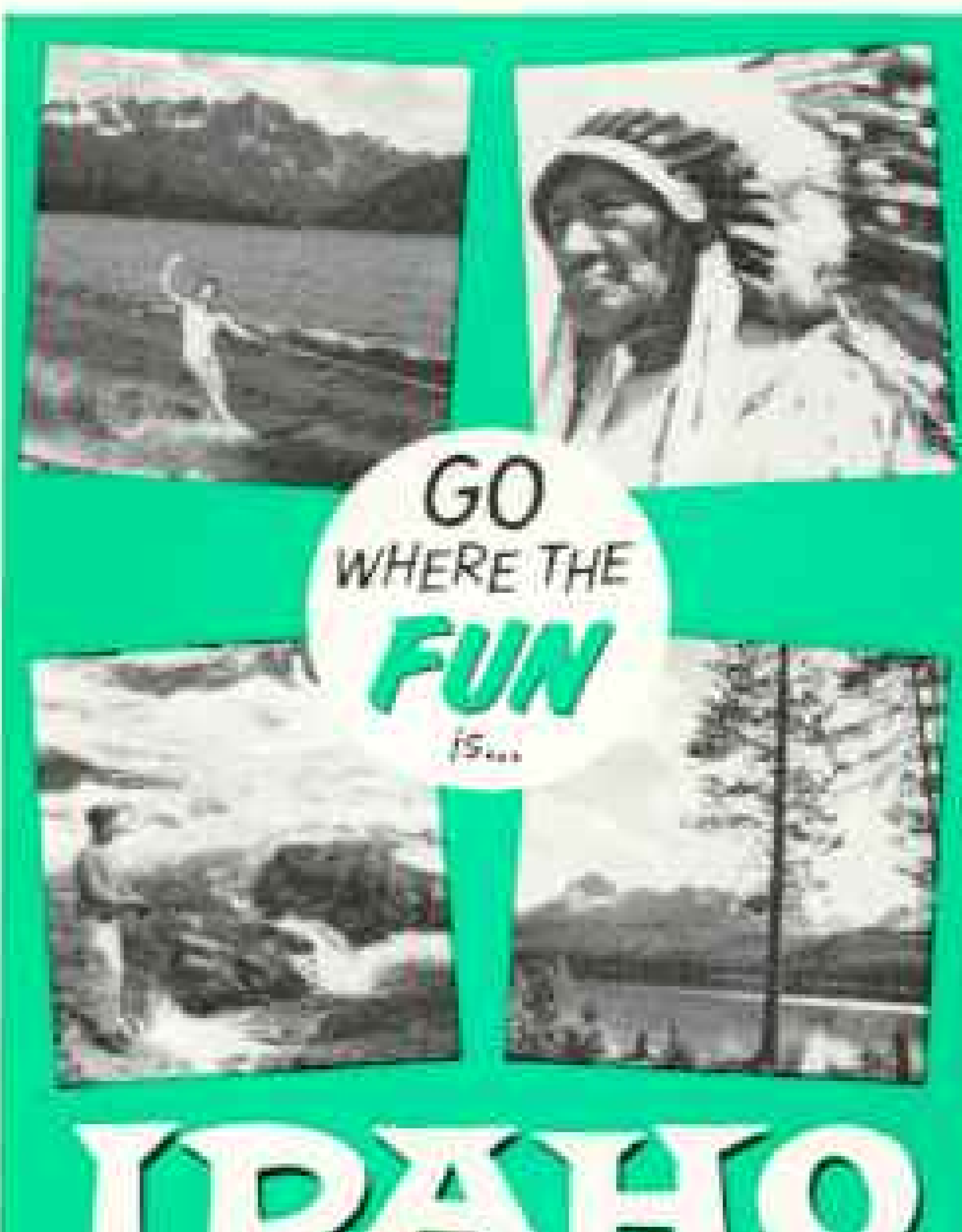

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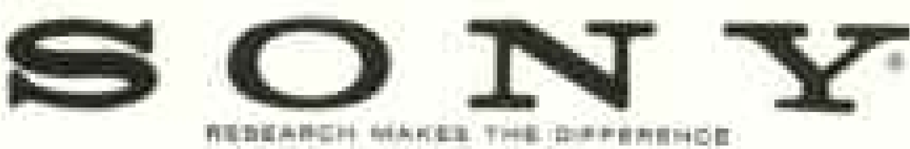

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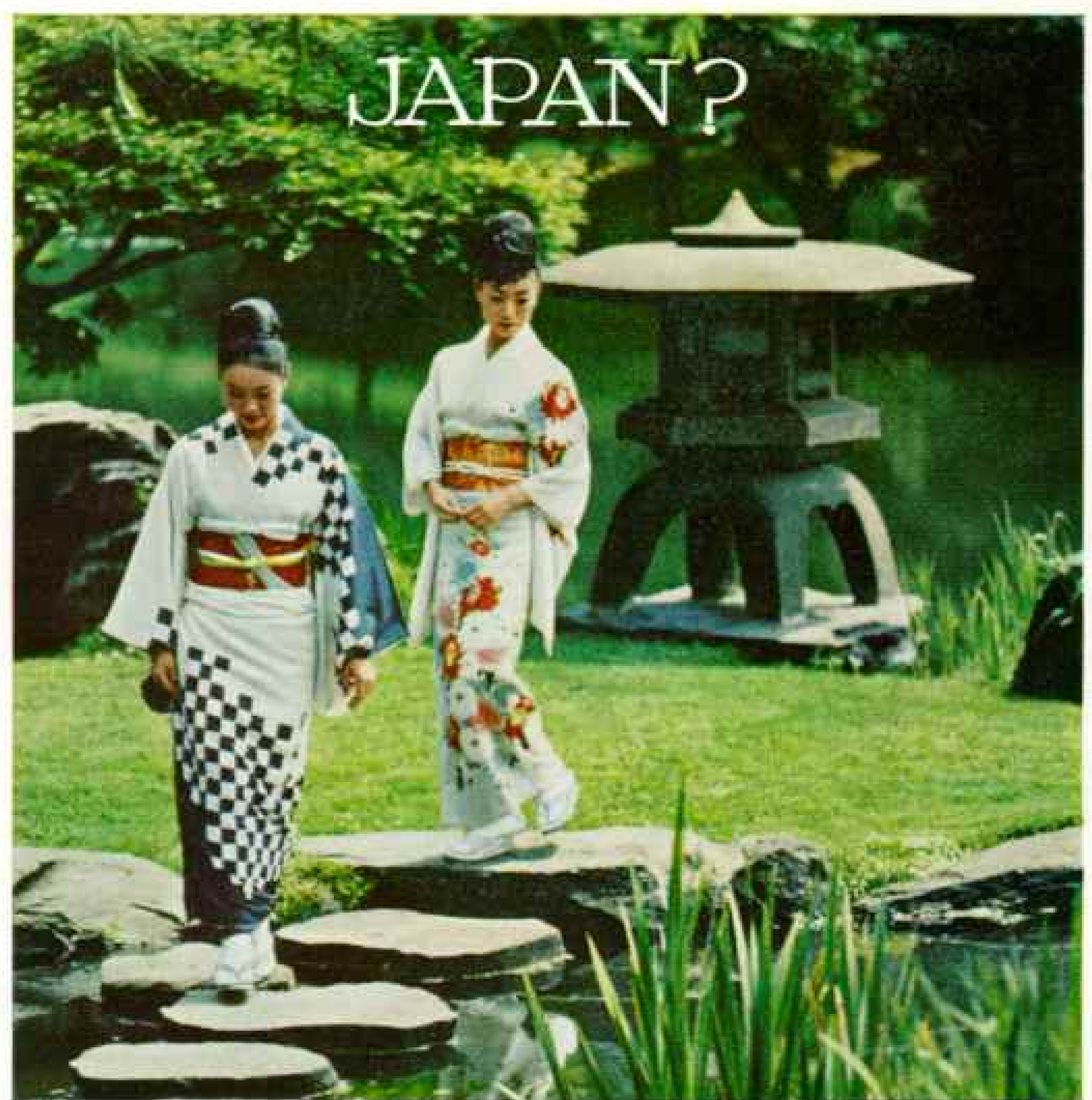

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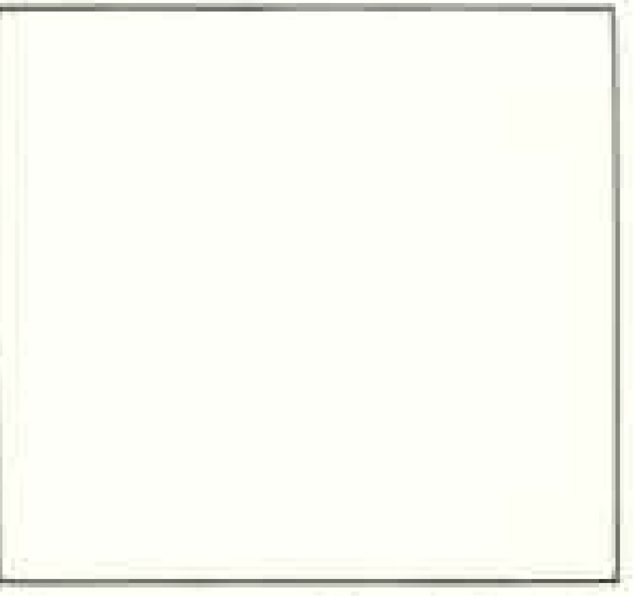
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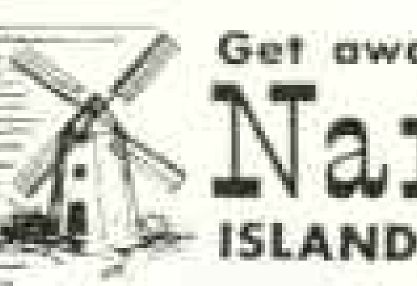

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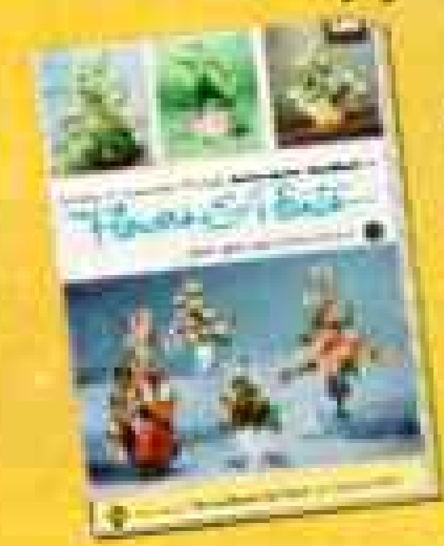

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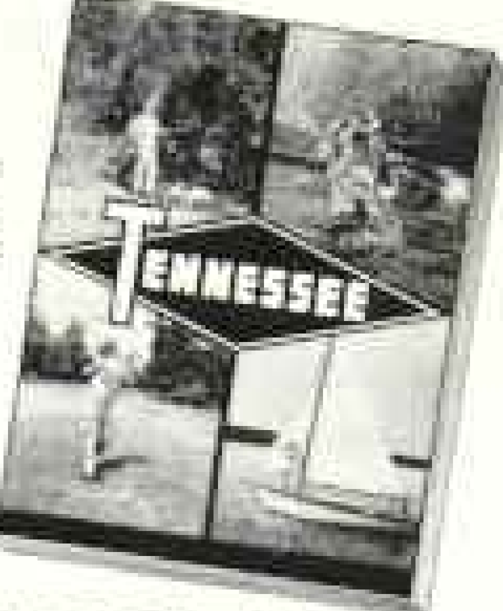

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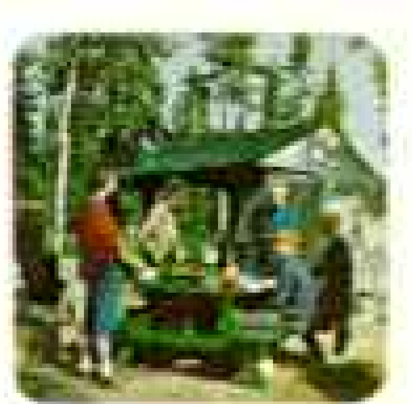

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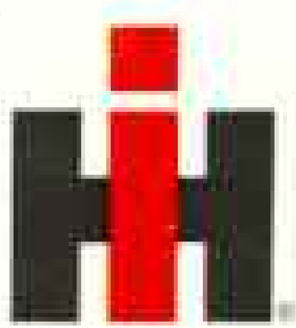

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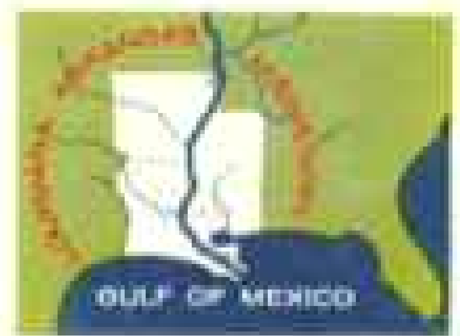

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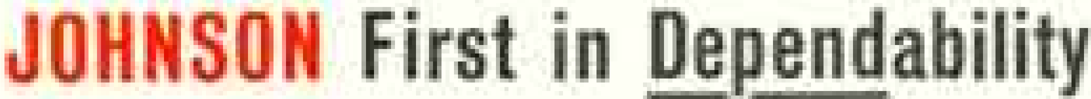

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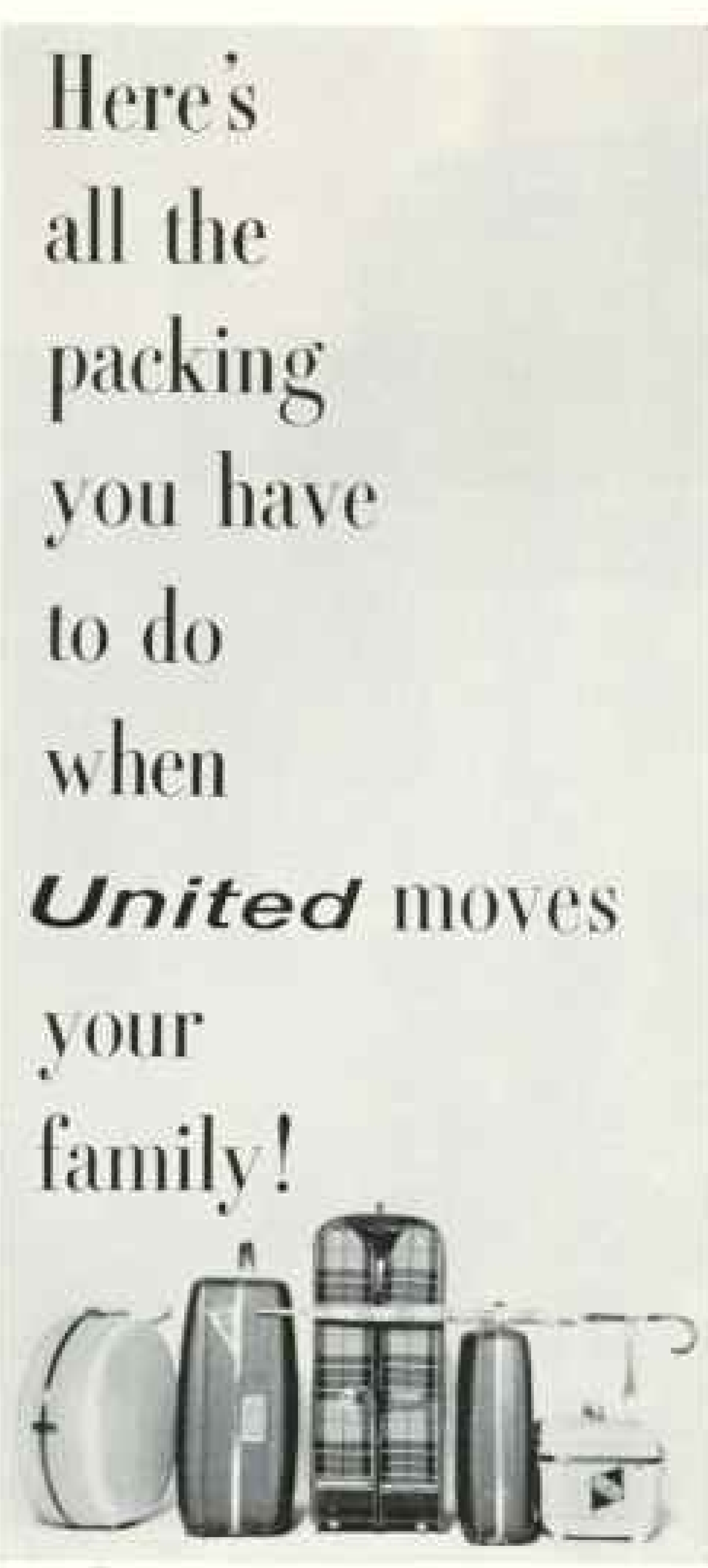

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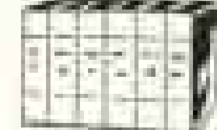

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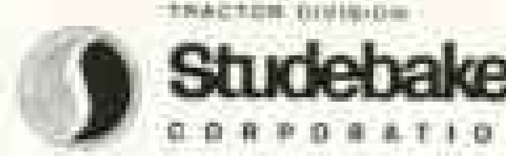

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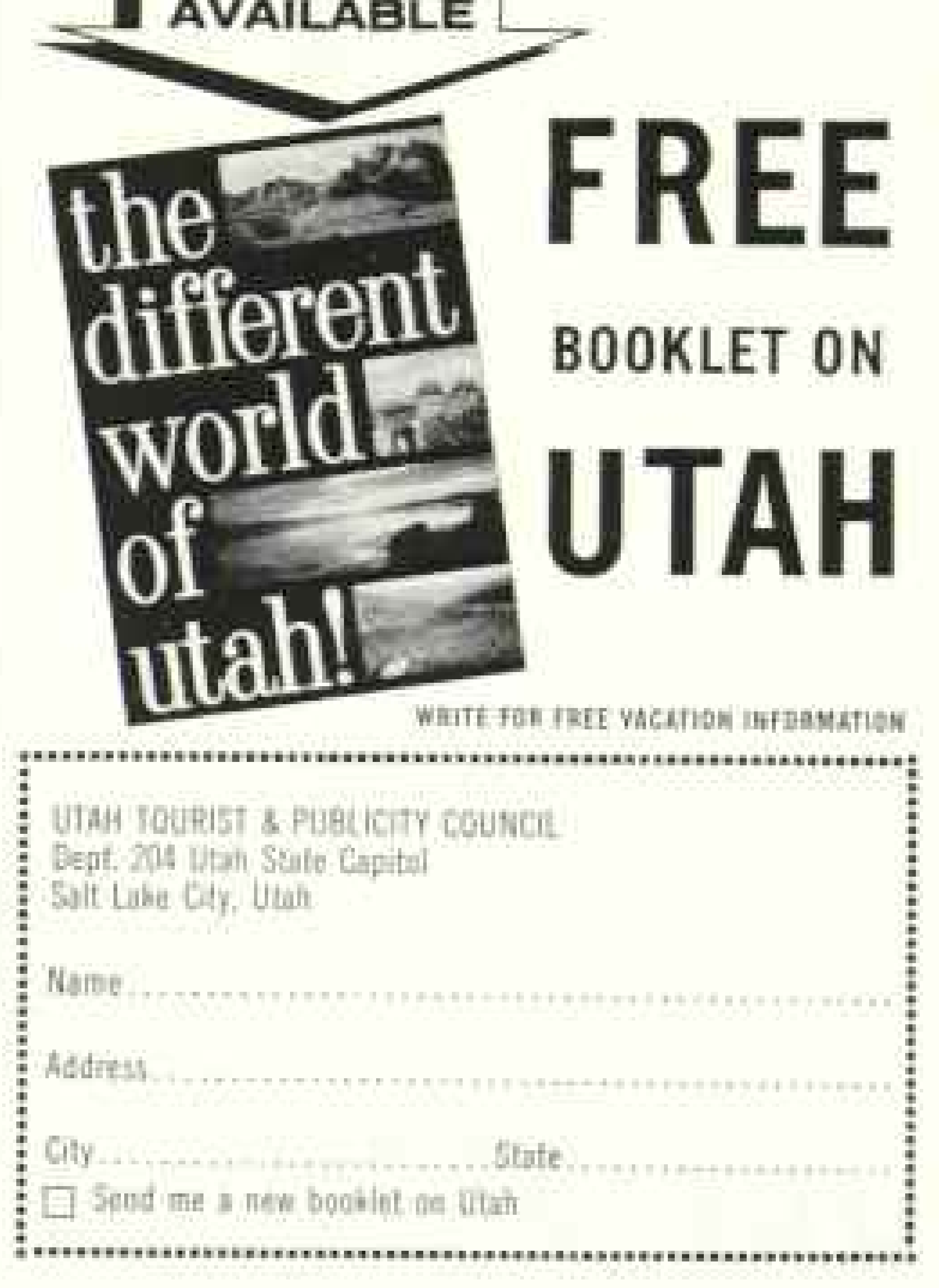

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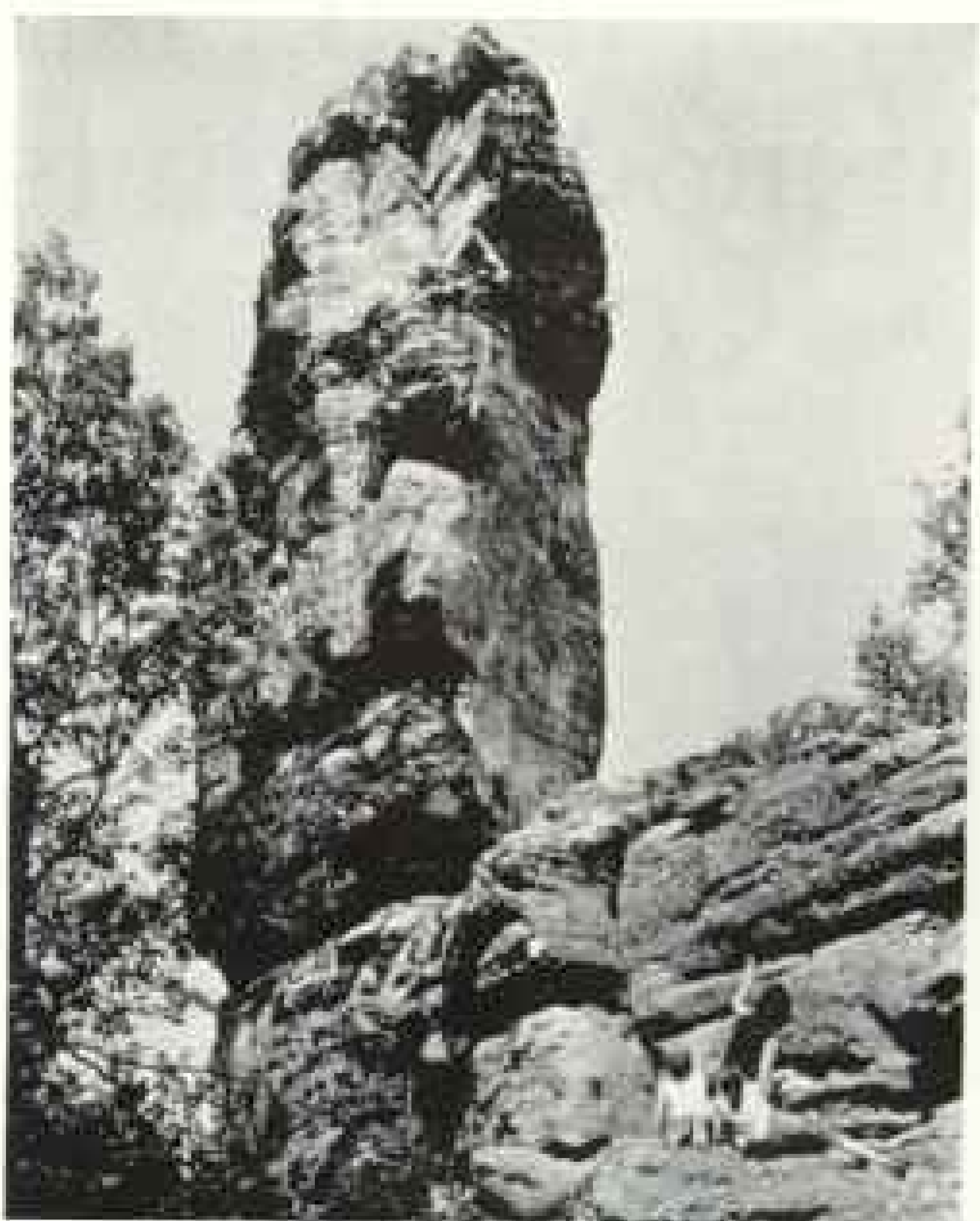

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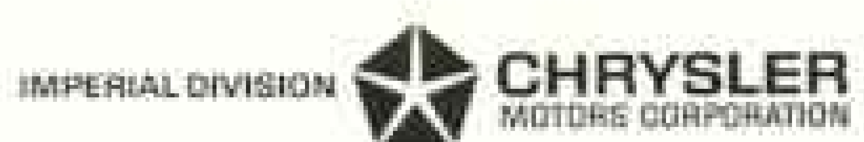

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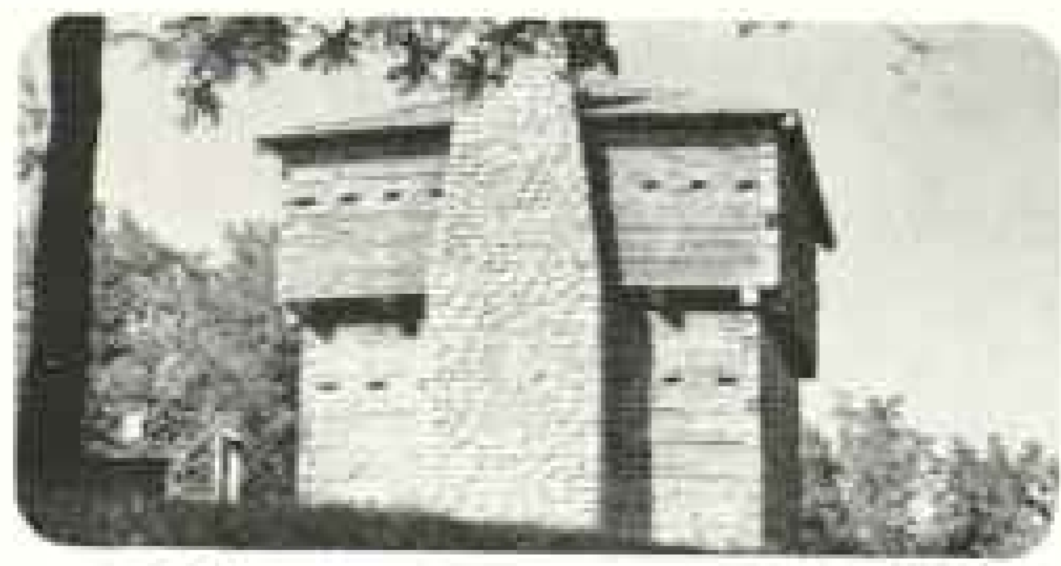

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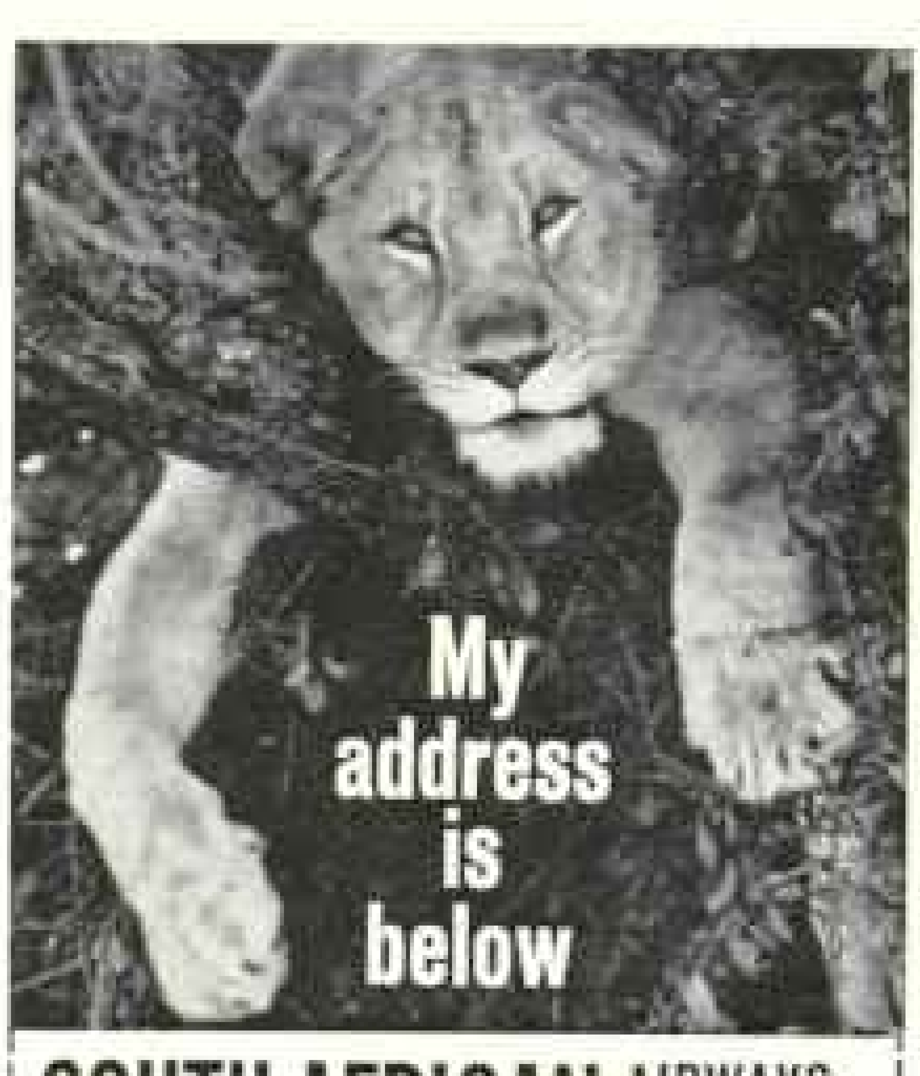

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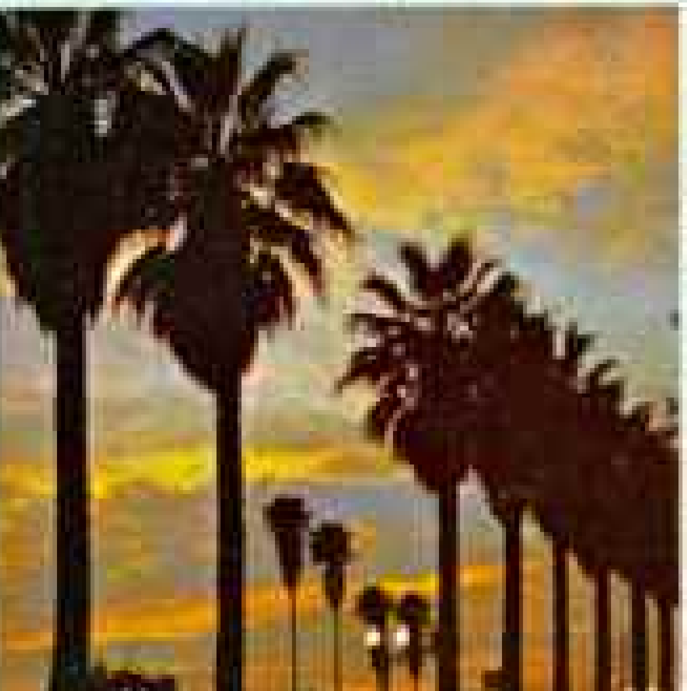

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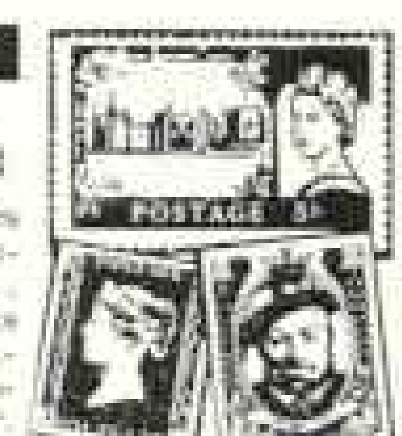

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