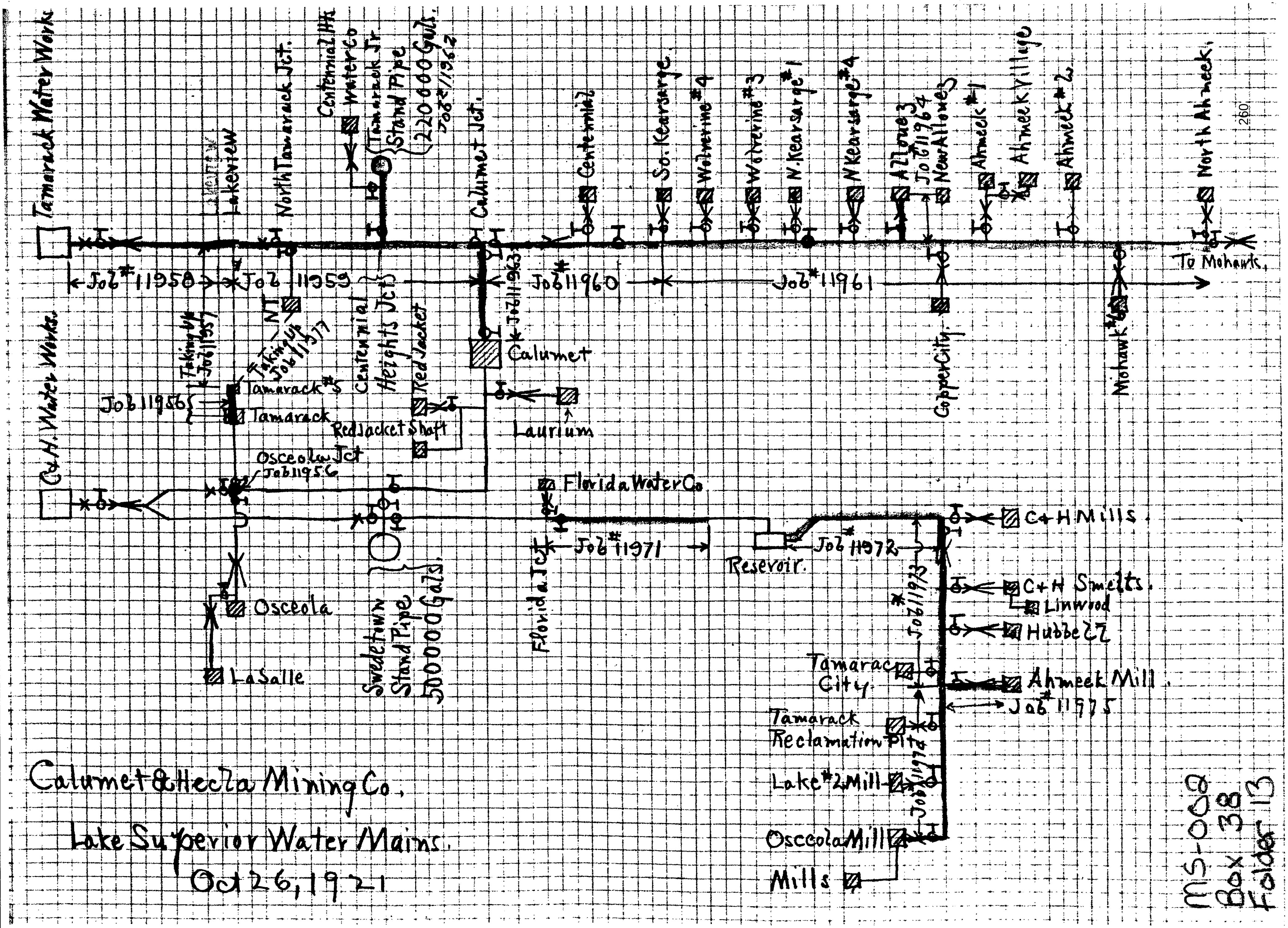
DOCUMENTS FROM THE ARCHIVES

AHMEEK MILL FACILITIES



Calumet & Hecla Mining Co.
Lake Superior Water Mains.
Oct 26, 1921
MS-060
Box 38
Folder 13
260
Tamarack Water Works
Job # 11958
Lakeview
Job 11959
North Tamarack Jct.
NT
Taking up Job 11957
Taking up Job 11977
Centennial Hts Water Co
Tamarack Jr. Stand Pipe 220000 Gals. Job # 11962
Centennial Heights Jct.
Calumet Jct.
Job 11963
Calumet
Job 11960
Centennial
So. Kearsarge
Wolverine # 4
Wolverine # 3
N. Kearsarge # 1
N Kearsarge # 4
Allouez 3
Job 11964
New Allouez
Copper City
Job # 11961
Ahmeek # 1
Ahmeek Village
Ahmeek # 2
Mohawk # 4
North Ahmeek
To Mohawks
C & H. Water Works
Tamarack # 5
Job 11956
Tamarack
Red Jacket
Red Jacket Shaft
Laurium
Osceola Jct
Job 11956
Osceola
LaSalle
Swedetown Stand Pipe 500000 Gals.
Florida Water Co
Florida Jct.
Job # 11971
Reservoir.
Job # 11972
C + H Mills
C + H Smelts.
Linwood
Hubbell
Job # 11973
Tamarac City
Ahmeek Mill
Job # 11975
Tamarack Reclamation Plts
Job 11974
Lake # 2 Mill
Osceola Mill
Mills

CALUMET AND HECLA CONSOLIDATED COPPER COMPANY

GENERAL OFFICE

CALUMET, MICHIGAN

JAS. MAC NAUGHTON, VICE PRES'T & GEN'L MGR.
J. G. BENNETTS, ASST. TREAS. & CHIEF CLERK
F. J. NICHOLAS, PURCHASING AGENT

March 14, 1925

Mr. E. A. Baalack
Calumet, Michigan

Dear Sir:

At the Ahmeek Mill we have a steam-driven booster pump for condensing water in connection with the low pressure turbine. Mr. Burgan believes that this pump should be run by electricity inasmuch as we shall have more than enough low pressure steam to operate the turbine when all the stamps at the Ahmeek Mill are running.

Please take this matter up with him to the end that you can advise me on the subject.

Yours truly,

J. MacNaughton
Vice Pres. & Gen. Mgr.

JMN/P

MS-002
Box 73
Folder 51b
(52 1 of 2)

STONE & WEBSTER ENGINEERING CORPORATION

EXECUTIVE:

49 FEDERAL STREET, BOSTON
February 20, 1930.

Mr. James MacNaughton,
President, Calumet & Hecla Consolidated Copper Co.,
Calumet, Mich.

Dear Sir:

POWER PLANT - AHMEEK MILL

We are submitting to you herein the results of our study of the steam and power supply problem at the Ahmeek Mill.

Following the procedure agreed upon in conference in your office on December 9, 1929, we have prepared estimates of construction and operating costs of a modern, low pressure, saturated steam boiler house to replace the present plant now approaching the end of its useful life. We have also prepared similar estimates of a larger, high pressure boiler house and power plant which would provide 7,500 kw. of new capacity for service in the Copper Company's system and would furnish steam extracted from the main turbine for the stamp mill and pumping engine.

CONSTRUCTION ESTIMATES

The low pressure boiler plant would supply the steam requirements of the mill at 155 lb. pressure and would include three 645 h.p. Stirling boilers equipped with forced draft underfeed stokers and would be designed for natural uptake draft operation. A coal handling system, consisting of belt conveyors between the rock bin structure and the new boiler bunkers, with crusher and auxiliary equipment would also be provided. Two boilers would have sufficient capacity to meet the steam demand for mill service but under normal conditions it is intended that three boilers would be in operation. We have assumed that, if constructed, this boiler house would be located on the southerly side of the present pump and power house and that it would be complete in all respects. We estimate that such a plant would cost $510,000, which includes an allowance for contingencies of about $48,000. A summary of this estimate may be found in Table I.

The second and larger program aside from supplying 155 lb. saturated steam for mill and pump service would generate enough additional steam to permit full capacity output of the 7,500 kw. turbine generator. For this purpose, we have selected three 865 h.p. Stirling boilers with superheater equipment to deliver steam at 410 lb. pressure, 650° total temperature. These boilers would be fired with underfeed stokers and would be equipped with feed water economizers, mechanical forced and induced draft and water-cooled furnaces, to permit operation at relatively high rates of steaming with good efficiencies. Coal handling equipment, consisting of receiving bunkers, crushers and a belt conveyor system and ash sluicing facilities would be provided. This plant would be located as contemplated for the lower pressure plant. We have planned on the construction of a separate power house located just west of the present pump and power house and in line therewith, which would contain a single 7,500 kw. extraction type turbine generator exhausting to a surfaee condenser through which mill water would be pumped for condensing purposes. Steam extracted from the turbine would be desuperheated to saturated temperature for mill supply service. A 13,200 volt switch house with six circuits and space for two more, has been included, as well as a 5,000 kva. bank of transformers for service between the 13,200 volt bus and the 2,300 volt mill system.

Our estimated cost of the combined high pressure boiler and turbine plants and substation is $1,500,000 including $123,000 as an allowance for contingencies. See Table II for the make-up of this estimate.

OPERATING ESTIMATES

Our estimate of operating costs for the proposed low pressure boiler plant is based on operation of the plant with a crew of eight men, which crew we believe would be sufficient for continuous boiler house service. The yearly operating and maintenance expense of this plant would total about $145,000 made up as follows: operating labor $10,700, miscellaneous supplies and expenses $2,300, maintenance labor and material $7,000, and fuel $125,000, with coal at $4.37 per net ton f.o.b. the high mill trestle. The anticipated net steam delivery is the same as that of the present boiler house, estimated to be 570 million lb. per year.

We believe that a crew of fifteen men, including a chief engineer, could operate the proposed high pressure boiler and turbine plant satisfactorily. The operators of the pumps and present low pressure turbine would remain as at present and their wages are not included in our estimate of operating costs. We anticipate that about 56,000,000 kw-hr. would be obtained from the new plant in addition to the usual steam supply to the mill, entailing an operating and maintenance cost estimated at $305,000 per year, i.e., operating labor $22,000, miscellaneous supplies and expenses $3,500, maintenance $15,500 and fuel $264,000.

COMPARISON OF PLANS

Either of the proposed programs shows a substantial reduction in operation and maintenance expense in comparison with present costs. At Ahmeek Mill the cost of boiler house operation and maintenance runs about $195,000 per year. The new low pressure boiler plant is estimated to require an annual expenditure some $50,000 less. The high pressure power plant would increase present steam generating expense at Ahmeek Mill by $110,000 but the generation of electric energy with the proposed new 7,500 kw. unit would result in a decrease of $220,000 in present operating costs at Lake Linden, assuming that the production of 56,000,000 kw-hr. per year is transferred to the new plant, so that the net saving in annual operation would be $110,000.

If capital charges be added, however, the overall result is added expense in comparison with present costs. If 6% per annum be taken for interest, 8% for appropriation to retirement reserve, sufficient, at compound interest, to retire the investment in ten years, and 1% for insurance and taxes, the annual capital charges on the replacement boiler house would be $76,500 and on the alternative power plant $225,000, so that the net total added cost over present conditions would be $26,500 annually for the one and $115,000 for the other.

The significance of these cost figures depends upon circumstances. The $26,500 added total annual cost of the new boiler house might be considered as the inevitable consequence of a necessary replacement.

The $115,000 per year, capitalized at 15%, represents an investment of $767,000, for 7,500 kw. relay capacity in the Copper Company's power system, or $102 per kw., which unit cost is low in comparison with usual costs for plants of this size.

Our analysis so far assumes that load carried on the new Ahmeek Mill power plant would be removed from the existing Lake Linden station. If, however, some or all of the energy produced at Ahmeek Mill is for the purpose of supplying new load, the situation is quite different. **Plate I** has been prepared to illustrate this condition.

The figures across the bottom of the chart represent kw-hr. annually supplied for new load service, and at 56,000,000 they coincide with the estimated plant output. The left-hand vertical scale represents annual costs in dollars, and the right-hand scale the incremental cost in mills per kw-hr. of the energy supplied to new load.

Line A represents the yearly fixed charges on the plant of $225,000. Line B is drawn through $530,000, to represent the addition of $305,000 operating and maintenance expense. Line C is below B at $335,000, representing a credit of $195,000, the present cost of steam production at Ahmeek Mill. Line D starts $220,000 below line C at zero new load and ends even with C at 56,000,000 kw-hr. new load. The distance at which it is below line C represents the saving in expense at Lake Linden due to load transfer, and the distance it is above the base represents the total annual increase over present costs incurred in supplying loads in excess of present loads. Line E represents the same cost expressed in mills per kw-hr. It will be noted that if the entire output of the new plant were to supply new load, the incremental cost of this energy would be six mills per kw-hr., including fixed charges, but after due credit for steam supplied to the mill.

Under such conditions there would be, of course, no relay capacity in the system.

NOTES ON SOME POINTS OF DESIGN

We attach hereto, three plates showing the location of the proposed new facilities in relation to the other structures at Ahmeek Mill, a plan and section of the proposed high pressure boiler house, and a plan and section of the proposed 7,500 kw. turbine plant. No drawing of the low pressure boiler house is included but we have had in mind that it would be essentially the same as the high pressure plant, excepting for the omission of economizers and induced draft fans and with such changes in dimensions as would naturally occur.

It will be observed that in the turbine plant, we show a turbine generator and frequency changer. We have had up with four of the principal manufacturers the matter of supplying a 25-cycle machine of this capacity and find that there is practically no modern development for such relatively small 25-cycle turbines. Four manufacturers have offered to build direct-connected, 1,500 r.p.m. extraction type units; two have offered 60-cycle extraction type machines, which are a standard development, to be used in conjunction with a frequency changer, and two have offered a geared machine, using the standard 60-cycle turbine and a 25-cycle revolving field alternator. The direct connected unit is the most efficient, most reliable and also the most expensive. The geared unit is the least expensive, about as economical but probably the least reliable, although that phase of the matter may bear further investigation. We have tentatively selected the 60-cycle machine with frequency changer because the price is lower than for the direct-connected machine and the reliability probably better than the geared machine, although the efficiency is not as good as either of the others.

We have made plans for handling coal as follows:

We propose constructing a steel coal bunker on the same bents and at the same elevation as the present rock bins. Our plan calls for cutting into two of the rock bins and taking approximately 12% of the capacity of each which it has seemed to us might not be objectionable. The capacity of the coal bunker thus provided will be about 180 tons and it will be possible to dump a trainload of coal into it in a short time so that interruptions to the rock unloading activities, if any, would be slight. The coal from the bunker would be discharged through two crushers to an inclined belt conveyor which would carry it over to the bunker in the boiler house. This plan seems to us to be simple, reliable, and not too expensive. If, however, there is grave objection to sacrificing a portion of the rock bin capacity for the storage of coal, we have worked out other alternatives utilizing the present storage facilities which can be employed satisfactorily.

The electric switching station and transformer substation has been placed on the easterly side of the Mineral Range Railroad tracks in order to keep the number of circuits crossing the tracks to a minimum. The plans call for cutting the Tamarack Reclamation and the Mutual Pumping Plant feeders, making the portion between the new switching station and Lake Linden power house serve as tie lines and the remainder as feeders. A one-line diagram of the switching arrangements is also attached hereto.

This shows a single main 13.2 kv. bus and a transfer bus with an oil circuit breaker between so that the feeder breakers may be inspected and repaired without interrupting service. We have considered that it is permissible to open all other circuits at particular times without any difficulty arising.

Yours very truly,

Joseph Pope,
Consulting Engineer.

Enclosures

J.O. No. 5556

Table I

PRELIMINARY ESTIMATE
FOR
PROPOSED 160 LB. BOILER PLANT
FOR
CALUMET & HECLA CONSOLIDATED COPPER CO.
-1-

Stone & Webster Engineering Corp.

February 20, 1930.

This estimate covers the cost of a boiler house approximately 47' x 91' and the installation of three 645 h.p. Class XXII, 21 wide, Stirling boilers for 180 lb. maximum pressure. There will be two 30,000 c.f.m. forced draft fans, concrete stack 8' x 200', two 150 g.p.m. boiler feed pumps, and a coal handling installation consisting of a belt conveyor discharging to a crusher which discharges to a bucket elevator and thence to an overhead conveyor.

Building	$91,200
Equipment Foundations (Stacks Only)	3,500
Boiler Plant	104,500
Draft System	34,500
Feed Water System	16,200
Piping and Covering	50,000
Coal and Ash Handling System	46,700
Switching and Control Equipment	3,500
Connections, Supports, Etc.	5,500
Auxiliary Equipment	8,000
Preliminary Operation	5,000
Inspection and Expediting	2,000
Insurance	4,000
Temporary Construction	7,000
Depreciation on Construction Equipment	4,000
	$385,600
Engineering Cost	22,000
Services of Constructing Engineers	46,365
Office at Works	7,500
	75,865
Contingencies	48,535
TOTAL	$510,000

J.O. No. 5556 Table II

PRELIMINARY ESTIMATE
FOR
PROPOSED BOILER PLANT, TURBINE PLANT AND SUBSTATION
FOR
CALUMET & HECLA CONSOLIDATED COPPER CO.

-1-

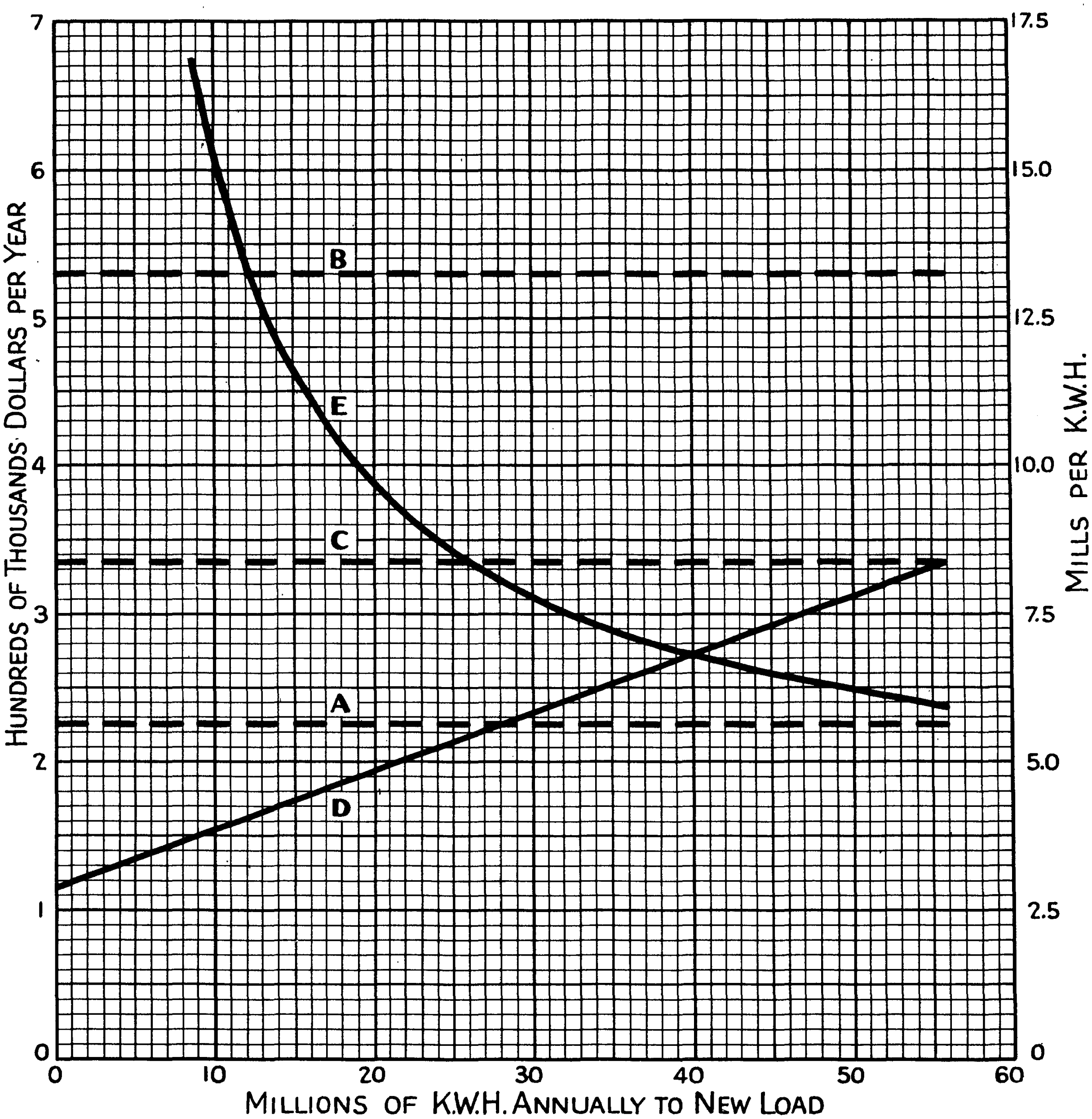
Stone & Webster Engineering Corp. February 20, 1930.

This estimate covers the cost of a boiler house approx. 56' x 104' containing three Class XXIII, 25 wide, Stirling boilers of 867 h.p. each, designed for 450 lb. pressure. Equipment includes stokers, concrete stack 10' x 175', three 30,000 c.f.m. forced draft fans, three 45,000 c.f.m. induced draft fans, 2 boiler feed pumps, three 5500 s.f. economizers and a complete coal and ash handling system.

The turbine house will be 46' x 58' and will contain one 7,500 kw. turbine-generator with air cooler and an 8,500 s.f., two pass condenser.

The substation will include three 1,667 kva. transformers and switching equipment for six 13.2 kv. circuits.

	Boiler Plant	Turbine Plant	Sub-station	Total
Building	$117,500	$34,000	$11,000	$162,500
Equipment Foundations	3,500	10,500	-	14,000
Boiler Plant	262,000	-	-	262,000
Draft System	52,000	-	-	52,000
Feed Water System	74,000	-	-	74,000
Condenser System	-	35,000	-	35,000
Piping and Covering	75,000	25,000	-	100,000
Coal and Ash Handling System	59,000	-	-	59,000
Generators and Exciters	-	217,000	-	217,000
Switching & Control Equipment	3,500	19,000	-	22,500
Connections, Supports, Etc.	5,500	7,900	-	13,400
Electrical Equipment (Substa.)	-	-	25,000	25,000
Switch Gear & Wiring (Substa.)	-	-	62,500	62,500
Auxiliary Equipment	10,000	20,000	-	30,000
Preliminary Operation	2,000	3,000	500	5,500
	$664.000	$371 400	$99.000	
Inspection and Expediting				5,000
Insurance				11,000
Temporary Construction				20,000
Depreciation on Construction Equipment				8,000
				$1,178,400
Engineering Cost				65,000
Services of Constructing Engineers				117,510
Office at Works				16,000
				198,510
Contingencies				123,090
			TOTAL	$1,500,000



A - Fixed Charges on New Plant
B - "A" plus Operat. & Maint. Expense
C - "B" less Credit for Mill Steam
D - "C" less Savings at L.L.P.P. and Additional Net Expense
E - Incremental Unit Cost

ADDITIONAL EXPENSE VS. ADDITIONAL LOAD

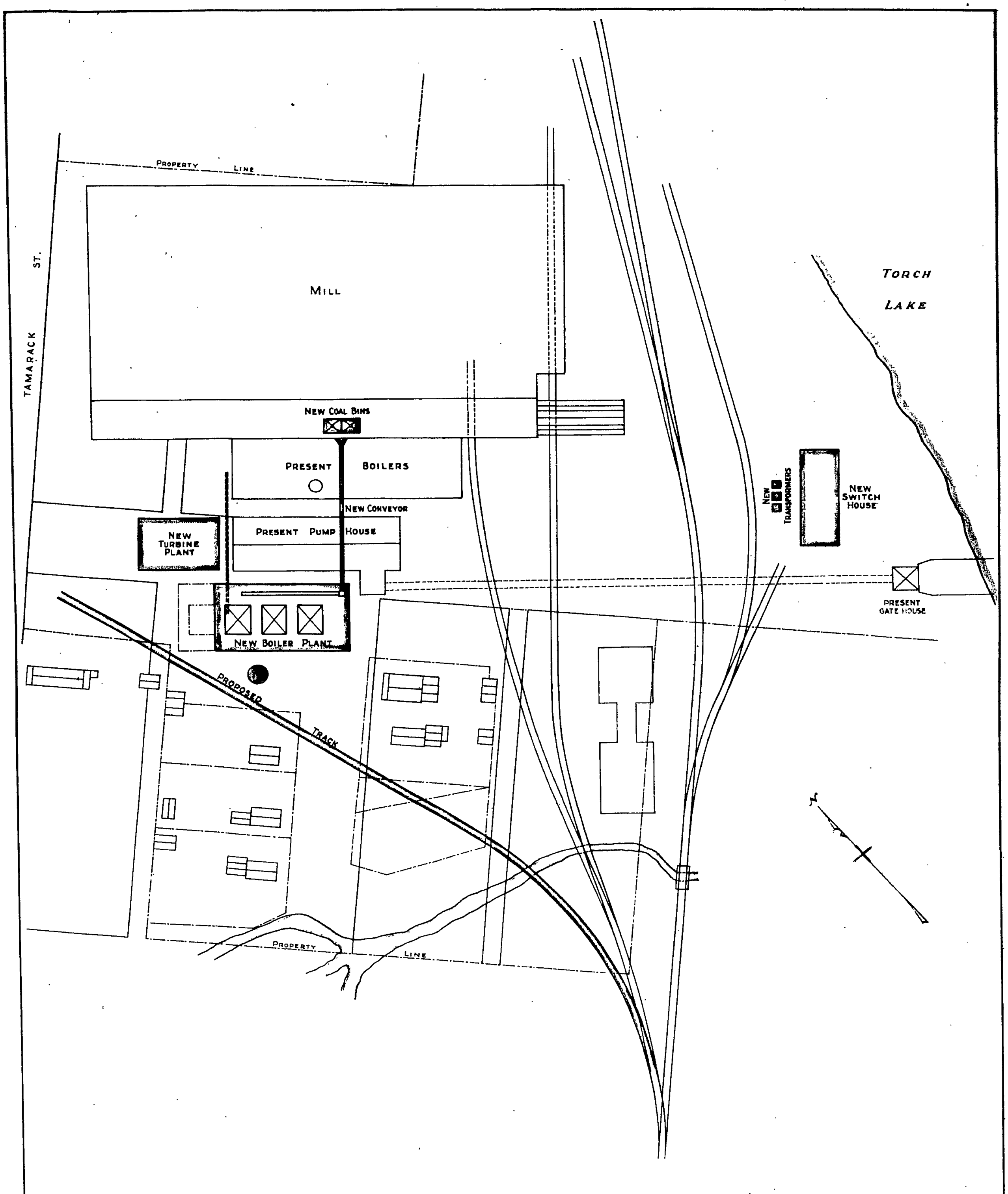
PROPOSED POWER PLANT

AHMEEK MILL

CALUMET & HECLA CONSOLIDATED COPPER COMPANY

STONE & WEBSTER ENGINEERING CORPORATION

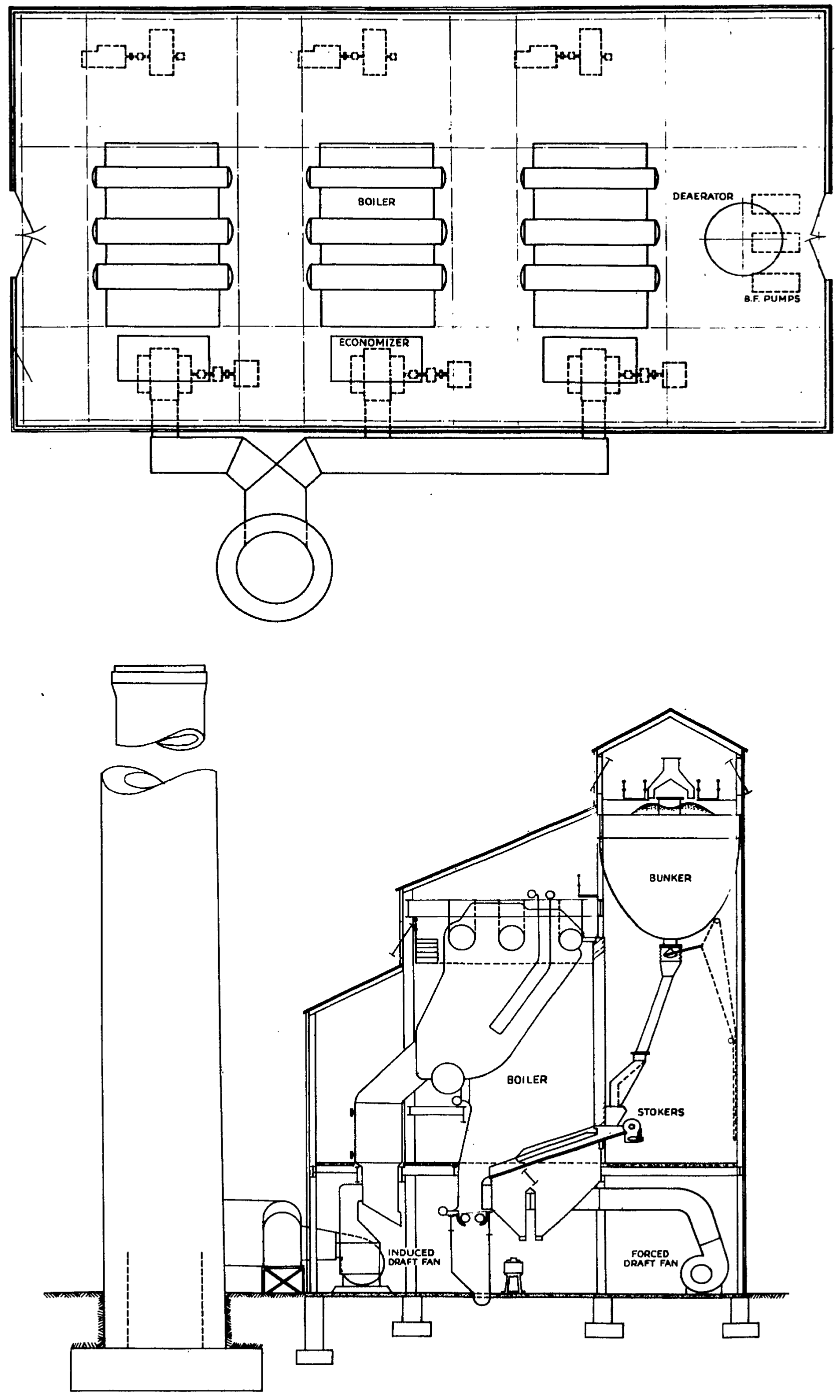
FEBRUARY 1930



GENERAL LOCATION
PROPOSED NEW POWER FACILITIES
AHMEEK MILL
CALUMET & HECLA CONSOLIDATED COPPER COMPANY

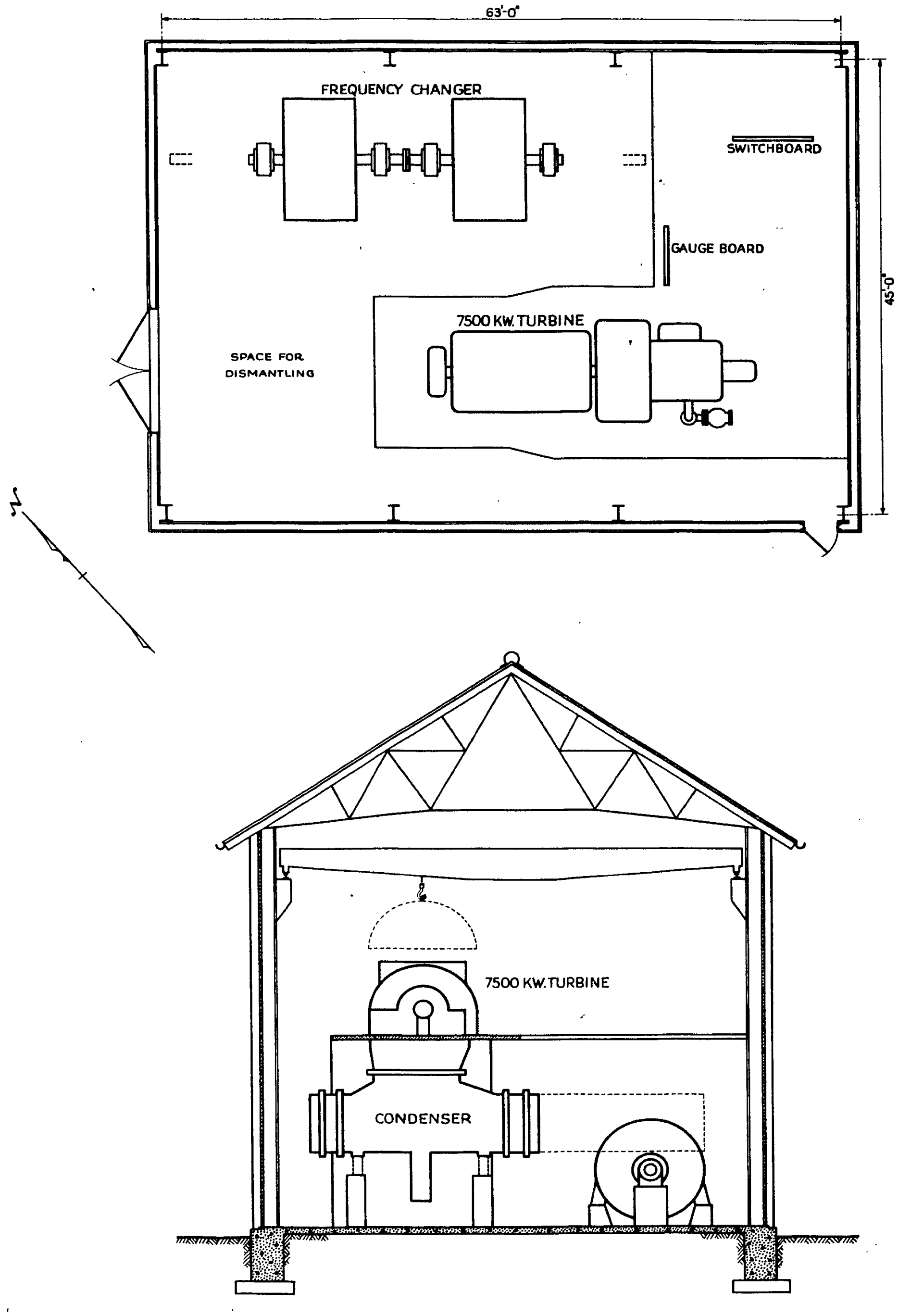
STONE & WEBSTER ENGINEERING CORPORATION
FEBRUARY 1930

PLATE III



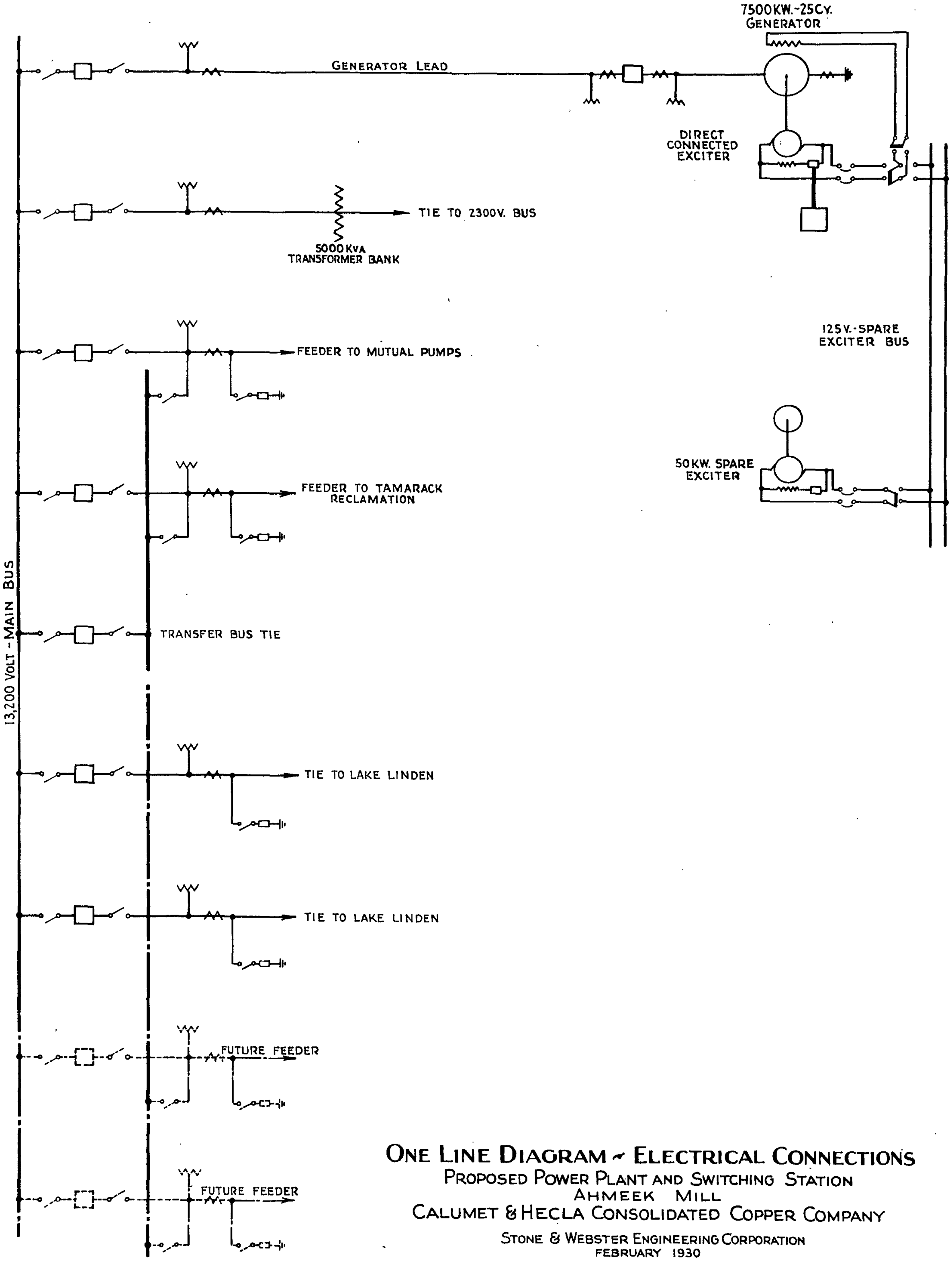
PROPOSED BOILER PLANT
AHMEEK, MILL
CALUMET & HECLA CONSOLIDATED COPPER COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
FEBRUARY 1930

0 5 10 15 20 25
FEET



PROPOSED TURBINE PLANT
AHMEEK MILL
CALUMET & HECLA CONSOLIDATED COPPER COMPANY
STONE & WEBSTER ENGINEERING CORPORATION
FEBRUARY 1930

0 5 10 15 20 25
FEET



One Line Diagram ~ Electrical Connections

Proposed Power Plant and Switching Station
Ahmeek Mill
Calumet & Hecla Consolidated Copper Company

Stone & Webster Engineering Corporation
February 1930

April 1, 1930

R E V I S E D

PRELIMINARY ESTIMATE OF CONSTRUCTION COST

STEAM POWER PLANT - AHMEEK MILL

Estimated cost of Materials, Contracts and Direct Labor on		
Boiler Plant	$ 628,900	
Turbine Plant	367,400	
Substation	61,000	$1,057,300
Estimate of undistributed expense for		
Inspection and expediting materials	$ 5,000	
Insurance	11,000	
Temporary Construction	20,000	
Depreciation of construction equipment	8,000	
Office at works	16,000	
Engineering and drafting	65,000	125,000
Estimated charge for services of construction engineer	109,700	109,700
TOTAL		$1,292,000
Allowance for contingencies		108,000
Estimate of Grand Total Cost		$1,400,000

April 1, 1930

Boiler Plant

Fire room labor	$ 10,700	
Proportion of Chief Engr.	1,300	$ 12,000
Maintenance- 62,000 tons @ 22.6¢		14,000
Supplies		4,000
Fuel- 62,000 tons @ 4.365		271,000
		$301,000

Steam produced- 1,092,000 M #

Cost of steam per M # produced 27.6¢

Distribution

Steam and New Power Plant	645,000 M #	$178,000
Steam and Ahmeek Mill for Stamping, pumping & electric gen.	447,000 M #	123,000

April 1, 1930.

Turbine Plant

Steam and Turbine	645,000 M #/year @ 27.6¢	$178,000
Operating labor		10,000
Maintenance		1,500
Supplies		500
Total cost Operation and Maintenance		$190,000

Energy by 7500 Kw. condensing turbine- 56,000,000 Kw-H	
Cost of energy by 7500 Kw. turbine per Kw-H	3.4 mills
Energy by 750 Kw. back pressure turbine- 5,000,000 Kw-H	
Maintenance and supplies - 750 Kw. turbine	$ 1,000
Cost of energy by 750 Kw. turbine per Kw-H	0.2 mills

Total new cost	$191,000
Total new energy - 61,000,000 Kw-H	
Average new maintenance cost per Kw-H	3.13 mills

April 1, 1930.

SUMMARY

Present cost steam production Ahmeek Mill	$200,000
Estimated new cost steam and Ahmeek Mill	123,000
Saving in costs of steam and Ahmeek Mill	$ 77,000

Energy generated L.L.P.P. at present	112,000,000 Kw-H
Energy to be generated at Ahmeek Mill	61,000,000 "
Energy remaining generation L.L.P.P.	51,000,000 "

Cost of production L.L.P.P. at present	$600,000
" " " " future	370,000
Saving at Lake Linden account load transfer	230,000

Recapitulation:	Saving steam & Ahmeek Mill	$ 77,000
	Saving in expense at Lake Linden	230,000
	Gross saving	$307,000
	Cost of generation new energy Ahmeek Mill	191,000
	Net Annual Saving	$ 116,000

April 1, 1930.

Summary of Operating Costs & Approximate Savings

Cost of steam production Ahmeek Mill 1929	$200,000
Cost of energy production Lake Linden 1929	600,000
Total for 1929	$800,000
Cost of steam and Ahmeek Mill 1931 estimate	$123,000
Cost of energy production Lake Linden 1931 "	370,000
" " " " Ahmeek Mill 1931 "	191,000
Estimated total for 1931	$684,000
Estimated net saving	$116,000

These figures are based upon the assumption that energy generated by new Ahmeek Mill power equipment is removed from Lake Linden power plant and that there is no increase in net output to load.

1220 S

CLASS OF SERVICE

This is a full-rate Telegram or Cablegram unless its deferred character is indicated by a suitable sign above or preceding the address.

WESTERN UNION

NEWCOMB CARLTON, PRESIDENT — J. C. WILLEVER, FIRST VICE-PRESIDENT

SIGNS

DL	Day Letter
NM	Night Message
NL	Night Letter
LCO	Deferred Cable
NLT	Cable Letter
WLT	Week-End Letter

The filing time as shown in the date line on full-rate telegrams and day letters, and the time of receipt at destination as shown on all messages, is STANDARD TIME.

Received at 1930 JUL 15 PM 7 51

JS72 63 NL=BOSTON MASS 15

JAMES MACNAUGHTON .PRESIDENT=

CALUMET AND HECLA CONS COPPER CO CALUMET MICH=

WITH REFERENCE ASH DISPOSAL NEW BOILERS STOP GIRTANNER ENGINEERING CORPORATION PROPOSE CLOSED HYDRAULIC SYSTEM DEPOSITING REFUSE IN TAILINGS LAUNDER PRICE SEVEN THOUSAND DOLLARS FOB JOB STOP ALLEN SHERMAN HOFF PROPOSE OPEN SLUICING SYSTEM TO SUMP IN BOILER ROOM BASEMENT INCLUDING ASH DISPOSAL PUMP PRICE NINE THOUSAND SIX HUNDRED EIGHTY FIVE DOLLARS FREIGHT ALLOWED TO JOB STOP RECOMMEND ACCEPTANCE GIRTANNER PROPOSAL STOP PLEASE ADVISE=

STONE AND WEBSTER ENGINEERING CORPORATION.

MS-002
Box 73
Folder 51b
(52 1of2)

J.O. No. 5649

July 26, 1930

Stone & Webster Engineering Corp.
49 Federal St.
Boston, Mass.

Atten: Mr. E. LaCrosse,
Ass't. Engineering Manager

Dear Sir:

We are in receipt of your letter of July 19th with accompanying prints of your drawing VC-3367, outlining the 2300 volt switchboard.

When writing our letter of July 2nd, it was our intention that you should design, purchase, and erect the complete new 2300 volt switchboard, making all connections to generators, exciters, transformers, etc., but ending your work at the outgoing side of the feeder oil switches, we to connect the existing feeders to the oil switches, and dismantle the old board.

You are correct in assuming our letter of July 2nd is sufficient authority for you to proceed with this work. We also note that it will increase the amount of your estimate by about $22,000.

We have checked over your letter and drawing, and suggest the following:-

1. Proposed arrangement of 2300 volt switchboard:

Panel 1 - 5,000 Kva. new transformer bank.
" 2 - 50 Kw. existing exciter for 1,000 HP motor.
" 3 - 1,000 HP existing motor.
" 4 - 2,500 Kva. existing generator #6.
" 5 - 1,563 Kva. new generator #7.
" 6 - 50 Kw. new exciter for generators.
" 7 - 25 Kw. existing exciter for generators.
" 8 - 500 Kw. new transformer No. 1, for auxiliaries.
" 9 - 500 Kw. new transformer No. 2, for auxiliaries.
" 10 - 100 amp. new lighting feeder.
" 11 - 100 " " " "

Panel	12 -	? amp. feeder panel for 2 - 250 HP synchronous motors. See rating of motors under item No. 12 on page 3.
"	13 -	For future synchronous motors, drilled for future switches, instruments, etc., for same service as Panel #12.
"	14 -	Same as Panel #13.
"	15 -	200 amp. existing power feeder No. 1.
"	16 -	" " " " " " 2.
"	17 -	" " " " " " 3.
"	18 -	" " " " " " 4.
"	19 -	" " " " " " 5.
"	20 -	" " " " " " 6.
"	21 -	" " new " " " 7.

Note that we have increased capacity of Panel #12 (your #18), and have added Panels 11, 13, 14. We are returning drawing VC-3367, revised accordingly.

2. We note you will provide 1-1/2" ebony asbestos panels. All our switchboards are of black marine finished slate, although we have no objections to the furnishing of the ebony asbestos if you feel this is equal or a better material to use.

3. This arrangement will be satisfactory.

4. The instruments on the motor driven exciter panel will not be available because this panel and exciter will be used for the excitation of the 1000 HP circulating pump motor, and located in close proximity to motor.

5. The present synchroscope is mounted on a swing bracket and will be available for the new board.

6. The present board had six power feeder panels and three single phase lighting panels. We have taken one single phase lighting panel and equipped it with a new circuit breaker to be used temporarily for starting the first 250 HP synchronous motor. We will, however, require seven 200 ampere feeder panels #15 to 21 incl.

July 26, 1930

7. Note the connection that you have made for starting and operating the 1000 HP motor. We have an auto transformer which we will use for starting this 1000 HP motor independent of the 2500 Kw. turbine as it is now installed. This starter will be located near the pump and panel #3 for this 1000 HP motor is to be connected directly to the buss. We have also shown this change on drawing VC-3367.

8. Watt meter arrangements on these panels are satisfactory.

9. Watt meter arrangements with a ratchet device for the 5,000 Kva. bank of transformers are satisfactory.

10. The mounting of the rheostats below the floor for the operation of the 2500 Kva. and the 1563 Kva. transformers is satisfactory, and according to our previous suggestion. The rheostat for the 1000 HP motor will be mounted independent of the new switchboard, in a location in close proximity to the motor.

11. The 250 HP synchronous motors are started directly across the line, but are provided with automatic starting. We will provide for the excitation for these machines, and exciter will be located somewhere in the Mill. The starting of these motors will have nothing to do with the new switchboard. Your switchboard equipment is satisfactory.

12. Regarding the panels for the 250 HP synchronous motor. Kindly refer to the panel arrangement, as given in item No. 1. The capacity of the switches on these panels has been left blank, but the following is the rating of the motors:-

P.F.	80%
H.P. rating	250
R.P.M.	300
Starting torque	200%
Pull-in "	120%
Pull-out "	300%
Eff. 1/2	87.9
3/4	90.5
4/4	91.6

K.V.A. inrush	675%
Kw. excitation	6.0 Kw. at 125 volts.
Motor running- 250 HP torque	254 K.V.A. input.
K.V.A. left for correction	153 K.V.A.

As stated before, there will be two of these motors connected to each panel, one motor will be installed at the present time. We have re-located these panels to avoid the necessity of carrying the heavy buss the full length of the board.

13. Note that you say there is plenty of room for the installation of this board.

14. O.K.

15. Agree with you in eliminating the oil circuit breaker slot, but you to provide drawings showing size and location of all floor openings, so we can place tubes through the floor for the outgoing power cables, and circuit breaker operating rods.

16. We feel that the slot in the rear should be left intact. This can always be closed up after the installation has been made if we feel that same will give a more finished appearance.

17. Note that you will provide conduit lay-out for the 2300 volt switchboard.

18. We feel that an additional 3 phase lighting panel, designated in item No. 1 as Panel #11, should be provided. This panel to take care of lighting in Mill, outside buildings, street lights, etc., thus providing protection from outside interference with the general lighting of the new turbine, boiler house and pump house, and to avoid the possibility of a complete lighting shut down through short circuits and the inability of the primary fusing to relieve the trouble before the operation of the oil circuit breaker.

July 26, 1930

19. The seven power conduits that now extend between the pump house and boiler house, will be connected to the new board and the extensions of same to their new location will be made inside of the old boiler house. This work to be done by C.& H.

20. This arrangement is satisfactory.

21. Your location for the 2300/460 volt transformers is satisfactory. If possible, transformers should extend not more than 12'-6" south of south face of pilasters on south wall of pump house. 2300 Volt cables can probably run underneath 2000 Kw. turbine floor and near its east edge.

Yours very truly,

President

HEW/AP
Enc. ✓
CC to HN, FNB, ALB

STONE & WEBSTER ENGINEERING CORPORATION

ENGINEERING:
J.O.No. 5649

49 FEDERAL STREET, BOSTON
August 5, 1930.

Mr. James MacNaughton,
President, Calumet & Hecla Consolidated Copper Co.,
Calumet, Michigan.

Dear Sir:

OPERATION OF 13,800 VOLT SYSTEM
POWER PLANT - AHMEEK MILL

In accordance with your request to Mr. Joseph Pope on June 4, 1930, and in connection with our design for the new power plant at Ahmeek Mill, we have investigated the possibility of operating the generators at Lake Linden in parallel with each other, and with the new Ahmeek generator.

The load of the 13,800 volt system at the present time, falls into two classes, a mine load and a mill load. The mine load amounts to about 7,000 kw. and is supplied over two feeders on wood poles, aggregating about thirty miles of line traversing the higher part of the peninsula. The mill load amounts to about 10,000 kw. and is supplied over five feeders on wood poles aggregating about six miles of line traversing the lake shore. An accidental interruption to service on any of the feeders is highly undesirable. It is particularly undesirable on the mill feeders as an unexpected shut-down of a mill entails considerable work in clearing the process machinery of accumulated material before the mill can be started again.

The mine feeders, on account of their great length and higher location are subject to somewhat greater hazard than the mill feeders. In a number of cases, due to improper relay action, disturbances on the mine feeders have found their way through to the generators, shutting down the generators and mill feeders as well. For these reasons, it has appeared desirable, under existing conditions, to safeguard the mill feeders by connecting them to a separate bus and separate generators. Undoubtedly this method of operation has, in some cases, avoided mill shut-downs that might have occurred as the result of trouble on the mine feeders, if the whole system had been operating in parallel.

The 13,800 volt double bus at Lake Linden station, which was built in 1905, for a capacity of 10,000 kva., has been extended, but only slightly modified, with the addition of synchronous

Copy to Mr. Williams

capacity, the total now aggregating about 30,000 kva. The bus is not considered mechanically strong enough to withstand safely short circuits of the magnitude that might be obtained if all the present capacity were operated in parallel. This is a second justification for separating the system, under existing conditions.

From the standpoint of station economy it is probably desirable to operate all generators in parallel so that the generating capacity in operation can be made to approximate closely the load at all times and this will become more important after the new generator is added at the Ahmeek Mill. From the standpoint of continuity of service, parallel operation should not present any serious difficulty if suitable relays are used and, in case of a fault in a generator circuit, parallel operation would be a distinct advantage.

We, therefore, recommend that improvements be made in the arresters, relays and buses and all generators be operated in parallel. The recommended improvements will now be discussed in detail.

<u>ARRESTERS</u>

The arresters at Lake Linden are of the indoor oxide film station type manufactured by the General Electric Company, one being connected to each feeder. They are located inside the building on the mezzanine floor and the connections are reasonably short and direct. We do not recommend any material changes. We suggest, however, that the gap settings be carefully checked and that the ground connections be measured and improved, if necessary, to give the lowest practicable resistance to ground.

Some decrease in lightning disturbances at the station and of insulator flashovers out on the lines can probably be obtained by installing line type arresters at intervals along the lines. Station records indicate that although the majority of the lightning disturbances have been experienced on the two mine feeders, yet in one case, a lightning disturbance of considerable importance occurred on two of the mill feeders. We believe it would be desirable to install a few arresters on the mill feeders as well as on the mine feeders. In all cases they should be placed at locations most exposed to lightning. Both the General Electric Company and the Westinghouse Electric & Mfg. Company are now manufacturing improved types of line arresters which are comparatively inexpensive and of small size, yet have characteristics at least as good as those previously available. About thirty sets of arresters would be required. The cost of the arresters and other material would amount to about $3,000.00. We have not estimated the total cost of the installation, as we assume you will wish to attend to the purchase and installation with your own organization.

RELAYS

The relays on the generators and feeders at Lake Linden are of the overload plunger bellows type made by the General Electric Company. We understand that they are set to operate at about three to four seconds on the feeders and six to eight seconds on the generators, with the intention that in case of a feeder fault, the feeder breaker will trip instead of the generator breakers. Station records indicate, however, that in many cases, a feeder fault has opened one or more of the generator breakers, thus interrupting service on other feeders. This is probably due to the inherent limitations of the bellows type relays, particularly after long service. We believe that carefully selected induction type overcurrent relays will give the desired protection on the radial feeders. We suggest, therefore, that either Westinghouse type "CO", or General Electric type "IA-201" relays be installed on the radial feeders in place of the present bellows relays. They should be set to operate as quickly as is consistent with the speed of operation of the relays and breakers out on the feeders. It would be desirable to have them capable of clearing the usual faults within one and one-half seconds or less. We understand you are now proceeding with the installation of relays of this type.

The two tie lines to the Ahmeek Power Plant should be provided with three overcurrent relays for each line and three selective differential current relays for the two lines, the same as we are planning for the Ahmeek end of these tie lines. Three new current transformers will probably be required for each line. The relays will disconnect the faulty line in case a fault should occur on one line, and will leave the other line with overcurrent protection. Either Westinghouse type "CO" overcurrent and type "CD" current differential relays or General Electric type "IA-201" overcurrent and type "PD3" current differential relays would be satisfactory. The relays must be interlocked with auxiliary switches on the oil circuit breakers, so that when one line is disconnected, the other will have inverse overload protection. The cost of the material only, for these relays would amount to about $1,250.00.

The generators and their transformers should be protected against internal faults, but in such a manner that they can not trip on external faults. As the neutrals of the generators are not brought out, the usual differential protection can not be applied, but we believe a sufficiently satisfactory protection can be obtained, without altering the machines, by the use of Westinghouse type "CR" directional power relays, in place of the present overcurrent bellows relays. They would be connected to new current transformers to be located in the leads between the transformer banks and the buses, and to the existing potential transformers. A generator field breaker would be required, for each machine, to open the field on the occurrence of a fault in the generator or transformer bank. An auxiliary relay would be necessary to trip the two main breakers and the field breaker simultaneously. The cost of the relays, current transformers, field breaker, wire and conduit, exclusive of installation costs, would amount to about $2,600.00 for the three generators.

The 13,800 volt buses will have no relay protection with the proposed scheme of relaying, which eliminates the overcurrent relays on the generators. Differential protection is occasionally applied to station buses, but, as a rule, all bus protection is omitted as bus faults are of very rare occurrence. As these buses are well enclosed and station records indicate they have been free from faults, we believe bus protection will not be required.

<u>BUSES</u>

Each of the two 13,800 volt buses consists of two bars of 3 in. by 1/4 in. copper per phase tapered to one bar at the ends. The bars are supported on small corrugated porcelain insulators of a now obsolete design, spaced at a maximum of 8 ft. 10 in. centers. The bus structure is of masonry construction with precast concrete horizontal slabs and red brick vertical walls, the insulators being carried on the horizontal slabs. The two buses are backed up against a central partition wall and the leads, consisting of varnished cambric insulated cable, are carried out and upward in front of each bus.

With the present type of bus supports and the long spans between supports, we believe the mechanical stresses that might result from a severe short circuit on a feeder, in case all the present generators were operating in parallel, would about equal the mechanical strength of the bus, leaving no margin of safety, and, therefore, the system should not be operated in parallel at the present time. After the new generators are installed at Ahmeek Mill, the stresses would probably about equal the strength of the bus if the system were operated in two separate groups, but would greatly exceed it if all generators were operated in parallel. We believe it is necessary, therefore, that the bus be strengthened before the new generators are installed at Ahmeek Mill, regardless of whether the system will be operated in parallel or separated.

Inspection of the bus structure indicates that additional holes can be cut in the outer brick walls and new insulators can be added at the centers of the longer spans so as to limit all spans to not over 4 ft. 5 in. In addition to this, the present obsolete insulators can be replaced by insulators of uniform design with the new ones, and of greater strength than the present ones, so that the entire bus structure will then have a mechanical strength sufficient for safely operating the entire system in parallel, after the new generators are installed at Ahmeek Mill.

We understand you wished us to estimate the cost of this item of work on the assumption it would be done by our own organization. We estimate the total cost, including the new materials and also the installation costs based on overtime work at times when a bus can be shut down, will amount to $12,000.00.

We shall be pleased to have you advise us in case you wish us to take any further action regarding any of these recommended improvements.

Yours very truly,

H B Wood

H. B. Wood,
Chief Electrical Engineer.

MS-002
Box 38
Folder 22

COPY

VERN E. ALDEN COMPANY
ENGINEERS
33 NORTH LA SALLE STREET
CHICAGO 2

J.O. 342

November 15, 1954

Mr. P. H. Ostlender
Project Engineer
Calumet Division
Calumet & Hecla, Inc.
Calumet, Michigan

Report on Lightning Protection
For the Electrical Transmission System of
Calumet & Hecla, Inc.

Dear Mr. Ostlender:

Following your inquiry letter to us dated April 6, 1953, Purchase Order No. 14418 was issued to cover the subject report.

We are sending you herewith five copies of this report. The completion of this report was delayed until the Osceola Unwatering Project was fairly well complete as was suggested in your letter.

A minute survey of your lines and substations was made and this report embodies our findings and our recommendations for certain improvements.

We will be pleased to review this report with you after you have had an opportunity to study it.

Yours very truly,

F. D. Troxel
Project Engineer

Encl

J.O. 342 November 12, 1954

REPORT ON LIGHTNING PROTECTION FOR THE ELECTRICAL TRANSMISSION SYSTEM OF CALUMET & HECLA, INC.

1. During past years there have been a considerable number of outages of the electrical transmission system which were traceable to lightning disturbances. This study was made in accordance with the instructions in your purchase order No. 14418 and was made in an effort to find the points in your electrical transmission system which are susceptible to lightning troubles and to determine what could be done, at not too great a cost, to correct these conditions, and thus provide more reliable service from the electrical transmission system.

2. In an electrical transmission system such as exists here, the principal forms of lightning protection which might be considered are:

   A. The use of modern lightning arresters correctly applied.

   B. The use of overhead ground wires and lightning rods properly installed.

   C. The maintaining of low resistance ground connections for the arresters, the overhead ground wires and the lightning rods.

3. We have looked at each of your substations individually and find that in general there are many old lightning arresters

now in service on your system. Many of these arresters are undoubtedly useless as lightning arresters and, perhaps, even worse than no lightning arrester at all. In general this report recommends the replacement of all these old arresters with new modern arresters. The new arresters should be as follows:

15 kv station type grounded neutral service
Westinghouse Type "SV" outdoor Style No. 1533116 or equal.

2300 V Line type ungrounded neutral service
Westinghouse Type "LV" Style No. 1535071 or equal.

At certain points on your system some of the old arresters have already been replaced and these, of course, do not have to be replaced again. This report discusses in detail the conditions which exist at each substation on your system. At a few points where overhead lightning rods or ground wires are not now installed, it is suggested that they be added. In general in protecting equipment from lightning disturbances, it is well to place the lightning arrester as close to the equipment being protected as is possible. On your system, for the most part, the major equipment which is being protected is transformers and for that reason the arresters in each case should be placed as close to the transformers as is possible.

4. This report is a part of the general effort to raise the level of the reliability of your entire electrical system and other items, germane to this program, have been carried out in the past year or so. These items included the reconditioning of the 13.2 kv breakers and relays in the Lake Linden power house, revision of relay settings, automatic transfer of auxiliary supply, replacing poles on lines, etc. This work has progressed along with the work on the Osceola project. In our report to you dated February 8, 1949 we made an engineering study of each of your substations. This report covered principally the possible short circuit conditions on your system at the various points and the interrupting abilities of the breakers at the various points. In this report we made a series of recommendations. While reviewing your system in connection with this lightning study, we checked to see if the recommendations contained in the report dated February 8, 1949 had been carried out. In many cases these recommendations had not been carried out. In the earlier report certain hazards were pointed out and recommendations made to remove these hazards. As long as these conditions exist, they are a hazard to the reliable operation of this system just as are the hazards from lightning disturbances. We suggest that the report dated February 8, 1949 be reviewed and the things recommended therein, which have not been done, be carried out as soon as possible.

5. Any overhead 2300 volt or lower voltage lines which are exposed to lightning surges should be equipped with modern lightning arresters at both ends of each line. All electrical equipment and lighting circuits should be solidly and permanently connected to ground.

6. Below are listed in detail our recommendations in regard to each of the substations. You will note that in certain cases we are referring to substations which no longer carry much load. However, as long as these substations are connected to your system they constitute just as much a hazard to the reliable operation of your system as if they were carrying a heavier load. In cases where certain substations are no longer carrying any load, we would suggest that that substation and as much of the line as possible, that originally supplied such a substation, be disconnected from your system.

   A. Quincy Substation - This substation is relatively new. The equipment for the most part is relatively modern. Modern G.E. type lightning arresters are installed. The substation is located in a low spot which should be relatively free from lightning occurrence. There is no record of a lightning stroke at this location. The ground resistance is quite low. Therefore, we would suggest no changes insofar as the lightning protection for this particular yard is concerned even though there are no ground wires above the substation proper. In our report dated February 1, 1949, we stated that the breaker which is installed on the high tension side of this transformer had an interrupting capacity of 50,000 kva and that the short circuit current that might flow in case of a short at the terminals of the transformer, would be about 91,000 kva. We suggested that this breaker be removed from service since it constitutes a serious hazard to the reliable operation of the system and is a source of fire hazard as well. This breaker has not been removed and we again recommend that it be removed just as soon as practical. When the breaker is removed, it will be necessary to change the settings of the relays for the Quincy Line at the Ahmeek Power House since the clearing of a fault will depend upon the operation of these relays.

B. <u>Tamarack Reclamation Substation</u> - In this substation there are two banks of transformers. These transformers are each 1,000 kva in capacity, arranged in two banks of three each, one stepping down to 440 volt and the other to 2300 volt. All of this equipment is located indoors. Both transformer banks are supplied by one feeder from the Ahmeek Power Station. There are located here, three old style G.E.Co.'s oxide film type of lightning arresters. These arresters are quite old and are obsolete. Most arresters of this type have been removed from power systems many years ago since it was found that the discs in the arresters deteriorated after a period of time and that it was impossible to determine their condition in any satisfactory manner. Furthermore, the porous block type of arrester has been developed since and it is a much better arrester in every respect. We would recommend that these arresters be removed and be replaced with modern arresters. In our report dated February 1, 1949 we stated that the three oil circuit breakers located in the circuit on the high tension side of these transformers each had an interrupting rating of 25,000 kva and that the possible short circuit current that might flow with a short circuit at the high tension terminals of these transformers could be about 136,000 kva. We, therefore, recommended that these breakers be all removed from service just as soon as possible. This has not been done. We recommend again that these breakers be removed just as soon as practical as they constitute a serious fire and system reliability hazard. Furthermore this substation is located in a room which has a door which leads to the Reclamation Plant. If the oil in these transformers or the breakers should get out of the tanks and catch fire, as it does when there is a fault in the equipment, this flaming oil could flow out through this door onto a wooden platform, down a wooden stairs, thereby starting what could be a serious and costly fire. We would recommend that a curb be placed immediately at this door entrance so that this flaming oil could not flow out onto the wooden platform and stairs. Furthermore certain of this equipment is located on an elevated platform which has a stairway at one end. If a fault occurs when a man was at the opposite end of this platform he would be trapped. We would suggest that at least an escape ladder of some sort be provided at the opposite end of this elevated platform.

C. No. 2 Regrinding Plant Substation - This substation was originally supplied by two lines from the Lake Linden power house bus. Two transformer banks were installed, one 3750 kva in capacity and another 6000 kva. The load at this time, however, has been very much reduced and at present only one line is connected from Lake Linden to the substation. All of the transformer capacity is, however, yet in service. Apparently there is a good chance that all of this equipment will be taken out of service before long due to the regrinding plant operation being discontinued. If this is true, of course, it is not desirable to spend any money here. However, if this equipment is to continue to be energized, even though it is not carrying any load for any length of time, we would suggest that the old lightning arresters on the one line that is in service be replaced with modern type of arresters. In our report dated February 1, 1949 we stated that the breakers which are in the high tension side of the feeds to these two transformer banks each had an interrupting rating of about 25,000 kva. The short circuit current that might flow is something in the order of 232,000 kva. We, therefore, recommended that these breakers be removed from service immediately. This has not been done. If this equipment is to remain energized we would recommend again that these breakers be removed just as soon as possible. All of this equipment is quite old and it is a source of hazard to the whole system. The equipment, however, is located in a separate building and if it caught on fire it probably would not do much damage to other buildings. When the high tension breakers are removed, the relay settings at the Lake Linden bus should be changed.

D. <u>The Smelter Substation</u> - The smelter substation has three 1000 kva single phase transformers. These transformers were formerly fed through breakers on the high tension sides from a line from the Lake Linden Power House. These breakers have been removed in accordance with the recommendations of our report dated February 1, 1949. The incoming line to this substation is provided with old G.E. lightning arresters which should be replaced with the new modern type. The ground resistance at this station is low and with the new lightning arresters, a minimum amount of lightning disturbance would be anticipated. We, however, would recommend that lightning rods be placed above the switchyard structure in the usual manner that has been done on many of the substations on the C&H system.

E. Coal Dock Substation - The coal dock substation is an outdoor substation. The transformer bank formerly had an oil circuit breaker on the high tension side but this breaker has been removed in accordance with the recommendation of our report of February 1, 1949. The incoming line is provided with old style Westinghouse lightning arresters and these should be replaced with new style arresters. We would also suggest that lightning rods be added above this switchyard. This substation is fed from the same breaker and line that feeds the smelter. The relay settings for this breaker in the Lake Linden Power House are satisfactory as indicated on the last relay settings list which we gave Calumet & Hecla.

F. Ahmeek Power Plant - All the lines going out of the Ahmeek Power Plant are equipped with modern lightning arresters. These arresters are mounted on a modern steel pull-off structure. The pull-off structure does not have lightning rod protection above it but it is set adjacent to the rather tall power house smokestack which is equipped with lightning rods and this affords good protection from direct lightning strokes. We would, therefore, suggest no changes at this point. The ground resistance at this point is very low which also will lead to good operation from these lightning arresters.

G. Lake Linden Power Plant - All of the lines going out from the Lake Linden Power Plant are equipped with modern arresters. These have been replaced in recent years. The switching equipment in the Lake Linden Power Plant is all relatively modern and has recently been reconditioned and tested. The relays have been carefully cleaned and adjusted. The relay settings have been checked in accordance with the system as it is at present. Therefore, no further work would need to be done at the Lake Linden Power Plant and a minimum of trouble should be expected from lightning at this point.

H. All of the transmission lines at Substation "B", both the 60 cycle and the 25 cycle, have been provided with modern lightning arresters. Ground resistance at this point is low. Overhead lightning rods have been provided. Therefore it would appear that no work need to be done at this point in order to have a good level of lightning protection.

I. Lines to Osceola No. 13 and No. 6 Shafts and to Tamarack No. 5 - These lines and the associated substations have recently been built and they are equipped with modern lightning arresters and other lightning protection features. All of this should give good lightning protection for these lines and the substations.

J. Calumet Waterworks Substation - All of the lightning arresters at Calumet Waterworks are old arresters. These should be removed and replaced by modern arresters. There are two sets, one for each of the two transformer banks. Lightning rods should be added over the switchyard. The ground resistance at this point is rather low and with the addition of the two items mentioned above a good level of protection would be assured. The arresters on both ends of the 2300 V line to the Tamarack Water Works should also be replaced.

K. Centennial Substation and Adjacent Lines - The area around the Centennial Substation has the record of having more lightning difficulties than any other spot on the C&H system. This is probably due to exceedingly high ground resistance and to, perhaps, a rather exposed natural position. We would recommend that the two old lightning arresters on the line to the transformer bank be removed and that the one modern arrester be retained. We would suggest the addition of a modern arrester at the point where this connection to the transformer bank cuts into the main line. We would suggest that another arrester be placed about one thousand feet away on the line to Substation "B" and that another be placed about one thousand foot distance in the opposite direction from this tap point. Anything that can be done to lower the ground resistance of all of these arresters should be done. Modern lightning arresters should be provided on the 2300 V. distribution system. With the addition of these arresters and a low ground resistance we would think that the protection afforded was about as good as possible.

L. Alloway No. 3 Substation - There are modern arresters at this substation and we would suggest no change here.

M. <u>Ahmeek No. 2 Substation</u> - There are choke coils in the connection to the transformer bank to Ahmeek No. 2. These choke coils serve no useful purpose and in fact are a hindrance insofar as lightning protection is concerned. They should be removed. The lightning arresters at this point are very old and should be replaced with modern arresters.

N. <u>Ahmeek No. 3 and No. 4 Substation</u> - The lightning arresters at this point on both the incoming lines and outgoing lines are all very old and should be replaced with modern arresters. All of these new arresters should be located out of doors.

O. <u>Seneca No. 2 Substation</u> - The lightning arresters at this point are very old and should be replaced with modern lightning arresters. Lightning rods should be placed above the substation.

P. <u>Iroquois Substation</u> - The lightning arresters at this substation are very old and should be replaced with modern arresters. Lightning rods should also be placed over the substation.

Q. <u>Trap Rock Valley Line and Substation</u> - This line and substation have been built recently and are provided with modern arresters, etc. and should be relatively free from lightning troubles.

The estimated cost of carrying out the foregoing recommendations is as follows:

42 -	15 kv lightning arresters @ $200. ea. installed =	$8,400.
12 -	2300 V. lightning arresters @ $10.ea. installed =	120.
5 -	Sets of lightning rods above substations =	500.
	Total =	$9,020.

We feel that if the recommendations which are made in this report are carried out that the reliability of your electrical transmission system, insofar as lightning disturbances are concerned, will be much improved. We will be happy to discuss this report with you, after you have had an opportunity to review it, if you so desire.

Signed: F. D. Troxel
F. D. Troxel
Senior Electrical Engineer

Copies: ASK
RJM
BCP
RLP
JPP

Report on

THE LEACHING OF AHMEEK MILL CONCENTRATES

by

L. C. Klein

November 5, 1958

FC/29

INTRODUCTION

This report will attempt to give answers to several questions that have been raised concerning the possibility of leaching certain Ahmeek Mill Concentrates to produce 25,000,000 pounds of copper per year in copper oxide, for production of copper powder. In addition to this, about 3,600,000 pounds of copper oxide would have to be produced to supply the regular demand for industrial and agricultural oxide, this material to be produced from either primary or secondary copper sources.

This report will cover the capacities of present leaching and distillation facilities; changes in leaching and distillation equipment necessary to adapt this equipment to the leaching of concentrates and distillation of the rich solutions produced; material handling; changes in leaching techniques; leaching solution control; types of concentrates that can be leached; and the control of impurities in the oxide produced. A rough estimate is also given for capital expenditures necessary and the cost of oxide production.

CONCLUSIONS

Certain of the Ahmeek Mill Concentrates can be leached to produce copper oxide. "Rich" and "Poor" can be leached with minor modifications to the present 54 ft. diameter leaching tanks and piping, although smaller diameter tanks would be more efficient. "Heading" can be leached in special tanks providing faster solution turnover. The Lake Linden Leaching Plant has tank capacity to leach three or more times the required amount of copper from high grade concentrates.

With the present distillation facilities at Lake Linden, about 1,300,000 pounds of copper as copper oxide can be produced per month consistently. The Tamarack Leaching Plant can produce an average of about 750,000 pounds of copper as oxide per month.

To produce 2,000,000 pounds of copper per month for copper powder, and 300,000 pounds per month of industrial and agricultural demand, it will be necessary to do one of the following:

1. Operate both the Tamarack and the Lake Linden Leaching Plants at near capacity, or

2. Install two additional stills and accessory equipment at Lake Linden.

Plan 1 requires a capital expenditure of about $30,000 at Tamarack, and $25,000 at the Lake Linden plant. Oxide produced at Tamarack would cost from 4.0 to 4.5¢ per pound of copper processed, and at Lake Linden the cost per pound would be about 2.75¢.

Plan 2 requires a capital expenditure in the order of $225,000, of which $25,000 would be spent in the Leaching Plant, and $200,000 in the Still House. With this plan, the cost of producing a pound of copper, as oxide, would be about 2¢.

The extent to which impurities in the concentrates, particularly arsenic and silica, will contaminate the oxide, and the possibility of the arsenic being evolved on reduction with hydrogen will have to be determined experimentally. These impurities can be precipitated from the leaching solutions if it is necessary. — ?

Plan 2 = 225,000
Plan 1 = 30,000
= 195,000

% of difference feeds -?

AHMEEK MILL CONCENTRATES

The grades of concentrates produced at the Ahmeek Mill are as follows: Heading, Rich, Poor and Flotation.

Rich is a more or less ideal material for ammonia leaching. The assay of this grade is about 90% copper, and the individual particles are not too large to be dissolved in a reasonable leaching cycle, nor is much of the copper likely to be entrapped in the gangue. The 10% of the gangue in the material is not enough to stop permeation of the solutions through the material, and slimes are not present in sufficient quantity to create a problem.

Poor, assaying about 70% copper, is more difficult to leach. The copper particles are smaller, but the increased amount of gangue and the finer texture of the gangue inhibits the solution percolation to some extent, and creates a greater problem with slimes.

Heading, which is relatively pure copper, but large in size, can be leached in a special tank, such as rectangular tank, with rapid circulation of solutions. Leached in the conventional tanks this material would take from six to eight months to dissolve. In the rectangular tank it could probably be leached in two weeks. COST.?

Mill mass is not considered a good leaching material. It would take a period of years to leach some of the larger pieces of mass, and then any copper entrapped in the ore would not be recovered.

Flotation concentrates can be leached if special equipment were used. Something on the order of an enclosed thickener, or counter-current decantation unit could be used to leach this material, so that rakes would continuously turn over the material and expose the copper to the leaching solutions. Percolation leaching would not work on this material because of the very fine nature of both the copper and the gangue. Before leaching this material, it would be necessary to determine whether the flotation reagents and oils would contaminate the leaching solutions and show up in the copper oxide as carbon and sulfur compounds.

It is safe to assume that Rich, Poor, and Heading can be leached with no particularly difficult troubles developing. An experimental lot of mixed Rich and Poor is now being leached at the Lake Linden Leaching Plant and is progressing satisfactorily. This test is being made in a 15 ft. diameter tank with reverse flow of solutions.

LEACHING OF CONCENTRATES

The large, 54 ft. diameter leaching tanks at Lake Linden and Tamarack are not ideally suited to the leaching of mill concentrates. Small diameter tanks, about 16 ft., would be much better because less trouble would be experienced with the solutions working through the area of least resistance in the charged tank, or "channeling". By reversing the flow of solutions on the large tanks and installing porous filter bottoms, no great trouble with leaching concentrates should be experienced. It may be necessary to drain a tank once or twice during the leaching cycle and turn over the material with a clam to counteract the effect of channeling. This can be done by one man in an hour or so.

Reversing the flow of solutions in the tanks will eliminate the problem of slimes plugging up the filter bottom and cutting off the flow of solutions. Any slimes in the effluent solutions can be removed by filtering, if these solutions are sent to distillation, or by settling if they go to the leach storage tanks. Slime settling in the storage tanks could be removed by flushing the tanks periodically.

Four of the large leaching tanks will be needed to leach 2,000,000 pounds of copper per month. About 1,000,000 pounds of copper would be charged in each tank, and the leaching cycle should take from six to eight weeks.

It will be simple to produce a consistently high cuprous oxide by leaching concentrates, that is a cuprous oxide content in the order of 70-75%. If a higher cuprous oxide content is desired, a small tank charged with copper shot or other pure copper material could be placed in the rich line between the stills and the preheaters in the Still House. This should boost the cuprous content of the oxide to about 90%, and would cut to less than half the theoretical amount of hydrogen necessary for reduction of the oxide to copper powder.

Careful control of the leaching solutions will be necessary if high grade concentrates are to be leached, since supersaturation of the solutions results in the precipitation of basic cuprous carbonate in the tanks with resulting high copper losses. Controlling the solutions is not difficult and the possibility of supersaturation of solutions occurring should cause no great concern if the concentrations of copper, ammonia, and carbon dioxide in the leach storage are kept in proper balance.

All equipment in the leaching plant is adequate for leaching the required tonnage of concentrates, the only expenditures necessary will be for tank bottoms and repiping. A pressure filter for rich solutions must be obtained. This could be located either at the Leaching Plant or Still House.

If maximum production of cuprous oxide is to be maintained with the present facilities, it will not be possible to operate two leaching circuits at Lake Linden. If different grades of oxide are to be produced at Lake Linden, it will involve a considerable expansion of still house facilities. This will be taken up in more detail later in this report.

IMPURITIES IN COPPER OXIDE PRODUCED FROM PRIMARY

Analysis of solutions obtained from leaching Ahmeek Mill concentrates indicate that arsenic in the mineral is being dissolved by the ammoniacal solutions, presumably forming ammonium arsenate or ammonium arsenite depending on the valence of the arsenic in the ore.

The ammonium arsenates would normally break down to form the respective arsenic oxides at distillation temperatures, but other reactions can take place. If chlorides are present in the solutions being distilled, the cuprous copper reduces the arsenates forming arsenious chloride which is quite volatile. Arsenic has been detected in the distillate from the decomposition of solutions containing arsenic, so this reaction may be taking place to some extent. Since Torch Lake water is used for leaching, chlorides are present in considerable quantity. If any amount of arsenic goes into the distillate, it will be returned to the leaching plant and eventually build up quite high in the solutions.

Since arsenic has a great affinity for sodium, and is readily dissolved by alkaline sodium compounds, it is quite possible that the introduction of a small quantity of a sodium compound, preferably sodium carbonate, to the still feed will result in the arsenic forming the sodium compound. Since the sodium arsenates or arsenites do not decompose at distillation temperatures, the arsenic would be eliminated in the still waste. There is also the possibility of precipitating the arsenic from leaching solutions with small amounts of magnesium compounds or other chemicals.

There is a strong possibility that if the oxide is reduced with hydrogen at temperatures over 1300°F., the arsenic compound will be sublimed, or that it will be evolved as arsine. Arsine, if it is formed, decomposes freeing metallic arsenic at elevated temperatures, which should sublime under the right conditions.

It is likely that the silica content of the oxide made from concentrates will be a little higher than in that made from secondary, because silica is very slightly soluble in the alkaline leach liquors. ?

There is a possibility that calcium and magnesium might be a little higher in oxide made fromprimary because of the presence of the chlorides of these two metals present in the ore. The Torch Lake water also contains a high percentage of these compounds. The presence of carbon dioxide in the leaching solutions precipitates both of these metallic ions as insoluble carbonates, and calcium and magnesium getting into the oxide is carried in the solutions as fine suspensions. It is likely that filtering the solutions to remove slimes will also effect the removal of most of these compounds.

The effect of the above impurities on the quality of oxide, and copper powder produced from it, can only be determined by distilling solutions made from concentrates in a large scale test, and reducing the oxide obtained. ?

HANDLING OF CONCENTRATES

Up to 100,000 pounds of concentrates will have to be handled per day from the Ahmeek Mill to the Lake Linden Leaching Plant, and into the tanks. There are at least two ways of doing this. If no expenditure of money is to be made, the concentrates would have to be loaded into gondola cars, or into pans on gondola cars, at the mill, so that they could be transferred into the leaching tanks either with a clam, or by picking up pans of concentrates with the crane and dumping into the leaching tanks. By either method, this material could be put into the tanks in about four hours a day by the regular scrap-handling crew. The mineral would then have to be leveled off in the tanks, when a tank is completely charged.

The alternative would be to use the present mineral cars, and build a pit under the leaching plant tracks from which an elevator would take the mineral to a storage silo, from which it could be dumped into pans for transporting to the leaching tanks, or a system of movable conveyors could be used for this purpose. This method of handling the concentrates would involve a considerable outlay of capital.

HANDLING OF LEACHING RESIDUES

The handling of the residues left from the concentrates after leaching will present two problems: 1. Removal of soluble copper and ammonia, and 2. Removal of the residue from the tanks and recovery of the silver contained therein.

1. The test now being run on the leaching of Rich and Poor minerals will provide information on how well ammonia and soluble copper can be removed from the residue by washing with ammonium carbonate "distillate" and water. It is assumed that sufficiently good washing can be attained, since the volume of residue is small in comparison to the initial tank charge.

It will not be economical to steam the residue for ammonia recovery if it can be reduced to below about ten pounds to the ton.

2. Because a considerable value of silver will remain in the residue, it is assumed that some effort will be made to recover it if the cost is not too great. This will rule out the use of conventional flushing methods for eliminating the residue from the leaching tanks. If the silver particles are not too fine, it may be possible to install riffles in the tailings launder, or a settling area in which the silver can be trapped. If half of the silver could be recovered by this method it will probably be worth doing, since flushing would be by far the cheapest way of getting rid of the residue. The alternate method would be to clam and shovel the residue from the tanks, or to flush them out into a settling tank or thickener, for dewatering, and then recover the silver by flotation, cyanidation, or pyrometallurgical means, or selling the residues as such. Tests will be made with the residue from the leaching test now in progress to determine the nature of the silver particles, and to determine the best way of handling the residue.

DISTILLATION

While the Leaching Plant has capacity to leach considerably more copper from concentrates than required for this program, the capacity of the distillation facilities is definitely limited.

With the three distillation units now at Lake Linden, the maximum copper that can be produced in a seven day week, with ideal conditions, is about 1,500,000 pounds. A comfortable average production is in the order of 1,300,000 pounds per month. If a fourth still were installed at Lake Linden, maximum production would approach 2,000,000 pounds per month, with a consistent average not much above 1,600,000 pounds per month.

The production figures shown above could only be met if only one grade of oxide--high cuprous--was produced. If high cupric oxide is to be made, or agricultural grades of oxide, the production figures would be reduced considerably. This would rule out use of two circuits at Lake Linden unless additional distillation and drying facilities are installed.

The Tamarack plant has on occasion produced 1,000,000 pounds of copper in oxide per month, however, an average production of 750,000 pounds per month is all that can be produced consistently.

COPPER OXIDE DRYING, BAGGING, AND HANDLING

The drying equipment at Lake Linden will handle up to 50,000 pounds of high cuprous oxide per day. Other oxides, higher in cupric oxide content, reduce the capacity of the dryer because they contain more moisture. If production in excess of 50,000 pounds of oxide per day is expected, new drying equipment must be purchased. Drying 50,000 pounds of oxide per day will require some departures from the normal way of operation, since heavy loads of oxide, as encountered when boiling out a still before shutting it down, would overtax the drying equipment. Controlling the flow of oxide from the dewatering cones to the filter should overcome this problem.

The drying of chippings will have to be spread over a longer period of time, so as not to overload the drying equipment when it is carrying its regular load. It is possible that this operation can be mechanized to eliminate the need for a man to shovel the chippings into the drying system.

The bagging equipment at Lake Linden is adequate to handle 50,000 pounds of oxide per day, but bagging will have to be done on two shifts, rather than on one shift.

It is assumed that the oxide will be dried and bagged before reduction to copper powder. If wet oxide is to be reduced directly to powder, it will be necessary to do this with no intermediate storage, since storing the wet, high cuprous oxide for even a few hours would result in a hopelessly caked mass.

It is possible, if the oxide is not to be stored for too long a period before reduction, to eliminate the bagging operation, and transfer the oxide from the drying plant to storage bins in the reduction plant by a pneumatic or other type of conveying system. In this case, the copper powder would have to be used as a basing point for figuring costs rather than the oxide. This would eliminate the need for complete assays on oxide produced for reduction to powder. The only control needed would be the cuprous oxide content, which is a simple analysis, and could be run by plant personnel if necessary.

FACILITIES NEEDED TO MEET ALL OXIDE REQUIREMENTS

The Lake Linden Leaching Plant and Still House will not be able to produce, with present distillation facilities, the high tonnage of copper oxide required for the production of copper powder, and also make the various grades of oxide required for industrial and agricultural customers. Spray grade oxide could be made from the high cuprous oxide made for powder if it were reduced in size by some such fine grinding device as the Micronizer. To produce upwards of 2,000,000 pounds of copper per month for powder, and 300,000 pounds of copper for agricultural and industrial requirements, the following two plans are suggested:

1. <u>Reactivate the Tamarack Leaching Plant.</u>

   All of the industrial and agricultural grades of oxide would be produced at the Tamarack Plant, from either Ahmeek Mill concentrates, or a combination of concentrates and pure copper scrap. The Lake Linden Leaching Plant would operate at its average capacity producing only high cuprous oxide for copper powder. The Tamarack Plant would have enough capacity, in addition to that required for special grades of oxide, to contribute about 400,000 pounds of high cuprous oxide for the manufacture of copper powder.

   The advantages of this plan are as follows:

   A. Lowest capital outlay.

   The disadvantages of this plan are:

   A. Steam costs, for distillation, are over 150% of the Lake Linden steam costs.
   B. Cost of production would be about double Lake Linden costs.
   C. Drying and bagging equipment would have to be purchased.
   D. Oxide would have to be transported to Lake Linden for blending, or reduction to powder. Oxide handling setup at Tamarack is inefficient.
   E. The Tamarack Plant is not serviced by a C&H railroad.
   F. Duplication of labor when compared to Plan 2.

2. <u>Install Two New Stills, and Additional Drying and Bagging Equipment at Lake Linden.</u>

   Using this plan, four stills would be used to produce oxide for powder, and the fifth still would be used for production of the various industrial and agricultural grade requirements. Total production of copper would be about 2,300,000 pounds per month. Additional drying and bagging equipment, and enlargement of the Still House building would be involved.

   The advantages of Plan No. 2 are as follows:

   A. Lower cost of production.
      (1) Few extra men needed.
      (2) Lower steam cost.
      (3) Lower Material costs. Two circuits could be used.
      (4) Lower oxide handling costs.

The disadvantages of this plan are as follows:

A. Large capital outlay.
B. Building would have to be enlarged.
C. Operating three stills at a time would require up to 45,000 pounds of steamper hour and making up 45,000 pounds of water at the boiler house per hour.

CAPITAL AND PRODUCTION COSTS

This report will not go into any detail on costs, however, reasonable estimates have been prepared.

To reactivate the Tamarack Leaching Plant, capital expenditures would include the purchase of drying and bagging equipment, and repairing tank bottoms. This would cost about $30,000. If 750,000 pounds of copper in oxide is produced per month at Tamarack, the treatment cost would be from 4.0 to 4.5¢ per pound.

To equip the Lake Linden Leaching Plant and Still House to handle all of the copper oxide production requirements for both copper powder and oxide sales would require an expenditure in the order of $225,000 of which $25,000 would be needed in the Leaching Plant to adapt the present tanks for concentrate leaching. This $25,000 expenditure would be necessary at Lake Linden under either plan. About $200,000 will be needed to add two distillation units and accessory equipment in the Still House, and to make the necessary building alterations.

Treatment costs at Lake Linden will vary from 2.75¢ per pound at a 1,300,000 pounds per month production basis, to 2.0¢ per pound at a production level above 2,000,000 pounds of copper per month.

Ahmeek Concentrator

May 18, 1963

The Ahmeek Concentrator was built in 1909 consisting then of four stamp units and it was expanded to an additional four units in 1914. The Ahmeek Concentrator is situated on Torch Lake, its west boundary boarders M26 at Hubbell Michigan. A Rail Road Trestle crosses M26 at 84 feet above the main highway. Aproximately ten different Mine Ores are shipped from the various mines over the Division's Diesel Railway system. The ore shipped from the upper and lower Railway Systems converge at Lake Linden and continues to the Concentrator's 8 storage Bins each with a capacity of 900 tons. This centralized site was well chosen, providing ample gravity flow for ore treatment and suitable disposition of the Tailings in Torch Lake which is 130 feet deep.

The Concentrator employs eight similar units each treating about 35 tons of ore per hour, or a total of 6080 tons per day for the eight units. Both Amygdaloid and Conglomerate ore are successfuly treated at the concentrator. Extra grinding is required to liberate the finely dessiminated copper in the Conglomerate Ore.

The ore as received from the mines, is reduced in mine Jaw Crushers set at 4" and is deposited in the concentrator ore bins which is fed by gravity to each steam stamp by an attendant who regulates the flow of ore, sorts out the large mass copper, breaks the larger ore pieces with a sledge, and removes any debris from the ore.

The Nordberg Steam Stamp has a high and and a low pressure piston. Steam enters the high pressure piston at 170 pound pressure, the expended steam goes to a receiver and thence to the low pressure piston at about 40 pound pressure and ... the exhaust steam from the low pressure piston is used for power generation. The stamp shaft is connected to the piston rod and carries a stamp shoe weighing about 840 lbs. at the bottom of the shaft. ~~Shaft stroke is about 24".~~ A steel casing known as a mortar is properly lined. The mortar employes two screens (Front & Rear) with 5/8 round hole openings. These screens are removable for inspection. Splash pans also removable, cover the grates. The ore enters the mortar and is broken to minus 5/8 inch. As the ore is being broken by stamping, native copper nuggets form, are discharged through an hydraulic chamber from which it is removed during the shift, when the stamp is shut down for mortar inspection. The stamp strikes 105 blows/min. The Ni-hard stamp shoe weighs 840 lbs new and is replaced at about 500 lbs. These shoes last about 3 days on conglomerate ore and about 9 to 12 days in Amygdaloid ore. The stamp shoes are cast at our Division's foundry.

The material discharged from the mortar goes to 4 trommels with 3/16 inch round openings and the oversize after jigging to remove the free copper, goes to rigid Nordberg Rolls in closed circuit.

The minus 3/16 inch trommel product flows to Dorr Classifiers which forms a sand and slime product. About 1/2 of the slime is returned to the stamp mortar in order to conserve fresh water, avoiding dilution. A portion of the other half of the slimes goes to the primary ball mill and classifier circuit for density control of the classifier overflow and the balance is routed to the primary flotation machine.

The rake product (sand) from the Dorr Classifier is treated on Woodbury jigs to remove the free copper and the jig tailings after

dewatering in a shovel wheel are ground in an 8 foot by 72 inch Hardinge ball mill in closed circuit with a Dorr Classifier. Circulating load is about 200% and the grinding is minus 35 mesh.
The removal of the liberated copper from the closed circuit is effected by an hydraulic discharge to a Wilfley table and the tailings of the table are returned to the circuit. Grinding is done at 75 per cent solids and is diluted prior to becoming the flotation feed to about 30% solids by introduction of the primary slimes product and hydraulic water.

The entire mill product except for the very finest overflow of the Dorr Thickeners is treated by Primary flotation on 24 inch Denver 10 cell flotation machines. The first two cells make a rougher concentrate and the middling from the other eight cells is in closed circuit with the feed. The tailing of the flotation cells go to waste except for a small portion removed by an hydraulic classifier which is routed to a Wilfley table. This product makes a concentrate and a tail. The concentrates are recovered if any on the basement concentrating tables while the tails go to waste. The Pilot Table serves as a visible guide to the flotation operator enabling him to make proper reagent adjustments in the Primary Flotation Circuit.

The flotation Rougher concentrates are pumped to an esperanza type classifier, the heavier particles are conveyed from the classifier to a 4'x8' Dorrco filter from which the dried product is discharged directly into 20 ton hopper bottom mineral cars. This product runs about 11% moisture and about 40 to 45% copper and is shipped directly to the smelter by rail.

One additional flotation unit in the basement is employed for the entire mill which treats the overflows from the esperanza classifier, filter and the Primary Grinding

units overflows which have been settled by six basement thickeners forming a thickener underflow or feed to the Secondary Flotation machine fourth cell. The 6 Thickener overflow goes to waste.
The Concentrate from the Secondary Denver 10 cell Flotation machine is pumped to a 30 ft dia Dorr Thickener and the middlinging of the eight cells is recirculated to the first cell of the Secondary Flotation Machine. The Tailings of the Secondary Flotation machine are discharged as waste.

The Concentrate from the Secondary Flotation Machine settled in the concentrate thickener (Thickener Underflow) is pumped to the filter by a Dorrco Suction pressure diaphragm pump. The Concentrate Thickener Overflow is run to waste.

Enter here Data on Page #5

The Reagents used in the flotation machines consists of #250 Dowfroth, a Frother and xanthate, a collector. The xanthate 0.075 pound per ton floated, enters the circuit at the Dorr classifier pool and #250 Dowfroth 0.043 pounds per ton, at the classifier overflow. Supplemental #250 Dowfroth is added as required at the Flotation machine.
#2 Fuel Oil is also used, a few cc/min as required to the float feed launder.

The final Flot tail range about 1½ lbs per ton for Amygdaloid and about 2 to 2½ lbs per ton for the Conglomerate Ore. Tailing losses vary with the richness of the ore treated.
The losses are mostly in the coarser meshes (28 to 65 mesh) and are a factor of the degree of grinding.

The mill Recovery ranges about 92 to 95% with an overall mineral grade assaying about 75% Copper.

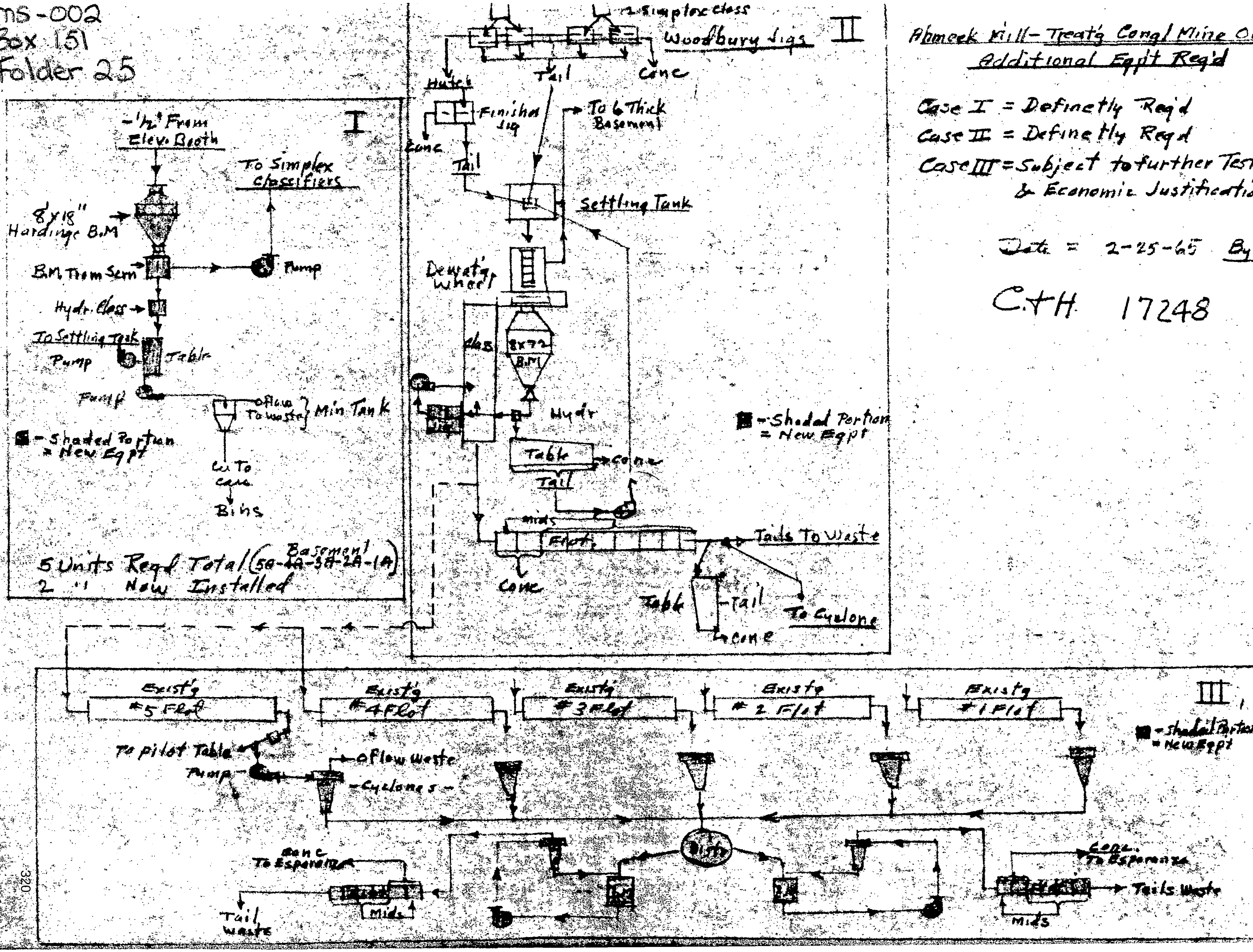
John J. Vittone
5/18/63.

Ahmeek Mill – Treat'g Cong'l Mine Ore
Additional Eqp't Req'd

Case I = Definetly Req'd
Case II = Definetly Req'd
Case III = Subject to further Test'g & Economic Justification

Date = 2-25-65 By J.J.V.

C+H 17248



MS-002
Box 151
Folder 25

CALUMET & HECLA, INC.
CALUMET DIVISION

Minutes of Meeting: Re: Revision of Ahmeek Mill to provide greater capacity.
Date: March 9, 1965 - for milling Conglomerate Ore
Time: 1:30 P.M.
Place: John Alico's Office

Present: John Alico, Lester Engle, Arne Hill, Laurence Kline, E. Matson, George Mehrens, Laurence Michel, John Vitton

This meeting was held to review the proposed flow sheet and to plan a program to carry out Phases I and II of this flow sheet.

The following items were brought out:

1. The existing and proposed ball mills in the basement of the South side shall be renumbered as 1a, 2a, 3a, etc. beginning from the West or highway side. Existing mills No. 9 and 10 shall be 4a and 3a.

2. Additional ball mills (new or used), Nos. 1a, 2a, and 5a, and their accessories, tables, pumps, etc. will be incorporated in Phase I.

3. New Mineral Jigs with accessories are to be installed in Phase II.

4. Phase III, a regrind program for further recovery, is not to be active (construction wise) at this time. Phases I and II will be active.

5. The activity sequence for Phases I and II as tentatively agreed to is:

   a. The catch basin pump pit and contents, which will interfere with unit 5a, are to relocated near the carpenter shop.

   b. The flotation machine which will interfere with units 1a and 2a is to be relocated near the Northwest end; and the moving of it is to be scheduled so that a minimum of actual moving is required during the next vacation shutdown.

   c. Ball mill No. 5a (8'x32") is to be moved from the Leaching Plant in Lake Linden. The installation can follow after the pump pit is relocated.

   d. Layout work for ball mills, 1a and 2a, cannot be completed until it is determined what mills will be used. Mill No. 2a will be installed prior to Mill No. 1a if these mills are brought in through the West wall.

   e. The installation of the jigs shall be done where practical in the schedule.

6. Crane facilities are desired for handling the ball mill liners, balls, etc..

7. The basement location for the ball mills is desired to save on foundation costs and provide more room.

8. The proposed ball mills should have large trunions for better flow of material.

9. Direct drive rather than the clutch system should be provided for the mills.

10. Ball Mill No. 5a and accessories installation must be completed by February 1, 1966 so as to be usable for experimental purposes for about 3 months. Mill No. 2a should be installed by October 1, 1966 and Mill No. 1a by January 1, 1967.

11. The chip chute will not need to be relocated.

12. Work to begin as soon as possible on M & C orders. However, a cost estimate is required for the entire project.

E. Matson

cc: JA
LFE
AWH
LCK
TWK
EDM
GHM ✓
LJM
JJV

CALUMET DIVISION
Calumet & Hecla, Inc.

Ahmeek Mill Project M. C. Order Numbers.

PHASE I.

0804 001 Purchase of Mechanical & Electrical Equipment - Phase I.

0804 002 Purchase and Installation of Power Facilities - Phase I.

0804 003 Construction of Ball Mill Foundations- Phase I.

0804 004 Mechanical & Electrical Installation of Ball Mills - Phase I.

0804 005 Construction and Installation of Launders - Phase I.

0804 006 Mechanical and Electrical Installation of Auxiliary Equip - Phaes I.

PHASE II.

0804 010 Purchase of Mechanical & Electrical Equipment - Phase II.

0804 011 Construction of Equipment Foundations - -Phase II.

0804 012 Mechanical and Electrical Installation of Denver Jigs - Phase II.

0804 013 Mechanical & Electrical Installation of Pumps & Piping - Phase II.

0804 014 Construction & Installation of Launders - Phase II.

0804 015 Purchase & Installation of Power Facilities - Phase II.

PHASE III.

0804 020 Purchase of Mechanical Equipment & Electriaal Equip. - Phase III.

0804 021 Construction of Foundation for Disbribution Tank - Phase III.

0804 022 Construction of Foundation for Ball Mills - Phase III.

0804 023 Constrution of Foundation for Cyclones & Floatation Mach.-Phase III

0804 024 Mechanical & Electrical Installation of Ball Mills - Phase III

0804 025 Mechanical & Electrical Installation of Cyclones - Phase III

0804 026 Mechanical & Electrical Installation of Floatation Mach. Phase III

0804 027 Mechanical & Electrical Installation of Pumps and Piping -Phase III

0804 028 Construction & Installation of Launders - Phase III.

0804 029 Mechanical & Electrical Installation of Auxiliary Equip. - Phase III

0804 030 Purchase & Installation of Power Facilities - Phase III.

MS-002
Box 78
Folder 9

Figure 1

AHMEEK MILL FLOWSHEET

(Crushing and Gravity Concentration)

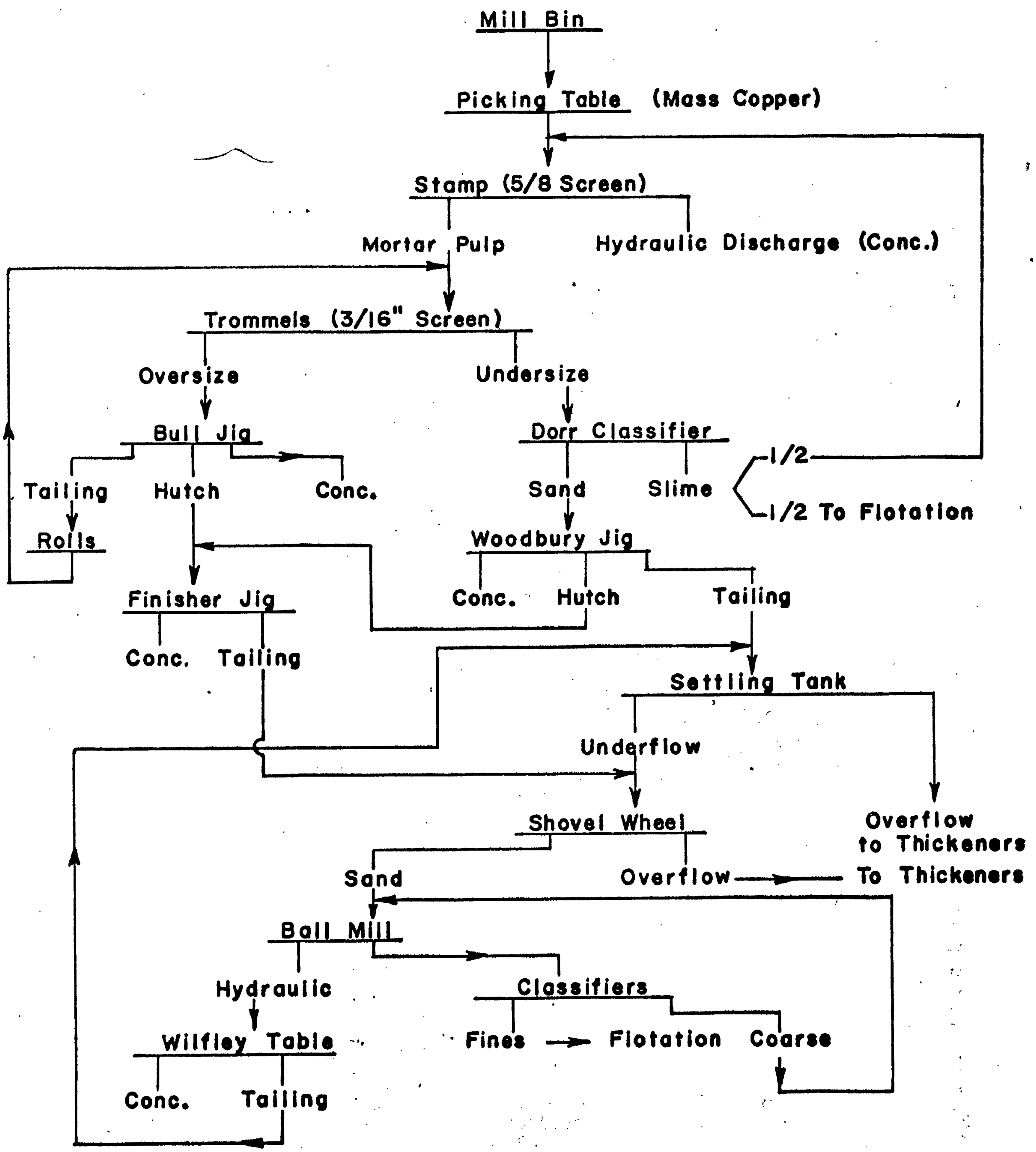
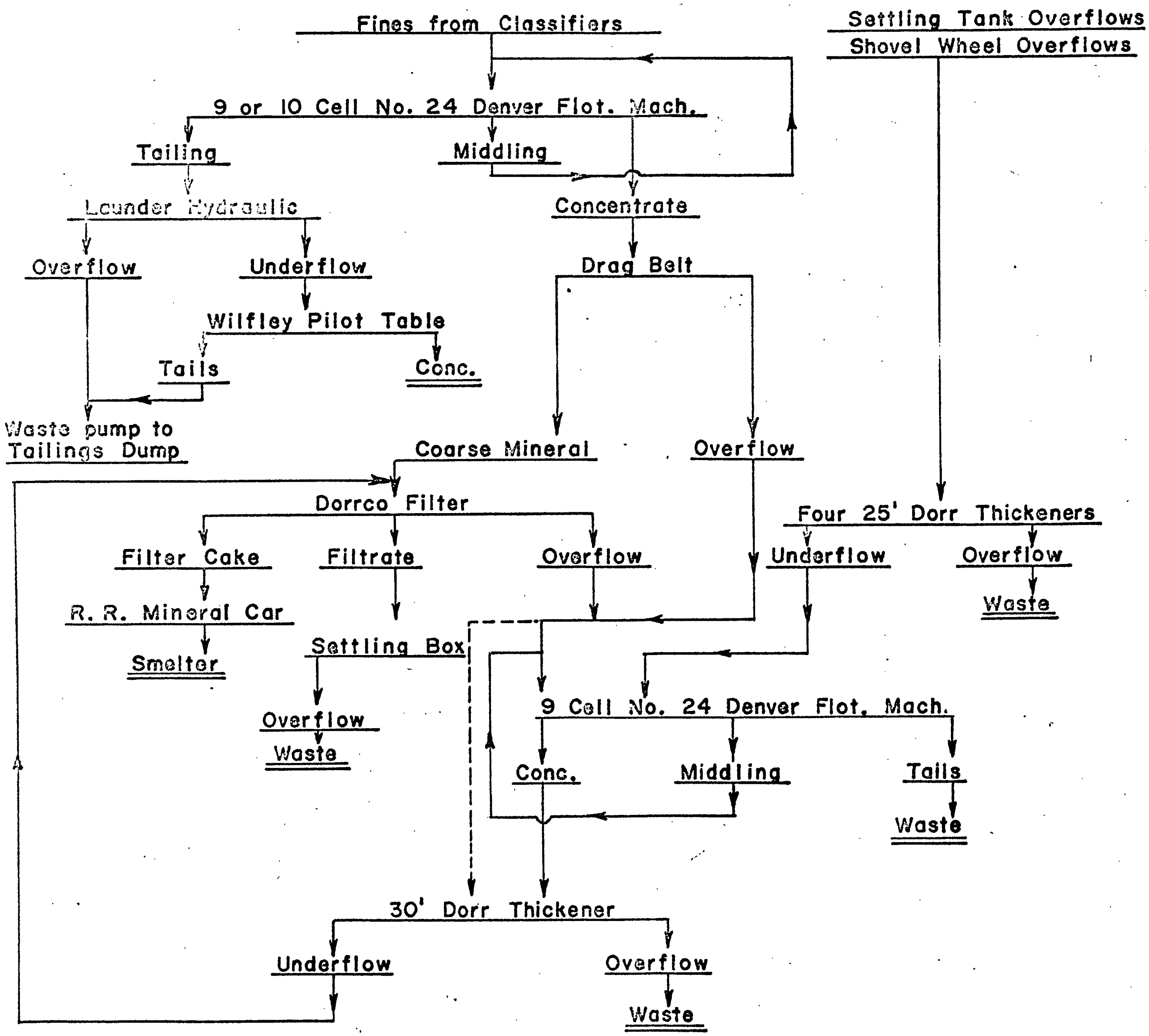


Figure 2

AHMEEK MILL FLOWSHEET

(Fines Concentration-- Flotation)



CALUMET DIVISION
Calumet & Hecla Corp.

AHMEEK MILL
Mineral Processing - Flowsheet
By J. J. Vitton
10/20/66

Introduction

The Ahmeek Mill concentrator consists of eight Units and is located at Hubbell, Michigan. Four units were constructed in 1908 and the remaining four units were installed in 1912 with Steam Stamps as crushers for each unit.

The concentrator was originally designed to treat amygdaloid native copper ore which consists of a great deal of mass and smaller coarse copper. Recent changes have been made in the Mill flowsheet in order to treat conglomerate ore as well as amygdaloidal ore. The capacity of the Mill with eight stamping units in operation is 5000 tons per 24 hours.

The Norberg Compound Steam Stamps are each rated at 300 H.P. The Steam Stamps are unique in the quantity of fines produced. About 50% of the minus 4-inch ore from the Mines is reduced to finished size (-35 mesh) and is ready for flotation. It would require two or three stages of gyratory crushing and one stage of rod milling or equivalent to equal the Steam Stamp reduction. The eight steam stamps are the only compound type in production in the world.

Flowsheet - Ahmeek Mill

The Ahmeek Mill flowsheet for processing amygdaloidal and conglomerate ores is shown on drawing No. 11898. The Mine ore is crushed in jaw crushers set at 4" at the Mine Shaft House and is delivered by the C&H Railroad to the Mill. The ore is dumped into eight (8) mill bins with a capacity of 800 tons each. The ore is fed into the Steam Stamps through chutes by gravity and by the Head Feeder Attendant who controls the flow of ore and removes any Mill mass copper before it enters the stamps. In the steam stamps, the ore is 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