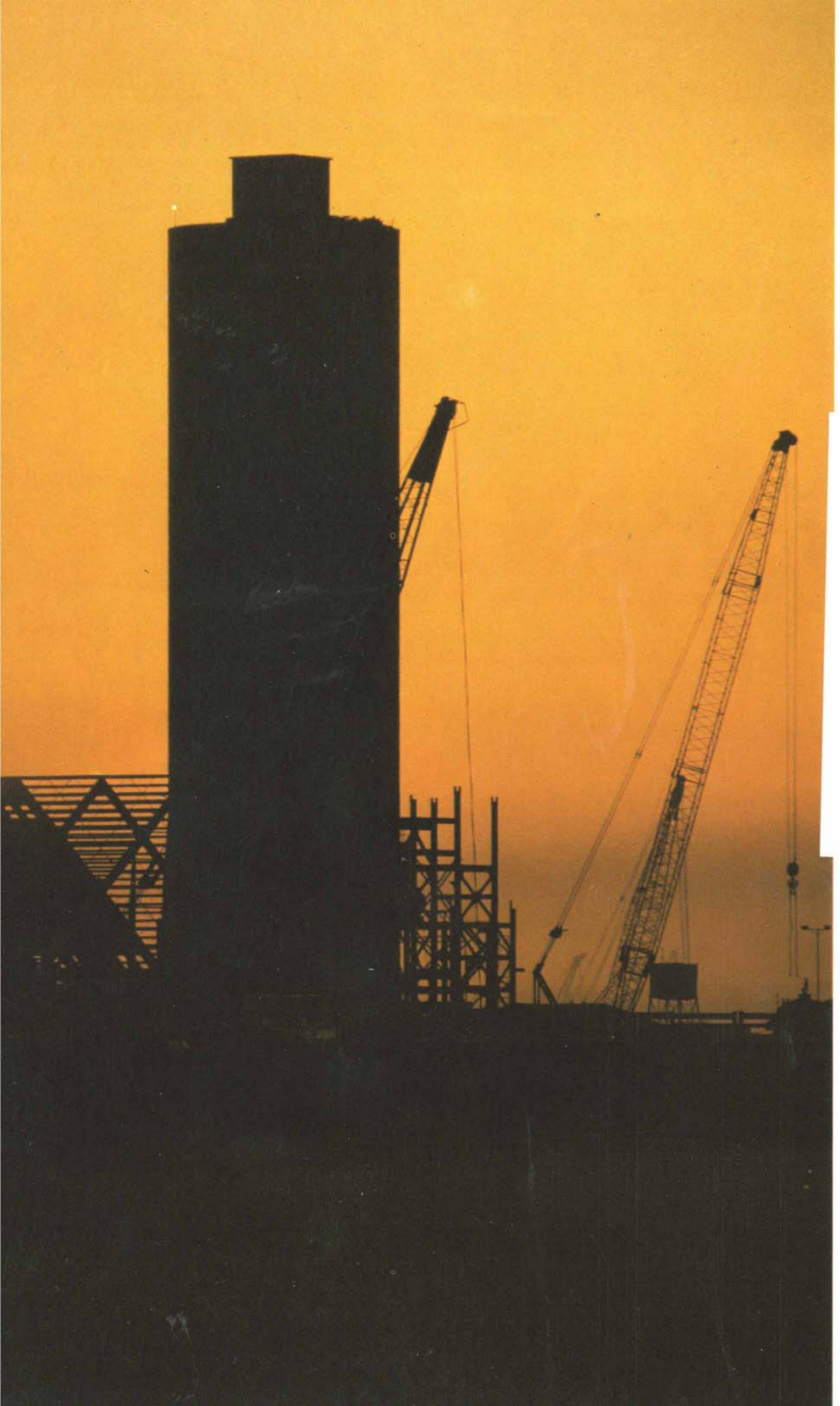

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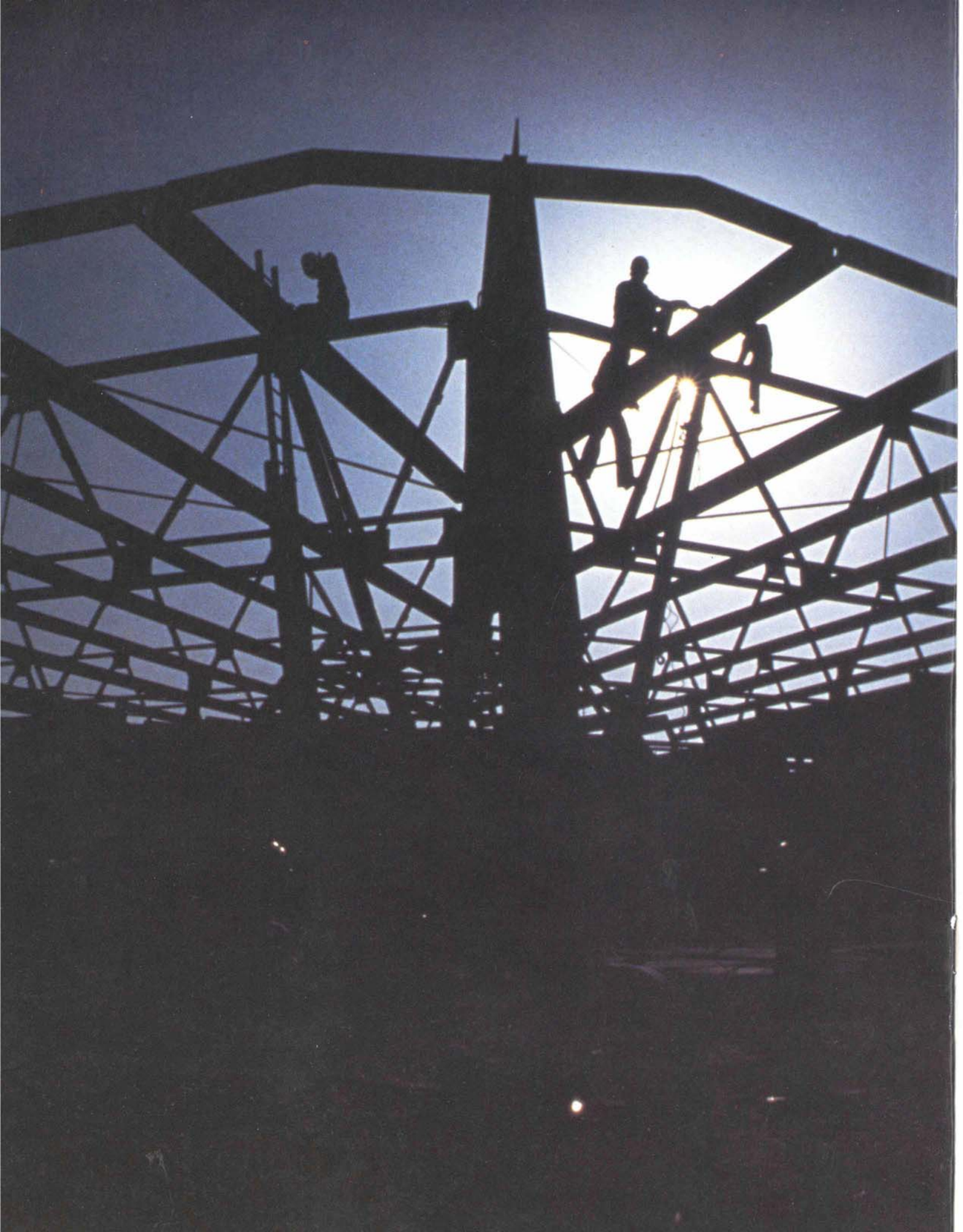
NOVEMBER–DECEMBER 1982

FOUNDATIONS

A Decade of Development



ARAMCO WORLD magazine

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Cover: The twin 62 - meter - high reduction towers (203 feet) of a new steel mill at Jubail symbolize Saudi Arabia's drive towards economic diversification through industrialization. The kingdom's first non-oil-related primary industry, the plant will produce 800,000 tons of steel a year and reduce by half Saudi Arabia's imports of reinforced bars and wire rods for building. Back cover: The 73-meter-high cooling tower (240 feet) of Jubail's new fertilizer plant, which will produce 500,000 tons of urea a year, mainly for export. Photographs by S.M. Amin.

◄ Racing towards completion: workmen put the finishing touches to the roof of the Jubail fertilizer plant, scheduled to start production early next year.

MAP BY BRIAN SMITH AND KAREN BAKER

A Decade of Development

Since September 22, 1932, when the Kingdom of the Hijaz and Najd and its dependencies – unified under King 'Abd al-'Aziz ibn Sa'ud – was renamed the Kingdom of Saudi Arabia, the country has been transformed.

Starting as a nomadic and pastoral society largely unknown in Europe and beyond, it has become a primary source of the world's energy and a pivotal factor in Middle Eastern political and economic equations, and today is involved in a concerted effort to modernize and industrialize an entire country in just a few years.

As the statistics in this issue of *Aramco World* suggest, this attempt, launched in 1970, is enormous; it has already absorbed close to $150 billion allocated between 1975 and 1980, the period of its second development plan, and under the third and current five-year plan will require at least $200 billion more – nearly eight times the amount spent by the United States to put men on the moon six times.

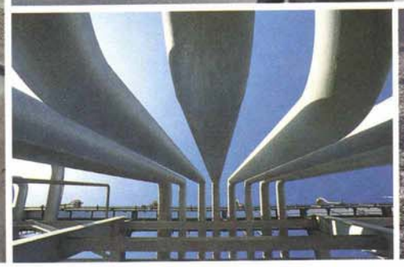
Such programs, obviously, are impressive. As London's *Financial Times* said: "There has rarely been a society exposed to such dramatic change, development and reorganization as Saudi Arabia is today."

If the statistics are impressive, however, they also tend to obscure the simple facts that measure the impact in human terms: the old tailor in Nariya adding an electric motor to his sewing machine after a lifetime of working it by hand; the grocer in a small Eastern Province town proudly displaying for the first time perishable goods and dairy products in his new, glass-fronted electric freezer; air conditioning in a village where hunting falcons still doze on a hitching rail in the afternoon sun.

The emphasis, nevertheless, is on the magnitude – and the pace. In October, for example, the *Cavendish*, a tanker, took on a shipment of LPG (liquefied petroleum gas) at the new NGL (natural gas liquids) export terminal at Yanbu': 105,000 barrels of liquefied butane and 190,000 barrels of liquefied propane from the new NGL fractionation plant–which was opened in August. A milestone in the development of the new and vital coast-to-coast Master Gas System, this first east coast shipment suggests the size and speed of the kingdom's development; the terminal can handle some 200 ships a year and–because it cuts 12 days from the round trip to Europe–is a significant addition to Saudi Arabia's growing hydrocarbon energy outlets.

No one article, of course, or even a series of articles, can really capture the scope and magnitude of such unprecedented change; it defies both pen and camera. Contributing editor, John Lawton, therefore, focused on the fundamentals of the development program and limited his attention to projects that were actually completed or underway rather than those on the planning board. Lawton, a former UPI correspondent, was assisted by Aramco writer Arthur Clark with backup from Richard Hobson and the Local Industrial Development Department in Dhahran. Photographs were provided by S.M. Amin – as well as Tor Eigeland, Burnett H. Moody, Aramco's chief photographer, M.E. Noble, Michael J. Isaac, Tomas Sennett, Aileen Vincent-Barwood, John De Bry, The Royal Commission for Jubail and Yanbu', Saudi Arabian Airlines, and Petroline.

–The Editors



FOUNDATIONS

The Introduction

On its 50th anniversary as a united country, the Kingdom of Saudi Arabia stands poised for the final phases of what must be one of the most ambitious national development programs ever undertaken.

Inconceivable 50 years ago – when 'Abd al-'Aziz ibn Sa'ud finally united the nomadic peoples and townsmen of the Arabian Peninsula into the kingdom called Saudi Arabia – this program has already laced the peninsula with highways and pipelines, sprinkled the country with airports and harbors, and reshaped its horizons with power plants and pylons – the foundations for industrialization.

Behind this growth, of course, was the world's soaring demand for oil and increased oil prices that swiftly boosted Saudi Arabia's earnings from $2.7 billion in 1972 to $27.8 billion in 1974, enabling the kingdom to embark on an extraordinary program of progress that, in effect, will cram a century of development into a decade.

"In Europe," says Muhammad Sa'id Farsi, the mayor of Jiddah, the country's largest port, "contemporary economic and social systems evolved gradually over more than a century. In Saudi Arabia, this was accomplished in a fraction of a century."

For the mayor of Jiddah, this is not rhetoric since his city is a microcosm of the dramatic change that has taken place in the kingdom in recent years. A medieval, walled town as recently as the 1940's, with 50,000 inhabitants crowded into a maze of narrow, twisting streets, Jiddah today is a modern metropolis with wide boulevards, high rise apartments and plazas decorated with abstract sculpture; with a population of more than a million, one of the most sophisticated harbors anywhere, the world's largest airport, and, underway, what will be the tallest building in the Middle East: the 44-story National Commercial Bank.

For the kingdom as a whole, the Saudi government's aim has been equally dramatic: the transformation of what was once a predominantly pastoral society into a modern state with a diversified industrial economy in which the export of crude oil will not be the sole source of great wealth.

The kingdom, of course, could not even begin to do this until it first provided the social and physical infrastructure on which industrial societies are founded; the first phase of the government's development plan, therefore, was devoted to laying the foundations.

Some progress had been made during the kingdom's first Five Year Development Plan (1970-1975), when several projects, such as the King Faisal Specialist Hospital (KFSH) in Riyadh, were completed (*Aramco World,* July-August, 1979) and others, like Jiddah's new jetport (*Aramco World,* July-August, 1981) and the Jizan Dam (*Aramco World,* May-June, 1978; March-April, 1974) were begun. But it was not until the kingdom's second-plan period – 1975-1980 – that Saudi Arabia's programs began to reach today's size and pace.

Because these programs have broken so many records, and established new dimensions, early press coverage leaned heavily on superlatives to tell the story – the biggest in the world, first in the Middle East, etc. But now even at a distance of some years, the construction still comes across as, quite simply, massive. Saudi projects, for instance, needed – and got – the largest number of planners, technicians and workmen ever assembled in a developing country, and millions of tons of materials, equipment and supplies almost literally poured into Saudi Arabia from all over the world. Simultaneously, battalions of earthmovers dug, scraped, moved and smoothed acres of land, building cranes bristled across the skyline, and the clamor of construction echoed from coast to coast.

Though it sounds like a cliché, new factory buildings actually *did* "sprout from the desert" in a few months' time, cities and towns *did* spread dramatically in a few weeks, and new neighborhoods *did* spring up virtually overnight. To visitors the growth was tangible, visible and measurable: 344 billion riyals worth of development ($100 billion), including four ports, 28 dams, 24,000 kilometers of roadway (14,913 miles), more than 175,000 new homes, the world's first nationwide computer-controlled telephone network – and an airport as big as Manhattan Island. Today, as a result, thousands of miles of modern transportation routes – air, road and rail – link the far-flung provinces of Saudi Arabia and in the main population centers the physical foundations for industrial development have been laid, along with efficient public utilities.

In addition, the industrial base of the kingdom is being rapidly expanded by encouraging the private sector to set up industries through numerous incentives, including exemption from customs duties on imported machinery and raw materials, nominal rents for industrial sites and interest-free loans. Foreign capital and technical know-how, also needed for the kingdom's development, are encouraged by the same incentives enjoyed by local investors plus tempting tax advantages.

The response has been good. Over the period of the second plan, the private sector achieved an 18 per cent growth rate – 4.6 per cent above target, and already many items, such as fertilizers and cement – previously imported – are being manufactured locally.

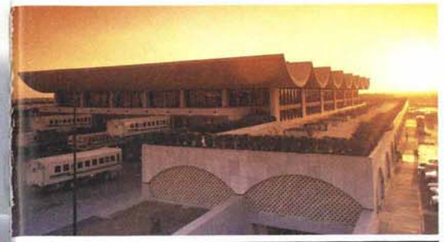
Development, in fact, is moving so fast that even the planners themselves sometimes have difficulty keeping up with it. "We are running," says Omar Abdullah Khadi, deputy minister for Town Planning Affairs, "to provide facilities."

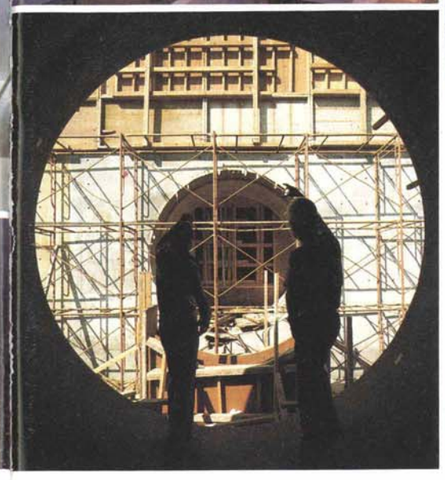
The need for urgency is real. For although Saudi Arabia possesses the world's largest known reserves of crude oil – about 170 billion barrels – this supply is limited and irreplaceable and national planners are acutely aware that one day it will run low.

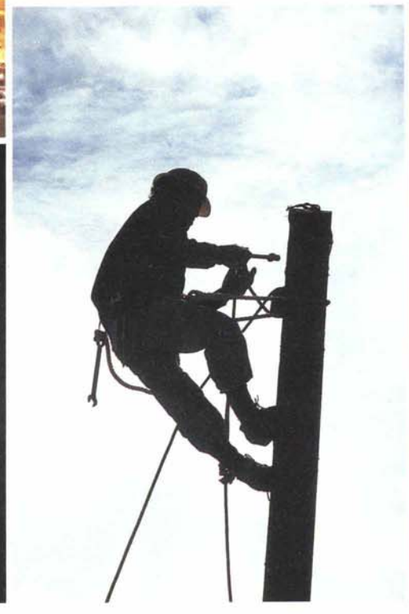
Recognizing this, the Saudi government has adopted a strategy aimed at husbanding its resources while maximizing its earnings from them, by building hydrocarbon-based industries in the kingdom and exporting finished products too.

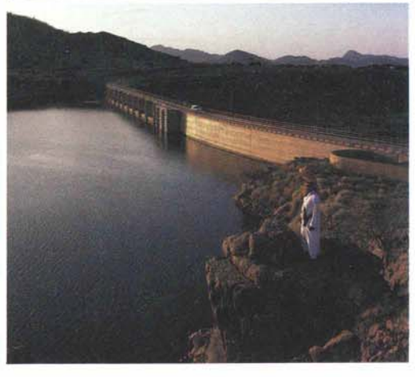
In 1982, it completed construction of the key elements in a massive new system to collect and process gas: the Master Gas System under which most of the once-burned gas will henceforth be used as fuel and raw material for the new industries. Saudi Arabia is presently building two new industrial cities that by the mid-1980's could be refining nearly three quarters of a million barrels of oil a day and manufacturing 3.2 million tons of petrochemicals a year. It is also developing other hydrocarbon-based and energy-intensive industries, such as methanol and steel plants, that will help Saudi Arabia attain self-sufficiency and continued self-generated growth.

It is a staggering task. But the foundations are largely in place – the Master Gas System, for example, is already operational – and the beginning of an industrial society is already being built upon them – a fitting milestone to mark the country's 50th year.









The Cornerstones

NOBLE

Thirty years ago there was not a single paved road in Saudi Arabia, but today thousands of miles of asphalt highways, like the one left, link the kingdom's far-flung provinces.

With a population smaller than London's scattered over an area the size of western Europe, and a development program heavily dependent on imported services and supplies, Saudi Arabia sees communications and transportation as vital elements – the cornerstones, in fact – of its economic growth.

No government, of course, can function effectively without efficient transport and widespread communications – a lesson the Saudi government learned the hard way when, in the mid-1970's, severe transportation bottlenecks halted – or at least hindered – the movement of materials needed for its development projects. The result was a spurt of inflation and brief disruption of the kingdom's plans.

In response, however, the Saudi government began to build – on an urgent basis – new seaports to receive world cargoes, new airports to link Saudi cities with each other and the rest of the world, new roads to channel progress to outlying areas, and a telecommunications network to speed business transactions. Between 1975 and 1980, the period covered by the Second Five Year Development Plan, Saudi Arabia laid 24,000 kilometers of roadway (14,913 miles), installed some 250,000 new telephone lines, and built the world's biggest and, at times, busiest airport.

Ports, of course, had the highest priority because it was here that the bottlenecks began. At one point in 1976, for example, there were a total of 355 ships waiting to unload cargo at Saudi ports – and one result was sudden, severe inflation, since goods, once ashore, could command almost any price.

Another result was a delay in vital development projects, and since this could not be tolerated, the government took an unprecedented step to break the logjam: it created a national Ports Authority with a mandate to eliminate port congestion whatever the cost. It was an unusual move, but the results more than justified it. Since then Saudi Arabia has completed four new deep sea ports and modernized three others, thus cutting waiting time to zero. Also added were new offshore loading terminals for gas.

Nowhere is this transformation more visible than at the expanded and modernized port of Dammam on the Arabian Gulf. A chaotic scene only a few years ago, Dammam's port now is so clinically clean that visitors hesitate to even drop cigarette butts on its spotless quays, and it is so efficiently quiet that dolphins have been heard answering the horns of giant "straddle" cars whisking containers smoothly and quietly around the docks.

Dammam today counts 38 spacious berths instead of the nine clogged quays available in 1975; cargoes are kept track of by computer rather than overworked shipping clerks; and a six-lane causeway has replaced the old trestle access to the port. As another measure, Dammam's gantries unload containers at the rate of 35 an hour – 10 more than Felixstowe, England, which holds the European record.

Dammam, which serves Saudi Arabia's oil-producing Eastern province, is not the only example of success with ports. Another example is at Ju'aymah where a 10 kilometer trestle (six miles) was built to carry pipelines to offshore loading terminals. In fact, says one Aramco economist, "ports are probably the best... example of the... achievements of the... Plan."

When discussing Saudi ports development experts frequently use the phrase "from chaos to showpiece" – a description graphically illustrated at Jiddah. This port, on the Red Sea, was once typical of the mystery and confusion graphically described by novelists in depicting eastern harbors, but is now thought to be one of the most sophisticated shipping centers in the world. Saudi Arabia's largest port, Jiddah today has 45 berths – 33 of them brand new – a modern computerized container terminal, and a total unloading capacity of 17 million tons a year – more than double what it was five years ago.

Further north, there is Yanbu,' also on the Red Sea, and one of Saudi Arabia's oldest ports. Long associated with sailing dhows and camel caravans, Yanbu' has been propelled into the 20th century with the construction of seven new berths – previously it only had two – and the widening of its entrance channel.

The Cornerstones

In addition to upgrading these three ports, the Ports Authority has built two new ones – one at Jubail on the Gulf, with 16 berths, and the other at Jizan on the Red Sea, with four berths – and the Saudi Ministry of Public Works and Housing has built two 10-berth ports, exclusively for construction materials. One is at Ras al-Ghar on the Gulf, the other at Qadimah on the Red Sea – bringing the total number of deep-sea berths in Saudi Arabia to 130, compared with 23 just 26 years ago.

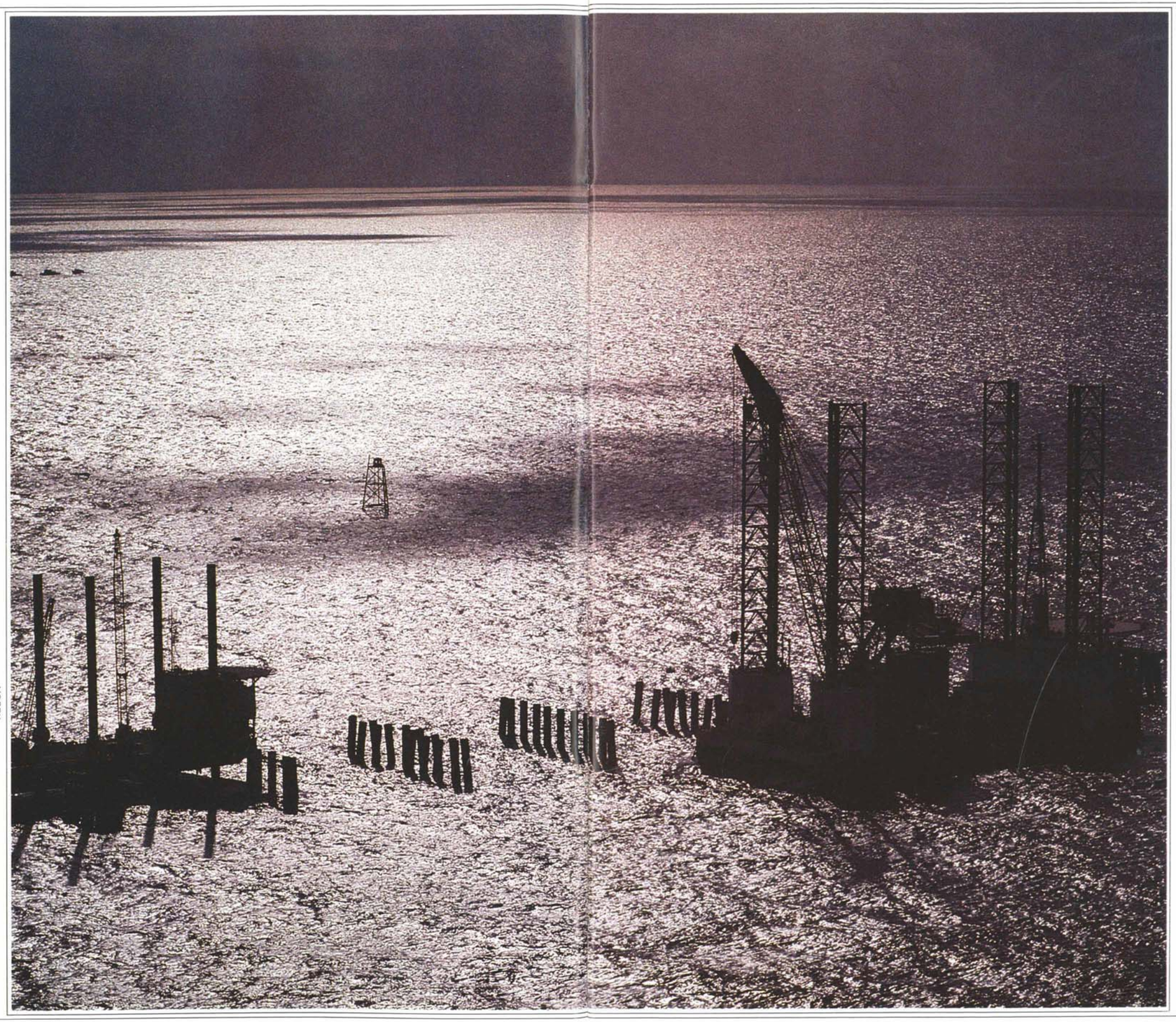
Another major problem facing the kingdom in the early days was the lack of roads – as Ali al-Ghamdi, a public relations officer in Dammam, makes clear. In 1957, he recalls, it took him 16 days to traverse the Arabian peninsula from his native village of Baljarshi, in the West, to Dhahran, in the East, in search of work – six days from Baljarshi to Taif, seven days from Taif to Riyadh, and three days from Riyadh to Dhahran – driving in six or seven car convoys at between 10 to 20 kilometers (6 to 12 miles) an hour.

Today, however, says al-Ghamdi, the same drive takes less than 15 hours and he frequently visits his family in Baljarshi for long weekends.

To measure that achievement, it must be recalled that 30 years ago there were no paved roads in Saudi Arabia and that in 10 years Saudi Arabia has almost tripled the length of its asphalted and paved road network and increased by nearly seven times its rural road system. By 1981 the kingdom's road network consisted of 11,825 kilometers (7,348 miles) of asphalt highways, 9,760 kilometers (6,064 miles) of paved secondary roads, and 24,186 kilometers (15,029 miles) of earth-surfaced rural roads linking 6,954 villages.

MOODY

Above, the new computerized container terminal at Dammam, and right, under construction and complete, the 10-kilometer-long pier (six miles) carrying pipes to the offshore gas loading terminal at Ju'aymah.



AMIN

AMIN

During the Second Five Year Plan period, 1975 to 1980, the Saudi government spent more than 23 billion riyals ($6.72 billion dollars) on road building, the most spectacular result of which was the 753-kilometer Jizan-Taif mountain highway (467 miles) linking the fertile farming areas of the south with major commercial centers of the west through tortuous terrain. More recently, construction has begun on an expressway linking Jiddah with Dammam.

Building roads in Saudi Arabia presents special difficulties in the flatlands because the big winds blowing across the desert can bury a road in hours unless special precautions are taken.

Speeding along the kingdom's smooth new highways now, visitors can see – though they may not recognize – these precautions by the roadside: what appear to be abandoned mounds of asphalt and discarded ruptured tires. In fact, these mounds are carefully molded aerodynamic shapes that deflect blown sand, and the "tires" are bituminized rubber strips that help contain shifting dunes.

Contractors building roads must also be careful in siting sign posts and crash barriers; wrongly placed, they could cause a buildup of sand and even create a dune.

Then – oddly in such an arid land – there is the problem of flash floods – even more

of a problem than sand. Rainfall, it is true, is scant, but as sand does not absorb cloudbursts fast enough, floods build up rapidly and thunder down wadis at a terrifying rate. Incongruous as it may look, therefore, dikes and culverts must be constructed.

Despite these problems, the Ministry of Communications is well on the way to achieving the main objective of the massive Saudi road building program; nothing less than integration of the whole country in order to spread industrial and agricultural development to every region.

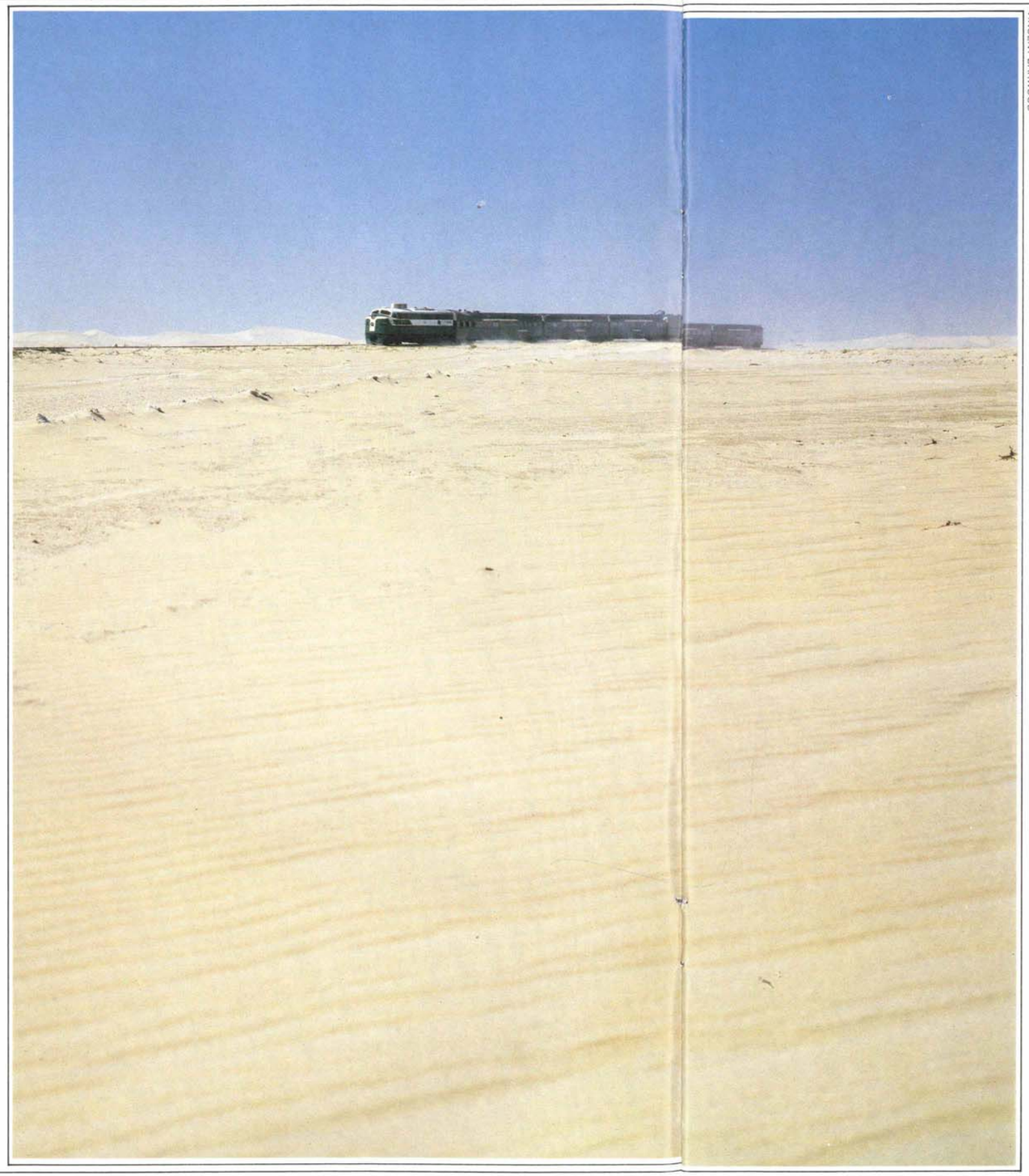
Because of the size of the Arabian Peninsula, air transport got off to a fast start after U.S. President Franklin D. Roosevelt gave a Dakota DC-3 to King 'Abd al-'Aziz in 1945. But even air transport has undergone an unprecedented transformation in the last decade.

Today, for example, the national airline, Saudia, operates a fleet of over 60 jets. Internal flights, in fact, are now so regular that a seat can often be obtained shortly before takeoff, and with the completion of the massive new Jiddah and Riyadh airports the kingdom will have one of the most comprehensive air networks in the world.

One of the wonders of the modern aviation world, the King 'Abd al-'Aziz International Airport in Jiddah covers an area of more than 103 square kilometers (40 square miles) – twice the size of Manhattan Island and half again as big as Kennedy, La Guardia, O'Hare and Los Angeles airports rolled into one.

Saudi officials say the jetport is second largest in area in the world after Montreal's Mirabel Airport. But a spokesman for the Canadian High Commission in London told *Aramco World Magazine* that Saudi Arabia was being too modest. "Most of the land originally part of Mirabel has since been given over to non-airport use," the spokesman said. "Jiddah airport *is* the largest in area in the world."

More than 11,000 men from 35 countries worked six years to build the airport in virgin desert 18 kilometers north of Jiddah (12 miles), and the results in statistical terms are spectacular. The new jetport, for example, has the largest air-cargo handling system in the Middle East – it is capable of handling 150,000 metric tons of freight a year – and the special Hajj Terminal can handle 80,000 pilgrims a day – arriving at the rate of 100 aircraft an hour,



VINCENT-BARWOOD

all landing alternately on its two more-than-3,350-meter runways (11,000 feet) beside the Red Sea.

Beneath a control tower 60 meters (197 feet) high there is a mall with parking for 44 jetliners. In the Royal Pavilion there are 150 antique carpets covering the floors and outside – shading an oasis-like forecourt – are palm trees. The airport, in fact, is surrounded by trees – 70,000 trees – planted as a barrier against sand.

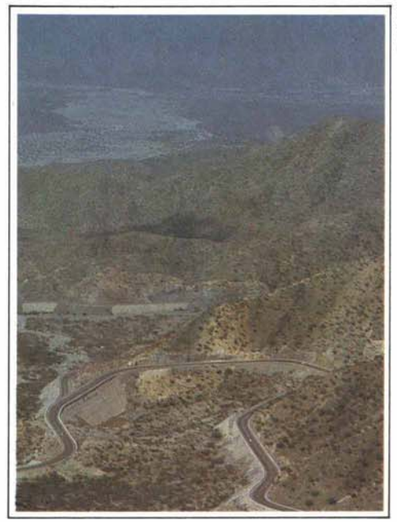
Altogether there are four terminals at the Jiddah jetport. The South Terminal serves passengers of domestic and international flights of Saudia. Spacious and cool, it is floored and walled with 6,500 tons of gleaming white marble and can handle up to 2,200 passengers an hour. The slightly smaller North Terminal is used by the 28 foreign airlines serving Jiddah. Its walls are faced with ceramic, its floors tiled with terrazzo and main passenger processing area completely enclosed in heat-resistant glass. At peak boarding times this terminal can manage 2,000 persons an hour and the airport as a whole will eventually employ 20,000 people.

Impressive as those terminals are, however, they pale into insignificance when compared to the airport's two other – and completely self-contained – passenger terminals, one for heads of state and governments, other important guests and the Saudi royal family, the other for Muslim pilgrims en route to nearby Makkah (Mecca).

The Royal Pavilion, with its copper roof, white marble walls and exquisite interior, is, as its name suggests, fit for a king. Its main reception hall, for instance, boasts Thai silk wallpaper and gold embroidered tapestries, and adjoining it are lavishly furnished banqueting and conference halls – plus an ultra-modern press room with full radio and television coverage facilities.

AMIN

The Dammam-Riyadh railroad left; the Jiddah jet port above; and the Taif-Jizan highway right.



MOODY

The showpiece of the airport is undoubtedly the Hajj Terminal – a complex comprising 20 enclosed passenger processing facilities, and scores of open air rest and prayer plazas, markets, kitchens, banks and bath houses – all sheltered from the desert sun by the largest fabric roof in the world – gleaming white fiberglass, suspended from 440 steel pylons and shaped by 396 kilometers (246 miles) of cable into 210 conical tents, that house pilgrims at the height of the pilgrimage (See *Aramco World*, July-August, 1981).

Despite its enormous size, the Jiddah jetport will not be the world's largest airport much longer. A new airport now under construction near Riyadh – and scheduled to open in 1983 – will cover an area of 243 square kilometers (94 square miles) – almost *three* times the size of the Jiddah facility.

Situated 35 kilometers (22 miles) north of the kingdom's inland capital, the Riyadh airport will be the hub of Saudi Arabia's fast-growing domestic air travel and an international gateway as well. By the end of the century it is expected to handle an estimated 15 million passengers a year.

Like Jiddah's jetport, Riyadh's $3.2 billion airport will have a number of terminals and special architecture: two international terminals and two domestic passenger terminals, each triangular in shape and roofed by 72 triangular sections stepped up in tiers. In addition there will be one of the largest mosques in the kingdom at 12,541 square meters (135,000 square feet), one of the tallest control towers in the world, its

operation floor 76 meters (250 feet) off the ground, and multi-story garages nearly as long as the terminal complex itself, that will house 10,000 cars.

And even this airport could be dwarfed by still another new airport; planned for the Eastern Province, between Dhahran and Dammam.

In addition to three international jet ports, Saudi Arabia today has no fewer than 22 domestic airports. The five main domestic airports are at Tabuk, Medina, Taif, Abha and Jizan in the Western Province. Other domestic airports are located at Wajh on the Red Sea, at Bishah, Najran and Sharrah in the South; and at Badanah, al-Jawf, Ha'il and al-Qasim in the North. There are also nine smaller local airports scattered around the country and eventually every settlement of any size will have reasonably easy access to air travel.

Another cornerstone is communications. Not long ago foreign correspondents visiting Saudi Arabia had to fly to neighboring countries to file their stories because adequate facilities simply didn't exist in the kingdom. As recently as 1978, for example, there were only 125,000 telephone lines in the entire country compared to 5,913,942 lines in New York city alone.

By 1982, however, there were some 650,000 lines, according to a Ministry of Post, Telegraph and Telephones release last February – a five-fold increase in as many years. The kingdom's Telephone Expansion Program, moreover, is the largest single project in the history of the telephone; it will provide more than one and a quarter million lines by 1985.

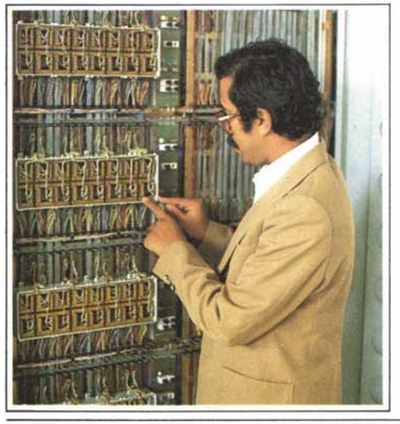
This is no mean feat when one considers that the ministry's trenching and cabling teams frequently had to work in cities and towns for which no maps or plans existed, and in which social norms forbade them from entering a house to work if no male member of the family was present.

To meet the rapidly growing needs of the kingdom, major companies from The Netherlands, Sweden and Canada have installed some of the most advanced computerized exchange systems available in the world today, with the result that Saudi Arabia was the first country in the world with a nationwide computer-controlled telephone network.

The most important aspect of the system is its flexibility and speed. If, for example, somebody wants to make a call from Jiddah to Riyadh, the computerized exchange first tries to connect the call through a coaxial cable link, then, if all lines are busy, it tries a microwave network until a free line is found – all in the space of a few seconds.

The coaxial cable and microwave system, of which Saudi Arabia's "Backbone Project" are part, stretches 10,000 kilometers (6,214 miles) from Jiddah, on the Red Sea, via Makkah, Taif, Riyadh and Hofuf, to Dammam, on the Arabian Gulf. Between them they provide a total of 42,000 channels for telephone conversations, four television channels, and facilities for Telex, telegram and radio transmission.

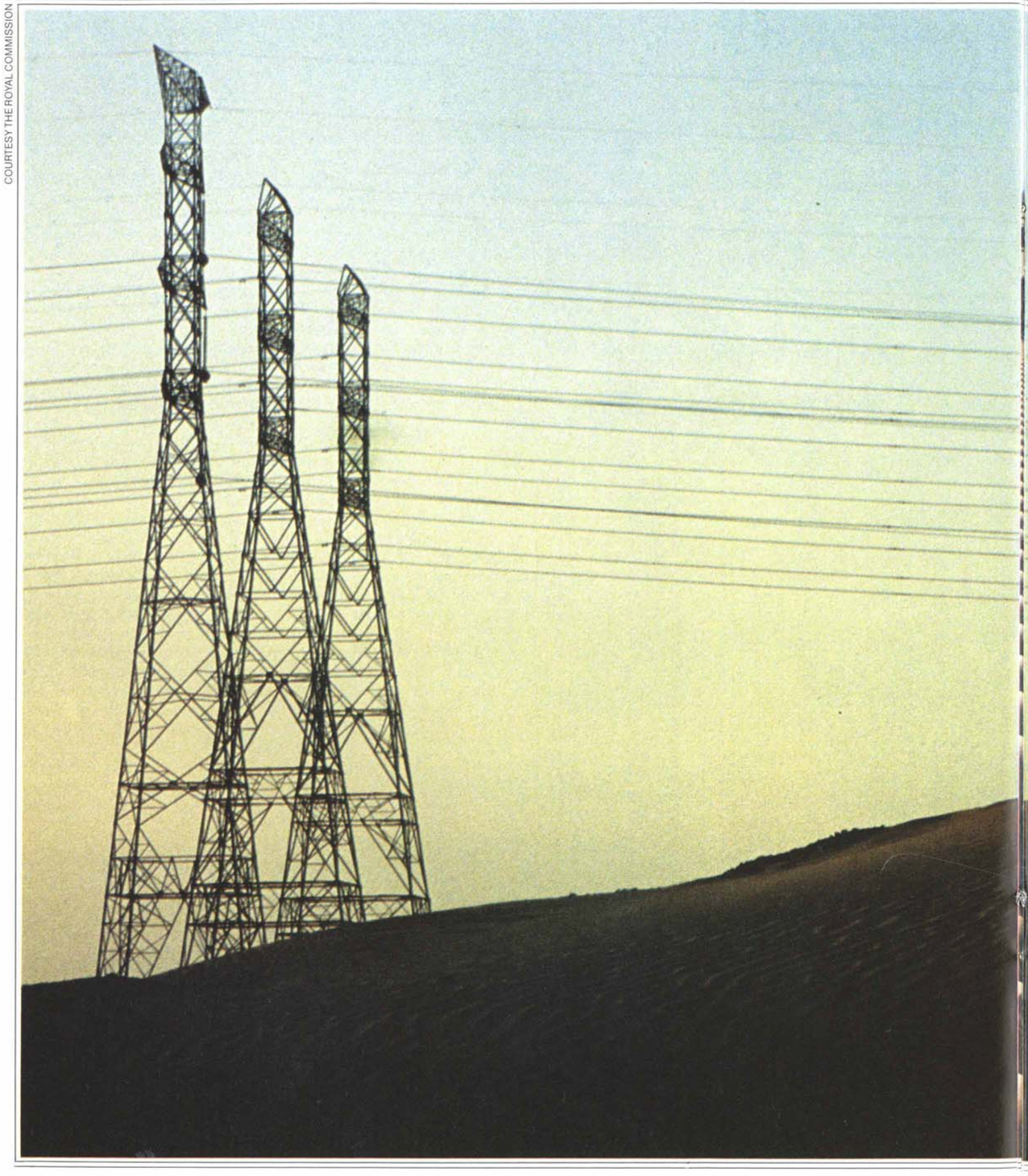
Saudi Arabia also has a domestic satellite system of 11 mobile and three fixed earth stations, linking its cities with the international telecommunications satellite organization Intelsat, and allowing almost anyone with a telephone in the kingdom to dial anywhere in the world direct.



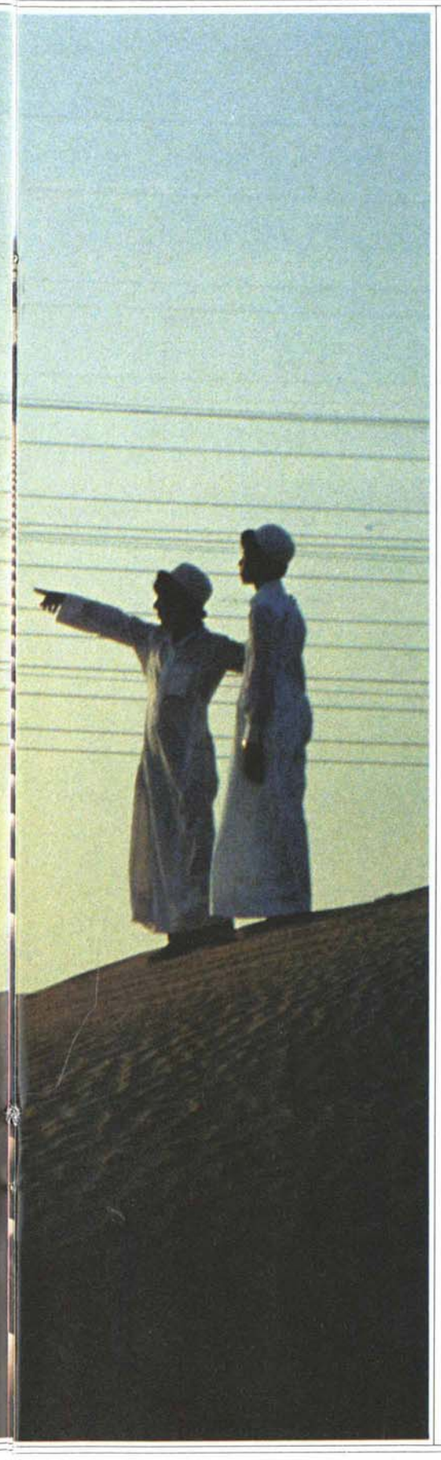
Above and left, Saudi technicians check parts of the world's first nationwide computerized telephone network. Right, Jiddah's new King 'Abd al-'Aziz International Airport, is as big as Kennedy, La Guardia, O'Hare and Los Angeles airports rolled into one.

COURTESY SAUDI ARABIAN AIRLINES

The Pillars



COURTESY THE ROYAL COMMISSION



In less than a decade backyard generators have been replaced in Saudi Arabia by regional power grids like the one left, carrying electricity to the new industrial city of Jubail.

In every country, power and water are vital to economic development – the pillars, in fact, of such progress – and in this respect Saudi Arabia is no different from the rest. Where it does differ, however, is in the difficulties involved in providing enough of both to meet its rapidly rising requirements.

With an average rainfall of between 30 to 100 millimeters a year, for example (one to four inches), Saudi Arabia is one of the most arid countries on earth; as a result, people unable to survive in the desert have often had to migrate. Now, however, and for the first time, the country, despite limited water resources, must cope with an influx of hundreds of thousands of people – from Yemeni laborers to American business executives – drawn by the kingdom's economic boom.

The problems are compounded, furthermore, by the uneven geographic distribution of rainfall. The southwest mountain region of 'Asir, for example – the region known as "Felix," or "Fortunate," Arabia – receives about 508 millimeters (20 inches) of rain a year from the monsoons that blow off the Indian Ocean. This area, consequently, is relatively green and fertile, while the southern deserts – the "Empty Quarter" – may receive no rain at all for up to 10 years.

But although it is predominantly dry on the surface – it has no perennial lakes, rivers or streams – the Arabian Peninsula has lots of water stored in enormous underground aquifers – geological strata of permeable rock and sand – located between 90 and 425 meters (300 and 1,400 feet) below ground.

Some of this – called "fossil" water because of its age – emerges on the surface through natural springs, and where it does – for example, at al-Hasa and Qatif in the Eastern Province – rich oases are to be found. But most of the water remains locked underground as it has been for thousands of years and will most probably stay there for some time to come; for although modern drilling techniques can now reach deep into the earth to get it, Saudi authorities are controlling the extraction of this water cautiously. Since this fossil water is irreplaceable, the government is going slowly until studies can determine just how much is there.

It is true that some wells have been drilled: 450 during the first four years of the second Five Year Development Plan, to supply 280 water projects in various parts of the kingdom. But for the time being, Saudi Arabia is concentrating on optimizing use of its renewable natural water resources – i.e., rain. This, however, means overcoming yet another problem: what little rain does fall tends to do so in sudden, torrential downpours that turn into flash floods and wash away topsoil, uproot trees, drown livestock and damage homes, then evaporate or disappear in the desert sands just as quickly as they came.

To hold back these flash floods and store water for limited periods, the Saudi Arab government has built more than 50 dams all over the kingdom; the largest are the Wadi Najran Dam, with a storage capacity of 85 billion liters (22.45 billion gallons) and the Jizan Dam, with a capacity of 51 billion liters (13.47 billion gallons) both in the southwest of the Peninsula.

These dams, in the words of one Saudi water official, have "reduced the risk to farmers' livelihoods [from flooding] by 100 per cent, and increased the certainty of them getting water to 90 per cent." In fact, farmers in 'Asir can now irrigate their lands five and even six times a year; whereas in the past they had no more than a few chances to harness a tiny fraction of the seasonal rains.

In addition, traditional dirt ditch irrigation methods – which lost 30 per cent of water through seepage and evaporation – are being replaced by elaborate networks of underground pipes and sprinklers and concrete-lined canals, reducing still further rain water wastage.

The lack of water is also a factor in the kingdom's need for electricity – and in its provision of electricity too. Lacking rivers and permanent lakes – even the dammed-up lakes dry up quickly after the rains – Saudi Arabia has no way to generate hydro-electric power. Yet, in solving its water problem, the kingdom also helps solve its power problem in a way uniquely practical on the Arabian Peninsula: because it is surrounded by seas, Saudi Arabia can produce both fresh water and electric

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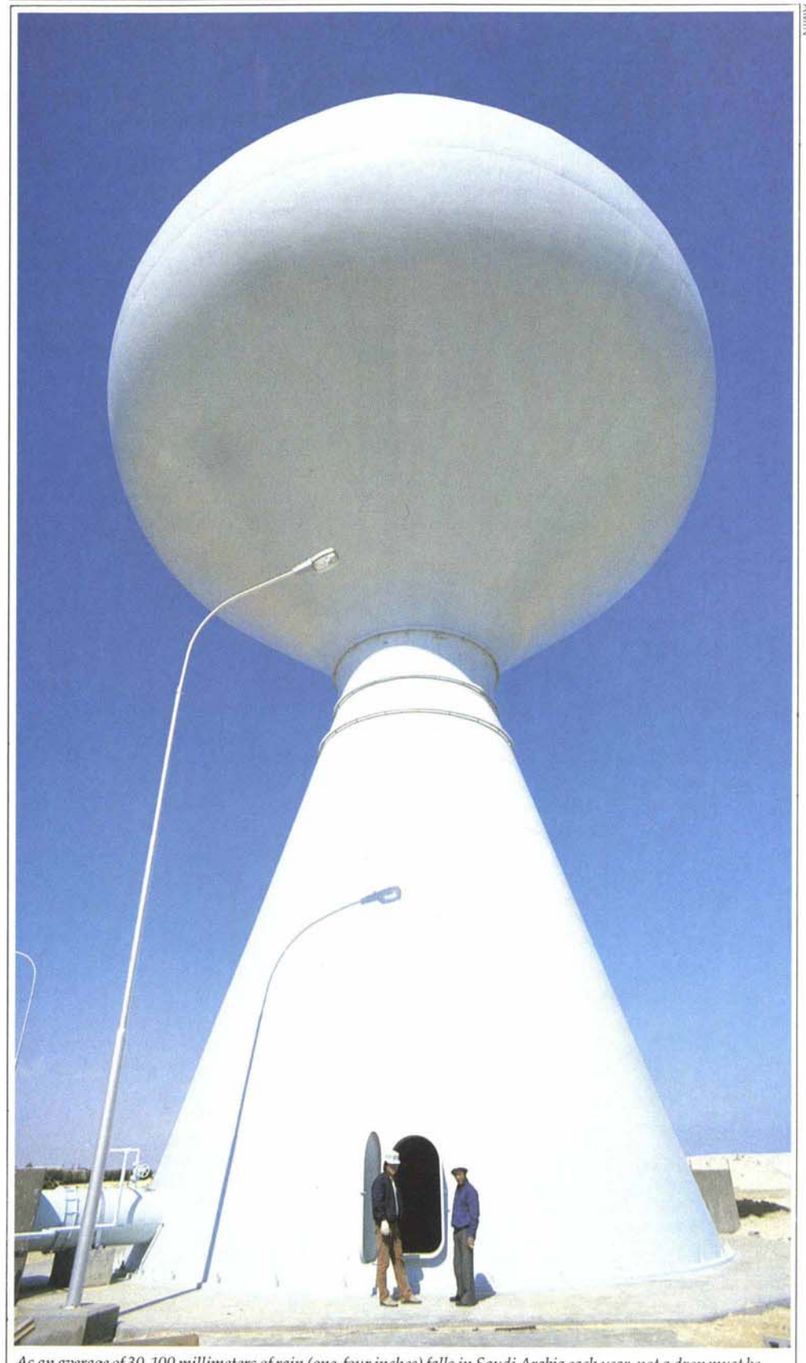

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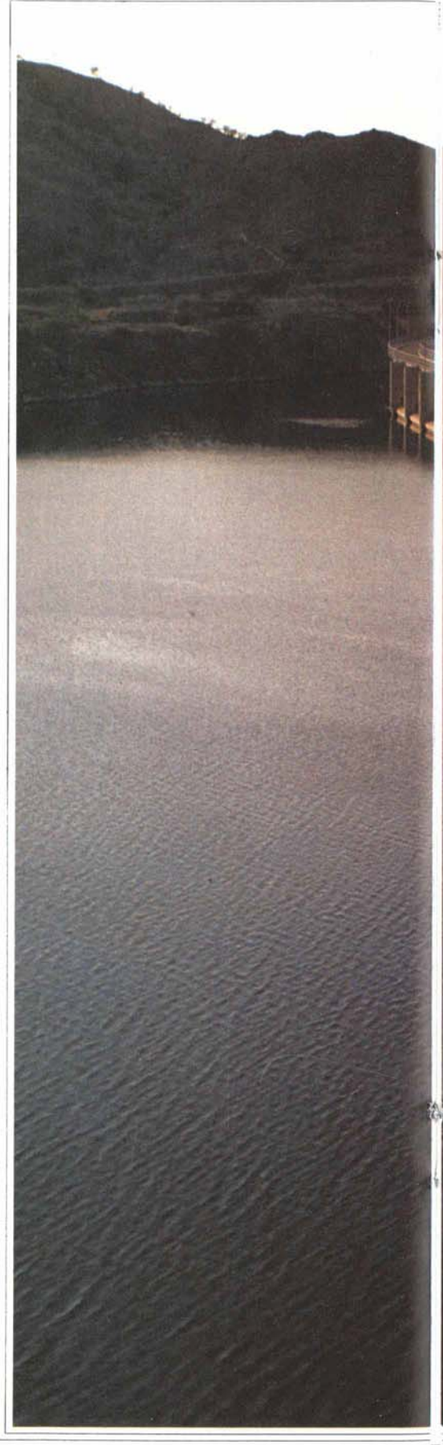
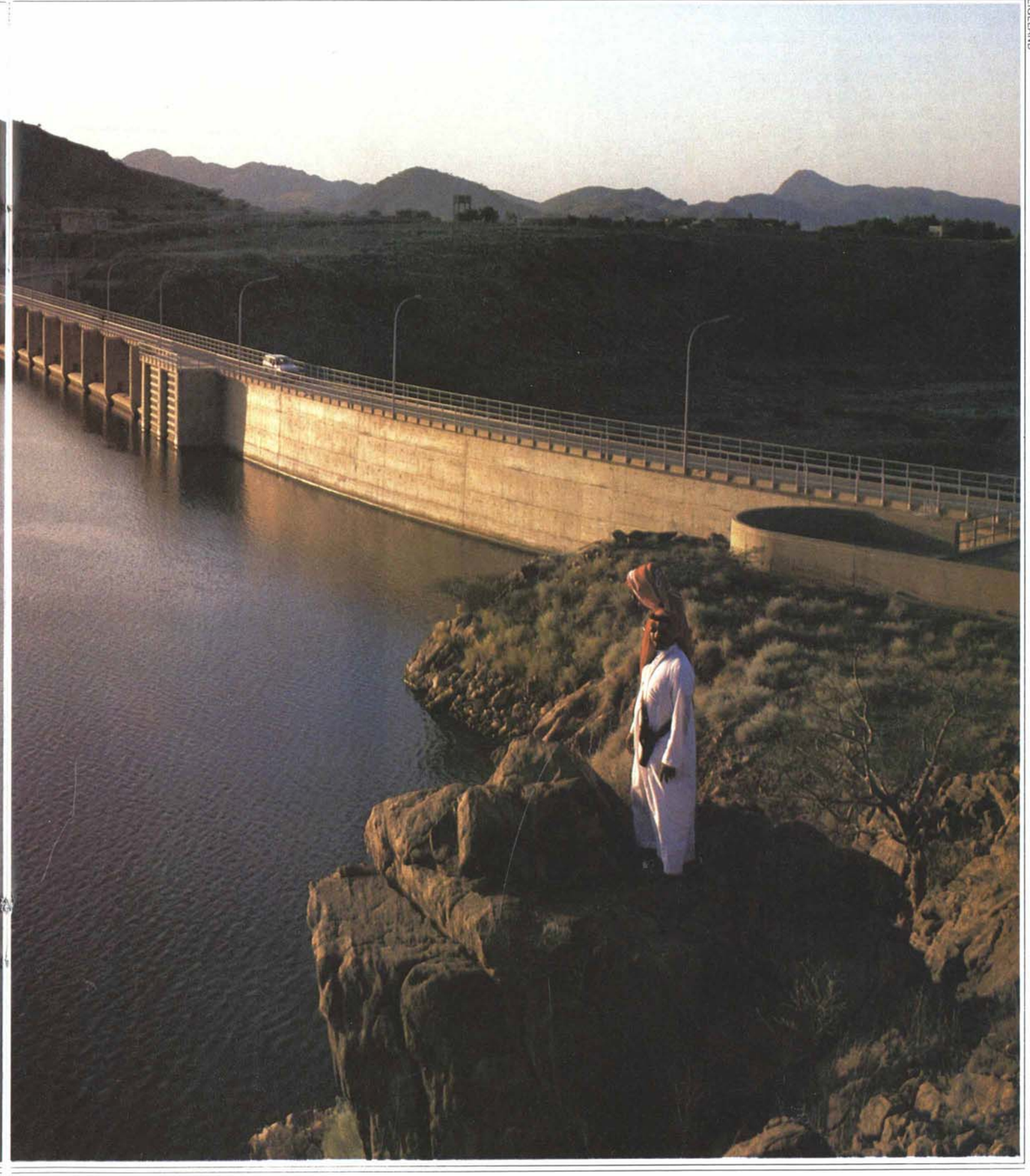




As an average of 30-100 millimeters of rain (one-four inches) falls in Saudi Arabia each year, not a drop must be wasted. The traditional dam at Jizan right, not only stores 51 billion liters of rain water (13.47 billion gallons) that would otherwise have run off down wadis, but it also prevents flash floods. While above, a futuristic water tower at Jubail stores fresh water made by boiling seawater to remove salt.

power by de-salting seawater.

Desalination, as this process is known, did not begin in Saudi Arabia until 1969, but has been expanded considerably since. Today 11 plants are in operation: eight on the western Red Sea shore, and three on the eastern Gulf coast – including the largest desalination complex in the world, near Jubail.

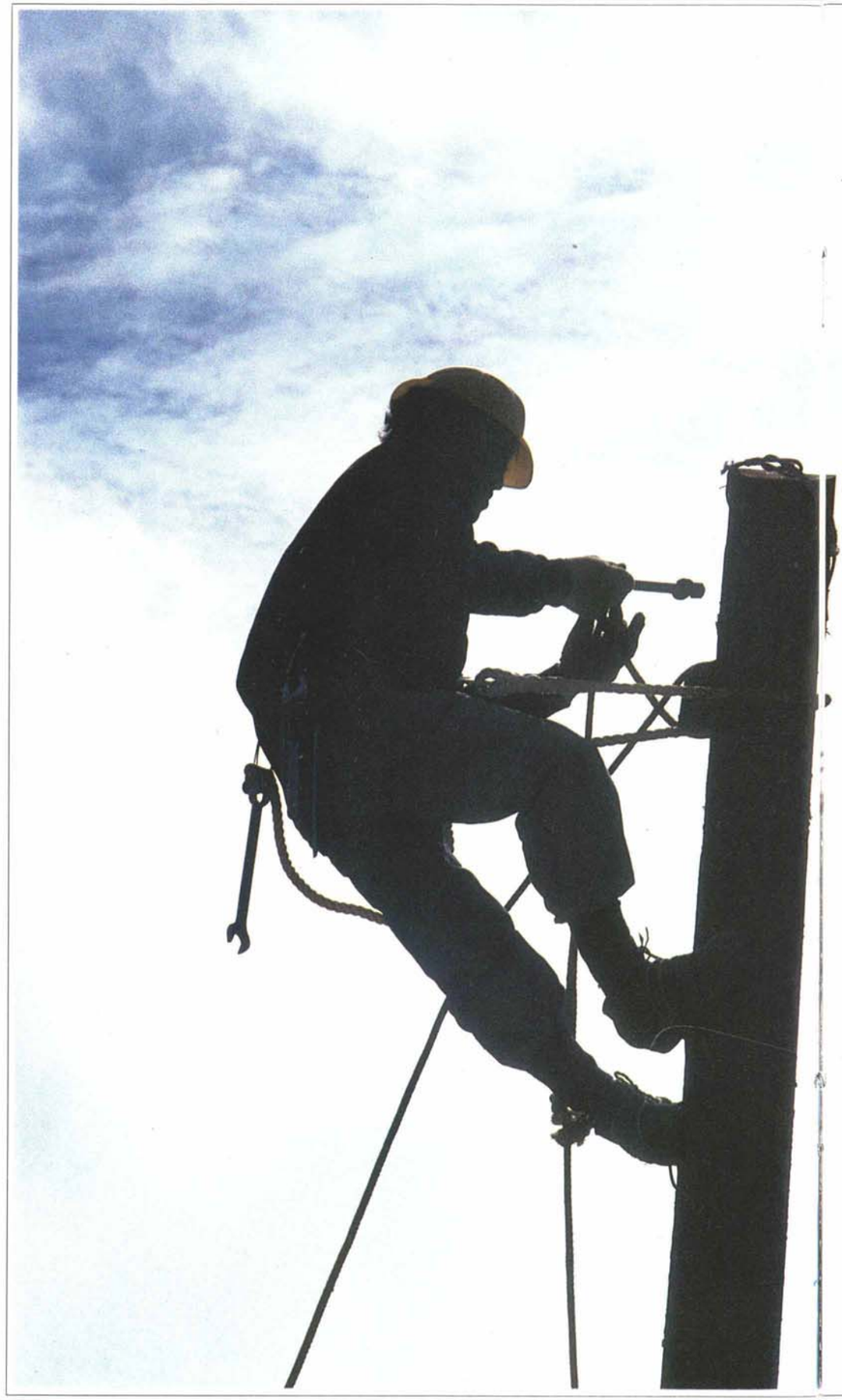
At this complex – in an area called al-Wusta – some 832 million liters (220 million gallons) of water will be produced by 46 giant evaporators every day, and over half of it pumped by twin 152-centimeter diameter pipelines (60 inches) to Riyadh, 500 kilometers (310 miles) away, where a city feeder system – three 203-centimeter pipelines (80 inches) – will circulate it through Riyadh. Combined with water from the recently commissioned 197 million liter-a-day (52 million gallons) Wasia groundwater scheme, this should meet the capital's needs well into the future.

To meet future demand for water elsewhere, work is also underway on expanding existing desalination plants and constructing new ones. Already the kingdom's total production from these plants is more than 1.9 billion liters a day (500 million gallons) – releasing considerable quantities of natural water, now being consumed by the cities, for agricultural use.

The water itself, obviously, is vital, but the desalination process offers a bonus; these plants will also generate electricity from the waste heat. Already, in fact, they produce more than 4,000 megawatts of by-product electrical power, and are helping fulfill the late King Faisal's promise to his people that electricity would reach every house and every village in the kingdom.

In the West, where consumers now take electricity for granted, this might not seem worthy of note, but considering the size of Saudi Arabia and the fact that its first public power generating station was opened in Taif in the late 1940's, electrification is one of the kingdom's biggest success stories of the past decade. With power lines extended thousands of miles to outlying settlements, the supply has increased to meet the spiraling demands of new factories, hospitals, hotels and schools, as well as the millions of modern appliances installed in Saudi homes.

Initially, faced with steeply rising urban demand, private city-based power companies instituted huge expansion programs – funded mainly by interest-free



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government loans. In addition, the government itself implemented numerous projects to provide electricity to rural and remote areas not covered by the power companies.

Two government projects alone, in 'Asir and in the southwest, have electrified some 900 villages – while others in Ha'il, Najran and Namas bring power to 600 more.

But the biggest, boldest steps in the power picture have been the ones taken by the government in creating regional public utility companies by consolidating private firms. Such government-subsidized organizations are now providing power in the Eastern, Central, Western and Southern provinces of the kingdom – with a public utility for the Northern area on the drawing boards.

Beginning in 1977 with the establishment of the first Saudi Consolidated Electric Company (SCECO) in the Eastern Province, massive electricity generation and supply programs are being tackled on a regional basis with the infusion of government funds to construct modern facilities and meet modern power demands head on.

Aramco provided assistance in the establishment of the original SCECO, which involved the consolidation of 26 private power companies in the Eastern Province and Aramco's own high voltage network and the bulk of its generating facilities into a single, efficient unit. In 1982, only a few villages in the 285,000-square-kilometer Eastern Province (110,000 square miles) remain without electricity.

During its first five years of operation, this utility boosted total generating capacity from 1,100 to 3,140 megawatts – with an additional 1,300 megawatts under construction – and more than doubled the number of customers from 90,000 to 195,000, many in remote villages which previously had no power.

One of the consolidated electric company's key payoffs can be seen in improved service. Today, when 100 per cent nighttime humidity and sand-laden high winds cause power outages, local maintenance crews set out, regardless of time and weather, to quickly locate and repair the fault; dispatchers in computerized control rooms watch remotely relayed weather data and, as temperatures climb, bring additional generators into service to meet anticipated increased consumption by air conditioners and water pumps – before it occurs; and tool-girded linemen proudly report to a district office that they have successfully installed a new section of feeder line over what has been called "impossible terrain."

SCECO in the Eastern Province, the oil-heart of the kingdom, must meet power demands both from that industry and a host of others – and their populations – exemplified by the industrial metropolis building at Jubail. Along with some 60 gas turbines and 25 diesel generators, SCECO East employs four giant 400-megawatt steam turbines at the kingdom's largest steam generation plant at Ghazlan on the Gulf coast. The latter is the hub of the province's 4,766 circuit-kilometers of transmission lines.

SCECO in the Central Province, founded in 1979, is built around the hub furnished by the Riyadh Electric Company and serves the kingdom's capital and a number of growing towns and villages. SCECO Central will be able to draw up to 200 megawatts from SCECO East in 1984 via a 230-kilovolt circuit which will be completed from Wasia to Riyadh – Saudi Arabia's first inter-regional circuit and the first step toward a national power grid.

In the Southern Province SCECO was established in 1980 – to oversee the electrification of numerous small villages in a predominantly agricultural area – and in the Western Province SCECO assumed responsibility for supplying power to the key port of Jiddah, the religious centers of Makkah and Medina (which see their population soar to 3,000,000 for two weeks every year at the time of the *Hajj* or Pilgrimage), the summer government headquarters of Taif and outlying villages. It was established in 1981.

Meanwhile, with an eye on the more distant future, the Saudi Arab government is investing vast sums of money in the development of solar power, including installation of a $16.5-million experimental solar energy system to electrify two villages north of Riyadh.

From oil lamps and backyard generators to thermal turbines and solar power systems is a great leap forward in less than a decade. In fact, electrification has probably had a greater impact on the everyday lives of rural Saudis than any other single element of the second Five Year Development Plan – making possible installation in their homes and on their farms such modern aids as air conditioners, refrigerators and water pumps, thereby greatly improving the quality of their lives.

The Keystone

At Ju'aymah, part of the immense coast-to-coast network of plants and pipes for collecting, treating and distributing oil-associated gases, previously flared.

The flares are going out in Saudi Arabia, but no one will miss them.

Once burned, the gasses that fed the flares are today being put to use. In fact, the immense network for collecting, treating and distributing the gas is the keystone in Saudi Arabia's on-going industrial development program. Called the Master Gas System, this network is already providing fuel to generate power and desalinate water, and will soon be furnishing invaluable raw materials – feedstock – to nourish new industries.

The most ambitious energy project in history, the Master Gas System is harnessing, for domestic and world markets, immense quantities of gas released from the ground with oil in Saudi Arabia's oil fields. Designed to process up to 9,900,000 cubic meters (3.5 billion cubic feet) of gas a day, the system is furnishing fuel for items as diverse as cigarette lighters and cement plants and, by 1983, will add the equivalent of some 750,000 barrels of crude oil a day to the world's energy supply. Above all, it will provide fuel and feedstock for plants now under construction, or about to be constructed, at the new Saudi industrial cities of Yanbu' and Jubail: mainly oil refineries, petrochemical and fertilizer plants, plus a steel plant and a rolling mill.

For a product that was once a problem it is a dramatic change. Dissolved in crude oil, the gasses were brought to the surface with the oil, separated from it, and burned – since until recently, collection and processing were not economically justifiable; there simply was no market for such gas.

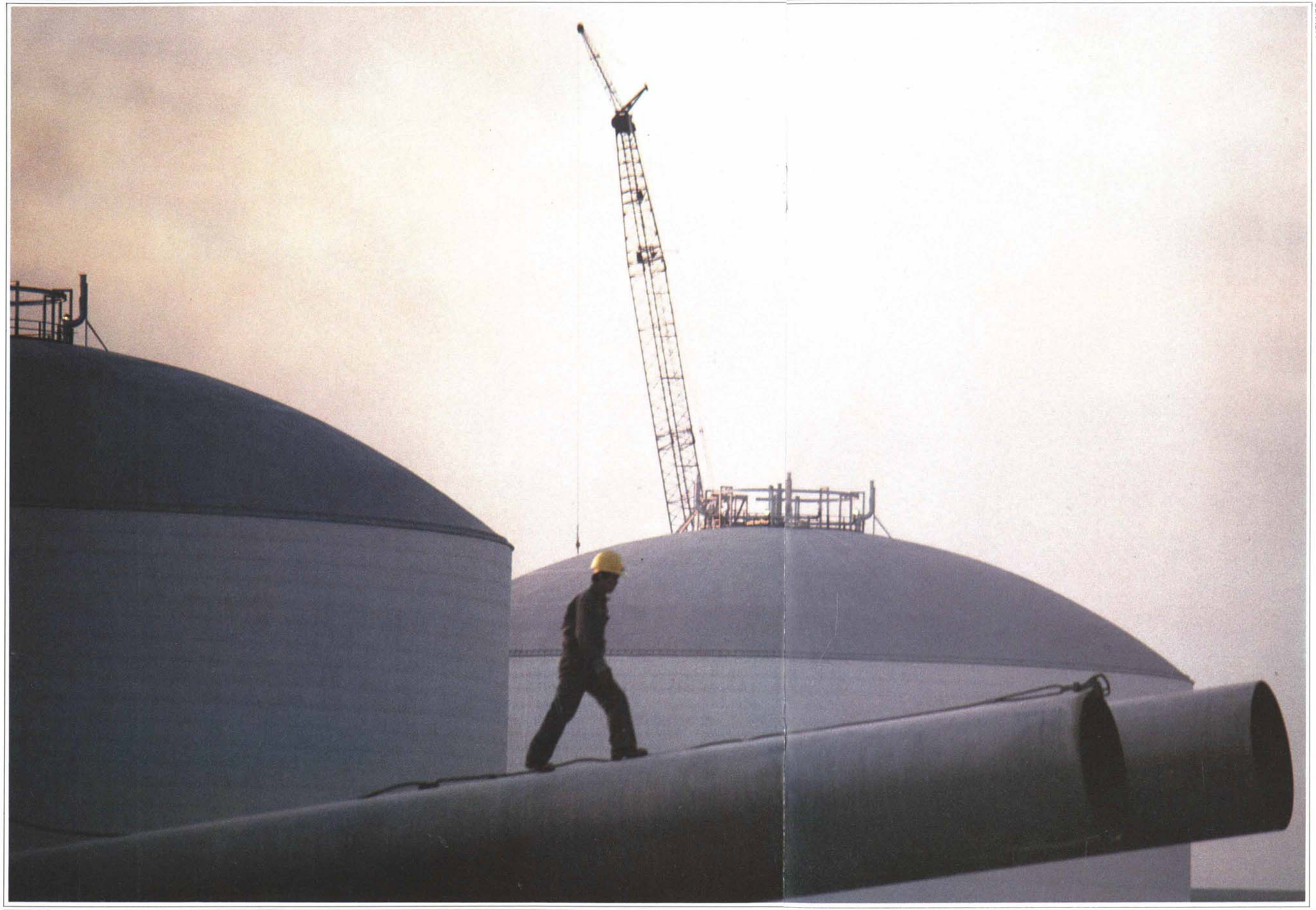
Aramco, which designed and built the Master Gas System – and now operates it on behalf of the Saudi government – used some gas on a small scale as far back as the early 1950s: primarily as fuel for Aramco plants, and, injected back into the ground, as a means of maintaining pressure in the Ghawar and Abqaiq oil fields. Some was also delivered to a number of local industries and power companies.

Later, in 1959, the company also began to develop a gas gathering system to recover what are called "natural gas liquids" (NGL) – a collective term used for some of the light hydrocarbon components produced with oil – and in 1961 began exporting liquefied petroleum gas (LPG). Aramco facilities, including gas processing and fractionation plants at Abqaiq and Ras Tanura, were expanded over the years until they were capable of producing and processing 360,000 barrels of natural gas liquids a day, making Saudi Arabia the largest NGL exporter in the world.

Although economic utilization of gas had long been an objective of Saudi Arabia, a lot of gas still had to be flared until, in the mid-1970s, the rapid climb in world energy costs, coupled with the Saudi government's decision to launch a massive industrialization program, finally justified the huge investments necessary for gathering and processing gas on a large scale. Even so – when the Saudi government announced in 1975 its decision to build a greatly expanded and integrated gas system – skeptics predicted that the project would prove unprofitable because of depressed international gas prices.

The mammoth gas program, however, *is* paying off. Already, fuel gas gathered and processed by the system is driving seven major power generating stations and a steam power plant – producing almost all the electricity in the Eastern Province; two huge water desalination plants, a glass factory, and cement, fertilizer and lime plants. And, attracted by the prospect of ready supplies of relatively cheap fuel and feedstock, several major international firms have entered into joint ventures with Saudi government agencies – Petromin and the Saudi Arabian Basic Industries Corp (Sabic) – in setting up industries at Yanbu' and Jubail. These industries soon will be producing chemicals, refined petroleum products and manufactured goods for both export and domestic use, thereby reducing Saudi Arabia's economic dependence on crude oil exports and industrial imports.

Sales of Saudi gas, moreover, have boosted world energy supplies substantially, with more production capacity still to come on stream. By 1983, the approximate total daily capacity of the integrated gas



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system will be 56 million cubic meters (two billion cubic feet) of methane fuel gas; 10.6 million cubic meters (370 million cubic feet) of ethane; more than 315,000 barrels of natural gas liquids; and 3,700 tons of sulfur by-product. In general, the fuel gas and ethane will be used domestically as fuel and petrochemical feedstock and NGL and sulfur will be exported.

Collection of the gas begins in the kingdom's eastern oil fields, where it is separated from crude oil at or near the well heads and piped to stragetically located gas plants. At these plants, the gas is treated to remove sulfur compounds and carbon dioxide. The gas is then compressed and chilled to extract the heavier hydrocarbon components or NGL. The remaining gasses, mainly methane, are compressed and distributed for use as plant fuel for industries and power generators in the Eastern Province. What's left – ethane and NGL – is piped to east and west coast plants for fractionation into component parts by controlled vaporization and condensation in a series of columns. Ethane, the lightest component, comes off first in gaseous form for use as fuel and feedstock for petrochemical complexes at Yanbu' and Jubail. Propane and butane, which are refrigerated and condensed for export as liquefied petroleum gas, are extracted in the second and third columns, leaving natural gasoline as the remaining product. Additional columns in the series process this product to make finished natural gasoline, also for export.

The integrated gas system comprises 34 gas-oil separator plants (GOSPs) located on the Berri, Ghawar, Abqaiq and Harmaliyah oil fields; four gas processing centers at Berri, Shedgum, 'Uthmaniyah and Abqaiq in the Eastern Province; and

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After fractionation at plants like the one above, at Yanbu', butane and propane liquefield gases are stored in special refrigerated tanks, left, prior to export.

three NGL fractionation plants and export terminals, at Ju'aymah and Ras Tanura on the Arabian Gulf and at Yanbu' on the Red Sea. Linking these facilities are more than 2,400 kilometers of gas pipeline (1,490 miles), including the longest and most advanced in the world, running east-west across the Arabian Peninsula from Shedgum to Yanbu'.

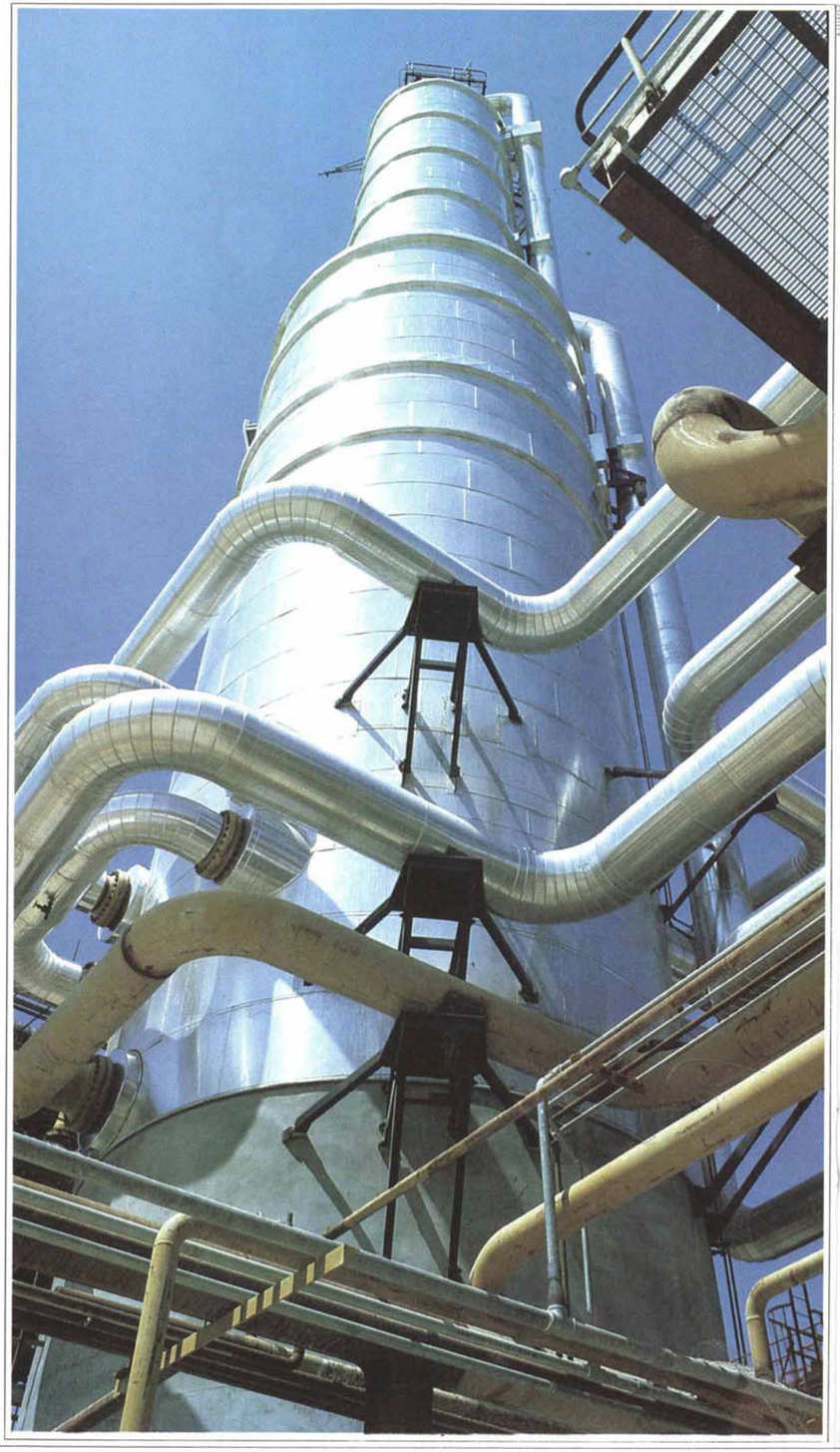
The total storage capacity at Ju'aymah, Ras Tanura and Yanbu' for the propane, butane and natural gasoline product streams exceeds 16 million barrels. To keep them liquid, propane and butane are stored in special 29-meter-high (95 feet) refrigerated, dome-roofed tanks, while natural gasoline, which does not have to be chilled to remain liquid, is stored in 19.5-meter-high (64 feet) floating-roof tanks at Ras Tanura and Yanbu'. The natural gas liquids are loaded for export at offshore terminals capable of handling vessels up to half a million tons. LPG is shipped to world markets in special refrigerated tankers, natural gasoline by conventional tanker.

To build the Master Gas System, many top-ranking international companies were contracted and tens of thousands of workers employed. Some 2,500 engineers and draftsmen alone were involved in the engineering phase of the project, which consumed nearly 200 million man-hours and some two million tons of imported equipment and materials.

Equipment and construction methods used were among the largest and most sophisticated in the world. Computers, for example, were used to work out precise settings for some 1,530 piles supporting a 10-kilometer-long (six-mile) pier carrying pipes to the offshore gas loading terminal at Ju'aymah. The Shedgum and 'Uthmaniyah gas plants, each covering some 121 hectares (300 acres), utilize some of the largest gas processing equipment available today, and the fractionation modules at Yanbu' are 261 meters long (856 feet) – just short of the length of three football fields.

The visual result is quite stunning: masses of gleaming steel pipes, polished aluminum spheres and shiny metal tanks and towers rising like futuristic cities from the desert sands; and giant arms reaching out to huge tankers tethered in the turquoise waters of the Gulf.

But not all of the components of the gas system are new or man-made. In fact, one is the work of nature and millions of years old – a vast underground reservoir into which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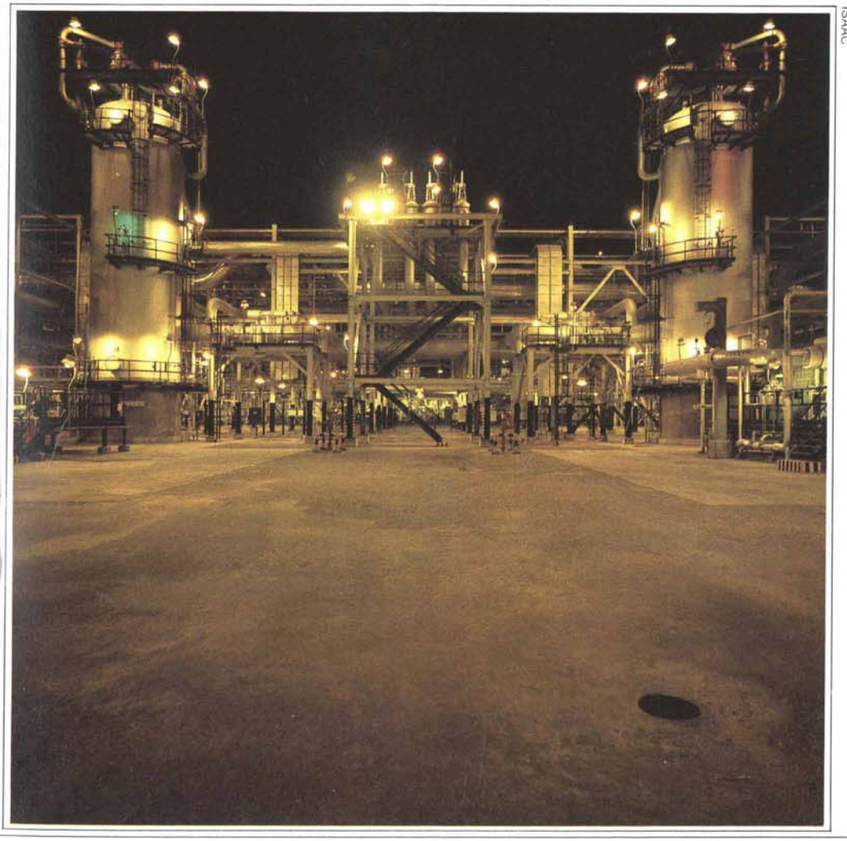
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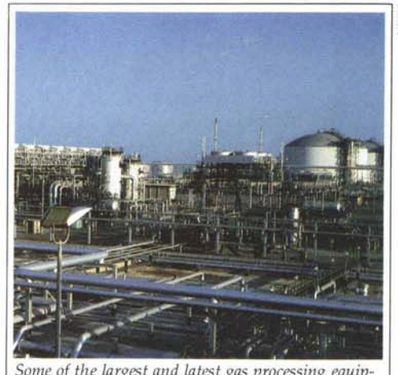
excess ethane can be injected for recovery and use later by domestic industries.

Marketing the products of the gas system is being handled by Petromin, which, already responsible for the domestic distribution of petroleum products and some overseas marketing of crude, is fast establishing itself as one of the biggest NGL marketers in the world. The main overseas customer at present for Saudi NGL is Japan.

To ensure complete reliability of gas supplies to Petromin's customers, the Shedgum and 'Uthmaniyah processing plants each have four separate identical processing modules, and the Yanbu' and Ju'aymah fractionation plants each have two independent fractionation trains, only one of which will be affected by maintenance shutdowns at a time, while the others continue production.

By the beginning of October, this year, the key components of the Master Gas System: the Berri, Shedgum and 'Uthmaniyah gas plants, trans-peninsular pipeline, and fractionation plants, and marine export terminals at Ju'aymah and Yanbu' were fully operational.

With their completion, Saudi Arabia, with gas reserves estimated in excess of 2.8 trillion cubic meters (100 trillion cubic feet), is making a significant contribution to conservation of the world's precious hydrocarbon energy supplies, and has laid a strong foundation for its own future economic development based on profitable marketing of natural gas liquids abroad and the availability of relatively low-cost gas fuel and feedstocks for its ambitious plans for industrialization at home.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Some of the largest and latest gas processing equipment available today is used at the Ju'aymah fractionation plant, above, and the 'Uthmaniyah, right, Shedgum, top, and Berri, far right, processing plants.

The Underpinning

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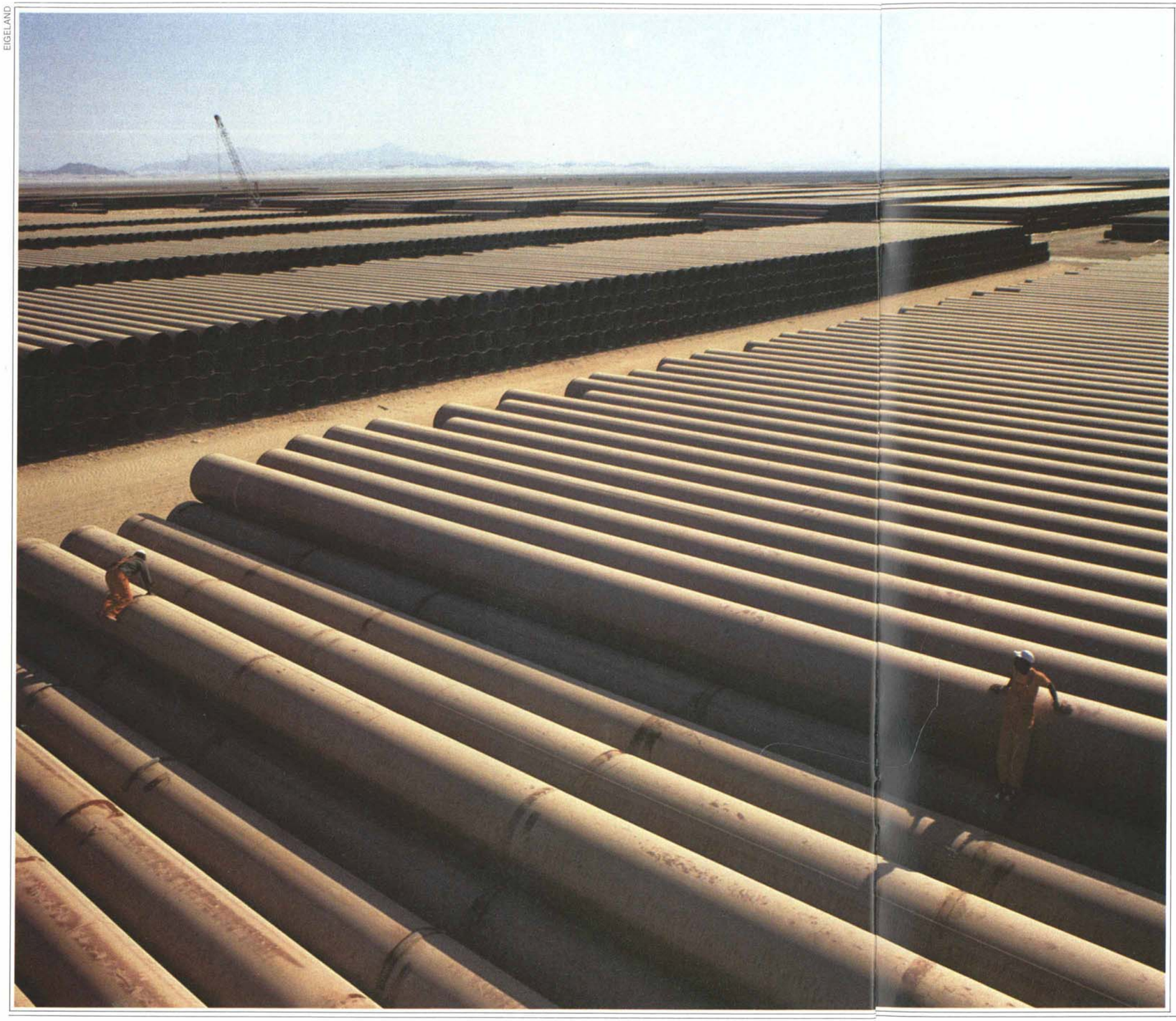

Some of the 10,000 tons of steel pipe, used to build the 1,202-kilometer (747-mile) crude oil pipeline across Saudi Arabia, stored at Yanbu' prior to installation.

Since oil was discovered in Saudi Arabia in 1938, pipelines have played an increasingly important role in the kingdom's economy. Initially, their role was small: to deliver crude oil from oilfields to coastal terminals for shipment overseas and to move petroleum from offshore wells to the tank farms and terminals. But two recently completed pipelines – one for crude oil, the other for ethane and natural gas liquids (NGL) – are no less than the underpinning of the kingdom's economic future.

Stretching side by side from Saudi Arabia's eastern oil fields along the Gulf, across the Arabian Peninsula to Yanbu' on its western Red Sea coast, the twin pipelines are key elements in the development and economic unification of the kingdom – parallel bands binding the nation together and bringing to the western edge of the country the full benefits of the east coast oil harvest.

Cutting across Saudi Arabia, through a sun-scorched and often desolate landscape, from the sand dunes of the Dahna and the cliffs of the Tuwaiq Escarpment to the lava fields south of Medina and the rugged mountains of the Hijaz, the two pipelines will provide fuel and raw materials for the giant industrial city of Yanbu', now taking shape on the Red Sea shore 300 kilometers north of Jiddah (186 miles), and other important west coast projects.

The benefits of the pipelines, however, will not be restricted to Saudi Arabia alone. They will also be shared by its oil and gas-consuming customers – by bringing Saudi energy exports closer to western markets and reducing the possibility of delivery bottlenecks in the Gulf.

In the past, the kingdom could move some oil through the Trans Arabian Pipeline ("Tapline"), the 1,720-kilometer crude oil pipeline system (1,069 miles), running across Jordan, Syria and Lebanon to the Mediterranean. Since the mid 1970s, however, this outlet has not been feasible. The kingdom, therefore, shipped virtually all of its export production – vital to the economies of Europe and the United States – through the Gulf. Now, however, Petroline – a new 1,202-kilometer pipeline (747 miles) – can transport oil overland *across* the Arabian Peninsula – from the east coast Abqaiq and Ghawar oil fields – rather than around it by sea. A new outlet for Saudi oil exports, Petroline now offers a brand new route, via Suez, to Europe and beyond.

Similarly, the 1,170-kilometer NGL pipeline (727 miles), linking gas processing plants in the Eastern Province with NGL fractionation and export facilities at Yanbu', will provide a partial alternative to Saudi shipments of natural gas liquids from the Gulf.

Constructed for the Saudi government by Aramco, which is responsible for designing, building and operating the kingdom's massive Master Gas System, the NGL pipeline was laid by a contractor's work force of 1,500 men, plus 100 support personnel, in less than 20 months.

Work on the NGL line began in November, 1978, when bulldozers first blazed a trail for backhoes that dug a minimum 1.83 - meter deep (six feet) trench across the peninsula. About one-third of the trench – some 400 kilometers (248 miles) – had to be blasted through rock – a job requiring 2,000 tons of explosives.

Compared to the early days of pipeline construction – when pipelaying was done by hand – laying the NGL pipeline was a highly sophisticated operation. Double jointed sections of pipe – two 12-meter lengths (39 feet) previously welded together and bent, where necessary, to fit the terrain – were strung over the trench by mechanical sidebooms, and the suspended sections were joined together by automatic welders. One of the welders passed through the pipe and the other moved along it; altogether, it took 45,000 welds to seal the 295,000 tons of the 66-, 71-, and 76-centimeter steel pipe (26, 28, and 30 inches) used in the project.

The NGL line was one of the first major pipelines ever to be built by totally automatic welding techniques. Welding operations began March 3, 1979, and were completed in 479 days. Finished welds were checked for defects by radiography, and the pipeline sections given a double plastic tape wrapping to guard against corrosion. Then they were lowered into the trench, mile after mile, until, on July 28,

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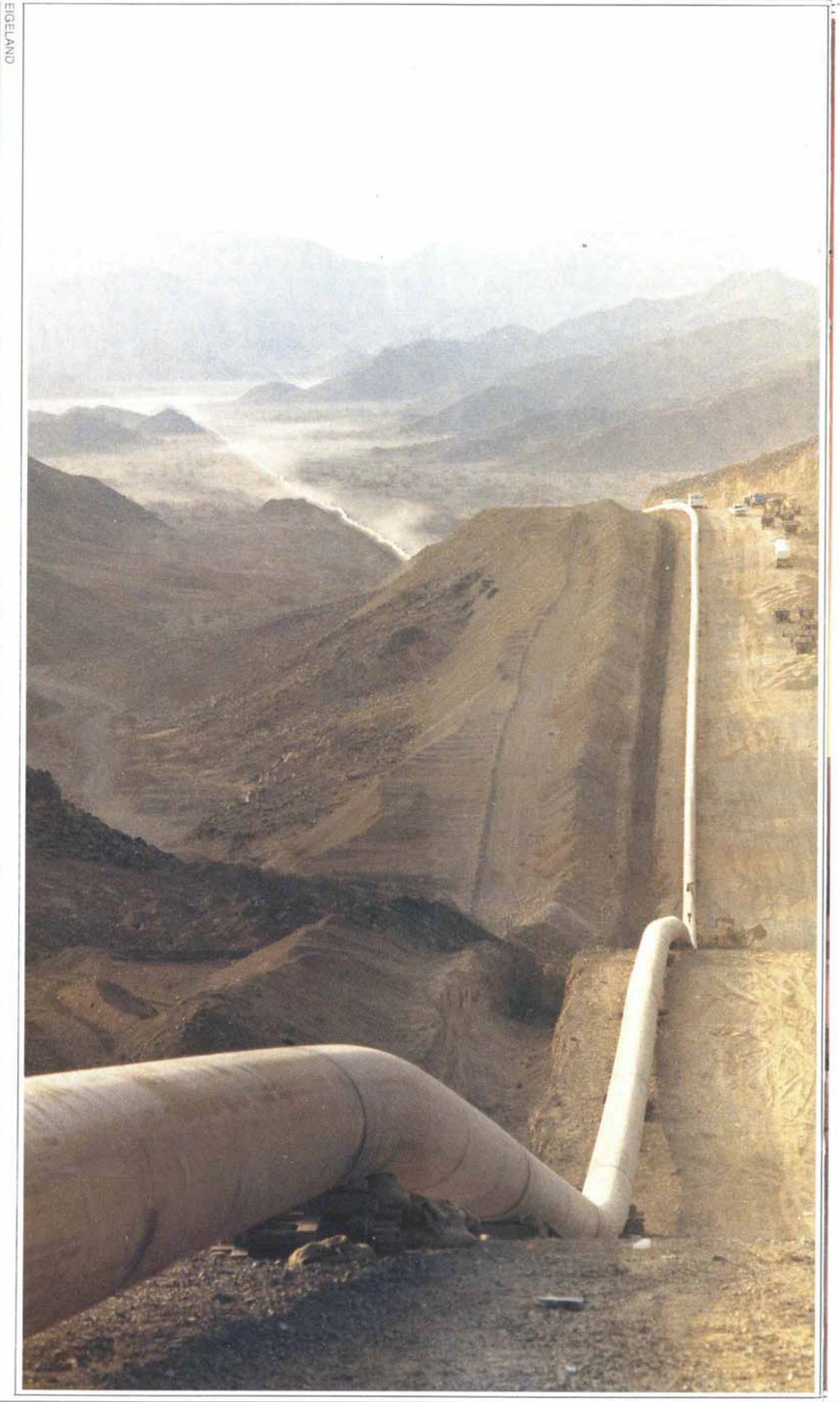
Transporting sections of the trans-peninsula pipeline, above and far right, for laying, right, through the rugged Hijaz Mountains. Left, the marine terminal at Yanbu' from where the first west coast shipment of Saudi gas was made this year.



COURTESY PETROMIN

1980, the final section was lowered into place at its highest point: "Gunsight Pass," 1,082 meters (3,550 feet) up in the Hijaz Mountains.

Operations, as well as construction, of the NGL line are highly sophisticated; indeed the high-pressure NGL pipeline, computer monitored and controlled, is not only the longest but also the most sophisticated pipeline ever built for transportation of natural gas liquids. Controlled from Aramco headquarters in Dhahran – which receives information by microwave from 40 locations along the pipeline – the NGL line receives instructions over the same microwave system. In Dhahran, the Central Dispatch Center can also open and close main line valves by remote control – to isolate a section of the pipeline in case of emergency. A computer-based pipeline operating model to help detect leaks is being installed.

Impressive though it is, the NGL pipeline still cannot eclipse the crude line – Petroline – beside it. Indeed, the crude line, in statistical as well as economic and strategic terms, is even more impressive. With a diameter of 122 centimeters (48 inches), the crude oil pipeline will have one of the largest capacities of any pipeline system in the world. The new pipeline is already capable of moving 1.85 million barrels of crude a day – about one fifth of Saudi Arabia's average production in 1981 – and could handle 3.7 million barrels a day if the Saudi government decided to expand output.

Construction of the $1.6 billion Petroline system for Petromin, Saudi Arabia's General Petroleum and Minerals Organization, was supervised by the Mobil Overseas Pipeline Company, Inc., (MORCI) a subsidiary of Mobil Oil Corporation. Some 7,000 men were involved in the four-year design and building of the pipeline and export terminal, which, like the NGL line, involved working in difficult conditions in some of Saudi Arabia's toughest terrain.

Finally, however, on July 1, 1981, the first shipment, 1.3 million barrels of crude oil, pumped across Arabia through Petroline, was ceremonially loaded aboard the aptly-named Petromin tanker *Yanbu' Pride* at Yanbu'. "It's a great day for us," said Petromin's Governor Dr. Abdulhady Taher, as the first crude to leave a Saudi Red Sea terminal gushed aboard the *Yanbu' Pride* at the rate of 130,000 barrels an hour.

Like the NGL line, the crude pipeline will be operated by remote control, but from Yanbu' rather than Dhahran. The controls will extend to the 11 pumping stations – spaced at roughly equal distances along the line – and to the 11 storage tanks which dominate the new export terminal and which suggest the importance of Yanbu' in Saudi Arabia's restructured oil export pattern. Each is capable of holding one million barrels of crude.

DE BRY

From the tank farm the export crude moves in two 142-centimeter (56 inch) diameter pipes to tankers offshore along a jetty and trestle causeway – stretching a total of 3.35 kilometers (two miles) out over coral reefs to three deep water loading berths; one can accommodate large tankers up to 500,000 deadweight tons, and the other two up to 275,000 tons each. And from there it goes, most probably, to Europe via a route 3,600 kilometers shorter (1,460 miles) and three to four days faster than the sea route around the Arabian Peninsula from the Gulf.

COURTESY PETROLINE

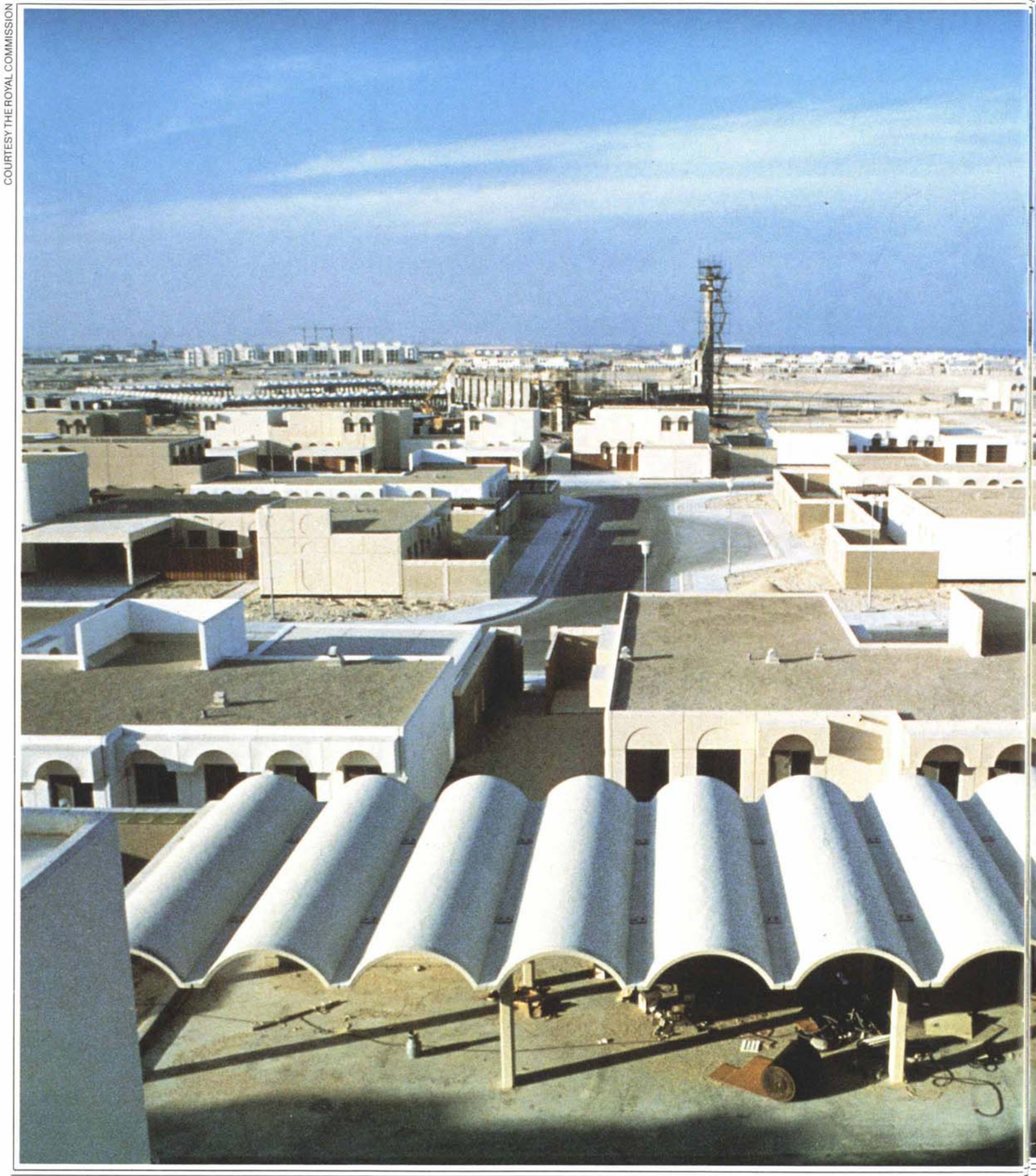
Both pipelines play a key role in Saudi Arabia's plans to create a new West coast industrial center at Yanbu' – and reduce the kingdom's dependence on crude oil exports. The NGL line feeds a gas fractionation plant built at Yanbu' by Aramco – to process up to 270,000 barrels of natural gas liquids daily for export – and provide ethane as feedstock for a petrochemical complex. In turn, the petrochemical complex will produce some 450,000 tons a year of polyethylene and ethylene, most of it for export.

The Yanbu' fractionation plant – one of the largest of its kind in the world – went into operation in August this year, and the first tanker was loaded at the NGL export terminal in October. Meanwhile, the NGL pipeline had been put into service to provide fuel for the crude oil pipeline pump stations and to industrial consumers in the Yanbu' area. It was switched to NGL when liquid feed was required at Yanbu'.

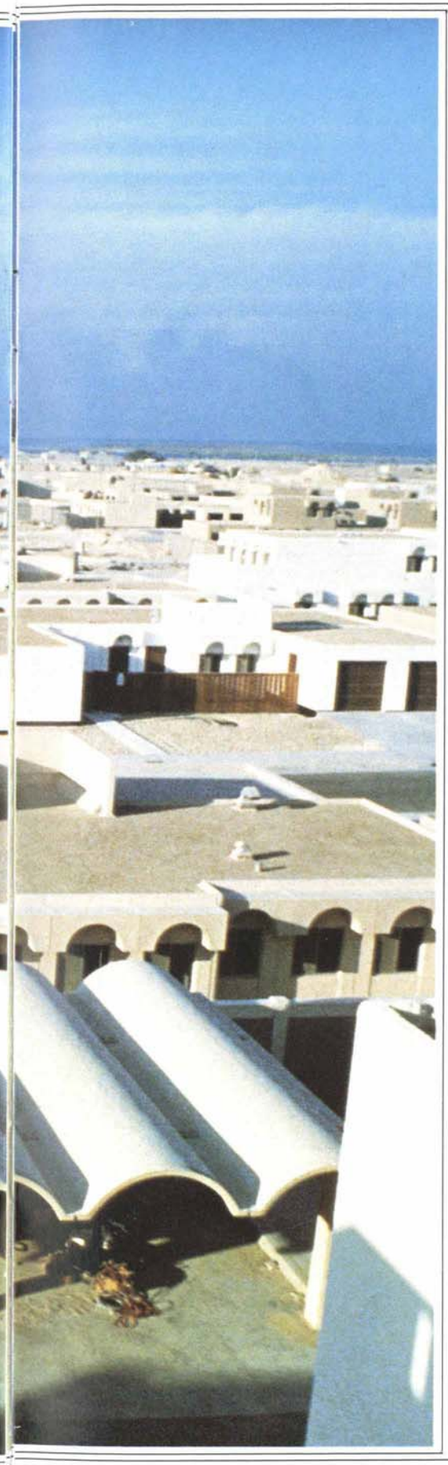
At the moment, virtually all of the crude moved to Yanbu' by Petroline will be exported, but later, upon completion of two new refineries, some will be processed. Initially, the refineries will have a combined capacity of 420,000 barrels a day, but will be expanded. The larger of the two refineries, a joint venture between Mobil and Petromin, will refine 250,000 barrels daily of crude into finished gasoline, naphtha, kerosene, diesel fuel and heating oil for North American and European markets. The other, owned by Petromin, will be able to process 170,000 barrels per day for domestic consumption. Eventually the crude oil pipeline will also supply petroleum via coastal tanker to other hydrocarbon-based industries planned for the smaller town of Rabigh, midway between Yanbu' and Jiddah, including a 335,000 barrel a day refinery.

All of these projects represent a major shift by Saudi Arabia – away from almost total economic dependence on export of crude oil towards processing and sale of finished petroleum products, and a diversified economy built on foundations bound together by the twin trans-peninsular pipelines.

The New Cities



COURTESY THE ROYAL COMMISSION



One of the new residential neighborhoods at Jubail — yesterday a small fishing village, today a growing city.

In 1977, Jubail, on Saudi Arabia's Gulf Coast, was a small fishing community of some 8,000 people. Today, it is the site of one of the largest civil engineering projects in the world – a project employing more than 40,000 men – and by 1985 it will be the industrial capital of the Middle East.

At that point, Jubail will be a home for industries producing everything from detergents to steel, with a population of more than 60,000, living in a modern, landscaped community with a wide range of educational, health and recreational facilities, huge power and water systems, telecommunications networks, industrial and commercial ports, roads, railroads, and an airport.

Jubail's stunning transformation is part of one of the boldest of the Saudi Arab government's schemes to restructure the kingdom's oil-export economy by building two completely new industrial cities in the sand: Jubail on the Gulf and – a smaller city, but an equally dramatic project – Yanbu' on the Red Sea.

For although sales of crude oil will continue to dominate Saudi Arabia's economy in coming decades, and although some alternative industries – not directly related to petroleum – are being developed in existing urban centers, such as Dammam, Jiddah and Riyadh, it is the heavy hydrocarbon, metal and mineral installations being built at the new cities of Jubail and Yanbu' that will make the initial contribution to the creation of a diversified, self-sustaining industrial economy less dependent on oil.

By 1985, primary industries located at Jubail and Yanbu' will be capable of producing over one million barrels a day of refined oil products and natural gas liquids, plus 3.84 million tons a year of petrochemicals, fertilizer and steel. Much of this will be exported. The rest will be used as raw materials for secondary industries, producing a wide variety of chemical, plastic and metal goods, with other satellite industries providing services and supplies to the cities' factories and workers.

The new cities' refineries are designed to maximize Saudi Arabia's oil earnings by producing finished petroleum products. Their other primary industries are aimed at diversifying the kingdom's economy away from oil, by harnessing cheap supplies of gas to produce petrochemicals and power energy-intensive metal plants, while secondary and support industries lessen Saudi Arabia's dependence on imported manufactured goods, and provide new opportunities for the Saudi private sector.

Equally important, the formation of a well-trained Saudi work force, capable of operating and maintaining the two urban-industrial complexes, will provide a nucleus of administrative and technical personnel for the continuing development of the entire kingdom.

And finally, the creation of two new industrial growth poles, on opposite sides of the Arabian peninsula, will stimulate growth in previously unindustrialized areas, and help spread wealth and progress throughout the country.

The creation, on remote coasts, of two completely new industrial cities is a gigantic undertaking. It involves a Royal Commission, two regional directorates, most government ministries and agencies, many international enterprises, scores of skilled consultants, hundreds of Saudi and foreign contractors, thousands of engineers, technicians and laborers, millions of tons of materials and equipment, and billions of dollars in expenditures.

"This is the biggest construction project in all history," says an official of the Arabian Bechtel Corporation, the firm that is providing technical and managerial assistance to the Royal Commission at Jubail. "There's never been anything like it."

Initially, for example, the planners had to cope with a basic but immense problem at Jubail: before anything could be built they had to provide a smooth, stable surface in place of the soft sand and wet salt flats that made parts of the project site impassable. To do so they moved nearly 400 million cubic meters (more than 14 billion cubic feet) of earth – enough, by Bechtel's reckoning, to build an

EIGELAND

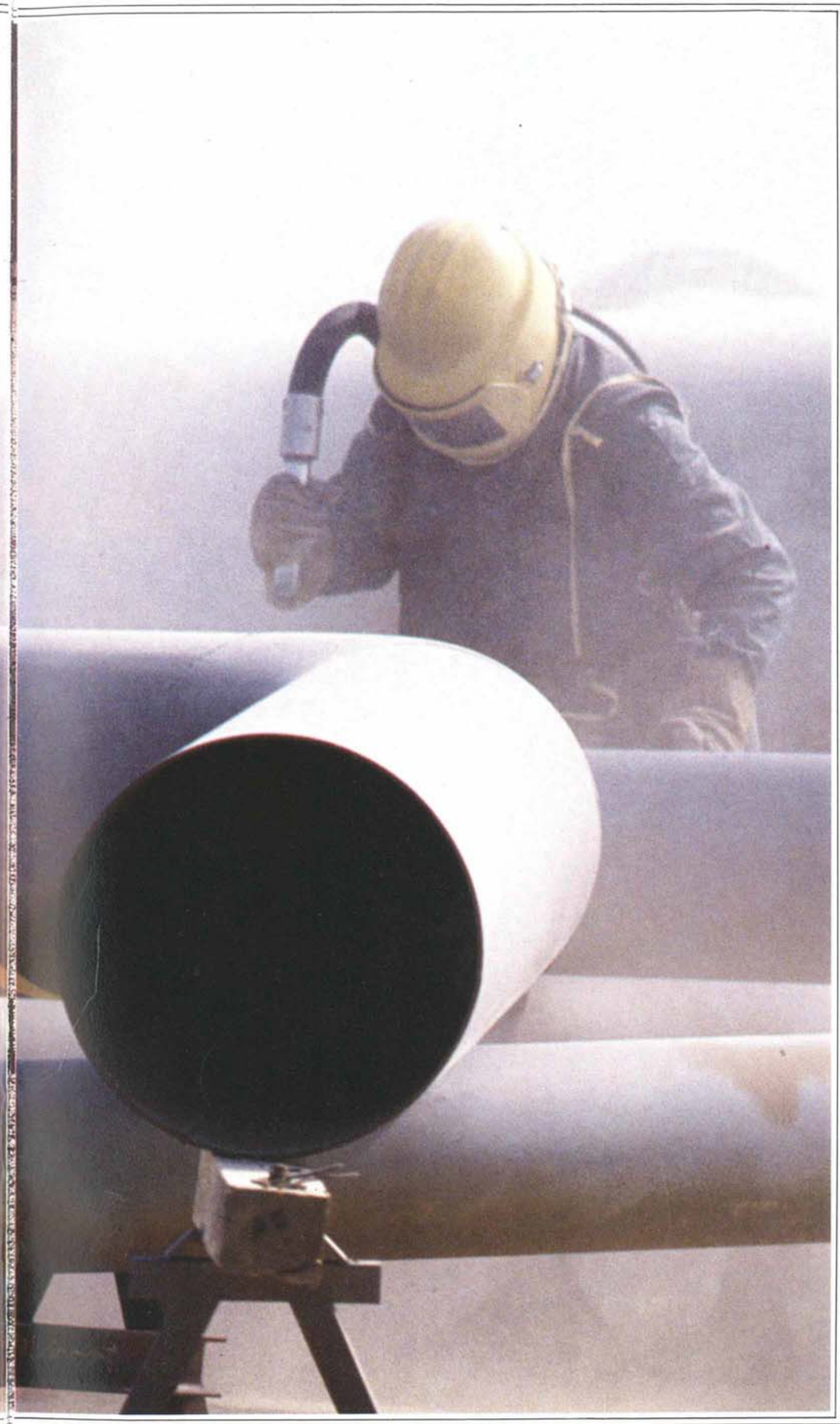
The picturesque old city of Yanbu', above and workmen, right, preparing the foundations of the new industrial capital of the Middle East at Jubail.

embankment nine meters wide (30 feet) and one meter (three feet) high around the equator. At the peak of site preparation, 2,000 men and 1,000 machines were engaged in transporting, compacting and grading the soil.

Before the bulldozers moved in, of course, planners had already spent years in preparation, starting in 1973, when the Saudi government ordered a master plan for the construction of two new industrial cities to spearhead the kingdom's drive to diversify its economy. Two years later the plan was completed and it called for cities at Jubail and Yanbu'.

Jubail, a small old port 90 kilometers (56 miles) north of Dhahran, was selected as the site of the larger of the two cities because it adjoins Saudi Arabia's oil fields and the navigable waters of the Gulf. When completed, the new city, not far from the old port, will occupy a 900-square-kilometer desert peninsula and bay (347 square miles). Yanbu', 300 kilometers (186 miles) north of Jiddah, was chosen as the site of the second city because of its natural Red Sea harbor and commercially strategic location; it is much closer to European markets. Located 19 kilometers (12 miles) south of Yanbu' al-Bahr, the Yanbu' industrial city will occupy 150 square kilometers (58 square miles) of coastal plain at the foot of the Hijaz Mountains.

In 1974, as the master plan was taking shape, the Saudi government gave the go-ahead for the expansion of the harbor at Yanbu' al-Bahr and construction of a new port at Jubail, in readiness to receive the millions of tons of equipment and materials required to build the two cities.



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At the Yanbu' site, a construction-supply port was also built; then in 1975, the late King Khalid appointed a special Royal Commission, headed by then Crown Prince Fahd, to lay the foundations of the new cities.

The commission's responsibilities included the planning, construction and operation of the infrastructure needed to support the cities, and coordination of their industrial growth. To help in its task the commission set up two directorates – one for each city – and selected two engineering and construction firms – Bechtel, for Jubail, and Saudi Arabian Parsons Limited for Yanbu' – to implement the planning.

Two government agencies – the General Petroleum and Minerals Organization (Petromin), and the Saudi Basic Industries Corporation (Sabic) – were assigned to develop the cities' primary industries through joint ventures with foreign firms. Responsibility for supervising the setting up of secondary industries was delegated to the Ministry of Industry and Electricity.

One of the main tasks of the Royal Commission was to coordinate the activities of these various bodies and cut through the red tape that automatically arises in operations of such magnitude.

At last, on November 1, 1977, construction of basic industrial facilities was initiated at Yanbu', with the arrival of the 10,000 tons of pipe for the crude oil pipeline which now runs across the kingdom from its eastern oil fields to the Red Sea. The industrial lifelines of Yanbu', the 1,202-kilometer (747 miles) pipeline and a natural gas liquids pipeline beside it will carry oil and gas from the east to the west coast to fuel and feed Yanbu's industries, provide a Red Sea outlet for Saudi oil and reduce the kingdom's dependence on a single Gulf outlet.

Oil and gas are basic to heavy industry, and most oil-producing countries dream of building their own industries instead of just exporting their oil to fuel those of others; at Jubail and Yanbu', Saudi Arabia is translating these dreams into reality.

Refining, of course, is the one industry which can be based directly on crude oil; and before World War II, refineries were usually located *in* oil-producing countries, with products – fuel oil, diesel, gasoline and kerosene – shipped to the consumer. Later, however, increased demand,

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diversification of products and the evolution of the super-tanker changed the economics, and companies moved refineries closer to the markets. A typical example of this was the growth of the giant Rotterdam refining complex in the Netherlands.

Now, however, the oil-producing countries want to see this trend reversed, and, in addition, use the gases dissolved in oil – and previously flared – as alternative feedstock for petrochemical and fertilizer plants.

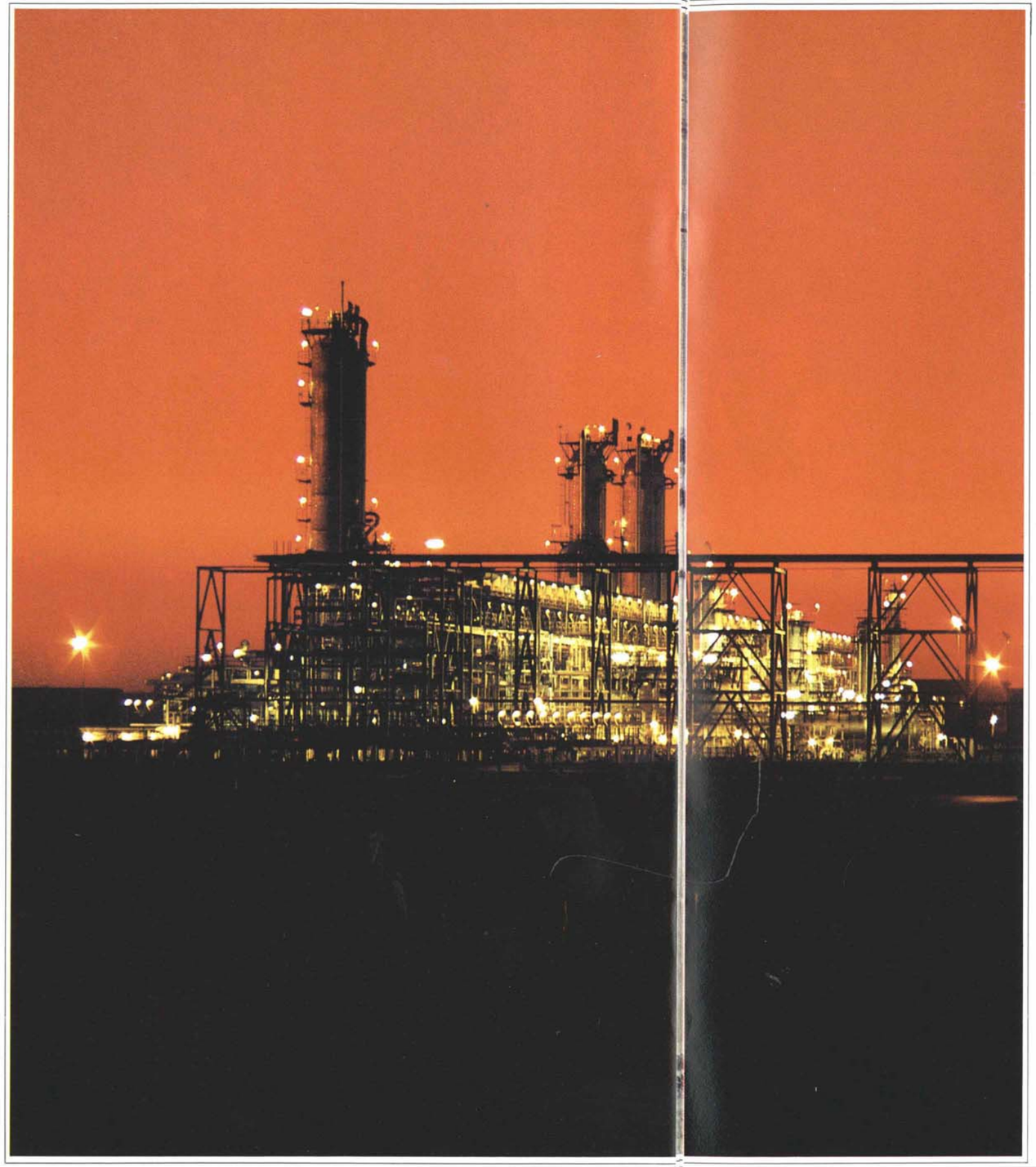
Energy-intensive industries, such as metal and mineral installations, also can benefit from locations in, or near, oil-producing countries if it does not mean importing raw materials, and in Saudi Arabia deposits of minerals, just beginning to be exploited, may make such industries feasible.

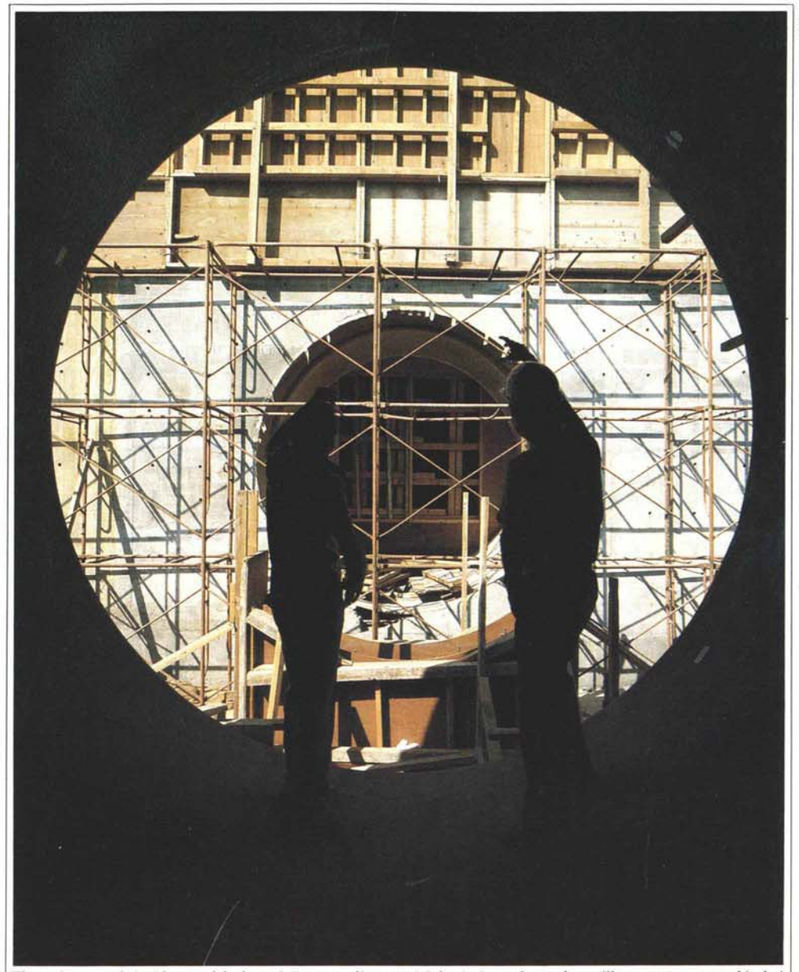
To set up and run such large and complex projects as refineries, chemical plants and steel plants, and market their products overseas, the oil-producing countries still need the technology and skills of the West, and Saudi Arabia, by using its unique position as the West's major supplier of oil, has been able to negotiate numerous arrangements by which they could obtain what they need. By the end of 1979, for example, Petromin and Sabic were signing joint ventures for Jubail and Yanbu', attracting partners by offering dependable oil supplies, as well as fuel and feedstock for their Saudi plants. In fact, says John Andrews, energy correspondent of the British daily newspaper *The Guardian*, "it is hard to fault the Saudi strategy."

In the early 1970s, the people of Jubail, a long settled site in Arabia and once an important port, eked out little more than meager livings from the sea; bypassed by the 20th century, Jubail had lain all but forgotten for years.

Across the Arabian peninsula, at Yanbu', the situation was similar. Once an important rest stop for caravans from Yemen, and later the Red Sea entry for Mediterranean Muslims making the annual pilgrimage to Makkah (Mecca), Yanbu' saw its stagnating economy decline sharply after the 1967 closure of the Suez Canal.

The tide of history, however, has once more turned. Today, Jubail and Yanbu' have been infused with renewed vigor as two new cities rise at incredible speed:





ISAAC

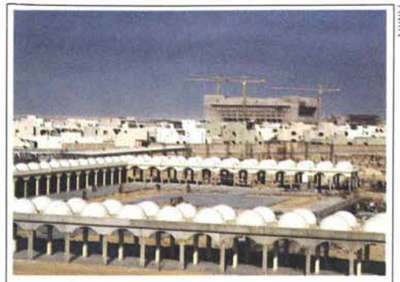
The writer stands inside one of the huge 3.7-meter-diameter (12 foot) pipes, above, that will carry sea water to Yanbu's power and desalination complex. Left, one of the many industries already dominating the new city's skyline.

only a few years after the start of construction, a large portion of project infrastructure is in place, and the population of the two cities already exceeds 70,000.

Yanbu', because it is smaller, is coming of age more quickly. Public works contractors have moved 1.5 million cubic meters (about two million cubic yards) of soil and have installed about 19 kilometers (12 miles) of piping every month; more than 80 projects have been under construction simultaneously.

Two of the city's primary industries, a crude oil export terminal and a NGL fractionation plant are already in business, while a whole range of secondary and support industries including precast concrete factories, bakeries, banks, two first class hotels and an excellent French restaurant are already functioning.

Jubail, too, is taking off. Nearly all of the industrial sites have been graded, and the first module of the permanent community has been built. Petrochemical, methanol, steel and fertilizer plants are under



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Two views, of Royal Commission headquarters at Jubail — by passed, until recently, by the 20th Century.

construction; the city's commercial port is complete and its industrial port nearly so. Jubail also has a modern 105-bed hospital, and an ice cream factory.

At both cities, new airports are in use and networks of roads link project sites, road building having followed closely on the heels of site preparation, the first contract being awarded at Jubail in August, 1977.

Today, as a result, wide highways criss-cross the industrial zone, and construction traffic is heavy; up to 400 vehicles an hour. A heavy-duty highway – looking more like an airport runway than a road, and capable of carrying 2,000-ton loads – cuts a broad asphalt swath through the city. Sections of factories, built overseas and floated to Saudi Arabia, are hauled along it from the port to the industrial zone, where they will become part of tomorrow's industry.

At the end of another wide, paved street is a giant blue-green water tower, its smooth sides and bulbous top cool-looking in the sun. Already the street is lined with electric lamps that automatically switch on as dusk touches the desert terrain.

Naturally, power and water are crucial elements in the new cities' infrastructure. Most of Jubail's drinking water is supplied by the Saline Water Conservation Corporation desalination plants situated south of the city, and a 1,200-megawatt steam power plant at Ghazlan supplies power.

The more remote city of Yanbu', however, must provide its own power and water. Initially, this was supplied by makeshift means – desalination barges, anchored offshore, and portable power

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turbines – but now the first phase of Yanbu's permanent power and water supply system is almost complete: a dual-purpose system, with waste heat from the power generating process used to boil seawater, which is then condensed for drinking. By 1985, it will have a total 960-megawatt power output, and produce 83.3 million liters of water a day (22 million gallons).

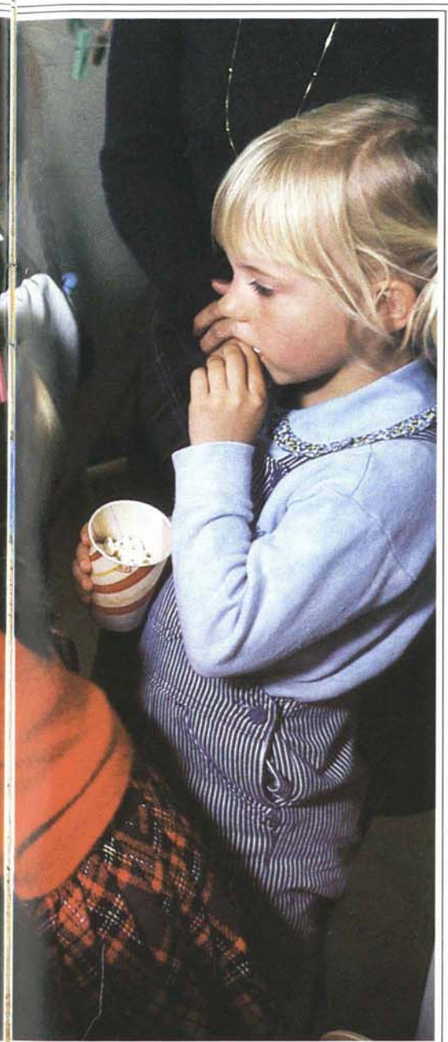
Seawater for the Yanbu' power and desalination complex, and for cooling the city's industries, will be drawn from the Red Sea through a series of 3.7 meter (12 foot) diameter pipes – among the widest in the world.

At Jubail, 14 pumps of 1,200 horsepower each will deliver the Gulf directly to the doorstep of the industries that need it, through an 10.5-kilometer (6.5 miles) network of canals, at a rate of 112 cubic meters (4,000 cubic feet), per second – an annual flow equivalent to two-thirds that of the Tigris and Euphrates rivers combined. But then – cleaner and not much warmer – it is discharged back into the ocean. And since fresh water is as precious as oil in Saudi Arabia, waste water collected from the new cities' industrial and community zones will be re-used to irrigate the parks and gardens that will surround them.

Today Jubail's commercial port has a total of 16 berths for handling breakbulk, palletized and containerized cargo. In addition, there is an industrial port with direct access to the open sea, and linked to the mainland by a causeway 10 kilometers (six miles) long. While this port is already operating at Yanbu', still another new port is rapidly taking shape as nine contractors dredge over 23,715,000 cubic meters (31 million cubic yards) of earth, dump 1.5 million tons of rock embankment, drive 2,700 piles up to 122 centimeters (48 inches) in diameter – and pour 143,744 cubic meters (188,000 cubic yards) of concrete for the new port.

On the telecommunications front, engineers are striving to complete underground telephone and telegraph cable systems, earth satellite and microwave stations, sea and air navigational systems, and an emergency services radio network for firefighting, security and medical services.

Jubail will eventually be linked with Saudi Arabia's national railway system by a 100-kilometer (60 miles) mainline railroad to Dammam, capable of



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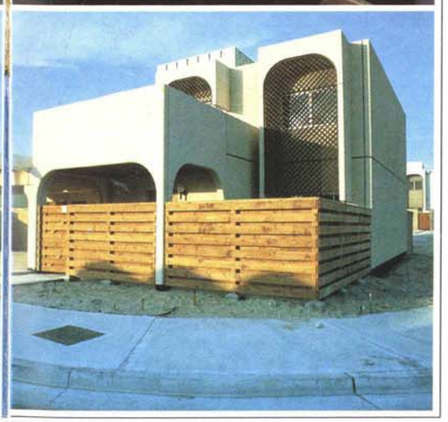

transporting over eight million tons of freight a year. And there is also the possibility – admittedly slight – of rebuilding the famous Hijaz Railway, which once linked Damascus and Medina – 154 kilometers (96 miles) east of Yanbu'. Rebuilding the railroad would give Yanbu' industries direct access to markets in Jordan and Syria, to the north, as well as to the populous cities to the south.

The economic heart of Jubail and Yanbu' are primary industry zones; by the mid 1980's, there will be 11 primary industries operating at Jubail and six at Yanbu', chiefly oil refineries and petrochemical complexes, making Saudi Arabia a major industrial force in the Middle East.

The six industrial centers at Yanbu' will be a crude oil export terminal, a natural gas liquid fractionation plant, three oil refineries and a petrochemical complex – all, by late 1982, completed or underway.

The first of the refineries, a 170,000-barrel-a-day Petromin plant, is scheduled to go on stream in 1983, and will produce gasoline, liquid petroleum gas, jet fuel, diesel and fuel oil for the home market. The output of the two other refineries, however, is for export. One, a joint venture between Petromin and a U.S. firm, will produce 5,000 barrels of lubricants a day, starting in 1984.

The third and largest of the Yanbu' refineries, with a capacity of 250,000 barrels a day, is a joint venture between Petromin and a U.S. company to produce gasoline, jet fuel, diesel fuel and heating oil among other products; it is scheduled to go on stream in 1984 – along with a huge petrochemical complex to produce 450,000 tons of ethylene a year, mainly for export.

At Jubail, two primary industries racing towards completion, will be up and running early next year; they will produce fertilizer and steel. Already, twin 62-meter-high towers (203 feet), used to reduce iron ore to "sponge" iron to feed the steel plant, and a 73-meter-high tower (240 feet) to solidify urea fertilizer for export, dominate Jubail's skyline. The iron ore will be moved from the port to the top of the reduction towers on a 14-kilometer long conveyor belt (8.5 miles). Initially, the ore will be imported from Brazil and Sweden, but eventually it is hoped to mine enough from deposits under investigation in the northwest of the kingdom.

Another joint venture, the

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Jubail today is a live and growing community — not just a planners dream. Top left, a school in the new city, and homes, below, and apartments, above, combining the best of modern living with traditional Arab design.

800,000-ton-a-year steel plant, will reduce by half Saudi Arabia's imports of reinforcement bars and wire rod for building.

As Saudi Arabia is already self-sufficient in nitrogenous fertilizer, most of the 500,000-ton-a-year output of the urea plant, a joint venture, will be exported. Jubail's chief export product, however, will be chemicals; Sabic has signed joint venture agreements to build four petrochemical complexes which between them will produce nearly four and a half million tons of glycol, ethanol, styrene, polyethylene and other chemicals each year.

Sabic has also concluded agreements to build two 600,000/650,000-ton-a-year methanol plants, and all six plants are due to go on stream by the end of 1985, making Saudi Arabia one of the world's leading petrochemical producers.

Jubail is also to have two export-oriented oil refineries. One will produce 250,000 barrels of fuel oil, naphtha, chemical gas oil and benzine a day. The second will produce 12,000 barrels of lubricants a day. The bulk terminal of Petromin's marketing agency – Petmark – scheduled to be completed in 1983 to store refined oil products for the domestic market is another primary industry.

The 17 primary industries located at Jubail and Yanbu' will have a major impact on Saudi Arabia's economy – first, by reducing the kingdom's dependence on the export of crude oil for income, second, by spawning satellite industries. Foreign sales of petrochemicals, methanol, fertilizer and steel, for example, are expected to amount to over 16 billion

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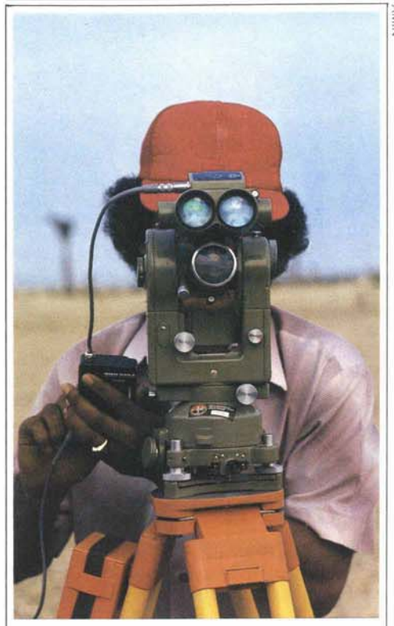

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Training centers at Yanbu' and Jubail teach young Saudi Arabs a wide range of skills, including, above, surveying. Inside back cover, silhouetted at dusk a surge sphere at Yanbu' gas fractionation plant.

Saudi riyals (more than $4.66 billion) a year and, as a natural outgrowth from the primary industries, secondary enterprises will take the output of the primary industries and use it as raw materials to produce manufactured goods.

Wire rod produced by the steel plant at Jubail will be made into fencing and nails at factories in the city's light industrial park. Products of the petrochemical complexes will be used to make vinyl, anti-freeze, adhesives, bleaches, disinfectants and plastic goods. The by-products of the oil refineries will be transformed into paints, insulation, solvents, nylon, polyester fibers and detergents.

Furthermore, a wide range of support industries to service and supply the primary and secondary industries, other businesses and the general public will develop. Already, in fact, over 150 companies have set up, or are in the process of setting up, businesses at Jubail and Yanbu'.

They include factories to make construction materials, such as cement, pre-cast concrete, asphalt and pipe; vehicle repair and maintenance works; plants to process food and bottle gas; print shops, gas stations and laundries.

In fact, such has been the response from Saudi firms wishing to set up business in Yanbu', that original plans for a 440-hectare light industrial park (1,087 acres) have had to be doubled.

Eventually all of the infrastructure and industry slated for completion at Jubail and Yanbu' by the mid 1980's will be expanded. In fact, the Royal Commission's master plan foresees development there through to the end of the century and beyond.

Already, provisions are being made for a fourth oil refinery at Yanbu', and another strong possibility is a plant to process minerals from Red Sea mud.

At Jubail, steel production will be expanded to four million tons a year, and other mineral plants built. Chemical production will advance from basic chemicals to intermediates, such as polystyrene and a gasoline additive, and another fertilizer plant will be built.

All told, Jubail, by the year 2000, is expected to have 16 primary industries and a population of 350,000 people, while Yanbu' should have at least eight primary industries and a community of 150,000.

For cities expected to have a combined population of 500,000 by the year 2000, sites at Jubail and Yanbu' are at first deceptive. But on closer inspection, the bustle of construction activity in the residential zones is also clear. Here, too, Jubail and Yanbu' are building.

Most of the two cities' present population live in temporary housing – construction camps and even a multi–story floating hostel towed to Yanbu'. And although several pleasant family and bachelor compounds have been built, these are but stepping stones to the "permanent" communities.

Work on these began, at both Jubail and Yanbu', in 1981, and the first of the hundreds of thousands of villas, houses and apartments that will eventually make up the new cities will soon be available for residents.

Separated from the industrial parks by wide, landscaped buffer zones, the two self-sufficient cities will combine the best of modern international living with the traditions of Arab architecture, typified by the attractive arch.

The communities will be multi-nuclear in form. The base of the inlet excavated at Jubail, for example, will be developed as a center serving the whole city. Here will be located the main administrative and cultural facilities, a central park, and community college or university. The residential area around it will be divided into districts, bounded by green space corridors or the coastline, each with its own essential services such as hospitals, secondary schools, sports complexes and stores. And districts will be made up of neighborhoods of about 2,500 people, each with its own mosques, elementary schools, playgrounds and shops.

The Royal Commission has retained several of the world's most renowned architectural firms to assist in community planning and design. Neighborhoods will have diversity and color, avoiding the conformity of many "master-planned" communities.

Housing will vary in size and style to suit all family and income levels.

Basic utilities, buried underground, are to be supplied by the same infrastructure network that serves the industrial areas.

Yachting marinas, museums, libraries, an aquarium and a zoo are also slated for development. Yanbu' even has a mangrove preserve, where wild birds already nest – apparently undisturbed by what is no less than the sound of growth.