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Suggested improvements for a Wisconsin zinc mill

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SUGGESTED IMPROVEMENTS FOR A WISCONSIN ZINC MILL.

by

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A

THESIS

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Sampling.

Samples from the over-flow of the V-Box at the end of the jigs were taken in the following manner. A cut was made in the side of the launder about the width of the launder and down to the level of the running water within. Beneath this cut a second launder was arranged to catch any material coming from this cut, leading it to a sample barrel. A board fitting the first launder closely was used to force the material for a certain length of time through the cut into the second launder and then into the barrel. Care was taken that all material removed from the first launder reached the barrel where everything was allowed to settle for three hours before the water was decanted. After several days the material collected in the barrel was removed and dried on boilers or in the sun.

The sample of the tailing was taken by letting them run into a barrel until filled. This was only done twice as the sample thus obtained was of considerable quanity, 159 pounds, the time of filling being thirty-six seconds and the volume taken being seventy-five gallons. This was dried and sifted through a 3/32 inch screen. As this was not weighed before shipping, and as a considerable portion of it spilled in the shipping, what this weighed is not known. On a similar tailing sample taken about six months before, the following results were obtained:

total wt. of tailing caught 254 pounds

passed through a 3/32" screen 105 1/8 pounds

time of test 54 seconds

105 1/8 pounds assayed 1.70 % Zn

From the above it will be seen that 41.3 % of the tailings go through 3/32" screen. If the material leaving the rougher over-flow, 46 lb/min, is added to this, 50 % will pass 3/32" screen. At least 95 % of it having been only once through the crushing section of the mill, which shows that 45 % of the material coming from the rolls will pass a 3/32" screen.

Tests

A screen test was made on the over-flow from the rougher with the results as shown in Table 2. The same was also done with the tailing passing a 3/32" as shown in Table 3 . A sample was taken of the rougher over-flow and panned carefully making concentrates and tailings. The tailings were allowed to settle and the water syphoned off, then dried on radiators. Another sample was taken and screened thru the 80 and 150 mesh screens. Each of these products were then panned and dried. After drying, all products were weighed and assayed with the results as shown in Table 4.

Conclusions from the tests

(1) The tests show distinctly that all the values are in the finest material, therefore any reduction of the amount of fines will increase the extraction.

(2) The panning test shows that it is possible to concentrate these fines on tables that even with material passing 150 mesh screen it is possible to make concentrates although the tailings will still contain a considerable quanity of blende.

The Mill as it is at present.

The ore is hoisted in 1000 pound buckets, dumped on to a 5" grizzly, the over size staying on the grizzly where it is hand picked. The barren rock is carried to the dump on a car. The ore is sledged so it passes the grizzly into a bin below. From this bin the ore feeds into two ton cars which carry it up an inclined tramway to the mill bin. The mill is about 300 ft. from the shaft. Hoisting is done entirely during the day shift (9 hrs.)

From the bin at the mill, which holds about 100 tons, the ore is fed by hand into a 14" Blake Crusher of the ordinary type. The ore is here crushed from 5" to 1" or 1 1/2", this size being regulated by the mill man. The crusher is belt driven from the main shaft.

The ore now goes to a pair of spring rolls. One of the rolls has a 1" flange on each side, the other runs in between these flanges. The shells are made of white cast iron and they give little trouble by breaking as there is practically no chert in the ore. The shells, however, wear very unevenly, becoming pitted to a depth of 1/2", the pits usually extending nearly across the roll face. No care is taken to keep the rolls in line or to have them wear even. One roll is driven by a belt and gear, the other by friction.

From the elevator it goes into a 3/8" trommel, the under size going directly to the jig, the over size going to another pair of similar but smaller rolls, the product being fed back to the elevator.

The tailings from the jigs go into a V-Box with a baffle-board down the center. The coarse tailings are taken off at the bottom with just enough water to convey them down the launders to the tailing pile and the over-flow goes off at the other side of the baffle board carrying considerable quanities of fines with it. This is done in all three of the jigs.

The mill works two shifts of ten hours with a crew of three men on each shift consisting of the mill man, a backer and a crusher feeder.

The complete flow sheet will be found at the end of the paper.

The losses of blende in the present mill all come in treating the fine ore, most of it being in the material that goes into the over-flow from the V-Boxes at the end of the jigs and in the fines of the tailing. This is shown by the tables at the end.

Prevention of Fines.

It will be seen by the flow sheet that the material is all fed to the crusher and the 1st rolls without first taking out the ore which is already finer than the size to which it is being crushed.

If the ore was fed to the crusher so that it was only one grain deep in the crusher at any time this would not make any difference in amount of fines produced but would not be ecconomical of power or capacity. As it is run the jaw is kept about 3/4 full of material all the time and any ore already fine enough is crushed still finer. This could easily be remedied by placing a short 1" grizzly in front of the breaker. The water now fed into the breaker jaws to wash the fine ore through, could be sprayed on the ore as it crosses the grizzly which would shorten the length of grizzly needed to screen the ore, a three foot grizzly being plenty long enough under these conditions.

Using the first rolls that are at present installed in the mill, a 3/8" screen should be placed in front of them because everything passing through is crushed finer unless it is accompanied by a larger partcle when the rolls may or may not be held apart long enough to allow it to pass. The rolls now used are both fines makers and uneconomical of power. They not only crush finer all material that is already fine enough but break that material which is coarse much finer than is necessary. This readily shown in Fig.

1. The large particle "A" gets into the rolls and is broken in the position shown. "B" a piece of "A" which has been dropped or thrown in the position shown and is there crushed again.

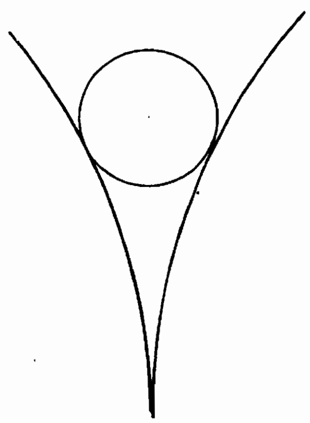


Fig. 1

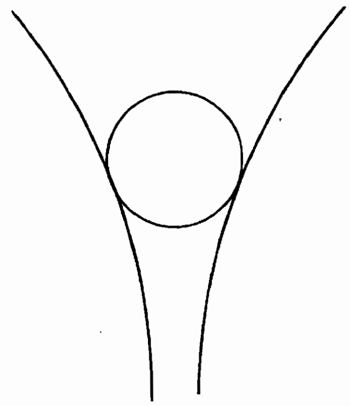


Fig. 2

If these rolls had been spaced the distance apart to which they are crushing this piece "B", if already reduced to that size, which would have fallen through as shown in Fig. 2, as would all other pieces smaller than the space, whether fed to the rolls in that way or crushed that way.

By spacing the rolls a saving is also made in power as well as in fines. The power consumed by rolls may be divided into two parts, first, in breaking the rock, which is proportional to the new surface on the crushed rock (see R. H. Richards' Ore Dressing Vol. III, page 1334) second, the friction in the bearings.

Under (1) all the unnecessary crushing is a loss of power. Take for example, a feed from 1 1/4 inches to 0 and this will be about the feed being fed to the rolls. Under the best condition, 30 % of it will pass a 3/8" the size to which we wish it crushed. If of this 30 %, one half as much new surface is added per unit, as is added per unit to the material coarser and if one half of the power is used in crushing, this would make a saving of 7 1/2 % of the power used by the rolls. If this is carried through also for the coarse material which has secondary crushing, I see no reason why we could not count on at least 12 % saving of power used by the rolls from this source alone. While some of the above figures are not based on any known data, I think they are under rather than over what might be expected.

The friction on the bearings is proportional to the pressure on those bearings, other conditions remaining the same. With closed rolls the pressure on the bearings is equal to the pressure of the springs plus the weight of the rolls and this pressure is always present. With the spaced rolls the pressure of the springs is only taken on the bearings when the rolls need it, that is, when they are actually crushing and then not any more of it than is necessary to crush the rock in them.

As the rolls run far from their full capacity it is easy to see that this in itself would be a considerable item in loss of power in the rolls.

The springs should also be strong enough so that the rolls are practically rigid, that is, will not spring back except for an unusual piece, as a hammer head, drill point or other piece of steel. This should be so, because, if the rolls are not strongly held together they will make a considerable over-size and every pound of unnecessary over-size is just so much lost power in elevating. It also means that rolls are in line as long as the face of the rolls is parallel to the line of the shafts.

The roll faces should be kept lined up by distributing the ore evenly across the face. If the faces tend to pit, they should be kept even by a block and emery as these pits also tend to make over sizes.

It will be seen therefore that for rolls to have economy of power and to best prevent fines, the following conditions should be fulfilled;

(1) rolls should be set apart at least the distance to which they are crushing

(2) the springs should be so strong that only under unusual strain would they give

(3) the shell should be of such material that the rolls can be kept in line and the face kept even.

Using a pair of rolls of this type, there would be no need of the second rolls as all the over size from the trommel could be returned to these rolls being small in amount and they would be perfectly safe in taking it.

The third or middling rolls have an entirely different feed. They are supposed to crush everything that goes thru them, since their feed ~~it~~ is mostly included grains and of all sizes, ~~and~~, As they have a small quanity of feed there should be a small space between them so that the full pressure of the springs will not be on the bearings causing a large loss in friction. The springs instead of being tight enough to be rigid, should be just tight enough to crush the particles.

Treatment of Fines.

Several years ago vanners were installed in the district for the treatment of fines that came from the jigs. They evidently were not a success as they have all been taken out and at present I believe there is not a mill in the district using them. Probably the reason for this was that the vanners made a product too low grade in zinc or too high in iron.

Tables of the Wilfley type have not been tried out to any extent. There are a few mills which have installed them lately but, with one exception, I do not know with what results. In that one case a Dunham Table was installed but it was not satisfactory. Just why I have not heard but these reasons present themselves. The Dunham Table is to take a whole feed and concentrates both the fine and the coarse material. The fines are treated on a small section on to which they have been washed by the wash water.

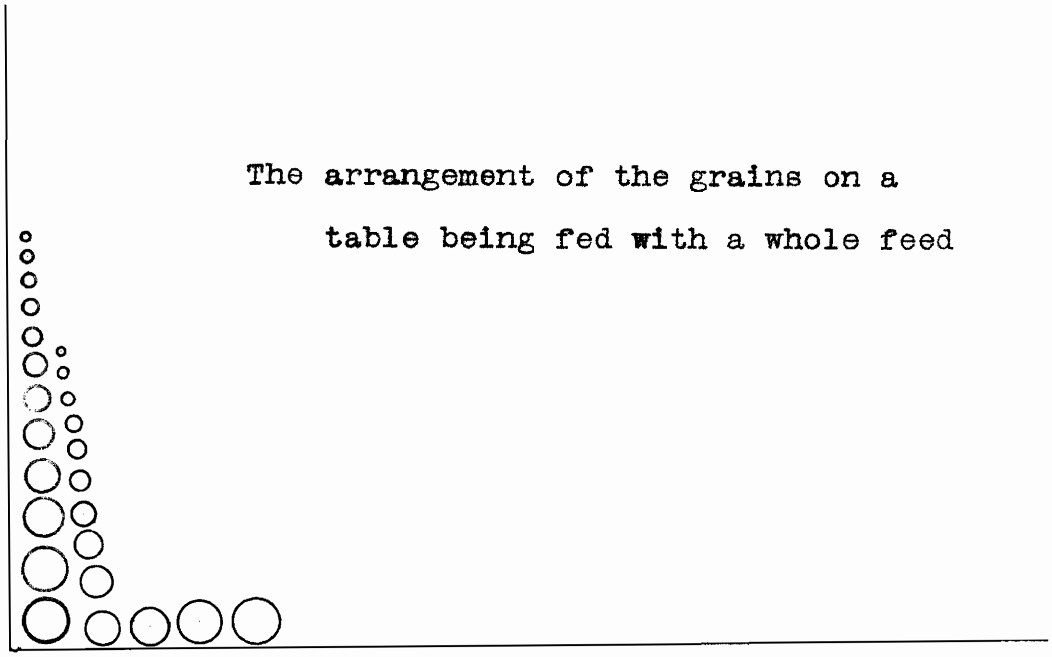
This portion of the table is small and has no independent method of regulation. The rest of the table treats the coarse material, now if the table is regulated to one of these sizes it would indeed be a coincident if it suited the other. In fact it is very improbable as finer material should have a short quick jerk while the coarse material should have a longer and slower jerk. At best, a blende, pyrite and calcite product is difficult to treat especially if it is desired to remove some of the pyrite. It seems therefore that a table of that type is not to be expected to do the work required especially when it is taken into consideration that the zinc ore must be very high grade.

The first problem, if tables are to be used, at what place shall the feed be taken in the present mill scheme. There are two places that present themselves, first, below the jigs, second, after the first trommel at the head of the rougher. In the first case a screen or classifier would have to be placed at the foot of each one of the jigs or all brought to one place and here classified or screened. In the latter case this would require another elevator as the mill is now constructed and this is not advisable from the stand point of power used. In placing the classifier after the jigs, the main objection is that there is too much water to handle. By placing the classifier or screen in front of the rougher, the amount of water in the classifier feed is not excessive and the jig is relieved of that material which it cannot treat and which, therefore, just takes up room in passing which should be occupied by other material thus cutting its capacity.

The next question is how shall table feed be separated from the jig feed? Shall a screen be used or a classifier? The size screen which would be used on this product would be rather fine, something under twelve mesh and may be considerably finer. This screen would have to be long and large as it must have a large capacity with a small screen hole. The wear on such a fine light weight screen would necessarily be heavy. A classifier would make as clean a product as a screen and probably much less power, also a classifier could be placed in the mill as it now is with very few changes while with the proper size screens several changes would be necessary. Therefore, it seems that a classifier is what would be wanted. One of the type of the Richards' Annular Vortex Classifier being probably the best if a free settling classifier is to be used, having been designed for a large capacity and a single but close seperation, and having worked very successfully.

The next question is what preperation if any should be given to the feed of the table? It has been shown that the position of the ore on a table is shown as in Fig. 3, that is, the coarse particles of heavy minerals come off

The arrangement of the grains on a table being fed with a whole feed



The arrangement of the grains on a table being fed with a classified feed

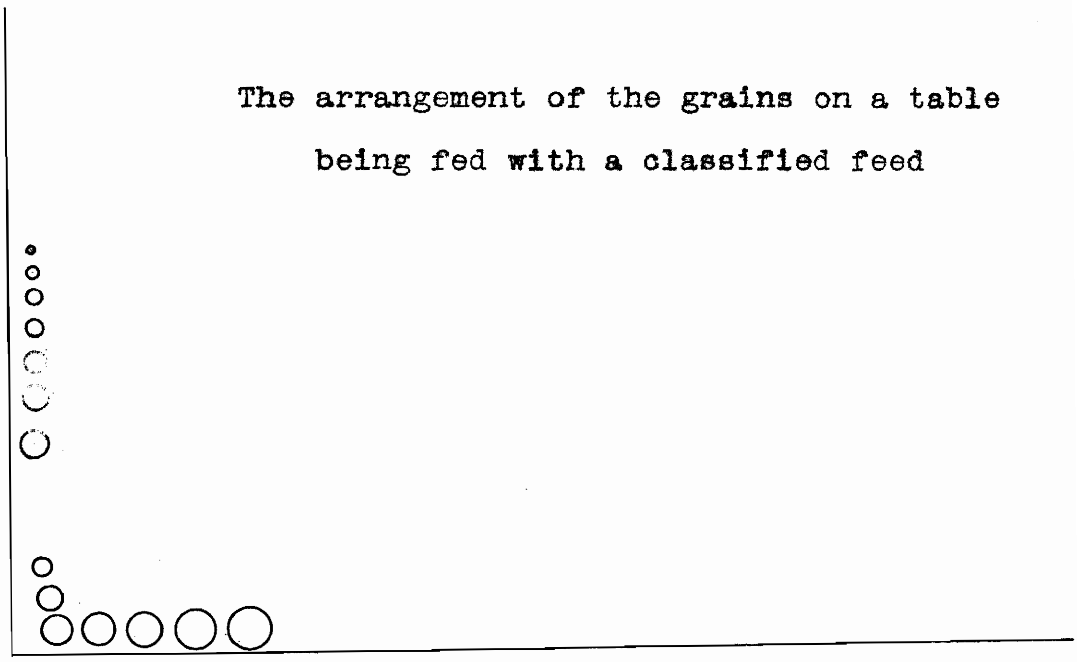


Fig. 3

at the corner and the particles get smaller going up the end till they get so small that the wash water has considerable influence on them, they then come back and are scattered all through the slimes. The larger particles of lighter mineral are over on the lower or tailing side of the table away from the concentrates and on coming toward the concentrate end the particles get smaller. The best feed for a table would be that which contains large grains of light mineral and small grains of heavy mineral as this feed would allow easy separation of the two minerals. This is exactly what is done by a classifier, the small grains of heavy mineral coming out with the large grains of light mineral. There fore it would seem that the classified feed is the ideal feed for a Wilfley Table and that a hindered settling classifier feed would be better than a free settling classifier as it empasizes the difference in ratio of diameters still more.

The next question is, what size shall this classifier begin its work? From the screen analysis of the rougher over flow and the tailing it would seem about forty mesh should be the place, because, at this point the tailings begin to run up in zinc showing that the jigs are not making a good extraction on this fine material. The next question is, could not tables treat material coarser than this better than the sand jig? Tables might save from 1 to 1.5 H. P. They would cut down to some extent the pyrite which the jig does not do. In a mill not running very high in pyrite it would not pay to remodel this part for the reduction in iron obtained but it would certainly pay to consider this seriously in construction of a new mill. If this is to be done 2 mm (10 mesh) would be the best point of division between jigging and table material. If run as it is at present with the addition of tables 0.5 mm (30 mesh) would be the point of division for the max. piece of blende going to the tables.

How close must classifying be performed under these conditions? There is a theoretical arrangement of a classifier for any given installation provided the classifier does perfect work. In our construction it would pay us to allow a factor of safety here either for the classifier or for the table or both in order to make easier the table separation.

The hindered settling ratio of blende and calcite is 2.1 the free settling ratio is 1.5. Suppose the over flow from the classifier preceeding the rougher jig will contain blende from 0.75 to 0 mm. (the pyrite will be discussed later.) This over flow could be sent to a two spigot hindered settling classifier, the first spigot giving blende between 0.5 mm. and 0.25 mm. and calcite between 0.75 and 0.50 mm., the second spigot containing between 0.25 mm. and 0.12 mm. and calcite from 0.5 mm. to 0.25 mm. the over flow containing the remainder. Each of these three products would be sent to a separate table. If 2 mm. material was to be the division point between jigs and table then two more spigots would be added to the hindered settling classifier taking in the first spigot material from 2 mm. calcite, and in the second from 1 mm. blende and 3 mm. to 2 mm. calcite, and 1 mm. to 0.5 mm. and 2 mm. to 1 mm. calcite, and 1 mm. to 0.75 mm. calcite going into the third. In this case a four pocket hindered settling classifier would be used with one table for each spigot product and one for the over flow. This has not taken any consideration of the amount of material going on to each table. As now run 25 % of the mill tonnage would go into the over flow of the classifier in the first case while 50 % would go in the second. The tonnage of the mill is about 200 tons in fifteen hours meaning 100 tons over the five tables and fifty tons over the three tables. This would be considerably more than this number of tables could handle. With the changes that have been proposed in the crushing department this would be cut to sixty and thirty tons respectively, this taking in the increase in capacity due to removal of fines from the jig. This would give an average of about ten tons per fifteen hours per table and would run the tables at about their full capacity. The amount of material that will be fed to each table if the spigots were regulated as has been suggested above, may not distribute the feed in the right proportions on each of the tables. The exact behavior as to amounts from each spigot cannot be told before hand, but changes could easily be made to give each table its proper amount of feed. What per cent of the pyrite and marcasite could one expect to eliminate on tables run as a screen? The hindered settling ratio of pyrite to calcite is about 3. Take for example material coming from the second spigot in the case where the sand jig is used. This would contain 0.12 to 0.25 mm. blende, 0.25 mm. to 0.50 mm. limestone and 0.8 to 0.16 mm. pyrite. It can be seen from the above that if the table is taken as a screen only 50 % of the pyrite may be taken from the ore. This wuold hold true in the same way for each of the other spigots.

A hindered settling classifier has been chosen to sort the product for the tables. The question now is what type of classifier to use? There are two types, The Richards' pulsating classifier (upright and inverted type) and what is known as the Wolf tongue type. Richards' pulsating (intermittent) hindered settling classifier has the disadvantage of not being flexible, that is, after it is once installed you cannot add a cell. It also seems to cause considerable trouble by clogging up in which case the mill has to be shut down and the entire top lifted off which means a large loss of time. This machine also takes some power besides the lifting of the water. The wolf tongue only requires lifting of the water, can do as good work as the Richards' hindered settling classifier and has the advantage of being flexible, one or more compartments can be added whenever it is desired. The Richards' settling classifier of the Wolfe tongue type is probably the best one of this type now in use.

What type of table should be used? The main points to remember in ordering a table are, simplicity in construction, ease of operation and adjustment and that it is designed for the kind of feed which is being placed over it. Under the latter a table constructed for a coarse feed should not be installed to work a fine feed, and a table designed for whole feed will not do for classified feed. With these points in mind any of the standard jerking tables would probably fill the requirements.

Summary

In reviewing it will be seen that the following suggestions have been made,

(1) a grizzly in front of the Blake Crusher to keep the finer ore from being ground finer

(2) the first rolls should be spaced, kept true and the springs kept at such tension as to make them almost rigid to prevent making fines and to reduce the power

(3) removal of the second rolls as they are unnecessary and the over size from the trommel being returned to the first

(4) the third rolls should be slightly spaced so as to reduce the power used by them

(5) a single spigot classifier should be placed after the first trommel and in front of the jig to remove ore that the

jigs cannot treat and allow more room for material that it can treat

(6) a two or four spigot (according to whether the sand jig was replaced) hindered settling classifier should receive the over flow from the first classifier to prepare it for the tables

(7) that three to five tables of any of the standard types would treat the feed from the classifier.

Table 1

Data on Sampling the Jig Over Flows

Date	Time	Sand Jig Sec	Sand Jig Gals	Cleaner Sec	Cleaner Gals	Rougher Sec	Rougher Gals	Time Settled
8/17	2:30 PM	10	22	10	31	10	32	19 hrs
8/18	11:30 AM	10	30	10	31	10	45	3 "
	2:30 PM	10	24	10	26	10	40	18 "
8/19	9:00 AM	10	17	10	27	5	26	3 "
	12:00 N	10	18	10	24	5	23	3 "
	3 PM	10	29	10	26	10	43	18 "
8/20	9:00 AM	10	18	10	33	10	36	3 "
	12:00 N	10	19	10	30	10	40	3 "
8/22*								
	10:00 AM	10	32	10	25	10	35	3 "
	1 PM	10	30	10	27	10	40	3 "
	4" PM	10	28	10	24	10	40	17 "
8/23	9 AM	10	30	10	28	10	40	4 "
	1 PM	10	35	10	28	8	35	3 "
	4 PM	10	30	10	26	5	20	17 "
8/24	9 AM	10	30	10	30	10	40	3 "
	12 N	10	30	10	25	10	40	3 "
Total		160	422	160	420	143	575	
Gals per min		158		157		241		

* Cleaned up sand jig barrel and changed height of cut in the side of the launder

Table 2

Screen Analysis of Rougher Over Flow

Thru	On	Wt.	% on screen	% Zn	% Fe
-	40	22	1.2	1.4?	1.2
40	50	29	2.7	.8	1.2
50	60	62	6.0	1.8	1.4
60	70	91	10.9	2.2	1.9
70	80	61	14.2	2.9	2.1
80	90	54	17.0	2.7	2.1
90	100	24	18.3	3.6	2.1
100	120	371	38.4	4.7	2.5
120	150	223	50.2	5.6	3.6
150	200	82	54.8	7.3	3.5
200	Inf	850	100.0	7.0	5.0
000	Inf			6.0	
Calculated from above				5.5	
Assay of Sand Jig Over Flow (1)				20.6	
" " " " " " (2)				21.0	
" " Cleaner " "				17.5	

Table 3

Screen Analysis of Tailings Thru 3/32 Screen

Thru	On	Total On	Total % On	% Zn
-	12	68	7.0	.55
12	14	171	17.5	.60
14	16	228	23.2	.90
16	18	303	30.8	.90
18	20	350	35.7	.50
20	24	429	43.4	.65
24	30	519	53.0	.70
30	35	564	57.5	.75
35	40	600	61.2	.70
40	50	697	71.1	.65
50	60	753	76.8	1.1
60	70	784	80.0	1.5
70	80	808	82.5	3.2
80	100	821	83.8	3.5
100	120	891	90.9	4.2
120	150	905	92.5	6.3
150	Inf	980	100.0	7.5

Table 4

Panning Tests

	Wt	% Zn	% Fe	% Total Zn	% Total Fe
Whole Feed					
Concentrates	53	16.7	12.7	29.5	30.5
Tailings	394	5.3	3.8	70.5	69.5
Screens Feed					
On 80 Conc	10.5	15.6	10.0	22.9	23.3
Tails	157.0	3.6	2.2	77.1	76.7
On 150 Conc	22	20.0	12.8	26.0	26.8
Tails	285	4.4	2.7	74.0	73.2
Thru 150 Conc	74	11.5	11.9	45.5	47.5
Tails	220	6.8	4.4	54.5	52.5

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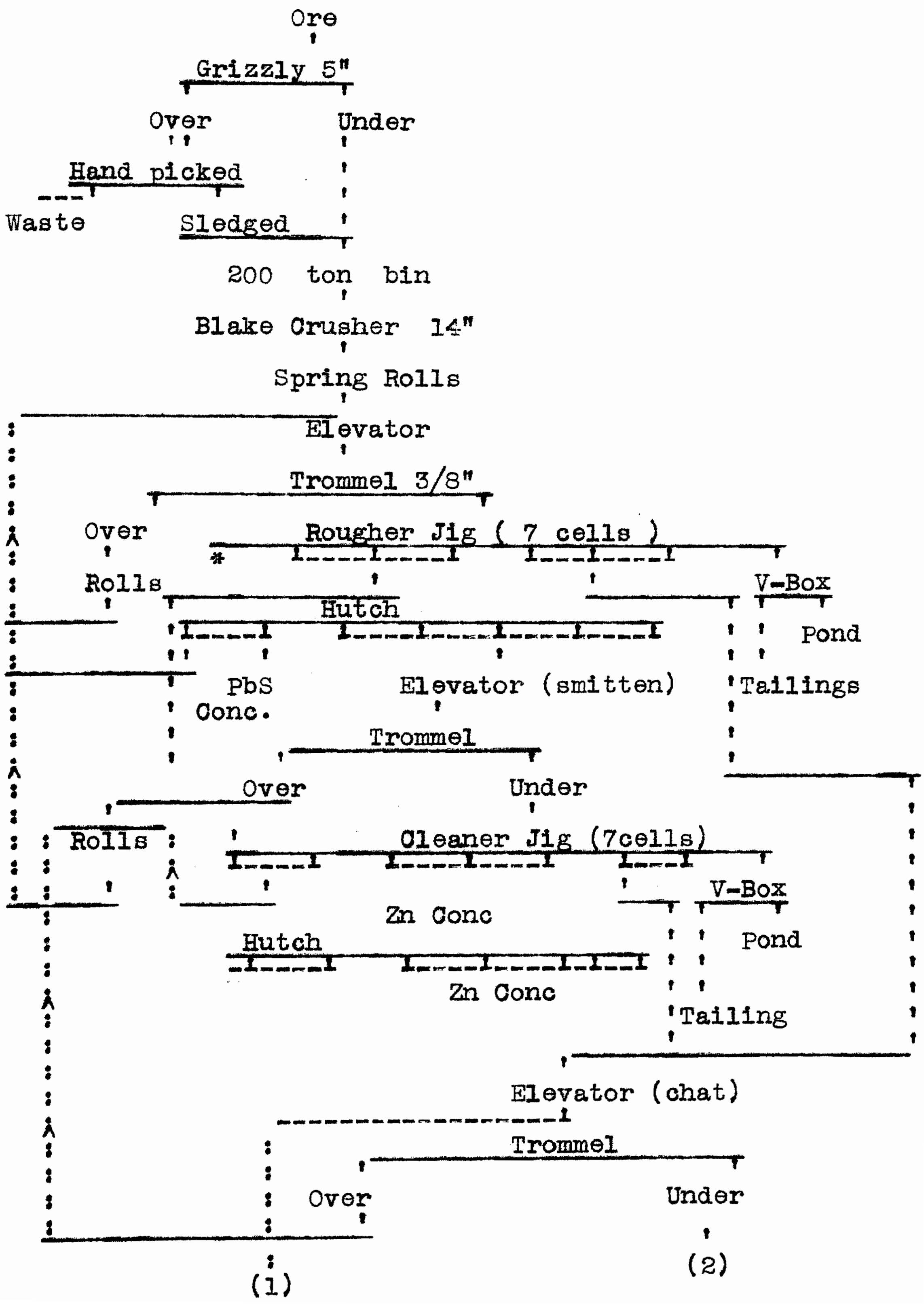
Ore
Grizzly 5"
Over
Under
Hand picked
Waste
Sledged
200 ton bin
Blake Crusher 14"
Spring Rolls
Elevator
Trommel 3/8"
Over
Rougher Jig (7 cells)
*
Rolls
V-Box
Hutch
Pond
PbS
Conc.
Elevator (smitten)
Tailings
Trommel
Over
Under
Rolls
Cleaner Jig (7cells)
V-Box
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Hutch
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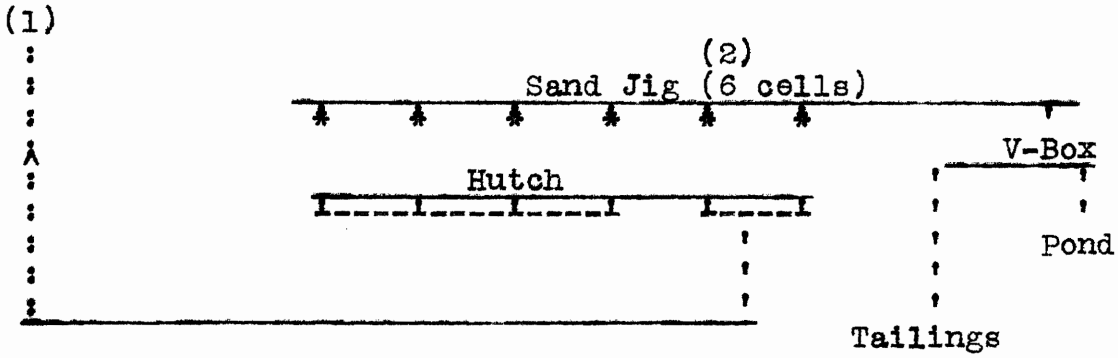

* Not used