2–2–6 Magnetic Separation Test

In order to improve the grade of concentrate, it is effective to carry out cleaning with tables a second time after the roughering stage to eliminate sulfides. However, since there are conditions in the sales of tin concentrate according to iron contents such as the below 5% bonus rule and the above 9% penalty rule, it is therefore necessary to eliminate iron.

Accordingly, tests to eliminate iron from the pre-concentrate of the mine were carried out.

The flow chart and results of the tests are shown in Fig. II–2–16 and Table II–2–7. In the test with a hand magnet, magnetic materials of high-iron grade 73.85% were separated, but iron elimination was not so effective, and even when strong magnetic force was used, it was difficult to eliminate iron.

When the non-magnetic materials, (Conc. Sn) are cleaned with tables, a rise in the grade of the iron contained is anticipated, so that it will be difficult to obtain results of Fe < 5% by means of magnetic separation, and the magnetic separation should rather be regarded as an auxiliary means to attain steady results of Fe < 9%.

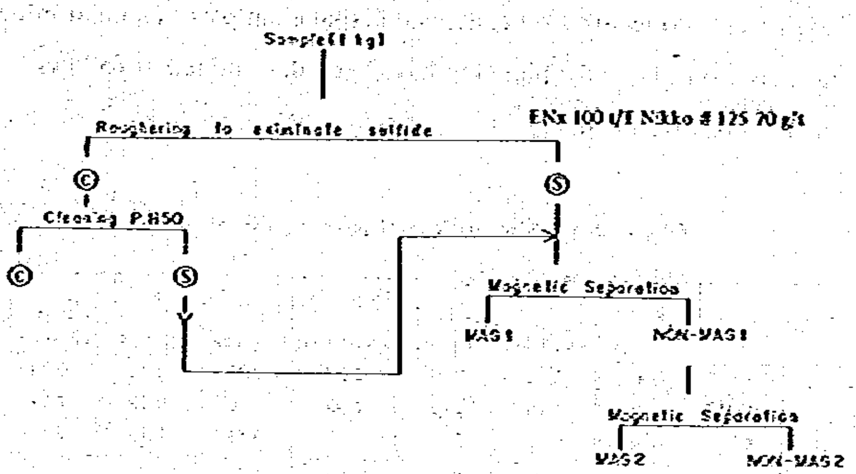


Fig. II–2–16 Flow sheet to Eliminate Iron Material

Table II–2–7 Cleaning Test of Preconc. –Sn

Product	Wt %	Grade %			Distribution %		
		Sn	Fe	S	Sn	Fe	S
Total	100.0	8.63	32.82	33.33	100.0	100.0	100.0
Sulphide	65.5	0.49	45.49	49.73	3.7	90.8	98.5
Flot-Tail	34.5	24.12	8.74	1.41	96.3	9.2	1.5
Mag.–1	1.7	0.98	73.85	3.05	0.2	3.9	0.2
Nonmag –1	32.7	25.35	5.28	1.32	96.1	5.3	1.3
Mag. –2	12.8	6.36	6.61	1.39	9.4	2.6	0.5
Nonmag –2	20.0	37.51	4.43	1.28	86.7	2.7	0.8

2-2-7 Summary of Concentration Tests

Matters clarified by these tests are as follows:

(1) Pre-concentration by means of sink-and-float is unsuitable.

(2) For grinding, multi-stage crushers should be adopted to avoid excessive crushing as far as possible, and the pulp density in the mill should be made lower.

(3) Grinding should be carried out so that the size distribution rate in the 50~200μ range may be increased.

(4) As the results of separation by means of a table, for concentrate with a grade of 48.9%, a recovery of 59.8% was shown, and for low-grade concentrate containing 5% Sn, recovery of 10% was obtained.

(5) It is difficult to eliminate iron completely by magnetic separation.

2-3 Conceptual Design of New Concentration Mill

2-3-1 Standard for Planning

From the field survey, concentration tests, and actual examples of similar mines in Japan and other countries, etc., standards for planning have been determined as follows :

(1) Physical properties of ores handled

Table II-2-8 Basic condition of processing mineral

		Mixed Ore			Desmonte	Total		
		1~7 year	8~10 year	average of 10 years	1~10 year	1~7 year	8~10 year	average of 10 years
Grade (%)	Sn	0.41	0.22	0.37	0.27	0.32	0.26	0.30
	Fe	2.46	2.46	2.45	2.00	2.16	2.09	2.14
	S	0.96	0.96	0.96	0.30	0.53	0.43	0.50
Specific Weight		2.75	2.75	2.75	2.70	2.72	2.71	2.72
Ratio of Water content (%)	Rainy season	1.5	1.5	1.5	3.0	–	–	–
	Dry season	1.0	1.0	1.0	1.5	–	–	–

(2) Processed ore and tin content

Table II-2-9 Processed Ore in the case of 10,000 t/day

	Mixed Ore			Desmonte			Total		
	1~7 year	8~10 year	average of 10 years	1~7 year	8~10 year	average of 10 years	1~7 year	8~10 year	average of 10 years
Processed Ore per day (t)	3,500	2,000	3,050	6,500	8,000	6,950	10,000	10,000	10,000
Tin content per year (t)	4,335	1,320	3,430	5,265	6,450	5,630	9,600	7,800	9,060

Note) Annual operation day : 300 days

(3) Concentration system

Although the existing concentration mills have handled ores of high-tin grade above 0.5%, the new concentration mill adopts a concentration system for processing low-grade ores of about 0.3% tin. The basic idea for the new system is all sliming processing, which principally consists of grinding ores of +65 mesh (208μ), classifying them into coarse grain, fine grain and very fine grain classes, and gravity concentration using tables suitable for each class.

As purchased ores, which have been used in the past, are of comparatively high grade, it is necessary to concentrate the ores properly to increase revenues, but since the quantity of such ores is about 100 t/D, their processing will be incorporated into the system at the stage of practical design and will not be included in the plan here.

(4) Grades of final concentrates and recovery

High-grade concentrate : tin grade 50.0%, recovery 55.0%

Low-grade concentrate : tin grade 4.0%, recovery 5.0%

(5) Operating conditions

Annual working days shall be 300 days. Generally, in a large plant which processes several tens of thousand tons per day, a reserve line is provided in the grinding process and will be used during the times of periodic maintenance of the regular lines. However, as the quantity of processed ores of this plant will be 10,000 t/D, an all-plant-stop maintenance system will be adopted here to apply a preventive maintenance system thoroughly and to reduce plant construction costs.

Shifts per day : 3 shifts

Hours per shift : 8 hours

Operating time : Primary crushing conforming to underground
Production : 6 hr/sh x 3 sh/D
Secondary and tertiary crushing : 7 hr/sh x 3 sh/D
Grinding process and after : 7 hr/sh x 3 sh/D

(6) Equipment capacity (for 10,000 t/D scale)

Crushing 1st ~ 7th year : Mined ores 3,500 t/D or less
Desmonte 6,500 t/D or less

8th ~ 10th year : The quantities of the two kinds of ores will be changed to :
mined ores 2,000 t/D; Desmonte 8,000 t/D.

Grinding ~ Table Concentration : 10,000 t/D or less

For 9,000 t/D scale, underground-mined ores will be 2,500 t/D through 1st ~ 10th year.

(7) Process standards

Crushing :

	Mined ores	Desmonte
Maximum size of entrance :	600mm x 800mm x 1,200mm	80mm square hole undersize
Final crushed products, 80% size	9 mm	9 mm

Ore storage capacity (minimum) : A capacity corresponding to the differences in operating time for each shift between series is required.

Grinding :

Final ground products, 80% size : 208μ (65 mesh)

Ore storage capacity (mill bin) : A minimum capacity corresponding to the equipment repair time (6 hr quantity/D) is required.

Work index : 15.5

Gravity concentration : Ores are processed after being classified into coarse, fine and very fine size ranges.

Sulfide-eliminating flotation : Pre-concentration and cleaner concentration are carried out at pH 4.5

Iron-eliminating magnetic separation : Carried out in weak magnetic force ranges.

Thickening of concentrate : Driers are omitted to reduce cost.

Thickening of tailings : Emphasis is placed on the recovery of used water.

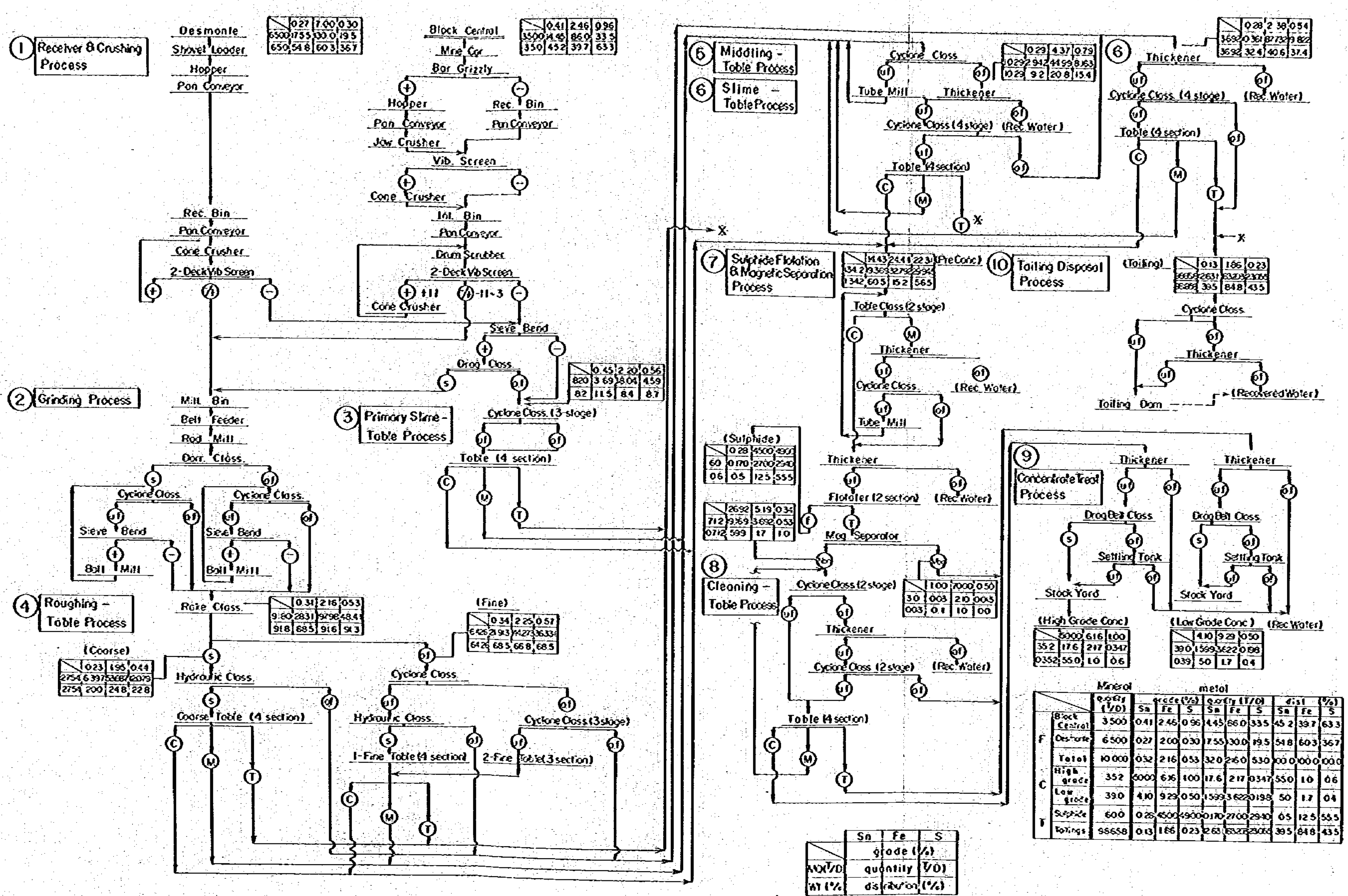
2–3–2 Flow Chart Planning

Fig. II–2–17 shows a summary of the appended flow chart.

(1) Crushing process

In consideration of the maximum sizes (mentioned above) of feed ores, underground-mined ores are crushed in three stages from the first to the third crushers, and desmonte is crushed in only one stage to obtain crushed products of 80% size 9 mm. For the first and second crushing of underground-mined ores open circuits are provided, while the third crushing has a closed circuit. All of the crushed products are washed.

This crushing method has been adopted to reduce the operating cost of the subsequent grinding process and also to avoid overcrushing the cassiterite separated during crushing. Because of changing the underground mining system from "block caving" as in the past to "sublevel stoping", the quantity of oversieve (distribution) of ores at the entrance may increase a little, but the largest block size will be about 600 mm, and one of the factors affecting



	Mineral quantity (T/D)	metal grade (%) Sn	Fe	S	quantity (T/D) Sn	Fe	S	dist (%) Sn	Fe	S
F Block Central	3500	0.41	2.46	0.96	14.45	86.0	33.5	45.2	39.7	63.3
F Desmonte	6500	0.27	2.00	0.30	17.55	130.0	19.5	54.8	60.3	36.7
F Total	10000	0.32	2.16	0.53	32.0	216.0	53.0	100.0	100.0	100.0
C High grade	35.2	50.00	6.16	1.00	17.6	2.17	0.347	55.0	1.0	0.6
C Low grade	39.0	4.10	9.29	0.50	1.599	3.622	0.198	5.0	1.7	0.4
T Sulphide	60.0	0.28	45.00	49.00	0.170	27.00	29.40	0.5	12.5	55.5
T Tailings	9865.8	0.13	1.86	0.23	12.63	[illegible]	[illegible]	39.5	84.8	43.5

Fig. II-2-17 New Concentrator Flow Sheet

plant stoppage, the manual crushing of large blocks, can be changed into mechanical crushing.

(2) Grinding process

In this grinding system, crushed ores are ground at first by a single-stage ball mill (open circuit), then are divided into two parallel lines, one being a single-stage ball mill for the classified sand series, and the other being a reclassification of the classified overflow series and a single-stage ball mill for reclassified coarse-particles. The two parallel lines both form closed circuits.

Since the crushed and ground ores range from fine grains to very fine grains, various classifiers each having suitable features for various size ranges will be incorporated into the process in sequence.

In composing the process, attention will be paid to making the process as simple as possible and to enabling the operation to be easily controllable, even when sizing fluctuates due to the age deterioration of the equipment or the wearing of parts which are in contact with the liquid. The sand slime washed away from the crushing process is classified, and coarse sand is added to the rod mill to blend desmonte and Block Central ores, while the slime portion is separated as primary slime series.

(3) Gravity concentration process

According to Fig. II–2–18 above, Plat-table tables for coarse grains, Deister tables for fine grains and James tables for very fine grains are interspersed.

(4) Process for improving grade of concentrate

As it is impossible to obtain high-grade concentrate by table alone because of the existence of accompanying impurities, it is necessary to combine general techniques with the sulfide eliminating and iron eliminating processes. Sulfides are eliminated by preliminary concentration with Agitair, the cleaner concentration is carried out by Fahrenwald flotation machines, and iron is eliminated by magnets made of low-strength magnetic materials of the order of 750 gauss to improve the grade of concentrate to a level advantageous for the purchasing conditions.

2–3–3 Plan for Balance of Materials

(1) Standard of balance of metals and minerals

Fig. II–2–17 also serves as the balance sheet of materials and metals, Fig. II–2–18 shows the balance sheet for materials and water, and Fig. II–2–19 is a summary of the water balance.

With regard to the principal planning items of the processes constituting the first half of the overall system, i.e., up to the grinding process, the design conditions are listed as follows.

[Crushing of mined ores]	Feed ore size	Set	Product size	Circuit
Primary Crusher	−600~190 mm	100 mm	−100 mm 80%	Open
Secondary Crusher	−200~ 40 mm	40 mm	−47.5 mm 80%	Open
Tertiary Crusher	− 70~ 11 mm	13 mm	−13 mm 80%	Closed
[Crushing of desmonte]				
Crusher	− 80~ 9 mm	13 mm	−13 mm 80%	Closed

[Grinding]

	F 80	P 80
Primary Grinder	9 mm	1 mm
Sand Series Secondary Mill	2 mm	295μ (48 mesh)
Overflow Series Secondary Mill	208μ (65 mesh)	147μ (100 mesh)
Middlings Processing Series Re-grinder Mill	147μ (100 mesh)	74μ (200 mesh)
Re-grinder mill for Flotation and Magnetic Separation	147μ (100 mesh)	74μ (200 mesh)

[Sieving and classification] See Fig. II–2–20

[Gravity concentration] See Fig. II–2–21

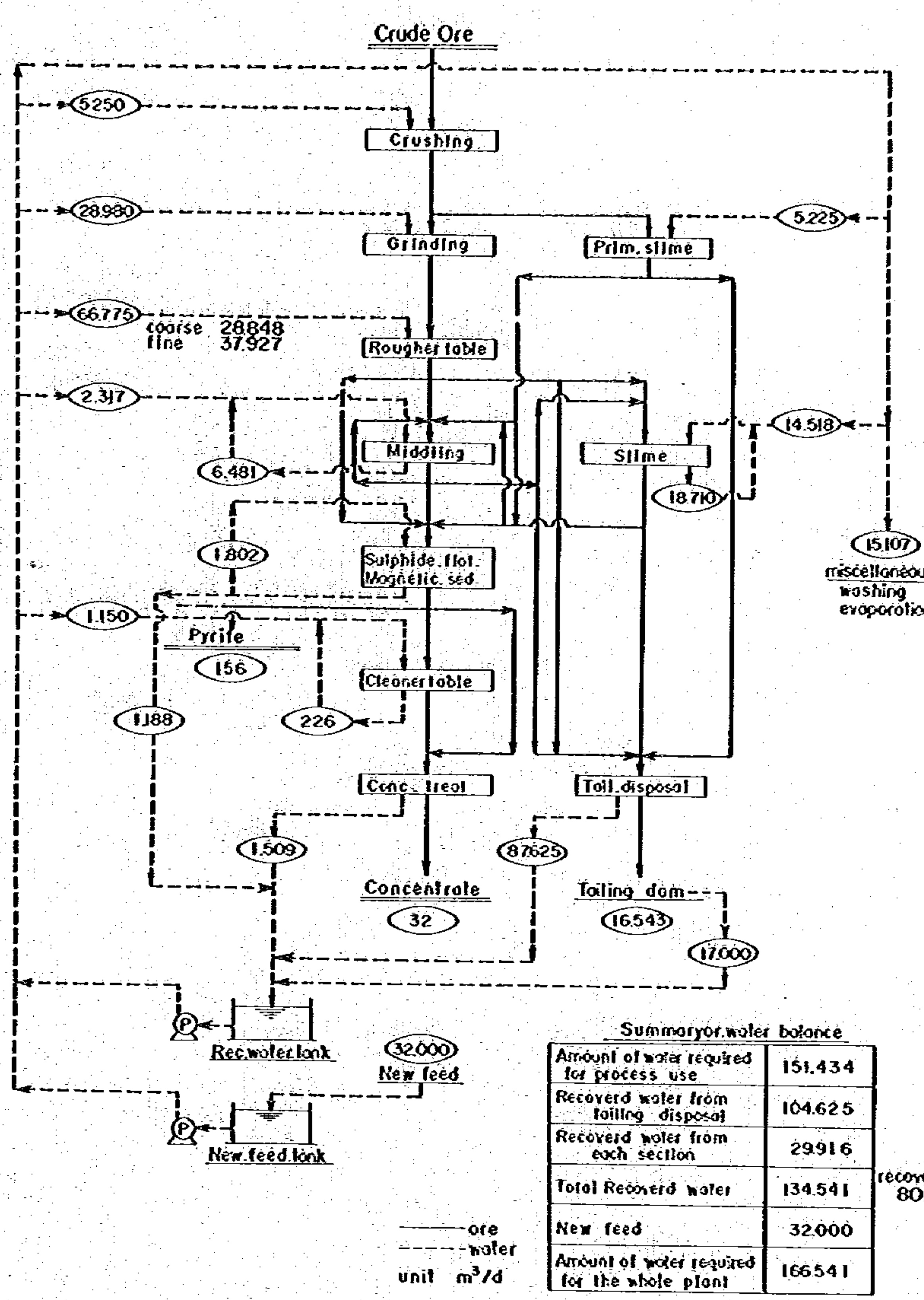
(2) Standards for Water Balance

1) Basic unit of water supply

In total 15 m^3/t-ore will be aimed at. As a reference, the results of other concentration mills are listed in the following Table.

Table II–2–10 : Water Consumption

	Water consumption for processed ore (m^3/t)	Ratio of use of recided water (%)	Supplied Water	(m^3/D)	Note (ccc)
Siglo XX	3.6	70	$1.05^{m^3/t} \times 154^{t/h} = 166$	4,000	value of 1981
Victoria	10.0	70	3.0 x 73 = 219	5,000	-
Huanuni	27.0	80~90	(5.4~2.7) x 41.7 = 225~113	5,400~2,700	1,000 t/D
Mikohata	15.8	87	2.1 x 62.5 = 131	3,000	
Hoei	15.0	70	4.5 x 2.5 = 11.25	270	



Summary of water balance

Amount of water required for process use	151.434	
Recoverd water from tailing disposal	104.625	
Recoverd water from each section	29.916	
Total Recoverd water	134.541	recover ratio 80.8 %
New feed	32.000	
Amount of water required for the whole plant	166.541	

Fig. II-2-19 Water Balance

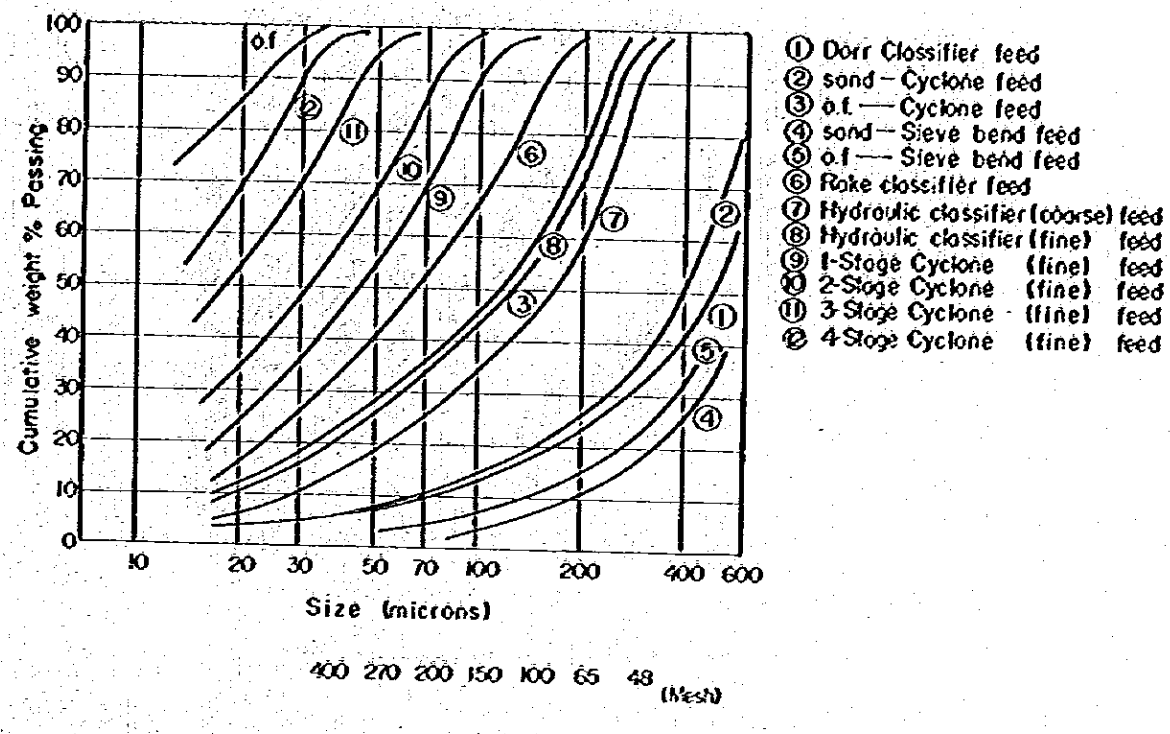


Fig. II-2-20 Size Distribution of Classifier Products

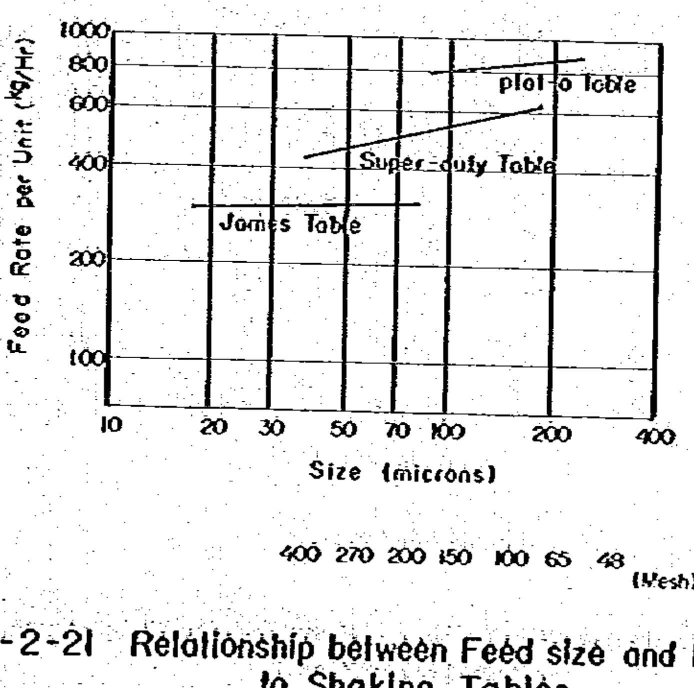


Fig. II-2-21 Relationship between Feed size and Feed rate to Shaking Tables

2) Table

	Plat-O	S-Duty	James
Density of feed :	20% max	15% max	10% max
Shower water quantity :	40ℓ/min. table	35 ℓ/min. table	35 ℓ/min. table

3) Cyclone

Density of feed : As a principle, the density will be 8% minimum, if it is below 8%, it will be fed after being thickened.

Density of underflow of stages :

In consideration of the points of classification, in cases where the density of feed is 20% or less :

200μ	55%	In cases where the density of feed is 40% or more,
150μ	50%	these shall all be 75%.
100μ	45%	
74μ	40~35%	60% in flotation series
53μ	37.5%	
37μ	35~30%	
−37μ	32.5~30%	

4) Hydraulic pressure classifier

Density of feed : coarse grain series 30%, fine grain series 30%

5) Desulfide flotation

Density of feed : 30%

Density of flotation reagents : H_2SO_4 : 5%, Etx : 0.1% Nikko # 125 : 100%

6) Recirculation of water

Excess water from middlings processing, slime processing, the flotation-magnetic separation system and the cleaning table processes is recovered in the systems by thickenens, etc., for reuse. The density of the thickener underflow will be about 15%. The final stage tailings, after being thickened by a thickener (the density of underflow shall be 22% especially to reduce the required quantity, flow by means of gravity as slurry to a tailings dam, and the dam overflow is recovered and reused. The ratio of recycled water will be 80% or more. The quantity of water supply will be planned to give a 10% surplus over the total required quantity, taking water for miscellaneous uses, leakage, evaporation and meter accuracy into account.

2–3–4 Selection of Main Equipment

Regarding main equipment closely related to construction costs, operating costs and concentration results, rough specifications and principal requirements in design are as follows.

(1) Hopper and ore bin for crushing process

For the series of mined ores, the capacity of the receiving hopper may be small, insofar as the capacity of the crushing equipment balances with the feed ore contained by each mine car in the receiving operation, with the mine cars organized as a train (5 t/car x 14 cars), and as long as ore feed is performed smoothly.

For the capacity of the intermediate bin, it will be sufficient if it has a total storage capacity corresponding to the time lag between the mining and concentration processes plus the quantity of residual ores. It is of course necessary to effect the preventive maintenance system for the equipment and to provide a system for preventing the bin from being emptied or damaged by falling ores.

The bin will be of ferroconcrete construction with a grizzly of underground type appropriate to the level of the rail tracks for carrying out the mined ores, and the ores shall be drawn out with a variable-speed heavy-duty type apron feeder. In addition, the dimensions and the shape of the bin gate shall be determined giving consideration to the blocking of mixed powder and mass of the ores.

As desmonte consists of sink-and-float tailings accumulated in an open space, i.e., the feed of desmonte ores is by means of collecting the ores from a kind of ore storage yard and receiving them, a hopper with a capacity corresponding to the loading cycle of a shovel loader and a receiving bin will be disposed appropriate to the contours of the land.

(2) Crusher (Mined ores)

a. Primary crusher

As the mining of underground ores has been changed to the sublevel stoping method, the largest block size will become a little smaller than that resulting from the block caving method, whereas the number of blocks will increase somewhat, so that a smoother size distribution is anticipated. In terms of quantity, for a total quantity of 3,500 t/D, oversize ores for the 190 mm mesh inclined grid will be about 65 t/h.

Since the largest block size will be 600 mm, a brake type crusher which can maintain a crushing ratio of 6 even when the quantities processed increase will be the appropriate type of machine. In terms of initial cost, a single-toggle type one is cheaper, but in terms of a required life span of 10 years of use, the usual type of brake crusher should be selected.

The main specifications of the brake crusher are as follows:

Opening set size : width, 1,050 mm

opening, 750 mm

Revolution speed of pulley : 220 rpm

Motor : 95 KW x 6P

Power transmission : V-belt single-stage reduction from motor

b. Secondary and tertiary crushing

The total quantity of the undersize material from the 190 mm inclined grid of the receiver and of primary-crushed products will be 200 t/h, a comparatively small amount, and in terms of ore quality, little clay will be included, so that a low-head type vibratory screen will be used for receiving these ores. This screen shall be a high-wear resistant rubber net, and the mesh size, type of crusher and set size will be determined taking the ratio of crushing, size distribution of crushed products and required size for the milling process into account.

To avoid overgrinding and conserve the energy required for crushing both of which we have emphasized thus far, a milling feed size of 9 mm (80%), a slightly smaller size than usual, has been adopted. Consequently, for the tertiary crushing process a closed circuit combining a short-head type cone crusher and a 2-stage deck vibratory screen (universal low-head type) will be used. For the secondary crushing process, as the quantity of processed ore is comparatively small, a coarse cone crusher of 40 mm set size will be used as an open circuit.

The main specifications of the secondary and the tertiary crushers are shown below. Although the quantity of desmonte is large, the required crushing ratio corresponds to that of the above-mentioned tertiary crushing, and so the specifications for desmonte have been omitted here.

b. Secondary cone crusher

Type : Coarse type

Mantle diameter : 1,300 mm

Feed mouth size : 200 mm

Rotation speed of pulley : 560 rpm

Motor : 130 KW x 6P

Power transmission : V-belt single-stage reduction from motor

c. Tertiary cone crusher

Type : Short head type

Mantle diameter : 2,100 mm

Feed mouth size : 115 mm

Revolution speed of pulley : 435 rpm

Motor : 300 KW

Power transmission : V-belt single-stage reduction from motor

(3) Scrubber

The scrubber is used for removing mud from crude ores, and for separating and feeding as quickly as possible the particles contained in the products which are generated in rough crushing and medium crushing. This makes it possible to collect cassiterite in or near the state of liberation without being overcrushed.

Its structure comprises a drum washer supported by trunnions and equipped with a lifter. Retention time is one minute, this slightly longer time being required to provide for sufficient washing.

Drum size : 2,400 mm dia. x 5,400 mmL

Rotation speed of drum : 20 rpm

Motor : 110 KW x 10P

Power transmission : V-belt from motor and single-stage reduction gear

Feeding system : Chute

In addition to the above specifications, the following precautions should be observed in construction.

The cell should be supported by trunnions.

No leakage of pulp from the feed mouth should occur.

SCMnH should be used as the material for the liner, the same as for the blades.

A rubber liner should be inserted between the liner and the cell.

It must be possible to use the gear and pinion of the drum on both faces.

An oil spray type of lubrication should be used for the drum gear. A safety device against oil spray problems is required.

FC 35 should be used as the material for the trunnion liner, and a rubber liner should also be inserted between the liner and the trunnion.

Note : These precautions for construction must be carefully examined for each machine in the practical design stage, and it is necessary to check them at the time of estimation, and ordering from or installation.

(4) Mill bin

The desmonte is located close to the concentration mill and its ore reserve is more than twice that of the underground-mined ores, so that there will be no large short-term fluctuations in the quality of the desmonte itself. In the cases of both underground-mined ores and desmonte, the absolue values of their tin grades themselves are low, so that there will be no requirement for a blending function from the mill bin nor an excessively large storage capacity for the bin, if the operation of the mills and classifiers is controlled carefully to provide the feeding of the ores to the mills blended via the two-stage vibrating screens of both the desmonte and mined ore series and for the feed to the table of each process. In addition, the table concentration system is basically a means of concentration based totally on a physical principle.

Accordingly, the capacity of the mill bin is determined to be about the quantity from one shift (2,800 t), in consideration of both the stopping time of the mill required for rod adjustment and of the reduction of construction costs.

(5) Grinding machine

Placing emphasis on the prevention of overgrinding, a multi-grinding system will be employed, comprising the processes of a single-stage rod mill and ball mills for the two ranges of coarse and fine grains.

For the rod mill, 20 mesh (0.833 mm ± 25%) is set as the first grinding target based on the properties of cassiterite. From a trial computation of the size distribution in the crushing process, F80 of the mill feed ore becomes about 11,000μ if the quantity of ore separated into primary slime is excluded. As the work index is 15.5, the required basic unit in kW per ton is :

$$W_1 = 15.5\left(\frac{1}{\sqrt{1,000}} - \frac{1}{\sqrt{9,000}}\right) \cdot \sqrt{100} = 3.27 \text{ (KW/t)}$$

Next, for the sand series of the tube mill, F80 = 2,000μ and P80 = 295μ ;

hence : $$W_2 = 15.5\left(\frac{1}{\sqrt{295}} - \frac{1}{\sqrt{2,000}}\right) \cdot \sqrt{100} = 5.56 \text{ (KW/t)}$$

For the overflow series of the classifier, F_{80} = 208μ and P_{80} = 147μ ;

hence : $$W_2 = 15.5\left(\frac{1}{\sqrt{147}} - \frac{1}{\sqrt{208}}\right) \cdot \sqrt{100} = 2.04 \text{ (kW/t)}$$

When calculating the motor capacity, it is required to multiply or divide these basic unit values by various correction coefficients, fluctuation rates and motor efficiency.

If the dimensions of a unit rod mill are too large, oversliming may occur in relation to the ball mill, so that its diameter should be rather small if possible. The aspect ratio (ratio of diameter to length) of the rod mill body should not be too large (i.e., should not exceed 1.4) to prevent overgrinding. In this case, the motion of the rods tends to become unsteady compared with mills of larger aspect ratios, and the eccentric wear to or breakage of the rods tends to occur.

For this reason, in extreme cases, it may be required to stop the mill regularly once every two days and to replace the rods or turn them over. As it is most desirable for the overall amount of ore processed in the grinding process to be fluctuated by such suspension of operation, plural rod mills will be installed to suppress the degree of fluctuation by stopping them in turn. To adopt the construction of the rod mill to the above-mentioned rod-controlling operation, open-end type mills will be adopted.

The main specifications of the rod mill and the ball mill are as follows:

Rod Mill

Type : Wet overflow type

Number of mills : 4

Drum size : 3,000 mm dia. x 4,200 mmL

Rotation speed of drum : 16 rpm

Motor : 520 kW x 8P

Power transmission system : Single-stage reduction gear directly coupled to motor

Ball mill (Coarse grain series)

Type : Wet overflow type

Number of mills : 4

Drum size : 3,600 mm dia. x 6,000 mmL

Rotation speed of drum : 16 rpm

Motor : 1,100 kW x 6P

Power transmission system : The same as above

Ball mill (Fine grain series)

Type : Wet overflow type

Number of mills : 2

Drum size : 3,000 mm dia. x 5,400 mmL

Rotation speed of drum : 18 rpm

Motor : 600 kW x 6P

Power transmission system : The same as above

(6) Sieve bend

For the sizing equipment, which is the most important apparatus in the gravity concentration process, a device which does not occupy a large space but can process large quantities and is suitable for the sieving of size (i.e., 65 mesh (208μ) is required.

For such requirements, a fixed-wedge bar-type sieve bend which does not require rotation, hydraulic power, etc., is most suitable, and the simplest and most convenient, and, by applying the proper maintenance measures, fluctuations in its performance can be reduced.

Corresponding to operational conditions and arrangements, a two-stage type can also be constructed.

Specifications common to each process are as follows:

Size : 2,675 mmL x 780 mmW x 1,550 mmH

Mesh : 0.40 mm

Number of units : 3 (12 sieves, 4 sieves, 6 sieves, one each)

(7) Hydraulic classifier

The hydraulic classifier plays a very important role in gravity concentration. It classifies fine grains and very fine grains, especially while removing particles or slime adhering to or accompanying each grain in the flow of pressurized water (constant head). By so doing, each unit can efficiently cover sizing ranging from +200μ to –74μ, so that it is an indispensable device for improving the recovery rate of cassiterite.

From among the various types, we have selected the Constriction Plate Classifier 10 cell/unit type.

(8) Tables

Three kinds of tables have been selected corresponding to feed ore grain size classes, to separate and collect cassiterite efficiently from ore liquid classified and sized from each series.

1) Deister Plat-O Table

Dimensions : 4,390 mm x 2,180 mm

Motor : 1.5 kW

2) Deister Super-Duty No. 6 Table

Dimensions : 4,650 mm x 2,360 mm

Motor : 1,5 kW

3) #3 James Table

Dimensions : 4,654 mm x 1,835 mm

Motor : 1.5 kW

Operational Standards

Table II–2–11 Standard of Operation of Table

Class of table	Processing quarity t/h	Number of stroke veu/min	Length of stroke mm	Note	
Plat – 0	0.6 ∿ 0.85	240 ∿ 250	27∿ 25	coase grain	115
S. Duty	0.3 ∿ 0.5	270 ∿ 290	20∿ 18	fine grain	404
James	0.1 ∿ 0.3	290 ∿ 310	18∿ 12	very fine grain	569
Total					1,088

(9) Flotation machine

To improve the concentrate grade, desulfide flotation is employed. The process is divided into two stages, rougher flotation and cleaner flotation. As the feed to the flotation machines is the concentrate from the gravity concentration process, most of the machines will be required to process pulp including both coarse and fine range grains. We have therefore selected Agitair flotation machines for rougher flotation and Fahrenwald flotation machines for cleaner flotation (both types of machines have acid-resistant lining). Their main specifications are as follows:

1) Agitair flotation machine

Type : #48 Agitair

Number of machines : 8 cells x 1 unit

Tank : Material : SS41 + rubber lining

Dimensions : 1,210 mmW x 1,210 mmL x 762 mmH (per cell)

Effective volume : 1.1 m^3/section

Peripheral speed of impeller : 366 m/min

Spindle motor : 15 kW x 6P x 4 (one motor per two cells)

2) Fahrenwald flotation machine

Type : FW #24, back gate and single flow type

Number of machines : 6 cells x 1 unit

Tank : Material : SS41 + rubber lining

Dimensions : 1,100 mmW x 1,100 mmL x 1,030 mmH (per cell)

Effective volume : 1.4 m^3/section

Peripheral speed of impeller : 597 m/min

Spindle motor : 11 kW x 6P x 3 (one motor per two cells)

(10) Magnetic separator

Another effective means of removing minerals other than cassiterite from the tin pre-concentrate separated by the tables is the elimination of iron. This iron ingredient is mainly magnetite including 7~8% iron; consequently if a strong magnetic separator is used, cassiterite will be lost together with the magnetite. Accordingly, we have selected a permanent magnet system of weak magnetic force.

The main specifications are as follows :

Model : Eliese permanent magnet wet-drum type magnetic separator

Type : 30"D x 18"W (High Gradient)

Dimensions : 14,788 mmW x 1,422 mmL x 1,500 mmH

Drum : Dimensions : 30"D (762 mm dia.) x 18" (457 mmL)

Magnetic field strength : 750 gauss

Speed of revolution : 25 rpm

Motor : Geared motor 1.5 kW x 4P x 1/30

2–3–5 Selection of Site for New Concentration Mill

(1) Location

As the construction site for the new concentration mill, we have selected the eastern slope of Cerro-Pichakani and Cerro-Konkomoni to the west of Siglo XX. The altitudes of the site are as follows :

Concentration mill bench level : 3,863 ~ 3,943 m above sea level

Water supply tank : 3,950 ~ 3,955 m above sea level (tank top)

Tailings thickener (96 m dia.)

Ground : 3,870 m above sea level, Top : 3,872 m above sea level (tank top)

Drawing point : 3,860 m above sea level.

(2) Topography and geology

The altitude of the peaks of Cerro-Pichakani and Cerro-Konkoni is about 4,100 m above sea level, and the gradient of the slope at the concentration mill site is 30 ~ 40%. Between the two peaks is a small valley, but the annual rainfall is about 540 mm and the water catchment area is small, so that inflow may be almost negligible.

The geology of the lower and middle parts of the slope is of the so-called Uncia formation type, consisting of alternate layers of green gray sandstone and slate, and the strike is in the direction perpendicular to the slope. In the upper part, light gray sandstone and quartzite of the Llallagua formation exist. Most of the buildings and the machine foundations of the concentration mill are built on the Uncia formation, and a load capacity of 80 t/m^2 or more can be expected. Receiving equipment will be constructed near the existing receiving equipment on the eastern side of Siglo XX Mill. This place is thought to be an ancient valley, and its geology consists of boulder and gravel layers sedimented in the valley forming the upper part of the Uncia formation, and the load capacity there is expected to be 60 t/m^2 or more.

With regard to the plant cover of the slope, only perennial grasses of several centimeters in height grow, but the ground is nearly bare. On the middle part of the slope, the remains of the incline and the accumulated tailings of Siglo XX exist, but there will be no problem in preparing the mill site.

Also within the planned space, there are a few dwellings of the local inhabitants and a little cultivated land, but they can be moved easily. In the lowest part of the site, the thickeners, concentrate yards and receiving equipment will be situated, and a portion of the existing rails will be transferred for receiving the mined ores.

As mentioned above, no particular problem arises from topographical, geological or other conditions in constructing the concentration mill.

2–3–6 List of Specification of Concentration Equipments

The specification of equipments and machines of concentration mill plant is shown as follows.

Table II-2-12 List of Concentration Equipment

(1)

Process	Usage	Q'ty	Specification or detail	Cap.
Mined ore crushing process	Hopper	2	with 50^t inclined grizzly and 25^t concrete	
	Ore bin	3	100^t x 1 300^t x 2 colgate	
	Apron feeder	5	900^{mm} x 8^m, 2–6 m/min 8" auto weight type	
	Belt conveyor	6	$1,000^{mm}$ x 5^m∿445^m less than 15" of inclined angle 87.5 Km	
	Belt conveyor	11	750^{mm} x 8^m ∿ 40^m less than 15" of inclined angle 68.6 Km	
	Vibrating screen	1	6' x 16' x 22 Kw simple floor type 40 mm	200 t/h
	Vibrating screen	2	10' x 24' x 90 Kw	340 t/h
	Brake crusher	1	25' x 36' x 95 Kw Set 100 mm	65 t/h
	Coase cone crusher	1	9' x 45' x 130 Kw Mouth 200 mm Set 30 mm	140 t/h
	Short head cone crusher	1	7', 300 Kw Mouth 115 mm Set 13 mm	170 t/h
	Constant feed wear	1	170 t/h momentary control system	
	Drum washer	1	8' x 18' x 110 Kw 20 rpm transmission hold type	340 t/h
Desmonte Crushing	Hopper	4	50^t with gryzzry x 1 50^t x 3 made by concrete	
	Apron feeder	4	90^{mm} x 8^m, speed 2 ∿ 6 m/min auto weight type	
	Belt conveyor	7	600^{mm} x 10 ∿ 30^m less than 15° 28.7 Kw	
	Belt conveyor	6	750^{mm} x 13 ∿ 16^m less than 15° 39 Kw	
	Belt conveyor	7	$1,000^{mm}$ x 10 ∿ 405^m less than 15° 127.5 Kw	
	Vibrating screen	6	10' x 24' 270 Kw	510 t/h
	Short head cone crusher	3	7', 900 Kw mouth 115 mm set 13 mm	510 t/h
Common	Crane	2	20^t, span 14 m total electric power 37.8 Kw	
Milling	Mill bin	8	500^t made of concrete	
	Belt feeder	16	$1,000^{mm}$ x 7^m Speed 2 ∿ 6 m/min 120 Kw	
	Belt feeder	4	600^{mm} x 15^m Less than 15° of inclined angle 22 Kw	
	Belt feeder	1	$1,000^{mm}$ x 66^m horizontal, 27.5 Kw	
	Constant feed wear	4	100 t/h momentary control system	
	Rod mill	4	10' x 14', 2,080 Kw	337 t/h
	Dol classifier	5	1.5^m x 9^m 37.5 Kw	
	Bend shieve	22	Wedge wire type mesh 0.4 mm	
	Cyclone	28	9" ϕ	
	Ball mill	4	12' x 20' 4,400 Kw	450 t/h
	Ball mill	2	10' x 18' 1,200 Kw	150 t/h
	Slurry pump	5	0.13 m^3/min	
	Crane	2	30 t/5^t x span 19 m, 20 t/5^t x span 19 m 141.9 Kw	
Rougher table	Raked classifier	4	4.8^m x 10.8^m 60 Km	
	Hydraulic classifier	10	10 room type	
	Table	529	Plat-O 97, S-Duty 195 James 235 793.5 Kw	
	Cyclone	128	9"ϕ x 44, 6"ϕ x 84	
	Slurry pump	25	0.21 m^3/min ∿ 22.2 m^3/min 855.4 Kw	

Process	Usage	Q'ty	Specification or detail	Cap.
Middling processing	Ball mill	2	10' x 16' 1,040 Kw	110 t/h
	Cyclone	42	9"ϕ x 17, 6"ϕ x 25	
	Thickener	1	$30^{m\phi}$ x 3m 1.5 Kw	
	Table	100	S-Duty 49, James 51 150 Kw	
	Slurry pump	12	0.07 m^3/min ∿ 4.5 m^3/min 236 Kw	
Primary slime	Cyclone	15	9"ϕ x 9, 6"ϕ x 6	
	Table	66	Plat-O 18, S-Duty 13, James 35 99 Kw	
	Slurry pump	5	0.13 m^3/min ∿ 6 m^3/min 88 Kw	
Slime processing	Thickener	1	$55^{m\phi}$ x 4^m 7.4 Kw	
	Cyclone	84	6"ϕ	
	Table	341	S-Duty 101, James 240 511.5 Kw	
	Slurry pump	8	1.1 m^3/min ∿ 9.5 m^3/min 410.7 Kw	
Desulphurizing flowtation	Table	31	S-Duty 46.5 Kw	
	Cone tank	2	9.5 mϕ	
	Cyclone	1	6"ϕ	
	Ball mill	1	3' x 10' x 30 Kw	15 t/h
	Thickener	1	20 mϕ x 3 m x 2.2 Kw	
	Flotator	14	No. 48 agitator 8 cell, No. 24 FW 6 cell 93 Kw	
	Reagent equipment	1	Sulfuric acid tank, pump etc. 4.25 Kw	
	Slurry pump	8	0.3 ∿ 2.2 m^3/min 54.8 Kw	
Magnetic separation for iron	Magnetic separator	1	Drum type (wet) 762 $^{mm\phi}$ x 457 ^{mm} 1.5 Kw	
	Cyclone	4	6" ϕ x 3" ϕ x 1	
	Cone tank	2	$4^{m\phi}$, $6^{m\phi}$	
	Table	21	S-Duty 15, James 6, 31.5 Kw	
	Slurry pump	8	0.16 m^3/min ∿ 0.6 m^3/m 23.3Kw	
	Crane	15	1.5^T Hand worked	
Concentrate processing	Belt conveyor	2	$\phi 600^{mm}$ x 18^m Incline less than 15° 4.4 Kw	
	Conveyor scale	2	1.3 t/h	
	Hickener	2	$8^{m\phi}$ x 3^m x 1.5^{kw}, $2^{m\phi}$ x 3^m x 1.5^{kw}	
	Drag classifier	2	500^{mm} x 5^m x 3^{kw}	
	Cone tank	2	$5^{m\phi}$, $5.5^{m\phi}$	
	Slurry pump	3	0.1 m^3/min ∿ 0.65 m^3/min 25.5 Kw	
Water recirculating and tailing processing	Hickener	1	96 mϕ x 11.1 kw	
	Cyclone	9	36 mϕ	
	Slurry pump	12	11.7 m^3/min ∿ 15.3 m^3/min 3,218.5 kw	
Other equipment	Incline	1	Winch 75 Kw	
	Wrecker	2	100^T	
	Bending roller	2		

(3)

Process	Usage	Q'ty	Specification or detail	Cap.
	Electric welding machine	20		
Water	Pump Pump	3 2	5 m^3/min x 270^m 1,110 Kw 4.5 m^3/min x 340^m 840 Kw	

2–3–7 Outline of Concentration Equipment Disposition

Receiving equipment for mined ores carried out of mine by mine cars, primary and secondary crushing equipment and receiving equipment for desmonte carried out of its accumulated area will be installed at the lowest level of the concentration mill.

As concentration will be carried out by all sliming system, the concentration mill will be constructed on the eastern slope of Cerro-Pichakani, and the concentrate and slurry will be transported through machinery on the upper level to the lower level of the slope to utilize the natural head as far as possible.

Mined ores which have passed the primary and secondary crushing processes will be carried up to the tertiary crushing equipment on the upper level of the concentration mill by belt conveyers. Desmonte also will be carried up to the crushing equipment on the upper level of the mill by belt conveyers.

Crushing equipment for desmonte, washing equipment and the tertiary equipment for mined ores, mill bin equipment, grinding equipment classification equipment, tables and dewatering equipment for concentrate will be installed between the upper level and the level of the concentration mill.

Tailings separated by tables will be carried to the cyclones and thickners on the lowest level of the concentration mill, water separated by thickening of slurry will be recirculated as water for concentration, and condensed slurry will be hydraulically transported to the dam through troughs.

Both fresh water and recycled water recovered in concentration processes used for concentration will be stored respectively in a fresh water tank and a recycled water tank which will be installed on the top level of the concentration mill.

For carrying in materials and equipment, an incline that will be constructed on the side of the concentration mill building will be used.

Overhead travelling cranes shall be provided to make maintenance work easy.

2–3–8 Outline of Concentrate Processing

In Victoria Mill, the grain sizes of concentrate are about –200 mesh 50%, and concentrate pulp from tables is collected on a drag belt, sand dragged up by the belt is dried by driers and packed in PP sacks.

In the new concentration mill, it is anticipated that size distribution of grains will shift to the finer grain side, about –200 mesh 65%, so that the concentrate will be thickened once in a thickener, classied on a drag belt, and then dried naturally in an ore storage yard. Although crude ore production will be 10,000 t/D, the quantity of concentrate will be about 25 m^3/D even when low and high grade are added together, so the concentrate should be dried naturally to reduce cost as far as possible utilizing high evaporation rate at the high land. (See Fig. II–2–18).

2–3–9 Outline of Tailing Processing

The quantity of tailings in the new plant will be above dry-t/hr accompanying the above 5,000 m^3/hr of water. It is necessary to recover this water to the maximum extent possible while simultaneously investigating the method and places of accumulating these tailings including the safety problems. Although the sizes of tailings will on the finer grain side when compared to those of present plants just as in the case of concentrate, as the tailings will be produced in vast quantities, the so-called free discharge will not be allowed and the tailings must be dewatered somehow for handling.

In this plan, after separating a part of coarse grains in a cyclone, the overflow will be thickened by a thickener to reduce flow quantity, then the tailings will be hydraulically transported to the tailing dam by a natural head. Accordingly, both the overflow of the thickener installed on the lowest level of the concentration will and the supernatant of the tailing dams will be recovered and reused. (See. Fig. II–2–19).

The reason why the above was adopted is in case the density of feed is as low as a few percent in a large thickener and yet the feed includes coarse grains of the same level as that of a copper porphyry plant, increase of concentration ratio to increase spigot density may cause trouble. The trouble in a thickener means the damage of its sludge collecting mechanism resulting from the unstable discharge of spigot. Thickenens must be carefully controlled because spigot discharge in a thickener fluctuates essentially in its quantity and/or density, and when the sedimentation speed of feed pulp is too high, so-called hang-up phenomena tend to happen.

The plan for tailing dams will be described later in another chapter.

2–3–10 Outline of Electric Equipment Installation

(1) Plan for Power Receiving Station

Power demand of the new concentration mill is estimated to be 21,000 KVA for power equipment and 600 KVA for lighting. In consideration of future increase or modification, power receiving facilities shall correspond to a mill equipment capacity of 25,000 KVA. Power supply to the receiving substation will be described subsequently.

The power receiving station will be built in the vicinity of the new concentration mill near its crushing and grinding stages which have heavy duty equipment. Transformer banks : There will be two main transformer banks, a 15,000 KVA bank and a 10,000 KVA bank. The load of the crushing and grinding equipment will on the 15,000 KVA bank, and others including the pump equipment to the tailing dams will be handled by the 10,000 KVA bank. Construction of the power receiving station : Outdoor closed type, three-phase three wire system and one 66 KVA incoming line system will be adopted. Main transformers are oil immersed self cooling type ones installed outdoors, and their secondary sides will be connected to a metal-clad outdoor cubicle through bus ducts.

Protecting device : Like the transformer equipment, a set of usual protecting devices against current overflow, ground faults internal troubles of equipments, etc., will be provided.

(2) Power Distribution Plan

Voltage classes for loads:

Motors over 100 kW	3,000 V
Motors of 100 kW or less	400 V
Lightint, heating and control circuits	200V or 100V
Instrumentation	100 V

Power control centers in the mill : Three centers each for ore receiving area, crushing and grinding stages, and table stage (collectively) will be set up. In the office rooms, power receiving panels, high voltage motor panels, power distribution transformers, motor control centers, low voltage panels, etc., will be provided.

Method of power distribution:

From the power receiving station to each power control center, 3 KV power will be supplied through cables contained in underground pits. Connection to each load will be made, as a general rule, through a cable enclosed in a conduit pipe. Power to load at the tailing dam position will be supplied through aerial lines (distribution line length 41 km).

(3) Instrumentation Plan

In a concentration mill, differing from general equipment industries, there is high possibility that processes may be disturbed by the fluctuation of ore quality as natural ores are processed directly. Such fluctuation must be suppressed to the least in the processes from grinding on possible, because if the quantities or quality of feed to tables, flotators, etc., change greatly, the capacities of these concentration machines may become excessive or insufficient, the machines may become unable to perform fully, or ore distribution to each step may become inappropriate, all of these will make the operation unsteady. However, in the grinding process, the fluctuation of ore quantity or quality will not matter so much in so far as the performance of grinding machines is well maintained and there is no drop from conveyers, etc.

To control the operation of the grinding properly, the quantity of ore feed to a rod mill must always be maintained at the required quantity. If ore quality changes, it will cause the change of distribution in the closed circuit of the ball mill or various classification devices. We will avoid the adoption of a high class control system for the above operation control and will cover processes with minimum instrumentation and monitoring system in this mill. The instrumentation shall cover the following:

i) Measurement of feed water quantity from the water supply tank in order to maintain the density in the mill as constant as possible,

ii) measurement of ore liquid densities at main points, and,

iii) for stabilizing classification, at least the level control of the cyclone feed pump tank, monitoring of fresh water and recycled water quantities in the water supply system, and keeping water supply tank head constant will be carried out, and also measurement and monitoring at main points will be carried out to prevent troubles such as irregularities in ore liquid handling in each process, liquid leakage, etc. For monitoring, remote controlled ITV's which can zoom shall be placed at main points.

2–3–11 Outline of Civil Engineering and Building Construction Works

(1) Preparation of Construction Site

Main concentration equipment will be constructed on the Uncia formation consisting of the alternate layers of slate and sandstone, and receiving equipment will be constructed on a hard compacted layer of boulders and gravels. The site for disposing these equipments will be prepared by bench-cutting the slope.

Benches are from the top,

For water tank : 1 step

Crushing and grinding equipment : 8 steps

Tables : 15 steps

Dimensions of a bench will be 1.5 ~ 7 m (H), 15 ~ 21 m (W) and about 140 m (L).

Bench cutting will be performed by cumbining blasting and heavy machine cutting. Broken rocks produced by the bench cutting will be used for banking the power station site and roads for construction work.

The upper layer of the lowest step is supposed to be the gravel, sand and conglomerate layer, and the lower layer, Uncia formation. The gravel, sand and conglomerate layer will be cut by heavy machines and the Uncia formation will be cut by a combination of blasting and heavy machine cutting.

The 96 mϕ thickener will be built within the space where Desmonte is accumulated, so its construction site must be cleared before construction by pushing up Desmonte with bulldozers.

The bench-cut parts are rock beds mainly consisting of slate, but as the frequency of using water will be high in the concentration mill, the rock bed will deteriorate and be separated early, especially in winter, the separation of rock beds will be accelerated because of freezing, so excavated rock bed surfaces will all be covered with concrete. In other words, riser parts will be made into concrete retaining walls, and horizontal parts into concrete floors.

(2) Construction-Work Road

The construction-work road will be made in the south-western side of the slope, i.e., from the upper part of the existing machine repair shop for mining equipment. This road will be extended to each level to be used for transporting construction materials, especially, for transporting concrete and erecting buildings. Specifications of the road are as follows:

Gravel road

Width : 7 m

Gradient : max. 10%

Extension : 1,000 m

(3) Specifications of Concentration Mill Buildings

The specification of building are as follows:

1 Crushing and grinding : 80 m x 122 m, maximum height 22 m ;
Steel structure ; Roof – corrugated galvanized sheet iron roofing ;
Outside wall – corrugated galvanized sheet iron boarding.

2 Table, concentrate 125 m x 245 m, height 10 m ; steel structure ;
Roof – corrugated galvanized sheet iron roofing,
Outside wall – galvanized sheet iron boarding.

3 Power control center for crushing and grinding building :
12 m x 35 m, height 4 m ; Concrete block construction

4 Power control center for table building :
12 m x 75 m, height 10 m ; Steel structure ; Roof – corrugated galvanized iron sheet roofing ; Outside wall – corrugated galvanized iron sheet boarding.

(4) Scope of Civil Engineering Works for Mill Equipment

Main structures and foundations for processes are as follows :

1 Crushing process

Crusher room, crusher room shed, crusher foundations, receiving bin, intermediate bins

2 Milling process

Mill foundations, mill bins

3 Primary slime processing process

Table foundations, cyclone foundations

4 Rougher flotation process

5 Middling processing process

30 mϕ thickener, mill foundations

6 Slime processing process

55 mϕ thickener

7 Desulfide flotation process

20 mϕ thickener, cone tank foundation, flotator foundations

8 Iron eliminating magnetic separation process

Cone tank foundations

9 Concentrate processing process

12 mϕ and 8mϕ thickener foundations, cone tank foundations

10 Water recovering and tailings processing process

(5) Water Supply Tanks

The specification of the tanks are as follows : Fresh water tank : Reinforced concrete construction, 2,000 m^3, one tank, including 300 m^3 of elevated tank part.

Recycled water tank : Reinforced concrete construction 5,000 m^3, one tank.

(6) Civil Engineering Works for Power Incoming Station

The power incoming station will be built in the north of the new concentration mill. In the planned site, Desmonte has been accumulated, so that it is required to move the Desmonte to some other place and accumulate it there beforehand. As the natural ground of the site is a valley, earth produced by bench-cutting will be used for reclaiming and banking to prepare the construction site.

Around the site net fences will be built.

Net fence specifications : Height 2.0 m, extension 200 m. Civil engineering works other than the above will be foundations for the buildings and floor concrete.

(7) Construction Work Materials

Materials which will be imported are steel members for buildings, roofing materials, outside wall materials, reinforcing steel bars, bolts and nuts, and consumable subsidiary materials such as welding rods, etc.

Other materials (cement, aggregate, paint, bricks, etc.) will be procured at the locale.

Steel members for buildings shall be fabricated in manufacturers' factories and rust proofed with paint, then transported to the site and erected and assembled.

The roofing materials, outside wall materials and reinforcing steel bars shall be transported there in the knocked down condition and shall be fabricated and assembled on the spot.

(8) Method of Execution

1) Earth works

Rock excavation will be carried out by the combination of blasting and heavy machine operations, and other works will be carried out by heavy machine operations alone. However, rock excavation will be finished by hand with coal picks.

Construction machines and blasting materials can be purchased in Bolivia.

2) Concrete works

One set of 0.75 m^3 batcher plant, one 80 m^3/hr concrete pump vehicle and three truck-mixers shall be imported, but small size concrete work machines can be purchased at the locale.

3) Building works

One 35-t truck crane shall be brought there by the orderer, but auxiliary truck cranes can be purchased in Bolivia.

All the construction works mentioned above shall be performed, as a principle, by local labor controlled by COMIBOL engineers, and one supervisor for civil engineering works and one for building construction works.

The costs of imported construction machines are included in the construction costs.

(9) Amount of Main Construction Works and Materials Required

Site preparation :

Mill site : Rock excavation 65,000 m^3

Banking 10,300 m^3

Waste debris 54,700 m^3 (used for power substation site and work roads)

Tailings thickener site :

Desmonte to be moved 150,000 m^3

Construction workroad : Rock excavation 26,000 m^3

Concrete work:

Concrete 37,000 m^3

Cement 12,500 m^3

Sand 16,700 m^3

Gravel 33,300 m³

Reinforcing bars 2,700 t

Building construction work :

Steel 4,500 t

Roof and outside wall materials 57,500 m² (225 t)

2–3–12 Rough Estimation of Construction Costs

Notes : Estimating conditions

i) Costs are based on present prices (escalation is not taken into account).

ii) Unit equipment prices are the prices estimated by specialist manufacturers.

iii) About cans, plate cutting and edge preparation of plates shall be finished in Japan, then transported to the site and fabricated and assembled there.

iv) Marine freight shall include $192.44 (¥ 50,000/m³ or t) and insurance [$192.44 (¥ 50,000/m³ or ton) + FOB price] x 0.7775%.

v) Inland handling charges shall consist of $129 (¥ 33,540/m³ or ton) and import tax and miscellaneous charges, (FOB price + marine freight) x 5%.

2–3–13 Construction Schedule

The schedule is shown in Fig. II–2–22 on the next page.

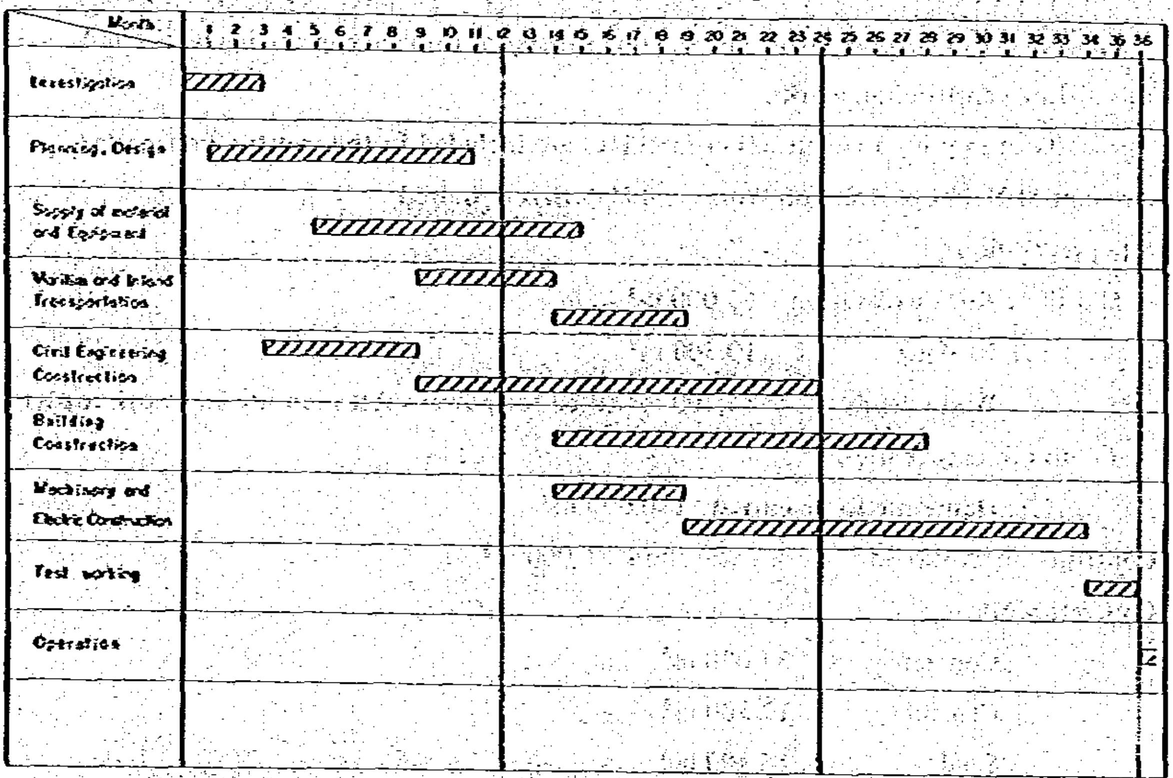


Fig. II-2-22 Progress Schedule of Concentration Equipment

Table II-2-13 Classified Expenditure by Quantities of Processed Ore

	Scale	10,000 t/D	9,000 t/D	8,000 t/D	Note
① Concentration Equipment	Machinery Construction	1,000$ 49,440	1,000$ 46,412	1,000$ 43,245	
	Electric Construction	9,568	8,982	8,369	The transmission of electricity in this is shown
	Civil Engineering Work	19,249	17,816	16,347	again in 4-2-4
	Subtotal	78,257	73,210	67,961	
② Dam, Water Service Equipment	Mechanical Construction	2,657	2,495	2,324	Total cost of ② is shown again 4-1-5
	Electric Construction	721	678	632	
	Civil Engineering Work	155	146	135	
	Subtotal	3,533	3,319	3,091	
③	Supervisor	3,427	3,427	3,427	
	Reserve	4,908	4,592	4,262	
	Engineering Fee	4,088	3,827	3,554	6% x (① + ②)
	Other Expense	8,519	7,996	7,446	5% x (① + ②)
	Subtotal	20,942	19,842	18,689	10% x (① + ② + ③)
TOTAL		102,732	96,371	89,741	

Table II-2-14 Classified Expenditure by Usages in the Case of 10,000 t/day

		F.O.B.	Marine transp. cost	Inland charge	Site construction cost	Spare parts	Total	Note
① Concentration Equipment	Machinery Construction	34,323	1,000$ 6,612	1,000$ 6,300	1,000$ 763	1,000$ 1,442	1,000$ 49,440	
	Electric Construction	6,464	1,031	1,027	768	279	9,569	
	Civil Engineering Work	5,250	1,590	1,306	11,102	0	19,248	
	Subtotal	46,037	9,233	8,633	12,633	1,721	78,257	
② Dam, Water Service Equipment	Machinery Construction	1,580	506	432	139	0	2,657	
	Electric Construction	389	160	132	42	0	723	
	Civil Engineering Work	53	14	12	76	0	155	
	Subtotal	2,022	680	576	257	0	3,535	
③ Supervisor and other expenses		13,084	–	–	7,858	–	20,942	
TOTAL		61,143	9,913	9,209	20,748	1,721	102,734	

2–4 Production Plan

The quantity of production and metallurgic balance in this project are shown below.

2–4–1 Quantity of Production and Metallurgic Balance

Table II–2–15 Production and Metallurgic Balance (1 ∼ 7 years 10,000 T/D x 25 days = 250,000 T/M)

Class of Mineral		Quantity (T/M)	Grade (%) Sn	Fe	S	Metal content (T/M) Sn	Fe	S	Weight proportion	Recovery Sn	Fe	S
Crude ore	Mined ore	87,500	0.41	2.46	0.96	361.25	2,152.5	840.0	35.0	45.2	39.8	63.3
	Desmonte	162,500	0.27	2.00	0.30	438.75	3,250.0	487.5	65.0	54.8	60.2	36.7
	Total	250,000	0.32	2.16	0.53	800.00	5,402.5	1,827.5	100.0	100.0	100.0	100.0
Concentrate	High grade ore	880	50.0	6.00	1.00	440.0	52.8	8.8	0.35	55.0	1.0	0.6
	Low grade ore	975	4.1	9.40	0.50	40.0	91.6	4.9	0.39	5.0	1.7	0.4
	Total	1,855	25.9	7.78	0.74	480.0	144.4	13.7	0.74	60.0	2.7	1.0
Tailing	Sulphide concentrate	1,500	0.28	45.0	49.0	4.2	675.0	735.0	0.60	0.5	12.5	55.4
	Tailing	246,645	0.13	1.86	0.23	315.8	4,583.0	578.8	98.66	39.5	84.8	43.6
	Total	248,145	0.13	2.12	0.53	320.0	5,258.0	1,313.8	99.26	40.0	97.3	99.0

Table II–2–16 Production and Metallurgic Balance (8 ∼ 10 years 10,000 T/D x 25 days = 250,000 T/M)

Class of Mineral		Quantity (T/M)	Grade (%) Sn	Fe	S	Metal content (T/M) Sn	Fe	S	Weight proportion	Recovery Sn	Fe	S
Crude ore	Mined Ore	50,000	0.22	2.46	0.96	110.00	1,230.0	480.0	20.0	16.9	23.5	44.4
	Desmonte	200,000	0.27	2.00	0.30	540.00	4,000.0	600.0	80.0	83.1	76.5	55.6
	Total	250,000	0.26	2.09	0.43	650.00	5,230.0	1,080.0	100.0	100.0	100.0	100.0
Concentrate	High grade ore	693	45.0	7.28	1.02	312.00	50.4	7.0	0.28	48.0	1.0	0.6
	Low grade ore	1,167.0	4.4	7.72	0.35	51.35	90.1	4.1	0.46	7.9	1.7	0.4
	Total	1,860	19.4	7.56	0.60	363.35	140.5	11.1	0.74	55.9	2.7	1.0
Tailing	Sulphide concentrate	1,500	0.23	43.58	39.93	3.45	653.7	598.9	0.60	0.5	12.5	55.5
	Tailing	246,640	0.11	1.80	0.19	283.20	4,435.8	469.9	98.66	43.6	84.8	43.5
	Total	248,140	0.12	2.05	0.44	286.65	5,089.5	1,068.8	99.26	44.1	97.3	99.0

Table II–2–16 shows the case on the basis of a production of 10,000 t/D scale in 1st ~ 7th year period following the standards for the new plant plan, Table II–2–17 shows a production plan in which the 10,000 t/D scale is maintained by increasing the processed quantity of desmonte corresponding to the drop in mined ore tin grade.

Tables II–2–17 and II–2–18 show production plans in which production scale is reduced respectively to 9,000 t/D and 8,000 t/D to maintain a consint tin grade through the ten years.

From these tables, total quantity of tin treated during 10 years will become as shown in the following table.

Table II–2–19 Quarity of Tin Treal During 10 Years

	10,000 t/D case	9,000 t/D case	8,000 t/D case
A Sn in Crude ore	7,550 t	6,950 t	6,275 t
B Sn in Concentrate	4,449	4,170	3,765
B/A	58.93 %	60.0 %	60.0 %

These case studies will be described later in the economic evaluation.

2–4–2 Organization and Personnel

The number of persons in this plan will be disposed as follows by supposing that the new plant would be of a certain technological level.

Table II-2-17 Production and Metallurgic Balance (9,000T/D x 25 days = 225,000 T/M)

Class of Mineral		Quantity (T/M)	Grade (%)			Metal content (T/M)			Weight proportion	Recovery		
			Sn	Fe	S	Sn	Fe	S		Sn	Fe	S
Crude ore	Mined ore	62,500	0.41	2.46	0.96	256.25	1,537.5	600.0	27.8	36.9	32.1	55.2
	Desmonte	162,500	0.27	2.00	0.30	438.75	3,250.0	487.5	72.2	63.1	67.9	44.8
	Total	225,000	0.31	2.13	0.48	695.00	4,787.5	1,087.5	100.0	100.0	100.0	100.0
Concentrate	High grade ore	764.5	50.0	6.00	1.00	382.25	45.87	7.7	0.34	55.0	1.0	0.7
	Low grade ore	847.5	4.1	9.40	0.50	34.75	79.69	4.2	0.38	5.0	1.6	0.4
	Total	1,612.0	25.9	7.79	0.74	417.00	125.54	11.9	0.72	60.0	2.6	1.1
Tailing		223,388	0.12	2.01	0.48	278.0	4,662.0	1,075.6	99.28	40.0	97.4	98.9

Table II-2-18 Production and Metallurgic Balance (8,000 T/D x 25 days = 200,000 T/M)

Class of Mineral		Quantity (T/M)	Grade (%)			Metal content (T/M)			Weight proportion	Recovery		
			Sn	Fe	S	Sn	Fe	S		Sn	Fe	S
Crude ore	Mined ore	62,500	0.41	2.46	0.96	256.25	1,537.5	600.0	31.25	40.8	35.9	59.3
	Desmonte	137,500	0.27	2.00	0.30	371.25	2,750.0	412.5	68.75	59.2	64.1	40.7
	Total	200,000	0.31	2.14	0.50	627.50	4,287.5	1,012.5	100.0	100.0	100.0	100.0
Concentrate	High grade ore	690	50.0	6.0	1.0	345.1	41.4	6.9	0.35	55.0	0.9	0.7
	Low grade ore	765	4.1	9.4	0.5	31.4	71.9	3.8	0.38	5.0	1.7	0.4
	Total	1,455	25.9	7.8	0.7	376.5	113.3	10.7	0.73	60.0	2.6	1.1
Tailing		198,545	0.12	2.10	0.5	251.0	4,174.2	1,001.8	99.27	40.0	97.4	98.9

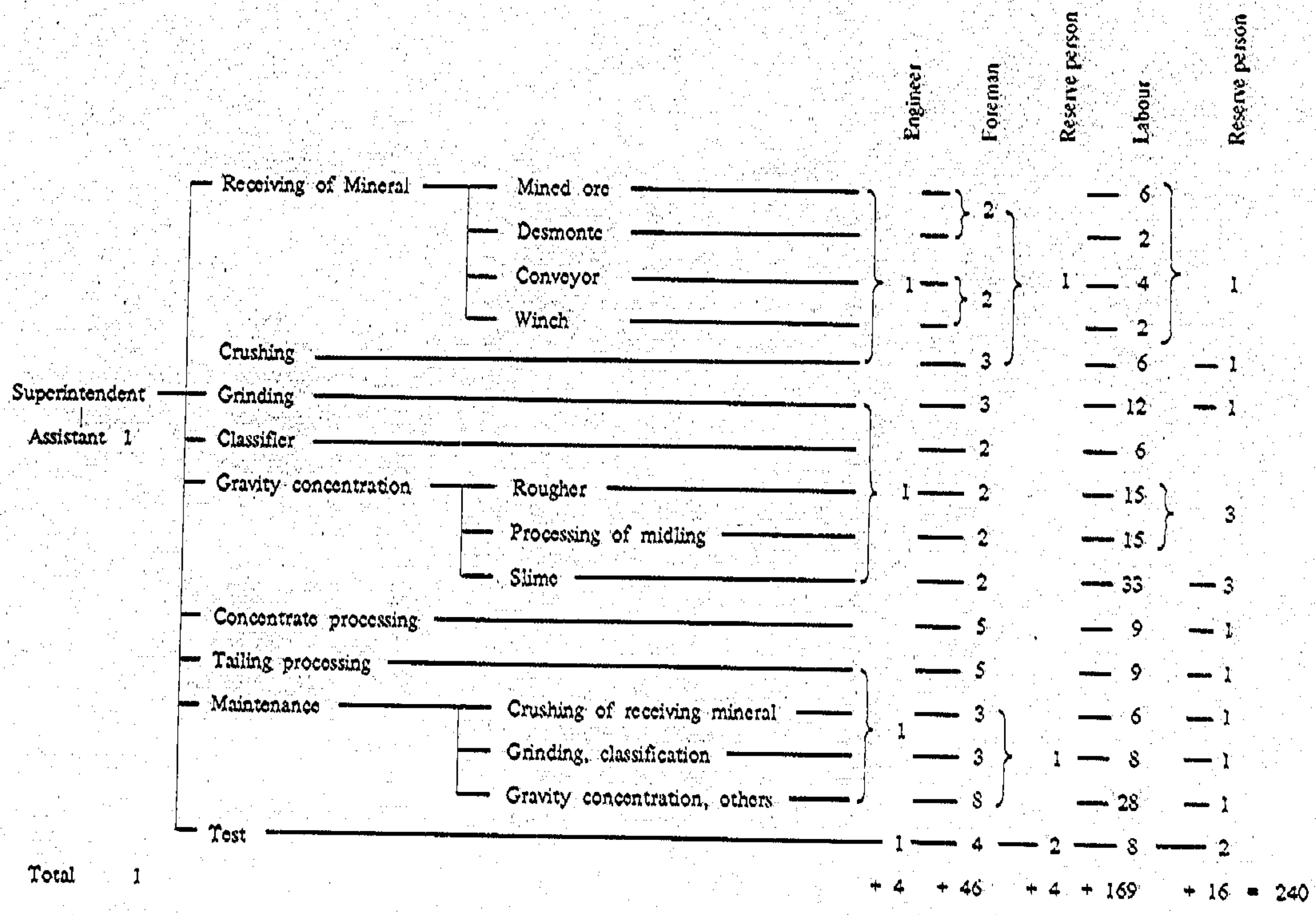


Fig. II-2-23 Organization and Personnel

2–4–3 Rough Estimation of Operating Costs

The operation costs are computed for each element. From the field survey results and data from many Japanese concentration mills, representative values were picked up as reference values.

(1) Personnel Cost

Properly disposed persons in accordance with the preceding article and persons in the existing plants are summarized in the following table for comparison.

Table II–2–20 Number of Persons of Mill Plant

		Chief	Engineer	Forman	Salary Labour	Day Labour	Total	Maintenance
Ⓐ New Plant	Receiving ore and crushing	1	1	8		22		
	Grinding concentrate		1	16		98		
	Tailing maintenance		1	20		55		76
	Test		1	6		10		
Total		1	4	50		185	240	76
Ⓑ Present Plant	Siglo XX	2	4	5	67	264	342	80
	Victoria	1	4	15	95	393	508	63
	(Keako)	1	2	6	14	42	65	8
	Total	4	10	26	176	699	915	151
Ⓑ – Ⓐ		3	6	152		514	675	75

Productivity of labor based on direct workers excluding the workers for maintenance is as follows :

Siglo XX : 19 t/D/man
Victoria : 5.6 t/D/man } 7.1 t/D/man on average
New plant : 56 t/D/man

In Mikohata, a typical example of Japanese tin concentration plants, the value is 16 t/D/man, and, although the kinds of minerals are different, among the concentration plants of copper, lead and zinc, which have been constructed concurrently with the development of ore deposits, there are examples showing the productivity of labour above 50 t/D/man.

About the number of maintenance workers, if the preventive maintenance system by means of regular maintenance after every two weeks is started, it is desirable to expand their activities to works outside Catavi Mine and in medium or long periods of time, to change the section into a self-supporting accounting system. In the maintenance works of equipment used in concentration plants many operations which can be performed by replacing parts are included, so that a two-bird-one-stone effect can be expected by making the operators of the equipment themselves understand the state of wear of rotary machines and have interest in elements which will make operation unstable, ans as a result the quality of operation control can be improved by putting the preventive maintenance system into practice.

The composition of personnel cost ore shown in the following table.

Table II–2–21 Details of Labor Cost of Victoria Mill Plant ('82 Jan ~ May)

Item	Amount		Ratio	Item	Amount		Ratio
	Jan~May Total	Average of month			Jan~May Total	Average of month	
Wages	81,878.93 $US	16,376 $US/month	1.00	Aid for pulperia	163,558.43 $US	32,830 $US/month	2.00
Overtime pay	33,635.51	6,727	0.41	Security 12%	26,010.50	5,202	
Piece wages	7,683.50	1,538		Security 16%	33,526.41	6,705	0.85
Bonus	176,782.99	35,357	2.16	Fund of unemploy	10,018.20	2,004	
Bonus for attendance	15,543.85	3,109		Fund for retirement	2,793.79	559	
Total (Direct cost)	315,529.78	63,106	(0.45)	Fund for reimbursement	54,843.54	10,969	0.67
(Direct + Indirect cost) Sum Total	688,471.95	137,694	(1.00)	Fund of bonus	66,154.45	13,231	0.81
				Others	15,596.13	3,119	
				Total (Indirect cost)	372,942.17	74,588	(0.54)

From Table II–2–21, it is found that the ratios of bonus, reserve for bonus, aid for pulperia etc., are very large compared with the wages.

If the above table is rewritten, the personnel cost of Victoria in the period from January to May in 1982 including direct cost and indirect cost is in total $137,694 /m (=¥34,424,000 /M), hence, for the new plant, @ ¥69,000 /man x 240 man = ¥16,560,000 /month → ¥20 million /M = ¥240 million / Y=US$923,000/Y. ÷ 3,000 t → US$0.31 /t → by considering a certain amount of escalation, US$0.5 t/ shall be used for computation.

(2) Material Cost

Materials used in a concentration plant are roughly divided into abrasives (consumable material), concentration agent, (reagents) and packaging materials. The basic units and the basic unit prices of these principal materials according to the results of Siglo XX and Victoria from January to June in 1982 are as follows.

In planning the new concentration plant, although the above results are taken into account, suppression of material running cost will be held as a primary object for which various measures will be carried out; e.g., crushing roll and lime use will be omitted, or rubber products will be used as mill liners and vibratory sieve screens (over 3 mm) to prevent wearing of the important parts of main equipment, and various measures to improve durability will be carried out; and for this purpose, principal equipment and main component parts will be purchased from foreign countries as a principle.

The above-mentioned values are summarized in the following table.

Table II-2-22 Comparison of Material Cost of New Mill Plant and Present One

	Present Plant		New Plant			
Crushing process	Crushing roll tire	0.2605 $US/t	Grease of crushing machines	Hi Ma	12 g/t	0.08 $US/t
	Screen net	0.0671	Screen net	Rubber		0.02
Grinding process	Rod	0.316	Rod	MC-2	0.5 Kg/t	0.35
	Ball	0.076	Ball	Special alloy		0.40
	Mill liner	0.215	Mill liner	Rubber	0.55	0.07
After grinding	Parts of pump	0.202	Parts of pump	Rubber etc.		0.20
	Parts of cyclone		Parts of cyclone	Rubber		0.10
	Lime	0.204	Lime			
	Reagents of flotation	0.027	Reagents of flotation			0.02
	PP sack (2 class)	0.184	PP sack			0.20
Total		1.5516	Total			1.44

Other than the above, flotator impellers, ripples of the shaking tables, linoleum etc., for tables, V-belt, etc., will be replaced by the operators of concentration equipment when these parts are worn out, but including these expenses in repair cost, $1.5 /t will be appropriated for material cost.

(3) Repair Cost

Usually, the repair cost of a plant is roughly estimated by multiplying its construction costs by a certain ratio. The ratio has a range 2 ~ 4% per year, is 4% for a refinery and about 2 ~ 3% for a concentration mill. In this plan, maintenance workers have already been included in the personnel cost plan, and a considerable part of repair parts cost is included in the material cost. Different from a mill plant which uses flotation as its main process, this mill plant employs a system whose main part is table concentration, so the cost of abrasives is regarded to be not so much. Also about the pipe of pulp in the grinding and classification processes, their repair cost can be reduced by adopting rubber lined pipes or inserting rubber hoses into gas pipes.

On the other hand, the construction cost itself becomes higher than the usual construction costs because it includes marine freight and inland transportation charge.

From the above conditions, annual repair cost will be computed by multiplying machinery and electrical equipment costs by 2.0% in this plan.

¥152 x 10^6 x 0.02 = ¥3.05 x 10^6 / Year → $1.13/t → $1.2 /t

(4) Electric Power Cost

The electric power cost is calculated from the kilowatt hour amounts of the capacity of each process.

Table II–2–23 Cost of Electric Power

	Height voltage (3 KV)	Low voltage (400 V)	Total	Base of Calculation
Receiving ore crushing	1,420 KW	904.7 KW	2,324.7 KW	x 0.7 x 21 h/day
Grinding	7,680	771.9	8,451.9	x 0.8 x 24 h/day
Rougher table	–	1,708.9		
Midling processing	1,040	389.7		
Primary Slime	–	187.0	4,255.3	x 0.75 x 24 h/day
Slime treatment	–	929.7		
Desulphurizing flowtation	–	230.8		
Magnetic separation of iron	–	56.3	323.7	
Concentrate processing	–	36.6		x 0.8 x 24 h/day
Tailing processing	3,200	29.6	3,229.6	
Total	13,340	5,245.2	18,585.2	x 0.8 x 24 h/day
Water	1,950	–	1,950.0	x 0.8 x 24 h/day
Sum Total	15,290	5,245.2	20,535.2	386.2 Mesh/day

From the result,

386.2 MWH ÷ 10,000 t/d = 38.62 kWH/t

This value is nearly equal to those of usual concentration plants. As unit electric power cost is ¥13.83 /kWH,

hence, 13.83 x 38.62 ÷ 260 = $2.05 /t

For rough estimation, a basic unit of $2.2 /t will be used.

(5) Other Costs

Other costs include analysis cost, concentrate transportation cost and concentration office cost. The analysis cost is $0.2 /t. About the concentrate transportation, as the quantity of concentrate is as small as 75 t/D which is very small compared with the quantity of crude ore, 10,000 t/D the cost was omitted. The office expenses including those of mining and concentration will be summed up in the general administrative expenses. In this plan, these costs are collectively summed up as $0.2 /t.

When (1) ~ (5) are summarized,

Personnel cost	$0.5 /t
Material cost	1.5
Repair cost	1.2
Electric power cost	2.2
Other costs	0.3
Total	$5.7 /t

Note : Water supply expenses were divided and summed up in the electrical cost and the repair cost.

2–5 Improvement in Operation of Present Concentration Mill

The operation control of a concentration mill depends fundamentally upon the smooth handling of materials. In addition, the operation of the concentration mill has features that even its tank and pump processes are open type ones and the handled object can be observed visually almost all throught its processes, compared with a plant of other kinds of equipment industries. On the other hand, the problem of wearing and corrosion caused by handling ores can be thought a subject in operation which requires some kinds of systematization for the maintenance of equipment.

In each stage of concentration processes constructed as per required design standards, the fluctuation of ore feed to main equipment or flow quantity must be small. Usually, the following measures are employed to suppress this kind of fluctuation:

i) A constant feed weigher will be provided for ore feeding to a primary grinding machine, and also the quantity of water is controlled to keep liquid density in the grinding machine as constant as possible.

ii) Production is controlled so that the metal grade of received ores may not fluctuate greatly and also the grade may be increased to as high as possible.

Matters to be improved which were recognized during the field surveys are summarized briefly as follows.

1 Grinding

In the operation of rod mills, changeover and replacement of rods are indispensable, because the ore feed sides of rods are abraded more than their ore discharge sides, so the rods must be supplemented and changed over corresponding to the total quantity of processed ores. Also, worn out rods or those which have become short by breakage (whose length has become 1/2 ~ 1/3 of their original length) must be removed.

In case feed to a mill is suspended or reduced, it is necessary to stop operating the mill or reduce the quantity of water to keep liquid density in the mill as constant as possible as mentioned above to avoid overgrinding.

Tighter control of liquid density in the mills and classifier overflow is desired to carry out proper grinding by carrying out density measurement and grain size measurement regularly or whenever required.

2 Classification

As the quantity of water supplied or the pressure of hydraulic pressure classifiers fluctuates greatly, subsequent table series are disturbed, and, in cases the fluctuation of the quantity or the pressure is especially large, it is sometimes inevitable to turn the concentrate collected in table concentrate zones to middlings. The repetition of such a state will generate big losses, it is therefore required to separate the water supply system to the hydraulic pressure classifiers from other water supply systems to keep the quantity and pressure of water supplied to the classifiers constant.

3 Tables

The stroke and the number of revolutions of each table must be controlled thoroughly and properly. As each table has different stroke length and the number of revolutions, they must be corrected corresponding the grain sizes of feed ore. It is important to set them in the following ranges as general standards.

	Number of Revolutions	Stroke Length
Deister Plat-O	240 ~ 260 rpm	25 ~ 27 mm
Deister S. Duty No. 6	270 ~ 280 rpm	18 ~ 20 mm

It is required to keep each part in good condition to make head motion smooth and fix ripples with nails or the like so that the ripples may not become free and float up from table surfaces.