1. DISTRIBUTION OF TIME

The following table shows the distribution of time for the year at the different properties and jobs and the percentage of time spent on each property:

TABLE VII

Property or Account	Total	%
Mining Engineering General	729.75	16.014
Bunker Hill Mine	568.25	12.470
Bunker Hill Mine Subsidence	38.00	.834
Cambria-Jackson Mine	16.50	.362
Cliffs Shaft Mine	419.25	9.200
Ohio Mine	70.00	1.536
Ore Improvement Plant	19.75	.433
Research Laboratory	.75	.016
Research Pilot Plant	3.00	.066
Tilden Mine	59.00	1.295
Morris Mine Inspection	5.00	.110
Canadian Cliffs - Project 17	.50	.010
Deferred Account - Empire	11.00	.241
Outside Exploration 1252	.25	.005
Outside Exploration 1429-C	.50	.010
E&A CC-822 (Fourth Addition - City of Negaunee)	2.00	.044
E&A CC-979 (Development - Bunker Hill Mine)	18.00	.395
E&A CC-980 (Development - Maas Mine)	2.50	.055
E&A CC-982 (Gladstone and Cornell Delta County Drilling)	7.25	.160
E&A CC-995 (Bunker Hill - Underground Development)	2.00	.044
E&A CC-23 (Pau Branco, Brazil)	2.25	.049

TABLE VII (continued)

Property or Account	Total	%
Republic Mine	517.00	11.346
Pelletizing Plant	30.50	.670
E&A MI-47 (House Moving - 1959)	11.00	.241
Mather Mine, "A" Shaft	715.25	15.696
Mather Mine, "A" Shaft Subsidence	2.50	.055
Mather Mine, "B" Shaft	683.25	14.993
Mather Mine, "B" Shaft Subsidence	6.75	.148
E&A NM-155 (Main Level Development - "A" Shaft)	54.50	1.196
E&A NM-156 (Underground Drilling Year 1959 - "A" Shaft)	14.75	.324
E&A NM-157 (12th to 9th Level Conveyor System - "A" Shaft)	42.50	.933
E&A NM-158 (10th to 12th Level Winze Development and Shaft Sinking - "A" Shaft)	40.00	.878
E&A NM-159 (Mining Conveyors, 10th Level - "B" Shaft)	23.00	.505
E&A NM-160 (Incline Conveyor Drift to 11th and 12th Levels - "B" Shaft)	16.00	.351
E&A NM-161 (Diamond Drilling Year 1959 - "B" Shaft)	11.00	.241
E&A NM-162 (Main Level Development - "B" Shaft)	39.00	.856
Humboldt Mine	62.75	1.377
E&A HM-43 (Stripping)	1.00	.022
E&A HM-44-A-1-g (Engineering and Administration - New Facilities - Shops, Office and Dry)	3.50	.077
E&A HM-44-B-1-a-2 (Field Engineering and Administration - Crushing Section)	.75	.017

TABLE VII (continued)

Property or Account	Total	%
E&A HM-44-B-2-a-2 (Field Engineering and Administration - Concentrating and Regrind Section)	6.75	.148
E&A HM-44-B-3-a-2 (Field Engineering and Administration - Agglomerating Section)	11.00	.242
E&A HM-44-C-d (Engineering and Administration - Power Distribution)	38.50	.845
E&A HM-44-E-e (Engineering and Administration - Water Supply)	15.50	.340
E&A HM-44-F-c (Engineering and Administration - Tailings Disposal)	160.75	3.528
E&A HM-44-G-12 (Engineering and Administration - General Surface)	73.00	1.602
E&A HM-45 (Diamond Drilling)	1.00	.020
	4557.00	100.000%

2. COSTS

The following table shows a comparison of costs for the Mining Engineering Department for the last three years:

TABLE VIII

	1959	1958	1957
Salaries	$153,461	$181,952	$261,552
Overtime & Special Allowances	0	45	4,269
Travel	940	510	567
Dues & Subscriptions	336	165	137
Telephone & Telegraph	1,386	683	806
Heat, Light, Power & Water	0	(9)	(32)
Furniture, Fixtures & Office Equipment	0	0	467

TABLE VIII (continued)

	1959	1958	1957
Payroll Taxes (Unemployment)	$ 2,238	$ 1,733	$ 812
Old Age Benefits Tax	3,338	3,254	2,360
Auto Expense	2,402	2,571	6,239
Entertainment	50	117	125
Field Equipment & Maintenance	867	845	1,405
Building Alterations	0	61	143
Repairs & Maintenance	296	150	375
Insurance	492	538	708
Postage, Express & Freight	76	56	108
Printing, Stationery & Office Supplies	3,106	2,224	5,785
Miscellaneous	441	397	(444)
Depreciation	5,454	5,569	6,881
Group Annuity	5,174	6,414	10,002
Property & Franchise Taxes	0	0	156
Totals	$180,057	$207,284	$302,421

B. AUTOMOBILES

The Ford Ranch Wagon (1956 model - #85) was operated by the Field Engineering Crew during the year. The Ford Ranch Wagon (1957 model - #115) was operated throughout the year by the Republic Mine Engineering Crew. The Chevrolet Carryall (1955 model - #69) was used for the transportation of underground personnel to and from the mines during the first half of the year. During the last half of the year, it was used by the Humboldt Mine Engineering Crew. The Plymouth Suburban (1957 model - #106) was used for general departmental use.

The following table shows the mileage covered in 1959, the total mileage to the end of the year and the date the cars were received in the Department:

TABLE IX

Car	Miles 1959	Miles Total	Date Received
Ford Ranch Wagon (1956 model), #85	8,736	47,645	6/1/56
Ford Ranch Wagon (1957 model), #115	17,809	45,204	5/8/57
Chevrolet Carryall (1955 model), #69	8,829	42,630	5/21/55
Plymouth Suburban (1957 model), #106	13,076	44,206	3/20/57

C. MAP REPORTS

Since the discontinuation of the bound volumes containing maps which show the yearly mining activities, such as, the advancement of the underground development and mining, the photographs of construction progress, the open pit cross-sections and the logs of diamond drill holes, the only manner in which this can be made of record is to print additional copies of the large scale, 1":50' mine working maps which are filed for future reference. In addition, the large scale drawings are substituted for the more convenient-size annual report maps in order to fulfill the map report requirements called for in the majority of the existing mining leases. These agreements stipulate that map reports showing the status of the various properties as of December 31 shall be submitted.

The following table shows the companies for which sets of working tracing prints were prepared and the Michigan mine or mines in which that company has an interest:

TABLE X

Company	Mines For Itself	Mines As Operating Agent
The Cleveland-Cliffs Iron Company	Bunker Hill Cambria-Jackson Maas Ohio Tilden Cliffs Shaft	Athens Humboldt Mather Republic
The Athens Iron Mining Company for Pickands Mather & Company		Athens
The Negaunee Mine Company Partner: Bethlehem Steel Company		Mather Mine, "A" Shaft "B" Shaft
Humboldt Mining Company Partner: Ford Motor Company		Humboldt

The printing of new maps on a quarterly basis rather than on a monthly basis has proven to be more adequate and economical with regard to both time and material. This has relieved the Mine Engineers of posting the tracings every month and gave the Mine Superintendents more of the Engineers' time for other work at the mine which was felt to be more important with the reduced number of engineering personnel.

At the end of each quarter, the Mining Engineers, assigned to the soft ore properties, inspected the underground workings and posted the quarterly mining progress, the advance of the development contracts and the diamond drill holes. Two sets of these quarterly progress maps were made; one set to be used by the Manager and the other set sent to the Superintendent for his use. Numerous prints of the various sub-level maps upon which there was active mining operations were printed, trimmed and folded to pocket size. These maps were carried by the Mine Captain, Foremen and Shift Bosses who used the maps in their day to day production planning.

The next few paragraphs describe the map reports sent out by the Mining Engineering Department:

ATHENS MINE

One set of quarterly progress maps, with mining advancement colored in red, was sent to Mr. E. L. Joppa, General Manager, Mines, of the Pickands Mather & Company throughout the year.

CLIFFS SHAFT MINE

One set of mining progress maps of the Bancroft and Section 10 Leases was forwarded to the Duluth Office of the Oliver Iron Mining Division after each of the Tri-Annual Surveys, showing the work done during that four-month period in color. The final issue of these progress maps for the year 1959 also showed the ore areas that were used in calculating the estimate of ore reserves as reported to the Michigan State Tax Commission.

HUMBOLDT MINE

Annual maps were sent to Mr. Harry B. Weber, fee-owner of the Weber Lease.

MATHER MINE

A complete set of working maps of both "A" and "B" Shafts was forwarded to Dr. Donald M. Fraser, Chief Geologist of the Bethlehem Steel Company, at the end of each quarter, showing the mining progress in color.

MICHIGAN STATE TAX COMMISSION

During the first part of September, copies of all maps which show any active workings were sent to Mr. Harry J. Hardenberg, Deputy State Geologist. Outlined on the maps were the known ore areas which were

used for calculating the ore reserve tonnages. A supplementary map report is sent to the Michigan State Tax Commission at the end of any year in which any large increase in ore reserves is discovered after the appraisal date of October 1. No such supplemental report was necessary for 1959. Upon the discontinuance of the making of the annual report-size prints, the large 50':1" working maps were prepared to be used as a permanent record of the ore reserve tonnages reported to the Michigan State Tax Commission. These are kept on file in the Ishpeming Mining Engineering Department.

NEGAUNEE MINE

Prints of the Bunker Hill main levels were sent to Negaunee Mine fee-owners. The yearly progress for 1958 was colored.

OHIO MINE

Because the Ohio Mine did not operate during 1958, the report to the State of Michigan stated that the figures as submitted for the previous year would remain the same for this year being reported.

REPUBLIC MINE

Quarterly reports, maps and cross-sections showing exploration, development and mining operations were sent to the Cleveland Office.

TILDEN MINE

Maps of the yearly mining progress, both stripping and ore operations, were sent to the Hanna Coal & Ore Company.

D. MINING LEASES - Robert G. Fountain

The following mining leases and options were executed and filed during 1959:

Lease No. 164 (A) -

Thirty-seven year mining lease from Cliffs to The Hanna Mining Company, dated January 1, 1959, covering an undivided 42½% interest in two parcels in Section 26, Township 47 North of Range 27 West (a part of the Tilden Mine).

Lease No. 164 (B)

Thirty-seven year mining lease from Cliffs to The Jackson Iron & Steel Company, dated January 1, 1959, covering an undivided 15% interest in the above parcels.

These two leases replace former Mining Lease No. 164 from Cliffs to Hanna covering an undivided 1/2 interest in the same descriptions, which lease was terminated December 31, 1958.

Lease No. 180

Three year option for ninety-nine year mining lease from Jessie W. Casey et al. to The Cleveland-Cliffs Iron Company, dated January 24, 1959, covering 1017.45 acres in various descriptions in Washington County, Missouri. Assigned on May 19, 1959, to Missouri Cliffs, Inc.

Lease No. 181

Three year option for one hundred year mining lease from Pittsburgh & Lake Superior Iron Company to The Cleveland-Cliffs Iron Company, dated February 10, 1959, covering mineral rights in the $SE\frac{1}{4}$ of the $NE\frac{1}{4}$, $SE\frac{1}{4}$ of the $SW\frac{1}{4}$ and the $SE\frac{1}{4}$ of Section 5, Township 40 North of Range 23 West, Cornell Area, Delta County, Michigan.

Lease No. 182

This number was assigned to the documents covering the Humboldt Mine, in particular the 1958 Stockholders' Agreement.

Lease No. 183

Federal Prospecting Permit No. BLM-A-045943, dated September 1, 1958, issued to H. C. Scott and John A Eversole, Potosi, Missouri, granting the right to prospect and a preference right to a mining lease under regulation 43CFR 200.37, covering 709.29 acres in various lands in Townships 37 and 38 North of Range 1 West, Missouri. Assigned on March 3, 1959, to Missouri Cliffs, Inc.

Lease No. 184

Federal Prospecting Permit No. BLM-A-046719, dated September 1, 1958, issued to H. C. Scott and John A. Eversole, Potosi, Missouri, granting the right to prospect and a preference right to a mining lease under regulation 43CFR 200.37, covering 271.40 acres in Section 3, Township 37 North of Range 1 West, Missouri. Assigned on March 3, 1959, to Missouri Cliffs, Inc.

Lease No. 185

Federal Prospecting Permit No. BLM-A-045703, dated April 1, 1958, issued to G. F. Cresswell and L. P. Kerruish, Potosi, Missouri, granting the right to prospect and a preference right to a mining lease under regulation 43CFR 200.37, covering 1570.38 acres in Townships 37 and 38 North of Range 1 West, Missouri. Assigned on February 28, 1959, to Missouri Cliffs, Inc.

Lease No. 186

Fifty year exploratory and mining lease from the Department of Conservation of the State of Michigan to The Cleveland-Cliffs Iron Company, dated June 10, 1959, covering 119.60 acres of fee ownership and 1379.20 acres of mineral ownership in Townships 40 and 41 North of Ranges 22 and 23 West, Cornell Area, Delta County, Michigan.

Lease No. 187

Three year option for one hundred year mining lease from Clayton C. Ford and wife to The Cleveland-Cliffs Iron Company, dated March 20, 1959, covering the NE¼ of the SW¼, Section 5, Township 40 North of Range 23 West, Cornell Area, Delta County, Michigan.

Lease No. 188

Three year option for one hundred year mining lease from A. P. Hertel and wife to Missouri Cliffs, Inc., dated April 4, 1959, covering 860 acres in Sections 15, 22 and 23, Township 38 North of Range 1 West, Washington County, Missouri.

Lease No. 189

Federal Prospecting Permit No. BLM-A-048606, dated June 1, 1959, issued to R. W. Robinson, granting the right to prospect and a preference right to a mining lease under regulation 43CFR 200.37, covering 2178.39 acres in Township 37 North of Ranges 1 East and 1 West, Missouri. Assigned on July 20, 1959, to Missouri Cliffs, Inc.

Lease No. 190

Federal Prospecting Permit No. BLM-A-048539, dated June 1, 1959, issued to R. W. Robinson, granting the right to prospect and a preference right to a mining lease under regulation 43CFR 200.37, covering 480 acres in Section 24, Township 38 North of Range 1 West, Missouri. Assigned on July 20, 1959, to Missouri Cliffs, Inc.

Lease No. 191

Three year option for one hundred year mining lease from Carlton L. Van Drese and wife to The Cleveland-Cliffs Iron Company, dated August 10, 1959, covering 140 acres in Section 4, Township 40 North of Range 23 West, Cornell Area, Delta County, Michigan.

Lease No. 192 (A)

Ten year mining lease from The Cleveland-Cliffs Iron Company to McLouth Steel Corporation, dated January 1, 1959, covering a 40% interest in the minerals in "Tract A", a portion of the Bunker Hill Property, Negaunee, Michigan.

Lease No. 192 (B)

Ten year mining lease from The Cleveland-Cliffs Iron Company to McLouth Steel Corporation, dated January 1, 1959, covering a 40% interest in the minerals in Parcels 1 and 2 of "Tract B", being portions of the Maas Mine and Pioneer & Arctic Lands in Negaunee, Michigan.

Lease No. 193 (A)

One year option from Dotson Minerals Corporation to The Cleveland-Cliffs Iron Company, dated July 8, 1959, granting Cliffs the right to purchase all of Dotson's ownership in forty unpatented lode mining claims and eight unpatented placer mining claims in Socorro County, New Mexico. Assigned on September 21, 1959, to New Mexico Cliffs, Inc.

Lease No. 193 (B)

One year option from Dotson Minerals Corporation to The Cleveland-Cliffs Iron Company, dated July 7, 1959, granting Cliffs the right to purchase Dotson's leasehold interest in forty unpatented lode mining claims in Socorro County, New Mexico. Assigned on September 21, 1959, to New Mexico Cliffs, Inc.

Lease No. 194

Three year option for one hundred year mining lease from Clayton C. Ford and wife to The Cleveland-Cliffs Iron Company, dated June 2, 1959, covering 120 acres in Section 5, Township 40 North of Range 23 West, Cornell Area, Delta County, Michigan.

Lease No. 195

Three year option for one hundred year mining lease from Octave J. Carignan to The Cleveland-Cliffs Iron Company, dated June 2, 1959, covering 220 acres in Section 4, Township 40 North of Range 23 West, Cornell Area, Delta County, Michigan.

Lease No. 196

One year option to purchase from Mackay Exploration Company to The Cleveland-Cliffs Iron Company, dated October 1, 1959, covering two patented and two unpatented lode mining claims in Custer County, Idaho.

Lease No. 197

This number reserved for Ausich Option, Idaho.

Lease No. 198

Ten year mining lease from The Cleveland-Cliffs Iron Company to The Jackson Iron & Steel Company, dated January 1, 1959, covering an undivided 7½% interest in the NW¼ of the SW¼ of Section 21, Township 56 North of Range 24 West, Itasca County, Minnesota.

The following mining leases and options were terminated in 1959:

Lease No. 174

Five year easement for ninety-nine year lease from Juneau County, Wisconsin, to The Cleveland-Cliffs Iron Company, dated July 15, 1958,

covering various descriptions in Townships 17 and 18 North of Ranges 3 and 4 East, Juneau County, Wisconsin. Surrender notice dated June 1, 1959, effective September 1, 1959.

Lease No. 175

Five year easement for ninety-nine year lease from Emil J. Duschek to The Cleveland-Cliffs Iron Company, dated August 12, 1958, covering the $N\frac{1}{2}$ of the $NE\frac{1}{4}$, Section 2, Township 17 North of Range 3 East and the $S\frac{1}{2}$ of the $N\frac{1}{2}$ and the $N\frac{1}{2}$ of the $N\frac{1}{2}$ of the $S\frac{1}{2}$, Section 36, Township 18 North of Range 3 East, Juneau County, Wisconsin. Surrender notice dated June 1, 1959, effective September 1, 1959.

Lease No. 176

Three year easement for ninety-nine year lease from Julie A. Small to The Cleveland-Cliffs Iron Company, dated October 4, 1958, covering the $NW\frac{1}{4}$ of the $NE\frac{1}{4}$, Section 25, and the $E\frac{1}{2}$ of the $NE\frac{1}{4}$ of the $NE\frac{1}{4}$, Section 26, all in Township 18 North of Range 3 East, Juneau County, Wisconsin. Surrender notice dated June 1, 1959, effective September 1, 1959.

Lease No. 177

Three year easement for ninety-nine year lease from Charles L. Krupa and wife to The Cleveland-Cliffs Iron Company, dated September 20, 1958, covering the $N\frac{1}{2}$ of the $NE\frac{1}{4}$ and the $NE\frac{1}{4}$ of the $NW\frac{1}{4}$, Section 1, Township 17 North of Range 3 East, Juneau County, Wisconsin. Surrender notice dated June 1, 1959, effective September 1, 1959.

Lease No. 178

Five year easement for ninety-nine year lease from T. E. Darrow and wife to The Cleveland-Cliffs Iron Company, dated September 19, 1958, covering various descriptions in Sections 1, 9, 12 and 23, Township 17 North of Range 3 East, and Sections 33 and 34, Township 18 North of Range 3 East, Juneau County, Wisconsin. Surrender notice dated June 1, 1959, effective September 1, 1959.

E. MINE SUMMARIES

1. BUNKER HILL GROUP - Bernhardt H. Petersen, Mining Engineer

The Engineering Crew at the Bunker Hill Group for the year consisted of an Operating Engineer and a Surveyor.

A resume of engineering activities at the Bunker Hill Group during the year of 1959 is as follows:

a. Complete ventilation surveys were made at the Bunker Hill Group in January and August-September with the assistance of the Safety Department. In November, a supplemental survey was made to incorporate the various changes made in the interim.

b. The Bunker Hill and Maas Shafts were gauged in the spring and fall and the Athens Shaft was gauged in the spring.

c. The northeast, southeast and west stockpiles were surveyed in October.

d. The 2600 Cross-cut was holed through to the 12th Level south drift. The results of the holing-through were excellent with respect to line and grade.

e. In an effort to evaluate the results of an underground water control program, daily moisture analyses were run on the Maas and Athens ores throughout the first half of the year.

f. The State Tax Ore Reserve Estimates were calculated in July.

g. During the strike period, the crew assisted in installing chain conveyors, new headframe scrolls for the north and south skips and the dismantling and replacing of two motors on the skip hoist generator set.

The balance of the time was spent on routine projects such as: establishing line and grade for development headings; quarterly surveys; quarterly maps; weekly, monthly and annual reports, Capital Expenditures Forecasts; E&A and R&M requests; production and cost of production estimates; steel and timber requirements; block estimates; block analyses; development and mining layout; and general mine operating problems.

2. CLIFFS SHAFT MINE - James P. Meyers, Mining Engineer

a. Engineering personnel gauged all the "C" Shaft runners, both counterweight and conveyance, twice during the year. The runners were gauged by the method which is standard at all other mines. The counterweight compartment runners were gauged by climbing through the shaft ladder road and measuring each set with a yardstick.

b. Tri-Annual Surveys were conducted, the maps posted and reports compiled and forwarded to the Oliver Iron Mining Division of the United States Steel Corporation.

c. Accurate production and analyses records were maintained throughout the year by the engineering personnel as per the 1954 mixing agreement between The Cleveland-Cliffs Iron Company and the Oliver Iron Mining Division of the United States Steel Corporation. All monthly analyses reports to the Lessor were prepared by the engineering personnel.

d. Engineering personnel spent some time on various performance studies conducted at the mine throughout the year. A number of studies were made on tests of several types of percussion drill machines and several types of tungsten carbide bits.

e. The annual estimate and report of proven ore reserves were prepared. The annual operating estimate of proven, probable and prospective ore reserves was prepared and reported. Several reports of other than routine nature were prepared and submitted.

f. Some time was spent planning and assisting in the operation of various pillar recovery projects throughout the year.

g. The routine underground surveys necessary for the mining and development contracts, the location and marking of lease boundaries underground, the location and noting of mining limit elevations and the resurveying of pillars in some old stopes were taken care of as called for throughout the year.

h. Results of all testing programs were tabulated and reported by the Mining Engineer. Several cost studies were made on crushing costs, screening costs, bit costs, truck maintenance costs, underground tractor-loader costs and wire rope costs.

i. A study of the productivity of the various teams of miners employed at the Cliffs Shaft Mine was made in the first quarter of the year. This study was made so that improvements in the mine's overall efficiency and productivity might be made in the future.

j. Geological plan maps and cross-section maps were posted once during the year by the engineering personnel. These maps are of use in planning development and mining.

k. Production estimates for the year were prepared for the mine as a whole and for the two leases. These estimates were submitted in letter form to management and the lessors, respectively.

l. Preparations were made for two arbitration hearings, and these hearings were attended. Various other labor and grievance problems were worked upon. Counter proposals to be used in contract negotiations, as pertaining to the Cliffs Shaft Mine, were prepared and submitted.

m. Screening practice at the mine was discussed and reviewed following a request for grade improvement. Further effort was also made underground in this respect.

n. Various fiscal budgets, production budgets and financial forecasts were prepared. A new economic study covering the remaining life of the property was prepared and submitted to management. This economic study entailed a review of labor needs for the current year and future years. Future reductions in working forces were studied together with attendant changes in mining activities.

o. Several comparisons were made of current and future expected occupational status of each individual employed. These comparisons, for all underground properties, were reviewed to check any inconsistencies between properties.

p. During the strike period, the Safety Department, with assistance from the Mining Engineer, made a ventilation survey of the mine. Maps of the survey were prepared and an investigation was made of the need for a second outlet from the mine. A program of local ventilation was carried out throughout the mine.

q. Studies were made of the removal of rock fill from several areas. The progress of the rock fill removal was checked and the areas were surveyed upon completion of the removal of the fill. Plans were made for future rock fill removal projects.

r. Considerable time was spent on the test work conducted on the various underground tractor-loaders throughout the year as new and different units were tried. Checks upon progress and various modifications of the units were made as testing continued.

s. Time was also spent upon numerous other projects, some of which are as follows:

(1) Maintaining tram car records.

(2) Checking fencing of idle and abandoned properties within the bounds of the Cliffs Shaft Mine area.

(3) Ventilation and air cleaning near the underground diesel tractor-loaders. (Devices - Exhaust Scrubbers)

(4) Monthly drill footage records and bit data.

(5) Stockpile surveys.

(6) Accident reports and investigations.

(7) Checking percussion drill machine maintenance and performance.

(8) Review of royalty payments, etc., in connection with Oliver Leases.

(9) Investigation of lower levels of the Moro Mine.

(10) Relocation of power line at No. 3 Shaft.

(11) Preparing prints of all geological maps for Oliver Iron Mining Division of the United States Steel Corporation Geologist in this area.

(12) Making new maps and tracings to replace worn out ones.

(13) Checking stockpile factors.

(14) Various other mine duties.

3. HUMBOLDT MINE - Harley E. Clickner, Mining Engineer

General

Construction of plant facilities for the Humboldt Mine expansion program was begun in the early part of May by the Arthur G. McKee and Western Knapp construction companies, and throughout the summer, construction work by these contractors continued to be the major source of activity at the property. Upon settlement of the AFL-CIO strike in November, a program of stripping and dike construction was placed in effect. This program commenced on November 9 on a one-shift basis and on November 13, a second shift was added. During the year, a total of 189,474 cubic yards of overburden was removed from the north central portion of the pit and utilized in the construction of dikes for McKinnon Lake tailings disposal area.

Engineering

During the early stages of the summer, only a very minor portion of the Engineer's time was spent at the Humboldt property, however, upon termination of activities at the Ohio and Tilden Mines on July 15, the Engineer's full time was devoted to the Humboldt project. Following is a list of engineering activities for the Humboldt Mine for the year 1959:

a. The area immediately east of the present stocking area was investigated as to its suitability for filling. It was necessary to blast the mat several times and remove a considerable amount of muck before the fill material could be properly stabilized.

b. The hilly area east of the pit was reconnoitered for a suitable route for a fresh water line from the Escanaba River to the mine water tank. A suitable route was picked, surveyed and marked for clearing. This route proved to be considerably shorter than a route west of the pit.

c. All dike areas for the McKinnon Lake tailings disposal area were marked for clearing and grubbing.

d. A new route for the pit power line was established and marked for clearing.

e. All clearing and grubbing for dikes, power lines and pipelines were supervised by the Humboldt Mine Engineering Staff.

f. Cross-sections necessary for pumphouse design were run at all pumping stations. Construction centerlines and benchmarks are being established at pumping stations as needed.

g. The general area near the McKinnon Lake tailings basin was quite thoroughly investigated for suitable borrow pit and access road locations for dike construction. A borrow pit in the northwest

portion of Section 15 was utilized for the construction of the large dike immediately east of Highway M-95.

h. In addition to the above, all survey control, layout work and records necessary to dike construction and general pit operations were furnished by the Mine Engineering Staff.

4. MATHER MINE

a. "A" SHAFT - Oiva W. Hakala, Mining Engineer

(1) Production for the year from the Mather Mine, "A" Shaft was 516,966 tons. Shipments for the year from the pocket and stockpile totaled 490,255 tons. Tons in stock as of the end of the year totaled 486,455 tons.

(2) Due to the steel strike, the mine was inoperative from July 14 until November 9. Supervisory personnel carried on maintenance work.

(3) During the strike period, the ore estimates were completed. On the basis of the ore estimates and, in view of the time element involved for the development of lower level reserves, it was recommended that the mine go on a reduced production schedule. The one-shift hoisting schedule planned made possible a new approach in the thinking as to how the lower levels should be developed. Subsequently, it was agreed that the main shaft, manway, pipe and cable compartments would be sunk on the afternoon and night shifts during the week and also on Saturdays and Sundays. The schedule permits fifteen shifts per week in the shaft. The sinking of the main shaft replaced the original plan of sinking a winze from the 10th Level. The main shaft will be deepened to the 12th Level elevation during the present sinking period. During November and December, careful inspection and maintenance of the shaft were carried out in preparation for the shaft sinking. A four-boom shaft jumbo was constructed in the mine shops. To enhance safety during the sinking period, a door was installed at the 9th Level elevation over the cage compartment. This door will be manually moved in and out as the cage approaches and leaves the 9th Level elevation. Rock from the shaft will be mucked out with a Cryderman shaft mucker and hoisted to the 9th Level with 70 cu. ft. buckets suspended below the cage.

(4) In addition to the shaft project, development during the year was carried on in the 12th to 9th Level inclined drift and on 10th Level. The 12th to 9th Level inclined drift advance totaled 673 ft. Very bad ground conditions were encountered at the end of the year. The 10th Level drift was advanced 494 ft. and holed through to the "B" Shaft heading on June 30

with excellent results in alignment and grade. Other work on the 10th Level consisted of excavating a short trench and a crusher box. Steel construction in the crusher box was under way at the year's end.

(5) Engineering duties performed during the year were as follows: providing lines and grades for development crews; posting of mine working maps; posting of ventilation maps; and printing of complete map sets and point maps for the mine supervisors. The annual task of surveying the stockpiles and calculating the tonnage of ore in stock was carried out during the strike. Shaft gauging was carried out twice during the year. In addition, alignment of the shaft skip guides was checked by plumbing in an effort to determine the cause of uneven and excessive wear. It was noted that spotty excessive wear could be correlated with misalignment.

(6) Other duties performed by the Engineer or Engineering Department were estimating supply requirements, estimating costs and budgets, planning present and future mine operations, checking on the operation of the mine and making weekly underground inspections.

b. "B" SHAFT - R. Charles Kincaid, Mining Engineer

(1) The Mather Mine, "B" Shaft's standard and special ore stockpiles were surveyed in the fall to determine the balance of ore in stock at the end of the shipping season.

(2) The main level drift on the 10th Level was connected with the Mather Mine, "A" Shaft on June 30.

(3) The Surveyor, assigned to this property, took care of the day to day surveying of the mining and development contracts, calculating surveying data and posting analysis maps.

(4) The shaft was gauged during the spring and fall by the Survey Crew.

(5) The Mining Engineering Department personnel conducted a check survey on the footwall heading on the 10th Level during the year.

(6) The Mining Engineer was responsible for writing weekly and monthly reports, figuring contract miners' incentive earnings, determining quarterly steel and annual timber requirements, laying out development and mining areas, calculating the Michigan State and Federal Tax Estimates and the 1960 production and cost estimates.

(7) Test hole drilling program continued throughout the year. The program required the presence of the Mining Engineer and Geologist to lay out, locate and report the data.

(8) A considerable amount of the Surveyor's time was required with the excavation for the 10th Level north and east mining conveyor.

5. OHIO MINE - Harley E. Clickner, Mining Engineer

General

Operations at the Ohio Mine commenced on April 6 and, during the early stages, consisted largely of pit dewatering and mill renovation activities. Pit dewatering operations were completed during the early part of June, however, the scheduled operating date of June 8 was postponed pending the settlement of labor negotiations with the AFL-CIO. As a result of this postponement, mining operations were confined to stripping in the eastern portion of the pit. During the year, a total of 113,589 cu. yds. of overburden was removed from this area. All mining operations at the Ohio Mine were terminated on the day shift of July 15 in accordance with the industry-wide AFL-CIO strike.

Engineering

General engineering at the Ohio Mine was routine in nature and consisted largely of supplying necessary layout and control for drilling and pit development. The majority of the Engineer's time was spent supervising drilling, blasting and pit dewatering operations.

6. REPUBLIC MINE - Robert J. Flynn, Mining Engineer

The engineering force at the Republic Mine during the past year consisted of one Engineer and one Surveyor.

Pit Work

a. The pit progress was surveyed on a monthly basis and the maps posted and distributed to the interested personnel.

b. The shovel location map was maintained during the year. This map shows the location of the ore removed each day. In addition to the shovel location, the metallurgical results are charted to provide an aid for predicting the types of ore which will be encountered in the lower benches. This information is also sent to the Pelletizing Plant.

c. The oxygen used in jet piercing is calculated on a monthly basis which aids the correlation of oxygen usage with machine-piercing time. It is also possible to determine any line loss which is experienced.

d. Testing was carried out during the year by increasing the oxygen flow from 10,000 c.f.h. to 12,000 c.f.h. with similar increases

in the other components. The results indicated some economical advantages in certain areas of the pit. As yet, the testing program is not complete.

e. Nineteen major field blasts were fired during the year with 14 being in ore and 5 in rock. These blasts contained 702 holes. The holes were surveyed, the water level checked, the volume and powder charge calculated and the loading of the holes supervised. The continual checking and dewatering of the blast holes has resulted in increased usage of prilled ammonium nitrate to 79.3% of the total powder used.

f. During the year, the mine engineering personnel assisted the Mine Geologist in the location of diamond drill holes and the mapping of outcrops.

g. A preliminary survey was made for an access road to the Park City area, and a study was made of the feasibility of hauling stripping from the Park City area to our present and proposed tailings areas.

h. Centerline and grade stakes were maintained during the construction of the 1560 haul road and the Park City access road now under construction.

i. Various projects completed during the year were:

(1) E&A maps for the extension of the tailings line, power line and oxygen line.

(2) The necessary pit records for the previous year's work.

(3) A 200' scale map showing the 1958 ore and stripping and new construction.

(4) Bench maps showing quantities of ore and stripping to be removed.

(5) Work on a permanent pit road.

(6) The 1960 ore and stripping requirements.

(7) Drilling and blasting schedule for 1960.

(8) The aero-section maps were brought up to date.

Tailings Area

a. Level boards were placed at various locations in the tailings pond and are checked monthly for the tails build-up.

b. A survey was made for the relocating of the 20" tailings line over the tracks and the eventual discharging of the tails at the present No. 2 dike.

c. A study was made of the life of the present tailings pond and the probable location of an expanded tailings pond.

d. Centerline and grade stakes were set for the dike and pipeline roads.

e. Water samples and weir readings were taken monthly at the assigned locations in the tailings system.

General

a. The layout of the extension of the "E" line wall of the mill was prepared and inspected during construction.

b. Benchmarks were established and a plan prepared for the checking of the rod and ball mills in the plant.

c. The engineering personnel helped provide watchman service during the strike period.

7. TILDEN MINE - Harley E. Clickner, Mining Engineer

General

Operations at the Tilden Mine commenced on a two-shift basis on May 18 and continued on that basis until June 2, at which time a third shift was added. Production continued on a three-shift basis until July 10, at which time production was terminated. During the 1959 operating season, a total of 206,113 tons of silica grade and 13,062 tons of low phos. grade ore was produced. Stripping operations commenced in the southwest portion of the West Pit on July 7 and continued until the AFL-CIO strike on July 15. The portion of the orebody exposed by stripping contains numerous stringers of intrusive, which tends to indicate that the large hangingwall intrusive may extend somewhat further to the south than was formerly believed.

Engineering

As at the Ohio Mine, engineering work at the Tilden was quite routine in nature and consisted largely of supplying elevations necessary for drilling and blasting control. A large majority of the Engineer's time was spent in supervising the drilling and blasting operations.

F. MISCELLANEOUS ACTIVITIES

1. FIELD ENGINEERING CREW - LeRoy Hosking and Frank A. Koski, Engineers

a. Eagle Mills Area

(1) Ore Improvement Plant

(a) At the Ore Improvement Plant, cross-sections were run and estimates were made of the material to be moved and the cost of the expansion of the stocking area.

(b) Levels were run and elevations were plotted of the areas required for the proposed expansion of facilities. The stockpiles were surveyed and estimates made of the ore in stock.

(2) Pelletizing Plant

(a) Annual report maps of the area were posted to date.

(b) Elevations of the stocking area were posted and stockpile surveys were made and plotted. Estimates were made of the amount of pellets in stock.

(c) A permanent base line was established to facilitate the future checking of the alignment of the travelling grate.

(3) Pilot Plant

(a) Lines and levels were established for the installation of various pieces of equipment in the plant.

(b) The tailings line was realigned from the plant to the basin to obtain a better flow of tailings through the line.

b. Cascade District

(1) Base line points were located and levels run to establish the necessary horizontal and vertical control for the preparation of maps from aerial photographs of a proposed plant site for the Empire Mine.

(2) Various surveys in the Palmer Area were calculated.

(3) Coordinates were posted on the new aerial maps.

(4) A check survey was run on a portion of the south line of Section 27, 47-26. The boundaries of a Pittsburgh & Lake Superior lease in Palmer were checked.

c. Tilden Mine

(1) The annual pit survey was made and posted on the mine maps and cross-sections.

(2) Survey control points were replaced in the pit area.

d. Lloyd and Section 6

(1) These areas were inspected for evidence of new subsidence.

e. Bunker Hill

(1) The annual report maps were posted and several surveys were recalculated.

(2) The regular subsidence checks were run.

f. Athens

(1) Several surveys were recalculated, the regular subsidence checks were run, and a new tracing made for subsidence records.

g. Maas

(1) Regular subsidence checks were run in the area and surface surveys run and posted.

h. Ohio

(1) The annual pit survey was made and posted (stripping only).

i. Mather Mine, "A" Shaft

(1) Regular subsidence check surveys were made and posted.

(2) Posting was done on the annual report maps.

j. Mather Mine, "B" Shaft

(1) Regular subsidence check surveys were made and posted.

(2) Posting was done on the annual report maps.

(3) A portion of the north line of Section 1, 47-27, was run to establish limits of the waste dump.

k. Cliffs Shaft

(1) Assistance was given in keeping up the analyses reports and in making the Tri-Annual Surveys.

l. Republic

(1) Annual report maps were posted.

(2) A map was assembled of the area in which the proposed tailings pond expansion will be made.

m. Humboldt

(1) Preliminary estimates were made of rock excavation quantities for the proposed expansion project.

(2) Annual report maps were posted.

(3) New plan maps and cross-sections were made.

(4) Considerable work was done on various road and mining plans based on new pit sections, road locations and pit development.

(5) A field check was made of elevations in the pit and haul road areas.

(6) Base lines were run and profiles run and plotted of the boundaries of the new tailings pond.

(7) A traverse was run on County Road 601 near the mine and possibilities of relocation were investigated.

(8) Surveys were made, calculated and plotted of the property lines of adjoining parcels of land.

(9) Levels were run through the McKinnon Lake area and west through the Mud Lake area to investigate the possibility of diverting the surface drainage in that direction.

(10) Surveys were run for estimating and construction of various tailings lines, pole lines, water supply lines, clearing areas, dikes, etc. Considerable field work was done on construction for contractors outside of the mill area. In the mill area, permanent base lines and benchmarks were established for the use of the principal contractors.

(11) Control surveys were extended in the pit and adjoining areas and miscellaneous base lines and profiles were run for tailings lines, pumphouses, Escanaba River water supply, etc.

(12) Estimates were prepared of work which would be done by the Humboldt Mining Company.

(13) Numerous drawings were made for crossing permits from railroads, utilities and State and County Road authorities.

(14) Plans were made of the drainage and sewage s ystems necessary for the mill and office area.

n. Republic Township

(1) Several lots in the new townsite were surveyed, sewer and water connections located and grades set for the year's house moving program.

(2) A site for the proposed new municipal water storage tank was tentatively chosen.

(3) A study was made of the Williams and Works' report of the Republic Township water problems.

o. Ishpeming Township

(1) Considerable work was done in connection with the proposed sewage collection and disposal system under consideration for the areas between North Lake and the City of Ishpeming.

p. Railroad Relocation

(1) A general reconnaissance survey was made of the area from east of Negaunee to west of Ishpeming.

(2) For preliminary control, a line was run from the Teal Lake Location to the Mud Lake area in Ishpeming. Through the Cambria Cave several permanent points were set for the checking of subsidence in this apparently active area. These were checked twice during the year.

(3) Estimates of quantities and costs were made in regard to various location possibilities.

(4) A composite map of Section 6, 47-26, and Sections 1 and 2, 47-27, was prepared showing the various relocation possibilities, ore reserves, underground mining limits and mining plans and schedules in relationship to present railroad locations.

(5) A field check was made of the materials used in the work already done on the DSS&A's "Old South Main" relocation near the Jackson Mine.

q. Negaunee District

(1) Calculations were carried on for the triangulation coordinate system.

(2) A map was prepared of the various lease descriptions in the SW¼ of Section 31, 48-26.

(3) Surveys were made of lots in the Cliffs Third and Fourth Additions to the City of Negaunee.

(4) Check levels were run over a system of pins in the east Maas Cave area where the possibility of a road location is being investigated.

(5) Numerous meetings were held with Negaunee City officials regarding municipal problems such as the elevation of the Teal Lake water supply, site for the proposed elevated water storage tank, subsidence damage and repair, etc.

(6) A study was made of the possibility of disposing of surface water from the Mather Mine, "B" Shaft area by pumping the entire output of the wells and Partridge Creek into Teal Lake, thus eliminating the necessity of further pumping at other mining properties, and also augmenting the Teal Lake water supply, which apparently was being lost. An arrangement was agreed on whereby the City furnished and installed a 10" pipeline from Partridge Creek sump to Teal Lake, and The Negaunee Mine Company diverts the pump discharge into this line. The Negaunee Mine Company also arranged for the elimination of several sources of contamination which were being discharged into Partridge Creek by various tenants of Company-owned houses.

r. Ishpeming District

(1) Several surveys and resurveys were made and maps prepared in connection with the sale of a site for the new National Guard Armory in North Ishpeming.

(2) A site was located for the Tilden Township's garbage dump.

(3) Additional work was done on the Ishpeming Township sewage problem.

(4) Proposed improvements in the Seventh Addition to the City of Ishpeming were checked for special assessment purposes.

s. Delta County

(1) Two drill holes were located in the Cornell area in Section 5, 40-23.

t. Miscellaneous

Miscellaneous jobs worked on during the year included:

(1) Temperature calculations for the Project Engineering Department.

(2) Assisted in moving the Land Department.

(3) Attended Board of Review meetings at several places.

(4) Printed, monthly, quarterly and annual report maps.

(5) Made signs for the various departments.

(6) Adjusted and cleaned surveying equipment.

(7) Annual reserve estimates.

(8) Located and mapped various land descriptions for sale and lease.

(9) Worked on Canadian maps for Project Engineering Department.

(10) Made innumerable trips to various airports.

(11) Assisted with the maintenance of the General Office Buildings.

2. ORE ESTIMATES

The following table shows a comparison of the tonnages as reported to the Michigan State Tax Commission:

TABLE XI

Mine	Tons As of 8/31/59	Tons As of 8/31/58
Athens	173,620	251,757
Bunker Hill	3,202,438	4,220,275
Cambria-Jackson	0	83,743
Cliffs Shaft	819,134	863,425
Maas	1,345,201	1,543,865
Pioneer & Arctic	484,191	1,291,258

TABLE XI (continued)

Mine	Tons As of 8/31/59	Tons As of 8/31/58
Mather,		
"A" Shaft	6,999,477	7,008,600
"B" Shaft	11,627,742	11,690,245
Total Developed Ore	24,651,803	26,953,168
Undeveloped Reserves		
Section 3, 47-27	302,378	302,378
Grand Total All Ores	24,954,181	27,255,546

The above total does not include the open pit properties as they are valued according to the Low Grade Iron Ore Bill, House Bill No. 315.

3. STOCKPILES

Estimates of the ore in stock were made by the Mining Engineering Department at the Bunker Hill--Maas, Cliffs Shaft, Republic and Tilden Mines, Mather Mine, "A" and "B" Shafts and the Pelletizing Plant.

The following table shows the comparison of the ore in stock on November 1, 1959 and November 1, 1958:

TABLE XII

Mine	November 1, 1959	November 1, 1958
Bunker Hill	73,507	154,790
Cambria-Jackson	0	35,781
Cliffs Shaft		
Lump	114,931	87,839
#1 Crushed	59,950	39,585
Humboldt	27,163	96,467
Lloyd	111,356	111,356
Maas	142,110	108,650
Mather,		
"A" Shaft	553,484	402,812
"B" Shaft	430,535	463,655

TABLE XII (continued)

Mine	November 1, 1959	November 1, 1958
Ore Improvement Plant	47,363	0
Republic	59,438	55,209
Pelletizing Plant	81,228	5,704
Tilden	196,869	70,403
Totals	1,897,934	1,632,251

4. SHAFT GAUGING

The runners in the various operating shafts were gauged on the dates shown on the following table:

TABLE XIII

Mine	Date
Athens	April 23
Bunker Hill	April 18 October 20
Cliffs Shaft (including counterweight runners)	January 14 & 16 July 27 & 29
Maas	April 21
Mather, "A" Shaft	April 4 October 9
"B" Shaft	April 18 September 2

5. SUBSIDENCE

Two meetings of the Mather Mine Subsidence Subcommittee were attended during 1959. One meeting was attended on the Bunker Hill--Maas subsidence during 1959.

During the year, the usual spring and fall surveys of the iron pin grids were run. There were no additions made to these grids during the year. There were no unusual or appreciable changes in the eleva-

tions of the iron pins. The line of pins established across the Cambria Cave at the approximate location of the proposed railroad route was checked twice during the year.

No further consideration was given to triangulation control of the iron pin grids. In order to do so, a considerable amount of additional survey and triangulation work is necessary. The reduction of personnel during 1958 left the Department with insufficient personnel for projects of this nature.

6. RAILROAD RELOCATION

During 1959, the major activity in connection with the railroad relocation concerned the invoices received from the C&NW and DSS&A covering the necessary rehabilitation of the "Old South Main" and new construction on the west end of the westerly section of Phase I.

On August 20, a meeting was held in Chicago attended by representatives of Cleveland-Cliffs, C&NW, DSS&A and LS&I. The purpose of the meeting was to review everything which had been completed to date and to discuss the future of the relocation project. Questions had been raised in connection with the allocation of the expenditures incurred by both railroads. The result of the meeting was an agreement to the effect that all expenditures to date would be allocated between the C&NW, DSS&A and Cleveland-Cliffs in accordance with the terms of the 1956 Memorandum of Understanding. Because of changed conditions, the original proposed relocation in two phases would be abandoned. That which had been completed would be considered as Phase I and any future move would be considered as Phase II.

In September, a meeting was held in Marquette with the DSS&A to discuss the allocation of costs incurred by the DSS&A. The railroad had submitted to Cliffs a statement of costs incurred to date. A review was made of each item in the statement to determine the allocation which is to be made in terms of the 1956 Memorandum of Understanding. At the same meeting, a revision of the agreement between the DSS&A and Cleveland-Cliffs was proposed concerning the reimbursement of that portion of the DSS&A's share of the relocation costs which was to be advanced by Cleveland-Cliffs. Under the 1959 relocation in connection with the Tracy Mine, certain tonnages from the Tracy Mine were assigned to the C&NW, DSS&A and LS&I. As a means of facilitating reimbursement to Cliffs, a portion of the tonnage assigned to the LS&I was reassigned to the DSS&A. See Figure 1.

7. TRIANGULATION - Maxwell H. Madsen, Engineer

Computations for the adjustment of quadrilaterals by the least squares method were completed. This work had been started in the fall of 1958. The side equation tests were applied to the quadrilaterals and the weakest angles determined. These angles should be turned again in the

FIGURE 1
MINING ENGINEERING DEPARTMENT
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Railroad Relocation

field. Some field reconnaissance is necessary to extend the triangulation net into the Empire and Cascade areas. A second base line should be established to enable adjustment of the entire net.

Computations of the traverses between Mather Mine, "A" and "B" Shafts were made. These traverses were balanced by the Crandall Method. This work was done to eliminate tedious calculations for holing-through jobs on lower levels.

8. VENTILATION - Daniel P. Isaacson, Engineer

The Safety Department made ventilation surveys at the underground mines on the following dates:

Mine	Date
Bunker Hill--Maas	August 31; September 1, 2 and 4, 1959
Bunker Hill	November 5, 1959
Cliffs Shaft	July 27, 28, 29, 30 and 31, 1959
Mather Mine, "A" Shaft	September 15, 16, 17, 18 and 21, 1959
"B" Shaft	July 21, 22 and 23, 1959

The results of the Maas Mine survey were posted on the 2nd Level Bunker Hill (1":100') map. Duplicate copies were made so that one could be filed in the Engineering Department and the other filed at the mine office as a fire map for use by the mine supervisory personnel. No problems exist in connection with the ventilation of the Maas Mine. There is one large fan on the 2nd Level drawing air from the Bunker Hill Shaft, blowing the air through the workings and exhausting the air up the Maas Shaft.

Deficiencies found in the August 31, September 1-4 ventilation survey at the Bunker Hill Mine were corrected and a second survey was made on November 5, 1959. Data from this survey was posted on the 10th Level, 12th Level and 14th Level Bunker Hill (1":100') maps. Duplicate copies were made for the Engineering Department and the mine office. Ventilation of the Bunker Hill Mine is assisted by the use of a fan on the 10th Level near the Athens Shaft drawing air from the Bunker Hill Shaft on the 12th and 14th Levels, passing air up to the 10th Level and exhausting air up the Athens Shaft. Data from both the Maas and Bunker Hill ventilation surveys was also posted on a "Generalized Cross Section through Athens, Bunker Hill and Maas Mines" (scale 1":200') filed in the Engineering Department.

The results of the Cliffs Shaft ventilation survey were posted on one set of 1":50' regular working maps and filed in the Engineering Department. The set consists of the following maps:

Map of Surface showing Limit of Underground Workings
1st Level "B" Shaft
2nd Level "A" Shaft
2nd Level "B" Shaft
5th Level Section 10
5th Level "A" Shaft
5th Level "B" Shaft
6th Level "A" Shaft
8th Level Section 10
8th Level "A" Shaft
10th Level Section 10
10th Level "A" Shaft
10th Level "B" Shaft
15th Level "A" Shaft
15th Level "A" Shaft

A block diagram cross-section was also made to trace the volume and direction of air movement. Fresh air is forced into the mine by a fan on surface at old "K" Shaft. Another fan on 6th Level draws air from the old Incline Mine. Numerous openings and large stope areas make it difficult to check all of the air movement. The balance of air intake against exhausted air up "A", "B" and "C" Shafts was reasonable.

The Mather Mine, "A" and "B" Shafts' ventilation surveys were posted on a special set of ventilation maps for the Mather Mine (scale 1": 200'). The following maps are in the set:

2nd Level	7th Level
3rd Level	8th Level
5th Level	9th Level
6th Level	10th Level

Duplicate sets are available on file in the Engineering Department and at the Mather Mine, "A" and "B" Shafts. A copy of the "Generalized Cross Section through Mather Mine" was also posted and is on file in the Engineering Department.

Air enters the mine through "B" Shaft and exhausts up "A" Shaft. A new program to increase the volume of air in the mine is under way to improve ventilation. Particular emphasis is placed on "A" Shaft which literally "eats" "B" Shaft's smoke. At the conclusion of the improvements in the ventilation system of the Mather Mine, a new ventilation survey will be made and the maps will be posted up to date.

A check was made of the natural air movement at all of the properties with all fans idle. The volume and direction of air flow was posted in blue figures on the respective sets of maps.

G. HOUSE MOVING ACTIVITIES - Donald W. Carlson

A total of fifteen houses was moved in the Republic area in 1959 at Company expense.

Indicated in red on the maps in Figures 2 and 3 are the houses moved by the Company in 1959; in green the houses torn down; in blue the houses sold for salvage in 1959; in brown real estate purchased in 1959; and in yellow the houses removed in 1958 for salvage.

In 1959, the following transactions took place:

15 houses were moved (14 to Plat and 1 to privately-owned land).

3 houses being removed on "tear-down" agreements.

4 houses were purchased outright.

8 Company houses were sold for salvage.

1 house and lot on real estate was purchased and is being rented.

H. MICHIGAN AD VALOREM TAXES - Donald W. Carlson

During the year, Mr. Magnuson continued to have the responsibility for the Michigan Ad Valorem Taxes. Thus the consolidation of making the estimates of ore reserves for mine valuations, the preparation of the tax lists, the recording of valuations on non-mining properties, the requesting of checks and the payment of taxes due continued. The normal sequence of events from the establishment of valuations through to the payment of taxes held throughout the year. The mine valuations were calculated by Harry J. Hardenberg, State Mine Appraiser, and were submitted by him to the local assessors by February 15. The conference between the Mine Appraiser and Company representatives was held in Lansing on January 16. At this conference, an opportunity is afforded the mining company to discuss the mine valuations before they are reported to the local assessors. Any data which will have an effect or should be reflected in the calculations of the mine valuations are discussed. It is sometimes possible to get the Appraiser to make changes in his tentative valuations. During the early part of March, the local Boards of Review in each city and township hold public hearings to permit the taxpayers an opportunity to view the assessment rolls. At this time, the valuations of non-mining properties are established. If necessary, it is possible to protest valuations which have been established by the local assessors. In 1959, no unusual protests were made. The meetings of the Boards of Review in the following cities and townships were attended by Company representatives:

FIGURE 2
MINING ENGINEERING DEPARTMENT
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Republic House Moving

FIGURE 3
MINING ENGINEERING DEPARTMENT
ANNUAL REPORT
1959

Republic House Moving

TABLE XIV
ATTENDANCE AT MEETINGS OF BOARDS OF REVIEW

Assessing District	Date	Name of Representative
Champion Township	3/3/59	Donald W. Carlson LeRoy Hosking
Humboldt Township	3/3/59	Donald W. Carlson LeRoy Hosking
Ely Township	3/3/59	Donald W. Carlson LeRoy Hosking
Tilden Township	3/3/59	Donald W. Carlson LeRoy Hosking
Sands Township	3/3/59	Donald W. Carlson LeRoy Hosking
Marquette Township	3/3/59	Donald W. Carlson LeRoy Hosking
Crystal Falls Township	3/4/59	Donald W. Carlson LeRoy Hosking
Iron River Township	3/4/59	Donald W. Carlson LeRoy Hosking
Mansfield Township	3/4/59	Donald W. Carlson LeRoy Hosking
Hematite Township	3/4/59	Donald W. Carlson LeRoy Hosking
Bates Township	3/4/59	Donald W. Carlson LeRoy Hosking
Mastadon Township	3/4/59	Donald W. Carlson LeRoy Hosking
Negaunee Township	3/5/59	Donald W. Carlson LeRoy Hosking
City of Ishpeming	3/5/59	Donald W. Carlson Robert G. Fountain
Spurr Township	3/9/59	Donald W. Carlson Ralph E. Magnuson, Jr.
Michigamme Township	3/9/59	Donald W. Carlson Ralph E. Magnuson, Jr.

TABLE XIV (continued)
ATTENDANCE AT MEETINGS OF BOARDS OF REVIEW

Assessing District	Date	Name of Representative
Republic Township	3/9/59	Donald W. Carlson Ralph E. Magnuson, Jr.
City of Negaunee	3/9/59	Donald W. Carlson Ralph E. Magnuson, Jr.
Ishpeming Township	3/9/59	Donald W. Carlson Ralph E. Magnuson, Jr.
Forsyth Township	3/9/59	Robert G. Fountain LeRoy Hosking
Richmond Township	3/9/59	Robert G. Fountain LeRoy Hosking
Village of Mineral Hills	3/20/59	Donald W. Carlson
City of Iron River	3/24/59	Donald W. Carlson
City of Marquette	3/24/59	Donald W. Carlson

Representatives of the Land Department attended the Board of Review meetings in the following townships to check the rolls for the Mining Department:

TABLE XV

AuTrain Township

Limestone Township

The properties in the townships which lie beyond the iron-formation are Electric Power Department's lands and power installations.

In October, the County Board of Supervisors at their annual meeting established the budgets for the county, townships and school districts within the county. These budgets along with the valuations which have been established provide the mill rate.

With the above information and the tax list, tax receipts were prepared for each city and township. These tax receipts were delivered or mailed to the various treasurers who filled in the valuation for each description, the mill rate and the tax due. After the completed tax receipts were returned, the information was checked against the data obtained from the rolls of the Boards of Review as to valuation, the mill rates checked against the County Board of Supervisors' report on mill rates and the estimate of tax due was checked. Next, a request was prepared and submitted

to Cleveland for the necessary checks to cover the taxes which were due. Michigan Ad Valorem Taxes are due and payable as of December 10 and a penalty is imposed after January 19. The request for checks were submitted early enough to permit the checks to be delivered in Ishpeming near the end of 1959. All checks were delivered during the first week of January. The tax receipts were stamped paid by the various treasurers at the time the checks were delivered. The following table is a tabulation showing the 1959 valuations as compared to the 1958 valuations:

TABLE XVI

Mine	Valuation 1959	1958
Cliffs Shaft	$ 4,260,000	$ 4,780,000
Cambria-Jackson	205,000	395,000
Mather Mine, "A" Shaft	9,265,000	8,830,000
"B" Shaft	10,835,000	10,345,000
Maas (including Pioneer & Arctic and Race Course)	2,370,000	2,585,000
Athens	450,000	655,000
Bunker Hill	2,460,000	2,595,000
Humboldt	1,178,000	1,422,000
Ohio	325,000	392,000
Republic	1,547,000	1,756,000
Tilden	325,000	345,000
Pelletizing Plant	1,281,000	1,330,000
Ore Improvement Plant	445,000	490,000
Totals	$34,946,000	$35,920,000

The next tabulation shows the amounts requested to pay the taxes as of January 19, 1960:

TABLE XVII

Assessing District	1959 Valuation	1959 Taxes	1959 % of Total*	1958 Valuation	1958 Taxes	1958 % of Total*
City of Ishpeming	$14,755,050	$703,815.94	60.48	$14,851,500	$689,109.60	60.88
City of Negaunee	16,650,460	832,439.79	66.80	16,898.795	774,023.97	66.60
City of Marquette	238,510	11,658.40	.98	238,510	10,974.09	1.00
Champion Township	44,780	1,447.28	2.85	44,780	1,259.50	2.27
Ely Township	18,750	624.97	.55	18,750	603.20	.52
Forsyth Township	188,675	7,241.35	11.40	190,840	7,295.81	11.67
Humboldt Township	1,185,050	38,001.59	73.49	1,429,350	39,844.59	76.27
Ishpeming Township	164,735	4,850.11	8.89	165,560	4,556.66	9.58
Marquette Township	609,815	20,017.19	29.90	609,665	15,609.58	30.73
Michigamme Township	21,050	940.83	1.97	21,050	916.35	1.98
Negaunee Township	2,512,521	82,473.58	77.90	2,546,096	72,903.77	77.74
Republic Township	1,620,725	45,932.42	59.58	1,835,750	47,929.21	61.91
Richmond Township	79,670	2,413.99	8.64	79,090	2,025.00	8.50
Sands Township	178,950	5,602.92	43.33	178,950	5,576.03	43.23
Tilden Township	346,115	11,623.41	12.72	366,115	11,869.86	13.10
AuTrain Township, Alger County	181,415	7,020.16		181,415	7,012.24	
Limestone Township, Alger County	10,875	338.21		10,875	339.67	
Spurr Township, Baraga County	326,400	14,759.06		393,200	19,205.29	
Crystal Falls Township, Iron County	7,600	380.00		7,600	357.20	
City of Iron River, Iron County	8,900	559.12		8,900	485.41	
Iron River Township, Iron County	3,750	105.75		6,250	181.25	
Village of Mineral Hills, Iron County	(3,750)	30.84		(6,250)	60.51	
Sagola Township, Dickinson County	400	22.76		400	16.40	
Knight Township, Iron County, Wisconsin	21,000	1,078.35		21,000	1,185.87	
Totals	$39,175,196	$1,793,378.02		$40,104,441	$1,713,341.06	

* Percentage shown is of the total taxes paid in the City or Township

I. 1959 LEGISLATIVE MATTERS

As a result of the hearings held in 1958 by the Interim Legislative Committee, two bills of interest to the mining industry were introduced during the 1959 session of the Michigan Legislature. The first bill was an amendment to the low grade iron ore bill. The purpose of the amendment was to clarify the language of the original bill making it clear that the tax is an "in lieu" tax, that is, in lieu of all other real and personal taxes. Another change in the bill required that years of no production be included in computing the average annual production after a low grade property had a five year experience record. A section was added giving the Deputy State Geologist the authority to calculate the allocations necessary when a low grade property is located in more than one taxing district. Because an opinion from the Attorney General, requested by Representatives Wales and Jacobetti, concluded that the bill amending the low grade iron ore bill was unconstitutional, the bill was rewritten to overcome the unconstitutionality. The final bill passed by both the House of Representatives and the Senate established a specific tax on low grade iron ore. During the construction period, the tax would be equal to 1% of the f.o.b. mine value of Old Range Non-Bessemer ore times the estimated plant capacity times the percent completion as of the tax date. After commercial production has started the tax is to be equal to the five year average annual production times 2% of the f.o.b. mine value of Old Range Non-Bessemer ore.

The second bill which was introduced and passed by both Houses set up a permit system for water use in connection with low grade iron ore properties. The Water Resources Commission was the commission designated to administer the bill.

J. HOUSE ACQUISITIONS AND DISPOSITIONS - Robert G. Fountain and Donald W. Carlson

1. City of Negaunee

The following houses in the City of Negaunee were acquired during 1959 because of anticipated subsidence:

TABLE XVIII

House No.	Description	Purchased From	Price	Date
Maas #227	Lot 7, Block 33, Pioneer Plat	Henry Henrickson & wife	Exchanged for Maas House #181 and Lot 31, Cliffs Fourth Addition	10/16/59
Athens #50	Lot 1, Boyer Plat	Victor Maki & wife	$14,000 and Lot 6, Block 1, Cliffs First Addition	12/30/59
Athens #51	East Part of Harvey Lot 2 lying north of Ann Street	Johanna Renaldi	$11,000	12/31/59

The following houses in the City of Negaunee were sold during 1959:

TABLE XIX

House No.	Description	Sold To	Price	Date
Maas #181	Lot 31, Cliffs Fourth Addition	Henry Henrickson	Exchanged for Maas House #227	10/16/59
Maas #204	Lot 34, Cliffs Fourth Addition	Turri Johnson	$6,200.00	5/19/59
Maas #226	Lot 1, Block 2, Kirkwood & Kellan's Addition	Edward Antilla	$ 125.00	11/13/59
No Number	Lot 4, Block 2, Kirkwood & Kellan's Addition	Richer Bros.	$ 62.50	3/18/59
No Number	Lot 3, Block 2, Kirkwood & Kellan's Addition	City of Negaunee	$ 1.00	3/18/59
Maas #227	Lot 7, Block 33, Pioneer Plat	Roland Juchemich	$ 156.50	11/13/59
Negaunee District Misc. 12	Lot 87, Iron Plat	Richer Bros.	$ 50.00	3/18/59

J. HOUSE ACQUISITIONS AND DISPOSITIONS (continued)

TABLE XIX (continued)

House No.	Description	Sold To	Price	Date
Jackson #1	South of Jackson Addition	Richer Bros.	$ 150.00	3/18/59
Jackson #49	Lot 15, Block 2, Jackson Addition	Richer Bros.	$ 125.00	7/30/59
Jackson #51	N½ of Lot 1, Block 2, Jackson Addition	Hilding Erickson	$ 50.00	8/14/59
Jackson #59	S. 60' Lot 8, Block 3, Jackson Addition	Edwin Hakala	$ 189.00	12/1/59
Jackson #64	Lot 3, Block 5, Jackson Addition	Charles Maki	$ 35.35	11/13/59
Jackson #65	Lot 2, Block 6, Jackson Addition	Richer Bros.	$ 200.00	7/15/59

2. Village of Republic

The following houses in the Village of Republic were purchased in 1959 because of proximity to the Republic Pit:

TABLE XX

House No.	Description	Purchased From	Price	Date
Republic #16	Parcel 16	Ingeborg Aeschbacher et al.	$4,000.00	4/20/59
Republic #17	Parcel 19	Milo A. Martell	$4,800.00	5/8/59
Republic #18	Lot 78, Republic Iron Co. Second Addition	Irene Kempany et al.	$1,600.00	7/8/59
No Number A	Parcel 404	Tyne Aho	$1,000.00	8/20/59
No Number B	E½, Parcel 21	Rufus E. Martin	$2,400.00 (approx.)	9/10/59
No Number C	W½, Parcel 21	Fowler Heirs	$2,400.00	9/24/59 10/14/59

J. HOUSE ACQUISITIONS AND DISPOSITIONS (continued)

The following houses in the Village of Republic were sold during 1959:

TABLE XXI

House No.	Description	Sold To	Price	Date
Republic #11	Parcel 461	Roy S. Cardew	$ 67.00	6/9/59
Republic #12	Parcel 520	Otto Kaleva	$ 40.00	8/31/59
Republic #13	Parcel 460	Axel Carlson	$ 40.00	6/23/59
Republic #14	Parcel 23	Herbert F. Anderson	$205.00	10/12/59
Republic #15	Parcel 22	Robert J. Venn	$250.00	6/1/59
Republic #16	Parcel 16	Edward Cardew	$266.00	6/9/59
Republic #17	Parcel 19	Rufus E. Martin	$750.00	9/10/59
No Number A	Parcel 404	Leonard Linna	$ 25.00	8/28/59
No Number B-C	Parcel 21	Thomas Warner	$200.00	11/2/59

Respectfully submitted,

Ralph E. Magnuson, Jr.

Ralph E. Magnuson, Jr.
Chief Mining Engineer

REM:jcj

3/11/60

RESEARCH LABORATORY

ANNUAL REPORT - YEAR 1959

The Annual Report for 1959 is subdivided into six main sections. They are as follows: (1) General Information, (2) Pyrolysis and Agglomeration, (3) Research and Development and Flotation Projects, (4) Microscopy Section, (5) MOC and Direct Reduction, and (6) Sampling Studies.

The Annual Report for 1958 included a seventh subdivision titled "Research Pilot Plant." A separate annual report will be issued this year covering the projects carried out at the Research Pilot Plant.

The Annual Report highlights various projects worked on during the year. No specific test data or conclusions are presented. In some cases, an overlapping of projects between the Research Pilot Plant and Research Laboratory have been covered since the Research Pilot Plant started operations during 1959. Some of the minor projects have been omitted, however, have been referred to in the monthly reports.

PART I

GENERAL INFORMATION

DISTRIBUTION OF CHARGES:

Listed below is a tabulation for the last nine years listing the Laboratory staff and total hours as reported on the cost sheets. The number of staff people assigned to the Research Laboratory decreased during 1959 due to a transfer of some of the personnel to the Research Pilot Plant. The number of employees listed for 1959 is based on the status as of December, 1959.

	Staff			
Year	Engineers	Technicians	Total	Total Hours
1959	10	54	64	84,726 Research Lab & Pilot Plant Combined
1959	7	18	25	55,902 Research Lab Only
1958	11	23	34	69,555
1957	13	30	43	98,205
1956	13	26	39	68,888
1955	10	17	27	55,275
1954	8	15	23	50,982
1953	8	18	26	66,005
1952	6	13	19	47,958
1951	6	11	17	31,369

The number of hours spent on specific projects is tabulated below. Approximately 73% of the time was devoted to the first six major projects, those being (1) Agglomeration Research, (2) Balling study conducted at Eagle Mills, (3) MOC Fundamental Studies, (4) Cliffs Group Studies, (5) Regrind-Reflotation Studies, and (6) Flotation Study.

Summary of Time Distribution
1959

Project		Hours		% of Total Time
Agglomeration Research		14,799		26.5
Study of Agglomerates at High Temperatures	7,376		13.2	
ACL Pilot Plant Control Tests	1,210		2.2	
Additive Studies - Agglomeration	1,116		2.0	
General Agglomeration Studies	893		1.6	
Direct Reduction	892		1.6	
Briquetting Spec. Hem. Ores	810		1.5	
Agglomeration Studies, Undg. Ores	567		1.0	
Asphalt Emulsion & Other Carbonaceous Additives	473		.8	
E.M. Quality Control (Conc)	473		.8	
Feeder Study	372		.7	
Small Scale Balling Studies	213		.4	
Sintering Tests - Undg. Ores	163		.3	
Study of Fe-SiO_2 Pellet Properties	135		.2	
Pelletizing Tests (Empire Conc.)	78		.1	
Fuel Sample Testing	28		.1	
Eagle Mills Balling Study		7,034		12.6
MOC Fundamental Studies		5,457		9.8
Operating Mines, Cliffs Group Studies, Etc.		5,348		9.6
Regrind-Reflotation Studies		4,406		7.9
Flotation Study		3,748		6.7
Land Offers, Outside Explorations & Special Samples		2,352		4.2
Plant Control Samples		1,846		3.3
Startup ACL Pilot Plant		1,846		3.3
Startup General, Pilot Plant		1,781		3.2
Research and Study		1,460		2.6
Domnarvet Kiln Test		1,336		2.4
Testing Drill Core		856		1.5
Pilot Plant		680		1.2
Empire Flowsheet Development		547		1.0
Pilot Plant, E&A Work		488		.9
Aerofall Mill Tests		450		.8
Accts.Receivable; Inland Steel, Bethlehem & A.C.		303		.6
Dry Magnetic Separation Studies		300		.5
MOC Tests - Minnesota Ores		197		.3
Flowsheet Development, Humboldt & Republic		170		.3
Armour Research Project		132		.2
High Intensity Conditioning		124		.2
Republic Expansion		112		.2
Humboldt Expansion		74		.1
Special Samples Shipped Out		56		.1
Total		55,902		100.0

Chemical Charges:

Presented below is the distribution of the Research chemical charges for 1959. The number of determinations made during 1959 was 19,250 which is roughly 5,000 less than the determinations made during 1958. The number of samples sent to the Chemical Laboratory for analyses was 10,612. The tabulation is also included listing the number of samples shipped in each month and the various analyses required. The tabulation is interesting as it reveals the number of analyses shipped during each month and the number of special analyses required such as phosphorous, sulphur, and special determinations.

TOTAL NUMBER OF DETERMINATIONS ANALYZED IN 1959 FROM RESEARCH LABORATORY SAMPLES

Account	Analyses	Account	Analyses
Fatty Acid Study	1788	Land Offer 3281C	6
Regrind-Reflotation Studies	1548	3725	499
Hi Intensity Conditioning	96	3748	47
General Agglomeration Studies	1678	3750	10
Study of Agglomerates at Elevated Temp.	268	3785	12
		3786	103
Eagle Mills Balling Study	40	3787	4
Empire Pilot Mill Tests	149	3790	40
MOC Fundamental Studies	3529	3791	12
Humboldt Expansion	2	E&A CC-982	44
Republic Expansion	6	984	29
J&L Aerofall Mill Tests	375	E&A NM-148	200
Dry Magnetic Sep. Studies	207	156	76
Agglomeration Studies-U.G. Ores	11	161A	312
Balling Studies (Spec.Hem.)	52	E&A MI-Hole 14	447
Direct Reduction Studies	1354	15	179
ACL Pilot Plant Control Tests	359	Project 17C	1042
Briquetting Spec. Hem. Ores	60	Maas Mine	65
Domnarvet Kiln Tests	140	Negaunee Mine Co. "Experiments & Investigation"	2
MOC Tests-Minnesota Ores	337		
Outside Exploration 1247	113	Cliffs Shaft Mine	42
1259	799	Republic Mine	599
1273	3	Cliffs Group Study	1020
1277	68	Operating Bunker Hill	246
1285	81	Humboldt Mine	5
1415C	6	Mather Mine A Shaft	73
1419C	67	Mather Mine B Shaft	115
1421C	24	Ore Improvement Plant	176
Land Offer 2836	2	Accts. Receivable, Bethlehem Steel	529
3163	96	" " Inland Steel	24
3279C	34		
		Grand Total	19,250

Number of Samples and Analyses in 1959

No. Samples	Month	Iron	Phos	SiO_2	Al_2O_3	Mn	Sul	TiO_2	MgO	By Ignition Loss	By Ignition Gain	CaO	Fe^{++}	Metallic Fe	Coal	Cu	Arsenic	Al_2O_3 & Fe	TOTAL
982	January	1168	5	236	7	20	4	26	6	2	4	14	160	10					1,662
785	February	973	8	282		3	9	22				15	113	3					1,428
496	March	617	8	248	4	4	7		4	4		39	117						1,052
926	April	1013	8	512	1	3	6		1			18	327	2					1,891
1,334	May	1351	15	395			16						294	2					2,073
714	June	720	74	208			74						117	1					1,194
970	July	954	64	292	4		63		2	4		42	209		1				1,635
836	August	1159	20	232	11	18	16	63	3			50	201			2			1,775
935	September	990	5	155	10		10	9				40	270	2					1,491
868	October	871	24	343	8		47		8	22		16	330	6					1,675
585	November	600	88	257	43	3	86	6	2	1		36	249				1		1,372
1,181	December	1233	71	352	30	1	58	2	8	4		28	213					2	2,002
10,612		11,649	390	3,512	118	52	396	128	34	37	4	298	2,600	26	1	2	1	2	19,250

Metallurgical Reports and Memoranda:

The metallurgical reports and memoranda issued by the Metallurgical Department during 1959 are listed below. All work completed at the Research Laboratory or Research Pilot Plant is covered in metallurgical reports or memoranda with the exception of weekly progress reports, and plant control samples test data which is covered in a specific mine memorandum.

METALLURGICAL REPORTS - YEAR 1959

Report No.	Subject
244	Microscopic Examination of the Isabella Low Grade Ores
245	1958 Mine Ore Structure Study
246	Effects of Additives on the Quality of Pellets produced from the Republic Reflotation Concentrate and Eagle Mills Filter Cake
247	Laboratory Investigation of MOC Samples from the Republic Crude Ore produced at different Temperature Levels
248	Testing of the Domnarvet, Sweden MOC Kiln
249	Microscopic Examination of Pellets produced by Grate-Kiln-Cooler Process at the Allis-Chalmers' Carrollville Pilot Plant
250	Laboratory Investigation of Pellets produced from Magnetite, Artificial Magnetite, and Specular Hematite by various Pelletizing Techniques
251 & Research Pilot Plant Report No. 1	Effect of the Pre-Heat Burner on the Capacity, Heat Requirements and Quality of the Products in the ACL Grate-Kiln System
252	The Effect of Temperature upon the Abrasion and Impact Resistance of Non-Indurated Pellets
253	Laboratory Investigation of Sample Nos. Mx-2050 A-M, & Mx-550 from Acandi Placer Deposit, Colombia

METALLURGICAL MEMORANDA - YEAR 1959

Memo No.	Subject
707	Werco Steel Company Tornado Crusher Test - Republic Ore
708	Report on Trip to Rosiclare, Illinois to see Plant Operations with heated Flotation Pulps
709	Metallurgical Testing - Sample Nos. Mx-2039 - Mx-2041 Land Offer 3748
710	Laboratory Examination of a Goethitic Coated-Carbonate Rock from Glenwater, Ontario, Canada
711	Properties of Pellets submitted to the Research Laboratory by the Taca Corporation of Miami, Florida
712	Magnetite Pellets produced in the Shaft Furnace at Lebanon, Pennsylvania
713	Pellet Growth and Balling of Coal
714	Results of Batch Flotation Study on Republic Aerofall Mill Products
715 (Supplement)	Metallurgical Testing - Acandi, Columbia Beach Sands Land Offer 3725
716	Benoit Lake Area Titaniferous Samples - Project 17
717	Occurrence of TiO_2 in the Magnetic Concentrate of a Beach Sand Sample from Acandi, Colombia - Land Offer 3725

Continued - - -

Memo No.	Subject
718	Observation of "Royer" Shredder at the Penokie Mine, North Range Mining Company, Ironwood, Michigan on March 4, 1959
719	Discussions with Professor Wiberg and Observations and Data from the Wiberg-Soderfors Sponge Iron Plant at Sandviken, Sweden
720	The O.C.C.R. Oil Gasifier
721	Identification of Fatty Acid Constituents in Flotation Concentrates by Vapor Chromatography
722 (Supplement)	Progress Report on Pilot Plant Reflotation, November 20-January 14th
723	Microscopic Examination of Rock Specimens from the Lac du Sauvage Area of Abitibi Territory, Quebec
724	Discussion of Lurgi Kiln Situation with Dr. Meyer, Rausch, Barwasser, and H. Viericke at Lurgie Chemie, Frankfurt/M, February 12-13, 1959
725 (Supplement)	Discussion of Fatty Acid Flotation with Dr. S.R.B. Cooke, University of Minnesota
726	Aerofall Mills - Republic Expansion
727	Sampling Bethlehem Marquette Mix Fines - Check Sampling
728	Reference Tests on Republic Sample sent to Booth Company and to Paris, France
729	Pilot Plant Reflotation Test of Humboldt Stockpile Concentrate
730	Visit to Oliver Iron Mining Division's Extaca Plant at Virginia, Minnesota
731	Mortsells Dry Magnetic Separator
732	The Bodas Mill, Pelletizing and Pellet Hardening Operations
733	Elevated Temperature Properties of Hematite Pellets - A Preliminary Investigation
734	Metallurgical Testing - Sample No. Mx-2266 Outside Exploration 1259
735	Metallurgical Testing - Sample No. Mx-2265 - O.E. 1273
736	Discussion with Hercules Powder Company Representatives on Identifying Constituents of Flotation Reagent Extracted from Concentrates
737	Analysis of Standard MOC Test
738 (Supplement)	Discussions of Submerged Combustion Heating of Flotation Pulps and Results of Linde Pilot Plant
739	Microscopic Examination of a Spannarhytten Crude Ore and its MOC Product
741	Solvent Extraction of Fatty Acids from Flotation Concentrates
743	Progress Report - Size Analysis of Reflotation Concentrate as compared to the Reground Primary Concentrate
744	Microscopic Investigation of MOC Products produced from the Republic and Tilden Low Grade Ores by the Domnarvet Kiln Process
745	The Arrangement and Observations on the "Royer" Sand Separator and Shredder at North Range Mining Company's Penokie Mine, Ironwood, Michigan - May 18, 1959
746	Progress Report - Indirect Heating of Pulp for the Reflotation Process
747	Discussions at Cleveland on June 4th, between Cleveland-Cliffs and R-N Corporation Personnel
748	Trip to Cleveland, Ohio to meet with Arthur G. McKee Company and Allis-Chalmers Manufacturing Company Representatives to Discuss the Problem of producing a uniform Feed for the Grate of the Grate-Kiln-Cooler System
749	Agenda for Meeting with Management regarding Humboldt Expansion with the ACL System of Pelletizing

Continued - - -

Memo No.	Subject
750	Progress Report on Pilot Mill Reflotation: Testing of various Reflotation Circuits
751	Notes of a Meeting held June 30, 1959 Regarding ACL System
752	Notes taken during a Meeting held at the Research Laboratory on July 1, 1959 regarding Problems encountered with ACL Pilot Plant, Possible Causes, with suggested Corrective Measures
753	Microscopic Examination of Iron-bearing Samples from Little Long Lac, Errington Township, Ontario, Canada
754	Discussion held at the Pilot Plant on July 16, 1959, regarding Programming of Modifications to CCI's Pilot ACL Unit
755	Results of a Preliminary Investigation into the Possibility of completely or partially reducing Hematite Pellets to Artificial Magnetite prior to re-oxidation and Induration at the High Temperature of 2400°F
756	High Intensity Magnetic Separator Tests made by Oliver Iron Mining Co's. Research Dept. of Republic Crude in the Separator designed by O.E. Palasvirta
757	Notes taken during a Meeting at the Pilot Plant on Monday, July 20, 1959 with Mr. Phil Dailey, from Surface Combustion Corporation
758	Notes taken during a Meeting on July 17, 1959 with Mr. Joseph Zwitt, Hauck Mfg. Co., Chicago, Illinois, regarding Burners now in use in the Pilot Plant ACL System
759	Heat Losses from the ACL Grate-Kiln System - Temperatures recorded July 16 (8-4, 4-12) and July 17 (8-4), 1959
760	Visit to the R-N Pilot Plant at Spaulding Mine, Birmingham, Alabama
761	Magnetic Tube Tests and Analyses - O.E. 1259
762	Metallurgical Testing - Heavy Liquid Test on Sample Mx-2066 L.O. 3750
763	Major Problems related to the Grate-Kiln Pelletizing Process as revealed by Pilot Plant Operation
764	Structure Analyses of Sample Mx-1936 which is a "Typical Fine Ore" from Brazil - O.E. 1277
765	Chemical Analyses of Samples MxC-1531, Mx-551 and Mx-552 L.O. 3281-C
766	Chemical Analyses of Samples MxC-1532, Mx-553, Mx-554 and Mx-555 - L.O. 3280-C
767	Chemical Analyses of Samples MxC-1533, Mx-556 thru Mx-561 L.O. 3279-C
768	Chemical Analyses of Samples Mx-1934 and Mx-1935 - L.O. 3780
769	Chemical Analyses of Sample Mx-1937 - L.O. 3725
770	Observation of the Dravo Briquetting Pilot Plant at Pittsburgh June 23, 1959 while treating Republic Reflotation Concentrate
771 (Supplement)	Metallurgical Testing - Acandi, Colombia Beach Sands - Second Series of Samples - L.O. 3725
772	Notes of a Meeting with Representatives from Dravo's Research and Development Department August 11 & 12, 1959
773	Six-Day Continuous Test of Allis-Chalmers' Grate-Kiln System at Carrollville, Wisconsin, July 28, 1959 to August 2, 1959
774	Highlights of Observation of and Participation in the Operation of the ACL Kiln System at Carrollville, Wisconsin July 28 - August 2, 1959
775	Batch Test Evaluation of Armour & Company's Fatty Acid Reagent FA-2000

Continued - - -

Memo No.	Subject
776	Addition of Asphalt Emulsion to both Reground and Unreground Humboldt Concentrate
777	Progress Report of Studies on the Fatty Acid Reagent Phase of the Flotation of Specular Hematite
778	Heavy Liquid Testing of Reflotation Pilot Circuit Products
779	Progress Report on the Analysis of the Fatty Acid Reagent Extracted from Flotation Concentrates
780	Laboratory Results of Amine Flotation Upgrading of Empire Magnetic Concentrates
781	Outline of Projects for Fatty Acid Flotation Studies for the Immediate Future
782	Tabulations of Pertinent Data from the Republic Mill Reflotation Test in September-October, 1958
783	Immediate Program for Elevated Temperature testing of Pellets
784	Dravo Briquettes made from Republic Concentrate on August 21, 1959 in Chicago, Illinois
785	Program for Agglomerating and/or Upgrading the Fine Fractions of Underground Ores
786	Laboratory Investigation of Pellets prepared from Eagle Mills Filter Cake at a Temperature Range between 1600°F and 2000°F
787 (Supplement)	Metallurgical Testing of Samples C231 thru C234 from Bruce Lake, Canada - O.E. 1419-C
788	Briquetting Republic Reflotation Concentrate by Dravo Corporation and Komarek-Graeves Corporation at Chicago, Illinois on September 25, 1959 (Trip Report)
789	Notes taken during a Meeting with Allis-Chalmers Representatives in Milwaukee, Wisconsin on October 1, 1959 regarding Improvements or Changes in Pilot Plant ACL Equipment
790	Visit to Lurgi Chemie at Frankfurt/Main, Germany September 28, 1959
791	Preliminary Estimate of R-N Operating Costs: Producing a Briquette Containing 92% Iron from a 35% Iron Crude with 85% Iron Unit Recovery
792	Strength Characteristics of Increment Layers of ACL Grate-Fired Pellets
793	Metallurgical Testing of Samples from Menominee and Dickinson Counties, Michigan - O.E. 1247
794	Discussions with J. Breitenstein of R-N at New York, November 5, 1959 concerning Applicability of the R-N Process to Treatment of Agenda Crude Ore
795	Report of a Meeting with F.L. Smidth Personnel to discuss the Practicability of the Domnarvet MOC Kiln
796	Standard Laboratory MOC Test Results from a Second Series of Taconite Drill Core Samples received from Minnesota, July 6, 1959
797	Metallurgical Testing of Samples from Relief, North Carolina, L.O. 3785
798	Chemical Analyses of Samples Mx-2385 thru Mx-2391 - L.O. 3789
799	Chemical Analyses of Samples Mx-2392, -2393,-2398 & -2399 L.O. 3796
800	Chemical Analyses of Samples Mx-2403 and Mx-2397 - L.O. 3797
801	Addition of Asphalt Emulsion to both Reground and Unreground Humboldt Concentrate
802	Observations made at the Briquetting Plant of the International Briquetting and Refractory Corporation, Baltimore, Maryland, November 17, 1959

Continued - - -

Memo No.	Subject
803	Topics for Discussion in regards to the ACL Pelletizing Process with Representatives of Arthur G. McKee & Company and Allis-Chalmers Manufacturing Company, December 1, 1959
804	A Discussion of the Possible Role of Conjugate Structures to be considered in any Reagent Development aimed at eliminating the present need for boiling a Flotation Pulp prior to Fatty Acid Flotation of a High Grade Iron Concentrate
805	Variations in Metallurgical Outcome from MOC Treatment of -3/4"+5/8" Republic Crude Ore at Different Temperature Levels
806	Quarter-Inch Screening of the Ore Improvement Plant
807	Meeting with Allis-Chalmers, Arthur G. McKee Company and Ford Motor Company regarding the Humboldt Plant. The Meeting was held on December 1, 1959 in Ishpeming, Michigan
808	Mineralographic Examination of Two Briquettes produced by the International Briquetting and Refractory Corporation, Baltimore, Maryland
809	Inequality of Agglomeration and Concentration Sections at the Expanded Pilot Plant
810	Progress Report No. 1 - O.E. 1419C - Iron Bay Mines Limited
811	The Orecarb-Kiln-Electric Furnace Production of Pig Iron from Republic Reground Refloated Concentrate
812	Testing of Bentonite Samples received from National Lead Company, Baroid Division
813	Spalling Resistance of Green Pellets made from Empire Magnetic Concentrate
814	Metallurgical Testing - DDH 7, Cerro Nahuatl Colima, Mexico - O.E. 1259
815	Metallurgical Testing - Hand Picked Samples, Mx-2310 through Mx-2332, from Colima, Jalisco and Zacatecas, Mexico - O.E. 1259

Sample Shipments:

Each year various samples are shipped to laboratories and companies for test work. Presented below is a list of the samples shipped during 1959.

Date	Company	Amount & Sample	Purpose
1/8/59	Allis-Chalmers Mfg.Co. Milwaukee, Wisconsin	48 barrels reground specular hematite concentrate. Eagle Mills	Initial tests with new ACL pilot plant
1/21/59	Mr. Voyislav Petrovic Paris X^{e}, France	15 lbs. -10 mesh low grade iron formation, Republic Nov.-Dec., 1958	For flotation studies
1/23/59	Mr. J. A. Anthes Dravo Corporation Pittsburgh 21, Pennsylvania	500 lbs. -1/4" Bunker-Hill Ore	For agglomeration tests, briquetting
1/26/59	Mine & Smelter Company Denver 16, Colorado	30 lbs. Humboldt flotation concentrate	For grindability tests
1/28/59	The Booth Company, Inc. Salt Lake City 15, Utah	1 bag, 67 lbs. Republic rod mill feed, Nov.-Dec., 1958	For flotation testing

Continued - - -

Date	Company	Amount & Sample	Purpose
1/29/59	Allis-Chalmers Mfg. Co. West Allis, Wisconsin	7 drums, 3 tons - 6" Mather A Underground Ore	Request of Mr. F.A.Young, Allis-Chalmers
2/11/59	M.W. Kellog Laboratory Jersey City, New York	2 drums, 588 lbs. hematite pellets	For direct reduction test work
2/25/59	Submerged Combustion Inc. Hammond, Indiana	1 can, 19 lbs. filter cake	For submerged combustion batch heating tests
2/25/59	Denver Equipment Company Denver, Colorado	1 bag, 100 lbs. of regrind flotation concentrates	For settling tests
3/2/59	International Briquetting & Refractory Corp. Baltimore 30, Maryland	100 lbs. Refloat Concentrate	For briquetting tests
3/10/59	Sandviken Steel Works Sandviken, Sweden	1 box, 75 lbs. ACL Hematite Pellets	For sponge iron reduction tests
3/13/59	Darin, Armstrong, Inc. Oak Park, Michigan	2 bags, 150 lbs. Cliffs Shaft Crushed	Requested by Mr. R.W. Jump
3/20/59	Aluminum Co. of America Cleveland 5, Ohio	2 barrels, 1 ton Humboldt Concentrate, H-272	Requested by Ore Sales Dept.
3/20/59	Semet-Solvay Division Allied Chemical Corp. Ashland, Kentucky	6 barrels, 3 tons Humboldt Concentrate, H-272	Requested by Ore Sales Dept.
3/20/59	Denver Equipment Company Denver, Colorado	1 bag, 100 lbs. Humboldt Concentrate, H-272	For grindability tests
3/23/59	Mr. John McClurgy, Cleveland20, Ohio	2 lbs. Humboldt Concentrate	Requested by Mr. S.K. Scovil
3/25/59	Professor Kilhstedt Royal Institute Technology Stockholm 70, Sweden	1 drum, 310 lbs. Republic Crude Ore	For flotation test work
4/6/59	Dings Magnetic Separator Co. 4740 Electric Avenue Milwaukee 46, Wisconsin	1 barrel, 450 lbs., 4, 100 lb. Aerofall Mill Product Samples	For dry magnetic and high tension concentration tests
4/6/59	Stearns Magnetic, Inc. Milwaukee 46, Wisconsin	1 drum, Approx. 750 lbs. 6 Aerofall Mill Product Samples	For magnetic and high tension concentration tests
4/9/59	Mich. Institute of Mineral Research Houghton, Michigan	5 barrels, 6,150 lbs. Republic Concentrate	For preliminary pelletizing studies
4/10/59	Jones & Laughlin Steel Corp. Benson Mines Star Lake, New York	1 barrel, 140 lbs; Rep. Soft May, 1958: Republic Hard October, 1957 & Empire Coarse	For grindability correlation study
4/24/59	Dravo Corporation Neville Island Pittsburgh 21, Pa.	10 drums, Approx. 10,000# net - flotation concentrate R-93	For briquetting tests

Continued - - -

Date	Company	Amount & Sample	Purpose
4/28/59	Professor Kihlstedt Royal Institute of Tech. Stockholm 70, Sweden	1 drum, 70 lbs. Empire Ore	For testing in Mortsell dry magnetic separator
4/28/59	Lakeview School Neenah, Wisconsin	3 bags, 175 lbs. pellets, Cliffs Shaft & Mather B	Classroom demonstration
4/30/59	Jones & Laughlin Steel Corp. Research Laboratory Negaunee, Michigan	500 lbs. Refloat Concentrate Pellets	For direct reduction tests employing the Udy Process
5/11/59	Allegheny Ludlum Steel Corp.	6 lbs. Cliffs Pellets	Requested by Mr. A.R. Ham
5/13/59	Inland Steel Plant No. 1	2 drums, 1000 lbs. ACL Pellets, Republic	E.D. Martin through J.S. Westwater
5/14/59	G.L. Allen Company 3602 Central Detroit, Michigan	2 barrels, Approx. 1900 lbs. Republic Concentrate	For briquetting tests
5/14/59	Professor P.G. Kihlstedt Royal Institute of Tech. Stockholm 70, Sweden	10 lbs. +3/4" Crude Empire Ore	Magnetic separation work
5/19/59	Darin Armstrong, Inc. Green Bank, West Virginia	4 bags, 200 lbs. Crushed No. 1 Cliffs Shaft Ore	Requested by Mr. A.R. Ham
5/19/59	Froehling & Robertson, Inc. Richmond, Virginia	2 bags, 100 lbs. Crushed No. 1 Cliffs Shaft Ore	Requested by Mr. A.R. Ham
5/19/59	General Mills, Inc. Minneapolis 13, Minnesota	Approx. 4 lbs, 1 box R-75, R-94 & Tilden	For tests on the E. Machine
5/20/59	Mr. O.E. Palasvirta Oliver Mining Division Duluty 7, Minnesota	25 lbs. Specular Hematite Crude Ore	For use in high intensity magnetic separator testing program
5/22/59	Shell Oil Company Wood River, Illinois	1 barrel, 897 lbs. Republic Coarse Concentrate	Agglomeration test work
6/12/59	Froehling & Robertson, Inc. 814 W. Cory Street Richmond, Virginia	2 bags, 100 lbs. Cliffs Shaft Crushed No. 1 Ore	Requested by Mr. A.R. Ham
6/22/59	John W. Cowper Company P.O. Box 3043 Buffalo 5, New York	25 lbs. Crushed Cliffs Shaft	Requested by Mr. A.R. Ham
6/24/59	Swindell-Dressler Corp. P.O. Box 1888 Pittsburgh 30, Pa.	1 car. Approx. 51 long tons Republic Flotation tests	For direct reduction
7/27/59	R-N Corp. Brooklyn Res.Lab Brooklyn 1, New York	200 lbs. New Richmond 200 lbs. Tilden	For direct reduction tests

Continued - - -

Date	Company	Amount & Sample	Purpose
8/3/59	Toledo Testing Laboratories Toledo, Ohio	1 drum, 200 lbs. Humboldt Flotation Tailings	Request by Mr. B.B. Allen, Ford Motor Company
8/3/59	Columbian Carbon Company Trenton, New Jersey	2 lbs., 2 samples Ohio limonite ore, Maas special ore	For examination
8/3/59	Allis-Chalmers Mfg. Co. Process Machinery Dept. Milwaukee, Wisconsin	130-55 gal. barrels reground Humboldt concentrate	For ACL test work
8/14/59	Shenango Furnace Company Oliver Building Pittsburgh, Pennsylvania	5 lbs Box Pilot Plant AC Pellets	Requested by Mr. A. McAfee
8/24/59	Eimco Corporation Palatine, Illinois	1 barrel, 1000 lbs.Conc 1 barrel, 200 lbs. Slurry	For filtering studies
8/25/59	Mr. Dreng Bjornaraa 2926 W. River Road Minneapolis, Minnesota	1 bag, 69 lbs. ACL Pellets	Requested by Mr. H.C. Swanson
9/24/59	Mr. Ernest J. Andberg Erdco Engineering Corp. Addison, Illinois	1-55 gal. barrel, 570 lbs. deslimed flotation feed	For direct reduction tests
10/12/59	U.S. Dept. of Interior Fishery Technological Lab. Seattle 2, Washington	1 barrel, approx. 337 lbs. Republic Crude-R-75	For flotation test work
10/19/59	International Milling Co. 323 E. Atwater Street Detroit 26, Michigan	1 box, 7-1/2 lbs. fired pellets, E.M. filter cake - 1 can, 15 lbs. green pellets, 1 barrel 640 lbs. E.M. filter cake concentrate	For sample testing
10/20/59	Allis-Chalmers Mfg. Co. Carrollville Pilot Plant Milwaukee, Wisconsin	2 barrels, 1035 and 1040 lbs. underground iron ore	For drying tests on underground ores
10/26/59	Paul O. Abbe, Inc. Little Falls, New Jersey	4 samples - 19 lbs. Humboldt reground concentrate	Agglomeration test work
11/5/59	International Briquetting & Refractory Corporation Baltimore 30, Maryland	5 barrels, 6210 lbs. refloated specular Hematite Concentrate	For pilot plant use
11/13/59	Dravo Corporation Neville Island Pittsburgh 21, Pa.	2 barrels, approx. 2300 lbs. Empire magnetic concentrate	For briquetting tests
11/20/59	Allegheny-Ludlum Steel Corp. M.W. Kellogg Co. Lab. Jersey City, New Jersey	1 barrel - Eagle Mills pellets	For direct reduction studies
11/30/59	Institute of Mineral Res. Houghton, Michigan	2 bags, 80 lbs. (Mx-613) Agenda Crude	Concentration for R-N

Continued - - -

Date	Company	Amount & Sample	Purpose
12/7/59	Pickands Mather & Co. Hibbing, Minnesota	2 bags, 200 lbs. Humboldt Specular Flotation Concentrate	For sintering test work
12/9/59	Mr. W.H. Treloar Mining Journal Marquette, Michigan	2 lbs. Empire Magnetite Concentrate	For test work
12/10/59	Dravo Corporation Neville Island Pittsburgh 21, Pa.	5 barrels Mather B 3 barrels Maas	Briquetting
12/15/59	Bethlehem Steel Corp. Bethlehem, Pennsylvania	1 box ore samples, Pellets	For display
12/17/59	Lurgi Frankfurt, am-Main, Germany	26 drums, 31,787 lbs. 6 drums Empire, 6 drums Republic Regrind-Reflot. Conc., 7 drums -1/4" OIP Fines, 6 drums Regular Republic Conc.	For preliminary agglomeration tests
12/23/59	Bethlehem Steel Bethlehem, Pennsylvania	2 pails, Humboldt Pellets 92 lbs.: Republic Reg. Conc. 72 lbs.	Samples for investigation
12/23/59	Blocked Iron Corp. Montrose, New York	2 barrels, 2,400 lbs. R-99 Flot. Concentrate	Agglomeration tests
12/23/59	Southwestern Eng. Co. Los Angeles 58, Calif.	1 can, 25 pounds Acandi, Mx-550	Direct reduction tests
12/23/59	National Lead Company 105 York Street Brooklyn, New York	1 bag, 50 pounds Mx-613 Agenda Ore	Test work
12/28/59	Institute of Mineral Res. Houghton, Michigan	2 bags, 175 pounds Mx-613 Agenda Ore	Test work

PART II

PYROLYSIS AND AGGLOMERATION

LABORATORY & PLANT TESTS CONCERNING THE EAGLE MILLS PELLETIZING PLANT:

The following studies were conducted at the Research Laboratory and the Pellet Plant in an attempt to aid the process and/or operation of the Pellet Plant; or to provide data for the design and operation of the new pelletizing units at the Humboldt Mine.

1. Initial two weeks of "running-in" the 9'x30' balling drum.

2. Second series of tests with the balling drum and screen operating in closed circuit. Slope of drum = 3/4"/foot.

3. Third series of tests with balling drum-screen at a slope of 1-1/4"/foot.

4. Establishment of "base-line" conditions for balling drum study.

5. The effect of reinforcing the 9'x30' balling drum with extra steel and lining it with concrete.

6. Set-up of program to attempt a correlation between variables at the Plant.

7. Operation of the balling drum-screen circuit during February and March of 1959. Drum at a slope of 3/4"/foot.

8. Operation of the balling drum at a slope of 1"/foot. Problems encountered during the rerolling of green pellets.

9. Establishment of a program to try and improve pellets placed onto "A" Line by using the balling drum or disc in closed circuit with the Allis-Chalmers screen.

10. Recommendations for balling layout and drum design for the Humboldt Plant.

11. Quantity and quality of breakage of green pellets as they are being laid on the grate machine.

12. The effect of "coarse" coal, No. 5 Buckwheat, on the Eagle Mills Pelletizing Process.

13. The effect of continuous operation of the balling-screening circuit on the Eagle Mills updraft process.

14. Status of proposed grate-pellet feeders for Eagle Mills.

AGGLOMERATION RESEARCH CONCERNING THE ACL SYSTEM:

During 1959, numerous meetings were held with Arthur G. McKee Company, Allis-Chalmers Manufacturing Company, and with other equipment suppliers to evaluate and discuss past operating experience with the ACL system.

The general object of the above and the laboratory and pilot plant test work was to provide data for the betterment of design of the Humboldt Pelletizing Plant.

1. One continuous six-day test was conducted at the Allis-Chalmers' Carrollville Pilot Plant. The objective of this test was to study the formation of rings within the kiln.

2. A meeting was held in Cleveland with Arthur G. McKee Company and Allis-Chalmers to discuss the installation of "Royer" Shredders, and uniformity of feed to the grate machine.

3. A discussion of the "ringing" problem was covered in several memoranda, with suggested avenues of attack. The "Preheat Burner" problem was also reviewed.

4. The availability of a "jet-pump" from Surface Combustion Corporation was discussed in another memorandum. This was to be used as a means of removing dust from hot gases.

5. Propane and oil burners were discussed with several representatives from Hauck Manufacturing Company.

6. The changes Allis-Chalmers has made in their pilot plant was reported. The estimated cost of these changes was included.

7. The problem of grate sidewall failure was reported in a memorandum covering a meeting of representatives from Allis-Chalmers and Arthur G. McKee Company.

8. The problems inherent in starting up the sintering machine now installed at the Pilot Plant was reviewed.

9. The erection shop of Allis-Chalmers was visited to observe partial erection of the Humboldt grates and coolers. The Allis-Chalmers' pilot plant was also observed as it was processing U.S.S. Group 13 ore.

10. Several Allis-Chalmers' drawings were reviewed and commented upon. These comments were forwarded to Allis-Chalmers by the CCI project engineer.

11. The process control equipment was covered in memoranda by both CCI and Allis-Chalmers. The confidence which Allis-Chalmers has in the grate-kiln process was also reported.

LABORATORY RESEARCH INVESTIGATIONS:

1. Binder Study

(a) Regular car-load shipments into Eagle Mills were sampled then submitted to Research personnel for evaluation of their effect on pelletizing.
(b) Several samples of "new" bentonites were evaluated.
(c) "Plasmofalt" from Taca Corporation was evaluated.
(d) Asphalt emulsions were checked for use as a binder and a fuel source with both reground and coarse hematite concentrates.

2. Briquetting Studies

(a) Several briquetting tests were made by Dravo Corporation and Komarek-Graeves to check the amenability of their process on ore concentrates. The products were evaluated and reported.

3. Elevated Temperature Properties of Agglomerates

(a) This program was initiated during 1959. The equipment was fabricated and placed into operation. A series of tests to check the following was begun:

Effect of Grind
Effect of Indurating Temperature
Effect of Pellet Size
Effect of Additives

(b) A program to investigate the abrasion and impact resistance of hot, preheated pellets was completed. The effect of the following variables was reported:

Preheating Temperature
Pellet Size
Height of Drop
Additives

The study was designed to approximate conditions with the commercial ACL units at Humboldt.

4. A preliminary study was conducted to determine the spalling resistance of pellets made from Empire concentrates.

5. A program was formulated to investigate the agglomerating (pelletizing) characteristics of underground ores.

6. A series of tests were conducted in the Allis-Chalmers pot grate apparatus to investigate the effect of:

Drying Temperature
Drying Air Flows
Preheating Temperatures
Indurating Temperatures

upon pellet rupture and quality -- Pellets rolled from U.G. ore.

7. A "Royer" Shredder was observed in operation at the Penokie Mine of North Range Mining Company. North Range was using the machines as sizing devices.

8. A laboratory study was conducted on balling coal and to determine the effect of rerolling various sized pellets.

9. Pellets made by Bethlehem Steel Corporation in their Lebanon, Pennsylvania shaft furnace were evaluated and analyzed. Both the normal and self-fluxing pellets were covered.

PART III

RESEARCH AND DEVELOPMENT WORK AND FLOTATION PROJECTS

REGRIND-REFLOTATION:

During the year regrind-reflotation studies were continued on a pilot and batch scale. Some of the major variables investigated on a pilot scale are listed below.

1. Metallurgical differences obtained when operating on a gravity flow system as compared to pumping between flotation stages.

2. Testing of different methods for heating the pulp; namely, direct, indirect, and submerged combustion.

3. Float cell arrangement for optimum recovery and grade.

4. To determine the effect aging the rougher flotation concentrates has on the grade and recovery produced in the refloat circuit.

5. The effect of agitation during conditioning on ultimate grade and recovery.

6. Determination of actual heat requirements for elevating the pulp temperature from 70-90°F to 208°F.

Some of the major variables investigated on a batch scale are listed below.

1. Differences in micron sizing between refloat concentrates and regular flotation concentrates that had been ground to approximately the same size as indicated by 325 mesh sizing.

2. Heavy liquid tests were conducted on several products to determine the extent of liberation obtained at different levels of grind.

3. Solvent extraction of reagents and testing of various pure reagents were carried out in order to determine the changes that take place during heating which renders the flotation more selective. Much of this work was aimed at a process or procedure that may eliminate the necessity for pulp heating in order to obtain the desired selectivity.

4. The effect of aging on concentrates was tested.

5. The effect of indirect versus direct heating was evaluated.

A trip was made to Rosiclare, Illinois to visit plant operations which utilize heating of pulps for metallurgical benefits.

Most of the refloat work was done utilizing Republic concentrates, however, pilot mill tests were also conducted on Humboldt concentrates.

PRIMARY FLOTATION:

Studies were pursued as related to the flotation of specular hematite crude ores to determine what factor or factors may tend to improve the flotation process. Some of the variables investigated are listed below.

1. High intensity conditioning - This study was carried out on a batch and pilot plant scale and a limited amount of work was conducted at the Republic Mine.

2. The effect of temperature during conditioning was investigated. As differences exist between summer and winter operation at the flotation plants, some improvement in recovery was realized when elevating the pulp during conditioning to the temperature level maintained during the warmer months.

3. Pure reagents such as oleic and linoleic were tested to determine the selectivity as related to the individual components which constitute the fatty acids in the reagents being utilized at the flotation plants.

4. Various flotation reagents submitted by companies were tested.

5. Emulsifying agents and emulsified reagents were tested.

6. The effect of pH on flotation selectivity was checked.

SPECIAL FLOTATION STUDIES:

Through the program designed to evaluate the factors that tend to affect the selectivity of specular hematite flotation, a modified conditioning procedure was developed that produced results very similar to those gained utilizing the reflotation process. The batch test results have been encouraging in that a variety of crude ore samples from the Republic Mine have been tested and concentrate grades in the range of 67% Fe have been produced while maintaining high recoveries. The modified conditioning procedure eliminates the need for elevating the pulp temperature and also in many cases eliminates the need for regrinding down to pelletizing size range in order to obtain desired grade and recovery. Test work will be continued on a plant scale in order to substantiate initial batch test work.

MISCELLANEOUS FLOTATION PROJECTS:

Amine flotation studies were continued during the year utilizing Empire magnetic concentrates as feed material. These studies were conducted on a batch scale utilizing concentrates that had been produced in the pilot mill magnetic flowsheet.

A batch flotation study on Republic Aerofall Mill products was conducted during the year.

DRILL CORE TESTING:

Drill core from Iron Bay Mines, Bruce Lake Iron Ore Deposit and the Albanel Area were tested in the Laboratory during the year. All of the test work for these areas was Davis magnetic tube tests conducted on a batch scale.

SURFACE SAMPLES:

During the year samples representing outside explorations and land offers were submitted to the Research Laboratory for test work. Most of these samples were processed in a routine manner.

GENERAL:

Several meetings were held throughout the year with Cleveland-Cliffs operating personnel and various equipment representatives to discuss various phases of flowsheets proposed for plant expansions. Much of this work was concerned with the flotation process and specifically with type of flotation cell, cell arrangement, and mode of conditioning.

PART IV

MICROSCOPY SECTION

PELLETIZING:

Laboratory Investigation of Pre-heated Pellets prepared from Eagle Mills Filter Cake at a Temperature Range between 1600°F and 2000°F

Object - To determine the mineralogical, physical, and chemical changes in the pre-heated pellets at the temperatures tested, and to explain why the pellets fired between 1900°F and 2000°F were considerably stronger than those fired between 1600°F and 1900°F.

Results - Texturally, there were no microscopically visible changes of ore particles in the pellets fired between 1600°F and 1900°F whereas the ore particles in those fired between 1900°F and 2000°F showed visible but very slight grain growth and marginal migration.

Textural Study of Specular Hematite and Artificial Magnetite Pellets Processed by Grate-Kiln-Cooler Process at the Allis-Chalmers' Carrollville Pilot Plant

Object - To determine the effects of (1) the type of concentrates, (2) the fineness of concentrates, (3) the type of additive, (4) the kiln temperature, (5) the size of green pellets, and (6) the kiln RPM, on the mineralogical and textural transformation of pellets.

Results -

1. All pellets made from specular hematite concentrates with bentonite tended to produce a spongeous texture and regardless whether the concentrates were Humboldt, Republic, or Eagle Mills filter cake.

2. The porosity reduction in pellets made from artificial magnetite is about three times as great as that in pellets made from the specular hematite with bentonite under the same pelletizing conditions.

3. Other factors being constant, the higher the percentage of fines in the concentrate, the higher the physical properties of the pellets.

4. Limestone is an effective additive in promoting the rate of grain growth and reducing the porosity considerably by slag formation, and consequently improving the room temperature physical properties.

5. The increase of kiln temperature with (1) the increase of hematite bridges in the bentonite-containing specular hematite pellets, (2) the increase of ore particle roundness and slag formation in the bentonite-limestone containing pellets, and (3) the increase of recrystallization of small hematite grains in the pellets originally made from artificial magnetite. However, as soon as the temperature exceeds 2500°F, magnetite tends to develop from the hematite and chert tends to form slag interstitially between the magnetite grains.

6. The size of green pellets and the kiln RPM employed during the tests showed little effects.

Investigation of Pellets produced from Magnetite, Artificial Magnetite and Specular Hematite by various Pelletizing Processes

Object - To evaluate the quality of pellets, particularly at the high temperatures, on the basis of micro-texture and mineralogical composition and in an attempt to explain why the pellets made from magnetite or artificial magnetite are superior to those made from specular hematite.

Results -

1. Under the standard pelletizing condition, magnetite particles will first oxidize to minute hematite grains which will then recrystallize to mutually contacted equigranular hematite grains, whereas specular hematite particles tend to retain their original size, particle outlines, and mineralogical composition and are linked together by tiny bridges which may either be formed by recrystallization of specular hematite fines or by the marginal diffusion of large particles.

2. The possible ways for the improvement of specular hematite are (1) fine grinding of the specular hematite concentrate, (2) contamination of magnetite or fine-grained hematite ores with the specular hematite concentrate, and (3) magnetic conversion of green specular hematite pellets.

Asphalt, an Additive for Pelletizing Specular Hematite Ore Concentrates

Object - To determine the effect of asphalt on the quality of specular hematite pellets.

Results - An addition of asphalt emulsion to specular hematite pellets could produce pellets having a micro-texture resembling those made from magnetite. However, the firing process involves reduction, oxidation, and induration and the air supply in firing system has to be closely controlled.

Microscopic Study of Ring Materials formed in ACL Kiln at the Eagle Mills Pilot Plant

Object - To study the ring formation in kiln of the grate-kiln-cooler system at the Eagle Mills Pilot Plant.

Results -

1. The ring buildup was likely intermittent or periodical which is attributed to temperature fluctuation.

2. The temperature gradient decreases appreciably towards the feed end. The ring was located in the temperature zone of 2200°F to 2100°F.

3. The addition of limestone accelerates the rate of ring growth considerably.

4. The size of ring(s) may be minimized by improving the quality of grate product and discontinuing the use of limestone.

MOC-CONCENTRATION:

Laboratory Investigation of MOC Samples from the Republic Crude Ore produced at different Temperature Levels

Object - To determine the degree of physical and chemical changes of crude ore at different temperature levels and to find which would be the most suitable temperature for producing the optimum MOC product.

Results - Above 1000°F and below 1100°F appears to be the suitable temperature range for obtaining a relatively minimum reduction of "silica-carriers"-submicroscopic hematite inclusions- and a maximum reduction of ore particles to magnetite.

Investigation of MOC Products produced by the Domnarvet Kiln Process

Object - To examine the mineralogical and textural transformation in the products produced by the Domnarvet kiln process in Sweden.

Results - Two tests were conducted during 1959. The study of the first samples revealed that the Domnarvet MOC system was unable to produce a desirable MOC product because of the incomplete reduction of ore particles accompanied by an intensive reoxidation of reduced particles.

The second test was conducted after the system had been revised. Although no samples have yet been microscopically examined, the metallurgical results proved very satisfactory.

LOW GRADE ORE STUDY:

Microscopic Examination of the Isabella Low Grade Ores, Marquette, Michigan

Object - To explain why the silica content in the MOC concentrates produced from the Isabella ore samples varies from 3.60% to as much as 22.60%, and the iron unit recovery from 97.18% to as low as 56.18%.

Results -

1. Micro-specular hematite, magnetite, and iron carbonate are the chief iron minerals in the samples studied.

2. Upon a minus 325 mesh grind, the ratio between the micro-specular hematite and magnetite determines the concentrate grade, and the ratio between the iron oxides and the iron carbonate determines the percentage of iron unit recovery.

3. As compared to the low grade ores from Tilden, Cascade, New Richmond, and North Lake areas, these materials were much less secondarily oxidized, and with the addition of a new rock type of micro-specular hematite-chert.

Laboratory Investigation of Beach Sands from Acandi Placer Deposit, Colombia

Object - To study the mineralogical and metallurgical characteristics of two beach sand samples.

Results -

1. The iron ore mineral in the beach sands is magnetite (with or without TiO_2-mineral inclusions) and occurs (1) as finely disseminated grains and granular aggregates in rock particles and (2) as individual sands finer than 48 mesh.

2. The material is not desirable for direct magnetic separation, however, it can be treated by gravity separation followed by magnetite separation.

3. Due to the intergrowth of TiO_2-minerals with magnetite, the concentrates produced always contain some TiO_2.

4. Although gold and zircon are present, they are rather negligible.

OUTSIDE EXPLORATIONS:

During the year, rock specimens and low grade ore samples from three outside exploration areas were examined. The purpose was to study the mineralogical composition, mineral texture, mineral associations in the specimens and samples in order either to ascertain the origin of the rock or to determine the possibility of ore beneficiation.

PART V

MOC & REDUCTION

MAGNETIC OXIDE CONVERSION:

Research effort during 1959 was divided into three main divisions: pilot plant testing of the MOC kiln at Domnarvet, Sweden, investigation of the use of x-ray diffraction and differential thermal analyses techniques as means of detailing best conditions for the MOC of various crude ores, and a series of tests to determine the effect of particle size (1", 3/4" etc.) on the magnetic oxide conversion of several types of Tilden crude ore at various conversion temperatures.

Two test runs were made in the MOC kiln located in the research plant of Stora Kopparbergs A.B. at Domnarvet, Sweden. Tilden crude, Humboldt rough flotation concentrate, and Republic crude were the ores used in these preliminary campaigns. This pilot kiln will handle 800 pounds of feed per hour, as operated in these preliminary tests, with a potentially much higher capacity than this.

Armour Research Institute made preliminary tests which indicated that the use of DTA (Differential Thermal Analyses) can yield definite knowledge of conditions important to the most effective MOC processing of an iron ore material. A number of crudes of interest to CCI are being investigated in this continuing study.

The laboratory started a detailed study of the MOC of Tilden crude ore. Various ore types from this deposit are being studied to determine the variations in results occurring when different particle sizes (1", 7/8", 3/4" etc.) of each type of crude are MOC treated at different temperature levels. This research is continuing.

DIRECT REDUCTION:

Active contact with the potential of various direct reduction and like processes has been maintained by two activities. First, a number of samples of ores have been tested in the laboratories or pilot plants of the people seeking to promote these processes. Second, a detailed literature search has been undertaken covering all processes of this general type. This search is being made by an outside, professional literature searching organization.

Tests made during the year and reported concern possible applications of the R-N process and pilot plant testing of the Lesher Process as used in the Swindell-Dressler pilot plant.

PART VI

CHECK SAMPLING PROGRAM

Early in 1959, a quality control program was conducted at the Mather Mine A and B Shafts and at the Bunker-Hill Mine on ores being stockpiled. The purpose of the program was to collect underground ore samples for quality and screen tests during the winter stocking season.

A visit was made to the Lackawanna Plant of Bethlehem Steel Company at Buffalo, New York. The purpose of the visit was to collect moisture samples from the Marquette Mix Fines stockpile and to discuss the handling problems of the fines in their sintering plant.

Ore samples were collected from mine pocket and stockpile shipments during the 1959 Season for general sampling correlation data and structure tests.

A special screening test was conducted at the Ore Improvement Plant with Mather B standard ore using quarter-inch screen cloth.

Samples were collected of screen products from tests conducted utilizing the Sheets-Hayden rod-deck screen installed in the Mather A Mine Headframe.

A number of ore and coal samples were collected for special tests during the year.

ELECTRIC POWER DEPARTMENT
ANNUAL REPORT
YEAR 1959

The Cleveland-Cliffs Iron Company produced 134,621,579 Kwh in its electric generating plants during the year 1959. This was an increase of approximately 1% above the amount generated during the year 1958. Of the amount generated 101,002,425 Kwh were billed directly to our Company and were used as follows: The Cleveland-Cliffs Iron Company used 28,239,102 Kwh (28.0%); The Athens Iron Mining Company used 569,640 Kwh (0.5%); The Humboldt Mining Company used 590,169 Kwh (0.6%); The Negaunee Mine Company used 26,770,043 Kwh (26.5%); The Marquette Iron Mining Company used 39,726,422 Kwh (39.3%); and Upper Peninsula Power Company used 5,107,049 Kwh (5.1%). Of this energy 72.1% was produced in our hydroelectric plants, 0.2% in our Ishpeming Diesel Electric Station, and 27.7% was produced by the Presque Isle Station of Upper Peninsula Generating Company.

Our Company billed to Upper Peninsula Power Company 5,107,049 Kwh during 1959. Of this amount 4,857,431 Kwh consisted of excess hydroelectric energy supplied on a special agreement to be described later. Our Company sold to Upper Peninsula Power Company for its load requirements only 249,618 Kwh, all supplied from the Ishpeming Diesel Plant for emergency service. This figure compares with 9,097,760 Kwh supplied from our plants in 1958, a reduction of 97.5%. In addition to the energy billed by us, the Power Company was billed by Upper Peninsula Generating Company for 33,619,154 Kwh which it used from the portion of the output of the Presque Isle Station to which we were entitled. This was an increase of 82.3% above the amount taken from that source last year. The Power Company put a steam generating station of 26,000 KW capacity into operation in Escanaba late in 1958. This plant made them practically independent of both our wholly owned facilities and that portion of the output of the Presque Isle Plant to which we were entitled. In order to encourage the use of the Presque Isle Plant (to obtain better economy and have the Power Company bear a portion of our idle equipment costs in that plant) a special agreement was made in the latter part of 1958. This agreement waived a portion of the fixed charges of the Presque Isle Plant which Upper Peninsula Power Company would assume by using energy from that plant above the half of the theoretical annual output to which we were entitled. Because of this agreement the Power Company operated only one of the two units available in the Escanaba Plant and increased its utilization of the energy produced by the Presque Isle Plant. Placing of the John H. Warden Station at L'Anse in operation in the latter part of this year made the Power Company still more independent of our energy generating facilities as a source of supply.

Our Company and others operated by it used 95,895,376 Kwh during the year which was a reduction of 9.4% below the amount used in the previous year. Energy use in 1958 was a reduction of nearly 20% below that used in 1957, putting this past year nearly 30% below the 1957 energy use. Continued idleness of the Humboldt Mine was a major cause of this situation as was the strike in the iron mining industry, which lasted for nearly four months. The operation of the Humboldt Mine used 16,196,014 Kwh during its last full year of operation (1957) and it is estimated that the reduction in energy used because of the strike period amounted to approximately 32,000,000 Kwh. This total reduction in energy consumption by our mining operations of approximately 35,000,000 Kwh below that required in 1957 left much idle equipment on which fixed charges in idle equipment costs were experienced. A full year of operations in 1960 and the resumption of operations by the expanded Humboldt property will do much to remedy this situation in the coming year.

Of the energy required for mining operations The Cleveland-Cliffs Iron Company and The Athens Iron Mining Company obtained their entire requirements from energy generated by the hydroelectric facilities. The Negaunee Mine Company, The Humboldt Mining Company and The Marquette Iron Mining Company received 58.2% of their energy requirements from the hydroelectric generating facilities and 41.8% of their requirements from the Presque Isle Plant of Upper Peninsula Generating Company. This latter amount was only 27% of our Company's share of the amount which would be considered a normal annual output of that plant.

Both operations and costs were seriously upset by the strike in the iron ore mining industry. During the period up to July 15th our Company's operations used between 10,000,000 and 11,200,000 Kwh a month. This energy requirement absorbed all available hydro production and utilized part of the output of the Presque Isle Station to which we are entitled. Although we had ample water to furnish a normal production of approximately 7,500,000 Kwh a month from hydroelectric generating facilities during the strike period it was necessary to curtail production during that time to approximately 2,500,000 Kwh a month, which was the entire energy requirement of all of the facilities operated by our Company. As a result, heavy precipitation beginning in August resulted in our filling our reservoir storage capacity and wasting water over the intake dams of all of our generating stations.

In order to minimize the water being wasted we made an arrangement with Upper Peninsula Power Company which permitted us to run our plants to capacity during this period with the understanding that they would use the power we did not require in our operations for furnishing a portion of their load requirements. This agreement provided that we could, at a later date after normal operations at the mines were resumed, draw upon their facilities for an equal amount of energy. To facilitate accounting an arbitrary charge of $.005 per Kwh would be made by each company to the other, which would result in no actual exchange of money between the companies.

As a result of the curtailment hydroelectric operations during the strike period and the heavy precipitation in the fall we ended the year with water equivalent to approximately 40,000,000 Kwh in our storage reservoirs, and 4,857,431 Kwh available at $.005 per Kwh from Upper Peninsula Power Company under the agreement mentioned in the previous paragraph. This reserve amount of electric energy available to us at a very small cost compares with 14,000,000 Kwh which we had in storage at the beginning of 1959. These conditions should materially help hydroelectric production and energy costs in 1960.

Precipitation for the year was 36.90 inches, which is slightly above normal and the highest since 1951 when it was 43.50 inches. Precipitation in the previous four years has been below 31 inches and it is felt that we are now in a wet cycle and will enjoy average or better than average water conditions for the next two or three years. Of the precipitation received this year 65% was received during the four months of the year when the mines were closed because of the strike.

Because of the reduced energy requirements from our generating facilities by our Company and by the Power Company the Ishpeming Steam Plant, which had not been operated since May 1958, remained inactive during 1959. The Ishpeming Diesel Plant was kept in readiness for operation in emergencies but was inactive for most of the year. A total of 249,618 Kwh were generated in the Diesel Plant during the year. This production is the equivalent of about 25 hours' operations at full load. All of the operations were for short periods during emergencies.

The unit charge to our Company for the wheeling of electric energy over the transmission system of Upper Peninsula Power Company increased approximately 10%

above the amount charged during the previous year. This increase was caused almost entirely by the decrease in the quantity of energy carried over the jointly used system during the period and by the fact that our small utilization of energy during the strike period resulted in us paying minimum bills for four months of the year. The actual cost of operating the jointly used system, including fixed charges and the earnings on the investment of Upper Peninsula Power Company, amounted to $438,291.00 during 1959, compared with $435,392.00 during the previous year. The amount of energy handled over the system during 1959 was 204,497,806 Kwh whereas during 1958 it was 215,702,582 Kwh. In addition to the increase in unit cost which was caused by both the slight increase in expense and the decrease in energy transmitted, we paid minimum bills during four months of the year. These minimum bills increased our wheeling cost $28,000 above that which would have been paid during the year if the contract had contained no minimum bill provision. In spite of this increase in unit cost of wheeling charges and the minimum bills, the actual money paid for the use of the transmission system during 1959 was $211,742.00, compared to $214,272.00 in 1958, which is a reduction of 1.2%.

The output of the Presque Isle Plant of Upper Peninsula Generating Company during the year amounted to 138,146,300 Kwh, an increase of 20% above the amount generated in 1958. This increase in output resulted in a reduction in unit operating costs from $.005193 per Kwh in 1958 to $.004821 per Kwh during the past year, a reduction of 5%. The overall unit rate was reduced from $.00876 to $.00825 per Kwh (5.7%) for the same period. This reduction was reflected in the unit cost to our Company which fell from $.01376 to $.01232 per Kwh, a reduction of approximately 10%. In order to take income tax advantage of the change in assessment date of Michigan taxes, the 1959 costs of energy included a double expense for taxes amounting to approximately $79,000. The burden of the fixed charges carried by our Company when we do not utilize our portion of the plant capacity is illustrated by the fact that of the overall cost of operating this plant approximately $.00343 per Kwh (40%) consists of fixed charges, whereas the fixed charges billed to our Company amount to $.00750 per Kwh (61%) of the total unit cost of energy.

Fixed costs which are independent of the amount of electric energy produced comprises a large portion of the total production costs of the electric energy generated in our power plants. The reduced energy utilization during the strike period increased the amount of these costs applicable to each unit of energy utilized. On the operation of our wholly owned plants (not considering compensation for the use of facilities) this increase was not as pronounced as it was to our associates because they carried the fixed charges on the Presque Isle Plant in addition to a proportionate part of the idle equipment costs of the Ishpeming Steam and Diesel Plants. Had it not been for the reduced operations in the strike period it would have been possible to utilize more of the available capacity in both our hydro plants and in the Presque Isle Plant which would have resulted in an overall annual cost to both our Company and our associates less than was obtained in 1958.

Notwithstanding the low energy utilization discussed previously we estimated that our Company, including the Athens Iron Mining Company, would have paid $237,150.00 (92%) more had they purchased their energy requirements at utility rates prevailing in the area than was charged by the Power Department. The associated companies, however, would have paid $7,510.00 less. For the overall operations of our Company and its associates the energy used during the year would have increased the costs of mining operations $229,640.00 had it been purchased at prevailing utility rates. In addition to this savings in mining costs the Power Department obtained earnings after depreciation from Upper Peninsula Power Company and our associates amounting to $275,024.00.

At the beginning of the year data was being collected on a proposed agreement between Upper Peninsula Power Company and our Company which was under consideration

as a replacement contract for the basic agreement under which we are now operating. Trial application of the principles of this proposed contract had revealed difficulties in the application and faults in the theory upon which the agreement was based. However, the immediate need for a new unit at the Presque Isle Station was still considered imminent and a revision of the basic agreement was necessary to provide the details under which such a unit would be installed. As the year progressed postponement of the additional capacity at the Presque Isle Plant made immediate revision of the present contract unnecessary. Difficulties in interpretation and in obtaining economical operating conditions under the basic agreement occurred from time to time but temporary procedures were agreed upon which reduced these difficulties. The result was that no action was taken on the new agreement during the year, but both parties agreed to do some serious work towards revising the agreement early in the coming year.

In the January meeting of Upper Peninsula Generating Company directors need for a new unit at the Presque Isle Station was still being considered necessary for operation early in 1962. However, by the time of the July meeting it was estimated that the new John H. Warden Plant, which the Upper Peninsula Power Company was placing in operation in the fall, would supply additional system generation until early in 1963. This meant that no immediate action need be taken on a second unit until after the current year. At the end of the year it was our opinion that our Company has sufficient capacity to satisfy our energy requirements even after the expansion of the production capacity at the Republic Mine. Any additional ore production facilities which are placed in operation subsequent to that expansion will, however, necessitate additional generating equipment. At the end of the year the exact timing of the expanded development of the Republic Plant was not definite.

The Electric Power Department has a labor agreement with the United Steelworkers of America which is separate from the contract between that Union and The Cleveland-Cliffs Iron Company's other operations. This contract expires October 15th instead of July 1st when the Mining Department agreement expires. As the expiration date of the Power Department agreement approached, Union officials agreed with that Department not to strike at the time of the expiration of the contract and agreed to extend the existing agreement. An agreement was signed to the effect that such an extension would be made under the condition that such changes in the Mining Department agreement as were made would be reflected in the Power Department agreement if they were applicable to the conditions set forth in the Power Department agreement. At the end of the year no specific agreement had been worked out between the Mining Department and the Union and, accordingly, no attempt had been made to execute a revised agreement for the Power Department.

Experience with the hydraulic generators at the McClure Plant continued to be satisfactory after the overhauling and reconditioning which was done in 1958. No serious difficulties were experienced in any of the Company's hydroelectric generating stations during the year. Difficulty was noticed during the month of January with automatic electrical equipment at the McClure and Escanaba Stations but the conditions were corrected by the installation of additional relay equipment. No further major changes were made nor overhaul of apparatus conducted during the year.

Early in the spring the Michigan State Highway Department indicated that they wished right-of-way to rebuild Highway M-28 in Alger County. This highway passes between our AuTrain Dam and the L.S. & I. Railway. We did not desire to grant full right-of-way privileges in this area because of the crowded conditions which existed and it was feared that if the construction work on the highway was not done properly and at the right period of the year it might adversely effect the stability and safety of the AuTrain Storage Dam. Accordingly, our Company worked with the Highway Department to give them an easement to do specific work in the area but did not grant any additional permanent right-of-way to them. This work will be done in an

agreed upon manner and will include additional drainage and maintenance facilities which we feel are desirable and which will be installed at Highway Department expense.

Original plans during the year had called for the Presque Isle Plant of the Upper Peninsula Generating Company to be shut down for annual inspection the latter part of April or early in May. Because of difficulties with the penstock of Upper Peninsula Power Company's Victoria Hydro Plant it was decided to have a shutdown of the Presque Isle Plant for boiler inspection and postpone the inspection of the turbo-generator until next year. Accordingly, the plant was taken out of operation on April 28 and remained out of service until May 3rd. Maintenance and inspection of the boiler, the coal pulverizing equipment, the draft fan, and many small items were accomplished at this time. Although as much of an inspection of the turbo-generator unit was made as could be conducted without dismantling it no complete dismantling and inspection of the unit was conducted. The inspection which was made, however, gave no indication of any difficulties or abnormal conditions existing in the unit. After the inspection the plant was operated with no prolonged shutdown until December 25th when a superheater tube in the boiler was ruptured. This failure necessitated the plant being out of service until December 30th. Sufficient capacity was available in other stations to supply load requirements and no curtailment of service was experienced.

During the month of February the penstock to Upper Peninsula Power Company's Victoria Plant failed and a considerable portion of the penstock was washed out. A failure had been experienced in this same penstock during 1958. The difficulty which occurred in February necessitated the plant being out of service from February 22nd until April 14th. This penstock was in very bad condition and Upper Peninsula Power Company decided that it was necessary to replace all of it in order to avoid expensive failures in the future. Accordingly, the plant was taken out of service in August and the work of dismantling and replacing the pipe was conducted until the middle of October. Because of voltage conditions in the Houghton territory it was necessary to run the Houghton Steam Station and to purchase energy from the White Pine Copper Company during the time that this station was out of service.

The John H. Warden Station of the Upper Peninsula Power Company at L'Anse was dedicated on October 14th. This station had been placed in operation previous to the dedication but trouble was experienced from time to time until the latter part of the year caused by thrash in the circulating water system. Dependable operation, however, was obtained early in November and the station has been operating as a source of energy for the Upper Peninsula Power Company. This station was constructed at the site of a new plant operated by the Celotex Company and supplies steam for processing in the Celotex plant as well as energy for its operation. The John H. Warden Station is estimated at a capacity of approximately 16,000 KW, of which the Celotex operations will require about 7,000 KW, leaving approximately 9,000 KW for system use. This plant adds to the Upper Peninsula Power Company's total generating facilities and makes its generating facilities adequate to supply its load requirements without utilization of our Company's energy producing facilities.

ELECTRIC POWER DEPARTMENT
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STATISTICAL DATA - 1959

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Precipitation -	.44	.61	1.57	1.86	2.82	2.98	6.25	6.98	4.82	5.91	1.13	1.53

Total precipitation at Ishpeming during 1959 - 36.90" (3.075 ft.)
Average " " " - 30.84" (47 year record)

CARP RIVER PLANT:

Drainage area above intake dam	66.66 sq. miles
Cubic feet precipitation in 1959	5,714,500,493
Kilowatt hours generated in 1959	17,157,000
Cubic feet water utilized in 1959 (90 cu. ft. - 1 kwh)	1,544,130,000
" " " wasted over intake dam in 1959	95,400,000
" " " in Carp storage Dec. 19, 1958	332,412,300
" " " " " " Dec. 21, 1959	899,028,000
" " " increase in Carp storage in 1959	566,615,700
Total run-off in 1959 (cubic feet)	2,206,145,760
Run-off per square mile of drainage area (cubic feet)	33,095,496
Second-feet run-off	1.044

	1913	1914	1915	1916	1917	1918	1919	1920	1921	1922	1923	1924	1925
Total Precip.	30.11	26.53	38.40	36.83	25.46	31.05	29.50	27.40	30.38	33.67	21.90	22.95	20.71
Sec.-ft. Run-off	1.03	0.67	0.93	1.29	0.70	0.79	0.83	0.73	0.68	1.06	0.59	0.50	0.25

	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938
Total Precip.	35.69	29.86	36.06	32.28	23.14	36.70	31.20	32.72	32.87	27.10	30.23	30.10	35.32
Sec.-ft. Run-off	0.85	0.98	1.11	0.67	1.10	0.83	1.13	1.14	1.00	0.79	0.89	0.86	1.33

	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951
Total Precip.	33.58	30.34	32.20	34.26	32.04	32.77	30.81	26.12	32.88	22.87	37.23	30.64	43.50
Sec.-ft. Run-off	1.47	1.05	0.83	0.84	1.17	0.70	0.81	0.56	0.88	0.44	0.77	1.09	1.54

	1952	1953	1954	1955	1956	1957	1958	1959
Total Precip.	24.35	35.42	33.77	30.82	25.52	24.53	30.81	36.90
Sec.-ft. Run-off	0.69	0.85	0.84	0.93	0.77	0.687	0.748	1.044

McCLURE PLANT:

Drainage area above intake dam	140.52 sq. miles
Cubic feet precipitation in 1959 (Hoist Plant - 41.91"-3.4925')	13,681,773,642
Kilowatt hours generated in 1959	32,457,000
Cubic feet water utilized in 1959 (125 cu. ft. - 1 kwh)	4,057,125,000
" " " wasted over intake dam 1959	256,320,000
" " " in Hoist storage basin Dec. 19, 1958	995,046,900
" " " " " " " Dec. 21, 1959	2,006,029,000
" " " increase in 1959	1,010,982,100
" " " in Silver Lake Dec. 19, 1958	0
" " " " " " Dec. 21, 1959	1,020,000,000
" " " increase in 1959	1,020,000,000
Total run-off in 1959 (cubic feet)	6,344,427,100
Run-off per square mile of drainage area (cubic feet)	45,149,638
Second-feet run-off	1.424

	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933
Total Precip.	35.10	42.03	26.60	30.49	24.06	43.95	35.51	43.80	38.75	30.81	37.02	32.54	35.07
Sec.-ft. Run-off	1.02	1.54	0.85	0.92	0.52	1.52	1.80	2.22	1.36	1.45	1.10	1.23	1.30

	1934	1935	1936	1937	1938	1939	1940	1941	1942	1943	1944	1945	1946
Total Precip.	35.02	29.96	32.16	38.18	40.93	41.22	36.59	38.15	40.20	35.64	37.62	37.94	31.91
Sec.-ft. Run-off	1.16	0.90	1.05	1.19	1.75	1.69	1.47	1.28	1.15	1.43	1.17	1.36	0.86

	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
Total Precip.	37.27	28.81	43.28	40.65	50.90	29.27	41.56	38.13	35.70	31.71	28.78	28.95	41.91
Sec.-ft. Run-off	1.22	0.78	1.24	1.37	2.09	0.97	1.33	1.29	1.03	1.18	1.237	1.119	1.424

Average precipitation at Hoist Plant - 36.11" (39 year record)

ELECTRIC POWER DEPARTMENT

STATISTICAL DATA - 1959

Energy Delivered to Transmission System by CCI Co. Generating Facilities

	Kwh Delivered to Lines			
	CCICo. Hydro	CCICo. Diesel	UPGCo. Steam	Total
Jan.	6,792,551	6,085	2,117,581	8,916,217
Feb.	6,468,865	4,050	4,122,743	10,595,658
Mar.	4,300,107	9,825	5,658,366	9,968,298
Apr.	6,128,369		4,292,935	10,421,304
May	8,053,489	227,270	2,819,769	11,100,528
June	6,618,138		4,549,716	11,167,854
July	5,510,724		3,816,460	9,327,184
Aug.	3,279,638			3,279,638
Sept.	2,454,591		88,365	2,542,956
Oct.	3,154,775			3,154,775
Nov.	9,382,744	2,388		9,385,132
Dec.	10,581,670		561,211	11,142,881
Total annual use by UPPCo. of CCICo. energy from UPGCo.			33,619,154	33,619,154
Total energy produced by CCICo. generating facilities	72,725,661	249,618	61,646,300	134,621,579

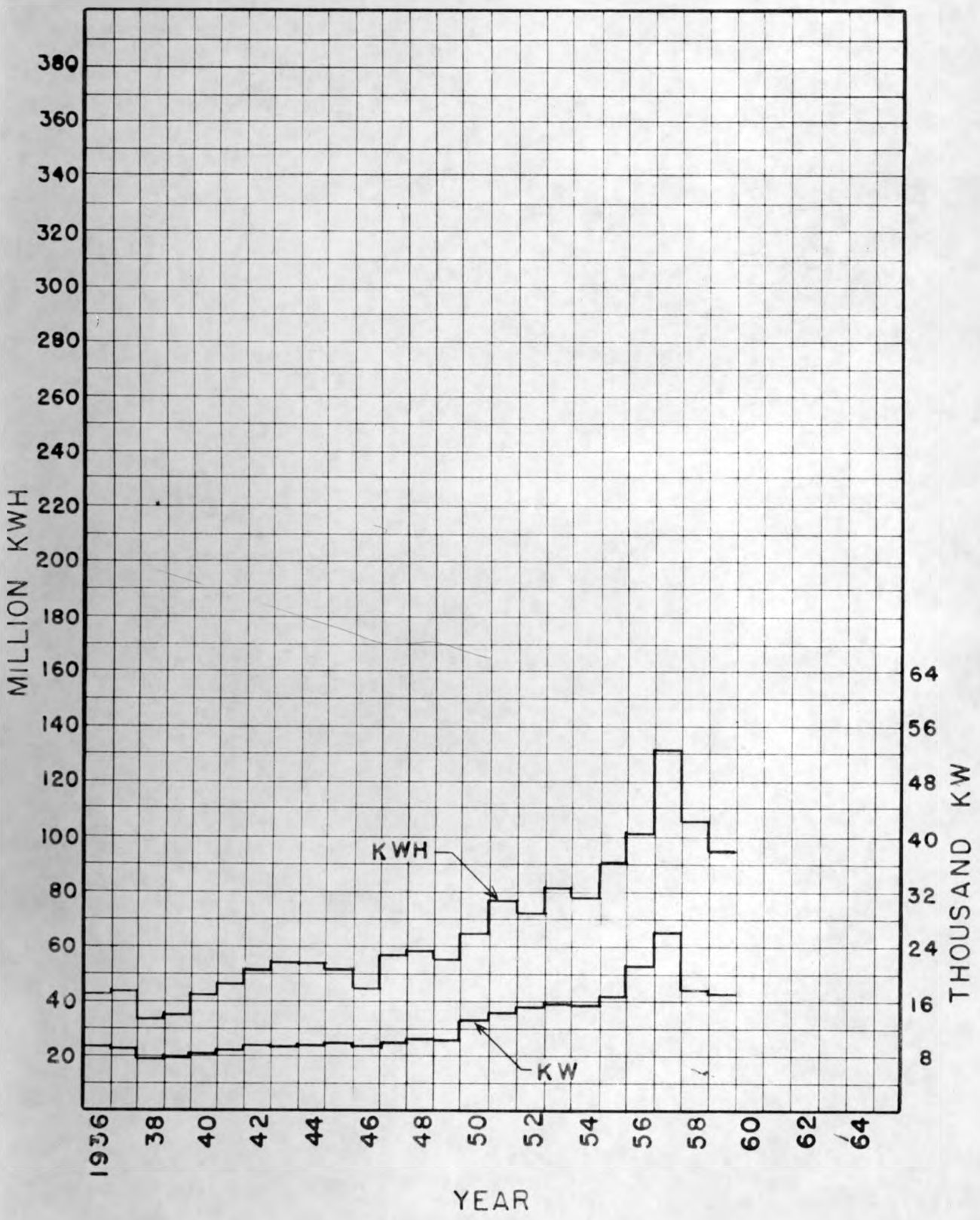
ELECTRIC POWER DEPARTMENT

STATISTICAL DATA - 1959

Utilization of Energy Delivered to
Transmission System by CCICo. Generating Facilities

	Hydro		Diesel		UPGCo.			
	Kwh	%	Kwh	%	Kwh	%	Total Kwh	% of Total
The Cleveland-Cliffs Iron Co.	28,239,102	20.9					28,239,102	20.9
Athens Iron Mining Co.	569,640	0.4					569,640	0.4
Negaunee Mine Co.	15,586,177	11.6			11,183,866	8.3	26,770,043	19.9
Marquette Iron Mining Co.	23,129,700	17.2			16,596,722	12.3	39,726,422	29.5
Humboldt Mining Co.	343,611	0.3			246,558	0.2	590,169	.5
Upper Peninsula Power Co.	4,857,431	3.6	249,618	0.2	33,619,154	25.0	38,726,203	28.8
Total	72,725,661	54.0	249,618	0.2	61,646,300	45.8	134,621,579	100.0

ENERGY & POWER REQUIREMENTS
C.C.I. CO. OPERATIONS



RESEARCH PILOT PLANT

ANNUAL REPORT - YEAR 1959

Construction of the Research Pilot Plant facilities was started in 1958 and the building was completed early in 1959.

The test operations in the new pilot plant facilities commenced early in 1959.

The purpose of the Research Pilot Plant is to provide facilities for continuous piloting of concentration and agglomeration processes. Prior to construction of the pilot plant, this work had been carried out at the central Research Laboratory in Ishpeming. Limited pilot mill facilities, an inefficient materials handling system, and a more intense diversified pilot mill test program dictated the need for a separate and enlarged pilot plant.

The new pilot plant is divided into two sections, one being devoted to pyrometallurgical processes and the other being utilized for hydrometallurgical flowsheet work.

The pyrometallurgical section started operations with an Allis-Chalmers grate-kiln pilot plant. This system has a capacity of approximately 1200 lbs/hour and is identical to the unit installed at Allis-Chalmers' Carrollville Pilot Plant. Related equipment such as bins, feeders, screens, a balling disc and a balling drum are also incorporated within the grate-kiln pilot plant.

The frame of the 32 square foot Dwight Lloyd sintering machine was erected in the pyro section, however, installation was not completed as test efforts were concentrated on the grate-kiln system.

The hydro section is subdivided into three flowsheets, one being a magnetic separation flowsheet circuit similar to flowsheets that are presently being used for concentrating the magnetic taconites. The two other flowsheets are concerned with flotation processes; one being a prototype of the Humboldt or Republic flowsheet. The other flotation circuit was set up to further explore the regrind-reflotation process which involves regrinding of the flotation concentrates followed by heating of the pulp up to the boiling point and a second stage of flotation separation.

Within the hydrometallurgical section a regrind mill was installed for regrinding of specular hematite concentrates to provide the proper size consist for balling and subsequent pelletizing in the grate-kiln system.

Other facilities at the pilot plant include an unloading station for handling of raw materials, a crushing and screening section and storage bins that have a total storage capacity of 350 tons. A small tailings area to which all tailings are pumped and stocking areas for stockpiling of ores were developed at the outset.

Limited laboratory facilities for testing of circuit products and a chemical laboratory for "on the spot" determinations for iron, ferrous iron, and silica were incorporated in the pilot plant facilities. Extensive batch test studies will still continue to be conducted at the Research Laboratory in Ishpeming.

PART I

GENERAL INFORMATION

PERSONNEL AND TIME DISTRIBUTION:

At the end of the year the Pilot Plant was staffed with the following people:

Engineers	3
Clerk	1
Technician Leaders	2
ACL Section	15
Hydro Section	10
Laboratory Testers	7
General Helper-Truck Driver	1
Total	39

The distribution of time as related to projects is presented below.

Time Distribution - Research Pilot Plant
1959

Project	Hours	%
Empire	3,781	13.12
Grate-Kiln System	20,386	70.73
Primary Flotation	2,000	6.94
Regrind-Reflotation	2,657	9.21
Total	28,824	100.00

The number of chemical analyses determined at the plant laboratory during the year are presented below.

1959 ANALYSIS TOTALS - PILOT PLANT CHEMICAL LABORATORY

Month	Fe	Fe^{++}	SiO_2	Totals
May	134	190	64	388
June	536	418	82	1,036
July	598	155	73	826
August	571	274	91	936
September	743	425	101	1,269
October	696	334	79	1,109
November	601	268	51	920
December	1,354	293	156	1,803
Totals	5,232	2,357	697	8,287

Reports or memoranda issued concerning pilot plant test work were assigned Metallurgical Department numbers and issued from the Research Laboratory. Weekly progress reports for the Hydro Section and Pyro Section and monthly reports were issued throughout the year.

PART II

PYRO SECTION

During the year the ACL pilot unit was operated on a three-shift-per-day basis conducting pelletizing tests on Cleveland-Cliffs specular hematite flotation concentrates. The following lists types of concentrates and approximate quantities tested.

		Long Tons
(a)	Humboldt - pilot plant reground	663
(b)	Republic - Eagle Mills reground	143
(c)	Republic - Pilot Plant "refloat" concentrates	6

Approximate distribution of operating time was 84.3 per cent, 15.3 per cent, and 0.4 per cent with concentrates a, b, and c, respectively.

OBJECTIVES:

Humboldt Concentrates - Pilot Plant Reground:

Testing of reground Humboldt concentrates was pursued as per the following general objectives.

(a) Determine and define optimum operating conditions with the pilot unit. This information would serve as guide parameters for startup and operation of the commercial plant.

(b) Operate the system on a continuous basis to bring out any design or materials of construction problems.

(c) Training of personnel which would greatly aid in startup and operation of the commercial plant.

In accordance with objective (a), the following factors and/or variables were studied.

1. The effect of concentrate size analysis on balling, firing rate (system performance), and final product quality.

2. Correlation of optimum balling moisture with the various levels of regrind.

3. Determination of system performance and final product quality while operating with small (-1/2"), medium (-3/4"+1/2"), and large (+3/4") pellets.

4. Determine final product quality and system performance as correlated to pellets containing only bentonite versus pellets containing bentonite and limestone.

5. Compare product quality and system performance with various indurating (kiln), preheating, and drying temperatures; along with corresponding air flows and system pressures.

6. Analysis of conditions causing ringing and accretion buildup on the kiln lining. The following lists factors studied.

(a) Preheat temperatures

(b) Additives

(c) Velocity of gases in the kiln and kiln feed end temperature as related to the size of the kiln feed end.

(d) Refractory glaze coatings for the kiln lining.

(e) Varying flame lengths and spin and no spin flame patterns.

(f) Elimination of preheated air from the cooler.

(g) Kiln temperature

(h) Various ratios of primary and secondary (cooler) air.

(i) Various levels of air (primary and secondary) and still maintain oxidizing conditions.

Routine quality control tests were conducted on samples of the balling disc, grate, kiln, and cooler product. The following lists properties investigated.

(a) Crush and drop strengths.

(b) Size analysis

(c) Chemical Analysis

(d) Abrasion resistance

(e) Bulk density

(f) Porosity

In addition to analysis of wear, fatigue, and heat resistance of the components of the ACL system as per objective (b), various insulating refractories, castable refractories, firebrick, bonding mortars, and refractory coatings were tested.

Republic - Eagle Mills Reground:

Testing of Republic Eagle Mills reground concentrate was pursued as per the following objective.

(a) Determine the influence of various preheating and indurating temperatures on product quality and system performance.

Republic - Refloat Concentrates:

A small tonnage of refloat concentrates was processed by the system to obtain some high-grade specular hematite pellets. Routine quality control tests were conducted on these pellets to compare their quality with pellets made from Eagle Mills reground and Humboldt reground concentrates.

FEED PREPARATION:

Regrinding:

All of the Humboldt concentrates were ball mill reground in open circuit, brought up to optimum filtering density in a slurry tank, and filtered.

Filtering:

The slurried concentrate was filtered in a 4-foot disc filter. Tests were conducted during the year to determine optimum filtering conditions. The following lists variables tested.

(a) Density of the pulp in the filter tank.

(b) Air flows

(c) Cake thickness as related to disc speed, pickup area, and vacuum.

(d) Bottom or side feeding of the filter tank.

(e) Removal of suspensed slimes and froth.

Concentrates which did not require regrinding, but whose moisture contents were above or below that desirable for balling, were slurried and refiltered to obtain the proper moisture content.

Balling:

All of the balling was done in a 3-1/2 foot disc. Optimum operating conditions in terms of slope and speed (retention time) were determined for each type of concentrate tested and desired ball size. When the ACL system is operated above 2.0 LT/ft^2/day the disc becomes overloaded and does not afford the desired surface area for optimum balling. The balling drum circuit was completed except for a tripper on the feed belt to provide steady feed to the drum.

SYSTEM MODIFICATIONS:

The following lists modifications made to the system and its components in order to improve operation.

(a) The rotating bin feeders were replaced by a B-I-F feeder. The old feeders were a constant source of trouble in terms of material hang-up, inaccurate weighing, and fluctuating feed output. The new feeder affords excellent control of feed rate, gives accurate weights, and delivers the correct proportion of additives.

(b) Leakage of ambient air into the ACL system required fabrication and installation of new kiln seals which have a grease groove to distribute the lubricant.

(c) The original curtain wall in the cooler proved to be a constant source of trouble in terms of jamming the cooler. This was replaced by a curtain wall with collapsible buckets.

(d) The original sideplate casting of the grate machine suffered excessive growth, warpage, and oxidation scaling. This resulted in improper sealing causing hot gases to short-circuit around the pellet bed. After the last run of the year it was necessary to cut 3 inches off the top of each casting. In effect, this removed the area where the castings bind. The refractory sidewalls were lowered to accommodate the lower castings. This change has resulted in very good sealing of the grate-chain.

PART III

HYDRO SECTION

PRIMARY FLOTATION SECTION:

The objectives for operating the primary flotation were: (1) production of regrind-reflotation feed and (2) pilot mill testing of Galigher Company's Agitair flotation cells.

1. During September and October of this year this circuit consumed approximately 100 tons of feed and yielded 35-40 tons of 59% Fe regrind-reflotation feed. Two flowsheets were tested; (1) scavenging all flotation tails with the concentrate returned to the head of the circuit and (2) scavenging only the rougher tails with this concentrate and the cleaner and recleaner tails all returned to the head of the circuit. Both flowsheets yielded the desired grade but slightly higher iron recoveries were obtained by scavenging only the rougher tails.

2. During the weeks of October 26th and November 2nd, a representative of the Galigher Company was present to assist in the testing of the Agitair flotation cells. Operation of these cells during this period gave the desired grade of 59% Fe with 90-95% Fe unit recovery based on flotation feed. On isolated shifts, higher grade recleaner concentrates were made but iron unit recovery fell off sharply. Time did not permit a correlation study to enable a comparison of the three cell types on a pilot mill scale.

REGRIND AND REFLOTATION PROCESS:

The substantial degree of upgrading which occurs in the regrind and reflotation process depends largely on the attainment of pulp boiling and the additional liberation achieved by regrinding the rougher flotation concentrates.

Pilot mill studies conducted during the year investigated pulp heating methods and closed or open circuit preconcentrate regrinding.

Pulp heating methods studied were the following:

1. Direct Heating

   (a) Submerged Combustion
   (b) Steam Sparging

2. Indirect Heating

   (a) Steam Coils

3. Combination of Direct and Indirect Heating

   (a) Steam sparging and Indirect Steam Coil heating

Evaluation of the heating methods was made based on the BTU input requirements of each method and final reflotation metallurgy.

Closed circuit preconcentrate regrinding was tested studying the following variables:

1. Additional BTU input requirements over open circuit preconcentrate regrinding.
2. Savings in grinding energy requirements.
3. Product size consistability.
4. Final reflotation metallurgy.

Regular Republic concentrate was used for the bulk of the pilot plant test work.

EMPIRE:

Empire flowsheet development testing commenced at the Research Pilot Plant on a one-shift-per-day schedule during June 1959 until November 30, 1959. At this time operations were continued on a two-shift-per-day schedule. The tonnage of crude processed during the total period was approximately 160 long tons.

During November 1959, 1250 tons of crude were obtained from the Empire Area. Approximately 1000 tons was crushed to pass 2 inch for flowsheet development tests and 250 tons crushed to pass 6 inch for future autogenous grinding tests.

The following flowsheet variables were investigated:

1. Cobbing Tests

   Cobbing or initial magnetic separation tests were conducted at three rod mill grind size consists.

   The purpose of this study was to determine:

   (a) The tonnage of material that could be rejected at each size.
   (b) The grade of cobber concentrate and magnetic iron loss.
   (c) If the material rejected at the three size consists influenced the final metallurgy.

2. Open and Closed Circuit Grinding

A series of tests using both open and closed circuit grinding were conducted.

The purpose of the tests was to determine:

(a) The number of grinding stages necessary.
(b) The grinding power requirements
(c) Overall metallurgy.