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8. UNDERGROUND: (Cont'd)

c. Timbering:

Statement of Ground Support Material Used Under Development and Mining Accounts

| Item | Amount | Cost per Ton |
|---|---|---|
| Cribbing | $ 171.64 | .00079 |
| Stull Timber | 5,242.98 | .02405 |
| Lagging | 5,846.01 | .02682 |
| Poles | 3,735.20 | .01713 |
| Steel | 290.75 | .00133 |
| Total | $ 15,286.58 | .07012 |

d. Explosives:

Explosives Used in Breaking 218,000 Tons of Ore in Development and Mining Accounts

| Item | Amount | Cost per Ton |
|---|---|---|
| 60% High-Pressure Gelatin | $ 1,519.14 | .00697 |
| Gelamite 1X | 311.20 | .00143 |
| Hercomite 2X | 23,196.00 | .10640 |
| Total Powder | $ 25,026.34 | .11480 |
| Blasting Supplies | 6,051.36 | .02776 |
| Grand Total Powder & Blasting Supplies | $ 31,077.70 | .14256 |
| Pounds of Powder per Ton of Ore | | .67912844 |

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8. UNDERGROUND: (Cont'd)

e. Pumping:

The pumping system at the Cambria-Jackson Mine consists of two automatic, Byron Jackson, vertical, centrifugal pumps located on the 4th and 7th Levels. Because all of the underground water flows towards the shaft, each level has a pump to relay the water to the main pumping station on the 4th Level. During the year the average flow from all of the levels was 325 G. P. M., as compared with 303 G. P. M. in 1955. Because there is a cave to surface the rate of pumping is directly proportional to the climatic conditions. The peak pumping period occurred in May with 445 G. P. M., whereas last year the peak was in the same month with 393 G. P. M.

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9. TAXES:

| | 1956 Valuation | 1956 Taxes | 1955 Valuation | 1955 Taxes |
|---|---|---|---|---|
| Cambria Realty<br>S½ of SE¼ of Sec. 35, 48-27)<br>Lots 7&8 of Sec. 35, 48-27)<br>Lots 5,6&7 of Sec.36, 48-27)<br>- 222.09 Acres) | $100,000 | $ 4,150.00 | $100,000 | $ 4,237.00 |
| Jackson Strip<br>N660' of N½ of NW¼ of Sec.1)<br>- 40 Acres) | 355,000 | 14,732.50 | 200,000 | 8,474.00 |
| Personal Property<br>Stockpiles, Supplies and Equipment | 225,000 | 9,337.50 | 435,000 | 18,430.95 |
| Total by Michigan State Tax Commission | $680,000 | $ 28,220.00 | $735,000 | $ 31,141.95 |
| Collection Fee | | 282.20 | | 311.41 |
| Total Taxes, Negaunee | $680,000 | $ 28,502.20 | $735,000 | $ 31,453.36 |
| Division of Payments | | | | |
| Cambria-Jackson Taxes, Ishp.* | $ 50,000 | $ 2,040.00 | $100,000 | $ 4,100.00 |
| Cambria-Jackson Taxes, Neg. | 680,000 | 28,502.20 | 735,000 | 31,453.36 |
| TOTAL | $730,000 | $ 30,542.20 | $835,000 | $ 35,553.36 |

*Cambria-Jackson Mine-Ishpeming

N660' of NE¼ of NE¼ of Sec. 2)
47-27 - 20 Acres)

Tax Rate per $1,000 of Valuation

| | 1956 | 1955 |
|---|---|---|
| City of Negaunee | 41.50 | 42.37 |
| City of Ishpeming | 40.80 | 41.00 |

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10. ACCIDENTS AND PERSONAL INJURY:

There were three compensable injuries which accounted for 365 lost-time days during the year. There was also one non-compensable injury which added three days lost time, for a grand total of 368 days. This results in a severity rate of 1,329 days lost per million man hours and a frequency rate of 14.44 injuries per million man hours, compared with the Company's averages in underground mines of 1,063 and 38.60. The total hours worked were 276,929, as compared with 289,622 for 1955.

| Date | Name | Nature of Injury | Days Lost |
|---|---|---|---|
| 2/8/56 | Clement Koski | Broken leg | 229 |
| 8/27/56 | Charles Jurmu | Broken bone, left leg, below the knee | 36 |
| 10/20/56 | Victor Carlson | Fractured bone, right leg | 100 |

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11. POWER:

| | Consumption K. W. Hours | Cost of Current | Average Price per K.W. Hour |
|---|---|---|---|
| 1956 - | 4,061,033 | $ 36,253.81 | $0.00893 |
| 1955 - | 3,408,730 | $ 35,000.97 | $0.01027 |
| 1954 - | 3,792,000 | $ 36,496.51 | $0.00962 |
| 1953 - | 4,579,200 | $ 78,251.09 | $0.01709 |

# MAAS MINE
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## 1. GENERAL

Production from the Maas Mine in 1956 totaled 394,329 tons. This is an increase of 9,194 tons over the budget estimate of 385,135 tons. The entire production, which was obtained from the 7th Level, was hoisted through the winze shaft between the 6th and 7th Levels.

A total of 439,853 tons of ore was shipped during the year. This is a decrease of 180,636 tons from the 620,489 tons shipped in 1955. The reduction in ore shipments is the result of a decrease in the amount of ore on hand as of January 1, 1956, and the steel strike of June 30, 1956.

The mine operated on a 5 day, 2 shift schedule throughout the year. A small crew was employed on the midnight shift to tram ore and supplies.

The industry-wide A.F.L.-C.I.O. strike began on the midnight shift of June 30th, and was terminated on August 6th, at which time normal operations were again resumed. Necessary maintenance during the strike was performed by the Mine Supervisory Force.

The proven ore reserves, as reported to the Tax Commission, showed a substantial increase over the tax figures of the previous year. The increase of 1,585,554 tons was largely the result of the change-over of the Pioneer and Arctic ore reserves from a Lindquist ore reserve figure to a standard ore reserve estimate of an operating property. Subsequent exploration has substantially increased the ore reserves in the Pioneer and Arctic Property.

Surface operations were of a routine nature, with hoisting and stocking operations being the major functions.

The year 1956 saw considerable progress made in a program, which was effected in the latter part of 1955, to change the mining methods at the Maas Mine from sub-level caving to block caving and long-hole stoping. This is evidenced by a decrease in the percentage of ore produced by sub-level caving from 56.9% in 1955 to 19.4% in 1956. This program of mining development was carried on at an increased rate during the year in anticipation of the Bunker Hill-Maas Mine consolidation, and required that a larger percentage of waste material be hoisted through the Maas Winze than during the previous year. The resultant decrease in the ore hoist was largely responsible for the decrease in tons per man per day from 6.85 in 1955 to 6.76 in 1956.

Exploration at the Maas Mine was confined to diamond drilling of the ore section remaining along the Maas-Pioneer and Arctic property line between the 1500-W and 1800-W coordinates, and the western extension of the Maas orebody from the 3000-W coordinate.

# MAAS MINE
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1. GENERAL: (Cont'd.)

There were two active E.&A.s at the Maas Mine during 1956. A total of $250,700 was expended under these capital expenditure authorizations.

The total valuation of the Maas Mine decreased $290,000 from the 1955 valuation. This decrease in valuation was largely the result of a decrease in the amount of ore on stock as of January 1, 1956.

There was an increase in the number of days lost due to injuries to personnel in 1956. The frequency and severity rates for 1956 were 67.60 and 1.739 as compared with 22.38 and .934 in 1955.

Effective August 6, 1956, there was a general wage increase of $0.075 per hour plus $.003 increment increase between job classes.

There was a slight decrease in the cost of power per kilowatt in 1956, from .00924 to .00873, and the total money expended decreased from $86,188 in 1955 to $80,406 in 1956.

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2. PRODUCTION

a. Production by Grades and Months

| Month | Maas | Race Course | City of Negaunee | Total | Rock |
|---|---|---|---|---|---|
| January | 25,655 | 941 | - | 26,596 | 6,700 |
| February | 27,868 | 1,547 | - | 29,415 | 2,120 |
| March | 29,314 | 3,932 | - | 33,246 | 2,520 |
| April | 26,156 | 3,872 | - | 30,028 | 530 |
| May | 39,134 | 3,894 | - | 43,028 | 1,570 |
| June | 36,190 | 3,120 | - | 39,310 | 170 |
| July | - | - | - | - | - |
| August | 30,539 | 727 | - | 31,266 | 5,810 |
| September | 34,394 | 2,745 | - | 37,139 | 728 |
| October | 39,709 | 1,651 | - | 41,360 | 1,625 |
| November | 36,462 | 67 | - | 36,529 | 3,615 |
| December | 31,902 | - | - | 31,902 | 2,950 |
| Total | 357,323 | 22,496 | - | 379,819 | 28,338 |
| Stockpile Overrun | 13,940 | 570 | - | 14,510 | - |
| Total 1956 | 371,263 | 23,066 | - | 394,329 | 28,338 |
| Total 1955 | 327,285 | 41,750 | 7,739 | 376,774 | 47,180 |
| Increase | 43,978 | - | - | 17,555 | - |
| Decrease | - | 18,684 | 7,739 | - | 18,842 |

b. Shipments

| Grade of Ore | Pocket Tons | Stockpile Tons | 1956 Total | 1955 Total |
|---|---|---|---|---|
| Maas | 4,784 | 407,209 | 411,993 | 534,654 |
| Race Course | 428 | 27,432 | 27,860 | 85,835 |
| Total | 5,212 | 434,641 | 439,853 | 620,489 |
| Total Last Year | 13,355 | 607,134 | 620,489 | - |
| Increase | - | - | - | - |
| Decrease | 8,143 | 172,493 | 180,636 | - |

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2. PRODUCTION: (Cont'd.)

c. Ore Statement

| | Maas | Race Course | Total 1956 | Total 1955 |
|---|---|---|---|---|
| Ore On Hand 1-1-56 | 86,233 | 4,822 | 91,055 | 334,770 |
| Product for Year | 357,323 | 22,496 | 379,819 | 353,292 |
| Stockpile Overrun | 13,940 | 570 | 14,510 | 23,482 |
| Total | 457,496 | 27,888 | 485,384 | 711,544 |
| Shipments | 411,993 | 27,860 | 439,853 | 620,489 |
| Balance on Hand | 45,503 | 28 | 45,531 | 91,055 |
| Increase in Output | 36,239 | - | 17,555 | - |
| Decrease in Output | - | 18,684 | - | 47,825 |
| Increase in Ore On Hand | - | - | - | - |
| Decrease in Ore On Hand | 40,730 | 4,794 | 45,524 | 243,715 |

Operating Schedule

| Year | Days Per Week Mine Operated |
|---|---|
| 1956 | 5 days entire year |
| 1955 | 4 days thru April 17th - 5 days balance of year |
| 1954 | 5 days thru April 4th - 4 days balance of year |
| 1953 | 5 days entire year |
| 1952 | 6 days thru May 18th - 5½ days thru Nov. 16th - 5 days balance of year |

d. Division of Product by Levels

| | 1956 | % | 1955 | % |
|---|---|---|---|---|
| Fourth Level | | | 20,685 | 5.9 |
| Fifth Level | | | 4,115 | 1.1 |
| Sixth Level | | | 45,409 | 12.9 |
| Seventh Level | 394,329 | 100.0 | 283,083 | 80.1 |
| Total | 394,329 | 100.0 | 353,292 | 100.0 |

e. Production Delays

There were no delays of any consequence during 1956.

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3. ANALYSIS

a. Average Mine Analysis on Output

| | 1956 | | | | 1955 | | | |
|---|---|---|---|---|---|---|---|---|
| Grade | Iron | Phos. | Sil. | Sul. | Iron | Phos. | Sil. | Sul. |
| Maas | 57.68 | .072 | 8.18 | .350 | 58.21 | .085 | 7.76 | .397 |
| Race Course | 57.98 | .069 | 7.86 | .286 | 58.44 | .088 | 7.31 | .394 |

b. Average Mine Analysis on Ore Shipped

| Grade | Iron | Phos. | Sil. | Mang. | Alum. | Lime | Mag. | Sul. | Loss | Moist. |
|---|---|---|---|---|---|---|---|---|---|---|
| Maas | 57.78 | .073 | 8.10 | .25 | 3.45 | 1.10 | .34 | .345 | 2.28 | 13.58 |
| Race Course | 57.50 | .078 | 8.20 | .26 | 3.70 | 1.08 | .37 | .314 | 2.37 | 13.01 |

c. Average Analysis of Ore in Stock

| Grade | Tons | Iron | Phos. | Sil. | Mang. | Alum. | Lime | Mag. | Sul. | Loss | Moist. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Maas | 45,503 | 57.81 | .076 | 8.19 | .25 | 3.45 | 1.10 | .34 | .432 | 2.28 | 13.58 |
| Race Course | 28 | 57.91 | .074 | 7.83 | .26 | 3.70 | 1.08 | .37 | .328 | 2.37 | 13.01 |

d. Straight Cargo Shipments

| Tons | Iron | Phos. | Sil. | Sul. | Moist. |
|---|---|---|---|---|---|
| 7,845 | 58.14 | .079 | 7.98 | .348 | 12.54 |

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## 4. ESTIMATE AND ANALYSIS OF ORE RESERVES

DEVELOPED ORE:

All of the ore reserves in the Maas property are considered developed except the ore pillar left along the Pioneer and Arctic property line above the 6th Level elevation.

In the Race Course Lease, the entire reserve is considered developed.

All ore adjacent to the 7500 cross-cut in the Mulvey Lease is considered developed. The remainder is undeveloped.

In the Pioneer and Arctic Lease, all ore adjacent to the 7500 cross-cut and in the 708 block is considered developed, the remainder being undeveloped.

The ore reserves in the following table are based on the figures submitted to the Michigan State Tax Commission.

| | Maas Lease | Race Course Lease | Mulvey | Pioneer & Arctic | Total |
|---|---|---|---|---|---|
| Ore Reserves - Dec. 31, 1955 | 2,708,173 | 65,899 | 376,243 | 885,000 | 4,035,315 |
| Ore Production - 1956 | 371,263 | 23,066 | - | - | 394,329 |
| Ore Reserves - Dec. 31, 1956 | 2,576,047 | 38,247 | 522,746 | 2,089,500 | 5,226,540 |
| Tonnage Proved in 1956 | 239,137 | -4,586 | 146,503 | 1,204,500 | 1,585,554 |
| 4th Level to 5th Level | 167,433 | | 196,121 | | 363,554 |
| 5th Level to 6th Level | 1,953,309 | 27,058 | 339,508 | | 2,319,875 |
| 6th Level to 7th Level | 933,761 | 21,205 | 45,200 | 2,321,667 | 3,321,833 |
| Total Gross as of July 31,1956 | 3,054,503 | 48,263 | 580,829 | 2,321,667 | 6,005,262 |
| Less 10% for Mining & Rock | 305,450 | 4,826 | 58,083 | 232,167 | 600,526 |
| Net Total as of July 31, 1956 | 2,749,053 | 43,437 | 522,746 | 2,089,500 | 5,404,736 |
| Less Production July 31, 1956 to Dec. 31, 1956 | 173,006 | 5,190 | - | - | 178,196 |
| Net Total as of Dec. 31, 1956 | 2,576,047 | 38,247 | 522,746 | 2,089,500 | 5,226,540 |

Expected Average Natural Analysis of Ore Reserves

The following analyses are based on the figures submitted to the Michigan State Tax Commission:

| Iron | Phos. | Sil. | Mang. | Alum. | Lime | Mag. | Sul. | Loss | Moist. |
|---|---|---|---|---|---|---|---|---|---|
| 50.50 | 0.094 | 7.50 | 0.18 | 3.00 | 0.90 | 0.35 | 0.35 | 2.25 | 13.50 |

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4. ESTIMATE AND ANALYSIS OF ORE RESERVES: (Cont'd.)

The increase in reserves in the Maas Lease is mostly due to the drilling of an ore pillar left along the Pioneer and Arctic property line between the 1500-W and 1800-W coordinates.

Exploration of the 3000-W coordinate has extended the Maas orebody westward, therefore, increasing the reserves in the Mulvey Lease.

The increase in the Pioneer and Arctic reserves is essentially due to the change from a Lindquist ore reserve figure to a standard reserve estimate of an operating property.

Exploration of the Boundary Ore Body, since this estimate was made, has significantly increased the reserves for this property.

5. LABOR AND WAGES

Labor Relations:

Labor relations between management and employees were excellent throughout the year. There were no formal grievances submitted during the year.

Employment:

The average number of statistical employees in 1956 was 234½ as compared with 236 during 1955.

There were 55 separations during the year -- 12 retired, 36 were transferred and 7 quit. There were 10 men rehired and 23 transferred to the Maas during 1956.

| | |
|---|---|
| Number of Men Beginning of Year | 263 |
| Added During Year | 33 |
| Separations | 55 |
| Total End of Year | 241 |

The mine was idle from July 1st thru August 6th due to a strike of the A.F.L.-C.I.O. Union.

Vacations - 1956

| | Number of Men | Number of Hours | Amount | Rate Per Hour |
|---|---|---|---|---|
| One Week | 13 | 520 | $ 1,180.04 | 2.269 |
| Two Weeks | 72 | 5760 | 14,922.04 | 2.591 |
| Three Weeks | 153 | 18360 | 48,001.32 | 2.614 |
| Total | 238 | 24640 | $64,103.40 | 2.602 |

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5. LABOR AND WAGES: (Cont'd.)

Paid Holidays - 1956

| | Number of Men | Number of Hours | Amount | Rate Per Hour |
|---|---|---|---|---|
| New Years Day | 191 | 1528 | $ 3,738.76 | 2.447 |
| Memorial Day | 190 | 1520 | 3,562.28 | 2.344 |
| 4th of July | 7 | 56 | 129.40 | 2.177 |
| Labor Day | 201 | 1608 | 4,054.23 | 2.521 |
| Thanksgiving Day | 167 | 1336 | 3,303.33 | 2.473 |
| Christmas Day | 205 | 1664 | 4,116.43 | 2.474 |
| Total | 160 | 7712 | $18,904.43 | 2.451 |

Statement of Wages:

| Average Wages Per Day | 1956 | 1955 | Increase | Decrease |
|---|---|---|---|---|
| Surface | $20.93 | $18.08 | $2.85 | |
| Underground | 22.90 | 21.94 | .96 | |
| Total | $22.54 | $20.95 | $1.59 | |
| **Average Wages Per Month** | | | | |
| Surface | $455.25 | $415.80 | $39.45 | |
| Underground | 498.08 | 473.76 | 24.32 | |
| Total | $490.25 | $453.60 | $36.65 | |
| **Average Days Worked Per Month** | | | | |
| 1956 - 19.00 | | | | |
| 1955 - 21.00 | | | | |
| **Tons Per Man Per Day** | | | | |
| Surface | 36.49 | 26.74 | 9.75 | |
| Underground | 8.29 | 9.20 | ---- | .91 |
| Total | 6.76 | 6.85 | | .09 |
| **Labor Cost Per Ton** | | | | |
| Surface | .574 | .676 | | .102 |
| Underground | 2.761 | 2.384 | .377 | ---- |
| Total | 3.335 | 3.060 | .275 | |

6. SURFACE

Surface operations at the Maas Mine were of a routine nature during the year. On May 1st, Maas Mine personnel were transferred to the Bunker Hill Mine, with the exception of a skeleton crew maintained at the Maas surface plant to carry out hoisting and stockpiling operations.

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6. SURFACE: (Cont'd.)

In the early part of October, a section of the Maas Mine rock trestle collapsed. This section was not repaired, as in the near future Maas rock will be hoisted through the Bunker Hill Shaft. The Maas Mine west trestle was dismantled during the year. The box beams were salvaged and utilized in the construction of the new northeast trestle at the Bunker Hill Mine.

Drainage:

The Mine discharge water is directed to a settling area northwest of the Carp River, where it is effectively cleaned before entering the river.

Purchase and Disposal of Dwellings:

The following property was acquired during 1956 by the Mining Department:

| Block No. | Lot No. | Property | No. of Houses |
|---|---|---|---|
| 33 | 6 | Pioneer Iron Co. Plat | 1 |
| - | 3 to 10 | Read and Winters | 1 |
| 32 | 10 | Pioneer Iron Co. Plat | 2 |
| 24 | 8 | Pioneer Iron Co. Plat | 3 |

7. UNDERGROUND

Underground operations were carried on during the year without any major changes from the procedures established during the previous year. The portion of the Maas Orebody lying east of the 7300 cross-cut is generally of a soft and friable nature -- suitable to gravity caving; however, loss of recovery due to dilution has been encountered in several blocks in this area. The dilution problem results from the tendency of the ore to cave in large and blocky pieces, while the highly friable jasper hangingwall caves as a much finer material. The long-hole stoping method of mining is now being used in these areas, with the exception of areas having insufficient height to warrant the development necessary for long-hole stoping. West of the 7300 cross-cut, the ore is quite hard and does not cave well. The long-hole stoping method of mining is being used exclusively in this area. Throughout the year, several contracts continued to mine by the sub-level caving method in areas not adapted to bulk mining methods either because of height or area limitations. All of the Maas production during 1956 was produced from the 7th Level.

A comparison of the proportion of production by mining methods between 1955 and 1956 is shown below.

| | 1956 Tonnage | % 1956 | 1955 Tonnage | % 1955 |
|---|---|---|---|---|
| Sub-Level Caving | 76,583 | 19.4 | 201,177 | 56.9 |
| Block Caving | 208,824 | 53.0 | 151,522 | 42.9 |
| Long-hole Stoping | 108,922 | 27.6 | 593 | 0.2 |
| Total | 394,329 | 100.0 | 353,292 | 100.0 |

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7. UNDERGROUND: (Cont'd.)

An accelerated development program was carried on during the year in preparation for the increased production quota which will be effected at the time of the Bunker Hill-Maas Mine consolidation. This resulted in an increase in the rock tonnage hoisted through the Maas Mine Winze, which is of a limited capacity, and necessarily reduced the ore hoist. The fore-mentioned reasons are largely responsible for the decrease in tons per man per day from 6.85 in 1955 to 6.76 in 1956.

Main Level drifting during 1956 totaled 2,152 feet, with the majority of this amount being driven in the Maas-Bunker Hill conveyor-haulage drift on the Bunker Hill 6th Level elevation. In the future, ore from the Maas 7th Level will be conveyed to the Bunker Hill Shaft by way of this installation. On the 7th Level, the 7500 cross-cut was "holed through" to the south main drift, and the ventilation drift joining the 7100 cross-cut with the Bunker Hill-Maas connecting drift was completed. The south main level drift was extended west to the 3300-W coordinate, and drifting in the 760 cross-cut was completed.

The major portion of the production during the year was realized from the block caving method of mining. Two blocks were active in the pillar along the Maas-Race Course boundary line, west of the 7100 cross-cut, while a third block was developed east of the 7100 cross-cut to mine the remaining ore reserves in the Race Course Lease. Recovery in this area failed to meet expectations, as block dilution resulted in difficulty in maintaining proper ore grade. A block, located south of Dike #81 along the Maas-Pioneer and Arctic property line, reached full production during March. Some difficulty was encountered in inducing this block to cave freely, and it was necessary to resort to long-hole drilling to break much of the ore. One block, which is located east of the 7300 cross-cut, mined a portion of the ore pillar remaining between the -170 sub-level and a mined-out area on the -100 sub-level.

Two long-hole stopes came into production during the latter part of 1956. One of these stopes is located south of Dike #82 along the Maas-Pioneer and Arctic property line, and will reach full production in the early part of 1957. Production from a long-hole stope located east of the 7400 cross-cut was near completion at the close of the year. West of the 7300 cross-cut, production from two long-hole stopes was terminated early in the year with good recovery being experienced.

At the close of the year, two block caves and five long-hole stopes were under development. Two block caves are being developed in the Maas area between the 7200 and 7300 cross-cuts, while long-hole stope 7202 is located immediately east of the 7200 cross-cut. Above the 7500 cross-cut, three long-hole stopes are being developed to mine the western extension of the Maas Orebody near the intersection of the Maas, Mulvey, and Pioneer and Arctic properties. Long-hole stope 7401, which is located west of the 7400 cross-cut, will mine a portion of the ore section remaining along the north footwall.

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7. UNDERGROUND: (Cont'd.)

During the latter part of the year, a ventilation drift connecting the 7100 cross-cut and the Bunker Hill-Maas connecting drift was completed, and the main ventilating fan installed. This fan was formerly at the Negaunee No. 2 Shaft. Prior to this installation, the auxiliary ventilating fan, located on the +100' Level of the Bunker Hill Shaft, was used as the main ventilation source.

Exploration:
Maas:

During the year, the major portion of the diamond drilling program was concentrated on three areas.

1. The south limb of the Maas orebody in the Pioneer and Arctic property along the 3000-W coordinate.
2. An ore section along the Pioneer and Arctic property line between the 1500-W and 1800-W coordinates.
3. The north side of the Maas orebody along the 2450-W coordinate.

One hole was drilled to test the ground conditions in the vicinity of the crusher site on the Bunker Hill 6th Level elevation. This hole is to be later used as a ventilation and guide hole when raising from the crusher station to the Maas 7th Level.

A total of 1,426 feet of diamond drill hole was drilled in the Maas and 2,295 feet in the Pioneer and Arctic property.

The following table gives the amount of ore cut and the total footage drilled during 1956:

| 1956 Holes | First Class Ore | Footage Drilled |
|---|---|---|
| No. 88 | 54' | 240' |
| 89 | 6' | 244' |
| 90 | 11' | 216' |
| 91* | 4' | 417' |
| 92 | 15' | 325' |
| 93 | 89' | 200' |
| 94* | 105' | 665' |
| 95 | 0' | 229' |
| 96 | 133' | 155' |
| 97 | 165' | 185' |
| 98 | raise hole | 349'*** |
| 99 | 43' | 83' |
| 100 | 123' | 160' |
| 66** | 178' | 206' |
| 68** | 25' | 47' |
| Total | 951' | 3372**** |
| | | 349*** |
| | Total | 3721 |

* Drilled from Bunker Hill - footage that of Pioneer & Arctic portion.
** Bunker Hill holes - footage that which drilled into Pioneer & Arctic.
*** Not included in footage drilled for ore exploration.
**** Footage drilled for ore exploration.

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7. UNDERGROUND: (Cont'd.)
Exploration: (Cont'd.)
Maas: (Cont'd.)

The following is a summary by N-S sections of the drilling program.

7th Level

3000 W. Section: Diamond drilling along this section explored for the westward extension of the Maas orebody in the Pioneer and Arctic property.

Drill holes 89 and 90 were drilled from the 760 cross-cut to outline the expected ore section. Both holes were stopped beyond the expected position of the hangingwall without intersecting a significant run of ore.

Drill hole 92 was drilled to determine the position of the fault which appears to be paralleling the 1200-S coordinate. Mapping in the 760 cross-cut reveals a highly sheared zone on about the 1200-S. coordinate, verifying the expected position of the fault.

6th Level

A mining limit left a section of ore about 100' wide along the Pioneer and Arctic property line between the 1500-W and 1800-W coordinates. Four short holes, #93 and 95 on the 1600-W coordinate and #96 and 97 on the 1700-W coordinate, were drilled to outline the ore section for mining.

-65 Sub-Level

2450 W. Section: Two holes, #99 and 100, were drilled along this section for control on the ore hangingwall contact in the 7401 block area. Control, previous to this drilling, was on the 2100-W and 2700-W sections, which is too distant for adequate interpretation.

Mapping in the 700 drift, on approximately the 3100-W coordinate, has shown that Dike #82 is changing in strike from E-W to NE-SW. Because this Dike is the south limit of the ore on the 3000-W section, this change in strike may have significant results.

The results of the 1956 exploration program indicate the following:

1. The ore occurring south of Dike #82 throughout the Maas orebody on 7th Level pinches out between the 2700-W and 3000-W coordinates. This appears to be the result of the lack of ore enrichment, as no faulting which would terminate this ore section can be determined.
2. A significant amount of minable ore occurs along the Pioneer and Arctic property line above 6th Level and between the 1500-W and 1800-W coordinates.

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7. UNDERGROUND: (Cont'd.)

Statement of Timber Used

| | Amount - 1956 | Amount - 1955 |
|---|---|---|
| Cribbing | $ 6,888.81 | $ 4,934.21 |
| Stulls | 10,394.38 | 15,176.57 |
| Lagging | 16,323.95 | 12,391.23 |
| Poles | 5,335.73 | 7,459.72 |
| Steel Beams | 19,022.47 | 20,173.04 |
| Steel Sets (Circular) | 17,981.96 | 9,376.02 |
| Total | $75,947.30 | $69,510.79 |

Total Cost of Timbering, Lagging, Poles, etc.

| Year | Amount | Per Ton |
|---|---|---|
| 1956 | $75,947.30 | .1925 |
| 1955 | 69,510.79 | .1845 |
| 1954 | 86,984.40 | .2169 |
| 1953 | 120,479.05 | .2052 |
| 1952 | 112,197.18 | .2254 |
| 1951 | 90,270.45 | .1267 |
| 1950 | 78,273.14 | .1236 |
| 1949 | 82,105.72 | .1361 |
| 1948 | 99,949.06 | .1485 |
| 1947 | 81,240.99 | .1125 |

Explosives

Statement of Explosives Used During 1956

| | 1956 | | 1955 | |
|---|---|---|---|---|
| | Quantity | Amount | Quantity | Amount |
| Total Powder Used | 241,308 | $45,045.09 | 252,100 | $47,769.98 |
| Total Caps, Fuse, etc. Used | | 17,819.59 | | 19,021.66 |
| Total | | $62,864.68 | | $66,791.64 |
| PRODUCT | | 394,329 | | 376,774 |
| Pounds Powder Per Ton of Ore | | .612 | | .669 |
| Tons of Ore Per Pound of Powder | | 1.634 | | 1.494 |
| Cost Per Ton For Powder | | .114 | | .127 |
| Cost Per Ton For Fuse, Caps, etc. | | .045 | | .050 |
| Cost Per Ton For All Explosives | | .159 | | .177 |

Pumping

The pumping set-up remained unchanged in 1956; however, automatic pumping equipment has been installed on 2nd Level at the Bunker Hill Shaft. This equipment will handle Maas Mine water early in 1957.

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## 8. COST OF OPENING, EQUIPPING, DEVELOPING AND OPERATING

There were two active E.&A.s at the Maas Mine during 1956. E.&A. CC-752 -- Underground Development and E.&A. CC-871 -- Drill Machines.

| Reference | Prior Year Expenditures | 1956 Expenditures | Total Expenditures |
|---|---|---|---|
| E & A CC-752 | - | $244,760 | $244,760 |
| E & A CC-871 | - | 5,940 | 5,940 |

Comparative Mining Costs

| | 1956 | 1955 | Increase | Decrease |
|---|---|---|---|---|
| Product | 394,329 | 376,774 | 17,555 | |
| Underground Costs | 3.882 | 3.385 | .497 | |
| Surface Costs | .465 | .465 | - | |
| General Mine Expense | .558 | .573 | | .015 |
| Cost of Production | 4.905 | 4.423 | .482 | |
| Depreciation | .101 | .127 | | .026 |
| Taxes | .277 | .372 | | .095 |
| Loading & Shipping | .112 | .141 | | .029 |
| Total Cost at Mine | 5.395 | 5.063 | .332 | |
| Budget Estimated Cost Per Ton | 5.298 | 5.415 | | .117 |

Number of Days Operated

| | | | | |
|---|---|---|---|---|
| 1-8 Hour | | | | |
| 2-8 Hour | 228 | 234 | | 6 |

| Proportion of Labor & Supplies | 1956 | % | 1955 | % |
|---|---|---|---|---|
| Labor Cost Per Ton | 3.584 | 73.1 | 3.307 | 65.3 |
| Supplies | 1.321 | 26.9 | 1.756 | 34.7 |
| Total Cost Per Ton | 4.905 | 100.0 | 5.063 | 100.0 |

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8. COST OF OPENING, EQUIPPING, DEVELOPING AND OPERATING: (Cont'd.)

Cost of Production

| | 1956 | | 1955 | |
|---|---|---|---|---|
| Underground Costs: | Amount | Per Ton | Amount | Per Ton |
| Development | $ 232,378.68 | $ .589 | $ 117,803.45 | $ .313 |
| Mining | 486,314.83 | 1.233 | 426,102.71 | 1.131 |
| Tramming | 278,770.90 | .707 | 275,323.44 | .731 |
| Auxiliary Hoisting | 70,331.09 | .178 | 61,000.37 | .162 |
| Ventilation | 18,783.10 | .048 | 31,586.20 | .084 |
| Pumping | 82,301.66 | .209 | 88,961.89 | .236 |
| Compressors and Air Lines | 55,435.95 | .141 | 43,043.76 | .114 |
| Underground Superintendence | 81,704.27 | .207 | 78,102.95 | .207 |
| Maint: Pockets and Chutes | 2,185.10 | .006 | 2,574.74 | .007 |
| " Mining Equipment | 79,604.10 | .202 | 44,298.57 | .117 |
| " Levels and X-Cuts | 24,181.70 | .061 | 11,971.80 | .032 |
| " Shaft | 13,488.88 | .034 | 10,910.13 | .029 |
| Telephones & Safety Devices | 14,061.43 | .036 | 10,982.54 | .029 |
| Holiday Pay | 21,338.76 | .054 | 22,088.68 | .059 |
| Vacation Pay | 69,969.14 | .177 | 50,690.93 | .134 |
| Total Underground Cost | $1,530,849.59 | $3.882 | $1,275,442.16 | $3.385 |
| Surface Costs: | | | | |
| Hoisting | $ 63,744.71 | $ .161 | $ 59,975.40 | $ .159 |
| Stocking | 38,721.47 | .098 | 43,898.41 | .117 |
| Timber Yard | 24,802.78 | .063 | 21,258.18 | .057 |
| Dry House | 17,594.43 | .045 | 17,066.73 | .045 |
| Policing | 10,181.39 | .026 | 11,600.03 | .031 |
| General Surface | 11,985.91 | .030 | 2,750.61 | .007 |
| Maint: Headframe Bldg. & Equip. | 291.87 | .001 | 1,187.09 | .003 |
| " Other Mine Buildings | 1,460.72 | .004 | 894.22 | .002 |
| Telephones & Safety Devices | 471.78 | .001 | | |
| Holiday Pay | 3,889.59 | .010 | 4,850.16 | .013 |
| Vacation Pay | 10,281.18 | .026 | 11,881.37 | .032 |
| Total Surface Cost | $ 183,425.83 | $ .465 | $ 175,362.20 | $ .466 |
| General Mine Expenses: | | | | |
| Electrical Engineering | $ 2,254.07 | $ .006 | $ 2,236.40 | $ .006 |
| Geological Department | 1,860.56 | .005 | 2,207.06 | .006 |
| Mining Engineering Dept. | 12,245.96 | .031 | 14,871.89 | .039 |
| Mech. Engineering Dept. | 386.25 | .001 | 2,451.37 | .007 |
| Safety Department | 4,698.94 | .012 | 4,240.33 | .011 |
| Research Laboratory | 2,592.31 | .007 | 3,706.54 | .010 |
| Analysis & Grading - Laboratory | 20,273.12 | .051 | 17,961.55 | .048 |
| " " " - Shipping | 3,573.04 | .009 | 3,009.61 | .008 |
| Special Expense - Pensions | 64.77 | ---- | 67.91 | ---- |
| " " - Retirements | 2,856.73 | .007 | 3,325.19 | .009 |
| " " - Hygiene Clinic | 1,002.06 | .003 | 4,699.54 | .012 |
| " " - Employment Off. | 757.67 | .002 | 743.25 | .003 |
| Ishpeming Office | 54,398.40 | .138 | 50,583.82 | .134 |
| Mine Office - Supt. & Clerks | 25,141.71 | .063 | 30,702.16 | .081 |
| Central Warehouse Overhead | 10,619.52 | .027 | 8,353.28 | .022 |
| Insurance - Property | 1,626.58 | .004 | 1,700.57 | .005 |
| " - Group, Health & Life | 14,449.53 | .037 | 2,916.01 | .008 |
| " - Group Annuity | 6,216.20 | .016 | 6,543.19 | .017 |
| " - Catastrophe | 2,907.50 | .007 | 2,450.37 | .007 |
| Personal Injury - Comp. & Doctors | 14,573.44 | .037 | 16,275.21 | .043 |
| " " - Comp. Dept. | | | 828.85 | .002 |
| E.&A. CC-640 - Automatic Pumping | | | 1,075.27 | .003 |
| Taxes - Unemployment Insurance | 6,268.11 | .016 | 2,761.95 | .007 |
| " - Old Age Benefit | 21,633.84 | .055 | 19,402.43 | .051 |
| Employees Ins. & Comp. | 12,591.84 | .032 | 12,665.46 | .034 |
| Power Credit | 3,769.10 | .010 | | |
| Supply Inventory Adj. | 698.26 | .002 | | |
| Insurance - Auto | 76.76 | ---- | | |
| Total General Mine Expenses | $ 219,998.07 | $ .558 | $ 215,779.21 | $ .573 |
| Cost of Production | $1,934,273.49 | $4.905 | $1,666,583.57 | $4.424 |

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8. IDLE EXPENSE

Detailed Idle Cost:

| Underground Costs | Idle Account of Strike |
|---|---|
| Development | $ 169.53 |
| Tramming | 140.44 |
| Ventilation | 586.85 |
| Pumping | 8,298.76 |
| Compressors and Air Lines | 2,250.57 |
| Underground Superintendence | 8,666.25 |
| Maint: Mining Equipment | 10.82 |
| Telephones & Safety Devices | 27.05 |
| Holiday Pay | 123.20 |
| Total Underground Cost | $20,273.47 |
| **Surface Costs** | |
| Hoisting | $ 2,936.94 |
| Stocking | 14.58 |
| Timber Yard | 177.88 |
| Dry House | 69.70 |
| Policing | 925.02 |
| General Surface | 749.83 |
| Holiday Pay | 154.88 |
| Telephones & Safety Devices | 222.33 |
| Total Surface Cost | $ 5,251.16 |
| **General Mine Expenses** | |
| Electrical Engineering | $ 275.69 |
| Mining Engineering Department | 1,558.40 |
| Geological Department | 38.28 |
| Mech. Eng. Department | 39.17 |
| Safety Department | 420.00 |
| Research Laboratory | 116.91 |
| Analysis & Grading - Laboratory | 615.44 |
| " " " - Shipping | 312.00 |
| Special Expense - Pensions | 6.00 |
| " " - Retirements | 326.00 |
| " " - Hygiene Clinic | 86.39 |
| " " - Employment Off. | 78.00 |
| Ishpeming Office | 5,544.00 |
| Mine Office - Supt. & Clerks | 2,875.34 |
| Central Warehouse Overhead | 487.40 |
| Insurance - Property | 209.50 |
| " - Group, Health & Life | 481.81 |
| " - Group Annuity | 569.12 |
| " - Catastrophe | 191.00 |
| Personal Injury - Comp. & Doctors | 138.60 |
| Taxes - Unemployment Insurance | 49.62 |
| " - Old Age Benefit | 262.69 |
| Employees Ins. & Comp. | 516.00 |
| Total General Mine Expenses | $15,197.36 |
| Cost of Production | $40,721.99 |

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9. TAXES

Taxes for the Maas Mine showed a decrease of $15,167.12 in 1956 as compared with 1955. The decrease is due to a smaller amount of ore in stock.

| | 1956 | | 1955 | |
|---|---|---|---|---|
| | Valuation | Taxes | Valuation | Taxes |
| Maas Mine | $ 2,135,000 | $ 88,602.50 | $ 1,815,000 | $ 76,901.55 |
| Race Course | 55,000 | 2,282.50 | 170,000 | 7,202.90 |
| Pioneer & Arctic | 240,000 | 9,960.00 | 150,000 | 6,355.50 |
| Stockpile & Equipment | 695,000 | 28,842.00 | 1,280,000 | 54,233.60 |
| Misc. Parcels | 11,930 | 495.12 | 11,930 | 505.51 |
| Total Maas Mine | $ 3,136,930 | $130,182.12 | $ 3,426,930 | $145,199.06 |
| Collection Fees | - | 1,301.82 | - | 1,452.00 |
| Total | $3,136,930 | $131,483.94 | $ 3,426,930 | $146,651.06 |
| Tax Rate | | 41.50 | | 42.37 |
| Maas Mine Rented Houses | $ 141,005 | $ 5,851.87 | $ 121,405 | $ 5,143.92 |
| Mineral Lands | 13,110 | 544.11 | 13,110 | 555.49 |
| Total Houses & Lands | $ 154,115 | $ 6,395.98 | $ 134,515 | $ 5,699.41 |
| Collection Fees | | 63.95 | | 56.98 |
| Total | $ 154,115 | $ 6,459.93 | $ 134,515 | $ 5,756.39 |

10. ACCIDENTS AND PERSONAL INJURY

There were 18 lost time accidents in 1956 as compared with 8 in 1955. A brief description of the accidents follow:

| Date of Accident | Name | Injury | Days Lost |
|---|---|---|---|
| 2/1/56 | Herman Peura | Severe laceration-right ankle and foot. | 27 |
| 3/3/56 | Jack Aho | Puncture wound of left foot. | 7 |
| 3/26/56 | Clarence Brisson | Amputation tip right index finger. | 100 |
| 3/28/56 | Elvin Velin | Laceration of 3 fingers. | 7 |
| 4/10/56 | George Aro | Fracture two toes - left foot. | 102 |
| 4/13/56 | Leo Romback | Puncture wound of right hand. | 8 |
| 5/1/56 | Benjamin Jewell | Injured right index finger. | 68 |
| 5/21/56 | Edward Ecklid | Lacerated thumb - left hand. | 34 |
| 6/11/56 | Wilho Maki | Crushed thumb. | 35 |
| 6/15/56 | Ettore Vecellio | Twisted right ankle. | 32 |

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10. ACCIDENTS AND PERSONAL INJURY: (Cont'd.)

| Date of Accident | Name | Injury | Days Lost |
|---|---|---|---|
| 6/14/56 | Casper Ruokalainen | Bruised right ankle. | 50 |
| 6/12/56 | Frank Mervar | Injured back. | 43 |
| 8/21/56 | Roy Haglund | Bruised left foot - cut right index finger. | 20 |
| 11/12/56 | Bruno W. Maki | Laceration left ear - contusion left knee. | 9 |
| 11/6/56 | Gunnard Anderson | Strained back. | 8 |
| 11/9/56 | Paul LeBoeuf | Laceration - right ankle. | 12 |
| 12/3/56 | Wesley Jennings | Contusions - muscles of back, left leg. | 40 |
| 12/19/56 | John W. Larson | Amputation right index finger between distal and middle joint. | 200 |

The accident statistics compiled by the Safety Department show the following rates for the past five years at the Maas Mine:

| Year | Frequency | Severity |
|---|---|---|
| 1956 | 67.60 | 1.739 |
| 1955 | 22.38 | .934 |
| 1954 | 19.51 | 3.420 |
| 1953 | 31.83 | .731 |
| 1952 | 47.24 | 8.547 |

11. POWER

The Cleveland-Cliffs Iron Company Electric Power Department generates the power, and the Upper Peninsula Power Company distributes it over their transmission lines. The average cost per kilowatt hour in 1956 was $0.00873 as compared to $0.00924 in 1955.

The rate per kilowatt hour is determined by dividing the total operating cost of the Cleveland-Cliffs Iron Company Electric Power Dept. by the total kilowatt hours sold and charging each consumer proportionally. To this is added a wheeling charge by the Upper Peninsula Power Co. for distributing the power to the Mine.

| | 1956 | 1955 |
|---|---|---|
| Total KWH Used | 9,215,132 | 9,326,657 |
| Total Cost of Power | $80,406.57 | $86,188.02 |
| Cost Per KWH | $0.00873 | $0.00924 |
| Cost Per Ton Product | $0.204 | $0.229 |

# MATHER MINE "B" SHAFT
# ANNUAL REPORT
# YEAR 1956

## 1. GENERAL:

Production for the year at Mather Mine "B" Shaft was an all time high. This record was attained even though 175,000 tons of production was lost due to the combined causes of an underground fire in June and the Steelworkers strike in July.

The production for the year totalled 1,288,044 tons. Of this tonnage, 185,963 tons were produced from the 6th Level; 307,671 tons from the 7th Level; and 794,410 tons from the 8th Level.

Two records in production were attained this year. The record hoist of 7,350 tons in twenty-four hours, set in 1955 was exceeded on May 17, 1956 when 7,440 tons were hoisted. The monthly high production of 120,844 tons for September 1955 was surpassed in May when 134,622 tons were mined.

Analysis on production was very good. The Mather Standard appreciably exceeded the guarantee for both iron and silica.

Average Mine Analysis on Output (Incl. Stockpile)

| Grade | Iron | Phos. | Silica | Sulphur |
|---|---|---|---|---|
| Mather Standard | 58.71 | - | 9.05 | .033 |
| Mather Special | 55.58 | - | 8.33 | 1.012 |

The shipping season started on April 6th and continued until December 3rd. Shipments from stockpile and pocket totalled 1,220,984 tons, which was approximately 100,000 tons under the banner year of 1955.

Average Analysis on Shipments (Total Average)

| Grade | Iron | Phos. | Silica | Sulphur |
|---|---|---|---|---|
| Mather Standard | 58.40 | .096 | 9.54 | .024 |
| Mather Special | 55.65 | .117 | 7.99 | 1.221 |

The cost of production increased $0.971 per ton above last year. The increased costs were due to a substantial wage increase coupled with a corresponding increase in cost of supplies. The unit cost of steel for ground support was greatly increased, due to the use of available but higher cost steel. Greater emphasis was also placed on development which had been retarded by a shortage of miners until the latter quarter of 1955. The additional development was necessary to regain broken reserves depleted in 1955.

Labor relations were satisfactory this year. Five grievances were advanced beyond Step 2. Two of the grievances were dropped by the Union and three continued into 1957.

Dewatering of the Jackson Pit area continued. Nine wells were drilled in the Partridge Creek locality and three pumps have been installed. The pumps have lowered the water table over the mine workings more than four feet.

MATHER MINE "B" SHAFT
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1. GENERAL: (Cont'd)

Valuable information was gained from the subsidence program. The cave over the large underground stopes reached the 2nd and 4th Level holes. An additional hole was drilled from surface above the cave area, which is used for microsiesmic studies. There is no activity in the surface holes as yet.

Installation of the 6th Level crusher, between the 6300 and 6400 Cross-cuts, was completed this year and will go into service in March when mining starts in Block 63-B. The ore from all future mining areas on both the 5th and 6th Levels will pass through the crusher. Secondary blasting costs will be reduced and hoisting from the 6th Level will be accelerated due to elimination of large chunks at the measuring pockets.

The 7th Level rope suspended conveyor was placed in operation this year. By means of this system all of the 7th Level ore is crushed and hoisted from the 8th Level, thus allowing larger grizzly openings to be used on the 7th Level, which appreciably reduced secondary blasting and tramming costs. Installation cost of the rope suspended conveyor was much lower than that for the conventional type.

Work was started on the 10th Level crusher-conveyor system during the year. Construction of this project will be completed by the time mining begins on the 9th Level, and this ore will pass through a raise to the 10th Level crusher.

Work on the emergency underground pumping system was well advanced this year. All of the sumps and pumphouses were completed and installation of pumps and switch gear was 40% completed by the end of the year. With the completion of this project it will be possible to pump 2,500 g.p.m. from the 10th Level to the surface, and an additional 1,500 g.p.m. can be pumped from the 10th to the 6th Level.

Drifting on 5th Level was completed. This consisted of advancing four cross-cuts a total of 1,470'.

The 9th Level main line heading holed-through perfectly to the "A" Shaft side on December 7th. The total main line footage driven was 1,897', of this footage 1,082' was driven with steel support and 815' was naked with roof bolts. The 9200 Cross-cut was driven 230' and the 9600 Cross-cut was advanced 140'. Both of these cross-cuts were driven to permit switching and diamond drilling the ore body above and below the level.

The 10th Level main line was advanced 1,190' with steel support. This heading was 80' east of the "A" - "B" Shaft boundary at the end of the year. The 10,700 Cross-cut was advanced 710' and the 10,900 Cross-cut was advanced 145'.

Increased life of drill steel and subsequent cost reductions were experienced when a change was made from carbon to alloy drill rods. This was one of the results of a testing program based on the constant effort to reduce costs.

Revision of ore outlines and depletion decreased the total ore reserves 2,495,763 tons in 1956.

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2. PRODUCTION, SHIPMENTS & INVENTORIES:

a. Production by Grade and Months:

| | Standard | Special | Total Tons | Rock |
|---|---|---|---|---|
| January | 84,851 | 12,520 | 97,371 | 10,704 |
| February | 107,812 | 14,699 | 122,511 | 13,319 |
| March | 105,854 | 16,889 | 122,743 | 18,372 |
| April | 111,415 | 20,216 | 131,631 | 12,600 |
| May | 115,667 | 18,955 | 134,622 | 9,972 |
| June | 91,922 | 19,455 | 111,377 | 9,936 |
| July | - | - | - | - |
| August | 87,496 | 12,550 | 100,046 | 12,641 |
| September | 96,544 | 15,928 | 112,472 | 11,988 |
| October | 110,297 | 24,123 | 134,420 | 12,780 |
| November | 104,763 | 15,252 | 120,015 | 7,848 |
| December | 85,460 | 15,376 | 100,836 | 6,012 |
| Total | 1,102,081 | 185,963 | 1,288,044 | 126,172 |
| After Stockpile Transfer | + 9,365 | - 9,365 | | |
| Total | 1,111,446 | 176,598 | 1,288,044 | |

b. Shipments

| | Pocket Tons | Stockpile Tons | Total Tons | Total 1955 | Increase or Decrease |
|---|---|---|---|---|---|
| Mather Standard | 600,030 | 412,241 | 1,012,271 | 1,155,504 | 143,233 |
| Mather Special | 11,991 | 196,722 | 208,713 | 159,759 | 48,954 |
| Total | 612,021 | 608,963 | 1,220,984 | 1,315,263 | 94,279 |

c. Ore Statement:

| | 1956 | 1955 |
|---|---|---|
| On Hand January 1, 1956 | 145,354 | 227,395 |
| Output for Year | 1,288,044 | 1,161,815 |
| Overrun | - | 71,407 |
| Total | 1,433,398 | 1,460,617 |
| Shipments | 1,220,984 | 1,315,263 |
| Balance on Hand | 212,414 | 145,354 |
| Increase in Output | 126,229 | 275,519 |
| Increase in Ore on Hand | 67,060 | 82,041 |

MATHER MINE "B" SHAFT
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2. PRODUCTION, SHIPMENTS & INVENTORIES: (Cont'd)

Working Schedule:

1956 - Five 2-8 hr. shifts from January 1, 1956 to September 9, 1956. Five 3-8 hr. shifts from September 10, 1956 to December 31, 1956.

1955 - Four 2-8 hr. shifts from January 1, 1955 to April 14, 1955. Five 2-8 hr. shifts from April 15, 1955 to December 31, 1955.

1954 - Five 3-8 hr. shifts from January 1, 1954 to March 31, 1954. Four 3-8 hr. shifts from April 1, 1954 to May 14, 1954. Four 2-8 hr. shifts from May 15, 1954 to December 31, 1954.

1953 - Five 3-8 hr. shifts from January 1, 1953 to December 31, 1953.

1952 - Five 3-8 hr. and one 2-8 hr. shifts per week from January 1, 1952 to May 31, 1952. Five and one-half 3-8 hr. shifts from June 1, 1952 to November 16, 1952. Five 3-8 hr. shifts per week from November 17, 1952 to December 31, 1952.

d. Division of Product by Levels and by Months:

| | 6th Level Special | 7th Level Standard | 8th Level Standard | Total Tons Standard | Special |
|---|---|---|---|---|---|
| January | 12,520 | 29,206 | 55,645 | 84,851 | 12,520 |
| February | 14,699 | 41,594 | 66,218 | 107,812 | 14,699 |
| March | 16,889 | 24,398 | 81,456 | 105,854 | 16,889 |
| April | 20,216 | 41,224 | 70,191 | 111,415 | 20,216 |
| May | 18,955 | 28,917 | 86,750 | 115,667 | 18,955 |
| June | 19,455 | 19,304 | 72,618 | 91,922 | 19,455 |
| July | - | - | - | - | - |
| August | 12,550 | 23,624 | 63,872 | 87,496 | 12,550 |
| September | 15,928 | 24,136 | 72,408 | 96,544 | 15,928 |
| October | 24,123 | 28,677 | 81,620 | 110,297 | 24,123 |
| November | 15,252 | 20,953 | 83,810 | 104,763 | 15,252 |
| December | 15,376 | 25,638 | 59,822 | 85,460 | 15,376 |
| Total | 185,963 | 307,671 | 794,410 | 1,102,081 | 185,963 |
| After Stockpile Transfers ..... | | | | ∔ 9,365 | - 9,365 |
| Total | | | | 1,111,446 | 176,598 |

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2. PRODUCTION, SHIPMENTS & INVENTORIES: (Cont'd)

e. Production Delays:

Two major production delays were experienced in 1956. One was the USA-CIO strike which was effective from the 1st of July to August 6th. The second delay was caused by the mine fire in 7000 Cross-cut on the 7th Level, which resulted in a loss of ten production shifts.

On November 23rd, one and one-third production shifts were lost when the upper part of the skip road runners became coated with ice.

MATHER MINE "B" SHAFT
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3. ANALYSIS:

a. Average Mine Analysis on Output: (Incl. Stockpile)

| Grade | Iron | Phos. | Silica | Sulphur |
|---|---|---|---|---|
| Mather Standard | 58.71 | - | 9.05 | .033 |
| Mather Special | 55.58 | - | 8.33 | 1.012 |

b. Average Analysis of Shipments: (Total Average)

| Grade | Iron | Phos. | Silica | Sulphur | Moist. | Iron Nat'l. |
|---|---|---|---|---|---|---|
| Mather Standard | 58.40 | .096 | 9.54 | .024 | 10.21 | 52.44 |
| Mather Special | 55.65 | .117 | 7.99 | 1.221 | 9.80 | 50.20 |

c. Average Analysis of Ore in Stock:

| Grade | Tons | Iron | Phos. | Silica | Mang. | Alum. | Lime | Mag. | Sulph. | Loss | Moist. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mather Standard | 203,443 | 58.88 | .096 | 9.02 | .34 | 2.80 | .50 | .76 | .065 | 1.86 | 10.21 |
| Mather Special | 8,971 | 55.55 | .117 | 9.15 | .62 | 2.49 | 2.79 | .56 | .629 | 3.26 | 9.50 |

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4. COST OF OPENING, EQUIPPING, DEVELOPING AND OPERATING:

a. Comparative Mining Costs:

| | 1956 | 1955 |
|---|---|---|
| Product | 1,288,044 | 1,233,222 |
| Underground Costs | $ 3.064 | $ 2.244 |
| Surface Costs | .333 | .283 |
| General Mine Expense | .486 | .385 |
| Cost of Production | $ 3.883 | $ 2.912 |
| Amortization of Defense Facilities | $ .198 | $ .360 |
| Depreciation: | | |
| Plant and Equipment | $ .186 | $ .163 |
| Development After 12/31/44 | .104 | .104 |
| Pre-Production Development | .013 | .013 |
| Movable Equipment | .008 | .010 |
| Taxes | .243 | .196 |
| Administration | .050 | .050 |
| Loading and Shipping | .045 | .046 |
| Total Cost at Mine | $ 4.730 | $ 3.854 |
| Budget-Estimated Cost Per Ton | $ 4.208 | $ 3.852 |
| Number of Shifts and Hours | 18 1-8 Hr.<br>165 2-8 Hr.<br>60 3-8 Hr. | 1 1-8 Hr.<br>233 2-8 Hr.<br>0 3-8 Hr. |
| Total 8 Hr. Operating Shifts | 528 | 467 |
| Number of Operating Days | 225½ | 233½ |
| Average Daily Product | 5,712 | 5,293 |

Proportion of Labor and Supplies

| | Amount | Per Ton | Per Cent |
|---|---|---|---|
| Labor | $3,405,480.19 | $2.644 | 58% |
| Supplies | 2,432,031.58 | 1.888 | 42 |
| Total Cost at Mine | $5,837,511.77 | $4.532 | 100% |

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4. COST OF OPENING, EQUIPPING, DEVELOPING AND OPERATING: (Cont'd)

b. Detailed Cost Comparison (Operating):

| | 1956 Amount | 1956 Per Ton | 1955 Amount | 1955 Per Ton |
|---|---|---|---|---|
| Development | $ 826,656.66 | $ .641 | | |
| Mining | 1,675,812.40 | 1.301 | | |
| Tramming | 560,393.22 | .435 | | |
| Power Adjustment | 2,726.91 | .002 | | |
| Ventilation | 22,581.34 | .017 | | |
| Pumping | 16,649.15 | .013 | | |
| Compressors and Air Lines | 62,343.39 | .049 | | |
| Crushing and Screening - Underground | 29,988.05 | .023 | | |
| Underground Superintendence | 205,189.36 | .160 | | |
| Maint: Pockets and Chutes | 2,918.74 | .003 | | |
| Mining Equipment | 197,469.19 | .153 | | |
| Levels and Cross-cuts | 47,927.27 | .037 | | |
| Shaft | 9,011.30 | .007 | | |
| Telephones and Safety Devices | 55,609.12 | .043 | | |
| Vacation Pay | 173,824.75 | .135 | | |
| Holiday Allowance | 49,197.32 | .038 | | |
| Fire Loss | 13,436.28 | .011 | | |
| Total Underground Cost | $3,946,280.63 | $3.064 | $2,767,519.84 | $2.244 |
| Hoisting | $ 155,701.05 | $ .120 | | |
| Crushing and Screening - Surface | 43,127.01 | .034 | | |
| Stocking | 72,243.72 | .056 | | |
| Timber Yard | 30,274.42 | .023 | | |
| Dry House | 36,980.88 | .029 | | |
| Policing | 19,860.27 | .015 | | |
| General Surface | 22,249.22 | .017 | | |
| Maint: Headframe Bldg. and Equipment | 1,447.66 | .002 | | |
| Other Mine Buildings | 4,148.22 | .004 | | |
| Telephones and Safety Devices | 2,363.99 | .001 | | |
| Vacation Pay | 34,583.81 | .027 | | |
| Holiday Allowance | 6,448.47 | .005 | | |
| Total Surface Cost | $ 429,428.72 | .333 | $ 349,671.93 | $ .283 |
| Geological Department | $ 8,432.94 | $ .007 | | |
| Mining Engineering Department | 40,454.86 | .031 | | |
| Mechanical Engineering Department | 5,585.77 | .005 | | |
| Safety Department | 12,231.23 | .009 | | |
| Research Laboratory | 5,685.64 | .005 | | |
| Analysis and Grading - Laboratory | 60,350.25 | .047 | | |
| Analysis and Grading - Shipping | 8,076.00 | .006 | | |
| Special Expense | 17,491.09 | .013 | | |
| Ishpeming Office | 135,568.55 | .105 | | |
| Mine Office - Superintendent and Clerks | 71,560.79 | .056 | | |
| Central Warehouse Overhead | 22,859.26 | .018 | | |
| Insurance | 87,757.64 | .067 | | |
| Personal Injury - Comp. and Doctors | 45,761.39 | .036 | | |
| Taxes - Unemployment Insurance | 28,646.86 | .022 | | |
| Taxes - Old Age Benefit | 57,470.72 | .045 | | |
| Electrical Engineering Department | 2,849.05 | .002 | | |
| Employees' Insurance and Compensation | 12,660.81 | .010 | | |
| Engineering - Relocation of R.R. Tracks | 2,173.14 | .002 | | |
| Design Department | 56.16 | - | | |
| Total General Mine Expense | $ 625,672.15 | .486 | $ 473,507.58 | $ .385 |
| COST OF PRODUCTION | $5,001,381.50 | $3.883 | $3,590,699.35 | $2.912 |

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4. COST OF OPENING, EQUIPPING, DEVELOPING AND OPERATING: (Cont'd)

b. Detailed Idle Cost: (Idle - Due to Steelworkers Strike 1956)

| | Amount |
|---|---|
| Development | $ 13,906.54 |
| Mining | 4,787.09 |
| Tramming | 2,839.91 |
| Pumping | 1,968.42 |
| Compressors and Air Lines | 1,261.99 |
| Crushing and Screening - Underground | 119.28 |
| Underground Superintendence | 5,614.60 |
| Maint: Mining Equipment | 97.23 |
| Levels and Cross-cuts | 4,386.67 |
| Shaft | 383.46 |
| Telephones and Safety Devices | 4,195.51 |
| Holiday Allowance | 125.04 |
| Total Underground Cost | $ 39,685.74 |
| | |
| Hoisting | $ 3,324.08 |
| Crushing and Screening - Surface | 12.33 |
| Stocking | 879.47 |
| Timber Yard | 16.11 |
| Dry House | 674.74 |
| Policing | 2,160.79 |
| General Surface | 898.82 |
| Telephones and Safety Devices | 7.16 |
| Holiday Allowance | 105.00 |
| Total Surface Cost | $ 8,078.50 |
| | |
| Geological Department | $ 708.15 |
| Mining Engineering Department | 4,280.22 |
| Mechanical Engineering Department | 392.14 |
| Safety Department | 1,068.00 |
| Research Laboratory | 197.55 |
| Analysis and Grading - Laboratory | 1,630.06 |
| Analysis and Grading - Shipping | 792.00 |
| Special Expense | 1,548.17 |
| Ishpeming Office | 14,352.00 |
| Mine Office - Superintendent and Clerks | 7,412.49 |
| Central Warehouse Overhead | 1,346.65 |
| Insurance | 3,913.16 |
| Personal Injury - Comp. and Doctors | 401.10 |
| Taxes - Unemployment Insurance | 46.48 |
| Taxes - Old Age Benefit | 438.19 |
| Electrical Engineering Department | 627.13 |
| Employees' Insurance and Compensation | 1,344.00 |
| Total General Mine Expenses | $ 40,497.49 |
| | |
| COST OF PRODUCTION | $ 88,261.73 |

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4. COST OF OPENING, EQUIPPING, DEVELOPING AND OPERATING: (Cont'd)

Expenditures under E&A's for the year amounted to $1,613,026.89, as follows:

| | |
|---|---|
| E&A NM-44 | $ 11,363.47 |
| E&A NM-95 | 601.77 |
| E&A NM-96 | 335.00 |
| E&A NM-111 | 169,222.00 |
| E&A NM-112 | 35,429.07 |
| E&A NM-113 | 1,117,294.40 |
| E&A NM-114 | 2,335.85 |
| E&A NM-115 | 82,686.48 |
| E&A NM-121 | 826.96 |
| E&A NM-123 | 192,931.89 |
| | $1,613,026.89 |

In addition there was an expenditure of $16,853.60 for railroad relocation.

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5. ESTIMATE AND ANALYSIS OF ORE RESERVES:

The net ore reserves reported to the Tax Commission on December 31, 1956 were 12,662,092 tons, a decrease of 2,495,763 tons from the previous year. The reserves were decreased because of normal mining depletion and more information was obtained on the ore above 5th Level which diminished the sulphurous ore 1,000,000 tons and the standard ore about 125,000 tons.

| | Mather Standard | Sulphurous | Total Tons |
|---|---|---|---|
| Above 5th Level | | 1,620,160 | 1,620,160 |
| Above 5th and 6th Levels | | 800,772 | 800,772 |
| Between 6th and 7th Levels | 2,239,298 | | 2,239,298 |
| Between 7th and 8th Levels | 4,071,674 | | 4,071,674 |
| Between 8th and 9th Levels | 2,279,166 | | 2,279,166 |
| Between 9th and 10th Levels | 2,588,437 | | 2,588,437 |
| Below 10th Level | 697,188 | | 697,188 |
| Sec. 1 Diamond Drill Hole Estimate | 403,172 | | 403,172 |
| Total Gross as of July 31, 1956 | 12,278,935 | 2,420,932 | 14,699,867 |
| Less 10% for Mining and Rock | 1,227,893 | 242,093 | 1,469,986 |
| Net Total as of July 31, 1956 | 11,051,042 | 2,178,839 | 13,229,881 |
| Less Production July 31 to Dec. 31, 1956 | 484,560 | 83,229 | 567,789 |
| Net Total as of December 31, 1956 | 10,566,482 | 2,095,610 | 12,662,092 |

Expected Average Natural Analysis of Ore Reserves as of December 31, 1956:

| Grade | Total Tons | Iron | Phos. | Sil. | Mang. | Alum. | Lime | Mag. | Sulph. | Loss | Moist. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| By Surface Diamond Drilling | 362,855 | 54.40 | .081 | 5.08 | .10 | 2.62 | .58 | .60 | .017 | 2.20 | 11.50 |
| By Underground Development | 12,299,237 | 51.50 | .090 | 8.85 | .45 | 2.62 | 2.50 | .50 | .300 | 2.00 | 10.50 |
| | 12,662,092 | | | | | | | | | | |

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## 6. LABOR AND WAGES:

### a. Comments:

Sufficient unskilled manpower was available during the year; however, a scarcity existed for skilled miners.

A total of eight grievances were initiated by the union this year. Of the eight, four were dropped by the union, one was settled in the second step and three continued in to 1957. Five of the grievances were on seniority, one on displacement, another on contract calculation and one on disciplinary action.

### b. Employment Record:

At the end of the year 683 men were employed at the mine. This represents a net increase of 33 employees for the year.

| | | | |
|---|---|---|---|
| Number of Men 1/1/56 ..... | | | 650 |
| Losses - Drafted ..... | 4 | | |
| Deceased ..... | 8 | | |
| Quit ..... | 26 | | |
| Retired ..... | 6 | | |
| Transferred to other properties..... | 7 | | |
| | 51 | | -51 |
| | | | 599 |
| Gains - Transferred from other properties ..... | 32 | | |
| Service Returnees ..... | 12 | | |
| Rehires ..... | 40 | | |
| | 84 | | 84 |
| Total on Payroll 12/31/56 ..... | | | 683 |

### c. Vacations and Holidays:

There was no scheduled vacation during 1956.

The men benefited from six paid holidays which were as follows:

New Year's, Memorial Day, Independence Day, Labor Day, Thanksgiving and Christmas. This was in accordance with the provisions of the labor contract.

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6. LABOR AND WAGES: (Cont'd)

d. Comparative Statement of Wages and Product:
(Operating Only - Not Including E&A Work)

| | 1956 | 1955 | Increase or Decrease |
|---|---|---|---|
| **Average Wages Per Day:** | | | |
| Surface | $ 21.25 | $ 19.10 | $ 2.15 |
| Underground | 23.12 | 21.81 | 1.31 |
| Total | $ 22.82 | $ 21.27 | $ 1.55 |
| **Average Wages Contract Miner:** | $ 24.28 | $ 23.88 | $ .40 |
| **Wages Per Month of 21 Days:** (1955 Based on 19½ Days) | | | |
| Surface | $446.25 | $372.45 | $73.80 |
| Underground | 485.52 | 425.30 | 60.22 |
| Total | $479.22 | $414.77 | $64.45 |
| **Tons Per Man Per Day:** | | | |
| Surface | 58.96 | 59.38 | .42 |
| Underground | 11.31 | 14.63 | 3.32 |
| Total | 9.49 | 11.74 | 2.25 |
| **Labor Cost Per Ton:** | | | |
| Surface | $ .360 | $ .321 | $ .039 |
| Underground | 2.044 | 1.490 | .554 |
| Total | $ 2.404 | $ 1.811 | $ .593 |

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7. SURFACE:

Buildings:-

Very few minor repairs beyond regular maintenance were required to keep the buildings in excellent condition. A temporary car repair enclosure was constructed in the storage area between the shop and dry buildings. This will be dismantled when the present car repair program has been completed.

New Installations and New Equipment:-

In the Partridge Creek area a sump was constructed and three pumps were installed to divert the water through a 1,000' pipe line from the pumps to the Negaunee storm sewer.

Two additional submersible pumps were installed in churn drill holes in the Partridge Creek area. These, in conjunction with a pump installed last year, are effectively lowering the water table in the area where the cave is ultimately expected to come through to the surface.

In conjunction with the underground emergency pumping system a 10" discharge line was installed from the shaft collar to the 21" storm sewer.

Engine House:-

During the strike the skip hoist motors were repaired and reconditioned.

Headframe and Stocking:-

The north stocking conveyor belt was replaced on December 23rd. The old belt was placed in service in June of 1951 and had conveyed a total of 5,389,175 tons.

Three hoist ropes were replaced this year. The counterweight rope, which had been in service since 1950, was changed on May 6th. The east and west skip ropes were changed on November 24th and December 15th respectively. The east rope hoisted a total of 1,484,904 tons. The west rope, which had been on the cage prior to being placed on the skip, hoisted a total of 964,188 tons.

Pumping:-

Pumping of the North Jackson Mine underground workings continued throughout 1956. The average rate of pumping was 400 g.p.m. The purpose of the pumping is to dewater the overburden and workings over the future mining areas.

A total of nine churn drill holes were drilled in the Partridge Creek area, this included one 6" observation well, one 8" observation well and seven 10" pumping wells. Three of the 10" wells were found to produce over 200 g.p.m. and pumps were installed in them. These three pumps have been running since April at

7. SURFACE: (Cont'd)

Pumping:- (Cont'd)

an average rate of 600 g.p.m. A fourth 10" well will have a pump installed in the near future. The purpose of these pumps is to intercept underground water which is draining toward the area overlying the present mining area. The 8" observation well shows a drop of 4'-3" in the water table over the present mining area since the pumps were installed.

Subsidence:-

A diamond drill hole was drilled from surface on the north side of the cave area to be used in connection with the hole on the south side in an attempt to trace the caving progress by microsiesmic means.

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8. UNDERGROUND:

a. General:

Because of the continued demand for iron ore the monthly average production was increased from 102,768 tons per month in 1955 to 107,337 tons per month in 1956.

Total production increased from 1,233,222 tons in 1955 to 1,288,044 tons in 1956. Of this tonnage 14% or 185,963 tons came from 6th Level; 24% or 307,671 tons from 7th Level and 62% or 794,410 tons from 8th Level.

An underground timber fire in a bulkhead in the 7000 Cross-cut on the 7th Level resulted in a production loss of ten shifts at "B" Shaft and seven shifts at Mather "A" and Cambria-Jackson Mines. The shutdown at "B" Shaft was from the beginning of day shift Saturday, June 2nd through the day shift of Wednesday, June 6th. The fire presumably started from hot metal in contact with timber when an oxy-acetylene torch was used by repairmen to cut steel sets in 7000 Cross-cut. The repairmen insisted they used the normal procedure of wetting down the work area before and after using the torch to cut steel. Rescue teams were organized immediately and brought the fire under control quickly. The fire had traveled to an old timber bulkhead in 7014 Top Timber. The fire was brought under control by drilling long holes over the fire area and forcing water through these holes into the fire.

5th Level:

Main level development work for the year consisted of advancing the 5200 Cross-cut 350', the 5300 Cross-cut 350', the 5400 Cross-cut 320' and the 5500 Cross-cut 450'.

6th Level:

Sub-level and long-hole stoping were employed in the mining of 170,587 tons of Hi-Sulphur ore from the 6th Level. Because of the extreme hardness of the Hi-Sulphur ore, the block caving system of mining is not adaptable to this deposit.

Area Between 6100 and 6200 Cross-cuts:

Block #61-A (Pillar): A small pillar between two stopes was undercut from a timbered slusher drift. From the pillar 16,740 tons were mined.

Area Between 6200 and 6300 Cross-cuts:

Block #62-B: A total of 53,940 tons of Hi-Sulphur ore were mined from the grizzly-sub area by a combination of the sub-level and long-hole stoping methods.

Area Between 6300 and 6400 Cross-cuts:

Block #63-A: Production from this area which began in January of 1956 totalled 91,000 tons. The ore was mined by the sub-level stope method with two drilling subs.

8. UNDERGROUND: (Cont'd)

6th Level: (Cont'd)

Block #63-B: Development work continues in this 300,000 ton Hi Sulphur area. The ore that will be mined in this area will be ore passed to a crusher that is located below this block and above the 6th Level.

7th Level:

The 7th Level conveyor-ore pass system was completed under the first mining block during August of this year. The ore from the block is fed onto a 380' gathering belt which discharges on to a second 380' belt. This belt conveys the coarse material to the ore pass which discharges into the 8th Level crusher trench. The belt which has eliminated motor haulage on the 7th Level, except for one small isolated mining area, has reduced tramming costs for the conveyed material about $0.20 per ton.

The block caving system of mining is adaptable for use in all the standard ore on the 7th Level. The production from this level totalled 307,671 tons for the year.

Area 7000 Cross-cut:

Block #70-C: A total of 45,880 tons were block caved from three slusher drifts before excessive repair work caused the temporary abandonment of the area.

Area Between 7000 and 7100 Cross-cuts:

Block #71-C: Block caving continues in this 285,000 ton standard ore block with 135,780 tons being mined during the year.

Area Between 7100 and 7200 Cross-cuts:

Block #72-A: This standard ore body, which is located along the south side of Dike #22, accounted for 167,960 tons of standard ore.

Block #72-C: Development of this 285,000 ton standard ore body, which lies along the footwall and north of #22 Dike, was started near the end of the year.

Area Between 7400 and 7500 Cross-cuts:

Block #75-B: Development and mining continued throughout the year in this small standard ore zone which is built-up along the footwall.

8th Level:

All of the 8th Level standard ore bodies are adaptable to the block caving system of mining. Production for the year totalled 794,410 tons from this level.

The 8th Level crusher-conveyor system, which was completed in October of 1955, has operated throughout the year very satisfactorily.

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8. UNDERGROUND: (Cont'd)

8th Level: (Cont'd)

Area East of 8400 Cross-cut:

Block #84-A (North): Two timbered slusher drifts were advanced and undercut in this small standard ore body located a short distance below the 7th Level. A total of 22,740 tons have been mined from this area this year.

Block #84-A: Block cave mining which began during 1955 in this combination grizzly sub-slusher drift block, totalled 66,960 tons during the year.

Block #84-B: Production totalled 18,260 tons during 1956 from this block which is being mined on the -1000 sub along the north side of the Negaunee fault zone.

Area Between 8400 and 8500 Cross-cuts:

Block #85-B: Block caving accounted for 110,000 tons in this standard ore body.

Block #85-E (East): Development of two timber and one yielding arch slusher drifts was completed near the end of the year. To-date 16,600 tons of standard ore have been block caved from this area.

Block #85-E (West): Four yielding arch slusher drifts were developed in this 165,000 ton standard ore body. The area was undercut from the two timbered drilling subs located 25' above the floor of the slusher drifts. Production from this block totalled 60,840 tons.

Area Between 8500 and 8600 Cross-cuts:

Block #86-B: Production totalled 44,600 tons in this standard ore body located along the south side of Dike #22 and the footwall.

Area Between 8600 and 8700 Cross-cuts:

Block #87-A: Block caving continued throughout the year in this large standard ore body located at top timber elevation and between the two cross-cuts. To-date 238,360 tons have been mined from this area.

Area Between 8700 and 8800 Cross-cuts:

Block #88-A: Block caving began in March of 1955 in this 275,000 ton standard ore body located along the south side of Dike #22 and east of an inferred fault zone. Production for this year totalled 118,680 tons of ore which was mined through four slusher drifts at top timber elevation.

Block #88-C: Development work was started during the latter part of 1956 in this 325,000 ton standard ore body located along the footwall and north of Dike #22.

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8. UNDERGROUND: (Cont'd)

8th Level: (Cont'd)

Area Between 8800 and 8900 Cross-cuts:

Block #89-B: Development continued in this 150,000 ton standard ore body located along the south side of Dike #22 and the footwall.

Block #89-D: A total of 114,640 tons of ore were mined through two yielding arch slusher drifts located at top timber elevation during the year.

9th Level:

The main level footwall heading, which was advanced 1,897' during the year, was completed on December 7th when the footwall headings of both the Mather "A" and "B" were connected. Approximately 815' of the footwall heading was advanced with roof bolts. The 9200 and 9600 Cross-cuts were advanced for mining development and exploration during the year.

10th Level:

The location of the main line footwall heading is 3,620' southwest of the shaft. A total of 2,045' was advanced during the year on the main line and in the 10,700 and 10,900 Cross-cuts.

Development of the 10th Level crusher-conveyor system was started early in the year with the majority of the work being done on the conveyor discharge end. When completed this project will be similar to the one now in use on the 8th Level.

A ventilation raise between the 9th and 10th Levels was completed during 1956. This raise will also be used as an ore pass to the proposed 10th Level crusher-conveyor system.

In the 10th Level pump station, a second 500 g.p.m. vertical pump and two 1250 g.p.m. submersible pumps were installed.

Excavation for the 10th Level east storage trench at the shaft was started during the year.

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8. UNDERGROUND: (Cont'd)

b. Exploration:

A total of 10,777' of exploratory drilling was done during 1956 as compared to 6,034' in 1955. The major portion of the drilling was carried out from 8th and 10th Levels, the remainder being distributed among 5th, 7th and 9th Levels. The main objectives of the drilling program were:

1. Detailing 5th and 8th Level ore.
2. Outlining 9th and 10th Level ore.
3. Exploring for 10th Level ore west of the Cambria-Jackson fault.

5th Level:

Six diamond drill holes were drilled from the 5th Level; two of these were drilled to explore the continuation of the 5th Level ore up the footwall and the remaining four were drilled to detail the ore above 5th Level.

Seven percussion holes were drilled from 5th Level to detail an ore block prior to developing the block.

Five holes were drilled downward from the Cambria-Jackson 8th Level to outline the ore above the Mather "B" 5th Level.

7th Level:

Three holes were drilled from this level to detail a small ore pocket below the level.

8th Level:

Eighteen diamond drill holes were completed on 8th Level; one was drilled for ventilation purposes, three were drilled to explore for ore south of the Negaunee fault at, and below, the 8th Level. Fourteen holes were drilled to outline and detail ore bodies prior to mining development.

9th Level:

Four holes were drilled from the 9th Level; three holes were drilled to detail the ore east of the Cambria fault prior to planning the mining development, and one hole was drilled to explore for ore west of the Cambria fault.

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8. UNDERGROUND: (Cont'd)

b. Exploration: (Cont'd)

10th Level:

Nine diamond drill holes were drilled from the 10th Level; one was drilled to outline the ore east of the Cambria fault and eight were drilled to explore for ore west of the fault.

Also three percussion holes were drilled to aid in planning the course of the main level drift.

In 1957 the emphasis on the diamond drilling program will be on detailing 8th Level ore and exploring for ore on 9th and 10th Levels west of the Cambria fault.

Subsidence:

A hole was drilled horizontally from the 6th Level of the Cambria-Jackson Mine and entered the caving area. A wooden plug with a wire cable attached was anchored in the bottom of the hole, and cave movement was noted as the wooden plug moved downward with the cave pulling the wire into the hole.

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8. UNDERGROUND: (Cont'd)

b. Exploration: (Cont'd)

The following table shows the drilling for the year.

| Holes Drilled From 4th Level For Subsidence Studies | From | Ore Drilled | Depth |
|---|---|---|---|
| Hole Number: 170 | 345' | 0' (not included in totals) | 1,500' |
| **Holes Drilled From Cambria -180 Sub To Explore 5th Level Ore** | | | |
| 234 | 0' | 105' | 139' |
| 235 | 0' | 4' | 200' |
| 236 | 0' | 49' | 206' |
| 237 | 0' | 125' | 260' |
| 238 | 0' | 75' | 75' |
| **Holes Drilled From 5th Level To Explore 5th Level** | | | |
| *140 | 0' | 164' | 164' |
| *141 | 0' | 126' | 126' |
| *142 | 0' | 120' | 120' |
| *143 | 0' | 92' | 92' |
| *144 | 0' | 148' | 148' |
| *145 | 0' | 100' | 100' |
| *146 | 0' | 55' | 55' |
| 339 | 0' | 105' | 226' |
| 340 | 0' | 40' | 188' |
| 346 | 0' | 0' | 160' |
| 349 | 0' | 0' | 309' |
| 356 | 0' | 63' | 160' |
| 363 | 0' | 100' | 220' |
| **Holes Drilled From 7th Level To Explore 7th Level** | | | |
| 337 | 0' | 10' | 39' |
| 338 | 0' | 45' | 55' |
| 354 | 0' | 38' | 60' |
| **Holes Drilled From 8th Level To Explore 8th Level** | | | |
| 313 | 295' | 20' | 50' |
| 320 | 0' | 50' | 462' |
| 322 | 0' | 0' | 357' |
| 347 | 0' | 170' | 240' |

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8. UNDERGROUND: (Cont'd)

b. Exploration: (Cont'd)

| Holes Drilled From 8th Level To Explore 8th Level (Cont'd) | From | Ore Drilled | Depth |
|---|---|---|---|
| 355 | 0' | 140' | 313' |
| 361 | 0' | 140' | 195' |
| 362 | 0' | 80' | 100' |
| 366 | 0' | 0' | 24' |
| 367 | 0' | 48' | 85' |
| 368 | 0' | 90' | 126' |
| 369 | 0' | 50' | 50' |
| **Holes Drilled From 8th Level To Explore 9th and 10th Levels** | | | |
| 316 | 0' | 0' | 202' |
| 321 | 0' | 36' | 131' |
| 325 | 0' | 157' | 275' |
| 328 | 0' | 430' | 480' |
| 351 | 0' | 0' | 90' |
| 353 | 0' | 50' | 85' |
| 364 | 0' | 105' | 210' |
| **Holes Drilled From 9th Level To Explore 9th Level** | | | |
| 341 | 0' | 63' | 250' |
| 345 | 0' | 190' | 225' |
| 365 | 0' | 170' | 459' |
| 370 | 0' | 49' | 101' |
| **Holes Drilled From 10th Level To Explore 10th Level** | | | |
| 317 | 0' | 196' | 865' |
| 326 | 0' | 150' | 369' |
| 327 | 0' | 0' | 158' |
| 336 | 0' | 20' | 360' |
| 348 | 0' | 15' | 202' |
| *147 | - | - | 38' |
| *148 | - | - | 38' |
| *149 | - | - | 26' |
| **Holes Drilled From 10th Level To Explore 11th Level** | | | |
| 329 | 0' | 0' | 95' |
| 330 | 0' | 0' | 286' |
| 331 | 0' | 60' | 225' |
| 350 | 0' | 105' | 350' |
| 56 | | 4,148' | 10,777' |

* Percussion Drill Holes

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8. UNDERGROUND: (Cont'd)

c. Timbering:

Statement of Ground Support Material Used Under Development and Mining Accounts

| Item | Amount | Cost Per Ton |
|---|---|---|
| Cribbing | $ 12,912.22 | $ .01002 |
| Stull Timber | 12,881.15 | .01000 |
| Lagging | 29,621.96 | .02299 |
| Poles | 11,345.09 | .00880 |
| Steel | 164,912.34 | .12803 |
| Total 1956 | $231,672.76 | $ .17984 |
| Total 1955 | $142,941.88 | $ .11591 |
| Total 1954 | $239,016.55 | $ .26281 |
| Total 1953 | $211,907.78 | $ .19618 |
| Total 1952 | $115,926.64 | $ .16895 |

d. Explosives:

Explosives Used in Breaking 1,288,044 Tons of Ore In Development and Mining Accounts

| Item | Amount | Cost Per Ton |
|---|---|---|
| Gelamite (1¼x8) | $ 44,747.88 | $ .03475 |
| Gelamite (1½x8) | 891.80 | .00069 |
| Gelatin 60% | 53,739.02 | .04172 |
| Gelatin 60% Extra | 637.48 | .00049 |
| Hercomite | 57,588.25 | .04470 |
| Total Powder | $157,604.43 | $ .12235 |
| Blasting Supplies | 105,166.48 | .08165 |
| Grand Total Powder and Blasting Supplies | $262,770.91 | $ .20400 |

| | |
|---|---|
| Pounds of Powder Per Ton of Ore | .62137 |
| Tons of Ore Per Pound of Powder | 1.60932 |
| Cost Per Ton For Powder | $0.12235 |
| Cost Per Ton For Fuse, Caps, etc. | $0.08165 |
| Cost Per Ton For All Explosives | $0.20400 |

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8. UNDERGROUND: (Cont'd)

e. Pumping:

Because of the rapid upward progress of the cave area an emergency pumping system was initiated this year. The system consists of two 1250 g.p.m. submersible pumps on the 10th Level with the starting equipment installed on the 8th Level. These pumps will discharge into a sump on the 6th Level. From the 6th Level two 1250 g.p.m. pumps will pump to the 2nd Level; the 2nd Level pumps are in series with no sump on the 2nd Level. The 2nd Level will have two 1250 g.p.m. pumps pumping directly to surface and discharging into the 21" storm sewer which is tied into Partridge Creek. Of this installation the following items have been completed; all pumphouses and sumps on the 10th, 6th and 2nd Levels have been cut-out; two submersible pumps were installed on the 10th Level; and one horizontal centrifugal pump was installed on the 6th Level. Some of the switch gear has also been installed. It is expected that the project will be completed in the first quarter of 1957.

All the mine water at "B" Shaft flows to "A" Shaft along the 6th Level footwall drift. The water from 7th, 8th and 10th Levels flows toward "B" Shaft where it is collected and pumped to 6th Level. Average flow of water on 6th Level was 59.5 g.p.m., 7th Level 41.1 g.p.m., 8th Level 28.4 g.p.m., 9th Level 9.5 g.p.m. and 10th Level 43.7 g.p.m. for a total of 182.5 g.p.m.

All the shaft water is collected behind a dam on 4th Level and is used as drilling water.

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9. TAXES:

Mather Mine "B" Shaft, including stockpile, supplies and equipment as placed by State Tax Commission:

| | 1956 | | | 1955 | | |
|---|---|---|---|---|---|---|
| | Valuation | Rate | Taxes | Valuation | Rate | Taxes |
| Section 1, 47-27 | | | | | | |
| Real | $6,975,000 | | $289,462.50 | $3,725,000 | | $157,828.25 |
| Personal | 1,330,000 | | 55,195.00 | 1,925,000 | | 81,562.25 |
| Total | $8,305,000 | 41.5000 | $344,657.50 | $5,650,000 | 42.3700 | $239,390.50 |
| Coll. Fee | | .4150 | 3,446.57 | | .4237 | 2,393.91 |
| Total Mather Mine "B" Shaft (Sec. 1 City of Negaunee) | $8,305,000 | 41.9150 | $348,104.07 | $5,650,000 | 42.7937 | $241,784.41 |

| | 1956 | | |
|---|---|---|---|
| | Taxes | Per Ton Produced | Per Ton Shipped |
| Operating | $313,244.07 | $0.243 | $0.257 |
| Idle Expense | 34,860.00 | 0.027 | 0.029 |
| Total | $348,104.07 | $0.270 | $0.285 |

| | 1955 | | |
|---|---|---|---|
| | Taxes | Per Ton Produced | Per Ton Shipped |
| Operating | $241,784.41 | $0.196 | $0.184 |
| Idle Expense | - | - | - |
| Total | $241,784.41 | $0.196 | $0.184 |

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10. ACCIDENTS AND PERSONAL INJURY:

There were thirty-three compensable injuries during the year. The thirty-three compensable injuries occasioned lost time of 1,464 days. There were also nineteen non-compensable injuries with a total of fifty-five days lost. The grand total days lost, including compensable and non-compensable injuries, was 1,519 days. This resulted in a severity rate of 1,200 days lost per thousand man hours worked and a frequency rate of 41.07 injuries per million man hours. The total hours worked were 1,266,059 as compared to 967,696 for 1955.

| Date | Name | Nature of Injury | Days Lost |
|---|---|---|---|
| 1- 5-56 | Kenneth Brown | Contusion right foot. | 11 |
| 1-24-56 | Allen Tatrault | Sore and swollen left ankle. | 25 |
| 1-31-56 | Frank Kallio | Puncture below right knee. | 24 |
| 2- 1-56 | Vertin Dobbs | Tore skin off second and ring fingers right hand. | 42 |
| 3- 6-56 | Brynold Larson | Cuts on head. | 7 |
| 3- 8-56 | Lester Bray | Fractured bone in left foot. | 126 |
| 3-13-56 | Ernest Burgess | Contusion left foot. | 9 |
| 3-21-56 | Angelo Meli | Bruised right shoulder, thigh and knee. | 13 |
| 4- 6-56 | Patrick Arseneau | Kink in back. | 8 |
| 4-16-56 | Iver Wisuri | Strained back. | 19 |
| 4-21-56 | Gerald Revello | Cut on index finger. | 31 |
| 5- 3-56 | Matt Laitinen | Puncture wound instep of right foot. | 50 |
| 5-11-56 | Elmer St. Onge | Fractured finger on left hand. | 26 |
| 5-18-56 | James LaCombe | Bruised right shoulder. | 54 |
| 6-18-56 | Wilho Ruhomaki | Fractured right thumb. | 39 |
| 6-18-56 | Hugo Soyring | Bruised left ankle. | 23 |
| 6-27-56 | Nestor Korpi | Sore left thigh. | 17 |
| 6-27-56 | William Williams | Sore back. | 24 |
| 8- 6-56 | Henry Posio | Severed left forefinger. | 200 |
| 8-10-56 | Bruno Lehtinen | Bruised and swollen right hand. | 35 |
| 8-13-56 | Eino Koskela | Sprained back. | 100 |
| 8-17-56 | Walter Lakari | Sore back. | 11 |
| 8-17-56 | Donald Uren | Bruised right hand. | 35 |
| 8-21-56 | Samuel Sexton | Sprained left side. | 13 |
| 9- 1-56 | Edward Liquia | Fractured bone right foot. | 35 |
| 9- 5-56 | Matt Levi | Bruised right foot. | 10 |
| 9-13-56 | William Pascoe | Hernia. | 55 |
| 10- 8-56 | Albert Jetty | Strained abdominal muscles. | 24 |
| 10-19-56 | Alfred Plattenburg | Compound fracture right leg. | 150 |
| 10-24-56 | Arthur Pellinen | Fractured right ankle. | 150 |
| 12- 7-56 | Edward Dauphinias | Sore left leg. | 8 |
| 12-11-56 | William Lehto | Fractured toe left foot. | 40 |
| 12-18-56 | Richard Liubakka | Sore right instep. | 50 |
| | | | 1,464 |

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11. POWER:

| | CONSUMPTION K.W. HOURS | AVERAGE MAX. DEMAND | AVERAGE DEM. FACTOR | COST OF CURRENT | AVERAGE PRICE PER K.W. HOUR |
|---|---|---|---|---|---|
| 1956 - | 17,699,459 | 3,532 K.W. | 57.8% | $157,953.08 | $0.00892 |
| 1955 - | 15,193,755 | 3,300 K.W. | 53.1% | $140,408.83 | $0.00924 |
| 1954 - | 12,486,451 | 3,020 K.W. | 47.6% | $116,430.27 | $0.00932 |
| 1953 - | 13,519,000 | 2,780 K.W. | 55.5% | $217,415.82 | $0.01608 |
| 1952 - | 10,626,000 | 1,161 K.W. | 66.7% | $170,935.03 | $0.01608 |

# PELLETIZING PLANT
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## GENERAL

The Eagle Mills Pelletizing Plant was constructed to agglomerate the flotation concentrates produced at the Republic Mill. Erection of the plant and equipment was sufficiently complete to permit operation of the grate machine and auxiliary equipment on June 1st. A number of mechanical difficulties were encountered in the equipment operation and the actual pelletizing was not attempted again until July 6th. Intermittent operation continued through July and August. The plant was placed on a three shift - five day per week schedule on August 22nd. Previous to September 1st the pelletizing section was operated by Cleveland-Cliffs personnel under the direction of members of the McDowell Co. On September 1st the entire plant was operated by the Cleveland-Cliffs Iron Co. and was continued until the end of the year on a three shift per day - five day per week basis.

Contractors who worked on the pelletizing plant and completed their contracts during the year were: McDowell Co., Pajula-Maki, R.G. Joiner, A. Lindberg and Sons, Walker-Jamar Co., Keilinen and Sons, and John Hennes Trucking Co.

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## I. PRODUCTION, SHIPMENT, AND INVENTORIES

### A. Operating Schedule

The plant started operations on July 6, 1956 and operated intermittently on a one and two shift basis until August 22, 1956 when the schedule was increased to three shifts per day, five days per week. The entire schedule is presented below.

omit
TABLE 1.

| | Days Operated | Shifts/Day | Days/Week | Total Shifts |
|---|---|---|---|---|
| Start Up | 15 | 1 | 5 | 15 |
| | 3 | 2 | 5 | 6 |
| | 6 | 3 | 5 | 18 |
| September | 19 | 3 | 5 | 57 |
| October | 23 | 3 | 5 | 69 |
| November | 20 | 3 | 5 | 60 |
| December | 18-1/3 | 3 | 5 | 55 |

### B. Production and Production Rates

The production and production rates for 1956 were as follows:

TABLE 2.

| | Total Tons Produced | Regrinding LTPH | | Pellet Firing LTPH | |
|---|---|---|---|---|---|
| | | Gross | Net | Gross | Net |
| Start Up | 4,816 | 36.1 | 39.0 | 10.7 | 22.4 |
| September | 9,542 | 33.4 | 34.7 | 20.9 | 30.6 |
| October | 12,342 | 33.2 | 35.3 | 22.4 | 30.2 |
| November | 14,465 | 45.1 | 46.3 | 30.1 | 36.4 |
| December | 14,592 | 45.7 | 50.6 | 33.2 | 42.7 |
| Total | 55,757 | 39.7 | 41.4 | 23.5 | 33.3 |

A more detailed description of production rates of the various sections may be found in tables 20 through 22.

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omit

C. Production Costs

The cost of producing the 55,757 long tons of pellets average 7.156 dollars per ton. A brief description of operating costs is presented below:

TABLE 3.

| | |
|---|---|
| Raw Materials - Unloading and Storage | 0.210 |
| Materials Preparation | 3.038 |
| Pellet Firing | 1.881 |
| Pellet Screening and Loading | 0.492 |
| Water Supply | 0.014 |
| Control and Analysis | 0.257 |
| Other Direct Plant Expense | 0.672 |
| Allocated Expense | 0.592 |
| Total | 7.156 |

A detailed monthly cost analysis may be found in table 16.

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D. Tonnage and Analysis of Pellets Produced and Shipped

During the shipping season, 35,000 tons of pellets were shipped to partners. The chemical analysis of the pellets produced and shipped is presented below.

TABLE 4.

Pellets Produced:

| | Fe. | Phos. | Silica | Sulph. | Moisture |
|---|---|---|---|---|---|
| September | 63.68 | 0.031 | 7.85 | 0.010 | |
| October | 62.92 | 0.040 | 9.16 | 0.008 | |
| November | 63.05 | 0.028 | 7.94 | 0.007 | |
| December | 64.11 | 0.044 | 7.03 | 0.005 | |
| Yearly Average | 63.48 | 0.036 | 7.91 | 0.007 | |

TABLE 5.

Pellets Shipped:

| | | | | | |
|---|---|---|---|---|---|
| Pocket | 62.76 | 0.034 | 8.54 | 0.008 | 3.44 |
| Stockpile | 63.17 | 0.034 | 8.64 | 0.007 | 4.71 |
| Total | 62.80 | 0.033 | 8.51 | 0.005 | 3.90 |

The weighed average of minus 28 mesh material in the final product was 14.9 per cent for the year. A portable screening plant was set up at the stockpile to rescreen the material and, as such, the largest portion of the fines will be removed from the final pellets when shipped.

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omit

E. Estimated Production and Analysis

The estimated tonnage and chemical analysis of pellets for 1957 is as follows:

TABLE 6.

Estimated Tonnage 487,800 Long Tons

| Estimated Analysis | Fe. | Phos. | Silica | Sulph. | Moisture |
|---|---|---|---|---|---|
| Dry | 62.05 | 0.027 | 9.13 | 0.012 | |
| Natural | 60.50 | 0.026 | 8.90 | 0.012 | 2.50 |
| | 59.57 | 0.026 | 8.76 | 0.012 | 4.00 |

The pellet analysis is based on Republic's 1957 analysis.

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## II. LABOR AND WAGES

### A. Report of Men Hired, Transferred, and Separated

TABLE 7.

| | First of Month | Hires | Trans. From Other Mines | Separations | End of Month |
|---|---|---|---|---|---|
| June* | 21 | 4 | 2 | | 27 |
| July | 27 | | | 1 | 26 |
| August | 26 | 24 | 1 | 1 | 50 |
| September | 50 | 10 | | 5 | 55 |
| October | 55 | 3 | 1 | 1 | 58 |
| November | 58 | | 2 | | 60 |
| December | 60 | | 8 | 2 | 66 |

*There were 21 men transferred from the Republic Mine payroll to the Pelletizing Plant payroll as of June 1st.

The above table includes hourly and salaried personnel on Eagle Mills Pelletizing Plant payroll.

### B. Annual Statement of Labor

TABLE 8.

| | Stat. Men | Hours | Amount | Average Rate |
|---|---|---|---|---|
| **Hourly Employees** | | | | |
| Straight Time - Classified | 50½ | 59,185 | 128,754.37 | 2.175 |
| Overtime | (41½) | (8,401) | 9,328.80 | 1.110 |
| Sunday Premium | (39¾) | (2,258) | 493.62 | .219 |
| Shift Differential - Aftn. | (30½) | (10,932½) | 696.85 | .064 |
| - Night | (26½) | (8,020½) | 755.56 | .094 |
| Holiday Allowance | (47¼) | (1,156) | 2,508.21 | 2.170 |
| Holiday Worked - Prem. Time Only | (15) | (120) | 264.75 | 2.206 |
| Sub Total | 50½ | 59,185 | 142,802.16 | 2.420 |
| Vacation Pay | - | - | - | - |
| Total Hourly Employees | 50½ | 59,185 | 142,802.16 | 2.420 |
| **Salaried Employees** | | | | |
| Mine Payroll - Straight Time | 2½ | 2,643 | 8,727.90 | 3.302 |
| Total Mine Payroll | 53 | 61,828 | 151,530.06 | 2.451 |
| **General Payroll** | | | | |
| Salaries - Straight Time | 3½ | 4,357½ | 15,904.17 | 3.650 |
| Overtime | (1½) | (119) | 144.07 | 1.211 |
| Labor from Other Mines | 7½ | 8,707 | 27,684.15 | 3.179 |
| Total Labor | 64 | 74,892½ | 195,262.45 | 2.607 |
| **Distributed as Follows:** | | | | |
| Operating Plant | 43¼ | 50,544 | 133,274.21 | 2.636 |
| Uncompleted Construction | 20½ | 24,016½ | 60,820.17 | 2.532 |
| Other Mines | - | - | 92.55 | - |
| Other Accounts | ¼ | 332 | 1,075.52 | 3.239 |
| Total as Above | 64 | 74,892½ | 195,262.45 | 2.607 |

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C. Labor Breakdown

The total operating and maintenance crew for 1956 was 48 hourly rate and 2 salaried. At the end of 1956 the crew was 59 hourly rate and 2 salaried. The breakdown is as follows:

TABLE 9.

| | Number of Men |
|---|---|
| Pelletizing Plant | |
| plant foremen | 1 |
| maintenance | 1 |
| shift leaders | 4 |
| Raw Materials Unloading and Storage | |
| dumpmen | 1 |
| helpers | 2 |
| Materials Preparation | |
| ball mill-filter operators | 3 |
| pulverizer operators | 2 |
| ball mill - pulverizer helpers | 3 |
| disc operators | 6 |
| Pellet Firing | |
| hardening furnace operators | 3 |
| hardening furnace assistants | 3 |
| Pellet Screening and Loading | |
| pocketmen | 3 |
| Plant Laboratory and Sampling | |
| plant analyst | 1 |
| plant sampler | 1 |
| Truck and Tractors | |
| Michigan loader | 1 |
| service truck | 1 |
| bulldozer | 1 |
| janitors | 1 |
| plant laborers | 8 |
| warehousemen | 1 |
| Plant Maintenance | |
| electrician leaders | 1 |
| electricians | 3 |
| mechanical leaders | 1 |
| plant repairmen | 6 |
| helpers | 1 |
| Total | 59 |

The list above includes only those men hired for permanent work at the Pelletizing Plant and does not include any temporary transfers from other properties.

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## III. PLANT

### A. Introduction

During the June, July, and August startup period, operation of the Pelletizing Plant was suspended intermittently as the machinery required alterations and repairs. After September every effort was exerted to maintain the plant at continuous operation. Minor equipment maintenance was completed through the week and major repairs which would necessitate shutdown were relegated to the weekend. Most of the revisions were performed by the plant maintenance crew. On the major plant alterations crews were also employed from the Cleveland-Cliffs shop and the John Hennes Trucking Co.

From September to December the monthly production was increased from 9,542 tons to 14,592 tons and the hourly production rate increased from 20.9 tons to 33.2 on a gross operating time basis. Per cent operation time was improved from 68.5 per cent in September to 82.7 per cent in November. The chemical analysis of the 35,000 tons of pellets shipped was 62.80 per cent iron and 8.51 per cent silica with a moisture of 3.90 per cent. The total pellet production of 55,757 tons averaged 63.48 per cent iron and 7.91 per cent silica.

Pellet shipments were begun in the month of October and were terminated on November 19 at the end of shipping season. Shipments were loaded both from pocket and stockpile.

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B. Concentrate Balance with Pellet Production

TABLE 10.

| | |
|---|---|
| Republic Concentrates Shipped | 83,039 LT |
| Eagle Mills Pellets Produced | 55,757 |
| Material Unaccounted for | 27,282 LT |
| Unaccounted for Material | |
| Moisture Differences | |
| 56,000 tons Coarse Concentrate @ 6% Water | 3,360 LT |
| 27,000 tons Reground Concentrate @ 8% Water | 2,160 |
| Loaded Coarse Concentrate Cars at Marquette | |
| 50 Cars @ 55 LT/Car | 2,750 |
| Storage in Eagle Mills Silos | 6,000 |
| Initial Loss in Start Up | 4,010 |
| Dust and Shipping Losses from Republic to Eagle Mills | |
| 27,000 tons Reground Concentrate times .06 | 1,620 |
| Roto Clone Losses | |
| Water | 3,900 |
| To Atmosphere | 430 |
| Loss in Filtrate Water | 552 |
| Loss in Spillage(including fired pellets from drive end of grate machine, thickener, overflow, etc.) | 1,500 |
| Dust Loss from Unscreened Pellets | 1,000 |
| Total | 27,282 LT |
| Actual Lost Material: | |
| Initial Loss in Start Up | 4,010 |
| Dust and Shipping Losses from Republic to Eagle Mills | 1,620 |

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B. Concentrate Balance with Pellet Production (Cont'd.)

TABLE 10.(Cont'd.)

| | |
|---|---|
| Roto Clone Losses | |
| Water | 3,900 |
| To Atmosphere | 430 |
| Loss in Filtrate Water | 552 |
| Loss in Spillage (fired pellets from drive end of grate machine, thickener, overflow, etc.) | 1,500 |
| Dust Losses from Unscreened Pellets | 1,000 |
| Total | 13,012 LT |
| Possible Recoverable Material | |
| Initial Loss in Start Up | 4,010 |
| Roto Clone Losses - Water | 3,900 |
| Loss in Filtrate Water | 552 |
| Loss in Spillage | 1,500 |
| Total | 9,962 LT |

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C. Monthly Hourly Operating Rates

The operating rates of major pieces of equipment is presented below. This data is presented on a net time basis.

TABLE 11.

| | Ball Mill & Filters LTPH | Pulverizer Coal LTPH | Pulverizer Limestone LTPH | Average No. of Balling Discs Operating | Grate Machine LTPH |
|---|---|---|---|---|---|
| September | 34.7 | 3.8 | 25.9 | 2.33 | 30.6 |
| October | 35.3 | 6.0 | 14.0 | 2.39 | 30.2 |
| November | 46.3 | 7.4 | 22.8 | 2.55 | 36.4 |
| December | 50.6 | 5.2 | 17.3 | 2.67 | 42.7 |
| Average | 41.7 | 5.6 | 18.5 | 2.47 | 34.9 |
| Start Up | 39.0 | - | - | - | 22.4 |
| Total Avg. | 41.4 | - | - | - | 33.3 |

omit

A complete description of the operating rates of these pieces of equipment may be found in tables 20 through 22. The average balling rate for the discs was 17.7 long tons per hour and the average feed rate to the grate machine was 43.7 long tons per hour. The capacity of the grate machine was 1.59 long tons per square foot per day over the firing zone.

OK

D. Major Delay Time - Materials Preparation

The pellet plant operated a total of 2,376 hours, with equipment and process delays requiring the plant to be down 702.3 hours during 1956. During the start up period the plant was down a total of 233.5 hours. The plant was started and stopped by McDowell Company personnel during this period and often operations were halted without any specific equipment causing the delay. A record of delay was not obtained during the start up period. From September through December the plant was down a total of 468.8 hours. A specific piece of equipment was not charged with delay time unless the production of the plant was halted because of that piece of equipment. The major cause of delay in the raw materials unloading and materials preparation section are presented below.

omit

TABLE 12.

omit

| Piece of Equipment | Hours Delay |
|---|---|
| 1. Diaphragm Pump | 25.9 |
| 2. Horizontal Line Plugged | 8.2 |
| 3. Frozen Concentrates | 8.7 |

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omit

E. Major Delay Time - Pellet Firing

The major causes of delay in the pellet firing and pellet screening and loading sections are presented below.

TABLE 13.

| Piece of Equipment | Hours Delay |
|---|---|
| 1. Number 23 Conveyor Repairs | 17.6 |
| 2. Number 24 Conveyor Repairs | 9.3 |
| 3. Number 26 Conveyor Repairs | 12.4 |
| 4. Oscillating Grate Feeders | 26.4 |
| 5. Coal Transportometers | 7.9 |
| 6. Grate Lubrication System | 24.2 |
| 7. Plugged Grizzlies and Chutes | 71.0 |
| 8. Discharge Screen | 25.9 |
| 9. Fines Slurry Pump | 69.8 |
| 10. Lost Expansion on Machine | 10.2 |
| 11. Replace Pallet Sidewalls and Wheels | 14.4 |
| 12. Finished Product Conveyor | 27.1 |

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F. Fuel, Power, and Raw Materials Consumption

The raw materials and power consumption used during 1956 is presented below. ~~These are divided into total consumption and consumption per ton of pellets produced.~~ Although Republic shipped 83,039 tons of concentrate, only 70,050 tons have been sent to the balling disc section and grate machine. omit A detailed explanation of this difference may be found in the Concentrate Balance With Pellet Production section of this report.

TABLE 14.

OK

| Raw Material | Amount Used | Amount/Ton of Pellets |
|---|---|---|
| Concentrate | 70,050 tons | 1.26 tons |
| Bentonite | 493 tons | 19.81 lbs. |
| Limestone | 1,233 tons | 49.53 lbs. |
| Process Coal | 4,466 tons | 179.42 lbs. |
| Ignition Coal | 645 tons | 25.91 lbs. |
| Propane | 287,376 gallons | 5.15 gal. |
| Power | 4,460,000 KWH | 80.00 KWH |

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F. Fuel, Power, and Raw Material Consumption (Cont'd.)

It required 2.90 million BTU to produce a ton of pellets. The heat required for ignition and process was 0.63 BTU and 2.26 BTU per ton respectively. A monthly distribution of the heat required for pelletizing is presented below. This table was based on the following values: (1) propane - 90,000 BTU/gal., (2) ignition coal - 13,196 BTU/lb., and (3) process coal - 12,642 BTU/lb.

TABLE 15.

| | Propane | Ignition Coal | Process Coal | Total |
|---|---|---|---|---|
| Start Up | .49* | .16 | 2.35 | 3.00 |
| September | .36 | .10 | 2.02 | 2.48 |
| October | .27 | .29 | 2.38 | 2.94 |
| November | .24 | .44 | 2.58 | 3.26 |
| December | .24 | .51 | 2.01 | 2.76 |
| Yearly Average | .29 | .34 | 2.27 | 2.90 |

*Figures are given as million of BTU.

G. Laboratory Testing

The bulk of the laboratory testing program was required in processing the production sample submitted each shift by the various equipment operators. This sampling program included (1) size and moisture analysis before and after materials preparation, (2) size, fuel, and moisture analysis of the green pellets, (3) size, chemical, and strength analysis of the fired pellets.

Special laboratory studies were confined to the materials preparation section and especially to the balling stage and green pellet transfer stage. A preliminary study revealed that the grind, moisture content, and additive addition of the concentrate was not adequate for favorable balling conditions in the balling discs. The average Republic concentrate produced at the Republic Mill contains 42.06 per cent minus 325 mesh material and requires approximately 13.5 horsepower-hour per ton to increase this amount to 65 per cent. This indicated the necessity of an additional ball mill, as the present mill could grind only 45 tons per hour. Large amounts of water had to be added in the discs because the disc feed was to dry. To eliminate this condition an Alpha Lux Moisture Determinator was placed at the filter desk and filter operators were instructed to maintain a moisture content of 9.0 to 9.5 per cent on the filter cake by adjusting the vacuum.

The addition of bentonite at its present location on number 12 conveyor belt makes it difficult to control balling conditions in the discs at all times. Small or excessive amounts of bentonite may destroy balling conditions and these conditions can not be immediately controlled. Instead an operator must wait one or two hours for the day bin to be cleared of the undesirable material. It was suggested the bentonite be added to the number 15 belts to give the disc operators a more exact control of balling conditions. However, other mining companies with large pelletizing plants report that bentonite should be added before the day bins to allow the bentonite to "set" during storage.

G. Laboratory Testing (Cont'd.)

Basic studies revealed that the addition of grate machine returns to the balling disc feed was detrimental to balling regardless of whether the returns were reground. The addition of soda ash to the returns after regrinding increased the strength of the green pellets but this increase was not sufficient enough to be comparable with the strength of green pellets produced without returns.

The Research Laboratory conducted tests on different chemical reagents in an attempt to destroy froth, which was continually overflowing the thickener onto the plant floor. The few reagents which either destroyed or prevented the froth also destroyed balling conditions in the discs and, as such, could not be used in the plant flowsheet.

A complete study of the balling disc discharge revealed that the large unagglomerated masses were forming on the stationary and oscillating scraper bars and a small per cent was coming directly from the balling disc feed. Several tests indicated that the average amount of plus ½ inch unagglomerated material in the disc discharge was only five per cent. A more exact control of the moisture content in the disc feed would decrease the amount of water required in the balling disc which should maintain these unagglomerated masses in the discharge at a minimum.

H. Metallurgical Changes in the Plant Circuit

The most important problems encountered during the intial operation of the plant was to prevent portions of the pellet bed from fluidizing and eliminate unburned areas from appearing in the grate machine discharge. Excessive amounts of fines in the pellet bed produced areas of high and low resistance to the flow of air causing preferential flow of up draft air which produced "blow holes". Stainless steel chutes were installed on the oscillating feeders to decrease the height of drop of the green pellets and minimize the amount of fines produced by breakage. The green pellets discharged from the balling discs must be strong enough to withstand handling to the grate machine and must be free of fines because the green pellets are not screened between the balling discs and grate machine. The 700 horsepower ball mill could not grind the concentrate to the size required to produce a strong green pellet (65% -325 M) at the designed plant capacity. Therefore, the plant was required to either operate at approximately 50 per cent capacity or sacrifice the quality of the green pellets. The latter was out of the question because the excessive amount of fines that appeared in the pellet bed when the strength of the green pellet was decreased. In November, the Republic Mill halted operations and started regrinding the concentrate in the stockpile to assure a fine grind of the disc feed. This regrinding coupled with further regrinding at Eagle Mills enabled the balling discs to produce very favorable green pellets at 26 to 28 long tons per hour.

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H. Metallurgical Changes in the Plant Circuit(Cont'd.)

On November 1, 1956 a watt-hour meter was installed on the ball mill, and it was discovered that the mill was drawing approximately 450 horsepower. Seventeen tons of $1\frac{1}{4}$ inch balls were immediately charged into the ball mill to increase the power and grinding capacity of the mill. The mill was maintained at 625 horsepower until December when it was increased to 650 horsepower. The ball level was even with the trunnion and it appeared impossible to maintain an average power reading higher than 650 horsepower. This increase in power was not sufficient to produce the required size concentrate. The addition of ten tons of one inch diameter and five tons of $\frac{3}{4}$ inch diameter Ni-hard steel balls to the mill did not increase the grinding capacity of the mill. However, it was impossible to obtain reliable data with the addition of such a small quantity of balls. A $10\frac{1}{2}$ by 14 foot ball mill with an 800 horsepower motor was ordered from the Allis-Chalmers Manufacturing Company to obtain the required amount of grinding capacity.

The problem of disposing of the grate machine returns existed throughout the initial operation of the plant. When originally installed, the double deck screen had a $\frac{1}{2}$ inch top deck and a 1/8 inch bottom deck. These screen sizes were changed to 7/16 inch and 3/16 inch respectively to provide a more uniform sized hearth layer. This was necessary to produce a more porous hearth layer and insure an even distribution of heat during ignition. The increase in the size of the bottom deck greatly affected the grinding of the returns and a considerable amount of the returns were not reduced in size in the ball mill causing coarse material to be present in the thickener. This coarse material greatly reduced the operability of the filters in that the horizontal transfer line under the thickener continually plugged with coarse material, and the filter cloths were receiving excessive wear because of abrasion and the sharp edges of the coarse material.

Several disadvantages of the original wet system for removing the grate machine returns included (1) high impeller wear, (2) the pump was not capable of handling pallet to pallet surges causing the pump and discharge lines to plug frequently, and (3) the absence of a surge bin between the pump and ball mill made it necessary to operate the ball mill and grate machine simultaneously. The surging of the grate machine discharge produced periods of high and low densities in the sump and pump discharge. Because the material was pumped directly to the ball mill it was impossible to maintain constant solids in the mill. The installation of a dewatering cone at the ball mill did not eliminate this problem.

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H. Metallurgical Changes in the Plant Circuit (Cont'd.)

Grate machine fines returned to the balling disc feed have been a source of trouble since the plant started operation. Either the coarse returns or the slaked lime in the disc feed destroys balling conditions and causes weak green pellets to be produced. Slaked lime is produced when limestone is calcined in the grate machine and slaked in the ball mill or thickener. Limestone was removed from the circuit on October 1, 1956 to investigate the effect of the slaked lime on balling conditions. However, the erratic operation of the remainder of the plant made it difficult to evaluate the omission of limestone from the plant circuit. The returns were eliminated from the circuit for three days to observe the effect of the returns on balling conditions. This short period was not sufficient to obtain reliable data.

The wet system of transferring the fines was replaced by a dry system on October 15, 1956. Conveyor number 26 was extended below the Simplicity screen and the entire grate discharge, except the hearth layer, was removed from the plant circuit as the final product. The disadvantage of the dry system included (1) a tremendous dust problem occured at the discharge end of the grate machine, (2) an unscreened finished product was produced, and (3) hot material burned the finished product conveyor belts.

A revised wet system will replace this dry system during the general shut down period in January. This system will include an additional screen and ball mill with a classifier and cyclones. The final product of the plant will contain plus 14 mesh material while the minus 14 mesh material will be reprocessed and returned with the balling disc feed. A flowsheet of the proposed system may be found in Figure 1. The additional screening and grinding should eliminate the possibility of coarse returns appearing in the disc feed and it is hoped the slaked lime will be eliminated from the plant circuit with the cyclone overflow.

The transportofeeders proportioning the bentonite, limestone, and process coal with the concentrate operated very erratic when set on automatic. Factory representatives stated it would be impossible for the transportofeeders to proportion the raw materials accurately as long as the concentrate on the conveyor belts continued to surge. The mechanical department has installed a levelling device on conveyor number 9 to aid the proportioning of bentonite and limestone while the new type bin bottoms installed on the day bins have minimized surging of the concentrate to the discs. All the transportofeeders have been placed on manual control and are operating satisfactorily.

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H. Metallurgical Changes in the Plant Circuit (Cont'd.)

On November 15, 1956 the first adverse effects of winter operation were experienced. It became impossible to unload raw materials in a reasonable time and the large frozen masses of concentrate continually plugged the table feeders under the storage silos causing an erratic operation of the wet section. Raw materials with high moisture contents were thawed in the L.S. & I. Railroad thawing sheds in Marquette to allow normal unloading and plant operation. A 20 car thaw shed is being constructed at the Pellet Plant.

The speed of the grate machine was increased from 28 to 40 inches per minute during the latter part of November. This delayed the burn through point well into the cooling zone and, as such, recuperative air temperatures were reached faster allowing the machine to be increased in capacity in a shorter length of time.

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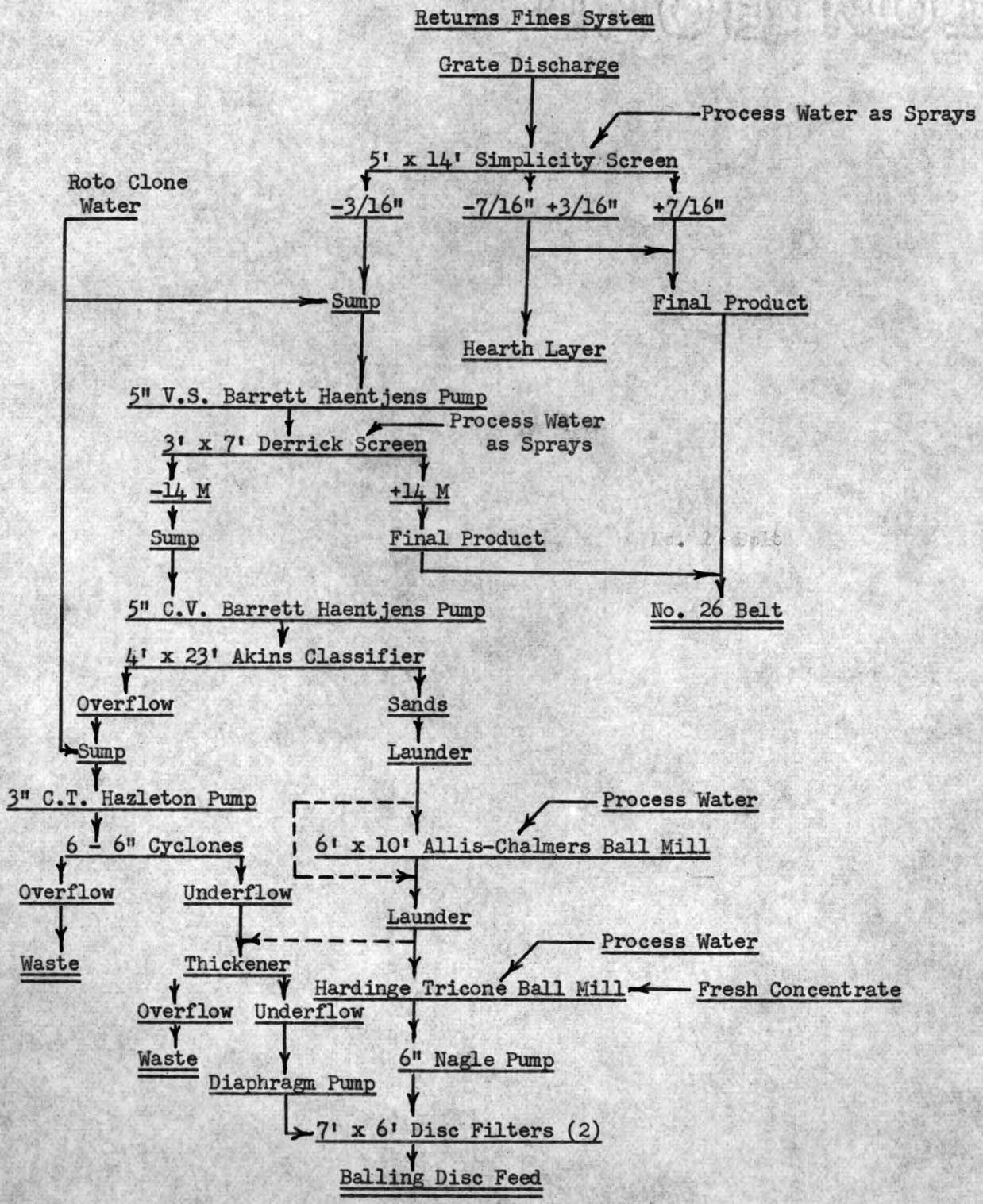
FIGURE 1.



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## IV. MAINTENANCE, REPAIRS, AND CHANGES

### A. Pellet Firing

Soon after pellet firing was initiated, it was apparent that the the capacity of the existing 15 horsepower down draft exhaust fan was insufficient to maintain proper ignition. The lack of sufficient capacity was attributed to air leakage over the leading edge of windbox No. 1 and from the updraft windbox section. Dead plates were welded on the leading edge of No. 1 windbox and between No. 2 and No. 3 windboxes, and a 50 horsepower fan from Humboldt Mine was substituted for the 15 horsepower fan. The high velocities encountered in the new fan combined with the abrasive action of the hearth layer fines caused excessive wear which necessitated frequent rebuilding of the fan blades and casing. The Humboldt fan was replaced with a fan of similar capacity and lower air velocity and a drop out chamber was installed in the intake. As a result repairs on the ignition exhaust fan have been reduced to a minimum. A second drop out chamber was installed on the grate machine ahead of the wet collector and the downdraft cooling fan. This chamber reduced the load of pellets and fines handled by the wet collector and decreased the possibility of wear on the down draft cooling fan from abrasive fines.

A wear problem also occurred in the wet collectors on the grate burn through zone. Large quantities of carbon dioxide were contained in the hot exhaust gasses derived from the burn through zone. The carbon dioxide dissolved in the water employed as filter media and caused an acid condition. The acid rapidly corroded the metal housings and the waste piping from the wet collectors. Temporary repairs were made by welding patches over the affected areas. During shut down the wet collectors will be coated with an acid resistant paint and the most severely corroded areas will be lined with stainless steel. Rubber lined pipe has been obtained to replace the present iron piping.

The seal shields in the updraft area gapped the pallet sidewalls causing air leakage and allowing fines to spill over the pallet sides. Adjusting the seal shields eliminated most of the clean up between the pallet cars and the hood.

The original down draft ignition windboxes were modeled after the updraft windboxes with a very shallow slope to the cleanout port. Moisture which condensed in the windboxes from the ignition gases wet the fines and made cleanout extremely difficult. The windboxes were modified with a steeper slope and the dust chutes were extended for easier cleanout.

A dust condition developed at the head of the grate machine due to the lack of provisions for retaining the dust from the hearth layer returns system. The hearth layer bin was totally enclosed and transfer points from 24 and 25 belts were hooded over and ducts run to the wet collectors. The hooding corrected the dust condition and eliminated spill at the transfer points.

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A. Pellet Firing (Cont'd.)

Radiation from the hot ignition layer overheated the water cooled burner manifolds and caused them to backfire. Overheating was remedied when the bottom of the burner manifolds were grouted with four inches of refractory cement. The refractory effectively insulated the manifold surface and eliminated blowback.

When the grate machine was installed, divider plates were included only between windboxes 2 and 3, 4 and 5, 6 and 7, and 8 and 9. To obtain proper control of the air flow in the burn through zone windboxes, divider plates were placed between the remaining windboxes through 12. Plans have been made to complete the installation of the divider plates during the January shutdown. In an attempt to improve the airflow, bleed-off pipes were fitted on windboxes 3 and 4 which were at the primary feed point. The bleed-off pipes permitted air reduction in these windboxes without altering the windbox dampers or the fan pressures.

The plastic tubing to the grate machine air controls proved unsatisfactory and had to be replaced with copper tubing. The fans and windbox dampers were controlled by air motors connected to the grate machine control panel with plastic tubing. When high heats were obtained on the grate machine, the plastic tubing extending over the hot air ducts melted and broke sending the fans and dampers out of control. Copper tubing has been run to the No. 1 and No. 2 fan controls and the replacement of the plastic tubing to the damper controls and meters is in progress.

The dust chutes and windboxes on the grate machine were continually loaded with clinkers, pellets, and fines. The majority of the material in the windboxes was carryover caught in the bottoms of the pallet cars. To avoid the carryover the spill chutes were revised on the discharge end of the machine and a vibrating conveyor was mounted beneath the breakover point to catch the spill at the grate discharge. Retarders were also poistioned on the pallet cars and the pallet rails were extended to prevent premature breakover of the pallets which decreased pellet spillage.

As the pallet cars became hot and expanded, the drive and scroll length was found to be insufficient. As a result the bottom drive sprocket teeth were exerting force through the pallet cars upon the upper srpocket teeth. The pressure exerted on the pallet cars heavily peened the wear shoes in the drive end scroll, and axles on several of the pallet cars were fractured. To relieve the strain on the scroll, the drive sprockets were moved forward to allow slack between the pallet cars in the scroll. The wear shoes were replaced in both the drive end and discharge scrolls.

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A. Pellet Firing (Cont'd)

Grate lubrication also proved to be a problem as the fines which were returned on the pallet seals plugged the lubrication vents in the grate seals. To maintain proper lubrication, the return pallet seals were coated with graphite and oil and the more easily accessible lubrication points were drilled out to remove dirt. In the future the Farval grease system will be moved to an easily accessible location to facilitate maintenance, and the lubrication points on the grate machine will be redesigned to assure a steady flow of grease. Any grooved or faulty seals are also to be replaced.

The oscillating grate feeders required continual repairs and maintenance to keep in proper function. The reversing limit switches were not positive in operation and their method of mounting resulted in abbreviated bearing life at the conveyor head pulley. The actual reversing mechanism on the grate feeders is a two-way piston controlled by compressed air. Fluctuations in air pressures to the cylinder caused erratic operation and the solenoids on the air valve failed frequently. Proper alignment of the conveyor belt was a problem and the belt scraper was not effective. This resulted in buildup of concentrate beneath the conveyor and in failure of the main pivot bearing on "C" line feeder. The bearings on the motor drives for the belts also failed due to the dirt and the excessive belt tension to keep them aligned. Guide rollers were attached alongside each bolt which reduced the amount of concentrate spill beneath the grate feeders. During November, Anker-Holth representatives completely overhauled the drive mechanism on the feeders. Some of the revisions were new limit switches, improved air valve with solenoids, and improved mounting of air cylinders. The changes which were incorporated in the grate feeder made it possible to lay an even layer of pellets on the bed for the first time, however, maintenance on the units remained high due to dust and difficulty in lubrication. Feed chutes were attached to the head end of the grate feeder that improved the deposition of the green pellets on the bed.

The bearings and gears on the Simplicity screen failed and were replaced in November. The bearings showed considerable wear which apparently resulted from a dusty condition in the hooded section over the screen. Screen cloths were changed several times for operating purposes, however, only a 1/8" by 1¼" screen and a 7/16" square screen were worn to the point of discard. When the plant was converted to a dry discharge, No. 26 conveyor was extended back beneath the screen and duct work was installed on the screened fines hopper to eliminate dust. The hot pellets and clinkers from the dry discharge deteriorated belts 23, 24, and 26, necessitating repairs to belts 24 and 26 and replacement of 23 belt.

When the plant was operated with a wet pump beneath the screen, the 2" Hazleton C.T. Pump would not handle the coarse fines and the impeller failed after a brief period of operation. The C.T. pump was replaced with a 3" Allis Chalmers C.W. pump until the C.T. pump would be converted to a 3" B.C.T. type pump. The 3" B.C.T. pump was installed but was removed when the operation was altered to dry discharge.

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A. Pellet Firing (Cont'd.)

A clinker breaker was installed in the latter part of October to handle the hot material which was retained on the discharge grizzly. Previous to its installation the clinkers would build up until it was necessary to halt the machine so that the operators could break the chunks with sledge hammers. The clinker breaker consisted of a drop weight hung over the grizzly and raised and lowered with an air tugger.

In November the thermocouples were located in the No. 2 fan air ducts to measure the recuperative air temperature. The temperatures were read on a single pyrometer mounted on the control panel which was connected to a selector switch.

B. Materials Preparation

For proper operation of the process equipment such as a ball mill, pulverizer, or balling disc, a closely controlled feed is required. The Linkbelt table feeders furnished by McDowell proved to be wholly inadequate in this respect. The 4 - 60 inch coal, 8 - 72 inch concentrate, and 4 - 96 inch concentrate table feeders (1) lacked feed rate regulation and (2) did not provide an even flow of feed to the processing equipment. Redesigned bin bottoms were fabricated and installed on all 16 table feeders. Except for the period when there were frozen lumps in the coal and concentrate, the new table feeders have provided a steady even flow of raw materials. Misalignment of ring gears and pinions on three of the concentrate table feeders caused excessive wear. The worn gears were replaced by the Linkbelt Co.

Several changes were completed in the regrinding circuit in attempts to improve the operation. A bin and a retractable chute were erected at the ball mill discharge to facilitate ball charging. The balls were loaded in the bin, the amount was measured, and the mill was charged while in motion.

As the tonnage of the concentrate to the ball mill was increased, the excessive froth seriously reduced the capacity of the 3" ball mill discharge pump. The pump was speeded up and the impeller was fitted with water jets. The pump capacity was improved but not enough to handle the entire discharge. The pump was replaced with a launder direct to the thickener.

In September and October an effort was made to grind the returns from the grate machine discharge in the regrind ball mill. The returns were pulped to 35 per cent to be pumped to the ball mill, and it was necessary to densify the fines in order to maintain grinding solids in the ball mill. A dewatering cone was installed at the feed end of the ball mill, but was not entirely sucessful because of variations in grate machine operation and surging of fines on the screen. The dewatering cone was eliminated when the plant was converted to dry discharge.

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B. Materials Preparation (Cont'd.)

A pump was placed at the ball mill discharge to return 50 per cent of the reground concentrate in hope of increasing the amount of fines. Due to froth locking, the capacity of the pump was reduced and the amount of pulp treated was not sufficient to determine whether there was an improvement in the resulting grind. Reground concentrates began to arrive from Republic at this time, and there was no further testing. As the reground concentrate frothed excessively in the thickeners, a 4" pump was mounted and a line was piped to feed half of the ball mill discharge direct to the "A" filter. The direct feed to the filters was successful, and a 6" Nagle pump will be installed during shutdown to feed both filters.

Sprockets were changed on the thickener drive to reduce the rake speed. The lower rake speed allowed time for more settling and a higher pump density in the thickener underflow.

Worn ball chips overflowed the ball mill and reported in the thickener underflow. When the chips passed through the diaphragm pump, they abraded and scored the check valves. As a result the discharge check valves were both replaced, and the rubber gaskets were changed frequently on both intake and discharge.

The fineness of the concentrate reground at Republic and Eagle Mills in November and December caused the filter cake to stick to the filter cloths. Various schemes were tried to obtain release of the cake, such as increasing the blow off pressure and delaying the blow off, but the only affective method of removing the cake was a snap blow produced by inserting a quick opening solenoid valve in a 20 p.s.i. air line.

As the filter cake is released intermittently, surges occur on the conveyor belts which interfere with proper blending and mixing. Number 8 belt which transports the filter cake from the filters was slowed down, shortening the intervals between the filter cake drops. A levelling device was also attached to the conveyor head pulley which smoothed the loading on No. 9 belt considerably. A Pekay mixer-muller was installed on No. 12 belt after the bentonite and limestone were added to the concentrate. The mixer-muller blended the raw materials and also improved their distribution on the belt.

A Sly dust collector was installed at the north end of the building to collect the dust at the transfer points between No. 10 and No. 11 and No. 11 and No. 12 belts. The Pekay mixer-muller was also tied into the Sly at a later date. Foreign objects had lodged under the belt skirts on No. 10 and No. 11 belts grooving them and causing a large amount of spill. Both belts were turned which removed this source of bentonite and limestone loss.

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B. Materials Preparation (Cont'd)

Pekay aerators were situated on belts No. 16 A and B to fluff the concentrate and break any masses before they enter the disc. The aerators are to be installed on No. 15 C and D lines at a later date. The angle of the feed chutes to the discs were altered so that the concentrate was fed into the center of the disc rather than on the steps. The coal feed chutes on the disc were also changed. The long drop involved in transferring the coal from the coal feeder to the disc reroll ring created severe dusting. The coal feed chutes were enclosed and the coal dust was exhausted to a Sly dust collector on the roof.

The gear reducers on the balling disc drive leaked oil after a few weeks operation. Representatives of Michigan Cone Drive, manufacturers of the gear reducer, visited the plant and replaced the shaft seals. No trouble has been encountered with the gear reducers since these new shaft seals were installed.

The No. 16 conveyors were completely remodeled to lessen the drop at the transfer points and eliminate as much pellet breakage as possible. The idlers beneath the lip of the balling disc were lifted to decrease the impact on the green pellets. The head pulleys on No. 16 A, B, C, and D conveyors were lowered to prevent pellet damage.

Hardinge representatives were on hand most of the summer making the necessary alterations and repairs to the disc roll mill to obtain optimum performance. In October the final repairs and adjustments were completed by the Hardinge personnel, and the mill is now operating satisfactorily. An Aeroturn dust collector has been installed on the roof to be operated in series with the existing air classifiers on the pulverizer. The Aeroturn will return coal and limestone fines to the circuit when its erection is complete.

C. General

The drive on the No. 2 A shuttle conveyor was situated at the north end of the conveyor, opposed to the flow of the majority of the raw materials. The drive end of the conveyor was reversed so that the drive pulled rather than pushed the loaded belt when unloading concentrate. Since 90 per cent of the material unloaded is concentrate which is stored in the south silos, remounting the conveyor drive eliminated belt slippage and spills above the silos.

Difficulty was encountered in zeroeing and calibrating the belt scales throughout the plant. During November the belt scales were calibrated with chains rather than the test weights furnished, and most of the scales were found to be several per cent out of adjustment while others could not be zeroed at all. After the calibration with chains, the belt scales provided better service, but were not wholly satisfactory. The Transportometer Division of McDowell Co. intends to convert these scales during January shutdown.

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C. General (Cont'd.)

Pellet returns and spill at the drive end of the grate machine created a dust hazard in the remainder of plant. A wall was erected around the drive end of the machine to contain the dust.

Additions were also made to the plant water system. A sump was constructed inside the building to take care of the plant waste water. The waste water from the thickener overflow, the rotoclone discharge, and the filtrate tank entered the central sump and was pumped to a drain field. A fire hydrant was placed outside the south wall of the building to allow utilization of local fire fighting equipment.

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## V. GENERAL SURFACE

### A. Stockpile

Ohio rejects were received during the year in the amount of 12,120 tons. In May and June 7,640 tons were unloaded and in November 4,480 tons. The rejects were unloaded from the railroad cars by conveyor and were distributed with truck and bulldozer to a depth of 8 inches. The stockpile sollar is now 90 per cent complete.

### B. Water Supply

To provide additional water pressure a second Fairbanks-Morse pump was installed at the process water pump house in June. During the summer a stone dam was placed below the pump house on the Carp River to assure an adequate water supply for the plant.

### C. Building Repairs

The large volume of air exhausted from the plant by the process fans resulted in a half inch of negative pressure within the building. A study was made of various methods to overcome this vacuum, and the down draft cooling section of the grate machine was hooded over to draw the cooling air from outside instead of inside the plant.

### D. Outside Lighting

Poles were erected and lights were strung at the propane storage yard, the unloading building, and the process water pump house and around the main building.

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## VI. COST OF PRODUCTION

TABLE 16.

### Monthly Operating Costs

| Processing Cost | Sept. | Oct. | Nov. | Dec. | Year |
|---|---|---|---|---|---|
| Raw Mat'l - Unload. & Storage: | | | | | |
| Operating Labor | .064 | .049 | .169 | .182 | .124 |
| Power | .025 | .017 | .006 | .006 | .012 |
| Operating Supplies | .011 | .010 | .013 | .132 | .046 |
| Maintenance Labor | .005 | .001 | .036 | .032 | .021 |
| Maintenance Supplies | .002 | .000 | .014 | .009 | .007 |
| Total Month | .107 | .077 | .238 | .361 | .210 |
| Material Preparation: | | | | | |
| Operating Labor | .656 | .552 | .536 | .514 | .557 |
| Power | .607 | .419 | .143 | .137 | .295 |
| Operating Supplies | 1.827 | 1.373 | 2.115 | 1.723 | 1.769 |
| Maintenance Labor | .172 | .254 | .266 | .260 | .243 |
| Maintenance Supplies | .178 | .156 | .113 | .248 | .174 |
| Total Month | 3.440 | 2.754 | 3.173 | 2.882 | 3.038 |
| Pellet Firing: | | | | | |
| Operating Labor | .851 | .786 | .371 | .374 | .562 |
| Power | .549 | .379 | .130 | .124 | .267 |
| Operating Supplies | .413 | .558 | .420 | .433 | .456 |
| Maintenance Labor | .405 | .345 | .264 | .228 | .300 |
| Maintenance Supplies | .356 | .240 | .208 | .391 | .296 |
| Total Month | 2.574 | 2.308 | 1.393 | 1.550 | 1.881 |
| Product Screening & Loading: | | | | | |
| Operating Labor | .245 | .249 | .147 | .167 | .196 |
| Power | .018 | .013 | .004 | .004 | .009 |
| Operating Supplies | .246 | .050 | .057 | .061 | .092 |
| Maintenance Labor | .049 | .068 | .046 | .092 | .065 |
| Maintenance Supplies | .404 | .044 | .119 | .035 | .130 |
| Total Month | .962 | .424 | .373 | .359 | .492 |
| Water Supply: | | | | | |
| Operating Labor | .003 | - | - | .001 | .001 |
| Power | .017 | .012 | .004 | .004 | .009 |
| Operating Supplies | .004 | - | .003 | - | - |
| Maintenance Labor | .003 | .006 | .004 | - | .003 |
| Maintenance Supplies | .002 | .001 | .001 | - | .001 |
| Total Month | .021 | .019 | .012 | .005 | .014 |

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TABLE 16. (Cont'd.)

Monthly Operating Costs

| Processing Cost | Sept. | Oct. | Nov. | Dec. | Year |
|---|---|---|---|---|---|
| Control and Analysis: | | | | | |
| Operating Labor | .166 | .209 | .198 | .161 | .185 |
| Power | .001 | .001 | - | - | - |
| Operating Supplies | .075 | .077 | .054 | .081 | .071 |
| Maintenance Labor | .003 | - | - | - | .001 |
| Maintenance Supplies | .002 | - | .001 | - | - |
| Total Month | .247 | .287 | .253 | .242 | .257 |
| Other Direct Plant Expense: | | | | | |
| Operating Labor | .411 | .359 | .316 | .508 | .398 |
| Power | .020 | .013 | .002 | .004 | .009 |
| Operating Supplies | .170 | .181 | .163 | .290 | .205 |
| Maintenance Labor | .037 | .013 | .022 | .044 | .029 |
| Maintenance Supplies | .029 | .013 | .019 | .058 | .031 |
| Total Month | .667 | .579 | .522 | .904 | .672 |
| Allocated Expense: | | | | | |
| Operating Labor | .190 | .583 | .250 | .449 | .376 |
| Operating Supplies | .149 | .381 | .125 | .211 | .216 |
| Total Month | .339 | .964 | .375 | .660 | .592 |
| Total Processing Cost: | | | | | |
| Operating Labor | 2.586 | 2.787 | 1.987 | 2.356 | 2.399 |
| Power | 1.237 | .854 | .289 | .279 | .601 |
| Operating Supplies | 2.887 | 2.630 | 2.950 | 2.931 | 2.855 |
| Maintenance Labor | .674 | .687 | .638 | .656 | .662 |
| Maintenance Supplies | .973 | .454 | .475 | .741 | .639 |
| Total Month | 8.357 | 7.412 | 6.339 | 6.963 | 7.156 |

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OK
VII. STATEMEMENT OF TAXES

TABLE 17.

| Negaunee Township | Valuation | Taxes |
|---|---|---|
| S½ of NW¼ and NE¼ of SW¼, Sec. 36, 48-26 Eagle Mills Pelletizing Plant | 510,000 | 13,135.05 |
| Tax Rate | | 25.50 |

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## VIII. ACCIDENTS AND PERSONAL INJURY

Following is the statistics completed by the safety department for Eagle Mills during 1956.

TABLE 18.

| | |
|---|---|
| 1. Number of Man Hours Worked | 61,828 |
| 2. Position Rating - Miscellaneous | 6 |
| 3. Accidents | |
| Compensable Injuries (59 Compensable Days) | 3 |
| Non Compensable Injuries (8 Days) | 2 |
| Total (67 Days) | 5 |
| Average Days Lost per Injury | 13 |
| 4. Frequency (number of accidents per million man hours worked) | 80.87 |
| 5. Severity (number of days lost per million man hours worked) | 1,084 |

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## IX. PROPOSED NEW EQUIPMENT AND CONSTRUCTION

A general shut down period will occur in January and February 1957 in which the following projects and new equipment will be inserted in the plant circuit. These changes are expected to minimize operational difficulties and allow the plant to attain the designed capacity sooner.

### A. New Construction

1. Installation of air torque wrench for railroad car unloading.
2. Catwalks around railroad cars.
3. Installation of solenoid brake for No. 2 conveyor.
4. Installation of centrifugal belt speed switches on No. 2A conveyor.
5. Installation of Trans-weigh belt scale on No. 7 belt.
6. Installation of water strainer on process water line to wet section.
7. Improve froth baffles on thickener.
8. Install steady head water tank for water between diaphragms of diaphragm pump.
9. Complete installation of snap-blow devices for filters with permanent piping.
10. Improve distributor on No. 8 belt conveyor to insure constancy of load for bentonite additions.
11. Improve dust collection system at limestone and bentonite transfer points.
12. Flip belt on No. 12 conveyor.
13. Install belt speed switch on No. 14 conveyor.
14. Install Denver-Dillon screen on No. 5 belt to remove tramp coal and foreign objects.
15. Install Trans-weigh belt scale with gravity takeup on No. 5 belt.
16. Install Republic propane flow meter to pulverizer.
17. Install Pekay aerators on conveyors No. 15 C and D.
18. Change oscillating scraper 60 degrees to 90 degrees on "C" line balling disc.
19. Recalibrate all transportometers.
20. Repair all ignition burners and replace one ignition manifold.
21. Replace 76 side walls on grate machine pallet cars.
22. Relocate Farval grease system and clean and drill grease system outlets.
23. Replace Simplicity finished product conveyor.
24. Install new flame rod safety cut-off on ignition system.
25. Install stainless steel liner on Syntron ignition coal feeder.
26. Replace all plastic air control tubing with copper tubing.
27. Install Carrier conveyor on drive end of grate machine to eliminate spillage.
28. Repair all Rotoclones.
29. Repair or replace piping from Rotoclone discharge.
30. Install dust legs from each windbox.
31. Install dust conveyor under grate machine.
32. Increase speed of No. 26 belt.
33. Relocate No. 26 transportometer.

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A. New Construction (Cont'd.)

34. Increase speed of No. 24 belt.
35. Provide chute to replace No. 25 belt.
36. Revise discharge end and install wet section for returns.
37. Install new air compressor.
38. Construct compressor enclosure and oil room.
39. Complete installation of Aeroturn dust collector from pulverizer exhaust.
40. Install brackets, crane rails, supports, and 10 ton crane.
41. Construct thawing shed.
42. Air recirculation in building to reduce negative pressure.

B. New Equipment

1. 6' x 8' Used Allis-Chalmers Ball Mill
2. 3' x 7' Used Derrick Screen
3. 48" Used Wemco Classifier
4. Six 6" cyclones
5. 10½' x 14' Allis-Chalmers Ball Mill
6. 500 cubic foot Ingersoll Rand Air Compressor
7. 4'x 26' Simplicity Feeder
8. 5" B type "VS" Barrett-Haentjens pump
9. 10 ton overhead crane
10. Used Aeroturn Dust Collector
11. Pekay Aerators
12. 2 Trans-Weigh Belt Scales
13. 2' x 4' Denver-Dillon Double Deck Screen
14. 1' x 10' Carrier Conveyor

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## X. MONTHLY OPERATING TABLES

TABLE 19. Raw Materials Unloading and Storage - Monthly Operating Data

| Raw Materials Unloaded | Tonnages | | | | | | |
|---|---|---|---|---|---|---|---|
| | Concentrate* | Process Coal | Ignition Coal | Limestone | Bentonite | Gallons Propane | Net Tons Grinding Balls |
| September | 14,350 | 534 | - | 582 | 104 | 81,245 | - |
| October | 16,199 | 1,024 | 61 | 202 | 51 | 60,193 | 51.0 |
| November | 22,870 | 1,428 | 247 | - | 99 | 20,088 | 25.0 |
| December | 20,957 | 1,076 | 119 | 358 | 152 | 62,870 | 56.0 |
| Sub Total | 74,376 | 4,062 | 427 | 1,142 | 406 | 224,396 | 132.0 |
| Start up Period | 8,663 | 2,019 | 341 | 429 | 193 | 85,530 | 51.5 |
| Total | 83,039 | 6,081 | 768 | 1,571 | 599 | 309,926 | 183.5 |

*1956 Republic shipping weights.

| | Operating Hours | | | |
|---|---|---|---|---|
| September | 59.5 | 4.5 | - | 1.5 |
| October | 41.3 | 9.7 | 0.3 | 2.7 |
| November | 151.1 | 14.5 | 10.0 | - |
| December | 160.4 | 29.0 | 4.5 | 10.0 |
| Sub Total | 412.3 | 57.7 | 14.8 | 14.2 |

Start up Period (unloading time not recorded)

| | Unloading Rate - LTPH | | | |
|---|---|---|---|---|
| September | 241 | 119 | - | 388 |
| October | 392 | 106 | 203 | 98 |
| November | 151 | 98 | 25 | - |
| December | 131 | 37 | 26 | 36 |
| Yearly Average Rate | 180 | 70 | 29 | 80 |

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TABLE 19. Raw Materials Unloading and Storage - Monthly Operating Data (Cont'd.)

| | Tonnages | | | | | | |
|---|---|---|---|---|---|---|---|
| Raw Materials Unloaded | Concentrate | Process Coal | Ignition Coal | Limestone | Bentonite | Gallons Propane | Net Tons Grinding Balls |
| September | 11,881 | 679 | 32 | 202 | 129 | 52,045 | 5.5 |
| October | 14.491 | 1,037 | 120 | 48 | 80 | 57,430 | 20.0 |
| November | 18,206 | 1,317 | 217 | 553 | 99 | 69,517 | 34.0 |
| December | 18,125 | 1,033 | 250 | 242 | 136 | 83,935 | 17.3 |
| Sub Total | 62,703 | 4,066 | 619 | 1,045 | 444 | 262,927 | 76.8 |
| Start up Period | 7,347 | 400 | 26 | 188 | 49 | 24,449 | 7.0 |
| Total | 70,050 | 4,466 | 645 | 1,233 | 493 | 287,376 | 83.8 |
| Raw Materials Storage | 12,989 | 1,615 | 123 | 338 | 106 | 22,550 | 100.0 |

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TABLE 20. Materials Preparation

Regrind Section - Monthly Operating Data

| Ball Mill and Filters | Tonnage Processed | Hours Operating | Delays | Per cent Operation | Regrinding Rate LTPH: Gross Time Basis | Regrinding Rate LTPH: Net Time Basis |
|---|---|---|---|---|---|---|
| September | 11,881* | 355.8 | 14.0 | 96.1 | 33.4 | 34.7 |
| October | 14,491* | 436.3 | 26.5 | 94.0 | 33.2 | 35.3 |
| November | 18,206 | 403.7 | 10.4 | 97.4 | 45.1 | 46.3 |
| December | 18,125 | 396.6 | 38.4 | 90.3 | 45.7 | 50.6 |
| Sub Total | 62,703 | 1,565.4 | 89.3 | 96.0 | 40.1 | 41.7 |
| Start up Period | 7,347 | 203.6 | 14.9 | 92.8 | 36.1 | 39.0 |
| Total | 70,050 | 1,769.0 | 94.2 | 95.7 | 39.7 | 41.4 |

*does not include fines returned to system in September and October.

| | Power Consumption** KWH | Power Consumption** HP-Hr/LT | Steel Consumption*** lbs./LT Reground | Structure - % -325 M: Initial | Reground | Difference |
|---|---|---|---|---|---|---|
| September | - | - | 0.93 | 42.3 | 61.4 | 19.1 |
| October | - | - | 2.76 | 45.2 | 61.4 | 16.2 |
| November | 172,800 | 12.72 | 3.73 | 42.4 | 59.9 | 17.5 |
| December | 220,000 | 16.27 | 1.90 | 57.1 | 67.4 | 10.3 |
| Yearly Average (sum) | 392,800 | 14.51 | 2.45 | 47.3 | 62.7 | 15.4 |

**ball mill watt-hour meter installed November 1.
***ball wear only

Pulverizer+

| | Tonnage Processed: Coal | Tonnage Processed: Limestone | Hours Operation: Coal | Hours Operation: Limestone | Pulverizing Rate - LTPH: Coal | Pulverizing Rate - LTPH: Limestone |
|---|---|---|---|---|---|---|
| September | 679 | 202 | 180.1 | 7.8 | 3.8 | 25.9 |
| October | 1,037 | 248 | 172.4 | 17.7 | 6.0 | 14.0 |
| November | 1,317 | 253 | 178.3 | 11.1 | 7.4 | 22.8 |
| December | 1,033 | 342 | 199.3 | 19.8 | 5.2 | 17.3 |
| Sub Total | 4,066 | 1,045 | 730.1 | 56.4 | 5.6 | 18.5 |
| Start up Period++ | 400 | 188 | - | - | - | - |
| Total | 4,466 | 1,233 | 730.1 | 56.4 | 5.6 | 18.5 |

+pulverizer watt-hour meter not installed until January shut down, therefore, there are no figures available on power consumption also there are insufficient hours on the pulverizer to obtain figures on steel consumption.

++operating time not recorded.