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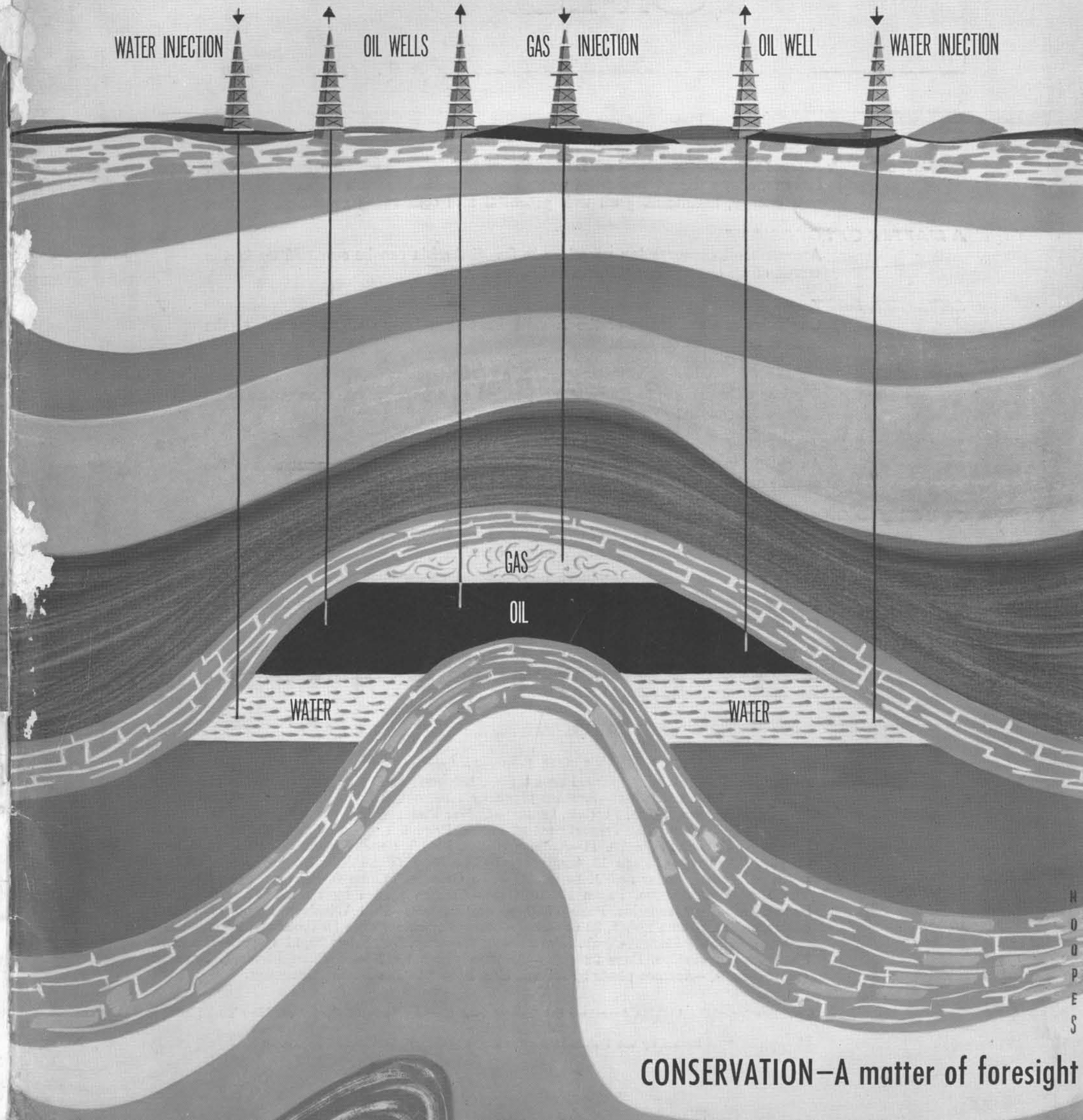
CSF

One of the Boeing 720B jetliners which will soon go into service for the Saudi Arabian Airlines in the Middle East. The green and white turbofan-powered jetliner is pictured during a crew-training flight.

TRACKS ACROSS THE DESERT

silk from China, bundles of incense from southern Arabia, spices and herbs from Eastern lands. Despite the waterless tracts, the sun that scorched from dawn to dusk, stinging sandstorms, robbers, despite every hardship the desert put in the paths of men who would use it as a highway, the skills of the caravaneers would defeat the desert. The spirit of the caravan lives on in Saudi Arabia. With the confidence that comes from hard-won experience and proud tradition, the challenges of desert travel are now met and mastered in new ways. ■

APRIL **ARAMCO WORLD** 1962



CONSERVATION—A matter of foresight

Aramco World

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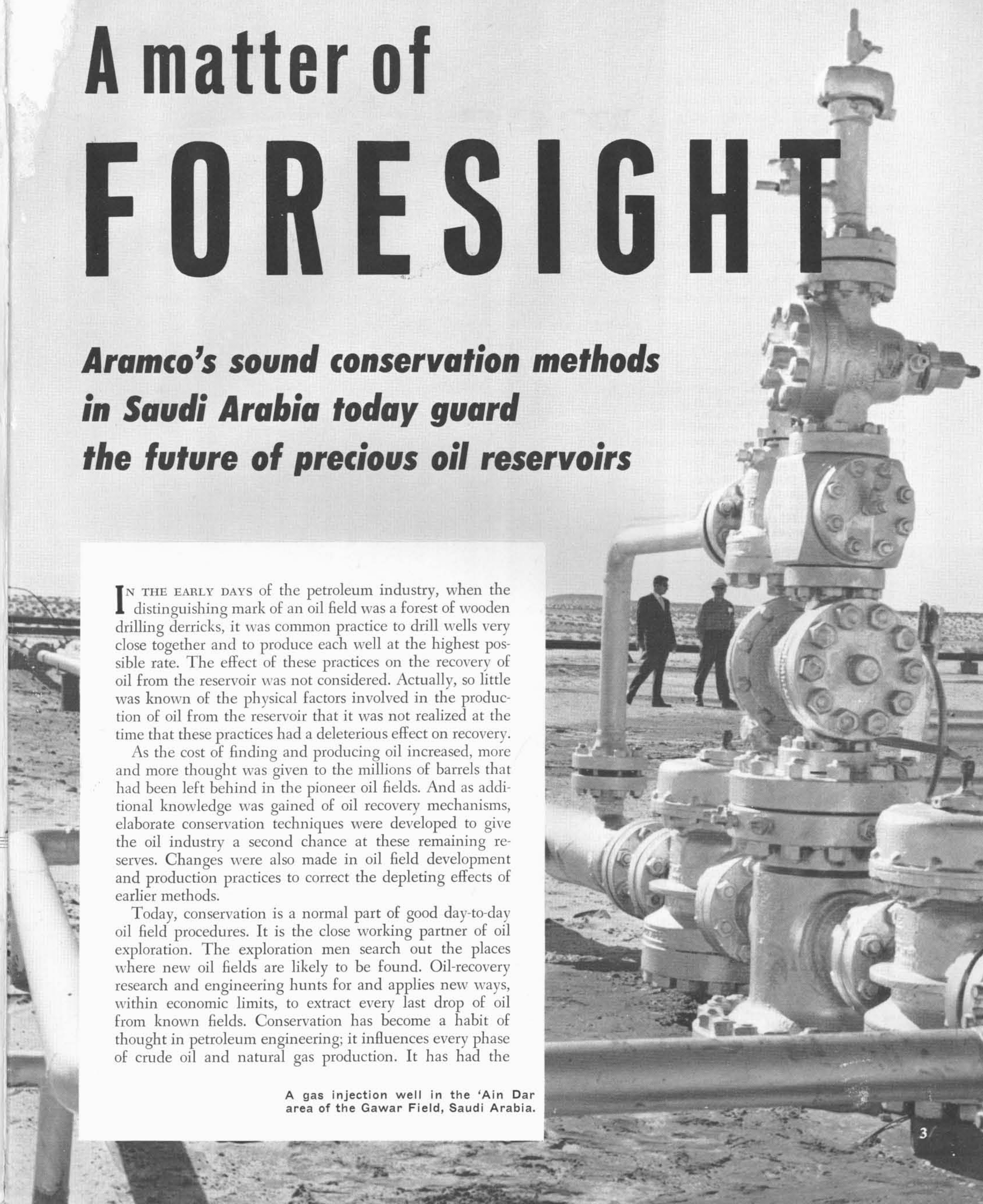
A matter of FORESIGHT

Aramco's sound conservation methods in Saudi Arabia today guard the future of precious oil reservoirs



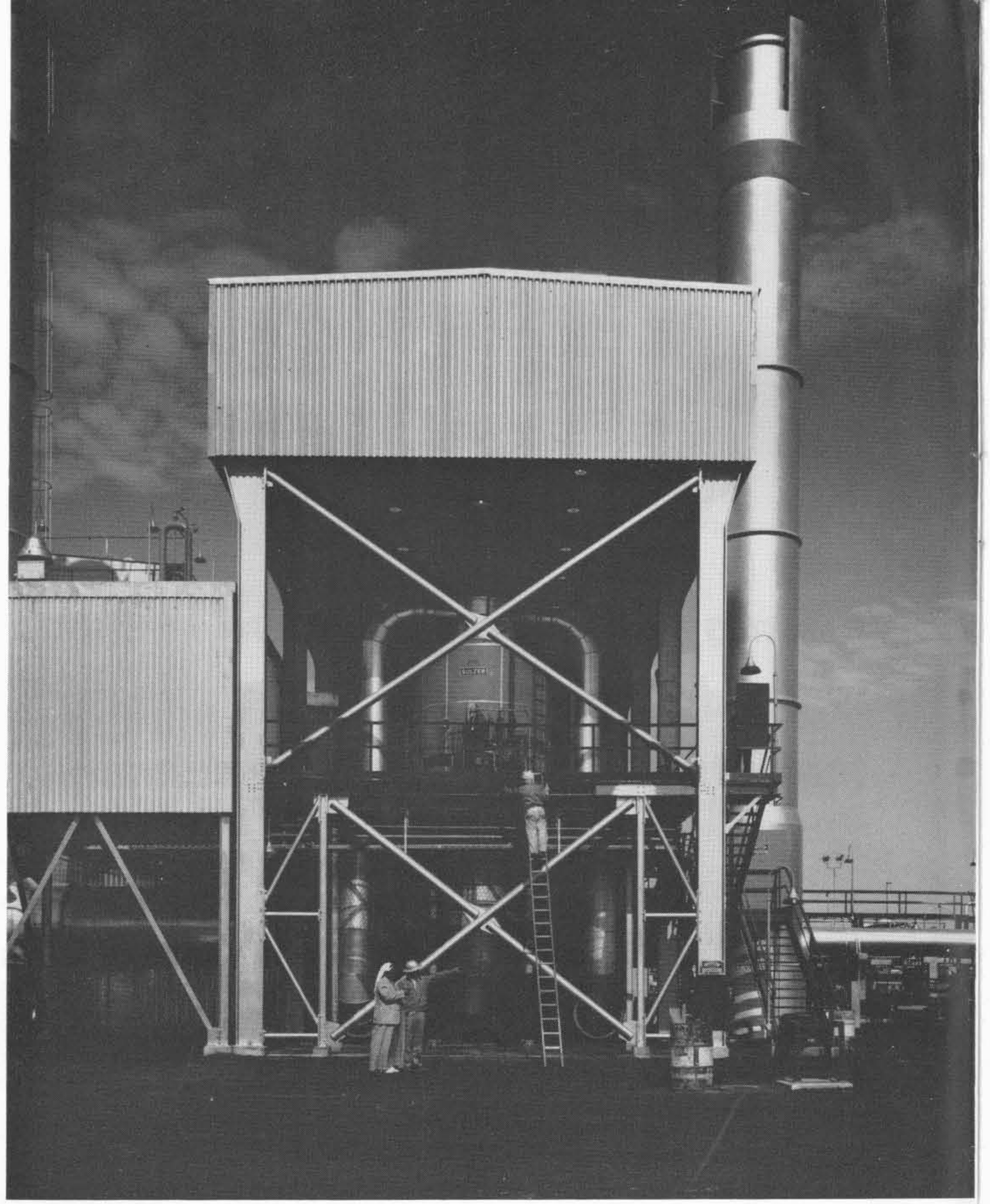
IN THE EARLY DAYS of the petroleum industry, when the distinguishing mark of an oil field was a forest of wooden drilling derricks, it was common practice to drill wells very close together and to produce each well at the highest possible rate. The effect of these practices on the recovery of oil from the reservoir was not considered. Actually, so little was known of the physical factors involved in the production of oil from the reservoir that it was not realized at the time that these practices had a deleterious effect on recovery.

As the cost of finding and producing oil increased, more and more thought was given to the millions of barrels that had been left behind in the pioneer oil fields. And as additional knowledge was gained of oil recovery mechanisms, elaborate conservation techniques were developed to give the oil industry a second chance at these remaining reserves. Changes were also made in oil field development and production practices to correct the depleting effects of earlier methods.

Today, conservation is a normal part of good day-to-day oil field procedures. It is the close working partner of oil exploration. The exploration men search out the places where new oil fields are likely to be found. Oil-recovery research and engineering hunts for and applies new ways, within economic limits, to extract every last drop of oil from known fields. Conservation has become a habit of thought in petroleum engineering; it influences every phase of crude oil and natural gas production. It has had the

A gas injection well in the 'Ain Dar area of the Gawar Field, Saudi Arabia.

In the compressor building at Abqaiq, Saudi Arabia, a 275-ton turbine compresses 57 million cubic feet of low-pressure gas per day. Gas is then cooled to change it to a liquid, which is pumped to the 'Ain Dar Field. There it is injected into the reservoir to help maintain reservoir pressure and thus increase recoverable reserves of crude oil.



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effect of "discovering" new oil supplies by adding billions of barrels to world reserves.

Conservation utilizes multi-million-dollar procedures to guard precious oil reservoirs. It now enters the picture as soon as a field is discovered and delineated. It is part of the planning that leads to efficient and orderly oil field development. As a result, the first-class oil field practices of a modern oil company aim to insure the maximum ultimate economic recovery of the oil in a reservoir.

The vast oil fields of Saudi Arabia afford an unusual opportunity to study the techniques and results of modern conservation. These fields have for the most part been developed during the past 20 years. This has been a time, of course, when progress in all technology has been extraordinary. During these two decades more than four billion barrels of oil have flowed from Saudi Arabian reservoirs. Yet the nation now has more than 45 billion barrels of proved crude oil reserves available for the future. Diligent exploration has led to the discovery of these reserves; their magnitude has been determined by scientific drilling programs that delineate the extent of each Saudi Arabian field. Conservation techniques are being developed, and in many areas have already been applied, to assure maximum economic recovery.

The Saudi Arabian oil fields are rather special in many respects. For instance, the petroleum engineers of the Arabian American Oil Company have been able to develop each reservoir in the Saudi Arabian concession with the assurance that other wells elsewhere in the field also were being drilled by their colleagues according to first-rate practices. In other words, Aramco engineers have been able to develop the Saudi Arabian oil fields in terms of ideal practices – ideal for both economic production and long-range conservation. They have been able to locate wells where the subsurface structure of the oil formations indicated that the wells ought to go. There is a "custom-built" quality in the way the wells are deployed in the Arabian oil fields.

The majority of advanced techniques for efficient oil production and conservation have been developed in the United States. However, because of the divided ownership of oil and mineral rights that exists in the United States, an oil company rarely finds itself in the position of having obtained all the mineral leases for a given field. As a result, it is necessary for an American company not only to drill wells to adequately produce its own leases in American fields, but it must also drill extra wells to protect its portion of the reserves from drainage by a neighboring competitor.

The East Texas Field, the largest in proven reserves in the United States, is roughly equivalent in surface area and proved reserves to the Abqaiq Field in Saudi Arabia. Approximately 30,000 oil wells have been drilled to date in the East Texas Field, while only 72 wells have been drilled in the Abqaiq Field. The prime difference in operations in the two fields is that well potential has been maintained in Abqaiq through pressure maintenance, while very substantial money has been spent in East Texas on drilling for the same purpose. Even though relatively few wells have been drilled in Abqaiq, high oil recovery is expected.

In Saudi Arabia large quantities of gas are produced along with the crude oil. Varying volumes of such oil well gas occur in all producing fields of the world. The gas comes to the surface mixed with the oil and has to be separated. In the United States, a tremendous market for natural gas has been developed and thousands of miles of pipeline serve consumers from coast to coast. However, American oil men are still faced with the problem of what to do with the uneconomical excess that is produced through oil wells and gas wells. Every economic avenue of utilization and storage is continuously explored. Still, it is necessary for producers to burn off some of the excess oil well gas so that efficient production can proceed. For example, about 17 per cent of the gas produced in Texas is "flared" because there is no present economic utilization for it. As the economics of gas consumption change (new uses, new pipelines, new storage techniques, and so on), this normal practice of gas flaring decreases.

In contrast to the United States, Saudi Arabia has only the beginnings of a gas market. Despite this lack of consumer base, the country has one of the highest gas utilization rates in the free world, outside the United States. Aramco engineers have in recent years been able to make unusual progress in the economic utilization of Arabia's oil well gas. The company spent about 70 million dollars on research and on substantial capital projects leading to the utilization of oil well gas. At present more than 50 per cent of this gas is put to use. In consequence, Saudi Arabia is the leader among the major oil producing countries of the Middle East in natural gas utilization.

Saudi Arabian gas plays a double role in Aramco's conservation projects. Most of it is returned to the underground oil reservoir. There it is stored for future use. But it does not lie idle. It helps maintain reservoir pressure and thus contributes to maximum recovery. Several different gas injection systems are used. In one system, liquefied petroleum gas is mixed with normal injection gas and the resultant mixture is injected into the reservoir. Once in the reservoir, this mixture functions much like a detergent separating stubborn dirt from the fibres of clothing. It strips the thin film of oil that clings tenaciously to reservoir surfaces and sweeps it toward the producing wells. (The "surface" area in an oil reservoir defies imagination: there can be as much as 16,000 square feet of surface in one cubic foot of the porous rock that is known as oil sand.)

Unfortunately, the injection of surplus gas into an oil reservoir is not always practical. The injection of gas into some reservoirs, because of properties of both the reservoir and the crude oil, will have a deleterious effect on the recovery of oil.

Sometimes oil wells produce gas over and above the gas that comes from the ground in solution in the oil. In cases such as this, Aramco's conservation procedure requires that the well be shut-in and *re-completed*. The natural gas economy of the United States has a shut-in feature that, for reasons that will presently be clear, cannot be applied to Saudi Arabia. A large percentage of America's natural gas is produced from dry gas wells (wells that produce no oil, only gas). If the natural gas market runs into a slump, such as might come from an unusually warm winter in the northern consuming areas, the gas wells can be tem-

At 'Ain Dar Gas Injection Plant a technician adjusts a pressure controller in final stage of gas compression.

By carefully worked out conservation practices, Aramco oil engineers determine optimum number of wells that will best produce a field and at same time guard the precious reservoir.

All possible utilization of oil products and by-products is part of conservation program. Industrial buyers like Saudi Cement Company (above) use natural gas, and more and more customers are developing for liquefied petroleum gas.

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porarily shut-in and the gas saved until the market revives. However, oil well gas goes right on being produced with routine crude oil production – it cannot be shut-in without stopping oil production. The evolving natural gas economy of Saudi Arabia (so far based almost entirely on Aramco conservation techniques and fuel needs) deals almost exclusively with oil well gas. The country cannot therefore apply the shut-in feature of the United States natural gas economy without halting oil production and stopping its principal source of income.

So far Aramco has been the major consumer of gas in Saudi Arabia. However, the company, in keeping with its traditional policy of stimulating the growth of domestic economy, has undertaken a number of projects leading toward an increased and more diversified "market."

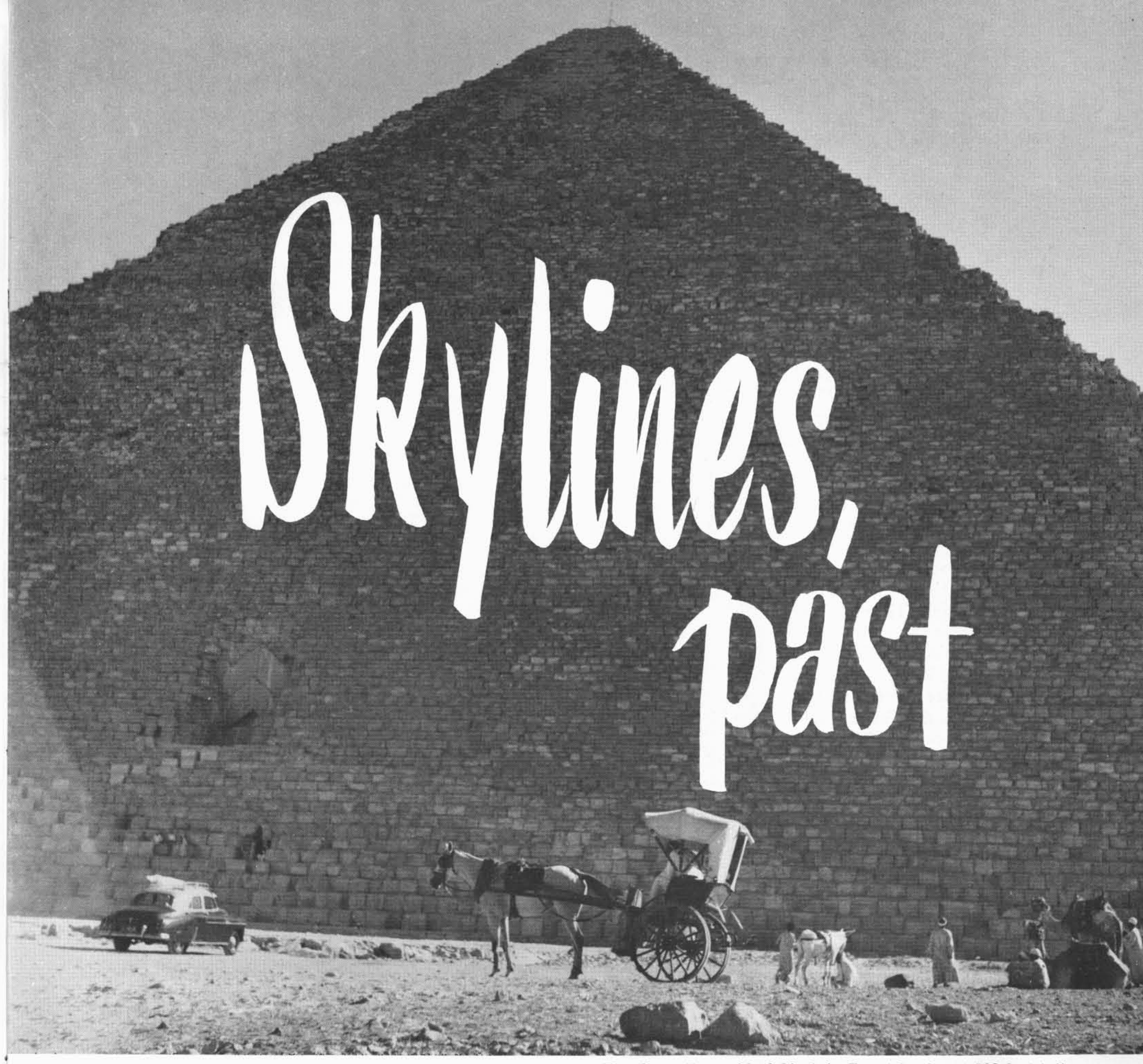
About nine years ago, an American engineering firm was retained to prepare a major study on uses to which Arabian natural gas could be put. Over two years ago, a special brochure was published describing Arabia's natural gas resources. Several thousand of the brochures were distributed to banks, newspapers, business associations and government offices in many countries. More recently, a German firm was retained by Aramco to make a more up-to-date study of the utilization of Arabian gas. This survey contained a number of economic studies of the products that can be manufactured from the gas.

Recent developments in the technology of transporting refrigerated liquefied petroleum gas by ship have led the company to invest eight million dollars in the world's first facility to process and handle such gas for delivery to tankers equipped to receive it. The successful transportation of liquefied gas from Lake Charles, Louisiana to England, a significant pioneer triumph, has led petroleum industry experts to predict a lively world-wide growth in the manufacture and sale of liquefied petroleum gases. It is possible that in the future Saudi Arabia may speak of the flaring of excess uneconomic oil well gas in the past tense. In the past decade a modest but steadily increasing business in liquefied petroleum gas has grown up within the country. Saudi Arabian businessmen have started distribution companies that are now selling more than 45,000 barrels of LPG a year. Sales in 1950 totaled only 88 barrels.

Saudi Arabia never had to go through the boom-town days of oil field expansion that saw oil towns grow overnight. But it has benefited from the conservation technology that grew out of the excesses of the early oil field practices in the United States. Saudi Arabia stands as one of the world leaders in the application of advanced conservation practices. However, Aramco recognizes that even further advances can be made. Aramco oil field procedures are an outstanding example of built-in conservation. Each field has been developed with scientific precision to insure maximum economic recovery of oil currently obtainable. Over 50 per cent of the nation's oil well gas is now being put to use and the company is actively promoting extensive future consumption.

Frugality through technology and economic development – such might be the slogan for conservation methods in Saudi Arabia. And, as Erasmus wrote, "Frugality is a handsome income." ■

Skylines, past



The Great Pyramid of Gizeh in Egypt is almost 500 feet tall.

Structures that enticed the eye upward were hallmarks of ingenuity in the Middle East of Old

LET IMAGINATION give us two travelers. Put 25 centuries between them. One traveler enters New York, 1962; halfway around the world, the other makes his way into Babylon, 600 B.C. Over 80 generations of mankind separate the two travelers, yet in our imaginary picture they share common reactions to their respective cities: awe and fascination directed to the structures that man has raised from the ground to compete with the clouds.

Skyscrapers are indeed a mark of the twentieth century, but today's towering buildings have worthy forebears in the ancient Middle East. Then as now, architects aspired to lead the eye of the beholder upward. The traveler to Babylon, for example, would gaze upon the High Place, the ziggurat known to history as the Tower of Babel. Perhaps a passerby would tell the visitor of King Nebuchadnezzar's inscription high in the Tower: "I prepared to place the summit in position so that it might compete with Heaven. . . ."

To Babylonians and other peoples of the Fertile Crescent, the ziggurats were material links between the earth and the heavens—between the known and the unknown. At least one ziggurat, serving as the sanctuary of the local god, was constructed in each city. It stood apart from the temple, much as the campanile stands apart from Italian churches or minarets from mosques.

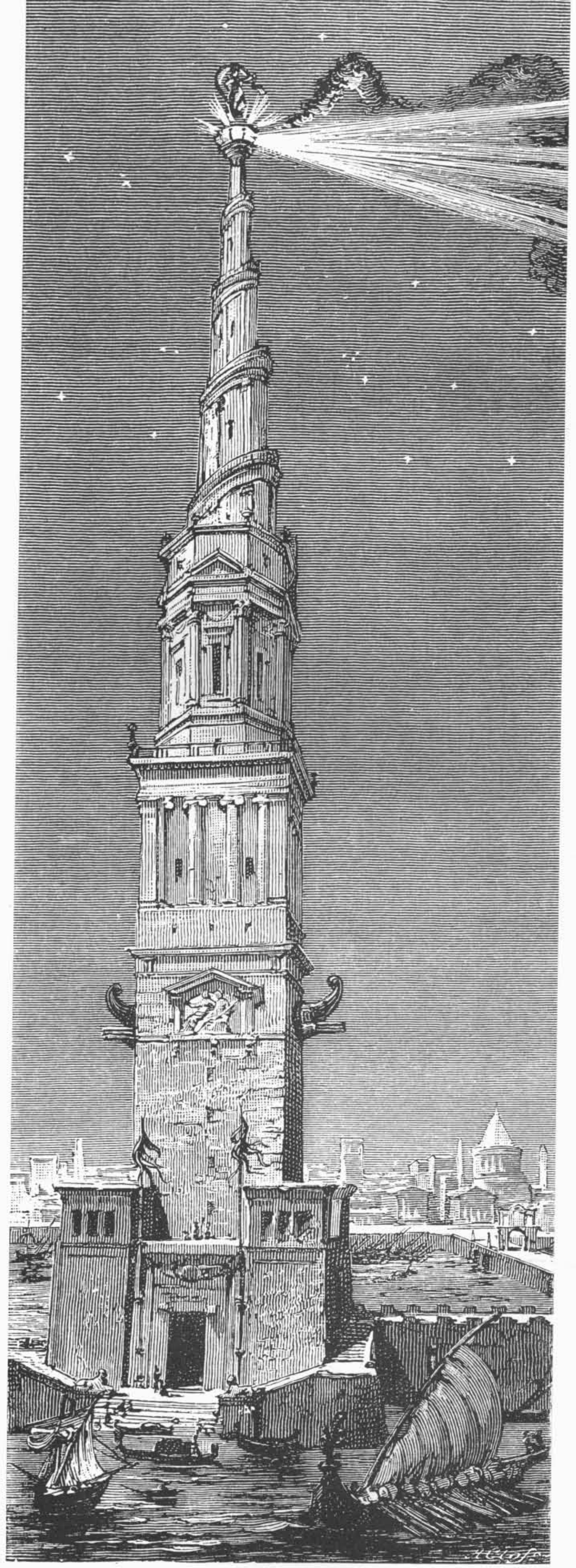
At the base was a rectangular hill of sun-baked brick. A spiral-shaped tower lifted itself from the base, with each story a different color. Ordinary citizens did not enter the sanctuary, but priests ascended on an outside ramp formed by the spiral. Atop the tower the priests made celestial observations and with their astrology counseled the lovelorn and recommended the best days for business transactions. The towers also served as meteorological stations from which weather predictions were issued.

Curiously enough, the Babylonians persisted in building with clay when they were well aware that fired bricks were much more durable. Thus it was necessary for monarchs to repeatedly repair the structures. When Nebuchadnezzar undertook the Tower of Babel's most famous face lifting, mentioned in the Bible, the structure was almost a thousand years old and had already undergone previous refurbishings. Completed, the Tower stood 297 feet high, just three feet short of the Statue of Liberty.

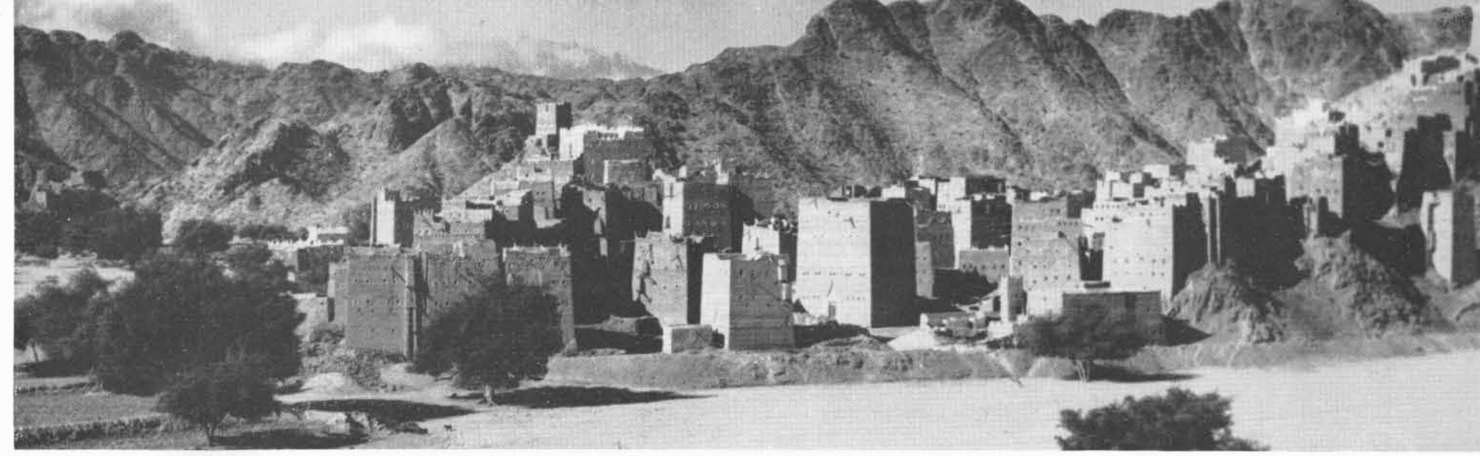
The Tower of Babel was, however, a relative latecomer to the ranks of ancient skyscrapers. Let us go back yet another 2,400 years—to about 3,000 B.C.—to the age when the Great Pyramid of Gizeh was built in Egypt. The Egyptians, too, were stargazers, and with astrological calculations that were phenomenally accurate, the Pharaoh caused the pyramid to rise with its sides facing exactly north, south, east and west.

For 20 years, more than 100,000 men—many of them highly skilled—labored to build the Great Pyramid. Blocks of limestone were quarried, then dragged on rollers to the Nile River and conveyed across it on barges to other workers who in turn dragged the huge blocks to the construction site. Working with simple tools—levers, inclined planes and rollers—the laborers slowly pushed the pyramid 481 feet into the sky. Into it went some two million blocks of limestone, each weighing two-and-a-half tons and fitted to its neighbors with a precision that precluded the need of mortar. Total weight of the stones was over eight times the weight of the steel and stone that went into the construction of New York's Empire State Building. Surfaced with a casing of polished limestone, the pyramid reflected the sun's rays like an enormous mirror.

Its massiveness is proof enough that the Great Pyramid of Gizeh was built to last. Perhaps, as many scholars claim, the structure was a funerary monument in which the Pharaoh's restless *bai* (spirit) was to live through the centuries. Others, considering its location, precise dimensions and lack of carvings usually found in pyramid-tombs, suggest that the Great Pyramid may have been a lofty temple

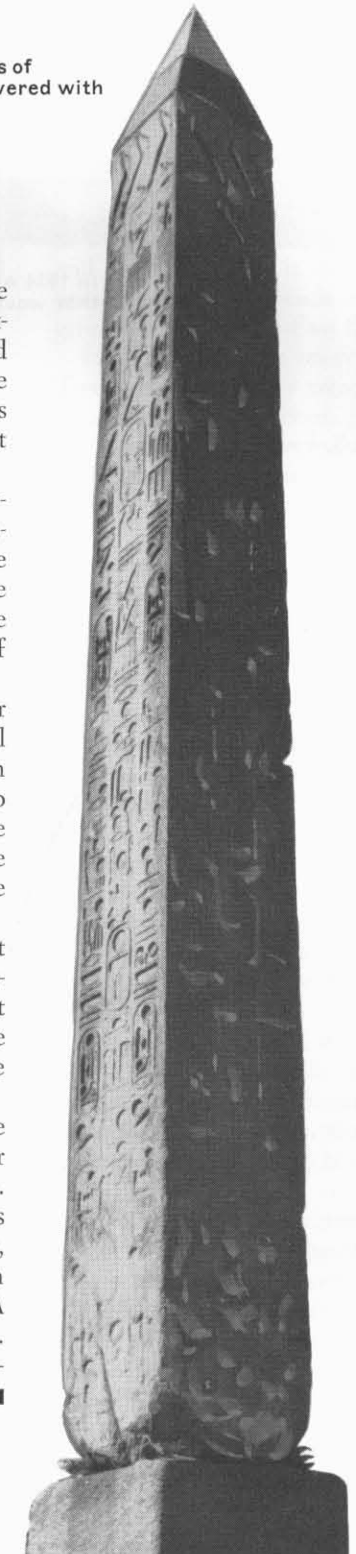


The Pharos of Alexandria, 600-foot-high lighthouse, stood for 1,600 years before an earthquake demolished it in 1375.



At the southern tip of the Arabian Peninsula, the city of Yeshbum, in the Aden Protectorate, presents a striking "skyscraper" profile.

Obelisks, solid shafts of stone, often were covered with historical records.



for one of old Egypt's famed mystery schools.

There are many structures of ancient times that can be called the "skyscrapers" of their day. The Pharos of Alexandria, a 600-foot-high lighthouse erected in the third century B.C., became one of the "seven wonders of the ancient world," as did the 350-foot-high Hanging Gardens of Babylon. Even the more modest obelisks found in Egypt and Ethiopia seemed to scratch at the floor of heaven.

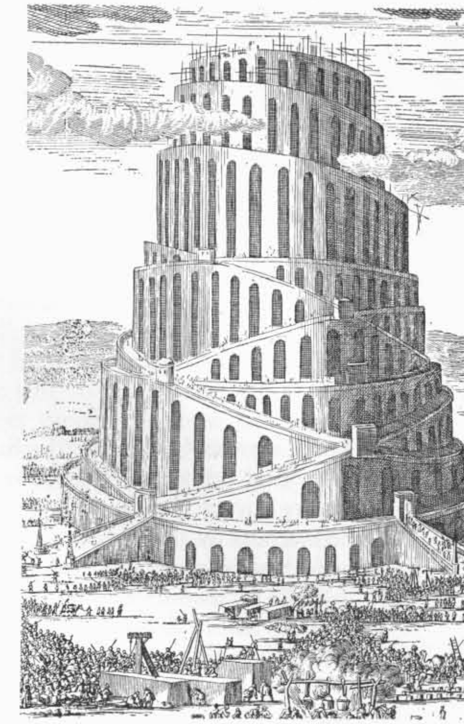
But perhaps closest to the modern conception of the skyscraper are the tall buildings found in the Wadi Hadhramaut in the Aden Protectorate at the southern tip of the Arabian Peninsula. The cities of Shibam and Tarim inspire awe as they rise starkly out of the desert. The larger of the two, Shibam, is sometimes referred to as the "New York of the Hadhramaut" because of its striking skyline.

Rows of buildings, many twelve stories high, seem to soar miraculously higher than their actual height. The optical illusion is created both by double rows of windows on each floor and by the surrounding flat vistas of desert that rob the eye of reference points. For centuries the people of the area have built their skyscraper homes of adobe brick. The first floor is used for storage, the second for servants, the third for guests, and the upper floors for the family.

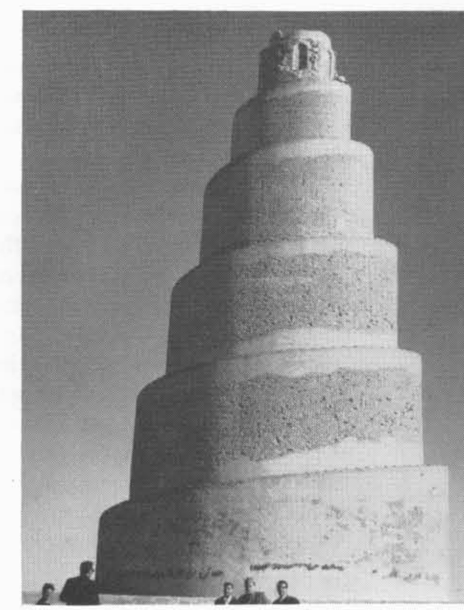
In the old days the lofty skylines of the Hadhramaut were based as much on practical considerations as on aesthetic ones. The tall, sturdy structures afforded excellent protection against looting invaders. Even today, a home erected in Shibam on the edge of the city is required to be at least 105 feet high.

While the height of the skyscrapers of the ancient Middle East may not measure up to some modern buildings, their longevity is beyond challenge. They were made to endure. Unlike today's skyscrapers, which often are erected in less than a year and torn down a quarter of a century later, those older skyscrapers stood for centuries, some more than a thousand years as in the case of the Tower of Babel. A few, such as the pyramids—5,000 years old—still stand.

They prove that reaching for the sky is not the sole province of the twentieth century. ■



Babylon's Tower of Babel (above), depicted as piercing the clouds, is an ancestor of Malwiya minaret (below), built in Samarra, Iraq more than a thousand years ago.



With a brand-new concession area to explore, Aramco's pioneers in Saudi Arabia eagerly awaited an assist from their first . . .

AERIAL "EYE"

In 1934 Aramco's first plane, specially designed for aerial photography that would aid oil exploration, landed at Jubail on the Persian Gulf.

Pilot Dick Kerr (center) and Charley Rocheville shepherded the Fairchild 71 from New York to Saudi Arabia by sea and air. Other early crew members were pilot Joe Mountain (left) and mechanic Rus Gerow (right).

In less than 60 minutes the S. S. *Exochorda* would weigh anchor. Streamers of fresh snow ran along her decks. A wintry voyage lay ahead, but in two weeks the crew would be warmed by the Mediterranean sun.

At that moment a barge bumped its rope-and-tire fenders into the *Exochorda's* hull. The ship's crew beheld a strange sight. A small monoplane, its wings folded back, stood on the deck of the barge. Alongside the crippled-looking plane two men waved their arms and called for the captain. They wanted to get aboard and bring their plane with them.

No luck. The captain had been expecting them but *not* just before sailing. For a few minutes Dick Kerr and Charley Rocheville argued with the captain to no avail. They were already overdue in Saudi Arabia. They *had* to get the plane aboard.

Then, as it had before and would again in this strange aviation odyssey, Dick Kerr's persuasive grin saved the day. At four P.M., when the *Exochorda* passed through the Narrows of New York Harbor and stood out to sea, Kerr and Rocheville were busy lashing down their new Fairchild 71 to the afterdeck. It was February 6, 1934.

During their first few hours afloat, as they laced the plane's canvas cover in place, they had little notion of what lay ahead. But at least they now had plenty of time to recall over coffee in the ship's mess the swift chain of events that had changed their lives.

Five months earlier, Dick Kerr, an ex-Navy pilot who was a partner in an aerial mapping service, received a call from an old friend. Could he come to Los Angeles as soon as possible? The caller, Clark Gester, chief geologist of the Standard Oil Company of California, had a problem.

The company had signed a Concession Agreement with Saudi Arabia in May to explore for oil. A handful of geologists were already on the job. But the Concession covered approximately 320,000 square miles. The geologists urgently needed an "aerial eye" that would help them to explore this vast desert expanse.

Would Kerr be willing to draw up a proposal for aerial geological reconnaissance on a contract basis, do the necessary aerial photography, and provide air support for ground parties in Saudi Arabia?

Gester knew he was asking the right man. Kerr had graduated as a geologist from the University of California. He was a pilot, a mechanic, and an excellent photographer. Just the man for a mission that called for ingenuity and imagination. Kerr was also well supplied with energy and enthusiasm. What he didn't know, he learned quickly in round-the-clock cramming.

Kerr checked an atlas and made a fast decision. Sand dune country would call for a small plane. Around that decision he evolved a plan that was immediately approved. The plane was ordered—a Fairchild 71, to be built in Hagerstown, Maryland.

Charley Rocheville, Kerr's co-pilot and mechanic, would install an extra gas tank when the plane was ready. That would give them an added 350 miles cruising range over dangerous desert waste. Other modifications called for a removable window on each side, a hole in the bottom for vertical photography and the biggest tires available to keep the plane from sinking into loose sand.

Kerr got busy and bought 5,000 gallons of aviation gasoline in five-gallon tins. The gasoline and other flight supplies were loaded aboard a company tanker bound for Bahrain Island in the Arabian Gulf.

By the beginning of December, Kerr and Rocheville were in Maryland advising the plane builders on the modifications they wanted for desert service. Kerr contacted various export lines and got an early February sailing date to ship the plane a third of the way around the world. Then he set a target date for completion of the plane.

Next, Kerr put on another of his many "hats." He became Kerr the photographer and rushed off to the Eastman laboratories in Rochester, New York. He had heard some troubling rumors about the high temperatures of the water in Saudi Arabia. It takes cold water to develop film. At least it had until then. By the end of December, Kerr and the Eastman specialists had worked out a way to develop film in water of temperatures up to 120 degrees F.

Kerr rounded out the year in New York buying electrical equipment and a water distillation unit for his darkroom.

However, when he got back to Hagerstown, he began to realize that the plane couldn't possibly be built in time to meet the shipping date to the Middle East. He started nudging. Then he brought all his natural good-humored persuasiveness into play. Finally all hands were put on.

One hour before Kerr's deadline the plane was ready for flight testing. Charley Rocheville took it up for half an hour. That afternoon, with time running out, he and Kerr flew the plane to North Beach in Flushing, Queens (renamed La Guardia Field five years later). They landed in a foot of fresh-fallen snow.

The next morning a crane hoisted the Fairchild onto a barge in Flushing Bay. Kerr and Rocheville rode the barge to their last-minute rendezvous with the *Exochorda.*

Twenty-three days later, the oversized tires that had last rolled through New York snow were turning in the streets of Alexandria, Egypt. The tail skid rested in a donkey cart.

One hundred Egyptians joined in the chore of pushing the plane to a small airport north of the city. There Kerr and Rocheville put it through a series of thorough flight tests. They made friends with British personnel and were given useful Middle East flight maps.

Finally, they were ready for the last leg of the journey. Two weeks later they were still on the ground—in Cairo. The British helped them get proper clearance and at last they were aloft—in a sandstorm. Visibility: 100 yards. They were lost in short order. Luckily they found the Nile delta and hedgehopped back to Cairo.

Another week passed. Aloft once more with a British escort and clear weather. Overnight at Gaza. Then a late arrival at Baghdad: another sandstorm. Lots of hedgehopping. More hospitality from the British. Then Basrah, and their final meal with English friends.

They were now close to their objective. Only one more flight. Somewhere down the coast of Saudi Arabia a group of American geologists anxiously awaited Kerr and Rocheville and their plane. The pioneer geological explorers were pretty sure by now that there was oil under the desert floor. But they yearned to get aloft for a panoramic view of the dunes, *jebels* (hills) and outcroppings which would help them determine the best place to start drilling.

In Basrah, Kerr and Rocheville bid their British hosts farewell. They took off with good wishes and helpful advice and set the plane on a southeasterly heading. Rocheville was at the controls.

They passed offshore of Kuwait and then followed the Saudi Arabian coast. Six months of planning, excitement and frustration lay behind. Now the fabled Arabian coast, lightly hazed, rolled away beneath them. Sea blue gave way to dazzling greens and finally to white where the water rested shallow and still at the shore line. Off to the right they now and then saw black patches that were Bedu tents. As they flew on they also saw fish traps that ran like thin arrows out toward deeper water.

There! Kerr pointed. Rocheville nodded.

The newly created Jubail airstrip rose up to meet them. Rocheville brought the plane around. The first "aerial eye" in Saudi Arabia leveled off for a landing. ■

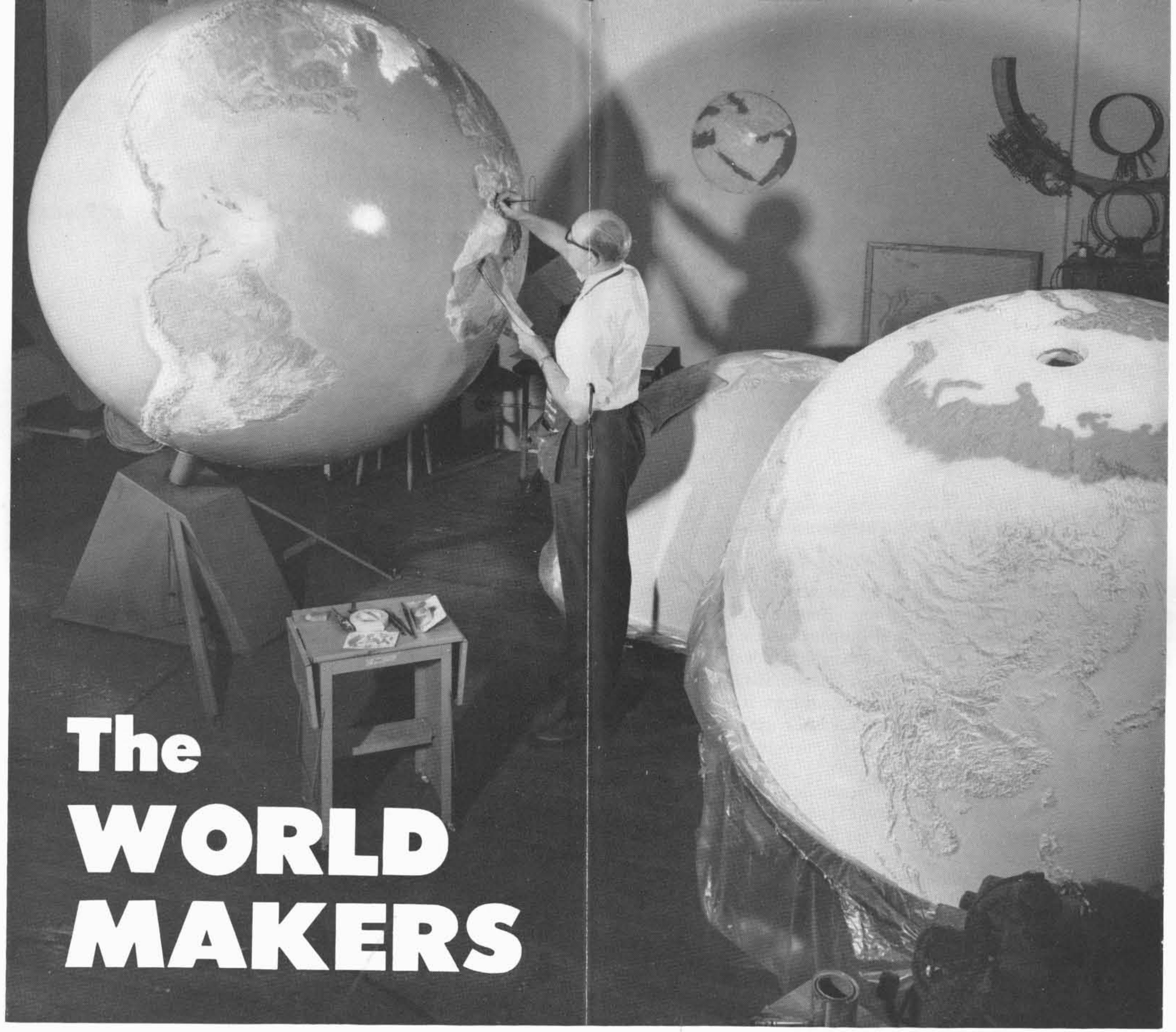
In every age

there were a bold few

who insisted on thinking globally

about the "flat" earth

The WORLD MAKERS



Coloring the earth's craggy face is as painstaking a task as molding the sculptured contours of these relief globes.

THE GIANT ROCKET roared away from its launching pad and vanished into the atmosphere. From its space capsule, an astronaut watched the cloud-shrouded earth recede – a huge, flat wafer in the sky. As the rocket accelerated and shot into orbit, the scene below shifted. The horizon stood out in bold relief. Continents and oceans appeared briefly, then dissolved. Suddenly the space traveler saw visible proof of a fact which, only a few centuries before, had periled the lives of those who espoused it: the earth is round.

The earth is indeed a globe, but in order to view it as such, men had to wait for the twentieth century and the technological miracle of a speeding observation point far out in the immensity of space.

They did not wait for the Space Age, however, to *represent* the world as round. Among the ancients were a few scholars who, through studies in the fields of astronomy, mathematics and logic, disproved the universally accepted idea of a flat earth that stood still while sun and moon made daily journeys across it. These scholars might well be called the "world makers." To demonstrate their revolutionary concepts, they created globes with known land and sea masses.

Their daring beliefs in a spherical earth violated the teachings of science and religion and the world makers were branded charlatan or heretic – later, genius. Some went to prison, some to the stake. Yet, but for them, the great voyages of discovery might have been postponed for centuries. Even so, at least 1,500 years elapsed between the appearance of the first globes and the actual circumnavigation of the earth that proved its roundness.

One of the first world makers was Crates of Mallus, a Greek whose ten-foot globe depicted the views on geography held by the Stoic school of philosophers. On this globe, created 150 years before Jesus' birth, an equatorial and a meridional ocean divided the earth into quarters, anticipating the discoveries of North and South America and Australia. Little else is known about Crates except that he probably drew on the inspiration of Egyptian and Chinese astronomers who believed in the earth's roundness and built crude celestial globes.

The distorted geographical notions that prevailed at the time Columbus, jingling Spanish gold, headed his caravels westward, can best be surmised from a globe produced at Nuremburg in 1492 by Martin Behaim. Although Behaim was believed to be a qualified cartographer, his 20-inch sphere is remarkably inaccurate. Not even the coasts of western Africa were laid down correctly, although the German claimed to have participated in one of the contemporary Portuguese expeditions.

Although many mariners lived in constant dread of disaster as they sailed farther into the uncharted seas, celestial and terrestial globes reached new peaks of popularity after the discovery of America. Columbus possessed a globe, but his navigational aid was a chart of the world by Juan de la Cosa. Magellan's world sphere was executed by Pedro Reinel in 1519. As more brave sixteenth-century sailors pushed off into the unknown, globes were almost always included among the scientific apparatus aboard their vessels.

In 1507 a map by Martin Waldseemüller, a distinguished cartographer, called the New World "America," after Amerigo Vespucci. This innovation led to the first globe that showed America as a continent instead of a group of islands, an early misconception perpetuated by map makers. The sphere was sculpted in 1523 by Johann Schoner, another Nuremberg resident.

Thus, accuracy entered into map making, and size, too, came under control. Soon after Behaim's achievement, James Ferguson, a Scottish physicist and astronomer, produced several portable globes, including a tiny model which he called the "Pocket Globe." One of these midgets, barely three inches in diameter, is owned by the Adler Planetarium in Chicago.

Globes have always appealed vividly to man's imagination. Kings and aristocrats, patrons of the arts and sciences, launched many a globe maker on the path to fame. Among

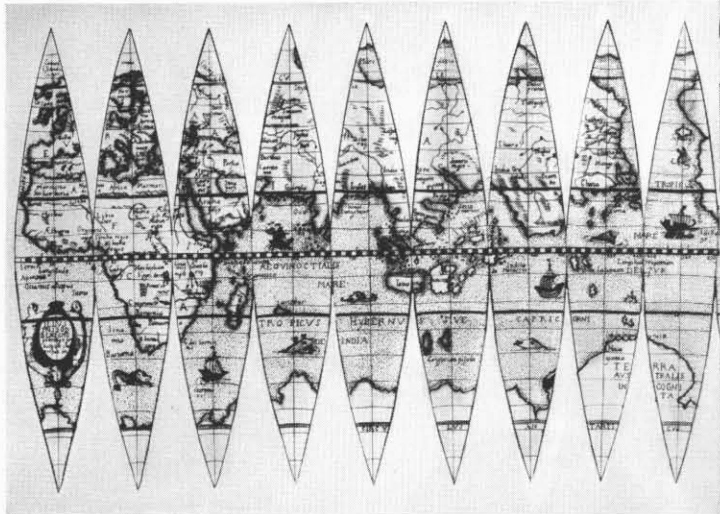
First globe, by Crates of Mallus
150 B.C.

Mohammed ibn Muwajed al-Ordhi's sphere
1279

French globe attributed to Vopel
1535

Celestial globe of Jodocus Hondius
1600

Geography students take a close-up look at the world in an Aramco industrial training class at Ras Tanura, Saudi Arabia.



Map strips called "gores" align in exact relationship when pasted to a curved surface. The idea of gores is as old as map shown above, designed by a seventeenth-century map maker.

early globe makers there was keen competition to create the largest and most elaborate spheres. A Venetian monk named Vincenzo Coronelli earned a healthy pension by creating a pair of globes for King Louis XVI of France. These huge worlds, each 15 feet in diameter, had doorways and could accommodate 30 courtiers inside. A similar globe in the United States is the 30-foot Mapparium at the Christian Science Publishing Company in Boston. This "inside-out" glass world, with painted maps illuminated by 300 hidden lights, affords the spectator a startling view of the earth as seen from its core.

Until the early nineteenth century, all globes were made in Europe. But in 1810, James Wilson, a Vermont farmer, launched the domestic globe industry shortly after he had seen a pair of spheres at Dartmouth College. Wilson sold his livestock for $130, bought an armload of books on astronomy and geography, and paid for a course in map drawing under the eminent cartographer, James Doolittle.

Filled with knowledge, but devoid of money, Wilson made his own ink, glue, varnish, press, and even a lathe to produce his first globes. They sold readily. Later he opened a factory in Albany and for many years turned out America's total output. More than half a century passed before others got into the business. Today there are a half-dozen American world makers.

Most of these companies produce globes printed in several languages, and some build special models on order, mostly for government agencies. The Navy and Air Force own several 25-inch spheres with chalkboard backgrounds, used for navigational training. The Department of State owns a unique aeronautical globe which indicates major air routes and distances throughout the world and is used in strategic planning.

Globe making is accelerated during times of war or international tension. World War I caused sales to jump as thousands of people suddenly became interested in cities and countries beyond their own borders. The sales spurt was repeated during World War II, and since then ownership of globes has become commonplace.

A growing interest in world travel has also aided globe popularity. Those planning a trip abroad needn't haul out an atlas with flat maps that give an untrue picture of the earth's curved face. Such maps distort geographical locations, shrink or expand land and water masses. Some show Greenland as larger than South America, whereas it is only one-fifth as large. The globe provides authentic shapes, sizes, angles and distances.

In globe making accuracy is the hallmark. Today's globes are far more precise than their predecessors because camera-equipped satellites aid the modern world maker by providing eyewitness photographs of the earth's surface, removing all inaccuracies of contour. Before the advent of space cameras, however, the cartographer depended entirely upon books, existing maps and the reports of observers and newsmen when a country exploded into being. Now he sees it all in black and white. His is an exacting art, a matter of erasing old boundaries, drawing in new, emphasizing place names in the news spotlight. On fairly large globes, air and ship routes with all ports of call, principal railways, famous parks, glaciers, air and ocean currents are delineated.

The building of a globe is relatively simple once the map's facts and figures are collected. Drawn and lithographed in long elliptical strips called "gores" – usually 12 to a globe – the maps are painstakingly pasted to a sphere so that the edge of each gore falls into precise relationship with its abutting strip. Globe coverers spend two years learning their trade and can complete about ten 12-inch or eight 16-inch spheres a day. The spheres are made of pressed steel, aluminum, wood, strawboard or glass.

The modern map ball is a far cry from the crude marble, wood and bronze giants of the old world makers. They built on theory and guesswork, defying an ignorant world hostile to new concepts. Two thousand years ago they began chipping away at a vast misconception that was not to be erased until barely 500 years ago.

During the half millenium since then, the enigmatic areas of the earth have disappeared. Today, as new countries are born, as armchair observers chart the girdling swathe of satellites, the globe is a welcome companion. ■

The Sound of Arabian Music

An American visitor to Beirut, Lebanon rode in a taxicab along a seaside boulevard. It was late afternoon and cool breezes wafted through the car's open windows.

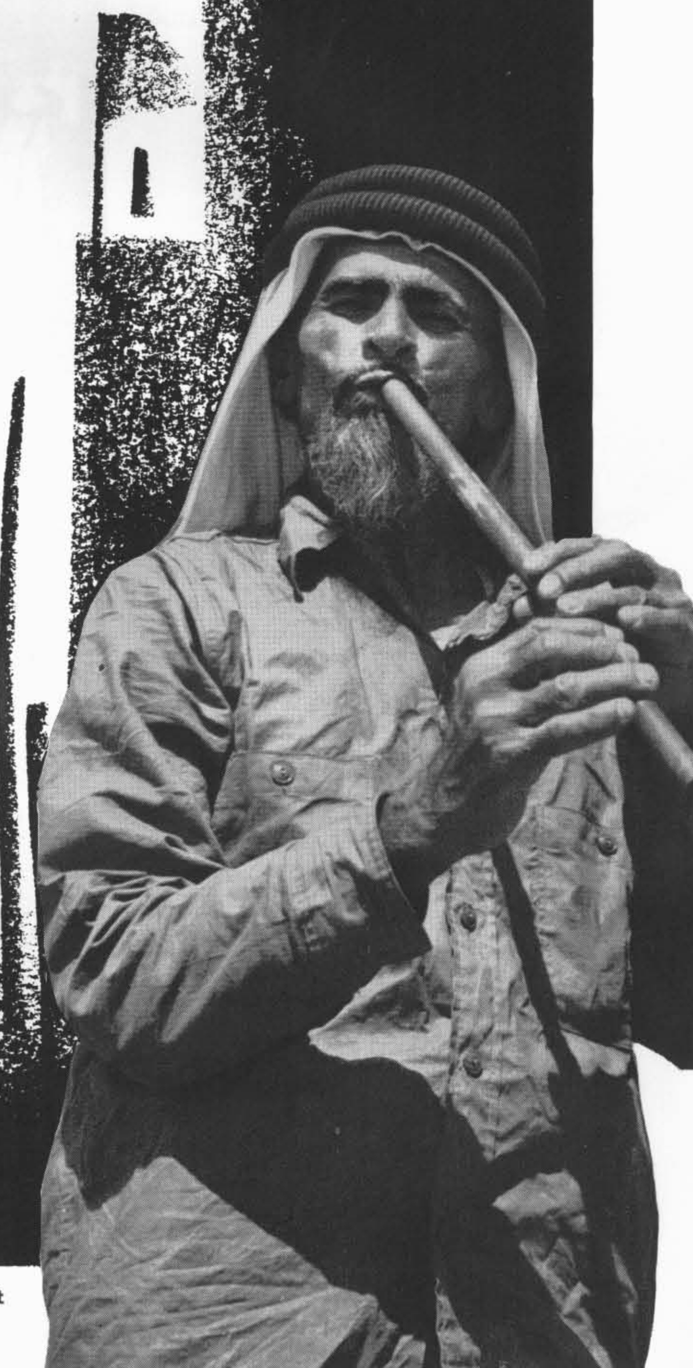
As he watched the fading Mediterranean sunset exhaust itself in the blue mountains behind the city, he thought he heard the driver murmur something. "Excuse me," the visitor said, "I didn't quite hear you." The driver continued to murmur, then turned and smiled. The sound still issued from his barely open lips.

The driver was, of course, merely singing to himself, his voice deep in his throat. The sound spun out softly in breathy vibrations with very little inflection. From time to time it rose in pitch but only slightly. For seconds on end the driver's voice wavered on a single high note. Then it fell quickly, tremulously, in short linked tones that slurred one into the other. Over and over the same tones buzzed in the driver's throat.

The American waited for a clue to this strange *vocalise* – something familiar in the rhythm, or at least a melodic turn that would signal the end of the unfamiliar song.

To the American visitor, and to most Western ears, Arabian music is unfamiliar indeed. In it may be hidden the whisper of the ages, for Arabian music is very old. In fact, the few clues to very early Arab music that still exist lead some music historians to conclude that the people of the Arabian Peninsula were the inheritors and conservators of much of the ancient Mesopotamian cultures.

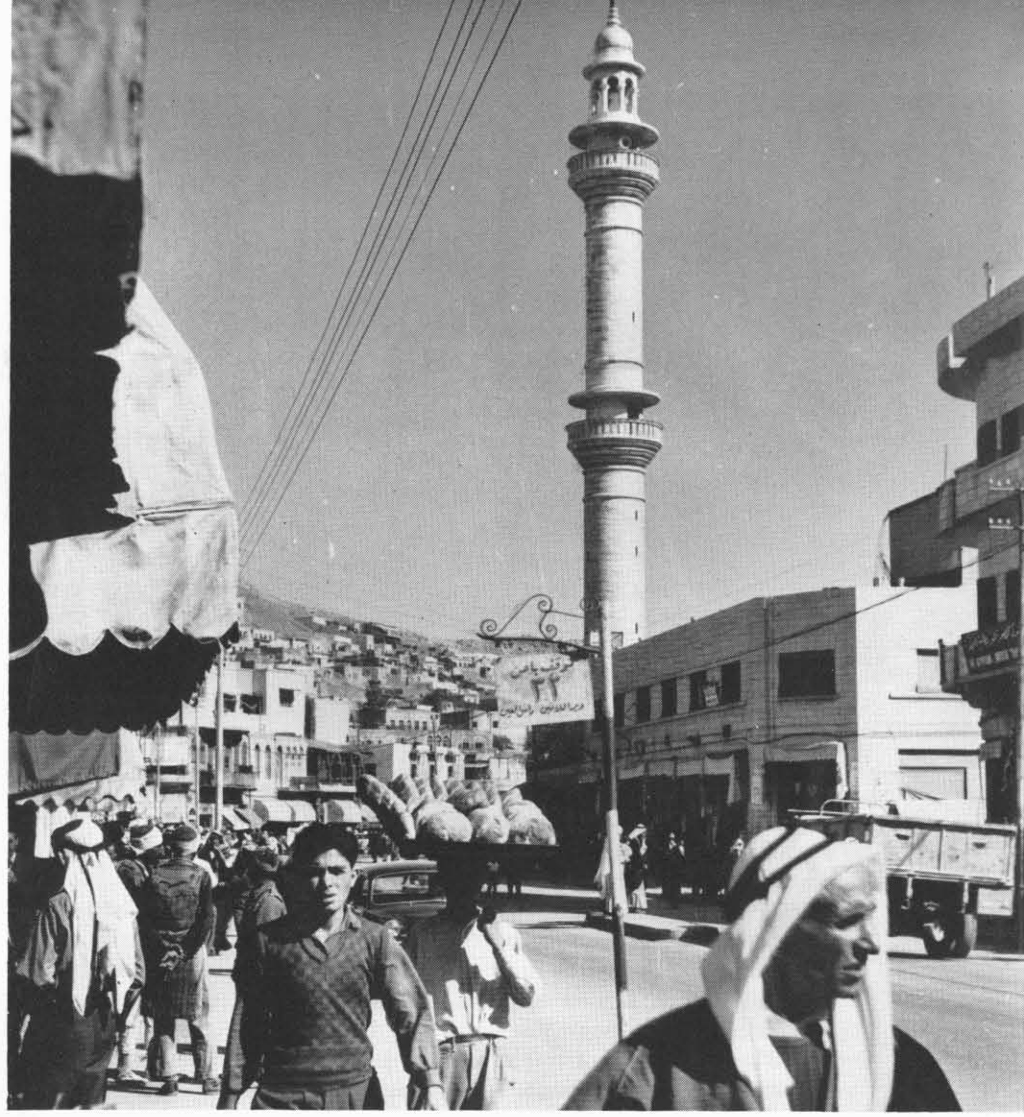
From earliest times music enriched the daily life of the



Bedouin Flutist

THE SOUND OF ARABIAN MUSIC

. . . so charming yet so unfamiliar to Western ears, is heard in the city streets of the Middle East, in the cries of vendors, in the call to prayer, in the songs of children.



Amman, capital of Jordan

Arab. Birth, death, marriage and all other private and public ceremonial occasions were marked by music making. In his study, *History of Arabian Music,* H. G. Farmer states that Arabian music often had a deep effect upon its listeners. Swooning, for example, was one result of the music's "killing charm," as it is described in the *Arabian Nights.* Other poetic Arab sayings compare music to "a fan on a sultry day" or "a painter's work set off with gold."

During the high tide of Islamic music from the ninth through the eleventh centuries, theorists such as Al-Kindi, Al-Farabi and ibn Sina (Avicenna), who were more philosophers, physicians and mathematicians than musicians, dealt with the problems of rhythm, acoustics, dissonance, consonance and musical production. Even before these men, Arab musicians had developed a system of notation, a fact that was long overlooked by Western historians.

Farmer notes that Arabian musical traditions have enjoyed a long continuity. He mentions "the toil song, a relic from the cradle of humanity" that "not only softened the sweat of toil, but ordered it rhythmically" and the domestic music such as the lullaby, children's ditties, the bridal song and the elegy. Camel chants were undoubtedly popular and devised to fit specific situations, such as loading camels, marching and stopping at water holes. The chants, perhaps accompanied by shepherds' pipes of antelope horn and rudimentary stringed instruments, were sung joyfully, much as sailors of later days sang their sea chanteys.

Despite Arabian music's long, rich past, its exotic sounds have always bewildered Westerners who find its unfamiliarity an obstacle to understanding. In the *Lexicon of Musical Invective,* Nicolas Slonimsky calls attention to the "psychological inhibition which may be described as the Non-Acceptance of the Unfamiliar." He cites a Viennese critic writing in 1804: "The Beethoven Second Symphony is a crass monster, a hideously writhing wounded dragon. . . ."

Lebanese musicologist Afif A. Bulos, who is familiar with both Eastern and Western music, claims that the absence of Western enthusiasm for music of the Middle East is no secret to the Arabs. "Arab music," he writes, ". . . is far from being popular with Europeans or Americans, who with few notable exceptions are firmly convinced that it is nothing but an incoherent jumble of discordant sounds. . . ."

A change in attitude is, however, in the making. Television, records, radio and especially jet travel, which transports entertainers quickly and frequently from one country to another, tend to break down barriers to musical appreciation. The ability to perform in Damascus one day and Sydney the next leads to a kind of *lingua franca* music—an international music that borrows what is easily assimilated from all music and levels out the differences.

The zither-like qanun (above), which sounds much like a harpsichord, is one of Middle East's oldest instruments, while the piano is a relative newcomer to Arabian music.

Recently an American visitor to the Middle East asked what he thought was a simple question: "Just what is it about Arabian music that sounds so unfamiliar to us?"

It would take many words to skim even the surface of the basic differences between Western and Eastern musics, but there are some differences in the *sounds* and *impulses* of these two worlds of music that quickly provide clues to the confusion of the Westerner hearing a performance of "Ah Ya Zain." This Iraqi folk song is often sung by a tenor and vocal ensemble accompanied by an instrumental group.

Let us assume the Westerner is English or American and is accustomed to hearing popular music played on saxophones, trumpets, trombones and pianos. He will search in vain for these familiar sounds as he listens to "Ah Ya Zain."

Patience will finally uncover the sound of violins, but they seem to slur weirdly around certain tones. An older American might recall the slurs of country musicians on their homemade fiddles. The alert listener may also detect several different plucked string instruments. One would be a *qanun,* a trapezoidal zither. Another might be a more ancient Arabian instrument, the *'ud,* or more correctly, *al-'ud,* precursor of the Renaissance lute.

A wind instrument emerges. It sounds like a flute and it is one, but probably a vertical flute tuned, as are all the instruments, according to the Arab ladder of tones and *not* according to the Western scale. Later an oboe solos briefly, and again the sound is vaguely familiar.

A few listenings to "Ah Ya Zain" and the instruments begin to sound less strange. But the American listener still complains that something is missing. The "something" is harmony, for there is no harmony in Arabian music.

The instruments and voices in a combo sound the same tone in unison. Or they sound the same tone an octave apart. Sometimes they play four tones apart and, rarely, five. Without the supplemental chordal fullness of the harmony that fleshes out a tone, Arabian music seems to drone to the untrained American ear. Perhaps, unconsciously, the American listener misses this richness he first may have admired when he heard a church choir sing a glowing "amen."

Harmony in popular music generally moves from discord to concord, from tension to relaxation. It thus adds its tonal weight to the forward impulse of a song. In "Ah Ya Zain"

Of ancient Persian origin, the nay is a vertical flute tuned to the Eastern scale. The violin, like the piano, has only recently been added to Arabian orchestration.

The al-'ud, similar in tone to the mandolin, is the ancestor of the Renaissance lute.

the American listens fruitlessly for chords that rest his ear, excite him or indicate the climax of the tune.

When the tenor enters for his first solo in "Ah Ya Zain," he does not sing the melody or the words of the song. Instead he steps out on a high, held note and then drops, through a series of quick slurs of linked sixteenth notes, to an octave below his original note. This dramatic cadenza, in which the singer uses his voice like an instrument, demonstrates his virtuosity and reveals yet another barrier to Western understanding – the microtonal variation in Arabian music that is commonly, and incorrectly, called a quarter tone. The microtones are minute variations in pitch that occur *between* the familiar tones in the Western scale.

As the tenor slurs, the American ear hears pitches that are not present in the Western scale. But there is quite a bit of microtonality in popular music derived from American Negro singing. For example, Negro blues singers almost invariably change the pitch downward on the third and fifth tones of the scale. However, these pitch deviations, as well as those heard in jazz, almost always lead toward or away from true pitch, either explicitly or by implication. The Arabian microtone *is* the correct pitch, a fact that tends to puzzle an American listener.

The melody of "Ah Ya Zain" is eight measures long, the same length as "Jingle Bells," and similarly constructed of two nearly alike four-bar phrases. It is also the same length as the first segment of a typical Tin Pan Alley tune. A standard such as "These Foolish Things" is made up of four melody segments: A-A-B-A. Tune A lasts eight bars. It is immediately repeated; then comes tune B, called the *bridge* or *release,* which also lasts eight bars. Then tune A is repeated once again. This is the basic blueprint of the American popular song.

In our performance of "Ah Ya Zain" there are fifteen choruses. Seven are vocal, with words; three are vocalise, without words; five are instrumental. The effect is that of going through the song fifteen times in a row.

To the American ear it sounds as though the song goes on and on. Subtle variations are lost on the newcomer, and there arises the complaint that Arabian music is repetitious.

But assume you are sitting in the ballroom of a large hotel. The orchestra launches into "These Foolish Things." One chorus passes. Then two, then four. Finally the dance ends after about six choruses. Remember that in the song, "These Foolish Things," there is one eight-bar basic melody that is repeated three times in each chorus. Therefore, you have just heard that same phrase *eighteen times!* Obviously the problem in listening to Arabian music is not one of repetition but of repeating the unfamiliar.

The melody of "Ah Ya Zain," which means "Oh Thou Beautiful," is very pretty. Fleshed out with familiar harmony, it might make a hit in the United States as a mood piece. But then it would no longer be Arabian music. Something of this smoothing-out process goes on constantly in the commercial use of the musics of the world.

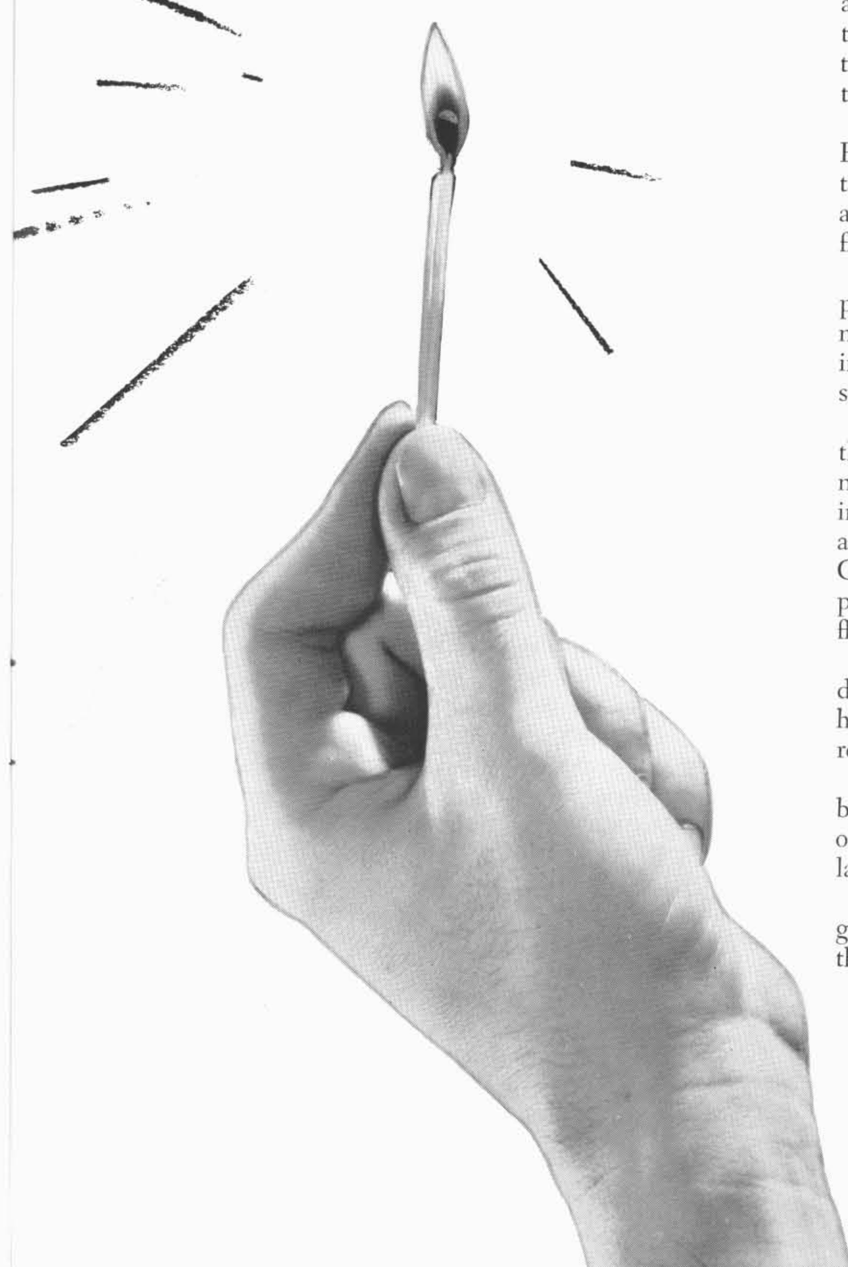
But there remains the beauty of the original. In ancient Arabia the rhythmic nature of traditional poetry almost demanded that the reciter chant it. It was this desert poetry that fashioned the classic Arabic language of the Koran, and a Westerner hearing the call to prayer from a mosque easily grasps the musical quality of the chanted words.

In his novel *Justine,* Lawrence Durrell, describing the cantillation of the Muslim call to prayer (*adhan*), comes exquisitely close to evoking the feeling of this fervent moment: "I caught the sweet voice of the blind *muezzin* from the mosque . . . a voice hanging like a hair in the palm-cooled upper airs of Alexandria. . . . The great prayer wound its way into my sleepy subconscious . . . coil after shining coil of words—the voice of the *muezzin* sinking from register to register of gravity. . . ." ■

In the Middle East, as elsewhere, people at work were a basic source of music. Rhythmic chants in the fields set a comfortable pace, and musical cries helped city vendors advertise wares.

Meet Your Match

It took years of trial and error to produce fire at your fingertips



LATE ONE NIGHT back in 1669 a German alchemist named Hennig Brandt came close to greatness. Alone in his Hamburg laboratory, Brandt squinted at his scribbled notes and carefully weighed out chemicals from a row of vials. If the experiment proceeded as planned, Brandt would become the world's richest man. His elixir, sought after for centuries, would transmute silver into gold.

When the last ingredients were added to the test tube, Brandt stepped back to observe their interaction. The container smoked, then fumed, then, as the alchemist jumped aside, burst into violent flame. The would-be King Midas fled from his laboratory, disappointed over his failure.

What he had unwittingly discovered, however, was phosphorus, an element that ignites when exposed to air. Brandt never did become the world's richest man, but others, seeing what he could not, made fortunes from phosphorus, the substance upon which the simple match depends.

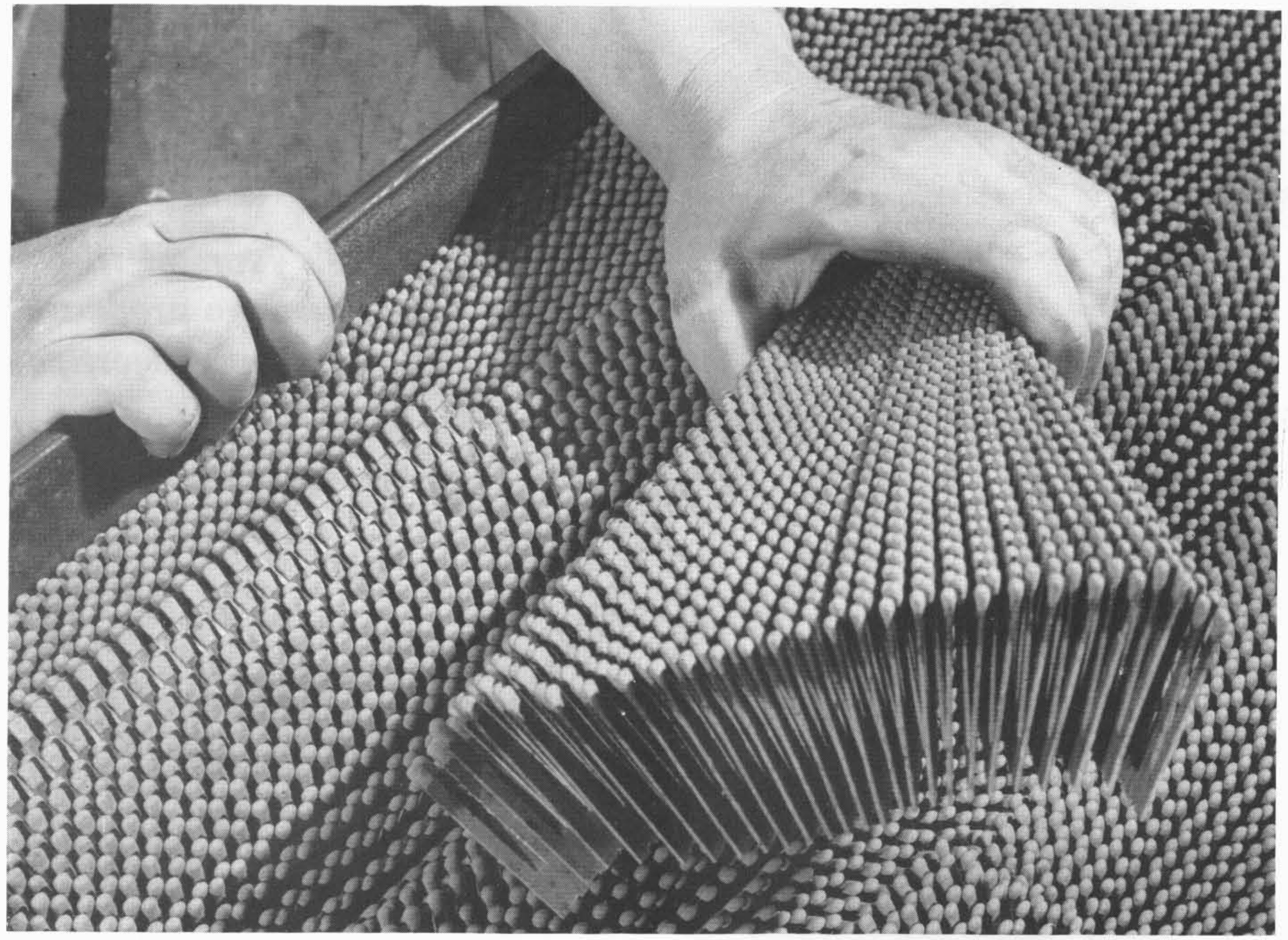
The story behind the match is not nearly as simple. More than 200 years and the inventive genius of dozens of international experimenters were required to turn Brandt's find into the modern match. The 500 billion matches produced annually in the United States and the billions more in Great Britain, Russia, Sweden, Norway and Japan are expressions of a long-cherished goal—the creation of a small flame, easily kindled and just as easily extinguished.

Americans each light between nine and 14 matches a day. They do it with a debonair flick of the wrist that would have aroused the admiration of their forebears who had to resort to ungainly tinderboxes for a light.

From the days of the Roman Empire, man had made fire by striking flint on steel – an operation that took a half hour of tedious work. Primitive peoples employed the still more laborious method of rotating a stick in a socket of dry wood.

Brandt's discovery changed this, but it took years of groping. First came a series of fantastic fire-making devices that were as dangerous as they were impractical.

An English scientist, Robert Boyle, was first to try his



Book matches, invented in 1892, are manufactured in "combs" of 60 to 100 matches, then cut and stitched into cardboard covers.

hand with phosphorus. In 1680 he coated coarse sheets of paper with the element and dipped long wooden tapers into sulphur. A taper drawn through a fold of the paper would sputter into flame briefly, then flicker out. It also produced a cloud of acrid smoke that nearly suffocated bystanders.

For a century no further progress was made. Then, in 1780, a group of French chemists invented the "Ethereal Match," a twist of paper tipped with phosphorus and sealed in a glass tube. When the tube was broken and air rushed in, the paper caught fire. It was, at best, a clumsy device. The "Ethereal Match" was followed by similar innovations, all dangerous, all utilizing the hard-to-handle phosphorus.

The first friction match bearing any resemblance to the modern one appeared in 1827 when a British pharmacist named John Walker made up a batch of three-inch splints tipped with antimony sulphide, potassium chlorate, starch and gum arabic. He dubbed his invention the "Congreve" and triumphantly called in the neighbors to demonstrate it.

"Behold!" Walker cried, holding aloft one of the splints.

As his audience watched, he quickly pulled it through a sheet of folded sandpaper. The result was spectacular. The "Congreve" ignited with crackling explosions and spark showers that sent Walker's guests scurrying for cover.

Charles Sauria, a French chemistry student, in 1831 finally produced the forerunner of today's match—the "Strike-Anywhere." This was a wooden splint with a white phosphorus tip (a substitute for antimony sulphide) that lit without Roman candle accompaniment when scratched across a rough surface.

Sauria made no attempt to commercialize his product, but six years later an enterprising Yankee named Alonzo Phillips began making phosphorus matches in his Massachusetts cellar and peddling them from door to door. Intrigued by the convenience of matches, the public started clamoring for them in the United States and Europe. The phosphorus experiment, which had floundered for decades, blossomed into a major industry.

Competition intensified and rival firms put out matches under such colorful names as "Vesuvians," "Flamers" and "Blazers." One ambitious manufacturer dreamed up a short-lived self-lighting cigar in 1839 by inserting a phosphorus and sulphur tip in the end of a cheroot. It had a habit of flaring up in the smoker's face after he thought it was safely lit.

Then the story took a grim turn. Workers painting match tips with phosphorus began to contract necrosis, a disease that entered the body through defective teeth, destroyed the jaw bone and usually proved fatal. As the industry spread, the effects of necrosis reached alarming proportions.

Late in the nineteenth century, the French discovered a process for making matches with non-poisonous sesquisulphide of phosphorus, but the formula would not work in America because of a difference in climate. In 1911 a young engineer, William Fairburn, discovered a method of adapting the non-toxic Gallic formula to the American climate. The threat of necrosis ended. A few years later, Fairburn became president of the Diamond Match Company, a giant of the modern match industry.

Wooden matches had one detractor who inadvertently turned out to be one of the trade's greatest benefactors. In 1892 a Philadelphia patent attorney got tired of carrying loose matches around in his pocket. Joshua Pusey cut several slivers from a piece of cardboard, dipped them into a matchhead solution and stapled the lot to a cardboard strip. Convinced he had hit on something valuable, Pusey patented the idea and later sold the rights to Diamond for $4,000.

But the public was used to wooden splints and distrusted frail paper matches. Stores and tobacco shops refused to handle the new product.

A young salesman named Henry Traute had an idea. Someone told him about a down-at-the-heels vaudeville troupe. On Traute's advice, the performers gave away several thousand matchbooks with cover advertisements boosting the act's pretty girls. The following night the theatre was sold out. This ingenious idea launched many an obscure firm on its way to wealth and renown.

Still the public balked on grounds that paper matches were dangerous to carry around in the pocket. Match companies began dipping their splints in a solution that would ignite only on a special striking surface. For further protection they placed this surface on the outside cover at a safe distance from the matchheads.

The making of matches today is a triumph of modern production. Huge "continuous method" machines devour thousands of tons of white pine and aspen blocks, slice them into matchsticks, treat them with chemicals and pack them into boxes at the fantastic rate of two million matches an hour. Recently perfected is a machine that cuts, folds, stitches and stacks eight matchbooks a second.

The machine that turns out wooden matches is 60 feet long and two stories high. The heart of the mechanical monster is an endless belt of metal plates, each with eight rows perforated with 100 small holes. At the top of each machine a setting head places up to 200 pre-formed matches in the chain, drumming them into the holes at the blinding speed of 40,000 splints a minute.

Moving along at a split-second pace, the plates make their first stop—a bath of ammonium phosphate which eliminates the "afterglow" that used to be the principal fire risk. Next they dip the splints into melted paraffin (a by-product of oil production), then into a chemical composition that forms the bulb-like head, finally into sesquisulphide of phosphorus to create the flammable tip.

At the end of their hour journey the matches are dried, punched out of the holes, and funneled into chains of moving matchboxes. As an added safety touch, an ingenious device turns half the matchheads to the right and half to the left in each box to decrease the fire hazard and insure a flat pack.

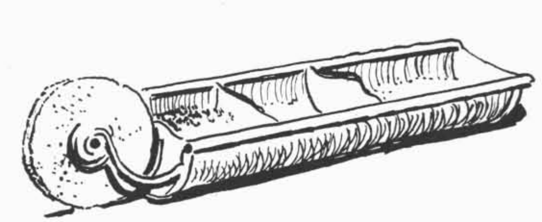
Book matches must pass through two machines. One slices rolls of pre-treated cardboard into "combs" of 60 or 100 matches, separates alternate matches so the heads will not touch, and carries them through paraffin and matchhead dips. The combs are then fed into a booking machine that assembles them and stitches each comb into an individual cover sliced off a long roll of pre-printed cardboard. This process results in completed books of 20 matches at the rate of 350 books a minute.

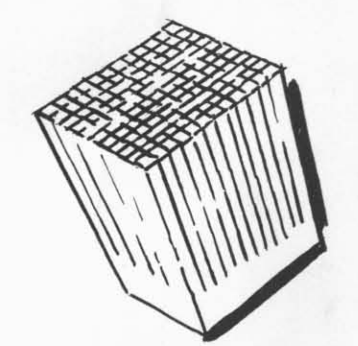
Since the early 1900's there have been tremendous strides in mass production—but few changes in the match itself. One significant advance was made during World War II when a waterproof match was produced at the request of the United States War Department. This novel version was specially coated so that it burned after eight hours under water and was highly useful in amphibious operations and in the sweltering humidity of the tropics.

The American public is the recipient of 196 billion matchbooks each year, two-fifths of total match production. Inspired by this vast output which reaches into virtually every home, some 300,000 firms spend nearly 30 million dollars a year supplying the public with free "lights" in order to bombard it with advertising.

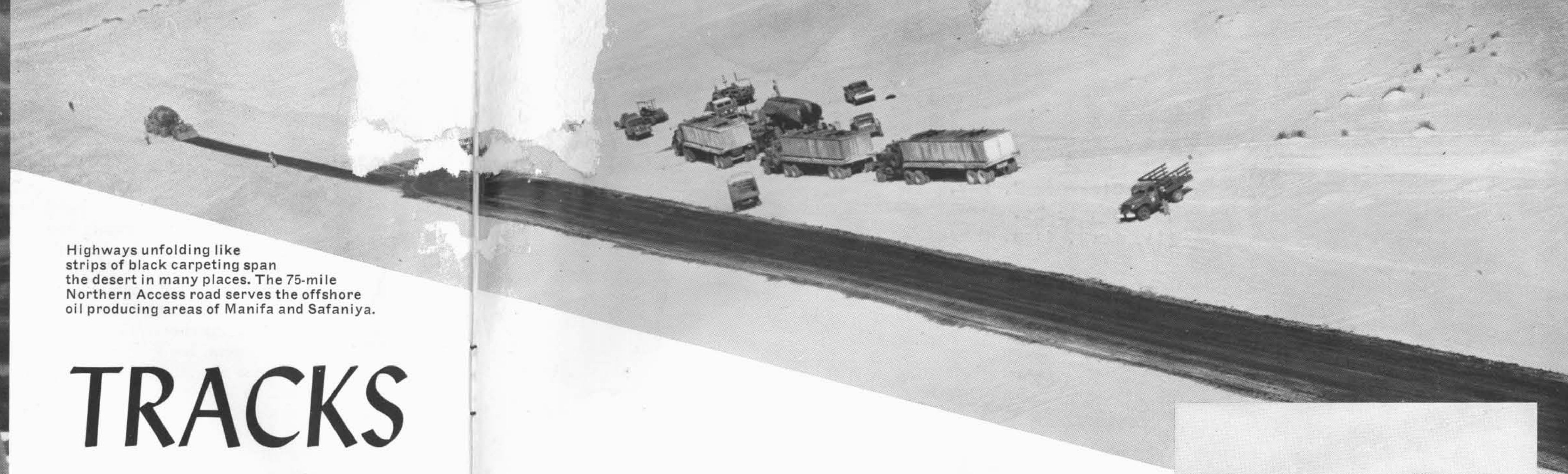
A survey recently demonstrated a startling fact about the public's regard for matches. Although they are cheap—usually free—*less than one booklet in 750 is thrown away before its 20 matches are used.* A small portable flame is not to be lightly discarded. ■

The heat of friction, created by twirling a stick in a socket, is one of the oldest means of producing fire. The tinder box (below) served as fire maker for centuries. Flint struck on metal caused sparks that ignited tinder in the trough. In the 1840's matches were sold in blocks of 144 matches.





Traveling on desert demands special equipment such as all-wheel drive, oversize radiators and low pressure tires. These tires, some of which are as tall as ten feet, have been compared to camels' hoofs. Hoofs and tires "splay" or spread out without sinking into the sand.

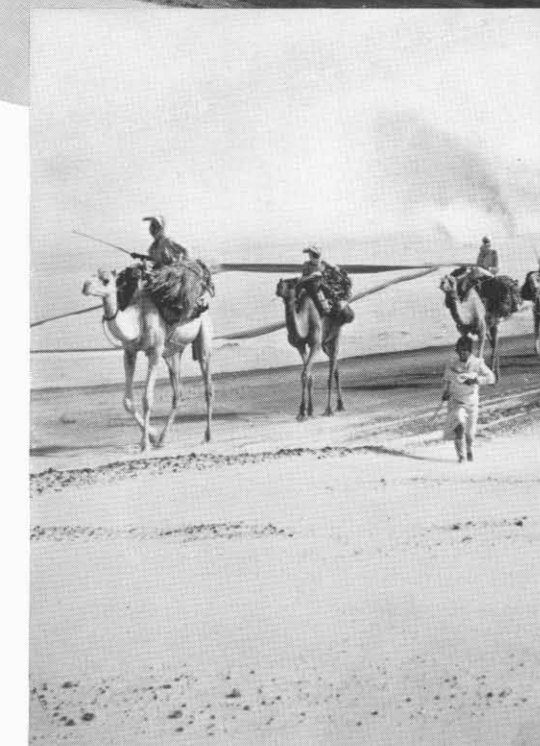


Highways unfolding like strips of black carpeting span the desert in many places. The 75-mile Northern Access road serves the offshore oil producing areas of Manifa and Safaniya.

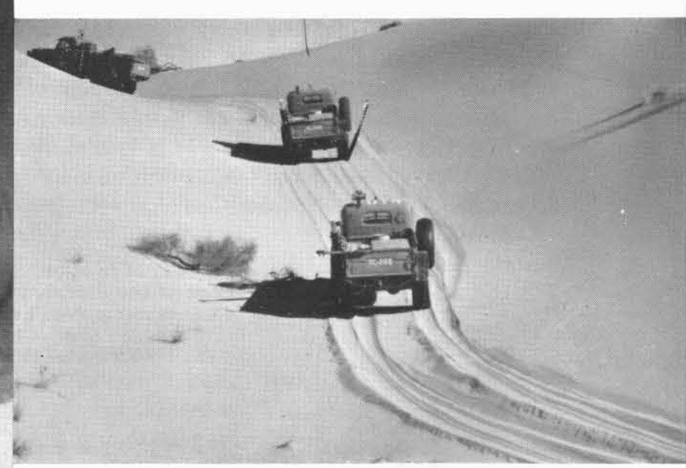
TRACKS ACROSS the DESERT

Determined men have made mastering the desert an everyday event in Saudi Arabia

THOSE WHO TRAVEL the desert in Saudi Arabia today are heirs to a long tradition of determination and ingenuity. Both qualities were vital to the hardy caravaneers who challenged the desert in years past. In those days, as the bashi *(leader) cried out the departure order, the caravan's banner was raised, signaling the end of long planning and the beginning of the march. Camels and mules had been selected, food and water carefully stowed, daily destinations worked out and places assigned in the long line of men and beasts. Nothing was left to chance, for the desert has always been a harsh taskmaster. For hours the caravan wound out of the city, accompanied by the jingling of camel bells and the shouts of men of many nationalities — merchants, soldiers, muleteers, camel drivers, adventurers, each anxious to reach a city across the sands. The caravan offered the surest means of arriving, even though its pace was no faster than the two-mile-an-hour plod of the camel. Far away in distant cities, merchants awaited the caravan's treasures — jewels from India,*



Camels as a major means of desert transportation are a thing of the past in Saudi Arabia today



Vehicle drivers must be trained to know correct speeds and when to shift gears to keep wheels grinding through tricky sand.

Saudi Government Railroad, which runs from the Persian Gulf port of Dammam to the inland capital city of Riyadh, carries everything that once would have been consigned to camel pack.