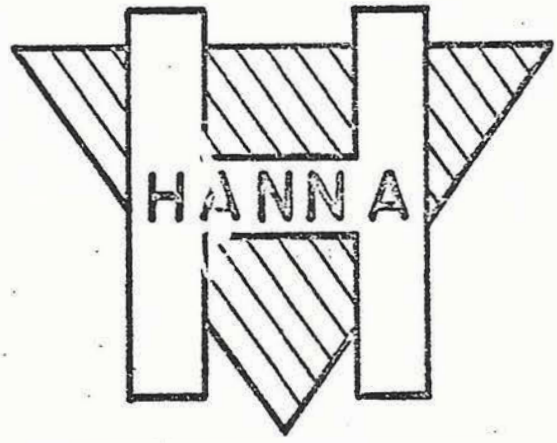
THE HANNA NICKEL OPERATION

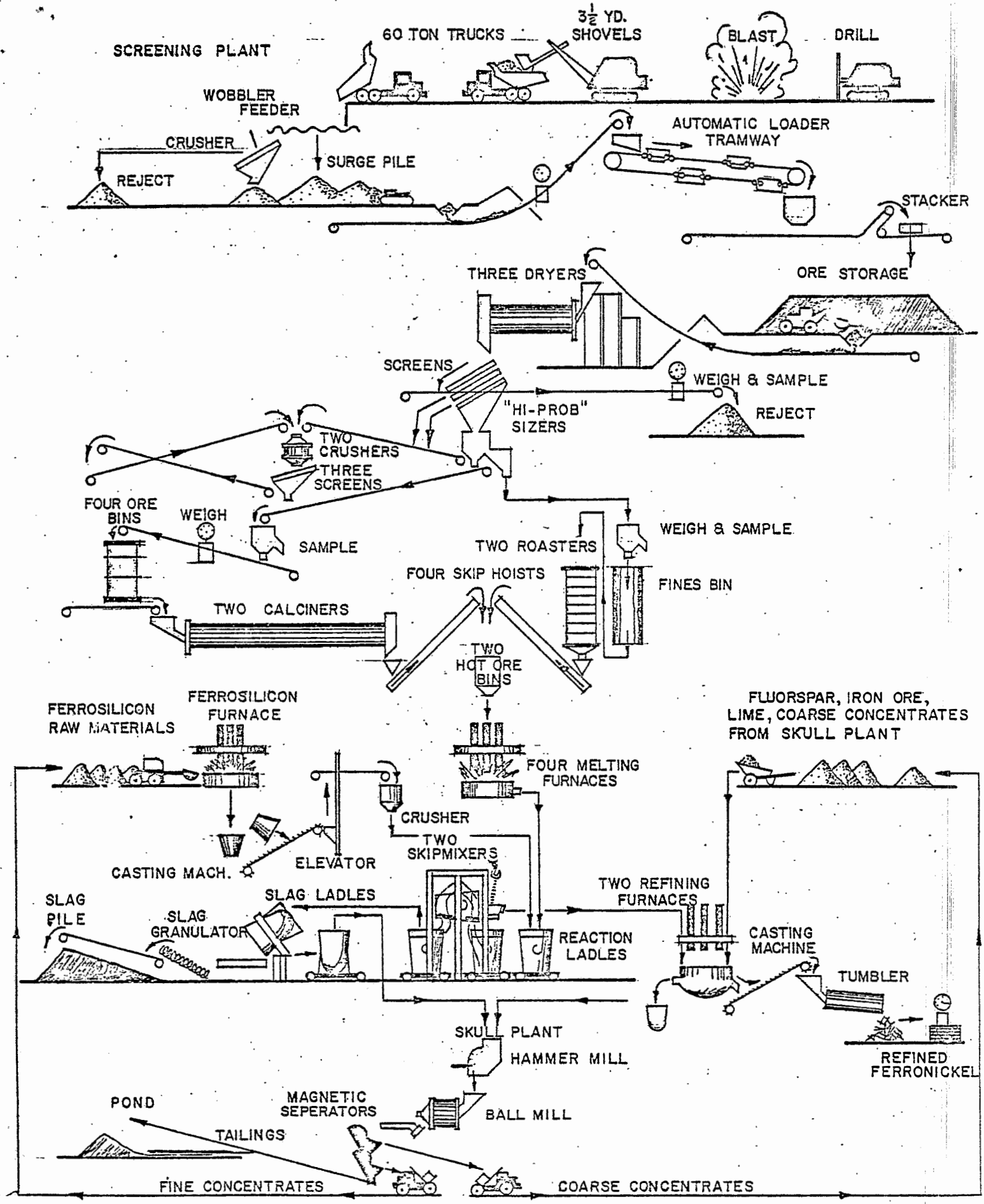


THE HANNA MINING COMPANY

HANNA NICKEL SMELTING COMPANY

RIDDLE, OREGON

JUNE 1, 1970



FLOW DIAGRAM

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Nickel Mountain is located in southwestern Douglas County, Oregon, four miles west of the town of Riddle. The deposit was discovered in 1864 by local settlers, but it was not until 1881 that the ore was recognized to be nickel silicate rather than copper carbonate as originally assumed. Subsequent to 1881 much prospecting and preliminary development work was done, but no ore was processed for other than metallurgical tests until the present mining operation began.

The Hanna Mining Company and Hanna Nickel Smelting Company began production of ferronickel, the first to be produced in the United States from domestic ores, in July of 1954. The companies have operated on an around-the-clock schedule since that time and have provided steady, year around work for over 450 employees.

MINE

Geology

The deposit is approximately 3,000 by 6,000 feet, averaging 60 feet in depth. Mineralization occurs in a sheared and altered peridotite, and in many cases, consists of finely divided veinlets in a chalcedony boxwork. Several nickel minerals are found with garnierite, a complex magnesium silicate of nickel, being most easily recognized. Chromium, cobalt and aluminum occur in very minor amounts. Iron oxides, magnesia and silica make up the major constituents of the ore. Average nickel grade of the deposit is approximately 1.2%.

Grade Control

Nickel content of ore delivered to the smelter stockpile must be maintained as uniform as possible to produce optimum metallurgical results. This is somewhat difficult due to the wide, inconsistent variations in nickel content throughout the deposit. Twenty foot bench heights, narrow shovel cuts, bank samples, drill-hole samples, geologic interpretations and visual classification, combined with widely spaced daily cuts, make up the grade control pattern.

Development

Open cut mining methods are utilized. The topography is ideal for the development of level mining benches at twenty foot vertical intervals. This interval was chosen for grade control purposes. Benches are a minimum fifty foot width and extend to the limits of the deposit. Main haulage roads, sixty feet wide, traverse the area at a ten percent maximum grade and intersect the mining benches at intervals controlled by the maximum haul on level benches.

Mining and Hauling

Much of the ore can be dug without blasting. When this is necessary, however, a 6-1/2" down-hole drill is used. Ammonium nitrate - fuel oil is the blasting agent.

Loading is accomplished with 3-1/2 cubic yard diesel shovels. Large residual boulders, called pit reject, are separated from the ore by the shovel operator and ultimately deposited on waste dumps. The ore is loaded into 60-ton diesel trucks and hauled to the screening plant.

Screening and Crushing

The ore is deposited directly into the screening plant feed hopper. A separation is made on a wobbler feeder and scalping screens with the minus 5-1/2 inch product going directly to the tramway surge pile and the plus 5-1/2 inch to the crusher. Crushed material is visually classified and directed to the ore product or to the reject stockpile. After screening and crushing, the ore product is deposited in a 12,000 ton tramway surge pile.

Tramway

From the surge pile the ore is fed to the tramway loading terminal where it is loaded automatically into 50 cubic foot tram cars. It is conveyed downhill to the smelter storage stockpile at a maximum rate of 250 short tons per hour.

The tramway runs continuously carrying ore in the upright tram cars on the upper pair of suspended track cables and returning empty in an inverted position on the lower pair of track cables. Ore is loaded automatically and discharged by inverting the cars at the lower discharge terminal, where it is bedded in the smelter stockpile by an overhead belt conveyor and traveling wing tripper.

A speed of 500 feet per minute is maintained by two 300 horsepower induction generators driven by the loaded tram cars through a gripwheel and gear train in the loading terminal. The braking action of the generators produces approximately 500 horsepower which is used in the operation of the mine facilities.

The tramway is 8,300 feet long and drops a vertical distance of 2,000 feet in its length.

SMELTER

Ore from the stockpile is processed at the smelter to produce ferronickel containing approximately 50% Nickel. Steps in the process include reclaiming of ore, drying, fines screening, rejection of lean rock by screening, crushing, sampling, calcining, melting, reducing to ferronickel, refining, casting, and skull metallics recovery.

Ore Preparation

Ore is reclaimed from the stockpile by rubber-tired front end loaders and is conveyed to the dryers where the moisture content is lowered from an average of 21% to 3% - 5% in three concurrent fired rotary dryers. The dryers are heated by hogged fuel waste wood product from local sawmills. Natural gas auxiliary burners are installed for use in case sufficient hogged fuel is not available.

After drying, the ore is conveyed to the screening, crushing and sampling plant, where the coarse, low grade rock is rejected from the top deck of a double-deck screen. The ore remaining on the second deck of the screen, normally +5/16" - 3/4" is passed through cone crushers in closed circuits before it continues to storage. The -5/16" ore passes through Hi-Prob screens where fines are removed and sent to a storage bin. The coarse fraction from the screens is sent to separate storage bins. Both fine and coarse ore is sampled and weighed before going to storage.

From the storage bins the coarse ore (-5/16" +28 mesh) is fed to two natural gas fired rotary calciners, while the fines are fed to two natural gas fired multiple hearth roasters. To the feed of both calciners and roasters, sawdust is added as a pre-reductant to convert approximately three-quarters of the trivalent iron contained in the ore to the divalent state.

After calcining to approximately 1300 degrees Fahrenheit, the ore discharged from both the calciners and roasters is transported by automatic skips to hot ore bins above four electric melting furnaces in the smelter building. Skips, transfer chutes and bins are insulated to conserve the heat in the calcined ore.

Melting and Reduction

The ore is charged to the melting furnaces by gravity and heated to a temperature of 2900 to 3000 degrees Fahrenheit. Molten ore is poured from the melting furnaces into ladles for the reduction process.

Reduction of nickel and iron is accomplished by the Ugine Process, which consists of adding a reducing agent containing metallic silicon to an oxide ore in the presence of molten, ferrous metals and using vigorous mixing action for good contact of reductant and ore. In Hanna's smelter, crushed 48% ferrosilicon is used as the reductant, the ferrosilicon being produced in a separate electric furnace in the smelter. After the vigorous mixing cycle, the ferronickel is allowed to settle to the bottom of the ladle, after which the slag is skimmed off and granulated with high pressure water jets.

Refining

As the reducing reactions continue, ferronickel accumulates in the ladle. At regular intervals, a portion of this product is removed, or "thieved," and transported to one of two identical small electric steel furnaces. Here the impurities, predominantly phosphorous, are removed by suitable refining slags, after which the ferronickel is cast into pigs weighing approximately 28 pounds.

Samples from each cast are taken for complete chemical analysis and an accurate record of all casts is available for consumers. The ferronickel pigs are packaged on 4,000 pound pallets, with the exact weight and analysis stamped on each pallet. It has proven to be a very desirable product for the major stainless steel manufacturers of the United States.