crushed to minus 1/2". This size is controlled by screens at both ends of the stamp mortar. Copper larger than 1/2" is taken out of the stamp mortar through a Krause Hydraulic. This is a port in the mortar that allows almost pure copper to settle out against a stream of high pressure water. Fines are re-circulated through the stamp mortar to reduce the amount of water required and to thicken the fines sufficiently for flotation.

In the steam stamp circuits a very large amount of water is used, somewhat on the order of seven to eight tons of water to one ton of ore. A Mill pump with a 1000 H.P. motor pumps about 17 million gallons of water per 24 hours and furnishes the necessary water requirement for milling. The steam stamps are operated at 170 PSI and the final exhaust steam is run through a low pressure turbine to generate electric power. The conglomerate ore contains practically no mass copper and since it now comprises the major part of the mill feed, it was possible to automate the steam stamps portion of the mill that treats conglomerate ore.

The minus 1/2" discharge from the stamps goes to 3/16 inch trommel screens where the fines are separated. The plus 3/16 inch product goes to oversize jigs for removal of liberated copper. Oversize jig taillings are reground in rigid rolls which are in closed circuit with the 3/16 inch trommels. The undersize from the trommels goes to a classifier where the minus 35 mesh fines are separated. Half of these fines (overflow portion) are re-circulated to the stamp mortar. The other half (underflow) go either to flotation or ball mill classifier density regulation as required. The oversize from the classifier passes over a set of (undersize) Woodbury Jigs for removal of the liberated copper, and the tailings are discharged to a dewatering wheel, hence to a ball mill and classifier in closed circuit.

When treating conglomerate ore, the (oversize) jig dewatered tails are discharged by gravity to an eight foot by 32 inch ball mill, instead of to rolls, and are then returned to the rough section for classification by the rough classifiers. All of the jig hutch products are upgraded in a Finisher Jig. The tails are dewatered and ground in the 8' x 72" Ball Mill circuit. In the 8' x 72" ball mill circuit, the ore is ground to a minus 35 mesh in closed circuit with a mechanical classifier, or cyclone. Both rakes, cyclone and spiral classifier are used. A launder hydraulic in the ball mill circuit separates a coarse and heavy fraction of the circulating load which is run over a Wilfly Table to remove the liberated copper. When processing conglomerate ores, a 24" x 36" mineral jig is used in addition to the table to process the entire circulating load. The minus 35 mesh classifier overflow goes to nine cell flotation. Reagents used are sodium isopropyl xanthate, No. 2 fuel oil, and Dowfroth 250 or equivalent. Tailings range from 0.8 pounds to 3.5 pounds per ton depending on the ore being processed. Tailings from the conglomerate ores using the same grind are generally higher. Tailings from flotation go to a 16-inch pump and discharges into Torch Lake. The flotation concentrates are pumped to an Esperanza type drag classifier which feeds the coarser material to a filter. The overflow from the Esperanza is fed to a nine cell flotation machine for upgrading. This flotation machine also treats thickened fines from various overflows of the entire Mill. The concentrates from this machine are pumped to a 30 foot diameter thickener with the underflow pumped to the concentrate filter. The overflow goes to waste.

Because of the difficulty in sampling the ore to determine grade, it is necessary to segregate the ores and calculate the head sample from the concentrates and tailings. All concentrates except the flotation concentrates are kept separate and are weighed and assayed separately. Flotation copper attributable to a certain Mine is determined by feed and tail assays.

Copper concentrates shipped to the Smelter are as follows:

Mass Copper - Large masses separated at the Mines. Copper content determined by specific gravity.

Heading - Assayed periodically and an average assay applied to all heading. Assay range from 94% to 96% copper.

Rich - Jig concentrates. Each shipment sampled and monthly composite fire assayed for each mine.

Poor - Hydraulic table concentrate and finishing jig concentrates are combined. Each shipment is sampled and monthly composite determined by fire assay for each Mine.

Flotation Concentrates - Each carload is assayed.

Recoveries range from 85% to 95% depending on the type of ore being treated.

Revised 9/20/68
J. W. Keck

9/24/68
JWK/ag

MS-002
Box 139
Folder 25

L. F. Engle

December 21, 1966

Ash Pump at Ahmeek Mill

On December 19 we discussed the possibility of bringing all effluent streams at the Ahmeek Mill to one point of discharge from which an accurate sample can be taken for copper analysis and density, and where the volume of pulp leaving the mill could be measured with reasonable accuracy. One difficulty with collecting a good sample on a regular interval basis from material leaving via the ash pump in the basement of the mill has been the presence of ashes from the boiler house in the effluent stream a good portion of the time.

In investigating why the boiler house ashes are pumped first to the mill ash pump and then pumped into the lake, no valid reason has been uncovered. This is just a hangover practice from when the tailings, etc. had to be pumped a considerable distance out on the tailing bank. Since this area has all now been dredged out, there seems no reason why the ashes from the boiler house cannot be pumped directly from the boiler house to the lake, or to a pile behind the boiler house from where they can be taken for use as fill by people desiring this material. If a pile were made on land, the water could be made to drain into the Hungarian creek or to the lake.

The ashes are pumped through a six-inch cast iron line through the mill, under the floor, and frequent choke-ups are experienced which have to be cleared by mill maintenance personnel. Apparently all maintenance costs on this line and on the ash pump are charged to the mill.

We have asked the Engineering Department to investigate the possibility of discharging these ashes by a different means, with the thought in mind that with a likely arrangement for collecting mill spills, etc., a few further changes can be made whereby the ash pump could be shut down or eliminated, with a considerable saving in power and maintenance costs, and all mill effluents would be discharged through one line from which acceptable sampling could be done.

It is my understanding that R&D has terminal responsibility for sampling process design based on B. C. Peterson's instructions to you last week. Suggestions for one or more schemes of centralizing the discharges and taking samples from the mill will be presented as soon as the investigation is complete.

L. C. Klein

LCK/wmh
cc: BCP
JA
TWK
JK
RW
RWK
✓RS

Preliminary Investigation

Ahmeek Mill Boiler House

Proposed Ash Handling Equipment Vs Present Hydraulic System

February 23, 1967

To: T.W. Knight

A recent request concerning the disposal of the Ahmeek Boiler House ashes, employing other methods than now used, are indicated as follows with relative cost:

Scheme I - Flush System direct to lake.

Ash disposition by 8" C.I. pipe directly to the lake involves 1200 feet of 8" C.I. pipe crossing under 3 railroad tracks, with 3 points of jetting along the line.

Total cost of material and labor.... $17,100

Scheme II - Belt Conveyor System - horizontal and inclined.

(a.) Belt conveyor, 100 feet horizontal X 16" wide, including excavation for belt, construction of concrete conveyor trench, and installation of conveyor, including complete drive. Cost of this conveyor, $6,700.

(b.) Belt conveyor, 36' wide X 16" wide, inclined at 20° to outside storage pile.
Cost includes material and labor, drive, and housing as shown by Sketch Scheme II attached.
Cost of this conveyor, $4,610.

Cost for Scheme II above a and b.... $11,310

Scheme III - Belt Conveyor plus Elevator.

(a.) 100 feet of 16" width horizontal belt conveyor. Same as Scheme II a. above, $6,700.

(b.) Suitable 50 feet center-center belt bucket elevator, material and labor, $7,700.

Total cost Scheme III above a and b... $14,400

Comments:

(a) If it is desirable to change from the present ash disposal system, Scheme I,appears to be the most suitable of the three systems indicated above. Only an extention of the present pipe line system would be required.

(b) Scheme III appears to be the second best, affording more storage. However, stacking of ashes may result in undesirable dust problems when strong winds prevail. It is to be noted that Scheme III ash storage pile would have a storage capacity for 45 days. Higher maintenance cost should not be overlooked for Schemes II and III.

(c) In reviewing a report to L.F. Engle by L.C. Klein, (attached) dated December 21, 1966, it is to be noted that the existing Ahmeek Boiler House ashes are pumped to the Ahmeek Mill and then pumped to the lake---actually the ashes are flushed from the Ahmeek Boiler House by high pressure water and are pumped out by the Mill 10" ash and tailing pump. This method appears to be the best and most common practice for ash disposal. Tests made during October, 1966, disclosed that the 10" ash pump solids averaged 1.20% solids with an average tonnage of 335 tons per 24 hours. This included 7 to 10 tons of ashes per 24 hours or about 2 to 3% ash. The ashes are discharged once on each shift for about 1 to 1 1/2 hour duration.

Since automatic sampling and instrumentation shown by drawing No. 12702 indicates a good possibility of measuring density, flow and tailing tonnage, it is apparent that if the ashes were allowed to be included, it would not be too detremental. Also, if the ashes were not wanted in the sampling circuit, the sampler could be shut off during ash disposal periods. Since this is a Research and Development terminal responsibility, and in view of the fact that several other testing problems to include changes and tests required for diversion and treatment of elevator shovel wheel overflows, as well as possible diversion of slime thickeners overflows and pending the requirement of several tests; more time is required to finalize a more definite conclusion.

We are attaching the following sketches and drawings for your study of this problem.

1. Proposed ash handling arrangement - Scheme II.
2. Proposed ash handling arrangement - Scheme III.
3. Existing overflow diagram No. 17331.
4. Automatic sampling and instrumentation arrangement, drawing No. 12702.

John J. Vitton
Industrial Engineering Dept.

Approved:

R.L. Ellison
Industrial Engineering Manager

JJV:11

cc: LE
LK,
JA,
JK,
KE,

Attachments (5)

L. F. Engle

December 21, 1966

Ash Pump at Ahmeek Mill

On December 19 we discussed the possibility of bringing all effluent streams at the Ahmeek Mill to one point of discharge from which an accurate sample can be taken for copper analysis and density, and where the volume of pulp leaving the mill could be measured with reasonable accuracy. One difficulty with collecting a good sample on a regular interval basis from material leaving via the ash pump in the basement of the mill has been the presence of ashes from the boiler house in the effluent stream a good portion of the time.

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We have asked the Engineering Department to investigate the possibility of discharging these ashes by a different means, with the thought in mind that with a likely arrangement for collecting mill spills, etc., a few further changes can be made whereby the ash pump could be shut down or eliminated, with a considerable saving in power and maintenance costs, and all mill effluents would be discharged through one line from which acceptable sampling could be done.

It is my understanding that R&D has terminal responsibility for sampling process design based on B. C. Peterson's instructions to you last week. Suggestions for one or more schemes of centralizing the discharges and taking samples from the mill will be presented as soon as the investigation is complete.

L. C. Klein

LCK/wmh
cc: ✓BCP
JA
TWK
JK
RW
RWK
RE

Calumet & Hecla

CALUMET
DIVISION
CALUMET, MICHIGAN 49913

For Inter-Office Correspondence Only B. C. PETERSON

April 17, 1967

cc: RJW, RWK, JA, TWK, JK, LCK, Engr. Dept., Ind. Engr. Dept., #1913, Reading #1

To Mr.

Subject: Ahmeek Mill Sampling and Effluent Handling

Form 022010

Some time ago, you asked R & D to study sampling and effluent handling at the Ahmeek Mill. The results of that study, as reported in L. C. Klein's memo to me of April 14, 1967, are attached. There was some delay in presenting this information since, during the course of the investigation, Mr. Klein did feel that test work on cyclones of shovel-wheel overflows could contribute greatly to the overall design. I am pleased to report that this test work did show that cyclones will conservatively add some 200 to 300 lbs/day of copper to mill recovery.

Various units of the Engineering Division and the Mill operators have, of course, contributed a great deal to the work presented here. In my opinion, there is sufficient information and justification for you to authorize the proper paper work from the Divisions concerned to implement the recommendations.

We are well aware of techniques of measuring mass flow from a mill of this sort. Use of nagnetic flow meter and density gauges is quite common for the job, and under certain situations, can perhaps be justified. Becoming more and more common also is the use of on-stream continuous chemical analysis instrumentation. We do feel, at this time, that the $20,000-30,000 expense for such devices is unjustifiable. We propose that the system attached be installed, and as further operating experience and needs are defined, we can re-evaluate the inclusion of sophisticated measurement devices.

Detailed equipment and design data pertinent to Mr. Klein's report are available at the Engineering Division, and are not attached here.

If there are any questions concerning the recommendations, we, of course, would be pleased to assist in clarification.

L. F. Engle

L. F. Engle

LFE/bv

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CALUMET, MICHIGAN 49913

For Inter-Office Correspondence Only

To Mr. L. F. ENGLE   Date April 14, 1967

Form 022010   SUBJECT Proposed System for the Sampling ~~and Disposal of Ahmeek Mill Taili~~

An investigation was made of the present method of disposing of tailings and other wastes from the Ahmeek Mill to determine a reliable method of automatically sampling and handling these waste streams. Presently, wastes from the mill leave the plant at three different points. Each of these streams contains wastes from different areas of the plant, so that even if a good sample of each stream were obtained, it would be difficult to pinpoint the source of abnormally high levels of copper in any one stream. Such samples would be practically worthless to the mill operators for the purpose of controlling the operation.

Wastes now leave the mill by way of the general tailings pump, the ash pump, or by a launder under the mill basement floor, by gravity (See attached drawing No. 17331-A). The general tailings pump handles the tailings from the eight primary flotation machines, and the overflows from the six slime thickeners. The capacity of this pump is overtaxed when more than six of the eight mill units are operating, and the pump sump overflows to the ash pump sump. This situation will be worse when two additional slime thickeners are activated to handle the additional amount of slime and water from the spill recovery system that will soon be in operation.

The ash pump disposes of ashes from the boiler house, the tailings from the slime flotation machine in the mill basement, spills from the basement of the mill, overflow from the general tailings pump sump, and at times, part of the shovel wheel overflows. Recently, the shovel wheel overflows have been diverted entirely to this pump for sampling purposes.

The gavity discharge launder normally handles the shovel wheel overflows and water overflowing from the mill constant head water tank.

Before attempting to set up a reliable sampling system, it is recommended that some re-routing of the effluent waste streams be made so that samples of these streams would be more valuable for the purpose of mill control, and so that these wastes be eliminated from the mill at only two points instead of three. All flotation tailings would be handled by the main tailings pump. All other "unprocessed" wastes would leave the plant by gravity through the basement floor launder. Automatic samplers would be installed to sample each stream in a conventional manner. A major change will be necessary in the general tailings discharge lines in order to install a sampler that will collect reliable samples. (See attached Drawing No. 17331-B).

3

A system is being installed in the mill to collect all spills. These will be returned to process entirely, except in very rare instances; such as a power failure or major spill when there is a possibility of some loss, but as a rule, this material will have no outlet from the plant.

The only materials leaving the plant will be flotation tailings and overflows from the thickeners and shovel-wheels. In the present flowsheet, the thickener overflows are combined with the primary flotation machine tailings and removed from the plant by the general tailings pump. These overflows represent over half of the total volume handled by the pump. The proposed scheme woul divert these overflows to the basement floor launder where they would flow out of the plant by gravity, relieving the load on the general tailings pump.

The tailings from the slime flotation machine in the mill basement which are now discharged from the mill by the ash pump would be pumped into the general tailings sump to be discharged with the primary flotation tailings. The reduced volume handled by the pump is more than sufficient to allow the pump to handle all possil flotation tailings from an eight stamp operation, with no overflow going to the ash pump.

Recent tests, using a cyclone to recover coarse material and enriched copper bearing fines from the shovel-wheel overflows have indicated that a substantial amount of copper bearing material can be recovered for reprocessing, and an essentially minus 200 mesh slime rejected. It is recommended that an additional cyclone be installed to process all of this material, and that the cyclone overflows be combined with the thickener overflows for sampling and discharging through the basement floor launder. It is conservatively estimated (based on test results) that from 200-300 lbs./day of copper can be recovered with this equipment.

The proposed system will have the following advantages in addition to those already mentioned: The ash pump will no longer need be operated except for the infrequent periods that ashes from the boiler house are being flushed. There will be a saving in power used to operate the main tailings pump because of the reduced load The "unprocessed wastes" will be deposited in an area away from the general tailings pile where the settled portion will probably be enriched in copper and would be accessible to the dredge for reprocessing at the Tamarack Reclamation plant at some future date

Following is a summary of what must be done to make the recommende changes in the Ahmeek Mill flowsheet and install adequate sampling stations:

1. The 16" general tailings pump discharges into a 22" pipe-line that goes directly to the tailings dump, approximately 300 feet east of the mill. It will be necessary to raise the pipe about three feet where it goes through the mill. This pipe would then terminate inside the mill at the east end and flow

4

into a short launder, on the end of which would be mounted an automatic sampler. The pulp would then discharge into a large box, from which two 22" pipes would take the tailings by gravity to the tailings dump. The 12" pipe from the ash pump would also discharge into the box that the tailings do. A second 22" pipe would replace the 12" pipe going to the tailings dump and this can be mounted along side the present 22" pipe on the same bents. A secondary sampler would be used to reduce the size of the sample collected by the primary sampler to a workable volume. Samples would be taken at ten minute intervals and analyzed for each shift. Equipment required for this includes two samplers, 300 feet of 22" pipe, launder, box, and supports. The estimated cost is $12,045.

2. To divert the tailings from the basement slime flotation machin to the general tailings pump sump will require a pump and motor installation and piping. A 4" pump and 10 hp motor are available. Total cost of installation is estimated at $440.

3. One 20" Krebs cyclone is now installed experimentally for processing shovel-wheel overflows. Two will be required to process the entire flow. These cyclones are currently available at the mill and could be used for possibly a year before they will be required for installation in the ball mill circuit. To reclaim the cyclone underflow product, a 2-1/2" pump with motor, a screen, and piping is required. Estimated cost, including new pump and motor will be about $1,540. Replacing the cyclones at a later date will cost approximately $3,400.

4. To combine the thickener overflows with the shovel-wheel overflows, install an automatic sampler and divert this flow to the basement floor launder will require an approximately 35 ft. extension of the floor launder, plus a catch box, and short launder with sampling station, and an automatic sampler. Estimated cost is $3,103.

Much of the work required on Item 1 can only be done when the mill is down. This work could presumably be done during the regular two weeks vacation shutdown. Work on the other three items could be mostly completed when the mill is operating, requiring, at the most, one day each to connect into the different systems when the mill is not operating.

Attached is a summary of labor and materials estimates for each of the items listed. Also attached are flow diagrams, 17331-A showing the present arrangement, tailings and overflow streams, and 17331-B showing the proposed arrangement with changes indicated by heavy lines.

L C Klein

LCK/bv L. C. Klein

5

COST ESTIMATES

	Labor	Materials	Total
Item 1. Raise 22" tailings pipe 3'. Procure and install launder, box, and sampler. New tailings pipe plant to tailings dump	$4,550.00	$6,400.00	
Contingencies	455.00	640.00	
	$5,005.00	$7,040.00	$12,045.00
Item 2. Pump and pipe to pump slime flotation tailings to main tailings sump. 4" pump and motor available.	200.00	200.00	
Contingencies	20.00	20.00	
	220.00	220.00	440.00
Item 3. Cyclone installation, including chip screen, pump and motor, and pipeline for returning recovered values for reprocessing. *	1,000.00	400.00	
Contingencies	100.00	40.00	
	1,100.00	440.00	1,540.00
Item 4. Slime thickener and shovel-wheel overflow sampling system, including sampler and relocation of outlet.	1,260.00	1,561.00	
Contingencies	126.00	156.00	
			3,103.00
Totals	$7,711.00	$9,417.00	$17,128.00

* No purchase of cyclones necessary for about one year. Cyclones awaiting installation in ball mill circuits can be used. Replacement cost approximately $3,400.00.

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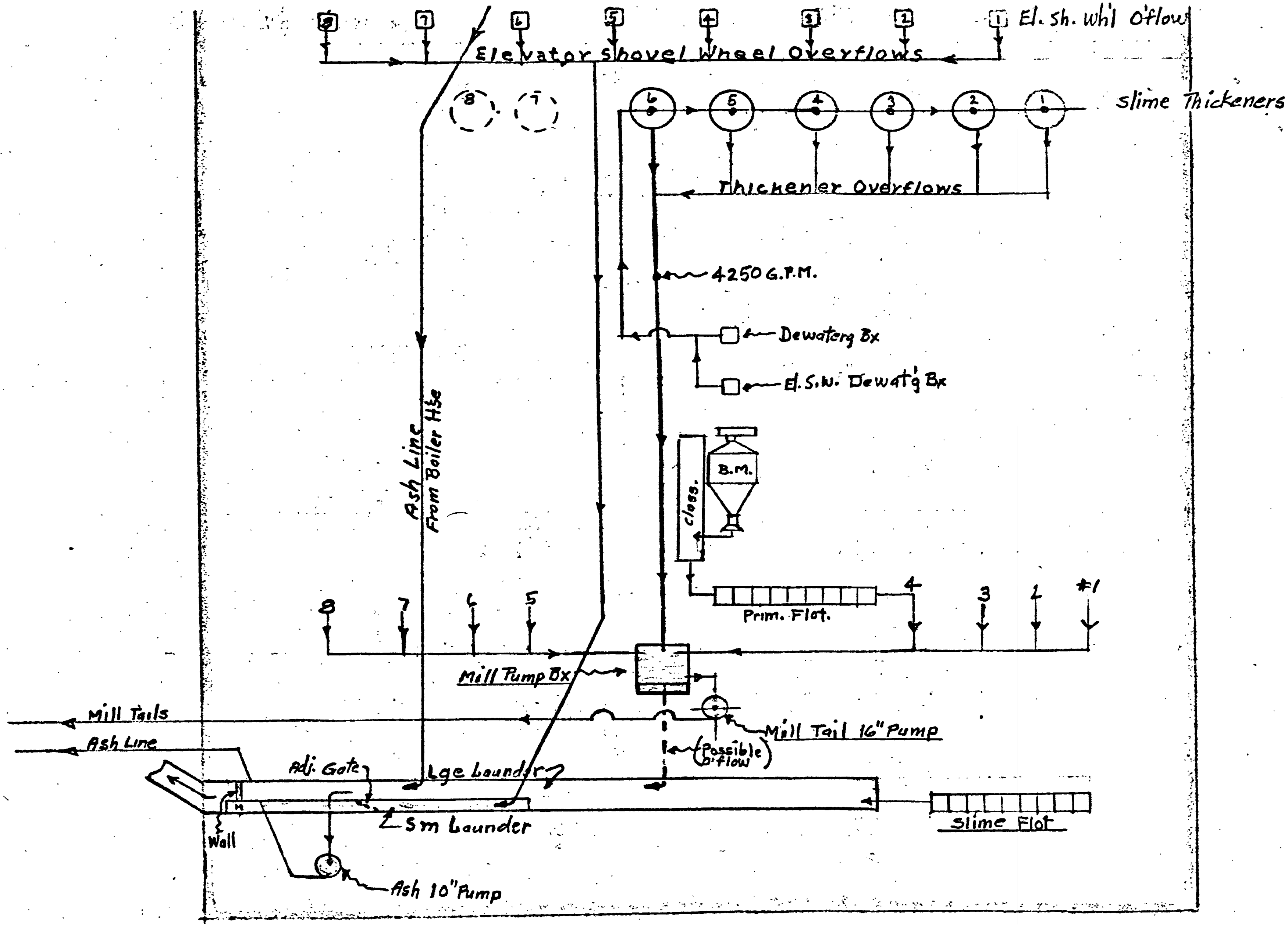
Folder 10



Calumet Division
Calumet & Hecla Inc

Ahmeek Mill

Exist'g O'flow Diagram

Date 2-8-67 By J.J.V. № 17331-A REV 4-12-67 EM

REF:
For Proposed Changes To Diagram see Dwg 17331-B Date 4-13-67

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Box 78
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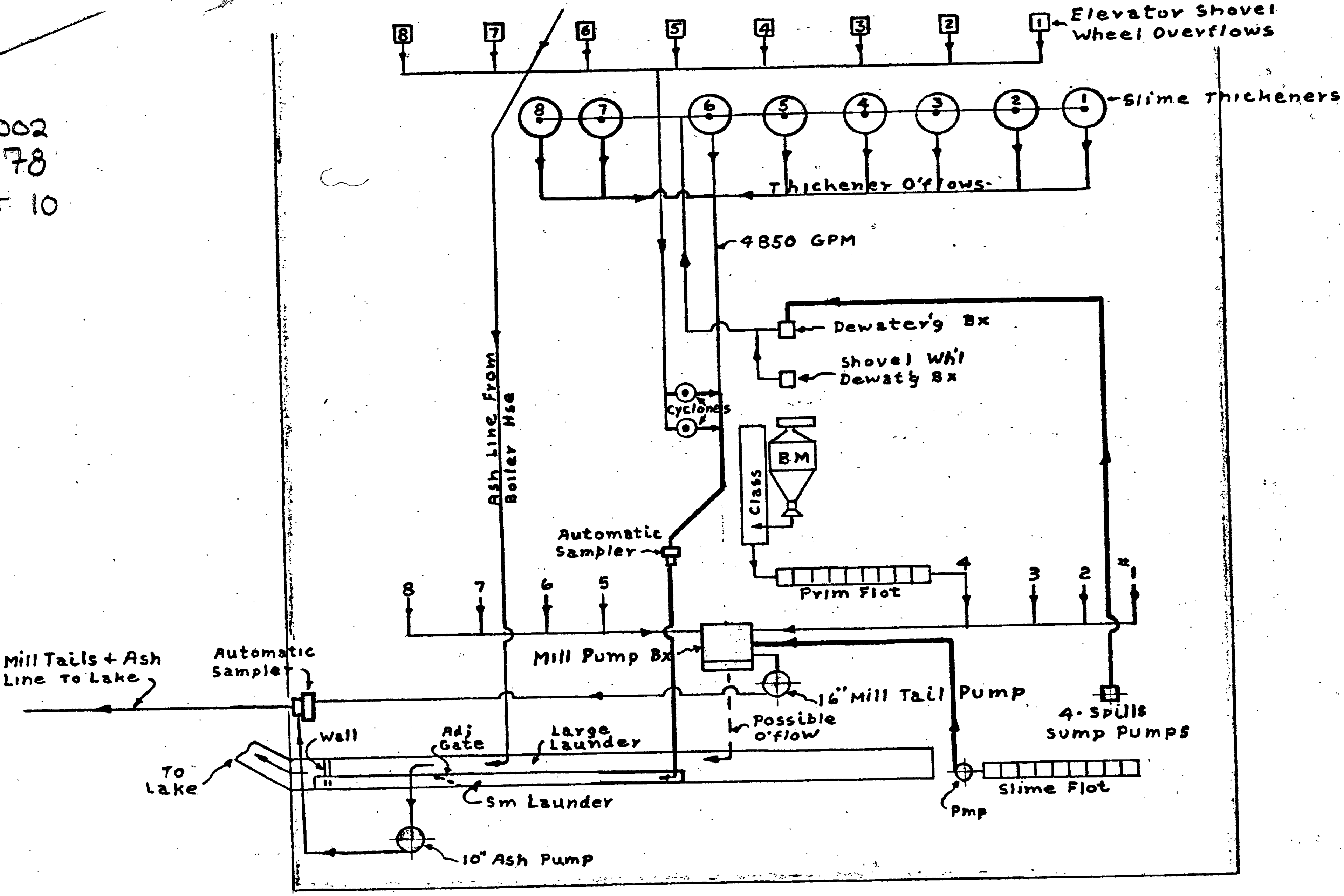

Calumet Division
Calumet & Hecla

Ahmeek Mill

Proposed O'flow Diagram

REF:
For Existg Diagram see Dwg 17331-A

Date 4-13-67 EM № 17331-B

MS-002
Box 151
Folder 27

Calumet & Hecla

CALUMET
DIVISION
CALUMET, MICHIGAN 49913

For Inter-Office Correspondence Only

April 17, 1967

To Mr. B. C. PETERSON

cc: RJW, RWK, JA, TWK, JK, LCK, Engr. Dept., Ind. Engr. Dept., #1913, Reading #1

Form 0220 10

SUBJECT: Ahmeek Mill Sampling and Effluent Handling

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L F Engle

L. F. Engle

LFE/bv

Calumet & Hecla

CALUMET
DIVISION
CALUMET, MICHIGAN 49913

For Inter-Office Correspondence Only

To Mr. L. F. ENGLE *Date* April 14, 1967

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into a short launder, on the end of which would be mounted an automatic sampler. The pulp would then discharge into a large box, from which two 22" pipes would take the tailings by gravity to the tailings dump. The 12" pipe from the ash pump would also discharge into the box that the tailings do. A second 22" pipe would replace the 12" pipe going to the tailings dump and this can be mounted along side the present 22" pipe on the same bents. A secondary sampler would be used to reduce the size of the sample collected by the primary sampler to a workable volume. Samples would be taken at ten minute intervals and analyzed for each shift. Equipment required for this includes two samplers, 300 feet of 22" pipe, launder, box, and supports. The estimated cost is $12,045.

2. To divert the tailings from the basement slime flotation machine to the general tailings pump sump will require a pump and motor installation and piping. A 4" pump and 10 hp motor are available. Total cost of installation is estimated at $440.

3. One 20" Krebs cyclone is now installed experimentally for processing shovel-wheel overflows. Two will be required to process the entire flow. These cyclones are currently available at the mill and could be used for possibly a year before they will be required for installation in the ball mill circuit. To reclaim the cyclone underflow product, a 2-1/2" pump with motor, a screen, and piping is required. Estimated cost, including new pump and motor will be about $1,540. Replacing the cyclones at a later date will cost approximately $3,400.

4. To combine the thickener overflows with the shovel-wheel overflows, install an automatic sampler and divert this flow to the basement floor launder will require an approximately 35 ft. extension of the floor launder, plus a catch box, and short launder with sampling station, and an automatic sampler. Estimated cost is $3,103.

Much of the work required on Item 1 can only be done when the mill is down. This work could presumably be done during the regular two weeks vacation shutdown. Work on the other three items could be mostly completed when the mill is operating, requiring, at the most, one day each to connect into the different systems when the mill is not operating.

Attached is a summary of labor and materials estimates for each of the items listed. Also attached are flow diagrams, 17331-A showing the present arrangement, tailings and overflow streams, and 17331-B showing the proposed arrangement with changes indicated by heavy lines.

L C Klein

LCK/bv L. C. Klein

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April 14, 1967

AR#3
Exp

COST ESTIMATES

	Labor	Materials	Total
Item 1. Raise 22" tailings pipe 3'. Procure and install launder, box, and sampler. New tailings pipe plant to tailings dump	$4,550.00	$6,400.00	
Contingencies	455.00	640.00	
	$5,005.00	$7,040.00	$12,045.00
Item 2. ~~Pump and~~ pipe to pump slime flotation tailings to main tailings sump. 4" pump and motor available.	200.00	200.00	
Contingencies	20.00	20.00	
	220.00	220.00	440.00
Item 3. Cyclone installation, including chip screen, pump and motor, and pipeline for returning recovered values for reprocessing. *	1,000.00	400.00	
Contingencies	100.00	40.00	
	1,100.00	440.00	1,540.00
Item 4. Slime thickener and shovel-wheel overflow sampling system, including sampler and relocation of outlet.	1,260.00	1,561.00	
Contingencies	126.00	156.00	
	1,386.00	1,717.00	3,103.00
Totals	$7,711.00	$9,417.00	$17,128.00

AR#1 CAP

AR#1 Cap.

AR#2 Cap

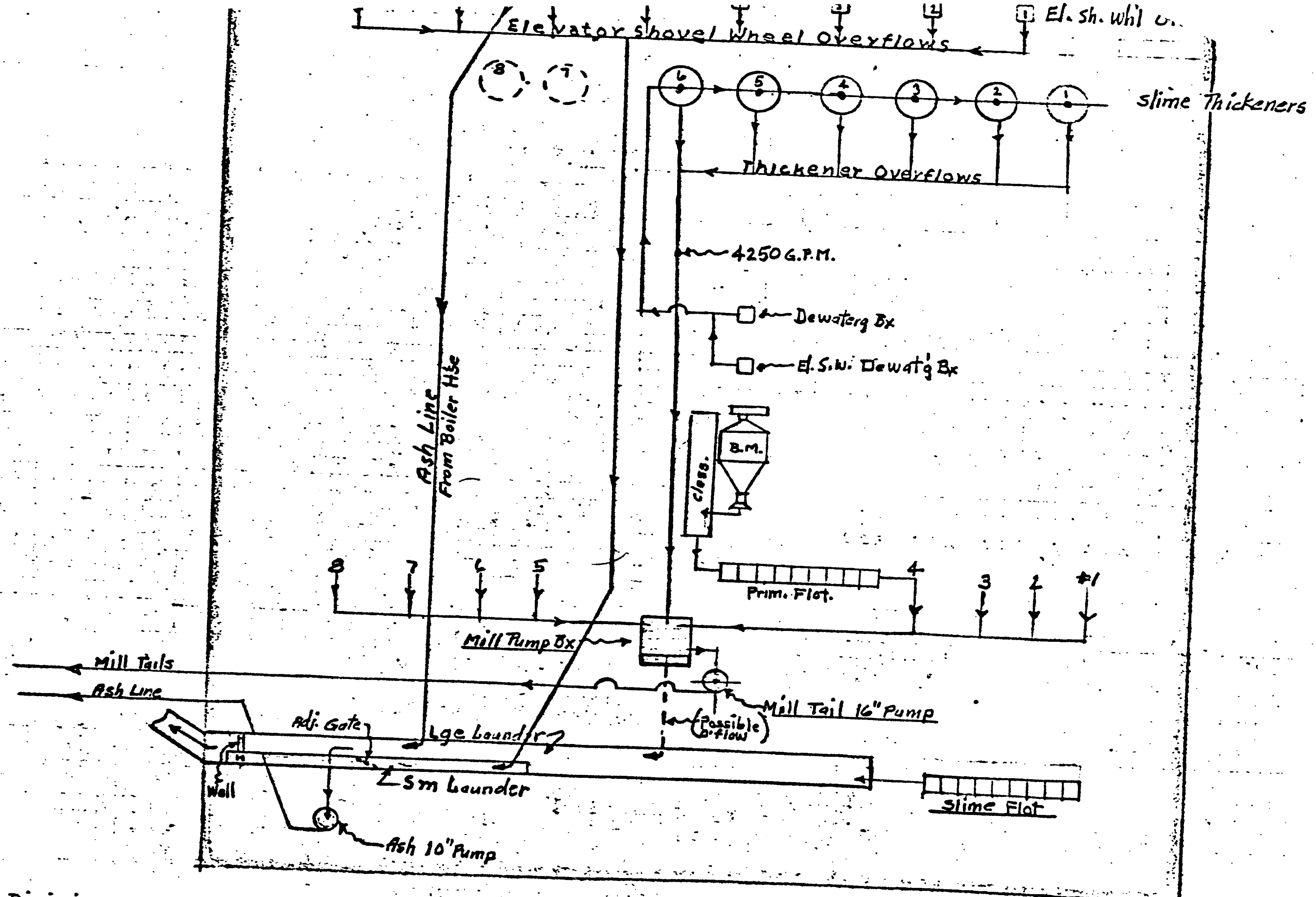
AR#2 CAP

* No purchase of cyclones necessary for about one year. Cyclones awaiting installation in ball mill circuits can be used. Replacement cost approximately $3,400.00

17,128.00
3,400.00
$20,528.00
12,377.00
8,151.00

AR#1 7,260.00
AR#2 5,117.00
12,377.00

Exp - AR#3 = $17,128 + $3,400.00 − (AR#1 + AR#2)



Calumet Division
Calumet & Hecla Inc

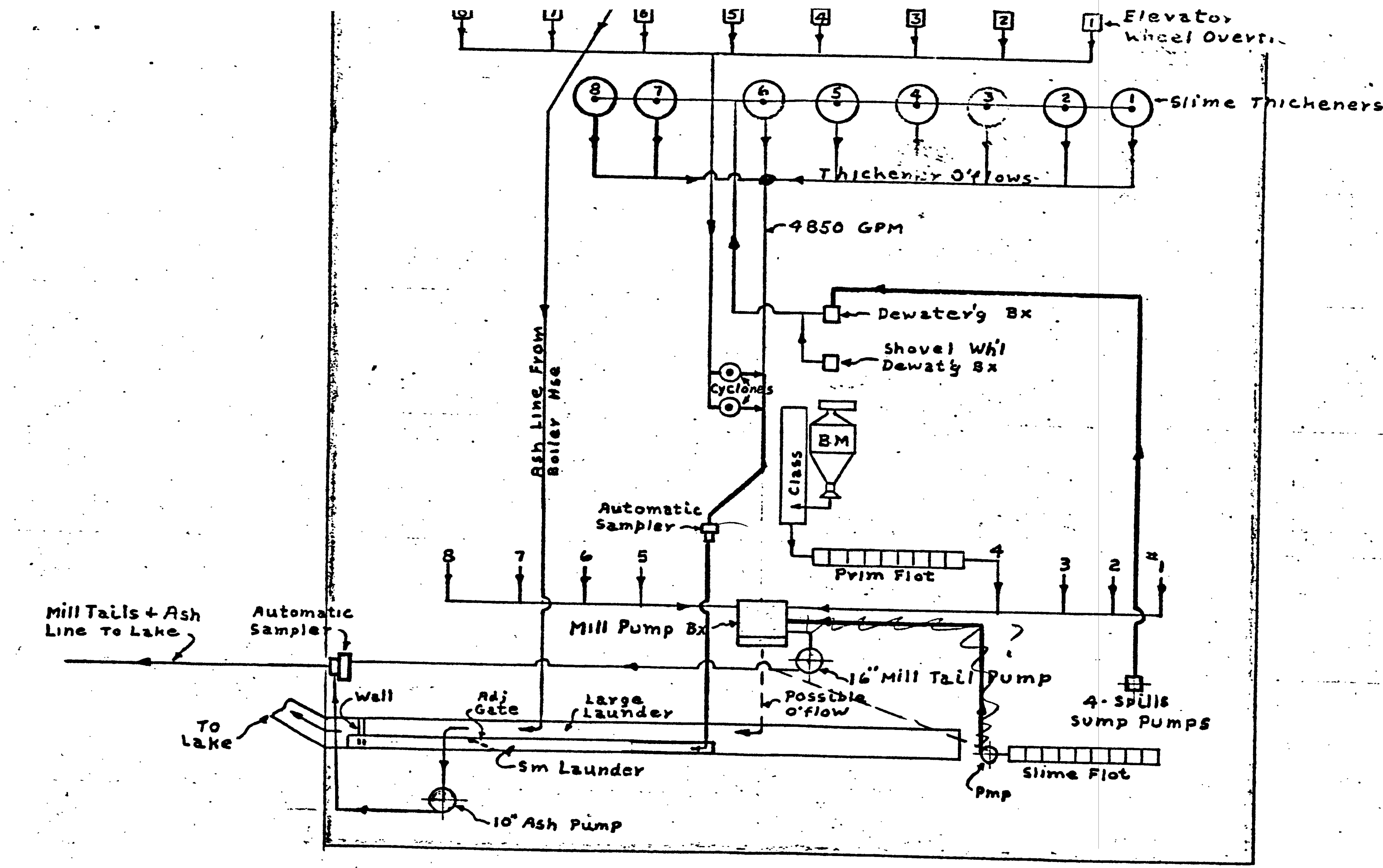
Ahmeek Mill

Exist'g O'flow Diagram

te 2-8-67 By J.J.V. No 17331-A REV 4-12-67 EM

REF:
For Proposed Changes To Diagram see Dwg 17331-B Date 4-13-67

6



Calumet Division
Calumet & Hecla
Ahmeek Mill
Proposed O'flow Diagram
ate 9-13-67 EM № 17331-B

REF:
For Existg Diagram see Dwg 17331-A

Tamarack Reclamation – Steam Main

STEAM LINE FROM AHMEEK MILL TO TAMARACK RECLAMATION

Length of Post Supports.
Number of Supports required.

Length given is from ground to center line of 8" steam pipe.

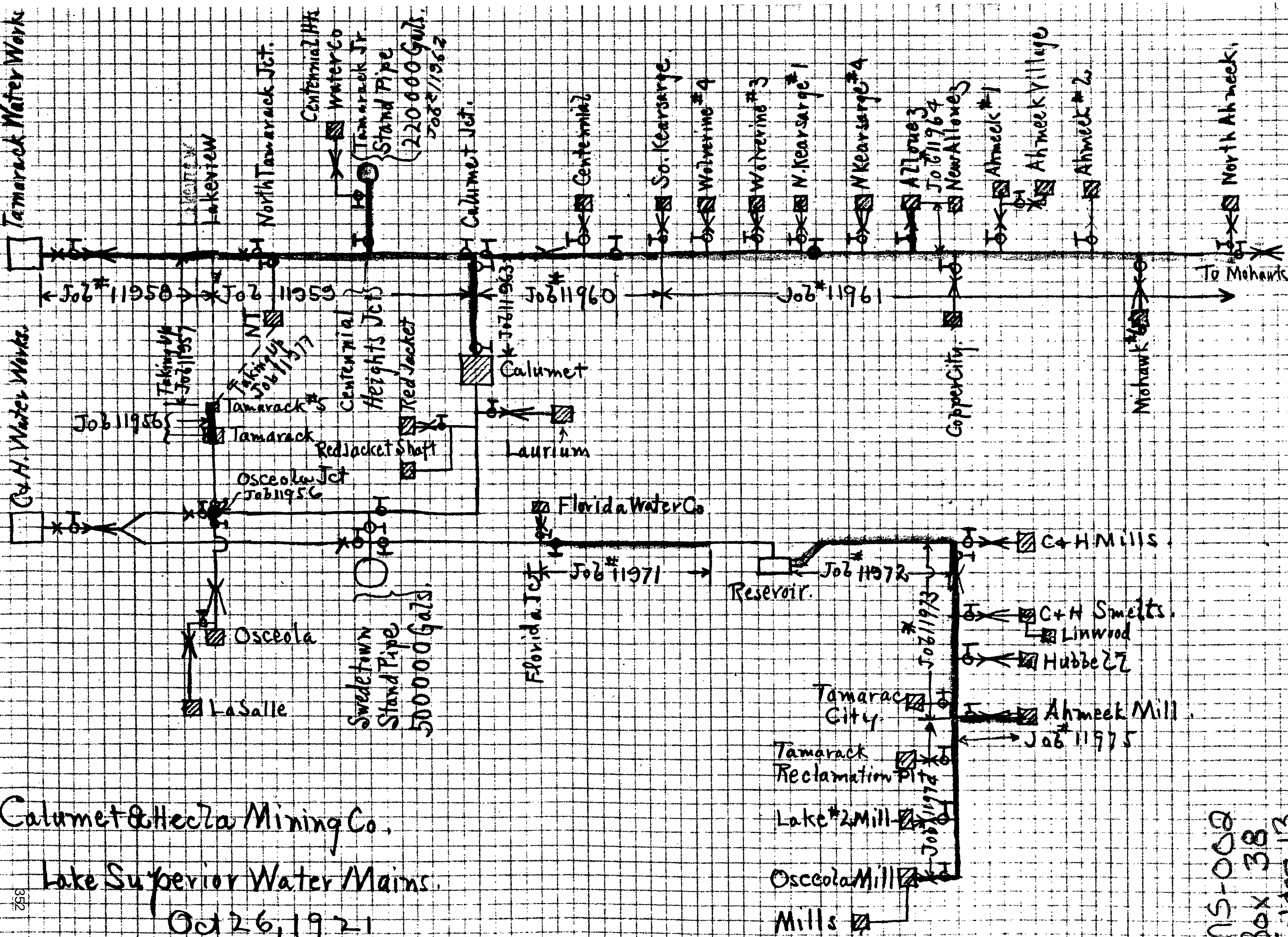
Post Number	Length	Post Number	Length	Post Number	Length
1	10½'	40	12½'	79	8'
2	10½	41	12	80	8
3	10½	42	12	81	8
4	3	43	11½	82	7½
5	3	44	11	83	7½
6	3	45	10½	84	7
7	3	46	10½	85	7
8	3	47	10	86	6½
9	3	48	3	87	6
10	3	49	3½	88	6
11	3½	50	3½	89	6
12	3½	51	4	90	6
13	4	52	4	91	6
14	4½	53	4	92	5½
15	4½	54	5	93	5½
16	4½	55	5	94	5½
17	5	56	5½	95	5½
18	4½	57	5½	96	5
19	4½	58	5½	97	5
20	4½	59	5	98	5
21	4	60	4½	99	5
22	3½	61	4½	100	5
23	3½	62	4	101	4½
24	3	63	4	102	4
25	3	64	4	103	4
26	2½	65	3½	104	7
27	2½	66	3½	105	7
28	2½	67	3½	106	7
29	2½	68	4½	107	7
30	2½	69	5½	108	7
31	3	70	6	109	7
32	3½	71	6	110	7
33	23½	72	6	111	7
34	24½	73	6	112	7
35	14½	74	6½	113	7
36	13½	75	6½	114	7½
37	13	76	7	115	7½
38	13	77	7	116	8
39	13	78	8		

Number of Posts	Length
16	3'
20	4
19	5
17	6
17	7
9	8
1	10
6	11
3	12
4	13
1	14
1	15
1	24
1	25
116	

No 1 nearest to Ahmeek Mill Boiler House

Req. #11744
Job #C-1297

TAMARACK RECLAMATION FACILITIES



Calumet & Hecla Mining Co.

Lake Superior Water Mains.

Oct 26, 1921

352

MS-002
Box 38
Folder 13

Six-cent Copper from Calumet & Hecla Tailings

Over 50,000,000 Tons of Sand, Accumulated During Half a Century, Being Treated by Tabling, Flotation, and Leaching

By C. H. Benedict
Metallurgist, Calumet & Hecla Consolidated Copper Co., Lake Linden, Mich.

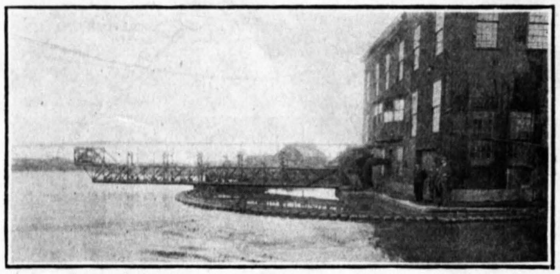
THE CALUMET & HECLA MINING CO. was organized in 1871 as a consolidation of four companies, two of minor importance, together with the Calumet Mining Co., formed in 1865, and the Hecla Mining Co., organized about a year later. Both these latter companies found profitable ground at once and began the erection of stamp mills. The Calumet Mining Co. first erected its mill at the mine, but in a few years moved to its present site on Torch Lake adjoining the site on which the Hecla Mining Co. had already built its original mill and which is about four miles from the mine. These mills have been in existence then, at the same site, for upward of fifty years and have been depositing their tailings continuously into Torch Lake during that period.

Torch Lake is one of a series of inland lakes in the Keweenaw peninsula of upper Michigan, but is distinguished by being on the same level as Lake Superior, with which it has navigable connection; and it is distinguished further by the fact that it is quite deep relative to its area. At the time the mills were erected on the shore of this lake there was no thought of anything except the desire to find room for the sand tailings, but considering the development of the mine and of the art of metallurgy in the fifty years following the foundation of the mills, no better site could have been found anywhere. The shore adjacent to the lake is relatively flat, so that all buildings are at approximately the same level, but the sloping hills running down toward the shore permit of a uniform grade to a gravity railroad, and a trestle of moderate length gives the necessary elevation for gravity run to the ore bins and stamps.

The mills were built close to the shore of Torch Lake, and for some years there was sufficient elevation so

Dredge and portion of pontoon line

that the tailings ran into the lake by gravity, but as the deposit increased in area the shore gradually receded and it was necessary to provide some means of giving the tailing sufficient elevation to reach the lake. For this purpose a device was developed unique in this country at that time, and even yet but few are in use outside of the Lake Superior copper district. This is



Shore plant, showing storage pool and swinging suction line

known as a sand wheel, a slowly revolving wheel with depressions or buckets in the periphery which take their load at the bottom and discharge tangentially on approaching the top. Starting with a 30-ft. wheel the diameter of successive wheels was increased to 40, then to 50, and finally to 65 ft., to reach the desired elevation.

Originally two mills were built, known as the Calumet mill and the Hecla mill, and there are two distinct tailing piles with their centers about three-quarters of a mile apart and with clear water between, the two almost inclosing a bay from which is drawn the water for the pumping station. These tailing piles covered an area of about 152 acres at one time and vary in depth from nothing at the shore line to 120 ft. The reclamation plants are erected centrally to the north of the Calumet pile, and it is this pile that is now being reclaimed. The Hecla bank was all of it conglomerate up to about 1900, but since that date the south or extreme end has been mostly amygdaloid tailings of much lower grade, and there will be a boundary line between the conglomerate and the amygdaloid, which, as dredged, will be a mixture of the two. When this mixed material is to be reclaimed it will result either in the inclusion of low-grade material which would not pay by itself to reclaim or in the exclusion of some conglomerate tailing which by itself would be profitable.

At the beginning of mining operations in the late 60's the ore was running better than 100 lb. to the ton by assay and the metallurgical methods were naturally crude compared to present-day standards. The ore increased in richness for some years after the opening of the mines, and tailing losses of 20 lb. to the ton and more were not out of the ordinary. In those years the smelters required a very high-grade product, and as the fine copper could not be concentrated profitably to smelter requirements, practically no effort was made to save the slimes until about 1884, when buddles or circular slime tables were introduced. Neither was any effort made, except spasmodically, to do any grinding other than that by the original stamp, which crushed all material to pass through a $\frac{3}{16}$-in. round opening screen. This made for very rich tailings, and it was not until

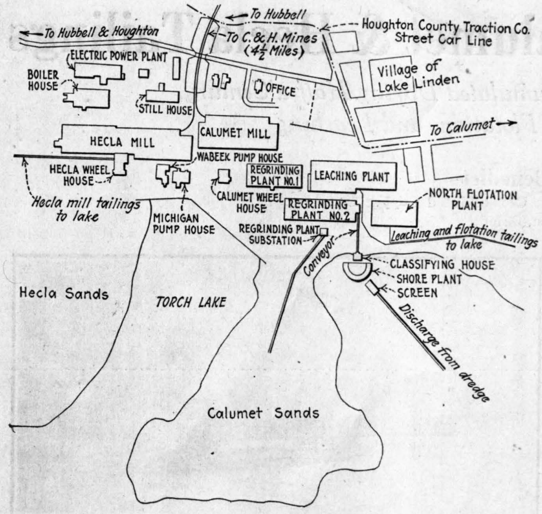


Fig. 1—Map of Calumet & Hecla units at Lake Linden

about 1898, with the introduction of Wilfley tables, soon followed by fine grinding in Chilean and later in Hardinge mills, that any serious attempt was made to reduce the losses of fine inclosed or attached copper. The introduction of this more modern machinery was coincident with a rapid falling off in the quality of the ore sent to the mill, owing partly to the lessening in grade of the deposit underground and partly to the fact that lower-grade ore could be treated economically. A further decided drop in the copper losses followed the installation of a regrinding plant in 1908 and made it appear that the tailings subsequent to that date might not be profitably reworked, although they still contained about 9 lb. of copper to the ton. These tailings were accordingly segregated on one portion of the Calumet pile. With the discovery of the leaching process in 1912 and the adaptation of flotation a few years later it became evident that these apparently worthless tailings were of economic value. In the year just passed the work was almost entirely on these later fine, low-grade tailings, and the curious fact is that while the recovery per ton was less, the cost per pound of copper recovered was as low as on the richer coarse tailings of previous operations. This is because the regrinding cost is entirely eliminated.

That these tailings had commercial possibilities was recognized for a great many years before any effort at recovery was begun. Until the development of modern fine-grinding machinery, coincident as it was in the Lake Superior district with the introduction of the low-pressure turbine and consequent cheap electric power, it was not felt that the time was right for beginning operations. Then, at first, the plans were only for finer grinding and Wilfley table treatment, and it was the expectation that the recovery might not exceed 40 per cent. Even this was attractive, and work was begun in 1912. The regrinding plant was not yet in operation, however, before the leaching process was developed, which promised to double the anticipated recovery. Construction work was started in 1914 on the leaching plant, designed to treat sand, and experimentation was continued on the treatment of the slime by the same process. The rapid development of flotation, however, and its adaptation at the Calumet & Hecla to native copper, made it advisable to discontinue work on the leaching of slime, and a flotation plant was erected for this material. This again increased the recovery, so that about 85 per cent of the values contained in these tailing piles will probably be obtained by the present process. Inasmuch as the recovery on the ore originally was about 75 per cent, over 95 per cent of the metal contents of the Calumet &

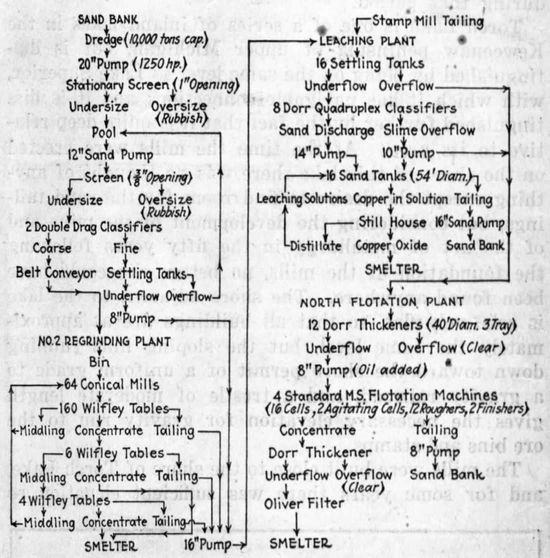
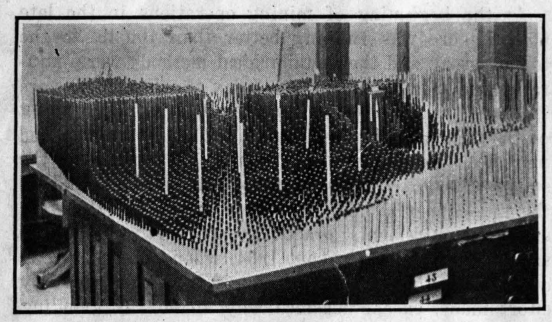


Fig. 2—Flow sheet of reclamation plant

Hecla conglomerate lode as mined will be obtained as refined copper, a record probably unique in the history of any copper-mining operation.

Although the commercial possibilities of these deposits had been recognized long before recovery plants were erected, their treatment was not sufficiently imminent to prevent surface contamination. All the rubbish of the stamp mills and from the adjacent towns was deposited on top of these sand banks, and although this rubbish does not constitute a large percentage of the total weight, it amounts to thousands of tons of every conceivable kind and size of material, and any plan for the reworking of the sand had to take into account a mixture of ashes, hoop iron, wire cable, launder plates, and submerged logs. After five years of operation the suction dredge originally chosen has been in commission without at any time having had serious difficulty in operation.



Model showing status of sands for reclamation plant. The white represents lake bottom, and the dark, reclaimable sands.

The reclamation plant as at present constituted consists of five units separately housed as follows:

1. Dredge.
2. Shore pumping plant and classifying house.
3. Regrinding plant.
4. Leaching and distillation plant.
5. Flotation plant.

Fig. 1 shows a diagram of the units of this plant in connection with the other mill buildings. Fig. 2 is a flow sheet.

1. *Dredge*—It was recognized at once that a suction dredge would be the only possible means of reclaiming these tailings, because of the depth of the deposit and the severity of the climate. It was not feasible to develop a dredge by experimentation on a small scale, because from the very nature of the problem large-scale operation only was possible. No dredge had ever been designed to dig 110 ft. below the water level. A bucket dredge was considered entirely unfit, because of the depth, and also because of the fact that although a bucket dredge might handle rubbish to good advantage, the sharp coarse sand would be very hard upon the innumerable bearings. Further, it was thought impossible to operate such a dredge in winter time in the Lake Superior district, with the thermometer frequently reaching 20 deg. below zero.

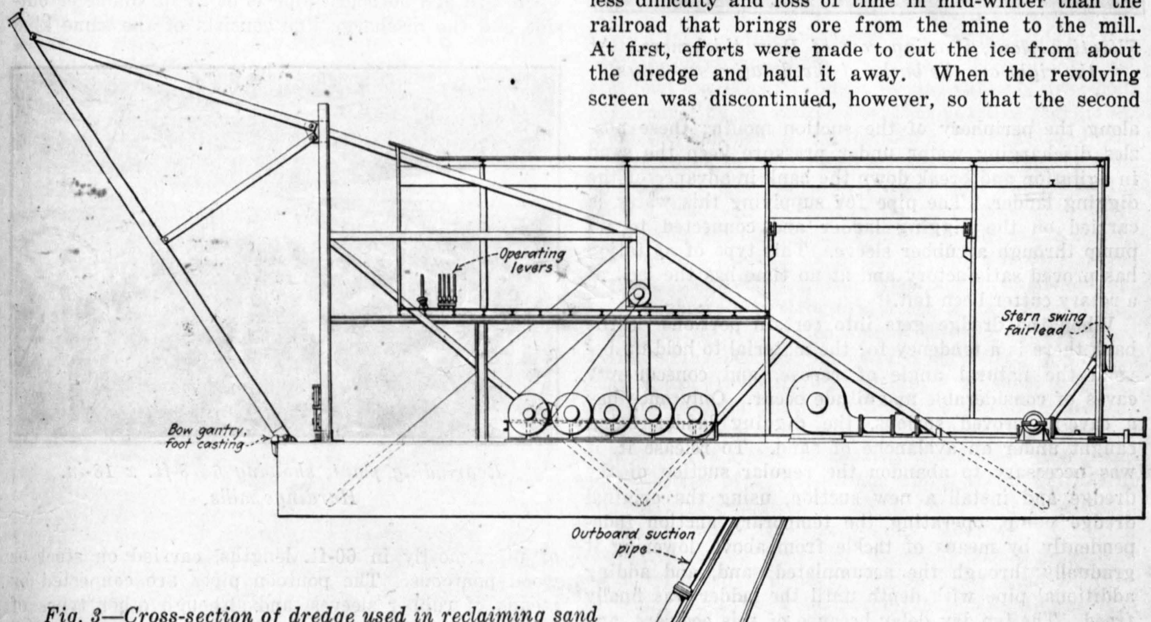


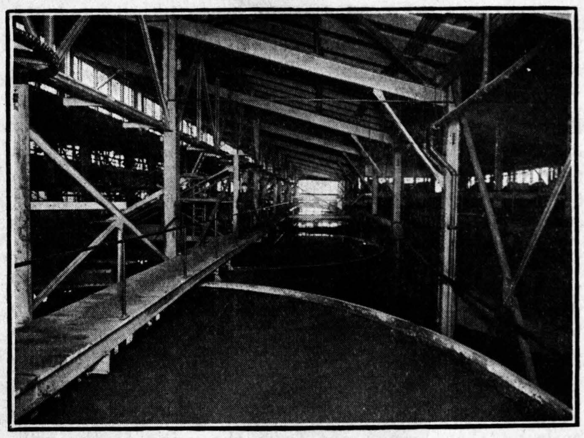
Fig. 3—Cross-section of dredge used in reclaiming sand

The dredge finally adopted was developed with the aid of the Bucyrus Company, of South Milwaukee. It is a steel-hull dredge 56 ft. wide and 110 ft. long, with an overhanging deck 8 ft. wide. As originally installed, having in mind the amount of oversize rubbish to be handled, the dredge was provided with two dredging pumps. The first discharged into a 1½-in. revolving screen for removing rubbish, the undersize going to a sump from which a second pump elevated the material and discharged it through the pontoon line.

After experiencing considerable trouble with the elimination of the oversize rubbish in this way, a method was finally devised of using but a single pump for dredging the sand directly from the pile and discharging it through the pontoon line to a stationary screen at the shore plant. This eliminated entirely the revolving screen on the dredge and the second dredge pump, and resulted in a tremendous saving of power and maintenance. It is surprising what large pieces of timber, rope, and even steel plate can be picked up by the pump and carried through 3,000 ft. of the 20-in. discharge pipe to the receiving pool on shore without choking pump or pipe.

In winter time 2 ft. of ice on the lake is usual, 20 deg. below zero is not uncommon, and usually for two to three weeks the temperature is continuously below zero. However, these conditions have caused no delay in the eight years of operation, and the dredge has less difficulty and loss of time in mid-winter than the railroad that brings ore from the mine to the mill. At first, efforts were made to cut the ice from about the dredge and haul it away. When the revolving screen was discontinued, however, so that the second dredging pump was not required, this pump was connected to a pipe surrounding the dredge and discharged water through a series of nozzles about 10 ft. above the deck of the dredge. The agitation from this water was sufficient to keep the ice from forming freely and also to melt such ice as had been formed adjacent to the dredge. For the last four years it has not been necessary to break or remove ice by other means, and the cost of operating this pump for a few hours each day is small.

Fig. 3 shows a cross-section of this dredge. The dredge pump itself has a 20-in. diameter inlet and outlet, with impellers 55 in. in diameter, operating at 360 r.p.m., and is equipped with a 1,250-hp. motor. The pump casing is split vertically and is lined throughout. Various types of material for liners have been used, and although the best results are obtained with manganese steel, chilled cast iron made in the local foundry is much the cheapest material per ton dredged. In addition to the main dredge pump, and an auxiliary pump for supplying water to prevent ice formation, there is a 4-in. centrifugal pump for service water and an 8-in. centrifugal pump for supplying water at 75-lb. pressure for agitating the sand. The dredge suction is supplied with nozzles reaching out in all directions



Flotation plant, showing row of Dorr thickeners. At the right are the backs of the flotation machines.

along the periphery of the suction mouth; these nozzles discharging water under pressure keep the sand in agitation and break down the bank in advance of the digging ladder. The pipe for supplying this water is carried on the digging ladder and connected to its pump through a rubber sleeve. This type of agitation has proved satisfactory and at no time has the lack of a rotary cutter been felt.

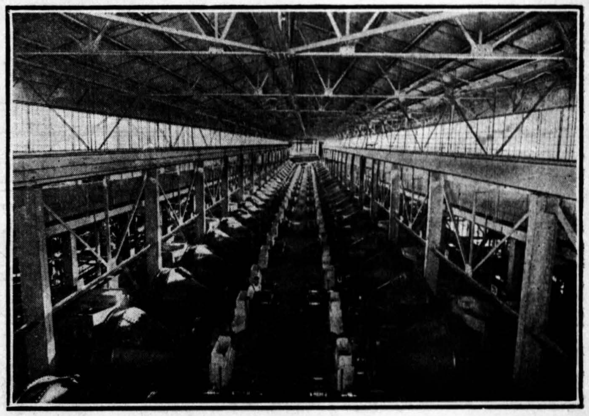
When the dredge gets into certain portions of the bank there is a tendency for the material to hold up beyond the natural angle of repose, and consequently caves of considerable magnitude occur. Only once has a cave-in proved serious, the digging ladder being caught under an avalanche of sand. To release it, it was necessary to abandon the regular suction of the dredge and install a new suction, using the original dredge pump, operating the temporary suction independently by means of tackle from above, lowering it gradually through the accumulated sand, and adding additional pipe with depth until the ladder was finally freed. The ten-day delay because of this accident, and a second shutdown of three weeks when the dredge was dry-docked and the hull scraped and painted, have been the only interruptions to continuous service during eight years of operation.

The suction ladder consists of two longitudinal latticed girders thoroughly fastened and well braced. It is 141 ft. from center of suspension to the end of suction, and will permit of dredging to a depth of 110 ft. It carries the outboard suction of lap-welded pipe and also an 8-in. water pipe for supplying water under pressure for breaking down the sand. The center of the dredge pump is on the same center line as the pivot of the suction ladder, and the suction pipe is connected to the pump by an elbow, swiveled on this same center line. Near the outer end of the suction ladder the lower block of the hoisting tackle is attached, and the upper block is attached to the bow gantry, forming part of the hull.

The dredge is not self-propelling, but is operated by swinging lines fastened to anchors in the water and deadmen along the shore. There are two four-drum winches for operating the lines, two drums of which are for the ladder swing, two for the bow-line swing, two for the stern-line swing, one for the stern line, and one for hoisting the suction ladder. The bow swing lines are $\frac{3}{4}$ in. diameter, the ladder and stern lines are $\frac{7}{8}$ in. and the ladder hoist rope is 1 in. diameter, all plow steel. All pumps and winches are electrically driven, but there is a small boiler on the dredge to provide steam for heat and also for operating capstans when the electric power is cut off.

Electricity is supplied to the dredge at 2,300 volts, the power lines being supported on towers attached to the pontoons carrying the discharge pipes. The main dredging pump motor is 1,250 hp. rating and consumes about 900 kw. when working through its maximum discharge pipe of 3,000 ft. length. An additional 200 kw. is consumed by the 8-in. and 4-in. water pumps. Water rheostats control the speed of the pump with a variation of about thirty revolutions, from a minimum of 335 r.p.m.

Inboard and outboard pipe is of 21 in. diameter outside and the discharge line consists of the same kind of pipe, mostly in 60-ft. lengths, carried on steel or wood pontoons. The pontoon pipes are connected by means of rubber sleeves, and although other types of flexible connections have been tried, especially ball joints, everything has been abandoned in favor of the rubber sleeve. The sleeves are held on by split steel bands, which arrangement, in connection with the beaded ends of the pipe, gives a simple flexible joint, and one that does not cause much trouble.



Regrinding plant, showing 64 8-ft. x 18-in. Hardinge mills

The pontoon line discharges at a fixed point on the shore into a stationary screen 16x20 ft., with round openings 1 in. in diameter. This discharge is placed so that the sand runs from the screen into a pond or reservoir which supplies the pumps in the shore plant about to be described. Not much rubbish accumulates on the screen, but it may consist of large pieces, including many relics of the early days. A chain 6 ft. long was once removed from the screen; also pieces of cast iron, innumerable rocks, and logs up to 16 in. in diameter.

The dredge has a rated capacity of 10,000 cu.yd. per day, which has been realized. No facilities have ever been at hand to make a definite test of its efficiency, and there is so much variation in the size and nature of the sand to be pumped, the length of discharge line, the condition of the impeller and pump casings, and depth of suction, that a test would be of little value. In the winter about sixteen hours, including delays, are required to do the necessary work, and sometimes during the summer, when the pontoon line is 3,000 ft.

long and the sand is fine and scattered, continuous operation is necessary.

No effort is made to synchronize the operation of the dredge with the plants on shore, which must run uniformly twenty-four hours per day. The capacity of the reservoir in front of the shore plant is such that the dredge can shut down two or three days at a time without the plants being short of sand. A dredge is necessarily intermittent in its operation, even when working under the best of conditions, and under the varying conditions met in this operation there is no possibility of supplying sand in either uniform quantity or dilution.

The general method of operating the deposit and the measurement and control of the work is carefully studied from day to day. Fortunately the United States Government had made accurate soundings in Torch Lake before the mills were operating for any length of time, so that the extent of the deposit both laterally and in depth is accurately known. A sectional model (shown in the illustration) has been made, consisting of vertical wooden pegs fastened into a horizontal board representing a base line. These pegs indicate conditions for each 50-ft. station and by means of different colors show lake bottom, lake level, and recoverable sand. Frequent soundings keep this model up to date, and operators on the dredge know at all times at what depth to expect sand and to what extent. Ranges along the shore and floating buoys assure accurate knowledge as to the position of the dredge, and a section of the model in the pilot house provides complete information as to conditions of deposit. The original lake bottom is fortunately a compact sand that resists dredging with this type of machine, and much of the area is as clear of tailing after dredging as a surface operation could be. In addition to this model, which is changed to show existing conditions, there is a cross-section for every 100 ft. which shows the progress from month to month.

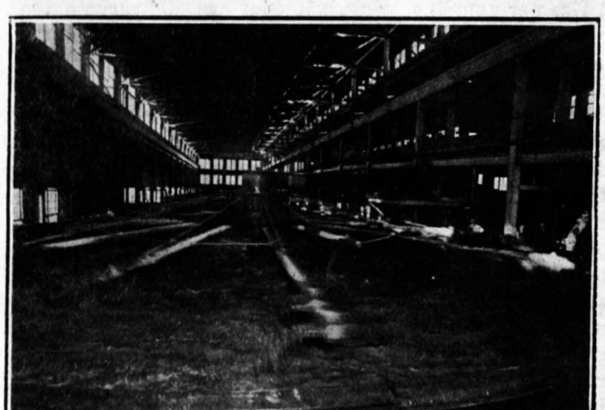
Row of tanks in leaching plant. First tank has launder and distributor in place. Second tank is uncovered. Others have covers in place.

A problem at first was to find room for current tailing. For this reason the outer and more recent deposit has been dredged up to this time. In winter when the climatic conditions are at their worst the dredge is moved close to shore to shorten up the pontoon line and minimize operating difficulties; in summer more distant material is attacked. The operation is from its nature a "one-stope mine," but the quality of the sand does not vary greatly from day to day, although the proportion of coarse to fine does show a wide fluctuation. This results in operating difficulties felt more particularly in the flotation plant.

The cost of this operation for 1923, including all replacements and renewals, was 6.30c. per ton dredged. This is made up roughly of 32 per cent for labor, 14 per cent for pump renewals, 40 per cent for power, and 14 per cent for other supplies. These costs are for an average discharge line of about 2,000 ft., and vary somewhat with the size of sand, length of line, and other factors. The costs are showing a downward tendency from year to year as capacity is being increased and as greater experience is being acquired.

2. *Shore Pump Plant and Classifying House*—This plant is built upon a concrete dock constructed by driving piles through the sand down into the original lake bottom and upon these piles putting a cap of concrete 3 ft. 6 in. thick. The shore plant contains a 12-in. Morris centrifugal pump for the elevation of the sand, stationary screens for removing fine rubbish, drag-belts for separating the coarse sand that requires regrinding, from the fine, pumps for handling this fine sand, and a belt conveyor for conveying the coarser sand from this plant to the top of the regrinding plant. In the pond or reservoir in front of the shore plant into which the dredge sand is discharged is a semicircular row of piles having a radius of 35 ft. on which is constructed a track. Supported on this track and pivoted in front of the plant is a structural steel bridge 55 ft. long, which carries the suction pipe of the pump in the shore plant. This suction pipe works on swivel joints, so that it can travel through an angle of about 150 deg. and its outer or suction end can be raised or lowered vertically through an angle of 90 deg. The effect of this is to get a storage capacity for this suction pump in the shape of a "V" section along about one-half of the circumference of the 55-ft. circle and to a depth of 30 ft. below the water line. Thus is obtained a storage reservoir equivalent to about 20,000 tons' sand capacity, from any part of which the sand may be reclaimed, depending upon the position of the suction pipe carried on this swinging bridge. In reality it is a stationary dredge working under uniform conditions as to length of suction line, so that uniform capacity is obtained and the re-treatment plants are kept operating under uniform conditions, a necessity for efficient metallurgical practice.

To guard against delays in the shore plant, the original design called for two pumps so placed that



Leaching plant, showing tank filling