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Mrs. Clarence E. May, Sr.
45 Mechanic St.
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FABRIC FROM THE PAST

THERE'S NO DOUBT that primitive mankind first trod the world without the benefit of clothing. Historians suggest that thousands, perhaps millions of years passed before animal skins became fashionable. Then, sometime in the dim past, man discovered that the hair of certain animals pressed together stayed together. The fabric known as felt replaced animal skins. No one knows the age of felt—only that it was in use long before Neolithic man learned how to weave cloth a mere 12,000 years ago.

The manufacture of felt is simple. Under a microscope, the hair of many animals appears as a barbed strand, the barbs all pointing toward the tip of the hair. When a number of hairs are pressed together, those which lie in opposite directions interlock barbs and resist efforts to pull them apart.

Legend has it that St. Clement (patron saint of felt makers) discovered felt when, at the beginning of a long journey, he put carded wool between his feet and the soles of his sandals. When he reached his destination, he found no carded wool in his sandals. The wool had been compressed into felt.

It is certain, however, that felt was around long before the Christian era. Because the nomadic tribes of central and northern Asia still make felt today for basic shelter, in the same way as their ancestors of thousands of years ago, it is possible that felt's first use occurred there. And certainly the Bedouins of Arabia and the herdsmen of Tibet were covering themselves and constructing tents of felt centuries before St. Clement.

The first Greek mention of the fabric occurs in the *Iliad,* when Homer relates that Odysseus wore a helmet of hide, lined with felt. Male Greeks and Romans of all ages wore skull caps of felt. In fact, so popular was the fabric that among the ruins of Pompeii is a complete workshop for making felt hats and gloves.

Among Roman citizens, the conical felt cap was a status symbol. When a laborer obtained his freedom, he shaved his head and put on the *pileus,* or cap, of undyed felt. Caesar put felt to more practical use. His legions, harried by Pompey's archers in a civil war, were instructed to wear breastplates of felt and to cover their tall raiding towers with a protective layer of the fabric. Far away in India felt was transformed into the richly embroidered Numdah rugs as an improvement over the coarse straw mats found in man's early dwellings.

Felt was again introduced to Europe centuries after the decline of Greece and Rome. Returning crusaders brought back reports of beautiful Arab tents made of felt, and Marco Polo, returning to Venice after 26 years in the land of Kublai Khan, reported to thirteenth-century Europe the many ways in which the Mongols used felt. Similarly, Ibn Batutta, the famous Arab traveler of the fourteenth century, journeyed to Sarai, ancient capital of the Golden Horde, and described their four-wheeled, felt-covered carts in a manuscript that was translated by European scholars.

The same properties of felt that prompted nomadic herdsmen to use it for shelter against heat and cold make the venerable fabric valuable today as weatherstripping for homes and cars and heat insulators for airplanes. The piano would not have its pleasant tonal quality if someone in the 1740's had not thought to replace the leather on its hammers with felt. And, of course, people of many nations favor felt as hat material.

Countless other industries employ felt, often in inconspicuous ways. Intravenous feeding, for example, is aided by two dramatic properties of felt—porosity and capillary attraction. A tiny sterilized felt washer, placed in the neck of a bottle, acts as a filter that pumps air but retains the saline solution which presses against its inner surface. Control of the intravenous feeding rate was adjusted by hand until several years ago when a Detroit doctor discovered that felt could do the job.

Each year some 30 million pounds of fiber go into the production of felt, proof enough that this fabric from the Stone Age has found its place in the Space Age. ■

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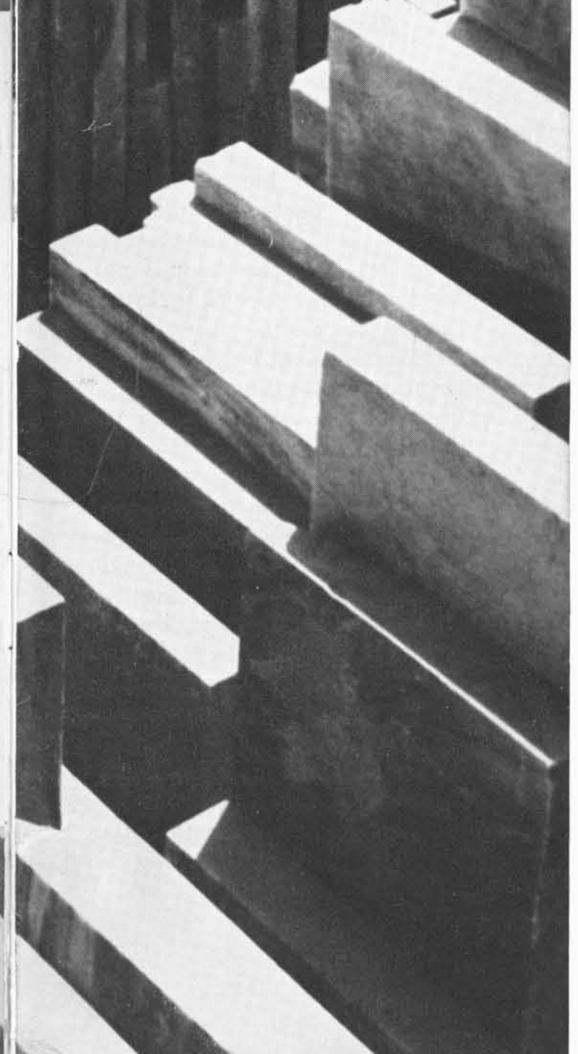
NOVEMBER 1962

FRIENDS



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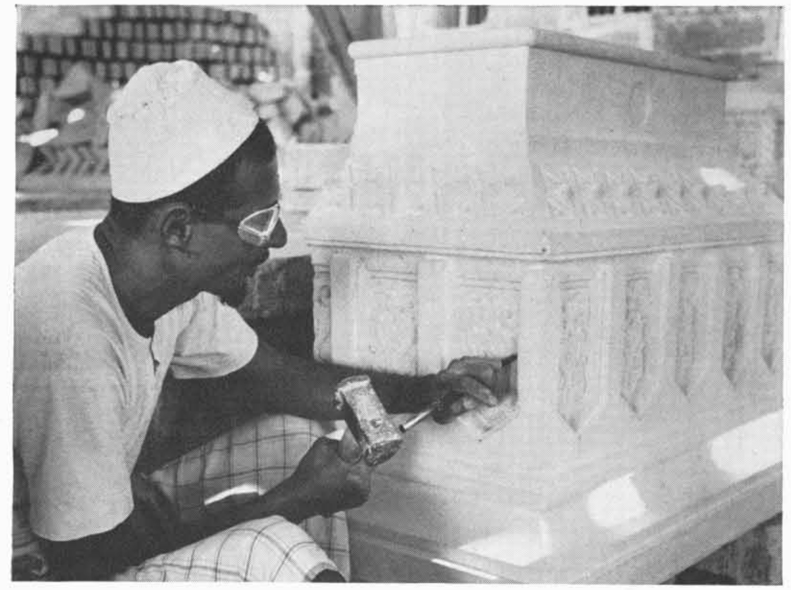


Decorative base of cast marble undergoes refining touches after removal from mold. At left, marble panels in storeyard await further cutting and polishing.

Marble for Mecca

In the Saudi Arabian Red Sea port of Jiddah, the hands of the marblecutters fashion some of the most beautiful stonework in the world

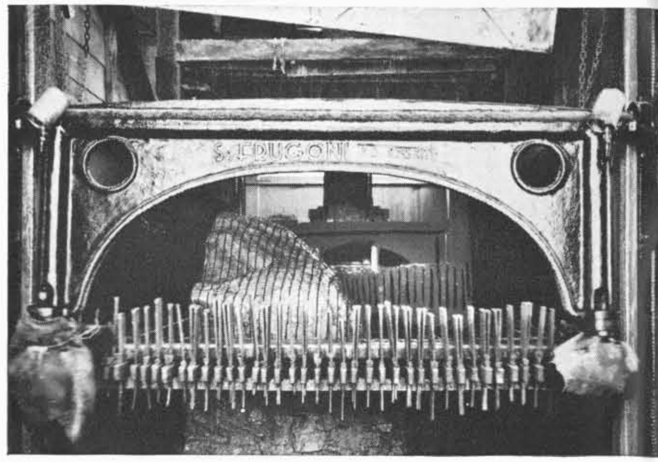
One afternoon during the first week of May this year two widely contrasting vehicles sped past each other on the highway between Jiddah and Mecca. Their missions were different, but curiously linked. One, a big red bus filled with Muslim pilgrims, rolled on toward Mecca, the Holy City of Islam. The other, a blunt-nosed ex-military truck altered for its peacetime role, lumbered cautiously into the seaport city of Jiddah to a large marble factory of considerable renown in Saudi Arabia.

The variety of pilgrim luggage roped to the top of the bus made clear the scattered provenance of those making the spiritual journey. Shortly they would enter the Sacred Mosque in Mecca. There they would look upon the increasing, but still incomplete, beauty of a vast reconstruction project initiated six years ago by King Sa'ud. On all sides they would see the gleaming surfaces of new marble pillars, gateways and wall facings, and the decorative beauty of arabesque panels incorporating in the cursive flow of Arab calligraphy the name *Allah*.

As the bus neared Mecca, the truck, its air brakes hissing in short bursts, pulled into the plant yard of the marble factory. It was a strange

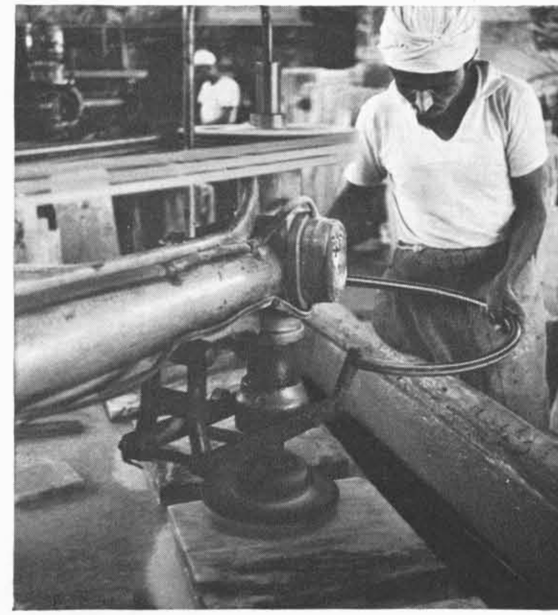
Blast-loosened marble boulders are rough-cut at quarry by wire ropes, giving flat surface seen at left of boulder. Wires, aided by water and sand, cut at a rate of two to three feet a day.

Mahmud ibn Khadra, director of the Marble Factory, coordinates the 300 employees who work at plant or one of the company's three quarries.



Steel blades of slicing equipment gradually cut through marble so that the boulder is reduced to thin slabs.

Saudi Arabian marble is extremely hard, but slabs are cut into smaller sizes by tough carborundum-edged wheels.



High gloss of finished marble is obtained by hand-guiding a polishing wheel over slab.

sight. The cab stood high in the air, covered only by a weathered khaki canvas top. American soldiers who had served in North Africa or with the Persian Gulf Command during World War II might have recognized its workaday silhouette. However, they would have been puzzled by the odd girdered cargo bed that had replaced its original body. Parallel I-beams ran the length of the frame behind the cab. This floor held another set of shorter I-beam sections which ran crosswise. The extraordinary structure carried a gigantic rock, whitish, nondescript and roughhewn, weighing about 13 tons. Hence the caution of the truck as it moved slowly along the highway and through city traffic.

The huge rock stood higher than the men who arranged the wire rope sling that permitted the factory's 25-ton crane to hoist it from the truck. Seen in its unprocessed form sitting in the plant yard near the battery of "saws" – attrition cutters – that would soon slice it into rough vertical slabs, the great stone gave no evidence of the handsomely veined and gleamingly polished panels of marble that would emerge from its indifferent mass.

When it was unloaded at the Marble Factory, as the company is formally known, the boulder succeeded to its place in a long procession of similar monoliths, most of which have yielded marble for the Great Mosque in Medina and more recently for the Sacred Mosque in Mecca. Thus the greater part of the production of this Saudi Arab enterprise has been put to religious use.

The plant and its nearby quarries went into operation only 12 years ago. The founder-owner of the factory is Muhammad ibn Ladin, a well-known businessman in Saudi Arabia whose enterprises have included large construction and highway projects, as well as manufacturing. A visitor to Jiddah in search of ibn Ladin may be hard put to track him down. Not long ago a caller tried to find him at his office at the Marble Factory. Ibn Ladin was not there, but the visitor learned that if he had been, he would have been working outside under an arbor fronting the low office building because he does not like to be confined indoors. Next the caller tried ibn Ladin's main office in downtown Jiddah. Again no luck. He then ran into a friend along King 'Abd al-'Aziz Street. It turned out that ibn Ladin was out near Tayif actively supervising a highway construction project from a tent he uses as field headquarters. An effort to contact him there revealed that he had left in the light plane he uses to get about quickly. By the end of the day it was finally learned that he had gone to Mecca to supervise some emergency street resurfacing preparatory to the influx of several hundred thousand Muslims making the *hajj* (annual pilgrimage).

It was obvious to the frustrated visitor that Muhammad ibn Ladin is an energetic businessman who enjoys being in the center of things. A story is told that years ago, when he was a foreman on a construction project for the late King 'Abd al-'Aziz, ibn Ladin demonstrated his ingenuity and devotion to the King in a daring manner. He proposed that a ramp be constructed to the second floor of the palace then under construction so that the King could drive up in his car and avoid a climb made painful by the lameness of his later years. The palace was being built of traditional mud-base material.

Some protested that the plan was dangerous, that the mud ramp would never hold the King's car. Ibn Ladin built the ramp, and when it was finished he drove the King's car to the top himself. Anyone who enjoys the lore of American business will recognize in this scene the image of John Gates standing behind a wire fence stretched across a Beaumont street as a herd of cattle was driven toward him. The fence held and the skeptical Texas cattlemen, so the story goes, gathered around Gates, later known as "Bet-a-Million," and helped him toward his fortune with huge orders for the formerly suspect wire fence.

One other aspect of ibn Ladin's marble enterprise that the American business observer would quickly recognize in the hustle and noise of the plant is a touch of showmanship. Against one wall, Mahmud ibn Khadra, director of the factory, has set up a display consisting of a section of a wall as it might appear inside the Sacred Mosque, with enormous pillar bases and plinths in place, a massive detail from the pediment of an entranceway and part of one of the exterior columns. Thus the non-Muslim who is forbidden access to the Holy City of Mecca can examine the imposing beauty of King Sa'ud's reconstruction project, the largest undertaking of contemporary religious architecture in the Muslim world.

In order to meet a deadline which is still about three years away, the plant works around the clock. The huge raw rocks are hoisted by the yard crane onto trolley pallets which can be pushed along a rail to a position in front of the cutters. The rocks are cemented to the flooring of the pallet to secure them during cutting. The multibladed cutters, or "saws" as they are sometimes called, stand 14 feet high. Ten such saws cut 24 hours a day. Two more are currently idle, in the process of being converted to work the extremely hard Saudi Arabian marble.

The rough cutting process takes eight to ten days for each rock. First the magazine of cutting blades is raised to permit the trolley pallet to be pushed into position. Then an overhead moving sprinkler bathes the boulder, and the long cutting blades are lowered onto its topmost part. The blades rock back and forth like a shuttle. The bath of water and sand floods into the narrow grooves made by the blades. It is the attrition of the blade riding on the film of the sand-water mix that cuts into the hard, raw marble. The muddy-looking water flows off through a drain network into an underground sump where the sand particles settle out. The water is then re-used, and each day 4,000 gallons of make-up water are added to the system. New sand is added, for during the cutting the sand is worn smooth and loses its abrasive quality.

The blades last about 20 to 25 days, and each month five tons of new blades are installed in the multiblade saws. The blades are four meters long on some of the saws and five on others. As the blades slowly cut down into the rock, wooden wedges are driven into the tops and sides of the grooves to prevent binding and facilitate the flow of the sand-water mix. Most of the equipment in the plant is of Italian manufacture, and nine Italian marble artisans supervise and train Saudi Arab and other workers.

There are now 294 employees on the Marble Factory payroll, either in the plant or at the three quarries at Farasan, Madrakah and the Wadi Fatima. It is believed that this is one of the five largest regular private payrolls in Saudi Arabia, other than that of the Arabian American Oil Company far across the Kingdom in the Eastern Province.

Many of the Saudi Arab employees have become skilled marble workers. After the raw boulder has been cut into large slabs, which may vary in thickness from two to 27 centimeters, workers break the slabs away from the cement footing that underlay the boulder and held it during the rough cutting. These big work slabs are then sized and formed by rotary carborundum wheels that look like circular saws. The "tire" of the carborundum cutter is pressure-cast on circular metal blanks in the plant. The shaping of the marble slabs into finished forms is based upon hundreds of templates, many of which have been memorized by the cutter operators.

After the marble has been rough cut and formed, it is then polished in a series of four steps. The polishing wheels last from one to five days depending upon the hardness of the marble. Saudi Arabian marble is much harder than the famous Carrara marble of northern Italy, a characteristic that makes it an excellent material for exposure to the elements. The beauty of Arabian marble as compared with Carrara marble is a subject that stirs a range of controversy. Ibn Khadra happily testifies to the superiority of his marble:

"It is more beautiful than Italian marble," he says. "We import some Carrara marble and it is lovely, but Arabian marble is harder and even more beautiful. You know, even the Italians bring in marble from France for the best trim pieces. And here we have a great variety of coloring in the stone. There is black marble and white and a reddish marble and one that is a cream color. Then there is the veined marble in grey, green and pink."

On his desk ibn Khadra keeps small unpolished samples of the various types of marble the factory has processed. One type had to be abandoned because the presence of metal in the stone ruined the cutter blades. Seeing the samples raises the question, how did Muhammad ibn Ladin find the quarries that supply his plant? Using the nine-year-old quarry in the Wadi Fatima as a case in point, the answer is simple. He sent word to the Bedouins of the Mu'abbad tribe that he was looking for specimens of marble. In a short time samples began to come in from the mountains east of Jiddah. Ibn Ladin then selected the

No marble is wasted. Residue from cutting and finishing operations is crushed, mixed with binder, then poured into mold to make cast marble. At right, craftsmen inspect finished panel after removal from mold.

mountains that appeared to have the greatest potential yield and bought them from the Government.

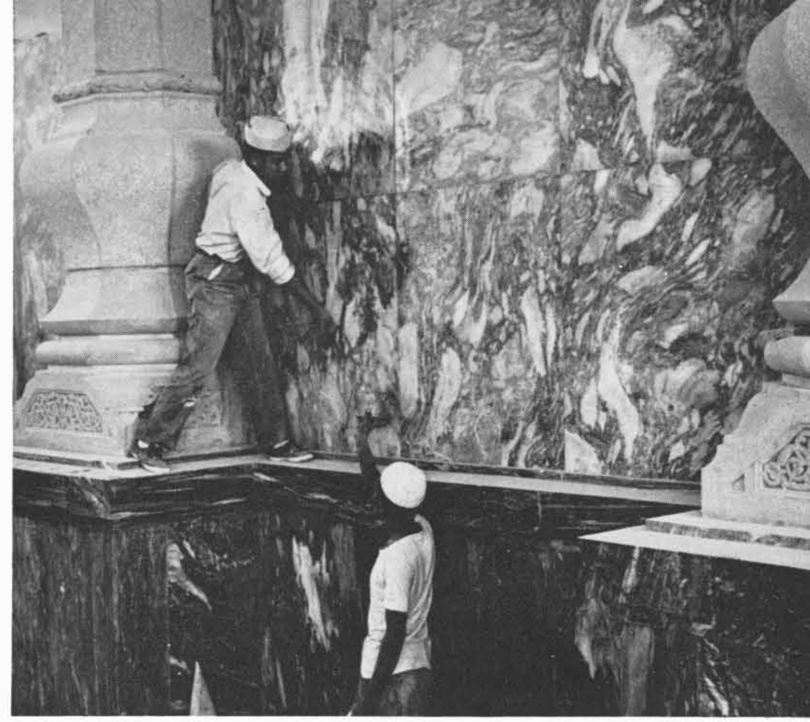
The quarry in the Wadi Fatima is on the slopes of a cul-de-sac about 60 kilometers from the road between Jiddah and Mecca. The highway turnoff is about ten minutes past the 'Um 'a-Salam police station. A track then leads through fine sand, coarse-sand washes (from which the sand is taken for the cutting operations at the plant), stretches of shard-like rocks, patches of rounded boulders with igneous fragments intermixed, long traverses of open ground, old and modern villages and farms to the quarry.

In the intense summer heat of the *wadi* (valley) the eye is deceived by the seeming movement of distant mountains swathed in haze. The further ranges appear to be cut from cardboard. Each has its own configurations and separate planes of light. Except for scattered shrubs exemplifying the hardiness of nature, the mountains are bare. Some gleam with igneous streaks suggesting the presence of iron and prehistoric geological convulsions. Suddenly the track turns into a small village and schoolboys run by, their briefcases balanced on their heads. They race toward the houses of the village. At another point a fat scarecrow sits watchfully in the sun not far from a group of circular thatch houses that rise to pointed roofs. The Wadi Fatima is a microcosm of quiet Arab folklife mixed congenially with the pulse of the new, as illustrated by the site of a consolidated municipal center now under construction which will house hospital and police services and a school. A radio antenna rises like a fragile twig from a seemingly abandoned mud building near a long mound that covers the aqueduct carrying the Jiddah municipal water supply from the upper reaches of the Wadi Fatima. From time to time this quiet world witnesses the slow passage of a boulder-laden truck on its way to the city.

At the far end of the wadi the eight-hour day is a reminder of the impact of industrial organization on older ways. There, 21 men using compressed air drills and explosives fracture the craggy jebels into boulders that can be dragged by tractor and cable down the slopes. The explosives slowly level the jebel. There are no open pits of the type familar in the United States.

When the boulders have been dragged down to the sandy floor of the wadi, a wire rope cutting rig is set up around each great stone which is then trimmed for transport. The thin wire rope, about three-eighths of an inch in diameter, passes through a series of pulley wheels and across the top of the boulder where it meets with a sand-water mix and slowly cuts its way downward. The wire rope then crosses and recrosses the wadi from jebel to jebel and is thus air-cooled. The cutter makes about two to three feet a day. When the rock is trimmed to a size the truck can carry, it is hoisted into place by a crane.

Each afternoon at five o'clock all the men assemble at the open end of the cul-de-sac. Roll is called. Then the explosives are set off to loosen a new batch of marble boulders. Smaller rock fragments that cannot be cut into



At the Jiddah plant a mock-up containing both cast and polished marble gives a hint of magnitude of work being done at Mecca.

slabs are gathered up and shipped to a crushing mill at the plant in Jiddah. There they are ground into carefully graded pellets along with the waste from the cutting operations of the plant. This material is mixed with a binding agent and poured into a variety of molds for decorative panels. The plant now uses some 800 molds, the patterns for which were created by a master of the art from Carrara.

As the trucks bringing the raw marble boulders from the Wadi Fatima roll along the Mecca road, it is probable that they pass near ancient quarries. The yield of the old quarries was undoubtedly microscopic compared to the tremendous volumes used by the Jiddah Marble Factory in the reconstruction of the Sacred Mosque at Mecca. The magnitude of this project can be seen in some of the production data. About 700 square meters of wall panel are cut and polished each month and about 2,000 square meters of floor sections are processed. The plant will process some 14,400 square meters of wall panels before the project at Mecca is completed. The walls of the Sacred Mosque are 18 meters high and their total span, inside and out exclusive of the great gates, is about 800 meters. Before the reconstruction project is completed, ibn Ladin's Marble Factory will have processed an estimated quarter of a million square meters of marble. For the time being, the Marble Factory is turning down all requests for marble to be used in commercial buildings or homes. Not for another three years will ibn Ladin have to assess the potential of the Saudi Arabian and export market for the marble in the mountains behind Jiddah. Being a highly resourceful man, he may already have plans for the day when work on the Sacred Mosque at Mecca comes to an end. Meantime, his World War II surplus trucks slowly wend their way through the Wadi Fatima day after day, and his batteries of multiblade cutters grind through the raw marble boulders night after night. ■

FRICTION a riddle in resistance

When a meteorite flashes into the earth's atmosphere, why does it flare up? What holds a nail in a board? How is a railroad embankment held up? Why does a match work?

Any scientist might answer these questions with a single word: friction. Despite its familiarity, men have spent centuries trying to unlock the secrets of friction. Researchers are still probing the effects friction produces to answer their own questions: how to get along in spite of friction; how to put it to work; how to overcome it.

It is not at all surprising that the first known definition of friction was set down by master-of-all-trades Leonardo da Vinci. Da Vinci observed that "the friction made by the same weight will be of equal resistance although the contact may be of different breadths and lengths" and that "friction produces double the amount of effort if the weight be doubled."

But long before the Italian genius, men were grappling with the effects of friction. As early as the eleventh century men reasoned that if a machine could be invented which would operate entirely on its own power, they would have, in effect, a "perpetual motion" machine, one that would defeat the effects of friction. Such a machine, in which the output would equal the input, would be a triumph equivalent to finding the philosopher's stone that would transmute base metal into gold.

One of the earliest recorded attempts to defeat friction was a perpetual motion wheel devised by Wilars de Honnecourt, a thirteenth century architect. His invention employed weights which descended on one side of a wheel and at the same time hoisted weights on the opposite side, up and over the midpoint of the wheel, where they in turn became the descending weights. Theoretically, the wheel, once started, was supposed to turn forever without help from an outside power. Friction, however, predetermined the wheel's failure.

The failure of de Honnecourt's wheel – and thousands more just like it – did not discourage inventors. The impossibility of perpetual motion on mathematical and mechanical grounds was completely ignored, and hardly a year passed without a scientist somewhere putting together a strange looking contraption that, in the end, as one exasperated inventor put it, "will not go even though I have labored over it the past twelve months."

It was not until the seventeenth century when the physical sciences had evolved to a point where the idea of perpetual motion ceased to be a logical possibility that the claims of inventors for it began to disappear. The development of the laws of friction, along with the doctrine of the conservation of energy, lead to more practical considerations in physics and mechanics.

Da Vinci's ideas about friction remained buried in his notebooks for some 200 years, until a French engineer, Amontons, reformulated them. Then, in 1781, C. A. Coulomb verified Amontons' observations in the laboratory and stated them in the form of the laws of friction as they are known today. The laws are quite simple. The two principle laws have been only slightly modified since Coulomb first proposed them.

The first of these laws states that the friction is independent of the area of the solids. If, for example, a book is pulled along a table the frictional force is the same whether the book is lying flat or standing on its end. The second law states that the friction is proportional to the load between the two surfaces. If, to use the same example, the load is doubled by placing a second book on top of the first, the force required to cause sliding is twice as great.

Examples of sliding friction at work are represented by countless phenomena in everyday life. Walking, the nails in the walls of houses, automobile brakes, earthworks for railroad embankments, etc. To state the matter in reverse, such things as matches, nails, and screws would be useless were it not for the existence of sliding friction.

Coulomb concluded that the nature of friction might depend on the *interlocking* of surface irregularities, and the "drag" we feel would be due to the work required to lift the load over the irregularities. Modern researchers are seeking an answer to Coulomb's question: "What actually happens on the surface during the sliding of one object over another?" Some of the answers are interesting.

They have found, for example, that *no* surface, no matter how highly polished, is without irregularities. The smoothest surface that precision engineering can obtain still contains microscopic rough spots with depths equal to 1/500th the diameter of a human hair. The rough spots, when magnified by an electron microscope, resemble a countryside filled with ravines and cliffs.

When the surfaces are put together, the effect is somewhat like turning Switzerland upside down and putting it on top of Austria. The metals or solids rest only at their points of contact so that the actual area of real contact is quite small. The pressure or load between the two surfaces gradually crushes the points of contact and causes them to flow together, plastically.

Friction is one of the problems that space scientists face in designing motors or mechanical systems for outer space. The parts of a motor compressor that function efficiently at ground level start to "cold weld" (adhere) through friction when they reach the high vacuums of outer space.

Temperatures are produced by friction not only by the movement of one body against another, but the movement of a solid against the air itself. Space capsules or missiles re-entering the earth's atmosphere generate enormous amounts of heat by literally "rubbing" against the atmosphere. The temperature at re-entry is 2,600 degrees F., enough to incinerate a capsule unless some means of cooling the surface is available. The most successful method to date has been to sacrifice a portion of the surface material of the nose cone by allowing it to vaporize in order to cool the heat shield.

At ground level, the temperature produced by the friction of one solid rubbing over another varies considerably, depending on the speed of contact, pressure exerted, and heat conductivity of the metal itself. The "points" that come into contact may become white hot, generating split-second heat up to 2,732 degrees F., even though the metal appears to remain cool.

In some cases where the rubbing surfaces have been brought together at speeds of more than 1,000 miles per hour, researchers have found that a thin film of metal was melted between the two surfaces, the film itself being a form of lubricant. Scientists suggest that this film may explain what happens in the act of polishing. Rubbing smears a melted layer that bridges and fills up scratches. When the surface cools, it forms a slick micro-crystalline layer.

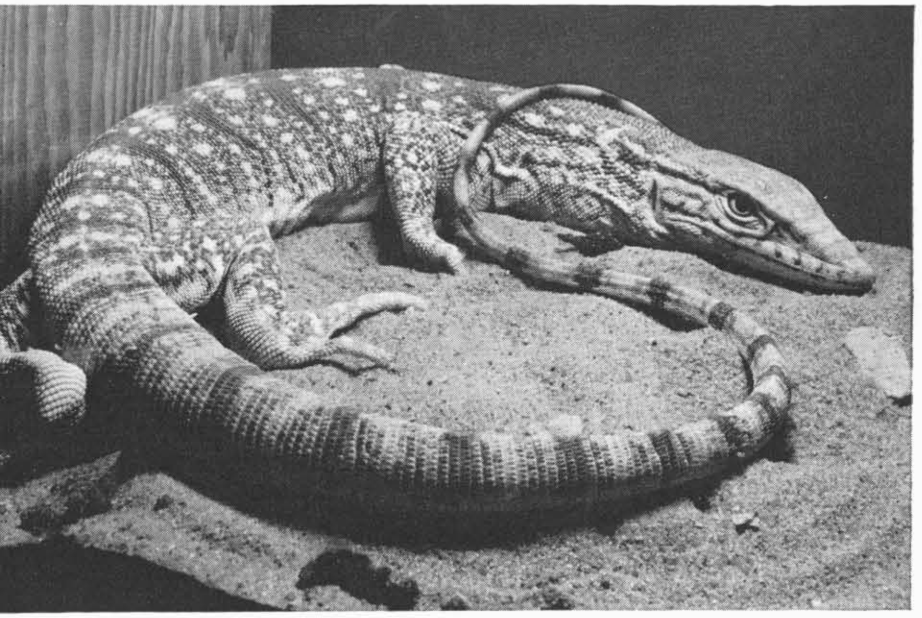
The lubrication of sliding solid objects presents special problems when the temperature at the point of contact is exceedingly high. Quite often a temperature flash at a rubbing spot leads to the failure of a lubricant just when its protective properties are most needed. To counteract this requires the right combination of lubricants for a particular pair of surfaces, speed, load, and melting point. Finding the right combination constitutes the exacting art of the lubrication engineer.

The problems of lubrication where such machinery as piston engines and motor compressors are concerned is a problem of surfaces separated by relatively thick films of lubricant. The oil is actually a "buffer" that prevents the two surfaces from coming into direct contact. In automobile engines, for example, the viscosity of the oil (its thickness or thinness) is adjusted to suit the requirements of the moving parts. If the oil is too thin, the friction between moving parts will damage the machine. If the oil is too thick, the lubricant will clog the action.

A revolutionary step in reducing friction and wear was taken in the eighteenth century with the invention of ball bearings. It has always been obvious since the birth of the wheel that it is much easier to roll an object than to slide it. Formerly such devices as shafts, or wheel axles, slid or rotated in their sockets around each other with correspondingly high frictional losses. Ball bearings allowed them to roll past each other with a great reduction in friction loss.

The use of ball bearings, better lubricants and the knowledge gained from a study of sliding surfaces have made it possible to run machines faster and hotter. However, to the engineer concerned with practical applications, it is neither the source of friction or the loss in power with which he is primarily concerned, although both are major problems. It is the damage in the form of wear or seizure of the vital parts of the machine that most concerns him. This factor more than anything else limits the design and shortens the working life of machines. It is the answer to this problem that physics in its study of friction is attempting to solve.

The complete answer to everything that happens when a meteor flashes through the earth's atmosphere is still unknown. But today man-made meteors, sparkling with the same brilliance as nature's meteors, are flashing through the heavens. They may find the answer. ■



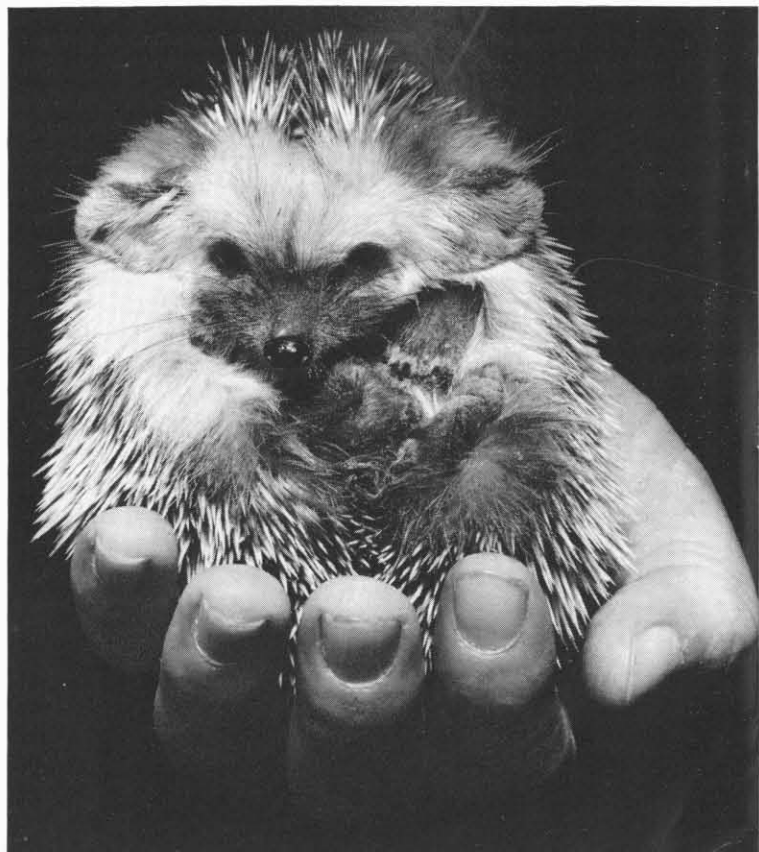
The diet of this 30-inch Arabian lizard, called a waral, provides sufficient water: locusts, grasshoppers, snakes and other lizards. The waral is known for its speed.

Australian dingo prefers arid areas, gets much of its water from flesh of its prey.

Creatures of the Dry World

Nature ingeniously promotes the well being of her desert creatures in some very special ways

Rodents, such as the American prairie dog, have few sweat glands, thus need less water than other animals.



The qunfidha (desert porcupine) dines mainly on insects, which have a high water content. Despite its quills, the qunfidha of Saudi Arabia is easy to hold and makes an affectionate pet.

Camels need almost as much water as horses but can go longer between drinks. Normally, five gallons a day is sufficient, but if camels go waterless for up to eight days, they will drink about 20 gallons. Water, in form of fatty tissue, is stored in humps.

Without water no animal can survive. In desert regions, especially, the greatest threat to life is desiccation—or, quite simply, drying up. But many creatures have achieved specialized adaptations to make full use of what little water exists in arid areas.

One of nature's masterpieces among creatures equipped to cope with desert life is the hardy camel. When H. St. John B. Philby made his historic crossing of The Empty Quarter in 1932, a Texas-sized desert in Saudi Arabia, his camels had no water for ten days of the final march of 375 miles, other than emergency rations for such animals as were in danger of collapse. Only an occasional "snuffing" was permitted. This, as Philby explains, was "an economical method of refreshing camels by administering a kettleful of water through the nostrils to cool the head and brain."

Stories range the desert lands far and wide about remarkable endurance feats by camels. It is said that one of the more famous records was set by Shaikh Naif ibn Humaid of the 'Utaiba tribe who rode from Riyadh on an urgent mission in the middle twenties and covered close to 800 miles in eight days.

The popular belief that camels store water in their humps is correct in substance: water is indeed stored there but in the form of fat. On long, waterless marches the camel draws on this reserve (as well as on the water stored in three special reservoir compartments in its stomach) by making metabolic water.

Anyone who has seen fat spluttering in a pan has seen the process: the spluttering is caused by water escaping from the fat in the form of steam bubbles. Something of the same sort occurs inside the body of the camel and other desert creatures. Water is released by the breaking down of sugars and other carbohydrates or by the oxidation of the hydrogen or carbon.

The camel, too, has a very special kind of blood. A camel loses very little fluid from its blood stream when it does not drink for days at a time. In contrast, the blood of most animals, including man, becomes so thick that finally the heart can't pump it through the system.

The deserts of the world are indeed populated but only by creatures having ingenious adaptations. American oil men exploring the vast Rub' al-Khali regularly run across the tracks of desert creatures. When St. John Philby crossed this huge arid area three decades ago, he gathered many specimens, such as the desert fox, cat, hare, jerboa, the oryx and white gazelle. He collected 14 species of birds, a dozen reptiles and many insects.

Some animals such as the Arabian or white oryx and its near relative, the addax, the gazelle, the jerboa and the desert mouse get sufficient water from dew and their food. In the strict sense of the word, they are non-water drinkers. Others such as the ostrich, giraffe, eland and pocket gopher also get much of their water from their food.

Many desert plants are good water sources for creatures with the right kind of stomach or mouth. The camel's leathery lips enable it to eat spiky plants that most other animals would not be able to swallow but which contain as much as 80 per cent water. The camel can even dine happily on razor-spined prickly pear found in North Africa.

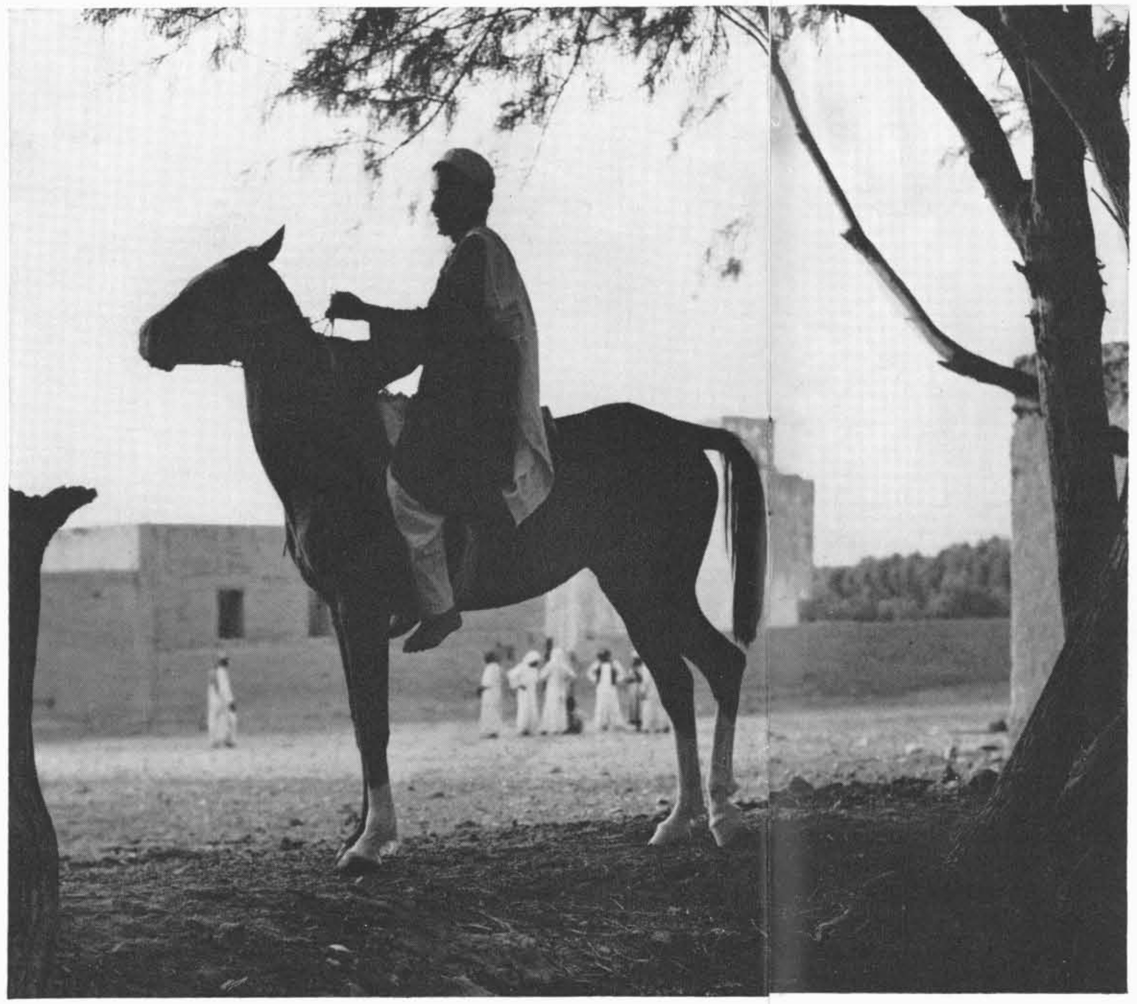
Some desert reptiles get much of their water from dining on insects such as ants and locusts, which have a very high water content. Tiny lizards, only three or four inches long, may eat 600 to 700 ants during a single day. Both the waral (snake-headed monitor) and the dhub (spine-tailed monitor) of Arabia get much of their water from insects, and particularly from grasshoppers and locusts. The waral has yet another water source in the snakes on which it preys.

Arabian desert carnivores such as the fox, cat, wolf, cheetah, jackal and the panther also get much of their water from freshly-killed prey. Most carnivores, indeed, do so—even the desert cat can live for weeks with no moisture intake other than water contained in newly slain food.

Many desert reptiles store food and water in deposits of fat in their bodies and tails. It has been reported that a species of Gecko lizard, in a laboratory experiment, lived for a year without food or water.

Another piece of nice adaptability designed by nature is the almost impervious body coverings of some of the more successful dwellers of desert and arid regions. These include reptiles (the most numerous), birds, many insects and some specialized animals. Some mammals such as men, apes and horses lose much water (and salt) through sweat glands. But most rodents and some ruminants—certain antelopes, for instance—nearly or completely lack sweat glands.

But even non-sweating creatures need other talents if they are to flourish in arid regions. Many desert creatures are nocturnal and thus conserve moisture. They avoid the desiccating effects of high day temperatures and low humidity. The deserts are never so populous as they are at night—as a silent observer can hear and see.



Arabian horses have always been famous for their stamina. Extra large windpipe, oversized heart and lungs, and muscular hind quarters enable them to cope with rigorous desert conditions.

Reptiles active during the day have particular problems. Day temperatures may go as high as 120 degrees F. and ground temperatures may go over 140 degrees F.—15 to 35 degrees above the lethal temperature for a day-active lizard. How, then, do so-called "cold-blooded" animals maintain their body temperatures some 20 degrees below their surroundings? They do so in a number of ways. Some raise their bodies and tails from the ground to leave an insulating layer of air between their bodies and the hot sand. Diurnal desert lizards almost invariably have an immaculate white belly which reflects heat from the hot ground. When they get too hot, some lizards pant, causing a respiratory heat loss that reduces body temperatures.

Burrowing is another reptilian way of coping with excessive temperatures. Both Old and New World lizards often have broad bodies designed for burrowing into loose soil or sand by lateral and vertical movements. Indeed, the remarkable spiral technique of the sidewinder of the Southwestern United States is also used by small horned vipers in North Africa and Arabia. And valve-like closing of nostrils, eyes and mouth in lizards and snakes burrowing in loose sand is found both in Arabia and California. On the other hand, the giant land lizards (chuck-wallas) of the arid Gulf of California survive the easy way—they have learned to drink salt water!

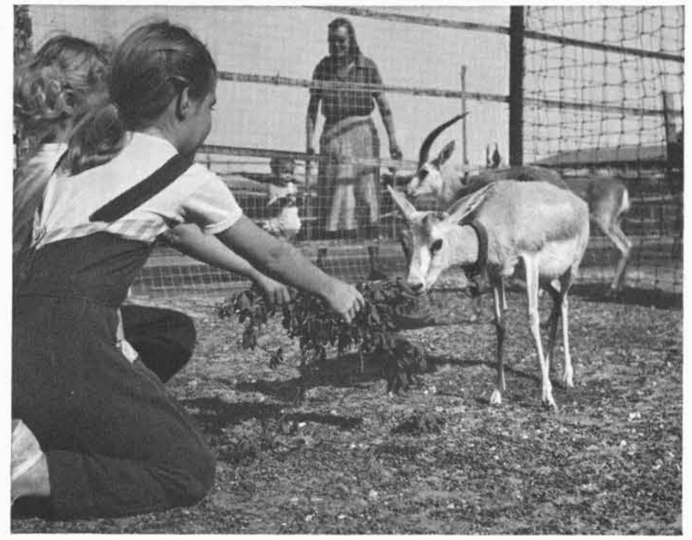
Many desert creatures are migrants and nomads, moving on when food and water become scarce. But desert snails aren't able to do so, and they have acquired the ability to put themselves into "cold-storage"—or, more correctly, into "nearly-desiccated" storage. Two specimens of the desert snail *Helix desertorum* were glued to cardboard and exhibited in the British Museum in 1846. Four years later an entomologist wondered what would happen if the dried-out creatures were placed in water. One actually revived!

Some desert animals emulate the snails, though not quite so dramatically. During hot summers and periods of drought they *estivate*—the word means "to pass the summer." Many reptiles estivate. Among the more accomplished are some water-storing frogs of the more arid regions of Australia and North America. The reservoir frog lives and breeds in pools which fill up in the rainy season. When the sun empties the pools, the frog goes down several feet into the mud, and after distending itself with water, shapes out a little moist cell whose walls later become dry, hard, and insulating. There the frog, in a torpor that is profound though not as deep as that of hibernation, calmly sits it out until the next rainy season.

The most remarkable of animal estivators are probably the desert ground squirrels, such as those found in the Turkestan deserts and elsewhere. These squirrels are active only for three and a half or four months each year, during the period when there is green vegetation. Their summer estivation merges almost directly into a winter hibernation.

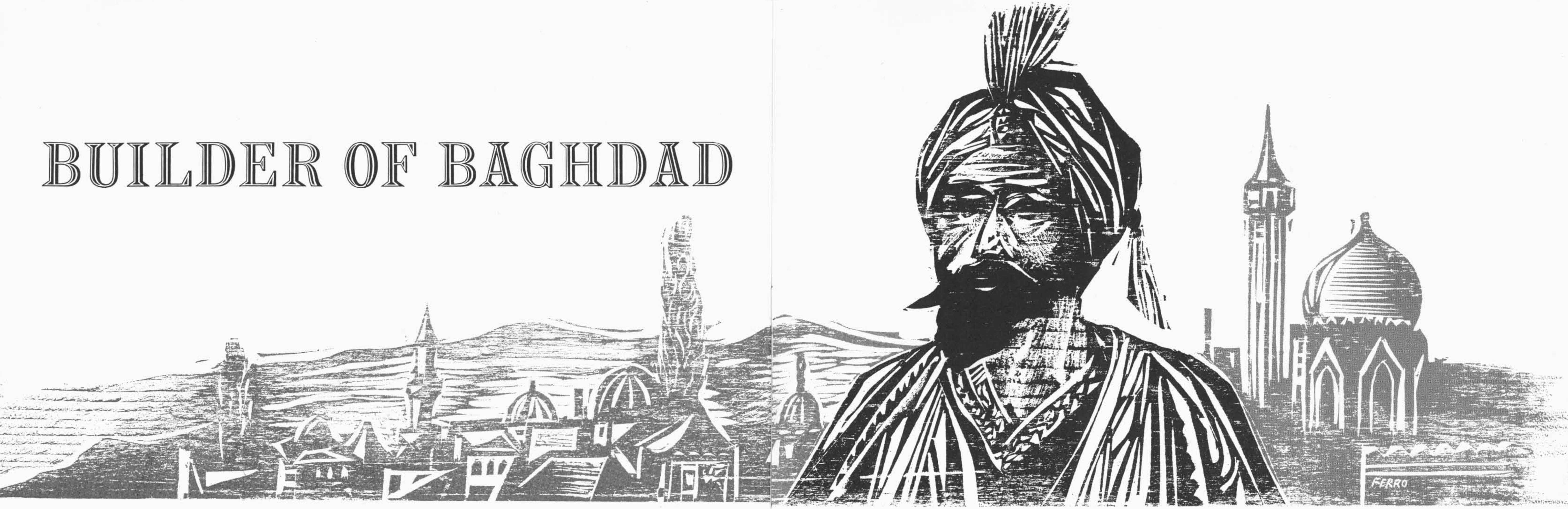
Life in deserts is strenuous and difficult. Death from desiccation and also starvation threatens constantly. A British climber on one of the Everest expeditions reported that on some of the arid Tibetan uplands the tufts of herbage were so few and far between the mountain sheep could only get enough to survive by running between mouthfuls. They chased their grass! ■

Desert lizard, called "thhaihi" by the Saudi Arabs, lives mainly on insects, burrows into sand by vibrating its body in order to reach cooler sand a few inches below the surface.



Gentleness of Arabian gazelle makes him a favorite with children. Gazelles obtain most of their water from food.

BUILDER OF BAGHDAD



Caliph al-Mansur gathered the finest artisans in the Middle East when he ordered his imperial metropolis to be built on the banks of the Tigris

One summer day in the year 762, a group of horsemen cantered toward the Tigris River where it turns west in the direction of the Euphrates. No one could mistake their leader. Jafar Abdullah al-Mansur sat on his prancing steed with the bearing of a soldier, the bridle held tautly in his left hand, his right in constant motion as he issued commands. His dark eyes, piercing as a falcon's, were those of a man who would not be disobeyed. He looked every inch the ruler of an Islamic empire.

At the riverbank, the Caliph ordered his companions to halt and, spurring his horse to a trot, he rode down to the water's edge. Carefully he surveyed the Tigris upstream and down with the practiced eye of a military man and monarch. The swiftly flowing river, he saw, was a natural defense, a hazardous obstacle for any invading army. The few farms in the area could easily be multiplied throughout surrounding fields to meet the needs of an expanding population. In short, here might stand a metropolis in peace and a citadel in war.

Such were the Caliph's thoughts as he gazed around him, twisting in the saddle to get a better view. One last long look, and he had made up his mind. Rearing his horse on its haunches, he pirouetted and galloped up the bank to his bodyguard. "This is where we will build our capital," he said.

Why a new city when he had so many old ones from which to choose? Before setting out, al-Mansur had explained his motives.

"We 'Abbasids," he said, "are a recent dynasty. We have supplanted the Umayyads, but we cannot be safe in their Syrian capital, Damascus. We must move closer to the Persian source of our power."

He was referring to the traditional conflict of two powerful Islamic families. When Omar the Great fell under an assassin's dagger in 644, Othman of the Umayyad clan was chosen to succeed him. The Umayyads gained most of their support from Syria: hence their decision to move the center of government from Medina to Damascus.

The House of Abbas, opposing the House of Othman but temporarily defeated, retired to Persia to wait for a change in their fortunes. It came with Abu Abbas Abdullah, who overthrew the Umayyad Caliphate and founded the 'Abbasid dynasty. His brother inherited his rule in 754 – Jafar Abdullah al-Mansur, the vigorous captain and statesman who extended 'Abbasid sovereignty around the huge geographical circle of Persia, Mesopotamia, Arabia and Syria.

As the Umayyads had moved from Medina to Damascus, the 'Abbasids would now move from old Damascus to – where?

The Caliph looked at the map of his empire, and placed his finger on its most strategic province. Centrally located, close to his Persian allies, Mesopotamia had been from time immemorial the base from which conquering armies dominated the civilized world. Al-Mansur saw that he could use the same base for his own imperial aims. The precise spot would be that known to the ancient Babylonians as Bag-Da-Du – Baghdad.

The commands were given. 'Abbasid Caliphate workmen, artisans and artists converged on the middle Tigris – 100,000 of them before the three years of labor were over. The Caliph himself supervised the construction of the city walls around a circle three miles in diameter – making Baghdad the "Round City" of folklore. He shouted orders, exhortations and advice as two-hundred-pound blocks of stone were placed on top of one another to a height of 90 feet and a width of 40 feet. He visited the foundries to inspect the casting of four massive iron gates. He leaped into the moat to be sure that it was deep enough.

Al-Mansur summoned his surveyors and architects to periodic conferences. "Lay out the streets in straight lines with a clear view to the walls on every side," he commanded. His metropolis was to look like a fort with broad, paved avenues radiating from the center like the spokes of a wheel. He wanted his sentries on the walls, to spot an

BUILDER OF BAGHDAD

enemy outside or a disturbance inside, to have his garrison marching to the scene within minutes.

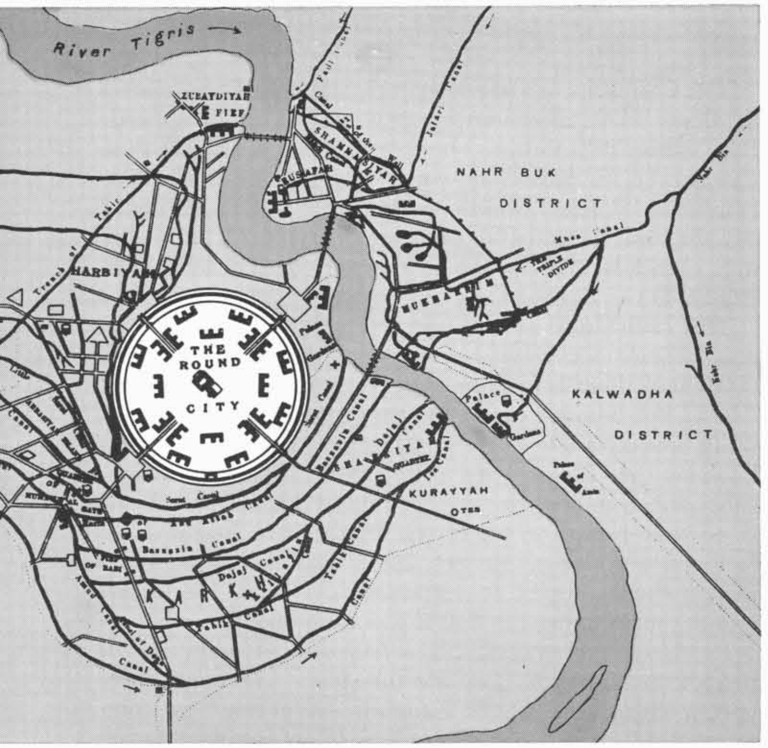
The Caliph's palace rose at the hub of the "wheel," until its lofty, emerald-colored dome, 130 feet high, dominated the city. The palace gained the nickname of "The Green Dome." It was also called "The Golden Gate" because its main portal was encrusted with the precious metal.

The palace of Baghdad formed a labyrinth of rooms and corridors leading into alcoves, cloisters and courtyards. The gardens were laced with rose bowers, dotted with splashing fountains, and ornamented with strutting peacocks. Here might the Caliph and his entourage stroll, converse and relax amid a scene that inspired delicate lyric poetry and magical tales of the *Arabian Nights*.

The audience chamber was an enormous room where hundreds of persons congregated on great occasions, such as royal weddings and the reception of foreign ambassadors. Down the walls of the audience chamber were hung heavy velvet drapes. Deep Persian carpets were underfoot and beautifully decorated cushions lay on every chair. In every corner flashed the sparkle of gold and diamonds.

The imperial dining room was a counterpart of the audience chamber. A thousand guests could be seated, and every dish, utensil and piece of cutlery was of silver or gold.

Thus did Caliph al-Mansur rule in Baghdad in Persian-style magnificence. His courtiers imitated him and achieved a splendor of their own. It was they who made priceless jewelry a part of everyday dress. It was they who first adopted the Persian slipper with its upturned toe and the magnificent coats of silk.



Heart of Baghdad was encompassed by 90-foot-high walls, three miles in diameter, with the Caliph al-Mansur's palace at center.

Culture flourished in Baghdad. The Caliph set an example for his subjects by patronizing scholars, poets and painters. Hakim the composer was not only al-Mansur's client but also his good friend. Schools of philosophy and science developed. A Spanish traveller who visited the city at this time remarked: "Baghdad is a hive of bees in which much honey is produced."

The capital of an empire, Baghdad soon was filled with ordinary citizens. They built houses, practiced trades, farmed the surrounding fields and did the routine jobs of any big city. But Baghdad's special flair prevented it from being just another city. The color of the palace filtered down to the populace. After the toil of the day, the citizen might frequent his choice from a thousand public baths. He might go to a polo game, or a poetry recital, or perhaps he would attend meetings of metaphysicians or wander through the darker quarters of the city in search of excitement and danger.

And there were always the bazaars filled with teeming, chattering humanity in search of a loaf of bread or an Indian diamond. Merchants became wealthy by sending caravans to Egypt and Syria and commanding ships down the Tigris to the emporiums in the Persian Gulf. The bazaars of Baghdad offered wares from the known world: African ivory, Indian teak, Chinese porcelain.

In spite of the aura of fantasy that lay over his metropolis, the Caliph al-Mansur was not a ruler who left the affairs of state to his subordinates. He chose able officials to carry out his laws and issued a standing order that appeals from the common people must be referred directly to him. He took the field at the head of his army and waged military campaigns against the Byzantine Empire, the Khazars of the Caucasus and rebels in Khorasan. These campaigns forced respect for his authority and frontiers. At home, the Caliph assumed more mundane duties, visiting the farms so that there might be no dereliction by his farmers or any danger of famine.

The second of the 'Abbasid Caliphs built so well that he remains one of the master city planners of history. He turned a primitive village into a scintillating imperial metropolis. He selected its site so wisely and gave it such strong political and economic foundations that it continued to grow long after his death in 775. A generation later Baghdad would reach yet another pinnacle of its glory under Haroun al-Rashid.

For five centuries it was a beacon of power and culture. 'Abbasid Caliphs lived in the palace, sending out decrees to an empire until the city was stormed and sacked by the ferocious Mongols in 1225. The splendor came to a devastating end amid flames and rubble. Its fame did not end, nor has it ever ended. Today, few remember the builder—Jafar Abdullah al-Mansur. But everybody remembers what he built—medieval Baghdad. ■

For many in the Persian Gulf hamlet, the newcomers were the first Americans they had ever seen, and they would long remember that day when the oil industry came to Saudi Arabia

Opening scenes of Aramco's 1955 film "Jazirat al-Arab" ("Island of the Arabs") recreated historic landing at Jubail of American geologists in September 1933.

VANGUARD AT JUBAIL

THE CENSUS of Jubail had almost doubled since daybreak. The Saudi Arabian pearl-fishing port and caravan terminus was in a holiday mood. Even Bedouin tribesmen had come in from the desert to see the two "strange" men arrive. A crowd waited at the customs pier.

The strangers were American geologists Robert P. (Bert) Miller and Schuyler B. (Krug) Henry. The Saudi customs launch had been sent to bring them from Bahrain Island to the Arabian mainland, a trip of several hours.

Miller had been in Bahrain for a year and a half and Henry for a year. Both had done geology in Venezuela for the Standard Oil Company of California. To seem less strange to their Saudi Arabian hosts, the Socal geologists had grown beards, adopted Arab dress, and had learned some everyday Arabic.

On the launch that had gone to pick them up were two men who would smooth their entry into Arabia and help them start their unusual mission: Muhammad Ali Tawil, the customs officer and Saudi Arabian Government representative, and Karl Twitchell, an American mining engineer who had investigated water and mineral resources in Saudi Arabia for King 'Abd al-'Aziz.

As the launch made its way along the coast toward Jubail, the geologists strained to get a look at an interesting group of sun-bleached sandstone hills they had studied from Bahrain on clear days. These barren jebels, scoured by hot winds, would one day mark the site of Dhahran, the oil center of Saudi Arabia.

It was Saturday, September 23, 1933. Four months earlier the Standard Oil Company of California and the Saudi Arabian Government had signed an oil exploration and development concession agreement. Bert Miller and Krug Henry neared Jubail eight days ahead of the target date, set in May, to begin the search for oil in Arabia.

Royal dispatches and the amazing Bedouin word-of-mouth "telegraph" that sends news and rumor racing across the desert had heralded the arrival of the geologists.

The Government launch slipped past the jetty into the breakwater. Dhows lay tilted in the mud tidal flats, their sails furled for the day. The festive crowd on the pier

VANGUARD AT JUBAIL

gathered to watch the two American geologists disembark.

Among those who greeted Henry and Miller were the amir of the area and dignitaries from Jubail and from Qatif, an oasis along the coast to the south. A soldier escort, provided by the King, was also on hand.

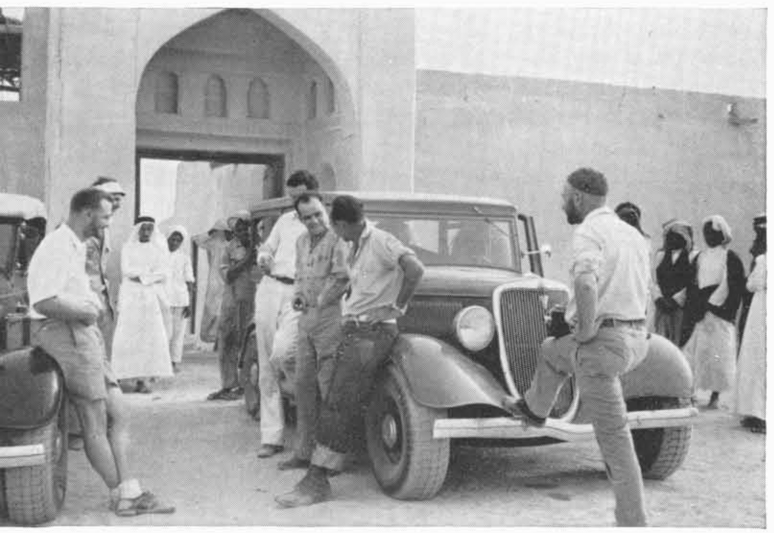
Dressed in long, white *thobes,* their heads covered by Arab *ghuttras,* the strangers certainly looked less strange than had they arrived in business suits.

Ten thousand miles away in San Francisco a group of Socal executives and officers had bet on the presence of oil in Saudi Arabia. It was a calculated risk that the company had to underwrite at a moment when the world was plunged into economic depression. The United States had gone off the gold standard and had staggered through a bank holiday.

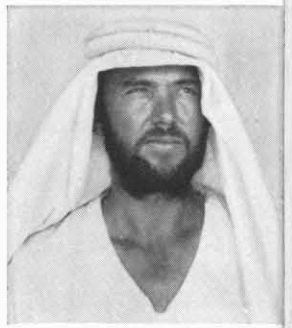
Thus, Bert Miller and Krug Henry had arrived on a crucial mission. They, and the other oil men who would soon join them, had to find out if the company was right – or wrong.

And they were in a hurry. As soon as they paid respects to the amir and exchanged courtesies with their Saudi Arab hosts, they went to work. Out came their sampling tools. They walked to a small island in the tidal flats and immediately started to chip away chunks of rock and examine them. The crowd that followed was puzzled by the way the geologists slipped quickly, but courteously, into high gear.

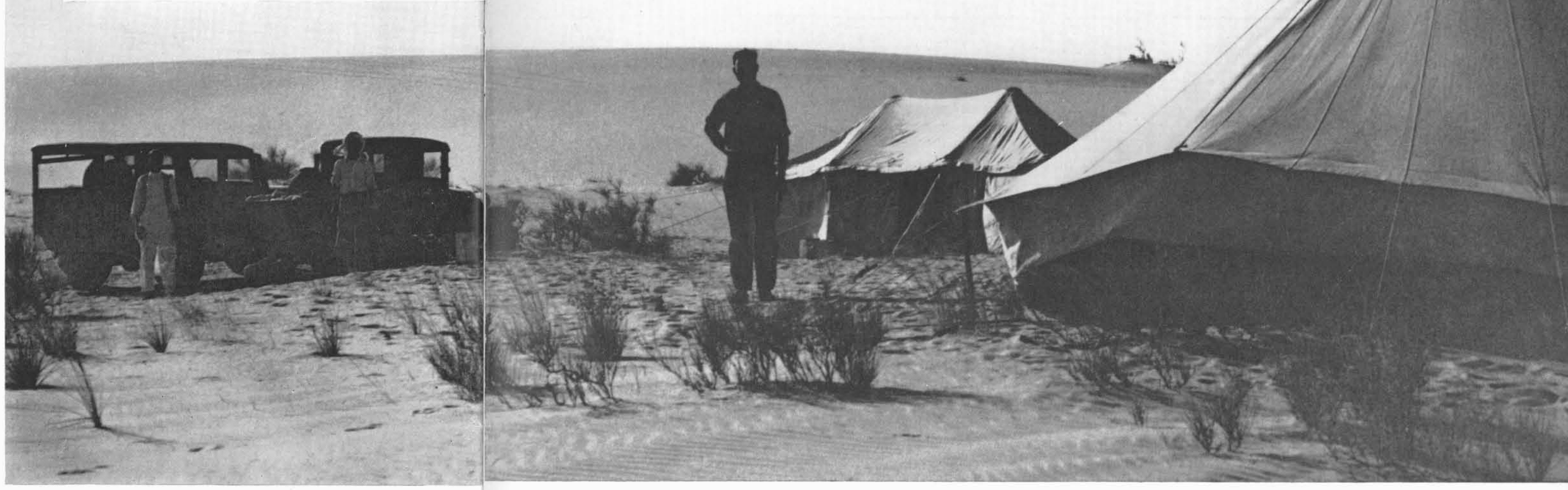
Henry and Miller learned that Karl Twitchell had rented two touring cars from the Saudi Government. He had driven them more than 800 miles across Arabia from Jiddah, the ancient Red Sea port. The cars were quickly put to use. With the help of Shaikh Tawil and Twitchell,



The people of Jubail always took a keen interest in the geologists and their equipment. The village remained a headquarters until 1936.



"Krug" Henry (left) and "Bert" Miller, first two American geologists in Saudi Arabia, set stage for the early days of exploration in the vast concession area.



the newcomers organized the first American geological reconnaissance party to enter the Arabian desert. Off they went – touring cars, soldiers, camels, and the crowd.

The specific goal Miller and Henry had in mind was a jebel, named Al Barri, 12 kilometers south of Jubail. But the greater goal that lay before them was a formidable and mysterious expanse of desert comprising the concession area – more than 300,000 square miles of virtually unmapped dunes, salt flats, hardpan and desert steppe.

Few Westerners had ever entered upon this desert heartland. The most sophisticated of these had come only recently: Bertram Thomas in 1931 and Harry St. John Philby a year later.

The maps available to the pioneer American geological parties were casually marked, largely inaccurate and far less useful then the trained eye of Bedouin guides.

Transportation was a difficult problem. Miller and Henry found this out before their historic Saturday ended. They hadn't gone far when their touring cars yielded to the deep, loose sand. The Americans climbed astride camels the soldiers had waiting for them and went on.

On the way back, the soldier escort showed the ready Arab sense of fun – they began to run the camels at a fair clip. For the Americans the ride was rough and wild. It was the first and last American geological trip aboard the lurching "ships of the desert." Thereafter, camels were used by the Americans as baggage animals only.

As the odd caravan of geologists, officials and interested stragglers crossed a salt flat coming back into Jubail, Miller and Henry experienced one of those suspensions of reality that would lead a desert greenhorn to suspect that his wits have fled.

The September sun burned down upon them relentlessly during their inspection of the Al Barri jebel and on the ride there and back. Their eyes began to play tricks. On the oven-hot salt flats the relentless sun and haze combined to distort reality and create weird, shifting images.

The geologists saw something tower in the air. It was a man on a camel coming over a distant dune. Then they saw other dunes ahead begin to rise from the desert floor and float in the air. Other objects grew, twisted strangely and vanished.

Suddenly Jubail loomed ahead, but not the cluster of low buildings they had left earlier. Instead, its skyline rose to impressive heights – a New York in the desert!

Day by day the geologists extended their range of exploration. On their fifth day in Arabia they searched the limestone hills that they had observed from Bahrain. They had a strong feeling that this was a spot worthy of close geological study, an area where the underground conditions might be right for the discovery of oil.

Only five days after their September 23rd landing, Bert Miller and Krug Henry began to feel that the company had made a good bet. ■