

MINE SURVEYS, MAPPING AND CALCULATIONS.

A brief description of the mine work will now be taken up under the separate mine headings:

ATHENS MINE.

At this property, where sinking is in progress, Mr. Hanst has been in charge of the concreting of the shaft. On surface the construction work has been looked after and the new buildings, railway tracks and changes in fence lines were surveyed for the annual report.

CHASE MINE.

The surface and underground diamond drilling was looked after, lines and locations being given for drill holes when necessary. The new pole line to the Dexter property was surveyed and other changes noted for the annual report. Check surveys for coordinates and elevations were carried from the shaft to the breasts on the 2nd and 3rd levels. The usual monthly survey was made at the close of each month.

CROSBY MINE.

A composite tracing of surface and underground workings was posted for Mr. Barber. The annual report tracings were photographed and prints colored in for the report books.

CLIFFS SHAFT MINE.

The routine engineering, which consists of monthly surveys, giving lines for drifts, raises and drill holes, was attended to. The pump house and sump on the 15th level "A" shaft received a great deal of attention. Lines and elevations were given for the excavation, pump foundations and piping. The estimate maps, after several years work, were finally finished. These maps show the analyses and amount of ore left in the pillars and floors, the total ore developed, the amount available and the tonnage that will have to be left in the shape of braces and pillars for supporting the back. A very careful

estimate of the ore in sight has been tabulated on these maps. Two years ago check surveys were carried all over the various levels and between levels. Last spring these surveys were carried forward into the breasts of the different contracts, thereby checking the monthly work. Plugs were set in nearly every contract, very close to the working face. It has been found by experience that plugs are the only satisfactory way of keeping accurate surveys in the working stopes. These are usually placed in the hanging wall of the stope or in the floor near the rib line. The old system of rail points is unsatisfactory due to the wearing down of the rail which obliterates the points and also due to the shifting of the track in the wide stopes. These check surveys were run principally on the 8th, 9th and 10th levels. The stopes and drifts were geologized about once in three months and the geological maps and sections posted.

DEXTER MINE.

On surface a ditch was laid out to carry the water from the shaft Southwesterly to Chase lake. As the mine was unwatered, the eight levels were surveyed and maps and tracings made. The underground diamond drilling was also looked after.

GWINN DISTRICT MINES.

The annual report tracings were photographed and prints furnished the Gwinn office.

IMPERIAL MINE.

The only time spent for this mine was in connection with the 1913 annual report.

JACKSON MINE.

The annual report work and the new quarter section tracings was all that was done for this property during the year.

LUCY MINE.

This property is closed and no surveys were made.

LAKE MINE.

In addition to the regular mine surveys, a special check survey was made on the 4th level on Election Day. The old 4th level points had become unreliable due to the shifting and repairing of the timber and a complete new survey was carried around both the East and West loops. These points were also tagged with the aluminum markers. On the 5th level, a check survey was carried from the shaft to the breast of both East and West drifts and all points tagged. All of the above surveys checked properly. On the 479' level or ventilation sub lines were given for drifting. The elevations were established on all the subs between the 3rd and 5th levels at the tops of all raises. A careful ore estimate was made for the State Tax Commission. Air tests were made in all working places and tests made on the drilling machines. At the close of the shipping season the ore in stock was estimated.

LLOYD MINE.

The 3rd and 4th level development drifts required a great deal of attention. On the 4th level two check surveys were made from the shaft to the ventilation raise and on the last survey all angles were turned four times. One additional survey was made for measurements only. Elevations were also carried out to the breast and checked back. The calculations of these surveys were based on the connecting level surveys between the Morris and Lloyd shaft, which were adjusted on the following basis: Previous to the holing of the Lloyd shaft from the 4th to the 2nd level, all the 2nd level Morris and 4th level Lloyd calculations were based on the Morris shaft plumbings, which gave varying results. When the Lloyd shaft was completed down to the 4th level a wire was hung from surface to this level. The coordinates of this wire when calculated from the 4th level surveys did not check the surface coordinates exactly and in order to make them agree the underground courses were adjusted $0^{\circ}1'40''$. A second plumbing was then used for a check and the surface and underground coordinates of the wire agreed by 0.01 in the Southing and 0.06 in the Easting.

This then is the maximum error possible in a distance of 1500', which is the length of the drift between the two shafts. Near the East end of the 4th level drift lines were given for the North-South crosscuts. The ore in these drifts was sampled. Lines and elevations were also established for both the vertical ventilating raise, which is intended to hole into a shaft being sunk from surface, and the inclined raise which was carried up to the elevation of the 3rd level. A careful survey was run up this inclined raise and lines given for the drift at the top. This drift is intended to hole into the ventilation raise and also the drift being carried due East from the main shaft. The ventilation raise was plumbed twice and its location staked out on surface, where a shaft is being sunk 9'9" by 10'10" in size. On surface a survey was carried from the collar of the Lloyd shaft to this ventilation and timber shaft, checking the previous work by 0.30 in the Southing and 0.06 in the Easting. The Lloyd shaft was also plumbed twice from the 3rd to the 4th level. The two plumbings checked by 00°00'15" and 0.01 and 0.03 for coordinates. The elevations agreed by 0.02. On the 3rd level a check survey was also carried around the turn to the main East-West drift and lines given to carry this drift due East on the 2700 coordinate line. The ore in this 3rd level drift was sampled. The plat and pocket on the 3rd level also required some of the engineers time. The limits of the Section 6 ore body were staked out on surface.

MAAS MINE.

This mine was operated until October 1st. After the 1913 annual report maps were finished check surveys were run on the 1st, 2nd and 3rd levels. All survey stations were tagged with aluminum markers and new point tracings made. A survey was also carried from the 2nd level Maas mine through the small drift at the boundary into the 10th level Negaunee mine. The Maas-Negaunee surveys tied in at this point by 1.18 in the Southing and 0.45 in the Easting. The winze that was being sunk from the 3rd to the 4th level, the 3rd level sump and pump house were looked after. At the winze lines were given for the bearers, the in-

stallation of the hoist was looked after and the sheaves lined in. The sump is being excavated from both ends and in the pump house lines were given for the discharge pipe, pump foundations and center line of pumps accurately established. The 2nd level raises and the boundary line drifts under the Roman Catholic cemetery were looked after.

MORRIS MINE.

Monthly and mid-monthly surveys were regularly made. There was no other work of importance except a check survey carried from the shaft to the breast of the main 1st level drift.

NEGAUNEE MINE.

The majority of the time spent at this mine was in connection with the 10th level development and construction work. In all the raises put up during the year plugs were set giving the direction and dip. Line plugs were set in all main level drifts. A check survey was carried around from the breast of No.38 contract into the breast of the drift for which this contract is headed and an exact check for course and a close check for coordinates secured with the old work. The elevations were also gone over. In the 10th level sump near No.3 shaft the engineers looked after the concreting of the walls and floor of the settling basin. The dam was also constructed in the drift leading to the winze in order to prevent the water flooding the bottom of the shaft. A drift was then driven underneath the sump and raises put up to drain the settling chamber and sump underneath the pump suction. Concrete walls were then put in this drift near the bottom of each of the above raises. The winze near No.3 shaft on the 10th level was plumbed twice in order to get accurate lines and elevations into the drift below the sump. The workings above the 10th level received only the usual attention.

REPUBLIC MINE.

At this mine, very extensive surveys were made. First a line was carried down the Pascoe shaft from surface to the 2050' level. Lines

were taken off on the 922', 1223', 1500', 1640', 1710', 1850', 1950' and 2050' levels. On the 2050' level we agreed with the Republic Iron Company's surveys by $00^{\circ}00'49''$ for course. On the 922' level two plugs were established. On the 1223' level the survey was carried from the Pascoe shaft to No.1 shaft; thence up No.1 shaft to the 1153' level and across on that level to No.9 shaft, tying into a vertical wire hung from surface by 0.25 and 0.43. On the 1335' level three new plugs were set and two plugs set on the 1500' level. The 1640-1665' level~~x~~ was surveyed from the Pascoe to No.9 shaft. The coordinates of the vertical wire in No.9 shaft only differed 0.40 and 1.07 from the surface coordinates, which is a good check considering the length of the combined surface and underground loop. On the 1710' level the Cleveland-Cliffs Iron Company and Republic Iron Company's surveys only differed one minute for course and 0.02 and 0.09 for coordinates in the breast farthest away from the shaft. On the 1780' level two plugs were established. On the 1850' level the Republic Iron Company and C. C. I. Company agreed exactly for course and differed only 0.02 and 0.05 in the breast. On the 1950' level on plug No.8 we disagreed in coordinates 0.06 in the Northing and 0.02 in the Westing. The 2050' level was checked over and no discrepancies found. No.9 shaft was plumbed from the 1665' level to the 1815' and 1935' levels. On the 1815' level near the shaft the check with the Republic Iron Company's surveys was $00^{\circ}00'10''$ for course and on the lower level $00^{\circ}00'30''$. The coordinates agreed closely on both levels. No where in the mine did we find any difference large enough to affect the position of the drifts and stopes on the mounted maps. Elevations were also carried from the D.S. & A. Railway bench mark near the depot to the collar of No.9 shaft. The measurements down the shaft agreed with the old work by 0.01 on the 1665' level, by 0.20 on the 1935' level and checked exactly on the 1815' level. Sea level elevations were then carried across on the

1153' and 1223' levels and on the 1640-1665' levels to the Pascoe shaft; thence down the shaft to the 2050' level where we disagreed with the old work by only 0.30. Elevations were carried from the shaft to all breasts on the 1815' and 1935' levels No.9 shaft and on the 1335', 1850', 1950' and 2050' levels Pascoe shaft. New mounted maps and tracings were then made of the 1153', 1665', 1815' and 1935' levels No.9 shaft and of the 922', 1223', 1335', 1500', 1570', 1850', 1950' and 2050' levels Pascoe shaft. The surface surveys are discussed later in this report.

SALISBURY MINE.

The only work of importance was in connection with the 14th level drift. A survey was carried down the main hoisting shaft from surface to the 14th level. This was started from two concreted iron pins that had previously been tied into the Maas coordinate system. A sight was taken from surface to the level and line points lined in on the footwall timbers to measure to. In every case measurements were taken twice and in two different ways. We measured the instrument point distance and also the distance from point to point along the foot of the shaft. There was only a few hundredths difference in the final results. After calculating and applying a correction factor of $2^{\circ}13'$, which is the difference in course between the Maas and Salisbury systems, it was found that the new survey checked the old one exactly for course and within a few hundredths for coordinates. An entire new set of tracings was made for the annual report and the elevations of all sub-levels changed to the sea level datum.

SURFACE SURVEYS.

REPUBLIC DISTRICT.

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All of Section 7 and a portion of Section 18, 46-29 was mapped. The South quarter corner of Section 7 was taken for the origin and the North-South center line as North. The Republic Iron Company had used the same origin and the same bearings. A survey was carried from the South quarter corner to the collar of the Pascoe shaft, establishing a point into which the underground surveys were tied. The line was then carried via No.5 engine house to No.9 shaft and thence along the railway tracks back to the Pascoe shaft. Another loop was carried completely around Smith's Bay. From this main loop other surveys were carried to the limits of the section. All fences, buildings, railway tracks, etc, were surveyed and mapped on 50' to the inch maps. The annual report tracings of the same were completed and photographed.

On Section 18 all of the Company's holdings on the West bank of the river were surveyed. A 200' to the inch map was made of the entire section and 50' to the inch map of the North half of the Northwest quarter. On all of the above surveys nothing but iron pin stations were established and all of the loops tied in very closely, the majority of the checks being within 0.25 of a foot each way for coordinates.

CRYSTAL FALLS EXPLORATIONS.

A contour map of the East half of the Neely lease was completed. This was made in order to determine where to standpipe for a shaft location.

NORTH LAKE EXPLORATIONS.

The diamond drilling on Sections 2 and 3 required attention, lines and locations for new holes being given when necessary.

CARP RIVER WATER POWER.

A profile and estimate for the proposed dam for storage basin No.1 was made and ^a blue print showing the position of the dam and character of the ground was colored in. A survey was made of Partridge brook and a possible route was surveyed for diverting this water and also the Negaunee sewage into the Carp river.

CITY OF ISHPEMING.

A survey plan and profile was made for the proposed trail leading from the President's cottage across Sections 11 and 14 to Lakes Sally and Ogden. The contour maps of lands within the city limits are discussed elsewhere in this report.

TRANSMISSION LINES.

A set of blue prints was prepared showing the heights of all telephone and electric light wires that cross the L.S. & I. Railway in the cities of Negaunee and Ishpeming. The proposed Dexter-Republic pole line was laid out on paper showing several possible routes and adjacent ownerships.

MICHIGANNE RIVER WATER POWER.

Elevations were carried up the Michigamme river from the town of Republic and checked back. The levels were based on a bench mark established by the D. S. S. & A. Railway near their depot. These elevations were carried via the Chicago, Milwaukee & St. Paul Railway tracks to the Kloman property and thence along the old railway grade on the West bank of the river to the West line of Section 27, 47-30. From this point the wagon road was followed to the bridge across the Spruce river; thence following the trail from the bridge to the dam at the South end of Lake Michigamme. Twenty seven bench marks were established along the railway grade and wagon road, four of these being near the dam at Lake Michigamme. A bench mark was also set at the foot of the second rapids near the South line of Section 16, 47-30. Levels were carried down to the river at least every half mile. Data showing the drainage area, flow of river, theoretical horse power, etc, was compiled for Mr. Jopling.

REPUBLIC IRON COMPANY'S LANDS.

The above lands include all of the landed estate bought by the Company, with the exception of Sections 7 and 18 at Republic. The sub-division of Section 4, 47-28 was checked over. These corners had previously been set by the M. A. Hanna Company's engineers and were found to be correct within a foot by the C. C. I. Company. Some work was also done on Sections 12 and 13, 47-29. An index map of all the Republic Iron Company's holdings was made.

LUCKY STAR & BREITUNG-HEMATITE MINES.

A survey of the new L. S. & I. tracks and new buildings was made on both of these properties. All of the Breitung-Hematite Company's drill holes that could be found were surveyed.

CONTOUR MAPS.

BUNKER HILL MINE.

The surveys run on the surface of this property during the summer of 1913 were plotted on the old mounted map of the North half of the Southwest quarter of Section 6, 47-26. All this information was then transferred on to a new mounted map. A tracing was made and photographed for the 1914 annual report.

CITY OF ISHPEMING SECTION 3.

The notes taken during the summers of 1912 and 1913 were plotted and traced during the spring of 1914. An entire new set of tracings was made because the old ones were ruled on the old Cliffs Shaft coordinate system and the new maps are on the Maas coordinate system.

CITY OF ISHPEMING SECTION 4.

Eight new 50' to the inch mounted maps were ruled and topography plotted. These maps were then traced and photographed.

NORTH LAKE DISTRICT SECTION 5.

A strip 3000' wide on the iron formation across the section from East to West was contoured and outcrops located. East-West lines on the 1600, 2400, 3200 and 4000 South coordinate lines had previously

been established with stations every 200'. Intermediate lines on the 2000, 2800 and 3600 South coordinate lines were run out with stadia. Short lines 200' in length at 200' intervals were then run North and South from the stations on the East-West lines. From these stakes all outcrops, fences, roads, test pits and contours were mapped. Elevations were run over the 1600, 2400, 3200 and 4000 foot lines with a level and readings taken on the other stations with stadia rods.

CITY OF ISHPEMING SECTION 9.

The North half of this section was plotted and traced from notes taken during 1913.

CITY OF ISHPEMING SECTION 11.

The notes taken on the North half of this section were plotted and a great many errors found. These errors were looked up and ^{the} corrected contours mapped on the old mounted maps. New maps were then made because the old ones were based on the Hard Ore coordinate system. Two of these maps have been traced and photographed and the others are being made.

IRON CLIFFS DRIVE TERRITORY SECTION 12.

The favorable iron formation on this section has been contoured. Most of the work was done on the North half of the section. The large and rugged diorite hills were only partially contoured, sometimes the only elevation being taken at the very top.

IRON CLIFFS DRIVE TERRITORY SECTION 13.

Lot No.5 was contoured during the spring of 1914.

BELLEVUE FARM DISTRICT SECTIONS 17 & 18.

A strip of land 1600' wide and a mile long on the favorable iron formation was contoured.

COORDINATE LINE SURVEYS.

IRON CLIFFS DRIVE TERRITORY.

Coordinate lines were established on Sections 12, 13, 22, 23, 24, 25, 26 and 27 T. 47 N. R. 27 W. and Section 19, T. 47 N. R. 26 W. All of these lines were based on the Maas coordinate system and iron pins used on all sight stations as well as for the 800' stations. Wooden stakes were set every 200' whenever possible. The 19200 South and 20000 South coordinate lines were run across Sections 22, 23 and 24. The 21600 South and 22400 South lines were run across Sections 25, 26 and 27. The 9600 West line was run North from station 160 X 96 to Lake Ogden. The 8800 West line was carried North from station 160 X 88 to Lake Miller. The 13600 South line was run from station 136 X 80 to 136 X 48. On Section 24 the 7200 West, 6400 West, 5600 West and 4800 West lines were run North and South across the entire section. The 8800 West and 9600 West lines were surveyed South from the 160 line to the lake in the Northwest quarter of Section 24. The 18400 South line was run West and the 10400 West line run South until the two intersected. On Section 12 the 5600 South line was run from station 56 X 96 to 56 X 48. The 7200 South line runs from station 72 X 48 to 72 X 64. The 6400 West line was run South from station 56 X 64 until it intersected the 8400 South line running East from station 84 X 104. On Section 19, 47-26 the 18400 South and 20800 South lines were run East from the North-South 4800 line for about a half mile. A survey was then run connecting the ends of these East-West lines and the Empire mine surface, buildings and equipment surveyed from this connecting line.

NORTH LAKE DISTRICT.

An area 1600' West by 3200' long South and East of North Lake on Section 1, 47-28 was contoured. Cross-section lines were run 200' apart from the main East-West 4800 line and elevations taken with stadia.

This area was contoured in order to find out whether it was possible to dump the water and mud from North Lake upon it in case the lake should be pumped out.

SPECIAL WORK.

AIR TESTS.

These were made in the Lake mine to determine the percentage of oxygen, carbon dioxide, humidity, temperature and barometric pressure in every working place. The air at various points on the main levels was also tested. These determinations were usually made by a party consisting of three men. The engineer recorded the condition of the air pipes, whether working place was smoky, whether drills were working and exhausting air, etc. A chemist manipulated the air testing machine and a man from the Safety department took the data regarding the temperature, humidity, etc.

ABSTRACT MAPS.

The maps of the Bunker Hill property, the Lucy mine and Gwinn district, which were started during 1913, were finished. The maps of the old Iron Cliffs Company's lands were started.

ANNUAL REPORT.

The 1913 report kept the department busy until the middle of February. Photographs were taken for the 1914 report in September by Mr. Cole. The Maas and Salisbury mine maps were photographed in November and the other maps photographed as soon as the December surveys were plotted.

CARBON REPORTS.

A monthly report is turned in to the Auditing department and special reports made at various times. The carbons in use are tested and determinations made on carbons before purchasing. Two inventories of the diamond drill equipment were made during the year 1914.

DUPLICATION OF SURVEY RECORDS.

All of the survey calculations of the mines handled from the Ishpeming office and all surface surveys made by this office were duplicated by Miss Gill. She made two typewritten copies and these were fastened into four sets of loose-leaf covers, two being for surface and the other two for underground points. Two other books were also made up covering all the level notes and bench marks. One set of these books was sent to the Land department and one to the Cleveland office.

DIVISION OF MINERAL RIGHTS.

Maps of Lakes Ogden and Sally were prepared showing the division of the mineral rights between the Iron Cliffs Company, Cleveland Iron Mining Company and the Jones and Laughlin Ore Company.

ESTIMATES.

Coal estimates are made once a year, about May 1st, at every mine. Stockpile estimates were made at the close of the shipping season at the Lake and Cliffs Shaft mines. The ore estimates of the Ishpeming, Negaunee and North Lake mines were made with the various superintendents.

EFFICIENCY TESTS.

At the Lake mine tests were made to determine the drilling speed of various kinds of machines in the same kind of ground and also the drilling speed of the same machine with various forms of bits.

LAKE SUPERIOR MINING INSTITUTE.

A map of the Marquette Range showing the mines, railways and furnaces as they existed in 1872, was drawn. Another map was prepared showing the Range as it is at present. Both of these maps were published in the Proceedings of the Institute for the year 1914.

MECHANICAL DRAWINGS.

The toboggan stretcher used by the Safety department was sketched and detailed and assembled view drawings made. Drawings were also made of the doors and equipment to be installed at the Lake mine in connection with the fan ventilating system. A set of drawings for the Athens mine steel sets was also made.

STATE TAX COMMISSION MAPS.

Blue print copies of the maps of all the mines operated during the previous year were furnished the Tax Commission. On them were shown the boundaries of the ore by colors, the dikes and the character of foot and hanging.

SURVEY COSTS.

The following items will give some ideas as to the cost of surveys and completed maps made during the past three years:

CARP RIVER STORAGE BASIN NO.1.

Field work, including labor, camp expenses, supplies	
and drayage - - - - -	\$907.25
Office work, including mounted maps and tracings -	130.68
Total cost	<u>\$1037.93.</u>
Area contoured - - - - -	1200 acres.
Cost of field work per acre - - - - -	\$0.756.
" " " " " " forty - - - - -	\$30.24.
Cost of combined field and office work per acre -	\$0.865.
" " " " " " " " " " " " forty -	\$34.60.

CARP RIVER STORAGE BASIN NO.2.

Field work, including labor, horse hire and supplies	\$557.17.
Office work, including mounted maps and tracings	197.00.
Total cost	<u>\$754.17.</u>
Area contoured - - - - -	1239 acres.
Cost of field work per acre - - - - -	\$0.449.
" " " " " " forty - - - - -	\$17.96.
Cost of combined field and office work per acre -	\$0.608.
" " " " " " " " " " " " forty -	\$24.32.

SECTION 1, 47-27.

Field work, including cost of base lines - - -	\$501.65.
Area contoured - - - - -	630.3 acres.
Cost of field work per acre - - - - -	\$0.796.
" " " " " " " " " " " " forty - - - - -	\$31.84.

SECTION 2, 47-27.

Cost of field labor - - - - -	\$324.58.
Area contoured - - - - -	633.8 acres.
Cost of field work per acre - - - - -	\$0.512.
" " " " " " " " " " " " forty - - - - -	\$20.48.

SECTION 3, 47-27.

Cost of labor in field - base lines	\$63.11.	
contouring	135.27.	
levels	31.37.	
horse hire	23.05	
Total		\$252.80.
Office work, calculating, mapping and tracing		241.33.
Total cost		\$494.13.
Area mapped - - - - -		601.25 acres.
Cost of field work per acre - - - - -		\$0.420.
" " " " " " forty - - - - -		\$16.80.
Cost of combined field and office work per acre		\$0.822.
" " " " " " " " " " forty		\$32.88.

SECTION 4, 47-27.

Cost of labor in field - base lines	\$128.48.	
levels	19.56.	
contours	198.94.	
Total		\$346.98.
Office work, calculating, mapping and tracing		164.07.
Total cost		\$511.05.
Area contoured - - - - -		633.52 acres.
Cost of field work per acre - - - - -		\$0.548.
" " " " " " forty - - - - -		\$21.92.
Cost of combined field and office work per acre		\$0.807.
" " " " " " " " " " forty		\$32.28.

SECTION 5, 47-27.

Cost of labor in field - contours	\$360.19.	
base lines	181.36.	
levels	18.90.	
horse hire	30.00.	
Total		\$590.45.
Office work, calculating, plotting, tracing		257.96.
Total cost		\$848.41.
Area contoured - - - - -		449 acres.
Cost of field work per acre - - - - -		\$1.315.
" " " " " " forty - - - - -		\$52.40.
Cost of combined field and office work per acre		\$1.889.
" " " " " " " " " " forty		\$75.60.

SECTION 9, 47-27.

Cost of field work - - - - -	\$104.59.	
" " office work - - - - -	116.86.	
Total		\$221.45.
Area contoured - - - - -		320 acres.
Cost of field work per acre - - - - -		\$0.327.
" " " " " " forty - - - - -		\$13.08.
Cost of combined field and office work per acre		\$0.692.
" " " " " " " " " " forty		\$27.68.

RECAPITULATION.

	FIELD WORK.	OFFICE WORK.	TOTAL
	COST PER ACRE.	COST PER ACRE.	COST PER ACRE.
Storage basin No.1	\$0.756	\$0.109	\$0.865
" " No.2	0.449	0.159	0.608
Section 1, 47-27	0.796		
" 2, "	0.512		
" 3, "	0.420	0.310	0.822
" 4, "	0.548	0.259	0.807
" 5, "	1.315	0.514	1.889
" 9, "	0.327	0.365	0.692

From the above tables it is evident that there is a wide difference in the cost of the contouring of the various sections. The reason for the high cost of Section 5 was due to the fact that nearly the entire section is wooded and consequently four axemen were employed and a great number of set-ups had to be made as it was impossible to see very far between the trees. The cost of Section 9 is low compared with the rest. This is due to the fact that the majority of the area contoured lies in the Carp river valley, which is low and swampy and fairly flat, consequently very few readings were taken.

COST OF COORDINATE LINES IN THE IRON CLIFFS DRIVE TERRITORY.

These surveys were made during the summer of 1914.

LINE.	LENGTH.	SECTION.	TOWN.	RANGE.	LINEAL COST PER MILE.
10400 N-S	4000.00	23	47	27	\$85.76
9600 N-S	2463.71	13 & 24	47	27	64.10
8800 N-S	3931.62	13 & 24	47	27	49.85
8000 N-S	1600.00	25	47	27	71.90
7200 N-S	4800.00	24	47	27	116.40
6400 N-S	4800.00	24	47	27	18.52
5600 N-S	4800.00	24	47	27	18.52
4800 N-S	5600.00	19	47	26	38.52
20800 E-W	3200.00	24	47	27	91.60
18400 E-W	2400.00	24	47	27	59.22
19200 E-W	12800.00	25,26 & 27	47	27	55.53
20000 E-W	12800.00	25,26 & 27	47	27	43.58
21600 E-W	12800.00	25,26 & 27	47	27	123.40
22400 E-W	12800.00	25,26 & 27	47	27	44.75
20800 N-S	1600.00	27	47	27	67.75
5600 E-W	4800.00	12	47	27	45.22
7200 E-W	1600.00	12	47	27	65.10
8400 E-W	4000.00	12	47	27	28.72
6400 N-S	2800.00	12	47	27	74.30
Average cost per mile					\$61.19.

MINE ABSTRACT DEPARTMENT.

The following have been employed in this department during the year: A. E. Primeau, Carl Brewer and Miss I. E. Gill.

A. E. Primeau was employed up to November 13th. He spent $111\frac{1}{2}$ days in Marquette obtaining abstracts and $3\frac{1}{2}$ days in Negaunee on tax matters. Abstracts of title to most of the Company's land on the mineral belt in Marquette County were made during the year, details of which are to be found in the report under the heading "Abstracts".

During March and April descriptions were prepared for the tax rolls, especially at Negaunee.

The acquisition of the lands from the Republic Iron Company increased the number of documents to be filed, etc, and necessitated more time than usual to be spent on current office work.

Carl Brewer spent six weeks in October and November making abstract maps of the Republic Iron Company's lands. On November 13th he took charge of the Abstract department after the departure of Mr. Primeau. The remainder of the year was occupied in becoming familiar with the work of the department. The abstracts left by Mr. Primeau were assorted, arranged and tabulated to show what work had been done and how much more was necessary. The abstract maps of the Republic Iron Company's lands were completed and filed. Mr. Brewer was absent five days.

Miss Gill was employed as a stenographer to copy the abstracts in final form and such documents as were necessary. Considerable of her time was occupied in copying all the survey notes of the Engineering department, this alone taking nearly six weeks, and doing work for other departments. She was absent $28\frac{1}{2}$ days, two weeks of which were vacation and the remainder on account of illness. She was transferred to the Shipping department on October 12th.

M. F. LaCroix, J. E. Hayden, H. O. Moulton, R. J. Chenneour and J. F. Hanst, of the Engineering department, made abstract maps during the year and assisted Mr. Primeau at Marquette and Negaunee.

REGISTER OF DOCUMENTS.

This book has been continued during the year for recording the date, disposition, etc, of the various purchases, sales, agreements, etc, received in this office. Copies of the documents affecting the Mining department are made and filed.

GENERAL INDEX PLAT BOOK.

This book has been continued during the year and the numbers of documents are entered before being filed. It is of great value to the department in locating desired documents. It is supposed to be kept posted up to date, but often in the stress of work this is neglected. The attempt will be made during the coming year to enter all documents on file not already entered.

GOVERNMENT PLAT BOOK.

No additions have been made to this book during the year. Several plats are missing and should be replaced.

CITY AND VILLAGE PLAT BOOK.

More or less complete copies of the Republic Iron Company's First (so-called), Second, Third and Fourth additions to Iron City (now Republic) have been added during the year.

Most of the copies of the various plats of the cities of Ishpeming, Negaunee and Marquette, now on file in this book, lack the information regarding the names of parties making the plat, dates, etc. Arrangements have been made with the Land department whereby this information, which is on file in the office of the Register of Deeds at Marquette, will be furnished to this department.

LAND OFFERS.

Land offers, numbering from 763 to 859 inclusive, were received during 1914. They are listed numerically and indexed, entered

in duplicate on township plats, one copy of which is sent to the Cleveland office and one copy filed in this office, and are posted in the Land Offer Plat Book.

OUTSIDE EXPLORATIONS.

Information of explorations by other parties is kept by the Geological department under this head, in numerical order, and is posted from time to time in the Land Offer Plat Book.

ABSTRACTS OF TITLES.

The following system was agreed upon and sanctioned by Mr. Jopling and Mr. Berg. Abstracts were divided as follows:

1. Lands held by the C.C.I. Company on the iron bearing formation.
2. Lands held by affiliated companies on the iron bearing formation.
3. Lands for water power.

Abstracts on all the lands indicated above were to be made and accompanied by maps to show the chain of title; these were to be filed in books, of several volumes if necessary, under the names of the various companies. The hydro-electric systems were to be kept separate.

The change consisted only in combining all the lands under No. 1 above into one book instead of dividing them into districts, such as Gwinn district, North Lake district, etc.

The condition of the work in the department under the divisions above, is as follows:

1. LANDS HELD BY THE C.C.I.CO. ON THE IRON BEARING FORMATION.

These are known as Cleveland-Cliffs Iron Company abstracts.

The following list contains the lands on which abstracts have been completed and filed:

TOWN.	RANGE.	SECTION.	DESCRIPTION.	REMARKS.
44	25	2	NW $\frac{1}{4}$ of NE $\frac{1}{2}$.	Gardner mine.
45	25	18	(SE $\frac{1}{4}$	
		19	(NE $\frac{1}{4}$ of NE $\frac{1}{2}$	Princeton mine.
		20	(NW $\frac{1}{4}$	
			S $\frac{1}{2}$ of SW $\frac{1}{2}$.	Stephenson mine.
		21	(NW $\frac{1}{4}$ of NE $\frac{1}{2}$ & S $\frac{1}{2}$ of NE $\frac{1}{2}$ (NE $\frac{1}{4}$ of NW $\frac{1}{2}$ & S $\frac{1}{2}$ of NW $\frac{1}{2}$ (NE $\frac{1}{4}$ of SW $\frac{1}{2}$ & SE $\frac{1}{4}$ (Lots 1 and 3.	Gwinn townsite.
		22	S $\frac{1}{2}$ of N $\frac{1}{2}$.	
		28	NW $\frac{1}{4}$ of NE $\frac{1}{2}$.	Jopling mine.
			NW $\frac{1}{4}$.	Gwinn mine.
		29	N $\frac{1}{2}$ of NW $\frac{1}{2}$.	Lease No.3.
		35	SE $\frac{1}{4}$.	Gardner and Mackinaw mines.
45	26	2	NE $\frac{1}{4}$ & N $\frac{1}{2}$ of NW $\frac{1}{2}$.	
		12	Lots 4,5,6,9,12 and SE $\frac{1}{4}$ of NW $\frac{1}{2}$.	
		20	SE $\frac{1}{4}$ of NW $\frac{1}{2}$, SW $\frac{1}{4}$ of NE $\frac{1}{2}$ and NW $\frac{1}{4}$ of SE $\frac{1}{2}$.	

There are many abstracts left by Mr. Primeau more or less complete, upon which the attempt has been made to bring up to date and finish.

During the year the abstracts and accompanying maps of the following lands acquired from the Republic Iron Company have been completed:

TOWN.	RANGE.	SECTION.	DESCRIPTION.
47	28	4	N $\frac{1}{2}$ of NW $\frac{1}{2}$.
		17	NW $\frac{1}{4}$ of SW $\frac{1}{2}$.
		18	E $\frac{1}{2}$ of SE $\frac{1}{2}$.
45	29	2	NE $\frac{1}{4}$ of NE $\frac{1}{2}$.
		4	NW $\frac{1}{4}$ of NE $\frac{1}{2}$.
		6	N $\frac{1}{2}$ & SW $\frac{1}{2}$.
		8	Lot 1.
		19	W $\frac{1}{2}$ of SW $\frac{1}{2}$ and SE $\frac{1}{4}$ of SW $\frac{1}{2}$.
46	29	6	N $\frac{1}{2}$ of NW $\frac{1}{2}$.
		26	SE $\frac{1}{4}$ of NE $\frac{1}{2}$.
		28	NW $\frac{1}{4}$ of SW $\frac{1}{2}$.
		30	S $\frac{1}{2}$ of NW $\frac{1}{2}$ and NW $\frac{1}{4}$ of SW $\frac{1}{2}$.
		32	S $\frac{1}{2}$ of NE $\frac{1}{2}$ and SE $\frac{1}{4}$.
		36	Lots 1,2, SE $\frac{1}{4}$ of NE $\frac{1}{2}$, W $\frac{1}{2}$ of SW $\frac{1}{2}$, SE $\frac{1}{4}$ of SW $\frac{1}{2}$, SW $\frac{1}{4}$ of SE $\frac{1}{2}$ and E $\frac{1}{2}$ of SE $\frac{1}{2}$.
47	29	12	SE $\frac{1}{4}$ of SE $\frac{1}{2}$.
		13	E $\frac{1}{2}$ of NE $\frac{1}{2}$.
45	30	20	SE $\frac{1}{4}$ of NE $\frac{1}{2}$ and NE $\frac{1}{4}$ of SE $\frac{1}{2}$.
		28	N $\frac{1}{2}$ of NW $\frac{1}{2}$.
46	30	1	SW $\frac{1}{4}$ of SW $\frac{1}{2}$.
		12	N $\frac{1}{2}$ of NE $\frac{1}{2}$.
		24	SW $\frac{1}{4}$ of NE $\frac{1}{2}$, NE $\frac{1}{4}$ of NW $\frac{1}{2}$, SW $\frac{1}{4}$ and W $\frac{1}{2}$ of SE $\frac{1}{2}$.
		27	NW $\frac{1}{4}$.
		28	E $\frac{1}{2}$ of NE $\frac{1}{2}$, SW $\frac{1}{4}$ of NE $\frac{1}{2}$, Lots 1,2, E $\frac{1}{2}$ of SW $\frac{1}{2}$ and SE $\frac{1}{4}$.

<u>TOWN.</u>	<u>RANGE.</u>	<u>SECTION.</u>	<u>DESCRIPTION.</u>
47	30	9	Lots 4 and 6.
		18	Entire.
		28	SW $\frac{1}{4}$ and S $\frac{1}{2}$ of SE $\frac{1}{4}$.
		32	NW $\frac{1}{4}$ and W $\frac{1}{2}$ of SW $\frac{1}{4}$.
		34	W $\frac{1}{2}$.
		36	SW $\frac{1}{4}$.
48	30	28	Lots 2 and 3.
43	31	4	E $\frac{1}{2}$ of NE $\frac{1}{4}$.
		7	Lot 5.
		18	Lots 1 and 3.
44	33	33	S $\frac{1}{2}$ of SE $\frac{1}{4}$.

Sections 7 and 18, 46-29, which include the Republic mine, have not yet been finished.

2. LANDS HELD BY AFFILIATED COMPANIES ON THE IRON BEARING FORMATION.

The Arctic Iron Company, Athens Mining Company, Bunker Hill Mining Company, Lucky Star Mining Company, Maas-Negaunee Mines, Pioneer Iron Company and Regent Iron Company are included in this division.

ARCTIC IRON COMPANY.

Partial abstracts of some of the lands of this Company are in the office. No attempt has been made to complete these since the departure of Mr. Primeau.

ATHENS MINING COMPANY.

In February, Mr. M. F. LaCroix finished the abstract maps of this company. The abstracts and maps were filed in book form and on September 22nd copies were sent to the Cleveland office and to the Land department.

BUNKER HILL MINING COMPANY.

Mr. H. O. Moulton completed the abstract maps in April. A memorandum left by Mr. Primeau states that the abstracts have been finished. Nothing has been done to assemble and file the abstracts and maps.

LUCKY STAR MINING COMPANY.

The abstracts and maps are reported by Mr. Primeau to be complete, but nothing has been done towards assembling and filing them.

MAAS-NEGAUNEE MINES.

These abstracts were finished and on December 7th, 1912 were sent in book form to the Cleveland office and the Land department. Nothing further has been done. It will be necessary to bring these books up to date.

As the Maas mine is leased in the name of the C.C.I. Company and the Negaunee mine in the name of the Negaunee mine, theoretically these should be divided according to the divisions above. The properties are so closely associated that it has been decided not to separate them and to include the book in division No.2.

PIONEER IRON COMPANY.

There are a few abstracts left by Mr. Primeau but nothing has been done towards completing them.

REGENT IRON COMPANY.

Mr. Primeau spent twenty nine days during the year in Marquette making these abstracts and according to information left by him they are complete. Nothing further has been done concerning them.

3. LANDS FOR WATER POWER.

Information left by Mr. Primeau states that the abstracts for the Carp river system is three fourths complete and for the AuTrain system one fourth complete.

A few necessary maps of the former was made during the year.

TAX HISTORIES.

On January 1, 1915 there were 467 tax histories on file in this office, of which 77 were acquired during the year. These refer mostly to lands acquired from the Republic Iron Company.

LAND AND OWNERSHIP PLAT BOOK.

Very little information was added to this book during the year. A large amount of work must be done to bring the book up to date.

LEGAL OPINIONS.

Legal opinions No.85 to No.96 inclusive were received during the year. These referred mostly to the lands acquired from the Republic Iron Company.

OPTIONS FOR MINING LEASES.

The following options were under consideration during the year but were not executed. These are mentioned to account for these numbers:

No.104, R. S. Archibald. Covers $S\frac{1}{2}$ of $NE\frac{1}{4}$, $W\frac{1}{2}$ and $SE\frac{1}{4}$ of Section 16, entire Section 17, $E\frac{1}{2}$ of $NE\frac{1}{4}$ of Section 18 and $N\frac{1}{2}$ of Section 21, 47-44,

No.106, A. J. Boyington et al. Covers $SE\frac{1}{4}$ of Section 13, 43-35 and $SW\frac{1}{4}$ of $SW\frac{1}{4}$ of Section 18, 43-34.

The following option was acquired during 1914:

No.105, Lake Superior Land Company and Philo P. Chase, dated June 12, 1914; expires June 12, 1915. Covers $N\frac{1}{2}$ of $S\frac{1}{2}$ of Section 3, 47-28.

The following option was acquired previous to 1914 but was not entered before,

No.107, Michigan Mineral Land Company, dated March 17, 1909, term unlimited.

The following options terminated during 1914:

No.96, Shelden Estate Company et al, dated August 20, 1912; extended to August 20, 1914; relinquished February 14, 1914. Covers $NW\frac{1}{4}$ of $NW\frac{1}{4}$ and $SE\frac{1}{4}$ of $NW\frac{1}{4}$ of Section 12, 42-33.

No.96A, Shelden Estate Company et al, dated August 20, 1912; extended to August 20, 1914; relinquished February 14, 1914. Covers $NE\frac{1}{4}$ of $SW\frac{1}{4}$ and $NW\frac{1}{4}$ of $SE\frac{1}{4}$ of Section 12, 42-33.

No.96B, Shelden Estate Company et al, dated August 20, 1912; extended to August 20, 1914; relinquished February 14, 1914. Covers $SW\frac{1}{4}$ of $NW\frac{1}{4}$ and $NW\frac{1}{4}$ of $SW\frac{1}{4}$ of Section 12, 42-33.

No.97, Shelden Estate company et al, dated August 20, 1912; extended to August 20, 1914; relinquished February 14, 1914. Covers $E\frac{1}{2}$ of $NW\frac{1}{4}$ of Section 1, 42-33.

No.97A, Shelden Estate Company et al, dated August 20, 1912; extended to August 20, 1914; relinquished February 14, 1914. Covers $W\frac{1}{2}$ of $SE\frac{1}{4}$ of Section 1, 42-33.

No.97B, Shelden Estate Company et al, dated August 20, 1912; extended to August 20, 1914; relinquished February 14, 1914. Covers $E\frac{1}{2}$ of $SW\frac{1}{4}$ of Section 1, 42-33.

No.97C, Shelden Estate Company et al, dated August 20, 1912; extended to August 20, 1914; relinquished February 14, 1914. Covers $SW\frac{1}{4}$ of $SW\frac{1}{4}$ of Section 1, and $SE\frac{1}{4}$ of $SE\frac{1}{4}$ of Section 2, 42-33.

No.98A, Spies Mineral Land Company et al, dated December 13, 1912. Drozdowski interest expired December 13, 1914. Covers $SW\frac{1}{4}$ of $NE\frac{1}{4}$ of Section 24, 43-35. The option for the Spies interests on this description was extended to December 13, 1916.

No.100, Kimberly Iron Company, dated September 23, 1913; expired January 1, 1915. Covers $E\frac{1}{2}$ of $NE\frac{1}{4}$ of Section 1, 42-33.

No.102, Seager-Smith Land Company, dated August 11, 1913; extended to August 11, 1915; relinquished October 7, 1914. Covers $SE\frac{1}{4}$ of $NE\frac{1}{4}$ of Section 19 and $NE\frac{1}{4}$ of $NE\frac{1}{4}$ of Section 28, 47-27.

No.89, Thomas Estate et al, was mentioned in the annual report for 1913 as being in force with an indefinite expiration. It was relinquished on August 27, 1913.

The following options were in force January 1, 1915:

No.98, Spies Mineral Land Company, dated November 21, 1913; extended to November 21, 1916. Lease No.41 was taken on $E\frac{1}{2}$ of $NW\frac{1}{4}$. Extension covers $W\frac{1}{2}$ of $NE\frac{1}{4}$, $SE\frac{1}{4}$ of $ME\frac{1}{4}$, $NW\frac{1}{4}$ of $NW\frac{1}{4}$, $NE\frac{1}{4}$ of $SW\frac{1}{4}$ and $SE\frac{1}{4}$ of Section 24, 43-35.

No.98A, Spies Mineral Land Company et al, dated December 13, 1912. Spies Mineral Land Company interest extended to December 13, 1916. Covers $SW\frac{1}{4}$ of $NE\frac{1}{4}$ of Section 24, 43-35. The option for the Drozdowski interest in this description expired December 13, 1914.

No.99, Mrs. Sophie Peterson et al, dated January 11, 1913, continues in force while work is going on. Covers $W\frac{1}{2}$ of $SW\frac{1}{4}$ and $SE\frac{1}{4}$ of $SW\frac{1}{4}$ of Section 2, 47-28.

No.103, Snider-Aitkin County, Minnesota, dated September 27, 1913; term unlimited 1914. Covers various lands in Aitkin County, Minnesota.

No.105, Lake Superior Land Company et al, dated June 12, 1914; expires June 12, 1915. Covers $N\frac{1}{2}$ of $S\frac{1}{2}$ of Section 3, 47-28.

No.107, Michigan Mineral Land Company, dated March 17, 1909; term unlimited.

During the year an option was taken from Mr. Finlay A. Morrison to purchase his interest of 15/16 in the surface of the $SE\frac{1}{4}$ of $NW\frac{1}{4}$ and also an option from Spies Mineral Land Company to purchase their 1/16 interest in the surface of same forty acre tract. Both these interests were purchased by the Company on May 27, 1914.

The following table shows the options acquired and terminated since January 1, 1910:

	<u>1910.</u>	<u>1911.</u>	<u>1912.</u>	<u>1913.</u>	<u>1914.</u>	<u>1915.</u>
Options in force January 1st	11	21	8	14*	15	6*
Options acquired during year	22	3	10	4	1	-
Options terminated during year	12	16	5*	3*	11*	-

* Indicates that parts of one option were terminated.

MINING LEASES.

The following mining leases were acquired during 1914:

No.40, Frederick I. Carpenter et al, dated January 2, 1914; expires January 2, 1964. Covers $N\frac{1}{2}$ of $NE\frac{1}{4}$ and $NE\frac{1}{4}$ of $NW\frac{1}{4}$ of Section 12, 42-33. This is known as the Neely lease.

No.41, Spies Mineral Land Company, dated July 1, 1914; expires July 1, 1964. Covers $E\frac{1}{2}$ of $NW\frac{1}{4}$ of Section 24, 43-35.

The following leases were surrendered during the year:

No.39, Minnesota State Leases No.736 to No.751 both inclusive, dated February 5, 1907; surrendered July 24, 1914.

The following table shows the mining leases acquired and surrendered since January 1, 1910:

	<u>1910.</u>	<u>1911.</u>	<u>1912.</u>	<u>1913.</u>	<u>1914.</u>	<u>1915.</u>
Leases in force January 1st	29	30	32	33	31	32
Leases acquired during year	2	3	1	0	2	--
Leases surrendered during year	1	1	0	2	1	

DEEDS.

Under this head is filed all documents relating to the purchase, or sale, etc, of lands in which the Mining department is interested. The documents are entered in numerical order and indexed. On January 1, 1915 the total number of deeds filed was 549.

PURCHASES.

All purchases by the Company are listed and indexed and given a purchase number. The document is then given a deed number and filed under "Deeds". The number of purchases during 1914 was 35, bringing the total number up to 193.

TAX TITLES.

The tax deeds are listed and filed as under "Purchases".

TRANSMISSION LINE EASEMENTS.

No easements were acquired during the year.

RIGHTS OF WAY.

As the Land department handles these, nothing was done by the department.

WATER RIGHTS.

No water rights were acquired during the year.

FARM AND LOT LEASES.

The Land department sends to this office for approval surface leases, such as farm, city lots, etc, on lands in which the Mining department is interested. These leases are entered and indexed and given a mine department number under Farm Leases. If satisfactory, the leases are initialed and returned to the Land department. No copies are kept in this office.

SALES.

Applications for purchase of Company lands are made to the Land department, which sends them to this department for approval. They are entered in the Farm Lease Book in a separate division.

TAX LISTS.

This department prepares tax lists of the Company's lands, on which the Mining department pays the taxes, either direct or through the Land department.

In the past much trouble and uncertainty has been caused on account of the discrepancies between the descriptions on the tax rolls and those on the tax list, so that there was doubt as to whether taxes on all the lands held were paid. During the year considerable time was spent in preparing descriptions of various lands, principally those included in the Maas and Negaunee mines, and placing them on the rolls.

To complete this work the tax list of 1915 is to be mapped and correct descriptions are to be entered on tax rolls where necessary.

UNEXECUTED DOCUMENTS.

Copies of the following unexecuted documents are in the office:

Pittsburgh & Lake Angeline Iron Company and Cleveland-Cliffs Iron Company; lease for Salisbury engine house site.

Cleveland-Cliffs Iron Company and Forsyth Township School District; W. D. to parcel in $\frac{1}{2}$ of NE $\frac{1}{4}$ of Section 35, 45-25.

Cleveland-Cliffs Iron Company and Jones & Laughlin Ore Company, agreement concerning division of Lake Ogden.

Cleveland-Cliffs Iron Company, Pittsburgh & Lake Angeline Iron Company and Jones & Laughlin Ore Company; agreement concerning division of Lake Sally.

Pittsburgh & Lake Angeline Iron Company and Cleveland-Cliffs Iron Company; transmission line easement No.3.

Cleveland-Cliffs Iron Company and Jones & Laughlin Ore Company; launder easement.

ITEMS BY J. E. JOPLING.

WATER POWER.

AU TRAIN.

Nothing was done by this department in connection with the Au Train surveys.

CARP RIVER.

The lands for storage basin No.1 have not yet been purchased, consequently nothing further was done in regard to this basin on the Carp.

DEAD RIVER.

No work was done during the year in connection with this water power.

MICHIGAMME RIVER.

In addition to the water power at the Republic mine, the Michigamme river was examined between that point and the outlet dam at Lake Michigamme.

PYRITES.

A special report is being prepared showing the work done during the year to secure a deposit of pyrites for the Marquette furnace. This is accompanied by a statement showing each offer. Briefly, there have been up to the present 111 offers of pyrites properties, of which nine have been received during the year. A trip was made by me to examine the most promising ones in Canada. Last August on this trip I made examinations at Graham on the Grand Trunk Railway, 200 miles West of Fort William, at points on the North shore of Lake Superior and also at Renfrew near Ottawa. At Lake Abitibi, which I reached by the T. & N. O. Railway, I met parties interested in properties and also at Sault Ste. Marie, Ontario. At the latter point in November I met Mr. Shilton, owner of a property at Graham.

Mr. J. E. Marks, of Port Arthur, continues to keep the Company informed as to pyrites discoveries and makes examination upon request.

Professor Smyth has given his advice as to prosecuting the search for pyrites.

LAKE SUPERIOR AND REGENT IRON COMPANY MINES.

Captain J. H. Rough and I examined the mines of the Lake Superior and also of the Regent and reported on them under date of December 3rd.

MICHIGAN MINERAL LAND COMPANY.

Certain maps were made for Mr. W. S. Prickett, Agent of the Michigan Mineral Land Company, to show the progress of developments near these lands.

EXAMINATION OF IRON MINES.

Beginning with April 20th, an examination of the Republic mine was made, previous to its purchase, in company with Professor Smyth and Captain Rough.

On December 12th, in company with Captain Rough and Mr. White, an examination was made of the Kennedy and Meacham mines on the Cuyuna Range, Minnesota.

On February 27th, an examination was made of the workings of the Dunn mine in company with Messrs. Bush and Brewer to determine their relation to the drilling done by this Company on the Kimberly property.

Professor Smyth and I examined the Breitung-Hematite mine South of Negaunee on September 21st in order to learn the relation of its ore bodies to the lands in which this Company is interested.

An examination was made on July 30th of the underground workings of the Empire mine, South of Negaunee, and the report was accompanied by a map from the operating company. Mr. Stakel was with me.

THE CLEVELAND-CLIFFS IRON COMPANY.

REPORT OF THE CHIEF GEOLOGIST FOR YEAR ENDING DECEMBER 31ST, 1914.

STAFF.

The staff of the Geological department during 1914 is given in Table I. Of these men, only Gustaf Afuhs and Ernest Allen are now with the department, although F. G. Rockwell, transferred to the Engineering department early in May, spent about one half of his time assisting me in the Geological department during November and December. Messrs. Freeman, Burton and Bennett had to be given a vacation without pay beginning the middle of October at the time when the general reduction of forces in the office took place:

TABLE I.

MEN ON PERMANENT STAFF OF GEOLOGICAL DEPARTMENT IN 1914.

<u>NAME.</u>	<u>OCCUPATION.</u>	<u>LENGTH OF SERVICE.</u>	<u>DAYS LOST. SICKNESS.</u>	<u>VACATIONS.</u>	<u>% OF WORKING DAYS WORKED.</u>	<u>WAGES PER MONTH.</u>
F. G. Rockwell	Asst. Geologist in Ishpeming	2 mo. 23 d.	0	0)		
	Vacation	1 mo. 14 d.	0	34 d)	64.4	\$115
R. R. Freeman, Jr.	Asst. Geologist in Ishpeming	9 mo. 15 d.	0	4	98.17	100 & 115
Geo. E. Burton	Supt. of Explorations in Aitkin Co.	5 mo. 25 d.	none reported)			
	Asst. Geologist in Ishpeming	3 mo. 8 d.	0	4½)	92.80	100 & 115
	Vacation	17 d.	0	11½)		
Gustaf Afuhs	Draftsman	1 year	5½	1	97.64	100 & 90
Ernest Allen	Visiting explorations of other companies, testing drill holes, etc.	2 mo. 9 d.	0	0)		
	Collecting core at North Lake, testing drill holes, labeling core, etc.	9 mo. 22 d.	0	7½)	97.01	75 & 67.50
Harry Bennett	Labeling core, etc.	9 mo. 15 d.	1	6½	96.58	45 & 50
Total		4 yr. 9 mo. 26 d.	6½	69	94.23	

NOTE: 275½ days of eight hours worked, 52 Sundays, 11½ holidays, 52 Saturday afternoons.

In addition to these men regularly with the department, Mr. J. H. Bush and Mr. Carl Brewer looked after drilling explorations in the Iron River and Crystal Falls districts respectively. After Mr. Bush left Iron River to become superintendent of the Republic mine about June 1st, Mr. Brewer looked after explorations in both the Iron River and Crystal Falls districts. These explorations were completed early in October and Mr. Brewer returned to Ishpeming and took charge of the Abstract department after Mr. Primeau was laid off.

Table II shows days lost by men working permanently for the department during the last three years, with the names arranged in order of the percent of time worked:

TABLE II.

TIME WORKED 1912 TO 1914 INCLUSIVE.

NAME.	LENGTH OF SERVICE.	DAYS LOST.			DAYS WORKED.	% OF WORKING DAYS WORKED.	
		SICKNESS.	VACATIONS.	TOTAL.			
Gustaf Afuhs	3 yrs.	7	4 $\frac{1}{2}$	11 $\frac{1}{2}$	3.8	816	98.61
E. A. Allen	3 yrs.	0	17	17	5.7	810 $\frac{1}{2}$	97.95
Harry Bennett	1 yr. 4 mo.	1	8 $\frac{1}{2}$	9 $\frac{1}{2}$	7.1	360	97.43
Geo. E. Burton	2 yrs. 9 mo. 20 d.	0	23	23	8.2	751 $\frac{1}{2}$	97.03
R. R. Freeman, Jr	2 yrs. 9 mo. 15 d.	2	32 $\frac{1}{2}$	34 $\frac{1}{2}$	12.4	736 $\frac{1}{2}$	95.52
F. G. Rockwell	2 yrs. 4 mo. 6 d.	4 $\frac{1}{2}$	43	47 $\frac{1}{2}$	20.2	600	92.67
Total	15 yrs. 3 mo. 11 d.	14 $\frac{1}{2}$	128 $\frac{1}{2}$	143	9.35	4074 $\frac{1}{2}$	96.61

No men were engaged temporarily on geological surveys during 1914 since no surveys of this kind were made.

DIVISION OF WORK AMONG THE PERMANENT MEMBERS OF THE DEPARTMENT.

H. L. Smyth. The work of the Geological department continued under the direction of Mr. H. L. Smyth, Consulting Geologist for the Company.

E. E. White. My work during the year has consisted chiefly of general oversight of the work of the department, which has included diamond drilling explorations in the Negaunee, Ishpeming, North Lake, Iron River, Crystal Falls and Aitkin County districts and in the Cliffs Shaft, Morris, Chase and Dexter mines; special tests for sulphur in union hole No.12 on the Athens property; retesting Breitung-Hematite holes L and K close to the Athens property; underground geological surveys in the Cliffs Shaft, Salisbury, Lake, Lloyd, Morris, Chase, Dexter, Maas, Negaunee, Stephenson, Gwinn, Gardner and Mackinaw mines; surface geological work in the Ishpeming-Negaunee district, and visiting and reporting on the explorations of other companies on the Lake Superior iron ranges. I was absent on a six weeks vacation in February and March and after my return was busy preparing figures regarding mine valuations to present to the State Tax Commission at the special hearing at Lansing in May. In June I made a trip to the Mesabi Range to examine exposures of cretaceous rocks in connection with our explorations in the Aitkin County district. In August I accompanied Mr. Smyth on trips to Iron River to inspect our explorations and to the Gogebic Range to look into the chances for ore at the East end of the Range. In September I made a concentrating test on Kloman and Republic ores at the Kloman mill by the courtesy of Mr. George S. Finney, who was offering us the Kloman property. In December I accompanied Mr. Jopling and Captain Rough in their examination of the Kennedy and Meacham mines on the Cuyuna Range and also made an inspection of the Lake Superior Iron Company's ^{Section 16} mine at Ishpeming for the purpose of laying out explorations to determine the amount of ore on our Junction 40. I made several examinations of lands offered in Mar-

quette, Iron and Gogebic counties during the year and also examined certain Company lands to determine whether it was advisable to sell the surface. Since October 15th, when two of my assistants were laid off, I have given particular attention to the geology in the Negaunee mine and have visited this mine each month and mapped the geology.

F. G. Rockwell. During January, February and March, Mr. Rockwell assisted with the underground geological and routine work in the Geological department and late in March left for a six weeks vacation. When he returned early in May, he entered the Engineering department. After reducing the force in October, it became necessary to have some help in the Geological department and Mr. Rockwell therefore spent about one half of his time assisting me during November and December.

R. R. Freeman, Jr. During 1914, Mr. Freeman assisted in the routine and underground geological work in the department until he was laid off with several other men on October 15th. In his underground work he gave particular attention to the Negaunee, Maas and Lake mines and put the maps and sections in very good shape. During July he made a geological survey of the old Dexter mine, which had just been unwatered, and prepared a set of geological maps. He also spent several days placing wedges in the Athens union hole No. 12, which had to be deflected in a certain direction to strike the ore, and during the summer spent considerable time on geological field work in the vicinity of Ishpeming and Negaunee.

George E. Burton. Mr. Burton continued in charge of our drilling in Aitkin County, Minnesota, until this work was completed late in June. He then took a two weeks vacation and after he returned assisted in the general work of the department at Ishpeming until he was laid off with several other men on October 20th. He was retained five days longer than the others since he had not completed plotting the geological field work which he did during the summer in the vicinity of Negaunee and Ishpeming. Mr. Burton kept

GEOLOGICAL DEPARTMENT.

the underground geological work up to date in the Salisbury mine and in the mines of the North Lake and Gwinn districts.

Gustaf Afuhs. Mr. Afuhs continued with us as draftsman during the year and in addition to his regular work has at times helped out in collecting and labeling core during the absence of Harry Bennett and Ernest Allen.

Ernest A. Allen. During January and February, most of Mr. Allen's time was spent visiting explorations of other companies on the Michigan iron ranges and in testing drill holes and assisting in the placing of wedges in Athens union hole No.12. Beginning early in March, Mr. Allen collected the core from our explorations in the North Lake district, still spending a few days now and then in visiting the explorations of other companies. The amount of diamond drilling in the Lake Superior district diminished so rapidly that in the fall he hardly had enough work to keep him busy and when Harry Bennett was laid off with other men on October 15th, Mr. Allen took charge of the work in the core room of labeling and filing core and sludge, in addition to his other work.

Harry Bennett. Mr. Bennett continued labeling and filing core and sludge samples in the core room until he was laid off on October 15th.

SURFACE GEOLOGICAL SURVEYS.

The only surface geological work done during the year was the work by Messrs. Freeman and Burton in the vicinity of Ishpeming and Negaunee. They had no assistants and since they worked at it intermittently when the weather was favorable and their other work permitted, no attempt was made to keep account of the cost, which was included in the general expenses of the Geological department.

This field work in the Ishpeming and Negaunee district is following the new set of maps on a 1" equals 50' scale which is being made by the Engineering department, showing the culture,

outcrops and contours at five foot interval. At the end of the year the engineers had practically completed mapping in this way Sections 1, 2, 3, 4 and the North half of Section 9, 47-27, and six forties in the South half of Section 6 and ⁱⁿ the North half of Section 7, 47-26. Of this area, we have completed tracings of the engineers maps showing in addition the geology on the North half of Section 1, Section 2, Section 3, East half of Section 4, and the South half of the Northwest quarter of Section 4, 47-27. We also have a map showing the culture and geology on a 200' scale of the South half of Section 1, 47-27 and tracings showing the culture and geology on a 50' scale of the Southwest quarter of the Northwest quarter of Section 15, 47-27, the Southwest quarter of the Southwest quarter of Section 6, 47-26 and the Northwest quarter of the Northwest quarter of Section 7, 47-26. The geological work had nearly caught up to the engineering at the end of the summer but by next year there will be a considerable additional area mapped and ready for geological work. This cannot be done until we are able to engage more men in the department.

UNDERGROUND GEOLOGICAL WORK.

The underground geological maps and sections of the Salisbury, Lake, Lloyd, Morris, Chase, Haas, Negaunee, Stephenson and Gwinn mines were kept up to date by members of this department and the geological maps of the Cliffs Shaft mine were posted by Mr. Hanst of the Engineering department. We also kept a record of the geology in the shafts which are being sunk at the Mackinaw and Gardner mines and prepared a set of geological maps of the old Dexter mine.

CLIFFS SHAFT MINE.

Mr. Hanst, assisted by Mr. Henry Moulton, who now has charge of surveying the Cliffs Shaft mine, has kept the geological

work up to date and has the geological maps and cross-sections in good shape. Now that Mr. Hanst has charge of the engineering at the Athens mine, he is not able to post the geology at the Cliffs Shaft so often, but since the workings in the hard ore mines stay open, I believe that it will still be satisfactory to have him continue with the geology.

LAKE MINE.

Mr. Freeman kept the geological work in this mine up to date until he left in October. Since then, Mr. LaCroix, who has charge of the engineering work in that mine, has done the geology in connection with his monthly survey. This arrangement is not entirely satisfactory since no record of the original geological notes is kept in accessible form but it seemed ~~the~~ to be the only way to get the work done.

SALISBURY MINE.

Mr. Freeman kept the geological work in this mine up to date until Mr. Burton returned from Minnesota. Mr. Burton then took charge of this and continued it until the mine was closed about October 1st. Since that time nothing has been done at the Salisbury except driving a drift towards the ore which was found by drilling further South during the year and I have not considered it necessary to examine the geology in this drift every month.

MORRIS, LLOYD & CHASE MINES.

These mines have been worked continuously during the year. Mr. Freeman kept the geological maps and sections up to date until Mr. Burton returned from Minnesota. After that Mr. Burton took charge until he left in October and since then Mr. Rockwell has taken notes on the geology in connection with his regular monthly engineering survey.

MAAS MINE.

Mr. Freeman did the geology in this mine until it was closed down October 1st. The maps and sections are in good shape.

MEGAUNEE MINE.

Mr. Freeman did the geology in this mine until he left in October and since then I have kept the work up to date.

GWINN DISTRICT MINES.

Mr. Freeman kept the geology up to date in the Stephenson and Gwinn mines until Mr. Burton returned from Minnesota. Mr. Burton then did the work until he left in October. Mr. Rockwell brought the geology up to date during December. The Austin and Princeton mines were not worked during the year but considerable work was done at the Stephenson and Gwinn mines and at the Gardner and Mackinaw shafts. The Gardner and Mackinaw shafts were stopped on October 1st. Work in the Stephenson and Gwinn mines was continuing at the end of the year.

DEXTER MINE.

During July, Mr. Freeman and I made a geological survey of the old Dexter mine, which had just been unwatered for the purpose of explorations, and Mr. Freeman prepared a set of geological maps.

EXPLORATIONS.

During the year we continued diamond drill explorations in the Ishpeming, Negaunee, North Lake, Iron River, Crystal Falls and Aitkin County districts and in the Cliffs Shaft, Morris and Chase mines. Drilling was also begun in the Dexter mine.

During the year we took an option from the Lake Superior Land Company on the $N\frac{1}{2}$ of the $S\frac{1}{2}$ of Section 3, 47-28 in the North Lake district. Early in January a lease was executed on what was the Neely option on Section 12, 42-33 in the Crystal Falls district.

On July 1st a lease was executed on two forties of our Spies option on Section 24, 43-35, namely, the E $\frac{1}{2}$ of the NW $\frac{1}{4}$. The remainder of the Spies lands are still held under option, except the Drozdowski interest in the SW $\frac{1}{4}$ of the NE $\frac{1}{4}$, which expired December 13th.

We relinquished the Seager-Smith option on October 7th, the Calverley-Shelden options on February 14th and the Kimberly option expired January 1st, 1915.

M A R Q U E T T E R A N G E.

ISHPEMING DISTRICT.

SECTION 15, 47-27, SALISBURY MINE SURFACE.

The fourth hole South of the Salisbury mine in the basin of iron formation in the Southwest quarter encountered 112' of first class ore together with 5' of lean ore and 7' of second class ore. Only 10' of the ore was Bessemer but the average was over 60% iron. Two more holes were drilled in an attempt to find an extension of this ore but were unsuccessful. It was a disappointment not to be able to follow up the ore, but considering that we found it in two holes, the find may be of importance and a drift is being driven over from the Salisbury mine to intersect the ore found by drilling. Considerable trouble and delay were experienced with caving ground in drilling so that the work proved very expensive and it was decided that it would be better to drift over and develop the ore by underground work.

In all, 184' of standpiping and 1187' of drilling were done on this section during the year, making a total of 1371'. This drilling was done under Mr. Eaton's superintendence and I have no figures as to the cost.

SECTION 19, 47-27, SE $\frac{1}{4}$ OF NE $\frac{1}{4}$, SEAGER-SMITH OPTION.

At the beginning of 1914, we were drilling a deep hole near the Southeast corner of this option to test the deep basin on the North side of the great East-West fault which is supposed to bound the Marquette Range on the South side at this point. This hole was drilled to a depth of 2659'. The greater part of the hole was in magnetite siderite schist, which was so unfavorable for any concentration of rich ore that it was decided not worth while to continue the hole to the footwall slate. The sludge samples from the last 50' or so of drilling were all lean and second class ore but the core was all under 45% and the true analysis is probably not as favorable as the sludge would indicate. Because of the character of the material, thin seams of rich magnetite being banded with chert and siderite, it is possible that more of the rich magnetite seams than of the leaner material came up with the sludge. Two short holes were drilled further North in the hope of finding hard ore close to surface but were unsuccessful. An examination of the other forty held under option showed that it was not worth exploring and the option was then relinquished. The results of this exploration were disappointing, not only as regards the land under option, but also as regards the adjacent lands owned by the Cleveland-Cliffs Iron Company.

During the year, 125' of standpiping and 2019' of drilling were done on this option, of which 231' were in doubtful lean ore and 70' in doubtful second class ore. The cost of analyses, engineering and general expenses amounted to \$140.71 during the year and the contract price for drilling the 2144' was \$7607.70, or an average of \$3.55 per foot. The total cost of the exploration, including drilling in 1913, was \$10,064.38 for 2880', or an average of \$3.49 per foot, including engineering, analyses, etc.

CLIFFS SHAFT MINE.

Drilling at the Cliffs Shaft mine continued under the charge of Superintendent Eaton and under the direction of Mr. Smyth. Drilling was discontinued from May to November inclusive since the drill had to be used in the Morris and Dexter mines. The drill was returned to Cliffs Shaft early in December, however, and immediately started on a program of exploration on the 9th level.

In all, 1273' of drilling were done, of which 313½' were in first class ore, 178½' in second class ore and 57' in lean ore. I have no figures on the cost of this work.

The locations and reasons of drilling these holes have been given in full in my monthly reports and I presume Mr. Eaton will discuss them in his annual report.

NORTH LAKE DISTRICT.

SECTION 2, 47-28, W½ OF SW¼ & SE¼ OF SW¼, PETERSON OPTION.

During the year the hard ore contact running East and West across the Northern part of this option was tested by six inclined holes and a seventh inclined hole was being drilled in slate at a depth of 262' at the end of the year. Hole No. 59, 100' East of the West boundary, encountered a little ore, and hole No. 65, on the West line, found what is probably an extension of the same ore. Holes Nos. 62 and 64, to the East, could not find any extension, however, and hole No. 66 found no extension in depth. No. 66 was finished in August and no drilling was done on the option until December, when hole No. 70 was started close to No. 66. No. 66 deflected considerably to the West and No. 70 was started deflecting a little to the East so as to be certain that we would not miss any extension of the ore in depth. Only 17' of ore or second class ore were encountered in each of holes Nos. 59 and 65 and this thickness was probably not at right angles to the dip of the ore. The true thickness of the lens is therefore small.

In all, 1247' of standpiping and 1186' of drilling were done on this option during the year, of which 26' were in first class Bessemer ore and 8' in second class ore. Of this total of 2433', 1359' was in union holes with the Lake Superior Land Company option on the West line of the property. The total drilling on the Peterson option for the year was therefore 1753½'. The cost was \$5730.75, or an average of \$3.27 per foot.

SECTION 2, 47-28, N½, BARNES & HECKER LEASE.

In February we started a series of drill holes to test the continuity of the ore body found by drilling several years ago at the West end of North Lake on this lease. Until the Morris and Lloyd mines were opened up we supposed that the drilling on the Barnes & Hecker lease was sufficient to show that there was a large and continuous body of ore worth developing. The results in the mines, however, showed that the ore in the North Lake district is very apt to be bunchy and that the drill holes often follow seams of rich ore between bands of jasper. We therefore were not certain whether it would pay to open up this ore West of the lake and decided to drill additional holes to determine more definitely the size of the ore body. At the end of the year we had completed four holes and were drilling two more. The results of this work were very disappointing since none of these holes encountered any considerable quantity of ore such as was found in old holes Nos. 25, 48 and 51. The drilling shows that these old holes must have been in bunches or seams of ore and the remarkable part of it is that these first holes drilled all showed such good ore that we thought there was a continuous ore body. This is exactly the same condition as at the Morris mine, except that at the Morris there were no check holes drilled and we supposed we had a large and continuous ore body until underground work was begun. There is still a chance that this ore West of North Lake is in the form of chimneys running down into a continuous body of ore in depth and Mr. Smyth has recommended that this possibility be tested by

deep drilling before relinquishing the lease.

There were 1093' of standpiping and 3483' of drilling done on this lease during the year, of which 105' were in first class ore, 335' in second class ore and 320' in lean ore. Although considerable ore and second class ore was encountered, the material was so mixed with lean ore and jasper that it would be difficult to mine. The cost of this work was \$26,691.33, or \$5.83 per foot. The cost per foot has been extremely high because of the large amount of reaming and cementing necessary. The jasper in the vicinity is hard and badly broken so that trouble with caving ground was encountered in practically every hole and most of them had to be reamed for the greater part of their depth. The last hole, No.69, was started with a large bit so that casing could be put in without reaming.

SECTION 3, 47-28, NE $\frac{1}{4}$, CHASE MINE SURFACE.

In August two drills were started standpiping West and South of the Chase mine to locate the quartzite-jasper contact with the purpose of later testing it for hard ore. The Chase mine is so nearly exhausted that it is considered important to test the remainder of the ground under lease on Section 3 at once so that if nothing of value is found the lease can be relinquished when the Chase mine is abandoned. If ore is found it might be so situated that the Chase shaft could be used in mining it.

Seven standpipes were sunk to locate the contact, three holes were drilled to test for hard ore and another hole was drilling at the end of the year. One hole, No.61, encountered 17' of Bessemer ore averaging about 60% iron, .027% phosphorus, and additional holes will be drilled along the strike in both directions to try and follow up this ore. At the end of the year the hard ore contact had been tested practically the whole way across the quarter section and it only remained to try and follow up this ore in hole No.61.

There were 1433' of standpiping and 487' of drilling done during the year, of which 17' was in Bessemer ore and the rest was in rock. The cost of this 1920' of drilling was \$4496.59, or \$2.34 per foot.

SECTION 3, 47-28, N¹/₂ OF S¹/₂, LAKE SUPERIOR LAND COMPANY OPTION.

In June an option was taken on these lands from the Lake Superior Land Company and P. P. Chase and Wife. Holes Nos. 65 and 66 Section 2 were drilled on the East line of this option, being union holes with the Peterson option, and hole No. 70 Section 2, another union hole, was drilling at the end of the year. The first of these holes encountered 17' of first class Bessemer ore, averaging about 62% iron and .028% phosphorus but the next hole, No. 66, located to cut this ore at greater depth, unfortunately missed it. The hole drilling at the end of the year was another hole located to strike the continuation of this ore in depth.

There were 650' of standpiping and 709' of drilling done in these three holes on the line but only half of this work is charged to this option, that is, 679¹/₂'. The cost of this work was \$1948.55, or \$2.87 per foot.

MORRIS MINE.

During January and February a hole was drilled dipping North at the East end of the 2nd level to test for an Eastward continuation below the level of the main ore body. This main ore body extends Southeast on the 2nd level as far as the fault which runs Southwest from the shaft through the workings and it was desired to look for an extension of this ore body on its Easterly pitch beyond the fault. Only 35' of ore mixed with lean and second class ore was encountered and since this was low in iron and high in phosphorus it was probably the footwall belt of ore and not the main ore body for which we were looking. It seems probable that the fault cuts off the ore body as the faults do at the other ore bodies in the North Lake district.

Late in April another hole was started at the West end of the drift on the 1st level and was drilled about N. 60° W. to test this ground for ore and to determine if there was a softer belt of formation between the drift and the footwall in which the drift could be driven West more cheaply. The hole was finished in July at a depth of 580'. A zone of enriched jasper carrying mixed bands of lean and second class ore was encountered but no first class ore. It was decided not to drift West on this level and it did not seem worth while to drill the hole deeper since it would have been several hundred feet further to the footwall.

There were 851' drilled in these two holes, of which 25' were in ore, 43' in second class ore and 167' in lean ore. This work was done as a part of the development of the Morris mine and I have not the figures of cost.

CHASE MINE.

A little drilling was done at the Chase mine during the year under the superintendence of Mr. Graff and with the advice of this department. During July and August two holes were drilled from the West end of the 3rd level to determine if the ore above on the 2nd level extended down to the 3rd. They found no ore and were very discouraging as regards the future of the mine. After drilling these two holes developments on the 2nd level made it seem possible that they had been drilled too much in a North-erly direction and during September another hole was therefore drilled more Westerly from the West end of the drift on the 3rd level. This hole was no more successful than the other two and the attempt to find any ore on the 3rd level was abandoned.

There were 440' of drilling done in these three holes, of which only 10' was in lean ore and the rest in rock. I have no figures for the cost of the work.

DEXTER MINE.

During July the old Dexter mine was unwatered for the purpose of examination and exploration and a set of geological maps was prepared. Drilling was started in August and two drills were kept busy practically all the time for the remainder of the year. Three holes were drilled into the hanging on the 7th level but the balance of the eighteen holes drilled were all on the 8th level. Practically the only ore found was an extension in depth of the ore in the bottom of the two Western stopes on the 8th level. Several holes were drilled to follow the ore below the Western stope and these succeeded in tracing it West on the dip for nearly 100'. The cross-section of the ore was so small, however, that we could not estimate sufficient tonnage below the 8th level to warrant Mr. Graff in sinking the shaft and developing the ore. There seemed to be no chance of developing any more ore in these small ore bodies and during November attention was turned to prospecting the formation in depth. A crosscut had previously been driven North about 70' into the hanging from the Western stope on the 8th level and this made an advantageous point for drilling to test the possibility in depth. Two fairly deep holes were drilled, dipping North, which encountered no ore, and hole No. 8, a vertical hole at the North end of the crosscut, was still drilling at the end of the year. It is intended to drill this hole to the quartzite-jasper contact where the quartzite turns back again on its normal dip to the South with hard ore jasper beneath it. There is a possibility that there may be ore at this horizon.

The results of this drilling in the Dexter mine have been very discouraging, especially in view of the rather optimistic statements concerning the mine made to us by Mr. Bradt. The ore was not very high in iron but contained enough manganese so that it would probably be desirable if there were enough of it. At the end of the year it was practically certain that no ore would be found

worth mining and explorations will be completed and the mine allowed to fill with water early in 1915. Our estimate is 22,700 tons of ore averaging 54.72% iron, 2.26% manganese and .097% phosphorus dried. This estimate includes the extension in depth of the two Western stopes on the 8th level and also the ore in the back of these stopes.

In all, 2505' of drilling were done, of which 159' were in first class ore, 249' in second class ore and 306' in lean ore. The total cost was \$6149.24, or \$2.45 per foot.

MEGAUNEE DISTRICT.

SECTION 1, 47-27, JACKSON.

In April Mr. Mather decided to drill another deep hole on the Jackson property and the large drill which we bought for the last deep hole was moved to the new location about the middle of the month. A steel head frame had been purchased to allow the rods to be pulled in 50' lengths and this was set up over the new hole. The location was 400' South of hole No.66 near the East line of the property, the idea being to determine the cross-section of the ore. So far we only have two deep holes in ore on the Jackson property and these are over 1000' apart along the strike. It is necessary to determine the cross-section in order to be certain of the large tonnage which is necessary before it will be safe to incur the great expense of developing ore at such great depth.

In view of the considerable trouble experienced in drilling hole No.66, only 400' further North, it was decided to start this new hole, No.68, with especially large bits so as to allow us to put in casing and go ahead without reaming when bad ground is encountered. The large bits will also serve to keep the drill hole straight, which is a very important item. No.66 was the second drill hole at the same point attempting to reach the ore. The first hole, No.65, was abandoned because of its considerable deviation from the vertical. A great deal of trouble with caving ground was

experienced in No.66 and altogether the two holes cost about \$17.60 per foot of effective drilling in No.66. It seemed certain that we could drill a hole to the ore much cheaper than this starting with large bits and keep it straight.

The first bit used was the size of an "I" standard reaming bit 3 19/32" diameter outside of carbon and cut a core 2 25/32" diameter. Progress with this bit was so slow and the carbon loss so heavy that the work cost about \$15.00 per foot and we therefore put in casing and went ahead with the next size bit after drilling less than 100'. The next size was the "I" standard bit 2 13/16" diameter outside of carbon, cutting a core 2 1/32" diameter. This bit was more successful and drilling was continuing with it at the end of the year at a depth of 1167'. During November and December the cost averaged only \$4.31 per foot and the average cost of the 1167' drilled was \$7.73 per foot, which though high, compares favorably with the cost of No.66. The total amount expended on this hole to the end of the year was \$9022.11.

Of the 1167' drilled, 71' were standpiping and 1096' were drilling. Practically all of the material was soft ore jasper but there were a few bands of dike and 35' of lean ore.

SECTION 5, 47-26, ATHENS PROPERTY.

At the beginning of the year we were drilling in union hole No.12 on the line between the Athens and Lucky Star properties, for the purpose of making special sulphur tests on the ore. Soon after the first of the year it was determined that the direction of this hole would have to be changed if it was to strike the ore body. It had deviated so much to the North that it was practically certain that it would pass over the ore unless an attempt were made to straighten it. It was therefore decided to place steel wedges in the hole to deflect it more to the East and back towards the perpendicular. The Breitung's agreed to stand their share of the expense and this work was started during January. Although the hole was 1146' deep, we could not place the wedges as deep as

this because the jasper was too hard to permit wedging off the hole and also because the inclination was $68\frac{1}{2}^{\circ}$ N. 45° E., which was so flat that we could not hope to correct it sufficiently. A 36' band of dike occurred from 928' to 964' and it was determined to place the wedges at this point. The inclination here was 73° N. 28° E. Several wedges were placed and the hole was deflected each time to a greater or lesser extent. The chief trouble experienced was that we could not seem to fill the old holes with cement and after removing the wedges the bit would tend to go into the old hole instead of into the new one. After withdrawing the third wedge it was found impossible to make the bit go into the third new hole and it was therefore decided to continue drilling in the second new hole drilled on the second wedge. The two wedges had succeeded in changing the inclination of the hole from 73° N. 28° E. at 930' to 1000' to $74\frac{3}{4}^{\circ}$ N. 45° E. at 994' in the new hole. This was not as much as we should have liked to deflect the hole but there seemed to be a good chance of striking the ore and the hole was continued. The work on the wedges was completed about the middle of June.

The ore was finally encountered at a depth of 1441' early in August and special tests for sulphur were made on the drill water as we had done several times before at the Athens and Jackson properties. This is the first and only hole which we have drilled which has shown high sulphur and it was rather gratifying to find that the sulphur analyses on the drill water agreed very well with sulphur analyses on the core. Analyses on the sludge showed no sulphur because the gypsum is all dissolved by the drill water. Furthermore, finding in this hole that sulphur can easily be detected in the drill water gives us more confidence that the previous tests showing no sulphur on the Athens and Jackson properties are correct. This union hole deflected so much to the East that where it struck the ore it was 178' East of the Athens line and where it passed out of the ore was even further East. The average

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analyses of ore encountered were as follows:

<u>FROM.</u>	<u>TO.</u>	<u>AMT.</u>	<u>IRON.</u>	<u>PHOS.</u>	<u>SULPHUR.</u>
1441'	1475'	34'	53.79	.128	3.290
1475	1500	25	60.34	.104	1.449
1500	1534	34	64.00	.097	.090
1534	1545	11	64.57	.052	.024
1545	1550	5	60.90	.082	.021.

Our sections show that the slate which this hole encountered at 1550' was probably not the true footwall but was the North fault wall of the deposit. If it had not struck this fault it would probably have gone at least 100' further before reaching the true footwall. The fact that the last 16' of ore had only a small amount of sulphur was encouraging since it is possible that the limit of sulphur in depth is a horizontal plane through the bottom of the high sulphur ore in this drill hole. If so, there would be very little sulphurous ore on the Athens property. As regards the Lucky Star property, the hole was discouraging in that it showed high sulphur ore to continue practically to the West line.

Only 471' of effective drilling were done in this hole during the year, although counting the part of the hole that was redrilled after wedging off and the several short holes drilled on the wedges, 723' were actually drilled. The total cost of this work for the year was \$4858.43, or \$10.32 per foot of effective drilling. This high cost was of course due to the considerable expense of placing wedges and cementing and of the extra drilling incidental to wedging off the hole. The total cost was \$8966.89, or \$5.77 per foot of effective drilling. Of this amount, one half is charged to the Athens and one half to the Lucky Star.

SECTION 6, 47-26, TESTING BREITUNG-HEMATITE DRILL HOLES.

In connection with an exchange of information between the Cleveland-Cliffs Iron Company and E. N. Breitung Company, concerning the Athens, Pioneer and Breitung-Hematite properties, the Breitung furnished us with records of all their drilling on the Breitung-Hematite property, including their tests of direction of the drill

holes. They also permitted us to test the direction of any of the old holes which we wished and it was decided to test holes L and K. Hole G was really the most important hole to test but a road has been built across the collar of the hole since it was drilled and it could not be found. Hole L had already been tested by the Breitung's but the tests were not quite concordant and we thought they might not be correct. Hole K was a blank hole close to the South edge of the Athens property and had not been tested. Work was started late in October and after considerable trouble in recovering hole L, it was finally successfully tested during December. It was determined that the three tests in this hole by the Breitung Company were approximately correct, although our tests determined the position of the ore in that hole with greater accuracy. The drill was next set up on hole K and this had been tested to a depth of 1200' at the end of the year. It was then attempted to clean out the hole deeper in order to get further tests and the rods were stuck in the mud at the bottom of the hole. At the end of the year we were trying to get the rods out.

The total cost of this work for the year was \$702.14, which was charged to the Athens Mining Company.

MENOMINEE RANGE.

IRON RIVER DISTRICT.

SECTION 22, 43-34, S $\frac{1}{2}$, THOMAS OPTION.

No work was done on this property during the year and Mr. Mather decided that he did not care to hold it under option any longer. It was therefore relinquished.

SEC. 24, 43-35, E $\frac{1}{2}$, N $\frac{1}{2}$ OF NW $\frac{1}{4}$, SE $\frac{1}{4}$ OF NW $\frac{1}{4}$ & NE $\frac{1}{4}$ OF SW $\frac{1}{4}$, SPIES LEASE & OPTIONS.

The only drilling in the Iron River district in 1914 was done on the Spies lands. Hole No. 25, which was drilling at the beginning of the year, encountered the Westward extension of the ore body but the ore was not as good quality as the other holes further

East. It may have been on the South edge of the ore body. This hole seemed to exhaust the possibility of developing any large amount of ore since the ore body is pitching West against the boundary line near which No.25 was located. Our estimate of developed ore on this property is as follows:

245,000 tons averaging	58.65%	iron and	.462%	phosphorus.
59,670 "	"	51.34%	" "	.487% "

The moisture will probably run about 7.25% so that the natural iron will be 54.39% and 47.62% respectively. This hole completed the drilling recommended by Mr. Smyth to develop the ore and the drill was moved to the East half of the section to try and locate a Westward continuation of the Bates mine iron formation and in general to determine if there were any chances for ore on the Eastern part of the section. Nine standpipes were sunk and one hole drilled to a depth of 916', of which all but three standpipes were on the NE $\frac{1}{4}$ of the NE $\frac{1}{4}$ adjacent to the Bates mine. A little iron formation was found on this forty but it was so lean and unfavorable for concentration of ore that no more work was done. The last standpipe was finished early in July. We took a lease dated July 1st on the E $\frac{1}{2}$ of the NW $\frac{1}{4}$, which includes the ore body found by drilling in 1913, and because of our taking this lease the Spies interests allow us to retain an option without work on the balance of the lands included in the original options. This extension without work runs to November 21st, 1916.

During 1914 we did 2580' of drilling, of which 1100' were standpiping and 1480' were drilling. There was encountered 20' of first class ore, 73' of second class ore and 46' of lean ore. The cost of this work for the year was \$12,422.29, including taxes, or \$4.82 per foot. This work was done by Cole & McDonald at a contract price of \$2.75 per foot and the balance of the cost per foot was due to taxes and to the cost of superintendence. The item of superintendence was high because only one drill was employed and because Mr. Bush was looking after drilling for the greater

part of the time instead of a member of this department as usual. The taxes amounted to \$1053.54. The total cost of the Spies exploration to date has been \$42,437.70.

CRYSTAL FALLS DISTRICT.

SECTION 1, 42-33, W $\frac{1}{2}$ OF SE $\frac{1}{4}$, E $\frac{1}{2}$ OF W $\frac{1}{2}$ & SW $\frac{1}{2}$ OF SW $\frac{1}{2}$,

SECTION 2, 42-33, SE $\frac{1}{4}$ OF SE $\frac{1}{4}$,

SEC. 12, 42-33, W $\frac{1}{2}$ OF NW $\frac{1}{4}$, SE $\frac{1}{4}$ OF NW $\frac{1}{4}$, NE $\frac{1}{2}$ OF SW $\frac{1}{4}$, & NW $\frac{1}{4}$ OF SE $\frac{1}{4}$, CALVERLEY & SHELDEN OPTIONS.

No more drilling was done on these lands in 1914 and the options were relinquished February 14th.

SEC. 12, 42-33, NE $\frac{1}{4}$ OF NE $\frac{1}{4}$ & NE $\frac{1}{4}$ OF NW $\frac{1}{4}$, NEELY LEASE.

A lease was taken upon this property dated January 2, 1914, but drilling continued during the greater part of the year. At the time of taking the lease we were not satisfied that ~~that~~ there was sufficient ore to warrant development but the option expired and the fee owners claimed that we were not entitled to a renewal of the option because we had found merchantable ore. Twelve holes were drilled during the year for the purpose of proving up a greater tonnage and one hole drilled in 1913 was drilled deeper in 1914. Seven standpipes were also sunk after the other drilling was finished to determine the best location for a shaft. The first nine holes drilled were in the syncline on the Eastern part of the property in the attempt to prove up a continuous body of ore. Although these holes, as well as those drilled last year, found considerable scattered ore, there seemed to be no continuous ore body and the work was in this respect disappointing. Since we did not consider that this drilling showed up enough ore to warrant development, attention was then turned to the Western ore body, which was encountered last year in several drill holes. A deep hole, No. 27, was first drilled to look for a continuation of the ore in depth to the Northwest and since this only showed 30' of first class ore, two shallow holes were then drilled on the upward extension of the ore body to the Southeast. These last holes were practically blank. Although our attempts to prove up an additional tonnage during 1914 were disappointing, after careful consideration it was decided that

sufficient ore was shown on the lease to warrant sinking a shaft and drilling was therefore stopped, except for the above mentioned standpipes, which succeeded in locating a favorable position for the shaft with ledge only about 45' from surface. Since Mr. Mather did not wish to start development at once, we stopped all work, closed our office at Iron River and Mr. Brewer, who had been looking after the exploration, returned to Ishpeming in October.

Our estimate of developed ore on the Neely property is: 533,000 tons, of which 428,000 average 59.09% iron, .272% phosphorus, .22% manganese dried, and 105,000 tons average 51.51% iron, .211% phosphorus, .17% manganese dried. The moisture probably averages not over 10% so that the natural iron would be about 53.18% and 46.36% respectively.

During 1914 we did 6129' of drilling, of which 1569' were standpiping and 4560' drilling. Of this, 252' were in first class ore, 240' in second class ore and 387' in lean ore. The amount expended during 1914 was \$21,226.06, including taxes of \$772.15. This was an average cost of \$3.47 per foot. The diamond drill work was done by Cole & McDonald by contract at a price of \$2.75 per foot, except for 41' drilled below a depth of 1000' in hole No.27, for which the price was \$3.25. The balance of the cost per foot was the cost of taxes, superintendence, analyses, engineering, etc. The total cost of the Neely exploration to the end of the year was \$44,334.25.

SECTION 1, 42-33, E¹/₄ OF NE¹/₄, KIMBERLY OPTION.

An extension was obtained on the Kimberly option from July 1st, 1914, to January 1st, 1915, but no work was done on it during the year.

CUYUNA RANGE - MINNESOTA.

AITKIN COUNTY DISTRICT.

SECTION 16, 49-23.

SECTIONS 24 & 36, 50-23.

Explorations continued on the state leases in Aitkin County until June. At the beginning of the year two drills were at work and early in February two more drills were started so that during the greater part of the time four drills were used. It was necessary to put on the additional drills so as to complete certain holes on the lake and in swampy ground during the winter. The greater number of drills also reduced the cost of superintendence.

During the year one hole was completed on Section 24, ten holes were drilled on Section 16 and seven holes were drilled and one completed on Section 36. These holes were located at 800' intervals, Northwest and Southeast across the land to be tested, except in two cases. The last hole on Section 36 was located half way between holes Nos.1 and 7 because of what an old explorer on the Range told us was favorable looking material in hole No.1, and hole No.5 Section 36 was drilled between holes Nos.2 and 3, which encountered gray slate and green slate respectively, with the idea that the iron formation might lie at the contact of these two slates. Practically all the holes encountered only soft gray to green slate but a few encountered a harder, light gray slate. Hole No.1 Section 36, the favorable hole above mentioned, encountered hard dark gray slate with a little vein quartz and ferruginous material. Since no trace of iron formation was encountered, it was decided to relinquish all the state leases, including a few scattered forties which had not been tested by drilling.

In all, 3914' of drilling was done, of which 3325' was standpiping and 589' drilling with diamonds on these three sections at a total cost of \$9,763.27. The total cost of the exploration

was \$11,751.74, or \$2.30 per foot for the 5108' drilled. This work was done by the Duluth Diamond Drilling Company by contract at \$2.00 per foot for standpiping in surface and \$2.25 per foot for standpiping and diamond drilling in ledge.

EXPLORATIONS OF OTHER COMPANIES.

Ernest Allen continued to visit all explorations of other companies in Michigan and Wisconsin and also made one or two trips to the Cuyuna Range. The maps of these explorations were kept up to date and also from time to time we brought up to date the index of these explorations in the form suggested by Mr. S. L. Mather. Mr. Allen has made written reports regularly of information thus acquired and these reports have been submitted to Mr. Duncan and Mr. Smyth.

During the latter part of the year so little drilling was going on in the Lake Superior district that Mr. Allen has been able to keep track of it in addition to his duties of collecting core at North Lake. He makes a trip to the other ranges occasionally and somebody else brings in the samples from North Lake in his place. This work cost only \$312.17 in 1914, of which \$128.59 was Allen's salary while engaged in this work and the balance was traveling expenses.

I examined the core from the Lake Superior Iron Company drilling regularly until all work was stopped on June 30th. Records were prepared of this drilling and I also gave the results in my monthly reports.

COMPARATIVE STATEMENT OF CHARGES TO GEOLOGICAL DEPARTMENT.

	<u>1913.</u>	<u>1914.</u>
Salaries - - - - -	\$15,443.54	\$15,448.80
Travel - - - - -	100.43	188.42
Supplies - - - - -	1,344.31	762.17
Miscellaneous - - - - -	95.71	15.11
Visiting outside explorations	<u>1,160.21</u>	<u>312.17</u>
Total	\$18,144.20	\$16,726.67
Expenses of H.L.Smyth, i.e. travel, supplies and mis- cellaneous - - - - -	1,016.80	922.85
Geological surveys - - -	<u>3,206.06</u>	0
Grand total	\$22,367.06	\$17,649.52.

In spite of the drastic cut in the staff and in salaries in October, the total salaries for 1914 is a little greater than 1913 because the same men continued in the department until October and their salaries were higher in 1914 since they had been longer with the Company. Supplies were considerably lower in 1914 because of an adjustment with the Engineering department by which a smaller proportion is charged to the Geological department. The very much smaller cost of visiting outside explorations is due to the small amount of exploration now going on in the Lake Superior district by other companies. The present expense per month in the Geological department is of course very much less than the average for 1914.

I have not the complete figures for the cost of explorations in 1913, but presume that they will be included in the annual report of the Mining department.

HARD COPY
CLIFFS SHAFT MINE.

No new equipment was installed in the shops during the year, and the usual amount of repair work was done until October, when the shops were placed on a "fix-over" work schedule.

The electric pumps were installed in the new pump station on the 15th level. The pump station is located 25 feet north of "A" Shaft. The floor is approximately six feet above the main haulage drift. It has a floor space of 38' x 40' and an average height of 14 feet. There are two pumps, a motor driven geared duplex reciprocating and a motor driven centrifugal, both manufactured by The Fred M. Prescott Steam Pump Company. The geared pump is designed to pump against 1000 ft. head, with a capacity of 600 gallons per minute. An 180 H.P. General Electric, 580 R.P.M., induction motor drives the pump through a Wuest herringbone gear and pinion. The gear revolves at 47 revolutions per minute. The centrifugal pump is also designed to pump 600 gallons per minute against 1000 ft. head. The discharge pipe is 5" and there are six stages, three stages grouped on each side of the motor. A 250 H.P., 1800 R.P.M., General Electric induction motor drives this pump. These pumps were ready for operation early in October, but have not been put in continuous service because of the shortage of electric power.

On February 22nd the flywheel was taken off the hoist and the engine disconnected and since that time this hoist has operated very satisfactorily. A few slight delays occurred.

The load on the Nordberg steam driven compressor was materially reduced by the aid of the Ingersoll-Rand electric driven compressor at the Morris Mine, which ran continuously at full load during working hours and delivered air through the 6" pipe line connecting the two mines.

Very few delays occurred during the year due to breakdowns and the machinery operated very satisfactorily.

HARD ORE.

No new equipment was installed in the shops during the year, and the usual amount of repair work was done until October, when the shops were placed on a five-day-a-week schedule.

In October a class in Mechanical Drawing was started. Instruction is given one evening a week by the Mechanical Department. The instruction book compiled by the Educational Department is being followed. Mechanical and electrical men from all mines and shops near Ishpeming are attending these classes. There is an average attendance of 18, with an enrollment of 25. The results are very gratifying. The men are very eager to learn and appreciate the opportunity given them. It is hoped that all the members of the class will at the conclusion of the course be able to make a correct drawing and also to read one intelligently. The efficiency of the force will be greatly increased if all the men have a knowledge of drawing.

LAKE MINE.

No new machinery was installed at this mine during the year.

On July the 3rd the cooling tower collapsed. This cools the water for the air compressor condenser and jackets. The timbers of which it was constructed had all rotted with the exception of the sills. A new tower was

LAKE MINE

(Cont'd)

immediately built about two thirds the size of the old tower which was a little large for the work

The brickwork in the boilers was completely overhauled.

No breakdowns of consequence occurred to the other equipment.

SALISBURY MINE

There was no interruption of hoisting during the year due to breakdowns and all of the equipment gave good satisfaction.

Mining operations were suspended on September the 30th.

In November a ventilating fan was installed on the 14th level about 200 ft. from the shaft. This is driven by a 5 H.P., 220 volt, 3 phase, 1800 R.P.M., General Electric induction motor. By means of a reversing valve fresh air is forced into the breast of the workings or smoke drawn out. About 1000 ft. of pipe connects the fan to the workings. This is used only in driving the rock drift.

ATHENS MINE

The electric driven hoist and air compressor were installed and ready for service in May and were put in commission the first week of June. These machines were operated with few delays. The small motor belt driven single stage air compressor purchased for the South Jackson Crusher Plant was moved to the Athens Mine and placed in the engine house to supply the small amount of air needed when there is no drilling in the shaft. This reduces the current consumption during light load periods.

The heating plant was put in good condition. A return line from the engine house was run to the boilers. The steam lines running to the various buildings was rebuilt, covered with insulating material and placed in a wooden launder underground. Traps were placed on all radiators.

LUCY MINE

This mine was idle the entire year.

The 11" x 14" duplex geared single drum Lake Shore Engine Works hoist was removed and shipped to the Lloyd Mine to be used in sinking a

LUCY MINE

(Cont'd)

winze on Section 6. A 10" x 14" duplex geared double drum Webster, Camp & Lane hoist and one 125 H.P. locomotive boiler is the only equipment left at this mine.

MAAS MINE

This mine operated until October without any delays or accidents to machinery. During this time the 10" water column was put in as opportunity offered for safe working in the shaft.

During July a small motor driven hoist was installed on the third level to be used in sinking the winze to the fourth level and ultimately to hoist ore. The hoist was furnished by the Lake Shore Engine Works and has a drum 48" in diameter by 42" wide. The motor, which is rated at 50 H.P., was furnished by the Allis-Chalmers Manfg. Company.

On October 1st the mine was closed down.

A 6" 8-stage motor driven centrifugal pump was installed in the new pump station on the third level. This pump is operated about two hours and twenty minutes each day, throwing 800 gallons a minute against an 1100 ft. head. This makes the flow of water into the mine about 77 gallons per minute. The pump was manufactured by the Alberger Pump and Condenser Company. It is driven by a 350 H.P. General Electric motor.

The power plant was put in good repair. A few repairs remain to be finished.

About the first of December the steam turbine was started and has been operating steadily furnishing current to the general power system.

MEGAUNEE MINE

This mine is now entirely equipped with electrical machinery.

The new electric pumps were installed and are handling all the water from the 10th level pump station. On January 13th the 8" 7-stage centrifugal pump was temporarily put in service because of the fire in the 9th level pump station near #2 Shaft. In February the high speed reciprocating pumps were put in service and have been operating ever since. Up to October 1st they

handled all the water below the 6th level. After October 1st they have handled all the mine water. The centrifugal pump was piped and ready for service in March. One triple expansion pump in the 6 $\frac{1}{2}$ level pump station is held in reserve until the reliability of the electric pumps is proven, steam pressure being maintained at #2 Boiler House.

Considerable trouble was experienced with the reciprocating and centrifugal pumps, most of which was caused by the sand, ore and chips of wood which accumulate in the sump. This dirt settles to the bottom of the sump and in time becomes deep and covers the suction foot valves and is in turn drawn into the pumps, causing excessive wear on all water end parts such as the valves, valve seats and poles in the reciprocating pumps thus hampering operations. The runners, shafts, etc., of all the centrifugal pumps in the station were also cut very rapidly by this dirt, necessitating extensive repairs on all revolving parts. Means are now being provided for cleaning the sump and keeping it clean and much better results are expected. Most of the dirt is merchantable ore, so the expense of cleaning the sump is offset by the value of the ore which otherwise would be pumped to surface and totally lost.

A 3 $\frac{1}{2}$ " x 4" triplex motor driven plunger pump, with a capacity of 50 gallons a minute, was installed near the bottom of #3 Shaft to handle all the water which goes down into the skip pit. It automatically starts and stops as the water rises and lowers. The installation of this pump makes it unnecessary to operate the air compressor after working hours. Since the electric pumps have been doing the pumping the current consumption of the air compressor is less than half of what it was when so many small pumps were using air.

The top tram plant, which formerly gave so much trouble, has run with little delay. The brake was altered so that it would not lock, the gear ratio reduced, roller bearings placed on all sharp angle sheaves and grease cups put on. The length of the rope at this plant is more than at any other mine, being about 4500 ft., while the speed of the car is about 1100 ft. per minute. On the steam plant at the Lake Mine the rope is about 2000 ft. long, while the speed of the car is 900 ft. per minute. The tram rope at the Lake Mine is

NEGAUNEE MINE

(Cont'd)

shorter because the rope is run only around the end on which stocking is being done. This indicates that the tram load at the Negaunee Mine is heavier than at any other mine.

The hoisting plant operated with no delays or breakdowns during the year.

The compressor operated most of the year, with slight delays and breakdowns. During most of the year its operation was under the care of a representative of the Nordberg Company. Extensive tests were run on both this and the Athens Mine compressor. The results show that the machines are operating below guaranteed efficiency and capacity. They have not yet been accepted.

SOUTH JACKSON

The crusher plant was operated from June 20th to September 10th. The new electrical equipment ran very smoothly and came up to expectations in every way. The only serious delay was caused by lightning setting fire to the hoist controller house in the crusher building. This caused a delay of three days. Alterations have been made so that similar accidents are not so likely to occur. After the plant was closed down the air compressor was moved to the Athens Mine in hopes of economizing in current at that mine during light load periods.

The plant is in good condition and needs practically no repairs before starting up again.

CHASE MINE

The Allis-Chalmers electric starter for compressor motor wore out and was replaced with a starting compensator made by the General Electric Company.

Some minor repairs were made on the compressor. The crank pin brass was rebabbitted and the cooling water piping changed.

A horn gap lightning arrester was placed in the engine house to protect the 2300 volt line from North Lake. Lightning got beyond this once

CHASE MINE

(Cont'd)

during the summer and punctured a coil in the compressor motor and also one in the Gould underground pump motor. These were repaired immediately and only a short delay resulted.

Both driving drums of the top tram plant were removed and their bearings re-bushed.

The water end of the centrifugal pump at the bottom of the shaft was badly worn. It was brought up and repaired, after which the whole pump was removed from the mine and used for unwatering the Dexter Mine.

DEXTER MINE

Preparatory work for unwatering the Dexter was begun in April. A 3" air line was laid from the Chase Mine, two hoists were set up in the engine house and a transmission line run from the Chase Mine.

A sleet and ice storm caused the first attempt at unwatering to fail as the high tension transmission line was out of service for 10 hours. The second attempt, started on May the 4th, was a success and the mine was pumped out by July 17th. Three centrifugal pumps were used and these were left on the second, third and seventh levels to keep the mine drained.

In July the engine house was destroyed by fire caused by lightning. The babbitt was melted from the hoist bearings and the electrical apparatus destroyed. The hoists were repaired and a new engine house built. Diamond drilling is still in progress at this mine.

LLOYD MINE

Some minor changes were made on the two hoists. The leaky spool valves on the air brakes were replaced with slide valves and electric safety overwinds were installed on recommendation of the safety committee.

The depth of the shaft was increased to the 800 ft. level and new ropes for this depth were put on both hoists. The speed of the skip hoist was increased to 900 ft. per minute by replacing the motor spur gear with a Wuest herringbone gear of a different gear ratio. Storage pockets were put in on the third and fourth levels and electric haulage started on the third

LLOYD MINE

(Cont'd)

level. This haulage equipment consists of a $6\frac{1}{2}$ ton locomotive and five tram cars. The locomotive is a duplicate of those on the fourth level and Morris Mine first level.

A portable loader was designed and built by the Mechanical Department and is operating on the third level. It consists of an endless elevating apron and is driven by an electric motor receiving current from the trolley wire. By the use of this loader more cars can be loaded with less work and the driving of the drift is not retarded due to slow removal of broken rock.

A 3" drain line was run from the second to the fourth level and all the water from this mine is now drained to the Morris Mine pumps.

A 6" air line was placed in the shaft between the fourth and third levels and a 4" line extended to the second level.

The fan on the fourth level was moved 3,000 ft. farther along the drift and is now used to ventilate the Section 6 raise.

MORRIS MINE

The most maintenance work in the engine house was required by the Nordberg compressor. A crack developed in the crank end of the low pressure cylinder head and the head was replaced with a new one. Braces were placed on the dashpots of the low pressure cylinder and a broken dashpot rod was repaired. In October two cylinder head gaskets leaked and new ones were put on. Tests on both this machine and the Ingersoll-Rand were run during the summer. These tests show a volumetric efficiency for the Nordberg compressor of 86.8%, while the efficiency of the Ingersoll-Rand machine was 85%.

Early in the year one of the rotor coils on the cage hoist motor burned in two and the machine was shut down one day for repairs.

Only one rope was replaced during the year, this being the cage rope.

The 8" water discharge line in the shaft from the 800 ft. level to surface was raised $1/4$ " and new gaskets inserted at all flanges. Two flanges broke on this line close to the second level. The trouble was due to a length of standard pipe put there by mistake, this being too weak. It was replaced with a length of extra heavy pipe and the flanges gave no more trouble.

The skips caused some trouble. The north skip broke loose at one time and the south one a little later. The trouble was caused by ice and worn runners. A more frequent inspection was then made and no further trouble occurred.

Electric haulage was started on the first level in February with one $6\frac{1}{2}$ ton locomotive and six tram cars. Automatic couplers were installed on this outfit and have given satisfaction. The locomotive is a duplicate of the one on the second level. A small electric hoist mounted on a truck is used on this level for hoisting timber up the raises. Current for this is taken from the trolley wire.

The 1,000 gallon per minute Prescott pumps on the second level gave very little trouble during the year. A new motor shaft coupling was placed on No. 1 pump as the other was badly worn. The main improvement made at this point was in the sump where a 5 ft. concrete dam was built between the pumps to facilitate the cleaning of the sump. The settling basin was cleaned three times during the year.

An 8" x 10" puffer was set up on the second level and is used in sinking the winze close to the shaft.

Few additions were made to the shop equipment. An electrician's work room was built in one corner of the carpenter shop and is constructed of angle and corrugated sheet iron.

A 3-pole Aldrich pump, with a capacity of 150 gallons per minute against 75 ft. head, was set up in the machine shop. This pumps water from the Carp River for the change house and the compressor cooling jackets.

A 3-pole Deane pump of 300 gallons per minute capacity against 400 ft. head was set up, temporarily, in the machine shop to supply water to the location water system as the spring supply is not adequate and is failing more each year.

A small sump for these two pumps was made at the side of the Carp River and a 4" suction line from each pump runs into this. This sump was made for the purpose of removing all high water and sand troubles.

MORRIS MINE

(Cont'd)

A 12,000 gallon wooden tank was set up back of the laboratory and is connected by a 4" line to the Aldrich pump. This relieves the pump from running continuously.

A telephone system was installed between the office and underground.

AUSTIN MINE

This mine was not in operation during the year. The only work done was to overhaul the hoist and put it in good condition.

FRANCIS MINE

No work was done at this mine.

JOPLING MINE

No work was done at this mine.

GARDNER-MACKINAW MINES

The work of installing the equipment at these mines, which was started in 1913, was completed early in the year, and was operated until the mines were shut down on October 1st.

Two electric power driven triplex pumps were bought for these mines. They were furnished by the Aldrich Pump Company and have a capacity of 250 gallons per minute against 300 ft. head, and are driven by 50 H.P. General Electric motors.

GUINN MINE

The compressor from the Princeton Mine was installed at this mine to furnish the air needed until a larger line could be laid from the Central Power Plant. A new 6" air line was laid during the summer and furnished all the air needed.

A General Electric primary panel was installed for the cage hoist motor, replacing Westinghouse equipment which was not satisfactory.

New herringbone gears were installed on the cage hoist. A counter-balance was also installed to work on this hoist.

GWINN MINE (Cont'd)

The skip hoist operated without trouble.

The installation of the underground plunger pump was completed early in the year and the pump was put into service. This pump was manufactured by the Fred M. Prescott Steam Pump Company and has a capacity of 1000 gallons per minute against 1000 ft. head. It is driven by a 350 H.P. General Electric motor.

The pumping equipment operated satisfactorily.

The top tram equipment, consisting of a double ore tram and rock tram, was installed in April. The ore tram consists of two independent endless rope haulage drums made by the Lake Shore Engine Works and are driven by two 37½ H.P. General Electric motors. Switchboard and control apparatus was furnished by the General Electric Company. The rock tram is driven by a 10 H.P. General Electric motor. This equipment operated satisfactorily during the year.

A second boiler, of 30 H.P. capacity, was installed in the change house for heating purposes.

PRINCETON MINE

Mine pumping equipment operated throughout the year without any trouble. Other equipment was used very little during the year.

PRINCETON CENTRAL POWER PLANT

The air compressor, which was changed to motor drive in 1913, operated satisfactorily.

The steam-electric plant was started up on August the 24th and has been run continuously since.

New General Electric lightning arresters were installed in the Substation for the Ishpeming-Princeton high tension lines, replacing those of Westinghouse make which did not give satisfactory service.

A serious accident occurred to Substation equipment in April. An explosion occurred in the Substation, blowing out the south wall of the building. This explosion was evidently caused by the old lightning arresters.

Other equipment gave no trouble.

PRINCETON CENTRAL PUMPING STATION

Repairs were made on one of the boilers.

Other equipment operated without any trouble.

STEPHENSON MINE

The hoisting plant operated through the year without any serious breakdowns.

During the summer the top tram layout was changed so that the top tram cars run under the dump from the side. This did away with the reverse curves in the track and greatly helped operating conditions. The rock tram engine was moved to a new location and is now also used to handle ore. The main tramping engine had one serious breakdown during the year.

The underground electric pumping equipment was in operation throughout the year. The centrifugal pump operated without trouble. A breakdown occurred on the plunger pump in November due to grouting under front end of the pump giving way. New gears were installed on this pump in December, greatly improving operating conditions.

The underground haulage equipment operated satisfactorily during the year with no serious breakdowns.

CROSBY MINE

The Crosby Mine equipment was destroyed by fire on May 31st. The boilers were only slightly injured and the hoist was repaired sufficiently to do development work, but will have to be replaced when mining is started again.

Estimate has been made on rebuilding this plant to suit Washing Plant conditions. Since making this estimate it has been learned that the Northern Power Company have extended their lines to this vicinity and would take our load at about $1\frac{1}{2}$ ¢ per K.W.Hr. This should be thoroughly investigated before we decide to rebuild. If a desirable contract can be made with them it would be better than to rebuild our plant.

This mine was shut down completely in October.

IMPERIAL MINE

No work has been done at the Imperial Mine during the year.

REPUBLIC MINE

The power for this property comes from three separate plants and this partly accounts for the high cost of power per ton of ore mined. Other reasons for this are the great depth of hoisting, excessive amount of air required on account of hard material and small product.

The consumption of air has been materially reduced by stopping leaks in the pipe line. It was recently discovered that there are a large number of leaks which ordinarily would not be detected. The main pipe line is made up of riveted sheets and there are leaks around some of the rivets which are only apparent when the pipe is wet and show by small air bubbles under the wet surface. The extent of these leaks can not be determined until warm weather.

The three power plants above referred to are the Central Power Plant, No. 5 Engine House and the Water Power Plant.

CENTRAL POWER PLANT - BOILER ROOM:

In this boiler room there are four 100 H.P., 72" x 16', fire tube boilers. Steel stack 60" in diameter by 60ft. high. Boilers are hand fired, have feed water heater and usual equipment of feed pumps, etc.

CENTRAL POWER PLANT - ENGINE ROOM:

The compressor is a two stage cross compound machine, with corliss valves on the steam, corliss valves on inlet of air and poppet discharge. Runs condensing and is an efficient machine, comparing quite favorably with our best equipment. It has capacity of about 4,000 cubic feet per minute. It was made by the Allis-Chalmers Company and was installed in 1900. It is in first class condition with the exception of the high pressure air cylinder. There is an irreparable crack in the partition wall separating air and water in the water jacket space making it necessary to operate this cylinder at the present time without water cooling. Correspondence for a new cylinder is progressing.

HOIST - The hoist in this engine house operates the two skips in balance in the Pascoe Shaft. It is a first motion, corliss, two drum machine built by the Sullivan Machinery Company and installed in 1904. It is a high class hoist and in excellent condition. The cylinders are duplex, 24" dia.

x 48" stroke. This hoist has two drums, each 8' dia. x 9' face.

There is also in this engine room an old obsolete hoist which is only good for scrap.

ELECTRIC GENERATOR - This is a so-called mixed pressure DeLaval steam turbine, driving two 75 K.W. Westinghouse generators. This is supposed to take the exhaust steam from the hoists at zero pressure and when this is not sufficient, to automatically augment it by high pressure steam. Under actual test it takes 20% more live steam than is required by a Corliss non-condensing engine and in addition to this puts a back pressure of 10 to 12 lbs. on all hoisting equipment. It is being used only as a spare.

NO.5 ENGINE HOUSE:

BOILER PLANT - The boiler plant consists of two 100 H.P. Babcock & Wilcox water tube boilers, hand fired, with the usual feed water heater, feed pumps, etc. One was bought in 1903 and the other in 1906. They are in first class condition.

HOISTS - There are two hoists at this plant. One is old and in bad condition and its use has been discontinued. The other one, which now hoists from #9 Shaft, is in good condition and is a serviceable machine. It is a single engine hoist with flywheel and was originally built by the E. P. Allis Company. The engine still remains but the drums have been replaced by the Sullivan Machinery Company. There are three drums - two 12' dia. x 56" face and one 12' dia. x 37" face. One of the 12' dia. x 56" face drums hoists the cage and the other one hoists the ore. The 12' dia. x 37" face drum controls the counterweight which is in balance with the ore drum.

ELECTRIC ENGINE - A 16" x 42" non-condensing E. P. Allis Corliss engine drives a 150 K.W. General Electric generator. This equipment is quite old but is used instead of the mixed pressure turbine for reasons given above.

WATER POWER PLANT:

This plant has been entirely rebuilt. The storage dam at Lake Michigamme was rebuilt last fall. A leak has developed which will need repairing, but this can only be done in the summer months. It is not serious.

REPUBLIC MINE (Cont'd)

The guard lock controlling the canal to the power house was rebuilt and is now quite permanent.

The bulkhead, wheel foundations, draft tubes and sheave room were rebuilt entirely of concrete. The larger of the old wheels, which was wrecked, was replaced by a new 600 H.P. S. Morgan Smith Company wheel and the smaller of the old wheels, which is about 300 H.P. capacity, was re-set. This plant is now in excellent condition. A small amount of concreting remains yet to be done and will be completed in warm weather.

Each of these wheels drives an air compressor by means of rope drive. These compressors are duplicates and in good condition. They are duplex two stage of the following dimensions, $32\frac{1}{2}$ " x $20\frac{1}{4}$ " - 36" stroke, giving 34 cubic feet of air displacement per revolution. They were manufactured by the Ingersoll-Sargeant Company and were installed in 1903.

The air line from this plant to the mine is about 4,000 ft. long and has many leaks. This has already been referred to. This will have to be corrected in warm weather.

PUMPING:

The quantity of water is very small and is pumped by several small plunger pumps electrically driven.

SHOPS:

The shop equipment is old but quite sufficient except in drill sharpening department. They have two old home made and obsolete drill sharpeners which should be scrapped. A modern drill sharpener would replace at least two men and do much better work. This purchase should be made at once.

CRUSHER PLANT:

This plant is built so that ore can be trammed direct from #9 Shaft and crushed. There are also bins into which ore can be dumped from railroad cars and from here re-hoisted and crushed. Crushed material is delivered direct to railroad cars.

A #6 Gates crusher is installed and is driven by 100 H.P. Westing-

REPUBLIC MINE

(Cont'd)

house motor. The re-hoist is driven by the same motor. This equipment was installed in 1901 and is in only fair condition.

STEAM SHOVEL:

The steam shovel is at least 20 years old and of obsolete type. It is in extremely bad condition. It should be replaced at once by a good one.

It is strongly recommended that this property be electrified. This was the subject of a special report dated May 29th and was supplemented June 25th. In times of low water or scarcity of electricity from any cause the power could be supplemented by compressed air from the steam compressor at the Central Power Plant as this is a highly efficient machine and in good condition. The use of power is varied and scattered very widely, making electricity particularly adaptable while steam is decidedly at a disadvantage.

REPUBLIC MINE - ELECTRICAL

The electrical equipment at this mine in general is of a somewhat older type than we have at the other mines but is apparently in fairly good condition.

There seems to be rather more transformers in service than are necessary and the extra ones are being disconnected as we are able to get at them. The condition of the wiring is rather below the standard maintained by the Company at all other properties, and it seems desirable that the entire plant be overhauled and brought up to standard.

The telephone and signal systems are in a particularly ragged condition and it is questionable whether the present signal system is as safe and reliable as we should have.

It would be desirable to have the mine lighting changed from 110 volt service to 220 volts for various obvious reasons.

The generating equipment at present consists of a duplex outfit of two 75 K.W. Westinghouse, 2300 volt, 3 phase, generators driven by a DeLaval mixed pressure turbine. This at present is used only as a reserve. The

REPUBLIC MINE - ELECTRICAL (Cont'd)

principal generating unit is a 150 K.W. General Electric generator with direct connected exciter belt driven by a Corliss engine. We have had some trouble with both of the generating units, but they seem to be giving fairly good service at the present time.

The motor applications are as follows:-

100 H.P.	Westinghouse	-	driving	Crusher.
75 "	General Electric	-	"	Water supply pump.
20 "	"	"	-	" " "
75 "	Allis-Chalmers	-	"	Coal tram.
20 "	General Electric	-	"	No. 6 hoist.
30 "	"	"	-	" Pascoe Shaft tram.
5 "	Westinghouse	-	"	Machine Shop.
15 "	"	-	"	Carpenter Shop.
50 "	General Electric	-	"	7th Level pump, #9 Shaft.
10 "	"	"	-	" 12th " " " "
10 "	"	"	-	" 16th " " " "
50 "	Westinghouse	-	"	Underground pump, Pascoe Shaft.
15 "	"	-	"	" 12th Level pump, " "
7 $\frac{1}{2}$ "	Wagner	-	"	Portable hoist.
3 "	General Electric	-	"	Laboratory.
5 "	Westinghouse	-	not in use.	
<hr/>				
Total,	490 $\frac{1}{2}$ "			

ELECTRICAL DEPARTMENT

This year has been largely one of routine application of the electric service and a matter of attention to necessary reserve supplies to avoid delay in case of minor trouble. Service has been uniformly good and reliable.

At the beginning of the year we had on hand a total of 2,964 H.P. in motors not connected. During the year a total of 156 H.P. in motors were purchased. At the end of the year but two motors remained unconnected, one being a 325 H.P. plunger pump motor at the Maas Mine, the other a 3 H.P. circulating pump motor at the Mackinaw Mine.

ELECTRICAL DEPARTMENT

(Cont'd)

On account of a lack of water for the Carp River Water Power Plant both steam plants were placed in service the latter part of the year. The Princeton Plant was started up on August 24th and the Maas Plant on December the 1st. By changing the runners in the circulating pumps at these steam plants a larger volume of water is now delivered, resulting in the maintenance of better vacuum, which has somewhat increased the efficiency and amount of load that the steam units can carry.

There was but one serious interruption to our service during the year. This occurred on April 28th and was due to a very severe sleet and wind storm. We were able to maintain fairly good service during this period in all districts excepting North Lake, which was out nearly the entire day. Service was re-established soon enough to prevent the submerging of underground workings or apparatus.

Improved lightning arresters were installed on our high tension transmission lines at the Brownstone, Maas and Princeton Substations. We have had no serious trouble from electrical storms since these were put in service.

The pumping load being the only load that can be controlled in any way, we have adopted a schedule of hours for operating underground electric pumps. This has resulted in somewhat of an improvement in our load curves.

Safety devices for hoists are being improved as seems desirable and are now somewhat more reliable than when first developed. At most mines slack rope alarms have been installed.

A complete inspection of all wiring for lighting and haulage underground was made at all mines during the year. Conditions were markedly improved and by continuing to follow up in this we hope ultimately to maintain as perfect workmanship as on surface.

During the year Tungsten lamps were adopted as standard for all lighting.

Considerable time has been spent during the year in making a record

ELECTRICAL DEPARTMENT (Cont'd)

of electrical apparatus and in testing and calibrating meters.

The total amount of current generated in 1914 is approximately 50% greater than for the year 1913, while the cost per K.W.Hr. has increased from \$.005077 to \$.005654. This increase in cost is due to our lack of storage capacity for water, which necessitates the operating of steam units about six months in the year.

The educational work started last year was continued this year and the results were good, showing positively in the interest and work of the electricians at all mines. This work, when taken up again in the fall, was broadened to include mechanics as well as electricians, and under Mr. Gallagher's instructions excellent interest is maintained. We hope to continue the work during the year for all classes of mechanical workers.

The trip of the Chief Electrician to the factories of the General Electric Company, Schenectady, N. Y., and the Westinghouse Electric & Manfg. Company, East Pittsburgh, Pa., was very satisfactory. This trip was made in the fall and covered a period of about three weeks.

The first stop was made in Detroit where the factory of the Detroit Brass & Copper Foundry was gone through. The process of drawing copper wire and tubes and rolling of copper plates was observed.

About five days were spent at the Westinghouse works. One day was spent investigating the forming of coils and winding of direct current motors for traction and haulage; one day observing the making of coils and winding of motors for alternating current service; one day in contactor, control and switchboard department; and a day on test floor and with Educational and Vocational Department.

At the General Electric works the same departments were visited and a comparison of methods made. In addition some time was spent in the cable and wire department, where the method of forming high voltage cables and wires was investigated. A visit was made to the department making baked clay and special insulators such as are used in mine hangers, strain insulators and controllers. A very profitable afternoon was spent with Mr. Pauly, who is

ELECTRICAL DEPARTMENT

(Cont'd)

recognized as one of the best authorities in the country on mine and mill applications. In company with Mr. Pauly an inspection was made of induction electric furnaces and special copper forging works in operation. Specific applications and troubles of The Cleveland-Cliffs Iron Company were discussed and much valuable advice secured.

No additions were made during the year to our transmission lines.

Total miles High Tension Three Phase Line -	34. 36
" " " " Wires -	204. 216
" number " " Towers -	377.
" miles Three Phase Primary Line -	30.
" " " " Wire -	90.
" " Primary Pole Lines -	26.

K.W.H. PER 1000 TON FEET HOIST

MINE	TONS OF ORE & ROCK	AVERAGE DEPTH OF HOIST	K. W. H.	K. W. H. PER 1000 TON FT.
Austin		(not working)		
Cliffs Shaft	320,893	609	497,060	2.54
Chase	82,675	300	71,115	2.87
Gwinn	98,021	885	205,290	2.37
Lloyd	143,283	425	172,960	2.83
Morris	104,278	730	159,290	2.09
Negaunee	345,909	950	887,730	2.70
Princeton	772	357	1,335	4.86
Salisbury	98,729	624	208,240	3.38

Average K. W. H. per 1000 ton ft. hoist = 2.64.

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ELECTRICAL DEPARTMENT

(Cont'd)

The following motors are installed and operating as needed:-

	INSTALLED TO JAN. 1, 1914	INSTALLED IN 1914	TOTALS
CARP RIVER POWER HOUSE:			
Auxiliaries - 2 - 15 HP pump motors	30 HP		
Water Supply Pump	<u>1</u>		
			31 HP
CLIFFS SHAFT MINE:			
Shop	25		
No. 8 Crusher	125		
No. 5 Crushers - 2 - 25 HP motors	50		
Screens	15		
Top Tram	50		
Lower Tram	20		
Underground Haulage Set	100		
Hoist	500		
Underground Plunger Pump		180 HP	
" Centrifugal Pump		<u>250</u>	
			1,315
HARD ORE:			
Machine Shop	25		
Carpenter Shop	<u>25</u>		
			50
LAKE MINE:			
Underground Haulage Set	215		
Surface Drainage Pumps - 2 - 30 HP motors	60		
Underground Plunger Pump	75		
" Centrifugal Pump	<u>125</u>		
			475
SALISBURY MINE:			
Hoist	400		
Underground Centrifugal Pump	400		
Compressor	150		
Underground Ventilating Fan		<u>5</u>	
			955
ATHENS MINE:			
Cage Hoist		400	
Compressor		325	
Circulating Pump		3	
Auxiliary Compressor (for hoist brakes)		<u>5</u>	
			733
MAAS MINE:			
(Circulating Pump	40		
Turbine Auxiliaries (Injection "	25		
(Exciter	33		
Underground Haulage Set	215		
Shop	10		
Underground Centrifugal Pump		350	
" Hoist		<u>50</u>	
			723
NEGAUNEE MINE:			
Underground Haulage Set	215		
"Ilgner" Hoisting Set	350		
Top Tram - 2 - 50 HP motors	100		
Laboratory Crusher	3		
Reserve Air Compressor (for hoist brakes)	3		
Underground Plunger Pumps - 2 - 300 HP motors	600		
" Centrifugal Pump	350		
" Suction Pumps - 2 - 15 HP motors	30		
Cooling Tower Pump	5		
Air Compressor	325		
Shop	15		
Sump Pump		<u>5</u>	
			2,001
fwd.,	<u>4,710</u> HP	<u>1,573</u> HP	<u>6,283</u> HP

ELECTRICAL DEPARTMENT

(Cont'd)

	brt. fwd.,	INSTALLED			TOTALS
		TO JAN. 1, 1914	INSTALLED IN 1914	TAKEN OUT IN 1914	
SOUTH JACKSON CRUSHER PLANT:					
Hoist			75		
Compressor			50		
Crusher			<u>150</u>		275
CHASE MINE:					
Hoist		200			
Compressor		175			
Underground Centrifugal Pump (to Dexter)				50	
Top Tram		25			
Underground Plunger Pump		50			
Water Supply Pump		<u>5</u>			455
DEXTER MINE:					
Underground Centrifugal Pump (from Morris)			50		
" " " (" Lloyd)			50		
" " " (" Chase)			<u>50</u>		150
LLOYD MINE:					
Skip Hoist		400			
Cage "		400			
Underground Plunger Pump		50			
" Centrifugal Pump (to Dexter)				50	
Top Tram - 2 - 25 HP motors		<u>50</u>			900
MORRIS MINE:					
Skip Hoist		400			
Cage "		400			
Shop		25			
Water Supply Pump		40			
" " "		50			
Air Compressor (Ingersoll-Rand)		250			
Underground Plunger Pumps - 2 - 350 HP		700			
Laboratory Crusher		3			
Top Tram - 2 - 25 HP motors		50			
Underground Haulage Set		150			
Air Compressor (Nordberg)		325			
Circulating Pump			<u>5</u>		2,398
PRINCETON CENTRAL POWER PLANT:					
(Circulating Pump		40			
Turbine Auxiliaries (Injection "		25			
(Exciter		33			
Underground Haulage Set		215			
Shop		25			
Compressor		625			
Boiler Room Fan			<u>25</u>		988
AUSTIN MINE:					
Hoist		150			
Top Tram		25			
Laboratory Crusher		<u>5</u>			180
fwd.,		<u>9,601 HP</u>	<u>2,028 HP</u>	<u>100 HP</u>	<u>11,629 HP</u>

ELECTRICAL DEPARTMENT

(Cont'd)

	INSTALLED			TOTALS	
	TO JAN. 1, 1914	INSTALLED IN 1914	TAKEN OUT IN 1914		
	brt. fwd.,	9,601 HP	2,028 HP	100 HP	11,629 HP
GWINN MINE:					
Cage Hoist	400				
Skip "	400				
Rock Crusher	25				
Underground Centrifugal Pump	400				
" Plunger "		350			
Ore Tram - 2 - 37 HP motors		74			
Rock Tram		10			
Auxiliary Compressor (for hoist brakes)		3			
Underground Ventilating Fan		<u>7</u>			
					1,669
GARDNER MINE:					
Hoist	400				
Sinking Pump		<u>35</u>			
					435
MACKINAW MINE:					
Hoist	400				
Shop		25			
Sinking Pump		35			
Compressor		<u>325</u>			
					785
PRINCETON MINE NO. 1:					
Hoist	75				
Underground Pumps - 2 - 50 HP motors	<u>100</u>				
					175
PRINCETON MINE NO. 2:					
Hoist	200				
Top Tram	<u>50</u>				
					250
STEPHENSON MINE:					
Underground Plunger Pump	250				
" Centrifugal Pump	<u>275</u>				
					525
	Totals,	<u>12,576 HP</u>	<u>2,892 HP</u>	(100HP)	<u>15,468 HP</u>
PIONEER FURNACE:					
Motor-generator Set (connected to system)	<u>750</u>				<u>750</u>
	GRAND TOTALS.	<u>13,326 HP</u>	<u>2,892 HP</u>		<u>16,218 HP</u>

The following motors are on hand, but are not installed:-

MAAS MINE:	
Underground Plunger Pump	325 HP
MACKINAW MINE:	
Circulating Pump	<u>3</u>
Total,	<u>328 HP</u>

Motors connected to Dec. 31, 1914,	(including Furnace)	16,218 HP
" on hand	(not installed)	<u>328</u>
	GRAND TOTAL,	<u>16,546 HP</u>

AU TRAIN HYDRO-ELECTRIC PLANT

The Au Train Hydro-Electric Plant operated satisfactorily through the year, being idle a total of 90½ hours all of which was due to transmission line trouble.

The record for the year is as follows:-

Total current generated at switchboard,	2,223,300 K.W.H.
" " delivered at Paper Mill switchboard,	<u>2,104,600</u> "
" " lost in transmission,	118,700 K.W.H.
Current sold - 2,104,600 K.W.H. @ \$.005 =	\$ 10,523.00
Operating expense, maintenance & taxes,	\$5,070.13
Depreciation,	<u>6,313.80</u>
	<u>11,383.93</u>
Loss,	\$ 860.93
Total investment, (Jan. 1st, 1915)	\$ 117,687.27

The plant ran light for a total of 138 days; 52 Sundays, 77 days, including holidays, on which the mill did not want current, and 9 days due to transmission line and plant trouble. The loss of output due to the above causes tabulates as follows:-

Output lost on Sundays,	390,400 K.W.H.
" " " account of Paper Mill,	534 300 "
" " " " " transmission line and plant,	<u>149,000</u> "
Total,	1,073,700 K.W.H.

By deducting 149,000 K.W.H., the loss due to transmission line and generating station trouble, from 1,073,700 K.W.H., we have 924,700 K.W.H. which is the additional output the plant could have shown had it operated at all times to the capacity of the stream.

AU TRAIN HYDRO-ELECTRIC PLANT (Cont'd)

SUMMARY OF OPERATIONS - 1914.

Month	K. W. H. Generated	K. W. H. Sold	Transmission Loss	Cost per K. W. H. (Incl. Depreciation)
January	77,900	69,000	8,900 = 11.4%	\$.0075989
February	60 600	52 700	7 900 13.0	.0065565
March	154 100	145 700	8 400 5.4	.0050180
April	234 500	221 900	12 600 5.3	.0035503
May	383 000	362 800	20 200 5.2	.0030557
June	212 900	204 600	8 300 3.8	.0036398
July	245 600	234 900	10 700 4.3	.0034918
August	173 100	165 200	7 900 4.5	.0041860
September	172 600	164 600	8 000 4.0	.0040512
October	137 300	129 300	8 000 5.8	.0044725
November	171 800	163 800	8 000 4.6	.0040145
December	<u>199 900</u>	<u>190 100</u>	<u>9 800</u> 4.9	<u>.0160704</u>
Totals,	2,223,300	2,104,600	118,700 5.3%	\$.0054090

CARP RIVER HYDRO-ELECTRIC SYSTEM

SUMMARY OF OPERATING CONDITIONS

Month	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Precipitation	1.44	.66	1.35	5.86	1.46	4.22	4.44	1.92	2.14	.69	1.96	.39
Total precipitation for 1914	- 26.53 inches.											

Average Marquette records - 46 years - 32.8 "

Drainage area above Intake Dam -	66.66 sq. mi.
Cubic feet Precipitation 1914 -	4,107,006,852
K. W. Hrs. generated at Garp River Plant in 1914 -	17,937,400
90 cu. ft. of water will generate 1 K.W.Hr.	
Cubic feet water utilized -	1,614,366,000
" " " in storage basin Jan. 1, 1914 -	304,748,800
" " " wasted in 1914 -	100,388,800
Total run-off for year 1914 -	1,410,006,000 cu.ft.
Run-off per sq. mile of drainage area -	21,152,200 " "

CARP RIVER HYDRO-ELECTRIC SYSTEM (Cont'd)

During 1914 the drainage area produced a run-off of 1,410,006,000 cubic feet with a precipitation of 26.53 inches, 7% of this being wasted over intake dam and the remainder utilized for producing power. About 19% of the power produced was made by water stored in the previous year. About 11.7% of the total power produced during the year was made by steam.

STEAM-ELECTRIC PLANTS & CARP RIVER HYDRO-ELECTRIC PLANT

SUMMARY OF OPERATIONS - 1914

Month	K. W. H. GENERATED			Total	Used By		K.W.H. Sold	Cost Per K. W. H. (Incl. Depr.)
	Carp	Maas	Princeton		Auxiliaries	Transmission Losses		
Jan.	1,528,600	62,720	0	1,591,320	10,505	16.8%	1,314,253	\$.004980
Feb.	1 570 000	2 505	17 800	1 590 305	9 395	14.0	1 358 730	.004627
Mar.	1 655 000	260	99 100	1 754 360	13 766	14.4	1 488 993	.005045
Apr.	1 684 900	315	61 700	1 746 915	12 339	14.1	1 489 668	.004811
May	1 856 600	320	18 300	1 875 220	7 998	15.1	1 584 854	.005230
June	1 754 400	27 915	0	1 782 315	7 222	15.0	1 509 182	.004625
July	1 723 700	75	1 300	1 725 075	6 260	19.0	1 391 304	.004535
Aug.	1 675 200	265	76 800	1 752 265	11 450	14.5	1 488 247	.005026
Sept	1 206 000	265	632 800	1 839 065	52 695	17.0	1 481 508	.007717
Oct.	1 171 200	12 585	590 750	1 774 535	47 410	11.6	1 527 571	.007735
Nov.	1 173 200	0	613 650	1 786 850	61 980	13.1	1 498 787	.007855
Dec.	938 600	398 525	323 050	1 660 175	69 945	11.8	1 402 650	.007933
	17,937,400	505,750	2,435,250	20,878,400	310,965	14.7	17,535,747	\$.005854

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COMPARATIVE TABLES

YEAR	TONS COAL BURNED	TONS ORE & ROCK HOISTED	CU. FT. AIR USED	TONS HOISTED PER TON COAL	CUBIC FT. AIR PER TON HOISTED	GALLONS OF WATER PUMPED
<u>CLIFFS SHAFT MINE</u>						
1900	7,969	221,857	359,115,086	35.4	1,410	345,630,130
1901	8 412	283 088	447 136 140	32.5	1 580	353 314 205
1902	9 381	278 756	401 970 520	33.2	1 442	377 910 450
1903	8 150	268 568	322 753 874	34.1	1 200	374 292 985
1904	6 287	169 651	191 094 862	27.0	1 127	372 046 285
1905	7 421	204 645	271 587 404	27.6	1 355	353 087 800
1906	9 204	272 735	451 440 636	28.3	1 794	--- --- ---
1907	8 880	302 924	692 018 970	34.0	2 239	242 599 222
1908	7 991	228 886	541 729 740	28.5	2 367	240 000 000
1909	7 328	242 573	680 952 960	33.3	2 796	166 079 249
1910	8 895	252 793	904 379 312	28.4	3 577	156 948 550
1911	8 095	246 334	898 424 112	30.4	3 647	165 101 640
1912	8 047	276 211	810 020 228	34.3	2 932	218 555 480
1913	8 027	295 105	833 987 419	36.7	2 826	276 582 240
1914	7 496	316 986	1 054 320 348	-- -	3 326	281 392 090
<u>SALISBURY MINE</u>						
1901	3,621	190,816	184,878,547	49.6	970	71,466,792
1902	3 800	175 782	191 100 362	46.1	1 090	71 962 803
1903	4 167	194 781	264 830 023	46.7	1 360	88 636 312
1904	3 540	159 878	216 911 720	45.2	1 358	77 897 201
1905	3 750	154 017	219 765 211	40.5	1 423	76 346 425
1906	3 909	152 034	219 345 241	39.7	1 461	77 100 543
1907	3 892	139 986	215 971 327	35.9	1 551	86 056 044
1908	3 606	116 724	218 591 828	32.3	1 895	66 957 839
1909	3 537	99 140	218 841 412	27.9	2 228	61 699 506
1910	3 308	113 574	162 828 098	34.3	1 433	63 430 079
1911	3 158	111 272	148 067 843	35.2	1 330	61 654 458
1912	2 788	118 635	154 493 210	42.5	1 301	55 855 799
1913	848	125 178	120 039 019	-- -	958	51 358 400
1914	583	97 318	94 530 000	-- -	971	56 786 400

COMPARATIVE TABLES

YEAR	TONS COAL BURNED	TONS ORE & ROCK HOISTED	CU. FT. AIR USED	TONS HOISTED PER TON COAL	CUBIC FT. AIR PER TON HOISTED	GALLONS OF WATER PUMPED
			<u>LAKE</u> <u>MINE</u>			
1900	8,218	510,132	376,482,932	62.0	740	-- --- ---
1901	9 117	472 730	393 632 563	51.7	840	62,998,188
1902	8 400	470 728	440 196 332	51.8	952	64 188 597
1903	8 502	468 277	441 329 198	50.0	993	70 848 359
1904	6 983	281 399	355 084 057	40.3	1,368	78 662 195
1905	10,346	505 321	885 737 363	48.8	1 753	77 492 105
1906	11 072	559 877	784 511 853	51.8	1 247	80 626 208
1907	10 934	549 449	773 662 287	50.7	1 410	90 105 988
1908	9 222	357 628	575 642 546	38.6	1 671	76 896 881
1909	9 640	381 060	826 433 227	39.4	2 245	81 268 184
1910	9 892	559 438	820 568 713	56.5	1 466	85 118 000
1911	7 558	309 519	583 930 820	40.9	1 886	93 643 210
1912	7 824	329 344	656 627 987	42.0	1 993	109 576 544
1913	8 059	473 848	962 459 483	-- -	2 031	95 007 553
1914	5 733	324 251	596 066 577	-- -	1 838	45 925 949

H. O. #3 HEATING PLANT

1913	729
1914	810

COMPARATIVE TABLES

<u>YEAR</u>	<u>TONS COAL BURNED</u>	<u>TONS ORE & ROCK HOISTED</u>	<u>CU. FT. AIR USED</u>	<u>TONS HOISTED PER TON COAL</u>	<u>CUBIC FT. AIR PER TON HOISTED</u>	<u>GALLONS OF WATER PUMPED</u>
<u>MEGAUNEE MINE</u>						
1904	8,182	166,781	233,721,669	20.4	1,401	476,056,512
1905	7 386	245 422	211 667 755	33.2	861	345 967 009
1906	10 465	258 354	235 730 810	25.5	921	--- --- ---
1907	11 216	315 069	250 046 615	28.4	795	707 070 097
1908	10 294	300 007	210 799 982	29.3	696	638 488 540
1909	9 088	316 072	263 322 702	32.0	911	623 789 512
1910	7 913	364 111	361 923 373	46.0	993	610 209 058
1911	7 805	368 352	599 630 043	47.1	1 627	634 100 040
1912	8 003	298 308	825 468 516	37.2	2 767	696 210 397
1913	7 647	368 956	741 224 169	-- -	2 008	789 153 091
1914	5 269	337 792	613 144 000	-- -	1 798	(#2 Shaft) 395 877 353
<u>MAAS MINE</u>						
1905	4,066	--- ---	139,268,772	-- -	- ---	311,792,458
1906	4 170	--- ---	260 733 698	-- -	- ---	--- --- ---
1907	5 861	29 690	--- --- ---	8.6	- ---	337 084 264
1908	6 671	83 075	--- --- ---	12.4	- ---	242 151 139
1909	6 494	141 510	291 338 833	22.1	2,095	231 101 590
1910	8 219	196 052	541 169 843	23.8	2 760	209 688 862
1911	7 252	--- ---	646 245 479	-- -	- ---	--- --- ---
1912	6 502	55 603	355 459 673	-- -	- ---	--- --- ---
1913	8 903	287 784	915 881 473	32.3	3 182	--- --- ---
1914	6 819	213 423	720 319 949	-- -	- ---	(3 months) 8 336 357

COMPARATIVE TABLES

YEAR	TONS COAL BURNED	TONS ORE & ROCK HOISTED	CU. FT. AIR USED	TONS HOISTED PER TON COAL	CUBIC FT. AIR PER TON HOISTED	GALLONS OF WATER PUMPED
<u>AUSTIN MINE</u>						
1905	1,867	61,878	51,808,300	33.8	837	--- --- ---
1906	- ---	165 445	56 931 414	53.4	374	--- --- ---
1907	3 863	194 571	58 452 975	54.0	300	--- --- ---
1908	- ---	204 769	-- --- ---	-- -	---	--- --- ---
1909	- ---	186 064	181 915 343	-- -	985	--- --- ---
1910	- ---	69 500	33 411 030	-- -	480	--- --- ---
1911	- ---	145 360	128 013 967	-- -	880	--- --- ---
1912	- ---	121 191	153 118 878	-- -	1,263	--- --- ---
1913	- ---	67 494	--- --- ---	--- -	---	--- --- ---
1914	(Mine idle entire year)					
<u>PRINCETON MINE</u>						
1909	3,104	143,620	181,915,352	47.8	1,265	144,540,000
1910	2 582	126 047	226 054 113	48.8	1 793	138 556 000
1911	570	100 150	171 032 509	-- -	1 707	--- --- ---
1912	184	22 639	48 083 876	-- -	2 123	107 537 270
1913	467	74 297	-- --- ---	-- -	- ---	108 366 555
1914	64	772	-- --- ---	-- -	- ---	99 939 295
<u>STEPHENSON MINE</u>						
1909	2,396	140,683	181,915,347	63.4	1,313	191,342,376
1910	2 867	217 096	294 935 118	75.7	1 358	383 590 401
1911	4 182	239 991	384 041 898	57.3	1 600	625 253 183
1912	4 856	241 931	460 478 796	49.8	1 903	886 471 232
1913	3 420	283 146	--- --- ---	-- -	- ---	1 028 287 849
1914	2 281	238 739	--- --- ---	-- -	- ---	772 327 870

COMPARATIVE TABLES

YEAR	TONS COAL BURNED	TONS ORE & ROCK HOISTED	CU. FT. AIR USED	TONS HOISTED PER TON COAL	CUBIC FT. AIR PER TON HOISTED	GALLONS OF WATER PUMPED
<u>GWINN MINE</u>						
1909	2,022	---	60,638,452	---	---	---
1910	5 116	---	143 309 920	---	---	---
1911	3 400	2 548	136 216 025	---	---	---
1912	- ---	(Idle entire year)				
1913	1 583	14 376	---	---	---	---
1914	1 400	95 510	---	---	---	90,245,720

PRINCETON PUMPING STATION

1909	598	---	---	---	---	137,037,480
1910	545	---	---	---	---	142 284 450
1911	497	---	---	---	---	153 854 205
1912	569	---	---	---	---	158 661 990
1913	633	---	---	---	---	172 438 180
1914	675	---	---	---	---	184 799 040

PRINCETON CENTRAL POWER PLANT

1909	4,630	---	(output) 606,384,494	---	---	---
1910	6 101	---	697 710 181	---	---	---
1911	7 493	---	819 304 399	---	---	---
1912	4 104	---	661 681 550	---	---	---
1913	2 360	---	---	---	---	---
1914	5 900 (for Heating & Steam-Electric Plant)					

GROSBY MINE

1909	1,735	119,410	---	71.6	---	---
1910	2 157	204 588	---	94.8	---	---
1911	1 493	80 976	---	69.3	---	---
1912	1 515	116 818	---	---	---	---
1913	3 305	207 728	---	62.8	---	---
1914	(10 mo.) 2 151	(8 mo.) 23 221	---	---	---	---

COMPARATIVE TABLES

YEAR	TONS COAL BURNED	TONS ORE & ROCK HOISTED	CU. FT. AIR USED	TONS HOISTED PER TON COAL	CUBIC FT. AIR PER TON HOISTED	GALLONS OF WATER PUMPED
<u>IMPERIAL MINE</u>						
1909	2,592	82,135	---	31.8	---	---
1910	3 665	137 527	---	37.5	---	---
1911	2 744	102 831	---	37.4	---	---
1912	(Mine idle entire year)					
1913	"	"	"	"	"	"
1914	"	"	"	"	"	"
<u>LUCY MINE</u>						
1910	2,718	66,660	---	24.5	---	---
1911	1 440	31 481	48,965,305	21.8	1,505	43,712,842
1912	(Mine idle entire year)					
1913	"	"	"	"	"	"
1914	"	"	"	"	"	"
<u>MORRIS MINE</u>						
1911	---	1,556	---	---	---	---
1912	---	41 140	---	---	---	---
1913	676	(Morris-Lloyd) 209 667	---	---	---	---
1914	578	242 476	655 119 000	---	2 701	343 466 920
<u>LLOYD MINE</u>						
1911	---	87,236	---	---	---	---
1912	---	140 404	---	---	---	---
1913	50	(See Morris)	---	---	---	68,591,636
1914	37	" "	(See Morris)	---	---	(5 mo.) 20,422,137
<u>CHASE MINE</u>						
1911	---	3,575	---	---	---	---
1912	---	5 433	---	---	---	---
1913	250	50 936	---	---	---	---
1914	138	79 222	202 237 750	---	2 552	54 206 045

COMPARATIVE TABLES

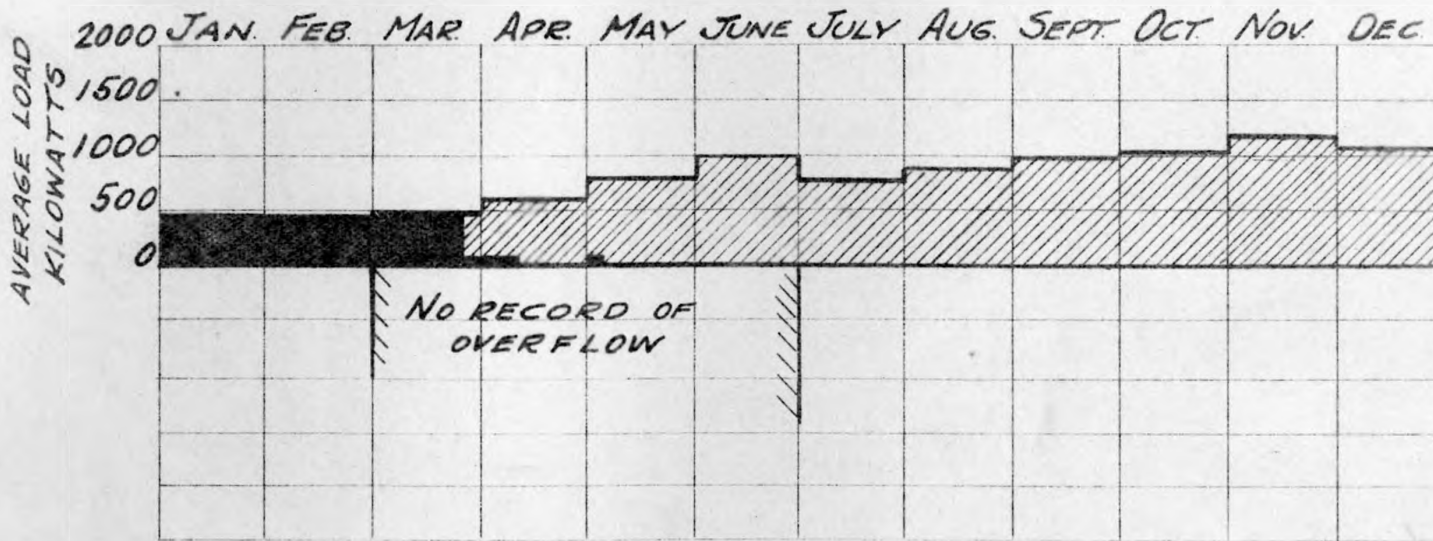
<u>YEAR</u>	<u>TONS COAL BURNED</u>	<u>TONS ORE & ROCK HOISTED</u>	<u>CU. FT. AIR USED</u>	<u>TONS HOISTED PER TON COAL</u>	<u>CUBIC FT. AIR PER TON HOISTED</u>	<u>GALLONS OF WATER PUMPED</u>
<u>SOUTH JACKSON MINE & CRUSHER PLANT</u>						
1912	381	42,790	---	---	---	---
1913	483	1 940	---	---	---	---
1914	0	15 281	---	---	---	---
<u>GARDNER & MACKINAW MINES</u>						
1914	303	-- ---	221,355,000	-- -	- ---	---
<u>ATHENS MINE</u>						
1914	231	7,404	120,048,750	-- -	- ---	---
<u>REPUBLIC MINE</u>						
1914	5,834	106,663	---	---	---	---

Note:-

- Cliffs Shaft Mine - Hoist operated by steam part of Jan. Part of pumping done electrically in Nov. and Dec. Receives some air from the Morris Mine.
- Salisbury Mine - Mining operations suspended Sept. 30th.
- Lake Mine - Single shift entire year.
- Negaunee Mine - Single shift June 8th. Rec'd air from Maas in Jan. and Feb. Electric pumps started in Feb. Electric pumps handled all mine water after Oct. 5th.
- Maas Mine - Shut down Sept. 30th. Electric pump started Oct. 15.
- Austin Mine - Idle entire year.
- Stephenson Mine - Single shift June 1st.
- Gwinn Mine - Steam compressor operated from Feb. to Aug. 12th.
- Prin. C. P. Plant - Steam-electric plant operating continuously after Aug. 24.
- Crosby Mine - Shut down entirely in Oct.
- Imperial Mine - Idle entire year.
- Lucy Mine - " " "
- Lloyd Mine - Pumps shut down April 21st. Water drains to Morris Mine.
- South Jackson - Entire plant operated electrically season of 1914.
- Gardner & Mackinaw - Sinking operations stopped Sept. 30th.
- Athens Mine - Large electric compressor started in June.
- Republic Mine - Mine taken over May 1st.

*Structure
M. M.*

1912

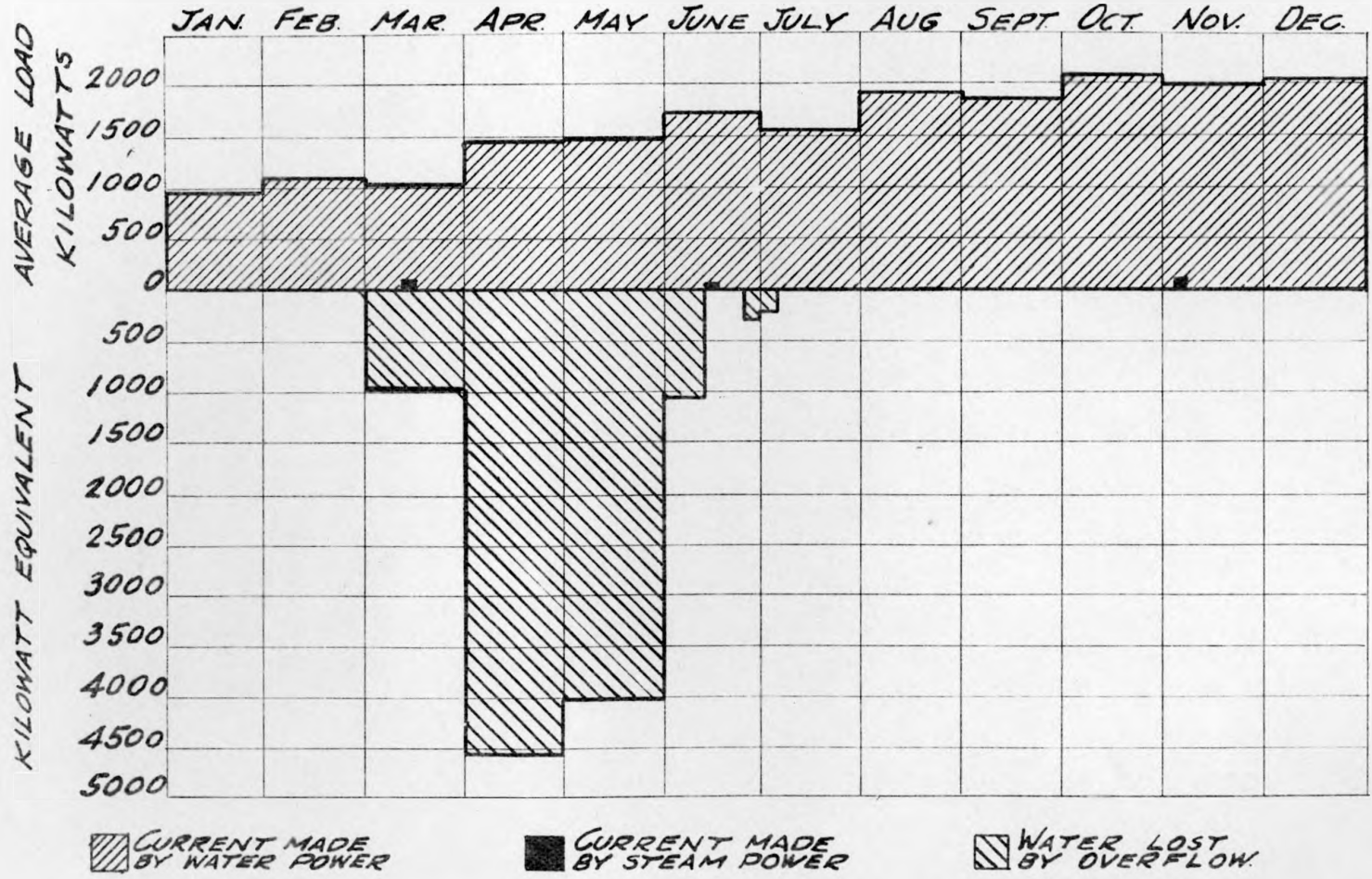


▨ CURRENT MADE BY WATER POWER

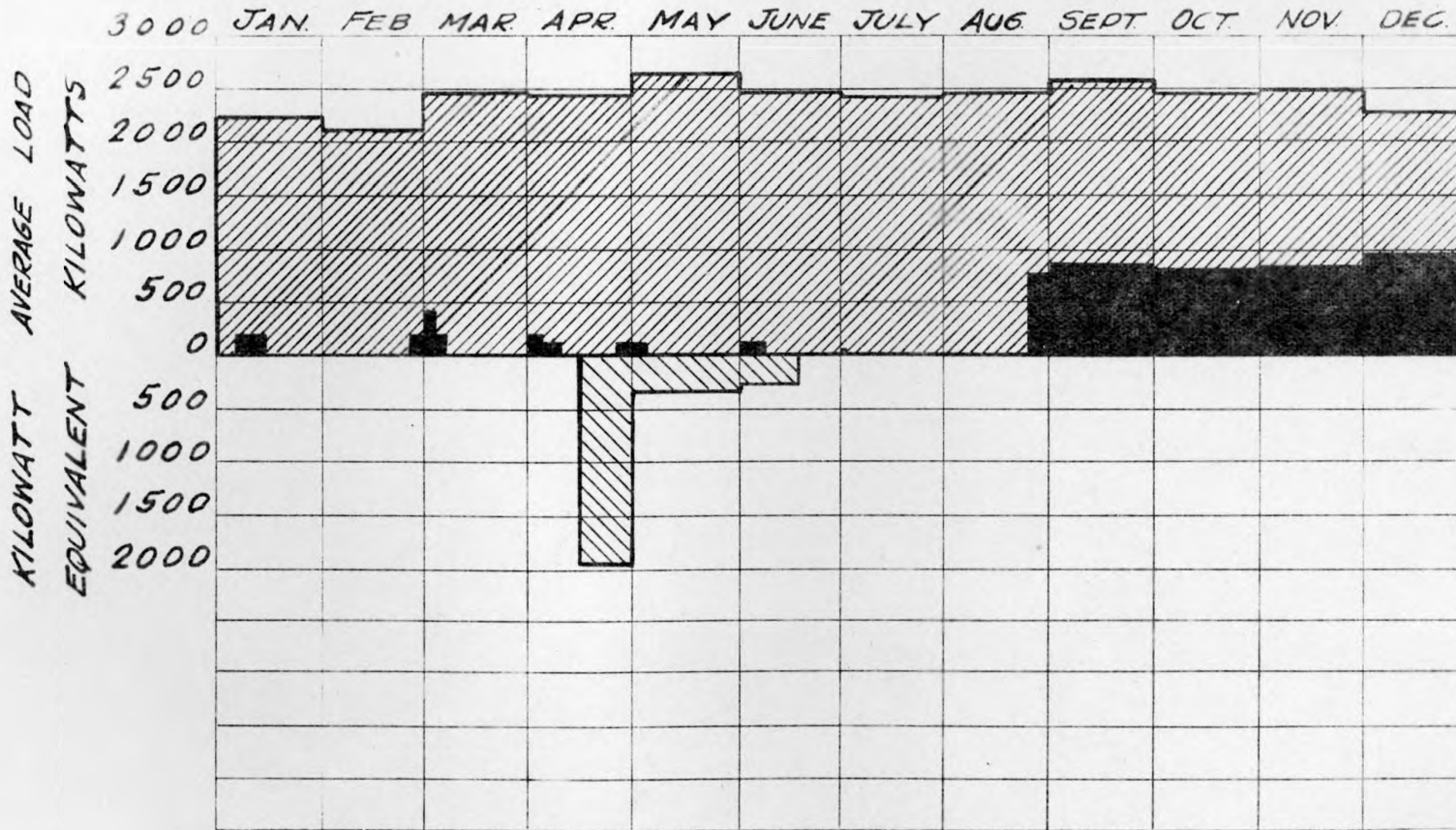
■ CURRENT MADE BY STEAM POWER

▨ WATER LOST BY OVERFLOW

1913



1914



CURRENT MADE BY WATER POWER

CURRENT MADE BY STEAM POWER

WATER LOST BY OVERFLOW

LEGEND