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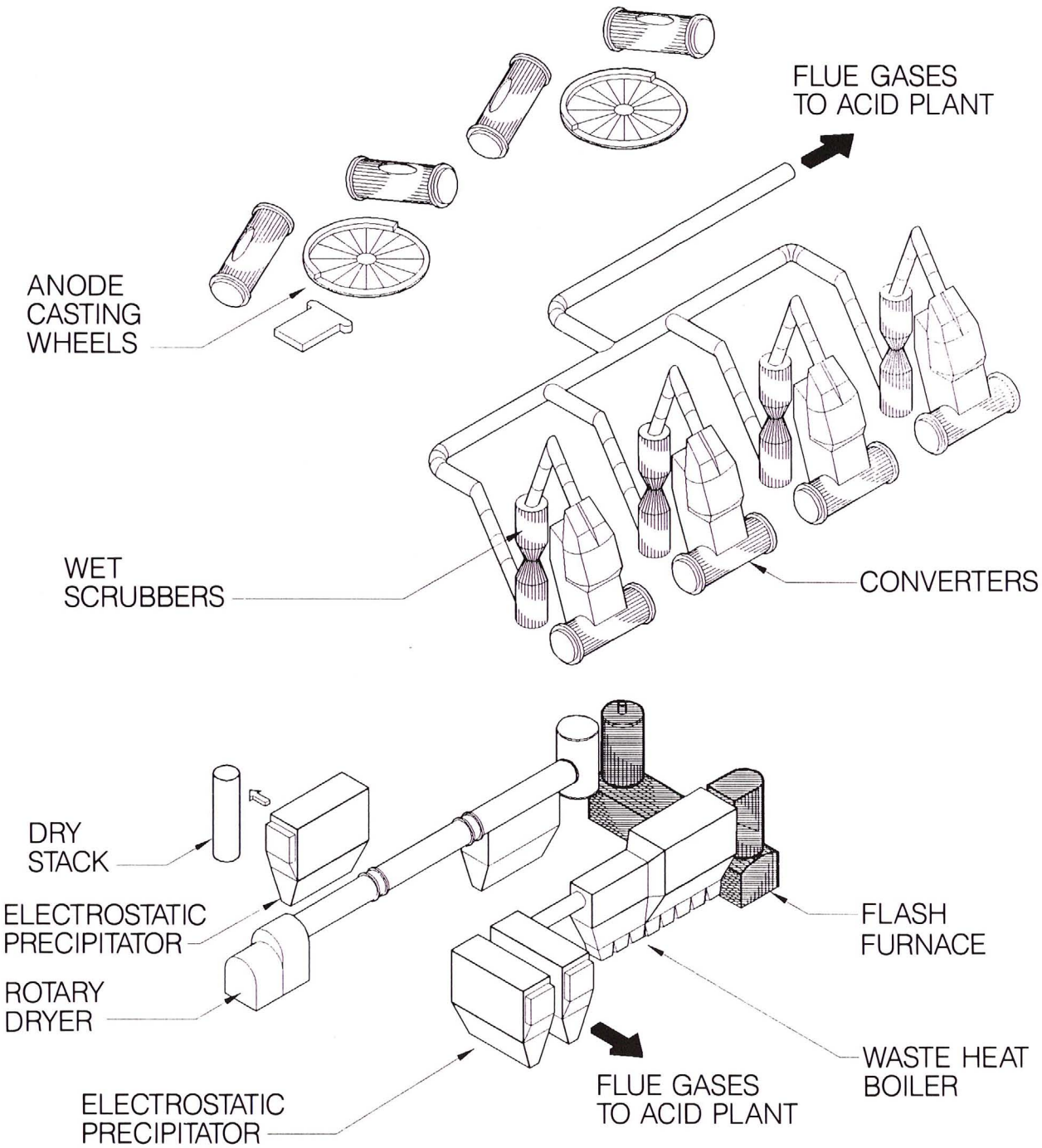
Magma Copper Company—San Manuel Division

Schematic of the Outokumpu Copper Flash Smelter



MAGMA

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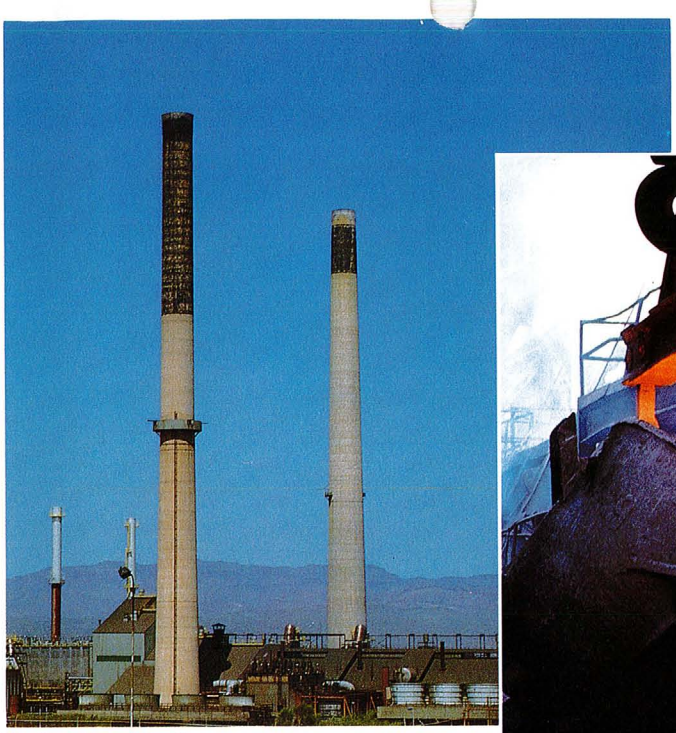
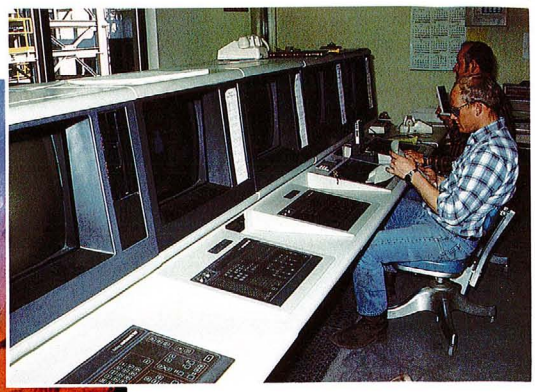
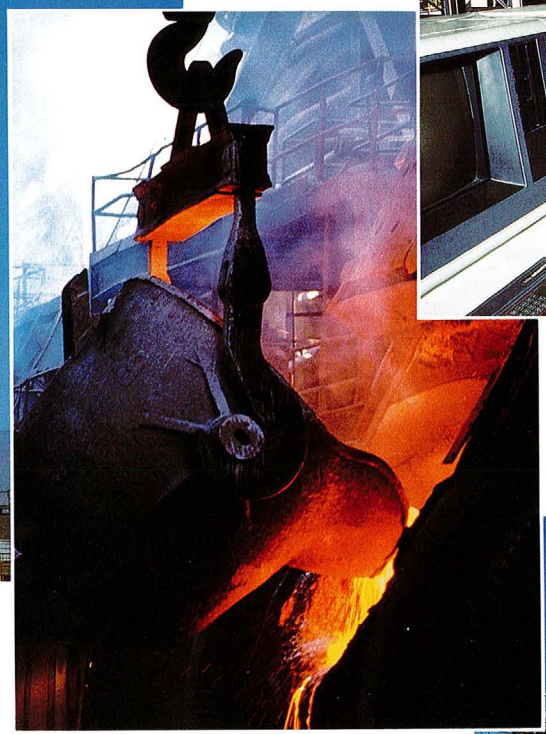
San Manuel



The San Manuel Smelter

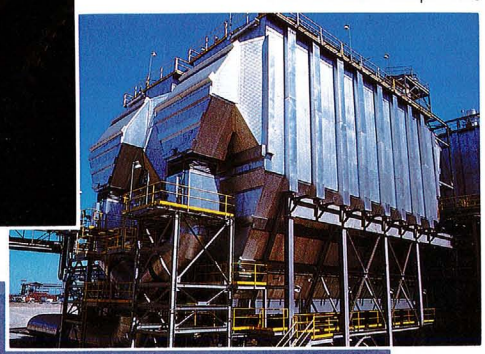
Flash Furnace Controls





Charging a Converter

Electrostatic Precipitators



Dumping Slag at Slag Pits

FLASH SMELTING

Designed to produce and capture the maximum amount of sulfur dioxide for the production of useful sulfuric acid, the Magma flash smelting system achieves air quality control as well as efficient smelting of copper concentrates and production of anode copper.

Copper concentrates contain approximately 30% sulfur, an unstable material which spontaneously oxidizes under favorable conditions. Flash smelting utilizes this natural phenomenon by providing an oxygen rich (44%) atmosphere into which fine, dry concentrates and fluxes are charged through a single concentrate burner.

The sulfur immediately ignites or "flashes" and produces sufficient heat energy to liquefy the other concentrate ingredients—iron and copper which rain down the 23′ high reaction shaft and into the settler.

The rich (28%) and dusty SO_2 gases are drawn through the companion uptake shaft into the waste heat boiler where their heat is transferred to water for the production of steam for the San Manuel power plant.

The cooled gases are ducted to the high efficiency electrostatic precipitator. Dust from the waste heat boiler and precipitator are contained within flues, collected and recharged into the furnace.

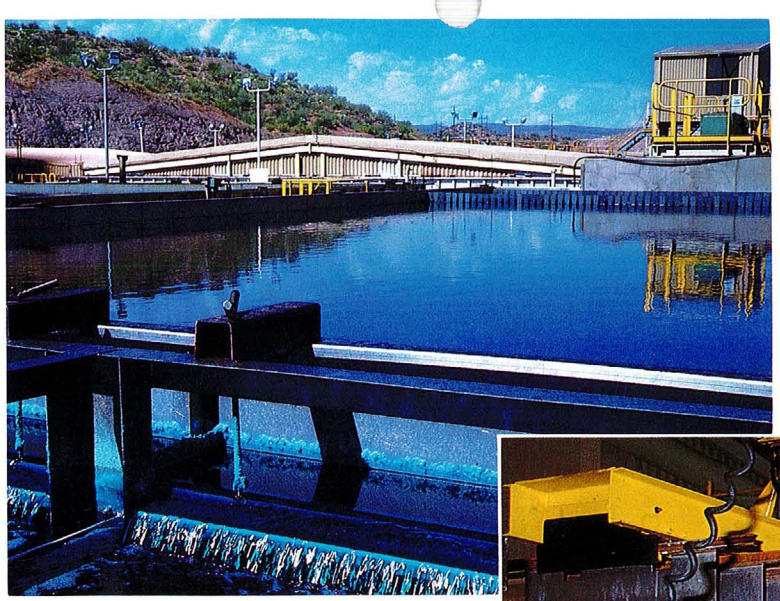
Molten copper matte containing about 63% copper is tapped through covered launders into ladles positioned in tunnels beneath the furnace. Filled ladles are taken by overhead crane and the copper is poured into one of four converters.

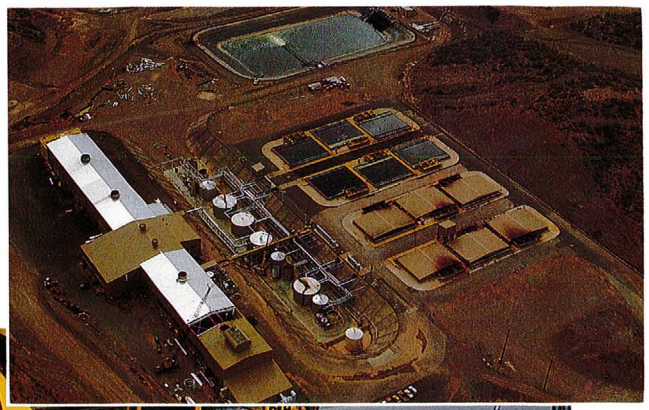
In the converters further oxidation of sulfur and slagging of waste metals takes place over a four to five hour period until the copper reaches a purity of 99%.

This molten copper, called blister, is conveyed by overhead crane to the casting department where it is fire refined for the removal of residual oxygen and cast into the familiar 820 pound anode for transport to the electrolytic refinery.

Molten slag containing approximately 1.8% copper from the furnace and/or 7% from the converters is skimmed into 25 or 50 ton pots which are picked up by rubber-tired, diesel haulers and taken to shallow slag pits. Here the slag is air cooled, then water cooled, broken, crushed and loaded into rail cars for transport to the concentrater for wet grinding and froth flotation of the copper content. The resulting slag concentrate rejoins the other furnace feed.

Continued on back





SX-EW/SOLVENT EXTRACTION-ELECTROWINNING

Solvent Extraction

While the process of electrowinning copper from a rich electrolytic solution is as old as industrial electrical applications, the technology of solvent extraction is newer and with the development of special reagents can now be applied efficiently to large scale operations.

The purpose of solvent extraction is to remove copper from the pregnant leach solution (PLS) by mixing it with an organic extractant and then removing the copper from the organic into a rich solution of sulfuric acid and copper sulfate.

The solvent extraction process takes place in four stainless steel tank trains at the rate of 4,000 gallons per minute each.

The resulting electrolyte solution is pumped to the electrowinning tankhouse, the organic and reagents are recycled, and the now barren PLS called raffinate is discharged to the raffinate pond for recycling to the leach dumps.

Electrowinning

Electrowinning is an electrochemical process in which copper from an electrolyte is plated onto a cathode. The primary difference from electro-refining is that refining uses a copper anode while a lead alloy anode is utilized in electrowinning.

The electrowinning tank house has 188 concrete cells each containing 61 lead anodes and 60 stainless steel cathode mother blanks.

The plating cycle is seven days to obtain a 100 pound cathode from each side of the mother blanks.

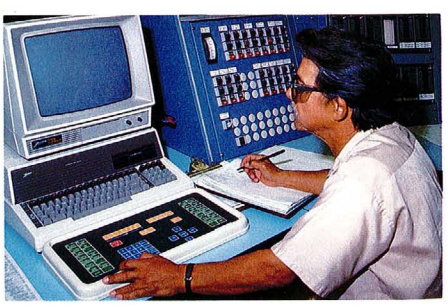
The cathodes are stripped mechanically from the mother blanks and are transported directly to the rod plant for continuous casting.

The extractant used in the solvent extraction process is very selective to only transfer copper from the leach solutions. This results in especially high purity copper metal production during electrowinning.

All SX-EW functions are fully instrumented for automatic operations and direction from a comprehensive distributive control system.

Altogether Magma operates three SX-EW plants:

Location	Production
San Manuel	100,000,000 lbs./yr.
Pinto Valley mine unit	15,000,000 lbs./yr.
Miami in-situ unit	10,000,000 lbs./yr.



MAGMA

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In-situ expansion is completed and pumping

By STEVE HILDEBRAND
In-situ engineer

The in-situ expansion, initiated in January, 1987, has completed the construction phase.

Presently the solution handling system for this 8,000 gallon per minute system is completing extensive pre-op testing.

The major components of the new system are the 1475 pump station with seven Ingersoll-Rand pumps and drivers, the 2375 pump station with seven Ingersoll-Rand pumps and drivers, and the 7NLD pump station with five Durco pumps and motors.

Two 12 inch stainless steel pipelines were installed in #4 shaft between 2375 level and the 1415 level.

The 2375 pump station will deliver PLS (pregnant leach solution) to the 1415 level sump which feeds the 1475 pump station, located at #4 shaft.

The 1475 pump station will pump PLS to the surface.

PLS crosses 1475 level to #1 shaft, up #1 shaft to the surface, and eventually to the SX-EW plant feed pond.

Again, two 12 inch stainless steel pipelines were installed in #1 shaft.

Across 2375 level, two 12 inch HDPE pipelines were installed.

The 7 NLD pump station delivers PLS to the 2315 sump, which feeds the 2375 pump station.

All pumps and pipelines were installed by the Magma pump and pipe department in a most timely and professional manner.

Bob Kelly's crew did a very credible and vital job during this in-situ expansion.

In fact, due to a manufacturer's faulty design, the HDPE lines across 2375 level had to be installed twice.

The pipe crew also hung the shaft piping in both #1 shaft and #4 shaft.

All pump station preparation prior to the installation of the pumps and pipelines had to be performed by other skilled Magma underground employees.

Harvey Cooper's skilled in-situ underground construction crew was responsible for all excavation.

This included all new dams, collection sump crossovers, pump stations, transformer stations, and motor control centers.

The main PLS collection sump located on the east end of the 2375 level involved extensive raise station preparation throughout the haulage drift.

Of course, the underground surveyors, under Cip Haro, had to mark the way.

Likewise, once the excavation was complete, surveyors again prepared the way for the concrete crew, which without fail, accomplished every difficult pour with professionalism and dedication.

Max Mikels and his concrete miners were instrumental in their support on the in-situ needs and always had means of solving even the most complex requests.

In order to run these pump stations, major electrical installations both on the surface and underground had to be constructed.

Two major transformer stations, 2315 north side and 1415 south side of #4 shaft stations were constructed.

Each pump station has an associated motor control center.

And finally a major electrical power substation was built next to #1 shaft, where the 115 KVA and 46 KVA transmission line service the power needs of in-situ.

Down #1 shaft and #4 shaft 13.8 KVA electrical cables have been hung.

All electrical installation was accomplished jointly by Magma and Bechtel crews.

Kent Billhartz's electrical crews were instrumental in the design and installation of these facilities.

Once the construction and installation was completed pre-op testing began.

Pipelines were statically tested.

Each motor was energized and run for short periods of time.

Electrical gear and cables checked out.

Finally instrumentation had to be calibrated.

During July, the PLS handling system was ready for initial pump tests; it was time to move some PLS.

Several of the five Durco 16A pumps at the 7NLD pump station were tested.

The PLS from the 2375 collection sump was pumped to the 2315 sump at #4 shaft.

Only minor startup problems occurred, which are being addressed.

In a manual mode, these pumps worked well.

Later in July at 1000 gpm pump on the 2375 pump station, using a 600 horsepower motor, was also tested in a manual mode.

PLS was successfully pumped up #4 shaft to the 1415 sump.

Finally, one 1000 gpm pump with a 800 hp motor was tested on 1475 pump station.

It also performed successfully and the first in-situ PLS was delivered to the SX-EW feed pond using the new PLS pumping system.

In August, the automatic controls for the whole pumping system were tested successfully.

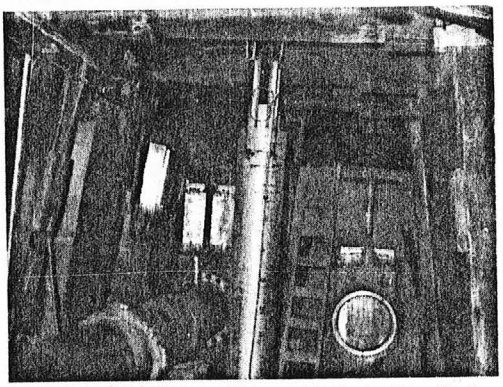
The success of these pumping tests cannot be over emphasized for as in-situ PLS production continues to increase steadily each month, it will not be long before these pump stations will be run continuously.

PLS production will exceed the capacity of the 1000 gpm large scale pumping system currently handling PLS production.

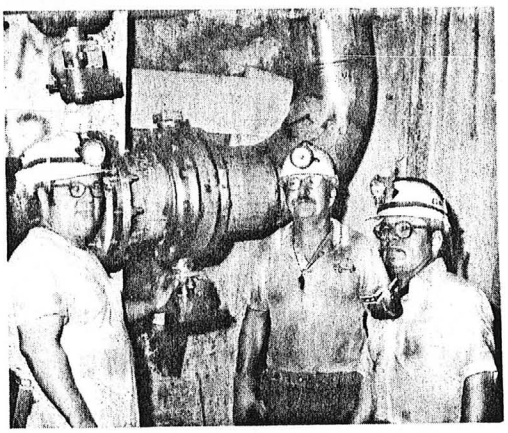
Much appreciation to all hands who participated in the design, fabrication, excavation, construction, and installation of this in-situ PLS pumping system.

Unfortunately, it is not possible to list all the Magma employees involved with the project.

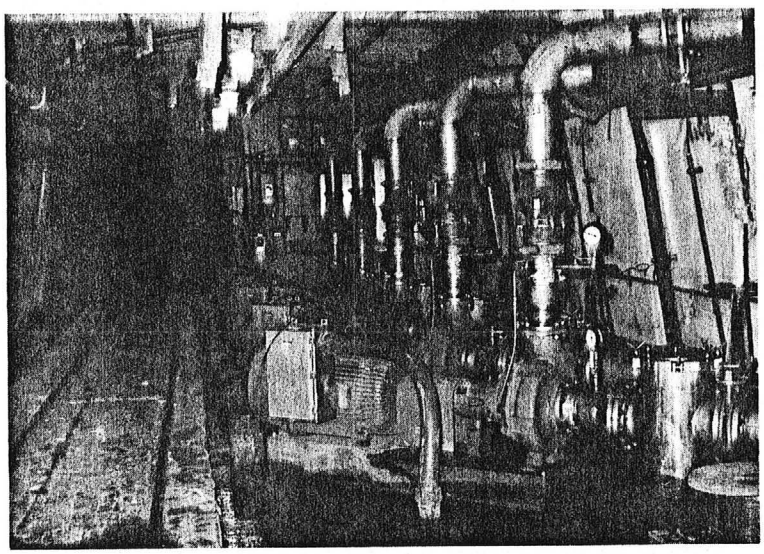
However, it was an essential element to the future of in-situ copper production and Magma's future profitability and could not have been accomplished without the high level of interest, enthusiasm, and initiative of all involved.



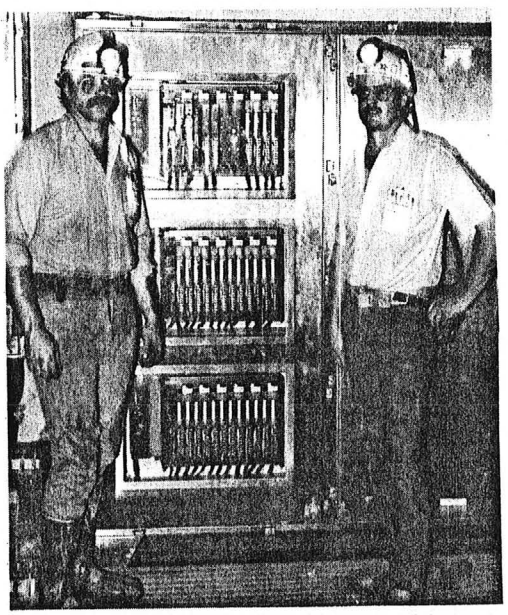
LOOKING TOWARD dam which creates the in-situ collection sump on the 2315 level.



PIPE CREW at 2375 level pump station are, from left, pipefitter journeymen Nat Mejia and Benny Encinas and pipefitter helper Miguel Garcia. The pipe is 12" stainless steel.



ARRAY of pumps on 2375 level will lift 2000 gallons per minute of leach solution from the 2375 to the 1475 level.



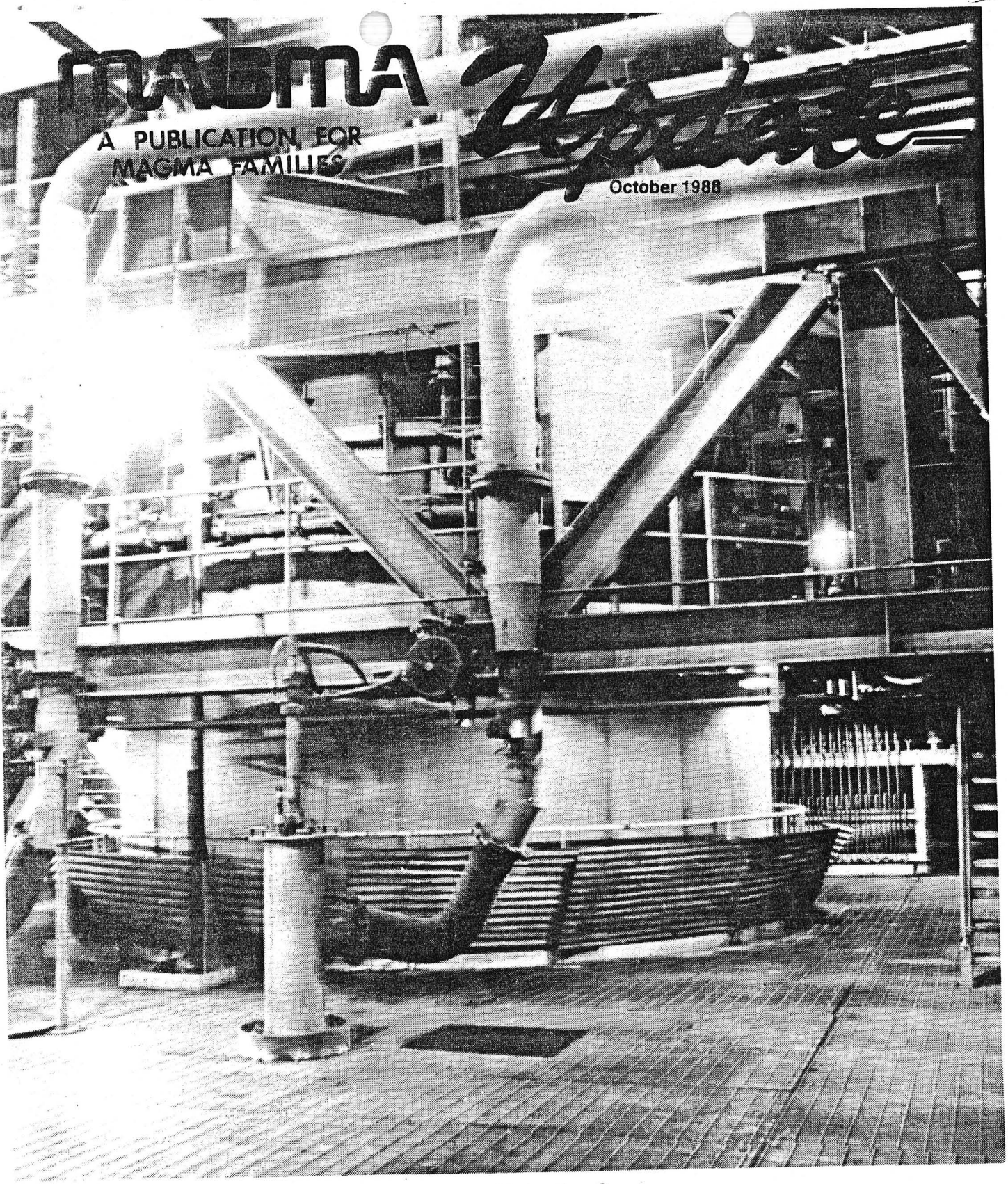
PUMP CONTROLS on 2375 level are inspected by pump foremen Bill Crown, left, and electrician Jim Watkins.

Photos by Richard Cole

MAGMA Update

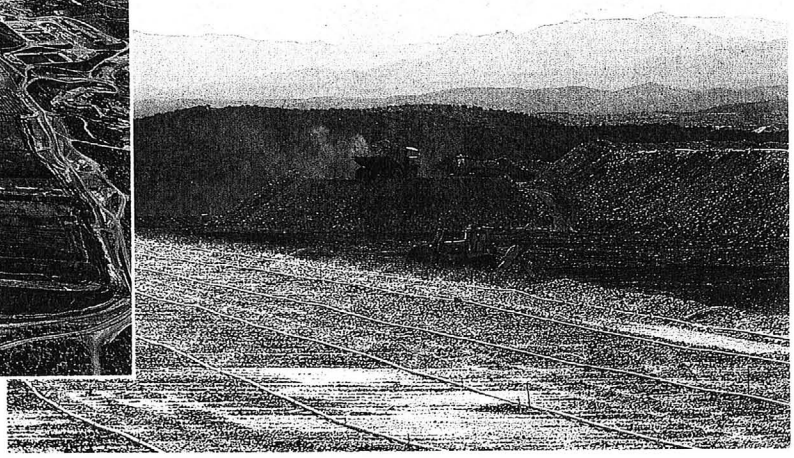
A PUBLICATION FOR MAGMA FAMILIES

October 1988



Our new flash furnace

GLEAMING CARBON STEEL reaction shaft of the new San Manuel flash smelting furnace is 23 feet high and 20 feet in diameter. Pouring down and around the shaft is a curtain of water keeping the skin cool and helping to prevent expansion of the steel. Concentrates are blown in at the top of the furnace through a single burner and into an atmosphere of 44% oxygen. Sulfur in the concentrate ignites when it contacts the oxygen and this "flash" reaction gives off enough heat to liquify the other concentrate ingredients - iron and copper which rain down into the settling chamber below. Read about the furnace dedication on page 1 and about our continued environmental responsibilities on page 8 of this issue.



THE OPEN PIT OXIDE MINE

Located in the subsidence zone of the San Manuel underground mine, the oxide open pit was established to recover a large reserve of copper oxide ore. The principal oxide mineral leached is chrysocolla.

Waste material is dumped into the adjacent cave area created by the underground mine and ore material is hauled a short distance to the heap leaching dumps.

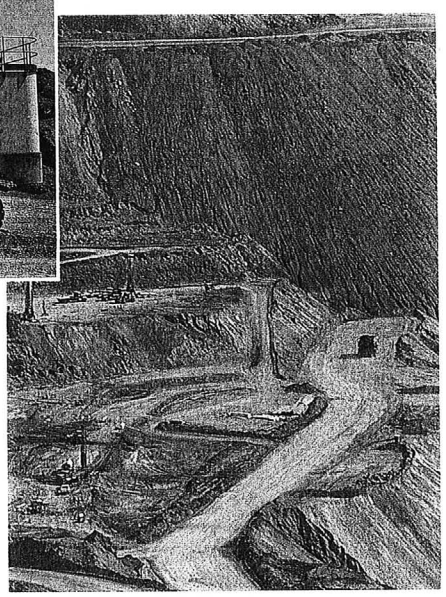
The pit is a medium-size operation which will produce approximately 22,000 tons of ore and 24,000 tons of waste per day over a nine-year period.

Blasted ore is loaded by front-end loaders and hydraulic excavators into 100-ton diesel electric haul trucks which operate on roads 80 feet wide with a maximum grade of 10%.

The leach dumps are built on an area of 113 acres underlain with a thick high density polyethylene liner to prevent any loss of leaching fluids into the surrounding watershed.

A typical leach dump has a surface area of 125,000 sq. ft. and contains approximately 110,000 tons of oxide ore. As leaching progresses and new dumps are built on top of the old the dumps become increasingly higher and will eventually reach approximately 200 ft. in height.

For leaching, a network of pipes and wobbler sprinklers is laid on the surface of a newly completed dump and a weak solution of sulfuric acid is continuously sprayed at the rate of 0.8 gallons per minute per 100 sq. feet of surface area.



The leach solution percolates down through the dump, dissolving copper in the ore, and flows from the dump's base as pregnant leach solution (PLS), drains into a collection pond, and is then pumped to the 10,000,000-gallon feed pond for the solvent extraction plant.

IN-SITU LEACHING

Additional reserves of acid-soluble oxide ore lie beneath the open pit area and above the depleted portion of the underground mine.

An ore reserve of approximately 272,402,000 tons has been rubblized by the underground mining activity and is available for the in-place method of in-situ leaching.

Injection wells are drilled into this zone to a depth of 1,000 ft. The wells are cased with PVC pipe, the bottom portion of which is slotted to allow solution into the ore.

A leach solution of weak sulfuric acid is injected into each well at a rate dependent upon the permeability of the zone into which it was drilled.

The solutions percolate down through the ore zone, dissolve the copper minerals, and drain into a prepared collection area. The collection area had previously been haulage drifts of the underground mine.

This PLS (copper-bearing solution) is pumped to the surface by means of a corrosion-resistant pumping system, where it joins PLS from the leach dump, for processing in the SX-EW plant.

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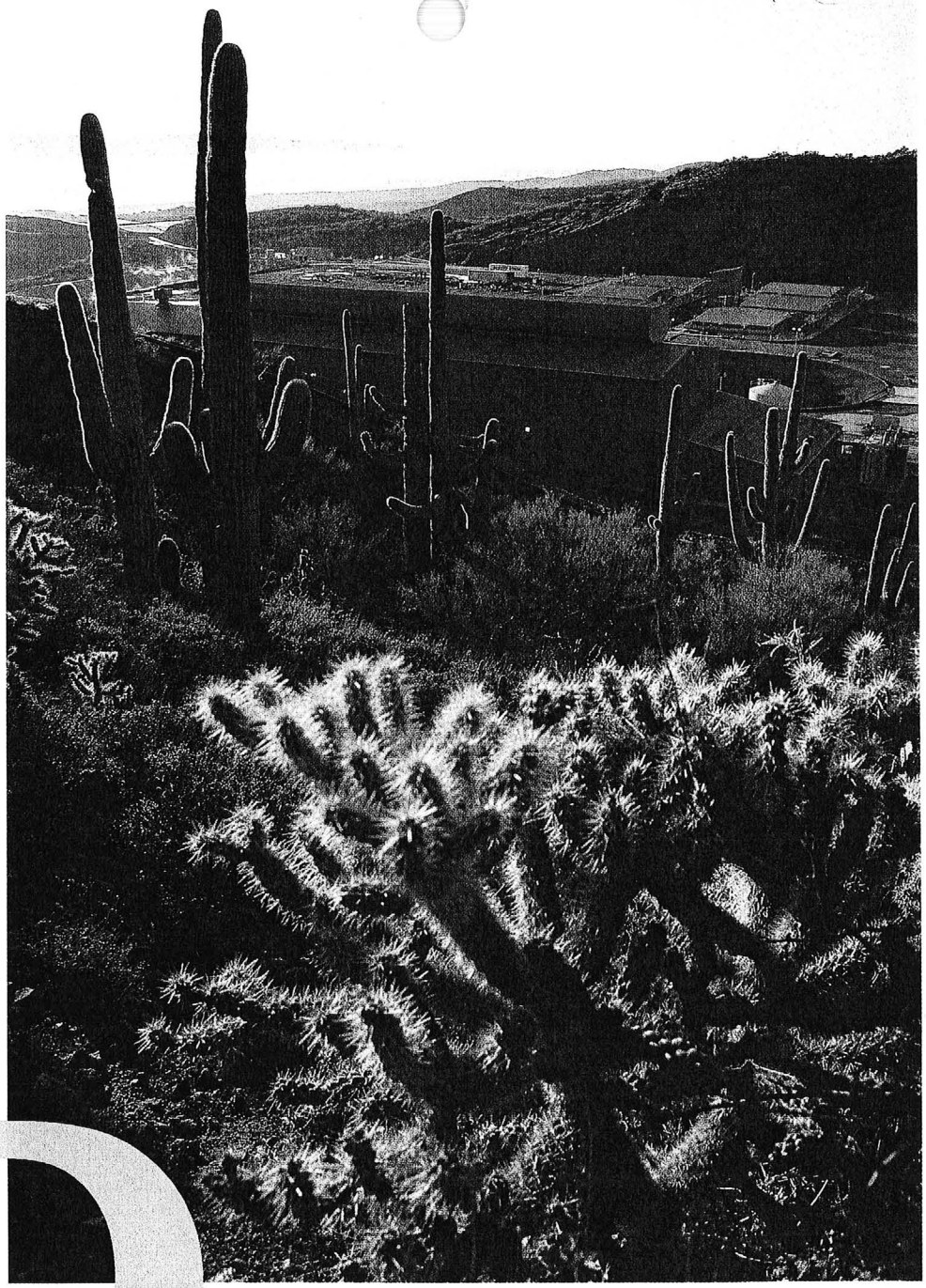
Magma Has a Plan For Arizona Copper

What to do when prices are down and production costs remain high



During the past few years United States copper companies have been working hard to keep costs down. It's a matter of survival. Copper prices—now hovering between 60 and 65 cents per pound—are the lowest, in real terms, since the 1920s. With average production costs considerably higher than the selling price, it's impossible to make ends meet.

Indeed, these tough market conditions have forced many U.S. copper companies to shut down mining operations. Others, in an attempt to bring production costs down below the current market price, are undertaking extensive modernization programs or building new facilities.

Magma Copper Company in Arizona is one such firm. In 1984, it hired Bechtel to engineer and build a state-of-the-art copper recovery facility that will help bring its overall production costs down to an acceptable level.

"This new solvent extraction-electrowinning (SX-EW) plant will be capable of standing on its own and competing in world markets in the foreseeable future," says Bechtel Project Manager Jim McLain.

well is 20 miles north of here at a depth of 18,060 feet," explains Weldon Sons, Elk Hills' superintendent of drilling. "Right now, we're at 12,000 feet, and our goal is to get down to a proposed 25,000 feet to determine whether additional oil or gas reservoirs lie below the existing producing formations."

Because the Naval Petroleum Reserve (so called because it had once been intended solely for use by the U.S. Navy) is in a declining production cycle, and oil is more difficult to find and recover, the Bechtel team must contend with a constantly shifting set of requirements. Recovery methods used when the field was young are no longer adequate, and enhanced recovery techniques must now be added.

"Even though Elk Hills oil is lighter and easier to recover than most of the oil in the area, additional stimulation is required to efficiently sweep the remaining oil from the reservoir," says Elmer Remkes, president of Bechtel Petroleum Operations, Inc.

Steam injection is one enhanced oil recovery technique currently being tried to increase recoverable reserves on the site. Other methods include chemical flooding, carbon dioxide or nitrogen injection and improved waterflooding.

To accommodate the changing reservoir recovery requirements, Bechtel is also modifying existing wells and production facilities as well as building new ones. Most important, however, is the need for the Bechtel team to balance the impact the various modifications will have on the whole field.

"In an oil field with more than 1,400 producing wells, 137 production centers and three gas extraction plants, we have to plan each modification carefully and review it for its potential impact on overall operations," says Remkes.

Systems engineering, as the study of this interdependence of all operating elements is called, is what will enable Bechtel to achieve the recovery goals and the efficiency of operations required by the owners.

"Elk Hills is more than an oil field," Remkes adds. "It's people, concerned about safety and the environment, and technology working together." □

Environmentalists at Elk Hills monitor San Joaquin kit fox dens

Rx for Lizard and Kit Fox

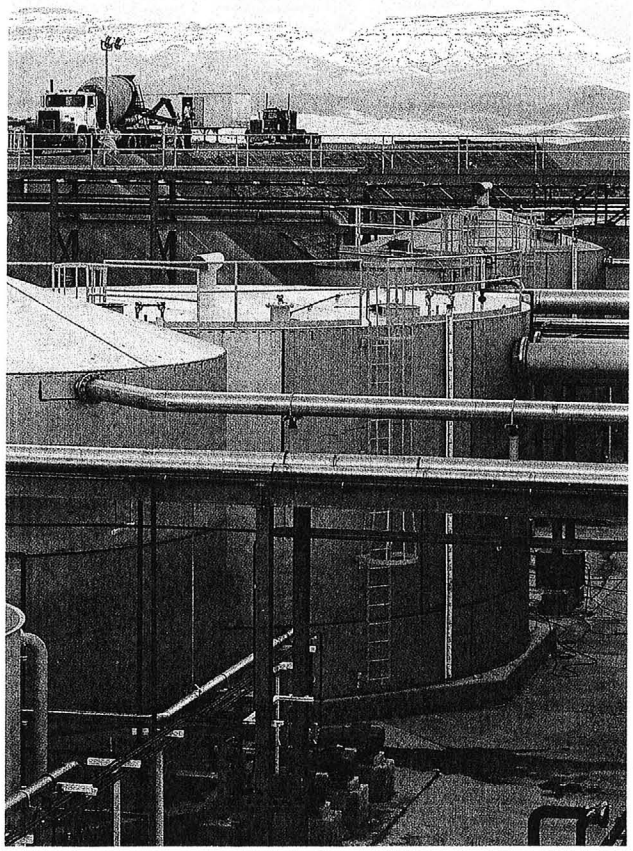
As part of his job, Rick Donahoe, manager of environmental services for Bechtel's Elk Hills operations, is charged with the responsibility of protecting two endangered species, the blunt-nosed leopard lizard and the San Joaquin kit fox.

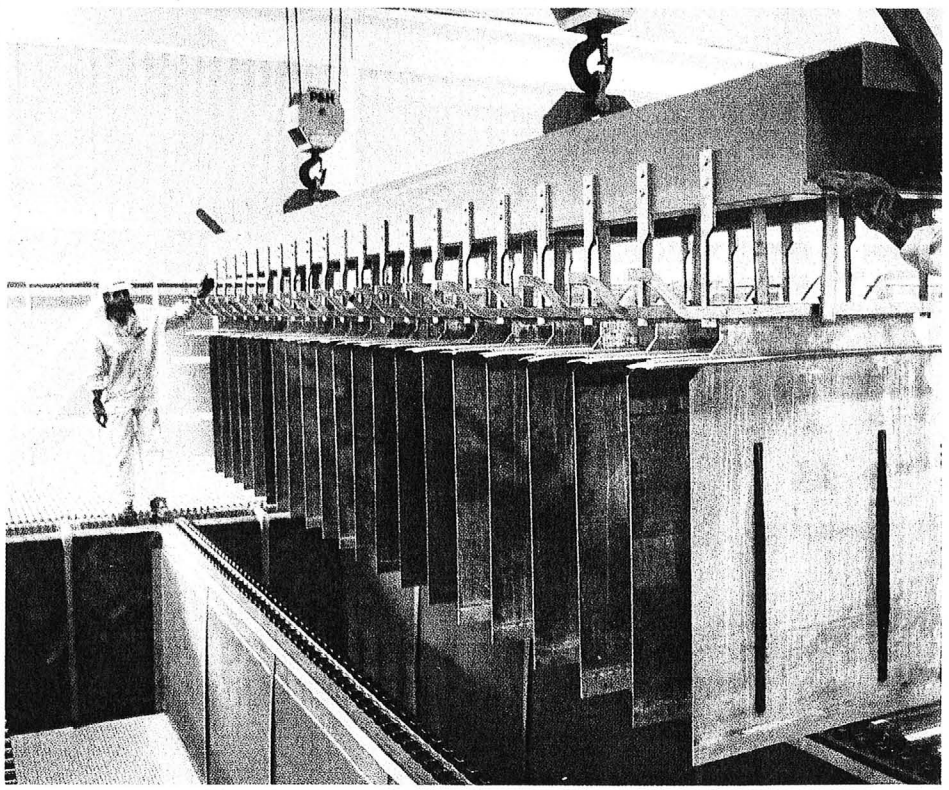
"These animals must be protected from the potentially disruptive effects of drilling and production activities," he says. "Wildlife biologists systematically monitor the animals' movements and regularly study their food and space requirements, as well as the impact of disease and natural predators. We make sure that none of our projects interferes with their well-being."

In addition to protecting endangered species, Donahoe oversees air quality and waste management activities at the Naval Petroleum Reserve. He is responsible for ensuring the annual renewal of 160 operating permits—granted by the county only when state and federal air quality standards are met. And his group continually monitors wells, storage tanks and processing facilities to ensure emissions levels are within the limits allowed.

In addition, Donahoe's department is responsible for all the waste materials that leave the reserve. "We make sure that everything is properly stored and documented before it goes out, and we have very tight controls over the chain of custody once the materials are on their way to the disposal sites."

Magma Copper's new SX-EW plant (left) is located in San Manuel, Arizona, 60 miles northeast of Tucson. Electrolyte holding and recirculation tanks (below) make use of gravity to transport solutions to the next processing area





The new facility supplements Magma's existing sulfide ore operations at San Manuel, Arizona, which consist of the largest underground copper mine in the United States, and conventional concentrating, smelting and refining facilities. Production in these facilities, however, is generally more expensive than hydrometallurgical processing (HP)—the method used at the SX-EW plant.

In addition, McLain says HP has several distinctive features. It is free of environmental emission problems; it results in salable, refined copper, requiring no further processing; and it is economical.

Yet perhaps the biggest advantage of the facility is that it allows Magma to recover copper from previously untouched oxide ore reserves. The oxide ore, which is considered low-grade, is near the ground surface and above the sulfide deposit. It is mined for leaching using open-pit methods.

"Although Magma has known about its oxide ore reserves since the 1940s, until recently there was no known technology that would permit profitable production," McLain says. "The latest developments in solvent extraction-electrowinning technology have changed that story."

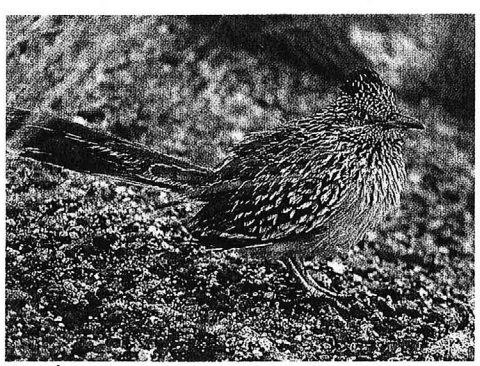
Bechtel, which built the first commer-

Construction Superintendent Bill Bystrom and Project Manager Jim McLain (top, left) review completion items in the tank area. Electrician (above) loads lead anodes into the production cells in the electrowinning area

Eighty-three-acre lined leach dump area (above) with Galiuro Mountains in background

cial SX-EW plant in 1968, is considered an industry leader in this technology. "Over the years, Bechtel has made pioneering developments in this area, making it possible to profitably recover copper from low-grade ores—even in today's depressed marketplace," McLain says.

"Electrowinning produces a pure cathode copper product that is in high demand. Electrical fabricators, who use the material to make all types of wire, can't get enough of it."



Road runner

To help Magma keep costs to a minimum, Bechtel has gone to great lengths to provide a facility that will operate as economically as possible.

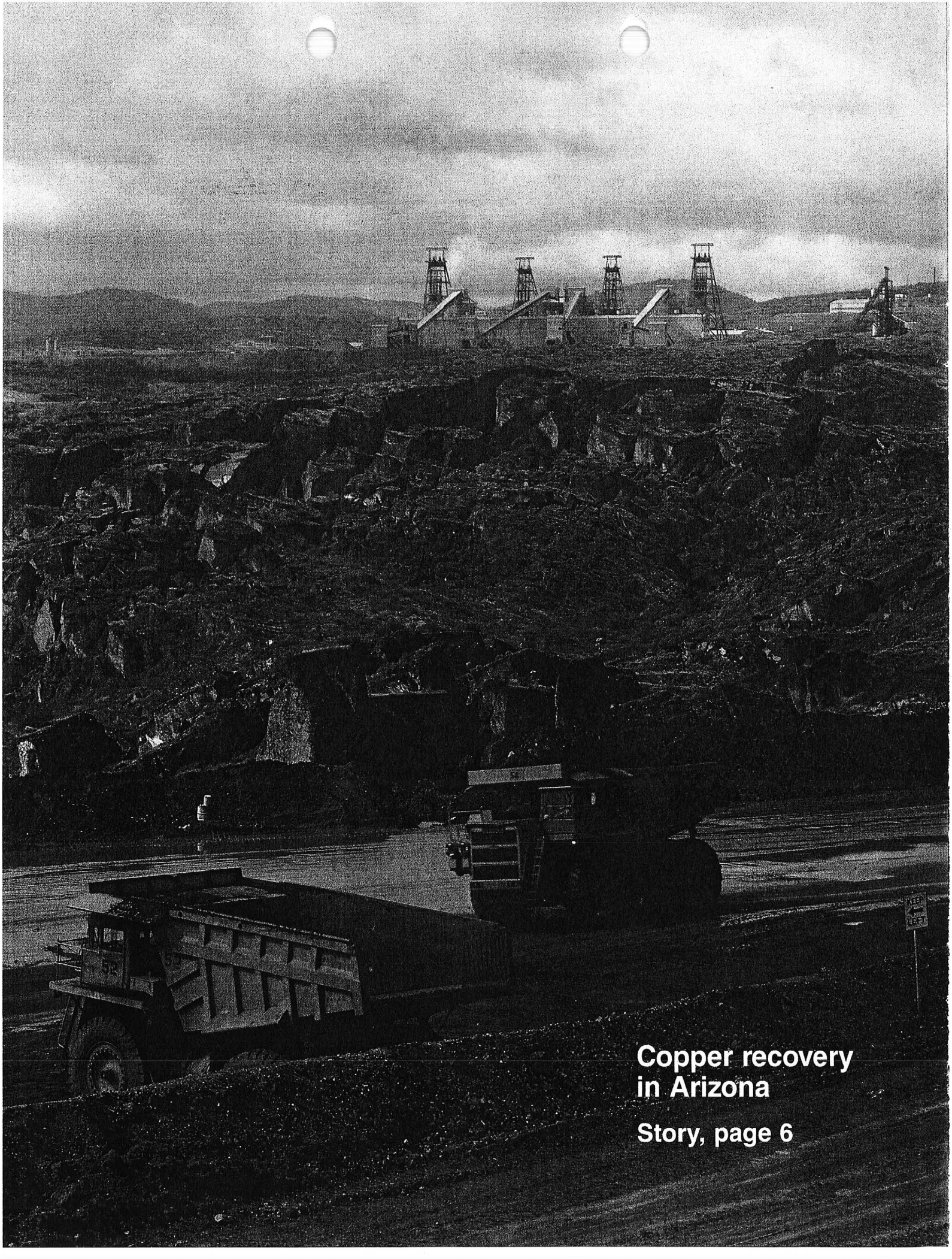
For example, the plant, located in mountainous terrain, works hand-in-hand with Mother Nature. "Tanks and holding ponds, whenever possible, are located at elevations where they can make use of gravity, rather than electricity, to pump solutions from leaching through the extraction process," McLain says.

The SX-EW facility is also highly automated. "It requires less materials handling than traditional smelting or refining operations," he explains. "The result is substantially reduced labor costs."

In addition to design innovations, Bechtel is using key members of the team that designed the plant for preoperational testing and startup assistance. "This saves time and money because we don't have to spend time learning plant systems," says Bechtel Project Engineer Bill O'Rourke.

Construction was completed ahead of schedule in just under 13 months. "Our construction plan used direct-hire construction crafts and specialty subcontractors for economy and control of the schedule in critical areas," says Bechtel Construction Superintendent Bill Bystrom.

The plant started producing cathode copper last month. Operations will continue 24 hours per day, 365 days per year with total availability in excess of 95 percent. □



Copper recovery in Arizona

Story, page 6

Bechtel Chosen for New Safety Program in California

Bechtel has been selected to be the first construction company in California to operate health and safety programs under the new Cal/Star cooperative self-inspection program.

Under the new plan from the California Occupational Safety and Health Administration (Cal OSHA), an employee/employer joint committee will form at selected jobsites to monitor and inspect Bechtel's safety and health programs, interacting with both management and the workforce.

The Cal/Star program is similar to the innovative and widely acclaimed self-inspection program Bechtel started at the San Onofre Nuclear Generating Station jobsite in Southern California in 1979. Since the program's successful implementation at San Onofre, Bechtel has started other self-inspection programs at the Cool Water coal gasification project in the Mojave Desert, the Richmond Oil refinery on the San Francisco Bay, and the Union Oil coker revamp project at Rodeo, California.

"The Cal/Star program allows a company, its employees, and Cal OSHA to work cooperatively to eliminate safety and health hazards in the work place," according to Ron Rinaldi, director of California's Department of Industrial Relations. "Through this designation," he adds, "we recognize the outstanding safety and health programs Bechtel operates on its construction projects, as well as the extremely high safety standards it demands on all of its jobs. We felt the company's excellent history in these areas merited the honor of being the first construction firm to operate under the new Cal/Star plan."

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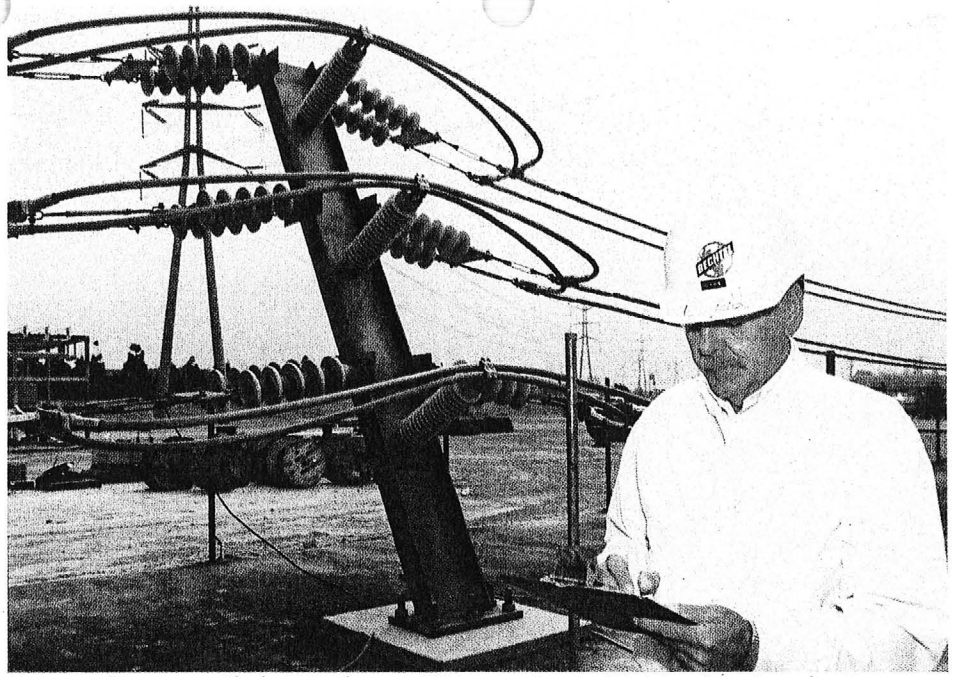


Lineman/Foreman Clyde Winsbury of Western Power Division/Los Angeles inspects Johanna Substation support structure

Johanna Substation Completed

In preparation for the peak loads that mark Southern California's electric energy consumption, Bechtel has completed construction of the Johanna Substation in Santa Ana, California. It is one of six substations scheduled for completion this spring for Southern California Edison by Bechtel's Western Power Division in Los Angeles.

Bechtel project superintendent was W.F. McPhail, followed by G.E. Rich. Construction manager for the Johanna Substation was J.R. Downs.

Finishing the six substations by June 1986 was important to the client. Summer, when air conditioner use is high, is normally the time of peak energy consumption in the Los Angeles Basin and the surrounding areas served by Southern California Edison.

Three substations are in Los Angeles County, one in San Bernardino County, and two—including the Johanna substation—are in Orange County.

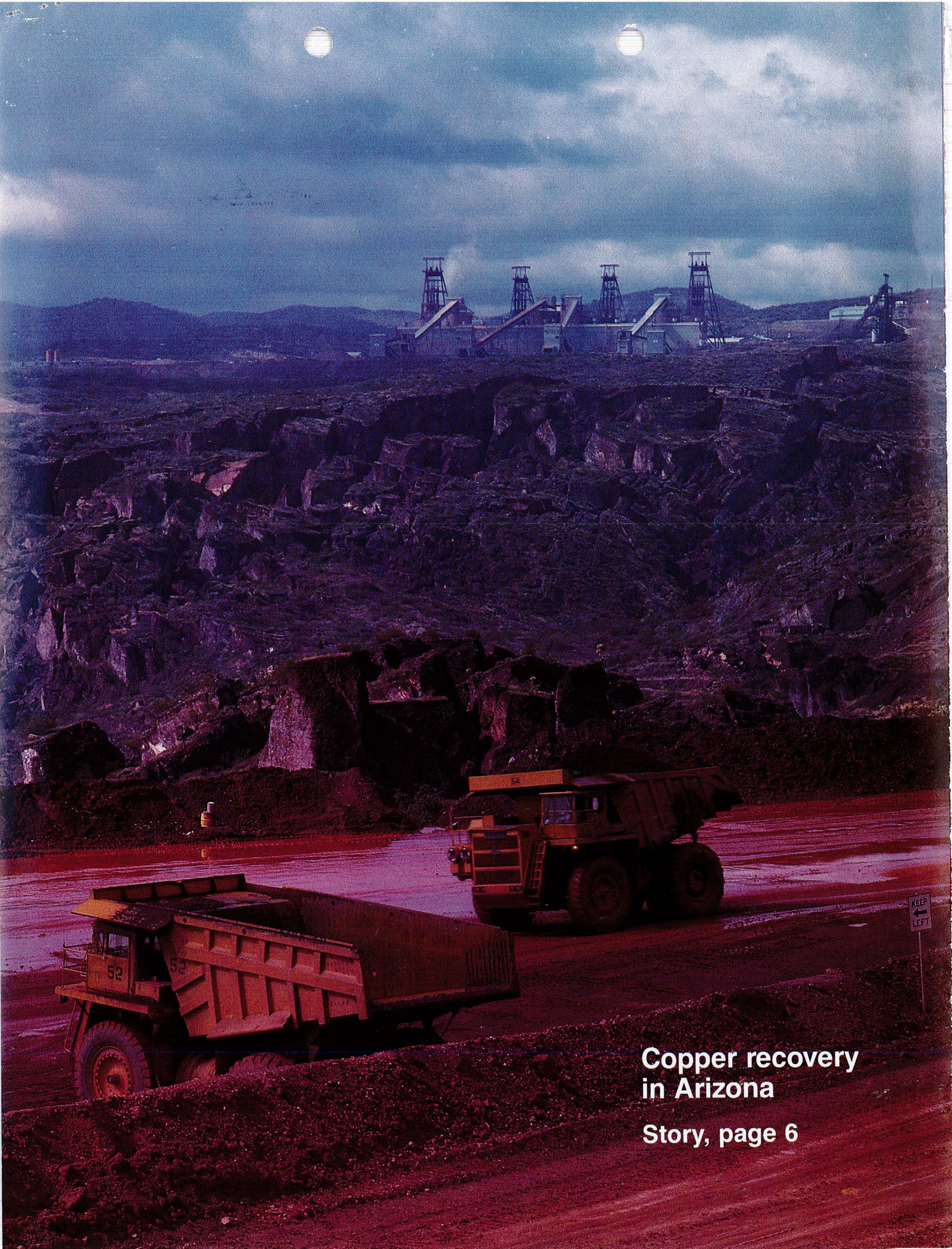
Contract Awarded in China

Bechtel has been awarded a contract by an electric utility in the People's Republic of China for construction of a 500-kilovolt transmission line. As part of the project, an overhead transmission line more than two miles long will span the Pearl River in Guangdong Province. This segment of the line will involve the erection of two suspension towers 790 feet in height. The elevation and length of the overwater line will rank it among the world's largest overhead crossings.

Guangdong General Power Company (GGPC) has retained Bechtel China, Inc. along with Bechtel North America Power Corporation, to provide engineering, procurement, and construction management for the 60-mile line linking a 700-megawatt coal fired generating plant under construction at Shajaio with GGPC's main power grid at Jiangmen.

Bechtel is subcontracting with Societa Anonima Elettrificazione of Italy, for the design and supply of steel towers and technical supervision. The construction work will be carried out by four Chinese contractors.

Value of the contract is estimated at about $20 million. Completion is scheduled for mid-1987.



Copper recovery in Arizona

Story, page 6

Bechtel Chosen for New Safety Program in California

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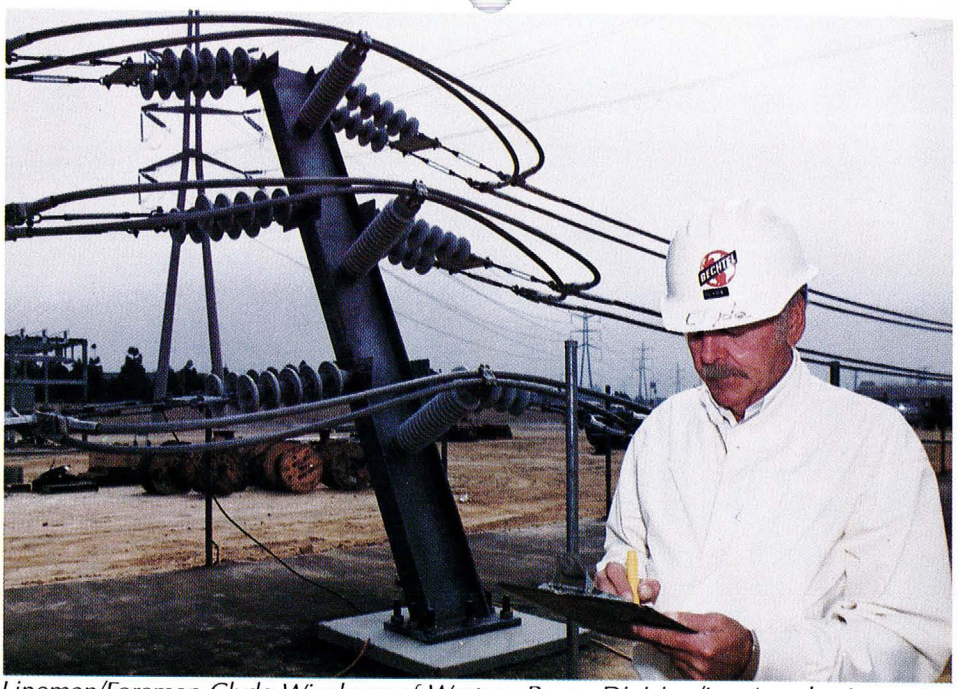

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THE OPEN PIT OXIDE MINE

Located in the subsidence zone of the San Manuel underground mine, the oxide open pit was established to recover a large reserve of copper oxide ore. The principal oxide mineral leached is chrysocolla.

Waste material is dumped into the adjacent cave area created by the underground mine and ore material is hauled a short distance to the heap leaching dumps.

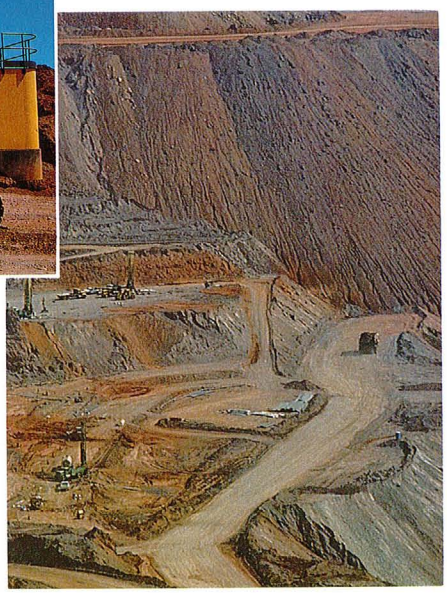
The pit is a medium-size operation which will produce approximately 22,000 tons of ore and 24,000 tons of waste per day over a nine-year period.

Blasted ore is loaded by front-end loaders and hydraulic excavators into 100-ton diesel electric haul trucks which operate on roads 80 feet wide with a maximum grade of 10%.

The leach dumps are built on an area of 113 acres underlain with a thick high density polyethylene liner to prevent any loss of leaching fluids into the surrounding watershed.

A typical leach dump has a surface area of 125,000 sq. ft. and contains approximately 110,000 tons of oxide ore. As leaching progresses and new dumps are built on top of the old the dumps become increasingly higher and will eventually reach approximately 200 ft. in height.

For leaching, a network of pipes and wobbler sprinklers is laid on the surface of a newly completed dump and a weak solution of sulfuric acid is continuously sprayed at the rate of 0.8 gallons per minute per 100 sq. feet of surface area.



The leach solution percolates down through the dump, dissolving copper in the ore, and flows from the dump's base as pregnant leach solution (PLS), drains into a collection pond, and is then pumped to the 10,000,000-gallon feed pond for the solvent extraction plant.

IN-SITU LEACHING

Additional reserves of acid-soluble oxide ore lie beneath the open pit area and above the depleted portion of the underground mine.

An ore reserve of approximately 272,402,000 tons has been rubblized by the underground mining activity and is available for the in-place method of in-situ leaching.

Injection wells are drilled into this zone to a depth of 1,000 ft. The wells are cased with PVC pipe, the bottom portion of which is slotted to allow solution into the ore.

A leach solution of weak sulfuric acid is injected into each well at a rate dependent upon the permeability of the zone into which it was drilled.

The solutions percolate down through the ore zone, dissolve the copper minerals, and drain into a prepared collection area. The collection area had previously been haulage drifts of the underground mine.

This PLS (copper-bearing solution) is pumped to the surface by means of a corrosion-resistant pumping system, where it joins PLS from the leach dump, for processing in the SX-EW plant.

MAGMA

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San Manuel, AZ 85631
Telephone 602-385-3100

well is 20 miles north of here at a depth of 18,060 feet," explains Weldon Sons, Elk Hills' superintendent of drilling. "Right now, we're at 12,000 feet, and our goal is to get down to a proposed 25,000 feet to determine whether additional oil or gas reservoirs lie below the existing producing formations."

Because the Naval Petroleum Reserve (so called because it had once been intended solely for use by the U.S. Navy) is in a declining production cycle, and oil is more difficult to find and recover, the Bechtel team must contend with a constantly shifting set of requirements. Recovery methods used when the field was young are no longer adequate, and enhanced recovery techniques must now be added.

"Even though Elk Hills oil is lighter and easier to recover than most of the oil in the area, additional stimulation is required to efficiently sweep the remaining oil from the reservoir," says Elmer Remkes, president of Bechtel Petroleum Operations, Inc.

Steam injection is one enhanced oil recovery technique currently being tried to increase recoverable reserves on the site. Other methods include chemical flooding, carbon dioxide or nitrogen injection and improved waterflooding.

To accommodate the changing reservoir recovery requirements, Bechtel is also modifying existing wells and production facilities as well as building new ones. Most important, however, is the need for the Bechtel team to balance the impact the various modifications will have on the whole field.

"In an oil field with more than 1,400 producing wells, 137 production centers and three gas extraction plants, we have to plan each modification carefully and review it for its potential impact on overall operations," says Remkes.

Systems engineering, as the study of this interdependence of all operating elements is called, is what will enable Bechtel to achieve the recovery goals and the efficiency of operations required by the owners.

"Elk Hills is more than an oil field," Remkes adds. "It's people, concerned about safety and the environment, and technology working together." □

Environmentalists at Elk Hills monitor San Joaquin kit fox dens

Rx for Lizard and Kit Fox

As part of his job, Rick Donahoe, manager of environmental services for Bechtel's Elk Hills operations, is charged with the responsibility of protecting two endangered species, the blunt-nosed leopard lizard and the San Joaquin kit fox.

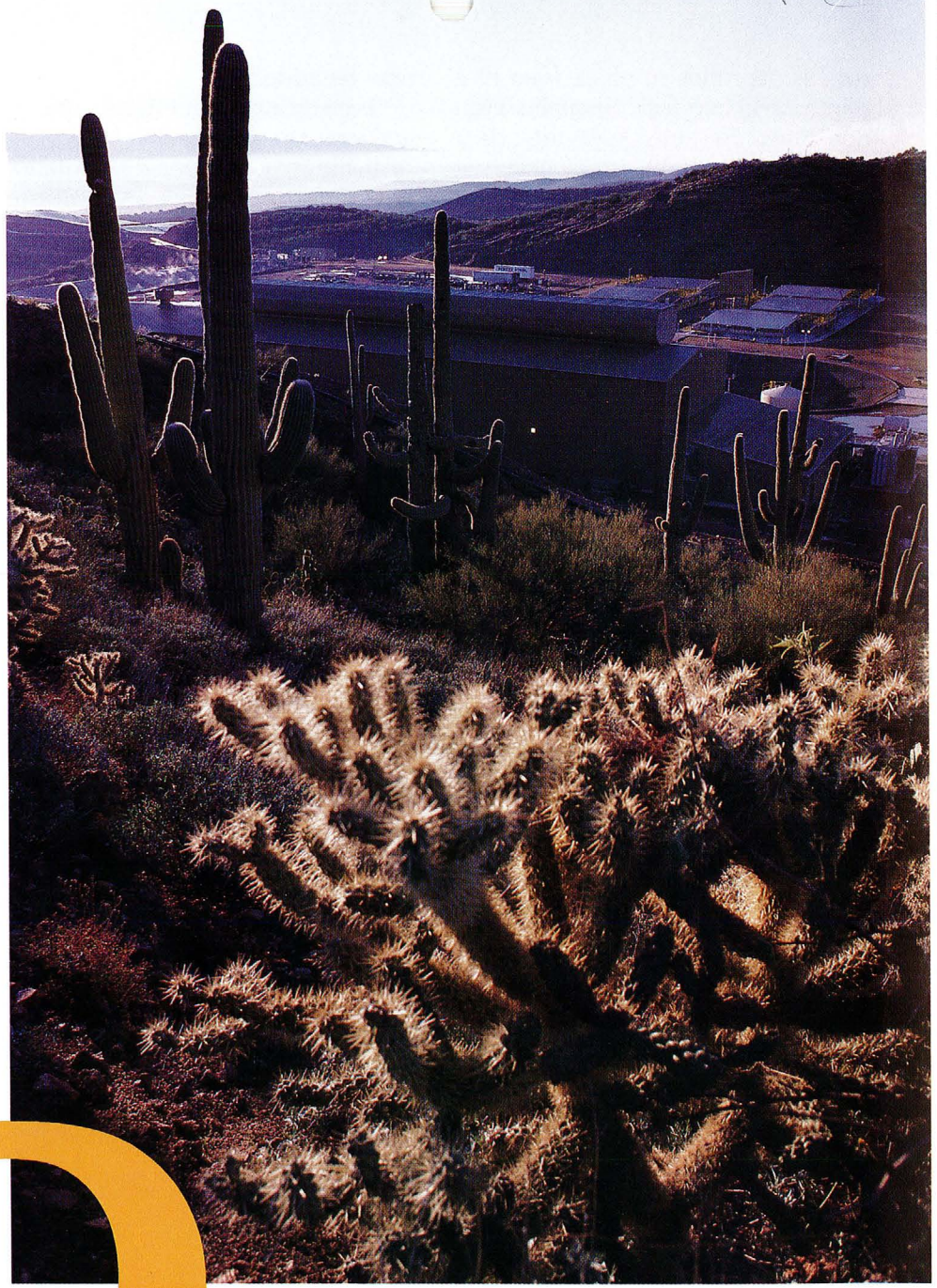
"These animals must be protected from the potentially disruptive effects of drilling and production activities," he says. "Wildlife biologists systematically monitor the animals' movements and regularly study their food and space requirements, as well as the impact of disease and natural predators. We make sure that none of our projects interferes with their well-being."

In addition to protecting endangered species, Donahoe oversees air quality and waste management activities at the Naval Petroleum Reserve. He is responsible for ensuring the annual renewal of 160 operating permits—granted by the county only when state and federal air quality standards are met. And his group continually monitors wells, storage tanks and processing facilities to ensure emissions levels are within the limits allowed.

In addition, Donahoe's department is responsible for all the waste materials that leave the reserve. "We make sure that everything is properly stored and documented before it goes out, and we have very tight controls over the chain of custody once the materials are on their way to the disposal sites."

Magma Has a Plan For Arizona Copper

What to do when prices are down and production costs remain high



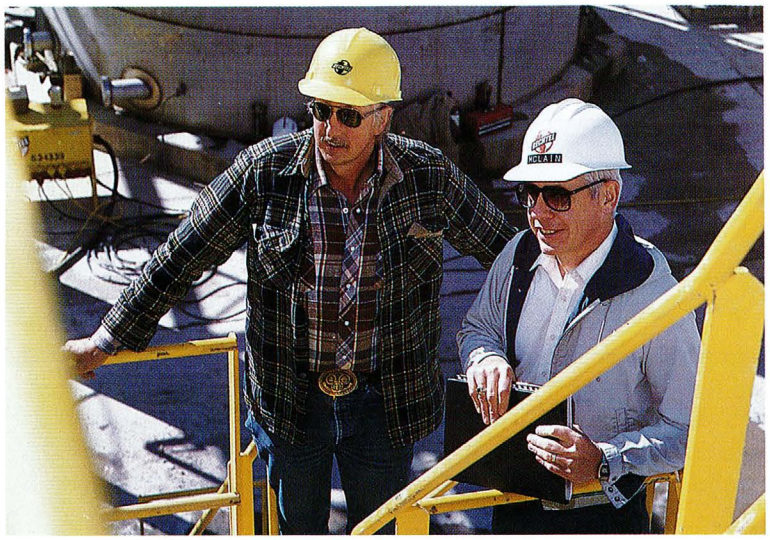
During the past few years United States copper companies have been working hard to keep costs down. It's a matter of survival. Copper prices—now hovering between 60 and 65 cents per pound—are the lowest, in real terms, since the 1920s. With average production costs considerably higher than the selling price, it's impossible to make ends meet.

Indeed, these tough market conditions have forced many U.S. copper companies to shut down mining operations. Others, in an attempt to bring production costs down below the current market price, are undertaking extensive modernization programs or building new facilities.

Magma Copper Company in Arizona is one such firm. In 1984, it hired Bechtel to engineer and build a state-of-the-art copper recovery facility that will help bring its overall production costs down to an acceptable level.

"This new solvent extraction-electrowinning (SX-EW) plant will be capable of standing on its own and competing in world markets in the foreseeable future," says Bechtel Project Manager Jim McLain.

Magma Copper's new SX-EW plant (left) is located in San Manuel, Arizona, 60 miles northeast of Tucson. Electrolyte holding and recirculation tanks (below) make use of gravity to transport solutions to the next processing area



The new facility supplements Magma's existing sulfide ore operations at San Manuel, Arizona, which consist of the largest underground copper mine in the United States, and conventional concentrating, smelting and refining facilities. Production in these facilities, however, is generally more expensive than hydrometallurgical processing (HP)—the method used at the SX-EW plant.

In addition, McLain says HP has several distinctive features. It is free of environmental emission problems; it results in salable, refined copper, requiring no further processing; and it is economical.

Yet perhaps the biggest advantage of the facility is that it allows Magma to recover copper from previously untouched oxide ore reserves. The oxide ore, which is considered low-grade, is near the ground surface and above the sulfide deposit. It is mined for leaching using open-pit methods.

"Although Magma has known about its oxide ore reserves since the 1940s, until recently there was no known technology that would permit profitable production," McLain says. "The latest developments in solvent extraction-electrowinning technology have changed that story."

Bechtel, which built the first commer-

Construction Superintendent Bill Bystrom and Project Manager Jim McLain (top, left) review completion items in the tank area. Electrician (above) loads lead anodes into the production cells in the electrowinning area

Eighty-three-acre lined leach dump area (above) with Galiuro Mountains in background

Road runner

cial SX-EW plant in 1968, is considered an industry leader in this technology. "Over the years, Bechtel has made pioneering developments in this area, making it possible to profitably recover copper from low-grade ores—even in today's depressed marketplace," McLain says.

"Electrowinning produces a pure cathode copper product that is in high demand. Electrical fabricators, who use the material to make all types of wire, can't get enough of it."

To help Magma keep costs to a minimum, Bechtel has gone to great lengths to provide a facility that will operate as economically as possible.

For example, the plant, located in mountainous terrain, works hand-in-hand with Mother Nature. "Tanks and holding ponds, whenever possible, are located at elevations where they can make use of gravity, rather than electricity, to pump solutions from leaching through the extraction process," McLain says.

The SX-EW facility is also highly automated. "It requires less materials handling than traditional smelting or refining operations," he explains. "The result is substantially reduced labor costs."

In addition to design innovations, Bechtel is using key members of the team that designed the plant for preoperational testing and startup assistance. "This saves time and money because we don't have to spend time learning plant systems," says Bechtel Project Engineer Bill O'Rourke.

Construction was completed ahead of schedule in just under 13 months. "Our construction plan used direct-hire construction crafts and specialty subcontractors for economy and control of the schedule in critical areas," says Bechtel Construction Superintendent Bill Bystrom.

The plant started producing cathode copper last month. Operations will continue 24 hours per day, 365 days per year with total availability in excess of 95 percent. □