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REPORT ON THE MATAHAMBRE MINE
PINAR DEL RIO, CUBA

BY

EDWIN LAWRENCE MILLER, JR.

A

THESIS

submitted to the faculty of the
SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI
in partial fulfillment of the work required for the
Degree of

ENGINEER OF MINES

Rolla, Mo.

1925.

Approved by

C. P. Forbes

Professor of Mining

TABLE OF CONTENTS

OWNERSHIP	Page 1
LOCATION	4
LARCR	6
SANTA LUCIA	7
GENERAL GEOLOGY	8
GEOLOGY AT THE MINE	10
THE MINE	
Development	13
System of Numbering	15
Method of Opening Stopes	17
Method of Mining	20
Contractors	22
Pay of Labor	23
Fill	24
Underground Sorting	27
Underground Equipment	28
SURFACE PLANT AT THE MINE	28
MILLING AND TRANSPORTATION	31
Shipping Facilities	36
POWER	37

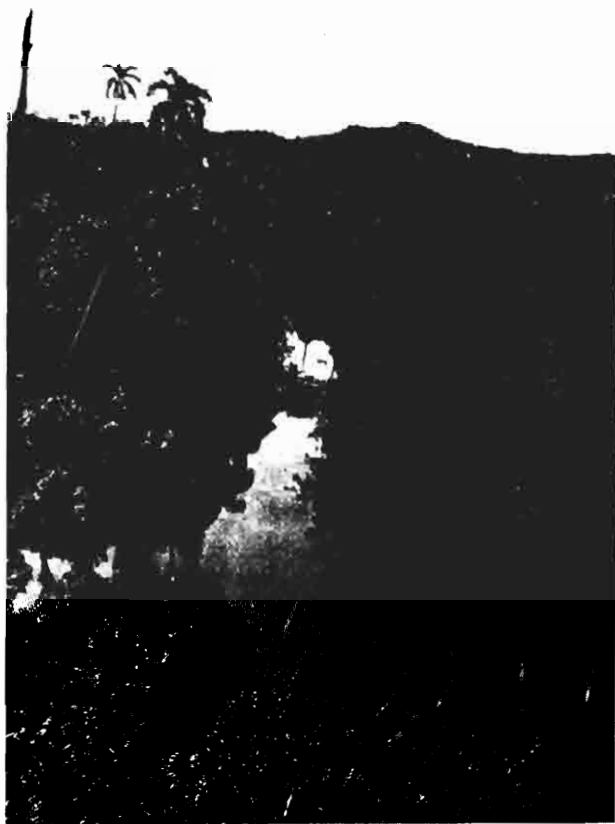
LIST OF ILLUSTRATIONS

	Page
Map of Cuba and Map of Western Portion of Cuba	3
Sketch Showing Plan of Mine Levels, 7th to 16th	14
Sketch Showing Method of Laying Floor	19
Sketch of Shute Mouth	22
Door Between Drainage Adit and Fill Raise	26
Mill Flow Sheet	32
Sketch of Storage Bin Layout at Santa Lucia	35
A Number of Kodak Views and Pictures	

OWNERSHIP

The Minas de Matakambre, S.A., is a Cuban corporation operating a copper-silver mine in the province of Pinar del Rio, Cuba. Until the spring of 1923 the stock was held entirely in the family of Manuel Luciano Diaz, a civil engineer of Havana who

financed the prospecting and development of the mine. At that time the corporation had fallen into financial difficulties through the fall in the price of copper and the continued high cost of production. As a solution of the difficulty, thirty per cent of the stock and the active management were offered to the American Metals Co. Ltd., of New York, whose subsidiary com-



pany, the United States Metals Refining Co., had been buying the ore since the inception of production.

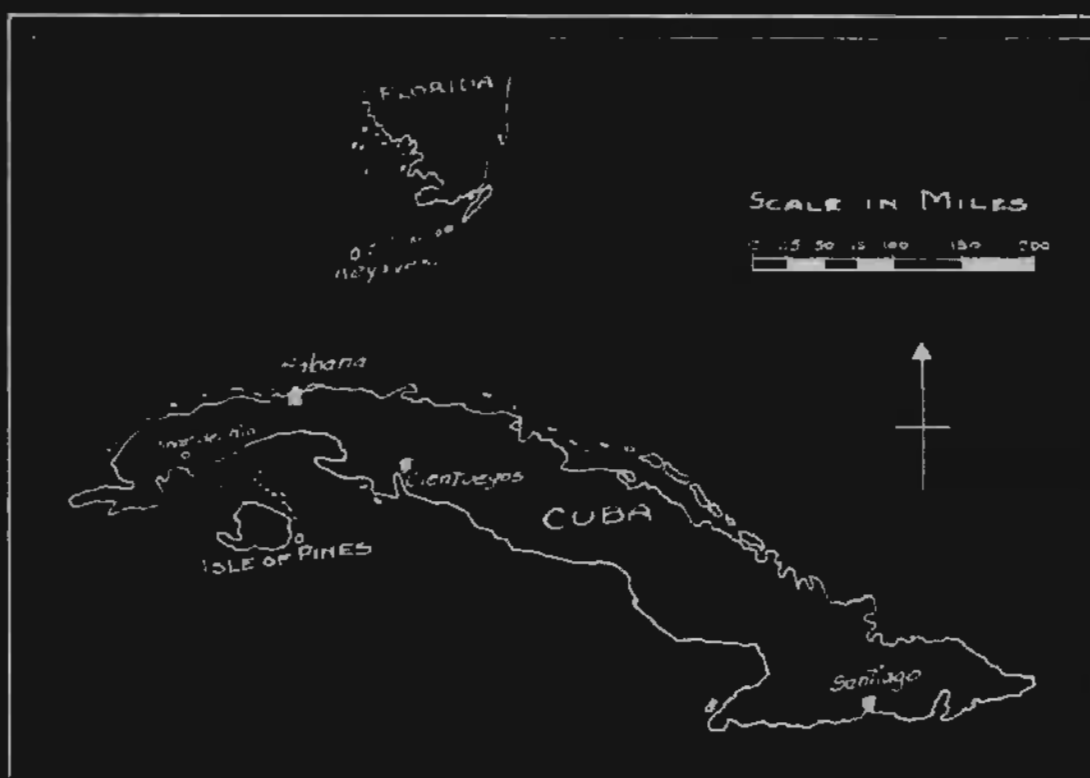
After an exhaustive examination by E. L. Brown, of Denver, consulting engineer for the American Metals Co., the offer was accepted on condition that they



LOOKING EAST FROM THE AMERICAN CLUB

On the Left is the Cuban Club and Ruiseñor Hill
On the Right is the North End of Matahambre Hill
and the edge of the North Glory Hole for Fill.

also receive an option on an additional thirty per cent of the stock. This option was soon exercised. A new operating staff soon replaced the old, methods of mining and concentrating were modified, a Leschen-type single-track aerial tramway replaced a Lawson-



MAPS OF CUBA AND WESTERN PORTION OF CUBA
SHOWING LOCATION OF MATAHAMBRE AND SANTA LUCIA

type double-track tramway, the power plant was changed from a battery of horizontal De La Vergne internal combustion engines to two G. E. steam turbines, and shipping facilities were improved. Now the mine is showing a good profit at the present low price level.

LOCATION

The mine is near the north coast of the island, about ninety miles west of Havana and six miles by airline from the sub-port of Santa Lucia. See map of Cuba, page 3.



DOCKS AT SANTA LUCIA

The town of Matahambre is adjacent to the mine and is entirely the property of the company except some few of the store buildings, which, however, are under

the control of the company as they are on company property.

About 800 men find employment with the company at Matahambre, in the mine shops, concentrator, etc. These form the basis for a town of three or four thousand inhabitants. The men pay from one to five dollars a month rent for rooms or houses, the average being about two dollars. Good filtered and chlorinated

water is piped to all parts of the town or camp to central hydrants. The streets are lighted with



RIO PEÑA BLANCA

Source of Water Supply for
Camp and Mill

electric lights.

There is no sewage system, but a sanitary gang empties refuse cans and keeps the streets cleaned. There are no churches.

The company maintains a hospital, a Cuban doctor, and several male nurses. The

company also maintains two schools.

At the camp is a post of the rural guards, and peace is very ably maintained. Telegraph

and postal service go together in Cuba and is fairly efficient, especially the telegraph. Mail comes

in once a day usually, by mule back over the mountains.

LABOR

Labor, including the contractors, are all called "natives", i.e., natives of some other country than the United States. While the Spanish-speaking laborers (mostly Spaniards and Cubans) predominate, yet practically every European and Asiatic nation is represented on the mine roster. This is because there is no limitation on immigration into Cuba, and until a few months ago, no limitation on immigration of Cuban "citizens" into the United States. Now, however, the American ruling is that place of birth counts instead of formal citizenship. Thus there are many laborers in Cuba now who went there from other countries planning to remain one year, then go into the United States as a citizen of Cuba. This is a "hardship" on those seeking to evade the U. S. immigration laws, but makes labor in Cuba fairly plentiful for the sugar centrals and the mine. The efficiency of the average Cuban laborer is only about half that of American, but as his pay is only half as much, the mining costs approximate those in the United States under similar conditions. He eats no breakfast, having only a cup of coffee. For lunch, if he is lucky, he has a loaf of bread and a piece of sausage eaten underground. Then for dinner he has a fairly

hearty meal of rice, bread and coffee, and occasionally some dried meat from the Argentine.

SANTA LUCIA

An old water-bound macadam road ten miles long connects the camp with Santa Lucia. This town is not owned by the company, and living conditions for the natives are much lower than at Matahambre. It contains the power plant, concentrate and shipping ore bins, and the docks.

Santa Lucia has not, in the strict sense of the word, a harbor. That part of the coast of Cuba is

covered with mangrove swamps, and has a parallel line of reefs five or six miles off shore.

What makes Santa Lucia is the fact that there is a low place in this reef which permits an



VIEW OF SANTA LUCIA

Tug and empty Lighters in Fore

ore boat to come in and load about two-thirds of its cargo before going outside to take on the balance.

DISCOVERY

The outcrop was discovered in 1913 by a native while out hunting. The native took refuge under a

ledge on Matahambre Hill during a rainstorm, and noticed some pretty green and blue colored rocks which had just been exposed by the rain. He took several pieces to a druggist, Alfredo Porta, in the city of Pinar del Rio, capital of the province. Sr. Porta analysed the rocks



MANAGER'S RESIDENCE

North Part of Matahambre Hill in Background

and found them to contain copper. Being unable financially or politically to follow up the "find", he informed Sr. Diaz of Havana, who thereupon became interested.

GENERAL GEOLOGY

The general geology of Cuba has never been worked out satisfactorily. The reason for this is partly

political and partly natural. Along the north coast of the province of Pinar del Rio there runs a mountain chain called the Organ Mountains, the highest peaks of which do not reach an elevation of 2000 feet about the sea. The general strike of the bedding and ridges is about at right angles to the long axis of the range. The ridges in the vicinity of Matahambre are not due to the regional folding but to hard beds of sandstone or quartzite. The strike of the beds is at about 45 degrees N.E. and S.W. and, at Matahambre, dip to the northwest at about 60 degrees. The predominating rock is a shale with occasional beds of sandstone. Underlying most of the region but cropping in the center are massive beds of



VIÑALES VALLEY, SHOWING LIMESTONE "SUGARLOAFS"
20 Miles East of Matahambre

limestone. No fossils have been found in this limestone but they have been assigned to the Tertiary. So far as known there are no igneous rocks, nor evidence of igneous activity outside of numerous quartz and sulphide stringers in the shales throughout the district. The predominating sulphide is pyrite carrying traces of either gold, silver or copper, but seldom both. Occasionally there has been found concentrations of chalcopyrite in the pyrite, but only at one place, Matahambre, has there been found a concentration of chalcopyrite free from pyrite.

GEOLOGY AT THE MINE

The Matahambre deposit is located on the west slope of Matahambre Hill, a ridge running parallel to the strike of the beds. The hill is caused by a bed of partly silicified sandstone, and has a more or less sharp drop to the eastward. To the west there is a more gradual slope, terminating in spurs marked by the excessive redness of the soil. This redness is the sole indication of the chalcopyrite concentrations below, as only at one point is there sufficient outcrop of copper carbonate for obtaining a showing for copper on analysis. The origin of the chalcopyrite at Matahambre is a subject for better geologists than the writer, and is still in dispute. Personally I think it is a primary emanation from the

same general source that produced the other extensive mineralization in the region.



LOOKING SOUTH AT MINE SURFACE PLANT
South End of Matahambre Hill

The principle occurrence of the copper is in the form of massive chalcopyrite, and during my stay I did not see any

chalcopyrite crystals or any of the other copper minerals in the present workings. However, in a cabinet of specimens from the upper workings are found every mineral of copper, also galena, sphalerite, native copper and silver, gold, pyrite and barite. The chalcopyrite carries a little silver, the ratio being about 1/10 oz. of silver to one per cent of copper, and also a very slight amount of gold. The latter is too low for payment of a premium by the smelter. The ore occurs entirely in shale or graywacke, a silicified shale, and no where has there been found ore occurring in sandstone or quartzite. Although the average dip and strike of the shales is as given above, there has been so much lo-

cal wrinkling and faulting that make the conditions peculiar. There has been pre-mineral faulting and post-mineral faulting in all relations to the bedding, and movement along some of the fault zones is still going on.

The ore occurs in "shoots", called orebodies locally, that are very persistent as regards area and shape but vary in value. There are no definite walls except a limit of commercial "ore". While in a general way the orebodies follow the dip and strike of the shale, none of them follow exactly. In fact, each orebody has its own peculiarities. For instance, the No. 2 orebody is about 250 feet long and 70 to 80 feet wide. Its long axis is about parallel to the bedding, and in a horizontal plane goes down about parallel with it. However, its average dip is only 45 degrees while that of the bedding is about 60 degrees. On the other hand No. 4 orebody, which has the same general size and shape of No. 2, has its long axis almost at right angles to the bedding, but not quite parallel to the dip, and maintains about the same relation to No. 2. These two ore bodies are in what is called the "south end." At the extreme north end there is an orebody, No. 14, that is over 400 feet long along its long axis, which is in the shape of a reverse curve. Its average direction, however, is about N 10° E, and its apparent dip is due west. Its

true dip is slightly north of west, but having a slight rake or pitch to the south, it actually goes down the dip of the orebody practically due west. This orebody occasionally widens out to over 100 feet and narrows down to nearly 10 feet, but its average width is about 35 feet.

Ore values vary considerable between any two particular places in the mine, but for the past few years the mine-run ore has remained very steadily at close to six per cent in copper and about one half ounce of silver. Within two "floors" of an orebody, or fourteen feet, the average value may vary from 3% or 4% to 10% or 12%. Where the grade is low, it is generally evenly disseminated, but where the average ore is high, it is usually streaked in character, with alternate streaks of pure chalcopryrite and practically barren waste.

THE MINE

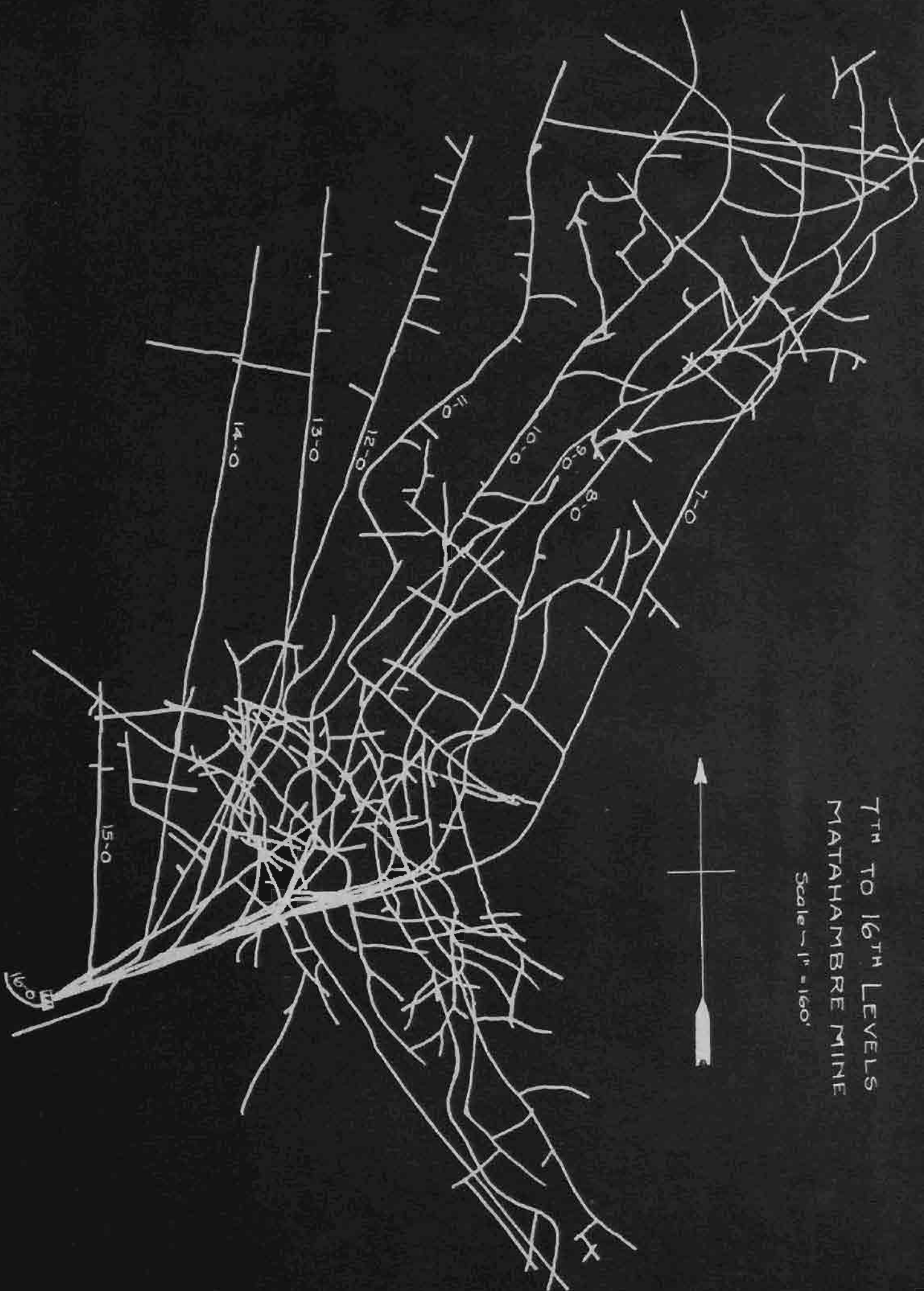
Development

The mine was originally developed through adits for each level as long as possible. Under the old method sub-levels were used and every stope carefully square-set. If the ground was heavy, never more than two floors were open at a time without filling, but where the ground stood well sometimes six or eight floors were allowed to remain open. The result was that when the roof did come in the stope would be almost hopelessly lost.

The levels in the mine are numbered consecutively,

7TH TO 16TH LEVELS
MATAHAMBRE MINE

Scale - 1" = 160'



and, down to the 5th level, are adits. Beginning with the 6th level, all are reached through the shaft. The distance between levels is generally 100 feet, but occasionally it is greater. For instance, between the 10th and 11th levels, the distance is slightly over 131 feet. As seen by the accompanying map, in the upper levels the main haulageway runs straight out from the shaft to the vicinity of the nearest orebodies, then branches to the north and south. Under the old method, these branches were used for locating the orebodies as well as for haulageways. As a consequence they had too many twists and turns for an ideal condition for economical haulage. As the lower levels are reached it will be seen that the southend orebodies are passing to the north of the shaft, thereby throwing all the stopes to the north of the shaft. This simplifies the haulway problem, as it can be run out from the shaft only a sufficient distance for an adequate station, then turned to a straight line to the north end of the mine. The shaft is now down to the 16th level, nearly 800 feet below sea-level and over 1200 feet below the collar. As the orebodies are dipping in general to the west, the station on the 16th level has been cut out on the west side of the shaft.

System of Numbering

The orebodies, as they cut the plane of the 6th

level, were more or less in a straight line running approximately north and south, and this level is used as the basis of stope numbers now in use. Starting at the south end, the orebodies were numbered consecutively from No. 1 to No. 16, and retain this number on the other levels.

Where lower down two or more orebodies join, one of the numbers only is retained, the rest abandoned; for instance, No. 14 is composed of Nos. 12, 13, 14, 15 and 16.

Generally speaking, a stope is that part of an orebody between two levels, and is given a combined number of level and orebody. For instance, the 11-4 stope



MATAHAMBRE - LOOKING WEST

Substation in Central Foreground

is that part of the No. 4 orebody that lies between the 11th and 10th levels. In the same way, the 13-14 stope

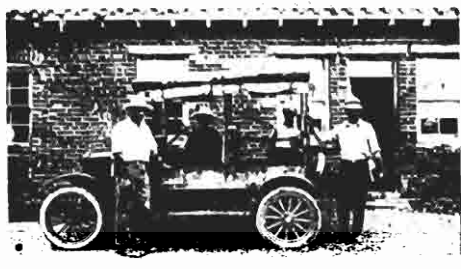
is that part of the No. 14 orebody between the 13th and 12th levels.

There is no orebody numbered zero, the "0" being reserved for the main haulageway. Thus on the 11th level it is 11-0; on the 14th level it is 14-0. The auxiliary drifts and cross-cuts are numbered consecutively using the stope number under which they were driven. Thus the first cross-cut driven under the 13-2 stope is numbered 13-2-1, the second is 13-2-2, and so on. Chute and manway raises are also numbered consecutively, using also the drift or cross-cut number from which they run. Thus the first raise from the 10-14-7 cross-cut has the number 10-14-7-1, the second is 10-14-7-2, and so on. The stope raises, thru the ore up to the level above for for fill and ventilation, are numbered consecutively, using the stope number. Thus the first one driven from the 10-7 stope is numbered 10-7 S.R. (stope raise) #1, the second is 10-7 S.R. #2, and so on. The fill raises to the surface are simply named according to their location, being the "south raise", "center raise", and "north raise".

Method of Opening Stopes

After the main heading of a level has passed the supposed location of an orebody for that level, a cross-cut is run out to intersect the ore, then run in ore for

10 or 15 feet to be sure it is the orebody--not just an isolated pocket of chalcopyrite. If the cross-cut



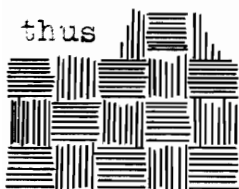
THE ENGINEERS' "GUAGUA"

Main Office in Back

comes in from the hanging-wall side it is pushed on through to the footwall, as chutes are put up in the footwall as nearly as possible. However, an orebody is generally approached from the footwall side where possible. When it is certain that the cross-cut is in the orebody, a 10-foot raise is put up 10 or 12 feet from the back of the drift and a chute constructed, leaving part of the opening as a manway. Then "silling out" is started. A 10- to 15-foot horizontal cut is taken out, leaving the floor from 10 to 12 feet above the rail in the level below. As soon as the footwall has been cleaned sufficiently to give an idea of its direction, a raise is pushed up through the ore to a convenient point on the level above. This first raise is rushed as it is for ventilation, though later it takes its place for filling. Air in the mine is very good as long as natural ventilation is given a chance.

As silling out goes on and the exact size and shape of the stope unfolds, additional cross-cuts and chutes

are put in so that no point is farther than 40 or 50 feet from a chute. As the back goes up later on, these chutes are branched out so that they become even closer together. As soon as one end of the stope has been silled out and cleaned up, the flooring is put in and the chutes and manways built up. The flooring is made by laying as close together as possible a layer of split lagging, called "rajada", 10 feet long in squares checker-board fashion,



thus 10 feet square, then another layer the same manner but with the rajadas running at right angles to the lower ones. The chutes are

built up at about 45 degrees with 7-foot round timbers to the back. They are carried up with this sized timber for about 30 feet of the stope, then branched and carried up with 5-foot timber. The manways are carried up all



the way with 5-foot timbers, and have a ladder on one side and air-pipe on the other. As the stope is silled out additional raises are put up wherever necessary and convenient, generally about 80 to 100 feet apart along the length of the stope. The raises go up in the orebody as long as the angle with the horizontal does not get below 43 degrees.

As soon as a stope is fully silled out and floored, it is left until needed for production, being gradually filled with development waste from the levels above. The waste is spread out to within 2 or 3 feet of the back. As about two years' supply of ore is kept developed ahead of production, sometimes it is a year or more before any more ore comes out of this stope.

Production of ore, outside of that from drifting and silling out operations, comes from the two highest working levels, the highest being pushed the hardest. At present the main producing levels are the 10th and 11th. The 10th is nearing exhaustion, the 11th is just getting into full production, while some stopes on the 12th level are beginning to be worked. However, all the stopes on the 12th level have not been silled out as yet.

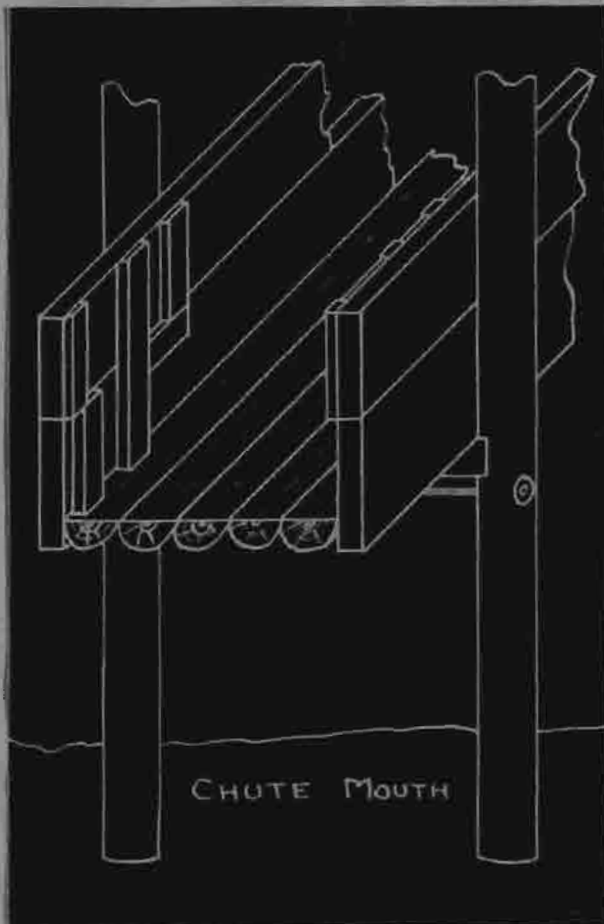
Method of Mining

The method used is the standard flat-back cut and fill. After the stope has been filled after the first

cut or silling out, another cut is started at one end. Generally the cut is made just as high as a stoper can drill from the floor, but sometimes when the back is extra good a deep cut, 15 to 20 feet, is taken. In this case the extra height is drilled from the top of broken ore. Generally the back will stand without support for a week or two without falling until the filling is in, but where the roof is weak, temporary cribbing is used. This is removed upon filling. When the back of a stope gets to within 12 or 15 feet of the floor of the stope above, square sets are resorted to. This generally amounts to 2 or 3 floors. The sets are 5 feet by 5 feet by 7 feet high, the timber being rounds from 10 to 12 inches in diameter and framed on the surface.

No. 2 shovels are used for mucking and where possible ore is thrown directly into the chute. Where it is too far to be thrown it is shoveled into wheelbarrows and then dumped into the chute.

Chute mouths are also of timber, and while they are of the same design (see sketch, page 22) yet each one is cut and made on the job to fit. The only standard dimensions are the width of the lip and its height above the rail. Ore is loaded into 20-cu.ft. cars and trammed to the level station by hand. There the cars



are run on to double-deck cages, one car to a deck, and hoisted. The shaft is three-compartment and verticle, two compartments being used for hoisting and the third for pipes, ladder, etc.

The mine makes from 90 to 125 gallons of water a minute, depending upon the season. This is handled by five Gould Triplex pumps. One of 250

g.p.m. capacity pumps from the 9th level sump to the surface. with one of 125 g.p.m. as a spare. On the 11th level there is one of 125 g.p.m. that pumps to the 9th level sump, and the 14th level there is one of 250 g.p.m. that also pumps to the 9th level. Now a Triplex of 125 g.p.m. capacity is being installed on the 16th level to pump to the 14th level sump. The water pumped is acid but contains practically no copper.

Contractors

Most of the development work is done by contract, while the stopes on production are usually company or

"casa" work. The practice is to give a whole level to one contractor, and the contractor is responsible for drifting, raising, silling out, etc., on that level. Then at the end of each month the mine surveyor measures up that contractor for work done and computes the gross amount coming to him. His men are carried on the mine payroll but charged to him. The paymaster takes the surveyor's report, deducts for payroll, supplies, rent, light, etc., and the contractor is paid the balance, or net "profit." If there is a deficit, the contractor's men are paid in full, and the contractor himself is advanced about \$2.00 a day worked "on account" so he can live, and the total deficit is carried over until the next month.

Pay of Labor

Casa miners are paid \$2.00 a day of eight hours, and the muckers and trammers get \$2.00 a day. The contractors are allowed to pay either a slight amount less or more than the "casa" but not unreasonably so. For the casa, cagers get \$3.00 a day, jigger bosses \$3.00, and a "capataz" or level boss gets \$4.00 (the latter being paid whether or not the mine works).

The mine is worked in two shifts, one starting down at 7 oclock in the morning and starting up at 3:30 in the afternoon. The other starting down at 6 oclock in the

evening, starts out at 2:30 in the morning. Each shift has a half hour for lunch. When labor is plentiful so the mine production can be pushed up to 750 or 800 tons



THE AMERICAN CLUB — FOR STAFF "BACHELORS"
Concrete Tennis on the Right

a day, the mine shuts down on Sunday; but when labor is scarce, the mine runs every day to keep the mill running 24 hours a day. Normal mill capacity is 600 tons a day.

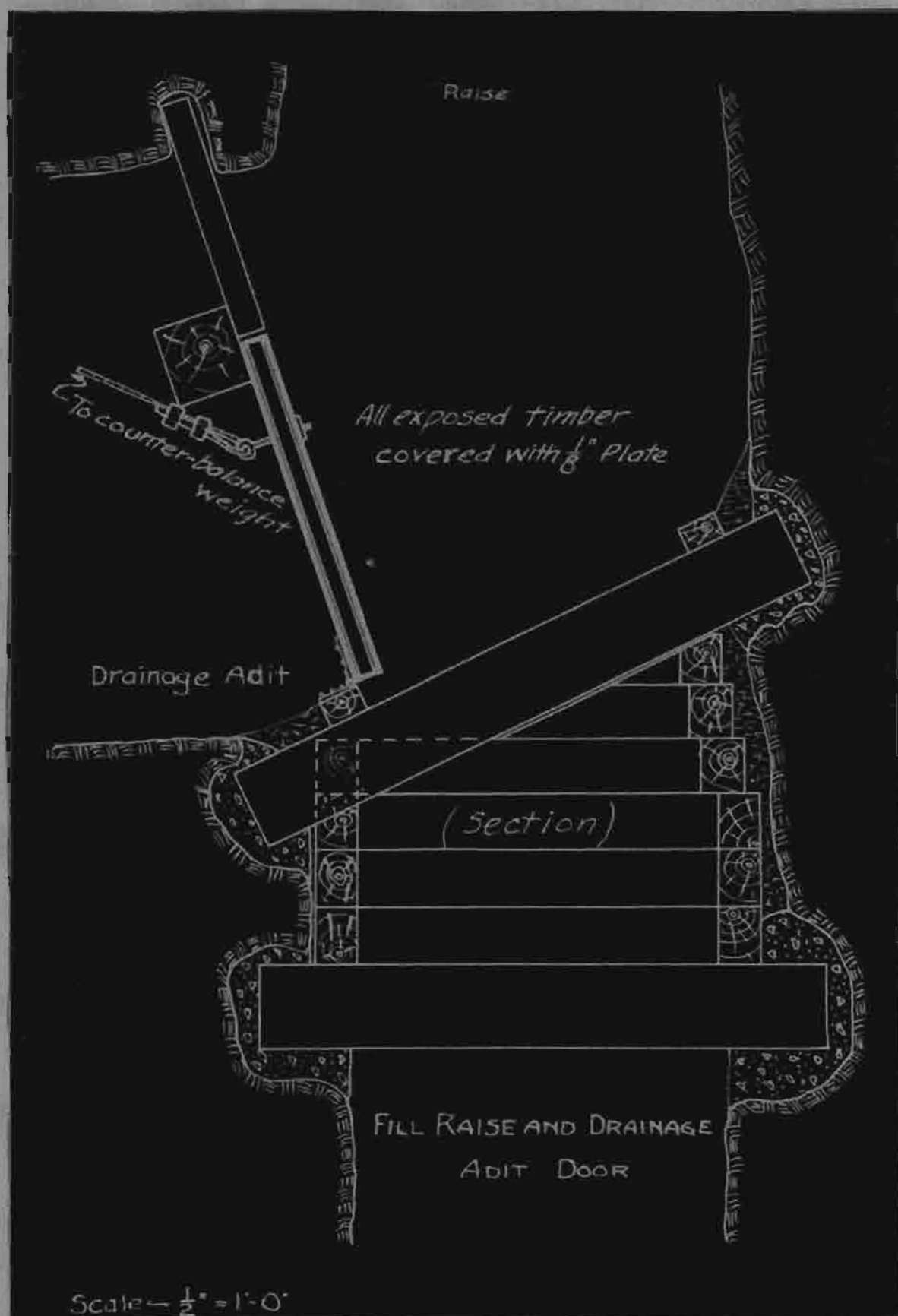
Fill

Sometimes three-shift days are used on fill, especially during and immediately following the rainy season, but generally two shifts are able to keep up with extraction. Aside from development waste, all filling comes from the surface glory holes, of which there are three, south, center, and north, corresponding to the fill raises mentioned earlier in this report.

The fill is picked or shot loose in the glory hole and runs by gravity through the raises, which are almost vertical. As the 10th and 11th levels are the present producing levels, the fill is taken off on the 9th and 10th. When the 12th level comes into production, cross-cuts will be run out on the 11th level to a point under the fill chutes on the 10th level and raises run up to connect.

Fill crews fill their cars at the fill chutes, tram them to that raise most convenient to the part of the stope below being filled, and dumped. At present, the "slusher" method is used for spreading where formerly men and wheelbarrows were used. Two men, a drag, an air winch, cable, and blocks can now do in an hour what it used to take ten men 8 hours to do. By a systematic shifting of blocks, all parts of a stope can be filled with one set-up of the winch. Of course, sometimes it is better to change the winch than to get into too complicated a system of blocks.

At the lowest point possible for each fill raise, a drainage adit is driven. This is to keep the water that falls during a rain over the area of the glory hole from going down into the mine. By use of a hinged door at the intersection of the adit and raise, fill can be continued without interference on down the raise, while by throwing the door down to cover the



raise and uncover the adit, rain-water can be deflected out to the "arroyo".

Underground Sorting

Although in places the orebodies run in masses of high-grade ore and low-grade ore, practically no effort is made to sort underground. This is because everything that comes out of the mine is considered "ore" until discarded in the tails at the mill. However, in the stopes the muckers try to throw only high-grade chunks down one chute and the remainder of the broken ore down another. This is only when two chutes are available and it is convenient to do so. Also the trammers, filling their cars and seeing that a car is being loaded with fairly



THE SHAFT — LOOKING NORTH

high grade ore, take a piece of wood, mark a cross on it with their lamps, and wedge it on the car as a signal to the "checker" above. This is the extent of underground sorting.

Underground Equipment

The only drills used are Ingersoll-Rand stopers and jackhammers. This is to save carrying a large stock of repair parts. For drifting, a jackhammer is mounted on a carriage and column. Hollow steel is used, but the bit is kept clear by air as the shale is rather damp and there is not dust.

All the stations are electrically-lighted, and also is the powder magazine on the 11th level about 400 feet from the shaft. Hoisting signals also are electric, the contacts operating under oil. These have proved very satisfactory.

SURFACE PLANT AT THE MINE



At the shaft is a 90-foot steel headframe with overwind safety devices and hoisting cables are one-and-a-quarter-inch Leschen wire rope. The hoist is electrically-driven, direct-connected double-drum, with all safety devices, built by the Wellman-Seaver-Morgan Co. It is

350 H. P. and the rope runs at 1000 f.p.m.

At the shaft-house is a 60-ton concentrating ore bin and a 10-ton high-grade or shipping ore bin, into which the cars are dumped. High-grade ore comes out of its bin by gravity, but concentrating ore is fed out by 24-inch Stephens-Adamson plate conveyor feeders. Both bins feed into two Kennedy primary gyratories, which crush to -3 inches at a rate of 50 tons per hour. From the primary crushers, the ore runs on to a 30-inch Good-year rubber picking-belt, with a speed of 40 F.P.M. The belt passes by a small auxiliary bin and over a high-grade or shipping ore bin at an angle of about 15° . This angle brings the ore high enough to dump into a 5-foot by 48-inch trommel, with $2\frac{1}{2}$ -inch round holes.



A crew of boys sit at the picking-belt on seats over the shipping ore bin and pick out the high-grade from the concentrating ore. Whenever the high-grade ore bin in the shaft house becomes full, the concentrating ore bin is shut off, and the high-grade ore is run through the primaries and onto the picking-belt.

Then part of the crew of boys picks out pieces of low-grade ore and toss it into the auxiliary bin. The high-grade is then scooped off the picking-belt by the remain-

der of the boys into the shipping ore bin. Later this low-grade ore is shoveled back onto the picking-belt and goes on up to the trommel.

The ore that actually gets through the holes in the trommel is $\frac{3}{4}$ -inch or less in size. The oversize goes through a Telsmith secondary gyratory and is crushed to $\frac{3}{4}$ inches, joining the undersize from the trommel onto a distributing belt (18" shuttle conveyor) that distributes to bins of a total capacity of 500 tons.

At the mine there is a small blacksmith shop for sharpening drill steel and making repairs to drills, cars, cages, etc. It is equipped with several forges and an Ingersoll-Rand drill sharpener.

Running from the mill to the mine is a narrow-gauge track used for transporting supplies brought from Santa Lucia by tramway to the mine and warehouse. The locomotive force is "one-bull-power". In other words, an ox or bull is used for pulling two or three specially-made cars. In this way all the mine timbers are brought to the framing shed, which is on a level with the "railroad". At this level, also, is a tunnel that connects with the shaft close by, so timbers can be loaded into cages without transporting them to the shaft collar, 20 or 30 feet above the shed.

Near the mine is a complete machine shop, foundry and forging shop, and carpenter shop. These are equipped

A schematic diagram of a mechanical system. At the top is a rectangular box. Below it, a dashed line leads to a motor unit on the left, which is connected to a large pulley. A dashed line also leads from the motor unit to a vertical roller on the right. The pulley is connected to a horizontal roller at the bottom. A dashed line leads from the horizontal roller to a small rectangular box at the bottom left. A dashed line also leads from the horizontal roller to a teardrop-shaped component at the bottom right.

4-Homemade Ratchet Belt Conveyor
Feeders - 20" wide, driven off M.M.
pinion shaft.

2- Elevators, 20" belts 10" cups staggered
speed 35 F.P.M. friction clutches and
gear reduction 4:1

2-Trommels Screens 48" dia. 156" long
3 mm. openings 251 F.P.M. gear
reduction 4:1

1. oversize distributor

1- Scooby Head Sampler cuts every 9 minutes

1- Undersize distribution

4. Butchart Pr. Tables 260 strokes/min
5" strokes

3-Deister Sec. Tables $\frac{5}{8}$ " Stroke
235 strokes/min.

2-Homemade Esperanza Drags 18" wide
speed 101 F.P.M. Tables, Els, Screens
Drugs, Samplers run by 1-25 HP
220 v. G.E Motor

2-Disc wheel Oil Feeders

3- Dewco 6x6 Ball Mills Coupling Drive

Gear reduction 15:1 3-100 H.P.G.E.
Induction Motors #1 & #3 in closed
circuit with Dorr Classifier
#1 or #3 run in conjunction with
#2, 2 mills operating.

2-Dorr Classifiers 24 R.P.M. driven
off Fine Mill Pinion shaft.

2-chain driven worm conveyors
for delivering sands to #1 or #3
mill

1-Flat Feed Distributor

3-Callow Duplex 2x8 Pneumatic Cells
"Primary"

2- Callow Duplex 2-8 Pneumatic Cells
1- Butchart 14' Flat Machine
"Secondary"

1- Callow Duplex 2x8 Cleaner
1- Froth return sump
2- 4" Krogh Sand Pumps froth return
1- 2" " " " " "

Air supplied by 2 Connersville
Blowers .588 ft³/rev, one operating
1-50 H.P. G.E. 2200v. motor
1-75 H.P. 2200v. Motor

1-floor sump
1-2" Krogh Pump

1-Scoby Tail Sampler

1. Scoby Conc. Sampler

2-30x12 Dorr Tail Thickeners
1 rev. in 8'-20"

2- Drags 8" belts, speed 63 F.P.M

2- sets cascades

2. Distributors for coarse concs.

2 - 30x12 Dorr Conc. Thickeners

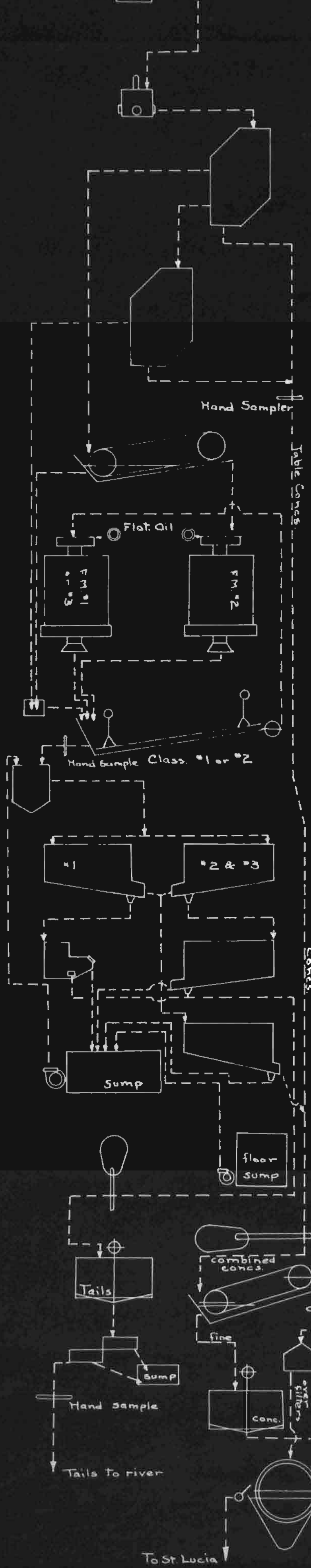
2 - Oliver filters 12x8 1-rev. in 6'

2-14x8 Vac. Pumps - 1 receiver

1- 1R. 12x10 Compressor 1-receiver

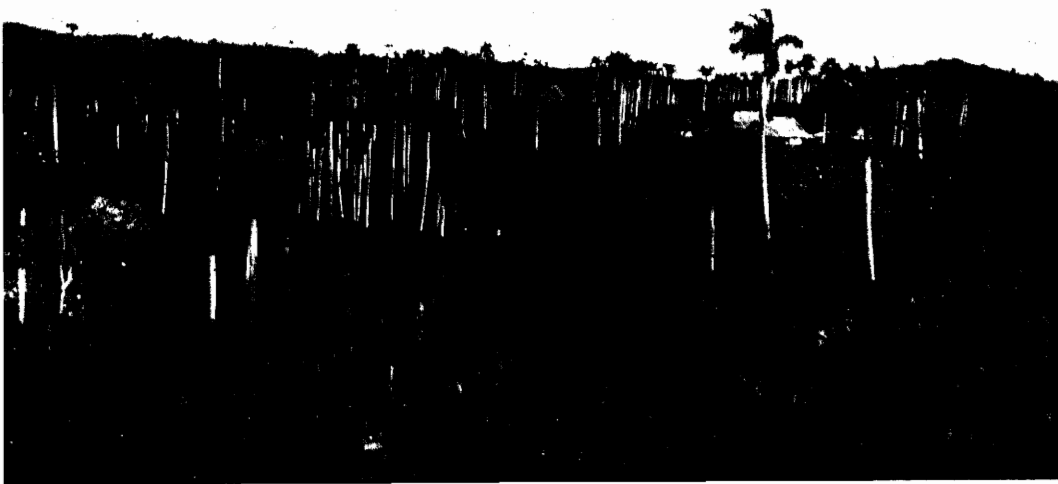
2- 6x8 Gould Triplex, In River
1- 7½ H.P. Motor, 1- 15 H.P. Motor

1- 6x8 Gould Triplex, for
Thickener return water



loading terminal bin, also 100-ton capacity, by belt conveyor.

For mill treatment of the concentrating ore, see flowsheet, page 32. The mill ratio of concentration is 5 to 1, with a daily production of 100 to 125 tons of concentrate, depending upon the mill head. Although the mine head remains fairly constant, the mill head varies indirectly with the amount of high-grade produced. The production of high-grade runs from 20 to 50 tons a day. This variation is partly due to character and wetness of the ore, and partly to efficiency, and number, of picking-belt boys.



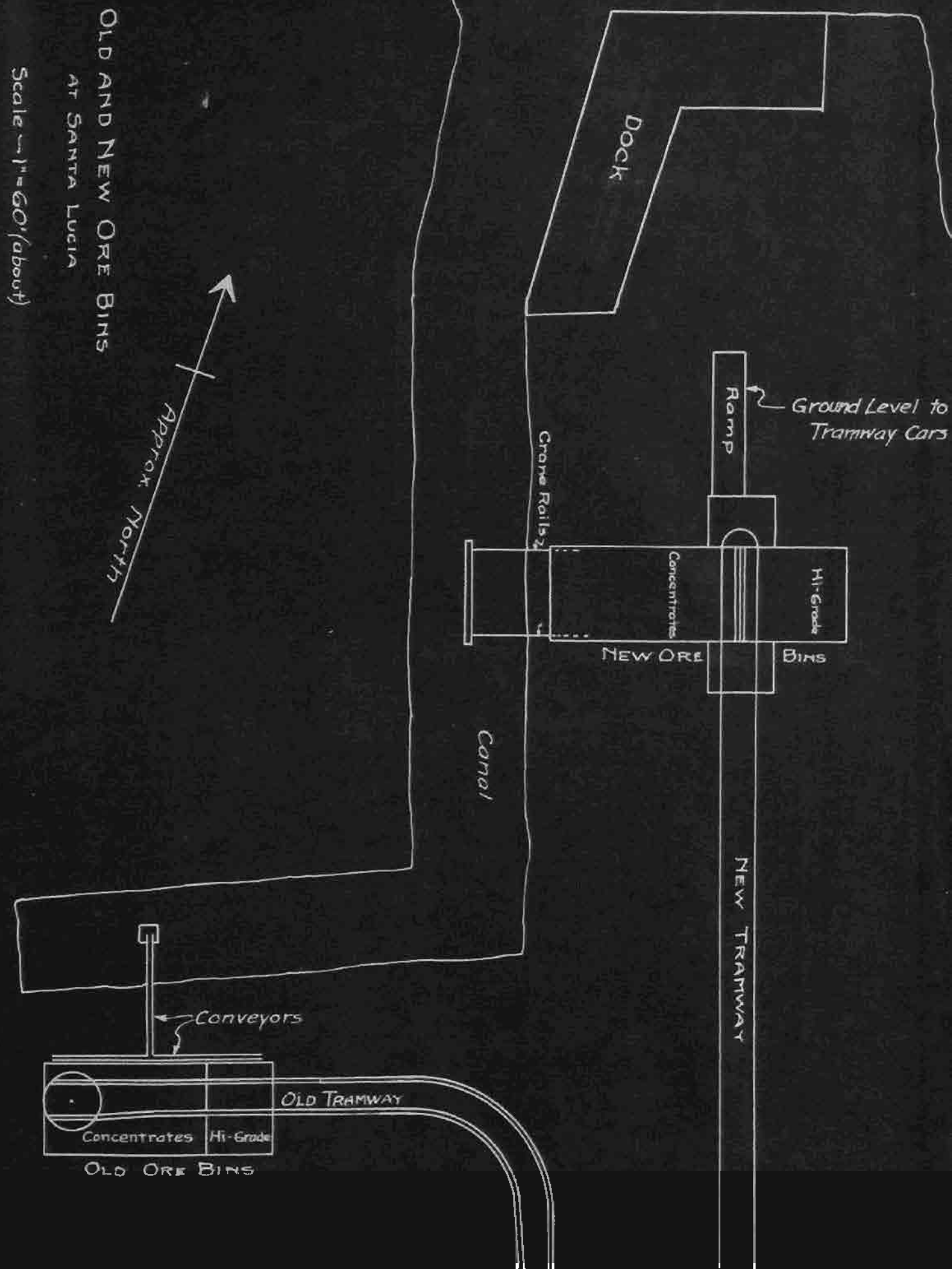
The table and flotation concentrates are mixed at the Oliver filters, from which they are conveyed to the 300-ton capacity concentrate bin at the tramway loading terminal by inclined belt conveyor. The present loading terminal, tramway, and discharge terminal were completed in January, 1924. Previous to this shipping ore and concentrates had been transported to the coast by the old double-track tramway and by motor truck. About 40 to 50 tons a day was the limit of the former, due to its delapidated condition. The new tramway is of the



LIGHTERS AT THE SHIP

Leschen-type and is six miles long. It uses the locked-coil type cable, the loaded side being $1\frac{1}{4}$ inches in diameter, while the return side is 1 inch in diameter. It runs at 500 feet per minute and the buckets carry an

average of 1100 pounds. Sling-cars are also provided for oil drums, timber, etc., to transport supplies up to the mine. With ore buckets spaced at 1000 feet apart, the mine production can easily be handled in an eight-hour shift, but when necessary the interval can be decreased to 500 feet. Clamps automatically attach and detach buckets, but loading is done by hand from chutes and the



buckets are dumped by hand into the storage bins at Santa Lucia.

Shipping Facilities

From the sketch on page 35 will be seen the layout of the former and present discharge terminals. The ore and concentrates are, and were, loaded onto lighters



"ON TOW"

and towed out to sea for loading ore ships. The lighter capacities range from 100 tons to 300 tons. For the first part of a ship load, the ship can come within a mile or two of the bins, but owing to the reef at the en-

to the "harbor", the latter part of the load must be

towed six or seven miles out to sea before loading. Under the old scheme, the ore and concentrates were delivered to the lighters in the canal by belt conveyor, but now are delivered by bridge-crane, which is also used for distribution in the bins.

POWER

Power is supplied by two G. E. steam turbines and generator sets. A new one of 1500 kw. capacity is for regular duty, and an old one of 1000 kw. capacity is a stand-by unit. Steam is generated by fuel oil in horizontal water-tube boilers, and sea-water is used for condensing. There are two boilers of the Wickes type and five of the Heine type.

Power is transmitted to the mine over a high-tension transmission line at 11,000 volts. This is stepped-down according to needs at Matahambre in a substation there.