Quicksilver in Oregon

By C. N. SCHUETTE

BULLETIN NUMBER 4

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PREFACE

Oregon in recent years has advanced to second place among the states in production of quicksilver. The value of the metal produced in the State during 1937 was about $380,000, judging by preliminary estimates. Owing in part to the situation in Spain, which is the dominant producer, there has been renewed interest generally in quicksilver production and certain districts in Oregon have received particular attention from quicksilver operators and prospectors.

Quicksilver is one of the "deficiency" or "strategic" war minerals, and its production should be encouraged in all localities where the existence of the mineral is known.

The last field work on quicksilver in Oregon, carried out by a Federal or State agency, was in the summer of 1930. In this the United States Geological Survey cooperated with the State of Oregon and the report of the work was published in 1934 as Bulletin 850, "Quicksilver Deposits of Southwestern Oregon", by the United States Geological Survey. The State Department of Geology and Mineral Industries deemed it expedient to bring the study of Oregon's quicksilver up to date in order to encourage the local industry and so arranged with Mr. C. N. Schuette, Consulting Engineer and an outstanding quicksilver specialist in the West, to do the work. This bulletin is the result. The chapter on metallurgy of the metal should be especially helpful not only in Oregon but wherever quicksilver is produced.

Mr. Schuette's analysis of the economics of quicksilver, the effect of the quicksilver tariff, and his comments on the attitudes of the Federal Agencies, all of which, of course, are his own, are worthy of careful study and consideration not only by producers in this and other states but also by Congressmen and members of the administrative branches.

Some might consider certain of Mr. Schuette's remarks as overcritical. It naturally would be the policy of this Department to grant Mr. Schuette, with his knowledge of the subject and his standing in the industry, a free hand in his preparation of the report.

As a summary of the quicksilver situation in Oregon at the present time, this Department takes pleasure in presenting this report. Later, perhaps next year, it is not unlikely that a study may be made of new or more remote quicksilver occurrences in the State.

<div style="text-align: right">EARL K. NIXON, Director</div>

Portland, Oregon
February 1, 1938

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By C. N. SCHUETTE

INTRODUCTION

The governing board of the State Department of Geology and Mineral Industries, in September, 1937, authorized a survey of the quicksilver deposits of Oregon. In accordance with this authorization the author made field trips to the central, southwestern, and southeastern quicksilver districts of Oregon in October and November of that year. The month of December was spent in preparing this report for publication.

ACKNOWLEDGMENTS

The author has received generous co-operation given with uniform good will from all the producers whom he contacted either personally or by correspondence. It was not possible to visit all the prospects, due partly to inclement weather and partly to lack of time, but it is thought that enough has been accomplished to form the ground work for a continuing effort in the future to aid the people of Oregon in the intelligent development of one of the important resources of the State.

Many courtesies were extended to the author by: S. H. Williston, M. F. Fredea, Lloyd W. Staples, and Q. S. Tracy of the Horse Heaven Mines, Inc.; H. A. Miller of Bend, Oregon; Mr. Lynn, H. S. Cram, and K. Hamblen of the Motherlode Mine of Prineville; W. J. Westerling of the Johnson Creek Mine; Mr. Davis of the Blue Ridge Mine; Fred C. Eickemeyer, Herbert W. Eickemeyer, and Frank W. Towner of the Maury Mountain Mine; J. E. Staley of The Staley and Barney Mine; Geo. Schumacher of Beagle, Oregon, and now at the Chisholm Mine, who gave generously of his time and placed his wide knowledge of the southwestern deposits at the author's disposal; Allen Postel, Wm. Rosendale, and J. E. Tyler of the War Eagle Mine; H. H. Sharp of the Roxana Group of Mines; Allan Mayhew of the Bonita Mine; H. C. Wilmot and Bob Finley of the Bonanza Mine; Fred Mills, John Madsen, and Frank Taylor of the Black Butte Mine; Worthen Bradley and O. L. Cash of the Opalite and Bretz Mines; and Calvin Peyton of Klamath Falls.

Besides these owners and operators, Dr. Warren D. Smith of the Geological Department of the University of Oregon, Edmund S. Leaver of the Reno Station of the United States Bureau of Mines, and Chas. W. Merrill of the United States Bureau of Mines, Mineral Production and Economics Division, supplied data and advice; and, last but not least, Director Earl K. Nixon, of the State Department of Geology and Mineral Industries, by his dynamic energy in getting things done was of inestimable help throughout the work.

OUTLINE OF REPORT

Since publications dealing with quicksilver are comparatively rare, most of the older ones being out of print, it was deemed advisable to preface the discussion of Oregon Mines and Plants with general information on the history, geology, mining, metallurgy, and economics of quicksilver generally. These chapters are brief and references are given to sources where more detailed information on these subjects can be obtained. Following these general chapters are those dealing with quicksilver in Oregon which show the remarkable progress that has been made in the quicksilver industry of this state during the last ten years.

GENERAL HISTORY

The mining and reduction of quicksilver ores is an ancient business. The beginnings of it precede written history.

According to early records an Athenian named Callias is credited with inventing a reduction process for quicksilver ores in 415 B. C., and becoming wealthy thereby. In China, also, quicksilver was mined and reduced several hundred years B. C. Cinnabar was used there, in the arts, as vermilion ink and paint. There are written records of the use of metallic quicksilver in 210 B. C.

Quicksilver and cinnabar were known in international trade from very early times. Some 10,000 pounds of cinnabar were taken to Rome annually from the quicksilver mines of Spain according to Pliny who lived from 27 to 79 A. D.

In early days very finely ground cinnabar was used for rouge; amalgamation was known, and this property of quicksilver was used both for recovering precious metals and for gilding. It was used in medicine and was known to have poisonous properties. Some 700 to 800 years later when the alchemists practiced their black arts, quicksilver was to them the means to many an end in their quest for the elixir of life and the transmutation of metals. One of their theories was that quicksilver was a component of all metals and that by adding the right amount of sulphur and other substances and muttering the correct incantations almost any desired metal could be produced. These efforts at transmutation did not succeed, but the various experiments did result in the discovery and production of red precipitate and mercuric bichloride.

In the succeeding centuries increased use was made of quicksilver and its compounds in treating skin diseases and from that day to this its use in medicine has been firmly established. The quicksilver barometer and thermometer were invented roughly 300 and 200 years ago, respectively.

Quicksilver has such a low freezing point ($-40°$ in both the Fahrenheit and Centigrade scales) that it had never been seen in the solid state until 1759-60 in which winter Prof. Braune of St. Petersburg observed that it solidified at that temperature. Up to the 16th century the world's consumption of quicksilver was small but when the Patio Process for recovering silver from its ores by amalgamation was invented at Pachuca, Mexico, in 1557, the first industrial process using large amounts of quicksilver had arrived.

Since that time the average annual consumption of quicksilver has increased from century to century until it has arisen to over 100,000 flasks per annum in modern times.

Another process using large amounts of quicksilver was invented in 1797 when Howard first produced mercuric fulminate which is used for detonating explosives.

In recent years it is being used for the development of power, a new use that promises to become a large consumer of quicksilver.

A few large mines have produced the bulk of the quicksilver used thus far in this world. Wars have been fought for

their possession, and commercial control of their output was the prize of many a battle of the world's financiers. The Almaden Mine in Spain which was owned successively by the Romans, the Moors and then by Spain, has not only been in continuous production for over 2,000 years but is still the largest producer of quicksilver in the world. No other mine in the world has a comparable record. Its total production is over 5,500,000 flasks of quicksilver.

The Idria Mine, formerly owned by the Austrians, held for a time by the French and then by the Austrians again until Italy took it after the World War, is another of the world's great quicksilver mines with a production record of some 400 years, and a total output exceeding 2,000,000 flasks.

Huancavelica in Peru which produced for some 300 years ending in the middle of the 19th century is the third largest producer with a total production of 1,500,000 flasks.

New Almaden in the United States is the fourth with over 1,000,000 flasks and Monte Amiata in Italy the fifth, with over half a million flasks. Russia, Mexico, and China are smaller producers among the nations. Great Britain, France, Germany, and Japan among the world's large consumers have no appreciable production of their own and are dependent on imports for their supply of quicksilver. The significance of this can be seen when it is remembered that no modern war can be waged without it and that quicksilver is indispensable to modern industry as well as to medicine and science. Thus quicksilver is a metal of far greater strategic importance than the value of its annual production would indicate.

GENESIS OF QUICKSILVER OREBODIES

Quicksilver deposits are not confined to any particular type of rock or to any particular age of rocks. Quicksilver occurrences are, however, definitely associated with volcanism and most of the deposits are found in regions of Tertiary and Quarternary volcanic activity where there has not been much erosion, as long continued erosion to great depths would have removed many of the deposits, most of which were deposited near the surface.

Geographically, mere occurrences of quicksilver are spread out over nearly all parts of the world. The productive areas, however, are largely confined to countries bordering the Mediterranean and to the west coast of North and South America.

Maps showing the most productive areas of the world are given in the United States Geological Survey, World Atlas of Commercial Geology, Part 1, Distribution of Mineral Production, Washington, D. C., 1921.

Quicksilver, in the form of its common ores, is a rare metal, a fact that is not always appreciated in view of the abundance in which it occurs in a few localities. In smallness of tonnage produced in any given year it ranks next to gold, and in value per ton it ranks third among the better known metals being exceeded in unit value only by gold and silver.

From the widespread occurrence of traces of the quicksilver sulfide, cinnabar, the metal must be a common constituent of rock magmas deep in the earth. It is also one of the most volatile of metals. This latter characteristic would seem to be responsible for the scarcity of its orebodies because, if special conditions do not obtain, the metal, upon escape from the parent magma, quickly reaches the surface and escapes. It may well be that great quantities of quicksilver thus escape into the atmosphere in volcanic eruptions.

Some seven years ago the author[1] advanced the theory that quicksilver ore deposits were formed by a concentration of the primary mineralization during deposition, and that the usual causes that induced such a concentration were largely structural features of the geology at the point of deposition.

Briefly, this theory states that the quicksilver has its origin in rock magmas deep in the earth. This, of course, is also the source of other metals. Then, when a fracture in the earth's crust breaks through to such a magma, or is opened by pressure from such a magma, the ore minerals escape and ascend through the fracture toward the surface. Such fracturing oc-

[1] C. N. Schuette: Occurrence of Quicksilver Orebodies. Trans. A. I. M. E. Vol. 96, 1931, pp. 403-488.

C. N. Schuette: The Geology of Quicksilver Ore Deposits. Calif. Jour. Mines & Geol., Vol. 33, 1937, pp. 38-50.

curs when volcanic activity takes place and dikes and sills of magma push surfaceward through faults in the crust of the earth.

Sulphur, water vapor or steam, and quicksilver must be among the first constituents of such magmas to escape. Even today, at Sulphur Bank, in California, and Steamboat Springs, in Nevada, these constituents are escaping in solfataras (the last or dying manifestations of volcanic activity) and are depositing cinnabar and sulphur at the surface. These are mineralizing solutions which have great pressure and temperature at depth both of which lessen as the solutions ascend towards the surface. These solutions are alkaline in nature. This was first shown by Christy[2] and was later confirmed by the work of Broderick[3] and of Allan and Crenshaw[4].

Incidentally, the waters now emanating at Sulphur Bank and Steamboat Springs are alkaline waters as are those of many hot springs in the vicinity of other quicksilver mines.

These alkaline carrier solutions on their way up to the surface often reached it quickly through large open fissures and emanated as hot springs without depositing any orebodies. In other cases, as they neared the surface, these solutions were diluted by surface waters and again no ore deposit resulted. Again, many of these mineral-bearing solutions were slowed down or dammed, on their way to the surface, by the impervious gouges of fault slips, or by shales which, upon fracturing, sealed up the fracture due to their soft and yielding nature. In such cases the ore minerals were deposited by cooling, by loss of pressure, or by precipitating agents such as organic matter or gaseous reagents.

When such a precipitation of ore minerals set in, deposition occurred in whatever open space existed in the rocks. These may have been fractures, pore space in such rocks as sandstone, or in the interstital space of breccia formed by the faulting.

Thus the deposition of the orebody, at the point where it was formed, was due to the trapping of the pregnant solution

[2] Christy, S. B.: On the genesis of cinnabar deposits: Am. Jour. Sci., Ser. 3, Vol. 17, 1879, pp. 453-463.

[3] Broderick, T. M.: Some experiments bearing on the secondary enrichment of quicksilver deposits: Econ. Geol., Vol. 11, 1916, pp. 645-651.

[4] Allan, E. T., and Crenshaw, J. L.: The sulfides of zinc, cadmium and mercury: Am. Jour. Sci., Vol. 34, 1912, pp. 341-396.

in the receptacle rock by an impervious rock. The cap rock which trapped the solutions determined where the deposit was to be formed and the receptacle rock determined the grade and shape of the ore deposited in it. Tight receptacle rocks, such as shales and schists, give little room for deposition, hence only low-grade ore can be deposited. On the other hand, an open-textured sandstone or a coarse breccia yields generous space for deposition and high-grade orebodies are found in them. The ore minerals in such a deposit are, of course, primary, and secondary minerals are rare, being formed later by surface agencies. These tenets of the theory of primary concentration as set forth above agree well with the facts concerning quicksilver deposits that can be observed in the mines and also with those that can be demonstrated in the laboratory.

In considering the general outline of quicksilver deposition as outlined above, these two conclusions can be reached:

Very high grade orebodies can be formed if the structure is favorable and many orebodies may be formed with little or no outcrop to show where they are.

It is also clear now why quicksilver mining is considered to be more hazardous than the mining of many other metals. The orebodies are apt to be irregular, but this very irregularity carries, in itself, the possibility of finding high-grade ore, and this balances the extra hazard because high-grade ore is the miner's dream, hope, and reward when he finds it.

Quicksilver Minerals

The most important, of the approximately 25 minerals which contain quicksilver, is cinnabar, the familiar red sulfide. Most of the others are rare—some of them very rare. Two United States Geological Survey publications, Bulletin 405 and Min. Res. of the U. S., 1917, Part 1, pp. 390-393, describe most of them.

The quicksilver miner is interested primarily in cinnabar from which practically all of the world's production of quicksilver has come. He may find some of the secondary quicksilver minerals, such as native quicksilver, metacinnabarite, and calomel, in the upper part of his mine. If limestone or calcite is present in the gangue rock he may also find the oxychlorides such as eglestonite and terlinguaite.

Cinnabar: It has a bright red color and occurs both in crystalline and amorphous forms. It is the sulfide of mercury (HgS) and pure crystals contain 86.2 per cent of quicksilver. Such crystals are rare in nature and specimens of "solid cinnabar" as found in the mines seldom assay higher than 40 per cent of quicksilver. It is a fairly soft mineral, 2 to 2.5 in the Mohs scale, but it is heavy, the specific gravity being 8 to 8.2. As found it is often discolored by impurities, but the true color shows up in the streak when scratched. Being heavy, it can be detected by panning. In some deposits, where silica and cinnabar were deposited together, (200-mesh particles of the so-called opalite deposits when examined by the microscope still show silica surrounding the cinnabar) the rock turns dark upon exposure to sunlight (like bottle glass in the desert) and the rock must be broken to show the color of the cinnabar. In such deposits the cinnabar cannot be panned from the gangue When the cinnabar is in decomposed rocks, containing a lot of clay-like and colloidal material, it is also difficult to estimate it by panning.

Native quicksilver: This shows up in the form of globules and these are readily panned out.

Metacinnabarite: This is the black sulfide and has the same chemical composition and weight as cinnabar. It pans well, but can be confused with black iron minerals, such as magnetite. When in doubt, it is best to heat the black mineral in a test tube with a little soda. If it is metacinnabarite a ring of quicksilver globules will form in the cool part of the test tube.

Calomel: This mineral often called horn-quicksilver is sometimes found as a white to yellow-brown, wax-like substance. It is soft and not as heavy as cinnabar (sp. gr. 6.48). When it does occur—which is rare—it is generally present in such small particles that it is difficult to identify.

Eglestonite and Terlinguaite: These two oxychlorides when present often occur together. They are bright yellow when first exposed; turn green upon exposure to light, and then become black. They generally occur as small pockets near the surface where limestone or calcite is present in the gangue and are generally associated with high-grade cinnabar.

Cinnabar is the primary ore in all cases. This primary cinnabar, after deposition near the surface, can be dissolved by acid surface waters and this dissolved quicksilver can be re-precipitated as metacinnabarite by hydrogen sulfide gas or as native quicksilver by the combined action of hydrogen sulfide and organic matter.

The primary cinnabar can also be dissolved by chloride surface waters. From such solutions calomel, metacinnabarite, and native quicksilver can be precipitated by reducing gases.

Again, such solutions, if in contact with calcite, can precipitate the oxychlorides.

These are the chief reactions by which the secondary quicksilver minerals form. While it is well that the prospector should be able to recognize them it is not necessary as all of them generally occur with cinnabar.

Gangue Minerals: The common gangue minerals found with cinnabar are pyrite or marcasite, calcite, and quartz or other forms of silica. Carbonates and oxide of iron and carbonates of calcium and magnesium are common. Soft altered masses of clay-like texture are often the altered and decomposed form of igneous rocks that have been changed by the mineralizing solutions.

Various forms of hydrocarbon compounds are often found in quicksilver deposits. These have various names and varying compositions. They were probably derived from the sedimentary rocks through which the magmatic solutions ascended. The heat of the intrusions probably caused distillation of organic matter from the sedimentary wall-rocks of the fractures and this organic matter ascended through the same fractures as the quicksilver bearing solutions and was trapped and deposited with the cinnabar.

PROSPECTING FOR QUICKSILVER

Prospecting, or the search for mineral deposits, is an art that is practiced as a vocation by many men and as an avocation by many miners who work steadily in the mines through the winter to accumulate a stake and who then set out on their search when the weather becomes favorable. Such men, with the ex-

perience gained through the years, go at their business with great intelligence; most of them make a good living from their work and a few achieve their goal of finding riches. They generally search for any mineral that promises a reward and are always on the lookout for high-grade ore that they can work themselves. It is for this reason that quicksilver is getting increased attention from prospectors as most of these deposits have at least some high-grade ore that the prospector can treat at a profit while developing it to the point where capital can be interested in taking it over.

Besides discoveries made by bona fide prospectors, chance finds are made by others, such as cattlemen, and by sheep and goat herders, particularly the latter, who traverse much country on foot while following their flocks. Recently, in the Big Bend country of Texas a ranchman noted the similarity of the geology on his ranch with that of the quicksilver district in Terlingua. He obtained specimens of the ore from the Terlingua district, gave them to his herders and instructed them to look for similar rocks. Within three months ore had been found in several localities and in at least two of them preliminary development has shown promising results.

The Cordero Mine near the Opalite Quicksilver Mine in Southeast Oregon was found by Basque sheepherders who noted the similarity of the outcrop of the Cordero orebody to that of the Opalite Mine.

Quicksilver-bearing outcrops may be hard or soft. The hill slopes below hard outcrops generally show some float while slopes below soft outcrops will generally pan. Float and pannings are then followed up the slopes to the croppings. Good mines often have poor outcrops. On the other hand, great croppings have often been missed by prospectors because the cinnabar was not readily visible. For example, the outcrop of the Opalite Mine in Southeast Oregon stood out prominently and could be seen for miles. Every chip knocked from it, over an area of some 200 by 250 feet, showed cinnabar, but that was the point: only the freshly broken rock showed the red cinnabar because sunlight had darkened it to a dull gray-blue color.

Prospecting is hard work and any individual attempting it must be physically rugged and able to take care of himself in

the woods, mountains, and desert. The pick, shovel, and pan are the prospector's main tools though some drilling and blasting is often necessary. Since the prospector generally works alone he should know how to prepare his own food, and what food to take along. Since the prospector stays out in the hills for weeks or months, he must have enough money to finance himself or he must have a grubstake partner. He gets about by automobile or with horses, mules, or burros and often he goes afoot. Automobiles are most used in desert regions, especially of late years, when more and more roads are being built. Mules and burros are more used in the mountains. Often it is advisable to build a semi-permanent camp by a spring nearest the territory that is to be prospected, and then work from this camp into the surrounding countryside. Burros are both a great help and a great nuisance. They are helpful in carrying loads and equipment and of little expense because they can live on the country, but they will wander off and about one day out of four is lost in rounding them up.

Camp outfit and clothing depends somewhat on the type of country to be prospected, the time of the year and weather conditions to be encountered. Two pairs of stout shoes should be taken. The water supply of the country to be prospected is important as water is needed for drinking purposes, for panning, and for washing. Keeping the camp supplied with the necessary water may require a large part of the prospector's time, particularly in desert countries.

Cinnabar ore that pans readily can be judged as to quicksilver content with fair accuracy. Silicified or kaolinized rock that cannot be panned accurately must be assayed. Prospectors can customarily have new finds of quicksilver ore assayed free of charge at the nearest quicksilver mine.

In Oregon three different sets of conditions are found in prospecting. In general, the deposits in the southwestern part of Oregon are in densely timbered country, are covered by deep soil, and trenching must be used to uncover ore in place after having been traced up hill by panning. Exposures in stream beds and outcrops near the tops of the hills are often the only clues to the underlying rocks.

In Central Oregon the rocks are principally John Day sediments and Columbia lava flows. Because vegetation is sparse

except in the mountains the general outlook of the country approaches that of a desert, with rock scarps and prominent exposures traceable for long distances. Often the outcrops present a rusty iron-stained appearance.

As one travels from Central Oregon toward the southeastern corner of the State, the country changes to an even more arid type with some sand dunes in evidence and with the vegetation approaching more closely that of the so-called deserts of the Southwest. The typical Columbia lava-flow type of geology changes also to that of the Basin Range structure which continues southward into the state of Nevada. The appearance of the topography indicates and geological field work demonstrates that the country in southeastern Oregon has suffered considerable deformation by block faulting. Along these strong faults, which bound the orographic blocks, some important quicksilver deposits have been found. Usually they are in the form of opalite or hot spring sinter deposits.

DEVELOPMENT AND MINING

After a prospect is located it must be developed. In locating a deposit the outcrop is usually traced by trenching and panning and when done by an experienced prospector the location claim is generally laid out with surprising accuracy to cover the ground wanted, so that the strike of the "vein" crosses the end lines correctly to secure his extralateral right. Usually a number of additional claims are staked around the discovery claim. This serves to protect the prospector's location by keeping his neighbors at arm's length and gives a little extra room in case the first hasty location did not cover all the ground wanted. In 9 out of 10 mines, one claim properly laid out will cover all the ore, but, of course, the trick consists in being able to tell where the ore will be.

In quicksilver mining, even more than in other kinds of mining, the rule of "follow your ore" is important. A prospector, of course, would rather drive a tunnel than sink a shaft. One man can drive a tunnel and the workings drain themselves while it takes two men to sink, and water must be bailed out or pumped. If development can be done by a drift tunnel this is advisable, but if a long crosscut tunnel is needed, sinking would

generally be better. More prospects have lain idle for years because a crosscut tunnel failed to hit the ore where expected than from any other cause. The same amount of money and energy spent in following the ore down from the outcrop might have shown enough ore to prove it up, after which a crosscut tunnel could be run to the point where the ore is known to be. Quicksilver orebodies often have decided rakes or pitches along the strike, so that a simple crosscut tunnel to a point straight under the outcrop is not enough. A great deal of drifting is often necessary to reach the oreshoot.

After a reasonable depth, say 50 to 100 feet, on the vein has been reached by sinking, drifting along the hanging wall is generally the next step.

Raises are next run between the levels and the ore is usually mined out using stulls or square sets. Shrinkage stoping is used in a few mines where conditions are suitable.

Quicksilver mining is a small tonnage operation and this must be kept in mind. Mining systems needing elaborate preparatory work are seldom economical as the cost of preparation is too great to be absorbed by the small tonnage mined. Small shafts and tunnels and hand or mule tramming are generally all that are needed at a quicksilver mine.

Surficial deposits are mined by glory hole methods or by shovel operations. The latter is usually preferable because it allows of selective mining.

In developing a new mine, accurate maps should be kept and all possible information on the grade of the ore, type of rock, gangue minerals, fractures, dikes, gouges, etc., should be recorded on the maps. Such data when carefully recorded become valuable guides to future work when their significance has become apparent as it generally does in the course of time.

Another thing to be remembered in quicksilver mining is that it usually pays well to mine selectively and to sort the ore. These two reasons account for much of the square setting done in quicksilver mines. Also, fines made in the mining process are usually ore, and tight flooring in chutes and stopes pays for itself by saving the fines.

In other items such as chutes, methods of tramming, ventilation, drilling and blasting, etc., the mining of quicksilver ore does not differ from other forms of small scale mining.

Mine samples are taken in the usual manner, either as cut samples from the face, or as muck or car samples. In some mines panning or a mere visual inspection serves to determine the grade of the ore.

METALLURGICAL TREATMENT OF QUICKSILVER ORES

This ancient art, practiced and written about for over 2,350 years, is still being improved upon. It is also still being practiced much as it was in its infancy by means of primitive retorts and therein lies its story and romance.

The ore of quicksilver, cinnabar, when heated to a comparatively low temperature in the presence of air breaks up into sulphur and quicksilver vapor. The sulphur combines with oxygen from the air to form sulphur dioxide gas and the quicksilver vapor condenses to liquid upon cooling.

These facts were probably first noted when a fire was built accidentally on cinnabar bearing rocks.

As late as 1915 a quicksilver mine (McCoy Mine in Nevada) was found in this way when a party of prospectors raked through the dead ashes of their campfire and noted globules of metallic quicksilver on the ground.

The first improvement upon this process was the addition of a cover over the fire to condense the vaporized metal and soon the process was carried on in closed earthenware dishes with outside heating. This, however, results largely in the formation of soot (black HgS) unless a little air was allowed to leak in. But retorting had been invented much as it is still practiced today in all manner and shapes of retorts large and small.

Clay retorts were used (they are still being used in China) in Europe at the Idria Mine up to 1641 when the first iron retorts were installed. Retorts were first arranged in benches with a common grate fire for several pipes some 55 years later. It was not until 1850 that lime was added to the charge.

Furnaces were invented much later than retorts. The first furnace invented exclusively for quicksilver reduction was that invented by Lopez Saavedra Barba at Huancavelica in Peru. This was in 1633 and some 13 years later it was introduced at Almaden, Spain, by Bustamente, and became generally known

by his name. Ten such furnaces were built at Almaden between 1646 and 1654 and they are still being used. They are simple, intermittent, shaft furnaces the vapors from which pass through many strings of potbellied clay pipes, luted together with clay. These serve as condensers in which the quicksilver is condensed and caught.

Reverberatory furnaces and muffle furnaces have been tried at various times and places.

Continuous shaft furnaces, the next improvement, were invented at Idria, in 1872, from where they were quickly brought to New Almaden in California.

The Knox continuous furnace, invented in 1874, in California, treated both fine and coarse ore, and in 1875 the Scott continuous fine-ore furnace was invented at New Almaden. This latter furnace dominated American quicksilver production until 20 years ago. At that time, in 1916-1917, both the multiple hearth and the rotary furnace were adapted to quicksilver ores.

Ore treated in furnaces is reduced by the simple reaction of the quicksilver being volatilized while the liberated sulphur combines with oxygen from the excess air to form sulphur dioxide gas.

In an iron retort, where no air is present, the sulphur from the cinnabar (and pyrite or other gangue sulfides) combines with iron from the retort to form iron sulfide. For this reason, it is advisable to add lime to the charge in the retort so the calcium of the lime will combine with the sulphur to form calcium sulfide and calcium sulphate instead of letting the sulphur attack the retort itself.

Fig. 2 shows two vapor pressure curves. Reading up on the vertical scale are pressures in millimeters of mercury from zero to 760, this latter being atmospheric pressure. From left to right on the horizontal scale are temperatures in degrees Fahrenheit. These two curves are important in quicksilver metallurgy as they show what happens when quicksilver and its ore cinnabar are heated.

Take the curve for cinnabar: It shows that when heated up to about 570° F. practically nothing happens. From that tem-
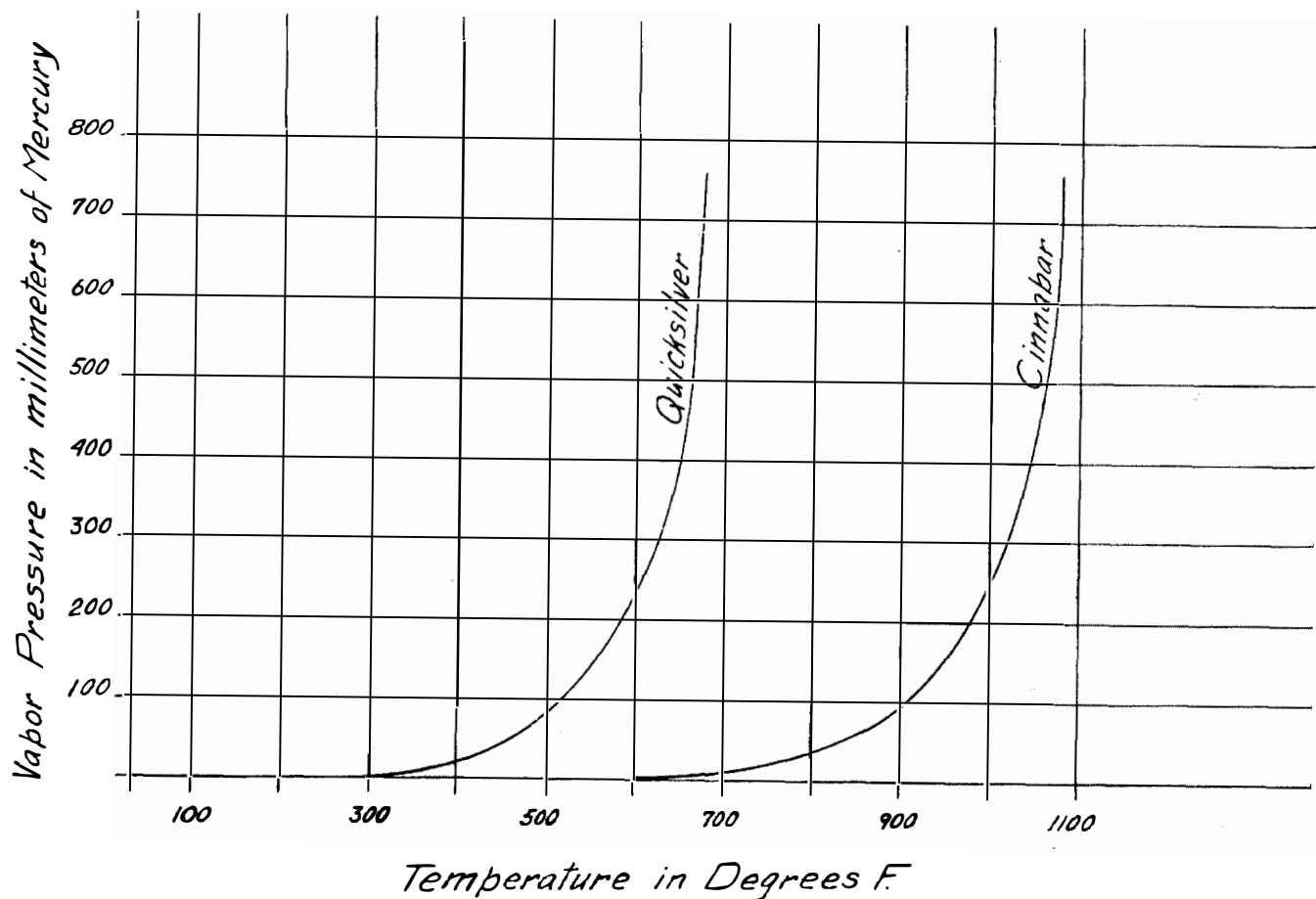
Figure 2--Vapor pressure curves of cinnabar and quicksilver.

perature on up the vapor pressure rises rapidly until it reaches the boiling point at 1076° F. Then, if ore is being dried in an open dryer or on top of a furnace, there is little danger of being poisoned by quicksilver fumes if it does not get hotter than 570° F. In a furnace or retort the ore should be heated to over 1076° F. as rapidly as possible in order to get the quicksilver out of the rock quickly.

The other curve, for metallic quicksilver, shows that vapors begin to come off of the metal as low as 212° F. and for this reason steam rather than fire should be used under the soot tables to prevent the table from getting so hot that enough metal is vaporized to endanger the sootman.

The above are the comparatively simple reactions and facts that govern the treatment of quicksilver ores.

Arsenic and antimony are sometimes found mixed with quicksilver ore. Both of these metals are also volatile like cinnabar. Arsenic ore, when heated in a furnace, is vaporized and condenses as arsenic trioxide, a gray powder.

The vapor pressure curve of arsenic trioxide, if drawn on Figure 2, would lie practically on top of that for quicksilver. Hence, the quicksilver and arsenic trioxide of a mixed ore will both condense together when treated in a furnace or a retort.

Antimony ore also volatilizes in a furnace and condenses as a mixture of several antimony oxides. These, however, have lower vapor pressures than quicksilver and hence will condense ahead of the quicksilver in the condensers so that at least a partial separation occurs between these oxides and the metallic quicksilver. Further separation can be accomplished by retorting as the oxides of antimony have a low vapor pressure at a temperature where quicksilver will boil and thus distil off the quicksilver rapidly before much of the antimony oxides are vaporized.

Sorting

Sorting should be practiced whenever the ore lends itself to this process. As usually practiced it consists of picking coarse pieces of waste out of the ore on the grizzly ahead of the crusher.

If one sorter at $4.50 per day can pick out 10 per cent waste at a plant treating 20 tons of 10-pound ore per day, he eliminates

two tons of waste, thus making room for the treatment of two additional tons of ore yielding 20 extra pounds of quicksilver each day. At a price of $1 per pound for quicksilver the dollar and cents gain from this operation is $20—$4.50=$15.50 per day or some $465 per month.

With ore of half the above grade, or 5 pounds per ton, the profit would be only about 1/3 as much. With ore twice as good, or 20 pounds per ton, it would be about 2½ times as great. Curiously enough, most operators are more inclined to try sorting when the ore is low-grade, and many a mine treating a good grade of ore overlooks this opportunity of adding substantially to its profits. The profit to be derived from sorting also increases with an increased price for quicksilver, and here again most operators only think of sorting when the price drops. It is the old story: When the price is high or the grade of the ore is high, the mine makes money and as long as it is making money why worry about such things as sorting a few tons more or less. Another expression for the same thing is poor management.

Crushing

The feed of rotary furnaces is often up to four inches in size. For Herreshoff furnaces the feed is generally not coarser than one inch in size. Since most quicksilver ores break fine on blasting and since the daily tonnage is not great, a small Dodge type crusher is usually all that is needed, though a few mines use one or two Blake type crushers.

Screening

Many quicksilver ores show a gradation in values when screened to different sizes. The coarsest screen size is lowest in grade and the finest screenings are highest in grade. At some mines advantage is taken of these screen characteristics to mine and screen old dumps and outcrop material. The coarse rock is discarded as waste and the fine material goes to the furnace for ore. Concentration ratios of 4–7 to 1 and recoveries of 60 to 80 per cent have been obtained with different ores. Grizzlies, trommels, and vibrating screens are used for this purpose.

Drying

The old practice of drying the ore in separate dryers before treatment has practically vanished with the Scott furnace.

The rotary furnace will treat wet ore (with additional fuel consumption, of course) so that with its use the dryer and furnace are combined in one apparatus.

The Herreshoff furnaces have a top drying hearth which eliminates a little moisture and, by rabbling, keeps the sticky, moist ore sufficiently broken up so it will feed into the furnace.

Sampling

The purpose of sampling and assaying mine and reduction plant products is to determine ore values and to guard against losses.

It is practically impossible to take accurate mine samples of high-grade quicksilver ore in the usual manner of mine sampling. The samples always run too high due to an excess of the brittle cinnabar getting into the sample. With a low-grade disseminated type of ore, more nearly accurate samples can be taken, but they are apt to run too high also. Newcomers in quicksilver mining generally refuse to believe these statements, and when production does not check their mine sampling they assign the difference to furnace losses, and then set out to invent an entirely new and revolutionary reduction process. So far no one has succeeded in doing this.

The reduction process for quicksilver ore is a simple roasting operation at low temperature. There are no intermediate products, such as table and flotation heads, middlings and tails, or pregnant and barren solutions, or mattes and bullion and slags of other metallurgical processes.

The feed enters the furnace and the burned rock comes out of it. The only other products from the furnace are gases which go through the condenser and then out through the stack, and such dust as is caught in the dust collector.

Stack Losses

Hence, in quicksilver plants losses can be checked rather closely. Samples of the hot rock as discharged from the furnace

are taken in iron scoops, quenched in water and then panned or assayed. These losses are practically zero in any well-run plant. If the furnace and condenser system are under draft, and they should be, then air might leak into them, but no gas will escape and no loss can occur there. The loss in the dust is determined by weighing and assaying it. This leaves only one additional chance for losses and that is through the stack. With an ample condensing system these losses should not be more than 2–3 per cent of the furnace input, and any well-designed and operated plant should recover at least 95 per cent of the furnace input.

Stack gases can be sampled and assayed rather accurately by a method first described in U. S. Bureau of Mines Technical Paper 96. The author[5] has determined the stack losses at some nine different plants treating ore from 5 to 25 pounds/ton in grade and in quantities from 34 to 130 tons per day.

The losses found ranged from less than $\frac{1}{2}$ per cent to over 26 per cent of the input and new condenser systems were designed for the plants showing large losses. These paid for themselves very quickly from the added recovery obtained.

The greatest danger of loss, and a loss that cannot be measured, is that which occurs when there is an outward leakage of hot gas from the furnace. This can occur around the top seal ring and upper hearth doors and feed hole of Herreshoff furnaces and around the feeder and dustchamber-kiln-connection on rotary furnaces. Escaping gas at these points is seldom visible and often goes unnoticed. The only sure way to prevent it is to have a small but definite in-draft at these points.

The above discussion shows why so many quicksilver plants are operated without having an assay office at all. Visual inspection or panning in the mine determines rather easily whether the rock is ore or waste. Loss in the rock discharged from the furnace is guarded against by the watchful eye of the furnace man. The stack loss, when known to be small, is no source of worry as it is not subject to more than nominal fluctuations even with the change from winter to summer temperatures and the usual variations of quicksilver and

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[5] C. N. Schuette: Limiting Factors in Quicksilver Metallurgy. E. & M. J., Vol. 132, 1931, pp. 398-400.
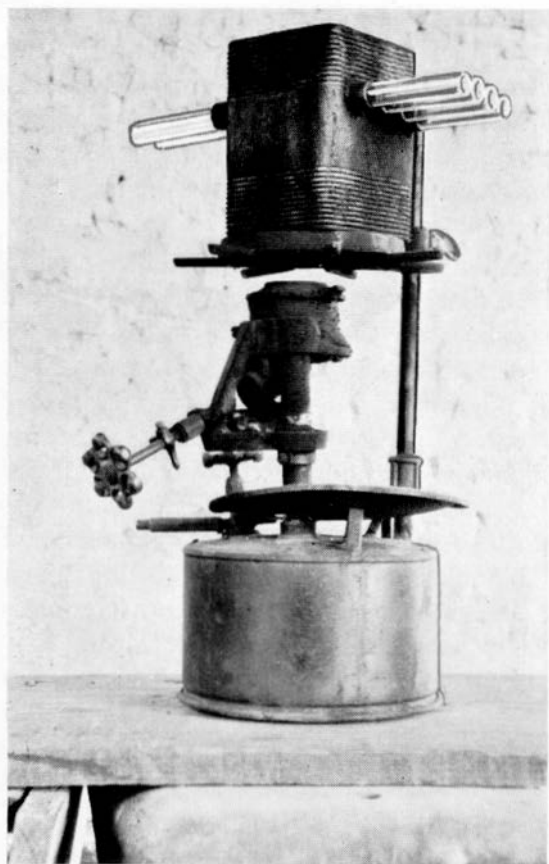
Photo No. 1—A simple homemade assay furnace that holds eight samples per batch.

moisture content of the ore. Hence, the furnace practically assays the mine ouput and the grade of the ore is generally reported as so many pounds per ton on recovery. This is simple and sensible and preferable to the expense of sampling and assaying and calculating mythical recoveries based on inaccurate samples. In some plants a grim satisfaction seems to be taken in reporting an 80 per cent recovery with its attendant cost of sampling and assaying, but nothing is ever done to improve the recovery nor is an effort made to see if 20 per cent of the input is really being lost through the stack. Actually the recovery is probably 95 per cent and the "missing" 15 per cent is due to inaccurate sampling. Stack loss usually advertises

itself by the relative amount of quicksilver recovered in the stack flue and stack. If the amount of quicksilver recovered there is not more than a few per cent of the total then the stack loss is at most a few per cent. If the amount of quicksilver recovered from the stack and stack flue is a large proportion of the total then the stack loss should be investigated to see how large it actually is.

One very ridiculous test is often used to "test the stack loss". This is to hold a piece of gold foil over the stack. Usually, a little moisture condenses on the gold foil and after a bit the foil is withdrawn, inspected, and then it is triumphantly announced that "no loss whatever" has been proven because the foil has not "amalgamated". This is ridiculous because the quicksilver that is uncondensed at the stack temperature must necessarily be lost and usually a roughly equal amount of "mist lost" accompanies it. Again, the author has seen such gold foil held over the stack by fingers or gloves that were filthy with soot and quicksilver and, lo! there was a stack loss. Actually, a dry gold foil, placed over a beaker containing dry quicksilver, will be discolored in time thus showing that the merest trace of mercury vapor will amalgamate but these conditions are so different from those obtaining in the stack gas that a so-called test of this kind means nothing as to the amount of the stack loss.

Assaying

Two methods of assaying quicksilver are in general use: the distillation-amalgamation method[6] and the distillation-titration method. Both are accurate, when properly carried out, and are usually of far greater accuracy than the sampling.

The Whitton apparatus is largely used for the distillation-amalgamation method. It is comparatively slow and a button balance is required to weigh the silver or gold foil before and after the process.

The distillation-titration method developed by the U. S. Bureau of Mines (U. S. Bureau of Mines Technical Paper 227) is more rapid and only an analytical balance is needed to weigh out the pulp sample.

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[6] C. W. Davis: Distillation—Amalgamation Methods for the Technical Determination of Mercury in Ores. U. S. Bureau of Mines—Information Circular 6202.

The samples are dried, then crushed, reduced by Jones riffle sampler, and ground to pass 80 mesh in the usual manner of preparing samples for assay.

In the distillation-titration method, a ½-gram sample of the ore is weighed out and put into a small test tube. A roughly equal volume of a 50-50 cupric oxide and lime mixture is mixed into the ore and then a sand cover is added. The closed end of the test tube is now heated and the quicksilver is driven off and condenses in a ring on the cool end of the test tube.

Photos 1, 2a and 2b show two types of assay furnaces used for this work. The first is a sheet-iron box with pipes through it and the second is an electric furnace invented by W. D. Burcham of Terlingua, Texas.

In five minutes or so, when the distillation is complete, the test tube, held horizontally, is withdrawn and broken at a point between the charge and the condensed ring of quicksilver by touching the hot tube with a wet rag fastened to a stick. The lower end is dropped into the slop bucket and the other end is placed, broken end down, in a small beaker. A little hot nitric acid is now used to dissolve and wash the condensed quicksilver from the test tube end into the beaker. Then the test tube end is further washed into the beaker with a little distilled water before it is thrown away.

The distilled quicksilver is now in solution in the beaker. Potassium permanganate solution is now added drop by drop to the beaker with stirring until the solution remains colored. This oxidizes all the mercury to the mercuric state. Then hydrogen peroxide (use C. P. and not the drug store variety that contains acetanilid) is added drop by drop until the solution is clear again. This destroys the excess of potassium permanganate. Then the indicator is added for the titration. Usually about 2 c. c. of a 10 per cent solution of ferric sulphate or nitrate is used. The indicator solution must be absolutely free from chloride or other halides.

If the indicator is prepared from anhydrous ferric sulphate it must be heated long enough to get a clear solution. When titrating, the solution should be cool and not over 30 to 35 c. c. in volume.
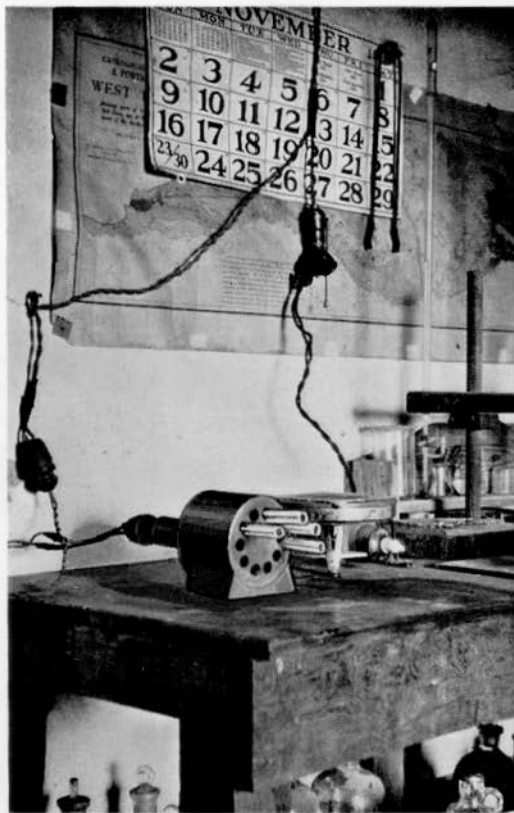
Photo No. 2a—An electrically heated assay furnace in which ten samples can be distilled at once. First made by Burcham in Texas.
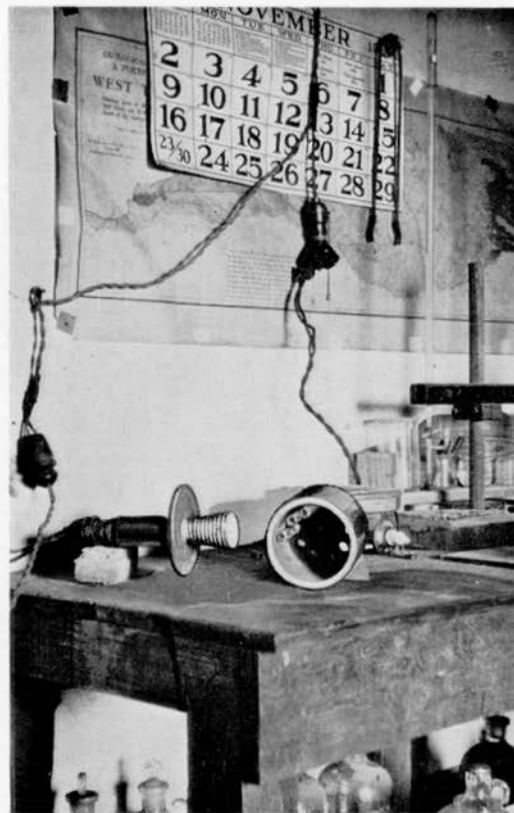
Photo No. 2b—Open view of the furnace showing heating element and asbestos lining in the can from which it was made.

The titrating burette should be placed in a good light and a white paper under the beaker will help greatly in seeing the end point. A 1/400 normal solution of potassium thiocyanate is convenient for low-grade ores. The solution in the beaker should be stirred as the titrating solution slowly runs into it from the burette. As the end point is approached, the titrating solution should be added drop by drop until a permanent color change is obtained, that is, one that does not fade on stirring. The end point is marked by a faint but distinct salmon to pink color. One drop is sufficient to make the change.

Upon longer standing, the color fades again, but this has nothing to do with the end point. The first permanent color change marks the end point. With 1/400 normal solution, each c. c. from the burette is equivalent to one pound quicksilver per ton of ore.

The method can easily be checked by dissolving and titrating small weighed quantities of quicksilver. The titrating solution should be checked occasionally in the same way but it has been found that it changes very little over long periods of time.

The chemical formula for potassium thiocyanate is $KSCN$. The molecular weight is 97.17.

TYPES OF FURNACES

Shaft Furnace

Coarse lump-ore can be treated in straight shaft furnaces. The fuel, about 2½ per cent of the ore by weight, usually coke or charcoal, is mixed with the charged ore. Oil-fired, coarse-ore furnaces use about 3 per cent of fuel by weight. Such furnaces are economical to build and operate. They will not treat fine ore (less than 2½ inches in size) and hence are but little used in this country, as all mines make fine ore and it is cheaper to crush coarse ore to fine ore for treatment in fine-ore furnaces than it is to make adobes of the fines for treatment in coarse-ore furnaces. Photo No. 3 shows a type of coarse-ore furnace formerly used in the United States.

Up to 20 years ago the Scott furnace was most used in this country for treating fine ore. Photo No. 4 shows a Scott fur-
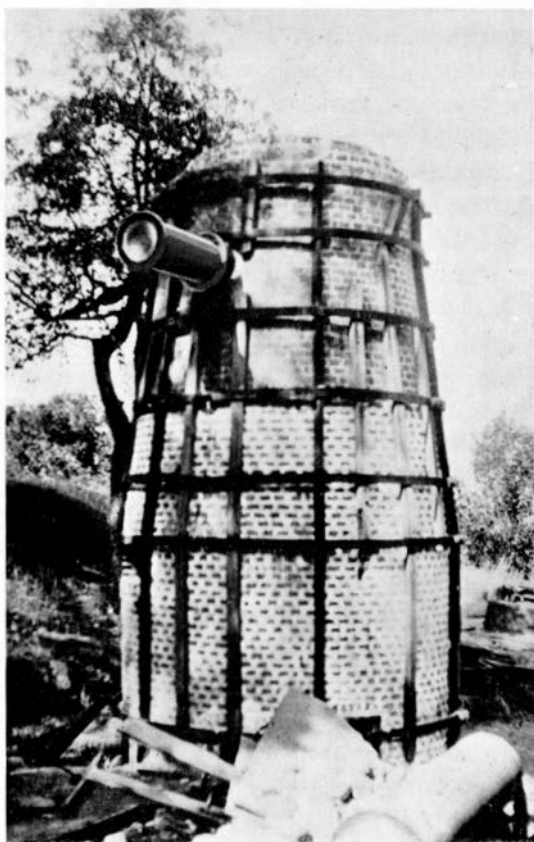
Photo No. 3—A "Neate" Coarse-ore furnace.
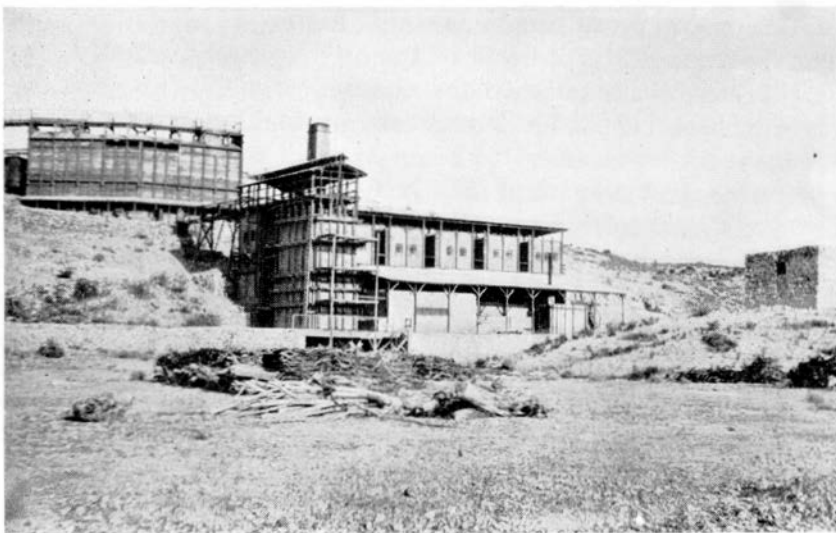
Photo No. 4—A Scott Furnace Plant with brick condensers.

nace plant. This was a shaft furnace modified for the treatment of fine ores by means of inclined tile shelves over which the ore descended in a zigzag column while the heating gases ascended through the furnace under these shelves.

This furnace, of which a number are still standing and a few are still operating in this country, is a most excellent furnace for its purpose. The cost of treatment in these furnaces was commonly 50 cents to 75 cents per ton as against costs of over $1 per ton with modern mechanical furnaces. Its disadvantage was that wet and sticky ores had to be dried before being charged. It was a big, cumbersome thing to build, brick had to be burned in field kilns for its construction and it took weeks to heat it up and cool it down. Its advantages were that it had the high-fuel efficiency (45 per cent) of the shaft furnace as against the low-fuel efficiency (25 per cent) of rotary kilns; it needed no power for its operation and only one man per shift was needed to run it, where its size was less than about 40 tons per day. Any thing that would burn could be used as fuel in a Scott furnace and when the cost of one fuel went up a cheaper one could be used. Many a Scott furnace was torn down and replaced by a mechanical furnace to no advantage except, perhaps, to the vendor of the mechanical furnace.

But there are fashions in mining and milling machinery just as in other things and many can remember that stamp mills were scrapped for an all-sliming process that worked little or no better and just recently the almost forgotten jig is being refurbished and is becoming the height of fashion again.

Mechanical Furnaces

These are of two types, rotary kilns and multiple-hearth furnaces.

ROTARY KILNS

These have been made in capacities ranging from 8 to 120 tons per day. They are two-tire kilns with one exception. Many sizes, shapes, and varieties have been made from the small, simple, unlined castings revolving on cast-on flanges to the standard kilns. Oil, butane, and natural gas are the

fuels used in them. Wood has been tried but not very success-
fully so far. The kilns are lined with kiln blocks, arch brick,
or with monolithic concrete linings of various compositions.
Some of them use insulating brick, or asbestos sponge, behind
the lining, to conserve heat and some have been painted on
the outside with aluminum paint for the same purpose.

The kilns used in quicksilver reduction are small compared
with those used in cement manufacture and other industrial
processes. The length is limited by fuel-consumption and tem-
perature-of-exit-gas requirements.

The lower, or firing end of the kiln (one kiln uses parallel
instead of counter-current firing) ends in a stationary firebox
(two have a movable firebox). This firebox is usually set
over a pit of some kind into which the hot rock drops. These
pits allow the rock to "soak" a while before being drawn and
conveyed to the dump and thus have an additional safeguard
against loss in the burned rock. From these pits the rock is
hauled to the dump in cars, by aerial tram, by dragline scrapers,
or other suitable devices.

The upper end of the kiln heads into a "dust chamber",
of late years reduced to a mere connecting flue between the
kiln and the dust collector. The kiln feeder projects through
this dust chamber into the kiln. Several types of feeders are
used. Shaking-pipe feeders are the most common and rotating-
pipe feeders and worm feeders are used. The openings through
which the feed pipe enters the dust chamber and the opening
through which the kiln enters the dust chamber must be kept
airtight by seal rings of which a number have been developed.

Rotary kilns are set on a slope of $\frac{1}{2}$ to $1\frac{1}{2}$ inches per foot
and revolve about 1 R. P. M. They must be shut down pe-
riodically for relining and require about 5 H. P. for their
operation.

HERRESHOFF FURNACES

As applied to the roasting of quicksilver ores these furnaces
have been used in 4-, 5-, and 6-hearth sizes and in diameters
from 10 to 16 feet. In the larger sizes they have shown the
fuel economy of the typical shaft furnace. The small, 4-hearth,
10-foot-diameter furnace has a burner on the bottom, or dis-

charge hearth, and discharges the rock at red heat just like a small rotary furnace and hence shows about the same fuel economy as a rotary kiln.

A Herreshoff plant is more cumbersome to erect than a rotary kiln plant but has the advantage that it does not have to be stopped for relining. There is no wear on the hearths— only on the rabble teeth and these are quickly and easily replaced without shutting down. It is easier to heat insulate a Herreshoff furnace than a rotary kiln and this heat insulation does not need to be replaced. Power requirements are about the same as for a kiln.

Dust in the Furnace Gases

Both the rotary kiln and the Herreshoff furnace, by their mechanical action, cause dust to be carried into the gas stream leaving them.

This dust is a highly undesirable product in the condensers. The first two rotary kilns placed in operation in this country were at the New Idria and Cloverdale Mines. It so happens that the ores of these two mines make but little dust in the kilns,—say, about one-half per cent of the kiln input. This was fortunate as the success of the rotary kiln was probably due to this fact. The small amount of dust, made in these plants, could be handled by the "dust chambers" and water sprays used for collecting it. The utility of the rotary kiln was proven before it was tried on a dusty ore (2 per cent of the kiln input) where the condenser pipes were clogged in short order.

Since it was known that the rotary kiln would work, the problem of handling the dust was recognized as a thing apart from the merit of the furnace itself and consequently various devices were tried to overcome it. One of these devices was the Cottrell precipitator which had already been used at New Almaden on the first Herreshoff furnace used upon quicksilver ore.

Next, cyclone dust collectors were placed between the furnace and condensers. The first of these was installed at the Knoxville Mine by George Gamble and was so successful that it found wide adoption.

LABORATORY REPORT FOR

SCREEN ANALYSIS		
SIEVE NO.	OPENING INCHES	% PASSED
325	.0017	28.45
200	.0029	.54.7
150	.0041	69.7
100	.0058	81.8
60	.0087	93.9
40	.0150	98.5
20	.0340	

Lake Co., Cal.

MATERIAL_____

TYPE__*8D-7½*_____COLLECTOR

TESTED___*Exhausting*_____

CONCENTRATION__*3*___GRAINS PER CU. FT.

DATE _*2-26-30*_ BY _*W.T.B.*_

WT.- 67 #/Cu.FT.
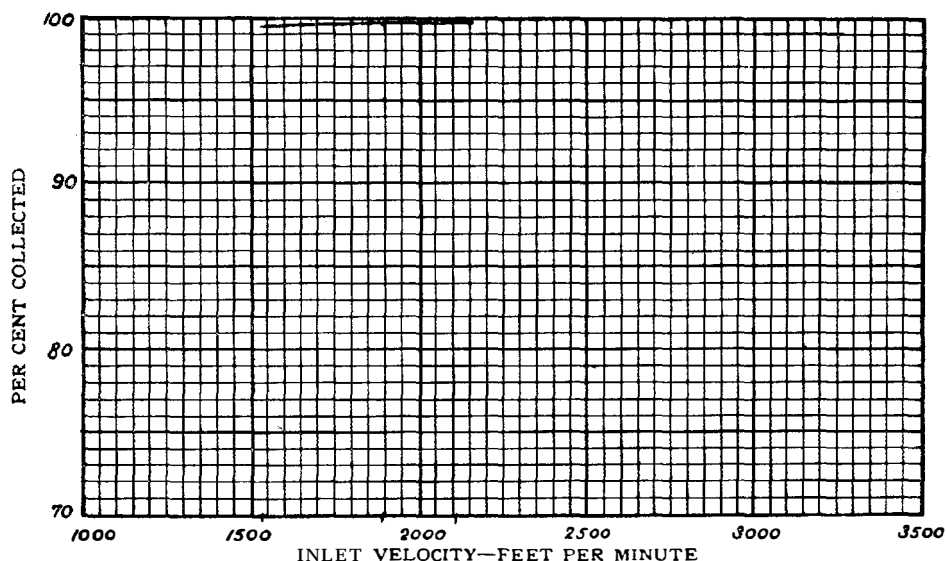
THE DATA GIVEN ABOVE SHOULD NOT BE USED FOR ANY MATERIAL OTHER THAN SAMPLE IN QUESTION AS SUBMITTED. IT MERELY INDICATES THE POSSIBILITIES OF AN ACTUAL INSTALLATION HANDLING THIS MATERIAL.

AMERICAN BLOWER CORPORATION
Collector Department

Figure 3—Sirocco Dust Collector; report of a test.

Western Precipitation Company next developed the multi-cone dust collector at the Sulphur Bank Mine and it was used as well as their Cottrell precipitator on a number of mechanical furnace plants.

The next forward step in dust collection was born of adversity at the Red Elephant Mine. Here a crude, little kiln made from a boiler shell was discharging gas and dust into a condenser system and the entire output of quicksilver had to be panned from the resulting mud. Something had to be done and there was but little money with which to do it. About that time the author[7] investigated the "Sirocco Dust Collector" and recommended that it be tried because it sounded promising and was by far the least expensive dust collector on the market.

Preliminary tests indicated that a high recovery of dust would be made as shown on the data sheet, reproduced as Fig. 3, so the collector was ordered and installed.

The plant was started on May 1, 1930, and to everyone's delight the dust collector not only worked but worked better than anything hitherto used for the purpose; and from that experiment its use spread until it has practically replaced the other types of dust collectors in the quicksilver industry.

These Sirocco Dust Collectors use alternate cones and cylinders of diminishing diameters to obtain a progressively increasing vortex to force the dust out and down to the discharge while the cleaned gas rises in the center of the vortex to the outlet above. It operates at some 3 to 4 inches of water gage. The small one at the Red Elephant Mine had a 6 inch by 6 inch inlet and outlet and the largest one in quicksilver practice is one of 20 inch by 20 inch inlet and outlet installed in November, 1934, at the Sulphur Bank Mine.

Quicksilver Condensers

A condenser has two functions. It must rapidly cool the gases so that the quicksilver vapor will condense to liquid and it must collect the condensed metal by separating it from the gas stream.

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[7] C. N. Schuette: Recent design of Quicksilver Plants. Eng. and Min. Jour., Vol. 131, 1931, pp. 316-318.
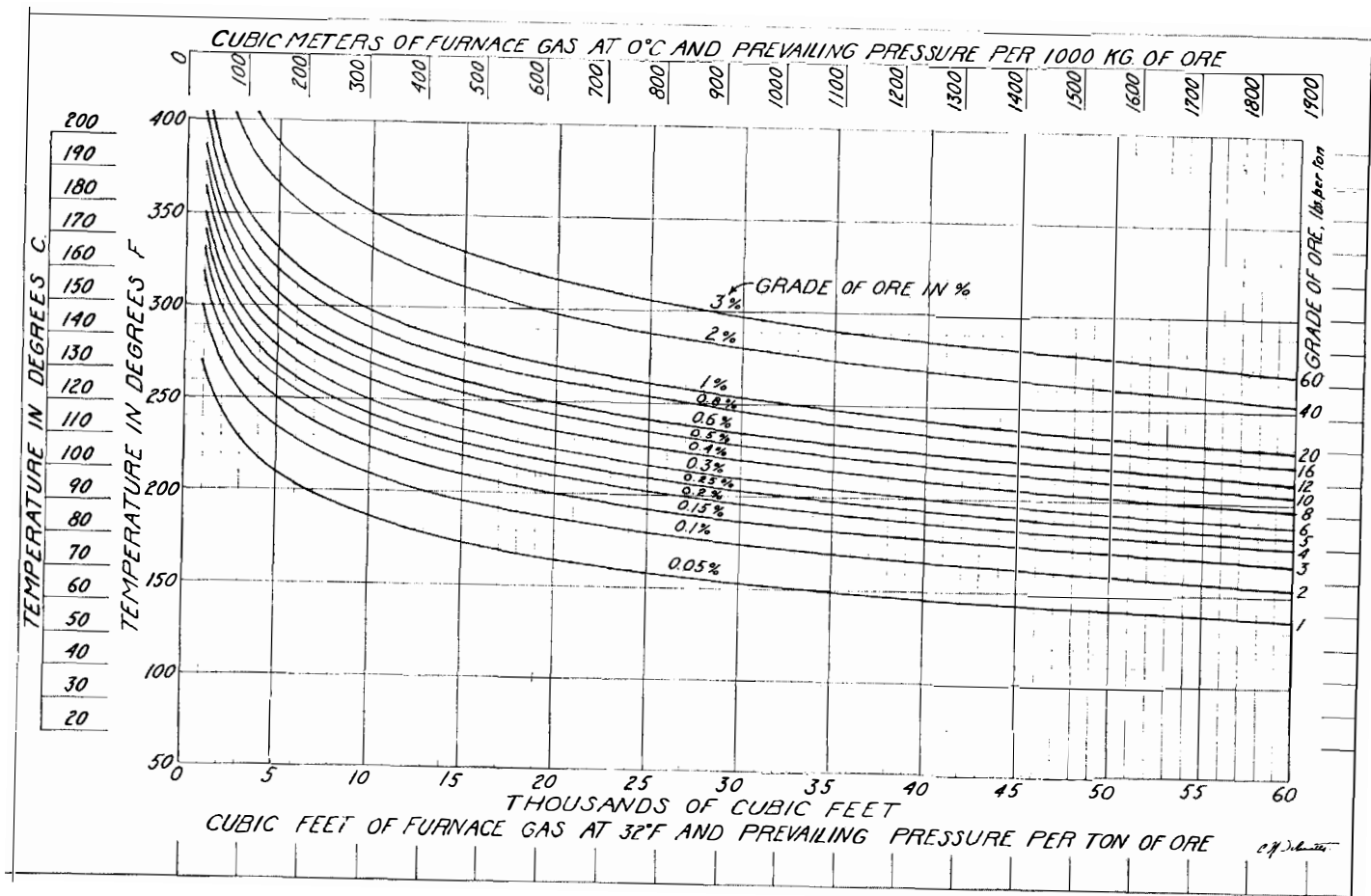
Figure 4—Temperatures at which quicksilver ore will condense for various grades of ore and various gas volumes.

The Coarse-Ore and Scott furnaces made little or no dust and dust made by mechanical furnaces can be eliminated as told above. Hence the condensing problem for all types of furnaces is the same.

The volume and composition of the gas leaving the furnace with various ores differ quite a bit. So do the temperatures. The amount of gas leaving the furnace per ton of ore treated is almost constant for any given ore and fuel. Hence the amount of gas per ton of ore is a convenient unit by which to compare the treatment of different ores. Gas volumes (re-calculated at 32° F. for comparison) actually measured by the author at various plants varied from 22,200 to 80,000 cu. ft. per ton of ore treated. When the unit gas volume is extra large it is usually due to water vapor (from wet ore) or from carbon dioxide (from limestone in the ore). The usual constituents of the furnace gases are: quicksilver vapor, sulphur dioxide, carbon dioxide, water vapor, nitrogen, and oxygen. Of these the nitrogen, an inert gas that performs no useful part in the process, is by far the largest unit.

Few people realize the weights of gas that are involved. The quicksilver is actually taken from one ton of ore and transferred to anywhere from ½ to 1½ tons of gas from which the condenser must separate it. The quicksilver vapor is seldom more than 1/10 per cent of the gas volume or more than ¼ to ½ per cent of the gas by weight.

The less the concentration of quicksilver vapor in the gases, the lower the temperature at which the quicksilver will con-dense. This can be seen by a study of the chart in Fig. 4, which gives the temperature at which quicksilver will condense for various grades of ore and various gas volumes. For ex-ample, if 3 per cent ore is treated in a furnace generating only 10,000 cu. ft. of gas per ton then the quicksilver in the gases will condense when the gas temperature drops to 350° F., and, if a 1 lb. per ton ore were treated with a gas volume of 50,000 cu. ft. of gas per ton, no quicksilver would condense until the temperature had dropped to 140° F.

Thus it is plain that plants treating low-grade ore need larger condensers than plants treating high-grade ore. This also explains why the old Scott furnace plants got along nicely

with thick-walled brick chambers for condensers. They were good condensers for 5 to 10 per cent ore.

Iron and tile pipe are now used for condensers. Iron pipe is good up to the point where moisture condenses. Beyond this point it corrodes rapidly and must be replaced frequently depending upon the amount of acid condensed. The amount of acid depends largely on the sulphur content of the ore and is usually due more to pyrite than to cinnabar in the ore.

When there is limestone or calcite in the ore and large volumes of CO_2 are formed (up to 20 per cent of the gas volume), a thick scale of iron carbonates often forms on the inner surface of iron pipe which greatly reduces the cooling effectiveness of the pipe.

Tile pipe sometimes cracks when not carefully set up but it does not corrode and remains as clean as when erected even after years of use and after several replacements of the iron pipe usually installed ahead of it in the condenser system.

The cooling of a gas stream moving through a pipe increases rapidly with increased velocity. Hence, it is better to use small-diameter pipe and thus get higher gas velocities. Small-diameter tile pipe is also stronger mechanically and resists thermal shock better than large diameter pipe. Tile pipe also costs less per square foot of cooling area in the smaller 8-, 10-, 12-inch sizes than in the larger sizes (24 inches and 36 inches).

Tile pipe is more troublesome to erect than iron pipe but it outlasts many sets of iron pipe and hence is worth the extra trouble. Lately, a high melting point tar (Sonamel made by Standard Oil of California) has been used to seal the tile pipe joints and this has prevented the pipe from developing cracks.

Outside water sprays or drips are used on condenser pipe to aid the cooling and are fairly effective, the more so when the wind is blowing.

A condenser should cool the furnace gases to within 20° to 40° F. of atmospheric temperature. Pipes accomplish such cooling very readily while a simple test with a thermometer will speedily convince anyone who cares to make the test

that large wooden tanks and chambers do practically no cooling whatever.

So much for the cooling of the gases. The collecting of the condensed quicksilver can also be accomplished in small diameter pipes—at high velocity—if the direction of the gas stream is often changed so that the heavy, condensed quicksilver fume is thrown against the wall and is thus caught. Baffling in this manner by sharply reversing the direction of the gas stream in the up and down pipes is the most effective way of recovering the quicksilver. Large open "settling chambers" have proven to be very ineffective. At several mines cyclones have been tried as collectors, but always at the end of the condenser system where so little quicksilver was left in the gases that the experiments proved nothing about their collecting efficiency.

Draft: Every fuel-fired furnace must have draft. In most furnaces it can be either natural draft or mechanically induced draft. But in quicksilver plants it must be induced draft because the gases are cooled in the condenser to a point where they are no longer hot enough to provide sufficient natural draft for the operation.

Draft then in a quicksilver plant is provided by fans usually of the straight-blade pressure type as the resistance of the condenser system must be overcome and the use of Sirocco Dust Collectors necessitates some 3 inch to 4 inch of water gage.

Since the condenser system should always be under draft the fan should be at the stack end of it. For this reason acid-proof fans are needed. Such fans built of wood are available and also rubber-covered fans are now on the market that serve the same purpose.

Many plants still have their condensers under pressure and blow through the condensers by having fans work in the hot gases at the dust collector. This is not the most desirable practice. Two fans, one blowing into and one exhausting from the condenser, are used at one Texas mine and are said to give a practically balanced draft in the condenser system.

Draft is a very much neglected subject in many plants. There should be enough draft to assure against outward leakage

Photo No. 5—A typical "Bottling Room" showing empty flasks in back, full ones at the side and pot. scales. weighing bucket and a flask in the clamp with wrench in place to tighten the stopper.

of hot gas from the furnace and feeder. It should always be remembered that the gas volume to be handled is practically a fixed quantity per ton of the particular ore that is being treated. Hence, if the tonnage put through is increased the speed of the fan must also be increased to handle the extra gas volume. If this is not done losses as great as 25 per cent of the input may occur[8].

The development of the pipe condenser has changed the clean-up methods in quicksilver plants. Twenty years ago monthly clean-ups were usual. Today the condensers are washed down daily and the quicksilver is bottled and ready for shipment immediately after production. This quick recovery is especially advantageous to small producers and has the further advantage of keeping the operator informed on the grade of the ore being treated. He knows what his last 24 hours run of ore has produced even before he gets the assay returns if he samples and assays at all.

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[8] C. N. Schuette: Limiting Factors in Quicksilver Metallurgy. Eng. and Min. Jour.. Vol. 132. 1931, page 400.

Since the introduction of the Sirocco Dust Collector very little dust comes over into the condensers and the product washed down each morning is practically all floured quicksilver. This is placed on a small sheet or cast-iron soot pan and hoed, either with a little lime, or it can be dried by heating the pan with steam or waste heat. The cleaned quicksilver is then bottled in iron flasks, each holding 76 lbs. net. Only black iron, enamel ware, and stoneware utensils, such as pans, or wooden buckets should be used in handling quicksilver. No galvanized sheet iron, galvanized pipe, tin cans, or brass sprays or nozzles should be allowed anywhere around the condenser room. Any quicksilver coming in contact with these will be contaminated by the zinc, tin, copper, or lead. The quicksilver as bottled must be pure and the best way to have it so is to prevent contamination. Bottles, a bottling room, and bottling methods are shown in Photos 5, 6 and 7.

Flasks should be hammered to remove scale and should be clean and dry before the quicksilver is poured into them. Operators, who are proud of the good quality of their product, mark their bottles by painting the tops of them with a distinctive color or color design, so that their quicksilver can be readily identified.

Photo No. 6—Filling the flask. Note the double soot pans in the background. Steam enters the lower pan to heat the upper one.

Retorts

Retorts of all shapes and sizes are still being used in the quicksilver industry. Some are used as adjuncts to furnace treatment though this use has greatly diminished since the Sirocco Dust Collector has eliminated the large quantities of dust that were formerly carried on into the condenser system. In modern practice, usually only a few buckets of soot remain on the soot pan after the daily cleanup, and this is put back into the furnace instead of being retorted.

At prospects the retort is still being used as a reduction plant. Where the ore can be sorted to a 20 lb. per ton (1 per cent) product or better, the operator can make money with a retort operation. Since the firing is indirect, more fuel per ton is needed than in a furnace; and the small tonnage makes the labor cost per ton much higher than in furnace plants. Still, one or two men can cut their own fuel, tend their retort, mine their ore and make a nice profit on sorted high-grade ore with only a small capital expenditure for plant. It cannot be said that such an operation is uneconomical under the circumstances, and especially so, when it is considered that low-grade ore for a future furnace operation is generally being developed as the work goes on.

Retorts are generally round or D-shaped castings. Round pipes are generally about 1 foot in inside diameter and 6 to 7 feet long while D-retorts are 15 inches by 24 inches and 10 or 12 feet long. D-retorts are used singly or in sets of 2 and 3 with a common fire box. Pipe retorts are set up in benches of from 2 to 12 pipes.

Typical installations of D- and pipe retorts are shown in Fig. 5 and Fig. 6.

Two things are important in setting up retorts. First, the bottom of the retort pipe must be protected from direct contact with the flames by one thickness of firebrick or tile. If this is not done the pipes burn out rapidly. Second, the condenser pipe which is fitted to the retort with Smooth-On or a similar cement must not be bricked in tight where it passes through the outer wall of the retort setting. The retort expands on being heated and if the condenser pipe is bricked in solidly the

Photo No. 7—Different sizes and shapes of flasks that are in common use. A filled flasks holds 76 pounds net, of quicksilver

joint between them breaks and the quicksilver vapors leak out. Retorts should always be tested for tightness before being used by attaching a manometer to the plugged end of the condenser pipe or by covering this end with thin (toy balloon) rubber and then heating the closed retort to see if pressure is developed from the expanding air in it. If no pressure develops the retort leaks, and the leak must be found and repaired before being used.

Lime should be used with the ore charged to the retort to prevent the iron of the retort from being attacked by the sulfur vapor.

Since the charging and discharging of a retort is accompanied by some danger of the operator being poisoned by hot quicksilver vapors, the retort should be set up in such a position that the prevailing wind blows quarteringly across the front of it. Also, the ore should be charged in black iron pans so that charging and discharging can be done rapidly. An extra cover should be at hand already mudded and ready to be slapped on when the retort is opened for discharging and charging again. Pans and hooks for handling them are shown

in Fig. 6. A table, topped with sheet iron, either hinged or on rollers, should be placed in front of the retort to help speed up the operation. On one side of this are three charged pans. The cover is removed and the three hot pans in the retort are quickly drawn out and moved aside. The three new charges are quicly shoved in and extra mudded cover is slapped in place. A few minutes only are needed for the entire operation. Retort pipes have double covers to prevent quicksilver from condensing on the outside cover and dropping out on the floor when the cover is removed. Since some quicksilver generally condenses here anyway, the inner cover can be left off. The retort pipe should be inclined toward the cover a bit. Then a hole is drilled through the cover to land flush with the inside of the retort pipe. This is threaded and three small street L's are put on as shown in Fig 6, to form a gooseneck. A pail containing water is hung under it. The quicksilver that now condenses on the cover runs out through the gooseneck and into the pail. The gooseneck is cleaned occasionally by blowing through it with a bicycle pump. With this scheme most of the quicksilver from the charge is collected at the front end of the retort instead of in the condenser pipe.

In late years rotary retorts have come into more general use. The first one of these was used by W. D. Burcham at the Big Bend Mine in Texas in 1929 and is described in U. S. Bureau of Mines Bulletin 335[9].

These rotary retorts shorten the roasting period and are therefore more economical in fuel consumption. They make dust however and this gives more or less trouble in operation, depending on the ore.

Inclined retort pipes are also used and some very large capacity retorts of this type have been in operation. The lower end of the retort is the hot end and ore is charged on top and discharged on the bottom. Usually half a charge is drawn at one time so that continuous operation is approached. In this type of retort it is easy to admit air to the charge from the lower end instead of using lime but the charging is attended with the escape of considerable fumes and attendant danger to the operator.

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[9] C. N. Schuette: Quicksilver. U. S. Bureau of Mines, Bulletin 335, p.103.

It would be practically impossible to describe all the different styles, shapes, and sizes of quicksilver retorts for new ones are being invented continuously. There are rotary, stationary, inclined, portable, tilting, and rocking retorts; pipe, D, square, oval and pot retorts; there are batch and continuous internal and external worm retorts. In fact, if a man walks up to the foreman of any foundry, say, in the San Francisco Bay region and states: "I want to see that quicksilver retort" he will immediately be shown one or more piles of castings left there by inventors unable to pay for the castings of their latest quicksilver retort.

Other Methods of Beneficiating Quicksilver Ores

Concentration by panning has long been practiced in quicksilver metallurgy and it is safe to say that every type of vanner and table and jig has also been used or at least tried for the concentration of cinnabar.

Several concentrating mills treating 200 to 300 tons per day have been built and operated at quicksilver plants. Flotation has been tried and used from about 1916 on.

Tabling in general gives poor recoveries, while either tabling followed by flotation or straight flotation gives very good results. But the combined cost of fine grinding, tabling, and floating or just floating alone with subsequent treatment of the concentrate in furnaces or retorts, costs more than would the direct treatment of the ore in furnaces. Hence, unless very special conditions obtained which would reverse this cost ratio, there is at present no field for concentration of quicksilver ores except the rough concentration by screening as described above.

LEACHING METHODS

These have been proposed and tried in an experimental way on many occasions. There is no great difficulty in leaching cinnabar ore with sodium sulphide and precipitating the quicksilver on aluminum. It can also be precipitated by hydrogen sulfide or electrolytically by using cast iron anodes and steel cathodes. Attractive regenerating features have been invented for some of these processes, but here again the extraction would be lower and the cost higher than with direct furnace treatment.

QUICKSILVER POISONING

Cases of quicksilver poisoning have become very rare in recent years. Among the miners, poisoning is practically unknown, and in furnace plants it is very rare. Retort operators sometimes have mild cases if they are not careful when charging and discharging the retort. This change for the better in health conditions is due to better ventilation in the mines, to better designed plants, to the training of the crews to observe meticulously personal cleanliness, and to be careful not to roll cigarettes or stuff pipes with fingers that are dirty with ore, soot, or metallic quicksilver.

Astringent mouth washes are provided at most plants as are wash and change rooms so that the crew can clean up before meals and after work. Periodic medical examinations are also provided for at many mines.

ECONOMICS OF QUICKSILVER

The economic status of quicksilver is different from that of many other metals for these main reasons:

1. It is a rare metal.
2. Production is limited to a few countries only.
3. All large industrial nations have need of it.
4. It is an important "war mineral".
5. The ultimate consumer buys it in exceedingly small parcels.

Only about 2,000 to 3,500 tons of quicksilver are produced per year in the entire world. Since it is worth roughly $1 per pound it is worth more than all other common metals, being exceeded in value only by gold and silver.

The world's production comes mainly from Spain, Italy, and the United States, but smaller amounts come also from Mexico, China, and Russia.

The main consumers of quicksilver are the large industrial nations, the United States, United Kingdom, France, Germany, and Japan. Of these only the United States produces appreciable amounts within its own borders and the others are dependent upon imports to supply them with this liquid metal which is so essential to their industrial life.

No modern war can be waged without quicksilver, which has three main war uses: Mercuric fulminate for detonating ex-

plosives, calomel for the troops in the field, and corrosive subli-
mate for camp and hospital sanitation. There are possible sub-
stitutes for all of these, but in war time the best and most
reliable, and most practical items only are demanded and are
represented by these mercurial compounds. Increased consump-
tion of quicksilver for industrial uses in war time, while not
for a direct war use, is no less necessary to the successful carry-
ing on of war.

The ultimate consumer of quicksilver is legion and hence
the price of quicksilver has little influence on its demand. About
100 different mercurial drugs are used and most of these con-
tain only very small amounts of quicksilver. The amount is so
small that the price of a prescription containing them need not
increase one cent when the price of quicksilver doubles. The
small amount the dentist uses for filling a tooth with amalgam
or the small amount a hunter uses in firing his shells are so
small that a great change in the price of quicksilver hardly
affects its cost to the consumer.

Hence it is a fact that more quicksilver is sold at high prices
than at low prices. Table No. 1 below illustrates this fact better
than words, but note that in the United States 54.5 per cent
more quicksilver was bought in the second four years at an
average price that was 73 per cent higher than in the first four-
year period.

TABLE No. 1

CONSUMPTION OF QUICKSILVER IN FLASKS

Year	Average Price	United States	Germany	United Kingdom	Japan	France
1921	U. S.	16,547	10,800	4,900	5,360	946
1922	$60.17	23,004	15,700	2,770	5,620	2,290
1923	London	25,692	13,000	18,100	10,580	4,740
1924	$48.51	23,047	14,420	10,700	7,450	4,980
Average, 4 years		22,072	13,480	9,120	7,250	3,240
1925	U. S.	29,825	22,950	15,100	8,700	4,980
1926	$104.17	33,500	23,500	13,400	9,620	6,240
1927	London	30,900	21,250	16,800	7,930	6,670
1928	$88.89	32,300	39,100	27,400	12,600	5,840
Average, 4 years		34,131	26,700	18,175	9,710	5,932

Hence in contrast to many other metals a drop in the price
of quicksilver does not stimulate consumption. The amount of
quicksilver consumed depends on industrial conditions and not
on the price of the metal.

YEAR	U. S. PROD. IN FLASKS	U.S. PROD. IN % OF WORLD PROD.	WORLD PROD. IN FLASKS	WORLD PROD. LESS U.S. PROD. FLASKS	U.S. N.Y. PRICE $	LONDON PRICE IN L-S-D	AVE. ANN. RATE OF EXCHANGE	EQUIV. PRICE $	IF EXCHANGE AT PAR	DIFF. N.Y. OVER LONDON PRICE $	TARIFF IN $ FLASK	IMPORTS IN FLASKS	EXPORTS IN FLASKS	STOCKS AT END YR. FL.	AVAIL. FOR USE FLASKS
1907	21,554	22.%	95,982	74,428	41.50	7 - 0 - 6	487	34.21		7.29	5.25	221	5,132		16,643
1908	19,752	20.2	97,612	77,860	44.84	8 - 4 - 8	487	40.10		4.74	5.25	202	2,996		16,958
1909	21,075	19.5	108,676	87,601	46.30	8 -12 - 0	487	41.88		4.42	5.25	213	6,802		14,486
1910	20,601	19.0	108,480	87,879	47.06	8 -16 - 0	487	42.85		4.21	5.25	9	1,923		18,687
1911	21,256	17.5	122,029	100,773	46.54	8 - 4 -11	487	40.16		6.38	5.25	6,292	291		27,257
1912	25,064	20.5	122,179	97,115	42.46	8 - 2 -10	437	39.65		2.81	5.25	1,103	310		25,857
1913	20,213	17.0	119,031	98,818	39.54	7 - 9 - 2	487	36.32		3.22	(5.25) (3.63)	2,289	1,140		21,362
1914	16,548	15.0	110,049	93,501	48.31	7 -15 - 0	491	38.05		10.26	3.80	6,198	1,446		20,300
1915	21,033	18.4	114,376	93,343	87.01	14 -10 - 8	475	69.05		17.98	6.90	5,625	3,372		23,286
1916	29,932	29.1	102,898	72,966	125.49	17 - 2 -10	475	81.59		43.90	8.16	5,659	8,880		26,711
1917	36,159	31.0	116,621	80,462	106.30	22 - 4 - 3	475	105.51		.79	10.55	5,207	10,778		30,588
1918	32,683	32.7	100,579	67,696	123.47	NOMINAL	475	-- --				6,719	3,098		36,504
1919	21,415	23.5	91,139	69,724	92.15	20 - 9 - 5½	443	90.69	99.70	1.46	9.07	10,635	9,107		22,943
1920	13,392	15.6	85,596	72,204	81.12	20 -14 - 9	366	75.90	100.99	5.22	7.59	14,169	5,553		26,008
1921	6,339	10.1	62,742	56,403	45.46	11 - 3 - 5	385	43.00	54.40	2.46	4.30 5.13	10,601	393		16,547
1922	6,375	6.8	93,043	86,668	58.95	11 -11 - 6	443	51.28	56.37	7.67	18.75	16,920	291		23,004
1923	7,937	8.4	94,281	86,344	66.50	10 - 4 - 9	457.4	46.83	49.85	19.67	18.75	18,073	318		25,692
1924	10,085	11.2	90,327	80,242	69.76	11 -19 - 8	441.7	52.93	58.36	16.83	18.75	13,170	208		23,047
1925	9,174	8.9	103,344	94,170	83.13	13 -17- 1	482.9	66.90		16.23	18.75	20,855	204	1,181	29,625
1926	7,642	6.6	115,969	108,327	91.90	15 -13 - 6	485.8	76.15		15.75	18.75	25,976	116	2,277	33,500
1927	11,128	7.4	149,905	138,777	118.16	21 - 7 -11	486.1	104.00		14.16	19.00	19,941	EST. 169	5,736	30,900
1928	17,870	12.0	149,083	131,213	123.51	22 - 6 - 1	486.6	108.53		14.98	19.00	14,562 "	132	5,476	32,300
1929	23,682	14.6	162,699	139,017	122.15	22 - 5 - 2	485.7	108.11		14.04	19.00	14,917 "	99	3,993	38,900
1930	21,553	19.8	108,985	87,432	115.01	21 -15 - 8	486.2	105.93		9.08	19.00	3,725 "	3,200	305	25,200
1931	24,947	26.1	95,569	70,622	87.35	19 -15 -10	453.5	89.75	96.38	+ 2.40	19.00	549	4,984	88	20,512
1932	12,622	16.5	76,844	64,222	97.92	13 -15 - 2	350.4	49.21	67.01	9.71	19.00	3,896	214	3,840	16,294
1933	9,669	16.4	59,076	49,407	59.23	9 -16 - 7	422.	41.64	47.87	17.75	19.00	20,315 "	200	5,370	29,700
1934	15,445	20.8	74,437	58,992	73.87	11 - 2 -10	504.	56.15	54.25	17.72	19.00	10,192 "	200	4,345	25,400
1935	17,518	19.1	91,625	74,107	71.99	12 - 7 -11	490.	60.74	60.36	11.25	19.00	7,815 "	200	3,682	25,200
1936	16,569	20.7 *	80,000 *	63,430 *	79.92	12 -18 -10½	497	64.33	60.03	15.59	19.00	18,088	263	2,533	34,400

\# 75 LB. FLASK ABOVE & 76 LB. FLASK BELOW

* NOT INCLUDING SPANISH PRODUCTION.

Figure 7—(Table No. 2) Pertinent figures concerning world's quicksilver industry for last thirty years.

Table No. 2, Fig. 7, shows pertinent figures concerning the world's quicksilver industry for the last 30 years.

The table shows that both United States production and world production varies over 100 per cent; for example, in 1929 (a boom year) production was 162,699 flasks. In the depression year of 1933 it was only 59,076 or only 36.4 per cent as great.

The third column shows United States production in per cent of world production and this column shows that the United States production is holding its own. For example, in the five prewar years, 1910-1914, inclusive, the United States produced 103,682 flasks out of a world production of 581,768 flasks or 17.8 per cent. In the last five years, for which complete statistics are available, namely 1931-1935 inclusive, the United States produced 80,201 flasks out of the world total of 397,551 or 20.2 per cent.

Drops in the price of quicksilver are due to production in excess of demand. From 1875 to 1883 a drop in the world price from £ 24-10 ($119.31) to £ 5-5 ($25.57) was caused by overproduction by the quicksilver mines of California. Since the World war, overproduction on the part of European producers has been the depressing influence. This is well shown in Table 2, Fig. 7. In the fifth column a tremendous increase in European production is recorded from 1926 to 1929, inclusive. This resulted in tremendous world stocks and in succeeding years the price dropped from over £ 22 ($108) to £ 9-16-7 ($41.64) in 1933.

Table 2, Fig. 7, starts with the panic year of 1907. From 1907 up to and including 1919, production and consumption of quicksilver in the United States was practically balanced, the excess of exports over imports for these years being only 2,903 flasks.

1920 was a critical year in the quicksilver industry of the United States. For 1916, 1917, and 1918 the average consumption in the United States was 31,268 flasks per year. With the end of the war in 1918 consumption dropped precipitately and the average for 1919, 1920, and 1921 was only 21,833 flasks per year.

In 1919 it was almost impossible to sell quicksilver as consumers were using up stocks and were holding back on buying because of the falling price. Imports increased from Europe, and even Mexican quicksilver was imported at a rate of 300 to 500 flasks monthly. (E. & M. J. Vol. 107, 1919, page 879).

For the first half of 1920 the price held close to the average price of 1919 ($91) and then declined steadily to under $50 by the end of the year. Large importations from Italian quicksilver mines, due to exchange conditions, caused the average price in quicksilver in London as quoted in £ to raise from £ 20-9-5½ in 1919 to £ 20-14-9 in 1920. In other words, as shown on Table 2, Fig. 7, the European producer selling for £ actually got more for his quicksilver in 1920 than in 1919 while the American producer received some $11 less per flask. Besides the Italian selling, Japan, where a financial crisis prevailed at this time, dumped resale metal in the United States and even our Navy Department dumped a stock of 1,400 flasks on the market for some $25 less per flask than it paid for it.

On June 20, 1920, the New Idria plant was wrecked by fire and, since this plant accounted for about half the California production, a good part of the domestic production decline for 1920 was caused by this single fact.

1921 was the bottom of the post-war depression and consumption of quicksilver in the United States dropped to some 16,500 flasks. The price for that year was $45.46 or about equal to the prewar average price from 1907 to 1914, while wages and cost of supplies had not dropped to anywhere near the prewar figures. Most of the mines had to shut down. New Idria, the largest producer, went into the hands of a receiver and was idle for two years, only resuming operation toward the end of 1923.

Late in 1922 a tariff of 25 cents per pound was placed on quicksilver and the long struggle to rehabilitate the industry which had supplied domestic requirements for 70 years was on.

While this was going on in the United States, events of great importance were taking place in Europe. Italy acquired the Austrian (Idria) quicksilver mine and the first understanding between Spain and Italy (now the only large producers outside the United States) was negotiated in 1919.

While the United States quicksilver mines, which had gutted their reserves at government urging in a time of national emergency, were fighting for protection which would give them a well-deserved chance to rehabilitate their industry, the European producers made a determined attempt to capture the

American market and kill the American industry. The depressed exchange helped them in this fight as illustrated below:

TABLE No. 3

Year	What European Buyer Got in Dollars, i. e. New York Price Less Tariff	London Price in Dollars at Average Annual Rate of Exchange	London Price in Dollars if Exchange Had Been Par	European Seller in U. S. Took This Much Less in Dollars Than London Price	Equivalent in Dollars of What European Seller Got in £ Purchasing Power	What U. S. Seller Got in $ in Purchasing Power
1919	83.08	90.69	(99.70)	7.61	91.31	92.15
1920	73.53	75.90	(100.99)	2.37	97.84	81.12
1921	41.16	43.00	(54.40)	1.84	52.06	45.46

Note that despite our tariff and because of currency depreciation, the European producer received more in purchasing power (i. e. for labor and supplies to operate his mine) by selling his quicksilver in our market then the American miner received.

After 1922 our new tariff of 25 cents per pound served to give a preferential price to our producers which gradually diminished as our production increased, until in 1931 the London price was $2.40 higher than the New York price as shown in Table 2.

The tariff granted in 1922 gave the operating mines a chance to get on their feet again, but the industry was in sore straits by this time. Equipment had deteriorated, trained crews were scattered, and, as in all depressions, capital for development and rehabilitation was hard to get. Improvement was slow and European producers, believing that they now had the greater part of the American market to themselves, raised the price in 1926-1927, and in 1928 formed a cartel to control prices.

This seemed to give assurance of permanently higher prices, business in the United States was on the upswing and capital became available for finding, developing, and equipping new mines as well as reopening old ones.

New development went on and new plants were built at the New Idria, Oat Hill, Oceanic, Aetna, Helen, and Big Bend mines.

Old mines were reopened and equipped, such as the Mariposa, Sulphur Bank, Knoxville, La Joya, Black Butte, Bella Oaks, Marabel, and Great Western.

New mines were found and equipped such as Opalite, Bretz, Nevada, Pershing, B & B, Beowawe, Steamboat Springs, Castle

Peak, Antelope Springs, Cinnabar King, Mina Mercury, Morton, Quicksilver Consolidated, Quicksilver Corp. of America, Arizona Quicksilver, Rinconada, Red Rock, Ivanhoe, Rainbow, Little Bonanza, and Nonpareil.

Besides these there were many retort operations underway at hundreds of prospects and a new district was found in Arkansas.

Of the new or newly opened mines mentioned above, eight have thus far produced in excess of 1,000 flasks per year and eight others have produced in excess of 500 flasks per year, a remarkably good showing for so short a time.

In 1930 and 1931 the United States mines were again supplying the domestic requirements and excess production to the extent of 4,984 flasks was exported because the London price for the year was higher than the domestic price.

Besides these exports, there were left in the hands of producers some 5,000 flasks that could not be sold and as the price dropped steadily from $103 in January to $66 in December many mines shut down during the year. Had the price remained at $100 per flask these mines would not have shut down and production would have been between 28,000 and 30,000 flasks for the year. In the latter half of 1932 the price was down to $47.50 and $48.50 and only a few mines kept running, more to keep their men from want than because it paid to do so.

During this severe depression which reached its greatest depth in 1932, foreign quicksilver was again shipped into the United States to the extent of 8,114 flasks. Most of this was bought by General Electric Company for the new mercury vapor boilers at Kearny, N. J., and Schenectady, N. Y. This is the same General Electric Company which cried out against the lack of patriotism of Americans who bought Japanese electric light globes which could be sold here cheaper than their own product because of the depreciation of Japanese currency[10].

In the last depression the United States producer was up against worse conditions than in the depression of 1921, for not only was the exchange against him but there was a tremendous European surplus production overhanging the world market for quicksilver.

[10] The Argonaut: Foreign Competition, March 10, 1933.
The Argonaut: Inconsistency's Jewels, March 24, 1933.

Fairly complete world production statistics on quicksilver are published annually, such as those by the United States Bureau of Mines and the Imperial Institute. Since neither Spain nor Italy use great amounts of their own production, the world consumption can be approximated from import and export figures of the consuming countries. These figures follow[11]:

TABLE No. 4

Year	World Production Flasks	World Consumption Flasks	World Surplus Flasks
1921	61,916	60,382	1,534
1922	91,816	64,065	27,751
1923	93,380	101,722	—(8,342)
1924	89,033	79,147	9,886
1925	103,370	103,390	—(20)
1926	115,786	106,937	8,849
1927	144,021	101,502	42,519
1928	147,073	135,785	11,288
1929	161,814	91,645	70,169
1930	110,410	77,150	33,260
1931	95,569	70,000	25,569
1932	76,844	70,000	6,844

From these figures it can be seen that conditions to the end of 1926 were normal in that production rose with consumption and only moderate stocks were on hand. Then, in 1927, a severe overproduction set in by the Italian and Spanish mines and this only stopped in 1932. Apparently they misjudged forward buying in 1928 on the part of Germany, United Kingdom, and Japan (see figures for that year in Table 1, on page 51) as being purchases for consumption and increased their production in 1929 to 70,000 flasks more than they could sell. From 1927 to 1933 then, these foreign mines piled up a surplus of some 190,000 flasks.

Both the Italian and Spanish mines were practically shut down in consequence of this rash overproduction and they sold as much of this surplus as possible in the United States. This foreign quicksilver was sold by them around $40 per flask, a price probably below their cost of production and too low for us to compete with. They, no doubt, hoped to drive our industry out of business and then to raise their prices to former cartel levels.

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[11] C. N. Schuette: Quicksilver and the American Producer. Mining Journal (Arizona), June 30, 1932.

ESTADO demostrativo de los resultados de la explotación de las minas de Almadén por presupuestos completos en el decurso de veinte años, de 1910 a 1930, ambos inclusive.

PRESUPUESTOS	Mineral extraido — Toneladas métricas	Beneficiado — Kilogramos	Azogue obtenido — Kilogramos	Rendimiento — Por 100	Frascos de 34,507 kilogramos	Gastos de explotación — Pesetas	Costo del kilogramo de azogue	Valor a los precios medios de ventas	Valor de la producción — Pesetas	Frascos vendidos	Producto de la venta — Pesetas
1910.....	15.489,893	12.793,946	1.102.828,400	8,620	31.959	2.110.033,98	1,913	6,394	7.051.384,78	34.900	7.598.198,17
1911.....	12.644,023	20.143,127	1.478.824,800	7,341	42.855	2.207.204,93	1,481	6,274	9.278.146,80	42.250	9.148.330,31
1912.....	13.668,027	16.643,740	1.186.900,600	7,131	34.395	2.199.797,88	1 853	5,660	6.717.857,40	42.087	8.220.591,49
1913.....	12.391,175	16.479,833	1.238.575,500	7,515	35.893	2.261.414,85	1,825	5,449	6.748.997,90	35.848	6.741.313,02
1914.....	11.155,871	12.117,285	956.801,500	7,896	27.727	2.109.270,12	2,204	5,546	5 306.421,12	30.325	5.804.065,27
1915.....	10.038,897	13.282,916	1.200.102,300	7,033	34.778	2.545.575,09	2,121	10,350	12.421.058,80	30.858	11.021.158,31
1916	10.613,495	9.575,862	771.056,891	8,050	22.348	3.871.289,34	5,020	12,090	9.322.077,81	38.969	16.258.010,61
1917....	10.127,686	11.944,306	827.115,300	6,922	23.969	3.838.345,05	4,646	11,563	9.563.934,20	19.532	7.793.506,96
1918.....	9.808,162	8.258,225	544.654,000	6,590	15.783	4.196.725,48	7,705	11,245	6.124.634,23	21.579	8.393.380,11
1919 a 920	14.071,601	16.475,875	988 111,585	5,997	28.632	7.643.171,12	7,735	10,611	10.484.852,02	45.298	16.586.925,58
1920 a 921	12.076,174	19.479,495	801.498,957	4,114	26.220	7.774.541,35	9,696	10,847	8.793.859,18	12.088	4.524.826
1921 a 922	13.512,898	13.072,994	761.638,505	5,825	22.072	7 272.989,44	5,535	7,087	5.397.732,08	16.638	4.069.273,42
1922 a 923	14.108,000	24.442,767	1.385.983,000	5,670	40.165	7.184.618,34	5,183	8,154	11.295.305,38	45.099	12.690.445,82
1923 a 924	13.431,295	18.213,352	864.368,857	4,746	25.051	6.730.167,80	7,786	8,116	7.015.217,64	37.750	10.572.676,85
1924 a 925	20.205,809	20.967,523	1.220.356,755	5,820	35.365	6.657.768,69	5,455	11,677	14.250.105,83	40.974	16.510.406,17
1925 a 926	26.529,564	27.309,085	1.615.054,000	5,914	46.825	8.078.277,30	5,001	11,679	18.862.215,66	48.045	19.364.395,01
1927.....	50.120,254	43.285,262	2.482.891,500	5,736	71.953	9.641.426,18	3,883	12,311	30.366.877,25	61.885	26.290.173,80
1928... .	46.832,147	38.564,673	2.185.530,637	5,667	63.341	8.817.726,59	4,034	14,537	31.771.058,87	40.604	20.364.199,83
1929.....	30.913,852	42.970,401	2.466.979,000	5,741	71.506	7.512.153,07	3,045	20,610	50.844.437,19	21.157	15.043.747,34
1930.....	17.999,932	15.687,299	652.845,978	4,161	18.923	6.466.050,33	9,904	25,040	16.347.263,28	20.081	17.348.206,65
Sumas ...	365.738.746	401.707.966	24.732.418.065	6,156	719.760	109.118.542,93	4,411	9,879	277.963.437,42	685.967	244.343 830,72
Promedios...	18.286,937	20.085,398	1.236.620,903	6,156	35.988	5.455.927,14	4,411	9,879	13.898.171,87	34.298	12.217.191,53

Figure 8—(Table No. 5) Almaden Mine (Spain), 1920-21 production and operating costs.

In Table 2, Fig. 7, note that after the panic in 1907 the price of quicksilver in the United States recovered from an average of $41.50 in 1907 to $47.06 in 1910. Increased production followed after the usual lag in time from 19,752 flasks in 1908 to 25,064 flasks in 1912. Meanwhile world production, outside the United States, increased greatly and, in 1911, 6,292 flasks were dumped on the New York market causing the price to decline from $47.06 in 1910 to $39.54 in 1913. Without this dumping a satisfactory price would, no doubt, have obtained because in these years United States production barely covered consumption.

After the World war when immediately available reserves of low grade ore had been used up and when production costs were still high due to increased costs of both material and labor, the industry was faced with declining prices in a market in which it was difficult to sell at all because consumers had stocks of metal on hand.

Imports which in the war years had been 5,000 to 6,000 flasks (see Table 2, Fig. 7.) jumped to 10,635 in 1919, 14,169 in 1920, and 10,601 in 1921.

Note in Table 5, Fig. 8, which is reproduced from "Los Almadenes de Azogue" by J. Z. Martinez, Madrid 1934, that in the season of 1920-1921 the Almaden Mine treated 19,479,495 kg. of ore to produce 801,499 kg. of quicksilver. This was a recovery of 4.114 per cent. Total operating costs are given as P 7,774,541.35 or P 9.7 per kg. of quicksilver. A flask weighs 34.473 kg. Then the cost per flask of producing this quicksilver was $9.7 \times 34.4735 = P\ 334.39$.

The average annual rate of exchange in 1921 was .135, so P 334.39 is equal to $45.14. (The year before the rate was .159 and the year after it was .155 which rates would have made the cost $53.17 and $51.83 respectively).

At any rate the operating cost for quicksilver produced at Almaden, Spain, in the 1920-1921 season was $45.14 per flask.

The American producer had a tariff protection of $4.30 per flask at that time and freight from Spain to New York plus insurance, etc., was $2 per flask more. Then to land the 1920-1921 Spanish quicksilver in New York cost $45.14 + $4.30 + $2.00 = $51.44 per flask without figuring in brokerage or handling charges.

The United States Geological Survey's "Quicksilver in 1921" (page 108) reported: "The smallness of domestic production in 1921 is apparently not due, directly at least, to unusually large imports of foreign quicksilver. . . ."

Perhaps not, but when foreign quicksilver, costing $51.44 per flask laid down in New York ($10 per flask less than at normal exchange rate) is sold for $45.46 per flask, it may have been due to the unusually low price at which the only "usually" large imports were offered.

Tariff protection was granted in 1922, and after the usual lag of time needed to finance, develop, and get new and old mines into operation, the domestic production increased from 6.6 per cent of the world's production in 1927 to 26.1 per cent in 1931. In other words, in six years the industry had advanced to where it supplied the total domestic demand and had an exportable surplus.

Meanwhile in Europe, senseless overproduction had piled up tremendous surplus stocks which were then dumped in the United States as usual. In 1932, 3,886 flasks were shipped in and 20,315 in 1933. These flasks were thrown on the market and every offer of domestic quicksilver was underbidden by importers so that the United States producer could not sell his product, therefore many mines were forced to shut down. Note in Table 2, Fig. 7, that while we theoretically had a tariff protection of $19 per flask, actually the foreign quicksilver was sold for only $9.71 more than the London price in 1932. This means that our domestic price was reduced $9.29 per flask due to this dumping when the London exchange dropped from 453.5 to 350.4. In the following year this was partially rectified when the United States raised the price of gold but imports increased, nevertheless, and in 1933 the United States quicksilver industry was again in desperate straits.

This was the year in which the N. R. A. was to lead American business out of the depression by allowing each industry to organize and adopt codes of fair competition.

The quicksilver industry did so organize and adopt a code. As soon as the news on N. R. A. was out in the spring of the year, the United States was flooded with foreign quicksilver sent over here to be sold before the domestic industry could

bring action to stop it. In the first three months of 1933 only 69 flasks came in. The next three months over 5,000 flasks came in and over 15,000 more in the last half of the year, a total of 20,315 for 1933.

The N. R. A. was organized:

1. To spread employment by decreasing hours of work and to increase wages.
2. To let business organize under codes to limit production to cover increased costs by increasing selling prices and to eliminate unfair competition.
3. *To protect domestic markets of industries competing against importations of more cheaply produced foreign goods* so that employment can be increased.

The United States quicksilver industry sought relief from the excessive imports under Section 3 (e) of the N. R. A. Hearings were held in Washington, D. C., on January 15, 1934, after a complaint had been filed in July, 1933.

A brief filed by the U. S. Quicksilver Producers gave returns from 48 mines reporting production in 1933. These mines produced 9,502 flasks, (thus representing 98½ per cent of the year's total production); of this production 4,220 flasks were produced before the President's Re-employment Agreement (P. R. A.) went into effect and 5,282 flasks were produced after P. R. A. went into effect. There were 32 producers before P. R. A. and 16 more or 48 producers after P. R. A. went into effect; 32 of the 48 mines were forced to close down again under P. R. A. operation because the price of quicksilver did not increase in proportion to the increased cost. The reason why the price did not advance was the dumping of foreign quicksilver on our market.

The increased number of mines operating after P. R. A. went into effect was because the industry gave to the President's Re-employment Agreement or P. R. A. wholehearted cooperation. The additional mines did not start up because of a price increase, because the price was almost stationary as shown below.

July,	1933	$62.90 flask
Aug.,	1933	63.50 flask
Sept.,	1933	64.58 flask
Oct.,	1933	66.50 flask
Nov.,	1933	66.00 flask
Dec.,	1933	66.33 flask

When the P. R. A. went into effect additional men at higher hourly rates of pay were put to work. It was estimated that this had increased costs some 12½ per cent of which two-thirds went directly to labor.

It was shown that United States consumption was about 1,700 flasks per month at that time and that domestic mines could supply this amount provided that they could sell their product at all instead of being continually underbid by dealers selling foreign metal.

In the five months after P. R. A. went into effect 15,057 flasks were imported or at the rate of 3,019 flasks per month or 1,300 flasks in excess of domestic requirements. Domestic quicksilver could only be sold under concessions in price greater than domestic mines could make in view of their increased costs under P. R. A. operation.

The quicksilver industry had cooperated fully with the National government and had asked for relief from imports in the middle of 1933 under provisions which clearly applied to its case and which the President was empowered to grant. But instead of restrictions on imports of foreign quicksilver, the industry got nothing. The Tariff Commission facetiously reported to the President that the troubles of the quicksilver industry had been due not to importations of quicksilver but to a drop in prices, and declined to recommend any restrictive action with respect to imports[12].

In times of war the government seems greatly concerned for the welfare of the United States quicksilver industry, but between wars the industry is treated as a problem child and doleful predictions of its early demise are published by some of the government agencies that were created with the ostensible purpose of helping it.

In 1918, Bulletin 666-FF was published by the United States Geological Survey. It aroused a storm of controversy and discussion in the technical press.

Eng. & Min. Jour. Vol. 107, 1919.
    Innes, Murray, Quicksilver in California, p. 56.
    Burcham, W. D., Quicksilver in Texas in 1919, pp. 145-146.

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[12] J. F. Callbreath: A Deliberate Deception. Mining Congress Journal, May, 1934.

Ransome, F. L., Future of the Quicksilver Mining Industry in the United States, pp. 876-877.

Innes, Murray, Page, Thomas and Hamilton, Fletcher, The American Quicksilver Industry, pp. 878-879.

Eng. & Min. Jour. Vol. 108, 1919.

Sharpless, F. F., The American Quicksilver Industry, p. 24.

Forstner, Wm., The American Quicksilver Industry, pp. 321-322.

Min. & Sci. Press, Vol. 118, 1919.

Editorial, p. 836.

Forstner, Wm., Protecting the Quicksilver Industry, p. 839-40.

Min. & Sci. Press, Vol. 119, 1919.

Forstner, Wm., Protection to the Quicksilver Industry, p. 146.

Sharpless, F. F., The Quicksilver Industry, p. 259.

Gleim, E. M., The Quicksilver Industry, p. 434.

Foote, A. B., Tariff Protection for Metals, p. 555.

Gleim, E. M., A Tariff on Quicksilver, p. 739.

This premature obituary of the industry published when the war was over (during the war the industry was treated with respect and lauded for its achievements) stated, "Quicksilver mining is a comparatively small industry in this country", and later refers deprecatingly to a "small group of producers". These statements were irrelevant. The point was that quicksilver mining was a *vital* industry, and that in 1917 the United States with inadequate equipment and low-grade ore *led the world* in production by producing nearly 30 per cent of the world's output and exceeding its nearest rival producer by nearly 23 per cent of the latter's production. The low grade of the ore is deprecated "only .38 per cent". Naturally, when the price went up from $45 to over $100 per flask, old dumps were raked over for low-grade rock that had become ore. In any mining the grade of the ore treated goes down as the price goes up. This means an increase in available ore reserves and is an asset to the industry.

In discussing the future of the industry, Bulletin 666-FF says "Production has failed to respond to the stimulation of moderate increases in price". One glance at Table 2, Fig. 7, disproves this statement: Note the "moderate price increase" from $41.50 in 1907 to $46.54 in 1911. Production is up from 19,752 in 1908,

to 25,064 in 1921. The years time lag between price drop and lower production and price rise and higher production is characteristic of the industry and represents the time needed to prospect, develop, and equip mines after an increase in price and the reluctance to stop production when the price drops. Note also that the drop in price beginning in 1911 is due to imports in that year.

The Bulletin further states, "During the last 20 years comparatively few new quicksilver deposits have been found." The author is not sure of the United States Geological Survey's definition of "deposits". If mines were meant, they are developed, not found, and certainly many prospects had been located, for example, the Bretz property in Oregon.

The Bulletin also says: "Of the total domestic production of 36,159 flasks in 1917 less than 600 came from new mines opened during the war period and not one of these promises to develop a production of 1,000 flasks or more annually." It was naive to believe that anyone would develop and equip—particularly at war prices—a new quicksilver "mine" during the war when there was no certainty at any time that the war and the high price of quicksilver would last even three months longer. Prospecting for quicksilver during the war was mainly in the hope of finding retort ore for quick profits rather than in the hope of developing a new mine.

Then came the crux of the Bulletin—"It is doubtful whether there is any wisdom in attempting to foster quicksilver mining by a high import duty whose effect would be to levy a tax on all users of quicksilver for the benefit of a small group of producers and it is still more doubtful whether the people of the United States would submit to this tax." It has already been shown that the ultimate consumer is hardly at all affected by the price of quicksilver, and though a tariff was granted the people did not rise in rebellion rather than "submit to this tax".

It is admitted that this report was written in 1917 when conditions in the quicksilver industry were in a somewhat chaotic state. The plants were old and worn out; there was no trained personnel; old dump and stope-fills were being treated instead of developing new ore; and the industry presented a picture of anything but a well-organized industry. Now the industry has

been rehabilitated and put on a sound basis. Its record through the years is now clear. Fortunately, the industry was given protection, and its present condition of importance has vindicated the faith the industrial states had in their home industries and in the efforts made by individuals to foster it.

When our tariff (which was granted in 1918, despite the United States Geological Survey's opposition) and the formation of the European cartel gave assurance of a sustained high price, old mines were reopened and new ones were found. Of these, Sulphur Bank, Nevada, Pershing, B & B, Black Butte, Opalite, Bretz, Morton, and Horse Heaven all produced over 1,000 flasks per year; and Mercury Mines of America, Knoxville, Bella Oaks, Rainbow, Rinconada, La Joya, Great Western, and Castle Peak produced over 500 flasks per year. An entirely new quicksilver district has been opened up in Arkansas. Many other mines show promise of similar performance with additional development work. These facts clearly refute the Bulletin's supposition that the nondevelopment of such mines during wartime meant that our reserves had been exhausted and prove true the counter-contention of the producers that only the uncertainty of the high prices during the war prevented the exploitation of old and new mines.

On page 8 the Bulletin says: "It is doubtful whether this country will in the near future be deluged with foreign quicksilver to the extent feared by some producers."

The answer to that is given in the following tabulation:

Year	Imports in Flasks
1919	10,635
1920	14,169
1921	10,601
1922	16,920
1923	18,073
1924	13,170
1925	20,855
1926	25,976

If this is not a deluge, it at least appeared very much like it to the domestic quicksilver producers.

Speaking of the tariff on page 8, of the Bulletin: "Such a duty would increase the profits of some of the larger mines, but would not transform a declining industry into a growing and self-supporting one".

The answer to that is that by 1930 the United States producers were again supplying the local requirements and in 1931 they exported 5,000 flasks because the price in London was higher than in the United States ($89.75 against $87.35). That, we submit, proves both growth and self-support.

The statement "It is still more doubtful whether the people of the United States would submit to this tax" (meaning the tariff) is answered by the fact that no objections were voiced and the people of the United States used more quicksilver when the price was high than when it was low. From 1921 to 1924 inclusive, as shown in Table 1, on page 51, the average price was $60.17 and average annual consumption was 22,072 flasks per year. From 1925 to 1928 inclusive the average price was $104.17 and average annual consumption was 34,131 flasks.

It is suggested on page 9 that the government "purchase quicksilver where it can be bought cheaply, (and) store it as an immediately available reserve supply against the next war . . ."

Just how cheaply European quicksilver can be bought when our industry is crippled or dead, was demonstrated in the past decade when the European cartel set the price at £ 22. Just how our Government takes to the idea of storing quicksilver was shown, in 1920, when the Navy Department sold 1,400 flasks that it had in storage at a price some $25 less than it had paid for it and thereby added materially to the distress of the market in that critical year.

This United States Geological Survey pessimism regarding the quicksilver industry was also evident in U. S. G. S. 1-17, "Quicksilver in 1917". This reviews the different mines and prospects and on page 421, under Malheur County, Oregon, it says: "The Rhyolite is silicified, but so far as could be seen from the shallow pits and trenches contains very little cinnabar". "The cinnabar occurs chiefly in the porous, siliceous hot-spring sinter and in the lake beds." This prospect which seemed so poor was later developed into the Bretz Mine.

On page 417 under Humbolt County: "The ore occurs mainly as cinnabar dispersed through masses of shattered limestone conglomerate or breccia that rest, as remnants left by erosion, on the crests of ridges and hills of soft shale. *It is doubtful whether any of the ore extends to a greater depth than 50 feet.*"

This pessimistic opinion refers to the Antelope Springs district where the Nevada, Pershing, and Antelope Springs mines were developed and equipped with furnaces; the two former mines both surpassed the shibboleth of producing over 1,000 flasks per year and thus far both have ore for 200 to 300 feet in depth. Instead of encouraging the prospectors that were working there at the time and pointing out to them the favorable geological features of the district, the United States Geological Survey discouraged them with its pessimism.

On page 409 under Lake County: "The Mirabel and Great Western mines near Middletown were idle in 1917, with no prospect of a resumption of activity." Both of these mines are producing today.

These examples—and many more could be cited—show that the U. S. G. S. "obituary of the quicksilver industry" (Bulletin 666-FF) was premature.

Fortunately the pessimistic view of the quicksilver industry is not shared by other departments of the government.

The United States Bureau of Mines, by its general as well as its research and experimental work, is directly responsible for many of the improvements in the mining and metallurgy of the industry.

The Mining and Geological departments of the various producing states have also been very helpful to the industry. Much statistical, informational, and geological work of great importance has been done by these state agencies often in cooperation with federal departments or with the mining and geological departments of the state and universities within their borders.

The official statistics of the industry are published annually by the U. S. Bureau of Mines. The figures are quite complete, but their interpretation does not always take all factors into account to give a true picture of the position of our domestic industry.

For example, the Minerals Yearbook of 1937 reviewing the year 1936 states that it "was characterized by a notable increase in demand—by lower domestic production in the face of a rise in price." This doesn't sound so good, but when it is remembered that the mines could not ship their quicksilver to market because of the maritime strike and hence curtailed production,

and that many mines could not get in supplies because of storms, and had to shut down in some instances, the drop of 1,000 flasks in production from that of the previous year is easily explained. In 1937 actual production was curtailed perhaps some 4,000 to 5,000 flasks in the last half of the year, because of slow sales due to imports of some 24,000 flasks.

The 1937 report also mourns again that increasingly higher prices are required to bring out a given production of mercury and increased output is supplied by ores of diminishing grades.

This may be true of the statistical record, but could easily be upset by the development of one large new mine or, say, the re-opening of such an old mine as the New Almaden. Hence, it does not picture the situation fairly.

As already pointed out, Table 2, Fig. 7, shows that the United States production is holding its own in percentage of the world's production, so if our industry is working on diminishing reserves so is the rest of the world's quicksilver industry.

For instance, the 1937 Yearbook in its "Production at price" argument gives the following figures for the United States:

Period	Average Annual Production in Flasks	Grade of Ore in Per Cent
1910-1919	24,188	0.47
1920-1929	11,282	0.42
1930-1936	16,903	0.35

This shows a drop in the grade of the ore from 0.47 per cent to 0.35 per cent or some 25.6 per cent reduction in grade.

Now take the following table showing results at the Almaden Mine in Spain for a comparable period:

Period	Total Flasks Produced	Grade of Ore in Per Cent
1910-1914	172,829	7.65
1915-1919	125,510	6.88
1920-1924	148,873	5.29
1925-1930	272,548	5.64
1931-1934	94,236	5.00

This shows a drop in grade of the ore from 7.65 per cent to 5.00 per cent or some 35 per cent reduction in grade. On the face of it this would seem to prove that Almaden is showing a greater rate of decline in grade than the United States mines especially when the low output of the last period is viewed in the light of being produced from the lowest grade

of ore. With us at least there is an increase in output when the grade goes down.

Such comparisons show that we need not necessarily "view with alarm" even if our domestic industry shows recessions in the "production at price" figures.

Let us see how Italy compares. Figures are available as follows:

Period	Flasks Produced	Grade of Ore	Average Grade of Ore
1925	53,898	1.040	
1926	54,998	0.900	
1927	58,672	0.910	0.92%
1928	57,677	0.868	
1929	57,966	0.884	
1930	56,069	0.838	
1931	37,652	0.720	
1932	29,480	0.810	0.79%
1933	17,605	0.826	
1934	12,804	0.765	

Here we have a drop in grade of 14 per cent in two successive 5-year periods and the average annual production has decreased from 56,642 flasks to 30,722 flasks. Spain in the comparable 5-year periods only shows a drop in grade from 5.64 to 5.00 per cent or 11 per cent as against Italy's 14 per cent drop.

The report says further: "From the preceding discussion it is clear that depletion of reserves results in smaller outputs as each price cycle returns to a previous level. A conclusion that might be drawn from this study is that an index price well above $93 a flask would be needed to produce the desired amount for even one year."

It is one thing to keep statistics, but a much more difficult matter to interpret them accurately.

If the United States quicksilver industry could be assured of a $90 price for five years—could be sure that foreign quicksilver would not be shipped in in such quantities as to break the price—statisticians would be surprised at the result.

Ostensibly, the United States quicksilver industry is protected by a tariff of $19 per flask, but in no year since 1923, the first full year when the tariff was in effect, has this produced a differential of $19 between the New York and

London price as can be clearly seen in Table 2, Fig. 7. In pre-war days the Italian lira and the Spanish peseta were worth 19 cents in American dollars.

The present tariff was granted in 1922, in which year the Spanish peseta was worth 15½ cents and the Italian lira was worth 4.8 cents. In the following years these currencies went down, the peseta as low as 8 cents in 1932 while the lira dropped —4 cents in 1925-1926 though it has since been higher.

Despite the devaluation of the American dollar by about 40 per cent, in 1933, the old parities of 19 cents were never reached again and for 1936 the figures were 12 cents for the peseta and 7 cents for the lira.

Thus the handicap under which the American producers work, due to the lower standards of living in foreign countries, was made greater and no change in the tariff was made to equalize this greater handicap. As a result of this the industry is periodically harassed by dumping of foreign supplies.

In view of this inadequate protection, the United States States quicksilver industry has done remarkably well in the last few decades and has given proof that it could do very much better if it were given a little intelligent protection by the government.

Just why a United States Government should allow stocks of foreign products, greatly in excess of domestic needs, to be shipped in and be sold here by a price-chiseling process that closes down its own ostensibly protected mines, is one of the mysteries of American government, and one that the producing states should seek to rectify.

USES OF QUICKSILVER

The world's quicksilver production has been at a rate of over 100,000 flasks of quicksilver per year since 1875. The uses to which it has been put have undergone a gradual change in the course of time. Formerly, a large percentage of the production was used for the amalgamation of gold and silver ores and quite a large part for making vermilion. These uses no longer consume such large quantities of quicksilver and their places have been taken by others.

From 25,000 to 35,000 flasks are consumed annually in the United States, depending on the state of business generally. Some 75 to 85 per cent of the world's production is probably used in the United States, United Kingdom, Germany, France, and Japan; in other words, by the large industrial nations.

The liquid metal is sold as quicksilver by the producer. When the consumer gets it, he calls it mercury. The producer may refer to it as "quick" or more commonly as "silver", but he *never calls it mercury* even though von Bernewitz[13] says it is improperly termed "quicksilver".

In the United States, quicksilver is used for drugs and chemicals in quantities up to 14,000 flasks in boom years. The following list of so-called "mercurials" in Table 7, gives some idea of its use in medicine:

MERCURIALS

Mercuric acetate
Mercuric acetylide
Mercuric amidosuccinate
Mercuric aminophenyl arsenate
Mercuric ammonium chloride
Mercuric ammonium
   propionate
Mercuric anilinate
Mercuric arsenate
Mercuric atoxylate
Mercuric benzoate
Mercuric bichromate
Mercuric borate
Mercuric bromide
Mercuric cacodylate
Mercuric carbolate
Mercuric carbonate
Mercuric chloride
Mercuric chloro-iodide
Mercuric chromate
Mercuric cyanide
Mercuric diiodosalicylate
Mercuric ethylchloride
Mercuric ferrocyanide
Mercuric fulminate

Mercuric gallate
Mercuric hydroxide
Mercuric iodate
Mercuric iodide
Mercuric lactate
Mercuric lithium iodide
Mercuric naphtholate
Mercuric nitrate
Mercuric oleate
Mercuric oxide
Mercuric oxycyanide
Mercuric phenolate
Mercuric phenylacetate
Mercuric p-phenylthionate
Mercuric phosphate
Mercuric potassium cyanide
Mercuric potassium iodide
Mercuric potassium
   thiosulfate
Mercuric pyroborate
Mercuric rhodanate
Mercuric salicylate
Mercuric santonionate
Mercuric silicofluoride
Mercuric stearate

[13] M. W. von Bernewitz: Occurrence and Treatment of Mercury at Small Mines. U. S. Bureau of Mines Information Circular 6966.

MERCURIALS—Continued

Mercuric subsulfate
Mercuric succinate
Mercuric succinimide
Mercuric sulfate
Mercuric sulfide
Mercuric sulfite
Mercuric sulfocyanide
Mercuric urate
Mercuric xanthate

Mercuricide
Mercurochrome
Mercurol

Mercurous acetate
Mercurous arsenite
Mercurous benzoate
Mercurous bitartrate
Mercurous bromide
Mercurous carbonate
Mercurous chloride
Mercurous chromate
Mercurous citrate
Mercurous iodide

Mercurous iodobenzene-
  p-sulfonate
Mercurous lactate
Mercurous nitrate
Mercurous oxide
Mercurous phosphate
Mercurous santonate
Mercurous sulfate
Mercurous sulfide
Mercurous tannate

Mercury nucleinate
Mercury ointment
Mercury periodide
Mercury peroxide
Mercury phenide
Mercury protiodide
Mercury protochloride
Mercury protoxide
Mercury rhodonate
Mercury rhodonide
Mercury saccharate
Mercury subchloride
Mercury subsulfate
Mercury sulfuret

A table of the common mercurial chemicals, together with prices is given in Table 8.

Name of Chemical—Chemical Formula	Molecular Weight	Wt. in lbs. of contained Mercury per lb. of Chemical	Price of Chemical per lb. June, 1932	Value of Contained Hg at ave. price of June, 1932.	Value of Contained Hg in per cent of Price	Price of Chemical per lb. May, 1931	Value of Contained Hg at ave. price of May, 1931	Value of Contained Hg in per cent of Price	Price of Chemical per lb. July, 1930	Value of Contained Hg at ave. price of July, 1930	Value of Contained Hg in per cent of Price	Price of Chemical per lb. Nov. 1929	Value of Contained Hg at ave. price of Nov., 1929	Value of Contained Hg in per cent of Price
Mercury. U. S. P.—Hg	200.61	1.00	$1.87	$ .78	42	$2.76	$1.33	48	$2.73	$1.55	57	$3.12	$1.62	52
Mercury. Tech.—Hg	200.61	1.00	1.74	.78	45				2.60					
Mercuric acetate—$Hg(CH_3CO_2)_2$	318.66	0.63	3.07	.49	16	3.42	.84	25	4.05	.97	24	4.70	1.02	22
Mercuric bromide—$HgBr_2$	360.44	0.555	6.12	.43	7	6.50	.74	11	6.80	.86	13	6.83	.90	13
Mercuric Chloride—CP	271.52	0.74	2.47	.58	23	2.72	.98	36	2.90	1.14	39	2.88	1.20	42
USP pdr.—$HgCl_2$	271.52	0.74	1.37	.58	42	2.78	.98	35				2.94	1.20	41
USP cryst.—$Hg Cl_2$	271.52	0.74	1.52	.58	38									
Mercuric cyanide CP—pdr. $HgCN_2$	252.63	0.76	4.28	.595	14	4.12	1.01	24	4.35	1.17	27	4.43	1.23	28
pur. pdr.—$HG CN_2$	252.63	0.76	3.60	.595	16									
Mercuric Iodide CP—pdr. $Hg I_2$	454.47	0.44	6.55	.34	5	6.85	.59	9	6.95	.68	10	6.97	.71	10
USP red	454.47	0.44	5.58	.34	6									
Mercuric nitrate CP cryst.—$Hg(NO_3)_28H_2O$	468.75	0.43	2.99	.34	11	3.19	.57	18	3.00	.67	22	3.22	.70	22
pur. cryst.—$Hg (NO_3)_2 8H_2O$	468.75	0.43	2.55	.34	13									
Mercuric Oxide CP—red pdr. HgO	216.61	0.925	2.78	.72	26	3.18	1.23	39	3.38	1.43	42	3.38	1.50	44
NFV—red pdr. HgO	216.61	0.925	2.29	.72	31									
Tech—red pdr. HgO	216.61	0.925	2.10	.72	34				2.99					
CP yellow pdr.—pdr.HgO	216.61	0.925	3.28	.72	22	3.86	1.23	32	3.85	1.43	37	3.86	1.50	39
USP yellow pdr.—pdr. HgO	216.61	0.925	2.72	.72	26									
Tech yellow pdr.—pdr. HgO	216.61	0.925	2.15	.72	33				2.35					
Mercuric sulfate—CP pdr. $HgSO_4$	296.66	0.675	2.29	.53	23	2.60	.90	35	3.05	1.04	34	3.47	1.10	32
Pr. Normal—CP pdr. $HgSO_4$	296.66	0.675	1.80	.53	29									
Mercuric Sulfide CP—bl pdr. HgS	232.67	0.86	2.48	.67	27				2.50					
Cp red pdr.—HgS	232.67	0.86	4.07	.67	16	3.57	1.14	32	4.50	1.33	30	3.57	1.40	39
Mercurous chloride Cp pdr. Hg_2Cl_2	472.12	0.425	2.68	.33	12				3.21					
USP (calomel)—pdr. $Hg_2 Cl_2$	472.12	0.425	2.18	.33	15									
Mercurous nitrate CP cryst.—$HgNO_3H_2O$	280.62	0.71	3.06	.55	18	3.67	.95	26	3.50	1.10	31	3.67	1.15	31
pur. cryst—$HgNO_3H_2O$	280.62	0.71	2.73	.55	20									
Mercurous Oxide Cp pdr.—Hg_2O	417.20	0.48	4.85	.37	8				4.85					
Mercurous Sulfate CP pdr.—Hg_2SO_4	497.26	0.40	3.06	.31	10				3.50					
Tech.—Hg_2SO_4	497.26	0.40	2.36	.31	13				2.56					
Averages of 13 italic items			$3.40	$ .56	16.5	$3.78	$ .96	25.4	$4.09 av. of 12	$1.11 av. of 12	27.2	$4.09	$1.17	28.6

The price figures in Table 8 were taken from the July, 1930, and June, 1932, catalogs of the J. T. Baker Chemical Co., of Phillipsburg, N. J., and the November, 1929, and May, 1931, catalogs of Merk & Co., Inc., of Rahway, N. J.

Data covering all four years were available for 13 chemicals. The averages of these 13 (italics in the table) were used in the following:

	November 1929	July 1930	May 1931	June 1932
Price of quicksilver per flask	$123.32	$117.46	$101.14	$ 59.48
Price of quicksilver per pound ..	1.62	1.55	1.33	.78
Average value per pound of quicksilver contained in 13 mercurials	1.17	1.11	.96	.56
Average price per pound of the 13 (12 for 1930) mercurials ..	4.09	4.09	3.78	3.40
Price of quicksilver in per cent (1929=100%)	100	95	82	48
Average price of 13 mercurials in per cent	100	100	92	83
The price of mercury went down		5%	18%	52%
The price of 13 mercurials went down		0%	8%	17%

Thus we see that the value of the contained mercury in the common mercurial chemicals is only 16 to 28 per cent of the price and a drop of 52 per cent in the price of mercury accounts for only 17 per cent of the corresponding drop in the price of mercurials.

Dental preparations account for 300 to 400 flasks of quicksilver per annum and a large part of this is redistilled mercury for amalgam. Mercurial chemicals used for disinfecting seed use greatly varying quantities of quicksilver both in the United States and Europe.

Mercuric Fulminate uses large quantities of quicksilver in wartime because, in point of safety and reliability, it is the best to detonate explosives and the Ordnance Departments will not accept substitutes. In peacetime, substitutes at least in part are used for firing explosives in mines, quarries, and for other industrial purposes, but even then as many as 6,000 flasks per year may be used for this purpose alone.

The use of quicksilver for manufacturing vermilion fluctuates greatly due to competition between domestic and foreign

makers and also because other colors are competitive. Several thousand flasks are so used annually in the United States.

Felt manufacture also uses a few thousand flasks per year in the form of mercuric nitrate for roughening the rabbits' fur in fashioning hats. In this use, again the amount of quicksilver used per hat is too small to be noticeable in the price of the hat to the ultimate consumer.

Amalgamation though now one of the minor uses has taken increased quantities of quicksilver since the revival of gold mining caused by its increase in price to $35 per ounce.

Among the truly modern uses of quicksilver are its use in electrical apparatus. Lamps alone use over 1,000 flasks per year.

There are mercury vapor lamps, mercury vapor quartz, arc, and sun lamps; and they are used for photography, water sterilization for scientific and medical purposes.

A water-cooled mercury vapor lamp of more than 100,000 candlepower has been invented by a Stanford University professor and is expected to be used in the motion picture industry and for flood lighting airplane landing fields.

Albee Square in Brooklyn, New York, is lighted by eight General Electric high-intensity mercury-vapor lamps.

A small lamp two inches long and thinner than a lead pencil has been invented by General Electric which emits a 200 candlepower glare.

The use of small mercury lamps giving a green-blue light has been reported of aid to dentists when examining teeth. Tartar, film deposits, and abscesses can be clearly seen under this light.

The manufacture of arc rectifiers and oscillators uses mercury in increasing amounts. Primary batteries, storage batteries, and standard cells and amalgamated battery zincs together use up to 1,000 flasks of mercury per year.

Rectifier bulbs and control switches are other electrical uses. Control instruments that act as automatic control pyrometers, resistance thermometers, tachometers, or CO_2 meters are equipped with mercury switches of the make-and-break type in sealed glass tubes so there is no danger of sparks causing an explosion.

Compensating mercury recording thermometers that allow of tube lengths up to 150 feet with absolute accuracy are advertised by manufacturers.

Electrical recording flow meters use a steel bell floating in mercury to translate fluctuating pressures into a written record of performance.

Weightometers which weigh material being transported by a conveyor belt depend upon the use of a steel float in mercury for their accuracy.

High vacuum pumps for evacuating radio bulbs and the tubes of neon signs need mercury for their operation.

Thermometers, barometers, and compensating clock pendulums use a few hundred flasks of quicksilver per year.

Altogether these more modern uses of quicksilver for electrical and industrial apparatus use over 5,000 flasks per year.

Perhaps 1,000 flasks are used in the laboratories of the nation in general chemical work. Every chemical and technical magazine is full of notes on laboratory devices depending upon mercury for some part of their functioning. Regulators, gages, electrodes, pressure generators, liquid pistons, agitators, and seals for water soluble gases, are common uses to which mercury is put. Literally hundreds of clever devices utilizing quicksilver are used daily in the laboratories and every laboratory must have its supply of mercury as has every drugstore, hospital, doctor's, and dentist's office.

The manufacture of caustic soda and glacial acetic acid uses about 1,000 flasks per year. Boiler-cleaning chemicals that are put into the boilers of locomotives to eradicate scale and prevent erosion seem to have a steady sale and lately a device consisting of 2-glass containers filled with an "inert gas" and containing "treated mercury" has been put on the market to prevent scale and rust in automobile radiators. This device is also available for industrial applications.

Anti-fouling paint using mercuric oxide for painting ship bottoms is another well-known use. The sea water changes the oxide to bichloride which is poisonous and kills off marine growths on the hull.

The clever Portre Process of printing which uses mercury in conjunction with a simple attachment that can be added to

any job press to print planographic plates on a typographic press is still being developed and is making progress in the commercial field. With this process, prints can be made on heavy ribbed stock from a 200-line half-tone plate which is better than can be done by straight offset lithography.

The gas regulators, on bottled fuel like the familiar pentane, control the flow by means of a mercury seal.

New mercury boiler units were built during 1936 by General Electric Company at its shops in Pittsfield and Lynn, Massachusetts.

The development of mercury vapor for powerplant use called attention to its advantages for other heat-engineering uses. Oils are being advertised as being produced by a mercury process. Mercury vapor baths are used where temperatures higher than those used with steam baths are needed. Its low vapor pressure helps to avoid high pressure problems as well as problems of fire hazard in treating inflammable fluids. In chemical processes in which heat is generated it is used to remove the excess heat by boiling and so maintaining the process at constant temperature.

Mercury has found a new use in photography[13]. It has been found that photographic emulsions can be "hypersensitized" by exposing the dry film or plate to the action of mercury vapor. The process is a bit slow taking 24 to 30 hours at room temperature, but it has been found that it is not necessary to unroll spooled film for the treatments as the mercury vapor penetrates and sensitizes the entire film uniformly making the process practicable and convenient.

Cadmium has been used[14] in late years as a base for bearing metals. In the experimental work attending this development it was found that to some extent mercury could be substituted for cadmium. Alloys containing from 99 per cent down to 60 per cent cadmium were tried, the percentage of mercury ranging from 0 to 40 per cent, the other alloy constituent being 1 per cent nickel.

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[13] F. Dersh and H. Dürr. New Method for the Dry Hypersensitization of photographic Emulsions. Jour. Soc. Motion Picture Engineers. Vol. XXVIII 1937, pp. 178-186.

[14] T. E. Norman and O. W. Ellis. Properties of Alloys of Cadmium and Mercury with Small Percentages of Nickel. A. I. M. E. Tech. Pub. No. 850 Metals Tech. Vol. 4, No. 7.

Many other small and experimental uses might be cited, but those mentioned above are the main uses at present. New uses requiring large amounts of this liquid metal may of course be invented, but it is more probable that a multiplicity of small uses will be responsible for increased consumption in the future. Certainly quicksilver has already become an essential and indispensable metal in general industry.

MARKETING QUICKSILVER

The United States quicksilver producers are mostly in the West, but the "mercury" is mainly consumed in the East.

Shipment is by boat from San Francisco, Portland and Gulf ports, and occasionally by rail.

At most quicksilver plants the cleaned product is finally gathered in a cast-iron storage pot. Here it is carefully inspected to see that no dust, dirt, or water have dirtied it and that it presents a bright perfect mirror surface. This is a sensitive test as the least contamination with zinc, lead, or tin, etc., will dull the surface because of the oxidation of these impurities on contact with the air.

After passing inspection the quicksilver is carefully weighed out in lots of 76 lbs. net and this weight of quicksilver is then poured into a clean, dry iron flask, which is closed with a taper-threaded stopper lubricated with a little flake graphite.

The flasks are of various makes—wrought iron, pressed and drawn steel, cylindrical tubes with head and bottom welded on, etc. Flasks are used over and over again. They are included in the price paid for the contents and are bought back through dealers. They usually cost from 50 cents to $1.00 each.

Operators that are proud of their product paint a distinctive mark on them to aid in their identification.

Selling is generally done through brokers though some mines contract a part of their production directly to consumers. At present there are three or four brokers in San Francisco and one in Los Angeles that handle most of the first-hand quicksilver. In the East, there are two large and several small quicksilver brokers that handle most of the metal there.

In former years the producers generally sent their quick-silver to eastern brokers on consignment. This always gave

rise to trouble and delay and the cost of selling in this way was about $7.50 per flask.

In recent years the western brokers pay cash on delivery, say, in San Francisco and this price is some $5.00 to $6.00 below New York quotations. While the producer does not have the satisfaction of receiving the quoted price by this system, he does get cash at once and just as much if not more than he would have netted under the former system.

The price of quicksilver has been over $100 per flask four different times since production began in the United States. First in 1850, then in 1874, then during the war in 1916-1917 and 1918, and again in 1927, 1928, 1929, and 1930.

By decades the average price has been as follows:

1850-59	$60.50
1860-69	45.67
1870-79	60.01
1880-89	34.44
1890-99	40.11
1900-09	43.03
1910-19	75.06
1920-29	86.26
1930-36	77.90

Anyone continuously in the business of producing quicksilver for the last 26 years then has had an average price of better than $75.00 per flask in the United States.

Any United States producer that managed to keep his costs down to $50.00 per flask since 1915 would have lost money only in 1921 when the average price dropped to $46.07 per flask. If he managed to keep his costs down to $60.00 per flask since 1915 he would have lost money only in 1921 and 1922, 1932 and 1933, and only in 1921 would the loss have been substantial.

With costs at $70 per flask since 1915 his loss years would have been 1921, 1922, 1923, 1932, 1933, or only five years out of 22.

Costs of $50, $60, and $70 per flask can be obtained by good management at small (say 20 ton) quicksilver mines having ore running 10, 9 and 8 lbs. per ton on recovery. This allows a total cost of $6.00 to $7.00 per ton. Larger plants can of course treat lower grade ore than this at a profit.

Note in the above figures that the highest price for any decade was $86.26. Hence, anyone venturing into quicksilver

mining with the idea of making it a business should be guided by the 10-year averages of prices.

From the 1921 depression the price of quicksilver picked up as follows:

Year	Average Price
1921	$ 46.07
1922	59.74
1923	67.39
1924	70.69
1925	84.24
1926	93.13
1927	118.16
1928	123.51
1929	122.15
1930	115.01

This is a pickup in price of about $10 per flask per year for eight years after which it dropped through the next depression in 1932. Price recovery from this low has been as follows:

Year	Average Price
1932	$57.93
1933	59.23
1934	73.87
1935	71.99
1936	79.92
1937	90.18

Evidently this is a slower rise than from the last depression. From 1932 to 1933 it was less than $2 per flask. In 1934 the price took a good spurt exceeding the $10 mark by $4.50, but it fell back in 1935 then picked up roughly $10.00 both in 1936 and 1937. Note, however, that recovery started from a higher price in this last depression and that in 1937—the fifth year after the depression low—the average annual price was $90.00. In 1926, the fifth year after the depression low of 1921 the average annual price was $93.13 or roughly the same as for 1937.

The future price of quicksilver depends on the outcome of the revolution in Spain, on other undeclared wars both actual and threatening, and on the recovery of industry throughout the world. Conservative quicksilver miners who keep their costs down and their development work up will no doubt come through the future as safely as in the past, but venturesome operators who gamble on a $100 price must take their chances. We are inclined to admire their enthusiasm.

The Quicksilver Industry in Oregon

HISTORY

The reverberations of the gold-rush days of '49 in neighboring California were felt throughout Oregon. Settled by hardy, venturesome pioneers, Oregon sent many of its men to the "diggings" and, being experienced woodsmen and used to rough life in the open, many of them fared well and occupied leading positions in those exciting times. So it is no wonder that the quicksilver excitement of California at a later date should find its reflection in Oregon also.

The earliest discovery of quicksilver in Oregon as far as is known was at the Nonpareil and Bonanza mines of Douglas County in 1865. The Nonpareil was developed in 1877 and the Bonanza in 1879. Furnaces were built on both properties, but records of productions are meager.

An early settler in the Rogue River Valley found cinnabar in the "Meadows" of the Gold Hill district of Jackson County in 1878. Some production was made here with retorts in the following years and was sold locally to the placer-gold miners in the vicinity. There is no record of the amount produced. The only record of quicksilver production for Oregon in these years are 65 flasks in 1887, 32 flasks in 1888 and 20 flasks in 1889.

Then there seems to have been a long interval of time in which no quicksilver whatever was produced here. The fact that the ground was cinnabar-bearing was well known however, and transfers of parcels of land around 1900 describe the land as "valuable cinnabar mines". This area now comprises the War Eagle, Chisholm, and Dave Force mines.

The Black Butte mine in Lane County was discovered in the early nineties. A small amount of development work was done and then a 40-ton Scott furnace was built to treat the ore. In 1898, the late W. B. Dennis acquired the property and operated it until 1908. During his regime some 15,000 feet of development work was done and the mine was well-opened up.

The low-grade ore of the Black Butte mine in combination with the very resinous Oregon fir that was used for fuel made
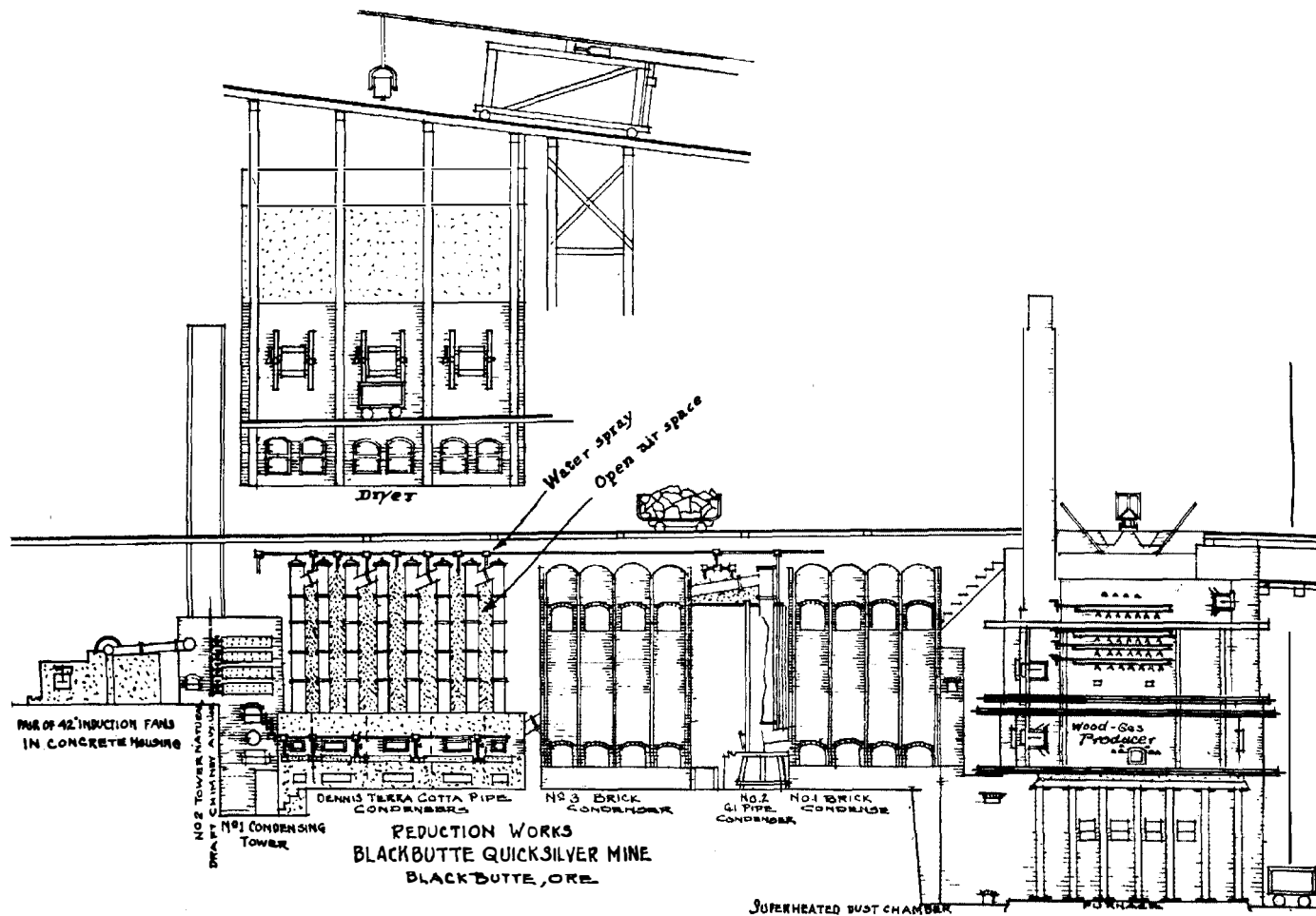
Figure 9—Elevation of old Black Butte plant.

the treatment of the ore anything but ideal. Seeking a remedy for these troubles, Dennis invented and patented a furnace (U. S. Patent No. 833679) with separate roasting zones in which a constant-temperature difference between ore and heating gases could be maintained. This was to increase the capacity by shortening the roasting time. He[15] also invented and patented a wood-gas producer (U. S. Patent No. 893462) in order to obtain a clean fuel from Oregon fir.

A small, experimental, Dennis furnace was built at Black Butte. It was operated for a few months in 1905 and aroused great interest. The roasting time was shortened from 24 to 4 hours, soot was completely eliminated and there was a considerable saving in fuel.

Lack of funds (the price of quicksilver averaged $36.22 in 1905) prevented the building of a full-size Dennis furnace. However, a down-draft wood-gas producer was built into the old Scott furnace and a tile pipe condenser system was added to the old brick condensers. This gas producer increased the capacity of the Scott furnace from 30-36 tons to 49-51 tons per day on practically the same fuel consumption.

This account of the Black Butte experimental work which the author obtained from Mr. Dennis himself many years ago is of great historical interest. The ideas that were worked out here were well in advance of the times and similar methods of using wood-gas producers were worked out in Europe at a much later time. Tile pipe condensers on the general principles developed by Dennis were used in the United States 20 years later.

Thus Oregon contributed to the general fund of knowledge on quicksilver metallurgy long before it had become an important producer of the liquid metal. An elevation of the old Black Butte Plant is given in Fig. 9.

The quicksilver of the Prineville District is first mentioned in 1906 when a production of three flasks was recorded for the Almaden Gold and Quicksilver Company at Howard in Crook County.

In 1908 mention is made of work being done by the Scotia Development Company near Drew.

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[15] William B. Dennis: Shortening the Roasting Period for Mercury Ores. E. & M. J. July 17, 1909, pp. 112-116.

No production is recorded for Oregon from the end of 1909 to the end of 1914. From 1887 to 1915 the total production of Oregon did not much exceed 1,000 flasks.

The next productive period in Oregon was during the World war. In this period from 1915 to 1920 inclusive the Black Butte mine was in production with its Scott furnace plant. The War Eagle mine operated by the Ranier Quicksilver Company produced with Johnson McKay retorts and later with a Scott furnace. Smaller mines and prospects also produced some metal and the total recorded production for the above mentioned period was about 1,860 flasks.

Then the activity in quicksilver mining died down again and only scattered production was reported to 1924.

By checking all available information from all sources it would seem that the total production of Oregon to the end of 1926 was close to 3,000 flasks of quicksilver.

In 1927 a new era of steady and continuous quicksilver mining set in for the state of Oregon. The price of quicksilver was over $100 per flask that year and it stayed above $100 per flask for the three subsequent years also. Aided by a high price the business of quicksilver mining in Oregon got off to such a good start that it weathered the recent depression and has produced an average of $275,000 worth of quicksilver each year for the last 11 years or a total for that time well over $3,000,000.

An interesting comparison of these first 10 years of steady Oregon production with that of the first 10 years of Texas production is given below:

TABLE 6

OREGON		TEXAS	
Year	Flasks	Year	Flasks
1927	2,082	1899	1,000
1928	3,759	1900	1,800
1929	3,657	1901	2,932
1930	2,919	1902	5,319
1931	5,011	1903	5,029
1932	2,523	1904	5,336
1933	1,342	1905	4,723
1934	3,460	1906	4,761
1935	3,456	1907	3,686
1936	4,126	1908	2,382
	32,335		36,968

In flasks produced, Texas was some 12½ per cent ahead of Oregon, but in value of the product the output of Texas was roughly only one-half or about 1½ million dollars to about 3 million dollars for Oregon.

GENERAL GEOLOGY OF OREGON

Before going into discussion of the various quicksilver districts of the state, it seems desirable to review briefly the general geology of Oregon.

Oregon is divided into two parts physio-graphically by the Cascade Range which extends across the state from north to south. It divides the state into a humid western and an arid and semi-arid eastern region, just as the Sierra Nevada farther south separates humid California from arid Nevada.

Speaking very generally, west of the Cascades the geology of Oregon is largely that of sedimentary rocks while east of them the igneous type of rocks predominate.

The northeastern part of the state is largely occupied by Snake River basalts which may be correlated with Columbia River basalts.

This northeastern area is bounded on the south by a mountainous uplift referred to as the Blue and Ochoco Mountains, running from the Idaho Rockies westward toward the Cascades through the east center of the state. The Columbia River basalts are Miocene in age, but in this uplifted area older rocks have been exposed by erosion.

South of this area, in the southeast part of the state, the geology is more nearly that of the Great Basin type found in Nevada although lava flows like those of the Columbia River basalts are found well down into Nevada.

The Willamette Valley in northwestern Oregon lies between the Cascade and Coast Ranges. The Cascade Range of Oregon continues south into California, where it is referred to as the Sierra Nevada. However, the Oregon Coast Range has its southern terminus about at the Coquille river, but is called the Coast Range again at points some distance south of the Oregon-California line. Occupying the territory west of the Cascades and extending to the coast in southern Oregon and northern California we find the Klamath Mountains.

These Klamath Mountains and the Sierra Nevada were formed at the end of the Jurassic or early in Cretaceous time when large intrusions of magma caused that country to rise.

Then during the Cretaceous times, Oregon and northern California sank and the sea came in over the land, as evidenced by the presence of marine sediments in some localities. As the land went down the Klamath Mountains became islands and the sea came around the north end of the Sierra Nevada through a strait at the present location of Lassen peak. Central Oregon was also covered by the sea. A period of erosion ensued in which the Sierra Nevada was worn down and the eroded material deposited as sediment in the Sacramento Valley.

At the close of Cretaceous time, the land was again elevated and the rocks folded—a diastrophic period which may have been contemporaneous with the Laramie revolution of the Rocky Mountain region.

Most of the present land surface was probably above sea level during Lower Eocene, and volcanic rocks were widely distributed. In late Lower Eocene the sea began to encroach upon the land, and reached its maximum extent in Upper Eocene, when it covered the coast area of the state east to a point beyond the present foothills of the Cascades. About the same amount of advance was recorded in Washington on the north and in California on the south.

In Oligocene time, the sea began retreating and exposing the land to erosion. By Lower Miocene time the coast line was even farther west than it is at present. In Middle Miocene, there seem to have been some minor subsidences in the coastal area, mainly in northwestern Oregon. It was about at this time that the great extrusion of Miocene volcanics occurred. The remaining geologic history is largely that of continental deposition until the Pliocene deposition of a series of conglomerates began. This culminated in the glacial deposits of the Pleistocene.

The geology of Oregon is not yet known in detail. Of particular interest are the comparatively recent volcanics. Some study of these has been made at Mt. Hood, Crater Lake, and the Three Sisters.

These volcanics are of interest to the quicksilver miner as all evidence tends to show that the quicksilver deposition occurred in late Tertiary or Quaternary time. For example, at

the Sulphur Bank Mine in California, ore is found in the Cache Lake beds which are Pleistocene in age. In the Aetna Mine in California ore is found in a decomposed basalt dike. In depth the columnar structure is normal to the sides of the dike, whereas at the surface it is vertical. The implication is that since the development of columnar structure is a function of the cooling of the dike material, that portion of the dike which shows the vertical columnar structure must have been at or near surface originally, and consequently that there has been little erosion since the deposition of the ore—a relatively recent mineralization. Again, at the Bretz and Opalite mines in Oregon and at the Cordero mine in Nevada the ore was deposited in lake beds of Lahontan age which is known to be Quaternary. At other mines on the west coast, evidence of former and present-day water tables also shows that little or no erosion has occurred since ore deposition.

Since it seems to be generally true of our western quicksilver deposits that they were formed by comparatively recent volcanic activity the prospector and miner is interested in finding evidence of such activity to aid his search for ore.

Such evidence lies in volcanic peaks and vents that have been active recently as shown by nearby ash deposits, lava flows, and above all by hot springs, mineral springs, or the sinter deposits left by such springs now no longer in an active state.

The thermal springs of Oregon, as far as known today, are described in U. S. G. S. Water Supply Paper 679-B and their relation to the quicksilver mines is shown on Fig. 1, reproduced from this paper. It must be remembered that these are only the active springs and the list is no doubt incomplete. The writer has added the location of one hot spring two to three miles southeast of the Opalite Mine (which was not listed). If all the mineral springs and sinters of former springs were added, the picture would be much more complete.

Note that a line drawn northwest and southeast through the Horse Heaven Mine on the north and the Opalite and Bretz region on the south passes along a great many hot springs and quicksilver mines. The region along this line then should be a good one to search for quicksilver deposits.

Note that another northwest and southeast line can be drawn through the quicksilver deposits in Douglas, Jackson and Lane Counties. Only one thermal spring (No. 25) is in line here, though the author knows of several sulphur springs along this general course.

Hot springs, of course, occur along major lines of faulting and when these major faults, with all their attendant springs, active and inactive, will have been completely mapped, it will be found that the quicksilver mines will lie along these same faults.

In California, which state has been more completely mapped in this manner, the concurrence is quite striking as it is also in Nevada around the edges of ancient Lake Lahontan[15].

Topographic maps are available for only a few of the quicksilver mining districts of Oregon and only one Geologic Folio (covering the Bonanza-Nonpareil District) of a quicksilver district is available. Two very helpful papers on Oregon quicksilver deposits are United States Geological Survey Bulletins, 850[16] and 846-A[17], both of which were prepared in cooperation with the Oregon State Mining Board.

OREGON QUICKSILVER DISTRICTS AND MINES

Ochoco District

A half circle having Prineville as a center, a 35-mile radius, lying east of Prineville, will just cover all of the quicksilver mines and prospects in this area—known as the Ochoco quicksilver district. It includes parts of Crook, Wheeler, and Jefferson counties.

Prineville, from where the mines can all be reached conveniently—though the road from Madras is more often used to reach the Horse Heaven mine—was named after Barney Prine, who lived there in a small one-room cabin on a 160-acre plot held by squatter's right.

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[15] C. N. Schuette: Lahontan Quicksilver E. & M. J. Vol. 134, pp. 329-332.

[16] U. S. G. S. Bulletin 846-A, Some Mining Districts of Eastern Oregon, by James Gilluly, J. C. Reed and C. F. Park, Jr.

[17] U. S. G. S. Bulletin 850, Quicksilver Deposits of Southwestern Oregon, by Francis G. Wells and Aaron C. Waters.

Barney Prine sold his right to Monroe Hodges, who came over the old Oregon Trail to Oregon in 1847. Late in 1870 Monroe Hodges filed a pre-emption claim on the 160 acres, which he had bought from Barney Prine for $25.00 and a pack pony. He proved up on his claim two years later, platted the townsite, sold and donated lots for business property. He himself built a livery stable, drug store, and meat market. Some of his descendants still live in the city he founded.

Prineville has an elevation of about 2,000 feet. The district lies in the westerly part of the Ochoco Mountains, and the mountain peaks range up to 6,600 feet in elevation on Lookout Mountain some 25 miles east of Prineville. In the mountains are fairly dense forests of pine, while sagebrush and juniper characterize the semi-arid lowlands.

Prineville is the terminus of the railroad. United States Highway 28, which runs from west to east through the state from Eugene to Ontario, passes through Prineville and many of the quicksilver mines can be reached from it. Others can be reached by way of the Crooked River Highway or State Highway No. 27.

HORSE HEAVEN MINE

This mine is owned and operated by the Horse Heaven Mines, Inc., a subsidiary of Sun Oil Company. The main office is in the Public Service Building, Portland, Oregon.

J. Edgar Pew is president, S. H. Williston is vice-president and treasurer, and E. E. Gardanier is general manager.

This most northerly mine of the Ochoco District is located in Section 12, T. 10 S., R. 18 E., in Jefferson County. It is reached from U. S. Highway 97 at Madras via county road to Ashwood 27.9 miles east, thence 15.9 miles further east over a dirt road. The road is rough, but fair in dry weather. It is difficult to travel on in wet weather. The mine has telephone connection to Antelope, 28 miles north by road and another road leads out to Mitchell on Highway 28 some 30 miles distant from the mine. Freight is hauled by company trucks.

The elevation of the mine portal is 3,250 feet. The climate is semi-arid without much snow or rain. It is a pleasant country, exhibiting a fairly old topography and sparsely timbered with juniper.
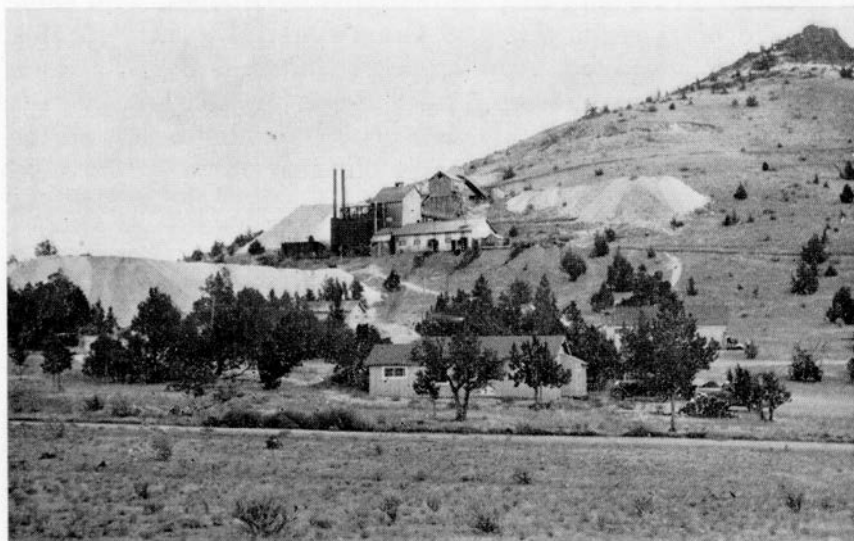
Photo No. 8--General view of the Horse Heaven Mine looking east. The glory hole that now marks the outcrop can be seen between the peak and the mine dump. Below the plant is the burned-rock dump.

From information given me by S. H. Williston, the mine was discovered and located by A. J. Champion in 1933. The discovery was made by panning in the saddle below the mine. Champion sold the prospect to C. C. Hayes and Ray Whiting for a small sum.

Hayes and Whiting being busy elsewhere, Ray Whiting, Jr., and his school chum, Harry Hoy, went to the claims to do some surface work. One day while eating lunch on the outcrop of ribbon rock on the side hill, one of the boys kicked off a piece of rock and thus found cinnabar in place.

The Crystal Syndicate was then formed in which the late Robert Betts of the Black Butte mine was given an interest to act as their advisor. Mr. Betts interested Captain E. W. Kelley, who financed the purchase of the Herreshoff Plant from the Maury Mountain Mine in 1934. Production began late in 1934 and the Horse Heaven Mine became the third largest Oregon producer for that year. The property was then sold to Horse Heaven Mines, Inc., in 1936.

It has produced steadily ever since 1934 and to the end of 1937 will have produced a total of some 4,500 flasks. This

makes Horse Heaven the fourth largest Oregon quicksilver mine in point of total production to the end of 1937. The writer estimates that in these three years some 20,000 tons of ore have been treated which would make the average grade of the ore about 17 lbs. per ton on recovery.

Dr. Lloyd W. Staples, the Horse Heaven geologist, informs me that he is now quite certain that the mine is in the Clarno formation. This formation is Eocene in age and lies unconformably on the Cretaceous and is in turn unconformably overlain by the Oligocene. The rocks of the region are chiefly tuffs, agglomerate, basalt, rhyolite and obsidian.

At the site of the mine a strong fault strikes northwest and southeast and dips from 30° to 45° southwest. This fault has a well-developed gouge. This gouge caps the mine. The rock under the fault is a fairly hard, silicified tuff, and in places is altered. The main crosscut-adit of the mine runs southwest into the hill and these tuffs as exposed in this adit dip gently northwest.

Above the fault, to judge by surface rocks, is a vesicular agglomerate. The outcrop is not prominent, though ore came

Photo No. 9—View from just below the glory hole towards the northwest along the Horse Heaven Fault. The fault crosses the saddle of the ridge. White flags in foreground mark diamond drill holes.

to the surface in a very limited area, now marked by glory holes.

The fracture pattern of the receptacle rock in which the orebodies occur is formed by fractures roughly parallel to the main or Horse Heaven fault and by other fractures roughly at a 45° angle to it. Silification took place before or during this period of fracturing, and brecciation occurred followed by mineralization and some silicification. Here again, we have the same condition found at so many quicksilver mines, namely, that the mineralization is preceded, accompanied by, and followed by silicification, or, as may be, that the mineralization is one phase of the silicification.

The system of faults at a 45° angle to the Horse Heaven fault strikes east and west and dips north as a general rule. These faults seem to have been the source-fractures through which the mineralizing solutions ascended until they reached the main fault gouge, which dammed and deflected them and they then rose under it on their way to the surface. This can be seen very clearly in No. 4 stope. In this stope the ore has been mined out on stulls, 6 to 10 feet high, just under the main fault-gouge. The strike is northwest and the dip varies from 35° to 40°. It is a most orthodox stope that has its counterpart in dozens of other quicksilver mines.

Lower down, however, that is, below and away from the main fault-gouge the shape of the ore bodies is controlled by the steeper source-faults. Brecciation is more in evidence here and the breccia has been recemented by a dark material in some places and by cinnabar in others.

Mineralization is quite as irregular in the Horse Heaven mine as in most other quicksilver mines.

No. 5 stope was being worked on square sets in October, 1937, and showed some very good faces of ore.

No. 3 stope at the second incline was in a local fold under a gouge and had very high-grade ore.

No. 1 stope extends from above No. 3 level down to No. 5 level and the ore is drawn out on No. 6 level. This was mined as a shrinkage stope, but was pretty well drawn down in October. The ore from this stope, the most productive in the mine, averaged about 25 lbs. per ton on recovery.

No. 2 stope, on the third level and below, lies under a wall striking east and west and dipping north. The ore from this stope ran about 11 lbs. per ton.

On No. 4 level near the station, a strong fault strikes east and west and dips south 35° to 40°, showing that strike and dip are quite irregular in different parts of the mine. A diamond drill was set up here taking a standard A-X (about 1½ inch) core. These cores are not assayed as they are taken more for the purpose of determining the formations than with the idea of finding ore. Some fifty 200-foot holes have been drilled and the cores are filed in a well-designed drill-core file.

On No. 4 level also near the winze, at survey station 16, some native quicksilver occurs in the ore.

No. 5 level was reached by going down the vertical winze from No. 4. Thus far, there are no stopes on this level as development has not been completed. Small streaks of ore said to be low-grade, that is under 10 lbs. per ton, were visible on this level.

No. 6 level, the lowest in the mine thus far, was also reached through the vertical winze. There was a little water on this level, but on the whole the mine is dry. Several good seams of cinnabar were visible on this level near station 44. Another quite obvious feature was a pronounced increase in the marcasite content of the ore.

On the fourth level and in several drill holes from the fourth level a basalt mass has been located which, according to Dr. Staples, may be an intrusive.

In a general way the ore bodies seem to pitch down in a northwest direction. It is difficult to become oriented in the mine as it has three inclined winzes, none of which run either on the dip, strike or pitch of the ore bodies. Level intervals are also irregular.

The outcrop is at elevation 3,310 feet. The portal of the main crosscut-adit is 3,250 feet. This is No. 1 level.

No. 2 level is a little distance lower
No. 3 level is 3,204 feet in elevation
No. 4 level is 3,164 feet in elevation
No. 5 level is 3,138 feet in elevation
No. 6 level is 3,106 feet in elevation

Thus the total vertical depth from the outcrop to No. 6 level is 204 feet and six levels serve to open this ground. Four systems of mining, namely, glory holes on the outcrop, on stulls and headboards in No. 4 stope, square sets in No. 5 stope and shrinkage stoping in No. 1 stope are being used.

The mine output is some 20 to 25 tons per day. Natural ventilation suffices in the mine and there is little or no water to handle.

Besides the diamond drill on No. 4 level a Sullivan "40" diamond drill is used for surface work. This is mounted on a truck and has been used to determine the position of the main fault.

The ore is hoisted up the various inclines. No. 3 incline connects No. 1 and No. 6 as the lowest and highest levels. An electric hoist pulls the ore up in standard 16 cu. ft. mine cars to No. 1 level. It is trammed out through the portal and here a small electric hoist pulls it up an incline to the head of the grizzly over the ore bin.

The undersize ore drops through the grizzly into the bin and the oversize is crushed in a 7x9 Blake-type Risdon Iron Works
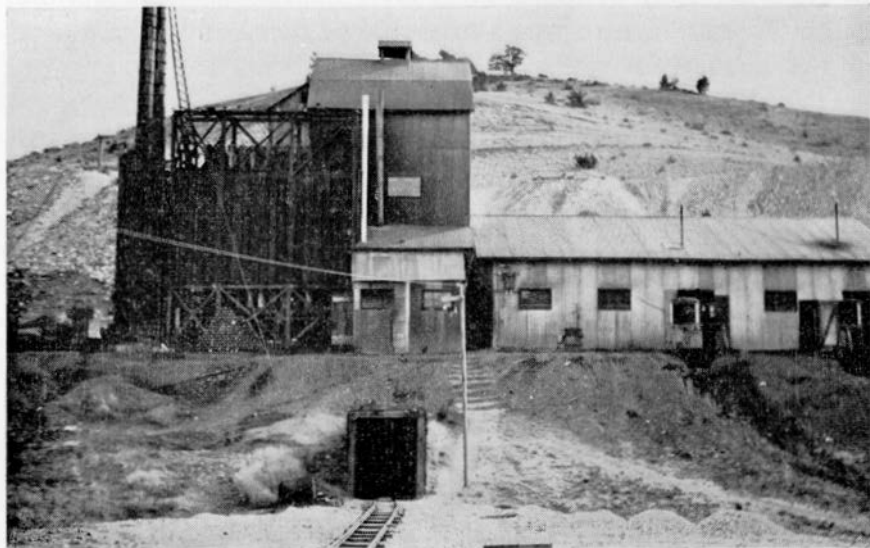
Photo No. 10—Close-up of the Horse Heaven Plant from the burned-ore dump. The tunnel in the foreground leads to the furnace pit. Power House is at the right.

Photo No. 10a—Close-up of the mouth of No. 1 Level of the Horse Heaven Mine.

crusher run by a 10 H. P. motor. Very little waste can be sorted out on this grizzly. Such waste as is sorted out is trammed to the dump in a 25 cu. ft. car.

From the bin, the fine ore is trammed to the furnace hopper in 16 cu. ft. cars. These are rated at 0.65 tons per car while the run of mine ore rates 0.74 tons per car.

The ore is grab sampled as it comes from the mine as panning is said not to be reliable for estimating the grade of the ore. Cut samples are taken in the mine. The Whitton method of assaying is used.

Reduction Plant: The reduction plant as stated before was bought from the Maury Mountain Mine. The furnace is a 4-hearth, 10-foot diameter Herreshoff. A steel hopper is suspended above it. The ore from this steel hopper feeds onto the center of the dry hearth by a feeder operated by the rotation of the center column. On the dry hearth the ore is rabbled toward the periphery to the feed hole through which it drops onto a plate and from which in turn it is scraped onto No. 1 hearth by a scraper attached to the rabble arm. The ore is rabbled inwards over No. 1 hearth, drops to No. 2 hearth through the center drop-hole, moves out again on No. 2 to outside

drop-holes, and so on until it is discharged through an outside drop-hole on No. 4 hearth into a concrete bin under the floor from which it is trammed to the burned-ore dump in 16 cu. ft. cars.

Two Hauck burners taking air from a Root's blower at 3 lbs. are used, one on No. 3 and the other on the lowest or No. 4 hearth. The firing-hearth temperature is kept at 1,500° F. on No. 4, 1,000° F. in No. 3, 800° F. in No. 2, and the temperature of the gases leaving the furnace from No. 1 hearth is 500° F. Fuel consumption is about 10 gallons of oil per ton and some 18 tons of ore per day are being treated.

The furnace draft is 0.2 inches and suction on the 6 x 6 Sirocco Dust Collector is 2.3 inches. Draft is induced by an 8-inch straight-blade fan running at 3,500 R. P. M. in the hot gases coming from the dust collector. The dust from the dust collector discharges into the burned-ore pit also.

A fan provides ventilation in the tunnel leading to the burned-ore pit as the discharge of the dust into this pit makes the operation of drawing too dusty without it.

As already stated, the gases are blown through the condenser system thus putting it under pressure instead of suction. The condenser system consists of two parallel vertical strings of cast-iron pipe. Between the condenser and the fan is a so-called surge tank. This has valves in it so that one string of the condenser pipes can be closed off while washing down. This idea is all right in theory, but in practice these valves become inoperative very soon after starting the plant and from then on the surge tank becomes quite useless and ever afterward the gas escapes around the wash-down hole each morning when the condenser is washed down.

The floured quicksilver washed down each day into cast-iron pots under the discharge U-bends is dried on a small soot-table heated by waste heat and is then bottled in the usual manner.

A General Electric mercury vapor detector is used in the plant regularly to test for leaks. On the whole, the plant presents a neat, clean appearance and operates smoothly with an alert and competent crew.

Power: Power for the mine and plant operation and for lights is generated by two 125 H. P. Caterpillar Diesel engines. One of these runs a Gardner Denver 7½ inch by 5¾ inch by 5 inch compressor at 870 R. P. M. The other runs a Westinghouse 30 KW—250 V., D. C. generator for the mine hoists, etc., and also a General Electric 60 KVA, 440 V., A. C. generator for lights and plant-drive with the exception of the furnace-drive which is on D. C.

The powerhouse also contains a shop with lathe, drill press, power saw, grinder, and a welding outfit.

In the shop also, as spare units, are a 66 h. p. 800 R. P. M. Foos Diesel engine which formerly ran a 15 KW, D. C. generator and a McCormick Deering 40 H. P. 1275 R. P. M. Diesel engine which formerly ran a compressor.

Water Supply: Water for the camp and plant is obtained from a spring some 4,000 feet from the camp. This water runs by gravity to a tank on a hill above the camp and from there, is distributed by gravity through the camp. A well in the camp (an old diamond drill hole) furnishes an additional supply of water by means of a gasoline-driven pump.

Camp: The camp is well built, has about 10 houses, an office, assay office, change room and boarding house. It is located in a little valley among juniper trees at an elevation of about 3,000 feet. The summers are hot, but there is little snow and rain in the winter months. The change house is equipped with flush toilets, showers, washstands, lockers, and a plentiful hot-water supply. The offices are well equipped. The business office has typewriters, files and adding machines and the engineering office has transit, plane table, and drafting equipment galore. The assay office not only has the usual sample crusher, grinder, Jones Riffle Sampler, balances, and assay equipment but also a petrographic microscope to aid in the geological work. Nothing apparently has been spared to make the camp as pleasant to live and work in as possible.

The operating crew consists of some 17 men. Wages are $4.50 to $5.00 per day. Compared to most small quicksilver mines the technical staff of the Horse Heaven mine is large and they have splendid equipment with which to work. The company has taken up a great deal of ground in the vicinity, but so far all the ore can easily be covered by one claim as is the case in most quicksilver mines.
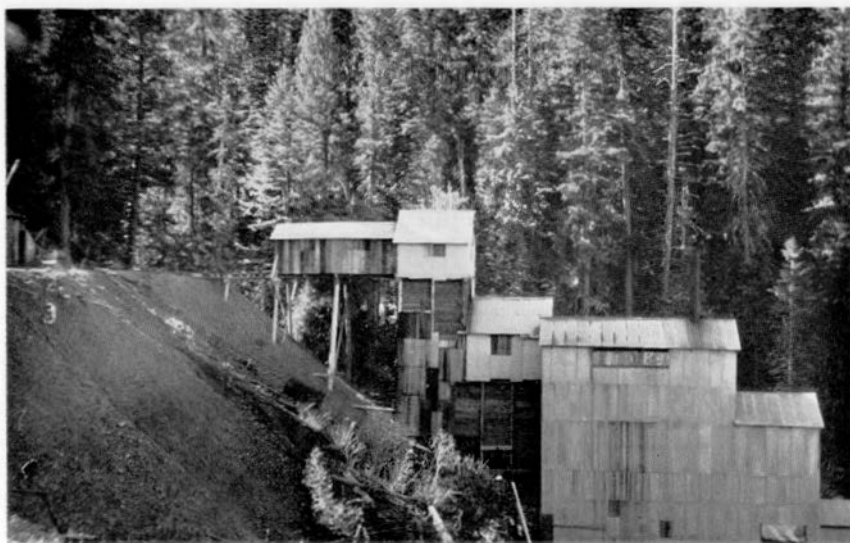
Photo No. 11—The furnace plant at Mother Lode Quicksilver Mine. Crook County.

LOUTHER PROSPECT

About five miles from the Horse Heaven mine towards Ash-wood there is a quicksilver prospect owned by Chas. Louther. A crosscut tunnel some 100 feet long runs to the ore and drifting has been started. It is said to have produced a few flasks.

MOTHER LODE MINE

This mine is some 32.3 miles distant from Prineville. The road is along United States Highway 28 for about 24.9 miles to a CCC camp and here a dirt road turns off up the hill behind the camp and runs to the mine some 7.4 miles distant. The mine is in Section 29, Township 14 South, Range 20 East, on the north slope of Lookout Mountain.

This property was first reported as a new producer in 1906 when it was credited with a production of three flasks. It was then known as the American Almaden mine and was operated by the Almaden Gold and Quicksilver Company. The location was given as Howard, Crook County. In 1908 it was credited with a small production from a 6-ton furnace. It was the origi-nal discovery of quicksilver in the Ochoco District. At a later date it was operated by the Quicksilver Consolidated Mining

Company and under this name it was described in United States Geological Survey Bulletin 846-A[15].

This Bulletin on page 122 shows a map of the workings as they existed at that time. At this time the mine was also referred to as the Canyon Creek Mine of the Consolidated Quicksilver Company.

Later the mine was taken over by Crams, Inc., and additional work was done as shown on Fig. 11. This company applied for and received a R. F. C. loan of $12,000 in 1935. The furnace plant was moved to below the mouth of the new or No. 4 Adit, from its former position at the Consolidated Adit. This plant is shown in Photo 11.

In October, 1937, the mine was inactive having shut down in September, 1936. The lowest or No. 4 Adit was open, but the others were caved. At present the R. F. C. holds the mine. The roads to the mine are practically impassible in winter so a shutdown in winter has been usual.

The plant consists of a small 2-foot by 24 rotary kiln having a cast-iron pipe and wooden barrel condenser. It is operated by a 15 HP Fairbanks Morse Company engine and can treat some 8 to 10 tons per day.

Ore is trammed out of No. 4 Adit to a grizzly over the bin, oversize is crushed in a Wheeling crusher, and from this bin the ore is fed to the furnace. The burned ore from the furnace drops into a pit from which it is trammed to the dump.

Production to date has been not much over 100 flasks. This is small considering the amount of work done and the poor showing is blamed variously on bad management, irregular ore, insufficient development, and development work in the wrong places. The mine does show good ore in places and if run by hard-headed experienced quicksilver miners might make a very much better showing.

INDEPENDENT QUICKSILVER MINE

On the road just below the Mother Lode mine is the prospect of the Independent Quicksilver Company. This was first worked in 1931 when 8 lb. ore was found at grass roots. Here diamond

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[15] J. Gilluly, J. C. Reed and C. F. Park, Jr.: Some Mining Districts in Eastern Oregon. U. S. G. S. Bulletin 846-A, 1933.

drilling was in progress in October, 1937. Some eight holes, 120 to 180 feet each, were put down and it was reported that only low-grade ore had been found.

JOHNSON CREEK MINE

Two miles from the Mother Lode mine on the road to Prineville another road turns off and runs down Johnson Creek. The Johnson Creek mine is 4.2 miles down this road from the turnoff. This mine was found in 1929 by W. J. Westerling who still owns it. It is located in Section 15, Township 14 South, Range 20 East, and is 31.9 miles from Prineville by speedometer reading.

This mine is described in U. S. G. S. Bulletin 846-A as the Paulsen and Saylor Mine. It was also known as the "International Mercury Inc."

Martin Paulsen and Evan Saylor leased the property from Westerling in April, 1930. During 1930 some 17 flasks were produced with a small retort.

In 1931, eight large D-retorts were installed in a bench with a common firebox much as a bench of pipe retorts is usually built. To judge by the appearance of the remains of this plant it must have cost as much as a small furnace plant would cost.
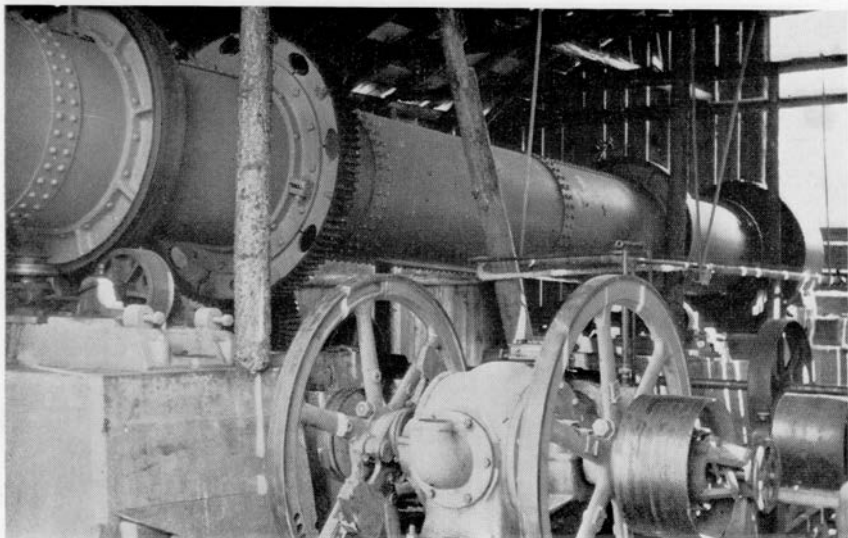
Photo No. 12—Rotary Furnace at the Blue Ridge Mine.

Photo No. 13—This shows the Condenser System of the Rotary Furnace shown in Photo No. 12. It was way too small for the size of the furnace.

These retorts were operated in 1931 and 1932 and with them the total production of the mine was brought up to about 250 flasks. Since 1933 there has been no production although mine development has continued.

The ore is found in highly altered rhyolite and the mineralized zone trends northeast, the ore occurring along fault fractures and fissures. Bulletin 846-A mentions only an open cut and one crosscut tunnel 120 feet long.

There are now three tunnels 125, 150, and 200 feet long, respectively, on the property, and another is being started lower down in the hill. Besides these workings there are a number of open cuts and short tunnels. Ore of good grade can be seen in parts of the workings and on some of the dumps. The mine has made a good showing for the amount of work thus far done on it.

WESTERLING PROSPECT

This lies in a flat on Johnson Creek about half a mile below the Johnson Creek mine. A side creek runs into Johnson Creek from the north at this point. There are no outcrops, but the occurrence of cinnabar has been traced in a northeast-south-

west direction by panning and drilling, according to W. J. Westerling who found it. Not much could be seen here in October, 1937.

BLUE RIDGE MINE

This mine is just over the hill from the Johnson Creek mine and on the same strike. It was found by Westerling also. In 1931 the Blue Ridge Mercury Company erected a plant, but to judge by the dump of burned rock it operated only a very short time. This plant is shown in Photos 12 and 13. Photo No. 12 shows the 4 by 40 kiln, a beautiful Allis Chalmers job. The engine in the foreground is a 20 HP Fairbanks Morse Company oil engine and another 10 HP Fairbanks Morse Company oil engine is available as a spare. An Ingersoll Rand Imperial type 14 compressor is also at hand. The furnace heads into a concrete dust chamber which is followed by a small cyclone dust collector and the very skimpy tile-pipe condenser system shown on Photo 13. The kiln was fed through a screw feeder.

The entire layout looks like a very amateurish imitation of a professional quicksilver plant and could never have operated satisfactorily. It could be made into a first-class plant for comparatively little money, however.

Western Resources Inc. was the successor of the Blue Ridge Mercury Company. Later in 1935 Oregon Cinnabar Inc. was organized with offices in the Vance Building, Seattle, Washington, and took over the property. This company was operating the Blue Ridge Mine in October, 1937. An 8 by 16 foot shaft, 100 feet deep, has been put down and about 100 feet of drifting had been done to November, 1937. A steam boiler furnished power for the hoist and compressor.

Two 10-pipe banks of retorts had been built to treat ore from development. These retort pipes were 16 inches in diameter and 9 feet long. The charge per pipe is said to be 500 lbs. The retorts are fitted with pipes to admit air to the charge while being burned. Photo No. 14 shows the headframe of the shaft and the retorts are barely visible in the building at the right.

High-grade ore can be seen piled up in the left side of the building and it *was* high-grade ore without doubt, though wet and sticky, and hence rather messy for retort treatment. For round pipes the retorts are larger than experience has shown they should be and admission of air to retorts has thus far only

worked well in inclined pipes. The furnace plant could probably have been put into operating shape for the cost of the retorts, and then the ore from development could have been treated in batches by intermittent furnace operation.

ROUND MOUNTAIN PROSPECT

Some three miles north of Johnson Creek, Westerling has another prospect. He located 10 claims here in 1933 and 1934 and calls this the Round Mountain mine. The workings consist of surface cuts along the outcrops and some 500 feet of tunnel work. Three dumps of ore in this prospect are said to run 8, 18, and 24 lbs. per ton respectively.

BEAR GROUP

Bulletin 846-A describes another prospect called the Bear group of claims near the head of Marks Creek in the southwest corner of Wheeler County. These claims are about 30 miles from Prineville via the Ochoco Highway and a 2-mile forest road, This location would place them some five miles and a little east of north from the Round Mountain prospect. In the summer of 1931 it was reported that an air compressor had been installed.

CHAMPION MINE

The name of Champion is connected with so many mines in this area that care must be taken to identify the Champion mine. Going out the Ochoco Highway from Prineville, there is a yellow Shell gasoline station on the right-hand side of the road, 22.3 miles out from Ochoco Inn. A road turns off to the right at the gas station and the Champion Mine is 0.6 mile up this road.

Unfortunately, A. J. Champion was away on a prospecting trip at the time of my visit and there was no one at the property.

A tunnel runs into a low hill and apparently connects with an inclined shaft or raise which collars at the top of the hill. Some 30 feet from this opening a vertical shaft or raise reaches the surface. Several surface cuts are farther along on the hillside.

The ore is brought out in mine cars and dumped on a 1-inch grizzly on top of the ore bin.

Photo No. 14—The shaft of the Blue Ridge Mine from which high grade ore was being hoisted for treatment in the retorts at the right. The man at the left is W. J. Westerling the discoverer of the mine.

Reduction equipment consists of a Joshua Hendy rotary retort run by a 5 HP 430 R. P. M. Sattley gas engine. To judge by appearance this retort has not been used very much.

Photo No. 15 shows the Champion plant. The Joshua Hendy retort is in the building at the right. Under the shed in the foreground is another rotary retort. It is a casting some 8 feet long and 3 feet outside diameter. It rotates on car wheels and the condenser pipe (visible in the photograph) is connected to the revolving retort by means of a stuffing box.

STALEY AND BARNEY MINE

This mine is about 20 miles from Prineville on the Ochoco Highway and half a mile north of it in the South ½ of the Northeast ¼, and North ½ of the Southeast ¼, of Section 7, Township 14 South, Range 19 East.

This is the mine described as the Champion mine in U. S. G. S. Bulletin 846-A. This mine was discovered in November, 1927, by A. L. Barney, A. J. Champion, and J. E. Staley. In February, 1928, two Johnson McKay pipes were purchased and by April retorting was in progress, and about 40 flasks were produced in 1928 and about the same in 1929. The property was then

bonded to the Cinnabar Mines, Inc., an Oregon corporation. They continued operation to the summer of 1933 and produced about 51 flasks in this time. In the summer of 1933 when the price dropped below $50 per flask they gave up the property. During the rest of 1933 and 1934 Staley and Barney produced an additional 18 flasks.

In September, 1935, W. J. Seufert acquired a bond and lease on the property and installed a small rotary furnace plant which is still on the property. The kiln is 30 inches in diameter and 30 feet long. The ore is fed through a rotary feeder. The plant has an iron-pipe condenser system. Between September, 1935, and June, 1937, 69 flasks were produced. The operation of the furnace plant was not entirely satisfactory from all accounts and it is reported that assays as high as 30 lbs. per ton have been obtained from the burned-ore dump.

The mine is now under lease to C. W. Cramer and is again on production. This group of claims or a part thereof has also been referred to as the Beardsmore mine, the Jimmie Ann mine, the Ochoco Mines Corporation or simply as the Ochoco Quicksilver mine, and as the Champion mine. Various parts of this

Photo No. 15—Reduction Plant at the Champion Mine. A. J. Champion, the owner of this mine, is the discoverer or co-discoverer of many of the quicksilver mines in the Ochoco District.
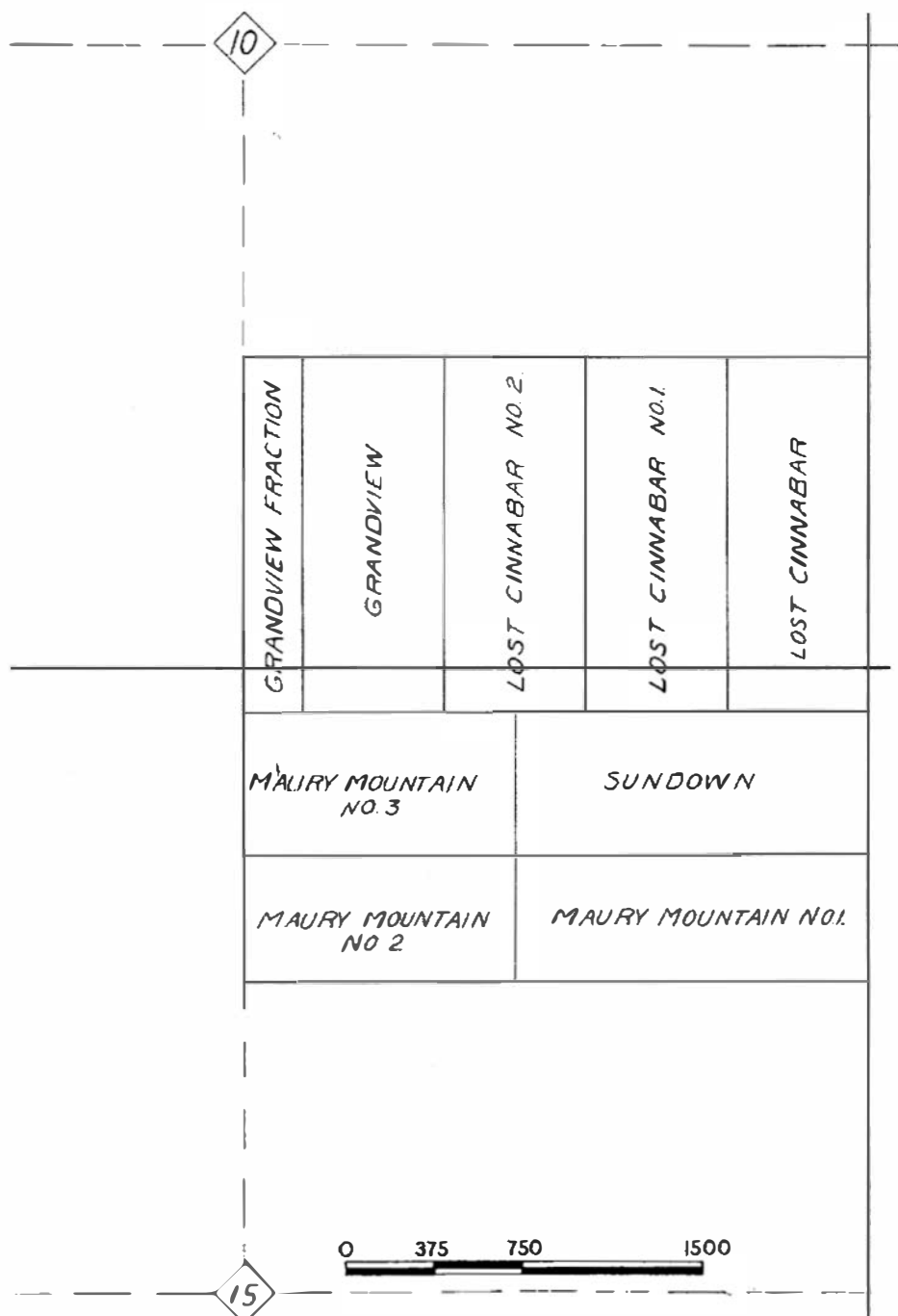
Figure 12—Claim map of Maury Mountain mine.

group of claims have produced simultaneously under different names.

The ore occurs along a shear-and-fracture zone in andesite. The general strike of the ore occurrence is north 45° to 55° east and the dip is southeast.

The hanging wall is definite, high-grade ore is found just under it and the ore grades off toward an indefinite footwall.

Considering its many difficulties probably due mainly to inexperienced operators, this group of claims has made a good showing thus far with a total production to the end of 1937 of about 253 flasks.

BYRAM-OSCAR MINE

This property, comprising some 120 acres, lies about 3½ miles nearer Prineville than the Staley and Barney Mine and on the opposite side of the highway. It is owned by the Byram-Oscar Co., of which H. F. Byram is president. It is developed by a shaft and 4 levels. A small production was made by retorts and a larger production was made by W. J. Seufert who operated the mine under a lease and reduced the ore in his rotary furnace plant on the Barney and Staley Mine. Total production is about 125 flasks.

MAURY MOUNTAIN MINE

This mine can be reached from Prineville via Post on the Crooked River Highway and is 33 miles distant by this route. A better road is by way of State Highway 27 south from Prineville to the Crooked River Highway and thence along this to Post and the mine. This is a longer route, being 45 miles from Prineville to the mine. The turn-off to the mine is 0.6 mile east of Post across a bridge over the Crooked River.

This mine was located by J. E. Staley and Frank Towner on Maury Mountain in the summer of 1930. The claims are located in Secs. 10 and 15, T. 17 S., R. 19 E. Fig. 12 shows the position of the claims on the ground, the original claims being those in section 10.

The Maury Mountain Mining Co. installed a 4-hearth 10-foot diameter Herreshoff furnace plant in 1932. This did not operate very long and produced only 51 flasks of quicksilver. The company ceased operation partly, no doubt, due to the falling price
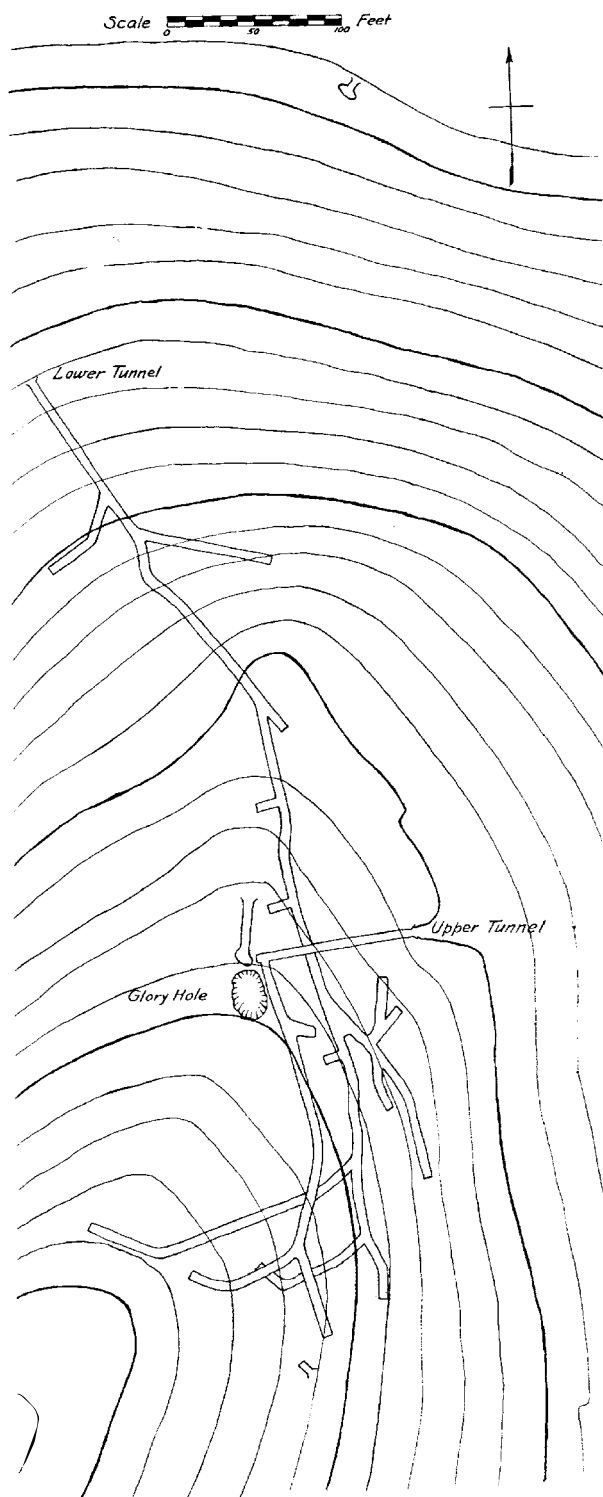
Figure 13—Plan map of Maury Mountain mine.
Contour interval = 10 feet.

of quicksilver in those years and in 1934 the plant was sold to the Horse Heaven Mine as related above.

Frank Towner now worked his claims of the group and the Staley claims were taken over by the brothers Fred C. and Herbert W. Eickemeyer who had been contracting the tunnel work for the Maury Mountain Mining Company.

The workings as they existed in October, 1937, are shown on Fig. 13. The strike of the ore occurrence is almost north and south with a steep dip to the east. The ore is in a volcanic rock probably an andesite and occurs in a crushed or brecciated zone having two fairly distinct walls. Cross fracturing occurs in the brecciated zone running northwest from the hanging to the footwall. Ore when found on the hanging wall of the crushed zone often crosses obliquely northwest towards the footwall on such fractures and may "make" on either hanging, foot, or in between according to the open space that was available for deposition.

Very rich ore is found in places and is being mined in an intelligent minerlike fashion. The ore is accompanied by a hydrocarbon locally called "gilsonite".

The ends of the upper and lower level that run southwest are on a mineralized cross fissure that strikes northeast-southwest and dips southeast.

Photo No. 16 shows a general view of the Maury Mountain mine, and Photo No. 17 shows the lower tunnel mouth.

The ore is treated in two rotary retorts one belonging to Frank Towner and the other to the Eickemeyer brothers. These retorts are shown in Photos 18 and 19.

Photo 18 shows Frank Towner at the drive end of his retort. Note the gas engine and the chain-and-sprocket drive. The condenser pipe is plainly visible as is the fan which keeps the retort under a ½ inch suction.

Photo 19 shows the charge end of the Eickemeyer retort. The rollers on which it revolves and the firebox beneath it are plainly visible. So are the inside cover and the hinged door. The two retorts are alike except in minor details. They are 24 inches, inside diameter, and 6 feet long. The Eickemeyer retort is driven by a 4 H. P. gasoline engine which also runs a small crusher. They burn ¾ of a cord of wood in 24 hours. The

Photo No. 16—General View of the Maury Mountain Mine. The building at the left formerly housed the Herreshoff Furnace Plant and now houses Frank Towner's rotary retort.
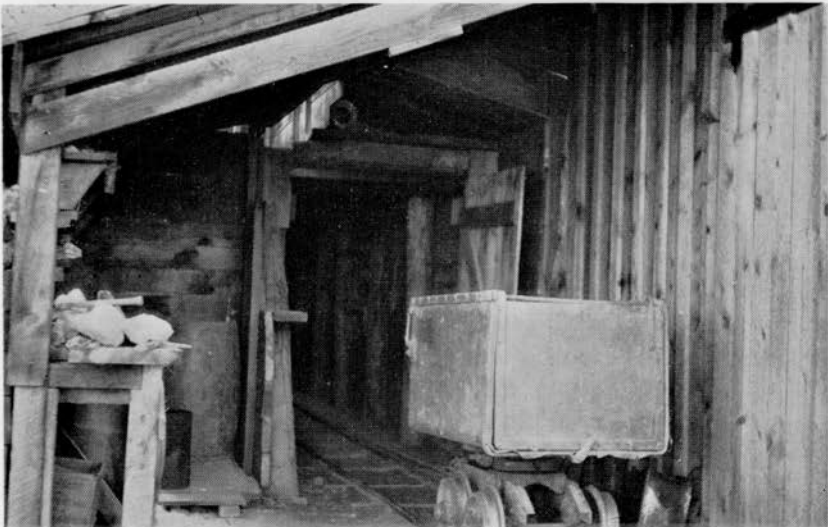

Photo No. 17—Mine entrance of the Maury Mountain Mine.

charge is 1,000 lbs. of ore and 4 to 6 charges can be burned in 24 hours so the maximum capacity is 3 tons per 24 hours.

These retorts are practical and economical small reduction units, well adapted for treating limited amounts of high-grade ore from prospects. The mine has produced 236 flasks to the end of 1937 and by far the larger part of this was made in these rotary retorts. The workings total about 1,550 feet so that about one flask of quicksilver has been produced for every 6½ feet of workings, not a bad record at all for a small mine.

PLATNER MINE

This mine is reached from Prineville via State Highway 27 and is 31.1 miles distant. The mine is 0.9 miles west of the highway. It is located in Secs. 18 and 19, T. 18 S., R. 17 E., on the hills west of Bear Creek. The topography is fairly old with low, well-rounded hills covered with a sparse growth of juniper. The country rock appears to be an andesite. A strong fault runs west of north through the country and silicification of the country rock along its course makes it stand out strongly as the ridge of a long low hill.

A crosscut tunnel some 500 feet long runs east into the hill to the ledge and then a 200-feet drift runs north.

Mineralizing solutions rising along this fault altered the wall rocks to some extent and deposited a little cinnabar. It is a strong outcrop, colored with iron oxides and cinnabar but to date no bodies of high-grade ore have as yet been found under it. No production has been reported to date.

DUNHAM PROSPECT

This property is north of the Platner in Sec. 31, T. 17 S., R. 17 E. (See U. S. G. S. Bulletin 846-A).

MINES IN SOUTHWESTERN OREGON
Meadows District

As related elsewhere, cinnabar was discovered in this district in 1878. This district is traversed from north to south by Evans Creek. Three properties have been productive, namely, the War Eagle, Dave Force and Chisholm. Evans Creek runs south through a valley half a mile wide and some 1,600 feet in elevation. West of the creek the hills rise steeply some 1,800 feet
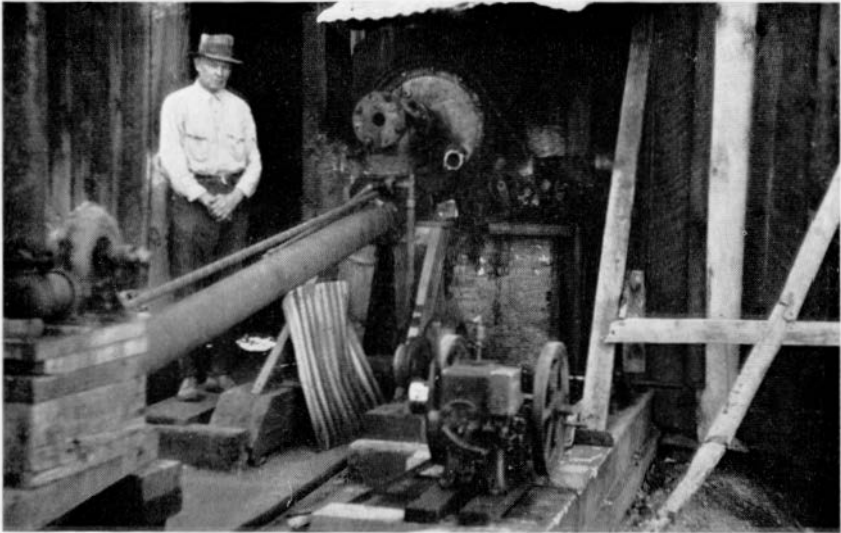
Photo No. 18—Frank Towner. co-discoverer of the Maury Mountain Mine at the drive and condenser end of his rotary retort. The little gas engine in the foreground furnishes all the power needed.

to the top of the ridge in which the War Eagle mine lies. The hill slopes are covered with a good stand of timber, mainly pine, fir, and oak. Water for drinking purposes is found in many springs.

The summers are hot and dry. Winter rains fall from November to April with an occasional light snowfall. Seasonal rainfall is about 12 inches. Medford is a convenient supply base and good labor is available at reasonable wages.

The rock formations having to do with the mines are only two, namely, the May Creek Schist which is thought to be Devonian in age, and the Umpqua formation of the Eocene Tertiary. The Umpqua formation, consisting of shales and tuffaceous sandstones, has been intruded by at least one basalt dike.

The May Creek Schist series of rocks varies considerably in its appearance and composition and has been intruded by a quartz diorite. In general the formation strikes northeast and dips southeast.

The Umpqua formation lies, unconformably of course, on the May Creek Schist. It strikes northeast also and dips north-

west at flat angles. Faults in the district are reported to be normal faults striking northwest and dipping northeast[19].

WAR EAGLE MINE

This mine is 26.2 miles north of Medford, Oregon, over the main highway, a county road and the last 3/5th of a mile over the mine road. The roads are good and the property is accessible at all times of the year.

Fig. 14 shows the present property bounds in Secs. 8, 17, and 16 of T. 34 S., R. 2 W., as well as the original claims which at one time were all included in the property.

Ownership of the property is now vested in a trustee for the bondholders of the former Medford Reducing and Refining Co. The chairman of the bondholders committee of five is Allan J. Postel, a banker of Mascoutah, Illinois.

The War Eagle mine was discovered in 1916 by Carl Burtelson. It was developed by the Rainier Mining Co. until 1919 when it was taken over by the newly incorporated War Eagle

[19] Francis G. Wells and Aaron C. Waters: Quicksilver Deposits of Southwestern Oregon. U. S. Geological Survey, Bulletin 850. 1934. p. 51.
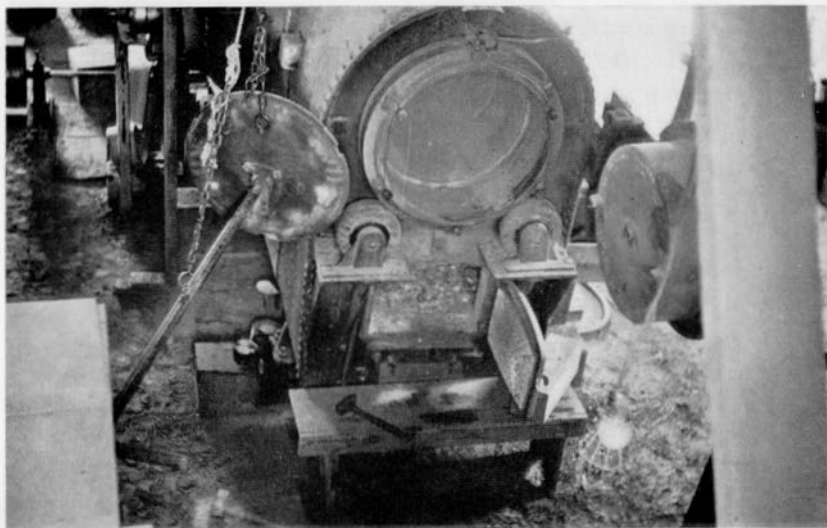
Photo No. 19—The fire box and charging end of the Eikemeyer rotary retort at the Maury Mountain Mine. This is the other end of a retort like the one in Photo No. 18.

Mining Co. During 1917 a Johnson McKay retort was in opera-
tion and 565 flasks of quicksilver were produced to August 11,
1920, according to a report of that date by Clifford Dennis.

Fig. 15 shows a plan and a longitudinal section of the mine
as it is today. At the time of Dennis' report, the stope under the
discovery shaft had been mined. The upper and lower tunnels
had been run. From the upper tunnel, drifts had been run 120
feet to the east and 100 feet west. Since then the east drift has
been extended some 40 feet.

From the lower tunnel drifts had been run east some 55 feet
and west for 160 feet. Since then the east drift has been ex-
tended 300 feet and the west drift has been extended from the
center of the stope to under the upper tunnel some 480 feet
and some 300 feet of work was done on a branch drift. Three
raises have been put up as shown on the map and a winze has
been sunk from the lower level.

A 25-ton Scott furnace plant was built on the property in
1920. It was a well-built plant and operated normally although
the operators seemed greatly troubled by the fact that arsenic
trioxide condensed with the quicksilver in the condensers. As
explained in the chapter on metallurgy this is unavoidable
when the ore contains arsenical minerals and the War Eagle ore
was known to have a large arsenic content.

The new plant was operated only a short time in 1921 as
this was a disastrous year for quicksilver mining in the United
States in which practically all our quicksilver mines were
forced to shut down due to low prices and inability to sell their
product.

By 1926 the affairs of the War Eagle Mining Co. had become
so involved that the property was sold under foreclosure to
satisfy debts and claims held against it.

It was bought by Bertelson, Harder, Kidd and Hilsinger.
They turned the property over to the Medford Reducing and
Refining Co. for stock and bonds of this company. This Medford
Reducing and Refining Co. was capitalized at $1,500,000 and
an issue of $160,000 first mortgage bonds were put out. This
company appears to have been largely a promotion scheme and
the property passed into the hands of the receiver in the spring
of 1928. The mine then became the property of the bondholders.

Total production to the end of 1937 is some 640 flasks. As most of this product was made in years of high prices the total value of the mine's output is about $69,000. Total tonnage treated was about 3,300 tons so that the average grade of the ore was 15 lbs. per ton. It is rumored that the production was larger but there are no figures available to prove it.

The workings total some 2,400 feet. Then about one flask of quicksilver has been produced for every four feet of workings thus far run.

This War Eagle mine on the War Eagle and Rainier claims is in the May Creek Schist, which strikes north east. The mine fault, in which the ore occurs, cuts through the schist with a strike of N 70° W as shown on the plan of the mine. In the upper workings the dip of the fault is steeply N E but it reverses at the lower level and is S W in the winze below it. The ore occurs in shoots between the walls of the fault. These walls are from 3 feet to 12 or more feet apart and are marked by distinct slickensides in hard tough fault gouge. The cinnabar has been smeared out on the slickensides by post-mineral movement.

The schist forming the wall rocks is a dense impervious rock and the rising mineral-bearing solutions which formed the orebodies were confined by it and by the fault gouge to the space between the walls of the fault zone. In this fault zone the schist was brecciated and a preliminary silicification deposited chalcedony in the voids of the breccia. Further movement of the fault brecciated this chalcedony and then mercury and iron sulfides were deposited from solution in the interstitial space of the breccia. The mercury sulfides deposited as the red cinnabar and the iron sulfides were deposited as pyrite and marcasite. The marcasite contans arsenic although no arsenical mineral has been identified. To judge by the striated surface of the slickensides the fault movement had both a vertical and horizontal component. Such a movement usually forms bodies of breccia, shaped like inclined flattened cylinders, which act as the receptacle rock for the ore.

In the War Eagle mine at least two such orebodies were formed and have been partially stoped. The mineralizing solutions rose in the fault zone because the impervious nature of the wall rocks and gouges prevented their dissemination. They
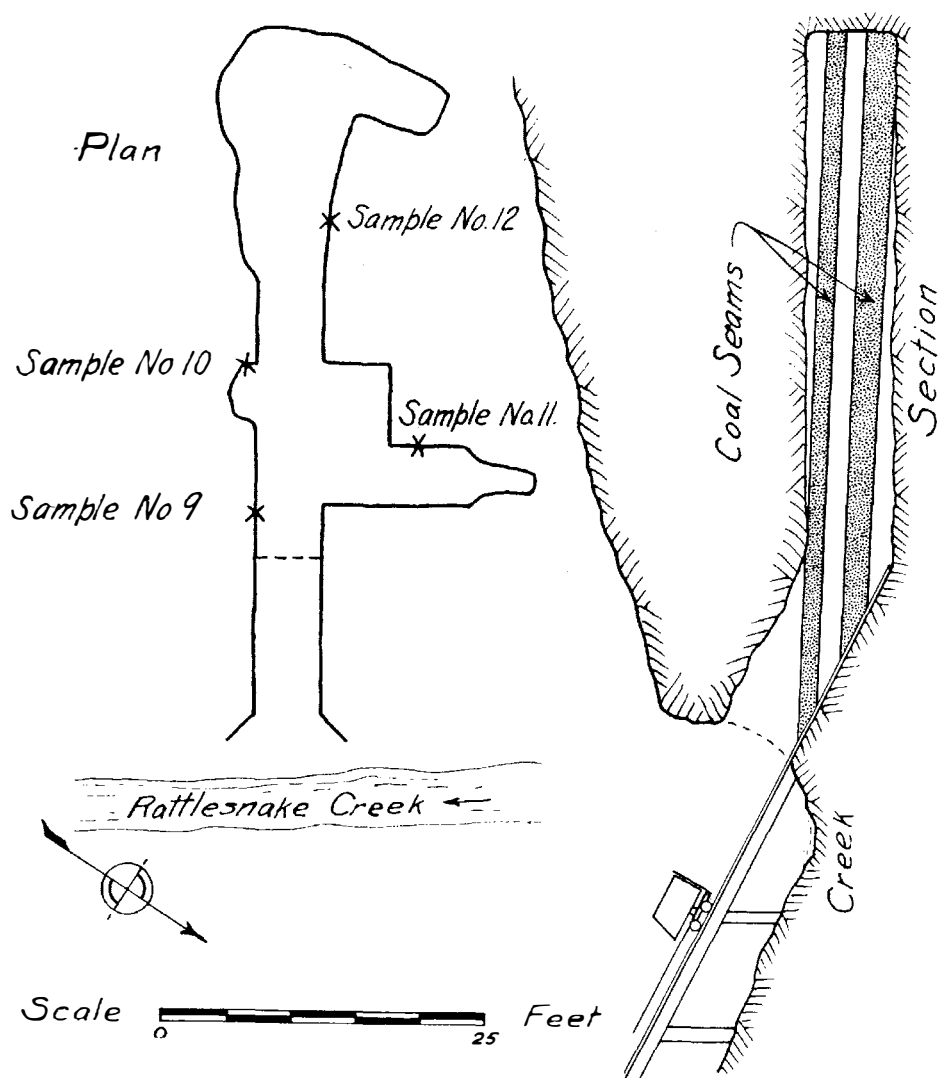
Figure 16—War Eagle Mine, plan and longitudinal section of coal seam containing cinnabar.

then carried their load of mineral matter into the interstitial space of the breccia and here their upward course was slowed down or they were trapped by overhead gouges and cooled sufficiently to precipitate the sulfides thus forming the orebodies. The workings shown in dotted outline under the discovery shaft are largely inacessible being partly caved and partly filled. Cinnabar could be seen on the wall slips and in seams in the back.

West of No. 3 Raise a narrow stope has been carried up on stulls. The east wall of this stope in the raise showed fair ore and ore can be seen in the back of the lower level.

East from these workings on the upper level the end of the level is in heavy sulfides showing no cinnabar. These are similar to the heavy sulfides occuring west of the ore in the lower level stope above the winze. The orebody on the lower level, at the winze, has been partially stoped above and below the level.

The east end of the lower level is in heavy sulfides again and is beginning to show faint streaks of cinnabar. The mining has been done in a rather slipshod manner due apparently to inexperience.

The oreshoots appear to rake or pitch down to the east at a rather flat angle. The cinnabar seems to be on the top and east side of the oreshoots while the heavy barren sulfides are on the bottom and west sides. This suggests that the cinnabar may have been deposited ahead of the other sulfides.

In 1936, Geo. Schumacher while prospecting down Rattlesnake Creek near the common corner of Sections 8, 9, 17, and 16, found cinnabar in a "coal" seam in the flat-bedded shales and sandstones of the Umpqua formation. This is shown in Fig. 14 as the Coal Area.

This coal area is south of the camp and below it in elevation. Here, Rattlesnake Creek runs southeasterly towards Evans Creek. The southwest side of the creek makes a steep 6-foot bank at the site of the new discovery. Here, a "coal seam" was exposed in the bed of the creek and on examination it was found to contain cinnabar.

A short inclined shaft was put down and a drift and some crosscuts were run from it. In August, 1936, the work was as shown in Fig. 16. The "coal seam" (actually a lignite) that out-
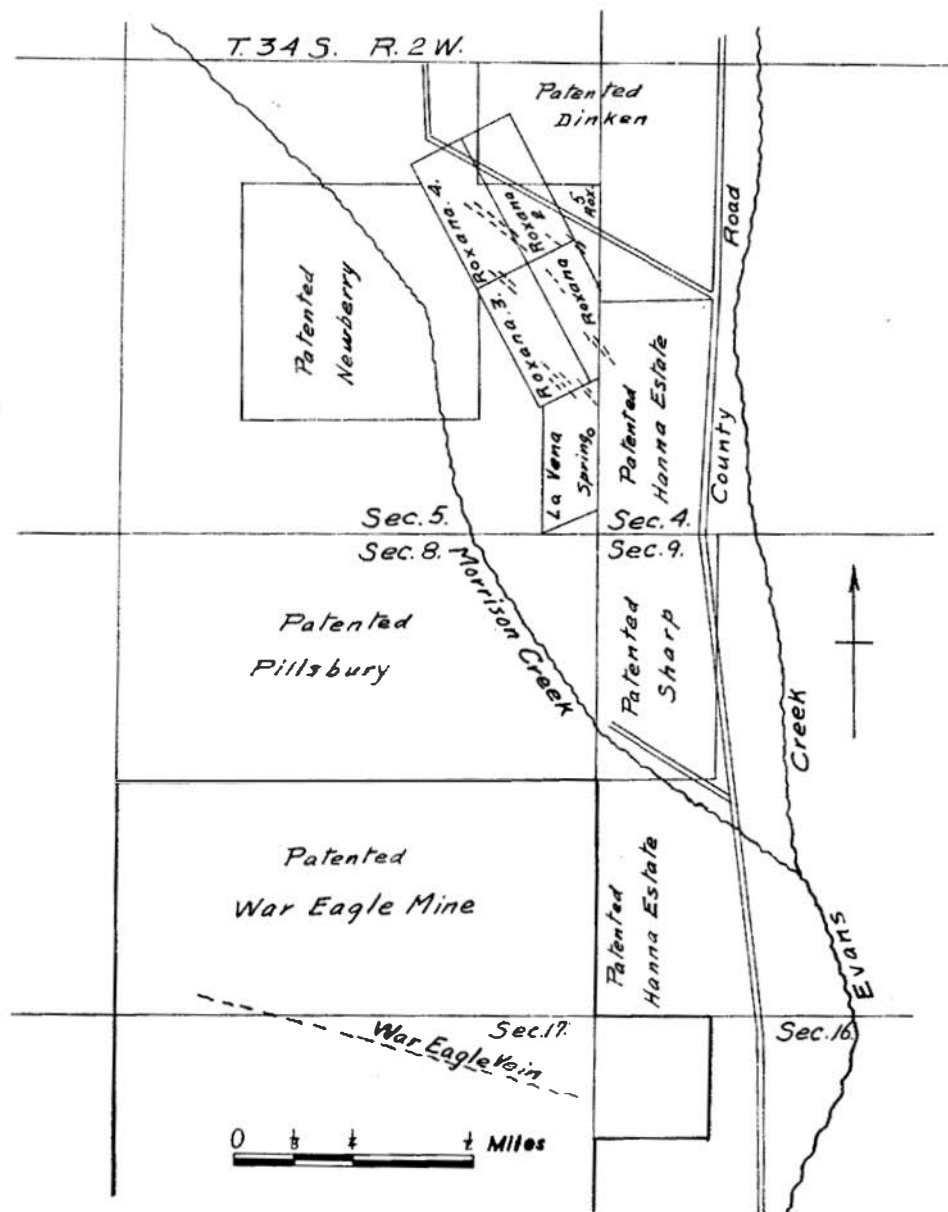
Figure 17—Property map of Roxana Group of Claims.

cropped was about 18 inches thick. Below this was a stratum of clay shale about 18 inches thick; below this was a coal seam some 24 inches thick and below this was clay shale for at least 12 inches.

The coal seams carry cinnabar while the intervening clay shale bands seem to be barren when panned. The coal seams vary in cinnabar content from place to place but as exposed they were nowhere barren and in places panned over 1 per cent in quicksilver.

In 1937 a new tunnel was started into the S.W. side of the creek some 200 feet below the discovery tunnel. This runs S.W. and then turns to the right parelleling the creek. This work exposes coal seams up to four feet thick in places that also carry cinnabar. The N.E. side of the creek has not yet been prospected for this coal seam.

In November, 1937, the work was being carried on with Gardner Denver drills, using Timken detachable bits. Air was furnished by a Gardner Rix 8 x 6 — 400 RPM compressor, driven by a 65 H. P. Waukesha 1000 RPM engine.

This work was being done by Mineral Mines Inc., which has the War Eagle property under option. The company office is in Seattle. Allan Parsons is president. Wm. Rosendahl was in charge of the work with J. E. Tyler in charge of the mining. A sawmill has been erected and ground has been cleared to put up a reduction plant invented by C. O. White of Seattle.

Photo No. 20 shows the inclined entry at the original discovery of the coal area. Photo No. 21 shows one of the miners cabins on the property.

Besides these two ore occurrences the so-called Big Dike Area along the top of the ridge south of the camp has cinnabar prospects. On top of the ridge is a white rhyolite tuff. In places a sharp offset, resembling a fault scarp, occurs. On the Ledge Pot claim a shaft has been sunk on this fault, the dump of which pans cinnabar. On the Homestake claim also there is a shaft and a tunnel the dumps of which pan cinnabar and show an occasional high-grade specimen.

Reduction Plant: The Scott furnace plant erected in 1920 has been partly torn down as can be seen in Photo 22. Part of

the firebrick and tile of the furnace has been used to build retorts at various sites on the property. The furnace could be restored but a new condenser would have to be built. This plant is just below the mouth of the lower tunnel shown in Photo 23.

The War Eagle mine is perhaps the only quicksilver mine in the United States that has an appreciable arsenic content in the ore. La Soterrana mine in Spain has a similar ore.

The arsenic vaporises on heating, as does the mercury, and it condenses as a gray powder in the form of arsenic trioxide. When retorting or furnacing these ores the arsenic trioxide powder and the finely divided mercury condense together and the mercury must be separated from the arsenic before bottling. In Spain the mixture was retorted with litharge yielding mercury and lead arsenate. Such a process would probably not pay here in the United States and it is better to waste the arsenic. Tests made on the War Eagle arsenical soot showed that the mercury could easily be separated from the arsenic trioxide by agitating the mixture in about 5 parts of water for half an hour, in which time the mercury droplets coalesce and the quicksilver can be drawn off ready to be bottled.

Since the arsenic is in the marcasite only, selective flotation would serve to remove the arsenic from the ore before it is roasted. Such a process has been developed for La Soterrana mine in Spain by Prof. Maurice Rey of the University of Liege in Belgium.

Some tests were made on War Eagle ore by the Rare and Precious Metals Experiment Station of the U. S. Bureau of Mines at Reno, Nevada, under the direction of Edmund S. Leaver. This investigation showed that the oxidized ore does not concentrate well by either gravity concentration or flotation. Leaching with alkaline sulfides was not thought feasible because of the acid salts in the ore.

The sulfide ore was amenable to selective flotation, using lime and alkaline cyanide to depress the pyrite. Recovery and ratio of concentration, it was found, would probably depend largely on the fineness of grinding.

ROXANA GROUP OF CLAIMS

North of the War Eagle mine in Sec. 5, T. 34 S., R. 2 W., is the Roxana group of claims owned by E. W. Hewitt, B. O. Force and H. H. Sharp of Beagle, Oregon. Fig. 17 is a sketch map of the location as furnished by Mr. Sharp. The claims are located on a well-timbered ridge between Morrison Creek and Evans Creek.

These prospects were discovered and located between 1919 and 1937. To date there has been no production as no retort has yet been installed on the property. All claims are held by location. The ore occurs in fractures in the May Creek schist and locally the wall rocks were altered by the mineralizing solutions. The ore-bearing fractures have a northwesterly strike.

La Vena claim has a good spring of water on it. On this claim ore is exposed by cuts for about 60 feet at the extreme north end.

Roxana claim has ore exposed by several cuts at the south end for a distance of 150 feet and this continues into the adjoining Hanna property. At the north end of Roxana several cuts expose ore for a distance of 200 feet approximately in line with the exposure at the southern end of the claim.

Roxana No. 2 claim has ore exposed by cuts at the south center of the claim for about 60 feet and also at the southwest corner which continues into Roxana No. 4.

Roxana No. 3 claim. On the south end of the claim, ore is exposed by several cuts over a distance of some 200 feet. At the north end a 100-foot tunnel crosscuts the ridge. 50 feet from the west portal ore was found and drifted on towards the south for 50 feet. This ore continues into Roxana No. 4. A stringer of ore was cut at the east portal of the tunnel.

Roxana No. 4. This has ore exposed by cuts over a distance of 800 feet and this runs across the sideline into Roxana No. 2 Some 60 feet below this ore, at the north end, another and parallel ore occurrence is exposed by open cuts.

Roxana No. 5. This fractional claim has ore exposed but it is not certain whether this is ore in place or a slide from the claim above.

The cinnabar is the heavy crystalline variety and some beautiful specimens of "solid cinnabar" have been obtained.
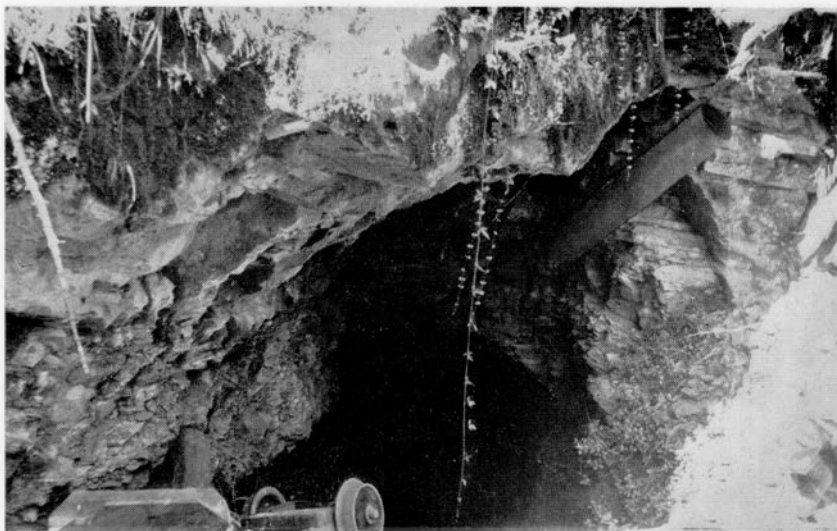
Photo No. 20—War Eagle Mine. The incline at the original discovery of the "Coal Area" in the bank of Rattlesnake Creek.

Photo No. 21—One of miner's cabins at War Eagle Mine. Jackson County, Oregon.

DAVE FORCE MINE

This lies south of the War Eagle in the northeast corner of Sec. 20, T. 34 S., R. 2 W. and was at one time covered by some of the claims of the War Eagle group as shown in Fig. 14.

The mine is well described and a plan of the workings is given in U. S. G. S. Bulletin 850 Plate 21. No additional work has been done since then. Plate 21 of Bulletin 850 shows the Umpqua-Quartz diorite contact of the left crosscut of Adit No. 1 as being 25 feet in from the fault. It should be 25 feet in from the end of the crosscut. It also shows the end of No. 2 Adit as being in quartz diorite. This is not so as the end is Umpqua formation but some 25 feet back from the end a small peak of the quartz diorite comes up into it and here under a flat gouge there are colors of cinnabar in it, though Bulletin 850 states on page 53 that the Umpqua formation and granodiorite show no signs of mineralization whatever. The mine as developed does not expose any ore whatever in the workings and the total production is a few flasks at most. The croppings on the surface are in a greatly decomposed and altered rock and, to judge by pannings, may constitute low-grade ore.

CHISHOLM CLAIMS

These lie in Secs. 17 and 20, T. 34 S., R. 2 W., and are owned by the Chisholm Estate. The late Dr. W. P. Chisholm acquired this property about 1900 and added to it from time to time until he held over 20 claims on both sides of a steep ridge. These claims have been prospected by many pits, cuts, and short tunnels all of the latter in the Umpqua formation though the May Creek Schist is only a short distance west.

The country is well timbered and the surface is covered with the usual heavy soil. The Little Jean claim had a small stope of high-grade ore but most of the other exposures show only low-grade material. Total production to date is probably 30-35 flasks. At present this property as well as the Dave Force mine is under lease to Geo. Schumacher.

Tiller-Trail District

This district running from Deadman Creek some six miles north of Tiller, to Trail on the Rogue River 25 miles to the south, has many quicksilver prospects. It is a rough, rugged country ranging in elevation from 1,000-1,400 feet in the river valleys to 4,000 feet on the mountain ridges. A topographic map of the area is available in the Ashland-Oregon Sheet of the U. S. Geological Survey. This is a reconnaissance map on a scale of four miles per inch. The Tiller-Trail area is in the upper left-hand corner of the sheet though neither Tiller, Drew nor Trail are shown on the map. Tiller is situated where Elk Creek runs into the South Umpqua River, Drew where Drew Creek empties into Elk Creek, and Trail where Trail Creek empties into the Rogue River. Most of the mines are inaccessible to automobiles after the rains start. A new state highway is being built from Trail to Canyonville and this, when finished, should help the district greatly. This region is heavily timbered and hence it is difficult to determine the rock formations.

The main mines and prospects in this district are the Buena Vista, Maud S, Pollanz, Red Cloud, Nivinson, Ash, Poole, and Red Chief. The general geology of the district and these prospects are well described in U. S. G. S. Bulletin 850. The field work for this Bulletin was done in the summer of 1930. The author was unable to visit the mines in this district in November, 1937, because the rains had made the roads impassable.

Of the properties listed above, Bulltin 850 listed the Buena Vista and Maud S as having produced a few flasks each.

Since then at least one other property known as the Mother Lode Mine (not to be confused with the Mother Lode Mine near Prineville) on Cow Creek has had further work done on it, and has produced some 35 to 40 flasks of quicksilver.

This Mother Lode Mine on Cow Creek consists of the Red Cloud, the Thomason Prospect located in 1931, and the Mother Lode. These three claims (or claim groups) were acquired by the Research Mining Co. Development work was carried on in 1932 and 1933 and 30 flasks of quicksilver were produced with a 3-pipe retort. In 1934 the property was idle. In 1935 the property was bought by the late Dr. Russel Keizer and a few flasks were produced from his operation.

There is an open cut on the outcrop. Below this is a 70-foot adit showing cinnabar in the last 30 feet. 50 feet below this adit is the lowest adit some 160 feet long and showing cinnabar in the last 60 feet. There is an intermediate adit the last 20 feet of which show ore and from the end of which a raise runs to the upper adit. A raise run up 54 feet from the lowest adit, missed the upper adit as it was on a parallel vein 12 feet from the ore in the upper adit.

The ore between the upper and lower adits varies from 0 to 3 feet in width. It can be sorted to a 30 lb. per ton furnace product. A small 3-pipe retort capable of treating 600 lbs. of ore per day is on the property. The mining was done mostly by hand drilling although a compressor was used for a short time. The workings are closely timbered.

Some eight full claims and one fractional claim comprise the Nivinsen property now held by Dr. Faucett, and some of the Lew Thomason claims overlap some Nivinsen claims.

BONITA MINE

This prospect lies between the Red Cloud and War Eagle localities in Sec. 13, T. 33 S., R. 3 W. H. S. Musson of Beagle, Oregon, is the majority owner and Allan Mayhew holds a substantial minority interest in the property which comprises six lode claims.

Most of the development work has been done on one claim. The ore occurrence has been traced along the surface by pits for some 2,000 feet in a N-S direction. At each end of this area, drift tunnels have been run in the ore. No. 1 Tunnel runs north into the hill for 230 feet and No. 2 Tunnel runs south for 110 feet. No. 1 Tunnel will develop 150 feet of backs while No. 2 is lower and will develop 450 to 500 feet of backs.

100 feet above No. 2 Tunnel a Crosscut tunnel has been run west for 180 feet and gives 150 to 200 feet of backs.

The vein on which this work was done strikes 10° west of north. It has two distinct walls and is about four feet in average width.

A 3-pipe retort has been erected but is not yet in operation so there has been no production to date. There is one dump containing some 250 to 300 tons of ore that runs 13 to 14 lbs.

Photo No. 22—The old Scott Furnace Plant at the War Eagle Mine.

Photo No. 23—Mouth of the Lower Tunnel of the War Eagle Mine.

per ton by assay and a retort test. Another dump of about 500 tons is said to run ¼ per cent.

The camp has cabins and a bunkhouse. A 25-ton bin has been built and a 20 by 80 foot mill building contains a 10-ton mill and a ¾ Gibson concentrating table set up to be run by a Fordson tractor.

The road to the mine is along the highway for eight miles from Trail to the new CCC road then along it for 9½ miles and then 1½ miles further by mine road, or about 19 miles from Trail.

OTHER PROSPECTS FARTHER SOUTH

The Birdseye Creek Mine in T. 37 S., R. 4 W. is said to be equipped with a flotation mill and retorts.

In T. 36 S., R. 2 W., and in T. 35 S., R. 2 W., cinnabar prospects are known near Table Rock and in Sams Valley toward Ramsey Canyon. Here the Mountain King mine, owned by a Mr. Hays, was in operation for a few years between 1910 and 1916.

In T. 34 S., R. 2 W., is the Cinnabar Mountain or Tainer and Webb Mine between the Dave Force Mine and Beagle. This property was acquired by Frank Tainer and M. B. Webb about 10 years ago. Altogether they hold five claims. There are two cabins, a blacksmith shop, compresser and three rotary retorts on the property. They have produced about 15 flasks.

Between Talent and Ashland, in T. 38 and 39 S., R. 1 W. and R. 1 E. there are cinnabar prospects and traces of cinnabar have been reported at various places from here south past Squaw Lake to the California line. From Wagners gap the mountain slopes towards the Little Applegate River and a trail leads down to an old quicksilver mine said to have produced in 1876. Remains of an old retort tend to support the story. This property now belongs to the Oregon-Montana Milling and Mining Co. and lies in Sec. 9, T. 40 S., R. 1 W. There are a number of old tunnels and shafts and open cuts on the property.

Another property in Sec. 24, T. 34 S., R. 2 W., is that of Sagar and Hull. This is on the opposite side of Evans Creek from the War Eagle. Years ago a 60-foot tunnel was run and a 40-foot

shaft was sunk. The water issuing from the tunnel is strongly acid like that of the War Eagle mine and the ore on the dump is similar to its heavy iron sulfide-cinnabar ore.

Another quicksilver prospect is located near Steamboat Mountain in T. 40 S., R. 4 W., and can be reached via the Thompson Creek road south from Applegate. Both a retort and a revolving furnace are said to be on this property.

Nonpareil-Bonanza District

This quicksilver mining district lies in northern Douglas county and the two most important mines, namely, the Nonpareil and the Bonanza are 8.2 and 7.9 miles east from Sutherlin respectively. Sutherlin is a station on the Southern Pacific Railroad and is on U. S. Highway 99. The road from Sutherlin to the mines is good and the mines are accessible the year round.

The geology of this general area is covered in the U. S. Geological Survey's No. 49, or Roseburg Folio. The topography in the vicinity of the mines is fairly old with smooth well-rounded hills rising to elevations of some 2,000 feet above the valley floor which is some 800 feet above sea level in elevation. Relief is due to differential erosion.

Both mines are in the Umpqua (Eocene) formation which here consists mainly of shales and sandstones with some conglomerate. The general strike of these shales and sandstones in the mines is N. E. and the dip is S. E. The mineralized strata, mostly sandstones, are marked by alteration of the rocks probably caused by the mineralizing solutions. Roughly paralleling the mineralized strata a short distance on the S. E. the Roseburg Folio shows a large mass of "diabase" supposed to be partly intrusive and partly extrusive in origin. U. S. G. S. Bulletin 850 however maps this "diabase" as basalt flows, beds of palagonite tuff and breccia, and conglomerate, and places these in the Umpqua formation.

Some three miles northwest of the mines are diabase dikes having a strike parallel to that of the mineralized zone. They are definitely post Umpqua and stand almost vertically. It is possible that the mineralization was associated with similar dikes deeper down along the zone of rock alteration. This zone of rock alteration extends from the Sutherland Mine in Sec.

20, T. 25 S., R. 4 W., northeast into Sec. 6, T. 24 S., R. 4 W., for a distance of over seven miles. This latter location is known as the Butte prospects. A little work has been done both on the Sutherland and Butte prospects but no production has been recorded from either one. Another quicksilver prospect has been reported to be at Glide some eight miles S. E. of the Nonpareil-Bonanza area.

NONPAREIL MINE

U. S. G. S. Bulletin 850 shows a topographic map of the mining area and a map of the old mine. The early history of the mine has been mentioned. Production from the work in the 1870's was not large. In 1928 the Nonpareil Quicksilver Co. began development work, and in 1929 and 1930 crosscut adits were driven N. W. into the hill some 2,000 to 3,000 feet north of the old mine. Some of these are reported to have shown good ore but as usual the ore was very irregular. As early as 1928 the claim was made that some 5,000 tons of 5 lb. ore were broken in the old mine and that 25,000 tons more had been exposed on three sides and that 25,000 tons more were exposed on one side, all of this being in the old mine.

In any case development work was reported as being done by the C. M. Everett Company of Seattle in 1929, by the Sutherlin Cinnabar Company in 1930, and in 1931 it was reported that the Nonpareil Quicksilver Corporation was about to build a furnace. At this time it was reported that 20,000 tons of ore were blocked out.

This plant which was built late in 1931 shipped its first quicksilver to market early in 1932.

The plant was a 4-hearth 10-foot diameter Herreshoff furnace with cast-iron pipe condensers and practically identical with that erected at Maury Mountain and later moved to the Horse Heaven mine.

Apparently the grade of ore developed had been over-estimated and this in addition to the low prices of 1932 and 1933 did not allow of operation at a profit.

The plant was sold and moved to a southern California mine, and no work has been done on the property since then.

BONANZA MINE

This mine lies in Sec. 16, T. 25 S., R. 4 W. Bulletin 850 shows a contour map of the hill in which it lies and shows the location of the prospect tunnels in existence in 1930.

Since that time two additional adits, Nos. 10 and 11, have been driven to the ore zone as shown in Fig. 18, which shows the mine workings as of the end of 1937.

In 1928 the Bonanza Mine was held by J. W. Wenzel, F. S. Skiff, and C. Scherer. The existing workings were sampled and disclosed a considerable tonnage of low-grade ore.

In 1931 control passed to the Northwestern Quicksilver Company of which Wenzel became the manager. Development work was done but construction of a plant was held in abeyance probably due to the depressed state of the industry.

In 1934 it was reported that H. W. Gould & Company had optioned the property and were doing development work. No plant was built, however.

In 1935 J. W. Wenzel sold out his interest to H. C. Wilmot. Early in 1937, H. C. Wilmot bought two Herreshoff furnaces that had been used in experimental work by the Santa Cruz Portland Cement Co. A reduction plant using some of this equipment was designed for the Bonanza Mine by C. N. Schuette of San Francisco. It was erected during the summer and began operation in October, 1937.

The outcrop of the mine is not prominent. It strikes a little east of north and runs along the east sidehill slope of a ridge having a north and south trend. The dip of the ore zone is about 40° east. The ore is found in a bed of altered tuffaceous sandstone, formerly mistaken for an altered andesite, overlain by shale. In places at least this has the appearance of being a fault contact and a fault gouge forms the hanging wall at these points. At other places shale forms the hanging and evidence of movement is not so clear. The footwall is not distinct in that it is a commercial footwall that must be determined by assay. From the hanging wall, cross fractures run out approximately at right angles to the strike; running from these to the south are small fractures roughly parallel to the strike of the hanging wall.

The ore deposition is governed by this fracture pattern, the ore being better close under the hanging and close to the cross fractures and grading off from the hanging to the west and from the cross fractures to the south.

Development has been by drift and crosscut adits as shown in Fig. 18. The early production in the 1870's came from the Glory Hole in the outcrop. No. 1 adit develops over 200 feet of backs and the hanging and foot are just outside of the drifts near the end of the adit. Assays show the full 90-foot width of the ore zone to average 3 lbs. quicksilver per ton. A 17-foot width on the hanging wall ran 6.5 lbs. per ton and a 6-foot width on the footwall averaged 9.3 lbs. per ton according to the assay maps made in 1928. The hanging wall drift averaged 11 lbs. and the footwall drift ran 9.3 lbs. of quicksilver per ton. No. 11 adit has cut the hanging wall but has not yet crosscut the ore zone. No. 10 adit has crosscut the ore.

The South Cut assayed 6.8 lbs. across the west face, but floor samples from 14 to 60 lbs. were taken in this cut which gave the highest samples in the mine.

The present production is coming from No. 7, 8, and 9 workings where stoping is in progress on the sides of the raises shown in Fig. 18. The levels are being extended north, then raises are run up and stoping follows on stulls and headboards. The rock is fairly "tight" so that in general only low-grade ore could form but occasionally rich seams of high-grade ore are found when the mineralizing solutions found open fractures in which to deposit their load.

In No. 7 tunnel, the ore assayed 14 lbs. per ton for four feet under the hanging wall. The next six feet ran 5.5 lbs. per ton.

The ore is mined with C-P-8 machines using auger bits and some five men in the mine were getting out 40 tons of 5 lb. ore per day. Since the dip of the ore zone is with the hill, the crosscut tunnels and tramming distances are short. The mine is fairly dry, and draft through the raises provides natural ventilation. Compressed air is furnished by a C. P. T. $9\frac{3}{8} \times 5\frac{1}{2}$ by $5\frac{1}{2}$ cog belt driven compressor. This is run by a 50 H. P. motor. Power is furnished by the California-Oregon Power Company over a 11,000 volt line and stepped down to 440 volts at the mine.
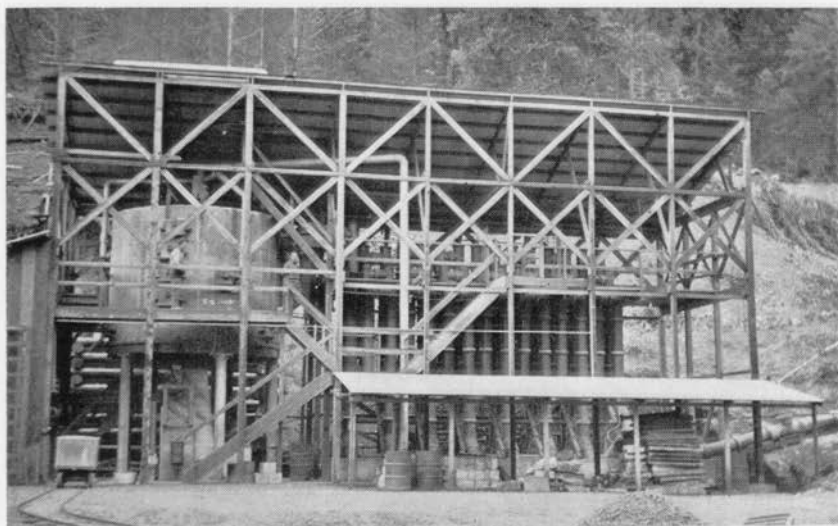
Photo No. 24—The Herreshoff Furnace Plant of the Bonanza Mine. This is the latest
Oregon Quicksilver Plant to go on production.

Photo No. 25—The feed belt carrying ore to drying hearth of Bonanza Furnace.

From the mine the ore is trammed to a 1-inch grizzly set over a 240-ton bin. The oversize from the grizzly goes through an 8 by 10 inch roll jaw crusher. No sorting can be done on this ore. From the ore bin a 16 inch by 6 foot belt feeder delivers the ore to a conveyor belt which carries it to, and drops it on the outside edge of, the drying hearth of the furnace. A head sample of the ore is taken from this conveyor belt. Furnace tails are also sampled and cut samples are taken in the mine. The distillation-titration method of assay is used.

The general layout of the Reduction Plant is shown in Fig. 19 and Photo 24, and Fig. 20 illustrates the furnace assembly.

The furnace has five hearths and is 14 feet $2\frac{1}{4}$ inches in outside diameter. It is built on a cast-iron circular girder supported by five 10-foot legs which give ample clearance below the furnace.

Having an odd number of hearths, it has center feed. The ore is delivered into the top or drying hearth by being dropped there from a conveyor belt and is then raked inwards to the feed hole. Photo 25 shows the conveyor belt taking ore to the furnace.

The speed of the furnace can be controlled by variable speed motor and is usually from 1 R. P. M. to 1 revolution in 40 seconds.

Firing is done by two low-pressure oil burners on hearths 2 and 3 respectively. An 11 by 11 inch Sirocco Dust Collector is attached directly to the furnace and removes practically all the dust from the gases before they enter the condenser system. The furnace makes only some 200 lbs. of dust per 24 hours and this assays from 1 to 3 lbs. of quicksilver per ton, so the loss from this source is negligible. The dust collector is shown in Photo 26.

The discharge of the burned rock from the furnace is by means of a balance gate in the lower hearth. This discharges into a hopper (see Photo 24) from which it is drawn into cars and trammed to the dump. The plant had been in operation only a short time when visited in November, 1937, so that long range average operating figures were not yet available. It was treating some 36 to 40 tons of ore per day having a moisture content of some 14 per cent with a fuel consumption of some nine gallons per ton.
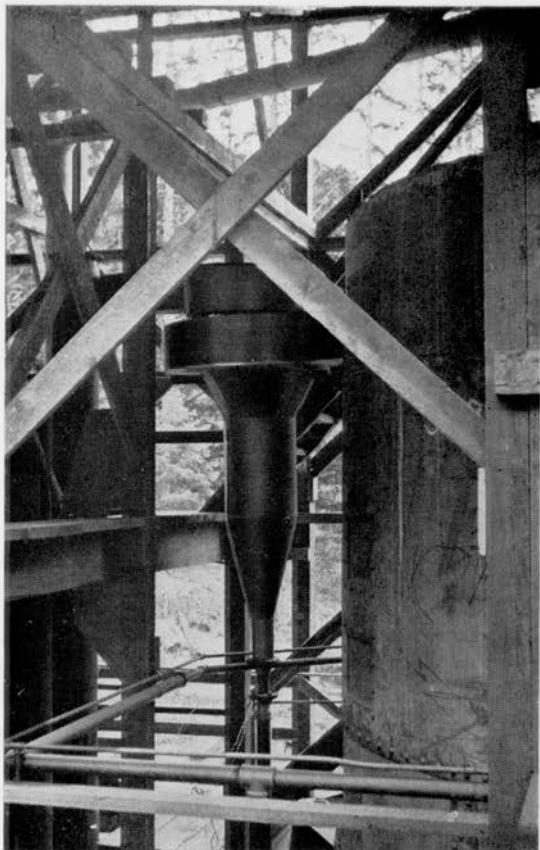
Photo No. 26—The "Sirocco" Dust Collector on the Herreshoff Furnace of the Bonanza Mine.
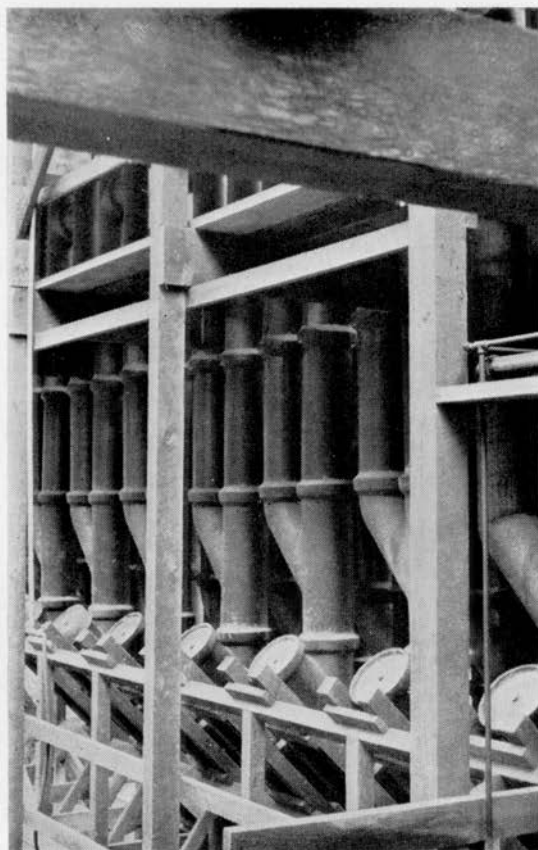

Photo No. 27—Rear of the Tile Pipe Condenser System of the Bonanza Plant.

The condenser system is of sheet-iron and tile pipe construction. The gases pass from the dust collector through three strings of U-bends to the exhauster. At the bottom, the U-bends are connected by inclined pipes which are sealed by dipping into a water-filled concrete trough as shown in Fig. 19.

This type of condenser system, which was originated by the author at the Red Elephant Mine in 1930, is easy to erect and easy to clean. It has also been adopted at two plants in Texas, at five plants in California and one plant in Nevada.

Ten-inch glazed tile pipe was used for this condenser system and the stack flue and stack are 12-inch tile pipe. The covers at the top of the vertical and inclined pipes have 1-inch holes in them which are closed with corks. The pipes are washed down daily by hosing them out through these small holes. Photo 27 shows the rear of the condenser system and Photo 28 the front where the pipes dip into the trough. Photo 29 is an end view of the condenser system and shows the washdown platforms at the top and rear of the condenser system.

White enameled pans (one is shown over the trough in Photo 28) are submerged in the trough under each pipe and after the daily wash-down these pans holding the days product are lifted out, the water is decanted, and the floured mercury is placed on the soot pan which can be seen at the left in Photo 29. This is heated by waste heat from the furnace and the dried, clean quicksilver is then drawn off and bottled in the usual manner.

Draft for the furnace is provided by an American Blower Company No. 30 Type E fan. Since this fan works in the acid gases on the cold end of the condenser system it is completely rubber covered on the inside. It operates at 2,200 R. P. M. The fan and its connections are shown in Photo 28. With the fan at this end the entire condenser system is under suction at all times. Any leaks in the condenser system may let air leak in but will not let hot quicksilver laden gases leak out and thus cause a loss. The cleanup-man is in no danger of breathing quicksilver vapors when washing down.

The plant has a neat clean appearance and was operating smoothly with a green, but intelligent, crew who were showing all the earmarks of rapidly becoming seasoned quicksilver operators.
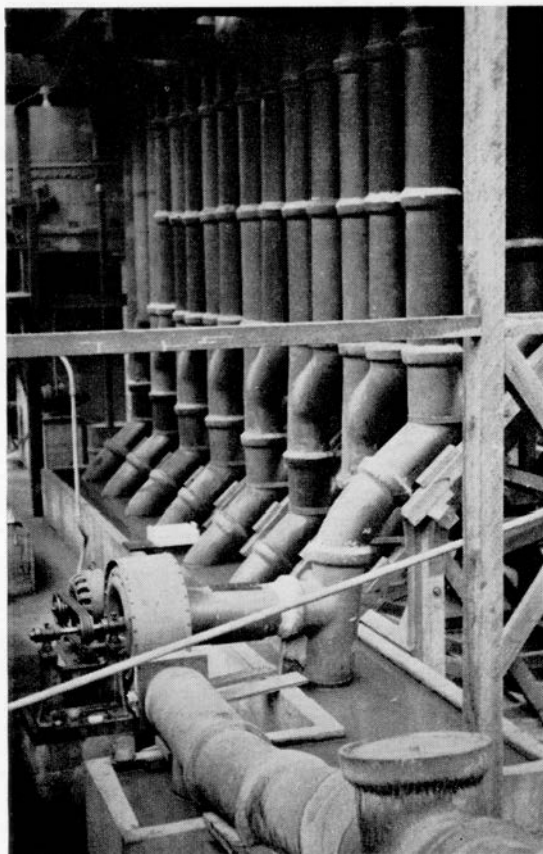
Photo No. 28—Exhauster and collecting trough of the Bonanza Condenser. The water in the trough seals the bottom of the gathering pipes.
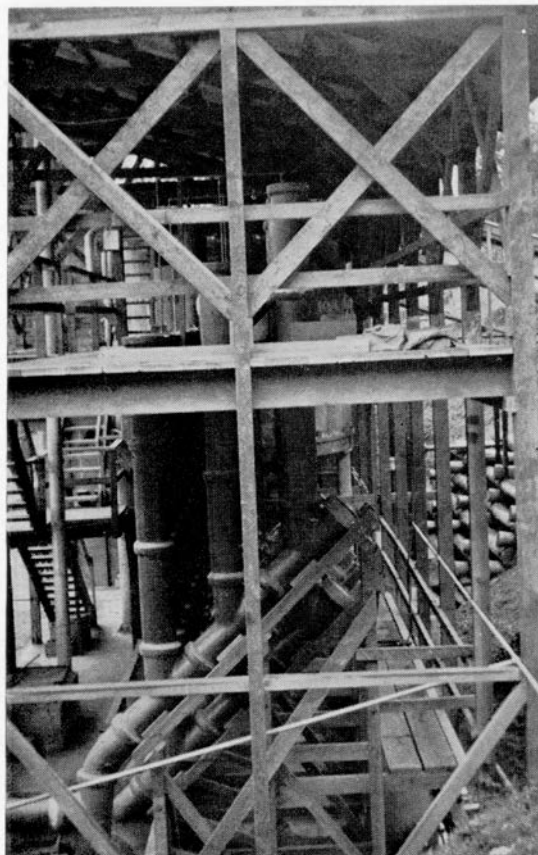
Photo No. 29—End view of the Bonanza Condenser System showing the wash-down platforms.

The property has living quarters for the superintendent, but the crew of 12 to 14 men lives on neighboring ranches or in Sutherlin so that no boarding house is necessary. Wages are $3.20 for roustabouts, $4.00 for muckers and furnace men and $4.50 for miners. Haulage and fuel costs are low and with such generally favorable conditions the Bonanza Mine should become one of the steady producers of Oregon.

Black Butte-Elkhead District

This district comprises parts of two counties, Black Butte being in Lane and Elkhead in Douglas County. From U. S. Highway 99 the district is reached by going east from Yoncalla or south from Cottage Grove.

Geologically, this district lies at the junction of the Coast Range and the Cascade Range at the head of the Willamette Valley. Drainage from the district is both north into the Willamette river and west into the Umpqua river. The Calapooya Mountains which run northwest through the district form the divide between the drainage basins. Elevations in the district range from around 1,000 feet in the valleys to 2,000 and 4,000 feet on the Calapooya mountain peaks.

The general geology of the area as well as the mine geology is well described in U. S. G. S. Bulletin 850. Briefly, an elongated anticlinal dome with a northeast trend and some 12 miles wide and dipping 10° to 18° is developed in the Umpqua formation in this district. A normal fault striking northeast and having a displacement of several hundred feet is found in the Black Butte Mine. Other faults of smaller throw also are normal and strike northeast.

Uncomformably on the Umpqua formation lies a series of volcanic conglomerates, pyroclastic rocks and lavas which constitute the Calapooya formation. Both the Umpqua and the younger Calapooya formation are intruded by basalt and diabase.

The core of the anticlinal dome is amygdaloidal lava and the flanks and top are shale and sandstone. During the flexing of the rocks when the anticline was formed, differential movement occurred between the lavas and overlying sediments. At the Elkhead mine where the dip of the east leg of the anticline is

locally as steep as 30° to 50°, this differential movement fractured the tuffaceous member just above the amygdaloidal lava. These fractures were the source fractures for the mineralization of the Elkhead mine.

The Calapooya formation had not been laid down when this anticline formed but came much later after erosion had leveled off the top of the anticline.

BLACK BUTTE MINE

This mine is just 17 miles from Cottage Grove by a good hard-surfaced road often greatly cut up by the abuse to which it is put by overloaded lumber trucks.

The early history of this mine has been related. In 1927 a 4 by 60 foot rotary kiln plant was installed and production has been continuous since then.

The mine is located in the northwest $\frac{1}{4}$ of Sec. 16, T. 23 S., R. 3 W., on a steep-sided butte rising 1,650 feet above the valley floor. This "Black Butte" is composed of andesitic lavas and breccias of the Calapooya formation. Thermal waters have altered and silicified these rocks. At the outcrop these altered rocks weather to a characteristic "brown iron rib" appearance. Being silicified and therefore hard they have withstood erosion and form a series of bold crags along the top of the Butte.

The channel through which the thermal solutions came up was a fault and shear zone striking north 69° west and dipping some 65° northeast.

A post mineral fault presenting a beautifully hard smooth surface forms the footwall of the ore mined in the upper levels. This was probably a recurrent movement along the original fracture as the greatest mineralization which forms the ore in the shear zone is close to this fault.

Plate 9 of U. S. G. S. Bulletin 850 shows a plan of the mine levels and a longitudinal section of the workings showing the stoped areas. Since 1930 a great deal of new ground has been stoped, as shown in Figs. 20-A and 20-B.

In the last two years most of the ore has come from the west end of the mine on the 5, 4, and 3 levels. This has averaged some 3.5 lbs. per ton. Unmined ore still extends for 130 feet farther west with backs of some 100 feet to the surface but being near the surface it is wet work mining it in winter.

In November, the 9 level was being prepared for mining between the Smoky stope and the Huckins stope. This is a block of ground some 160 feet long and between levels 6 and 9. From 6 up this has been mined out. The block from 6 to 9 is expected to run 3.5 lbs. quicksilver per ton.

On the 9 the ore lies some 45 feet under a basalt dike. On the 11 level on the west end where mining was carried on a year ago the ore is on the hanging instead of the footwall and up against the basalt dike. 250 feet below the 11 the ore is still under the dike but only runs 2 lbs. per ton.

In the Dennis Creek Tunnel, the lowest level in the mine there are 2 dikes, one of them in the hanging.

On 3 level the West Crosscut was run to the footwall and 3 was driven on the footwall and stoped from there to the surface, west of the crosscut. East of the West Crosscut a block of 3 lb. ore is left that is 10 to 15 feet wide and runs 50 feet to the surface.

Altogether, there is ore for a length of about 300 feet along the strike, left between the Middle and East Crosscut on this level, and 150 feet along the strike between the West and Middle Crosscuts. This ground gets too wet to be worked in winter.

On 3 level, crosscuts into the footwall showed spots and bunches of 7 lb. ore some 20 feet under the footwall.

The East 5 level is all prepared for stoping for a length of 500 feet and from the 5 level to the surface. It is expected to run 3 lbs. Diamond drilling on this level showed ore some 80 feet in the footwall. On the hanging a diamond drill hole cut a basalt dike and this now furnishes a good stream of cool drinking water. The ore in this east end should extend down to 6 but this level has not yet been run out under it.

9 level runs under the footwall and a basalt dike is under it. The "Copenhagen" stope some 200 feet in from the surface shows soft, greatly altered, and decomposed rock with streaks of bleached white clay-like masses in it. When panned this showed small amounts of cinnabar, meta-cinnabar, and native quicksilver. The ore "makes" quite a streak of high-grade just under a fault gouge but is too wet, sticky, and messy to be handled.

Photo No. 30—Black Butte Mine. Gasoline locomotive bringing a train of ore to the plant from the Dennis Creek Tunnel.

11 level is connected with the Dennis Creek Tunnel by a 12 by 6 raise some 650 feet long on the incline. Vertical distance between these levels is 413 feet.

The Dennis Creek Tunnel is 7 by 9 in section and was driven 60 feet into the footwall. No definite hanging was discernible. The ore zone was found some 250 out from the footwall. On the footwall are some 6 to 7 feet of calcite and it goes under the footwall in two or three places. Some of this calcite was mined, ground and sold for agricultural purposes.

The ore on Dennis Creek Tunnel level is very low-grade and spotty as thus far developed.

Ore can be dropped to this level through the raise from 11 and is then mule-trammed out in 5-car trains of 1-ton cars. These cars are dumped on a grizzly over an 800-ton storage bin. Oversize from the grizzly goes through a 12 by 20 Blake Crusher into the bin.

From this bin the ore is taken to the plant by gasoline locomotive in trains of 5, 1-ton side dump cars illustrated in Photo 30.

The mining method is shrinkage stoping and has been described in detail by Elmer[20] and Schuette[21].

The individual stopes are 20 to 40 feet wide and several hundred feet long. Occasional pillars of low-grade rock are left. The ground is hard and stands open indefinitely and the dip is steep enough to let the ore flow freely. Chutes are 25 feet apart with 3 by 2½ foot openings. At present with only one furnace in operation, 11 men in the mine keep the plant supplied with ore and do the necessary development work. Wages are 50, 55 and 60 cents per hour at present. This is some 50 cents per day less than in 1930 when the price of quicksilver was much higher.

From 9 level the ore is trammed by mule train to a jaw crusher set over a fine-ore bin from which an aerial tram delivers it to the 70-ton plant bin below. Photo 31 shows the tram which consists of 110 buckets on a ⅞ inch cable, each bucket carrying 90 lbs. The use of this tram may be discontinued in the near future and all ore will then come out through the Dennis Creek Tunnel as described above.

[20] William W. Elmer: Mining Methods and Costs at the Black Butte Quicksilver Mine, Lane County, Oregon. U. S. Bureau of Mines Information Circular 6276. 1930.
[21] Schuette, C. N. Quicksilver, U. S. Bureau of Mines Bulletin 335, pp. 37-43.

Photo No. 31—Black Butte Mine. Aerial tram which brings ore down from No. 9.

The basalt dikes in the mine are very interesting and rela-tively little seems to be known concerning them. They may be associated with the ore deposition here as similar dikes cer-tainly are associated with it in other mines. If so, a crosscut or raise into the hanging through the dike, say, on 9 level might find a parallel ore body at some distance on the other side of it.

Little if any prospecting has been done outside the main workings though lately some development has been proposed on a seam of high-grade ore that outcrops near the mouth of Dennis Creek Tunnel on the opposite side of the creek. A small tonnage of high-grade ore was minded from this prospect by a leaser. Across the creek, that is, on the side where the railroad is, some ore has been stoped in cuts and underground but it was said that this was too low-grade to pay.

The Black Butte Plant: A plan and elevation of the original rotary furnace plant at Black Butte is given in U. S. B. M. Bulletin 335. This was placed in operation late in 1927 and the second kiln was added in 1929.

The original plant had a large concrete dust chamber fol-lowed by the tile pipe condensers of 15-inch pipe. Twelve strings of this pipe, each 20 feet long, and inclined at 45° to aid clean-ing constituted the cooling unit. This was followed by a wooden chamber and from there a long stack flue of 15-inch tile pipe led to the stack. Connection at the top of the condenser pipes was by a clumsy wooden box and at the bottom the pipes headed into small concrete chambers. Water sprays in the pipes served to collect dust in the form of quicksilver laden mud. Draft was induced by an air injector at the base of the stack. The fire box of this kiln was of concrete, lined with firebrick. This plant used a helical screw feeder on the furnace.

The new unit of the plant added in 1929 was another 4 by 60 kiln but had a dust chamber and firebox inclosed in sheet iron and two cyclones to remove the dust. The kiln was fed with a shaking feeder. The condenser system of the new unit is shown in Photo 32. It was similar to that of the first one but was fol-lowed by large wooden barrels the top of one of them being visible in the photo. This unit had its own stack flue and stack as shown in Photo 33.

The new unit was not as satisfactory as the old one and has operated only about three years since it was installed. The

original unit has been improved by placing a Sirocco Dust Collector between the dust chamber and condenser to eliminate the dust and both condenser systems are being used with the one furnace. This is a good practical illustration of the fact that in treating low-grade ore a larger condenser system is needed than when treating high-grade ore. Photo 34 shows the Sirocco Dust Collector installed in the original plant.

Photo 35 shows a general view of the plant from the railroad coming from Dennis Creek Tunnel, and the aerial tramline from 9 can be seen as well. Up high at the left is the new stack, and the stack flue of the original stack runs through the foreground. The original set of condensers is in the center and at the right center a corner of the new condenser can be seen.

The kilns are lined with 5-inch kiln blocks. The helical screw feeder is best for the Black Butte ore as the clay in it causes it to stick in the shaking feeder. The screw feeder is very sturdily built and can crush any ordinary rock that tends to stick it.

Gas temperature in the dust chamber is 800° F. A fan draws about one-third of the gas stream through the Sirocco Collector into the small original condenser system and another fan draws the other two-thirds of the gas through the two cyclones into the larger new condenser system.

When running one kiln about 75 tons per day are furnaced. When two kilns are operating, they treat about 65 tons each.

The Sirocco Dust Collector collects about 1½ tons of dust and the two cyclones collect about one ton of dust per 24 hours.

Here as in other plants the dust nuisance has been eliminated by use of the Sirocco Collector and such little mud as is collected is dried, hoed and returned to the furnace.

Fuel consumption is about 10 gallons per ton. This is partly due to the high moisture content of the ore and partly because the feed is fairly coarse and it takes more fuel to heat a large lump of ore than a small one. Finer crushing rapidly runs into money and so most plants strike a happy medium between increased cost of finer crushing and higher fuel consumption for coarser ore.

Wages in the plant are 45 and 47½ cents per hour. There are two men in the plant on night and graveyard shifts and on

Photo No. 32—Condenser System, Black Butte.

Photo No. 33—Stack and Stack Flue, Black Butte.

day shift there are two men and two helpers and one mechanic. The tramway brings down the ore on one shift. The crew aside from the 11 men in the mine totals 15 men.

Black Butte is an outstanding mine in many ways. The average grade of the ore from which its production has come is about 3 lbs. of quicksilver per ton on recovery. This makes it the outstanding low-grade producer of the United States quicksilver industry. This is even more creditable when it is remembered that the ore is mined by underground methods and not by open-cut operations as one might expect for the No. 1 producer from low-grade ore.

Besides this it is the largest quicksilver mine of Oregon in point of total production to date. Taken from all available sources, it would seem that the total production in three active periods was as follows:

Prior to 1910	911 flasks
1916-1919	1,271 flasks
1927-1938	11,060 flasks
Total to 1938	13,242 flasks

OTHER PROSPECTS

U. S. G. S. Bulletin 850 on plate 7 shows 4 other areas of altered rock similar to that on Black Butte. These have been prospected for cinnabar without tangible results. They are called Hobart Butte northwest of Black Butte, Sullivan Prospect on the north side of East Garoutte Creek, and Bald Butte and Cinnabar Mountain on the south.

ELKHEAD MINE

This mine is located in the northeast $\frac{1}{4}$ of Sec. 21, T. 23 S., R. 4 W. about six miles east of Yoncalla. It was discovered in 1870 and is said to have produced in those early days although there is no record of such production. In 1895 a small Scott furnace was built but again there is no record of any production. U. S. G. S. Bulletin 850 on Plate 12 shows a plan and section of the mine, and Plate 13 shows the geology of the mine area.

The rock alteration along the ore zone is similar to that at Black Butte forming the typical iron ribs. The formation strikes northwest and the dip is southeast. The lowest formation is an amygdaloidal basalt. On this lies a tuffaceous sandstone and

Photo No. 34—The original rotary kiln at the Black Butte Plant. Note the newly added "Sirocco" dust collector at the upper left.

Photo No. 35—General View of the Black Butte Plant. It shows the railroad from the Dennis Creek Tunnel, the aerial tram, new stack at left, old stack flue in foreground, and condensers at the right.

this is overlain by shales. The alteration and mineralization of the rock occurred along the basalt-sandstone contact. Cinnabar is disseminated throughout the altered amygdaloid near the contact. The fractures which permitted mineralization must have been localized along the amygdaloid-sandstone contact by a differential movement on flexing. The sandstone must have been too "tight" and "soft" at the time of mineralization to permit of open fractures in it. If it had been a hard open-textured sandstone it would have fractured and let the mineralization concentrate in it under the overlying shale cap rock. As it was, the sandstone itself was a semi-permeable cap rock on the poorly-fractured basalt and only low-grade ore could form.

This mine also has been the scene of recurrent activity for many years. In 1931 J. W. Wenzel was in charge of development work at the property and considered repairing the old 20-ton Scott furnace on the property. Then C. O. White of Seattle optioned the property in 1931 and installed his patented retort.

A satisfactory test run was reported in 1934. Despite all this activity the production in all those years is reported as being only 16 flasks.

Opalite Quicksilver District

This district lies in the southeastern part of Oregon near the town of McDermitt. The structural geology in the district is of the Basin Range type with the various long narrow orographic blocks bounded by large north and south faults and smaller east and west faults. Elevation at the mines is between 5,000 and 6,000 feet.

The Great Basin is an area of interior drainage lying between the Rocky Mountains and the Sierra Nevada. The northwestern part of this Great Basin extends for some 160 miles north into Oregon. The greater part of this area has never been mapped and the results of geological reconnaissance surveys only have been published[22].

The mountains in this area are formed by tilted blocks with one gentle slope corresponding to the dip of the strata forming it, and one steep abrupt slope or cliff along a great border fault.

[22] Russell, Israel C.: A Geological Reconnaissance in Southern Oregon. U. S. Geol. Survey. 4th Ann. Report. 1884.

The valleys and plains between the raised mountain blocks are generally covered with alluvium and lake sediments. Along the Oregon-Nevada boundary the country is an arid desert but northwards it merges into semi-arid country.

Aside from the rather recent lake sediments the rocks are largely of volcanic origin. Basalts, rhyolites, andesite and tuffs predominate.

In comparatively recent geologic times, Lake Lahontan occupied some 8,422 square miles of the Great Basin extending from Walker Lake in Nevada up to and a little distance into Oregon near McDermitt. The Opalite, Bretz, and Cordero Mines of the Opalite District are in these Lahontan Lake Beds. The high-water stage of Lake Lahontan and the position of the mines is shown in Fig. 21. Photo 36 shows the lake beds behind Opalite.

The lines of major faulting in this area are marked by numerous hot springs and quicksilver deposits[23].

Both Opalite and Bretz are in hot-spring sinters and the cinnabar deposition seems to have been a phase of the sinter deposition.

[23] Schuette, C. N. Lahontan Quicksilver. E. & M. J. Vol. 134, pp. 329-332, 1933.

Photo No. 36—The Lahontan Lake Beds at Opalite, shown between the horizontal arrows. The mine and camp are a little to the right of the center.

OPALITE MINE

The mine is located in Sec. 33, T. 40 S., R. 40 E. in Malheur County, Oregon. It is reached via Winnemucca, Nevada, by a splendid highway, 76 miles to McDermitt on the Nevada-Oregon border. From McDermitt a fair but rough road 19.6 miles long leads to the mine. Excepting a few miles near McDermitt the entire road was built and has been maintained by the Bradley Mining Co. Only an old wagon trail, parts of which can still be seen near the new road, led into this country before the mines were started. The road from Winnemucca to McDermitt was only a dirt road when the mine first started. Freight from Winnemucca to the mine was then $30.00 per ton as against $8.50 per ton at present. This is a good illustration of the importance of good roads to mining districts and in this respect the southeastern part of Oregon leaves much to be desired. The roads in Oregon down here are so bad that this part of the state is tributary to Nevada.

The Opalite Mine was discovered in 1924 by William Bretz and his partner Murphy. They met Clifford Dennis in Winnemucca and told him that they had located a quicksilver deposit with an outcrop 150 feet wide and 250 feet long every bit of which showed cinnabar. Dennis didn't believe it could be true but did go to have a look at it. It was true, however, and at Dennis' recommendation, F. W. Bradley in April, 1925, formed the Mercury Mining Syndicate which took over the property. A road and a telephone line to the property were built and a substantial camp was established. A water supply was found at a spring three miles from camp and was piped to the camp through a buried line consisting of 2,500 feet of $1\frac{1}{2}$ inch pipe, 3,000 feet of $1\frac{1}{4}$ inch pipe, and 1 inch pipe the rest of the way. The need for burying the pipeline emphasizes the extreme cold winter weather and the hot summer weather necessitated the installation of an ice machine for the preservation of food. An auxiliary water supply was developed with a well and pump near the camp.

Development was undertaken by means of tunnels driven into the hill some 80 feet below the outcrop. These proved to be under the ore so sub-levels were run 40 feet higher, and raises were run to the surface from these to prepare the ground for
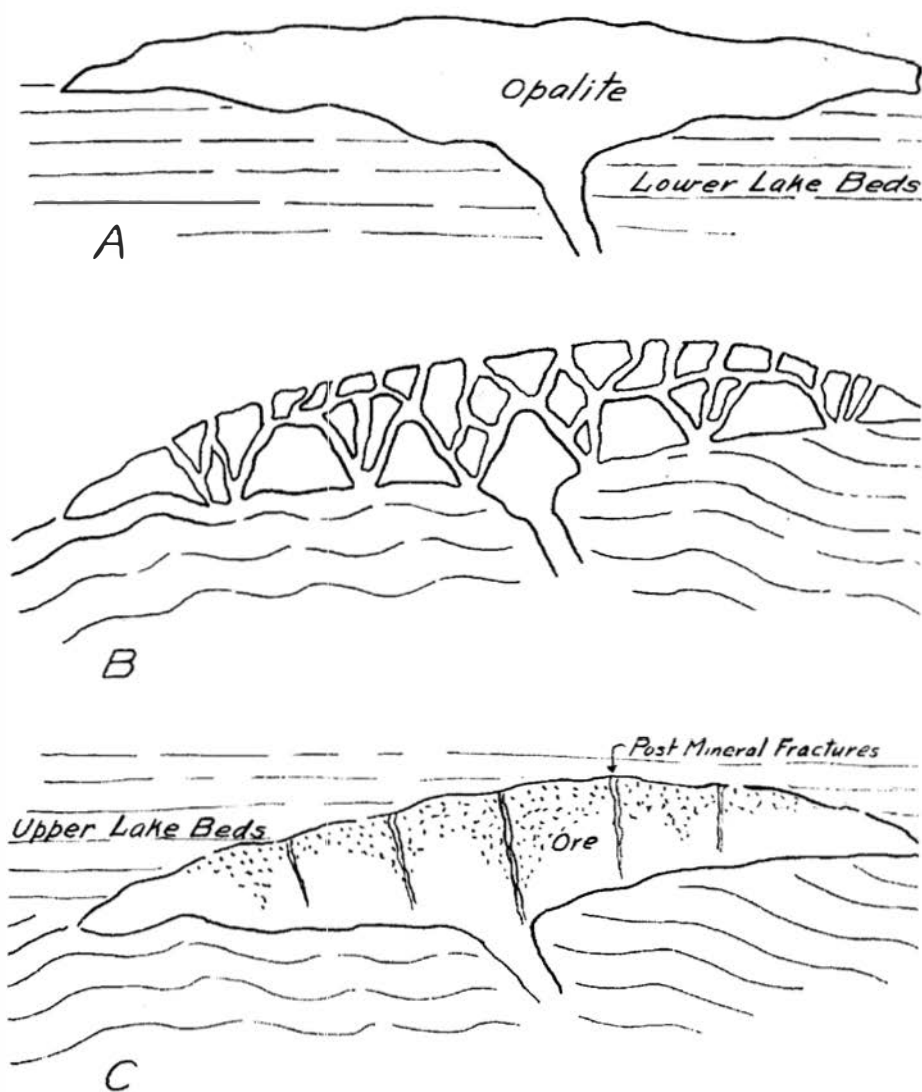
Figure 22—Sections A, B and C, Showing Geology of Opalite Beds.

glory-hole mining. A reduction plant was built in 1926 and was finished late in the year.

At the site of the Opalite Mine hot springs coming up an east-west fault deposited an irregularly lens-shaped mound of siliceous sinter on the shore of the lake. It was sub-aerial deposition as no lake bed material is mixed with it. This opalite is vuggy in places, banded in others, or in great massive blocks but its deposition must have been a fairly continuous process as no sediments are intercalated in it as, for example, is the case in the neighboring Cordero Mine.

Fig. 22a illustrates the opalite lens as originally formed. After it was formed, folding occurred in this area and the opalite deposit happened to be on the crest of an anticlinal fold. The folding movement bent and contorted the soft lake beds underlying the opalite and shattered the hard brittle mass of silica lying above it as indicated in Fig. 22-b. The folding and contortions of the lake beds as well as the accompanying faulting are clearly visible in the underground workings and also on the surface west of the mine.

After this fracturing, the surface of the opalite lens was covered with breccia and this also filled V- and funnel-shaped fissures running through the deposit. A renewal of the silica deposition set in and at least one phase of this new thermal activity was mineral bearing as well. The breccia was re-cemented with silica and cinnabar. No cap rock was present and such mild concentration of mineralization as did take place was due to a slowing up of the solutions as they spread out through the breccia and cooled, thus depositing part of their load of cinnabar before they overflowed into the lake and lost their identity.

After the formation of the orebody, lake beds were deposited at least over part of the orebody. Still later, a slight recurrent bending movement again fractured the opalite and these fractures filled with lake-bed material from the overlying beds. These last fractures seem to have followed the lines of the previous fracturing and, being easily visible in the pit today, they form valuable guides in prospecting.

The ore can be ground to 200 mesh and these particles when viewed under the microscope still show that silica surrounds

the cinnabar. Thus it is clear that the cinnabar and silica were deposited simultaneously. The silica turns dark under exposure to the sun and this accounts for the comparatively late discovery of this deposit. Only freshly-broken rock shows the color of the cinnabar.

Along the post-mineral fractures, secondary minerals consisting of chlorides and oxychlorides are found in rich pockets of high-grade ore. In the western part of the mine, cinnabar has also been deposited in the lake beds underlying the opalite deposit.

Fig. 23 is a plan of the Opalite Mine and the development workings in relation to the pit are clearly shown. Fig. 24 is a series of sections through the mine. The plan shows the largest of the post-mineral fractures in serrated lines. The main one extends a little south of west across the northern part of the large pit and is continuous past N raise through H pit. Cross fractures, running northwest, cross the pit on both sides of D and F raises and a smaller southwest fissure runs between K and F chutes. If these fractures formed at or near the lines of pre-mineral fracturing, a reasonable assumption as both were formed by similar causes, the greater mineralization of the northeast half of the large pit is accounted for by the fact that the greatest amount of brecciated receptacle rock was formed here.

The sections of Fig. 24 show the general lens-shaped form of the opalite deposit. The main post-mineral fracture is shown by a serrated line. The lens of opalite thins out both towards the east and west. It is thickest in section C and perhaps for this reason the pre-mineral fracturing caused by the bending movement here took the form of faulting as indicated on the south end of sections B and C. These faults made only narrow fractures, through which the mineralizing solutions were quickly conducted to the surface where they entered the lake and lost their identity without having had a chance of depositing their load of mineral. It is in these sections also where the solutions spread out in the lake beds below the unfractured and therefore impervious opalite and deposited cinnabar in the rather dense clayey lake beds.

There is a north-south fault between sections A and B which displaced the western block northwards. A north-south fault

which crosses section C at the winze shows a drop of the western block of some 12 feet. The block of ground between this fault, on which the winze was sunk, and a smaller fault near O raise was displaced slightly toward the south.

The lake beds, deposited after mineralization, can be distinguished by descriptive names as follows: Upper Lake beds, Opalized Wood beds, Brown beds, and White Shale beds. Below the opalite deposit are the Lower Lake beds and the Variegated Opaline Shales. These latter beds were first mistaken for a basalt which they resemble in appearance.

Only a little low-grade ore is exposed around No. 1 Tunnel on A and B sections. Some low-grade ore shows on the surface of section B.

Along section C the mineralization seems to be related to the north-south fault along the winze and some very good ore was taken from pits L and H. Between here and the big pit no stripping has yet been done though ore should be found at least along the course of the main fracture in this area. The big pit is shown in Photos 40 and 41.

Opalite was the first deposit of this surficial type to be worked. Had the nature of these deposits been understood it would probably have been mined by shovel and truck instead of by glory-hole method with its attendant expense of tunnels, raises and other underground development.

The raises have bulldozing chambers over 8-inch grizzlies on the sub-level while at the haulage level they end in loading chutes with counter-weighted arc gates.

Drilling in the pit is done with jackhammers as is the block holing in the bulldozing chambers. Air is furnished by a Sullivan Angle Compound compressor run by a 120 H.P. Fairbanks Morse Diesel engine as shown in Photo 37. From the receiver at the powerhouse a 4-inch air line runs to a second receiver in the mine from which the air is distributed to the working places.

The rock is hard and steel consumption for drilling and crushing is high. It breaks well, however, due to its brittleness. When the cones from the individual raises flattened out so that the ore would no longer drop down by gravity a system of scraping was devised run by one centrally located double drum
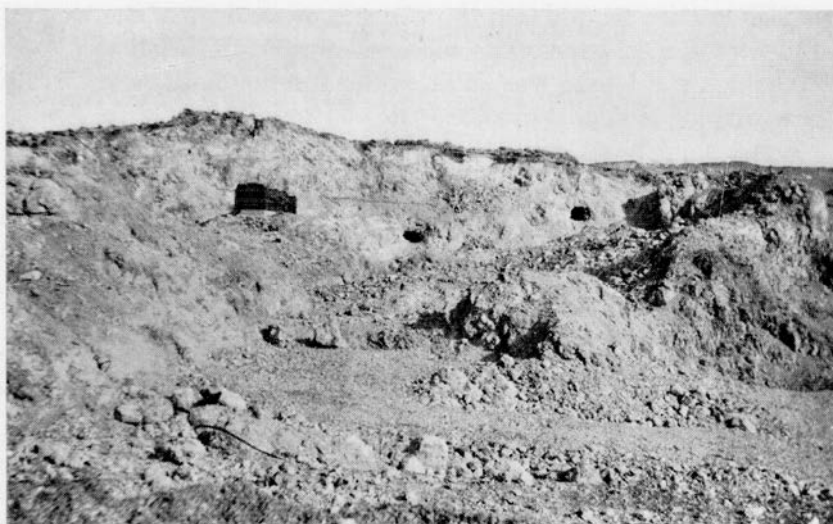
Photo No. 40— Looking north across the shallow part of the Opalite pit. Two of the exploratory tunnels shown in Fig. 23 can be seen. The crib work in the center holds the hoist that moves the scrapers.

Photo No. 41—The deep part of the big pit at Opalite looking east. Note the rough floor and large rock on which the scrapers work.

hoist. This works well despite the rough nature of the floor and the larger angular fragments of rock that are handled.

From the raise chutes the ore is loaded into trains of 5, 1½ ton rocker bottom dump cars. Mule haulage is used. Track gage is 18 inches.

The ore is dumped on a 2-inch grizzly over a bin above the crushers. Oversize from the bin runs out on a sorting platform and into a 10 x 20 Blake crusher. Sorting was practiced at first but the rock is not well adapted to it. The ore from the bin is fed to a belt conveyer by a reciprocating feeder. The crusher product drops directly onto this conveyer belt also, being cushioned by the ore from the bin. This belt feeds over another grizzly into a second 6 by 20 Blake crusher which is set to a 1½ inch feed. An Allis Chalmers 3 D gyratory was first used as a secondary crusher but the lining and head wore out too fast because of the extremely abrasive nature of the ore.

The second Blake crusher discharges to the boot of a bucket elevator which raises the ore to a belt conveyer which drops it into the furnace bin. Two men tend the crushing plant which runs one shift per day.
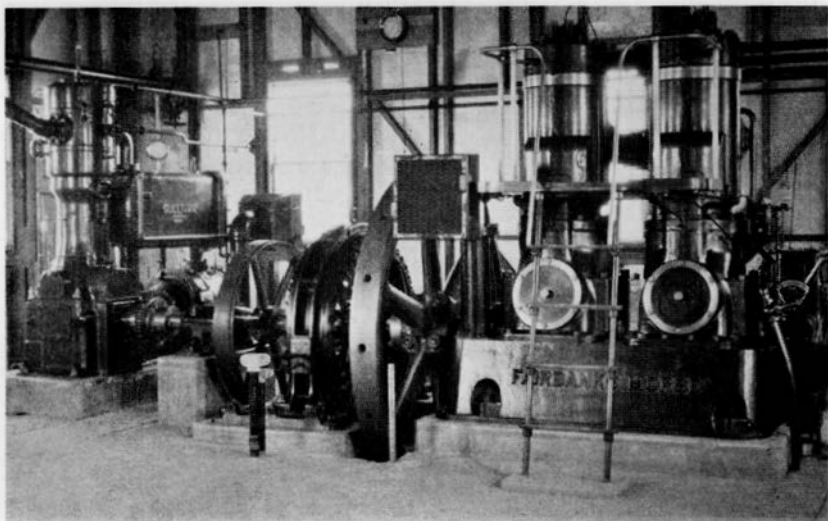

Photo No. 37—Diesel Engine. Generator and Compressor in a straight-line hook-up in the Power House of the Opalite Mine.

From the furnace bin a Challenge Feeder drops the ore into a reciprocating feeder which serves the furnace. The furnace is a rotary kiln, 4 feet in diameter by 70 feet long, and thus is the largest furnace of this type operating on quicksilver ore.

The firebox of the kiln is built of brick and stands on concrete piers at one side of a large concrete soaking pit. When this plant was built in 1926, dust collectors had not yet been invented. Hence the soaking pit was placed at one side of the kiln and the ore dropped from the kiln to a 45° chute down which it slid into the pit through a swinging door that opened whenever the weight of the ore resting against it became great enough. The top of the pit was open to the side of the firebox. This arrangement prevented the ore from dropping straight down into the pit and having the upward draft carry the dust back into the kiln.

From the pit the ore was first discharged through arc gates into cars in a tunnel under it and trammed to the dump. Later a bucket-chain conveyor raised the ore from the pit and dumped it on a pile at the surface. This pile was then periodically scraped away with power scrapers that have in time built up the three tremendous burned-ore dumps that dwarf the plant as shown in Photo 38.

The kiln was first lined with kiln blocks but later a monolithic concrete lining has been used with better results. The ore was too abrasive for firebrick but a concrete, composed largely of the hard rock itself, does much better work. An enlarged section of the kiln which was tried as an experiment was not very successful and this was soon filled in, making the kiln of constant diameter throughout. A low-pressure burner is used and fuel consumption is around seven gallons per ton with a capacity of 100 to 120 tons of opalite rock per day.

The dust chamber of the kiln is a large concrete structure divided into two parts with doors to facilitate cleaning one side while the other side is in operation. Chain curtains were hung in these chambers to stop dust. The ore proved to be much dustier than anticipated and a Cottrell precipitator was added to remove dust.

Beyond the dust chamber, some 300 feet of 12-inch iron pipe is followed by some 2,400 feet of 12-inch tile pipe arranged in

inclined rows each about 25 feet long. From these the gas passed through two small wooden barrels to the exhauster and then out through the stack.

It is a good condenser system but more difficult to clean than the later ones with vertical arrangement of the pipes. This condenser system is under draft using the wooden blower illustrated in Photo 39. This condenser is a good illustration of tile versus iron pipe. The iron pipe has been replaced several times but the original tile pipe, put up in 1926, is still doing duty and is as clean on the inside as on the day of installation. A drawing of this 11-year-old plant is given in Fig. 25.

Clean-ups are conducted every five days in the usual way by hosing down the pipes with water and collecting the quicksilver under water in concrete troughs. It is then hoed on soot tables and bottled.

Since the opalite ore will not pan it is assayed to determine its grade. A well-equipped assay office serves the mine and plant. Sample crusher and grinder are run by electric motor. An oil-fired sample drier was used for the Bretz ore. The samples are reduced with Jones Riffle Samplers and are assayed by the distillation-titration method.

The shop at the mine entrance has an I. R. steel sharpening machine, oil-fired furnace, forge, drill press, grinding wheel, and welding outfit.

The powerhouse has a 120 H. P. Diesel which drives the compressor and a 90 KVA generator. A smaller 60 H. P. Diesel drives a 47½ KVA generator.

The camp has two large bunk houses, a large boarding house, an office building and superintendent's house as the original camp. Several other houses have been built since and tents have been used temporarily in summer time. A garage serves to house the trucks, and a barn and a corral have been built for the mules.

Operation on Opalite ore was not continuous. At times Bretz ore only was treated in the Opalite Plant and in severe winters the plant was shut down some three months of the year.

Since the beginning of operations however some 152,400 tons of Opalite ore have been treated in the plant which yielded

Photo No. 38—The tremendous dumps of burned-rock that have been built up around the Opalite Plant in 11 years of operation. The mine dump of No. 1 Tunnel shows in the foreground.
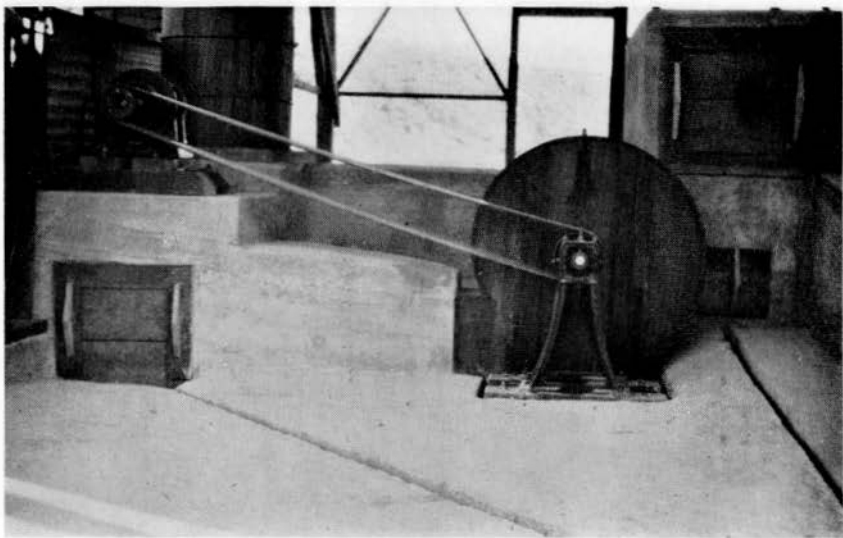

Photo No. 39—Wooden exhauster that furnishes draft for Opalite reduction plant.

a total of 11,300 flasks of quicksilver to the end of 1937. The grade of the ore then was 5.6 lbs. per ton on recovery. For the period of its life, that is 1926-1937, Opalite is the largest producer in Oregon though Black Butte has a greater total output to date.

Wages at the plant have varied with the price of quicksilver as is usual with quicksilver mines. In November, 1937, wages were $4.50 and $5.00 per day. The average crew numbers some 30 men. Fuel oil costs in 1937 were about 8 cents per gallon for 19° B and 9½ cents per gallon for 27° B delivered at the mine.

BRETZ MINE

This mine is located in Sec. 3, T. 41 S., R. 41 E., also in Malheur County, Oregon. It is 13 miles from McDermitt and 11 miles from the Opalite mine.

The Bretz mine was located in July, 1917, by William S. Bretz who also later found the Opalite mine. Assessment work was done for many years without finding any high-grade ore. Some hard opalite croppings showed low-grade cinnabar and much of the assessment work was done in this hard rock. It was not until 1931 when pannings from a trench in some soft
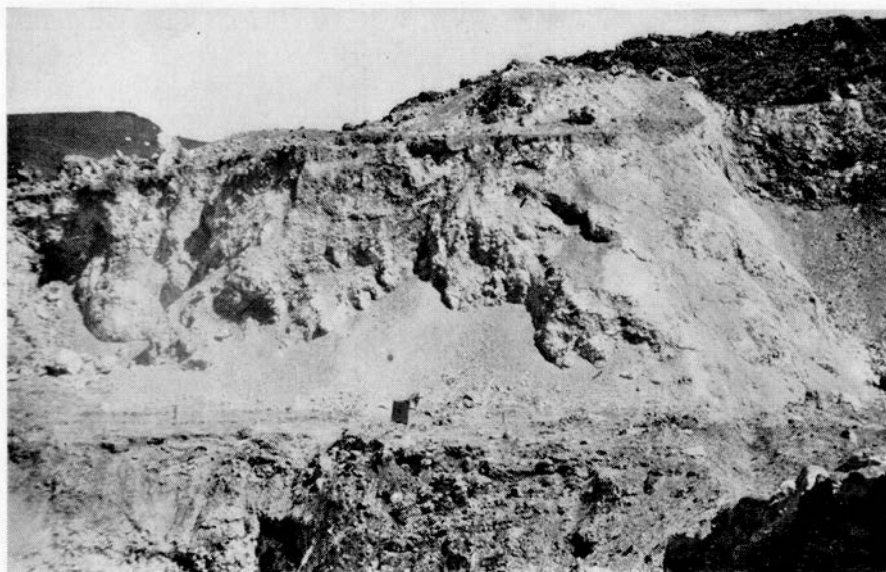

Photo No. 42—Bretz Mine. The calcareous sinter as first exposed in the West Benches of the mine.

lake beds disclosed high-grade ore that interest in the prospect was aroused.

Mercury Mining Syndicate had meanwhile been dissolved and Bradley Mining Co. was operating the Opalite mine 11 miles away. Bretz now sold his second quicksilver mine to the Bradleys and they began operations with a ⅜ yd. shovel and trucked the ore to Opalite for treatment.

At Bretz the ore deposition was also one phase of sinter deposition by thermal waters coming up an east-west fault.

The lake beds at Bretz and Opalite show striking similarities and suggest the same order of deposition as is only natural if they were both deposited on the shores of Lake Lahontan. If the fossil-wood strata found at Bretz and Opalite were laid down at the same time—and this seems probable—then Opalite is older than Bretz geologically speaking. The Opalite deposit was formed in a low-water stage of the lake before the fossil-wood strata were deposited in a later high-water stage. The Bretz deposit was formed just after the fossil-wood strata were deposited in this high-water or rising water stage of the lake.

At Bretz, sublacustral hot springs were active in depositing an irregular mound of calcareous sinter near the shore of the lake. The source of the thermal waters was an east-west fault along the shore of the lake. The north boundary of the lake at this point was an upstanding block of hard indurated tuff the strata of which dip some 30° south. The dropped block south of the fault formed the bottom of the lake basin and lake beds were being deposited on it.

The calcareous sinter is a fairly dense rock near the bottom (it was cut through in the mine workings) but near the top it shows a more open or spongy texture and reticulated structure. Lake beds were being deposited while this calcareous sinter was being built up. Photo 42 shows the calcareous sinter as first exposed in the West Benches of Bretz pit.

Fig. 26 gives an early plan and sections of the Bretz mine. On the north is the fault that bounded the lake at this point. North of the fault is the hard indurated upstanding old tuff. South of the fault the lake beds lie against it with gentle southerly dips and exhibiting the typical sag-dips of close-to-shore lake beds. This formation of calcareous sinter occurs

with varying prominence at different points for some 600 feet
in an east and west direction. This position of the ground is
covered by Carnation claim as shown in Fig. 26 and 27. On both
ends of this claim creek beds have cut through the lake beds
from north to south. Between these creeks the lake beds formed
a mound covered with desert wash. Ore had been found both
on the east and west of this mound where erosion had cut
through the lake beds and a little trenching had disclosed ore.
The calcareous sinter was found on both the west and east side
of the mound and on the west side there was ore in it. On both
the east and west sides there was ore in the lake beds adjacent
to it.

It was thought that the hot-spring action which deposited
the calcareous sinter had also deposited the ore and that the
ore should be continuous between the east and west exposures.

However, to make sure of this before inaugurating a mining
system based on this premise a shaft was sunk and underground
exploration was undertaken. This work is shown by dotted
lines in Fig. 27.

It was not long before many new and unforeseen facts had
upset the entire theory of the ore deposition. It was found that
the calcareous sinter was not continuous and that a siliceous
sinter carried the ore in the underground workings. This caused
a re-examination of the surface for siliceous sinter and it was
found to exist in crustal sheets, nodules, and other "geyser
basin" forms in two district fan-shaped areas as shown by the
dotted lines in Fig. 26. The shape of these areas suggested two
spring vents and surface flows of siliceous waters down the
fan-shaped areas.

These siliceous waters flowing into the rising lake silicified
the beds forming at that time. Two such silicified lake bed
strata about 18 inches apart are well developed and illustrated
in Photo 43. They are both some 4 to 6 inches thick.

Now, and apparently as a phase of the silicification, cinnabar
came up with the silica carrying solutions. Some deposition took
place on the edges of the calcareous sinter and some of the
mineralizing solutions ran out into the lake because the upper
lake beds for hundreds of yards around the spring vents will
assay a trace to 1 or 2 lbs. of quicksilver per ton.

Photo No. 43—Bretz Mine. The silicified lake beds that formed the cap rock under which a concentration of the primary mineralization took place.
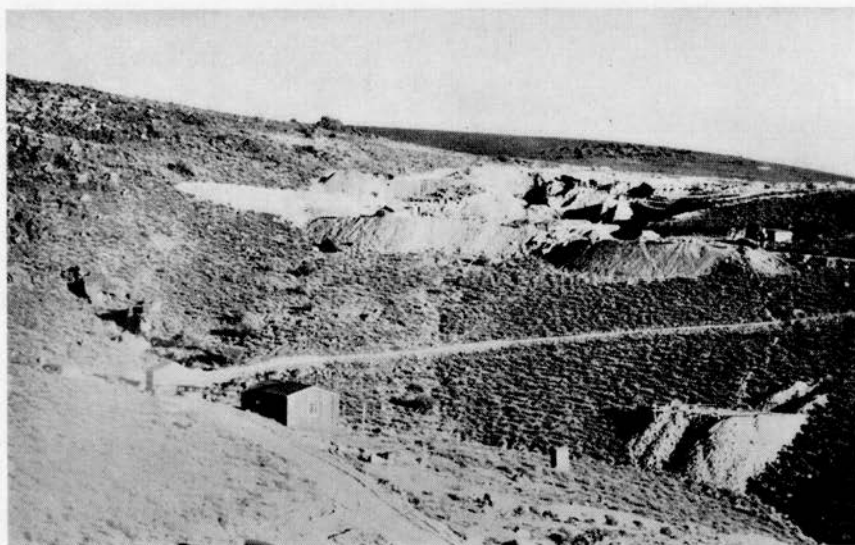

Photo No. 44.—The Bretz Mine in 1932 after about one year's operation. Bradley Tunnel at the lower right. The hard indurated tuff is at the left.

Such part of the mineralizing solutions however, that sought escape into the sand, gravel, and clay strata of the lake beds, were trapped under the dense impervious silicified strata that capped this area and here a concentration of the primary mineralization took place that made Bretz the highest grade quicksilver mine thus far found in Oregon.

The two fan-shaped areas on the surface delineated the underground distribution of the ore with fair accuracy and high-grade ore bodies predicted by the author on the basis of the general theory of deposition, as here related, were found practically where and as predicted.

Since no plant was built at Bretz, relatively high-grade ore was needed because of the cost of transportation to Opalite. Varying tonnages of Bretz ore were treated at Opalite plant from 1931 to 1936 inclusive. At the end of the mining season in 1936 the option to purchase the Bretz mine was released and no work has been done by the Bradley Mining Company in the Bretz mine since then.

Total production to date from the Bretz Mine is 7,751 flasks from 33,058 tons of ore. This makes the average grade of the ore treated some 17.8 lbs. per ton on recovery or just a little better than that of the Horse Heaven mine.

The Bretz mine has of course reverted to William Bretz, the discoverer, and he has just recently found a narrow vein of good ore back in the hard indurated tuff. The mining operations of Bradley Mining Company were entirely by open cut with a $\frac{3}{8}$ yd. shovel and Photos 44 and 45 taken in 1932 and 1937 show the tremendous cuts and waste dumps made in these five years. The dump, just showing at the right in Photo 45, is low-grade ore and the so-called waste dumps are by no means barren either as assays of the dump samples run over 2 and 3 lbs. per ton for the various waste dumps.

The fault on which the ore was brought up can be traced to the west for a considerable distance and some exploratory work has been done on it by tunnels. It is mineralized, but no high grade has yet been found in quantity outside of Carnation Claim.

Fig. 27 shows the present condition of the Bretz pits and dumps in relation to the exploratory work done underground, and Photo 46 shows the big cut.

The Bretz ore was hauled to Opalite in two 6 yd. and one 10 yd. trucks each capable of making four round trips per day, so that some 88 cu. yds. per day were hauled over. This was fairly expensive but as Opalite was not worked out that plant could not be moved to Bretz.

A flotation mill to treat Bretz ore was considered and flotation tests were made on it. Colloidal matter in the ore indicated that high recoveries were possible only with a 6½ to 1 pulp dilution when floating. This would require some 600 to 700 tons of water per day for a 100-ton mill. McDermitt Creek, some four miles from the Bretz Mine and 900 feet lower in elevation is an adequate source of water and has good mill sites. The cost of pumping water from here to Bretz or trucking the Bretz ore to the mill on the creek would be about the same per ton of ore treated.

There is lots of low-grade and some high-grade ore left in the Bretz Mine waiting for the man who can devise an economical method for recovering it.

The treatment of two such dissimilar ores as those from Bretz and Opalite in the same plant afforded some interesting comparisons. Comparative runs on Opalite and Bretz ores were made under test conditions when the construction of a furnace plant for the Bretz mine was under consideration.

An excellent U. S. Bureau of Mines paper[24], that is not known nearly as well as it deserves to be, gives a practical and accurate method of determining the time of passage of ore through rotary kilns. This method was used to obtain the time of passage for Opalite and Bretz ores through the 4 by 70 foot kiln at Opalite. Both ores traveled through the kiln in practically the same time, namely 61.6 minutes for Opalite ore and 62.4 minutes for Bretz ore. This calculated time checked well with observed time of test particles that were sent through the kiln.

Opalite ore is practically all silica and is practically dry.

[24] Sullivan, John D., Mauer, Chas. G., and Ralston, Oliver C.: Passage of Solid Particles Through Rotary Cylindrical Kilns. U. S. Bureau of Mines Technical Paper 384.

Bretz ore, which has a moisture content of 28 per cent, gave the following analysis:

SiO_2	59.30 per cent
FeO	4.10 per cent
Al_2O_3	13.90 per cent
CaO	2.30 per cent
MgO	2.26 per cent
*Ignition	15.19 per cent
Alkalis (by difference)	2.95 per cent
	100.00 per cent

The composition of the gases leaving the furnace per ton of ore was as follows:

	Opalite	Bretz
Quicksilver	6.0 lbs.	20.0 lbs.
Sulphur dioxide	1.9 lbs.	6.4 lbs.
Carbon dioxide	165.0 lbs.	298.0 lbs.
Water vapor	90.1 lbs.	686.7 lbs.
Nitrogen	838.0 lbs.	1,676.0 lbs.
Oxygen	70.2 lbs.	176.5 lbs.
	1,171.2 lbs.	2,863.6 lbs.

In other words, in treating Opalite ore the quicksilver was transferred from one ton of ore to roughly ½ ton of gas while in treating Bretz ore the quicksilver from one ton of ore was transferred to roughly 1½ tons of gas.

The gas volume was both calculated and then measured to check the calculation. The calculated gas volume at standard conditions was 1,560,800 cu. ft. per 24 hours for Opalite ore and 1,704,000 cu. ft. for Bretz ore.

The measured gas volume at standard conditions came out 1,629,000 cu. ft. for Opalite and 1,813,500 cu. ft. for Bretz ore per 24 hours.

These checked within 4 and 6 per cent respectively and, as the measured volume is a little higher in each case, a little inward leakage of air into the condenser probably accounts for the difference. The volumes are nearly the same as they should be because the speed of the exhauster was not changed.

* This sample had been dried at the conventional temp. of 105° C. Ignition loss includes water of combination, S, Hg, and CO_2.

Photo No. 45—Same view as above taken in 1937. Note that the entrance to the pit is now from the lower instead of upper road. The dump just showing at the right is low grade ore.

Photo No. 46—Bretz Mine. Looking into the big cut or west pit from the entrance. The stratified lake beds can be seen clearly at the right.

Thus under these test conditions everything was kept the same, such as speed of the exhauster and rate of rotation of the kiln, yet the inherently differing qualities of the ore caused the following differences in the treatment of the two ores:

	Opalite	Bretz
Average CO_2 analysis	10.6%	9.5%
Average tons treated per day	108	49
Average gallons of oil burned	782	640
Average grade of ore treated	6 lbs./ton	20 lbs./ton
Average dust chamber temp. °F.	500	536
Average stack temp., °F.	86	122
Average atmospheric temp., °F.	45	62
Difference between atmos. and stack temp., °F.	41	60
Wt. of ore per cu. ft. in place	152 lbs.	92.3 lbs.
Weights per cu. ft. of broken ore	95.9 lbs.	56.8 lbs.
Moisture in %	1.0%	28.0%
Wt. per cu. ft. of furnace tails	83.75 lbs.	58.0 lbs.
Fuel consumption gals./ton	7.25	13.0
Excess air used	39.0%	54.5%
Lbs. of gas leaving furnace per ton of ore treated	1,171.2	2,863.6
Cu. ft. of gas leaving furnace per minute	2,200.0	2,770.0
Cu. ft. of gas leaving furnace per ton of ore	29,300.0	81,500.0
Dew point of water vapor, °F.	117°	153°
Dew point of quicksilver vapor, °F	234°	243°

Note that fuel consumption is much higher for Bretz ore because more water must be evaporated. The excess air on Bretz ore is a little higher, though both are remarkably low for quicksilver furnaces. The cooling of the gases in the condenser is better with Opalite ore because there is less water in the gases. The cooling would be closer to atmospheric temperature if the plant had a better dust collector. The outstanding difference, however, is the fact that only 49 tons of Bretz ore can be treated per day as against 108 tons of Opalite ore,

because of the greater gas volume per ton of the Bretz ore. If the plant were equipped with a Sirocco Dust Collector, this tonnage could have been increased by speeding up the exhauster and so handling the extra gas volume per ton of ore.

This data shows clearly that plants must be designed to fit the ore. On Opalite ore for which the plant was designed, it did excellent work. Working on Bretz ore it could only treat half the tonnage. Despite the fact that Bretz ore ran 20 lbs. per ton the dew point, that is the temperature where quicksilver begins to condense, is only 243° F., or only 9° F. higher than for the 6 lb. Opalite ore. This is due to the greater gas volume. If the gas volume per ton for the Bretz ore had been the same as for Opalite ore the dew point would have been 280° F.

OTHER PROSPECTS

Doan Prospect: This is located some 35 miles north of Denio in Harney County, between Fields and Andrews. It is about six miles north of Fields, and one or two miles west of the road. Nine claims have been staked. Only discovery pits and one cut have been dug so far. Assays on various samples have run from 0.4 to 42.2 lbs. per ton of quicksilver.

Another prospect is described vaguely as being some six miles south of the Doan Prospect. Two or three claims have been staked. One 35-foot shaft has been sunk. This prospect shows a 3 to 6 inch stringer of livingstonite, an antimony-quicksilver ore. Samples of this stringer ran 32.6 lbs. and picked specimens ran 104 lbs. of quicksilver per ton.

Farther west in southern Lake County a quicksilver prospect is reported eight miles north of Plush, and another one as being at Lakeview near the Willow Ranch.

In northeastern Lake County a few miles east of Glass Buttes and a few miles south of the Bend-Burns Highway in Sec. 34, T. 23 S., R. 23 E., and Sec. 3, T. 24 S., R. 23 E., 48 lode claims were located in 1935. These cover a low-grade opalite deposit that assays from 2 to 10 lbs. of quicksilver per ton. The property is held by H. A. Miller of Bend, Oregon. There has been no production, but some development work has been done.

Cinnabar has been reported in the Blue Mountains, for example in the Columbia mine*. It has also been reported in placer deposits around Susanville, Granite, and from north of Sumpter. Most of these finds report its occurrence on the John Day River. These localities are in Grant and Baker Counties.

There is a cinnabar prospect some 14 miles from Powers, in Coos County. A road from Powers can be followed for eight miles and the rest of the way is by trail. The prospect is developed by pits and a tunnel. Cinnabar occurs in steeply dipping conglomerate under a slate wall. Samples of the ore are reported to run from 2 to over 30 lbs. quicksilver per ton.

Clackamas County is also one of the quicksilver producing counties of Oregon. A small production has come from the Oak Grove Mine near Estacada during the last six years, and totals nearly 100 flasks.

In Josephine County float cinnabar has been reported from Pickett Creek and Palmer Creek. In the latter locality cinnabar has also been reported in place.

Cinnabar has also been reported from Tillamook and Yamhill and Curry counties, but detailed information is lacking. Thus to date the occurrence of cinnabar has been reported from about half the counties in Oregon.

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* Lindgren, W. The Gold Belt of the Blue Mountains of Oregon U. S. G. S. 22nd Ann. Rept. Part II, p. 664.

OREGON QUICKSILVER PRODUCTION

The recorded quicksilver production from Oregon is as follows:

Year	Flasks Produced	Number of Producing Mines	Value	Average Annual New York Price per Flask
1887	65	2	2,754	$42.375
1888	32	1	1,360	42.50
1889	20	1	900	45.00
1900	200	1	8,988	44.94
1901	75	1	3,634	48.46
1905	43	1	1,558	36.22
1906	3	1	118	39.50
1908	346	2	2,032	44.17
1909	493	1	22,407	45.45
1915	5	1	441	88.17
1916	303	3	38,530	127.16
1917	388	3	41,795	107.72
1918	702	2	87,834	125.12
1919	435	3	40,620	93.38
1920	24	1	1,973	82.20
1921	25*	1	1,152	46.07
1922	2	1	119	59.74
1923	10*	1	674	67.39
1924	5*	1	353	70.69
1927	2,082	3	242,761	118.16
1928	3,759	4	458,147	123.51
1929	3,657	5	446,864	122.15
1930	2,919	7	335,711	115.01
1931	5,011	5	437,716	87.35
1932	2,523	7	146,145	57.93
1933	1,342	5	79,483	59.23
1934	3,460	11	255,573	73.87
1935	3,456	10	248,798	71.99
1936	4,126	13	329,750	79.92
1937	4,200*	14	378,000	90.18
	39,711		$3,617,010	

Oregon has so far produced close to 40,000 flasks of quicksilver to a value exceeding three and one-half million dollars.

The occurrence of quicksilver ore has been reported from all parts of the state. It is only in recent years that Oregon prospectors have familiarized themselves with quicksilver ore and

* Estimated.

the nature of its occurrence. As the search has become inten-
sified, more and more new prospects have been found.

Thus far four large mines capable of producing over 1,000
flasks per year have been found in widely separated parts of
the state. Several smaller mines are producing with fair regu-
larity and promise to become more important as producers in
the future.

Most of the quicksilver mines thus far found are rather sur-
ficial deposits and none of the present mines promise to become
100,000 flask producers. There should be a good possibility,
however, of finding many more quicksilver mines in Oregon
that will have a total production of somewhere between 5,000
and 15,000 flasks, and a great deal of money can be made from
such mines if the grade of the ore is not too low.

Since many promising prospects lie idle because the owner
and prospective buyer cannot agree on price and terms it might
be well to cite the terms of such transactions, that have worked
out successfully.

It is practically impossible to determine the value of a
quicksilver mine, because the amount of ore developed at any
one time is too small, and accurate sampling is very difficult.
This applies, doubly so, to quicksilver prospects.

Hence quicksilver mines and prospects are generally sold
on a royalty basis. The buyer usually lets the seller set the
price if the seller will let him decide the terms.

The buyer sets the terms that will let him operate at a profit
after paying his royalty to the owner. Under such terms he
operates as long as he can make money and pay off on the mine
while doing so. If the mine produces long enough to pay out its
price in royalties he gets the mine and the owner gets his asked
price. If the mine peters out or if the price drops too low for
profitable operation the buyer quits with such profit as he has
made and the mine reverts to the seller with such additional
development and improvements as have been made by the
buyer. This is fair to both.

The royalty is usually around 10 per cent of the gross pro-
duction, and the price is some figure that both buyer and seller
will accept. Sometimes the royalty depends on the price and
increases or decreases 1 per cent for every $10 change in the

price per flask. Down payments are not usual unless ore is actually blocked out, but generally some minimum monthly payment of $100 or $200 per month is agreed upon to show good faith on the part of the buyer.

CONCLUSION

In the last eleven years, a substantial quicksilver mining industry has been built up in the state of Oregon. The number of producers has grown from 3 to 14 in this time. Many of the present discoveries deserve to be developed. A great deal of promising territory remains to be prospected for cinnabar occurrences. Since more prospectors are familiarizing themselves with this mineral and becoming active in the search for it, many new discoveries can be expected in future years.

The Oregon quicksilver industry has learned how to "ride the bumps" of the business and how to operate on the "cut and run basis" that is necessary in the United States due to lack of protection from the dumping of foreign quicksilver produced by people living on a much lower scale than our own.

In late years Oregon has advanced to the position of the second largest producer among the states. Its record production in 1931 was over 5,000 flasks and the average annual output of the last eleven years has been some 3,300 flasks.

Men, trained in the business of quicksilver mining, are becoming available in increasing numbers, and modern plants both large and small are being operated with increasing skill. Hundreds of men are gaining their livelihood in this growing business founded upon one of the natural resources of the state.

The quicksilver mining industry of Oregon proved its inherent soundness by the manner in which it weathered the 1932-33 depression, and many equitable ventures are available to mining capital in the development and exploitation of Oregon quicksilver deposits.

SUPPLEMENT

Quicksilver in Oregon

By C. N. SCHUETTE

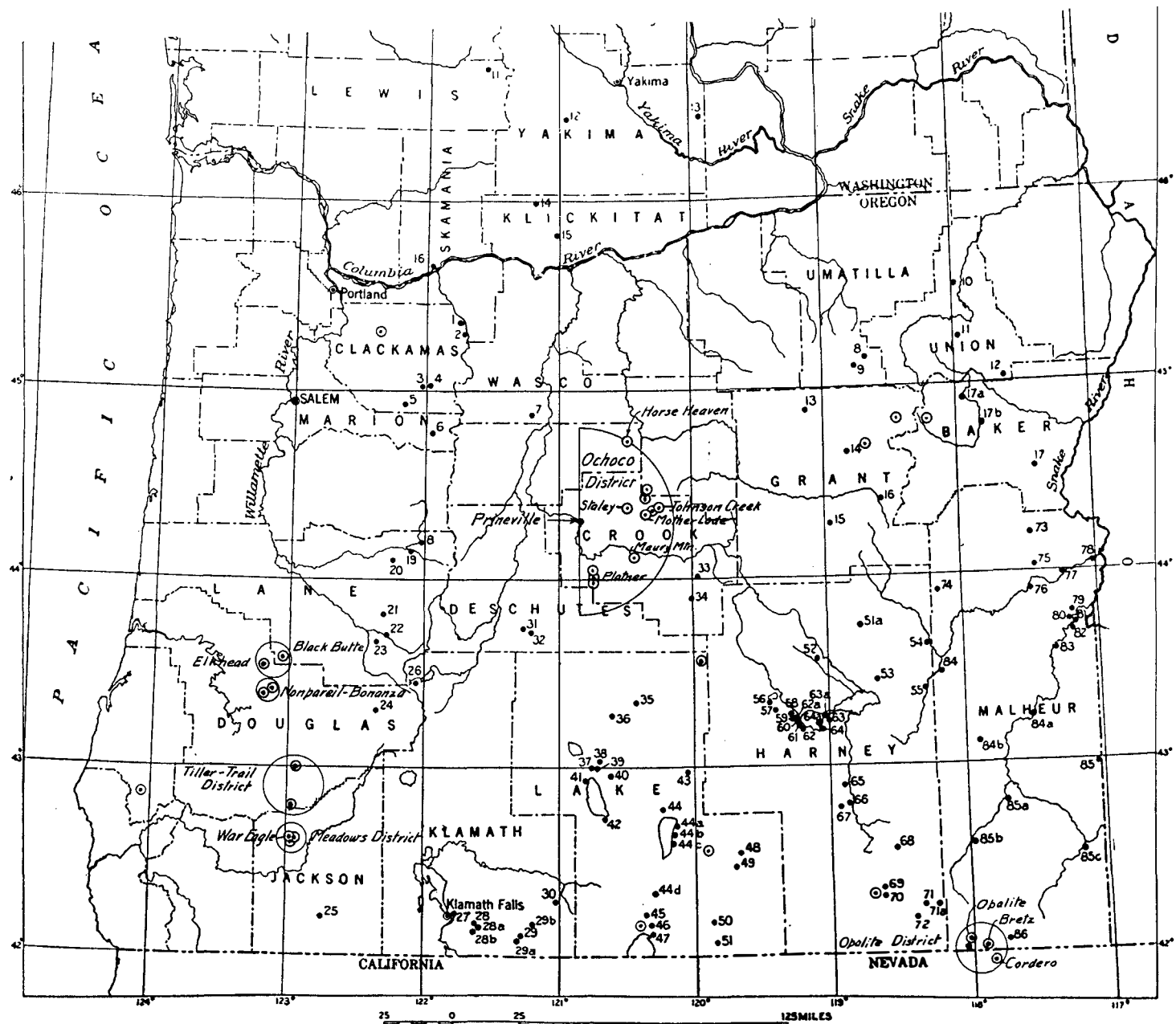
Figure 1—Map of Oregon showing thermal springs and quicksilver deposits. Solid black dots are springs; with dots and circles, are mines.
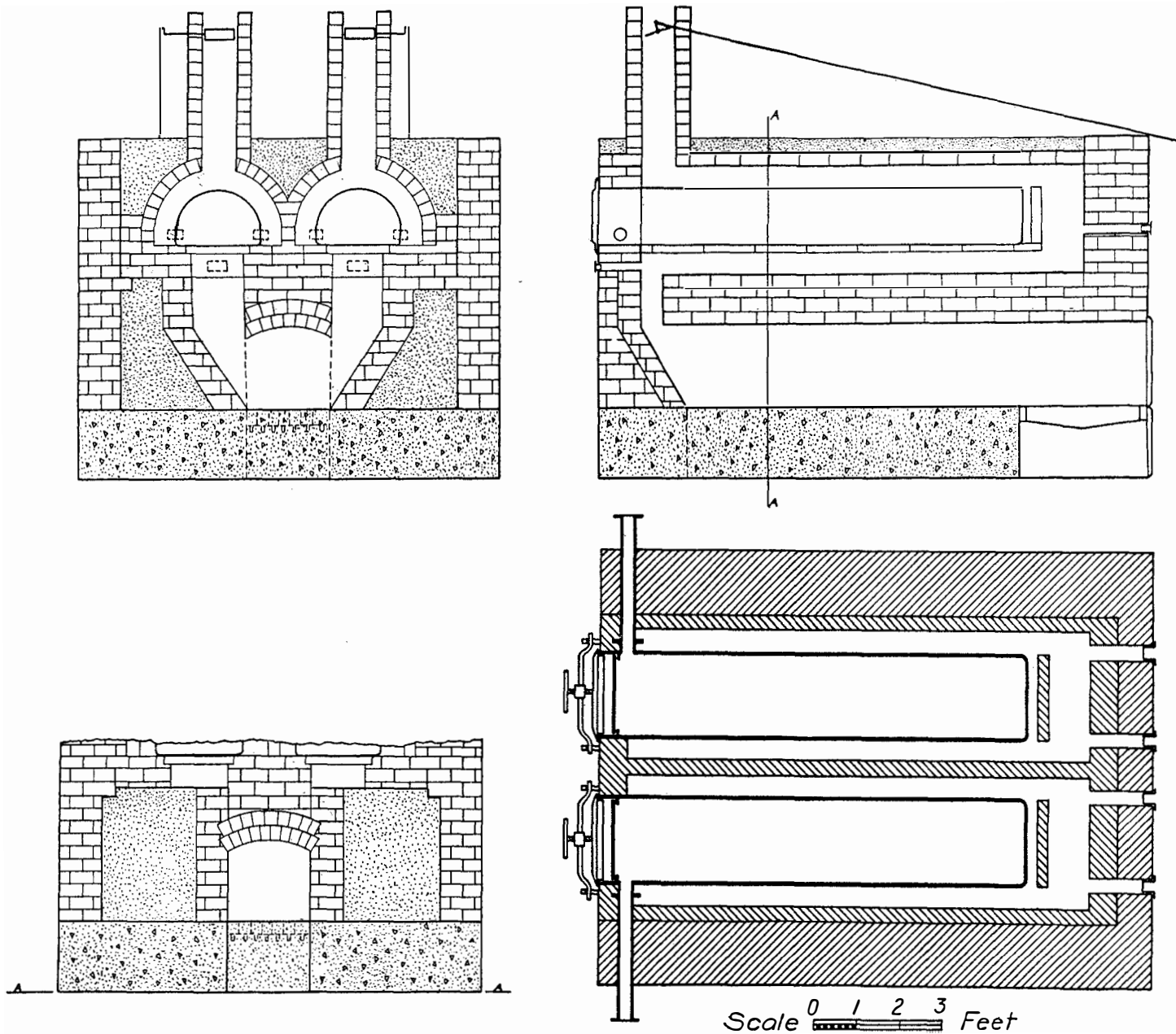
Scale 0 1 2 3 Feet

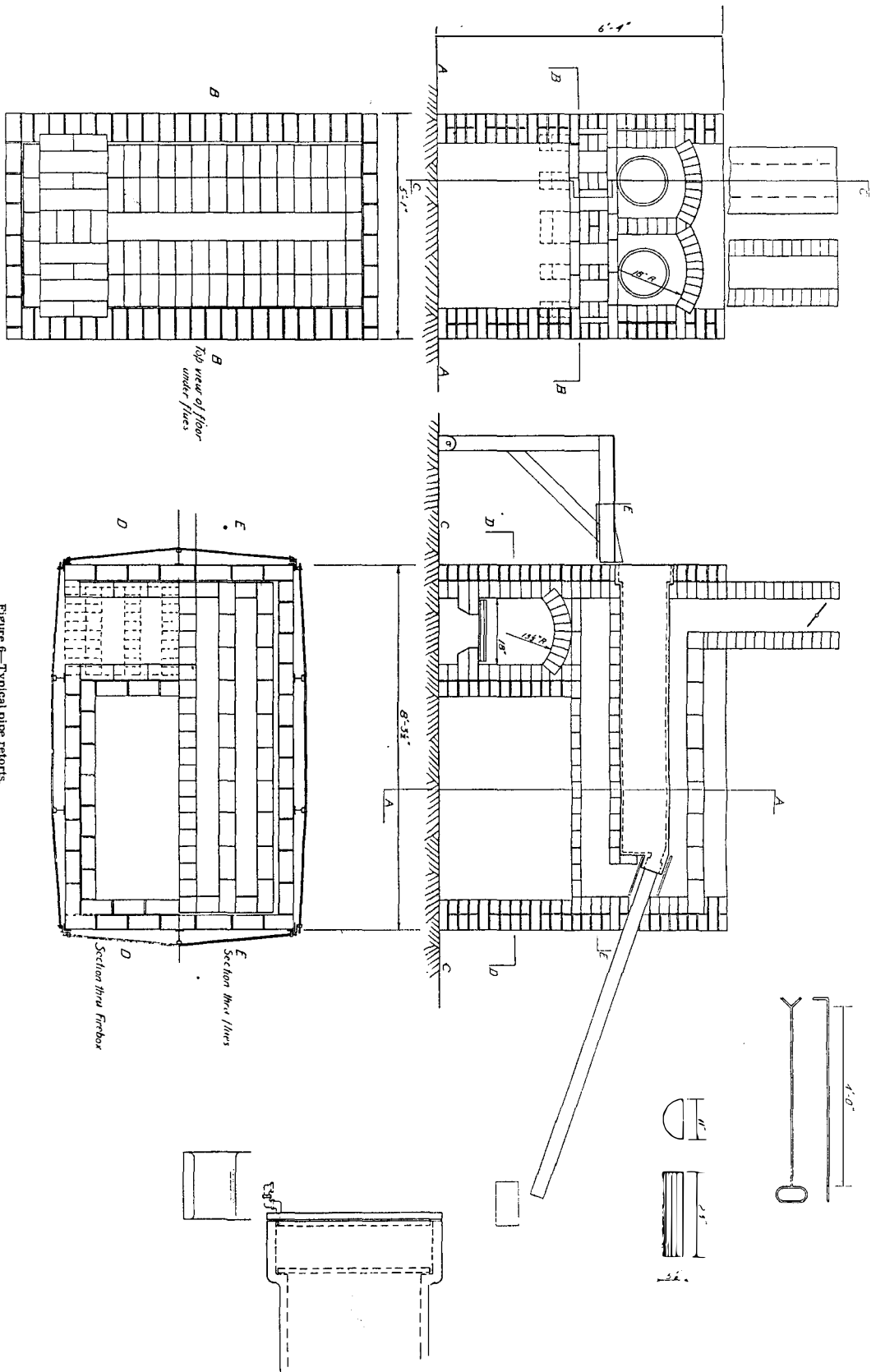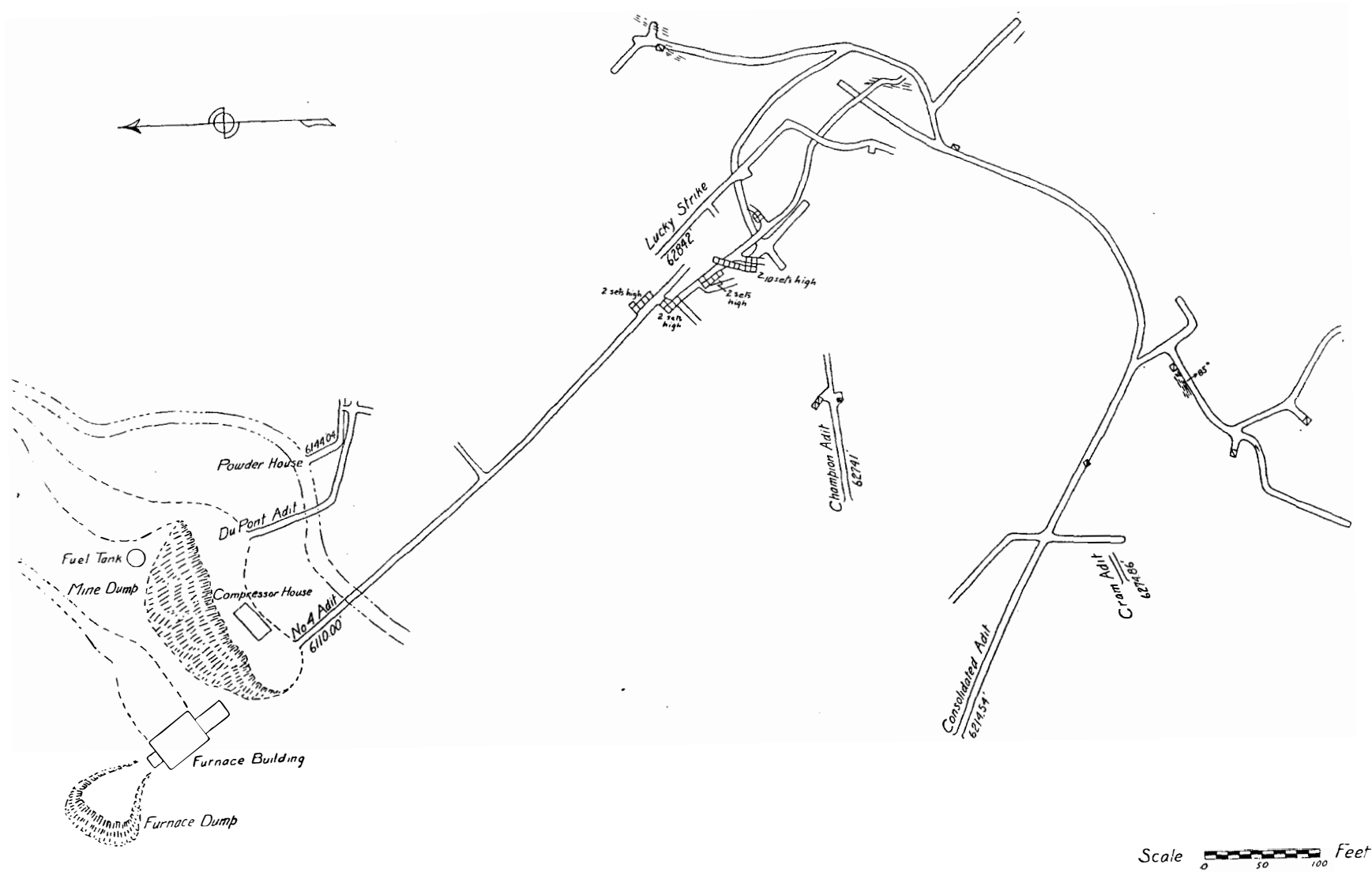Figure 5—Typical D-retorts.

Top view of floor
under flues

Section thru flues

Section thru Firebox

Figure 6—Typical pipe retorts.

Figure 11—Plan Map of Mother Lode Mine, Ochoco District, 1935.

Lucky Strike
6284.2

Du Pont Adit

Powder House
6144.04

Fuel Tank

Mine Dump

Compressor House

No 4 Adit
6110.00

Furnace Building

Furnace Dump

2 sets high

2 sets high

2 sets high

2 to sets high

Champion Adit
6274.1

Cram Adit
6274.86

Consolidated Adit
6214.54

Scale   Feet
0   50   100

War Eagle Mine

Property Map

Scale Feet
0   500   1000   1500   2000

August 1936   C. H. Schuette

Section 8

Section 7   Section 9

Section 18 | Section 17   Section 16
Section 19 | Section 20   Section 21

Blue Ribbon 6-9-16
Outcrop 6-9-16
Red Ridge 6-9-16
Broadway 6-3-16
Lucky Shine 6-18-16
Shoonvin 6-3-16
Blue Bell 6-9-16
Rainier 6-1-16
Harold 5-12-16
Lorena 5-12-16
Robin 5-10-16
Utah 6-1-16
Selma 6-1-16
Quicksilver 6-1-16
Tacoma 5-10-16
Elmer 5-10-16
Camp
Coal Area
Cardwell
Cupola
War Eagle 2-15-?6
Challenge 5-35-?6
Summit 6-14-16
Rainbow 6-3-16
Hampshire 4-15-16
Ledge Pa?
Shaft
Josephine 5-12-16
Cedar 6-14-16
Lucilla 6-11-16
Blue Jay
Wedge 7-3-16
Ruston 6-11-15
Red Daisy
Lynn 6-14-16
Mountain View
Meadows 1-1-00
Fir 5-4-16
Badger 7-18-16
Agnes 5-11-16

Figure 14—War Eagle Mine, property map, August, 1936.
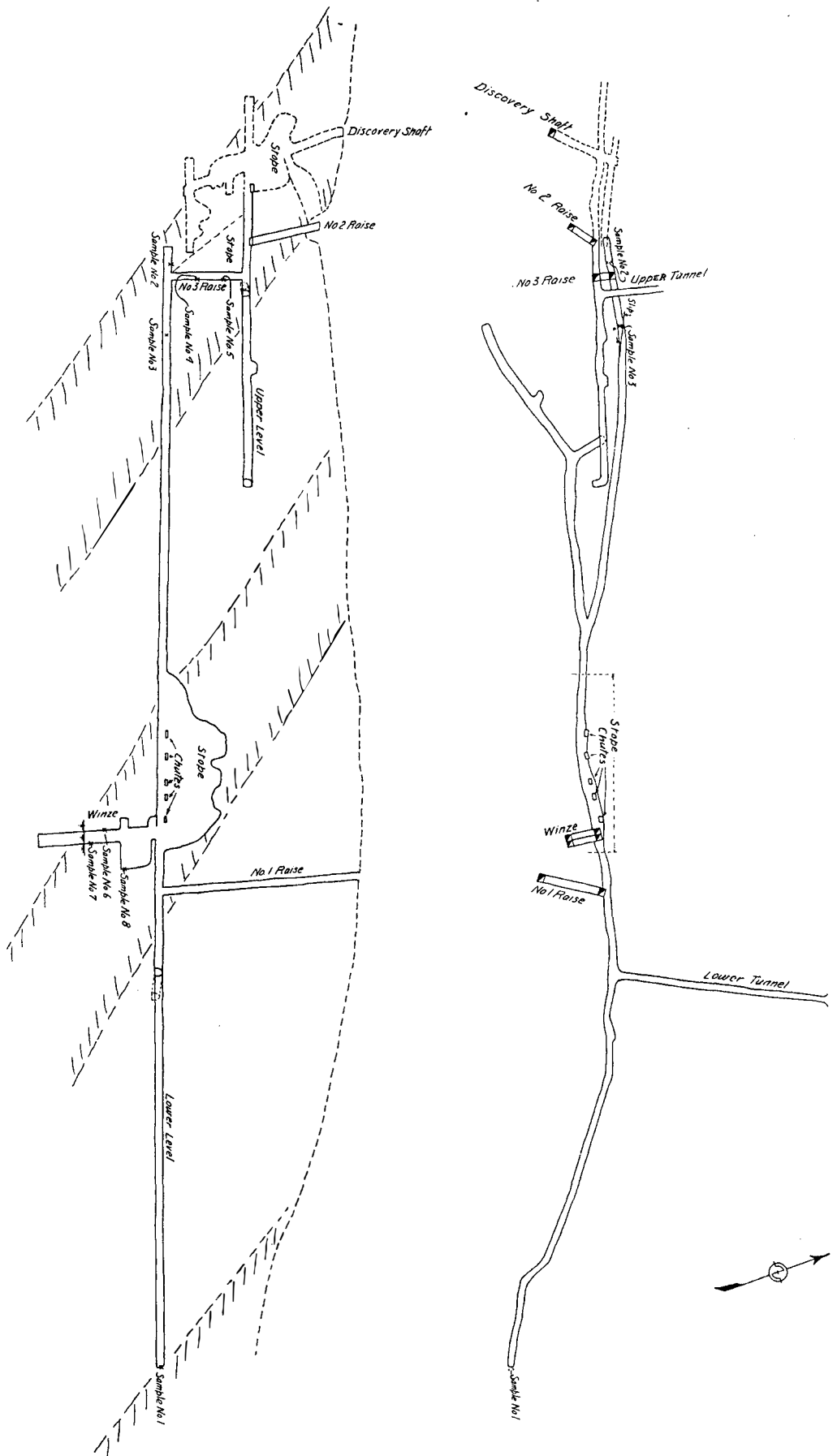
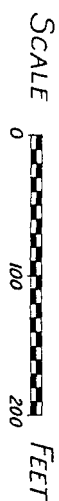Figure 15—War Eagle Mine, plan and longitudinal section, 1937.
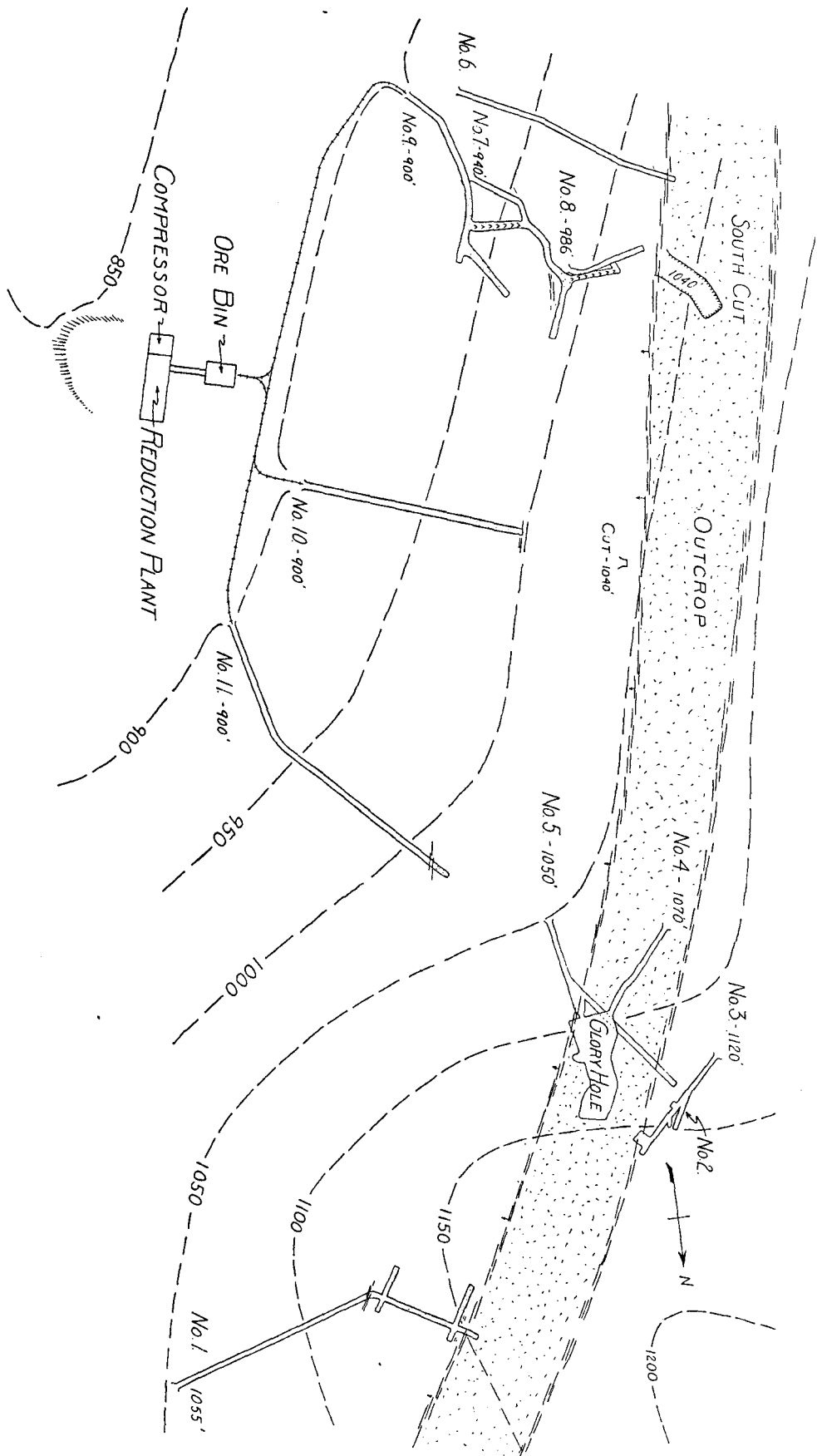
Figure 18—Bonanza Mine—Plan of workings.
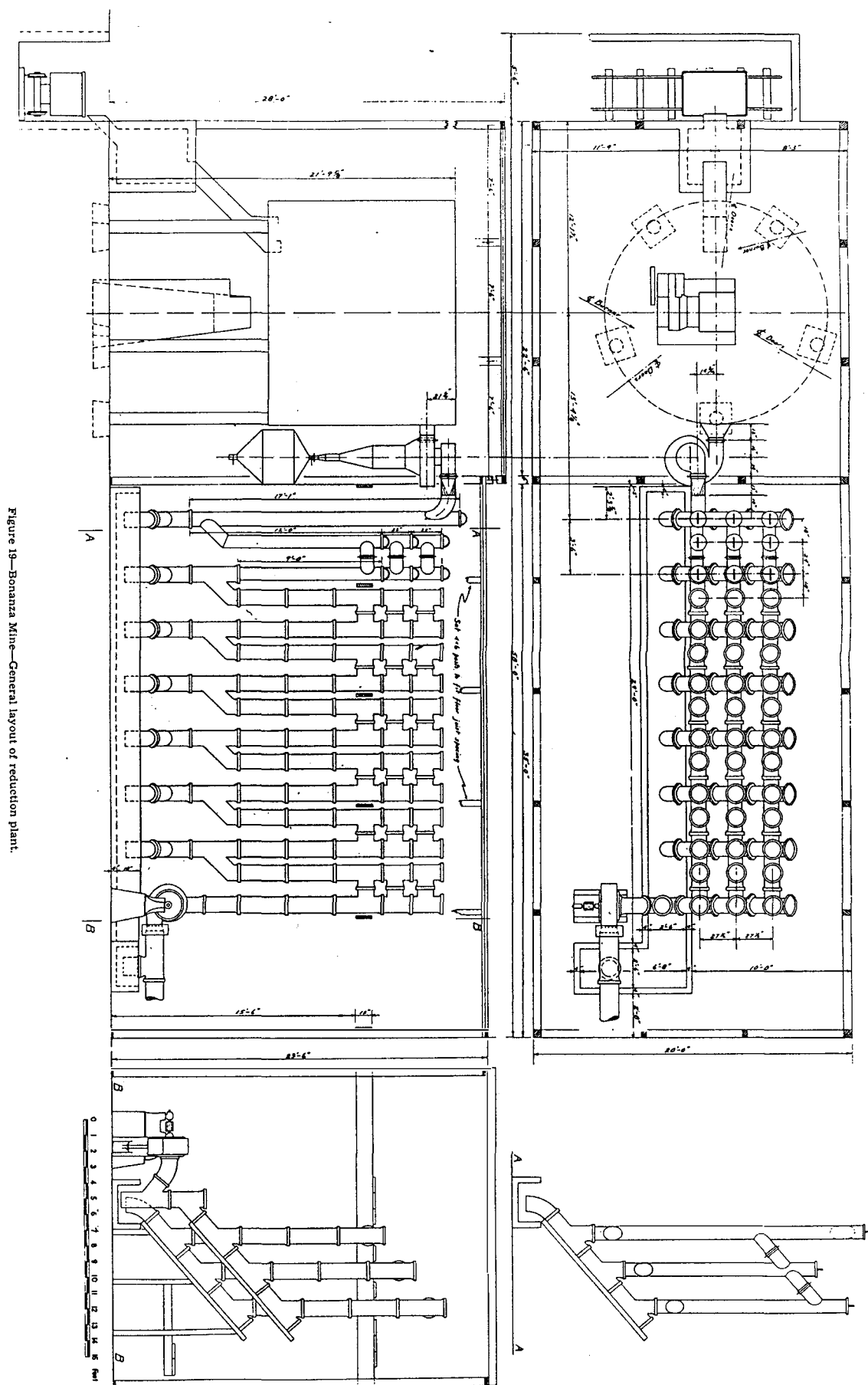
SCALE

0   100   200   FEET

Figure 19—Bonanza Mine—General layout of reduction plant.
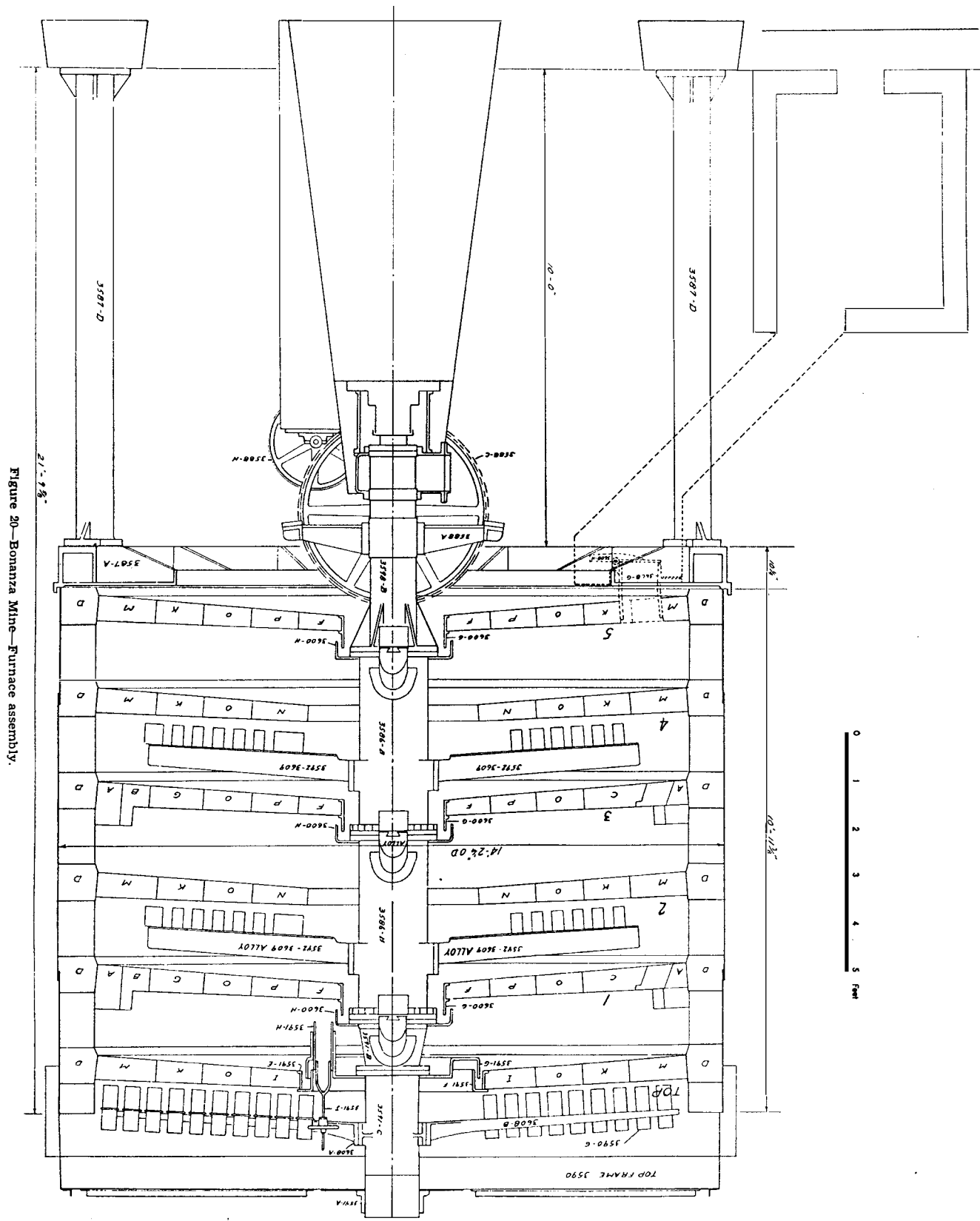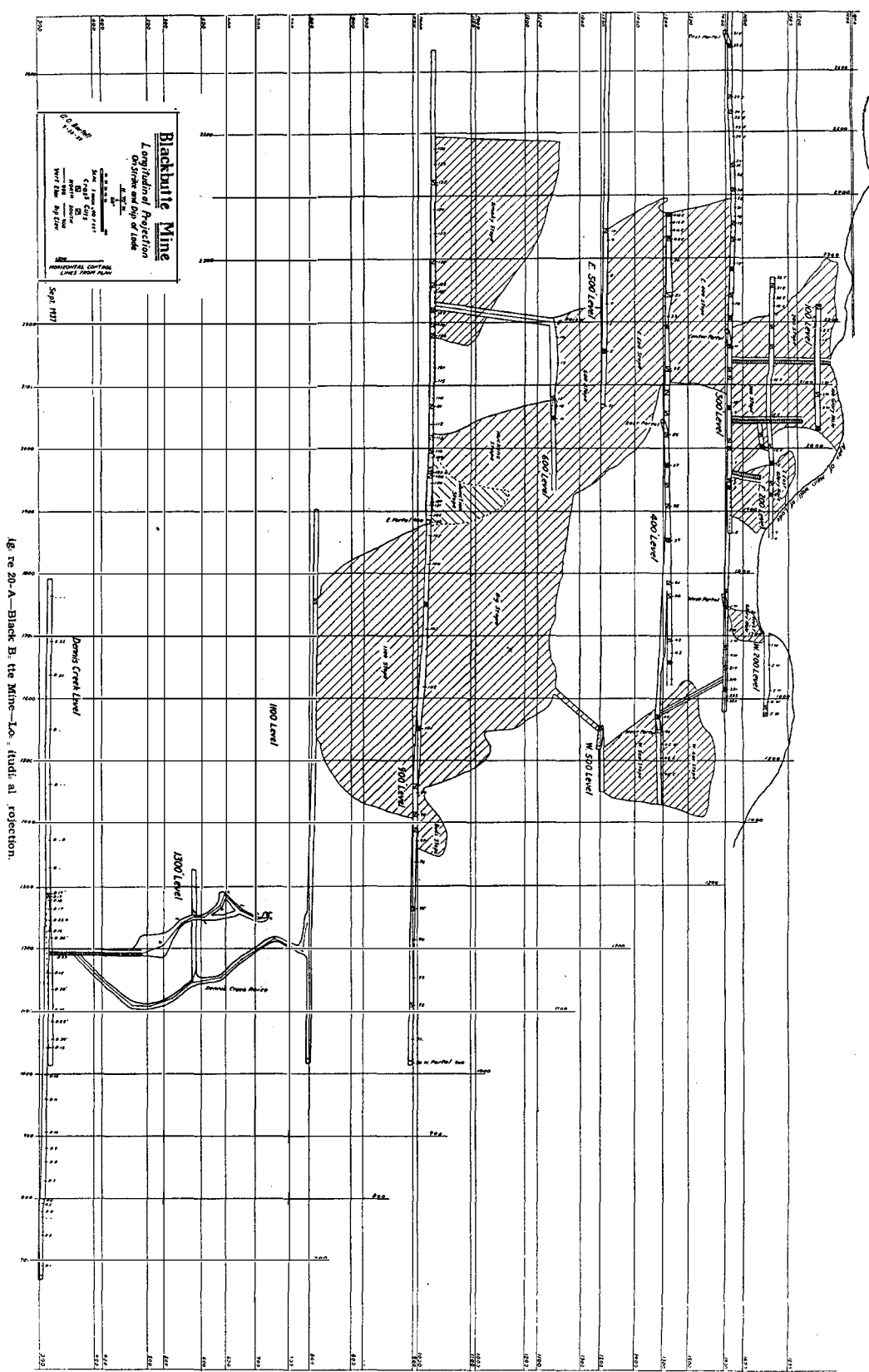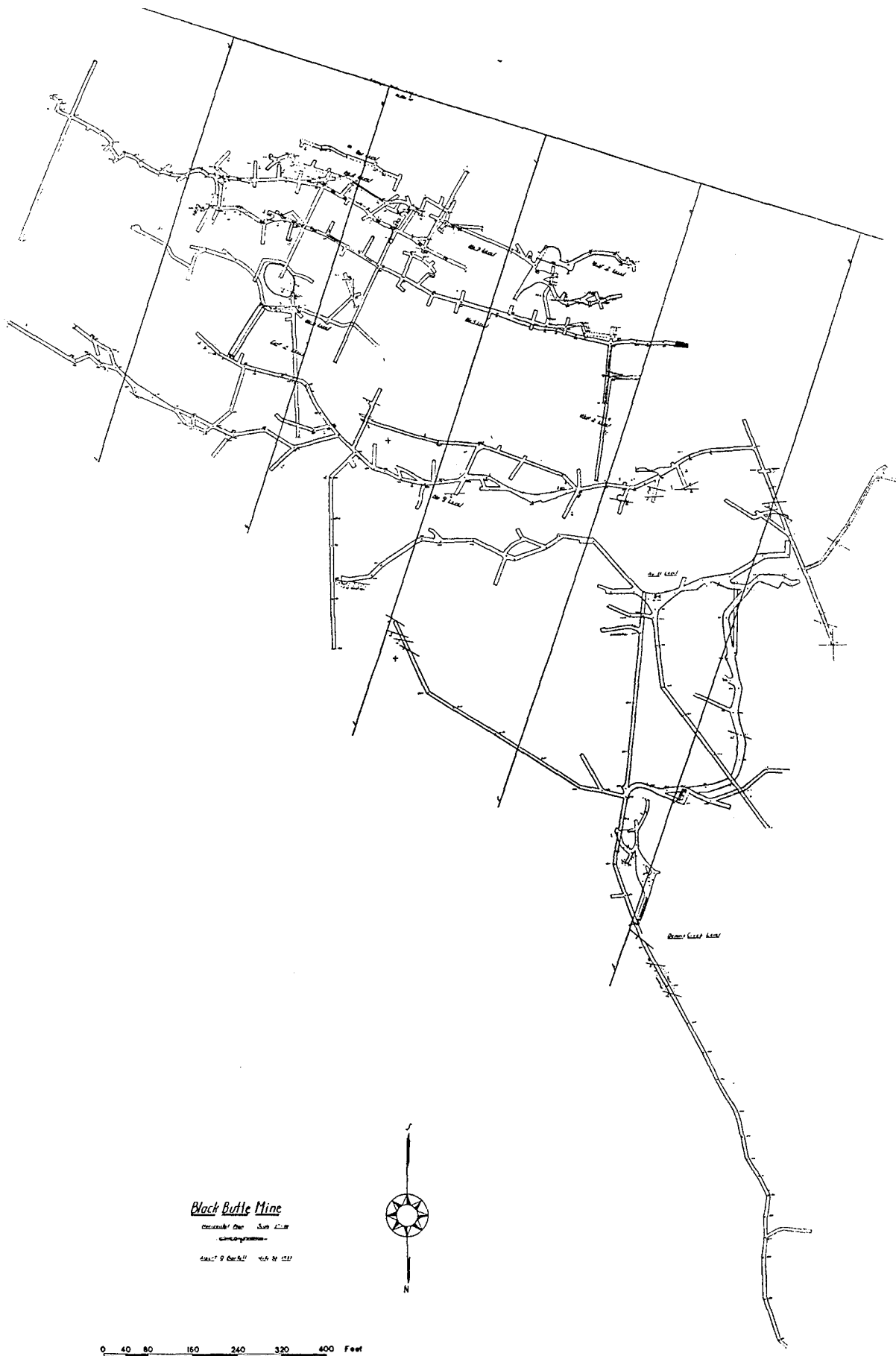
Figure 20—Bonanza Mine—Furnace assembly.

Blackbutte Mine

Longitudinal Projection
On Strike and Dip of Lode

Sept. 1937

Figure 20-A—Black Butte Mine—Longitudinal Projection.

Black Butte Mine

Black Butte Mine

0   40   80   160   240   320   400 Feet

Figure 20-B—Black Butte Mine—Horizontal Plane.
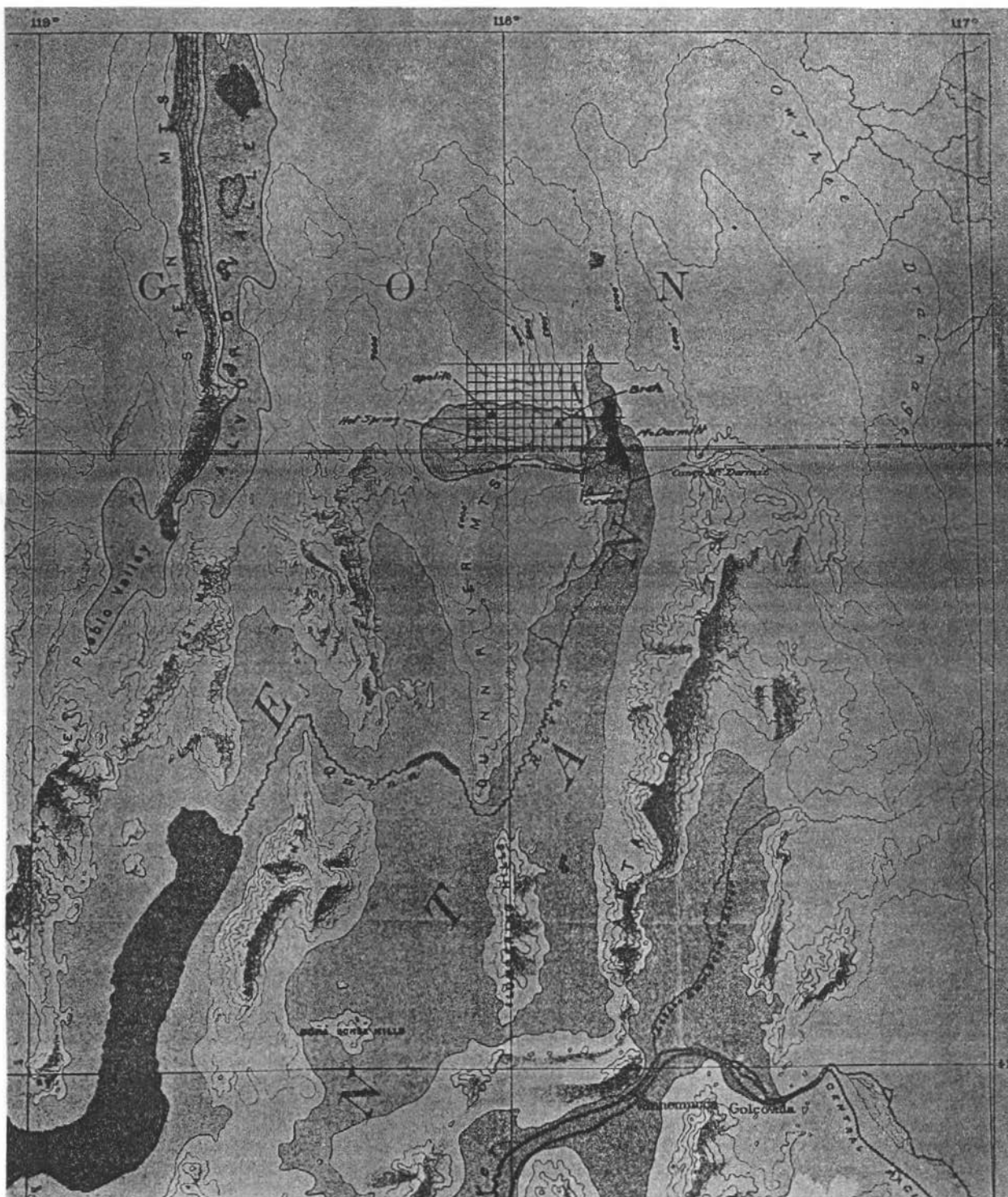
Figure 21--High-water stage of Lake Lahontan.
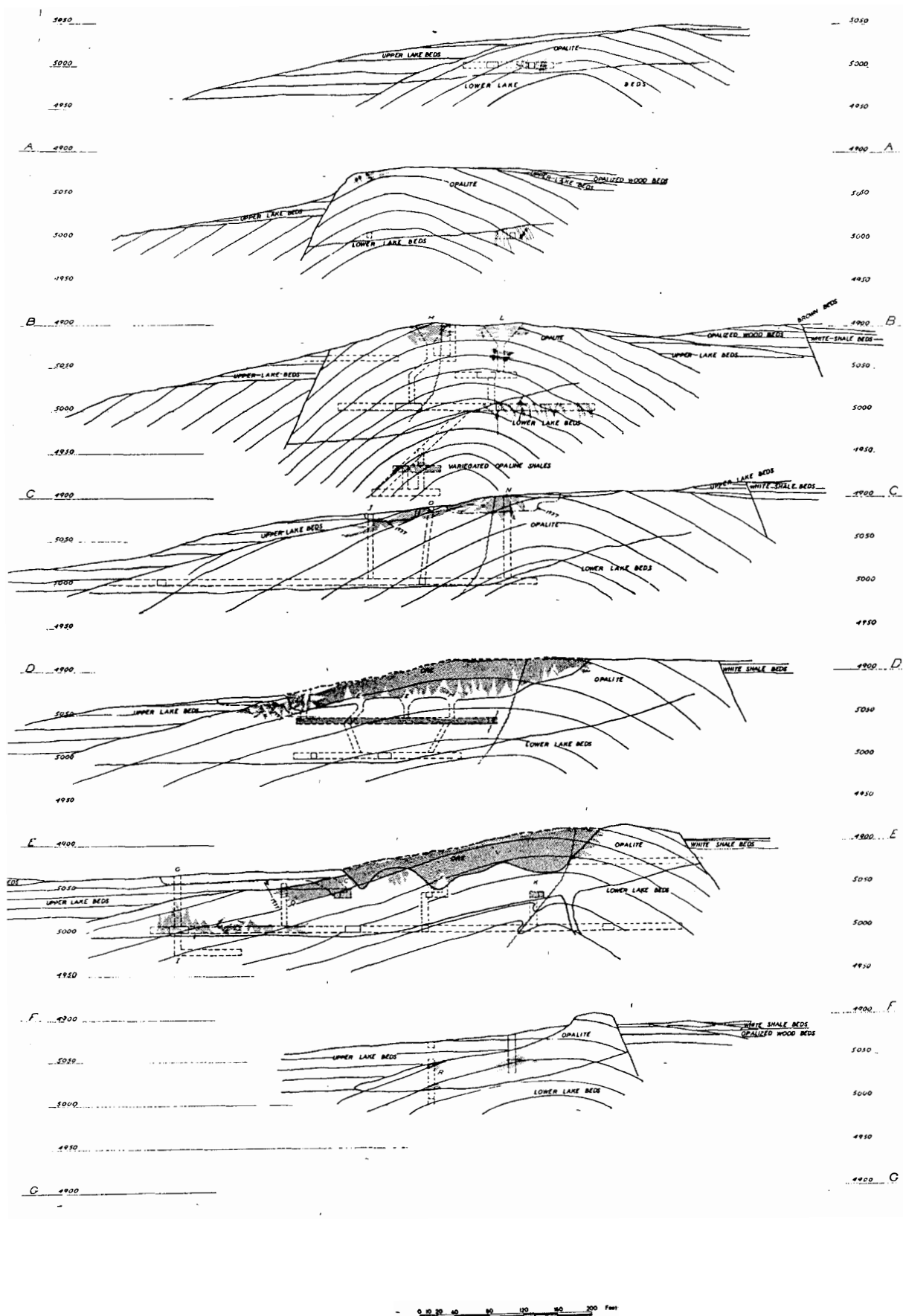
Figure 24—Opalite Mine—Series of vertical sections.
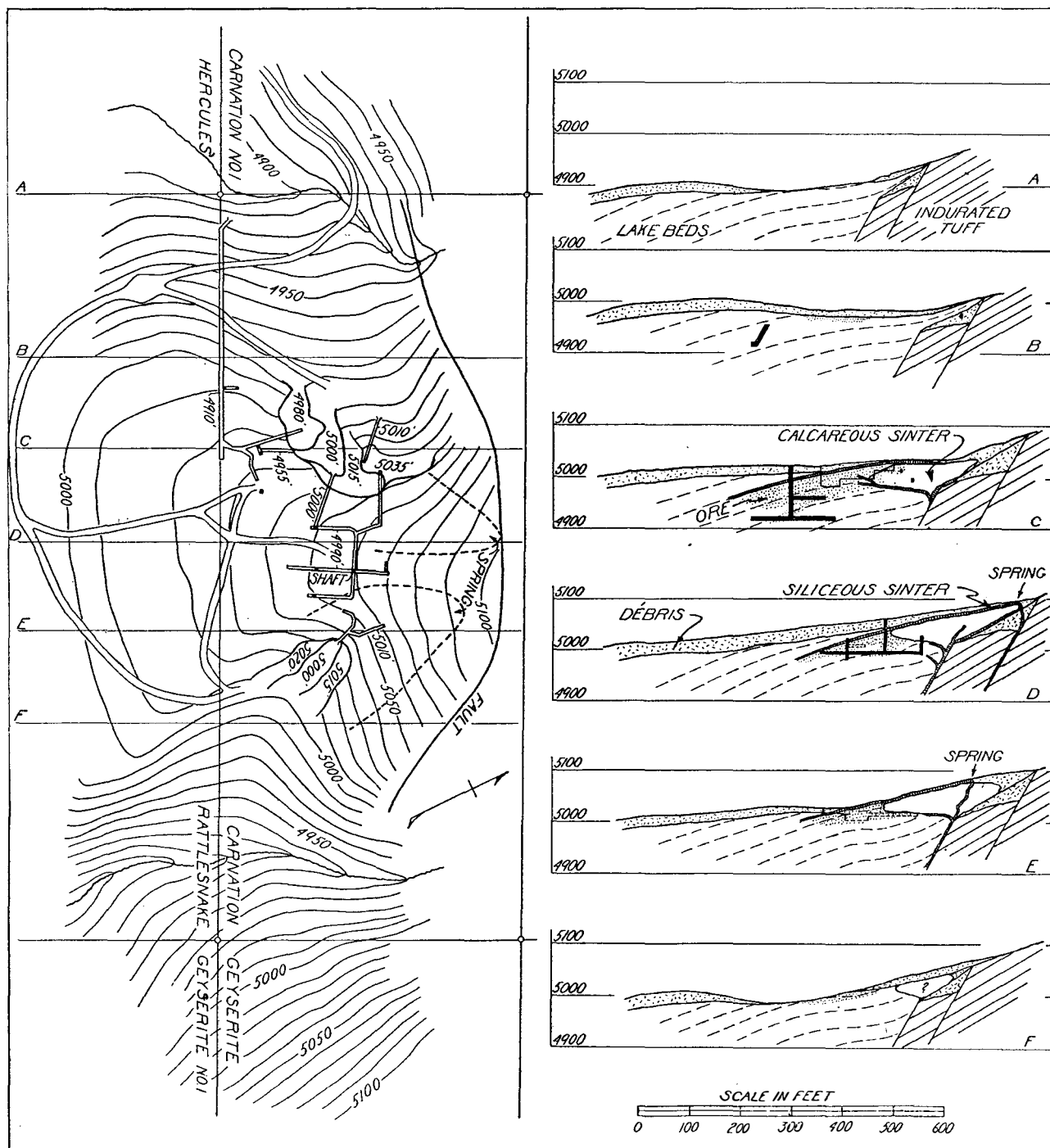
Figure 25—Opalite Mine—Drawings of condenser plant.

Figure 26—Bretz Mine—Early plan and sections.

Figure 27—Bretz Mine—Topography, plan of workings, etc.