THE EXPLOSIVES ENGINEER

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Forerunner of Progress in Mining, Quarrying, Construction

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The description of the activities of Cuba's Minas de Matahambre, S.A., in the article by Arthur P. Nelson, general manager, beginning on page 41, offers a definite contribution to the literature on metal mining.

Minas de Matahambre, S.A., is a Cuban-owned corporation with producing properties in the Matahambre district of the Province of Pinar del Rio. The mines are located in the town of Matahambre, 6 miles inland from the subport of Santa Lucía on the north coast of Cuba and about 100 miles west of Havana. With an annual production during the past five years that has averaged more than 36,000,000 lb. of copper, Minas de Matahambre, S.A. is the richest mining camp in Cuba and one of the leading copper mines in the world.

The oxidized outcrop at Matahambre was first discovered by a local farmer in 1912. He sold his interest to two Cubans, one of whom, Engineer Don Manuel Luciano Díaz, provided the capital to initiate the development of the outcrop discovery. The initial development work was extremely difficult because of inadequate equipment, machinery, and roads. Ore was extracted near the surface and transported by mules over 9 miles of crude roads to an improvised subport at Santa Lucía.

The American Metals Company assumed the management of the business in 1921 and, three years later, acquired control of the corporation. In 1944, the Cuban stockholders purchased the interest of American Metals Company, reorganized the corporation, and elected Dr. Ernesto Romagosa as its president.

Because of its isolated location, Minas de Matahambre has had to provide a variety of facilities to be as self-sufficient as possible. In addition to the normal mine auxiliary plants at Matahambre, the corporation maintains aerial tramways, a foundry, a sawmill, a 60,000-acre timber farm, stores and restaurants, a bakery, hospital, school, and recreational facilities. At the subport of Santa Lucía, complete dock facilities, concentrate bins, tugs, lighters, miscellaneous shipping equipment, and a power plant are maintained by the corporation. A 33,000-ft. electric power transmission line connects the mine with the power plant. Concentrates are transported from the mine at Matahambre to the Santa Lucía subport by a 30,325-ft. Leschen aerial tramway.

The underground mines are equipped with three vertical shafts. Shaft No. 1, a three-compartment timbered unit, is 2,100 ft. deep. Shaft No. 2, a four-compartment steel-set unit, is 3,600 ft. deep. Shaft No. 3 is a three-compartment timbered shaft with a present depth of 2,825 ft. It is being deepened to the 3,600-ft. level to augment ventilation and to facilitate exploration in the lower levels.

Wherever ground conditions permit, a cut-and-fill system of mining is used. In stopes where the ground is not strong or is broken by faulting, the square-set method of mining is employed. The total mine production is hoisted through Shaft No. 2 to the crushing plant, located about 2,000 ft. from the shaft. The crushed ore is delivered to the concentrator by a jigback aerial tramway.

In presenting this comprehensive article about Cuba's Minas de Matahambre, S.A., the editorial staff of The Explosives Engineer wishes to acknowledge its gratitude to the author, Arthur P. Nelson, general manager, to Dr. Ernesto Romagosa, president, and to their associates who cooperated in its preparation. We are grateful also for the cooperation of Raimundo Martinez de Castro and Eduardo J. Castellanos, vice presidents of Minagro Industrial, S.A., Cuba, in making this presentation possible.

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DR. ERNESTO ROMAGOSA

Dr. Ernesto Romagosa

PRESIDENT

MINAS DE MATAHAMBRE, S.A.

A Biography

IT IS NOT UNUSUAL for a man to become prominently identified with an industry or a profession after thorough training in the fundamentals and long years of concentrated effort. But it is unique when a man attains leadership in two totally different fields of endeavor – dentistry and mining. Such a rare achievement is exemplified in the career of Dr. Ernesto Romagosa, president of Minas de Matahambre, S.A. – "Mr. Miner of Cuba."

"Doctor," as he is known to his friends and associates, was born in Punta Arenas, Costa Rica, Central America, September 4, 1892, the son of Juan E. Romagosa and Catalina Sanchez. After completing his elementary education at the primary school in Manzanillo, Oriente, Cuba, and the Instituto de la Havana in Havana, he matriculated at Havana University, School of Dentistry, and was graduated in 1913 with a D.D.S. degree. During undergraduate years at the institute and the university, his extracurricular activities were highlighted by outstanding performances as an all-around athlete on his schools' varsity teams.

Following his graduation at Havana University, Dr. Romagosa came to the United States for one year of post-graduate work in dentistry at the University of Pennsylvania in Philadelphia. Upon his return to Cuba, he began the practice of dentistry in Manzanillo, Oriente.

In 1917, he moved to Havana and, for the next ten years, continued in the practice of his chosen profession. While in Havana, Dr. Romagosa became deeply interested in geology and mining. In 1925, the board of directors of Minas de Matahambre elected him to membership. He discontinued his dental practice in 1927 and started devoting part of his time and energy to help in the management of the affairs of the company. Five years later, his efforts were rewarded when his associates elected him to be the company's vice president.

In 1943, the management of Minas de Matahambre was confronted with serious problems brought about by low ore reserves, high production costs, labor difficulties, and the price of copper in the United States. A continuation of successful operations became extremely doubtful. In this emergency, the company was completely reorganized and, in 1944, Cuban interests acquired control and Dr. Romagosa was made its president. Under his direction, an expanded program of exploration was started immediately and, during the year, a new, large body of ore – the famous "44 Orebody" – was exposed. The new discovery, coupled with help from higher copper prices and greatly improved employe relations, resulted in the company's enjoying some of its most successful years.

At present, mill capacity averages 1,100 tons of ore a day. This production, requiring a company employe payroll of 1,100, provides, directly or indirectly, the means for sustaining modern standards of living in a community of approximately 7,000 people.

Besides directing the affairs of Minas de Matahambre, Dr. Romagosa is the president of two other mining properties in Cuba: Compania Inspiracion Cubana de Cobre, S.A. (zinc and copper); and Compania Inspiracion Occidental de Cobre (copper, lead, and pyrite).

Ernesto Romagosa married Amparo Díaz on May 18, 1917, in Havana. They have three daughters and one son: Mrs. Ricardo Sierra (Ernestina), Mrs. Raimundo Martinez de Castro (Amparo), Mrs. Martin Lleras (Olga), and Ernesto, Jr. Mr. Sierra and Mr. Lleras are associated with Minas de Matahambre, S.A.; Mr. de Castro is vice president and general manager of Minagro Industrial, S.A.; Mr. Ernesto Romagosa, Jr., is manager of Compania Inspiracion Cubana de Cobre, S.A. The Romagosa family home is at Fifth Avenue and Fifty-fourth Street, Miramar, Marianao, Havana, Cuba.

When work schedules and other responsibilities permit, Dr. Romagosa enjoys playing golf or billiards with his friends at the Havana Biltmore Yacht and Country Club. One of his pet hobbies is deep-sea fishing in the waters off Cuba during the summer months, accompanied by "the boys" from the Matahambre mine.

An Introduction to Minas de Matahambre, S.A.

Minas de Matahambre, S.A., is a Cuban-owned copper-mining corporation with producing properties in the Matahambre district of the Province of Pinar del Rio, Cuba. The mines are located in the town of Matahambre, 6 miles inland from the subport of Santa Lucía on the north coast of Cuba, and about 100 miles west of Havana. With an annual production during the past five years that has averaged more than 36,000,000 lb. of copper, Minas de Matahambre is the richest mining camp in Cuba and one of the leading copper mines in the world.

The word *Matahambre* was derived from a combination of two Spanish words: *mata*, meaning kill; and *hambre*, meaning hunger. Back in the days when Cuba was a Spanish colony, the natives made a large, round loaf of bread which they called *matahambre* because it was so big that one loaf would kill anyone's hunger. The mine was discovered in the Matahambre hacienda, a large farm located in the Cordillera de los Organos, a mountain range with a hill that resembles a *matahambre*, the Spanish loaf of bread.

The town of Matahambre and the subport of Santa Lucía are connected by a 9-mile graveled highway, constructed and maintained by the corporation. Until 1952, this highway was the only usable entry to the mining community. Since 1952, a 20-mile graveled highway has been completed to connect Matahambre with the island's central highway system. All heavy equipment and bulky supply materials are still received and handled through the subport of Santa Lucía.

A Variety of Facilities

Because of its isolated location, Minas de Matahambre has had to provide a variety of facilities to be as self-sufficient as possible. In addition to the normal mine auxiliary plants at Matahambre, the corporation maintains aerial tramways, a foundry, a sawmill, a 60,000-acre timber farm, stores and restaurants, a bakery, hospital, school, and recreational facilities including a golf course. At the subport of Santa Lucía, complete dock facilities, concentrate bins, tugs, lighters, miscellaneous shipping equipment, and a power plant are maintained by the corporation. A 33,000-ft. electric transmission line connects the power plant with the mine. The copper concentrates are transported from the mine to the Santa Lucía subport by a 30,325-ft. bi-cable Leschen aerial tramway.

The underground mines are equipped with three vertical shafts, Nos. 1, 2, and 3. Shaft No. 1 is a three-compartment, timbered unit that reaches a depth of 2,100 ft. Its primary use is in handling men and supplies for all stopes above the 2,200-ft. level. Shaft No. 2 is a four-compartment, steel-set shaft lined with native hardwood. Its present depth is to the 3,600-ft. level. All of the mined ore is hoisted to the surface through this shaft. It also handles the transportation of men and supplies below the 2,200-ft. level. Shaft No. 3 is a three-compartment, timbered shaft. At present, its depth is 2,825 ft. It is being deepened to the 3,600-ft. level to augment ventilation and to facilitate exploration in the lower levels. When completed, Shaft No. 3 will be available for use as an operational shaft if a breakdown should occur in Shaft No. 2.

Outcrop Discovered in 1912

The oxidized outcrop of Minas de Matahambre was first discovered in 1912 by a local farmer named Victoriano Miranda. He sold his interest to two Cubans: Engineer Don Manuel Luciano Díaz, at the time First Secretary of Public Works of Cuba, and Dr. Alfredo Porta Rojas, Senator of the Republic. Engineer Díaz decided to assume all of the risk and invested the necessary capital out of his own funds to initiate the exploitation of the outcrop discovery into, as previously related, the richest mining camp in Cuba and one of the leading copper-producing mines in the world.

The lack of equipment, machinery, and roads made the initial development of Minas de Matahambre extremely difficult. High-grade ore was extracted near the surface and transported by mules to an improvised port at Santa Lucía. As capital accumulated through the years, it was reinvested in sinking shafts, building a power-generating plant, a gravity-flotation concentration plant, and in mechanizing the mine. Nevertheless, after the First World War, when faced with a general economic crisis because of a lack of copper demand, low price, high production costs, and other difficulties, it became necessary to seek additional capital. During that period, Antonio H. Díaz, one of the older sons of Don Manuel, was president of the company. Faced with these critical difficulties, he reorganized the company and brought the American Metals Company into the picture. The management of the latter company invested the necessary capital and assumed management for a period of 22 very successful years, starting in 1921. Three years later, American Metals Company purchased the stock holdings of Dr. Porta, thus gaining control of the company.

In 1943, during the Second World War, the future prospects for the continuation of profitable operations at Minas de Matahambre were darkened by low ore reserves, high production costs, labor troubles, and the low price of copper in the United States. In December of that year, the company, basing its opinion on technical geological reports, stopped all development work and concentrated on extracting all of the existing ore reserves, with the idea of closing the mine once these reserves were exhausted. This program was strongly opposed by Dr. Ernesto Romagosa, then vice president of the corporation, representing the interests of the Cuban stockholders.

The "44 Orebody"

In April, 1944, American Metals Company sold its interest in the company to the Cuban stockholders, the majority of whom was represented by the heirs of Don Manuel Luciano Díaz, and Dr. Ernesto Romagosa was elected president. On April 29 of the same year, Dr. Romagosa, with his profound faith in the *Virgen de la Caridad del Cobre*, the patron of Cuba, and his knowledge of the mine, made possible the continuance of operations. Under his aggressive leadership, a program of expanded exploration activities was immediately set in motion. Shortly thereafter, a new large body of high-grade ore — the "44 Orebody" — was found on the 3,200-ft. level, a just reward for his courageous struggle with the former management and technical personnel who had stated that the mine was completely worked out.

In spite of the low price of copper, controlled at 11.75 cents a pound during the Second World War, the corporation, under the leadership of Dr. Romagosa and its board of directors, established good relationships with the employes, which to date have permitted 11 successful years of operation, the best in the history of Minas de Matahambre, S.A.

Havana, Cuba
March 22, 1955

Raimundo Martinez de Castro
Vice President and General Manager
Minagro Industrial, S.A.

CUBA'S MINAS DE MATAHAMBRE

With a production that averages more than 36,000,000 lb. of copper a year, the Matahambre mine in the Province of Pinar del Rio, Cuba, is one of the important copper-producing properties in the world today

ARTHUR P. NELSON*

The copper-bearing area at Matahambre, because of accompanying silification, is marked topographically by a hill of more than 800 ft. in elevation. The surrounding terrain is a mature erosion surface of less than 300 ft. of relief. This surface has been cut in the upturned strata of the Jurassic[1] San Cayetano formation,[2] made up of interbedded sandstones, siltstones, and shales. The soil mantle is thin, the usual heavy tropical vegetation is lacking except in the arroyos, and the depth of superficial rock alteration is shallow. As would be expected, the zone of oxidation in the orebodies is likewise shallow and the zone of enrichment thin. The rapid diminution of the known orebodies in the upper levels suggests that very little of the bodies has been eroded.

Although the sandstones are locally quartzitic, the rocks are remarkably unmetamorphosed. At least 75 per cent of them exhibits good bedding, and ripple marks and cross bedding are common. Fracture cleavage and evidences of rock flowage are found in disturbed zones, but elsewhere intricately interbedded and interfingering laminae of sandstone and shale are undisturbed. Rock types within the mineralized area vary from massive sandstone to thin-bedded black shale and include intermediate types of interbedded sandstones and shales.

*General Manager
Minas de Matahambre, S.A.
Matahambre, Province of Pinar del Rio, Cuba

[1]Dickerson, R. E. and Butt, W. H. "Cuban Jurassic," *Am. Assoc. Pet. Geol. Bull.*, vol. 19, pp. 116-18, 1935.

[2]Palmer, R. H., "Geology and Oil Prospects of Cuba," *Proc. 8th Ann. Sci. Congr.*, vol. 4, pp. 627-37, 1940.

The strata have a regional northeast strike, and dip at angles of 45 to 65 degrees north. Exceptions to this attitude are in locally folded and faulted zones. Characteristics of the formation are occasional to closely spaced quartz stringers following a joint pattern in the sandstone beds, and the regional occurrence of thin pyrite layers following bedding planes in the shales.

Four Systems of Faults

The structures described are the generally barren faults in contrast to the predominantly ore-bearing ones. As a single unit, the known mineralized area is delimited and controlled by four principal systems of deep-seated faults. These systems divide the area into a number of blocks, usually with greater vertical dimensions than horizontal. In attitudes, the faults are classified as follows: No. 1, vertical N.E. faults; No. 2, steep N.W. faults; No. 3, E.W. north dipping faults; No. 4, N.E. north dipping faults (bedding faults). All of the currently known orebodies are closely related to one or more of these four systems. The movements on some of these faults are considerable, as much as 450 ft. on the most prominent member of the systems (No. 1). Although most of the movement appears to be premineral, there is sufficient postmineral movement in many cases to displace and fracture the orebodies at Matahambre.

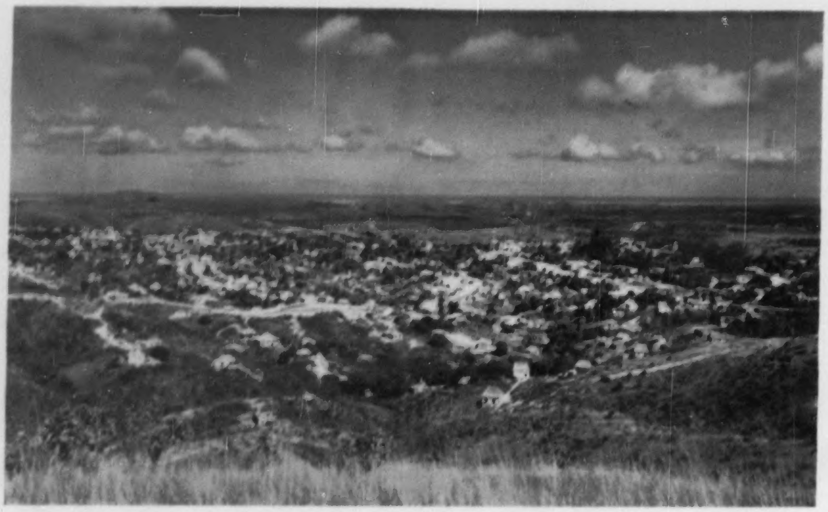
Certain members of all the fault systems exhibit strong premineral control on the orebodies. It is probable that some parallel structures with no age-relation evidence are wrongly ascribed to a respective premineral system and may actually be postmineral. At present, these systems have a vertical range of 3,500 to 4,000 ft.

Another group of faults not listed here, but which deserve attention, are the "flat faults." These are undulating faults with no definite strike, with dips of 0 to 30 degrees. Most of the observed flat faults are in the intermediate levels of the mine, but one has been seen on the surface. These are associated with thrusting and local close folding. They affect the ore zones strongly, usually greatly increasing the copper content immediately below and abruptly decreasing it above.

Ore Zones Elongated Vertically

The major ore zones are all elongated vertically and, though varying in strike, are by reason of rake or dip converging with depth. This trend is to the N.W. at minus 50 to minus 70 degrees, in the direction of the bedding, but steeper. The ore zones and the individual ore "shoots" follow one of three strikes: northwest, north-south, or northeast. All three directions are well represented in the ore zones and even in many of the ore shoots.

The ore zones lie between, under, and sometimes in, members of the four fault systems described. The shoots are



MATAHAMBRE: The mining camp of Minas de Matahambre, S.A., in the Province of Pinar del Rio in Cuba, has a population approximating 7,000 people. Because of the isolated location of the camp, the corporation has had to provide a variety of facilities to make it as self-sufficient as possible. The Gulf of Mexico, visible in the distant horizon, is 6 miles away.

closely related to these systems, but commonly to less prominent members. The N.W. strike is the most exclusively ore-bearing one, and the principal N.E. ore zone is a combination of regularly offset N.S. segments with intervening locally ore-bearing faults of systems No. 2 and No. 4. The N.W. ore strikes are normal to the bedding and have been referred to as "tension fractures."[3] This strike appears to be favored in the predominantly sandstone portions of the section.

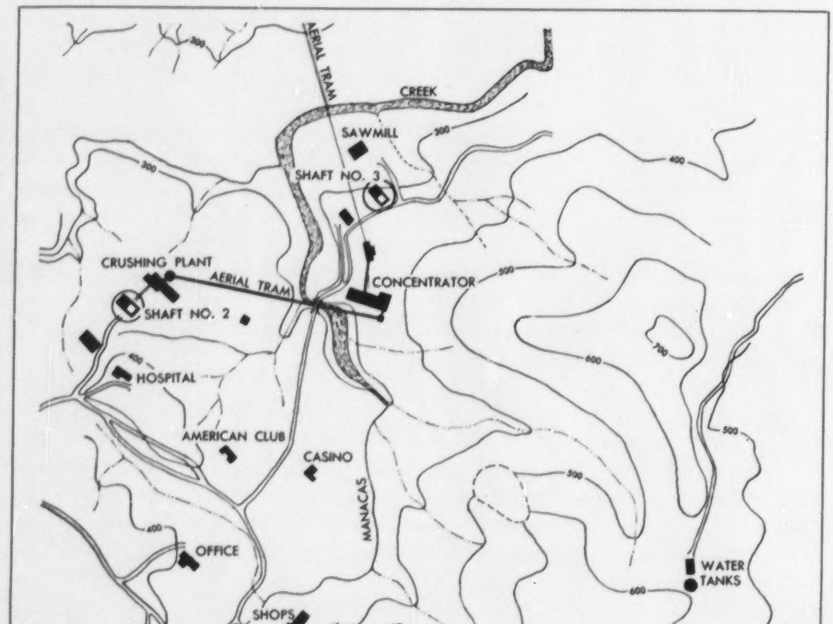
In one ore zone, N.S. ore strikes are predominant in the upper third, N.S. and N.W. strikes equally important in the middle third, and N.W. strikes stronger in the lower third. The result is a 90-degree rotation of the ore zone in 1,200 vertical feet.

The ore shoots occur as vein segments, lenses, and wedges – generally in breccia. The breccia can usually be related to parallel or diverging faults and is usually of greater extent than the ore. The ore zones are tabular or pipelike, each one containing several to many shoots. The sandstone favors fracturing and brecciation of haphazard orientation and the chalcopyrite as one of the cementing materials has an interstitial pattern. In contrast, the shale favors closely spaced parallel shearing and brecciation resulting in "ribbon-vein" structure. The relation of ore strikes to the fault blocks can be modified by the rock types within the blocks. For example, the "rotating" ore zone referred to previously has N.S. ore strikes in the upper part, and lies between E.W. faults in a predominantly shaly block. In the lower part, the ore strikes are N.W. between N.E. faults in a block now predominantly sandstone.

Sequence of Mineralization

The primary vein minerals are quartz, siderite, chalcopyrite, pyrite, and calcite. Some secondary chalcocite, covelite, malachite, azurite, and chrysacolla are present. The apparent sequence of mineralization after faulting and possibly contemporaneous brecciation are:

1. An early introduction of quartz



MINING CAMP FACILITIES: This map shows the relative locations of Shafts No. 1, No. 2, and No. 3, and other mining camp facilities of Minas de Matahambre, S.A.

[3] Pennebaker, E. N., private report, June 25, 1939.

and siderite which recemented most of the breccia zones.

2. A stage of sulphide mineralization bringing chalcopyrite and pyrite, apparently preceded by refracturing of many of the breccia zones.

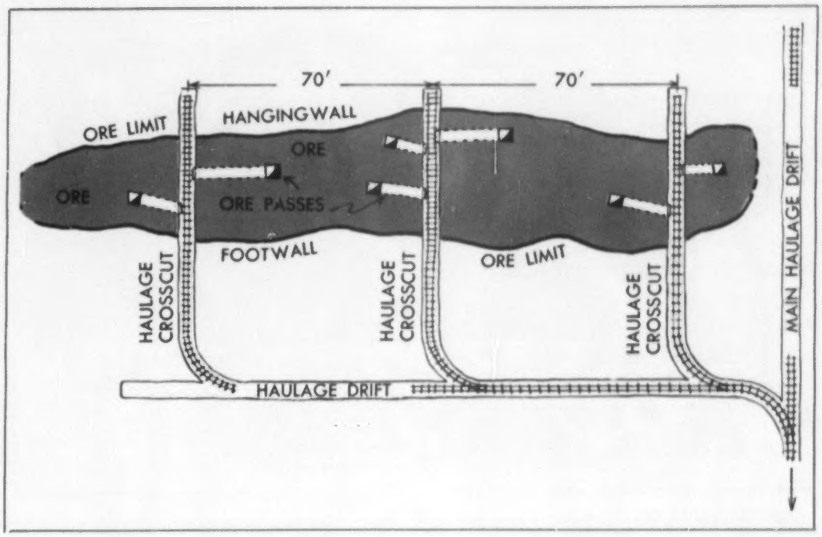
3. A later period of quartz and siderite mineralization producing cross-cutting veinlets of these minerals.

4. Calcite and pyrite have followed later open fractures.

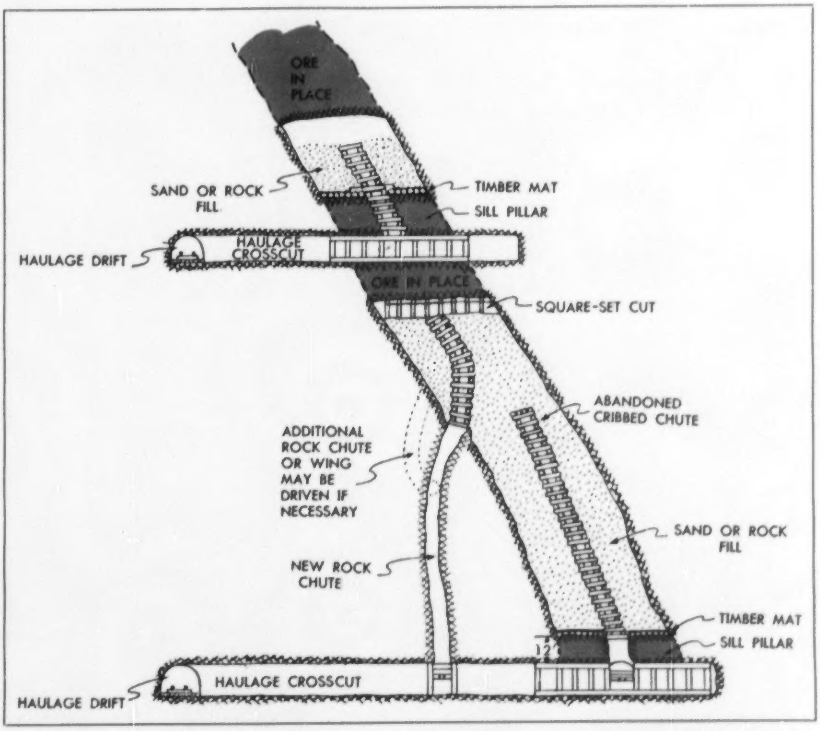
5. Superficial alteration with the deposition of secondary copper minerals and some quartz.

Mining

In developing a new level, access drifts are driven in the footwall of the orebodies. From these, crosscuts are driven through the orebodies from the footwall to the hangingwall, spaced at intervals to provide a maximum of 70 ft. between ore chutes. From each of these crosscuts, at least two parallel ore chutes are raised. At a height of about 15 to 20 ft. above the rail the first horizontal cut is made, thereby leaving a solid sill of ore below the stope. The ore is mined by a horizontal cut-and-fill method until the stope approaches a silled-out area above. When back conditions become hazardous, sills, are laid down in the sand and square-set timber is used. Level intervals vary betwen 150 and 200 ft. When stopes have reached the midway point between levels, new rock raises are usually driven from the access drift to intercept the footwall of the mining floor. Except where development waste is available, the stopes are filled with sand from the concentrator tailings. Minas de Matahambre was an early pioneer in the use of mill tailings for stope fill. Experiments with this type of fill were first made in 1922. Many difficulties were encountered; however, the system was finally perfected in 1925 and has been in continuous use since that date. Minas de Matahambre was also a pioneer in the use of measuring pockets for loading skips at skip pockets.



CUT-AND-FILL STOPE: A general plan of a large cut-and-fill stope in the Matahambre mine to indicate the layout of haulage crosscuts.

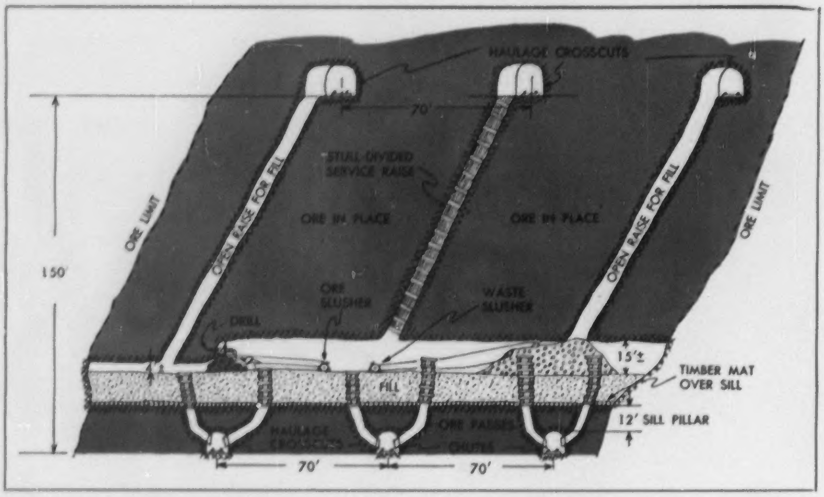


NEW ROCK CHUTE: This drawing shows a new rock chute in footwall connected to stope and raised with cribbing. Pillar below upper level is being removed with square sets.

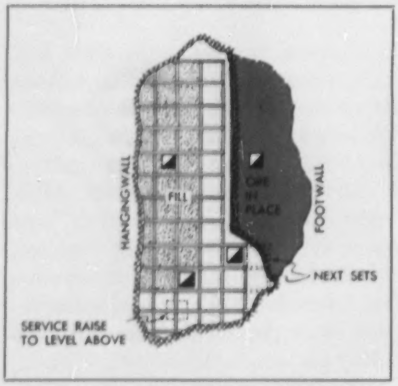
Drilling Equipment

The drilling equipment used in the Matahambre mines includes the following: Drifters — Gardner-Denver CF-93 with 4-ft. aluminum shell, Gardner-Denver CF79 with standard shell, and Ingersoll-Rand DA-30 with 7-ft. aluminum shell. Stopers — Gardner-Denver RB-94, used with ⅞-in. quarter-octagon steel. Jackhammers — Gardned-Denver S-55W and Ingersoll-Rand J-50, used with ⅞-in. quarter-octagon steel. These machines, with JR jacklegs, are used for stoping. Jackdrills — Ingersoll-Rand JR 38A, used with ⅞-in. quarter-octagon and alloy hexagon drill steel.

In most of the stopes, light jackhammers and jackdrills with jacklegs are used in breaking the ore. The drifters are employed primarily in driving drift headings and in some of the larger stopes. In drift headings, the drifters are mounted on jumbos. Three types



ORE CHUTES AND RAISES: A general longitudinal view of a large cut-and-fill stope showing the arrangements of ore chutes and raises. Stopes are filled with development waste or sand.



CHUTES AND SERVICE MANWAY: A plan view of a typical floor of square-set stope to show arrangement of chutes and service manway. Three-set panel has been wired to hangingwall; shaded area has been sand- or rock-filled.

are employed: Joy DJTA single- and double-hydro truck-mounted drill jibs, and Gardner-Denver JIH single offset-boom hydraulic jumbos mounted with two CF-93 drifters.

The steel used with the drills is Crucible 1¼-in.-round and ⅞-in. quarter-octagon, Copco "Coromant" ⅞-in. hexagon with a tungsten carbide insert, and Crucible No. 551 ⅞-in. hexagon. The drill bits are Ingersoll-Rand Jackbits 1⅝ in., 1⅞ in., and 2 in.; Ingersoll-Rand Carsets 1¾ in. type T1XCS4. Experiments are being conducted with some I-R carbide insert bits. Also, tests are under way in the use of small-diameter drill holes, employing Copco "Coromant" ⅞-in. hexagon drill steel with integral tungsten carbide insert, and Crucible No. 551 ⅞-in. hexagon drill steel with Ingersoll-Rand detachable XL carbide insert bits. Results have proved the economical advantage of the smaller drill holes but the type of bit to be used has not been determined as yet.

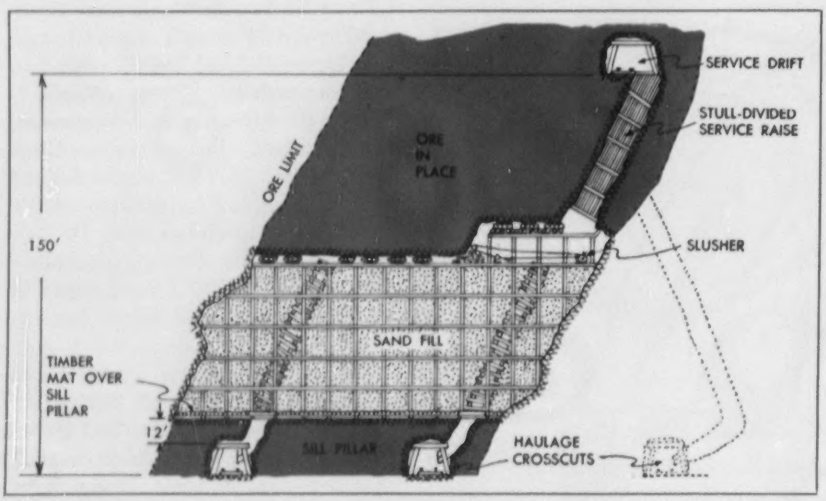
Compressed air at Matahambre is supplied by two Ingersoll-Rand, type PRE-2, 3,450-c.f.m. compressors; two Ingersoll-Rand, type 10 Imperial, 1,000-c.f.m. compressors; and one Gardner-Denver 600-c.f.m. skid-mounted compressor used in the Shaft No. 3 sinking operation.

Blasting

The depth and spacings of drill holes are governed by the nature of the ground to be blasted. In the open stopes where ground conditions are favorable, drill holes are usually spaced at 3-ft. intervals with a 2-ft. burden. The depth of the holes varies from 7 to 15 ft., depending on the size of the stope. Where bad ground conditions are encountered in the stopes, square-set timber is used. In such circumstances, the number of holes drilled depends entirely on the nature of the ground and how much ore can be broken safely in individual blasts. A typical round in a drift is made up of 18 to 22 holes 7 ft. deep, including a four-hole pyramid cut. The average diameter of these holes varies from 1⅜ to 1⅞ in., according to the type of drill bits used.

Explosives used in the mine are Hercules Gelamite® 2 in 1 by 8-in., 1¼ by 8-in., and 1¼ by 6-in. cartridges. The 1¼-in.-diameter cartridges are used only in raise and drift rounds. When all the drilling machines have been converted to the smaller diameter drill steel and bits, the use of the 1¼-in. cartridges will be discontinued.

The explosives loading ratio for blasting in the stopes is approximately 1.15 lb. of Gelamite 2 per cu. yd. of ore broken. In raises and drifts, the average ratio approximates 4.6 lb. of Gelamite 2 per yd. of rock broken. In most of the stopes and development headings, blasts are fired with Hercules® No. 6 Blasting Caps and Orange Wax Clover Brand safety fuse. In shaft-sinking operations and in some of the drifts, the rounds are fired elec-



CRIBBED CHUTES: This section through a typical square-set stope shows how cribbed chutes are raked to conform with the dip of the ore. Caps and girts are removed when necessary.

trically, using Hercules No Vent® Delay Electric Blasting Caps, comprising "0" through "9" delay periods, with 12-ft. leg wires. In some of the stopes, Hercules Short-Period Delay Electric Blasting Caps are used. The cap leg wires are connected in parallel to short-length buss wires, and blasts are fired by a switch from the 110-volt electric mains.

Loading Out Blasted Ore

In a normally loaded and fired round in drifts, fragmentation of the rock is consistently satisfactory. At times, blasts in the stopes produce a few large slabs because of the nature of the ground. These slabs are reduced to easy-handling size by secondary blasting, using a jackhammer and the block-hole method, or by breaking them with a sledge hammer.

The blasted material in all of the headings is excavated and loaded out by Eimco Model 12-B loaders. If ore, the Eimcos load into 1½-ton Card rocker dump cars for tramming to the ore pass or ore pocket on the level. If waste material, it is loaded into Card 1-ton end-dump cars and caged to the surface. When the waste can be used as backfill in stopes below the level, it is handled in the 1½-ton cars.

In all of the stopes that are square-set or horizontal cut, the blasted ore is slushed into chutes with Gardner-Denver, HME and HKE, and Ingersoll-Rand A5-MNOH double-drum air winches equipped with 26-, 30-, and 36-in. scrapers. The maximum grizzly spacing over the chutes is 14 in. The ore is pulled from the stope chutes on the level into 1½-ton Card rocker dump cars and trammed to the ore pass or pocket on the level.

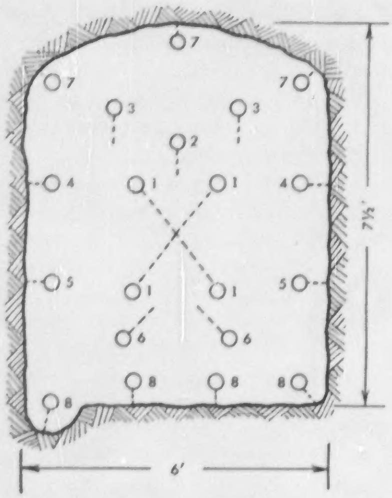
All haulage underground is done with Mancha Trammer electric storage battery locomotives.

Loading pockets are located at the main shaft on the 2100, 2400, 2600, and 3400 levels. Ore from intervening levels is passed through a transfer raise with connections on each level and then trammed to the loading pocket. The ore is hoisted in 5-ton Kimberly-type skips to an ore bin in the headframe on the surface.

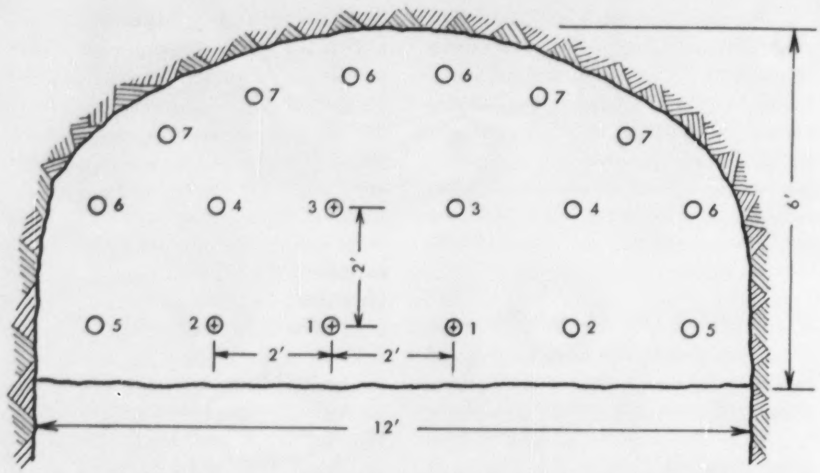
Hoisting and Ventilating

The various hoists in use at Matahambre are: At No. 1 Shaft, a Wellman Seaver Morgan double-drum electric hoist with a 7-ft.-diameter drum

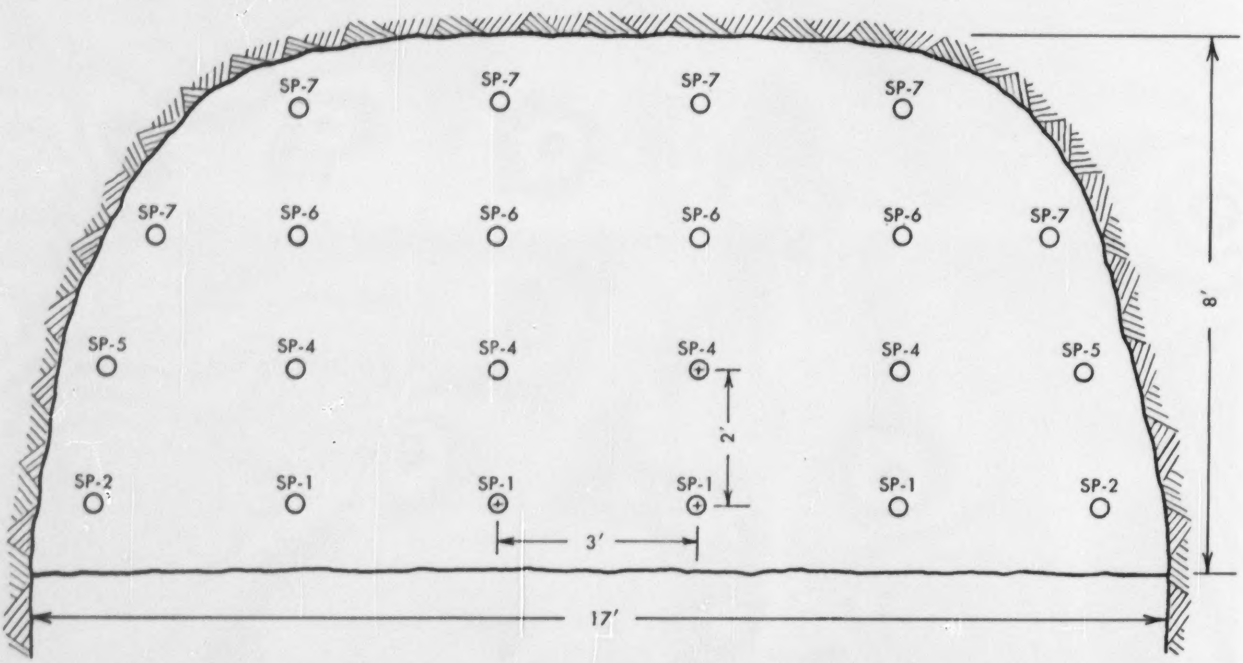
DRILLING: Two miners with an automatic drifter machine drill holes for blasting in high-grade ore in a stope on the 3500 level.



DRIFT ROUND—PYRAMID CUT: This 20-hole drill round in a drift uses a 4-hole pyramid cut. With holes 6½ ft. deep, the round is loaded with 160 cartridges of Gelamite 2 primed with Hercules Blasting Caps and Orange Wax Clover Safety Fuse. Numbers indicate the order of firing. The round averages an advance of 5½ ft.



STOPE ROUND —18 HOLES: A typical 18-hole drill round in a cut-and-fill stope with the depth of holes 7 to 10 ft., depending upon the width of the stope. Loaded with Gelamite 2 and primed with Hercules Blasting Caps and Orange Wax Clover Safety Fuse, blasting results average a ton of broken ore to 0.45 lb. of dynamite used. The numbers alongside the holes indicate the order of firing the blast.



STOPE ROUND — 22 HOLES: A typical 22-hole drill round in a cut-and-fill stope with holes 8 ft. deep. Loaded with 154 cartridges of Gelamite 2 primed with Hercules No Vent Short-Period Delay Electric Blasting Caps, blasting results from this round average a ton of broken ore to 0.60 lb. of dynamite used. The numbers indicate the order of firing.

and a maximum rope speed of 1,000 ft. per minute. It is equipped with 2,400 ft. of 1$\frac{3}{16}$-in. steel cable and a 300-hp. General Electric A.C. induction motor. At No. 2 Shaft, the main hoist is a Nordberg double-drum electric unit with a 10-ft.-diameter drum, and a maximum rope speed of 1,700 ft. per minute. Its equipment includes 4,500 ft. of 1$\frac{3}{8}$-in. steel cable and an 800-hp. General Electric D.C. motor. The service hoist at this shaft is a Nordberg single-drum electric hoist with a 7-ft.-diameter drum, and a maximum rope speed of 800 ft. per minute. It is equipped with 4,500 ft. of 1$\frac{3}{8}$-in. steel cable and a 350-hp. General Electric A.C. induction motor. No. 3 Shaft has a Nordberg double-drum electric hoist with an 8-ft.-diameter drum, and a maximum rope speed of 1,500 ft. per minute. It is equipped with 4,200 ft. of 1$\frac{3}{8}$-in. steel cable and a 500-hp. General Electric A.C. induction motor.

The Matahambre mines are ventilated by means of four 330 FH DIDW CCW THD American rotar fans, belt-driven by 40-hp. General Electric induction motors and by two Jeffrey 12A40 Aerodyne propeller fans driven directly by 125-hp. General Electric induction motors. The four rotar fans operate in parallel on the intake side of the ventilation system. The two propeller fans operate in parallel on the exhaust side of the system. Shaft No. 1 is upcast with exhaust air, while Shafts Nos. 2 and 3 are downcast with intake air.

Stoping

In developing orebodies on a new level, they are first outlined roughly by diamond drilling from a main haulage drift. Access haulage drifts are then driven parallel to and in the footwall of the orebody. From the main haulage drift, crosscuts are driven through the orebody. From each crosscut, at least two chute raises are raised in the ore to the sill level, which varies from 15 to 20 ft. above the track level. One or more of these raises are extended to the haulage crosscut of the level above for service raises. A horizontal sill cut is then started from one or more of the raises.

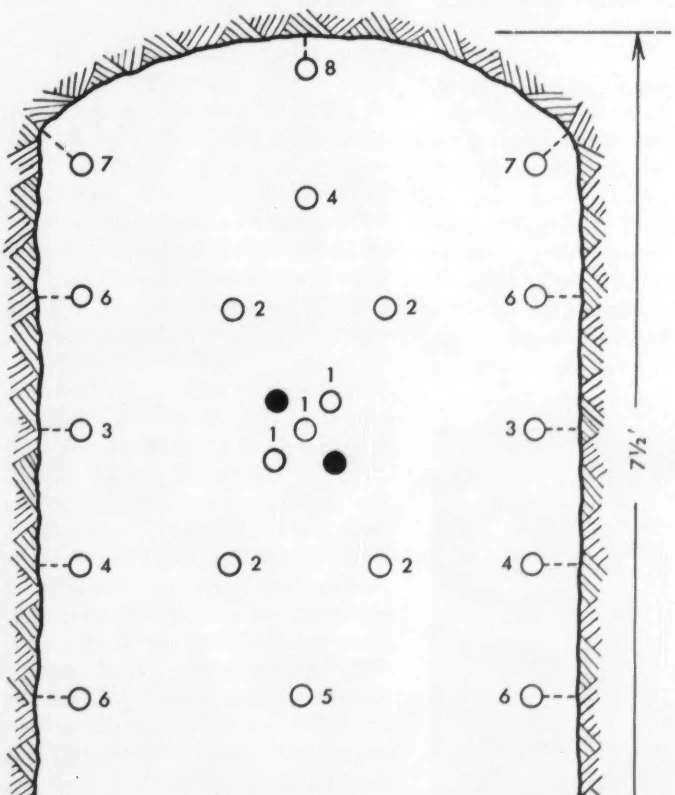
The access drifts are driven in the footwall of the orebodies to permit subsequent chute raises to be driven off the haulage crosscuts to intersect the footwall of the vein at a point midway between levels. Experience has proved that when the stope reaches this midway point, the costs to repair the original chutes make it more practical to drive new chute raises.

Having several haulage crosscuts permits the damming of one of them during the sand-filling of the corresponding section of the stope above, thus preventing the spillage of sand into the main haulage drifts. The spilled sand, thus confined, is easily cleaned up with a mucking machine.

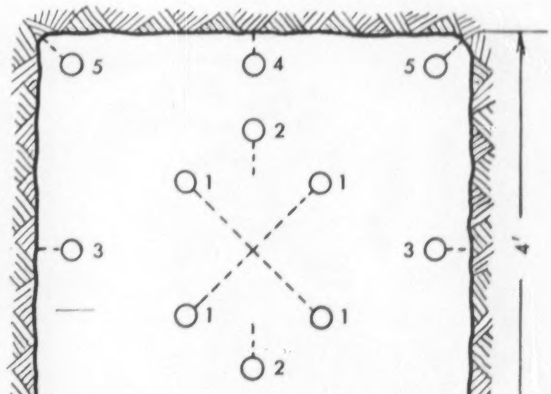
Cut-and-Fill System

Wherever ground conditions permit, a flat-back cut-and-fill system of mining is used. Approximately 50 per cent of the total production is obtained by this method. Depending on ground conditions, the stope is carried as cut-and-fill from the sill to about 30 to 10 ft. below the next level, where it is converted to square-set to remove the final level pillar.

After the first cut is completed, cribbed chutes are raised over the chute raises. The cribbing consists of 5 to 6-in.-diameter, round, treated pine with one flat side. The flat side is placed toward the inside of the chute to facilitate lining the chute with lagging. Standard cribbing is 5 ft. long with each end dapped 6 in., making the chute 48 by 48 in. inside dimensions. In some of the larger stopes, 6-ft. cribbing is used. This permits



DRIFT ROUND—BURN CUT: This 25-hole drill round in a drift uses a 5-hole burn cut. With holes 7 ft. deep, the round is loaded with 161 cartridges of Gelamite 2 primed with No Vent Delay Electric Blasting Caps. Numbers indicate the order of firing. The round averages an advance of 6 ft.



CHUTE RAISE ROUND—PYRAMID CUT: This 14-hole drill round in a chute raise uses a 4-hole pyramid cut. With holes 4 ft. deep, the round is loaded with 65 cartridges of Gelamite 2 primed with Hercules Blasting Caps and Orange Wax Clover Safety Fuse. Numbers indicate the order of firing. The blasting results with this round average an advance of 3¼ ft.

MUCKING OPERATIONS: In all of the headings the blasted ore is mucked out with Eimco Model 12-B units and loaded into mine cars.

raising a new 4-ft. chute within the old chute when it becomes worn, thus effecting great savings in time and repairs and avoiding the possibility of a sand spill during repairs. All cribbed chutes are lined with 2 in. by 8-in. by 5-ft. treated pine lagging.

Before filling, the outside of the chutes is wrapped with painted burlap to prevent the leakage of the sand fill.

Wherever possible, cut-and-fill stopes are filled wholly or in part with development waste from the level above, thus cutting down on the amount of nonproductive hoisting done by the main shaft.

Fill raises are driven from the back of the stope to the level above at intervals to allow one part of the stope to be filled in while the cut is advanced in the other part. The usual practice is to spread the fill as much as possible with a slusher and then top it off with hydraulic sand fill, which fills in all the corners and makes a smooth, hard floor onto which the next cut is broken.

The slushers used in the cut-and-fill stopes are Gardner-Denver HKE and HME types, pulling 32-in. and 36-in. scrapers. One Ingersoll-Rand KLML-2G three-drum hoist is in service.

LOADING FROM CHUTES: In the stopes, blasted ore is slushed into chutes. Later, it is pulled from the chutes into dump cars for deliveries to the ore passes on the levels.

Square-Set Method

In addition to sill-pulling operations in stopes where the ground is not strong or is broken by faulting, the square-set method of mining is used. The standard square-set is 5 by 5 by 7 ft. high. The timber used is round, untreated pine with framed ends. Posts and caps vary from 8 to 10 in. in diameter, while girts run from 6 to 8 in.

Ore chutes are cribbed in the same way as in the open cut-and-fill stopes, and are raked as required to keep the top in a convenient position in the stope. Where a set post interferes with the raking of a chute, the cribbing is raised around the post. Later, the protruding cap and girt are cut out when they no longer support the stope back.

The general method of advancing a square-set cut across the ore is shown in an accompanying illustration. The width of the panel advanced and the number of sets left unfilled depend on the ground conditions.

All square-set stopes are hydraulically sand-filled. When a block is prepared for fill, it is lagged up with light slabs and lined with painted burlap. The chutes are raised and wrapped the same as in the cut-and-fill stopes. Sand fill is brought into the stope through permanently installed rubber-lined pipelines, and the water is drained off through a chute to the level below. While a block is being filled, mining continues in the adjoining blocks. A new floor can be opened in a filled stope immediately after the fill has been finished.

Nearly all square-set stopes are equipped with slushers. The types used are Gardner-Denver HKE with 30-in. scrapers and Ingersoll-Rand 5MNOH with 26- and 30-in. scrapers.

The Crushing Plant

The total mine production at Minas de Matahambre is hoisted through Shaft No. 2. This shaft is located about

2,000 ft. from the mill, and a wide ravine separates the two. Since it is easier to transport finely crushed ore than crude ore, it was decided to place the crushing plant next to the production shaft and deliver the crushed ore product to the mill by a jigback aerial tramway.

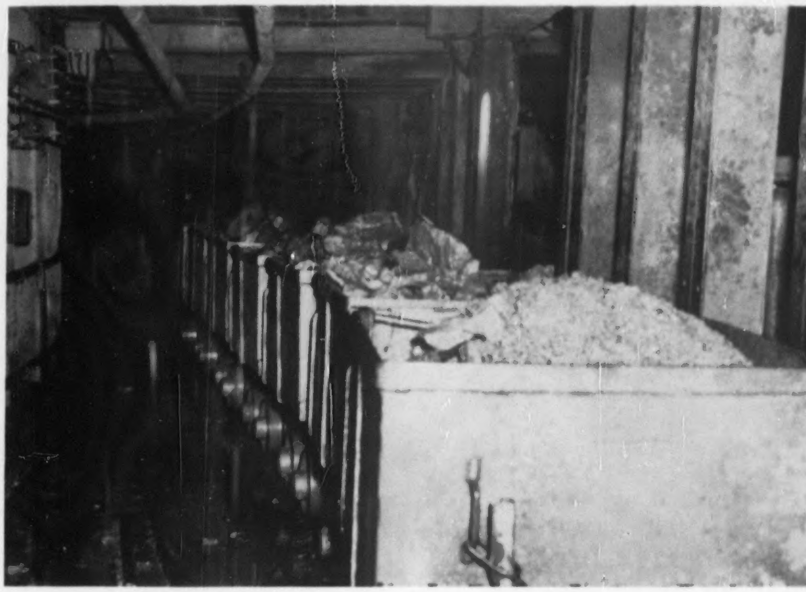
The crushing plant was put into operation during November, 1935. Five-ton mine skips discharge a minus 12-in. product from the mine into a 250-ton coarse ore bin (see Flowsheet, Crushing Plant). The ore is drawn from this bin and over a 3 by 10-ft. Sheridan grizzly feeder with 3 by 4-in. openings. The undersize falls onto a 30-in. conveyor belt and the oversize drops into a 14-in. Traylor gyratory crusher which is set to minus 4 in. on the closed side. The crushed ore falls through the crusher onto the conveyor belt carrying the undersize product from the grizzly feeder.

The product from the Traylor crusher is conveyed under a No. 45 Cutler-Hammer magnet which removes most of the tramp iron, and is discharged onto a 4 by 10-ft. double-deck Tyler Niagara vibrating screen. The upper deck screen openings are 1 by 1 in. The lower deck openings are 5/16 by 1 in. Water is sprayed on the screen to remove the mud which, at times, is considerable. The undersize from the screen falls onto a 20-in. conveyor and is carried to the fine-ore concrete storage bin. The oversize falls into a 4-ft. Symons standard cone crusher.

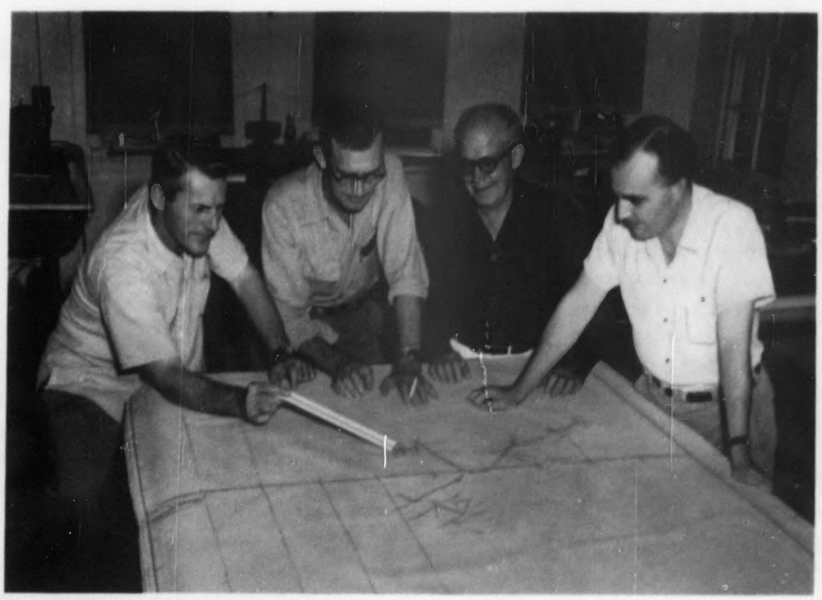
The 4-ft. Symons cone crusher is set to deliver a minus 1-in. product. The discharge is received on a short 20-in. conveyor which, in turn, discharges onto a 24-in. conveyor. This product is conveyed to two 4 by 8-ft. double-deck Tyler Niagara screens. The top decks of these two screens have 1 by 1-in. openings and the lower deck openings are 5/16 by 1 in. The undersize from these screens falls to the 20-in. conveyor carrying the undersize from the primary screen to the fine-ore concrete storage bin. These are the final products from the crushing plant and are conveyed to a 1,700-ton concrete storage bin.

The oversize from the secondary screens is conveyed to a 5½-ft. Symons short-head cone crusher. This crusher is in closed circuit with the secondary screens and is set to minus ¼ in. on the closed side. The product from this crusher falls onto a short 20-in. conveyor which carries it over to the previously referred to 24-in. conveyor carrying the product from the 4-ft. cone crusher. A No. 24 Cutler-Hammer magnet is located above the pulley of the conveyor discharging onto the secondary screen. This magnet removes all of the tramp iron that was not removed by the first magnet, or that which has fallen into the circuit.

The conveyor carrying the crushing plant's finished product from the screens passes over a Merrick Weightometer. A moisture and assay sample is cut as the ore falls into the concrete storage bin.



UNDERGROUND HAULAGE: Trains of 1½-ton Card rocker dump cars are moved through the mine by electric storage battery locomotives to loading pockets on the various levels.



REVIEWING EXPLORATION PLANS: At left, Robert M. Grantham, Matahambre's chief geologist, discusses new locations for exploration activities with Arthur P. Nelson, general manager; Dr. Ernesto Romagosa, president; and James P. Elwell, mine superintendent.

Dust Collection

Dust is collected by a 11,400-cu. ft. American Blower Company No. 55 Type E exhaust fan. It is connected to the 4- and 5½-ft. cone crushers and the belt transfer point by air ducts in such a manner as to also collect the dust where the 20-in. conveyors discharge onto the 24-in. conveyor. The dust is recovered by an American Blower Company No. 28 cyclone dust collector with a No. 7½ head. After installation of this equipment, it was found that the exhaust still carried too much dust, so a bag house was constructed. The bag house has 45 bags, each 15 ft. long and 15 in. in diameter. The bags fit over nipples at the top and bottom. The bottom nipples extend into a tank of water that acts as a seal. The collected dust falls into this tank.

Dust that settles in the building is collected periodically with a Spencer Turbine vacuum cleaner. On starting or shutting down the plant, water is sprayed on the ore at each transfer point. While the plant is in operation, a spray is likewise maintained under the 5½-ft. short-head cone crusher to help settle the dust.

A 10-ton Maris Monorail hoist is located over the Symons crusher to lift heavy parts whenever repairs are necessary.

Tramming the Ore

The ore from the concrete fine-ore bin discharges through a chute regulated by an arc gate and is conveyed by a 20-in. conveyor to a 55-ton bin in the No. 2 tramway loading terminal. A reversible Leschen jigback tramway is used to convey the ore to the concentrator. This tramway has 2-in. locked coil track cables and ¾-in. traction ropes for the two 8-wheel aluminum buckets and carriers. The self-dumping buckets are filled by a 20-in. belt feeder through a butterfly chute. At the concentrator, the buckets dump into a 10-ton surge bin. The distance from tower to tower is 806 ft. The buckets travel at a rate of 600 ft. per minute, with each carrying 3 tons of ore.

The Concentrator

The first concentrator, built in 1917, was equipped for both gravity and flotation uses. In 1924, the mill was converted completely to flotation. The ores from the mines have never been difficult to concentrate. Except for changes in reagents, and minor changes in equipment and the flow, the concentrator is essentially unchanged since it was remodeled in 1924. In performance, the plant has maintained a high degree of efficiency; for many years it has milled an average of 1,000 tons a day. Composite assays for the past year average:

Heads	6.609 per cent Cu
Concentrates	32.279 per cent Cu
Tails	0.175 per cent Cu
Recovery	97.880 per cent Cu

The Ball Mills

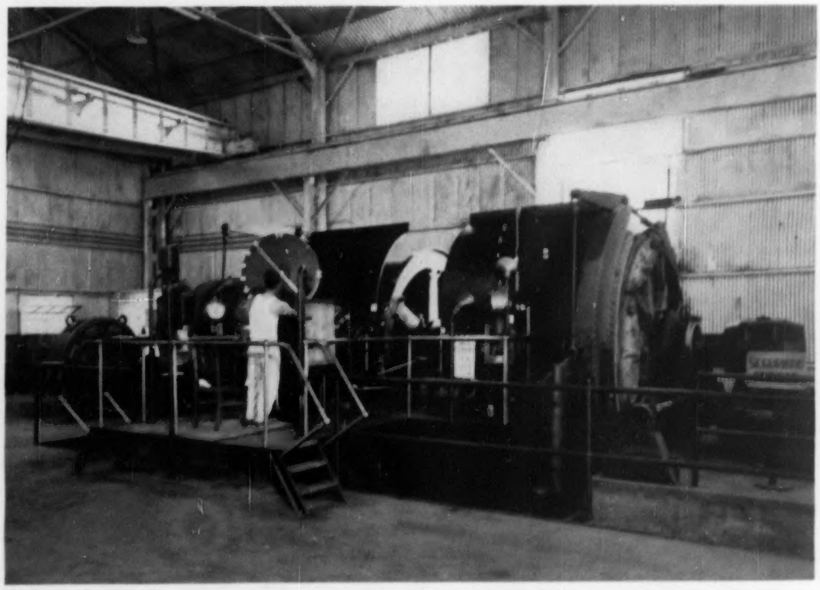
Ore is discharged from the fine-ore bin through rack and pinion gates onto

MINE INSTALLATIONS: In this view of Matahambre's mine installations, the headframe of Shaft No. 1 looms up in the center; Shaft No. 2 headframe and the crushing plant are at left center; Shaft No. 3 headframe, the mill, and the tailings dam are at right.

SHAFT NO. 1: This group of buildings includes the headframe of Shaft No. 1 which provides service to the 2,100-ft. level in the mine, the machine shop, the hoist house, the foundry, the warehouse, the compressor house, and a commercial store.

SHAFT NO. 2: A close-up of the headframe at Shaft No. 2 also includes the primary crushing station facilities at left.

20-in. conveyors which deliver it to each of five ball mills. The grinding section consists of four 6 by 6 overflow-type ball mills manufactured by the Denver Equipment Company, and one No. 64½ Marcy grate mill. Each mill is in closed circuit with a 5 by 25½-ft. Dorr DSFX classifier, with a slope of 2½ in. operating at 28 strokes a minute. Ball mill discharge is maintained at approximately 76 per cent solids; the classifier overflow is 41 per cent solids. The objective is to grind to 10 per cent plus 48 mesh. The circulating load is 200 per cent of the original feed. Each classifier overflows into a common launder which carries the stream of ground ore to a trommel with 3/16-in. punched holes. Water is sprayed against the outside of the trommel to wash the wood chips that cascade on the inside. The chips are discharged into a small launder and are carried to the outside of the concentrator. The ore pulp stream is sampled by a Geary-Jennings automatic sampler and then continues to the No. 1 rougher of the flotation section.



DOUBLE-DRUM HOIST: This Nordberg double-drum hoist, equipped with an 800-hp. D.C. motor and 4,500 ft. of 1⅜-in. cable, has been in service at Shaft No. 2 since 1933.

Flotation

The flow of ore through the concentrator is shown by the simplified flowsheet (see illustration). The flotation rougher circuit consists of four "modified" Britannia-type deep air cells.

The classifier discharge from the head sampler, along with the tails from the regrind "Forrester" cell, enter the No. 1 rougher. Tails from each rougher flow by gravity into each succeeding cell. The concentrate from the No. 1 rougher is sent to the No. 1 cleaner. The concentrate from the No. 2 and No. 3 roughers is sent to regrind. The tails from the third rougher are sampled by a Geary-Jennings automatic sampler before entering the fourth cell. Here, one-tenth of a pound of copper sulphate per ton of heads is added to the stream of pulp to activate the pyrite. The pyrite concentrate removed from this last cell is sent to a 4-in. Wilfley sand pump where it joins the overflow from the sand classifier and is pumped to the tailings dam.

The reagents used at Matahambre are slightly different from those usually found in a modern copper concentrator. Hercules Yarmor® F pine oil is used as the frothing agent. It has been found that the best place to add this reagent is to the mills. It is evenly divided among the four operating mills.

Sodium ethyl xanthate has been in regular use as a collector since February, 1942. It replaced potassium ethyl xanthate. By the use of sodium ethyl xanthate, the requirements have been reduced 25 per cent. The collector is added to the ball mills' discharge launders as a 2.50 per cent solution and at the rate of approximately one-tenth of a pound per ton. The balance of sodium ethyl xanthate required is fed to the discharge of the No. 1 rougher. The total collector necessary varies with the ore and is adjusted from time to time to maintain the desired froth condition.

Pyrite is depressed by potassium cyanide. The amount used not only varies with the amount of pyrite present in the ore, but also with the type of froth. Some of the cyanide is used as a froth

SHAFT NO. 3: The tall structure in the center is the headframe at Shaft No. 3. In the background are the sawmill, the wood-treating plant, and the tailings pond. A bucket suspended from a cable of the aerial tramway is at extreme left.

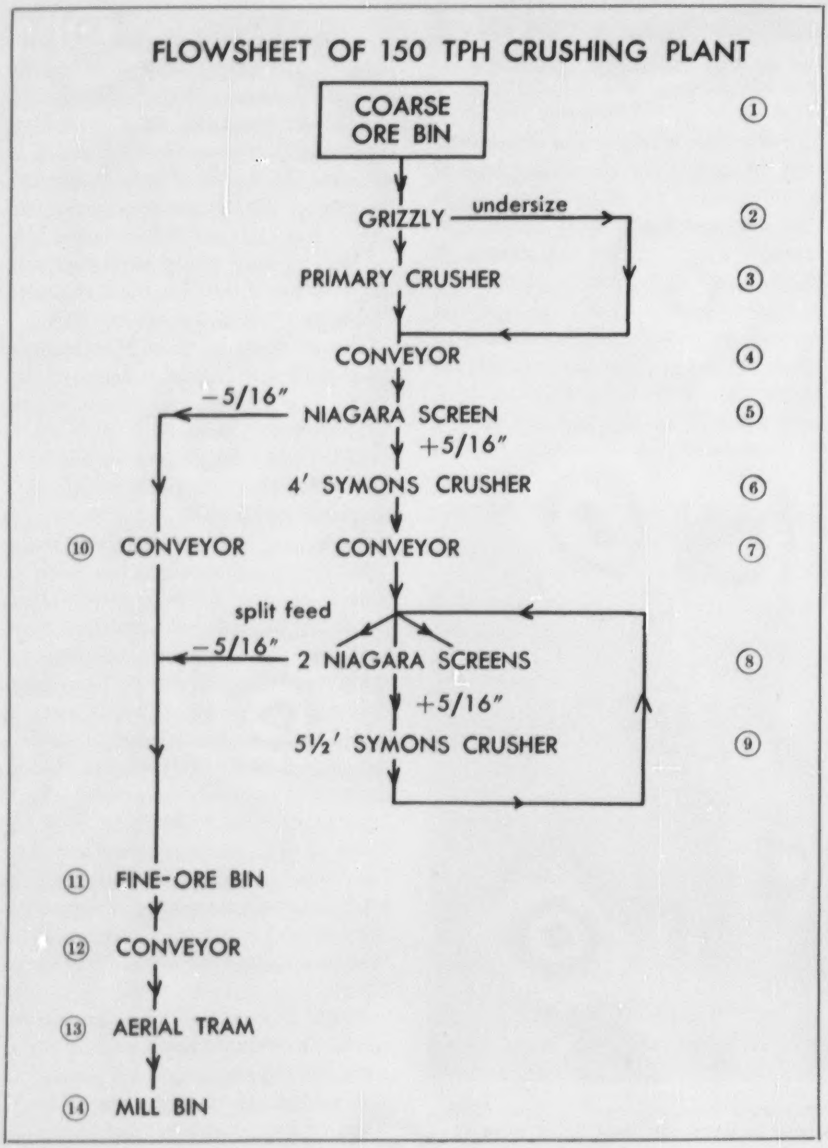
"modifier" to help maintain the desired froth characteristics. Usually, the amount necessary is about 0.075 lb. per ton of heads. Of this amount, 67 per cent is fed to the discharge launders of the ball mills, 11 per cent to regrind, 10 per cent to the No. 1 cleaner, 8 per cent to the No. 2 cleaner, and 4 per cent to the No. 3 cleaner.

The reagents are prepared on and fed from a floor above the ball mills. They are mixed by either the laboratory men or the shift boss. All reagents flow by gravity to Geary reagent feeders and then to the various points of addition. Numerous tests have been made substituting lime for cyanide as the pyrite depressant. The results have always been discouraging. In every instance both recovery and grade dropped. Sodium ethyl xanthate is made up each day in a 10-ft.-diameter by 30-in. tank as a 2.50 per cent solution. Potassium cyanide is made up as a 3.50 per cent solution.

The Cleaner Circuit

The cleaner circuit consists of three pneumatic cells of the Forrester type. The first cleaner is 19 ft. long and the other two 9.5 ft. long. Each cell is divided in the center by a baffle which extends from 6 in. above the overflow lip down to within 12 in. from the bottom. The first cleaner is also divided in the center of the second section. It has been found that the baffles increase the recovery.

The concentrate from each cell is sent to the following cell. The tails from all three cleaners are sent to regrind. Water is added to the launders to bring the density of the heads of



(1) 250 t. coarse-ore bin receiving entire mine production from adjacent No. 2 Shaft; (2) Sheridan grizzly; (3) 14-in. Traylor primary crusher with – 4-in. discharge; (4) 150 t.p.h. 30-in. conveyor at 125 f.p.m.; (5) 4 x 10-ft. vibrating Niagara screen with superimposed + 1-in. and – 5/16-in. openings; (6) 4-ft. Symons crusher with – 1-in. discharge; (7) 24-in. conveyor at 290 f.p.m.; (8) 2 sets 4 x 8-ft. vibrating Niagara screens, split fed, each set superimposed with + 1-in. and – 5/16-in. openings; (9) 5½-ft. Symons crusher; (10) 20-in. conveyor at 290 f.p.m.; (11) – 5/16 in. – 1700 t. concrete fine-ore bin; (12) 20-in. conveyor; (13) aerial shuttle tram to mill with 3 t. buckets; (14) mill bin 1350 t.

each cell down to a point where the ratio of solids to solution is approximately 1:3.5. As described above, the cyanide is fed to each of the three cleaners.

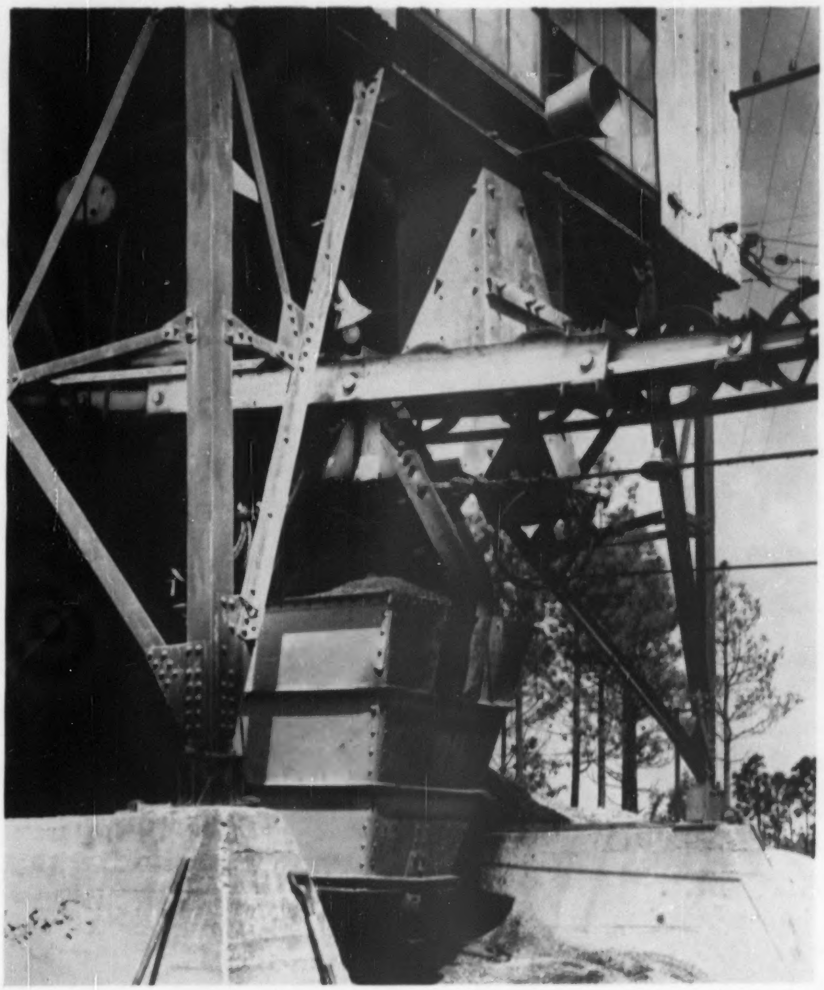
The concentrate from the third cell is sampled by a Geary-Jennings automatic sampler and then continues to two Esperanza drag classifiers.

Middlings

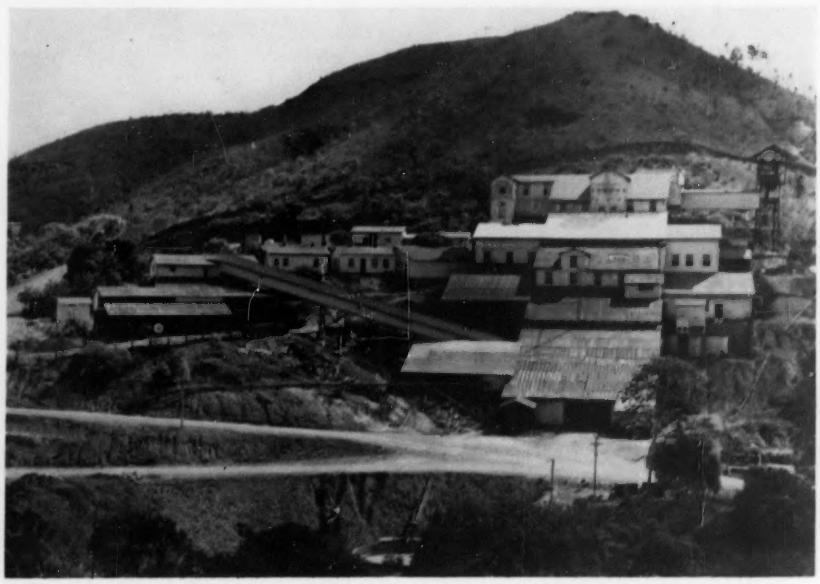
The middlings include the concentrate from the No. 2 and No. 3 roughers and the tails from the three cleaners. These various products join in a common launder and flow into a sump. The combined middlings are then pumped by a 4-in. Wilfley sand pump to a dewatering cone located on an unused floor above the ball mills.

The spigot discharge flows by gravity to the No. 3 ball mill. The flow is regulated to deliver not only the oversize mineral but also all the water needed for the operation of this mill. About 225 tons of middlings are realized each day. This tonnage varies over wide limits.

A 6 by 6 ball mill is used for regrinding. The mill is too large for the amount of ore to be reground, so crude ore from the bin is added to the mill to utilize the extra capacity. This mill grinds about 80 per cent as much crude ore as the other mills. The classifier is operated at 28 strokes a minute, and the overflow density is adjusted to allow less than 4 per cent plus 48-mesh material in the overflow.



LOADED TRAM BUCKET: **A close-up of a loaded 5-ton tram bucket at the crushing plant ready to be moved, via aerial tramway, to the concentrating plant.**



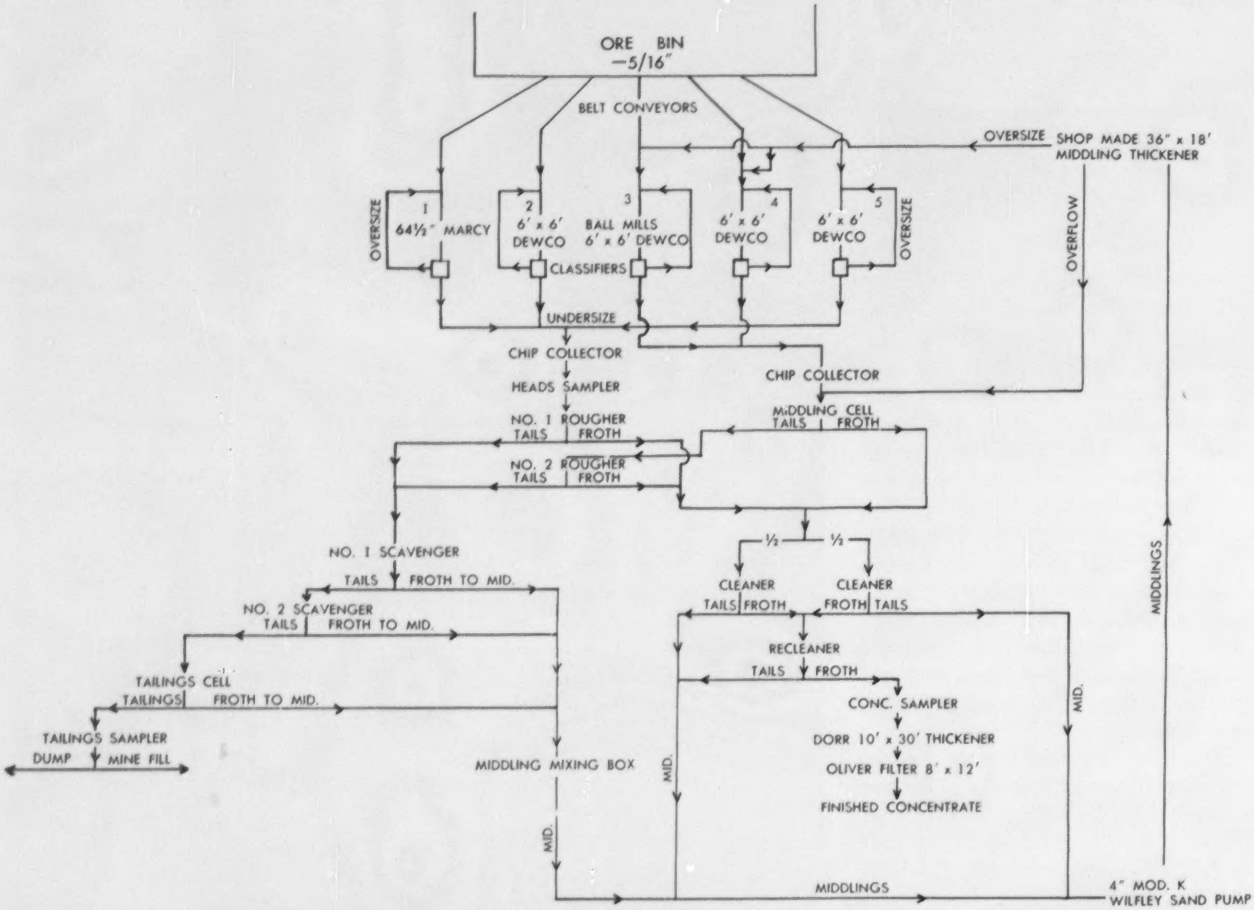
CONCENTRATING PLANT: **The concentrating plant with a daily capacity of 1,100 tons, the laboratories, and the storage bins for concentrate are located at the end of the aerial tramway.**

Thickening and Filtering

After sampling, the concentrate from the No. 3 cleaner continues to two 10-ft. drag classifiers. The coarse chalcopyrite removed flows directly to the filter tank, and the overflow goes to two 10 by 30-ft. Dorr thickeners. These thickeners have a rake speed of one revolution in each 9 minutes.

The spigot discharges to one of two 8 by 12-ft. Oliver filters. The drum rotates at a rate of one revolution in each 7½ minutes. Agitating rakes are operated at the rate of 14 strokes a minute. The filter medium is a No. 175 T.W. "Palma Twil" canvas held in place by bronze wire. Each filter is used one week, after which it is washed with a very weak solution of caustic. The rotation of the filters has

FLOWSHEET OF CONCENTRATOR



A. Feed to ball mills Nos. 4 and 5 consists of 74 per cent bin and 26 per cent oversize from middling thickener.
B. Classifiers are Dorr Model FX 5 ft. x 25 ft. 6 in., overflow 12-14 per cent plus 48 mesh.
C. The middlings, two cleaners, and one recleaner are Forrester flotation units 5 ft. x 18 ft. x 62 in. deep.
D. The two roughers, two scavengers, and one tailings cell are Britannia cells as follows:
- **a. No. 1 and No. 2 roughers, and No. 1 scavenger are 5 ft. x 30 ft. x 10 ft. deep.**
- **b. No. 2 scavenger 5 ft. x 10 ft. x 10 ft. deep.**
- **c. Tailings box 5 ft. x 17 ft. x 10 ft. deep.**

E. Ball feed: 3 in. on Nos. 1, 2, and 5; 2½ in. and 3 in. on Nos. 3 and 4.
F. Reagents: sodium ethyl xanthate Z4, sodium cyanide, and Yarmor F pine oil.
G. Mill capacity: 1,000 t.p.d.

increased the life of the canvases.

Twenty-six inches of vacuum is maintained by one of two Oliver dry vacuum pumps, model No. 155. These pumps operate at 230 r.p.m. The air needed for the filters is supplied by an 8 by 8-in. Ingersoll-Rand compressor. The compressor also supplies the air needed in the sample filters and in the sample grinding room. The filtered concentrate is conveyed to the concentrate storage bin.

Sand-Fill Classifier

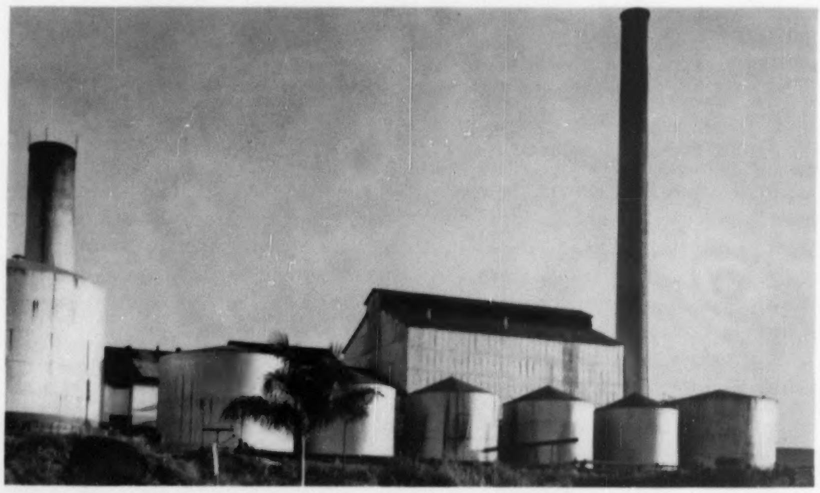
The tails from the No. 4 rougher flow to a 6 by 16-ft. Dorr bowl classifier. The wash water added amounts to 65 g.p.m. This classifier recovers 96 to 97 per cent of the plus 200-mesh material in the tails. The material going into the mine for filling stopes, etc., amounts to about 45.8 per cent of the mill heads.

The Tailings Dam

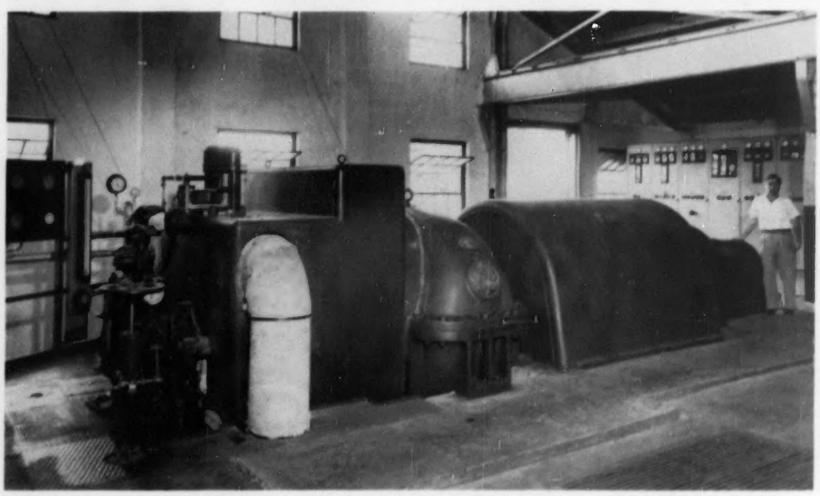
The tailings from the sand-fill classifier and the concentrates from the No. 4 rougher (pyrite) join and are pumped to the tailings dam. The 4-in. Wilfley sand pump used for this purpose has sufficient capacity to handle all of the tailings in the event that the sand-fill classifier is shut down. The 6-in. line carrying the tailings to the dam is 3,047 ft. long with a vertical rise of 19 ft.

The tailings dam is built up in lifts of about 5 ft. with mine waste. Mill tailings are distributed along the pond side of the dam. Workmen shovel the coarse tails against the face of the dam. As pulp falls along the face of the dam, there is a segregation. The coarse particles stay about where they fall and the finer particles flow toward the pond. When the dam fills to the height of the mine waste, it is raised another 5 ft. An overflow has been provided

PORT OF SANTA LUCIA: At the port of Santa Lucía, the corporation maintains complete dock facilities, concentrate bins, tugs, lighters, miscellaneous shipping equipment, and a power plant.



POWER PLANT: The power plant has four condensing A.C. turbogenerators with an installed capacity of 7,500 kilowatts. The tanks in the foreground provide storage for fuel requirements.



TURBOGENERATOR: A close-up of one of the four turbogenerators in the power plant at Santa Lucía with a rated capacity of 3,500 kilowatts.

for water in case of a heavy rain, otherwise the water is drained into a lake to guard against contamination of the creek water and, also, to store water for the concentrator should the need arise.

Leschen Aerial Tramway

The copper concentrate is shipped to the subport of Santa Lucía over a bi-cable Leschen aerial tramway. The distance to the port is 30,325 ft. and the difference in elevation is 400 ft. The track cable on the load side is 1⅛-in. diameter, and the cable on the return side is 1-in. diameter, both of lock-coil construction. The traction rope is ⅝-in. diameter. All towers are of wood. Carriers are clamped to the traction cable through Leschen heavy-duty screw grips which are actuated through a lever. Loaded tram buckets pass over a Toledo scale and are weighed before being sent out over the line. Each bucket carries about 900 lb. of concentrate and the tramming rate is 24 tons an hour. Buckets travel at 470 ft. a minute.

The Santa Lucía Division

The Santa Lucía Division of Minas de Matahambre includes four departments – the Power Plant, the Dock, the Fleet, and the Fleet Maintenance.

The Power Plant Department has four condensing alternating current turbogenerators, with an installed capacity of 7,500 kilowatts. Supplying steam to these turbines are three steam boilers totaling approximately 2,500 boiler horsepower. Electrical generation is three phase, sixty cycles, at 2,300 volts, with transformation to 11,000 volts. Two high-tension, three-phase, 11,000-volt transmission lines, each 33,000 ft. long, supply power to the mines at Matahambre. Switching facilities and safey devices are incorporated in new, modern switch gear, both for 2,300- and 11,000-volt operations. For maintenance and repair of its facilities, the Power Plant has its own completely equipped repair shop.

The Dock Department provides the facilities for storing and handling the copper concentrate, and maintaining the seagoing fleet. The copper concentrate, received from the mine via aerial tramway, goes into a storage bin which accommodates 8,000 tons. The concentrate is loaded into barges by a

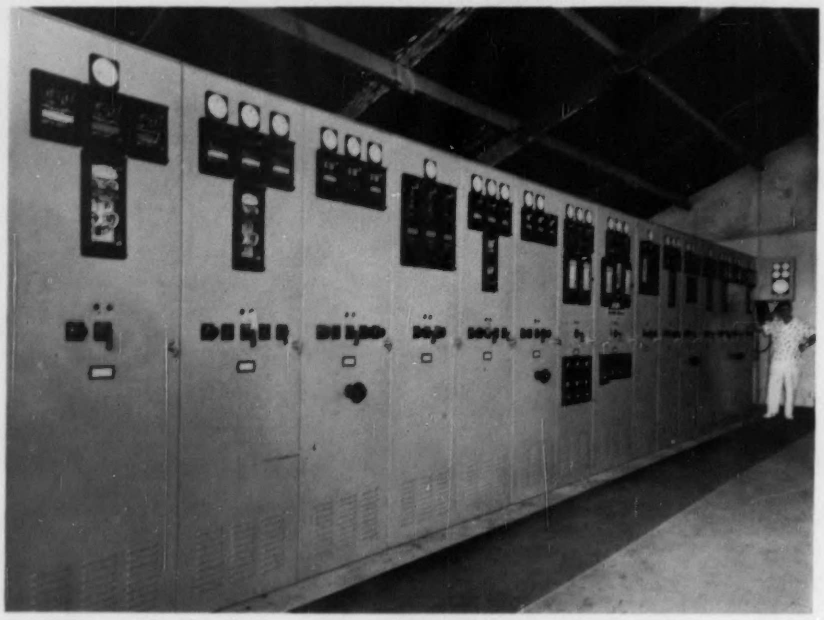
5-ton electric motor-driven, overhead traveling crane made by Northern Engineering Works. For overall maintenance, a complete carpenter shop is equipped and maintained in the Dock Department, along with a 50-ton traveling dry dock to accommodate the largest piece of fleet equipment. The Dock Department also receives and dispatches all materials for the mine arriving by coastal freighters.

The Fleet Department is composed of stevedores and all seagoing equipment. Included are three tugboats, a 10-ton floating dredge, and eight barges. The total loaded capacity of each barge is 1,000 long tons. The seagoing freight vessels are loaded at three different anchorages, depending upon the draft of the ship. The last anchorage is on the high seas. The barges, when loaded, are towed by tugboat to the various anchorages of the freighters. In an eight-hour day, upward of 1,000 long tons of copper concentrate are loaded in a freighter, using the ship's winches and the 10-ton floating dredge.

The Fleet Maintenance Department is carried on by two groups: the carpenters for deck and hull work, and the fleet engineers for mechanical work. When necessary, the stevedores are used to augment the repair group.

Management Personnel

Minas de Matahambre, S.A., maintains offices at Edificio Banco del Caríbe, Prado esq. a Refugio, in Havana, with general offices at Matahambre. The management and supervisory personnel include Dr. Ernesto Romagosa, president; Arthur P. Nelson, general manager; Willis L. Parent, treasurer; Antonio Rey Lopez, accountant; Richard P. Gerwels, chief engineer; Rene R. Díaz, engineer and member of the management committee; Robert M. Grantham, chief geologist; Martin Lleras, manager of the exploration department and member of the management committee; Ricardo Sierra, chief of the commercial department; Dr. Juan F. Sordo, director of the hospital staff; and Santiago Famada, purchasing agent. The Legal Department is ably managed by Attorneys Dr. José Gorrin, Dr. Jorge Herrera, and Dr. Alberto Gutierrez de la Solana.



SWITCHBOARD: This General Electric switchboard was installed recently in the power plant at Santa Lucía as an operations control center.

Supervisory Personnel

In the Mine Department, James P. Elwell is superintendent; Arthur B. Winters, Curtis Stanius, David Lleras, and Marion Casper are foremen. In the Mechanical and Electrical Departments, R. O. Moses is superintendent; J. Rojo, chief electrician; and Fidel Garofalo, foreman of the mechanical shop. Humberto Aluicio is superintendent of the mill. Guillermo Martinez, Jr., is in charge of the crushing plant and a member of the management committee. At the Santa Lucía power plant, E. T. Zimmermann is superintendent and Edward F. Robinson is assistant superintendent.

In assembling material for this ar-

GENERAL OFFICES: This modern brick structure provides attractive office space for Matahambre's officers, department heads, operating supervisors, and their assistants.

MATAHAMBRE'S STAFF: The photographer took a picture of Matahambre's staff grouped around President Ernesto Romagosa (dark shirt) and Arthur P. Nelson, general manager, alongside at right.

ticle, the author extends grateful appreciation for the cooperation of his associates in Minas de Matahambre, S.A.: Dr. Ernesto Romagosa, president; Richard P. Gerwels, chief engineer; Robert M. Grantham, chief geologist; James P. Elwell, mine superintendent; Humberto Alucio, mill superintendent; E. T. Zimmerman, power plant superintendent; and Guillermo Martinez, Jr., crushing plant chief. Valuable assistance was also received from Raimundo Martinez de Castro and Eduardo J. Castellanos, vice presidents of Mingro Industrial, S.A., Havana, Cuba.

EXAMINING ORE SAMPLES: In his Havana office, Dr. Ernesto Romagosa, president of Minas de Matahambre, examines a sample of ore with two of his sons-in-law: Martin Lleras, manager of the Exploration Department and member of the management committee, left; and Raimundo Martinez de Castro, vice president and general manager of Minagro Industrial, S.A.

NEWS

TRIPLE-DUTY DRILLMASTER

According to Ingersoll-Rand, its new Triple-Duty Drillmaster is a self-contained unit designed to speed up the drilling of blast holes in rock and to provide a range of hole sizes and drilling depths heretofore not available in a blast hole drill.

The manufacturer says the new Drillmaster embodies three combinations of methods of drilling. In combination one, it utilizes a new revolutionary Depth-Master or "down the hole" drill for deep blast holes up to 6 in. in diameter. In combination two, it is available with the Power Master, a new heavy-duty hammer drill for holes 4¼ in. in diameter. In combination three, with the Roto-Master, it is ideal for rotary drilling of holes up to 6¼ in. in diameter. The user can have any one or all three of the drilling combinations to suit his requirements or rock conditions.

Features included in the new Drillmaster unit, according to the manufacturer, are: a well-engineered, easily lowered tower, providing long steel changes; positive chain feed; a dust collector; and an I-R 600CFM rotary compressor; a motor-driven crawler assembly; "out in front" full-vision drilling; and many other features. The manufacturer is also making available the tower and drills for mounting by users on their own tractors or trucks.

Additional information can be obtained by communicating with your nearest Ingersoll-Rand Branch Office, or by writing to Ingersoll-Rand, 11 Broadway, New York 4, New York, and requesting Form 4164.

PORTABLE AIR COMPRESSOR

An all-new rotary portable air compressor, which is said to combine the basic rotary advantages of compactness, light weight, and simplicity with the weather-defying advantages of water cooling, has been announced by Gardner-Denver Company, of Quincy, Illinois.

The compressor has a capacity of 600 cu. ft. a minute, and has been named the Gardner-Denver Rotary 600.

The new water-cooled rotary compressor, features of which are said to be exclusive with the Gardner-Denver design, is reported to provide reliable operation under severe weather conditions ranging from 40 degrees F. below zero to 115 degrees above zero. The water-circulating system is fully automatic. In cold weather, warm water from the engine heats up the compressor oil system before the compressor starts to turn.

The Gardner-Denver Rotary 600 is equipped with a simple, automatic speed control, the Gardner-Denver Thriftmeter, which is reported to save fuel and wear and tear on the engine and compressor.

For more information on the new portable air compressor, write to Gardner-Denver, Quincy, Illinois.

CATERPILLAR D8 TRACTOR

A four-page booklet on the completely new Caterpillar D8 tractor has just been released by the manufacturer.

The booklet depicts the new unit in both torque converter and direct drive models. Some of the new advance designs mentioned in the booklet are engine, controls, "live shaft" drive, welded one-piece steering clutch case, 7-roller track frame, "water-quenched" track shoes, hydraulic booster steering, starting engine, "in seat" starting, larger fuel tank, and new attachments.

The booklet, Form 31496, may be obtained from any Caterpillar dealer or from Caterpillar Tractor Co., Peoria, Illinois.