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INFORMATION CIRCULAR

METHODS AND COSTS OF CONCENTRATING TUNGSTEN ORE AT THE NEVADA-MASSACHUSETTS MILL, MILL CITY, NEVADA

BY

OTT F. HEISER

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METHODS AND COSTS OF CONCENTRATING TUNGSTEN ORE AT THE NEVADA MASSACHUSETTS MILL, MILL CITY, NEVADA[1]

By Ott F. Heizer[2]

INTRODUCTION

This paper describing the practice at the tungsten concentrator of the Nevada-Massachusetts Co., Inc., at Mill City, Nev., is one of a series being prepared by the Bureau of Mines on milling practices, methods, and costs in the United States.

The ore, which contains about 1.10 per cent of scheelite ($CaWO_4$), is concentrated on tables and by means of a magnetic separator and roasters. A product containing 70.43 tungsten trioxide is shipped. The plant was designed for a capacity of 100 tons per 24 hours, but at present 142 tons of ore are milled per day.

The author acknowledges the assistance of William O. Vanderburg, associate mining engineer, U. S. Bureau of Mines, in preparing this paper.

LOCATION

The mill and the mines of the Nevada-Massachusetts Co. are situated in Pershing County, Nev., 8 miles northwest of Mill City--a station on the main line of the Southern Pacific Railroad. An automobile road connects the property with the railroad. Supplies and concentrate are hauled by trucks. The property, situated on the rolling east slopes of the Eugene Mountains, has an elevation of about 5,500 feet above sea level. The climate is semiarid; operations are carried on throughout the year.

ORE TREATED

At present the ore is derived from two mines--the Stank, which is 730 feet deep, and the Humboldt, which has reached a depth of 620 feet and is now being deepened. The mines are developed through inclined shafts; the shrinkage system of mining is employed.

The economic mineral in the Mill City ores is scheelite; it occurs unevenly disseminated as small white grains barely larger than grains of wheat in a gangue composed

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1 - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6280."

2 - One of the consulting engineers, U. S. Bureau of Mines.

principally of garnet, quartz, epidote, calcite, and pyrite. A total of 17 minerals has been identified in the ore, but their distribution is very erratio. Such gangue minerals as garnet, zoisite, epidote, vesuvianite, clinozoisite, and quartz are harder than the scheelite and in grinding they pulverize this last mineral, which is friable and readily slimes.

The main aim in milling is to crush the ore to liberate the scheelite grains with a minimum amount of sliming. Rolls are used to give reduotion in stages, which results in the recovery of scheelite in coarser form with a minimum of slime loss. The use of stamps or ball mills for crushing is not conducive to a good recovery. Some of the ore is extremely hard, whereas in other places it is of medium hardness.
tremely hard, whereas in other places it is of medium hardness.

About 95 per cent of the ore is broken fine enough in blasting to pass though the ore pocket grizzlies with 8-inch openings. At present the mine ore averages about .10 per cent of scheelite or about 0.9 per cent of tunsten trioxide.

Tungsten concentrates, which are used in the manufacture of alloy steels, is subject to rigid requirements as to impurities. The Mill City concentrates are used principally in the steel industry and are sold under a quality guarantee similar to the following:

Tungsten trioxide, per cent.....	65-70
Tin, per cent, maximum.....	Trace
Copper, per cent, maximum.....	0.05
Sulphur, per cent, maximum.....	0.75
Phosphorus, per cent, maximum.....	0.05
Arsenic)	
Antimony)per cent, not to exceed	0.035 each
Bismuth)	

All of the above undesirable elements occur in the minerals of the Mill City ores and are eliminated during the concentrating process. The scheelite concentrates carry from 4 to 6 ounces of silver and a trace of gold per ton, but no effort is made to recover the precious metals.

HISTORY OF THE CONCENTRATOR

The mill was erected in the latter part of 1918, under the stimulus of the demand for tungsten alloys in the manufacture of munitions for war purposes. Due to the inability to compete with the tunsten ores from foreign sources, which were thrown on the market after the Armistice, the mines and mill were closed after running only a short time.

In September, 1922, a tariff of 45 cents per pound was placed on tungsten, and in 1924 operations at Mill City were resumed; they have been continuous to this time.

With the exception of the installation of roasting equipment when sulphide ores were encountered, the mill flow sheet is essentially the same as when first designed.

GENERAL FLOW SHEET

Figure 1 shows the mill flow sheet. The treatment of the scheelite ore is briefly as follows:

1. Breaking, crushing, screening, and classifying.
2. Tabling, producing a bulk concentrate; concentration begins at 14 mesh.
3. Magnetic separation of garnet and epidote from scheelite and pyrite.
4. Roasting to magnetize pyrite.
5. Magnetic separation of iron from calcine.
6. Final complete or "sweet" roast to drive off remaining sulphur, producing shipping concentrates.

The average grade of the shipping concentrates are above 70 per cent tungstent trioxide; and a single carload lot has assayed as high as 76.88 per cent.

The mill site is on a hillside location. The ore from the mines is delivered to the upper end of the mill in cars hauled by a gasoline locomotive and dumped into two flat-bottomed bins having a combined capacity of 500 tons.

BREAKING

Eight 24 by 30 inch rack-and-pinion gates control the discharge of ore from the bins onto a 24-inch variable-speed steel apron conveyor. The conveyor discharges on a grizzly with 1-1/2-inch openings, the oversize going to a 9 by 16 inch Blake-type roll-jaw crusher with manganese steel wearing plates. The average life of the wearing plates is about 60 days.

CRUSHING AND SCREENING

The broken ore from the Blake crusher and the undersize from the grizzly are discharged onto a 24-inch belt conveyor and into a belt and bucket elevator feeding a trommel with 9/16-inch punched holes. The undersize from the trommel falls on a 12-inch belt conveyor equipped with hand-propelled tripper, and the oversize goes to a pair of 36 by 15 inch, 63 revolutions per minute, heavy-duty rolls operating in closed circuit with the trommel. The conveyor discharges through the tripper into either of two cylindrical redwood-stave bins, each holding 200 tons. The concentrator is fed from the bins through either of two Hammil ore-feeders at the rate of 6 tons per hour. The ore is carried on a 12-inch cross-conveyor belt to a belt-and-bucket elevator where water is added before the ore is elevated to a trommel covered with No. 23 Tyler Ton-Cap steel screen, which has openings approximately 1/8-inch wide and 1/4-inch long; the percentage of openings is 38. The oversize from this trommel goes to a set of 36 by 16 inch, 95 revolutions per minute, Gates B coarse rolls, set to 1/4-inch, which operate in closed circuit with the trommel. The undersize passes onto a 24-inch, 14-mesh, Callow duplex traveling belt screen of phosphor-bronze. The oversize from the screen passes to a set of 36 by 16 inch, 100 revolutions per minute, Gates B rolls, set fine, and thence back into the elevator. The undersize from the 14-mesh

screen passes to a 22-mesh, Callow duplex traveling belt screen of phosphor-bronze, the oversize from which furnishes the coarse table feed. The undersize from the 22-mesh screen is again screened by a 48-mesh Callow simplex traveling belt screen of phosphor-bronze. The oversize from the 48-mesh screen is divided between two Deister-Overstrom fine sand tables and the undersize, after thickening in three 8-foot Callow cones, between two Deister-Overstrom slime tables.

GRAVITY CONCENTRATION

Each of the five tables mentioned above yields three products--concentrates, middlings, and tailings. The concentrates from the tables go to the dryers, the middlings to a set of 36 by 16 inch Gates B rolls, running at 105 revolutions per minute, set close, and the tailings to the dewatering plant, except part of the tailings from the two slime tables which handle the undersize from the 48-mesh screen. The tailings that do not go to the dewatering plant are pumped into an 8-foot Callow cone. The gooseneck discharge from the Callow cone is treated on a double-deck Deister slime table with vibratory head motion. The concentrates from the double deck slime table go to the dryers and the tailings to the dewatering plant.

ROASTING AND MAGNETIC SEPARATION

The table concentrates are dried by two dryers, one of which is a coal-fired, continuous Snowco sand dryer, and the other a locally designed flat-top bath dryer fired by fuel oil atomized by air under a pressure of 20 pounds. With the last-named dryer a batch of 300 pounds is dried in about 30 minutes. The two dryers are necessary to handle all the product. Concentrates are shoveled by hand into the dryers from a shoveling platform. The dried concentrates are carried by a conveyor and a bucket elevator in a hopper from which they are fed to a six-pole Wetherill magnetic separator which removes the faintly magnetic garnet and epidote. A strong magnetic field is necessary. The magnets are wound for 30,000, 60,000, and 100,000 ampere turns. Although there is an appreciable difference in the specific gravity of the three principal minerals in bulk concentrates (scheelite, specific gravity, 6.00; pyrite, specific gravity, 4.9 to 5.0; garnet, specific gravity, 4.0 to 4.4), it is practically impossible to eliminate the pyrite and garnet by tabling, even when close sizing is employed, without incurring a heavy loss of scheelite.

The concentrates from the first magnetic separator, with the garnet and epidote removed, are roasted in a 16-inch outside-diameter and 12-inch inside-diameter iron furnace 12 feet long, placed on a slope of 2 inches per foot. This roaster was designed and built locally. The interior of the pipe is lined with fire clay. It is chain driven and rotates at about 10 revolutions per minute. The roaster is internally fired at the discharge end with fuel oil of plus 27° Baumé, atomized by air under 20 pounds pressure. Only enough oil is used to ignite the sulphur in the ore; oil consumption is 1 gallon per hour. The concentrates are fed by a screw feeder made out of a 2-inch coal auger. The fumes and dust entering the stack on the roaster pass through a 36-inch blower to a 30-inch diameter by 8-foot Cyclone dust precipitator.

The concentrates fed into the roaster contain about half scheelite and half pyrite. The pyrite is rendered magnetic by a short roast (about 5 minutes) in the presence of air. A chemical change analagous to the following takes place:

$$n\ (FeS_2) + (2n-2)\ O = Fe_n\ S_{n+1} + (n-1)\ SO_2.$$

The exact sulphide which is formed varies with the length of the roast. The artificial magnetic sulphide is formed only on the surface of each grain, and the kernel remains unaltered pyrite (FeS_2), providing the roast is short. If the roast is carried too far, hematite (Fe_2O_3) results which is only faintly magnetic. It is not feasible to roast the garnet with the pyrite as the garnet would agglomerate and form crusts and thus prevent magnetic separation. Dust losses in roasting are not important, as the scheelite remains unaltered and retains its original weight.

The calcine discharges into a spiral screw conveyor 20 feet long and 6 inches in diameter with cast-iron flights and a cast-iron trough. The product cools on the way to the second magnetic separator, where the magnetized iron sulphide is removed. This magnetic separator is also a Wetherill of the same type as the one which removes the garnet and epidote. The reject from both separators is returned to the middling rolls and over the tables. The garnet reject from the No. 1 magnetic separator is eliminated by passing into the slime. The pyrite reject from the No. 2 magnetic separator is rendered porous by roasting, thus lowering its specific gravity and making it amenable to separation from the scheelite by table concentration when returned to the mill circuit.

The concentrates from the second magnetic separator are subjected to a dead or complete roast in an externally-fired, chain-driven roaster 8 inches in diameter and 12 feet long. This roaster was also designed and built locally. It rotates at about six revolutions per minute and is inclined 1 inch to the foot. Fuel oil atomized by air is used for fuel. Oil consumption is 1-1/4 gallons per hour. The dead roast removes practically all the remaining sulphur, producing the shipping concentrates, which are packed in double canvas and burlap sacks holding about 120 pounds each. A carload shipment averages about 35 tons.

DEWATERING AND DISPOSAL OF TAILINGS

The tailings from the tables is conveyed by a wooden box launder to a 54-inch by 10-foot Akins classifier, set to a slope of 2 inches to the foot. The sand is sent to the tailing pond and the overflow containing the slime goes to a Dorr thickener, 20 feet in diameter and 10 feet deep. The water recovered in the thickener overflow amounts to about 75 per cent of the mill water used. The slime product of the thickener is sent to the tailings pond with the sand. The greater percentage of the mill loss occurs in the slime product, and all the tailing is impounded with a view to some day recovering the scheelite. The tailings are disposed of by gravity flow from the dewatering plant. Unlimited tailings-disposal ground is available and earth dams are constructed around the lower end of the pond to hold the tailings in one place. The dams are raised from time to time as the pond is filled.

Six tons of water is in the mill circuit for each ton of ore. The water from the thickener overflow is pumped back by a triplex plunger pump into the mill supply tank of 50,000 gallons capacity.

CONVEYING

Due to the high specific gravity of the pulp and the abrasive action of the garnet in the ores, special consideration was given to the construction of the mill launders. The tailings launder is made of wood, lined on the bottom with 1/2 by 4 inch strap iron; the slope is 2 inches per foot. The steeply inclined launders feeding the tables are made of wood lined with armorite, which is a high-quality rubber vulcanized to a fiber or sheet-steel base.

The 2-inch centrifugal pumps for handling pulp have white cast-iron casings, the wearing qualities of which are equal to the manganese steel casings formerly used, and the cost is about one-third.

SAMPLING

Mill operations are controlled not by assay but by panning, which is a very reliable method in experienced hands because scheelite pans as readily as gold. A rapid reliable method has not been worked out for assaying tungsten ores similar to those at Mill City. With the standard methods now in use there is a wide variation in results unles extreme care is exercised in manipulation. Taking into consideration (1) the uncertainties incident to the determination of tungstic acid, (2) the time required to obtain reliable assays, and (3) the cost, the best results on the Mill City ores are obtained by panning.

A specific-gravity method for approximate analyses has been used on other tungsten ores. This method is feasible when the gangue minerals are of low specific gravity in comparison with tungsten and are uniformly distributed in the ore. However, this method is not applicable to the Mill City ores because of the amount of pyrite and garnet present and the wide variations in their distribution.

WATER SUPPLY

Water for milling purposes is obtained from the mines. The domestic water supply is obtained from a well 56 feet deep, sunk in the valley to the east of the property. This water is pumped into a tank by a 2-inch centrifugal pump on the well casing, and is relayed to a 100,000 gallon tank in two lifts by two 7 by 10 inch vertical triplex pumps each belt-driven by a 50-horsepower, 870 revolutions per minute, 440-volt motor. The centrifugal pump is direct-connected to a 10-horsepower, 1,700 revolutions per minute, 440-volt, alternating-current motor. The total lift is 776 feet and the total length of the 6-inch redwood stave pipe is 21,150 feet. The capacity of the plant is 250 gallons per minute. The cost of pumping is about 20 cents per thousand gallons. The pumping installation was financed jointly by the two companies operating in 1918. The total cost of construction and equipment of the water plant was about $48,000.

POWER

Power is purchased from a power company at a cost of about 2 cents per kilowatt-hour. The electricity is generated at the Lahontan Dam of the Truckee-Carson Irrigation

project, 140 miles distant. The power company had a line to Oreana, 42 miles from the mine, and from this point a transmission line was run to the mines. This line was built by the mining companies at a cost of $65,000. Electricity is transmitted at 60,000 volts and stepped down to 6,000 at the mine substation for distribution around the property. It is further transformed to 440 volts for all motors.

LABOR

A crew of 12 men working on three shifts is required to operate the mill.

CONCENTRATOR RECOVERY

The average mill recovery of scheelite is estimated at about 80 per cent. A partial chemical analysis of an average carload of scheelite concentrates is as follows:

	Per cent
Tungstic acid	71.43
Sulphur	0.43
Copper	0.03
Arsenic	None
Antimony	None
Bismuth	0.12
Tin	None
Molybdenum	0.13

A partial analysis of the tungsten concentrates before roasting is as follows:

	Per cent
Tungstic acid	42.55
Sulphur	17.76
Copper	4.20
Arsenic	0.004
Antimony	0.11
Molybdenum	0.15
	Oz. per ton
Gold	Trace
Silver	4.90

A partial analysis of the roasted artificial sulphide is as follows:

	Per cent
Tungstic acid	4.51
Sulphur	33.54
	Oz. per ton
Gold	0.01
Silver	6.19

METALLURGICAL DATA

Mill City Concentrator	Year 1928
Tons of ore milled	40,924
Days operated	362
Hours operated per day (from Jan. 1 to July 15)	16
Hours operated per day (from July 15 to Dec. 31)	24
Average hours operated per day	19.67
Average ore milled per day, tons	113
Total scheelite concentrates, tons	450.2
Total scheelite concentrates, pounds	900,410
Total tungstic acid (WO_3), pounds	634,159
Total tungstic acid (WO_3), units of 20 pounds	31,708
Total concentrates per 24 hours, pounds	2,487.3
Total tungstic acid (WO_3) per 24 hours, pounds	1,751.8
Total tungstic acid (WO_3) per 24 hours, units of 20 pounds	87.59
Tungstic acid (WO_3) recovered per ton of ore, pounds	15.5
Tungstic acid (WO_3) recovered per ton ore, units of 20 pounds	0.775
Recovery of scheelite, per cent (estimated)	80
Ratio of concentration	91.1
Average assay of concentrates, per cent tungstic acid	70.43
Net water consumption per ton or ore, gallons	352

SUMMARY OF COSTS

Mill City Concentrator
Gravity and magnetic separation
Tons of ore treated: 40,924

Year 1928
Pounds of concentrates produced: 900,410

	Labor	Power	Supplies	Total
Breaking and crushing to 9/16 inch	$0.069	$0.080	$0.013	$0.162
Crushing, screening, and conveying	.117	.127	.062	.306
Tabling	.123	.033	.004	.160
Magnetic separation and roasting	.098	.046	.082	.226
Dewatering and pumping	.053	.014	.001	.068
Superintendence	.066	-	-	.066
Miscellaneous	.047	-	.211	.258
Total	.573	.300	.373	1.246

Note: Above costs are direct costs only.

SUMMARY OF COSTS IN UNITS OF LABOR, POWER, AND SUPPLIES

Mill City Concentrator — Year 1928
Gravity and magnetic concentration
Tons of ore treated: 40,924 — Pounds of concentrates produced: 900,410

A - LABOR (Tons per 8-hour man-shift)

	Tons
Breaking and crushing to 9/16-inch	75.9
Crushing, conveying, and screening	44.8
Tabling	42.6
Magnetic separation and roasting	51.8
Superintendence	111.2
Dewatering	101.8
General	98.9
Tons per 8-hour manshift, total labor	9.4

B - POWER (kw.h. per ton of mine-run ore)

	kw.h.	Per cent of total power
Breaking and crushing to 9/16 inch	4.00	26.7
Crushing and screening	5.00	33.3
Tabling	1.66	11.1
Magnetic separation and roasting	2.31	15.4
Dewatering	0.69	4.6
Conveying and elevating	1.34	8.9
Total	15.00	100.0

LEGEND, FIGURE I

The following numbers correspond to the numbers on the flow sheet.

1. Two flat-bottomed wooden bins, combined capacity 500 tons, equipped with eight 24 by 30 inch rack-and-pinion hand-controlled gates.

2. Steel apron pan conveyor, variable speed 24 inches wide, 50-foot centers.

3. Grizzly made of taper bar grizzly steel 3/8 by 3/4 by 3 inch, 6 feet long, set at a slope of 45° and with 1-1/2-inch opening.

4. One 9 by 16 inch Blake-type roll jaw crusher, belt driven equipped with manganese steel wearing plates.

5. Belt conveyor made of 6-ply rubber with 3/16-inch extra cover on wearing side, 24 inches wide on 33-foot centers; speed 280 feet per minute.

6. Belt and bucket elevator, with 14-inch belt fitted with 12 by 6 inch buckets spaced 16 inches apart, 48-foot centers, speed 300 feet per minute.

7. One 38-inch by 8-foot revolving trommel, 9/16-inch punched perforations 3/16-inch plate, set on 20° slope; speed 19 revolutions per minute.

8. Heavy-type Worthington rolls crushing dry, set to 1/2 inch, 36 by 15 inch, speed 63 revolutions per minute, chrome steel shells.

9. Six-ply rubber belt conveyor, equipped with hand-propelled tripper, belt 12 inches wide on 75-foo centers, speed 300 feet per minute.

10. Two 16-foot diameter by 20-foot ore bins made of 3-inch redwood staves, capacity 200 tons each, equipped with 18 by 24 inch rack-and-pinion gates.

11. Two right-hand, 14-inch, Hammil ore feeders, now set to deliver at the rate of 6 tons per hour.

12. Four-ply cross conveyor belt made of rubber, 12 inches wide, on 30-foot centers; speed 300 feet per minute.

13. Water tank, 50,000 gallons capacity, built of 3-inch redwood staves.

14. Two belt-and-bucket geared-head elevators, with bottom take-ups, belt 14 inches wide, 8-ply, 1/8-inch extra cover on bucket side. Buckets 12 by 6 inches on 18-inch centers. Belts on 55-foot centers, speed 300 feet per minute.

15. Two trommels, 36 inches diameter, 5 feet 10 inches long, covered with No. 23 Tyler Ton-Cap steel-cloth screen with openings approximately 1/4-inch long.

16. One set of 36 by 16 inch Gates B coarse rolls set to 1/4-inch; speed 95 revolutions per minute, chrome steel shells.

LEGEND (Continued)

17. Callow, duplex, 24-inch, traveling belt screen made of 14-mesh phosphor-bronze, speed 50 feet per minute.

18. One set of 36 by 16 inch Gates B rolls, set fine, chrome steel shells; speed 100 revolutions per minute.

19. Callow, duplex, 24-inch, traveling belt screen made of 22-mesh phosphor-bronze; speed 75 feet per minute.

20. Two Deister-Overstrom No. 6 tables, one operating, one in reserve.

21. Callow, simplex, 24-inch, traveling belt screen, 48-mesh, speed 75 feet per minute.

22. Three Deister-Overstrom No. 6 tables, two operating, one in reserve.

23. Three 8-foot Callow classifying cones used as thickeners, gooseneck discharge.

24. Three Deister-Overstrom slime tables, two operating, one in reserve.

25. Centrifugal sand pump, 2-inch, belt-driven, feed box suction.

26. Callow cone classifier, 8-foot, gooseneck discharge.

27. One double-deck Deister slime table.

28. Centrifugal sand pump, 2-inch, belt-driven, feed box suction.

29. One set of 36 by 16-inch Gates B rolls, 105 revolutions per minute, chrome-steel shells.

30. (a) Snowco continuous sand dryer, coal-fired; (b) locally designed and built flat-top iron batch dryer, size 6 feet 10 inches by 16 feet, drying surface 4-1/2 feet high, oil-fired.

31. Spiral screw conveyor, 6 inches in diameter, 18 feet long.

32. Belt-and-bucket elevator, belt 8 inches wide, buckets 6 inches by 4 inches spaced 12 inches apart, centers 16 feet 10 inches, speed 150 feet per minute.

33. Sheet-iron hopper attached to magnetic separator, capacity 1,000 pounds, ore fed onto belt uniformly by steel roller.

34. Six-pole, Wetherill magnetic separator with 3-inch rubber cross belts.

Poles	Ampere-turns	Amperes	Volts
2	30,000	14.4	120
2	60,000	11.4	120
2	100,000	21.4	120

LEGEND (Concluded)

Motor-generator set for separator No. 1 consists of 10-horsepower, 1,140 revolutions-per-minute, 440-volt, alternating-current motor, belted to a 6-kilowatt, 125-volt, 48-ampere, 1,180-r.p.m. generator.

35. Belt-and-bucket elevator, 8-inch belt and 6 by 4 inch buckets spaced 12 inches apart on 12-foot centers; speed 150 feet per minute.

36. Inclined belt conveyor, 8 inches wide, speed 50 feet per minute.

37. Locally designed and built continuous roaster, 16 inches outside diameter, 12 inches inside diameter, lined with fire clay, chain-driven, 10 revolutions per minute, fired on discharge end with fuel oil of plus 27° Baume, atomized by air under 20 pounds pressure. Slope of roaster 2 inches per foot.

38. Inclined screw conveyor, 6 inches diameter, 20 feet long, equipped with cast-iron flights and operating in a cast-iron trough.

39. Sheet-iron hopper attached to magnetic separator, capacity 1,000 pounds, ore fed onto belt uniformly by steel roller.

40. Six-pole Wetherill magnetic separator. Same as separator No. 1:

Poles	Ampere turns	Amperes	Volts
2	30,000	3.5	120
2	60,000	11.5	120
2	100,000	21.5	120

41. Belt-and-bucket elevator, 8-inch belt and 6 by 4 inch buckets spaced 12 inches apart, on 21-foot centers; speed 150 feet per minute.

42. Spiral screw conveyor, 6 inches diameter, operating in wooden trough.

43. Two roasters, locally designed and built, consisting of 8-inch pipe 12 feet long, chain-driven, externally-heated by fuel oil of plus 27° Baume atomized by air pressure furnished by motor-driven blower, 6 revolutions per minute, inclined 1 inch per foot, one roaster operating, one in reserve.

44. Spiral screw conveyor, 6 inches diameter, 20 feet long.

45. Chain-and-bucket elevator, 15-foot centers; speed 150 feet per minute.

46. Burlap sacks canvas-lined; size empty, 14 by 24 inches.

47. Akins classifier, 54 inches by 10 feet, slope 2 inches per foot.

48. Dorr thickener, 20 feet in diameter, 10 feet deep.

49. Belt-driven triplex plunger pump, 8 by 10 inches.

50. Tailings pond.

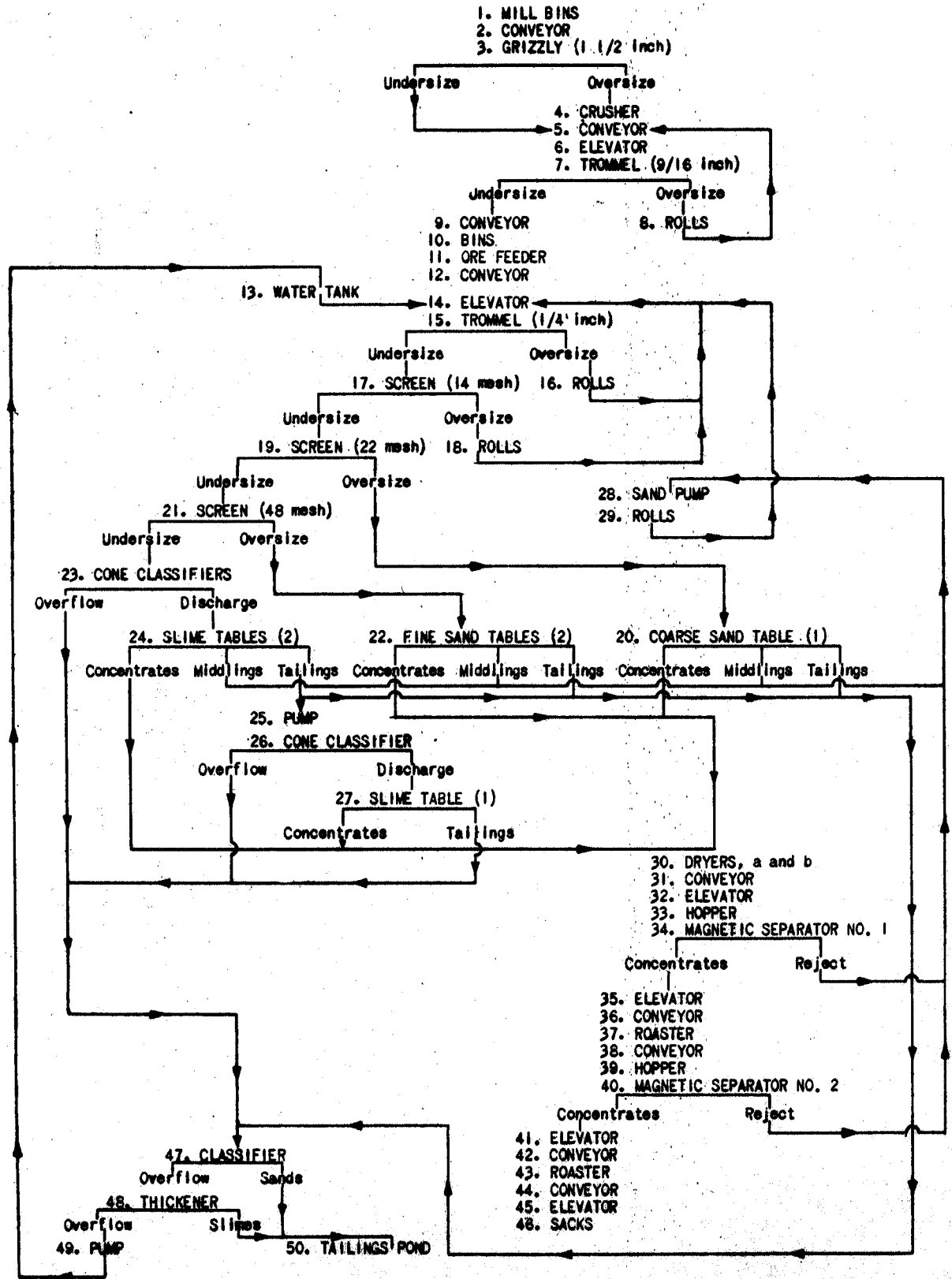

Figure 1.- Flow sheet of Mill City concentrator

STATE: COLORADO
COUNTY: WASHINGTON
API 05-121-10610
FIELD: DENOVA
WELL CLASS: DG
OPR: STELBAR OIL

4-7X PRICE

2S-49W 7
NE SE SE
911 FSL 607 FEL
STATUS: **GAS**

SPUD: 05/15/98 **COMP:** 05/17/98 **ELEV:** 4457 KB 4451 GR
TD: 3127 (05/17/98) **FM/TD:** NIOBRARA **PBTD:** 3072
CONTR: EXCELL DRLG **RIG** #2 (R)
PROJ DEPTH/FM: 3100 NIOBRARA **PERMIT** #98-462

COMP 5/17/98, GAS WELL. PROD ZONE - NIOBRARA INT NOT RPTD. NO CORES OR DSTS

LOC DESCRIPTION: 19 1/2 MI NE ANTON, CO; LAT: 3989037 LONG: 10289813;
CASING: 7 @ 379 W/150 SX, 4 1/2 @ 3105 W/150 SX;
LOG TYPES: CNL, CORL, DITE, FD; CBL 1450-3072, CCL 1450-3072, GR 1450-3072;
LOG TOPS:

SMOKY HILL	2961	1496	NIOBRARA	2997	1460
B/ SMOKY HILL	2997	1460			
TD	3072	1385			

SUBSEA MEASUREMENTS FROM KB;
PRODUCING INTERVAL: PERF (NIOBRARA), IP NOT RPTD.
OPER ADD: 155 N MARKET STE 500, WICHITA, KS, 67202 PHONE (316) 264-8378;

DATE 07/27/98**CARD #00017-SE RM**