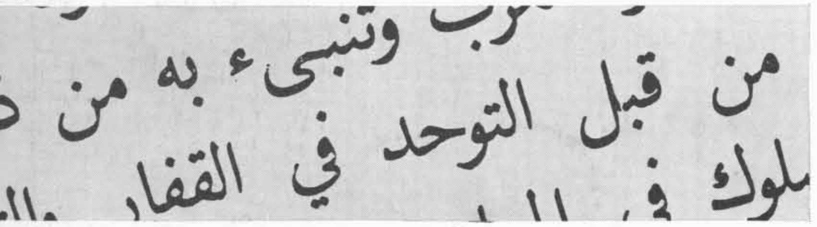
ARAMCO WORLD
505 PARK AVENUE, NEW YORK 22, N. Y.
Return Requested

BULK RATE
U. S. POSTAGE
PAID
New York, N. Y.
Permit No. 10

Mrs. David Carlson
62 Grove St.
Fitchburg, Mass.

CSF



ARABIC LANGUAGE, U.S.A.

harder at learning Arabic than other languages. But, though Arabic presents some problems for a Western student, it is not as impenetrable as many imagine. One teacher says, "Fortunately my students approach Arabic with a sense of fascination—it is mental gymnastics."

The government is spurring student interest by offering large scholarships in Arabic studies. Fellowships of the National Defense Education Act pay as much as $2250 for an academic year, plus tuition and a stipend for books.

This year the N.D.E.A. awarded 108 fellowships for advanced students of Arabic and related area studies to students who are enrolled at 20 different institutions.

Across the country, schools have responded to this encouragement with programs nearly as varied as the language itself. California leads the nation, with five universities and the United States Army Language School teaching Arabic. While several Ivy League schools in the East have offered courses in the language for some time, Midwestern and Southern state universities have started Arabic programs more recently.

The Program in Near Eastern Studies at Princeton was established 16 years ago as an outgrowth of summer seminars and the training of army students in Arabic and Turkish during World War II. Since then its curriculum has expanded to include courses ranging from beginning Arabic language to reading and translation of selected passages from the Koran.

An extensive Arabic program developed in Utah after a Utah college administrator headed an agricultural mission to Arabic countries and personally encouraged an interchange of studies. Besides college courses, Utah high schools teach Arabic to more than a hundred students. Middle Eastern Studies department at the University of Utah, headed by Aziz S. Atiya, offers conversation courses, great books of the Middle East in Arabic, and basic classes.

The dialects appear at various schools: the University of California, in Los Angeles, teaches spoken Moroccan Arabic, while Columbia University specializes in Egyptian colloquial Arabic.

Scholars are not in complete agreement as to whether a student should be taught to write or speak the language. Yale emphasizes grammar and reading; at Harvard University stress is placed on speaking, reading, and writing—"one strengthens the other." A professor at one Eastern college commented that "anyone not interested in Arabic for serious purposes takes colloquial courses," but a course in conversational Arabic begins the program at Portland State College, Portland, Oregon. Most schools teach a combination.

With the growth in Arabic studies, the number of qualified teachers also has increased. But most scholars think more research is needed on the problems of teaching Arabic to Americans.

Will Arabic studies in the United States continue to attract more and more students?

Yes, the teachers say. They suggest more students should be sent to Arab-speaking countries, in programs like the new Princeton plan which sent eight students to Lebanon this year (NUPOSA – National Undergraduate Program for Overseas Study of Arabic).

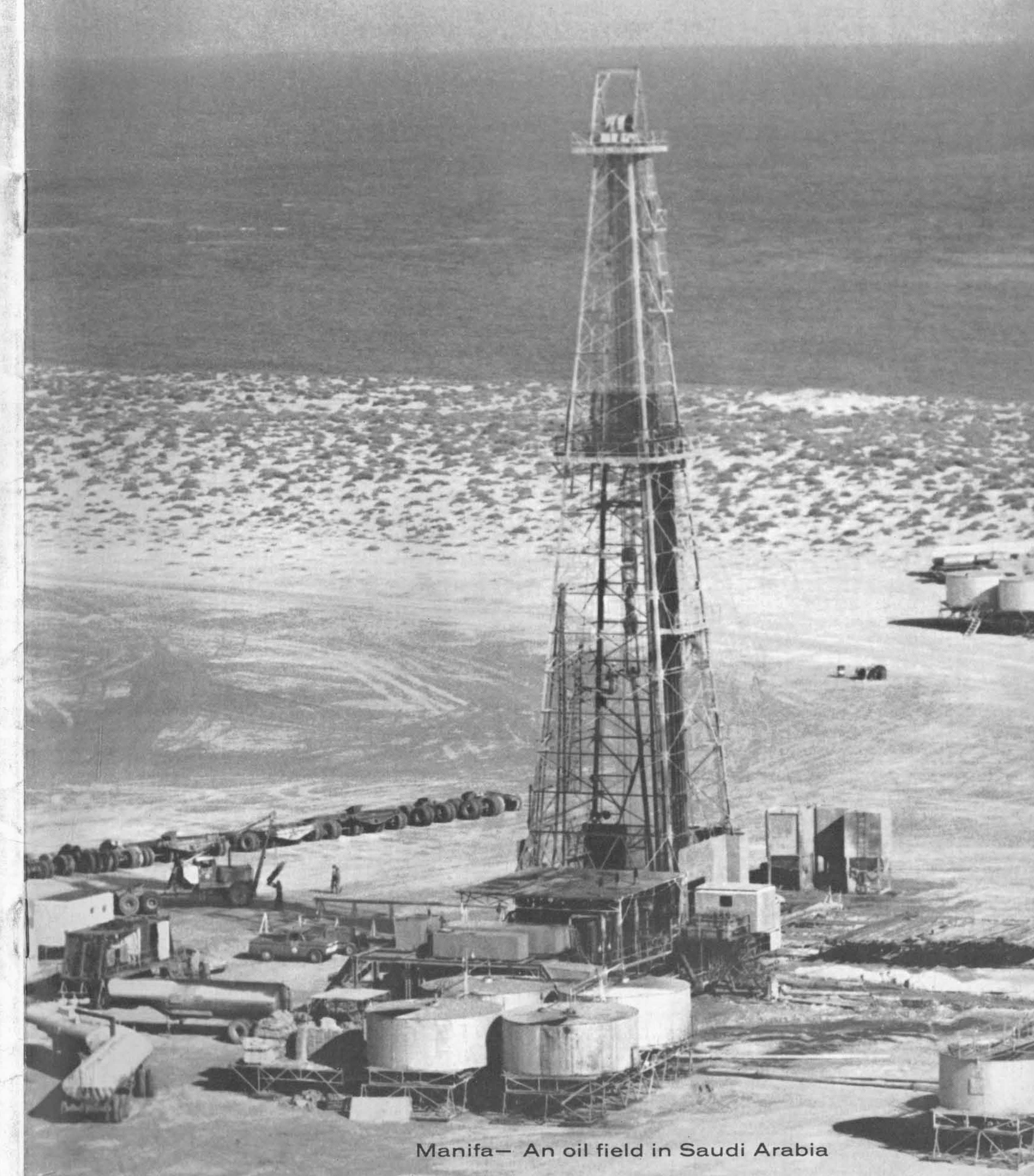
Summer studies such as the Inter-University program in Near Eastern Languages have proven highly successful, and teachers hope they will be expanded. "Students fight to get into the Inter-University program," Professor Madina said. "They meet every day for two hours of instruction, one hour of tutoring, and a language lab in the afternoon. They do nothing during these seven weeks but learn a language."

Almost everyone in the field expects more students and more extensive programs. Dr. Atiya believes there will be "scores of high school seniors enrolling in Arabic in the coming years."

The seventh graders at St. John's who stay an hour after school to learn Arabic and the language students in colleges across the country have a common bond – they soon may demolish Arabic's reputation as a neglected language in the United States. ■

ARAMCO WORLD

JUNE/JULY 1963



Manifa— An oil field in Saudi Arabia

ARAMCO WORLD

JUNE/JULY 1963 • VOL. 14 • NO. 6

PICTURE CREDITS: Front cover, pages 2-3, 5 (right) & 6 – Aramco photos by B. H. Moody. Pages 5 (left), 8 (left and center), 18, 20 (bottom right) & 21 – Aramco photos by V. K. Antony. Pages 8 (right), 9 & 10 – Aramco photos by Abd al-Latif Yousef. Pages 12-13 – Based on illustrations from the Oil and Gas International, May 1963. Pages 14 & 16 (top right) – Aramco photos by T. F. Walters. Pages 15 (bottom left) & 16 (top left) – A. Devaney, Inc. Pages 15 (center) & 16 (bottom) – Aramco photos. Pages 15 (bottom right), 17 & 19 – Aramco photos by E. E. Seal. Page 20 (top left) – Aramco photo by Russell Lee. Pages 22-23 – Courtesy St. John the Baptist school, Fairview, N. J.

A publication of the Arabian American Oil Company — A Corporation
505 Park Avenue, New York 22, New York
T. C. Barger, President; J. J. Johnston, Secretary; E. G. Voss, Treasurer
Issued by the Public Relations Department, T. O. Phillips, Manager

Here's what happened during 1962 to make it a

Year of Growth for Aramco

In the waters off Safaniya a skeletal tower looms against the Persian Gulf sunset. As twilight dies over the northern desert of Saudi Arabia, pinpoints of light begin to wink on the spare frame of the offshore drilling rig and worklights flood the derrick floor. The light spills onto the galleries of drillpipe along the deck of the adjacent tender. The gritty clank of the rotary drill continues as stars gather overhead. On through the night the voices of the drilling crew call out, and the drill hollows a deepening wellshaft into the oil-bearing geologic strata under the waters of the world's largest offshore oil field....

This was a familiar scene at Safaniya during 1962. The heavy Safaniya crude oil is a prime source of the fuel oil that powers the growing industry of Europe and the Far East. Last year, the Arabian American Oil Company (Aramco) added ten new wells to the field and boosted

Safaniya capacity to 360,000 barrels a day. When the Safaniya field was put into production in 1957, its daily capacity was only 50,000 barrels. Besides reflecting the continued growth in demand for oil throughout the world, the high level of activity at Safaniya symbolized a year of record achievement for Aramco, a company that is wholly owned by four American corporations: Standard Oil Company of California, thirty per cent; Standard Oil Company (New Jersey), thirty per cent; Texaco Inc., thirty per cent; and Socony Mobil Oil Company, Inc., ten per cent.

The year 1962 was the twenty-fourth anniversary of Aramco's discovery of commercial quantities of oil in Saudi Arabia. It was a year highlighted by a wide range of accomplishments, some of which were:

- Record crude oil production for a single year: 555,056,388 barrels, an increase of more than nine per cent over 1961.
- During the year the company passed its *five-billionth* barrel of crude oil production.
- A new oil field—Abu Hadriya—was brought into production, and the Fazran area of the world-famous Ghawar field was also put onstream.
- But despite record production, the proved liquid hydrocarbon reserves of Saudi Arabia were estimated at close to *fifty-seven billion* barrels at the end of the year.
- The company and its employees spent about $76,000,000 within Saudi Arabia. This was in addition to royalties and income taxes paid to the Saudi Arab Government.
- Two new intermediate schools for boys were built by the company and turned over to the Saudi Arab Government's Ministry of Education, and construction was started on two new schools for girls.
- Thirty-four Saudi Arab students were awarded Aramco scholarships for advanced study in the Middle East during the 1962-1963 academic year.
- Five hundred and ninety-six Saudi Arab employees built or purchased homes with Aramco loans. By the end of the year a total of 3,963 Saudi Arab employees had acquired homes under the Aramco plan.

OPERATIONS

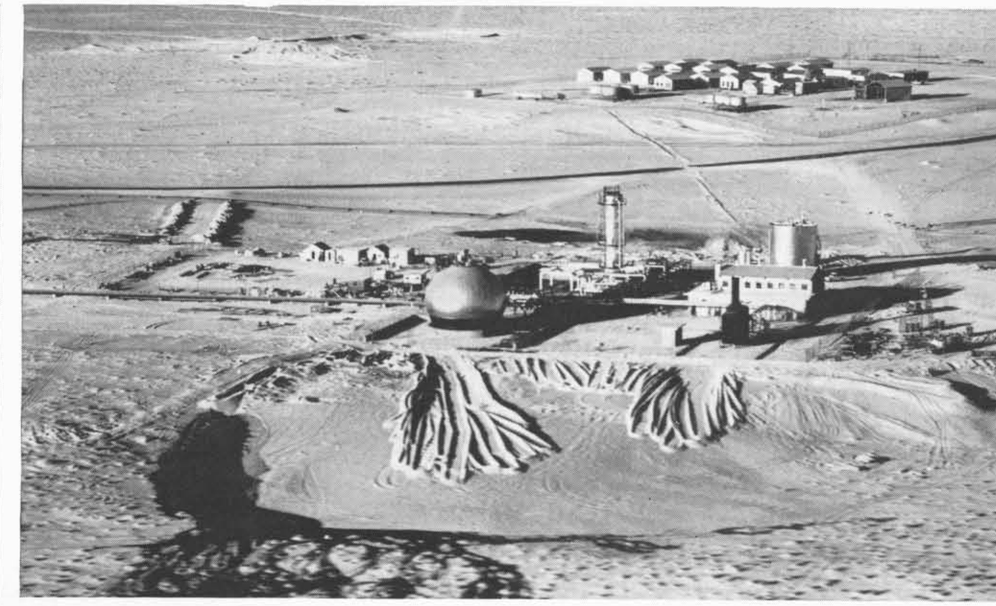
Throughout the company the year was a good one. The Aramco refinery at Ras Tanura processed 90,886,021 barrels of crude oil, a slight increase over the previous year. Exports of crude oil and refined products reached a new high level: 544,656,660 barrels compared to 497,690,167 in 1961.

In addition to the ten new wells drilled at Safaniya, twenty-one miles of submarine trunk lines were laid last year to boost the field's capacity. Additional storage and transport facilities were completed onshore. Work was also started that will result during 1963 in a further increase in the field's capacity to 425,000 barrels a day.

South of Safaniya in the Persian Gulf, another Aramco offshore field—Manifa—was being readied in 1962 to begin production next year. It will go onstream early in 1964 with an initial capacity of 125,000 barrels of production a day. It will be the ninth oil field in Saudi Arabia.

The seventh field, Abu Hadriya, was put into production by Aramco last December. The facilities at Abu Hadriya include a combination gas-oil separator (50,000 barrels a day) and stabilizer (90,000 barrels a day). It is the first unit of its type to be built by Aramco. The natu-

Electronic gear, used to aid in oil explorations, is given a thorough check prior to a seismic shot.



New gas-oil separator plant and stabilizer at Abu Hadriya processes crude oil by removing natural gas and corrosive hydrogen sulfide.

ral gas produced with the field's oil is removed in the separator, and the oil is then processed in the stabilizer where its hydrogen sulfide, a poisonous gas which is highly corrosive, is taken out.

The Abu Hadriya crude is then delivered through pipelines northwest to Qaisumah, where it is turned over to the Trans-Arabian Pipe Line for transport to the Mediterranean Sea.

During 1962 still another field—the Fadhili field, the eighth in Saudi Arabia—was being prepared to add its output to world production. It will be put onstream this year. Fadhili is only thirty-one miles south of Abu Hadriya. A pipeline will carry 30,000 barrels of Fadhili crude oil a day to the stabilizer at Abu Hadriya.

While production increased, the search for new oil fields continued. Four exploration parties covered widely separated areas in the Saudi Arabian concession. Two carried out seismic refraction surveys, and two drilled stratigraphic structure wells. The exploratory work ranged from the Rub' al-Khali (The Empty Quarter) in the south to sand and gravel plains in the west, offshore waters in the east, and border areas in the north.

Seismograph parties surveyed 2,468 miles of seismic lines. Offshore seismic surveys covered 242 miles. Electronic computation played a part in the exploration programs. It permitted faster seismic calculations and rapid revision of earlier data as new information was gathered.

Aramco virtually completed its work on the co-operative mapping of Saudi Arabia established by the company and the United States Geological Survey in 1954 under the joint sponsorship of Saudi Arabia and the United States. Saudi Arabia is now one of the best mapped areas of the world.

The efficient recovery of oil from the earth is based in large measure upon knowledge of the nature of oil reservoirs and the ability to predict the behavior of a reservoir under production. Last year Aramco's major programs in reservoir research included determinations of reservoir rock properties, predictions of reservoir behavior, and several other special studies of Saudi Arabian oil fields.

Tests of reservoir rock properties provided new data on fluid flow in the reservoirs. Research engineers devoted special attention to the effects of water displacement of oil in the reservoir. Earlier Aramco research had indicated that water flooding of a reservoir to maintain the production pressure will probably be the most efficient recovery method in Saudi Arabia.

Laboratory predictions are checked against data from observation wells. The oil content of reservoir rocks is determined by analyzing electronic, sonic, and radioactivity logs of surveys made in these wells.

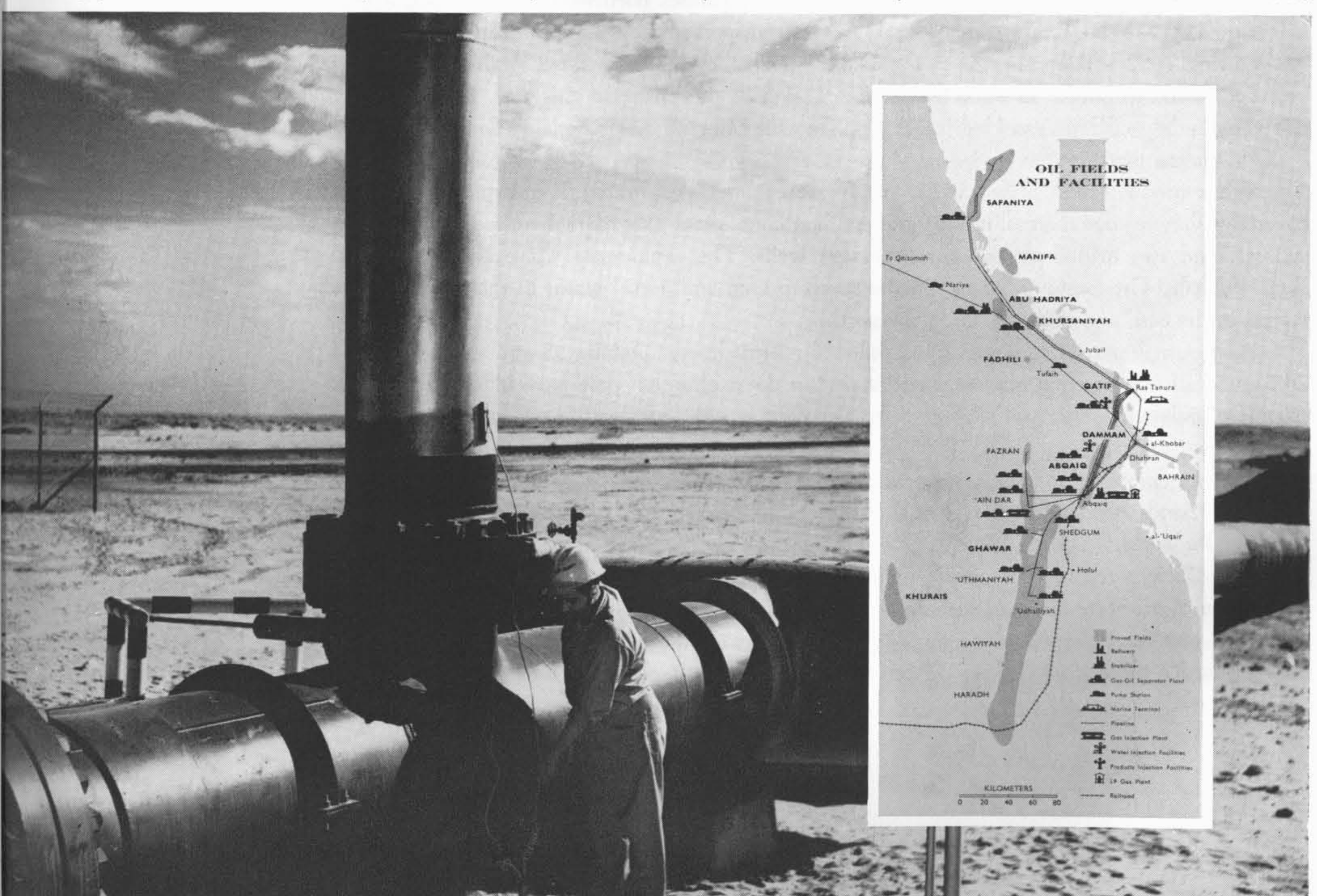
Drilling activity increased during 1962. Six rotary drilling rigs were used in oil field development and exploration. Three heavy Aramco rigs drilled 154,727 feet, compared to 147,950 feet a year earlier. Twenty-two development and delineation wells were completed in the Safaniya, Manifa, Khursaniyah, Abu Hadriya, Fadhili, and Qatif fields.

The combined exploration, development, and research programs of the company brought an increase of more than *nine billion* barrels in Saudi Arabia's proved liquid hydrocarbon reserves. Proved gas reserves were more than *twenty-three trillion* standard cubic feet, another significant increase over the previous year.

Water and gas are injected by Aramco into the oil fields of Saudi Arabia to maintain pressure in the oil reservoirs and assure the maximum efficient recovery of the country's crude oil. Last year the rates of injection were increased.

An average of 163,446,000 cubic feet of gas was injected daily into the Abqaiq field—and an average of 143,950,000 cubic feet was injected daily into the 'Ain Dar area of the vast Ghawar field. Both fields use gas that is processed at a new plant at Abqaiq. Limited amounts of excess gas production from the plant were sent to the Ras Tanura refinery for processing starting in December. The gas was transported as liquefied-petroleum-gas condensate.

This pipeline connects offshore Safaniya field with refinery at Ras Tanura. Map shows Aramco's oil operations in the Eastern Province of Saudi Arabia.



At Abqaiq field water injection into the reservoir averaged 277,601 barrels daily. In the Ghawar field a test begun in 1960 was continued at a nearly tripled rate. In this test undrinkable water flows by gravity from one layer in the field to the water-bearing section of the oil reservoir. Pressure in the reservoir is thus increased.

A significant gain was made during the year in the use of the natural gas that is produced in association with Saudi Arabia's crude oil. Aramco utilized 48.2 per cent of the gas. This was a 17.5 per cent increase by volume over 1961. At the same time, more gas was injected into oil reservoirs, and sales to Saudi Arabian industry increased.

In keeping with the upward trend of Aramco activities, the company refinery at Ras Tanura posted a slight gain in throughput to reach a daily average of 249,003 barrels.

The marine terminal delivered a record 348,761,965 barrels of crude oil and refined products into the holds of 2,242 ships during the year.

In mid-year the company began construction of facilities at the Ras Tanura Marine Terminal designed to more than triple the export capacity of its refrigerated LP Gas (liquefied petroleum gas) plant. When the $14,500,000 project is completed late this year, the expanded plant will have an export capacity of 12,000 barrels a day.

PEOPLE

By the end of 1962, Aramco had greatly reduced the number of its American and other foreign employees. It had 13,573 regular employees in Saudi Arabia at the close of the year—10,852, or *eighty per cent,* were Saudi Arabs. The average income of the Saudi Arab employee had been more than doubled since 1955. More than half of the Saudi employees had been with Aramco for at least ten years, and forty-one of them had worked for the company twenty-five, or more, years.

As in past years, employee training was emphasized in 1962. About one fourth of the company's Saudi Arab employees were given instruction at Aramco's three Industrial Training Centers or three Industrial Training Shops. This instruction was a part of the normal work day. Many employees attended classes voluntarily after working hours.

Ninety-three Saudi Arab employees were given educational and training assignments outside Saudi Arabia. This special training enabled them to gain additional knowledge and skills to do a better job and to meet the requirements for higher positions.

Thirteen were given practical work assignments. Some studied the latest oil field techniques in the United States. Others worked with companies that manufacture, market or service specialized equipment used by Aramco.

Ten attended technical schools and received training in building crafts, drilling and production technology, television photography and various branches of industrial safety.

The remaining seventy studied courses at high school or university levels. Graduate training was given in education, geology and medicine.

During 1962, Aramco paid $2,411,000 to Saudi Arab employees for various benefits and services. In 1960 the company established an Annuity and Death Benefit plan for Saudi Arab employees. Two hundred and eighty-seven Saudi employees have retired under the plan. By the close of 1962 they had received $1,053,000 in lump sum severance benefits, employee Thrift Plan savings and rewards, monthly pension payments, and special benefits.

An Aramco Saudi Arab employee puts a tape on an electronic computer unit.

During 1962, Aramco's Medical Department sponsored family health classes for wives of Aramco employees.

Tank truck operators check on the refueling of jet airliners at Dhahran International airport.

More than ninety-six per cent of the Saudi Arab employees participated in the Thrift Plan. Their savings reached $5,478,000. If an employee resigns, retires, or has his service terminated after fifteen years of service, Aramco matches his savings. Such thrift rewards are provided on a graduated scale for service of less than fifteen years.

During the year, Aramco sponsored a maternal and child care program. Under this program individual instruction was given to 1,500 pregnant wives of Saudi Arab employees and to 2,000 mothers. As a result, there was a significant improvement in family health. In many instances, diseases were prevented, or they were detected early enough to permit effective treatment. The company Medical Department sponsored family health classes for wives of Aramco employees in various communities.

More than 159,000 immunizations against twelve diseases were given employees and dependents. Last year great emphasis was placed on industrial hygiene to assure employees a work environment free of gases, excessive noise, and eye and other irritants.

The diagnosis and treatment of tuberculosis among Aramco employees and their dependents was continued during 1962, and the company's inoculation program using BCG anti-tuberculosis vaccine was accelerated.

Aramco spent $4,983,000 on the medical treatment of employees and their eligible dependents, and $995,000 on the treatment of others.

ARAMCO AND THE COMMUNITY

The continued growth of Saudi Arabia's economy was reflected in the increased use of petroleum products. Aramco supplied 4,373,047 barrels of products to industrial and domestic consumers. This was a 9.5 per cent increase over 1961.

Sales of liquefied petroleum gas and natural gas rose to record levels. Jet air travel affected sales; aviation jet fuel volume almost doubled over 1961, while the sale of aviation gasoline declined sharply.

Aramco's Products Distribution Department made a survey during 1962 that showed 383 service stations were operating in Saudi Arabia. The service stations are built and owned by independent operators.

The company's expenditures were higher than ever in Saudi Arabia. In addition to the money paid to the Saudi Arab Government in royalties and income taxes on oil operations, the company and its employees spent about $76,000,000 in the country during 1962.

This included payments to local industry for goods and services, income taxes paid by non-Saudi Arab employees, public welfare expenditures, customs payments, and freight and miscellaneous payments to the Saudi Arab Government. It also included all payments to, or on behalf of, Saudi Arab employees, and estimated expenditures by non-Saudi Arab employees in the various local markets.

Payments to Saudi Arab companies for services increased to $11,957,000 from $10,560,000 in 1961. One hundred and ninety-seven new contracts were made with firms that paved roads, developed residential land areas, printed the company's Arabic and English weekly publications, constructed schools for Saudi Arab children, installed pipelines, and provided other services. They also participated to an increasing extent in the testing, overhaul, and inspection of refinery and other units.

A total of $15,107,000 was spent on purchases made through Saudi Arab merchants. This was a thirty-four per cent increase over 1961. These purchases included complex industrial equipment. The services of the Aramco Overseas Company and Aramco's New York office were used to coordinate purchases between Saudi Arab firms and overseas suppliers, to analyze price quotations, and to make inspections needed to meet Aramco requirements.

For the first time, Saudi Arab firms undertook both the supply and processing of all the pipe needed to place an oil field in production.

Also for the first time, Aramco bought frozen and chilled foods from locally-owned cold storage plants.

Under an agreement with the Saudi Arab Government, the company has built eleven elementary and four intermediate schools for boys. Two of the intermediate schools were completed last year at a cost of $632,000. Upon completion the schools are turned over to the Ministry of Education, and the company maintains them and provides the funds for the teachers' salaries.

Construction of two girls' schools got under way during the year. The company also made available to the government forty-four portable buildings for use as additions to present schools or for use as temporary schools.

The Aramco scholarship program for Saudi Arab students awarded thirty-four scholarships for the 1962-1963 academic year. These are for advanced study in the Middle East. During the previous academic year twenty-two scholarships were awarded. Aramco plans to boost the number to sixty next year. The final selection of scholarship students is made by the participating schools: Alexandria University, the American University of Beirut, the American University in Cairo, and the Beirut College for Women.

Intermediate school for boys, finished during 1962 in the Persian Gulf city of al-Khobar, is one of fifteen schools completed by Aramco.

Last year an Aramco medical team, with the approval of the Ministry of Health, inoculated more than 1,200 infants and children against trachoma using a vaccine developed in the Harvard University-Aramco Trachoma Research Program. Reinoculations were given in the fall to 750. Careful records and controls were maintained to insure accurate analysis of the results. However, long and extensive inoculation trials and further research must be carried out before the vaccine can be proved effective.

Aramco made an initial grant of $500,000 to Harvard in 1955 for a five-year research program. In 1960, the company made a further grant of $585,000 for an additional five-year period. In 1958 the strains of the trachoma virus found in Saudi Arabia were isolated. The vaccine was developed in 1959. The progress made to date in controlling this disease, which impairs vision, has been very encouraging.

In another field of medicine, an elementary health book was prepared by Aramco in co-operation with the Ministry of Education. Almost 8,000 copies were distributed within the company and in Saudi Arab schools. Leaflets, posters, and movies were also used by the company in its health education programs.

Aramco in 1962 assisted local utility companies in their efforts to provide electric power at lower cost to home and industrial consumers. The company guaranteed payments by the Dhahran Electric Supply Company of about $2,089,000 for the purchase of heavy equipment. Aramco also agreed to make interest-free loans to the utility to assist in the financing of other facilities.

The Rahimah Power Company at Rahimah was given technical assistance and a guaranteed loan for new generators.

A new hospital completed from plans prepared by Aramco was opened in al-Khobar, and the company guaranteed to pay for services to 65 patients for a ten-year period.

In cooperation with the Ministry of Agriculture, the company provided technical advice to farmers and poultry dealers. The 46 farms assisted had a yield of more than 1,800,000 pounds of produce – a record.

In oil operations, employee relations, and community relations, 1962 was an outstanding year for Aramco. For the twenty-first consecutive year the company increased crude oil production. Saudi Arabia thus strengthened its position as one of the great oil countries of the world. ■

Aramco medical team inoculates infant with a vaccine developed by Aramco-Harvard Trachoma Research Program.

An Aramco employee newspaper, which is printed in Arabic in al-Khobar, carries all the news from company operations to company sports events.

Secrets of Inner Space

The earth he's been walking on for millions of years is more of a mystery to man than outer space

"Look, that's not basalt! It's the mantle! We've made it!"

A dozen men are clustered around the end of a grimy piece of pipe. From its end a rod-shaped piece of rock about 2 inches in diameter is slowly emerging. The scene is the drilling floor of a huge derrick like the ones that dot the skyline above oil country. But this derrick is on a ship and gently swaying with the sea's swell.

When the object is clean enough to see its details, a dozen heads close in to screen this fascinating rock.

"What is it? What have we got?"

"It looks like . . ." but the last word is indistinct.

Hopefully, in a few years the team of top U. S. earth scientists on the boat described will be able to finish off that sentence. But first they will have to successfully complete "Project Mohole." They will have to push present engineering knowledge to its limit – and beyond, to drill for the first time through the earth's crust and into its mantle. The precious sample they will then obtain will be studied for years and will yield hundreds of secrets about the earth. Long-held theories about this and other planets, many of them the results of entire lifetimes of work, will be destroyed – or supported – by that tiny 2-inch core of rock.

Physicists, mathematicians, biologists, astronomers, and geologists have been waiting for a long time for someone to obtain a deep sample of the earth underfoot, the earth no one really knows yet. But until recently, no one has dared to even dream of such a herculean probe.

For thousands of years man has pointed his biggest questions upward into the skies, achieving in the past few years the ability to hurtle a man hundreds of miles into space to learn its secrets. The best he has been able to achieve in the other direction is to sink an oil drill bit five miles and a mining shaft two miles. Now scientists are preparing to look not to *outer* but to *inner* space. They hope that their findings will tell them how the planets were formed, when this took place, and what the future holds for them. There are scores of mysteries to be unraveled from inner earth. For example:

- What creates the earth's strange magnetic field?
- How old are the oceans? Life itself?
- Why are we jarred by a million earthquakes each year? Why do they occur at such great depths as 500 miles? How can we detect quakes like the convulsion in 1556 that killed 830,000 people in China?
- What caused the Krakatoa explosion in 1883, wherein a Pacific island actually disintegrated with a blast that hurled rocks 34 miles into the air and used a hundred times more power than the largest H-bomb detonations?
- Why did a 400-mile-long section of the earth's crust sink 1,300 feet in the area of the Dead Sea? Could it ever happen again?
- Do continents wander? Sir Francis Bacon suggested land masses may move about, after he noticed that the coastlines of South Africa and South America roughly "fit" like separated pieces of a puzzle.

Speculation, if not much action, concerning the earth's interior, has always been popular. In 1678, a Dutchman named Athanasius Kircher published two weighty volumes devoted entirely to the inner earth. Much of his writing was on "dragons and other dark-dwelling beasts," but the author also suggested theories of which at least 50 have since been proven by geologists. The nineteenth century saw British and German mathematicians Leslie and Euler both writing that the earth was a hollow ball with a separate fiery core at the ball's center. That century also brought Dr. Edmund Halley (discoverer of Halley's Comet), who avowed earth consisted of "three concentric hollow spheres without any openings and with a hot spherical core in the center," and Darwin, who wished "some one would bore a hole so we might see."

The earth, science has since learned, is a solid, but not rigid, ball which weighs 5,887,613,230,000,000,000,000 tons. We also know it gets hotter the deeper we descend into it. In the world's deepest gold mine, at Robinson, South Africa, the walls are so hot a $500,000 air-conditioning plant had to be installed to keep the miners from being roasted alive. Yet, the total heat coming up from below the surface is so slight it is 30 million times smaller than the amount the earth receives from the sun.

Not entirely unlike their forebears, most modern geologists believe the earth consists of a number of concentric shells of different materials, arranged in the order of increasing density. On the surface there is a thin *crust* of solidified granites and basalt, then the *mantle,* a thick layer of heavier rocks in a fairly plastic state. Next, comes a liquid *outer core.* Finally, there is a solid ball within the liquid, called the *inner core.* This supposed separation of materials probably took place in the earth's early youth. When it was still quite liquid, or even gaseous, the heavier materials easily sank to the center of the ball, where they remain still. The crust cooled off and solidified perhaps five billion years ago, but

Secrets of Inner Space

temperatures in the deep interior are believed to have been unchanged during all this time.

The crust, which varies in thickness from three to 40 miles, is thought of as a thin, comparatively soft veneer of lightweight rocks. Its most abundant metal is aluminum, estimated to make up 7.85 per cent of the crust. Beneath the sea the crust's composition differs radically from that under the land masses. The continents are seen as thick blocks of relatively light granite rock, the ocean basins as floored with a much thinner, but heavier basaltic rock. But both crust types act as though they are floating on the much denser rock of the mantle.

The mantle, comprising 85 per cent of its bulk, would be, of course, earth's largest section. It is estimated to be 1,800 miles thick and made of basalt (dark volcanic rock) or something even heavier. We know less about the mantle and the part it plays in our events than we know of the sections beneath it.

The mantle's rocks probably exist under a pressure equivilant to that of 40,000 tons of weight put on a U. S. ten-cent piece. This in turn causes mantle temperatures of at least 5,000 degrees above zero Fahrenheit. Thus, the rock bends, twists, and possibly even flows like bread dough, and the mantle may well be the reservoir of molten matter that feeds volcanoes. Seismologists are convinced it is where the severest earthquakes originate.

Below the mantle is the earth's outer core. It is about 1,300 miles thick and may consist of liquid iron and nickel. Part of the enormous heat there is caused from the pressure of the above weight, and part is thought to be heat originated when the planet was born.

Floating in this liquid is the inner core, a solid ball of 1,600 miles diameter which may be made of iron and a little nickel. The pressure (which keeps the ball compressed as a solid) is about 4,000,000 times earth's atmospheric pressure at sea level. A professor in California is attempting to prove the inner core can be moved. He claims it moved toward Japan as a result of a "kick" supplied by the Chilean earthquake of 1960. He is waiting for another strong quake to produce a "kick" that his university can measure.

Earthquakes (the results of rocks fracturing under stresses) have seemingly proved this crust-mantle-core theory of the earth's composition. Seismologists have observed that when an earthquake wave enters the core, for example, it bends twice, once as it goes in and again as it comes out. From this, they've concluded that there *is* a core and that its texture and weight differ enormously from the mantle. Some types of quake waves won't go through the core at all. Scientists studied them and found they won't go through liquid either. Therefore, it seems likely the core is liquid, perhaps as thick as hot asphalt.

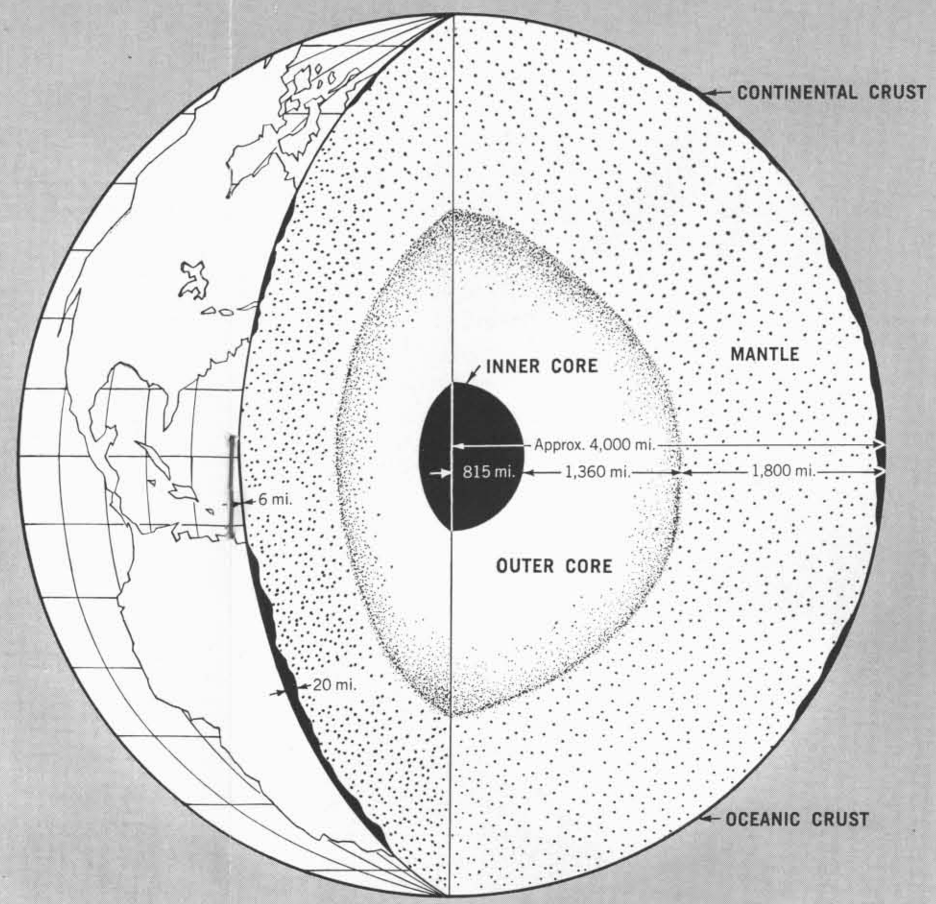
Among other clues to the nature of the inner earth, there is the fact that the earth acts like a great magnet. Iron is the magnetic element, so the bulk of the earth should be iron. Meteorites, generally assumed to be pieces of some broken planet, also support the "iron earth" theory. These come in two categories: meteorites containing up to 90 per cent iron and stone meteorites which are similar in chemical composition to the rocks of the earth's surface. The conclusion seems inescapable to geologists that the difference between the two types of meteorites is due to their having originated at different depths of the disintegrated planet and that the earth contains a like composition.

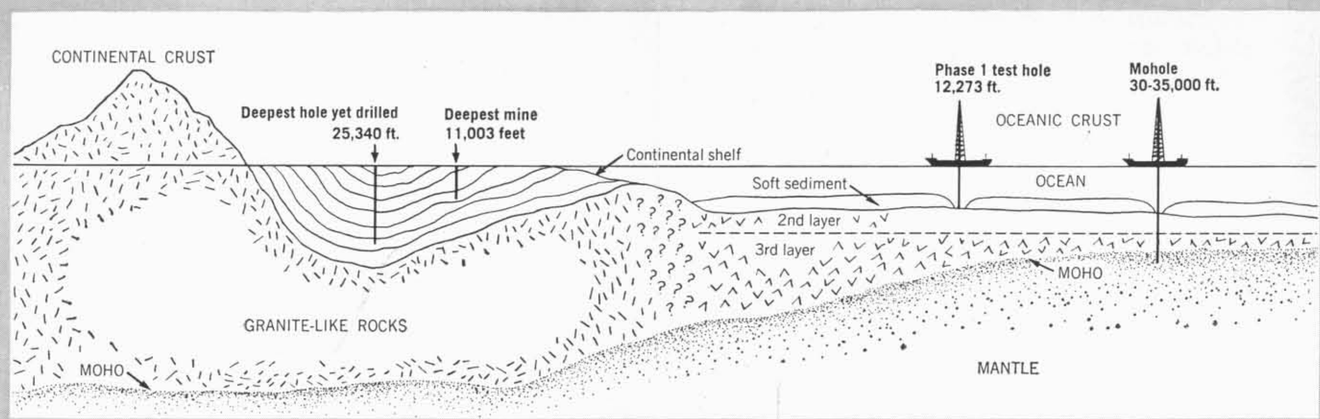
Although a great deal of the foregoing is not new, the surprising thing is that at this point in world history very little of it has been proven. Until man can journey deeper into earth than he has, or obtain temperature measurements and composition samples, *he will simply have no factual knowledge concerning 99 per cent of the planet he lives on.* This is why the 1957 announcement of the American "Project Mohole" created worldwide scientific interest.

"Mohole" is often modestly described as "a plan to drill a hole in the bottom of the sea." Actually, it is a considerably complicated experiment which will cost the National Science Foundation from $45 to $68 million and probably not be completed until 1967.

The plan calls for a hole which would reach through the crust, pass the Moho, and enter the mantle. The project takes its name from the Moho, the popular term for Mohorovicic Discontinuity. The latter is the narrow boundary between the crust and the mantle. It was named for the Yugoslav seismologist, Andrija Mohorovicic, who discovered the discontinuity in 1909 when, during a quake, he noticed that seismic-wave speeds abruptly increased there. Today, some geologists believe the Moho was the primordial surface of earth.

Scientists believe that the earth's interior consists of several concentric rings, each composed of a different material. They hope current experiments will confirm this theory and reveal even more of the earth's secrets.





The project directors have decided that the easiest route to the Moho, and thence the mantle, is through the ocean floor. There, the crust averages just one third of the average thickness under the continents. While the aim is to sample the mantle, examination of the sediment layers on the sea floor as the drilling progresses should be an important by-product. The layers are believed to contain a continuous record of all life forms as they have evolved.

From an ocean site where the crust is but three to five miles thick, the mantle can be reached by a drill-string 30,000 to 35,000 feet long. The string, or pipe, would pass through 15,000-20,000 feet of water, then about 15,000 feet of crust. The only hole which comes even close to this – a Texas oil probe which came up dry – went down just under five miles – 25,000 feet.

Though there still remain many problems to be worked out, the project's study of American offshore petroleum technology and its own test drillings in the Pacific, both have proven the feasibility of using the standard rotary drill common to the oil industry. But this record-depth drilling will entail many peculiar and unprecedented hazards. For one thing, the floating drilling platform will have to maintain its position, perhaps for years, within a 500-foot radius circle in an average of 18,000 feet of water! Even minor drifting could snap the 4½-inch pipe. Radar targets mounted on floats and an array of sea floor-stationed sonar targets will help keep the drilling vessel positioned. And to re-enter the hole, an act comparable to threading a needle through 18,000 feet of water, the drillers may possibly use a funnel-type target at the entrance in conjunction with television and still more sonar equipment.

The bold scope of "Mohole" has sparked international enthusiasm. This was verified when late last year the Soviet Union decided also to begin a subterranean study. Thus, as is already the case with outer space, a race to conquer inner space is about to begin.

The Russian drill teams will attempt holes at five land sites – one of them up to nine miles deep – solely in the crust. Although they will be connected with oil and metal prospecting, the principal reason for the holes will be to make scientific discoveries. "Such penetration," asserts the head of Russia's Geology Institute, " is just as grandiose a task as penetrating into the cosmos!"

A spokesman for the National Science Foundation, in Washington, D. C., is equally confident of the project's success. "All we really know about earth," he has pointed out, "is by the indirect methods of geophysics. Now, man will receive actual samples . . . to confirm or deny some of his theories." An additional possibility is that the first mantle core brought to the earth's surface may also *answer questions no one has yet asked.* ■

Tenacious plants that thrive even where water is scarce and the sun is hot are among

NATURE'S HARDIEST

NATURE excels in nichemanship. Wherever there is the slightest chance for survival, animal and plant life contrive to fill the niche—but only by some very ingenious and specialized adaptations. Thus, all plants that grow in desertlands are cleverly equipped to withstand the heat and make full use of what little water exists in arid areas.

Deserts confront plants with many problems. It is always very hot during the day—soil temperatures may rise to 150 degrees but can drop swiftly to the freezing point or below at night; the air as well as the soil is often bone dry. When rain does fall, it often comes in torrents, and much of it runs off swiftly instead of sinking into the ground.

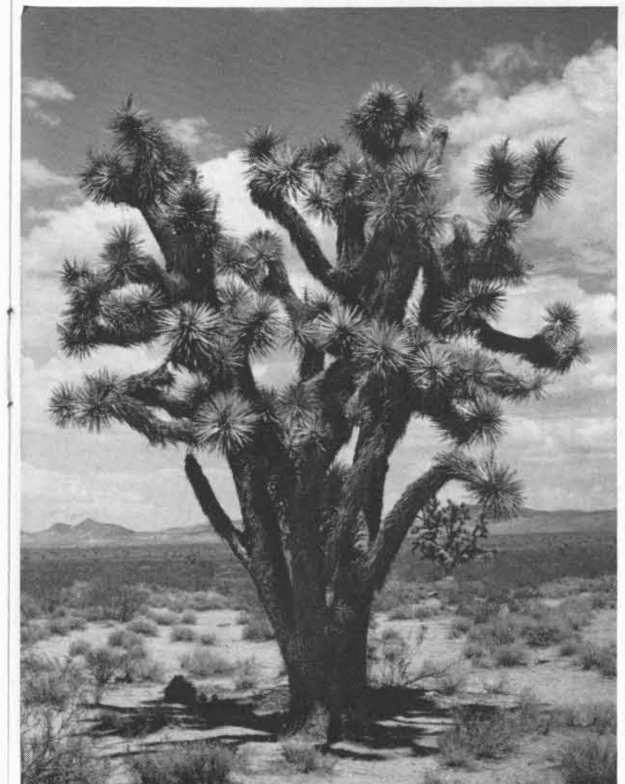
Cacti and other succulents, such as the agaves and the aloes, brilliantly solve the problem of growing where the rainfall is low but where there are occasional heavy showers. Cacti, which are native to the southwestern United States and Mexico, have no leaves, except for a few which have tiny leaves for a short time during the year. Their stems do the job which leaves perform for other plants. Thick and pulpy, the stems are first-class water reservoirs—a cactus is about 90 per cent water. But large reservoirs are not much use unless the plants can fill them during a quick run-off of water. Most cacti have very extensive root systems. A tiny *barrel* cactus, only five inches high may have lateral roots *four or five feet* long. This far-ranging root system is typical of most of the hardy trees that live in lands where water is scarce. The desert eucalypti of Australia, standing only as tall as a man, may have root systems extending a quarter mile. These great networks of roots, mostly close to the surface, enable the cactus and other desert plants to soak up quickly any water that reaches them.

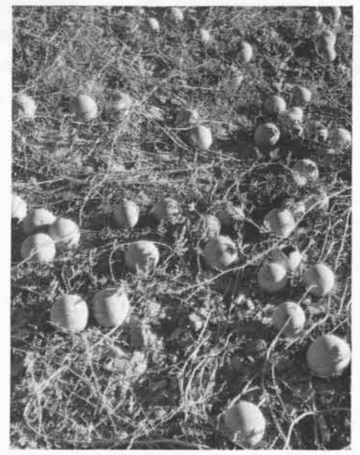
Because the cactus has no leaves, it can better conserve water it has stored. With their enormous leaf surface, oak and beech trees lose hundreds of gallons of water through evaporation on a hot day. But a barrel cactus weighing 200 pounds may only expose a total surface of 10 square feet. Cacti, too, have thickened, tough skins with a waxy covering to guard against excessive evaporation. Moreover, they have fewer breathing pores than other plants, and these are sunken into the skin to form a cushion of still air that retards loss of moisture.

Hardy because they can sit out the longest of droughts, cacti are among the slowest-growing and longest-living forms of life. One of the barrel cacti of Central America grows from six to nine feet tall, three to four feet in diameter, weighs over two tons and lives for a thousand years. A cactus of this family, a *bisnaga*, at the University of Arizona is just over two feet tall although it was planted more than 40 years ago.

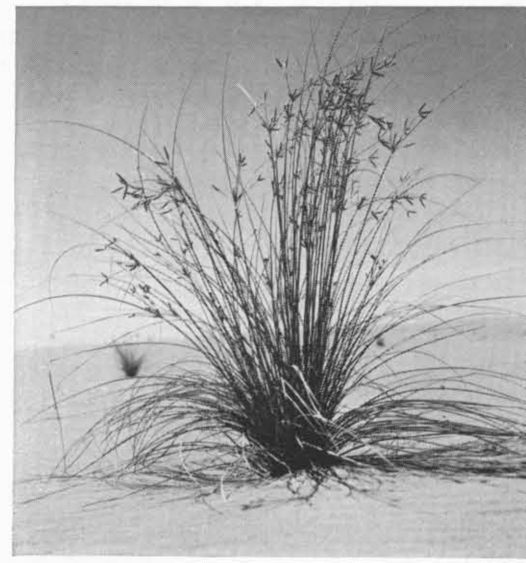
The largest and most spectacular of the cactus family is the *saguaro*—the "sage of the desert." This giant cactus, whose fluted columns may soar 40 feet or more, is a spiny fortress of the desert for hawks that build their nests in the forks and for woodpeckers and owls that make nests in holes in the fluted stems.

Cacti and other succulents do not grow in deserts from choice. Many American and African deserts were at one time great lakes surrounded by jungles of water-loving





Even camels avoid hundhal, known as the "bitter fruit of the desert."

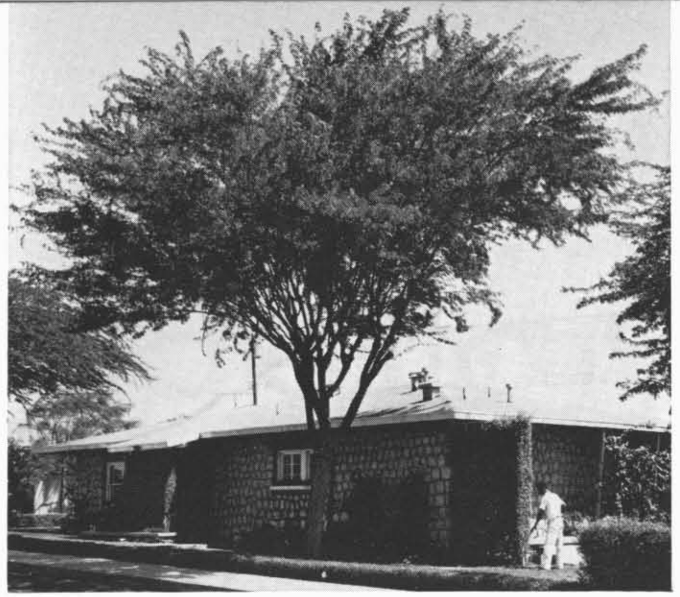


Some plants, such as sedge, grow even in the harsh environment of the Rub' al-Khali in Saudi Arabia.

At far left, date palms in Saudi Arabia prove that sun and sand are not handicaps to hardy trees. Left, a Joshua tree flourishes in the Mohave Desert, western United States.

King of the cactus family is the saguaro, shown here in Arizona. Saguaros, with fluted limbs, sometimes reach a height of 40 feet.

On the Arabian peninsula stubborn camel grass clings to the sand and, with the aid of a far-ranging root system, soaks up enough water to survive.



The home of an Aramco employee in Saudi Arabia is graced by a shade-giving acacia tree, native to the Arabian Peninsula.

Popular frangipani plant is often cultivated in Saudi Arabia as "home" plant. In India the frangipani grows to tree size.

plants. When the climate changed and the lakes dried up, most plants were unable to survive, but others like the adaptable cactus dispensed with leaves and developed special talents to meet the changed conditions. Many cacti still flourish in wet conditions; some grow even in cold climates and survive winter snow.

The most famous of the cacti are the prickly pears or opuntias. They have been exported to many parts of the world including Australia, North Africa and the northern Mediterranean. In Australia the prickly pear quickly overran millions of acres of grazing land and was only finally controlled when the cactoblastis insect was imported from North America.

Among the cacti is one that has no spines and relies on protective coloring, much as a stick-insect does; this is the living rock cactus of Mexico and southern Texas, with its grey warty and triangular projections.

Many cacti have very large and beautiful flowers. Some, such as the famous Mexican *Queen of the Night,* open at sunset, but by morning are faded and dead-appearing. The plant which looks like a mass of dead twigs all the year bursts into colorful display with great white flowers six inches and sometimes a foot long. Near Tucson the night-blooming *selenicereus* explodes into fragrant glory about June 15 each year. It is still the custom in some old Spanish-American homes to invite friends for a fiesta when *La Reina de la Noche* blooms.

Among the more bizarre members of the lily family are the thirty kinds of yuccas, native to arid regions of Mexico, the West Indies and the United States. Some of the yuccas are Spanish daggers, desert candles and the Joshua trees. Desert candles in bloom are a magnificent sight; from the porcupine-like rosettes of basal narrow leaves rise the strong flowering stalks crowned with an immense cluster of creamy-white flowers. No plant is more dramatic than the Joshua tree which grows to 40 feet tall with an irregular head of bent and twisted branches, covered with short stiff narrow leaves. The Mormons gave the trees this name when crossing the California deserts on their way to Utah because its outflung branches looked like the arms of Joshua pointing the way out of the wilderness.

Agaves, whose basal rosettes twist into giant spine-tipped and serpentine curves, are natives of the deserts of Mexico and California but have migrated with man's help to many parts of the world. They grow so profusely all along the Riviera coast that they're considered natives there. Agaves are popularly called century plants because they flower infrequently. They produce a flowering stalk 20 feet tall once every 20 or 30 years and sometimes die afterwards.

In Africa and Asia, too, other plants that had been water-lovers adapted themselves to change and developed into the euphorbias (or spurges) and mesembryanthemums. (This last Greek-derived name means "mid-day flower" because of the habit of opening only in sunshine.)

Euphorbias are cactus-like succulents of the arid regions of Africa and the Arabian Peninsula. One of the most famous and most prickly is popularly known as the Crown of Thorns. Unfortunately for the legend, it does not grow in Jordan but is a native of Madagascar, where it is known by the impressive name of Soongo Soongo. Euphorbias are perfect examples of convergent evolution—two quite unrelated groups of plants gradually came to look alike after long exposure to the same environment. Many of the euphorbias resemble cactus so closely that laymen confuse them.

Mesembryanthemums are tough, sturdy African plants which are very popular in gardens because of a brilliant range of daisy-like flowers. Among the family are some very unusual spineless ones which mimic pebbles and stones. These plants, called split rock, stone faces and flowering quartz blend so well with their backgrounds that it is almost impossible to see them unless they are in bloom. Some have mottled patterns resembling lichen. Other unusual members of this family are the window plants which grow embedded in rocks with only their flat tops exposed to the sun; these surfaces have translucent membranes that filter the hot sun just as windows do. In some of the African deserts these plants may get no water for years other than the night dew.

Aloes, those other king-sized members of the lily family, are mainly African plants and are most abundant in the Cape area. Some grow on the Arabian Peninsula where their white, yellow and red clusters of tubular flowers on tall stalks growing out of rosettes of thick succulent leaves bring a sudden beauty to dry areas.

In all the arid and semi-arid regions of the world are lovely wild flowers whose seeds or bulbs lie dormant, often for years when no rain falls. Within a few days or weeks of rain, the dry lands explode into masses of vivid color.

Trees, too, have developed special talents to survive in desertlands. Like the cactus and other succulents, they, too, have water reservoirs in their trunks or in their vast boles below the ground. The most stoical desert trees have sparse, leathery or spiky foliage or even dispense with leaves completely, as the cacti do. Many are protected by thorns. In the most inhospitable areas of the American Southwest, the spiny mesquite or screw bean survives—even in Death Valley. In the waterless places of Arabia the *nibq* (also called the *'ilb, sidr,* or *ber*), struggles against adversity where the dates cannot grow "with their feet in water and their heads in the fires of heaven," and produces a fruit, the *dom,* so profusely that passers-by are allowed to shake the small berries from the branches. Even in Saudi Arabia's Empty Quarter, a Texas-sized desert, H. St. John B. Philby in 1932 observed almost fifty species of trees and shrubs, including four species of acacia, which the Bedouin called *salam,* and the sturdy tamarisk.

In the production of desert trees, nature seems sometimes to have been experimenting with the truly strange. No plant is weirder than the tree that isn't a tree of the Mossamedes Desert of Angola (South West Africa). This tree with the awesome scientific name of *Welwitschia Bainesii* grows *sideways,* instead of up, and often goes 10 years without a single drop of rain. Looking like a foot-high, round table, the tree stops growing upward when it produces its first pair of leaves! It then grows sideways and increases its diameter until its circumference may be as much as 14 ft. The sideways-growing tree has no immediate relatives, living or fossil, and lives for a thousand years!

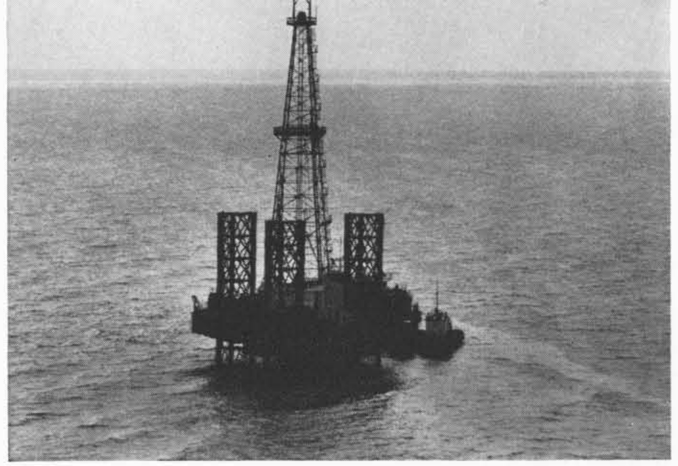
The desert plants are indeed nature's triumph of stoical endurance and bold opportunism. The plants may have to wait somnolent during years of drought; when rain comes they leap into frenzied life, flower, propagate and store up water in a great burst of energy. They combine the talents of the marathon runner and the sprinter! ■

Part of Aramco oil exploration team pauses in the Rub' al-Khali, where even moving sand "mountains" 400 feet tall cannot discourage plants.

Manifa: Profile of a Decision

Before Aramco decides to develop a new oil field in Saudi Arabia, scores of questions must be asked—and answered

Arthur Bolles (standing) checks equation calculations run through computer in Aramco's Data Processing Center. Console operator is Edward O'Mara.



Offshore drilling is much more expensive than drilling on land.

IN THE LIFE SPAN of an oil field in Saudi Arabia there are usually four major phases: exploration; wildcatting and delineation; production and development; and, when necessary, pressure maintenance.

This story is an account of the complex – and costly – events that take place from the time a new oil field is discovered to the moment the field goes onstream as a component of world oil production.

The events to be recounted here would have little meaning, however, were they left to stand simply as an isolated, though ingenious, exercise in engineering and economic analysis. They require a backdrop against which their larger significance can be plainly seen.

The first phase in the life of a Saudi Arab oil field is, of course, the search by the Arabian American Oil Company above and below ground for geological features that indicate the possible presence of oil.

The next phase begins with the decision to drill the first well, known as a wildcat, on the prospective structure. If the wildcat turns up oil in commercial quantity, it is thereafter called a discovery well in a new field. This shift of phraseology reflects the progress from risk to routine that, hopefully, characterizes the development of an oil field.

After the discovery well has been completed, other wells are drilled to delineate, or define, the limits of the field. Subsurface logs, recordings of measurements of various physical properties of the formations encountered in drilling the wells, are used extensively in this delineation. In addition, the crude oil from the field and rock that makes up the reservoir are analyzed. The reservoir pressure is determined, and preliminary predictions of the field's pressure-production behavior are made.

A target date for commencing the daily production of crude oil must then be set. Once this date is established, oil handling facilities are designed, fabricated and installed, and additional production wells are drilled. The field is then ready for continuous, round-the-clock production and for further development.

Finally, at some future date the reservoir pressure (the force that drives the oil to the surface) may decline to the point where gas or water injection techniques will be needed to maintain production.

Each phase in the life of an oil field in Saudi Arabia begins with a decision by Aramco management. Each of these decisions commits the company to spend a very large sum of money, often many millions of dollars. There is an overriding factor that links, and governs, these decisions: the economics of world petroleum with its endless permutations in supply and demand.

The distant but profound effect of changing market conditions, for example, in the Far East or in Western Europe, is reflected in the time lag between the discovery of a new field in Saudi Arabia and the beginning of daily production from that field. There may be only a short lag to allow facilities to be built, or the gap may be three, five, or six years, as in the case of various Arabian fields.

This variation in the production timetable is obviously not a matter of technical problems alone. To put a very complex matter in the simplest possible terms, there is a *right* time to bring in an oil field. And, to continue this simplified thought, the right time is when the market demands the particular type of crude oil the field produces, and in a volume that will consume the field's production. *Any other time is the wrong time.* There is more than abundant opportunity to make wrong decisions.

The decision to bring in an oil field is complicated by many factors, for the market is not nearly as simple as may have just been suggested. Actually, an elaborate structure of competition rises above the classic underpinning of supply and demand.

Today, competition in the free world oil markets by private companies, nations and even blocs of nations tends to become increasingly severe. For example, Russia has introduced into the market a complicated barter system under which "profit" is merely a component of political strategy. Operating from the home base of a controlled economy in which each element is the servant of political expediency, Russia is free to apply extraordinary competitive pressures abroad. She can, in effect, sell her oil at below "cost" and still show a profit on the complicated balance sheet of national economic planning.

In such fashion, competition in the free-world petroleum markets grows more and more rigorous. One consequence for private companies is that any decision to risk millions of dollars for oil field development is now exceedingly involved.

Against this backdrop of world petroleum economics,

Field crew prepares to take pressure measurement deep in oil reservoir. Information is used at Dhahran to aid in predicting reservoir performance.

Manifa: Profile of a Decision

Aramco in 1957 decided to drill a wildcat well – Manifa No. 1 – in the Persian Gulf off Manifa Bay, a natural shallow water harbor about 120 miles northwest of Dhahran. During the following year, Manifa No. 1 became the discovery well of the Manifa field.

Manifa was the second oil field discovered by Aramco in Saudi Arab coastal waters. It has attracted widespread interest among oilmen because Aramco's first offshore discovery, Safaniya, has turned out to be the world's largest underwater field. Safaniya was discovered in 1951 and went into production in 1957, the same year the wildcat was started at Manifa.

The preliminary delineation of Manifa was completed in 1960, and further drilling was temporarily suspended while petroleum engineers proceeded with detailed reservoir studies. Other engineering and economic studies were undertaken to answer many questions such as: Is there a demand for Manifa crude? If not, will there be in the future? What would be the ideal rate of production at Manifa? How many years could the field produce at a given rate before gas or water injection might be needed? How much would it cost to bring in Manifa? Where would it fit in Aramco's long-range growth plans? Can Manifa be tied into any existing facilities, such as pipelines, gas-oil separator plants and crude oil stabilizers?

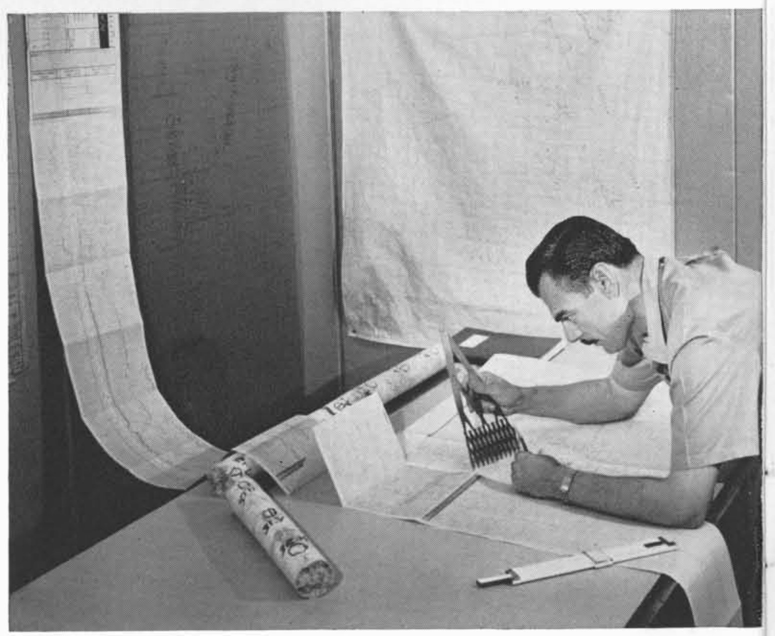
So far in this account Manifa has been considered apart from other Aramco oil field projects. Actually, its development was a "choice among prospects." Other fields in other areas of the Aramco concession were also competing for management's favorable decisions and for the large funds those decisions would require. In the diligent exercise of its responsibilities under the concession agreements, the company had already run a costly risk in wildcatting offshore at Manifa. Despite the increasing precision of geophysical instruments, it still takes a drill bit to find oil, and every wildcat project is guided, at least in part, by human judgment, as well as by science. Also, Aramco had learned several years earlier, when it discovered and developed Safaniya, that an offshore field can cost up to three times as much to get into operation as an onshore field. Thus, Manifa needed to make a compelling claim for the millions of dollars it would need to get into production.

Manifa produces a *sour* crude, so called because it contains hydrogen sulfide, a poisonous, highly corrosive gas which must be removed in a stabilizer before the oil can be pumped into the hold of a tanker.

By the end of 1960, the year drilling was suspended at Manifa, Aramco was already exporting three types of crude oil: *Safaniya Grade,* a sweet crude (one that contains no hydrogen sulfide), produced in the Safaniya field; *Khursaniyah Grade,* a sour crude produced from the Khursaniyah field; and *Arabian Crude,* another sour crude with properties different from the Khursaniyah Grade, and coming from the rest of Aramco's fields. The three types vary in their physical and chemical properties and in product yield. Their range gives Saudi Arabia a unique position and a relative, competitive advantage among the petroleum-exporting nations.

Manifa zone crude proved to be similar to one of the export grades, the crude from Khursaniyah. Both are sour and both yield a high proportion of fuel oil when refined. However, it so happened that in 1958, the year Manifa was discovered, a market had yet to be established for this type of crude. This lack of demand weighed heavily in Aramco's 1960 decision to suspend further drilling operations at Manifa.

In the oil business, though, the market picture is constantly shifting; ups and downs of supply and demand fluctuate continuously. Today's market data, like today's headline, are past history tomorrow morning. One of the reasons Aramco decided to defer placing Manifa on production was that Khursaniyah, which also produces a sour crude with a high fuel oil yield, was being brought into production. This happenstance was to have a significant influence on the future of Manifa. It meant, for one thing, that the oil economists could foresee a rise in future fuel oil consumption.

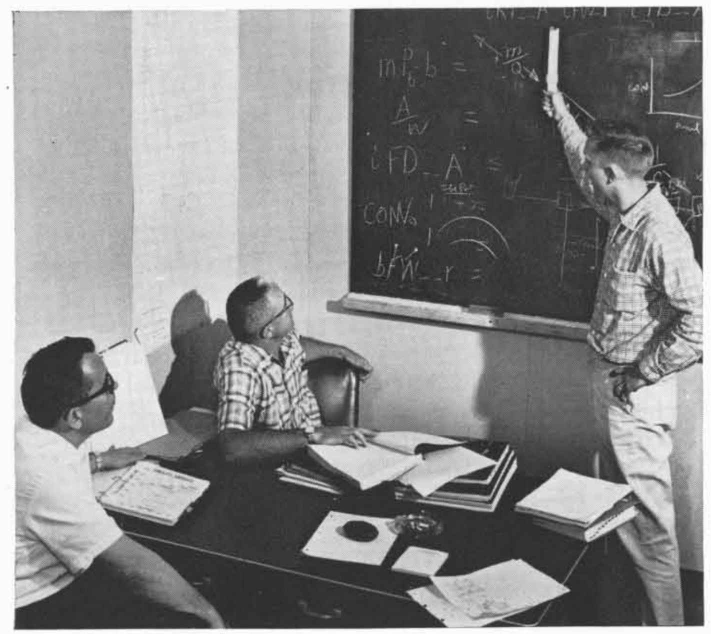


At Dhahran, Aramco geologist R. L. Maby correlates the electrical characteristics of selected rock zones shown in circles on core for use in contouring equal porous intervals on the Manifa field map.

Further, the fact that the crude from the two fields, Khursaniyah and Manifa, could be mixed and shipped through the same pipeline without damage to either favorably weighted Manifa's economics. Manifa could make efficient use of the existing pipeline from Khursaniyah to Aramco's marine terminal at Ras Tanura.

The rising demand for Khursaniyah crude, a trend foreseen by oil economists in 1960, has indeed come about, but at a greater rate of increase than had been predicted. As the demand curved upward, Aramco had to choose between expanding production from Khursaniyah or bringing in another field, such as Manifa, with the same type of crude. In order to expand production from Khursaniyah, Aramco would have had to build additional facilities. And there were other factors requiring study before a decision could be made.

When oilmen who are daily involved in the mathematics of oil field engineering and economics start to point out the many factors that go into decision-making, the non-expert feels, justifiably, that the world will end long before all the possibilities of a given situation can be explored. The outsider seizes a few terms to help serve him as guideposts of understanding.



Some information for computer comes from "brain sessions." Dick Bales discusses a linear equation with other Aramco engineers in research group, including Matt Sladic (left) and Arthur Bolles.

There is, for example, a *right-cost logic* that governs the evolution of an oil field. It seems a simple enough term. However, it embraces in its implications a number of elements: the field itself, the field's facilities, Aramco's projections for *all* the fields in Saudi Arabia and market trends for three, five, and even ten years. Every possible set of variables, or at least a mathematically significant number of them, must be studied.

Fortunately, high-speed computers make it possible to complete a lifetime of hand calculations in a single day. An oil field can thus be "produced" on paper under a number of different sets of conditions. Rates of production, for example, can be altered. Demand figures can be changed. Reservoir pressures can be reduced at different rates. And a range of production costs can be explored.

Out of this succession of computations a moment comes when the per-barrel cost of placing a field on production fits into the framework of *right-cost logic.* This means that the per-barrel development cost of a given field, at a given rate of production, at a given time is in balance with the cash register realities of the market. The time has then come for Aramco management to risk the necessary funds.

At the time Aramco management had to decide about how to meet the demand for more Khursaniyah crude, the engineering and economic studies of Manifa made the advantages of placing the field in production increasingly apparent. Continuing studies showed that Manifa's cost data were beginning to fit within the limits dictated by *right-cost logic.*

Further, Manifa was becoming a more attractive development choice for another reason. The reservoir pressure at Khursaniyah had dropped faster than anticipated in the preliminary predictions of the pressure-production behavior of the field. Since these preliminary predictions are based on a very limited amount of information (one of the reasons why there is a large element of risk in the development of an oil field), it is not unusual for the actual performance of a given field to be different from that predicted in the preliminary estimates.

A more rapid than anticipated pressure decline in Khursaniyah meant two things. The target year for expensive gas or water injection would have to be moved forward. And, the long-range economics of Khursaniyah would have to be adjusted to take into account the capitalization of pressure maintenance at an earlier date than had been predicted. In dollars-and-cents terms, the per-barrel cost of producing Khursaniyah over its life span had risen—and so had Manifa's opportunity.

The decision was made by Aramco management to bring Manifa into production. It was decided that facilities should be designed to handle up to 125,000 barrels of production a day. The company announced its decision in July 1962. It also announced that the new installations will be ready on January 1, 1964, to start the first barrel of oil flowing to Aramco's marine terminal for shipment abroad.

The decision to produce Manifa committed Aramco to an investment of $13 million. ■

ARABIC LANGUAGE, U.S.A.

There was a time, not too long ago, when very few American schools taught a language spoken by over 80 million people

Seventh-graders at St. John's school, Fairview, New Jersey practice writing "I, You, He, She" in Arabic. Unlike English Arabic is written right to left.

On a tour of the United Nations in New York, a group of grade school students from New Jersey met a king from Africa. The king, whose English was perfect, was startled when some of the children greeted him in French. He was even more surprised when one boy spoke to him in Arabic.

"Marhaba," the eighth grader said.

"Marhaba," the king said, returning the Arabic for "hello."

The students were from St. John the Baptist school in Fairview, New Jersey, a grade school that began teaching Arabic to seventh grade pupils last year. Although they are getting an earlier start than most language students, they share a new enthusiasm for learning Arabic which has spread to many educational institutions in the United States.

In the last five years, the enrollment in Arabic language courses has almost doubled. There are currently about 700 Arabic language students in United States colleges and an unknown number in grade schools and high schools that have added programs. Last December, teachers of Arabic met as a professional group for the first time. The growth has been so rapid that the Modern Language Association is making a special survey of Arabic and other previously neglected languages this year.

Students in the Western world became interested in Arabic during the last century — usually for the religious study of Islam. English, French, and German scholars led the way.

But after World War II, students in the United States turned to Arabic. The expansion of United States political and economic interests and the vital position of Middle Eastern countries opened an important international door to student inquiry.

Then, six years ago, when the Russians launched Sputnik, they indirectly prompted American schools toward new efforts in science, mathematics, and language. Some comparisons between the two countries tended to show that the United States was lagging in foreign language instruction. Many language courses were strengthened, but many teachers think that Arabic showed particular gains.

Why did American students turn to Arabic?

To many scholars there's no clear-cut answer. Charles Ferguson, who heads the Modern Language Association's Center for Applied Linguistics, isn't sure why the teaching of Arabic has increased so rapidly in the past few years when "there has not been such an increase in the teaching of Hindi and Portuguese," which are other important but neglected languages.

Like others in the field, Maan Z. Madina, Arabic professor at Columbia University, New York City, agrees that the teaching of Arabic is definitely increasing from year to year because people are more interested in the Middle East from an academic and practical point of view. "On the whole, the impetus for Americans to learn the language comes from government and businesses in the countries. In line with the American position of leadership, it's necessary to have ambassadors who speak the language; and American companies abroad want more people who know the language and customs."

A spokesman for Harvard University, Boston, which has taught Arabic "for some decades now," finds that most students take the language because of the demands of scholarship (to understand Middle Eastern history or literature) or because they want to enter government service or industry in the Middle East.

But what do the students themselves say—why are they studying Arabic when European languages are generally much more popular?

A second-year Arabic language student at Columbia University began studying the language after he spent a summer working in Jordan. An older student returned to Columbia to study Arabic after a successful career as an economist and management consultant. Another second-year student, from California, wants to be an anthropologist, and a junior from New York says he plans to teach Arabic or enter government service.

Arabic courses in the United States also are drawing more foreign students. Enrollment in the language at most universities reads like a small United Nations roster: at the University of Utah, candidates in Arabic come from Afghanistan, Egypt, Japan, and a half dozen other countries.

Takaya Suto, of Japan, an elementary Arabic student at Columbia, is the third man being trained in Arabic by the Japanese Foreign Service. Next year, he will move on to Lebanon for two more years of study before entering the Japanese diplomatic corps.

Another first year foreign student, Francis Botchway, of Ghana, intends to work in Islamic jurisprudence when he finishes his studies.

Although the students' background and motivation range widely, one trait is common to most: they are serious students. A few try Arabic out of curiosity, but soon drop out. Professor Madina admits that in his elementary course "the rate of fatality is often high" and only the most promising students survive.

Because the vocabulary is vast, the syntax unlike anything the Westerner has seen, and the accent and sounds, especially guttural sounds, are difficult, students often must work