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P. N. DENN. Mr. Denn was a full time member of this Department during January, February and March. During the remainder of the year only one fourth of his time was so employed, the balance being in the Engineering Department as chauffeur. His time in the Geological Department was completely taken up with collecting, labeling and filing all diamond drill core and sludge samples from current drilling and in looking after the core room.

SURFACE GEOLOGICAL SURVEYS.

ISHPEMING DISTRICT.

The only surface geological work of any consequence done during the year was the survey of the $S\frac{1}{2}$ of Section 15, 47-27 Salisbury Mine. The surface outcrops and test pits were located and contours taken by members of the Engineering Department and the rock determinations and geological notes were made by Mr. Allen, who was attached to the survey party.

UNDERGROUND GEOLOGICAL SURVEYS.

Following Mr. Nicolson's transfer to the Engineering Department at the end of January and continuing until Mr. Pinger became familiar with the work of the Department, the underground geological work was only partially accomplished and surveys were very irregular. During the latter part of the year, however, this work was pretty well caught up, with the exception of the Cliffs Shaft and Republic mines. The latter are hard ore mines and the workings are accessible for a comparatively long time, consequently we hope eventually to bring the geology of these properties up to date.

ANGELINE MINE.

Operations were continuous at this property throughout the year but the workings are quite limited and required comparatively little geological work. All ore mined was taken from the so-called Middle Deposit. A small amount of development work, however, was done in the old part of the mine at the West end of the "D" shaft workings. Here a rock raise is being put up to explore for additional hardore ~~to explore~~ and possibly

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recover some of the old hard ore pillars.

ATHENS MINE.

The Athens Mine continued to be a large producer and regular geological surveys were made and the geological maps and cross-sections posted. All mining during the year, however, was confined practically to the territory above the 8th level.

BARNES-HECKER MINE.

The work at the Barnes-Hecker was all of a development nature, consisting of the extension of the three main levels which had just been started the latter part of 1919 at depths of 600', 800' and 1000' from surface respectively. Because of very heavy flows of water from the porous iron formation, work was stopped on the 1st and 2nd levels before reaching the main ore body. Trouble was also experienced with water on the 3rd level but not until the West end of the ore body at this elevation had been encountered. The drift was temporarily abandoned, however, shortly after this so that no crosscutting to determine the characteristic or extent of the ore was done. Because of the excessive flow of water which was rapidly approaching the capacity of the pumping equipment, concrete dams were constructed on all three levels and all work stopped until a drainage ditch could be constructed on the surface to lead the water away from the property so that a vigorous campaign of pumping can drain, or partially drain, this ground.

CLIFFS SHAFT MINE.

Mining at this property was continuous throughout the year, but as mentioned before, geological work was necessarily limited for reasons already explained.

FRANCIS MINE.

Geological surveys were made more or less regularly at this property and the geological maps and cross-sections posted, the intervals between surveys averaging about two months. Considerable additional ore was developed during the year on the South side of the basin at the elevation of the 5th level and between the 5th and 4th levels. A rock drift is

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being extended from the 5th level Northwesterly in hanging wall slate towards the Gwinn Mine and will eventually be connected by a raise to the 10th level Gwinn Mine for purposes of ventilation. It is expected that a limited amount of drilling, at least, will be done from this drift to ~~the~~ explore the intervening territory.

GWINN MINE.

Geological surveys were made and maps and cross-sections posted at regular intervals of about two months, as was the case with the Francis. At this mine the shaft was sunk from the 10th to the 11th level and a drift was driven on the latter level and in the footwall of the ore body from which raises were put up to the 10th. Mining operations were continuous throughout the year and were carried on chiefly between the 9th and 10th levels, some work, however, being done at higher elevations. As explained in connection with the Francis Mine, the 10th level is being extended Southeasterly towards the latter property in the hanging slate and will be connected with it by raises for ventilation purposes.

HOLMES MINE.

The Holmes Mine was also a continuous producer throughout the year. The 3rd and 4th levels, which had just about reached the ore body at the beginning of the year, were advanced and crosscuts driven which by the end of the year had practically outlined the ore at both elevations. The ore body ~~was~~^{is} also being developed on two intermediate sub-levels, one half way between the 2nd and 3rd and the other half way between the 3rd and 4th. Mining operations were confined to the territory above the 2nd level. Geological surveys were made regularly at monthly intervals and the geological maps and cross-sections kept posted.

JOPLING MINE.

The only work at the Jopling Mine consisted in extending the main level Southeasterly about 400', from the breast of which exploring by diamond drilling was done. No ore was found and the lease on the property was surrendered in May. Previous to this, however, a concrete dam was constructed to cut the property off from the 7th level Gwinn Mine.

MAAS MINE.

The Maas Mine continued to be one of the large producers, mining being carried on over a very wide area, extending all the way from sub-levels above the 1st level to the territory between the 3rd and 4th levels. For the first part of the year what little geological work was accomplished was done by the Engineering Department in the course of their regular surveys. Following the arrival of Mr. Pinger, we were able to resume regular geological surveys and keep the geological maps and cross-sections posted.

MACKINAW-GARDNER MINES.

During the year practically all of the remaining available ore in the Mackinaw Mine above the 4th level was mined and considerable ore on the Gardner. The method of mining this ore, which is a hard hematite, is by shrinkage stopes separated by rib pillars extending from foot to hanging. The ore body has an average dip of between 40° and 45°. A drift was driven from the 4th level on the Mackinaw property Southwesterly into the hanging for a distance of about 300', from which some drilling operations were conducted and additional drilling planned. Geological surveys were made at regular intervals of about two months and the geological maps and cross-sections posted until the mine was shut down the first of December.

MORRIS-LLOYD MINE.

Mining continued throughout the year in all three mines, the East Lloyd, Lloyd and Morris. Work in the first two was confined chiefly to mining, whereas in the Morris considerable development work was done on the 6th level and the shaft sunk and a new level, the 7th, started. The geological work was rather irregular during the interval between Mr. Nicolson's transfer to the Engineering Department and Mr. Pinger's advent into this Department. During the last half of the year, however, geological surveys were made regularly at monthly intervals and the geological maps and cross-sections kept posted.

NEGAUNEE MINE.

The Negaunee Mine continued to be one of the largest producers on the Range. Practically all work was confined to actual mining operations

and the principal tonnage was taken from the territory between the 9th and 11th levels. As was the case at the Maas Mine, practically all the geological work accomplished before Mr. Pinger came into the Department was done by the engineers. During the last half of the year, however, regular geological surveys have been made and the geological maps and cross-sections posted.

PRINCETON MINE.

At intervals of approximately two months, geological surveys were made by this Department of all new development work. Similar surveys were made by the engineers at the property of the sub-level mine workings but their results, as well as our own, were posted on our geological maps and cross-sections. Geological mapping at this mine is not complicated by unusual structural features or intrusive masses so that geological mapping in mine workings is comparatively simple and we found this arrangement very satisfactory.

REPUBLIC MINE.

As previously stated, comparatively little geological surveying has been done in this mine during the year, although mining has been continuous. The workings remain open a long time so that we will probably be able to get into them and bring the work up to date when the opportunity of resuming these surveys is found. Mining was carried on continuously throughout the year and several new important ore bodies were discovered on the lower levels and extensions of known ore bodies found.

SALISBURY MINE.

The only geological work done at this property was in connection with the South Deposit where an occasional geological survey was made and the maps and cross-sections posted. A winze was sunk from this deposit and a short crosscut driven from which a small amount of diamond drilling was done. No additional ore was discovered. The mining in the old part of the mine was chiefly confined to scrambling in old workings and removing pillars which necessitated no geological mapping.

SPIES MINE.

Geological surveys were made of all the Spies workings and the geological maps and cross-sections posted at irregular intervals during the year. Mining continued from the main stope and the so-called North Lens. A small amount of development work was done on the 2nd level and also on the 3rd level. A crosscut was driven Westerly from the South end of the ^{3d} level to the Virgil boundary and, following the leasing of the latter property, across the boundary, where it is being continued. Some ore was developed in this drift and a small amount of additional ore discovered by ~~the~~ diamond drilling from this drift. It is hoped that enough ore will be developed below the 3rd level to warrant the sinking of the Spies shaft another lift.

STEPHENSON MINE.

The Stephenson Mine was finally unwatered during the year and mining operations resumed. Following this geological surveys of all new development work have been made at regular intervals of approximately two months and the geological maps and cross-sections posted. Several surveys were also made of the working sub-levels by this Department, but as was the case in the Princeton Mine, most of the latter work was done by the engineers at the property and the information submitted to this Department for posting.

No underground geological surveys of the Mesabi Range properties were conducted from this office during the year.

EXPLORATIONS.

Drilling explorations were carried on during 1920 in the following districts and mines:

FROM SURFACE.

<u>DISTRICT.</u>	<u>RANGE.</u>
Ishpeming,	Marquette,
Gwim,	Swansey,
Crystal Falls.	Menominee.

FROM UNDERGROUND.

<u>MINES.</u>	<u>DISTRICT.</u>
Barnes-Hecker,	North Lake,
Cliff's Shaft,	Ishpeming,
Francis,	Gwinn,
Jopling,	"
Mackinaw,	"
Morris-Lloyd,	North Lake,
Negaunee,	Negaunee,
Republic,	Republic,
Salisbury,	Ishpeming,
Spies,	Iron River.

No options for exploring or no mining leases were acquired or surrendered during the year.

Mining Lease No.1, covering Lots 2 and 3 of Section 21, 45-25 at Gwinn, was surrendered January 1st and Mining Lease No.7, covering the NW $\frac{1}{4}$ of the NE $\frac{1}{2}$ of Section 28, 45-25, also at Gwinn, and known as the Jopling Mine, was surrendered May 16th.

Mining Lease No.51 was taken out August 9th, covering the Virgil Mine, SW $\frac{1}{4}$ of the NW $\frac{1}{4}$ of Section 24, 43-35, adjoining on the West the Spies Mine at Iron River. The term of this lease is 45 years.

Table IV, which follows, gives the footage drilled, the ore encountered and the cost per foot of drilling for both surface and underground explorations. It will be noted that the average cost of surface drilling was \$5.45 per foot, excluding certain items from the drilling done by the Company in order to compare these results with the contract drilling costs. By including these items, the average cost was \$6.18 per foot. This large differential is due mainly to the total cost of the Neely Exploration, against which has been charged the entire amount of taxes on the property for the year, which amount to \$6390.49. The average cost of underground drilling in the same way was \$4.06 and \$4.56 respectively. The latter figure includes a charge of \$593.69 for drifting in connection with the Francis Mine drilling and \$4220.99 for drifting in connection with the Mackinaw Mine drilling. The average cost of all drilling was \$4.81 and \$5.41 respectively. The increase of these costs over those of last year, which amounts to about 11.6%, is due to several causes. Chief among these is, first, the higher

wage scale with perhaps a slight decrease in efficiency during the early part of the year when labor was very scarce, and secondly, the unusually deep drilling in Section 3, 47-27 where no less than five holes were drilled deeper than 2000' during the year.

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TABLE IV.

SUMMARY OF DRILLING FOR 1920.

EXPLORATION.	DESCRIPTION. SEC. T. R.	STAND- PIPING FT.	CHURN DRILLING FT.	DIAMOND DRILLING FT.	TOTAL FT.	FIRST CLASS ORE FT.	SECOND CLASS ORE FT.	LEAN ORE FT.	TOTAL COST "A".	COST PER FT. "A".	TOTAL COST "B".	COST PER FT. "B".
<u>SURFACE DRILLING.</u>												
Dead River Hoist	8, 48-26	314			314	0	0	0	(\$ 2343.35	\$4.39	\$ 2341.35	\$4.38
" " "	17, "	220			220	0	0	0	(
Ishpeming Section 3	3, 47-27	480		10814	11294	180	175	157	59681.02	5.29	56195.48	4.98
Neely Lease	12, 42-33	327	46	1334	1707	195	120	140	① 14997.87	8.79	8284.66	4.85
Princeton Mine	20, 45-25	11	10	169	190	0	0	0	1570.81	8.27	1559.06	8.20
Stephenson Mine	29, "	283	199		482	0	0	0	9149.88	18.98	9130.17	18.94
Total Surface Drilling		1635	255	12317	14207	375	295	297	\$87742.83	\$ 6.18	\$77510.72	\$ 5.45
<u>UNDERGROUND DRILLING.</u>												
Barnes-Hecker Mine	2, 47-28			639	639	70	60	62	5150.10	8.06	5044.63	7.89
Cliffs Shaft Mine	9 & 10, 47-27			2627	2627	135	208	161	9429.22	3.59	9182.43	3.50
Francis Mine	27, 45-25			629	629	0	20	25	② 2307.92	3.67	1658.23	2.64
Jopling Mine	28, "			570	570	0	0	5	2004.92	3.52	1964.72	3.45
Mackinaw Mine	35, "			935	935	76	40	5	③ 7967.09	8.52	3635.94	3.89
Morris-Lloyd Mine	(6, 47-27 (1, 47-28			804	804	20	10	70	3292.19	4.10	3191.51	3.97
Negaunee Mine	6, 47-26			209	209	0	0	78	1083.75	5.19	1044.82	5.00
Republic Mine	7, 46-29		2	3619	3621	254	74	128	18443.37	5.10	18190.85	5.02
Salisbury Mine	15, 47-27			1211	1211	0	0	0	2279.82	1.88	2272.75	1.88
Spies Mine	24, 43-35		4	1182	1186	145	140	160	4541.44	3.83	4392.53	3.70
Total Underground Drilling			6	12425	12431	700	552	694	\$56499.82	\$4.56	\$50578.41	\$4.06
Grand Total Drilling		1635	261	24742	26638	1075	847	991	\$144242.65	\$5.41	\$128089.13	\$4.81

NOTE: Cost "A" includes taxes, office expense, engineering, analysis, legal and personal injury.

Cost "B" excludes " " " " " " " " " " " " (to compare with contract price).

The contract drilling for the year comprised the surface drilling on the Neely Lease and was done by the Cole & McDonald Exploration Company.

① Includes taxes - \$6390.49

② Includes drifting - 593.69

③ Includes drifting - 4220.99

SURFACE EXPLORATIONS.

MARQUETTE RANGE.

ISHPEMING DISTRICT.

SECTION 3, 47-27.

All drilling from surface in the Ishpeming District was confined to the exploration on Section 3, 47-27. An ore body was discovered in the SE $\frac{1}{4}$ of the NW $\frac{1}{4}$ last year by drill hole No.18. This was quite completely developed by holes Nos.19, 20, 22 and 25, the tonnage being approximately 535,000 tons. This ore lies to the North of an East-West fault of large displacement, which also was discovered by this drilling. The work for the past year, following the outlining of the ore North of the fault, has been centered in the territory South of the fault where we hoped to find ore on the slate, which, as mentioned above, has been faulted down considerably.

Our hopes of discovering ore South of the fault were realized with the first deep hole to be sunk, No.24. One hundred and thirty five feet of good ore was encountered in this hole from 2255' to 2390' and was found to lie directly on the slate. This hole deviated approximately 200' to the South by the time the ore had been reached, consequently it was decided to attempt to wedge a branch hole to the North from a point about 1200' below the collar where the soft ground was favorable. We were entirely successful in this attempt, the hole when bottomed being about 140' away from the original hole. Twenty feet of good ore was encountered from a depth of 2280' to 2300', following which the hole entered pinitrock and slate. I do not believe that this ore represents the true thickness but that it is merely the fringe at the fault contact and that the slate in the bottom of the hole represents the slate to the North of the fault rather than the true footwall of the ore itself. Although the footage of ore is relatively insignificant in this branch hole, the information obtained is very important in assisting us to arrive at the approximate dip of this main fault and ^{to} assist us in locating future holes.

The second deep hole to be drilled South of the fault, No.26, un-
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fortunately deviated to the North about 200' and encountered only 15' of ore on the slate. It is of course possible that this ore, like that in the branch hole at No.24, is merely the upper fringe of the main ore body which is terminated on the North by the fault. We attempted to wedge a branch hole from this hole to the South but soon found that we could not wedge in this direction satisfactorily, or at least get far enough away from the original hole to be of any use. The reason for this seems to be that a hole will more readily wedge off approaching the normal position to the dip of the formation than is the case with one approaching parallelism to the formation. Accordingly, another hole, No.30, was located 200' South of No.26. In the meantime, hole No.29 was located about 300' West of the latter location in an attempt to find an Easterly extension of the ore in No.24, the former hole being about 400' East and 200' South of No.24.

A drill was also set up on hole No.3, which was a shallow hole drilled several years ago. It is planned to deepen this to the slate in an attempt to cross-section the ore discovered in No.24, the former hole being about 400' South of No.24. Holes Nos .3, 29 and 30 were all drilling at the end of the year; No.3 was drilling in greenstone at 751', No.29 in soft ore jasper at 1842' and No.30 in lean soft ore at 1797'.

DEAD RIVER DISTRICT.

DEAD RIVER HOIST, SECTIONS 8 & 17, 48-26.

A series of ten standpipes were sunk to determine the depth and test the character of ledge Southwest of the main Dead River on the site of the proposed new storage dam at the Hoist. This work was carried on during the latter part of the year at the request of Mr. McClure.

GWINN DISTRICT.

PRINCETON MINE SURFACE, SECTION 20, 45-25.

Two holes, Nos.48 and 49, were drilled just Southwest of the stockpile ground at No.2 shaft, chiefly to test the thickness of the jasper capping over the caved ground and possible open stope beneath in order that the condition of the stockpile ground itself might be determined as to its

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safety. Hole No.48 broke through into the old stope at 86' and was lowered 54' before encountering the mat. Hole No.49 broke through into the old stope at 104' and the rods were lowered 51' before striking the mat. The drilling also showed that the capping above was quite generally cracked.

STEPHENSON MINE SURFACE, SECTION 29, 45-25.

Early in the year it was decided to sink a large standpipe over the center of the ledge basin, which by previous standpiping was found to exist over the Section 29 ore body, and in this way attempt to drain the ledge of the water held in this basin and prevent any future chance of flooding the mine. Accordingly, an 8" standpipe was sunk to ledge with the Keystone churn drill outfit. This is hole No.66. Ledge at this point is unusually deep and considerable difficulty was met in getting such a large pipe down. Ledge was finally encountered, however, at 276'. The churn drill was then used to drill a 7 5/8" hole in the rock, hoping to get this size hole through to the bottom level of the mine. Progress was very slow, even after employing the services of an expert from the Keystone Driller Company. After drilling to a depth of 358' it was deemed advisable to reduce the size of the hole to 6", after which slightly better progress was made. The work was still going on at the end of the year, the hole being 482' deep at that time. It is expected that the underground drift will be encountered at approximately 515'.

CRYSTAL FALLS DISTRICT.

NEELY LEASE, SECTION 12, 42-33.

Drilling was resumed on this lease the middle of August after six years of inactivity. The first hole, No.37, was located approximately 50' North of the South property line in the Southwest corner of the NE¹/₄ of the NE¹/₄. This location is roughly 125' North of hole No.22 drilled by the Oliver Company on its lease immediately to the South, which encountered a considerable footage of first class ore. The latter company developed an appreciable tonnage of ore in the latter vicinity and the present campaign is an attempt to determine if possible whether this ore extends any distance on to the Neely, or possibly connects in some way

with the main Neely ore body to the North. It is hoped that this drilling will prove up enough additional tonnage to make the opening of the Neely property look more attractive. Five holes, Nos.37 to 41 inclusive, were completed up to the end of the year. They were all drilled on an East-West line commencing at No.37, and going Easterly at 100' intervals, with the exception of No.41, which was located 135' East of No.40. Holes Nos. 37 to 40 inclusive were vertical. Small lenses of ore were encountered in Nos.37 and 38 and a thicker body in No.39, the ore extending from 65' to 95'. Hole No.40 had 55' of good ore at a depth of from 160' to 215' and it is very likely that it connects with the 30' of ore in No.39. No.41 was inclined to the West at an angle of 57° to encounter the ore in No.40 at approximately its central point and determine if possible its thickness. The results in No.41 were decidedly encouraging as good ore was encountered from 185' to 235' and confirmed the results of No.40. It is quite unlikely that the small runs of ore in Nos.37 and 38 are continuous with this latter ore, but are probably separate small lenses. At the end of the year a new location was being laid out half way between and 100' North of Nos.39 and 40 to follow up this ore body to the North. This far the results of this present campaign are very encouraging and may possibly lead to an important extension of the ore on this lease.

UNDERGROUND EXPLORATIONS.

BARNES-HECKER MINE.

When the 1st level drift had reached the slate-jasper contact, it seemed advisable before going ahead blindly and laying out the development work in connection with the ore body to try and outline the Westerly end of the ore. With this in view two horizontal holes were drilled from the breast of the drift. Hole No.1, drilled on a course of S.68°58'E., encountered good ore from 227' to 270'. This, however, represents a lens of only about 15' in normal thickness. Hole No.2 was then drilled from the same point but on a course of S. 54°57' E. to follow up this lens to the West. One 5' seam from 195' to 200' and a 10' seam from 210' to 220'

were the only occurrences of ore in this hole, which seemed to indicate that we had encountered practically the Western limit of the main ore lens. Both these drill holes encountered porous ground and released a large flow of water and it was decided to bulk-head the drift with a concrete dam and concentrate development on the lower levels.

CLIFFS SHAFT MINE.

Drilling in this mine continued until the middle of November when the drill was needed at the Holmes Mine. Hole No.311, which was drilled from the 2nd level "B" shaft, had just been completed at the beginning of the year, and holes Nos.312 to 324 inclusive were drilled up to the time the drill was moved. All holes, with the exception of No.324, were located in "B" shaft, Nos.312 to 319 inclusive on the 13th level, Nos.320 and 321 on the 11th level and Nos.322 and 323 on the 6th level. No.324, the last to be drilled, was located on the 9th level "A" shaft.

The usual scheme of exploring in this mine was followed in all this work, namely, to explore the contact between the slate hanging and the iron formation and the several fault areas where droppers, or so-called fault veins, are found.

A total of 135' of first class ore, 208' of second class ore and 161' of lean ore were encountered. The most important occurrence was that in No.324 which started in ore and showed the ore body, which was being stoped at this location, to extend for a distance of 59' to the South towards the footwall.

FRANCIS MINE.

A series of five holes, Nos.14 to 18 inclusive, were drilled in this mine during the months of February and March. They were all located on the 5th level in the drift going West towards the Gwinn Mine and were started in the hanging wall. No.14 was drilled vertically from a point half way between the series of holes Nos.9, 10, 11 and 13, which cross-sectioned the basin on the East end of this drift, and found the main Francis ore body to extend that far, and the series of holes Nos.6, 7 and 8, that cross-sectioned the basin 150' farther West and found it barren.

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This hole was also barren. No.15 was drilled from the same point but horizontally due South. The only enrichment encountered was that between 75' and 90', which averaged about 54% iron. No.16 was then drilled horizontally and South from the same location as the series of holes Nos.6, 7 and 8, 75' West of No.14 and was barren. No.17 and No.18 were located 180' farther West, No.17 being drilled horizontally to the South and No.18 vertically, but neither of them encountered ore.

This work demonstrated that the Francis ore body does not extend any great distance West on its pitch beyond the series of holes Nos.9, 10, 11 and 13. Apparently the only chance of a continuation of this ore is to the Southwest, where a minor ^{fold}~~fault~~ may occur and carry the ore down in that direction.

JOPLING MINE.

Shortly after the Southeasterly exploration drift was completed on the main level at the Jopling Mine, a series of three horizontal holes were drilled from its breast in hopes of finding a downward extension and a possible widening of the small lens of ore encountered on the exploration sub-levels above. Hole No.5 was drilled S. 56° W. to the hanging wall; hole No.6 was drilled due South to the hanging wall, and hole No.7 was drilled due East into the footwall, and all were blank. It was then definitely decided to surrender the lease on this property, which was done, as previously mentioned, on May 16th.

MACKINAW MINE.

The first drilling underground at this mine was begun in April when a series of three horizontal holes were drilled from the Northwest end of the 4th level to exhaust the possibilities of extension of the ore in this direction, at least at this elevation. Hole No.1 was drilled North 18°30' E. into the footwall and was blank. Hole No.2 was drilled S. 60° W. into the hanging wall and in addition to seams of second class ore encountered 10' of good ore at a depth of from 30' to 40'. This ore is bounded on both foot and hanging sides by jasper which acts as the hanging wall of the main ore body. Hole No.3 was drilled due North into the foot and

like No.1 was blank.

After completing the exploration crosscut driven into the hanging from the 4th level drift in October, two holes were drilled from it at approximately 200' from the hanging contact of the main ore body. The first hole, No.4, was drilled vertically and encountered 46' of good ore between the depths of 139' and 185', which is undoubtedly a continuation on the dip of the main Mackinaw-Gardner ore body. Hole No.5 was then drilled S. 30° E. in a dip of -45° to cut the ore horizon also in depth but farther to the East. It encountered 15' of ore from 305' to 320'. This is also probably a continuation of the Eastern end of the same ore body but is much thinner.

In addition to proving an extension of this ore body, these two holes were laid out to get some idea of the sulphur content of the ore in depth. From the hard character of the ore on the 4th level and throughout the mine above, we anticipated no difficulty in getting an appreciable amount of core in this drilling, from which accurate determinations of sulphur could be made. We were disappointed in this, however, as the ore proved to be of entirely different ~~px~~ physical character, being more like a typical soft hematite and did not make core, consequently the sulphur analyses were not complete as the sulphur occurs in the form of gypsum and is readily dissolved in the drill water. Accordingly, when No.5 encountered ore, careful samples of the drill water were taken and an appreciable footage of ore recovered with the use of a double tube core barrel, which heretofore had not been used to any extent in the Lake Superior District. This ore averaged .314% sulphur, which is somewhat less than the average sulphur content of the ore above.

Several more holes were planned from this hanging wall crosscut but the work had to be discontinued in December owing to the mine being closed down the first part of that month.

MORRIS-LLOYD MINE.

Drilling was carried on in these properties intermittently during the year.

Hole No.61, which was drilled South from the West drift on the 6th level Morris Mine, was completed in hanging jasper the early part of January. Drilling was resumed again the latter part of April and two more holes, Nos.62 and 63, were also drilled horizontally and due South from the West drift on the 6th level Morris Mine, carrying out the plan of drilling South from this drift at regular intervals of 400' to systematically explore the iron formation, a distance of from 200' to 300' South from the slate footwall contact. This was completed early in June, the only ore encountered being 15' from 30' to 45' in hole No.62. Late in December drilling was again resumed, this time in the East Lloyd Mine, where hole No.64 was drilled horizontally and S. 25° E. from the first crosscut West of the shaft on the 3rd level. The purpose here was to try and develop a lens of ore in this vicinity in which a raise could be located to tap the working sub-levels above so that the ore could be handled directly on this level without a previous transfer, which prevails at present. The hole was drilling in soft ore jasper at a depth of 78' on the last of the year.

NEGAUNEE MINE.

The drilling of two holes on the 11th level Negaunee Mine was started early in December 1919. They were drilled horizontally from the first Northwest crosscut North of the shaft to more definitely outline the irregular hanging wall contact as an aid in laying out the development drifts on this level; also to find any possible concentrations in the hanging which seemed likely in this vicinity. The first hole, No.26, which was drilled N. 47°40' W., was completed the last of 1919 and encountered 36' of good ore between the depths of 162' and 200'. Hole No.27 was drilled from practically the same point but on a course of S. 33°50' W., with the idea of exploring for the limits of the comparatively narrow tongue of ore extending along the South footwall, which had been cut by the crosscut from which this drilling was done. Although the formation was enriched in several places, no commercial ore was encountered, thus limiting the extent of this narrow tongue of ore in the crosscut. This completed the drilling in the Negaunee Mine for the year.

MADE IN U.S.A.

REPUBLIC MINE.

Drilling in this mine was practically continuous throughout the year. Twenty eight holes, Nos.439 to 466 inclusive, were completed, one hole No.415, was deepened and hole No.467 was drilled to a depth of 119' during that time.

All the holes, as in years past, were drilled for general and systematic exploratory purposes from the current working levels, or levels immediately above. They were all drilled horizontally, with the exception of hole No.443, which was drilled vertically from the floor of a stope on the 1850' level Pascoe Shaft to determine the depth of ore below the floor of this stope in order to enable the development of the downward extension of this ore from the level below. Up to this time it had been impossible to trace this ore as far as the next lower level, although it may extend that distance. With the exception of holes 436 to 440 inclusive and 453, all were drilled from the Pascoe shaft workings. The others were drilled from the new levels in No.9 winze, the 2170' and 2270' levels. To repeat from former reports, the plan followed in the drilling at this mine may be divided into three parts. In the first place, an attempt is made on all new levels to locate the downward extension of known ore lenses above where they are not found by drifting along the quartzite hanging contact but have probably dropped back into the jasper footwall. Secondly, the hanging contact zone is explored for new ore bodies by drilling in cases where rock drifting is not warranted until a discovery of ore is made. Lastly, a systematic exploration of the jasper formation is made back to a horizon ~~from~~ 100' to 200' from the hanging contact.

The results of the drilling the past year have been most satisfactory. Large extensions of known ore bodies on lower levels have been found on the new levels developed below and a number of new ore bodies have been discovered in virgin territory, and more particularly West of the Pascoe Shaft on the levels from 1720' to the 2050'. By referring to Table IV it will be seen that during the year 254' of first class ore, 74' of second class ore and 128' of lean ore were encountered. The footage of first

Damascus Bond

class ore, curiously enough, is exactly the same as that discovered during the year 1919, which was the largest footage discovered by drilling in the history of the mine during the same length of time.

SALISBURY MINE.

A series of five horizontal holes, Nos.55 to 59 inclusive, were drilled from the 15th level South Deposit in the Salisbury Mine, commencing the middle of June. The purpose here was to explore for possible ore bodies in the fault zone that limits the South Deposit on the South side, or a downward extension of a possible branch from the main South ore body in the system of dikes in the fault zone. All holes were in greenstone, however, and further drilling was discontinued.

SPIES MINE.

The first drilling to be done in this mine was started in September and completed early in December. It consisted of seven holes, all drilled from the 3rd or bottom level in quest of further extensions, both in depth and laterally, of the Spies ore bodies. Hole No.1 was drilled vertically from the first North crosscut driven from the Virgil drift. It encountered ore to a depth of 90' below the level. Hole No.2 was then drilled from the same location but horizontally and a little East of North. No good ore and only a small amount of concentration was discovered, the hole being in hanging wall material practically its entire depth of 277'. A series of three holes was then drilled from the Virgil drift at the Spies and Virgil boundary. ^{The} First, No.3, was drilled vertically, No.4 horizontally to the South and No.5 horizontally to the North. The only good ore encountered in these holes was the first 15' in No.3, extending vertically below the level. This was very disappointing as it was hoped that the ore going over on to the Virgil property would prove more extensive. It is possible, however, that this may be only a local pinching out of the zone of concentration and that it will widen out again in going West and in depth along the pitch. Hole No.6 was then drilled vertically near the downward extension of the main ore body, hoping to develop an appreciable extension of this ore below the 3rd level. This

hope was partially realized as ore averaging 55.20% iron was encountered from a depth of 115' to 170', or 55'. The last hole, No.7, was drilled horizontally to the West from the hanging side of the North vein out into the hanging wall but failed to encounter any additional ore in this direction and the drilling was discontinued until additional development work is done by drifting.

EXPLORATIONS BY OTHER COMPANIES.

Mr. Ernest Allen continued to make occasional visits to the explorations of other companies on the Michigan and Wisconsin iron ranges. He has prepared maps of these explorations and submitted special reports covering his visits, giving detailed information thus acquired. Very little drilling, however, was done during the year by other companies in these districts and was relatively unimportant. The work commenced the latter part of the summer of 1919 by Escanaba interests in the vicinity of Pine Ridge on Section 28, 39-23, about four miles West of the City of Escanaba, was discontinued about the middle of the year and failed to discover any merchantable ore. This was really the only new field in which explorations were carried on during the year.

Mr. Afuhs has copied for our files ~~at~~ outside exploration results of any importance which have come to this office in the form of land offers, etc.

EXAMINATIONS OF MINERAL PROPERTIES.

Three mineral properties were examined and reported on during the year:

Holdsworth claims,
Rand Consolidated Mines property,
Heidelberg lands.

The first two are pyrite properties located in the Michipicoten District of Ontario, Canada, and were visited by Mr. Jopling and myself in September. They were both offered to this Company and declined.

The Heidelberg lands are located several miles East of Palmer on the Cascade Range and are underlain by the Cascade iron formation. Mr. Jopling also accompanied me on this examination, which was made in October. This property was also offered to this Company.

Tables No.V and No.VI, which follow, show a detailed statement of charges to Geological expense for the year and a comparative statement of charges to the Geological Department for the last three years and I believe are self-explanatory:

TABLE V.

DETAIL STATEMENT OF CHARGES TO GEOLOGICAL EXPENSE FOR YEAR 1920.

GEOLOGICAL DEPARTMENT.

<u>Salaries.</u>	<u>Travel.</u>	<u>Operating Autos.</u>	<u>Supplies.</u>	<u>Office Expense.</u>	<u>Total.</u>
\$18,846.76	\$412.74	\$1,189.45	\$1,365.96	\$199.30	\$22,014.21

DETAIL OF LARGER ITEMS GROUPED AS SUPPLIES AND OPERATING AUTOS.

Proportion of expense of painting building	-	\$187.50			
Rental of Maas Drill Hole Compass	- - -	50.00			
Map negatives, etc, from Childs Art Gallery	-	190.74			
Repairing Buick auto	- - - - -	279.40			
Depreciation of auto for Geological Department		237.50			
" " " " Eng. & Geol. Depts.	-	45.18 (Geol prop)			
" " truck " " " "	-	67.58 " "			

EXPENSES OF H. L. SMYTH.

<u>Travel.</u>	<u>Supplies.</u>	<u>Misc.</u>	<u>Total.</u>
\$548.32	\$17.87	\$120.00	\$686.19

EXPENSES ACCOUNT VISITING OUTSIDE EXPLORATIONS.

<u>Salaries.</u>	<u>Travel.</u>	<u>Total.</u>
\$105.85	\$91.81	\$197.66

SUMMARY.

Expenses of Geological Department	- -	\$22,014.21
" " H. L. Smyth	- - -	686.19
" a/c visiting outside explorations		197.66
Grand total		\$22,898.06

TABLE VI.

COMPARATIVE STATEMENT OF CHARGES TO THE GEOLOGICAL DEPARTMENT FOR

THE LAST THREE YEARS.

	<u>1920.</u>	<u>1919.</u>	<u>1918.</u>
Salaries - - - - -	\$18,846.76	\$18,890.02	\$16,694.85
Travel - - - - -	412.74	839.03	329.64
Operating autos - - - - -	1,189.45	1,000.09	796.56
Supplies - - - - -	1,365.96	1,309.03	1,409.31
Visiting outside explorations	197.66	72.41	254.22
Miscellaneous - - - - -	199.30	5.61	4.89
	<hr/>	<hr/>	<hr/>
Total	\$22,211.87	\$22,116.19	\$19,489.47
Expenses of H. L. Smyth, i.e. travel, supplies and miscella- neous - - - - -	686.19	642.52	763.86
	<hr/>	<hr/>	<hr/>
Grand total	\$22,898.06	\$22,758.71	\$20,253.33

ANGELINE MINE

There have been no changes or additions to the mechanical equipment at this mine during the year.

We have had considerable trouble with the Cameron centrifugal pump due to excessive wear on the revolving balance plate. This balance plate has been replaced by one having a steel face and the pump is now operating in a satisfactory manner. There were no delays to mining operations on account of the trouble with this pump.

All other mechanical equipment operated in a satisfactory manner.

CLIFFS SHAFT MINE

It was necessary to install a new Lake Shore Engine Works tram plant in order to stock the ore. This plant is of the standard type, with 6 ft. rubber lined sheave, and has a hauling speed of 750 ft. per minute. It is driven through a set of Falk herringbone gears by a General Electric 50 H. P. motor. This plant was started up on January 12th and operated satisfactorily.

There were no other changes or additions at this mine and all of the mechanical equipment operated in a satisfactory manner.

HARD ORE SHOPS

A Westinghouse Traction Brake Co., Type E-1, motor driven air compressor, capacity 56 cu. ft. per minute, has been installed in the Machine Shop. This compressor is to furnish air for the shop tools when the Lake Mine closes down.

There were no other changes or additions to the shop equipment.

HOLMES MINE

The Aldrich temporary plunger pump on the second level was taken out in February and stored on surface.

On December 31st, 1920, this mine started to furnish air to the Angeline Mine through a 6" air line.

There were no other changes and all mechanical equipment operated in a satisfactory manner.

LAKE MINE

The Ingersoll-Rand electric driven compressor was dismantled and shipped to the Maas Mine; also the Allis-Chalmers centrifugal pump that was used for circulating cooling water for this compressor. We are now using the Nordberg steam compressor to furnish air for the mine.

There were no other changes during the year and all mechanical equipment operated in a satisfactory manner.

SALISBURY MINE

The mechanical equipment at this mine operated in a satisfactory manner. There were no changes or additions during the year.

ATHENS MINE

On May 2nd a 10" tee in the pump discharge line broke at the 1,000 ft. level, making it necessary to pump the water to the Negaunee Mine for a few days until temporary repairs could be made. The new 10" tee was received in August and installed in the line. This discharge line is now in good condition.

A little trouble developed in the gear on the cage hoist. This gear was repaired and is now in good condition.

On September 5th a bad overwind occurred on the cage hoist. The

ATHENS MINE (Cont'd)

engineer hoisted the cage too high, breaking the counterweight rope off at the drum. The rope dropped inside of the counterweight pipe to the bottom of the shaft. The overwind attachment operated perfectly, but on account of having only one-half of a turn of rope on the drum when the counterweight is at the bottom of the shaft the brake did not operate fast enough to catch it as the hoist started to overspeed as soon as the power was cut off. It is impossible to get a better adjustment on this overwind as there is no over-speed attachment on it. An order has been placed for a Lilly Hoist Control for both the skip and cage hoist at this mine. This control has an over-speed attachment which should prevent any future accidents of this kind.

All other mechanical equipment operated in a satisfactory manner.

MAAS MINE

There have been a number of changes in the mechanical equipment at this mine. The old steam hoisting equipment has been replaced by electrical equipment.

The steam driven cage hoist was dismantled and it is now being rebuilt into an electric hoist to be used as a skip and cage hoist at the Princeton Mine. To replace this hoist we have installed a Lake Shore Engine Works hoist having a drum 10 ft. in dia. x 8 ft. face, with a rope capacity of 2,000 ft. of 1-1/8" rope. Hoisting speed is 1,048 ft. per minute. Maximum pull on rope 13,760 lbs. This hoist is driven through a set of Falk herringbone gears, enclosed in oil tight gear guards, by a General Electric induction motor, 400 H.P., 360 R.P.M., 2200 volts. This hoist is equipped with a Lilly Hoist Control which was manufactured by the Duro Metal Products Company. The automatic protection provided for includes the following:

- (a) Against failure of air supply.
- (b) " excessive overload.
- (c) " excessive drop in voltage.

MAAS MINE (Cont'd)

- (d) Against excessive overspeed in hoisting or lowering without power.
- (e) Against re-setting the primary circuit breaker until the brake is set and the primary reversing control is in the off position.
- (f) " overtravel.
- (g) " starting of motor when brake is set, but is so arranged that the brakes can be set with power on motor, which will act to cut off power.
- (h) A speed limit and slow down device that can be set at any speed at any desired point in the shaft.

This hoist was put in operation on March 11th. It is very satisfactory in every respect.

The old steam driven skip hoist was also dismantled and is now stored at the mine. It was replaced by a Lake Shore Engine Works electric driven hoist. This hoist has a drum 10 ft. in dia. x 8 ft. face, with a rope capacity of 2,000 ft. of 1 $\frac{1}{4}$ " rope. Hoisting speed is 1500 ft. per minute and maximum pull on rope 20,120 lbs. This hoist is driven through a set of Falk herringbone gears enclosed in an oil tight gear guard, the gears running in an oil bath at all times. The motor is a Westinghouse 700 H.P., 390 R.P.M., 2300 volt, equipped with liquid rheostat control. This is the only hoist motor with this type of control in use by this company. The application in general is very satisfactory. This hoist was put in operation on August 30th and has given satisfaction. It is also equipped with a Lilly Hoist Control same as the cage hoist.

It was necessary to build an addition to the power house to accommodate these two hoists. The installation of the hoists was completed without interfering in any way with the operation of the mine.

The Sullivan steam driven compressor was dismantled in July and is now stored at the mine. To replace this steam compressor we installed an Ingersoll-Rand electric driven compressor taken from the Lake Mine. This installation was completed October 23rd and the machine put in operation. We also moved the second Ingersoll-Rand compressor from a temporary building and installed it in the power house. This machine was put in operation in December. These compressors were built by the Ingersoll-Rand Company. They

MAAS MINE (Cont'd)

are Class P.R.E.-2, electrically driven, capacity 2443 cu. ft. per minute each, direct connected to a 400 H.P. General Electric motor. This gives us a combined capacity of 4,886 cu. ft. of air per minute. Both machines are operating satisfactorily.

On September 2nd we put in operation an electric driven tram plant to handle the rock. This plant replaces a steam plant formerly used. It was built by the Lake Shore Engine Works and is our standard type rubber lined sheave endless rope haulage 6 ft. sheave, with a rope speed of 750 ft. per minute. It is driven through a set of herringbone gears by a General Electric 50 H.P. motor, 600 R.P.M., 2200 volts. This machine is operating very nicely.

We are at present installing a steam heating plant in the Change House. It is a 50 H.P. locomotive type boiler and is located in an addition built for that purpose. The installation of this plant is necessary on account of the mine being entirely equipped with electric driven machinery and on account of having no steam in the main boiler plant when the steam turbine is not in operation.

All of the mechanical equipment operated in a satisfactory manner.

MAAS CRUSHING PLANT

This plant operated satisfactorily during the year. It was shut down on November 11th. There are a few minor repairs to be made to the conveyor, and the lump ore pocket has to be re-lined before the shipping season opens. These repairs are being taken care of and the plant will be ready for operation on time.

NEGAUNEE MINE

There were no changes or additions to the mechanical equipment during the year and all equipment operated in a satisfactory manner.

SOUTH JACKSON CRUSHER PLANT

The crusher was not used during the year.

On July 15th we completed the installation of an Ingersoll-Rand "Imperial" Type 10, Duplex, Short Belt Drive compressor, size 16"-10" x 14", capacity 599 cu. ft. per minute at 185 R.P.M. This machine is driven by a General Electric 100 H.P., 875 R.P.M. motor, and is operating very nicely. This machine replaced a 12 $\frac{1}{4}$ " x 12" Ingersoll-Rand compressor which was too small. The old compressor and motor was shipped to the Hill-Trumbull Mine.

There were no other changes in the equipment at this mine.

The plant was shut down on October 1st.

BARNES-HECKER MINE

On January 19th we completed the installation of the tram plant. This plant was built by the Lake Shore Engine Works and is our standard type. It has an 8 ft. rubber lined sheave and is driven through a set of herringbone gears by a General Electric 50 H.P., 575 R.P.M. motor. It has a rope speed of 1,300 ft. per minute. This plant will be used to stock ore.

On May 18th we completed the installation of the Aldrich triplex plunger pump and it was put in operation on August 12th. This pump is of the vertical type, size 10" x 16", capacity 1,000 G.P.M. against 1,000 ft. head. It is driven by a belt through a set of herringbone gears by a 350 H.P. General Electric motor, 885 R.P.M., 2300 volts. This pump has been in continuous operation and has not given us much trouble.

On September 11th we were pumping about 800 G.P.M., making it necessary to install another pump to help handle the water. We had a 1,000 G.P.M., 1,000 ft. head, 8" - 6-stage, Worthington centrifugal pump stored at the mine and this was installed in the same pump house as the Aldrich on the third level.

On September 18th we had some trouble with the Worthington centrifugal pump, making it necessary to get another pump from the Stephenson Mine.

BARNES-HECKER MINE (Cont'd)

This pump was installed on the second level on a temporary foundation. It was put in operation on September 29th. It is an Allis-Chalmers centrifugal pump, capacity 1,000 G.P.M.

During September and November concrete bulkheads were built in the drifts to stop the flow of water. If it becomes necessary these dams can be closed by putting in square timber or stop logs. In November and December we had a large increase in water, making it necessary to plug the second level dam with a slug of concrete as timber would not stand the excessive pressure. This is a very wet mine and we are pumping about all the water we can handle with the present equipment.

Three one-car Pneumatic Rotary Dumps were installed underground. These were built by the Wood Equipment Company and one was installed on each level to dump the mine cars into the skip. This equipment has given satisfaction.

LLOYD MINE

There were no changes at this mine and all mechanical equipment operated satisfactorily.

MORRIS MINE

A considerable amount of repairing was done to the two Prescott plunger pumps on the 4th level. The front end of the foundations were rebuilt and a sole plate put under the pumps. The gears were in very poor condition. They were re-cut and re-set; also ground in. This put both gears back in very good condition. We also put oil tight gear guards on so that the gears are now operating in a bath of oil, which should lengthen the life of the gears considerable.

There were no other changes or additions to the mechanical equipment and everything operated in a satisfactory manner.

SEC. 6 SHAFT

No changes or additions to the mechanical equipment.

AUSTIN MINE

This mine was idle the entire year, having been shut down Dec. 31, 1919.

FRANCIS MINE

Operation very satisfactory. No new installation or changes in the mechanical equipment.

GWINN MINE

Operation very satisfactory.

During the year a small electric driven sump pump was installed on the 9th level.

GWINN CRUSHING PLANT

This plant operated satisfactorily all season, with no delays of any consequence. It was shut down on November 6th.

A new conveyor belt will be needed for next season.

GARDNER MINE

With the exception of an overwind in March, in which the skip was badly wrecked, the operation of this mine was very satisfactory.

The mine was closed down on November 30th for an indefinite period.

MACKINAW MINE

On March 26th a main bearing burned out on the Nordberg air compressor due to lack of attention by the attendant.

On March the 23rd, while loading the skip at the 4th level the clevis connecting the rope and skip broke, allowing the skip to fall to the

MACKINAW MINE

(Cont'd)

bottom level and badly wrecking it.

In July, due to a misunderstanding of signals between the landers and the engineer, an overwind occurred and the skip was badly wrecked.

The mine was closed down on November 30th for an indefinite period. The underground pumps, however, are still in operation.

PRINCETON MINE

Operation satisfactory.

A new steel water line was laid from the 8" wood main to this mine in April.

A new hoist for this mine is under construction at the Lake Shore Engine Works. It is being built from the old drum and other available parts of the old Allis-Cahlmers cage hoist from the Maas Mine. This hoist is now overdue and the engine room and foundation are all ready for its installation.

A new 8 ft. Lake Shore Engine Works tram plant is on the ground ready for installation.

As soon as the hoist is received it is planned to shut down the mine and raise the shaft house 14 ft. and change over to the new hoist.

A small vertical electric driven pump, manufactured by the Chicago Pump Company, was installed in the old #1 Shaft in October and delivers the water up to #2 Shaft. The old pumps in #1 Shaft were taken out November 4th.

PRINCETON CENTRAL POWER PLANT

The fire at this plant on May 28th, which destroyed the coal dock and cooling tower and burned the roof of the boiler room and did some minor damage to the electric wiring outside the Substation, was the outstanding feature for the year. It was only a short job to replace the wiring and get the power plant functioning, so that all the mines were working again as usual on the 29th. Work was immediately started cleaning up the wreckage

PRINCETON CENTRAL POWER PLANT (Cont'd)

around the boiler plant preparatory to getting it back in working order should a shortage of water at the hydro-electric plants make it necessary to have the steam turbine help out in supplying current. This need developed in October and the work was rushed to completion. On October 24th the turbine was started and it has been working practically continuously since that time.

The fire proof tile roof was laid, but due to cold weather it was covered with a temporary tar paper covering to protect it until summer, when the felt covering will be cemented in place.

A temporary coal handling equipment was installed because the new one could not be supplied in time.

PRINCETON PUMP STATION

Service continuous and satisfactory.

In December a new 1,000 G.P.M. Allis-Chalmers centrifugal pump was installed in this station. It is driven by a 100 H.P. Allis-Chalmers motor. This pump was started up on December 11th and operates intermittently.

STEPHENSON MINE

Operation very satisfactory.

In January the gear and pinion on the Prescott plunger pump on the 5th level were re-set and ground in and a flexible coupling installed between the motor and pinion shafts. The pump has been working much better and quieter since this improvement.

In July the old Allis-Chalmers centrifugal pump in the 5th level pump station was re-lined and new shaft and impeller installed. The foundation was lowered, bringing the pump nearer the water in the sump, which was a decided improvement, as well as allowing the top casing to be removed

STEPHENSON MINE (Cont'd)

at any time for a quick repair or examination.

A new electric driven rock tram plant has been ordered to replace the old worn out steam plant. It has not yet been received.

In November a concrete dam was put in on the 5th level to hold back and control the water from a drill hole being sunk into this level from the surface. The purpose of this drill hole is to drain the basin formed by the ledge over the mine of all water. The purpose of the dam is to hold back and regulate the water, letting it flow to the 5th level pump station as the pumps there can handle it.

In September the 1,000 G.P.M. Allis-Chalmers centrifugal pump and motor was taken out and shipped to the Barnes-Hecker Mine.

BOEING MINE

A permanent hoist with 5' x 5' drum, built by the Lake Shore Engine Works and driven through one herringbone gear reduction by a 200 HP. General Electric motor, was received and placed in the engine house. A bad flaw was discovered in the drum. This was called to the attention of the Lake Shore Engine Works and a new drum was furnished. The hoist was placed in operation in March, but the proper overwind equipment was not secured until December. It is now attached and the hoist gives satisfaction.

After the permanent hoist was placed in operation, the temporary hoist used for sinking was moved into the engine house and installed to operate a light cage in the cage compartment.

The pump house excavation was finished in March, but it required several months more to cut sump and put in concrete bulkheads. After this the pumps were installed and the load was shifted from air driven to electric driven pumps on August 23rd. To date a flow of not more than 170 gallons per minute has been the maximum. The station is 18 ft. wide by 34 ft. long and contains two electric driven pumps, one a triplex plunger type and the other a centrifugal. The vertical triplex pump, made by The Aldrich Pump Company, has plungers 11" x 12" with a capacity of 850 G.P.M. against 350 ft. head, and is belt connected to a 100 H.P., 600 R.P.M., Form M., General Electric motor. The centrifugal pump was made by the Allis-Chalmers Manfg. Company. It has a capacity of 800 G.P.M., against 350 ft. head, and is direct connected to a 125 H.P., 1800 R.P.M., 2200 volt, Allis-Chalmers motor. The present pump house floor is only 190 ft. from surface, but the pumps were purchased heavy enough so that they may be lowered as conditions warrant.

A permanent Change House was completed and completely equipped with water and heat. A 125 H.P. boiler from the Helmer Mine boiler house was installed for heating.

To eliminate the high rent charged for transformers by the Great Northern Power Company a Substation was purchased and installed. This equipment consists of three 150 K.V.A. transformers, one three-phase Aluminum Cell

BOEING MINE (Cont'd)

Electrolytic Lightning Arrester and a steel Substation structure with horn gap switch, choke coils, fuses, etc., the whole supported on a concrete foundation. It was installed during the late summer and has given no trouble.

The underground haulage system consists of a motor-generator set in the engine house, two Type L.M.-2-T-6 six ton General Electric locomotives and fifteen 65 cubic ft. roller bearing tram cars designed to operated in a rotary dump located over shaft pocket. The General Electric Company motor-generator set consists of a 150 H.P., 2200 volt, synchronous motor direct connected to 100 K.W., 250 volt, D.C. generator. Some delay was experienced in getting this equipment running due to poor delivery of switchboard, which arrived a month after the motor-generator set was installed in the engine house. The haulage system was placed in operation on August 9th.

The one-car rotary dump was built by The Car Dumper & Equipment Company and is equipped with catches and trips so that a train of cars can be dumped independent of the locomotive after the first car is located in the dump.

An Armstrong "Shuveloder" was purchased for use in driving the main drifts. This broke down so frequently that before the year was over the manufacturers replaced it free of charge with a new one. The new one contains some radical improvements and it is hoped will give better service than the old machine.

CROSBY MINE

There were very few changes at this mine during the year.

The Marion "60" steam shovel was overhauled and after loading out the stockpile was shipped to the Meadow Mine in July.

In March the pumpman allowed the sump to overflow and drowned the motor on the skip pit pump.

In August some falling ground caught one "28" Marion shovel and pushed it over on its side.

In September a collision occurred between our #2 locomotive and a

CROSBY MINE (Cont'd)

Great Northern engine, due to misunderstanding of orders. No one was hurt and only some draw bar equipment was broken.

Very good use was made of the Shops during the summer for turning out work required at the Hill-Trumbull Mine and washing plant.

The 125 H.P. locomotive boiler was shipped to the Hill-Trumbull Mine for heating the Shops.

HILL-TRUMBULL MINE

Most of the rush work for the year occurred in completing the Washing Plant. The plant foundations were put in during the fall of 1919, and the remaining concrete work during the summer ahead of the steel erecting crew. The steel crew arrived on May 14th and the mill was placed in operation on August 22nd, washing 143,584 tons of concentrates before it was closed down for the winter on November 6th.

The main items of information in connection with the mill are as follows:

- 1 Concrete receiving bin, capacity 400 tons.
- 1 - 8 ft. Pan conveyor operated by 60 H.P. D.C. motor, feeds at variable speed between 0 and 30 ft. per minute.
- 1 Inclined bar grizzly, opening between bars 6".
- 1 - 5' Pan Conveyor operated by belt through clutch pulley on crusher shaft.
- 1 - 42" x 40" Superior type jaw crusher belt driven by 100 H.P. motor.
- 1 Merrick Patent Weightometer for 36" belt conveyor, maximum capacity 125 lbs. load per ft. of belt.
- 1 - 36" Belt conveyor furnished by Stevens-Adamson Manufacturing Company, feeding at rate of 300 ft. per minute. Inclination 20 degrees. Centers approximately 200 ft. Driven by 50 H.P. motor. Capacity 1,000 tons per hour.

HILL-TRUMBULL MINE (Cont'd)

- 1 - 6' x 12' Allis-Chalmers screen operated by 20 H.P. motor. Diameter of holes 1", 1½", and 2". R.P.M. 11.
- 2 - 25 ft. Hutch type Allis-Chalmers log washers, each operated by 25 H.P. motor. R.P.M. 13.
- 1 - 36" Picking belt conveyor, 20' centers. Speed 40 ft. per minute. Driven by 2 H.P. motor.
- 4 - 18 ft. Hutch type Allis-Chalmers log washers, each operated by 5 H.P. motor.
- 2 - 36" x 48" Chip screens, each operated through James Speed Reducer by 2 H.P. motor.
- 18 - Deister Overstrom Tables, single deck with rubber tops, driven by one 20 H.P. motor.
- 2 - 3" Concentrate Morris centrifugal pumps, each operated by 10 H.P. motor.
- 1 Dorr Classifier, operated from table countershafting.

Capacity of mill 2500 tons per 10 hour shift. Total rated motor capacity 671 H.P.

Water supplied from Little Penacie Lake 3,000 ft. from plant through 20" spiral riveted pipe by two 2,000 G.P.M. pumps, one a duplex plunger Prescott pump driven by 125 H.P. motor and one Allis-Chalmers centrifugal operated by 150 H.P. motor.

Tank - capacity 25,000 gallons - 97 ft. steel structure - 14 ft. diameter x 16 ft. high.

Rock disposal - by a 3-ton electric locomotive and three 65 cu. ft. rocker dump cars.

Power supplied by three - 150 K.V.A. transformers in Substation similar to one described at the Boeing Mine.

New equipment received for the mine included:

- 16 - 20 yd. Type "R#20" Kilbourne & Jacobs dump cars.
- 3 - 19" x 26" 060-134 six wheel Switching Locomotives built by the American Locomotive Company.
- 1 - 88-C Bucyrus steam shovel equipped with 3½ yd. manganese dipper.

A set of Shop Buildings was erected, consisting of machine, blacksmith and carpenter shop, with locomotive shed connected through an enclosed passageway. The machine shop is 50' x 100', with tool room, electrician's room, store room, compressor room and wash room on one side.

A standard gauge track runs through the center and the 12' x 16' rolling steel doors are large enough for the locomotives and shovels to run in.

HILL-TRUMBULL MINE (Cont'd)

This track is equipped with drop pit and hydro-pneumatic pit jack allowing drivers of locomotives to be removed without raising engine. The machine shop contains the following equipment:

- 1 - 10-ton Traveling crane over track.
- 1 - 24" South Bend lathe with 14' bed.
- 1 - 20" American Engine lathe with 8' bed.
- 1 - 48" Ryerson radial drill.
- 1 - 24" Hollingworth back geared crank shaper.
- 1 - 24" Silvers sliding head drilling machine.
- 1 - 32" x 32" x 8' "Grey" planer.
- 1 - 58" 200-ton Caldwell wheel press.
- 1 - #316 C Oster bolt and pipe threading machine.
- 1 - Floor grinder for emery wheels 14" x 2".
- 1 - Grindstone.

With the addition of a power hacksaw the shop will be complete.

The blacksmith shop is 50' x 50' and contains the following equipment:

- 1 - 10-ton Traveling crane.
- 2 - Forges.
- 1 - Ryerson steel punch and shearing machine, Type S.C.A.P.4.
- 1 - 2000 lb. Niles-Bement-Pond steam hammer.

The carpenter shop is 39' x 49' in size and contains the following:

- 1 - 5-ton Hand crane.
- 1 - #260 Fay & Egan variety saw.
- 1 - 36" Bank scroll saw.
- 1 - #316 Hand planer and jointer.

This shop is also equipped with track to run in broken dump cars.

The track in the machine shop extends through the blacksmith shop and three rolling steel doors permits a locomotive to run through both shops and out opposite end of the building.

The 125 H.P. boiler for heating system is located in the small

HILL-TRUMBULL MINE (Cont'd)

building attached to the blacksmith shop and the pipes were arranged with reducing valve so that the steam hammer can either be operated from this boiler or by an air compressor.

MEADOW MINE

A 3" suction line was put in for boiler feed pumps. This line connected to the surface water instead of the mine water and stopped scaling in the boilers.

The triple expansion pump was brought to surface and stored near the shaft house.

An excess flow of water was experienced during the summer. In previous years it was necessary for the compound condensing pump to work at maximum capacity from four to six weeks, but this year the flow lasted for five months and is still above normal. If the excess increases in like proportion next year a larger pumping equipment will be required.

WADE-HELMER MINE

Three of the four Lima locomotives were given a thorough overhauling. On removing one engine it was found that where 24 studs were supposed to hold it to the side of the boiler all were crystallized and broken off buth three. A new house was built over the "60" Marion shovel in addition to overhauling the engines. A new cab was put on #4 locomotive.

A 60-ton Bucyrus shovel, C.C.I. #20, was secured from the Gwinn District to load out the Wade stockpile.

Some lubricating troubles were experienced on the compressor due to poor oil and poor attendance. Both troubles have been improved, but some carbon still accumulates in the high pressure cylinder and has to be cleaned out every two months.

At the Helmer Incline hoist 4" of oil soaked concrete was removed from surface of foundation and the hoist re-grouted with an addition added to

WADE-HELMER MINE (Cont'd)

foundation to accommodate a 200 H. P. motor and gearing for attaching motor to drum. The economy of changing from steam to electric drive was shown in the saving of coal for the season. Where an average of 8 tons per day was used in 1919, the total power cost for 1920 was \$780.00. The tonnage hoisted in 1919 was 228,664, while in 1920 it was only 120,724, but even operating on one shift in 24 hours and using 4 tons of coal at \$12.50 per ton, the saving in 180 days is \$8,220.00 for power alone. There was the additional saving of one fireman at \$6.60 per day, which equals \$1,188.00, making the total saving for the season of 1920 \$9,408.00. This more than covers the cost of electrifying, which was \$8,845.00.

A new electric driven endless rope top tram plant was installed at the Wade Shaft. This is similar to the Boeing Mine plant and consists of a 6 ft. diameter rubber lined sheave driven through a herringbone gear by a 50 H.P. General Electric motor. It was started in November and has given us no trouble.

REPUBLIC MINE

The small underground hoist ordered from the Lake Shore Engine Works in 1918 for use on the 7th level in the Pascoe Shaft was received and installed. This hoist has a drum 5' x 5' and is driven by a 100 H.P., 450 R.P.M., 2200 volt, General Electric motor through double gear reduction, the main gearspur and secondary gears herringbone.

A small underground hoist with 4' x 6' drum, ordered from the Lake Shore Engine Works in 1918, was received and installed on the 9th level in #9 Shaft. This is driven by a General Electric 50 H.P., 600 R.P.M., 2200 volt motor through double gear reduction, main gears spur and secondary gears herringbone.

A new 72" x 12' Roller Type Spur Gear Driven Screen was purchased and installed during the year.

Two Lake Shore Engine Works endless rope haulage plants, with 6' rubber lined sheave, were received and installed for #9 Shaft top tram. The rope speed is 750 ft. per minute. They are driven by 50 H.P. General Electric 600 R.P.M., 3 phase, 60 cycle, 2200 volt motors. These plants were started up in December.

A 48-cell Storage Battery was ordered from the Electric Storage Battery Co. for the underground locomotive.

SPIES MINE

Operations were resumed at this mine in May.

The hoist motor, which was overhauled and repaired in the Hard Ore Shops, was returned to the mine and placed in service. Some improvements were made to the hoist control equipment.

A 2 $\frac{1}{4}$ ton gasoline locomotive was purchased from the Milwaukee Locomotive Manfg. Co. for use underground.

ELECTRICAL DEPARTMENT

The year 1920 has been a difficult one as regards power plant operation and a very satisfactory year when considered from the standpoint of power supplied and service rendered.

There were a number of reasons why the year was difficult in power plant operation. This was the fourth consecutive season with less than normal amount of rainfall, resulting in serious shortage of water. During the summer, particularly the month of July, very severe and unusual electrical storms occurred in series. The first ones injured our protective devices and the succeeding storms, following very soon thereafter, injured generating and switching apparatus. To add to our difficulties a fire occurred at the Princeton Central Power Plant, putting this generating plant out of service for several months.

In the use of power and service rendered conditions were very satisfactory, as we were able to supply uninterrupted service at a reasonable cost when fuel and labor were expensive and difficult to obtain.

Comparatively little new construction was undertaken and the increase in connected load has not been as great as during some other years.

Improvements and adjustment of capacity were made at the Brownstone and Maas Substations by moving three 600 K.V.A. transformers from the Brownstone to the Maas and installing three 400 K.V.A. General Electric outdoor type transformers at the Brownstone. These changes double the Substation capacity at the Maas, providing sufficient to care for the electrification of the compressor and hoists at the Maas Mine. The installation of outdoor transformers at the Brownstone decreases the fire hazard at this point.

Four high tension circuit breakers were installed in the Brownstone Substation; two of these having been released at the Carp Plant and one each at the Maas and Princeton Plants.

A bank of storage batteries was installed in the Brownstone Substation for emergency lighting and new feeder panels.

ELECTRICAL DEPARTMENT (Cont'd)

Two Westinghouse 50,000 volt circuit breakers were installed at the Carp Plant to replace the original circuit breakers, which were not of large enough capacity to rupture safely the high currents possible after the connection of the McClure Plant.

These changes and improvements increase the safety and very much facilitate the switching and segregating of circuits in case of trouble.

The construction of the new transmission line from the McClure Plant to the Maas Mine, E. & A. 403, is well along toward completion. This will practically double our line capacity from the two larger generating plants and should reduce the probability of serious interruption of service by about 50%. This new pole line will be 8 miles in length.

An extension of line to the L. S. & I. dock was made, the additional service to them increasing their consumption by nearly 100%.

A general overhauling of the hydraulic equipment in the Carp Plant was made and all worn and eroded parts replaced.

The governors on the water wheels at the Au Train Plant were repaired and adjusted by a man from the factory and are now in better condition than at any time since the original installation was made.

The generator at the Hoist Plant was rewound and a new governor pump installed.

Some corrections were made on the relief valves at the McClure Plant and we have somewhat better operating results than before.

Load limiting devices were attached to the governors at all plants except the Au Train.

The general mine installations have been gradually improved, particularly in the matter of switches and wiring, and we are holding well to good work as a standard. This policy has much to do with our low maintenance charges against electric equipment.

The considerable amount of construction on the Mesaba Range has been held up to our standards, and by following up the older work we feel

ELECTRICAL DEPARTMENT

(Cont'd)

that we have in general in that district a very creditable electrical installation and much better than the average. Permanent equipment for the conveyor at the Hill-Trumbull Washing Plant was not received in time to use the past season and temporary motors were used. We think that the variable speed drive, with Ward-Leonard system of control and driven by synchronous motor, is a decided departure from common practice and will result in very efficient operation, both electrically and also in product per man.

During the electrical storms in July practically all the switch gear and meters, also one bank of transformers, were burned out at the Carp Plant. Up to the close of the year replacement material had not been received. On account of this burnout we have not been able to measure the output of this Plant and have had to estimate the amount of current generated. The reported transmission losses, therefore, must be considered as estimated, and there is no reason for supposing that our losses were actually greater in 1920 than during the previous year.

The maintenance labor and material cost shows approximately \$20,000.00 decrease from the previous year in spite of the troubles which occurred. Our operating labor and material, however, has increased by about \$60,000.00 as compared with the previous year. This was due to coal and labor cost at steam plants. To produce 7% of our total output by steam cost us 46% of our total cost of production. Our total cost of steam-electric power was over \$100,000.00. There was a demand for electric current at our own properties which we could not supply, and which was made up by operating steam compressors and pumps at the mines, amounting to \$16,900.00. The outside commercial load which we could not carry amounted to about \$32,750.00. All of this should add to our profits about \$150,000.00 per year when adequate storage has been developed to carry us through dry periods.

Even though the Electric Power System was under stress a considerable part of the year, our power cost seems very reasonable, and it has been very satisfactory in every way in the matter of service.

There appears to be an increasing demand for commercial power at

ELECTRICAL DEPARTMENT (Cont'd)

profitable rates and it may be a good business proposition to encourage this class of business as a stabilizing load to fit in with our own power demands, which must vary somewhat from year to year.

During the year a study of the L. S. & I. R. R. was made with a view to possible electrification. While there are many matters which have a bearing on this and which are hard to report accurately, it is entirely possible that this development would prove a profitable one. The reports were submitted to the executives of the Railway Department.

In addition to the motors listed in the accompanying table we have the following in service:

10 A.C. Generators with aggregate capacity of	27,000 H.P.
64 Miscellaneous Direct Current Generators & Motors,	5,500 "
54 Mining Locomotives with 108 motors,	4,000 "

There are in round numbers 800 watt-hour meters in use and 350 service and Substation transformers for company and commercial purposes.

The usual graphic diagrams and detailed reports accompany this report.

ELECTRICAL DEPARTMENT (Cont'd)

SUMMARY OF OPERATING CONDITIONS - 1920.

Month	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Precipitation	0.60	0.80	2.53	2.52	0.85	3.93	4.96	3.68	2.26	1.14	2.36	1.77
Total Precipitation for 1920 (Ishpeming)	- 27.4 inches.											
Average " at Marquette	- 32.8 " (46 years record)											

CARP RIVER HYDRO-ELECTRIC PLANT

Drainage area above Intake Dam,	66.66 sq. mi.											
Cubic feet Precipitation in 1920,	4,237,093,000											
K. W. Hrs. generated at Carp River Plant in 1920,	15,471,100											
Cubic feet water utilized (90 cu. ft. = 1 KWH)	1,392,399,000											
" " " in Storage Basin Jan. 1, 1920,	229,725,000											
" " " " " " Dec. 31, "	204,682,000											
" "" " stored in 1919 used in 1920,	25,043,000											
" " " wasted over Intake Dam in 1920,	116,020,000											
Total run-off for the year 1920,	1,533,462,000											
Run-off per sq. mile of drainage area,	23,010,000											
	<u>1913</u>	<u>1914</u>	<u>1915</u>	<u>1916</u>	<u>1917</u>	<u>1918</u>	<u>1919</u>	<u>1920</u>				
Total Precipitation,	30.11	26.53	38.41	36.83	25.46	31.05	29.50	27.40"				
Second ft. per sq. mile,	1.03	.67	.93	1.29	.70	.79	.83	.73				

McCLURE HYDRO-ELECTRIC PLANT

Drainage area above Intake Dam,	140.52 sq. mi.											
Cubic feet Precipitation in 1920,	8,931,848,000											
K. W. Hrs. generated at McClure Plant in 1920,	24,477,200											
Cubic feet water utilized (125 cu. ft. = 1 KWH)	3,049,650,000											
" " " in Storage Basin Jan. 1, 1920,	---											
" " " " " " Dec. 31, "	---											
" " " stored in 1919 used in 1920,	---											
" " " wasted over Intake Dam in 1920,	2,383,618,000											
Total run-off for the year 1920,	5,433,268,000											
Run-off per sq. mile of drainage area,	38,600,000											

ELECTRIC POWER SYSTEM

SUMMARY OF OPERATIONS - 1920.

	KILOWATT HOURS GENERATED						TOTAL	Used by Auxiliaries	Delivered to Line	K. W. H. Sold	Losses	Cost Per K. W. H. (Incl. Depr.)
	McClure	Carp	Hoist	Au Train	Maas	Princeton						
Jan.	2,034,900	1,469,200	394,000	172,050	70,100	0	4,140,250	14,584	4,125,666	3,424,798	16.99%	\$.00593
Feb.	1 631 100	1 433 200	329 000	121 660	527 050	0	4 042 010	36 551	4 005 459	3 432 145	14.31	.00821
March	1 642 100	1 167 200	348 000	126 810	398 050	412,900	4 095 060	61 813	4 033 247	3 468 530	14.00	.00984
April	2 334 600	1 050 700	516 000	497 090	0	0	4 398 390	8 850	4 389 540	3 662 147	16.57	.00545
May	1 638 900	1 667 000	609 000	478 860	0	0	4 393 760	8 223	4 385 537	3 672 639	16.25	.00536
June	2 438 500	1 378 000E.*	446 000	212 020	0	0	4 474 520	6 662	4 467 858	3 678 221	17.67*	.00568
July	2 499 200	1 316 400E.	418 000	199 130	0	0	4 432 730	8 517	4 424 213	3 609 122	18.44*	.00558
Aug.	2 776 900	1 325 000E.	302 000	105 330	0	0	4 509 230	8 149	4 501 081	3 618 364	19.60*	.00570
Sept.	1 689 200	1 885 900E.	261 000	115 280	348 000	0	4 299 380	30 078	4 269 302	3 474 610	18.61*	.00861
Oct.	1 547 100	1 453 600E.	326 000	141 620	622 200	8,600	4 099 120	48 558	4 050 562	3 338 623	17.58*	.01216
Nov.	1 985 700	636 300E.	383 000	181 600	477 500	327 600	3 991 700	75 332	3 916 368	3 259 565	16.77*	.01607
Dec.	2 259 000	688 600E.	496 000	297 070	302 100	215 800	4 258 570	50 495	4 208 075	3 460 701	17.76*	.01468
TOTALS	24,477,200	15,471,100	4,828,000	2,648,520	2,745,000	964,900	51,134,720	357,812	50,776,908	42,099,465	17.09	\$.00850

*Note:-

Output of Carp Plant estimated since June 7th. Meter transformers burned out on that date. This accounts for losses being high the balance of the year.

ELECTRICAL DEPARTMENT

(Cont'd)

The following alternating current motors are installed and operating as needed:

	INSTALLED TO JAN. 1, 1920	INSTALLED IN 1920	TAKEN OUT IN 1920	CONNECTED JAN. 1, 1921 TOTALS
CARP RIVER POWER HOUSE -				
Auxiliaries - 2 - 15 HP pump motors	30 HP.			
Water Supply Pump	<u>1</u>			
				31 HP.
ANGELINE MINE -				
Hoist	250			
Underground Haulage Set	150			
Top Tram	10			
Underground Centrifugal Pump	100			
Surface Drainage Pump - East End		<u>15</u>		
				525
CLIFFS SHAFT MINE -				
Shop	25			
No. 8 Crusher	125			
No. 5 Crushers - 2 - 25 HP motors	50			
Screens	15			
Top Tram	50			
Lower Tram	35			
Underground Haulage Set	100			
Hoist for "A" Shaft	500			
Underground Plunger Pump No. 1	180			
" Centrifugal Pump	250			
Compressor - Allis-Chalmers	175			
Hoist for "B" Shaft	500			
Underground Plunger Pump No. 2	200			
Laboratory Crusher	5			
Coal Crushing Plant	15			
" " " Exhaust Fan	$\frac{1}{2}$			
Lower Tram No. 2	50			
Cooling Water Pump	10			
Ingersoll-Rand Compressor #1	400			
" " " #2	<u>400</u>			
				3,085 $\frac{1}{2}$
HARD ORE -				
Machine Shop	7 $\frac{1}{2}$			
Carpenter Shop	25			
Blacksmith Shop Punch	3			
Water Supply Pump in Shop	2			
Armature Banding Machine	2			
" " "	$\frac{1}{8}$			
" " "	1/8			
Lathe Grinder	1			
Portable Drill	$\frac{1}{4}$			
" " - Large	$\frac{1}{4}$			
Commutator Slotter	1/8			
Air Compressor		<u>10$\frac{1}{2}$</u>		
				52 $\frac{1}{4}$
BROWNSTONE SUBSTATION -				
Test Set	$\frac{1}{2}$			
Oil Filter Press	$\frac{1}{4}$			
Battery Charging Motor-Generator Set		<u>3</u>		
				3 $\frac{3}{4}$
fwd.	<u>3,669 HP.</u>	<u>28$\frac{1}{2}$ HP.</u>	0	<u>3,697$\frac{3}{4}$</u>

ELECTRICAL DEPARTMENT (Cont'd)

		INSTALLED TO JAN. 1, 1920	INSTALLED IN 1920	TAKEN OUT IN 1920	CONNECTED JAN. 1, 1921 TOTALS
HARD ORE #3 SHAFT -	brt. fwd.	3,669 HP.	28½ HP	0	3,697½
Hoist		25			
Sinking Pump (stored)		150		150	
Underground Centrifugal Pump			50		
Sinking Pump (from Gardner-Mackinaw)			35		
U.G. Plunger Pump (from Spies Mine)			<u>125</u>		
					235
HOLMES MINE					
Air Compressor		340			
" " Cooling Water Pump		3			
Skip Hoist		400			
Cage "		400			
Underground Haulage Converter		150			
Machine Shop		7½			
Top Tram		25			
No. 8 Crusher		100			
No. 6 Crushers - 2 - 40 HP. motors		80			
Screens		20			
Laboratory Crusher		2			
Temporary Underground Plunger Pump (to Gwinn)		50		50	
Permanent " " "		250			
" " Centrifugal Pump		<u>400</u>			
					2,177½
LAKE MINE					
Underground Haulage Set		215			
Surface Drainage Pumps - 2 - 30 HP. motors		60			
" " Pump		50			
" " "		20			
" " "		5			
Underground Plunger Pump		75			
" Centrifugal Pump		125			
" Ventilating Fan		40			
Ore Crusher		25			
Coal Crushing Plant		15			
Air Compressor (sent to Maas Mine)		400		400	
" " Cooling Water Pump (to Maas Mine)		<u>3</u>		3	
					630
SALISBURY MINE					
Hoist		400			
Underground Centrifugal Pump		400			
" Plunger "		100			
" Ventilating Fan		7½			
Compressor Cooling Water Pump		2			
Surface Drainage Pump		30			
Compressor (to H.O.Shop for repairs)		150		150	
" (from H.O.Shop - rewind)			<u>150</u>		
					1,089½
	fwd.	8,194	388½	753	7,829½

ELECTRICAL DEPARTMENT (Cont'd)

	brt. fwd.	INSTALLED TO JAN. 1, 1920	INSTALLED IN 1920	TAKEN OUT IN 1920	CONNECTED JAN. 1, 1921 TOTALS
ATHENS MINE -		8,194 HP.	389½ HP.	753 HP.	7,829½ HP.
Cage Hoist		400			
Compressor		325			
" Cooling Water Pump		3			
Auxiliary Compressor (for hoist brakes)		5			
Underground Ventilating Fan		15			
Sinking Pump (1080 ft. station)		35			
" " (2400 " ")		50			
Skip Hoist Set		850			
" " " Oil Pump		1			
Shop		10			
Underground Haulage Converter		150			
Skip Pit Pump		2			
Laboratory Crusher		5			
Underground Plunger Pump #1		400			
Top Tram - 2 - 50 HP. motors		100			
Carpenter Shop		20			
Underground Ventilating Fan		15			
" Plunger Pump #2		400			
					2,786
MAAS MINE -					
(Circulating Pump		40			
Turbine Auxiliaries (Injection " (Exciter		25			
		33			
Underground Haulage Set		215			
Shop		10			
Underground Centrifugal Pump		350			
" Hoist		50			
" Plunger Pump #1		320			
Winze Pump (4th level)		15			
Compressor Cooling Water Pump		5			
Skip Pit Hoist		15			
Top Tram - 2 - 50 HP. motors		100			
Coal Crushing Plant		15			
" " " Exhaust Fan		½			
Underground Plunger Pump #2		250			
Ingersoll-Rand Air Compressor		400			
Small Air Compressor for U.G. Pumps		2			
Ingersoll-Rand Compressor (from Lake Mine)			400		
Compressor Cooling Water Pump (from Lake)			3		
Rock Tram			50		
Skip Hoist			700		
Cage Hoist			400		
					3,398½
MAAS CRUSHING PLANT -					
Crusher		100			
Pan Conveyor		50			
Belt "		50			
					200
	fwd.	13,025½ HP.	1,941½ HP.	753 HP.	14,214 HP.

ELECTRICAL DEPARTMENT (Cont'd)

	INSTALLED TO JAN. 1, 1920	INSTALLED IN 1920	TAKEN OUT IN 1920	CONNECTED JAN. 1, 1921 TOTALS
	13,025½	HP. 1,941½	753	14,214 HP.
NEGAUNEE MINE -				
Underground Haulage Set	215			
"Ilgner" Hoist Set	450			
Top Tram - 2 - 50 HP. motors	100			
Laboratory Crusher	5			
Auxiliary Compressor (for hoist brakes)	3			
U.G. Plunger Pumps - 2 - 300 HP. motors	600			
" Centrifugal Pump	350			
" Suction Pumps - 2 - 15 HP. motors	30			
Compressor Cooling Water Pump	3			
Nordberg Air Compressor	325			
Shop	15			
Skip Pit Pump	5			
Ore Crusher	25			
Ingersoll-Rand Air Compressor	400			
Commutator Grinder	1			
12th Level Plunger Pump	15			
11th " " "	75			
Exciters for U.G. Pump Motors (2)	40			
11th Level Plunger Pump #2		75		
Hoist at #2 Shaft		<u>25</u>		
				2,757
SOUTH JACKSON CRUSHER PLANT -				
Hoist	75			
Compressor (sent to Hill-Trumbull)	50		50	
Crusher	150			
Compressor		<u>100</u>		
				325
BARNES-HECKER MINE -				
Cage Hoist	400			
Skip "	400			
Water Supply Pump	10			
Underground Haulage Converter	150			
Temporary Underground Plunger Pump (stored)	50		50	
Underground Ventilating Fan	15			
" Centrifugal Pump (from Stephenson)		400		
Top Tram		50		
Underground Plunger Pump		350		
" Centrifugal Pump		<u>400</u>		
				2,175
LLOYD MINE -				
Skip Hoist	400			
Cage "	400			
Top Tram	40			
" "	40			
Ore Crusher	<u>25</u>			
				905
MORRIS MINE -				
Skip Hoist	400			
Cage "	400			
Shop	25			
Water Supply Pump	40			
" " "	50			
Ingersoll-Rand Air Compressor	250			
U.G. Plunger Pumps - 2 - 350 HP. motors	700			
fwd.	<u>17,887½</u>	<u>HP. 3,341½</u>	<u>853 HP.</u>	<u>20,376 HP.</u>

ELECTRICAL DEPARTMENT (Cont'd)

	INSTALLED TO JAN. 1, 1920	INSTALLED IN 1920	TAKEN OUT IN 1920	CONNECTED JAN. 1, 1921 TOTALS
brt. fwd.	17,887 $\frac{1}{2}$ HP.	3,341 $\frac{1}{2}$ HP.	853	20,376 HP.
MORRIS MINE (Cont'd)	1,865			
Laboratory Crusher	5			
Carpenter Shop	25			
Underground Haulage Set	150			
Nordberg Air Compressor	325			
Compressor Cooling Water Pump	5			
Winze Plunger Pump	50			
" Centrifugal Pump	50			
Triplex Pump	50			
Top Tram - 2 - 50 HP. motors	<u>100</u>			
				2,625
SECTION 6 SHAFT -				
Hoist	200			
Water Supply Pump	<u>3</u>			
				203
AUSTIN MINE -				
Laboratory Crusher	3			
Hoist	200			
Top Tram	<u>25</u>			
				228
FRANCIS MINE -				
Underground Ventilating Fan	7 $\frac{1}{2}$			
Air Compressor	403			
Underground Centrifugal Pump	400			
Skip Hoist	400			
Compressor Cooling Water Pump	3			
Shop	5			
Top Tram	50			
Underground Haulage Converter	150			
Cage Hoist	400			
Underground Plunger Pump	350			
Rock Crusher	25			
Ore Tram	<u>37</u>			
				2,230 $\frac{1}{2}$
GWINN MINE -				
Skip Hoist	400			
Cage "	400			
Underground Centrifugal Pump	400			
" Plunger "	350			
Top Tram - Ore	37			
Underground Haulage Set	150			
Rock Tram	10			
Shop	5			
9th Level Pump	<u>35</u>			
				1,787
GWINN CRUSHING PLANT -				
Crusher	85			
Pan Conveyor	50			
Belt "	<u>40</u>			
				175
GARDNER MINE -				
Hoist	400			
Top Tram	<u>25</u>			
				425
fwd.	<u>25,561</u> HP	<u>3,341$\frac{1}{2}$</u> HP	<u>853</u>	<u>28,049$\frac{1}{2}$</u> HP.

ELECTRICAL DEPARTMENT (Cont'd)

	INSTALLED TO JAN. 1, 1920	INSTALLED IN 1920	TAKEN OUT IN 1920	CONNECTED JAN. 1, 1921 TOTALS
	25,561 HP.	3,341½ HP.	853 HP	28,049½ HP.
MACKINAW MINE				
brt. fwd.				
Hoist	400			
Compressor	325			
Shop	7½			
Sinking Pump	7½			
Top Tram	25			
Underground Haulage Converter	150			
" Triplex Pump (to Morris Mine)	100		100	
" Plunger Pump	350			
Compressor Cooling Water Pump		<u>3</u>		1,268
PRINCETON MINE #1				
Underground Plunger Pump (taken out and)	50		50	
" Centrifugal " (stored)	50		<u>50</u>	0
PRINCETON MINE #2				
Hoist	200			
Top Tram - 2 - 50 HP. motors	100			
Underground Plunger Pump	150			
" Centrifugal "	<u>125</u>			575
PRINCETON MINE #3				
Hoist	<u>75</u>			75
STEPHENSON MINE				
Top Tram	50			
Aldrich 5th Level Plunger Pump	250			
Prescott " " " "	250			
Underground Centrifugal "	275			
" " " " (to Barnes-Hecker)	400		400	
" " " " (6th Level)	50			
Top Tram		<u>50</u>		925
PRINCETON CENTRAL POWER PLANT				
(Circulating Pump)	50			
Turbine Auxiliaries (Injection ")	25			
(Exciter)	33			
Underground Haulage Set	215			
Compressor	625			
" Cooling Water Pump	7½			
Boiler Room Fan)	25		25	
Coal Crushing Plant) Destroyed by	15		15	
" " " Exhaust Fan) fire.	½		½	
Boiler Room Fan (from Gen'l Storehouse)		<u>40</u>		995½
PRINCETON CENTRAL SHOPS				
Shop Motor	25			25
PRINCETON CENTRAL PUMP STATION				
Centrifugal Pump		<u>100</u>		100
McCLURE PLANT				
Water Supply Pump		<u>2</u>		2
HOIST PLANT				
Exciter Motor-Generator Set	<u>20</u>			20
fwd.	29,992 HP.	3,536½ HP.	1,493½	32,035 HP.

MECHANICAL DEPARTMENT

ELECTRICAL DEPARTMENT (Cont'd)

	brt.	INSTALLED TO JAN. 1, 1920	INSTALLED IN 1920	TAKEN OUT IN 1920	CONNECTED JAN. 1, 1921 TOTALS
ISHPEMING HOSPITAL		29,992 HP.	3,536½ HP.	1,493½	32,035 HP.
Passenger Elevator		7½			
Dumb Waiter		3			
Large Washer		2			
Small "		1			
Extractor		2			
Vacuum Cleaner		3			
" Pump		1			
					19½
REPUBLIC MINE					
Crusher		25			
"		100			
Auxiliary Air Compressor (for hoist brakes)		5			
Pump in Engine House		75			
Centrifugal Pump in Engine House		20			
Coal Tram		7½			
Pump		20			
Pascoe Shaft Tram		30			
Machine Shop		5			
Pump - 4th Level		15			
" - 3rd "		50			
Pascoe Shaft Underground Pump		50			
" " Top Tram		15			
Portable Hoist		7½			
Laboratory Crusher		3			
Picking Belt		5			
Fan		7½			
Screen		10			
Tram		15			
Carpenter Shop		20			
#9 Shaft Hoist - 2 - 500 HP. motors		1,000			
Motor-Generator Set for Underground Haulage		30			
Underground Hoist		100			
9th Level Winze Hoist		50			
#9 Shaft Top Tram - 2 - 50 HP. motors			100		
					1,765½
TOTAL MINING DEPARTMENT		31,677 HP.	3,636½ HP.	(1,493½)	33,820 HP.
PIONEER FURNACE					
Motor-Generator Set		750			
Sawmill (8 motors)		445			
					1,195
L. S. & I. RY.					
Shops)					
Ore Dock & Pumps)		800			
Sawmill)					800
MARQUETTE BRANCH PRISON					
3 Motors		180			
					180
MUNISING WOODENWARE COMPANY					
Veneer Mill (13 motors)		695			
Woodenware Mill (returned to Gen. Storehouse)		100		100	
					695
ELECTRIC LIGHT & POWER CO., MUSING					
City Pumping		125			
					125
REPUBLIC TOWNSHIP					
Water Supply Pump		25			
GRAND TOTAL CONNECTED LOAD		34,797 HP.	3,636½ HP.	(1,593½)	36,840 HP.

ELECTRICAL DEPARTMENT (Cont'd)

The following motors are not connected to our General Power System:

	INSTALLED TO JAN. 1, 1920	INSTALLED IN 1920	TAKEN OUT IN 1920	CONNECTED JAN. 1, 1921 TOTALS
SPIES MINE				
Hoist	200 HP.			
Triplex Pump	50			
Crusher	50			
Air Compressor	200			
Grinder in Shop			<u>3</u>	
				503 HP.
MESABA RANGE -				
BOEING MINE				
Sinking Hoist	35			
Air Compressor	200			
Underground Plunger Pump	100			
" Centrifugal "	125			
" Haulage Set			150	
Hoist			200	
Top Tram			50	
Compressor Cooling Water Pump			2	
Shop			10	
Sump Pump			<u>7½</u>	
				879½
CROSBY MINE				
Hoist	75			
Air Compressor	50			
Plunger Pump	50			
Centrifugal Pump	85			
Shop	3			
Conveyor Belt	40			
Screen	20			
Picking Belt	3			
Log Washer	20			
Turbo	20			
Chip Screen	3			
Tables	20			
Underground Haulage Set	150			
Feeder Motor	20			
Shop	5			
Centrifugal Pump	85			
Sump Pump			<u>5</u>	
				654
HELMER MINE				
Pump	20			
Hoist			200	
Sump Pump			<u>5</u>	
				225
WADE MINE				
Hoist	125			
Air Compressor	150			
" " Cooling Water Pump	2			
Underground Haulage Set	150			
Machine Shop	20			
Pump	50			
Centrifugal Pump	100			
Sump Pump	5			
Ventilating Fan	15			
Top Tram			50	
Locomotive Water Pump			5	
Clear " "			<u>15</u>	
				687
	fwd.	2,246 HP.	702½ HP.	0
				<u>2,948½ HP.</u>

ELECTRICAL DEPARTMENT (Cont'd)

	INSTALLED TO JAN. 1, 1920	INSTALLED IN 1920	TAKEN OUT IN 1920	CONNECTED JAN. 1, 1921 TOTALS
brt. fwd.	2,246 HP.	702½ HP.	0	2,948½ HP.
HILL-TRUMBULL MINE				
Temporary on Feeder		50		
Log Washers - 2 - 25 HP. motors		50		
Turbos - 4 - 5 " "		20		
Picking Belt		2		
Chip Screens - 2 - 2 " "		4		
Crusher		100		
Screen		7½		
Sand Pumps - 2 - 10 " "		20		
Prescott Plunger Pump		150		
Centrifugal Pump		150		
Conveyor		50		
Tables		20		
Shops		30		
Punch & Shear Machine in Shop		5		
Band Saw in Carpenter Shop		5		
Compressor (from South Jackson)		50		
				<u>713½</u>
TOTAL	2,246 HP.	1,416 HP.	0	3,662 HP.

The following motors are on hand (Dec. 31, 1920), but are not installed:

CLIFFS SHAFT MINE				
Top Tram (stator only)				50 HP.
GENERAL STOREHOUSE				
Spare Motor-Generator Set				15 HP.
" from Athens				10
" " Republic concrete mixer				5
" General Electric Top Tram				50
" " " Pump				50
" Westinghouse Motor-Generator Set				220
" Allis-Chalmers				30
" " "				10
" from McClure Plant				7½
" Hoist Motor				400
" motor				5
" from Stephenson pump				250
" " " "				275
" " Salisbury compressor				<u>150</u>
				1,477½
HARD ORE #3 SHAFT				
Centrifugal Sinking Pump (from Austin)				150
Plunger Pump (" Mackinaw)				<u>35</u>
				185
NEGAUNEE MINE				
Flywheel Hoist Set				350
BARNES-HECKER MINE				
Small Plunger Pump				50
MORRIS-LLOYD MINE				
Underground Haulage Set Motor				150
U.G. Triplex Pump (from Mackinaw)				100
" Centrifugal Pump (for 1450 ft. level)				<u>175</u>
				425
				fwd. 2,537½ HP.

MECHANICAL DEPARTMENT

ELECTRICAL DEPARTMENT (Cont'd)

Motors on hand.	brt. fwd.	2,537½ HP.
AUSTIN MINE		
Laboratory Crusher Motor	3	3
GWINN MINE		
Plunger Pump (from Holmes)	50	
Sump Pump	<u>20</u>	70
MACKINAW MINE		
Centrifugal Pump		75
PRINCETON CENTRAL POWER PLANT		
Rock Crusher from Francis	25	
New Motor for Fan	<u>50</u>	75
STEPHENSON MINE		
Plunger Pump	50	
Layne & Bowler Pump #2	<u>350</u>	400
REPUBLIC MINE		
Spare	10	
"	<u>10</u>	20
LOANED TO MUNISING WOODENWARE CO.		<u>100</u>
TOTAL ON HAND 12/31/20		3,280½ HP.

Sold:
Layne & Bowler #1 from Stephenson Mine 250 HP.

Spare motors on Mesaba Range:

CROSBY MINE		
Pump	20	
"	3	
Sump Pump	<u>3</u>	26 HP.
WADE MINE		
Pump		<u>5</u>
TOTAL		31 HP.

The following motors have been ordered, but not received up to Dec. 31st, 1920:

MAAS MINE		
Auxiliary Air Compressor for brakes		2 HP.
PRINCETON MINE		
Top Tram		50
STEPHENSON MINE		
Rock Tram		25
HILL-TRUMBULL MINE		
Motor-Generator Set	75	
Spare Log Washer motor	<u>40</u>	
TOTAL		<u>115</u> 192 HP.

ELECTRICAL DEPARTMENT (Cont'd)

Total C.C.I.Co. load connected to General Power System -	33,820 H.P.
" Outside " " " " " " -	3,020 "
" connected load at Spies Mine -	503 "
" " " Minnesota Mines -	3,159 "
" Spare Motors on hand Dec. 31st, 1920, Ish. Dist. -	3,280 $\frac{1}{2}$ "
" " " " " " " Minn. " -	31 "
" Sold -	250 "
" Ordered, but not received - Ishpeming District -	77 "
" " " " " - Minnesota " -	115 "

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COMPARATIVE TABLES

YEAR	TONS COAL BURNED	TONS ORE & ROCK HOISTED	CU.FT. AIR USED	CUBIC FT. AIR PER TON HOISTED	GALLONS OF WATER PUMPED
<u>ANGELINE MINE</u>					
1916	----	5,772	6,128,112	1,060	
1917	----	38,310	23 257 417	607	
1918	442	57 814	79 443 122	1 374	
1919	423	48 580	89 137 049	1 834	57 792 500
1920	177	50 249	82 011 330	1 632	54 307 500
<u>CLIFFS SHAFT MINE</u>					
1905	7,421	204,645	271,587,404	1,355	353,087,800
1906	9 204	272 735	451 440 636	1 794	--- --- ---
1907	8 880	302 924	692 018 970	2 239	242 599 222
1908	7 991	228 886	541 729 740	2 367	240 000 000
1909	7 328	242 573	680 932 960	2 796	166 079 249
1910	8 895	252 793	904 379 312	3 577	156 948 550
1911	8 095	246 334	898 424 112	3 647	165 101 640
1912	8 047	276 211	810 020 228	2 932	218 555 480
1913	8 027	295 105	833 987 419	2 826	276 582 240
1914	7 496	316 986	1 054 320 348	3 326	281 392 090
1915	5 181	347 955	889 280 382	2 555	283 489 900
1916	5 226	368 090	878 041 710	2 262	398 818 855
1917	4 500	377 177	885 993 944	2 349	345 847 725
1918	5 135	382 804	861 374 720	2 276	315 252 828
1919	3 494	377 901	907 895 024	2 402	298 889 689
1920	3 854	334 347	872 225 408	2 638	262 308 003
<u>HOLMES MINE</u>					
1916	729	32,951	---	---	---
1917	739	90 225	425 227 500	4 712	---
1918	700	130 295	368 456 686	2 840	---
1919	947	173 178	521 145 000	3 009	(8 months) 25 471 515
1920	682	260 118	448 965 000	1 726	26 099 690

COMPARATIVE TABLES

YEAR	TONS COAL BURNED	TONS ORE & ROCK HOISTED	CU. FT. AIR USED	CUBIC FT. AIR PER TON HOISTED	GALLONS OF WATER PUMPED
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HARD ORE #3 HEATING PLANT

1913	729				
1914	810				
1915	883				
1916	922				
1917	1,038				
1918	955				
1919	970				
1920	801				

LAKE MINE

1902	8,400	470,728	440,196,332	952	64,188,597
1903	8 502	468 277	441 329 198	993	70 848 359
1904	6 983	281 399	355 084 057	1 368	78 662 195
1905	10 346	505 321	885 737 363	1 753	77 492 105
1906	11 072	559 877	784 511 853	1 247	80 626 208
1907	10 934	549 449	773 662 287	1 410	90 105 988
1908	9 222	357 628	575 642 546	1 671	76 896 881
1909	9 640	381 060	826 433 227	2 245	81 268 184
1910	9 892	559 438	820 568 713	1 466	85 118 000
1911	7 558	309 519	583 930 820	1 886	93 643 210
1912	7 824	329 344	656 627 987	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
1915	6 019	359 185	586 965 354	1 634	96 375 565
1916	6 708	397 021	637 468 347	1 605	192 033 482
1917	7 181	497 272	782 431 925	1 573	134 142 986
1918	6 588	457 399	592 308 718	1 294	145 707 330
1919	5 884	334 419	510 718 170	1 527	192 626 467
1920	5 558	167 590	447 465 848	2 670	177 012 016

MECHANICAL DEPARTMENT

COMPARATIVE TABLES

YEAR	TONS COAL BURNED	TONS ORE & Rock HOISTED	CU. FT. AIR USED	CUBIC FT. AIR PER TON HOISTED	GALLONS OF WATER PUMPED
<u>SALISBURY MINE</u>					
1905	3,750	154,017	219,765,211	1,423	76,346,425
1906	3,909	152,034	219 345 241	1 461	77 100 543
1907	3 892	139 986	215 971 327	1 551	86 056 044
1908	3 606	116 724	218 591 828	1 895	66 957 839
1909	3 537	99 140	218 841 412	2 228	61 699 506
1910	3 308	113 574	162 828 098	1 433	63 430 079
1911	3 158	111 272	148 067 843	1 330	61 654 458
1912	2 788	118 635	154 493 210	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
1915	522	27 150	134 776 200	---	53 503 200
1916	496	100 803	273 558 000	2 713	126 831 364
1917	445	104 082	188 563 500	1 811	104 560 277
1918	436	113 073	166 455 000	1 472	100 958 079
1919	617	115 764	228 578 500	1 974	144 138 375
1920	482	112 603	216 351 000	1 921	152 694 797
<u>ATHENS MINE</u>					
1914	231	7,404	120,048,750	- - - -	- - - - -
1915	385	21 245	242 196 750	- - - -	- - - - -
1916	419	26 930	222 840 000	- - - -	- - - - -
1917	277	23 988	211 612 500	- - - -	- - - - -
1918	609	101 394	498 600 000	- - - -	- - - - -
1919	740	155 643	414 045 000	2 660	85 503 850
1920	593	214 601	505 035 000	2 353	82 794 824

COMPARATIVE TABLES

YEAR	TONS COAL BURNED	TONS ORE & ROCK HOISTED	CU. FT. AIR USED	CUBIC FT. AIR PER TON HOISTED	GALLONS OF WATER PUMPED
<u>NEGAUNEE MINE</u>					
1907	11,216	315,069	250,046,615	795	707,070,097
1908	10 294	300 007	210 799 982	696	638 488 540
1909	9 088	316 072	263 322 702	911	623 789 512
1910	7 913	364 111	361 923 373	993	610 209 058
1911	7 805	368 352	599 630 043	1627	634 100 040
1912	8 003	288 308	825 468 516	2 767	696 210 397
1913	7 647	368 956	741 224 169	2 008	789 153 091 (#2 Shaft)
1914	5 269	337 792	613 144 000	1 798	395 877 353
1915	1 703	404 020	363 242 060	933	--- --- ---
1916	1 223	526 237	474 099 050	900	--- --- ---
1917	1 414	548 083	455 525 250	831	780 000 000
1918	1 293	524 869	443 996 750	845	828 575 874
1919	1 320	525 894	591 104 600	1 185	603 198 543
1920	1 095	569 895	729 139 000	1 279	610 132 854
<u>MAAS MINE</u>					
1907	5,861	29,690	--- --- ---	- ---	337,084,264
1908	6 671	83 075	--- --- ---	- ---	242 151 139
1909	6 494	141 510	291 338 833	2 095	231 101 590
1910	8 219	196 052	541 169 843	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	3 182	--- --- --- (3 months)
1914	6 819	213 423	720 319 949	- ---	8 336 357
1915	4 325	85 150	486 626 678	- ---	190 534 750
1916	8 062	272 802	763 134 066	2 797	363 273 050
1917	8 656	333 290	879 808 672	2 639	337 467 390
1918	9 351	312 634	935 128 335	2 991	510 265 180
1919	9 639	343 810	644 597 449	1 874	573 373 848
1920	5 097	351 521	571 224 659	1 625	513 176 403

COMPARATIVE TABLES

YEAR	TONS COAL BURNED	TONS ORE & ROCK HOISTED	CU. FT. AIR USED	CUBIC FT. AIR PER TON HOISTED	GALLONS OF WATER PUMPED
<u>SOUTH JACKSON MINE</u>					
1912	381	42,790	---	---	---
1913	483	1 940	---	---	---
1914	0	15 281	---	---	---
1915	0	56 026	---	---	---
1916	0	0	(No ore taken out)	---	---
1917	0	46 994	---	---	---
1918	0	15 879	13 203 000	931	---
1919	0	56 840	---	---	---
1920	162	69 222	30 001 500	434	---
<u>BARNES-HECKER MINE</u>					
1918	646	16,330	221,420,000	---	---
1919	603	29 731	---	---	(8 months) 5,461,940
1920	410	62 426	(From Morris-Lloyd) 272,817,000	4 370	137 026 242
<u>MORRIS-LLOYD MINE</u> (Included Sec. 6 Shaft)					
1911	---	88,792	---	---	---
1912	---	181 544	---	---	---
1913	726	209 667	---	---	---
1914	615	242 476	655,199,000	2,701	363,889,057
1915	533	298 816	722 622 750	2 418	322 295 660
1916	1 004	304 849	---	---	320 074 400
1917	886	296 589	667 908 000	2 370	319 198 700
1918	959	299 360	681 964 000	2 378	315 454 220
1919	1 132	313 887	936 264 700	2 982	340 883 140
1920	971	283 400	802 952 000	2 832	311 061 125

COMPARATIVE TABLES

YEAR	TONS COAL BURNED	TONS ORE & ROCK HOISTED	CU. FT. AIR USED	CUBIC FT. AIR PER TON HOISTED	GALLONS OF WATER PUMPED
<u>AUSTIN MINE</u>					
1907	3 863	194 571	58 452 975	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)		
1915			(Mine idle entire year)		
1916	-	23 697	---	---	---
1917	-	54 167	---	---	---
1918	-	759	(Mine flooded in January)		
1919	19 212	19 212	---	---	---
1920			(Mine idle entire year)		
<u>FRANCIS MINE</u>					
1915	603	---	---	---	---
1916	3,513	15,656	---	---	---
1917	1 223	21 420	353,070,000	---	66,723,400
1918	796	65 739	565 920 000	---	49 625 600
1919	499	102 651	291 060 000	---	45 865 547
			(Air used in Francis and Gwinn Mines)		
1920	479	93,548	420 340 000	---	45 855 040
			(Air used in Francis and Gwinn Mines)		
<u>GARDINER & MACKINAW MINES</u>					
1915			(Mine idle entire year)		
1916			(Mine idle entire year)		
1917	443	29,235	323,595,000	---	---
1918	533	37 883	388 395 000	---	---
1919	412	93 501	325 845 000	3,485	26,941,948
1920	387	139 057	367 830 000	2,645	36 770 855
			(Mine shut down November 30th)		

COMPARATIVE TABLES

YEAR	TONS COAL BURNED	TONS ORE & ROCK HOISTED	CU. FT. AIR USED	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	(Mine idle entire year)				
1913	1 583	14 376	---	---	---
1914	1 400	95 510	---	---	90,245,720
1915	807	151 474	---	---	131 676 720
1916	871	186 839	---	---	131 783 700
1917	976	191 080	---	---	148 022 900
1918	844	177 051	---	---	168 172 800
1919	1 132	154 002	---	---	199 404 200
1920	921	115 497	(Air supplied by Francis Mine)	---	165,004 020
<u>PRINCETON MINE</u>					
1909	3,104	143,620	181,915,352	1,265	144,540,000
1910	2 582	126 047	226 054 113	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
1915	87	2 833	---	---	94 629 250
1916	105	2 636	---	---	136 569 170
1917	101	734	---	---	109 949 035
1918	354	182 760	---	---	112 926 605
1919	468	219 230	---	---	131 496 940
1920	476	184 912	---	---	129 512 469

COMPARATIVE TABLES

YEAR	TONS COAL BURNED	TONS ORE & ROCK HOISTED	CU.FT. AIR USED	CUBIC FT. AIR PER TON HOISTED	GALLONS OF WATER PUMPED
------	------------------------	-------------------------------	--------------------	--	-------------------------------

PRINCETON CENTRAL POWER PLANT

(output)

1909	4,630	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	---			
1915	7 092	---			
1916	5 322	1 375 169 052			
1917	2 121	1 051 739 302			
1918	6 279	971 385 234			
1919	3 614	1 236 341 627			
1920	2 598	1 264 675 500			

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
1915	794			202 554 240
1916	814			224 152 095
1917	986			275 717 100
1918	917			262 232 600
1919	920			237 147 315
1920	890			233 913 900

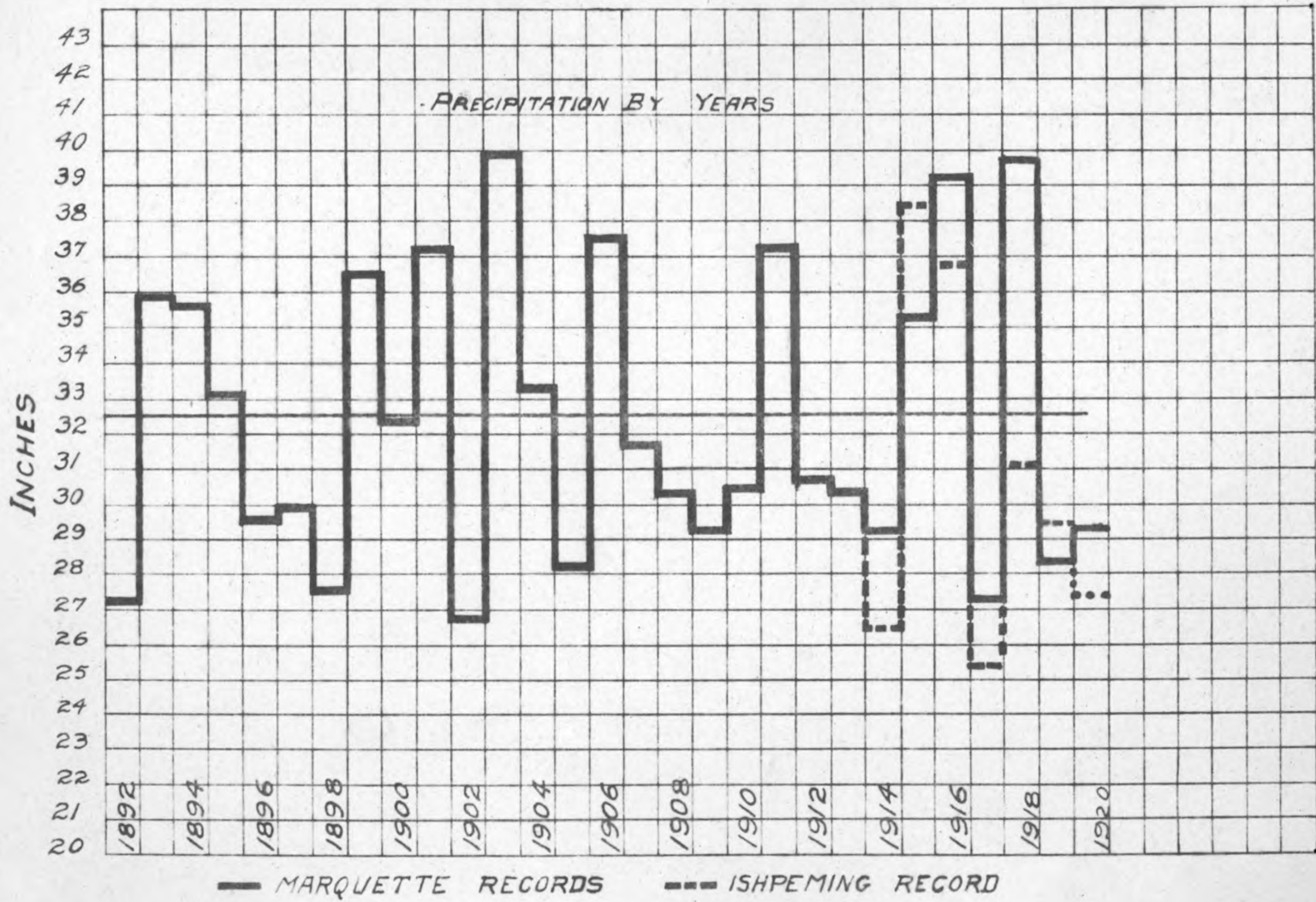
YEAR	<u>COMPARATIVE TABLES</u>				
	TONS COAL BURNED	TONS ORE & ROCK HOISTED	CU. FT. AIR USED	CUBIC FT. AIR PER TON HOISTED	GALLONS OF WATER PUMPED
<u>STEPHENSON MINE</u>					
1910	2,867	217,096	294,935,118	1,358	383,590,401
1911	4 182	239 991	384 041 898	1 600	625 253 183
1912	4 856	241 931	460 478 796	1 903	886 471 232
1913	3 420	283 146	--- --- ---	-v---	1,028 287 849
1914	2 281	238 739	--- --- ---	- ---	772 327 870
1915	2 220	230 575	--- --- ---	- ---	763 683 450
1916	1 658	327 395	--- --- ---	- ---	785 501 510 (11 months)
1917	3 073	256 756	--- --- ---	- ---	961 713 000
1918	1 560	(Mine flooded in December 1917)			
1919	724	1 662			
1920	2 064	205 366			1 381 633 440
<u>CROSBY MINE</u>					
1910	2 157	204 588	--- --- ---	- ---	--- --- ---
1911	1 493	80 976	--- --- ---	- ---	--- --- ---
1912	1 515	116 818	--- --- ---	- ---	--- --- ---
1913	3 305	207 728	--- --- ---	- ---	--- --- ---
1914	(10 Mo.) 2 151	(8 Mo.) 23 221	--- --- ---	- ---	--- --- ---
1915	250	-- ---	--- --- ---	- ---	--- --- ---
1916	2 069	127 373	--- --- ---	- ---	--- --- ---
1917	2 504	300 142	--- --- ---	- ---	--- --- ---
1918	3 097	255 787	--- --- ---	- ---	--- --- ---
1919	2 578	208 449	--- --- ---	- ---	--- --- ---
1920	1 280	263 478	--- --- ---	- ---	--- --- ---
<u>HELMER MINE</u>					
1918	3,125	216,428	--- --- ---	- ---	--- --- ---
1919	1 274	71 867	--- --- ---	- ---	--- --- ---
1920	(See Wade)	42 159	--- --- ---	- ---	--- --- ---

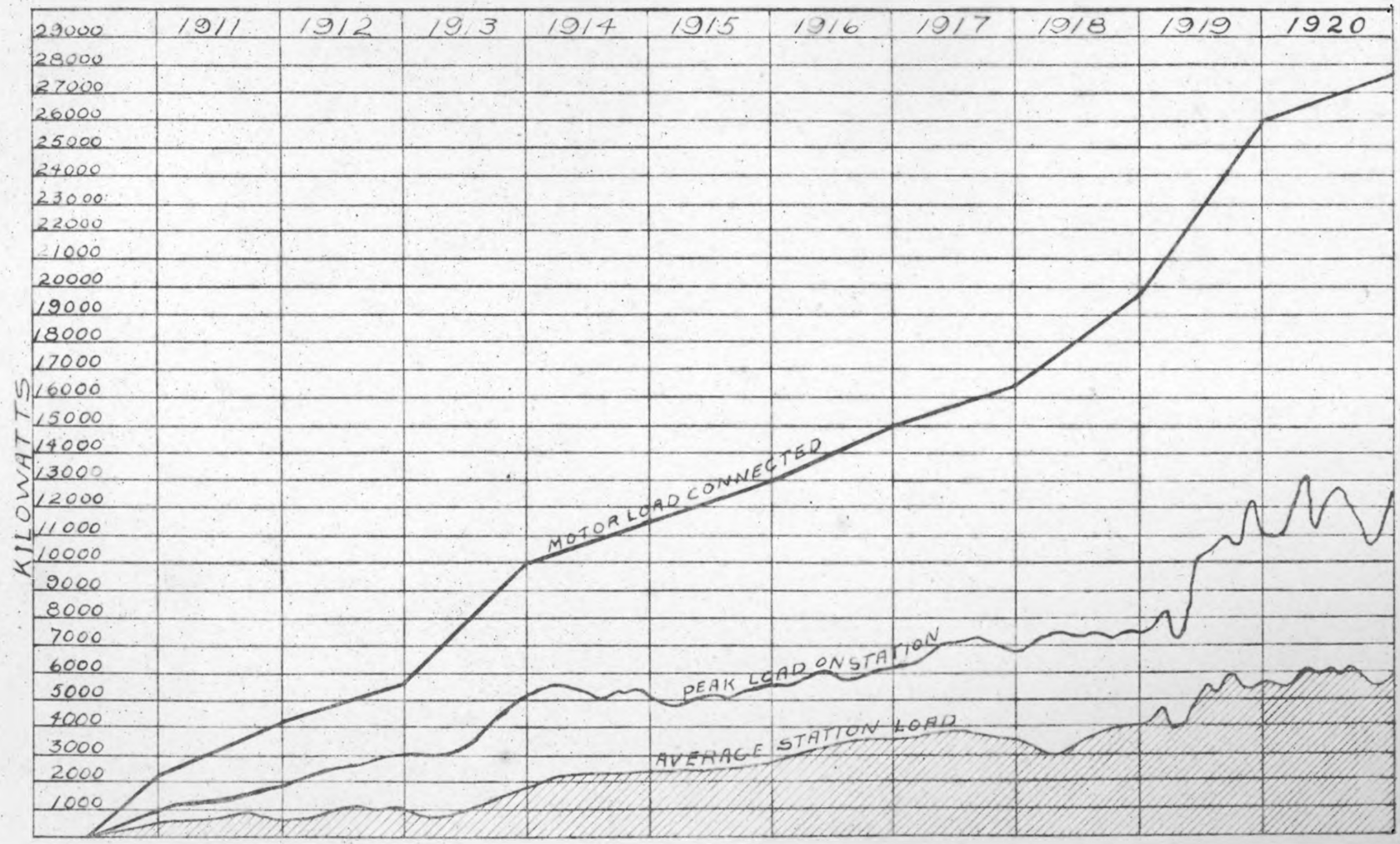
COMPARATIVE TABLES

YEAR	TONS COAL BURNED	TONS ORE & ROCK HOISTED	CU. FT. AIR USED	CUBIC FT. AIR PER TON HOISTED	GALLONS OF WATER PUMPED
<u>BOEING</u>					
1919	- - - -	2,048	- - - - -	- - - -	- - - - -
1920	491	34 428	- - - - -	- - - -	- - - - -
<u>HILL-TRUMBULL</u>					
1920	7,670	191,927	- - - - -	- - - -	- - - - -
<u>MEADOW MINE</u>					
1917	3,007	102,519	40,658,040	386	- - - - -
1918	3 087	95 353	53 433 980	560	- - - - -
1919	3 247	101 113	49 352 710	488	- - - - -
1920	3 840	77 152	- - - - -	- - - -	- - - - -
<u>WADE MINE</u>					
1918	3,820	72,305	- - - - -	- - - -	- - - - -
1919	5 516	238 644	- - - - -	- - - -	- - - - -
1920	4 095	200 254	- - - - -	- - - -	- - - - -
<u>REPUBLIC MINE</u>					
1916	8,637	226,797	1,841,863,000	8,033	- - - - -
1917	8 755	196 996	1 582 113 000	8 031	- - - - -
1918	6 780	172 955	1 141 454 000	6 605	- - - - -
1919	5 709	185 383	1 228 202 000	6 625	34 770 380
1920	3 972	181 058	1 347 129 000	7 440	35 559 650
<u>SPIES MINE</u>					
1917	3,657	80,204	186,701,680	2,327	- - - - -
1918	2 154	124 477	- - - - -	- - - -	- - - - -
1919	962	71 000	- - - - -	- - - -	- - - - -
1920	377	93 519	- - - - -	- - - -	- - - - -

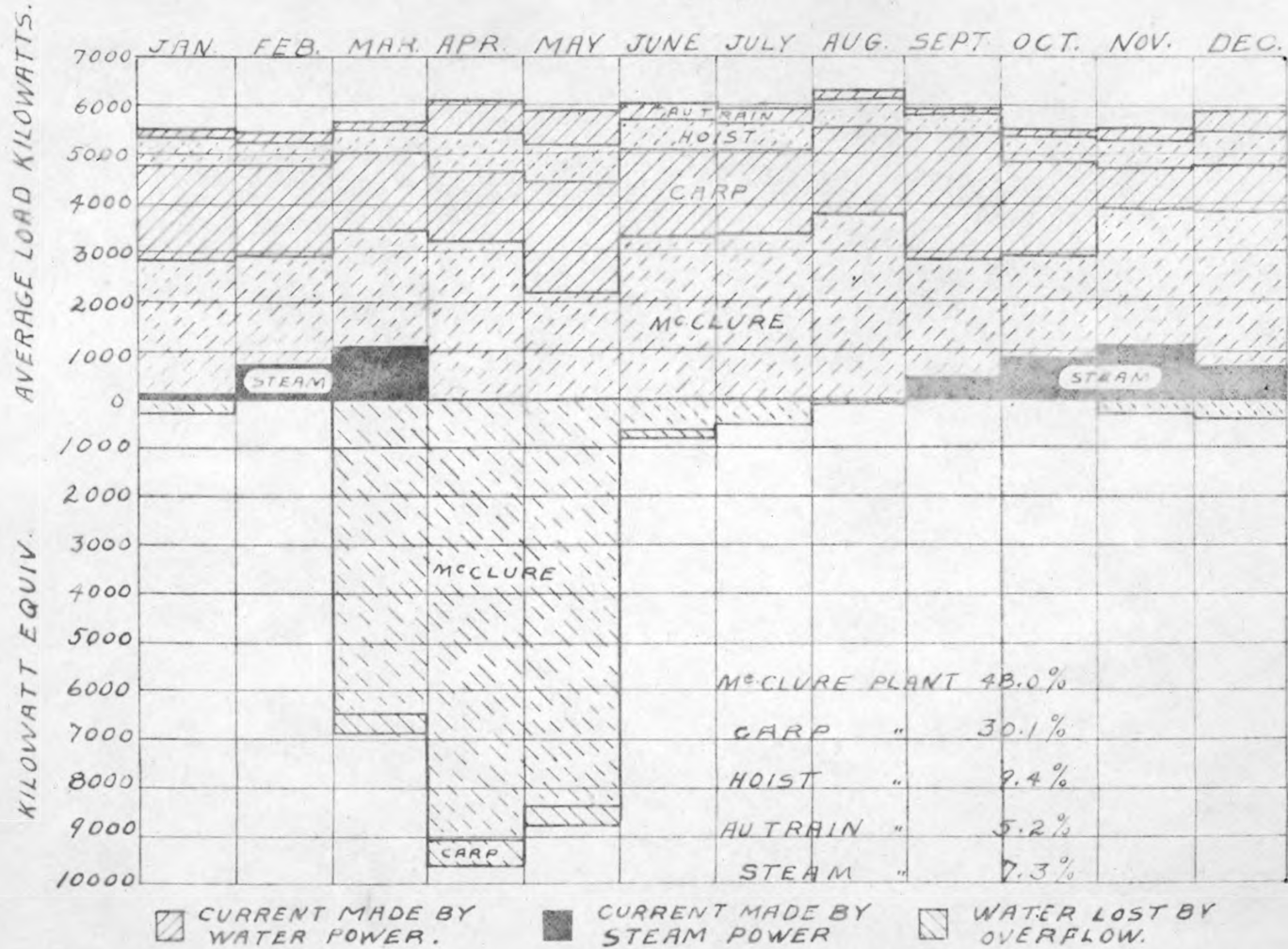
Note:-

Lake Mine -Furnished air to Angeline Mine and Hard Ore Shops.
 Negaunee Mine - " " " Maas Mine.
 Morris-Lloyd Mine - " " " Barnes-Hecker Mine.
 Austin Mine -Idle
 Francis Mine -Furnished air to Gwinn Mine.
 Spies Mine -Started operations in May.

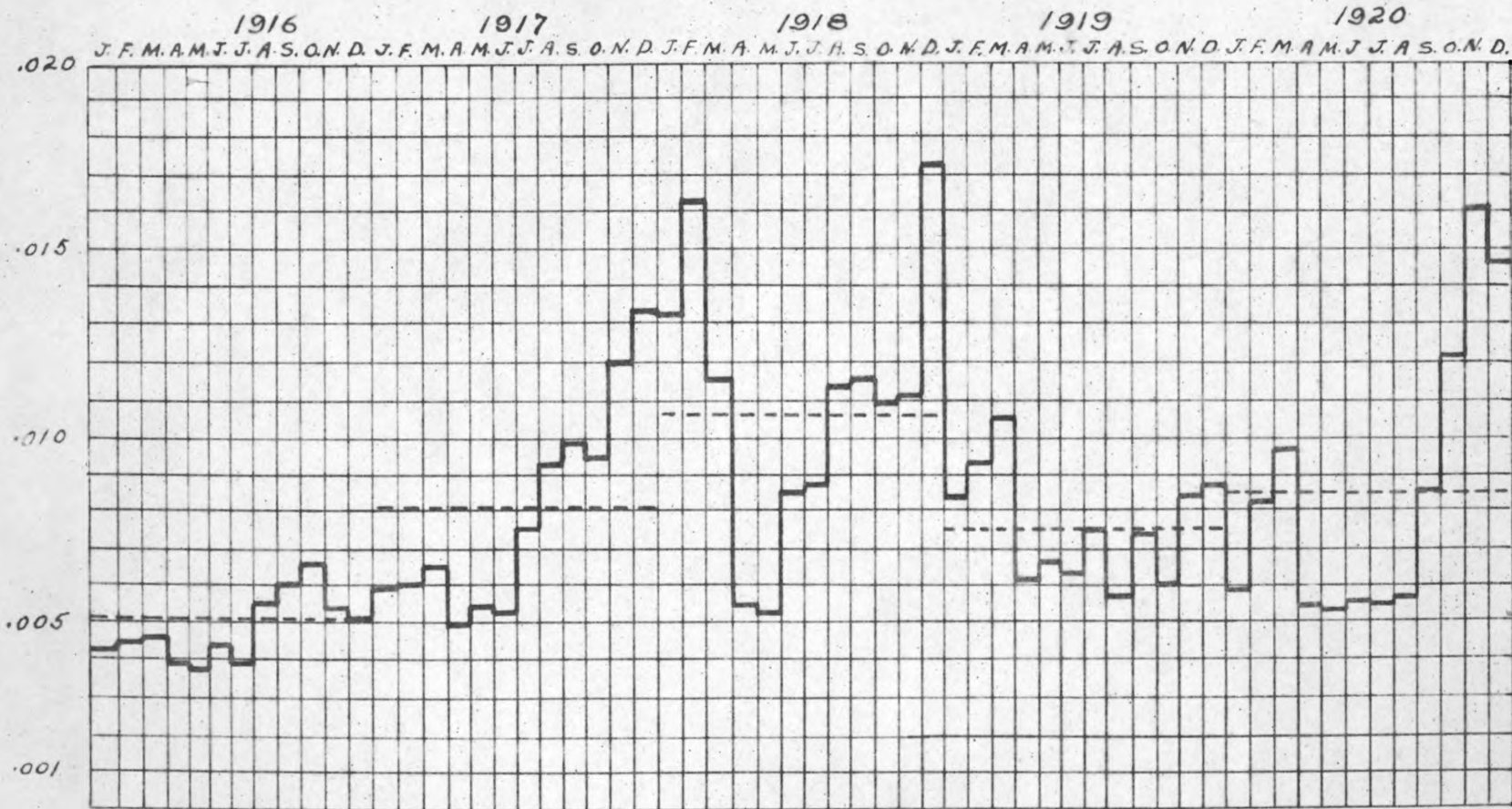




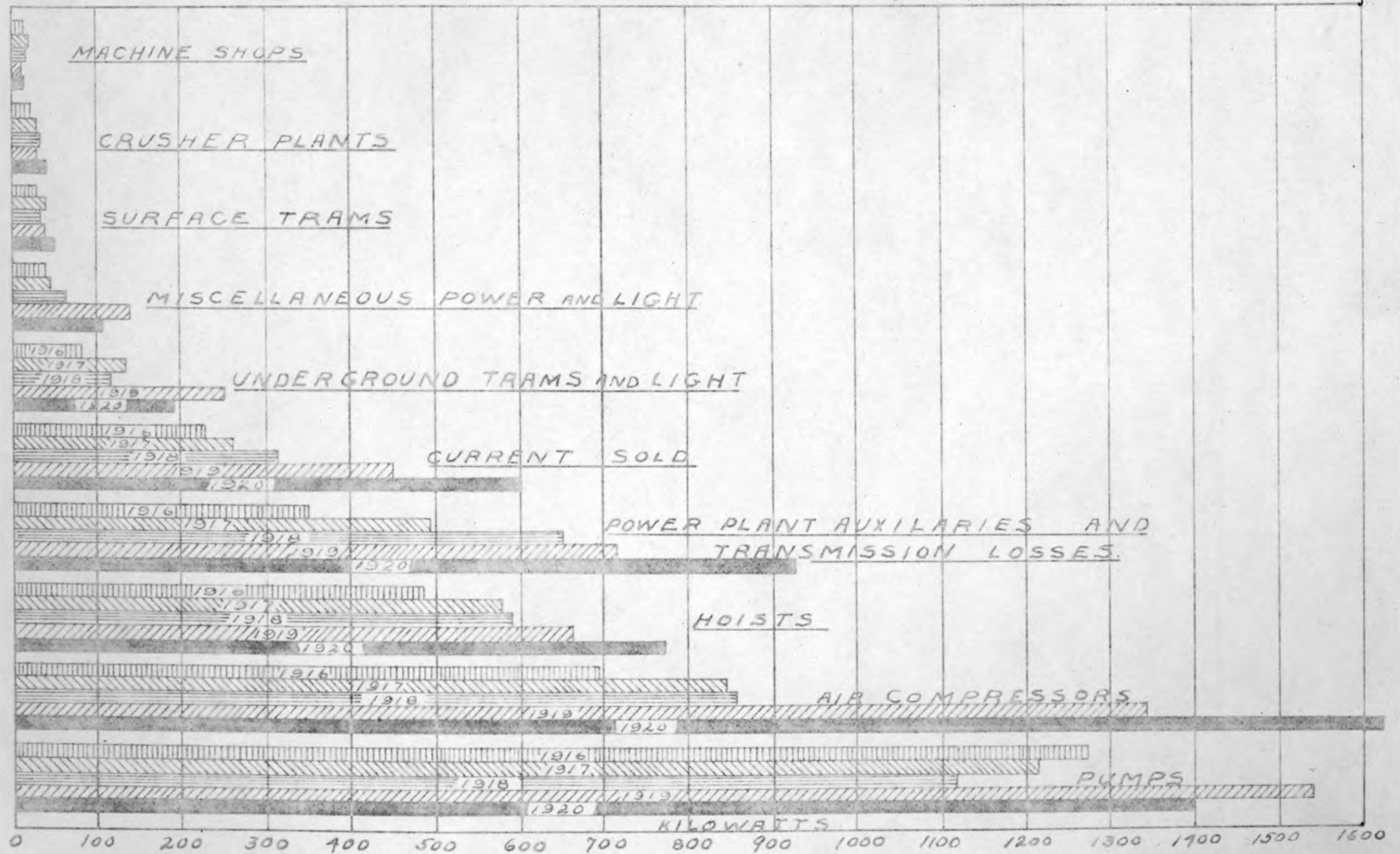
1920



COST DIAGRAM



DISTRIBUTION OF ELECTRIC POWER 1916, 1917, 1918, 1919, 1920.



MECHANICAL DEPARTMENT 661

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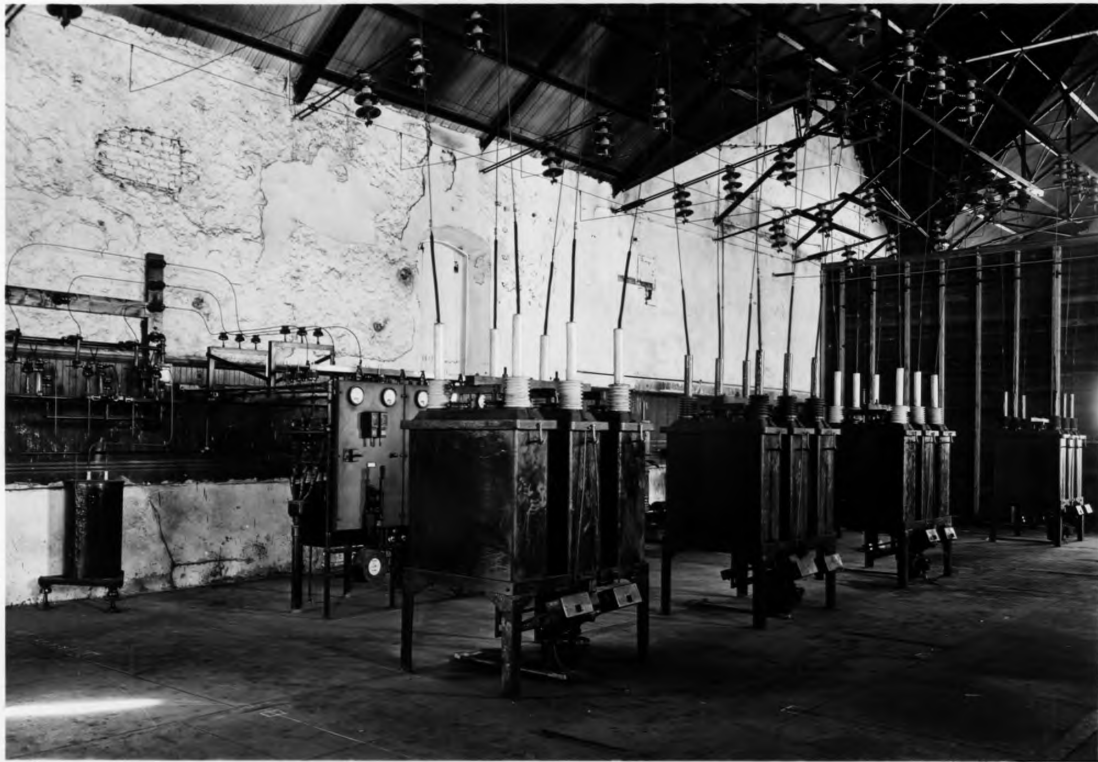


Plate No. 202 - High Tension Circuit Breakers - Brownstone Substation



Plate No. 203 - Outdoor Transformers - Brownstone Substation



Plate No. 204 - Cage Hoist & Motor - Maas Mine

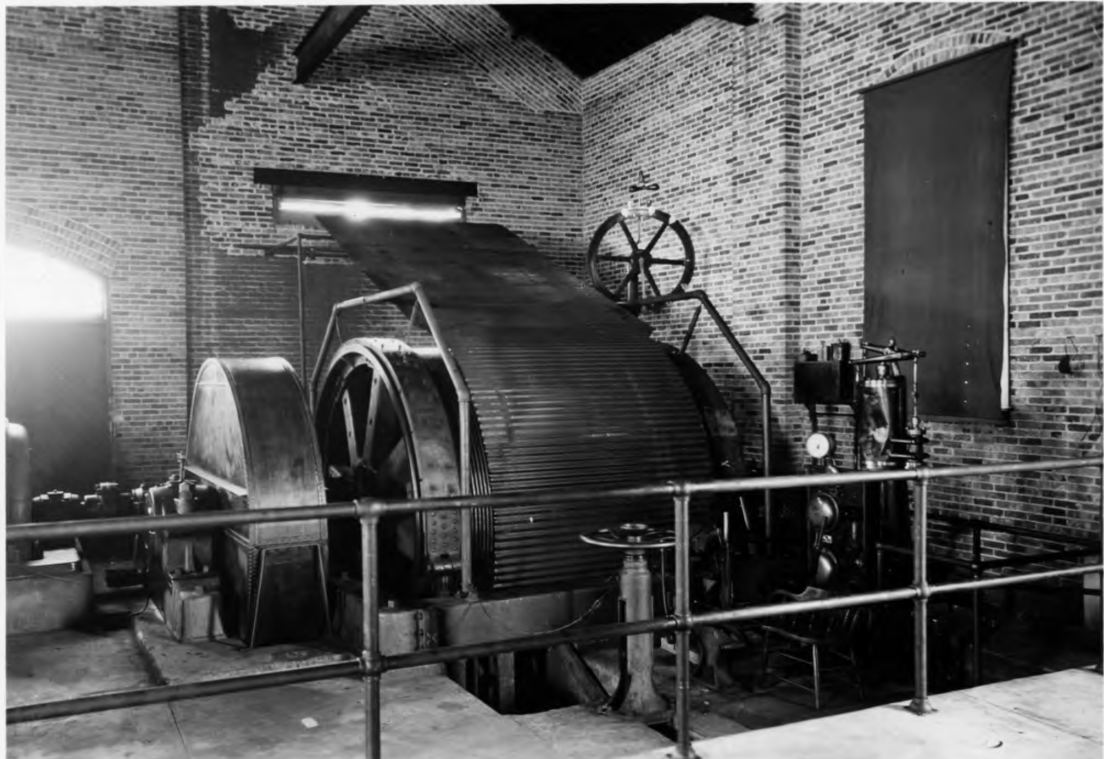


Plate No. 205 - Skip Hoist & Motor - Maas Mine

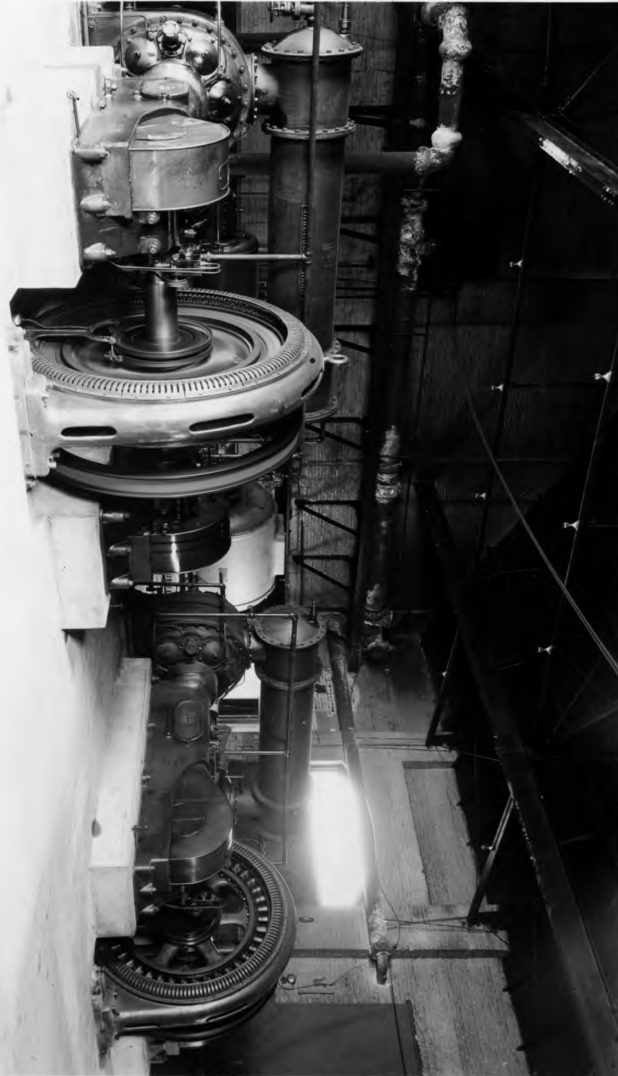


Plate No. 206 - 2 Ingersoll-Rand Compressor & Motors - Maas Mine.

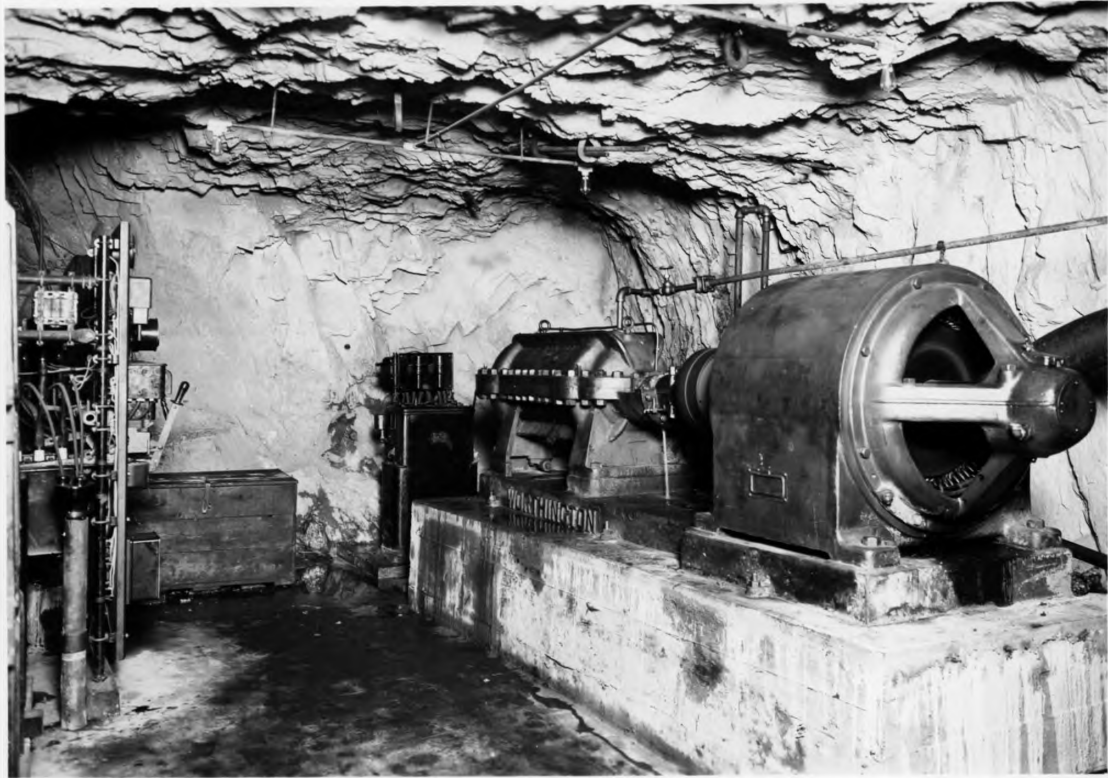


Plate No. 207 - Worthington Centrifugal Pump & Motor - Barnes-Hecker Mine

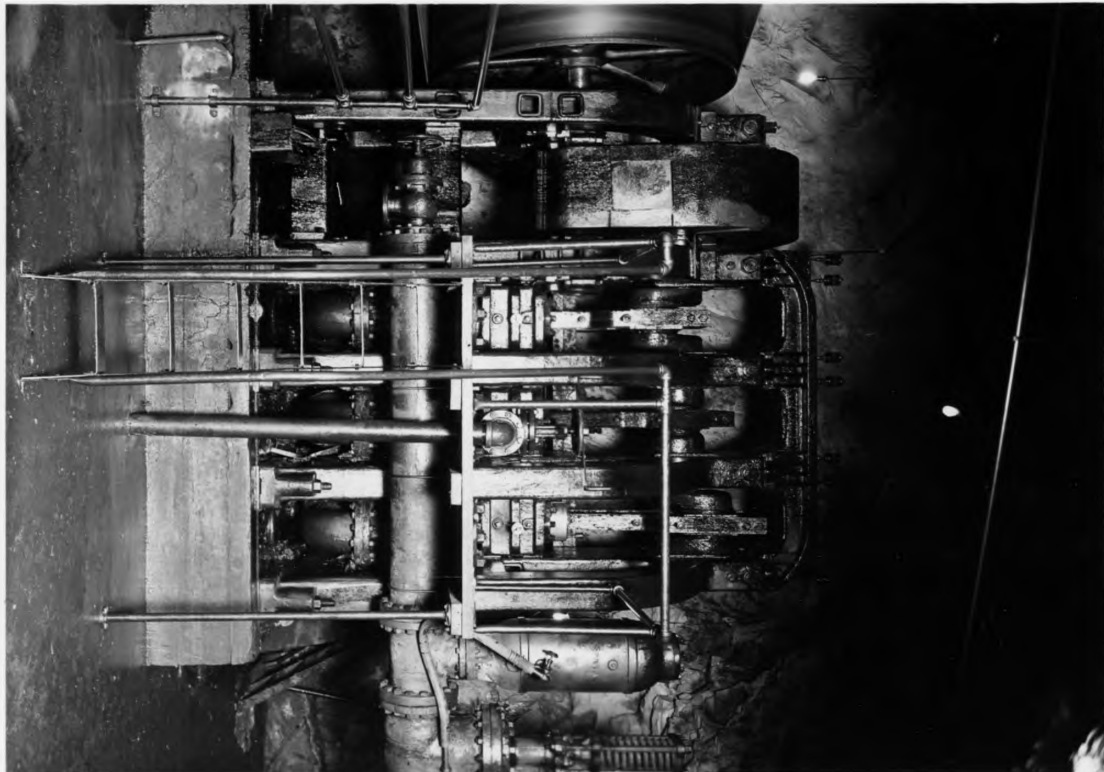


Plate No. 208 - Aldrich Triplex Pump - Barnes-Hecker Mine

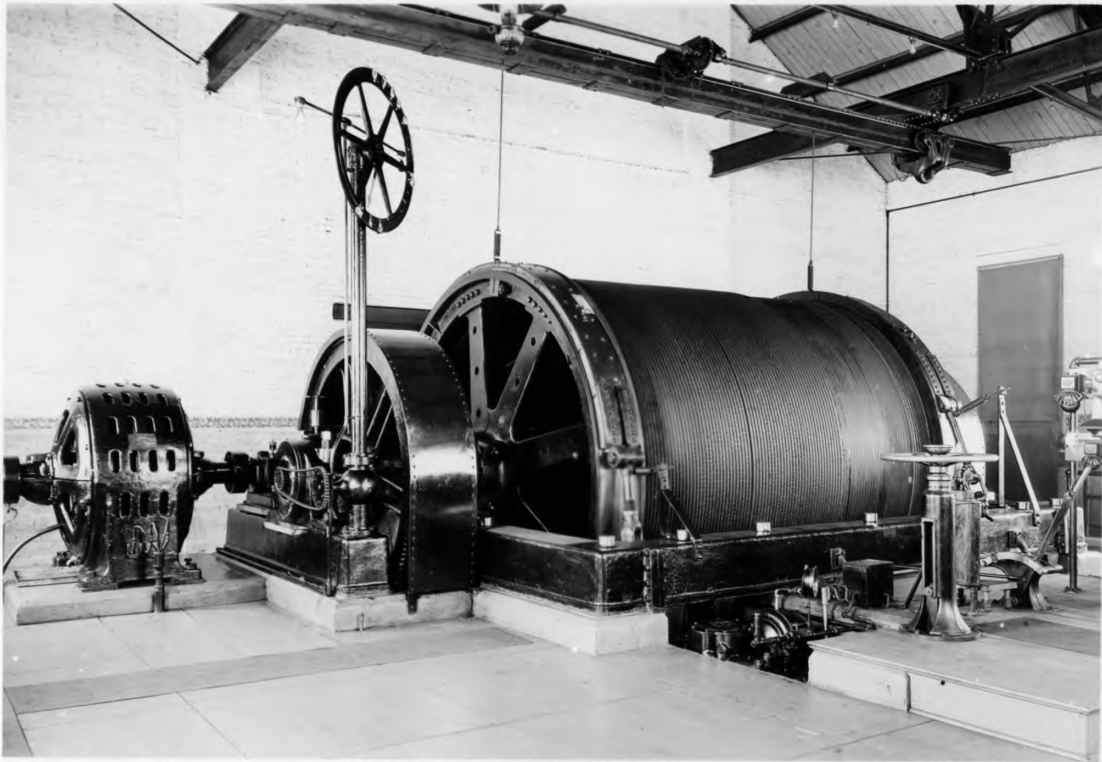


Plate No. 209 - Hoist & Motors at #9 Shaft - Republic Mine

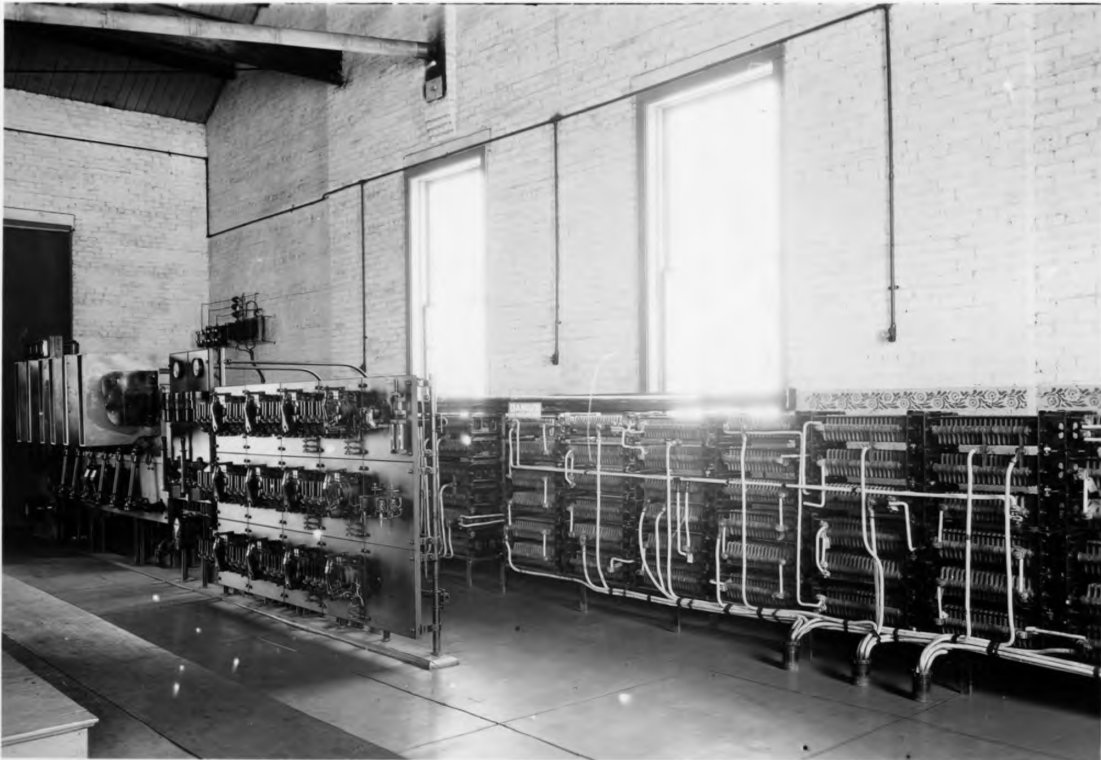


Plate No. 210 - Switchboard for Hoist at #9 Shaft - Republic Mine.



Plate No. 211 - Charging Set for Storage Battery Locomotives - Republic Mine



Plate No. 212 - Storage Battery Locomotives - Republic Mine



Plate No. 213 - Washing Plant - Hill-Trumbull Mine



Plate No. 214 - Crusher Bldg. at Washing Plant - Hill-Trumbull Mine



Plate No. 215 - Pan Conveyor - Hill-Trumbull Washing Plant

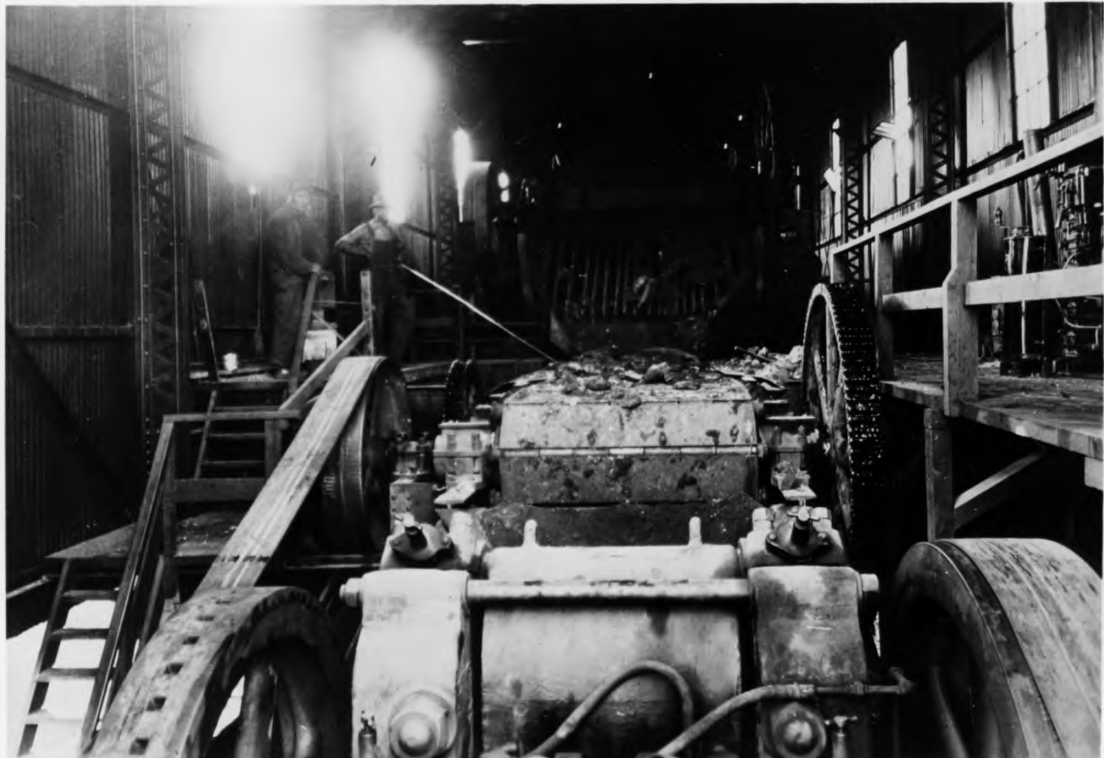


Plate No. 216 - Picking Belt & Crusher - Hill-Trumbull Washing Plant

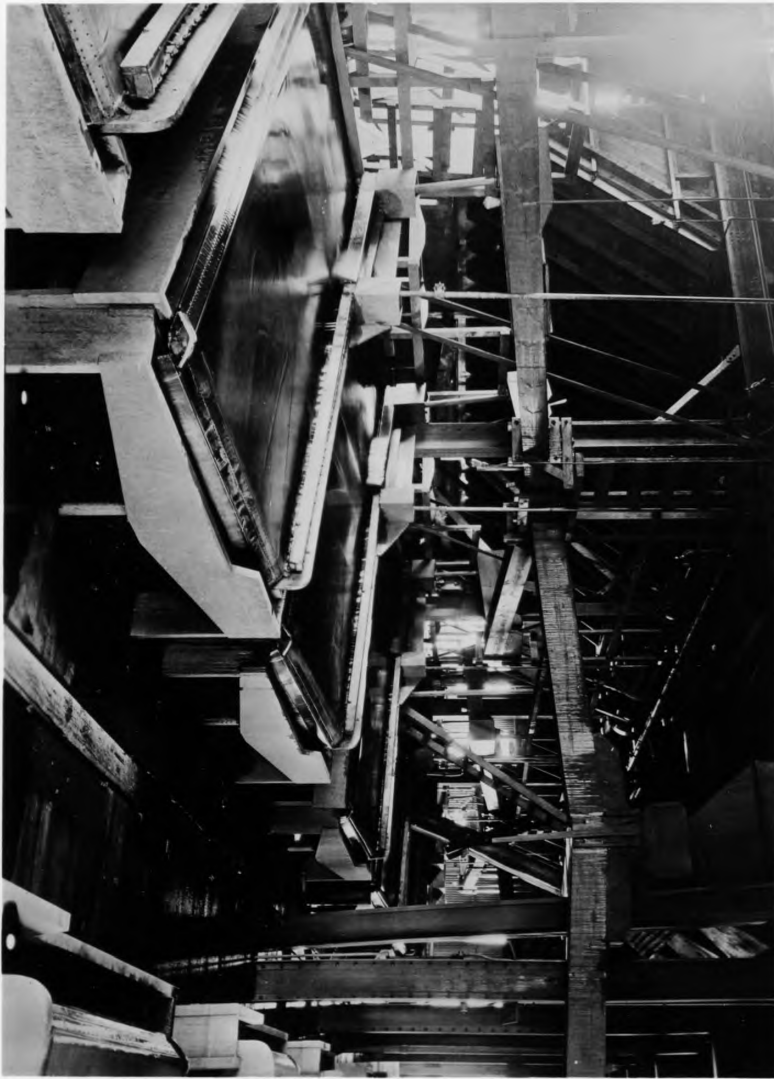


Plate No. 217 - Tables - Hill-Trumbull Washing Plant



Plate No. 218 - Wood Pole on New Line from McClure Plant to Maas Mine.

ANNUAL REPORT
OF THE (1920)
SAFETY DEPARTMENT

.....

This report of the Company's Safety Department for 1920 is outlined under the following subjects: fatal, serious and slight accidents; safety inspection; general safety precautions; first aid and mine rescue training, and statistical tables. Safety inspection was directed by Wm. Conibear, first aid and mine rescue by J. H. Williams and stenographic and clerical work by Miss Elsie Baker.

FATAL ACCIDENTS

The death rate in the mines of the Company in 1920 shows a marked decrease from the record of any previous year in the history of the Company. Four men were killed at the mines and one at the McClure Dam. As there were employed an average of 4,125 men during the year, the fatality rate was therefore 1.21 per 1000 men employed, as compared with 1.71 per 1000 men for 1912 and 1.89 for 1911, the two lowest rates in previous years. The average rate for the past ten years, 1911 to 1920 inclusive, which represents the period of the Safety Department, was 2.57 per 1000 men employed. The average rate for the ten year period from 1901 to 1910, inclusive, was 5.16 per 1000 men. If the rate for the early period had prevailed during the later period the total number of deaths would have been 163, compared to 78 the number which actually occurred.

Three fatalities occurred underground by falls of ground, one each at the Republic, Maas and Wade-Helmer mines, and two occurred on surface, one at the McClure Dam by a slide of sand, gravel and water and one at the Hill-Trumbull mine by an oiler being overtaken by a steam locomotive and crushed beneath the tender when walking a railroad track. The Ishpeming, Gwinn and North Lake districts were exempted from fatalities and but one fatality occurred at the Company's mines which have been in continuous operation the past

ten years. All the men who were killed were single and left no dependents. With the exception of the Hill-Trumbull accident, they were classified trade risk accidents by the Central Safety Committee.

The classification of fatal accidents by the Central Safety Committee is as close a correct classification as is obtainable. The average number of fatalities during the past ten years has been 7.8 annually; the average number of trade risk accidents has been 3.6 and the average number of preventable accidents has been four. During this time there were only two years when the trade risk accidents were abnormally high and those years were 1914 and 1918, when they were eight each year. In 1915 there were five fatalities and all were classified trade risk.

If all the fatal accidents, which have been classified by the Central Safety Committee as preventable, were eliminated, the average fatality rate for the past ten years would have been 1.24. The trade risk fatality rate of our mines would then have been about the same rate that has prevailed in the metal mines of England for many years. One must be very careful in making statements relative to accident statistics. At times there seems to be a swing in the pendulum from a period having few accidents to one having many accidents and the oscillation of the pendulum appears to be beyond our control. The main factor however in the elimination of preventable accidents is the devising and putting into force efforts by which employees will think and observe the safety rules when busy at their daily occupations. To what extent the Company's system of examining employees on rules and regulations had last year in this direction cannot be stated. It would appear that it had a salutary effect if the statistics for the number of fatal and serious accidents, compared to the number prevailing in former years, are of any value.

DESCRIPTION OF FATAL ACCIDENTS.

Number One

Fred Johnson, a laborer, was injured at the Republic mine by a fall of ground, February 4th, which caused his death sixteen hours later. The accident occurred in a new stope, the back of which was so low that there was

SAFETY DEPARTMENT.

scarcely room for a man to stand in an upright position. THE ground had been trimmed by miners and was considered a safe working place. It was classified a trade risk accident.

Number Two

John Kohloff, a surface laborer, was instantly killed at the Hill-Trumbull mine, March 4th, by being struck by a steam locomotive. Kohloff rode the locomotive from the waste rock dump into the yard and when the locomotive stopped he stepped off and started toward the pit, walking in the middle of the track. When the locomotive started up, he evidently gave no heed to the ringing of the bell and he was crushed underneath the tender. It was classified due to carelessness.

Number THREE

Jerri Roma, a surface laborer, was buried in a slide of sand, gravel and water at the McClure Dam, April 10th, and suffocated before his body was recovered. He and his partner were planting shrubs and trees on a bank of the Dear River, below the Dam, in order to make the place more secure. They had completed their work and were leaving the place when the slide occurred. It was classified a trade risk accident.

Number Four

John Kusisto, a miner, was killed at the Maas mine, June 11th, by a fall of ground. The accident occurred at the breast of a main level haulage drift, where room for a set of timber had been made the day previous. The night shift crew did not report for work, and early in the morning of the next day, while advancing scollar boards this man was killed by a fall of ground from the back. His partner claimed that they had trimmed the ground thirty minutes before the accident occurred, but it is very doubtful that such had been done, as the nature of the ground indicated that if it had been trimmed the accident would not have occurred. As the man's statement could not be positively disapproved the accident was classified a trade risk.

Number Five

Steve Timinivich, a miner, was instantly killed at the Wade-Helmer mine by a fall of ground, October 11th. It was thought that an opening had formed in the cemented over-burden and that it caused a fall of ground which

SAFETY DEPARTMENT.

crushed the drift where this man and his partner work. Both men were caught in the cave. It was classified a trade risk.

TABLE 1.

Showing number of fatalities and rates per 1000 employees for ten years prior to safety work and also for ten years of safety work.

Year	Fatalities	Rate	Year	Fatalities	Rate
1901	9	6.83	1911	5	1.89
1902	8	5.38	1912	4	1.71
1903	8	5.15	1913	11	4.12
1904	4	2.97	1914	10	4.10
1905	12	6.54	1915	5	2.15
1906	10	4.13	1916	8	2.61
1907	17	5.97	1917	6	1.73
1908	6	2.52	1918	13	3.45
1909	13	5.15	1919	11	2.79
1910	20	6.88	1920	5	1.21
	<u>107</u>	<u>5.16</u>		<u>78</u>	<u>2.57</u>

Tons of ore mined per fatality 171,984 347,929

SERIOUS ACCIDENTS

Using the Bureau of Mines classification for a serious accident as one that causes a loss of more than 14 days, the record for last year shows a reduction compared to the number in 1919. The rate per 1000 men employed is the lowest in the history of the Company. The average annual rate for 1912 to 1919 varies from 61 to 86 per 1000 employees. Last year the rate was 54.

There was but one accident which caused a loss of limb and that occurred at the Carp River Power Plant when an electrician reached hold of a high tension transmission wire and was electrocuted. He lost his right arm.

Two trammers at the Cliffs-Shaft mine had the ends of their fingers severed which are classified permanent partial disability. In addition to these three accidents several employees at the Wade-Helmer mines were so severely wounded that they lost 15 weeks or longer. The worst of these accidents was caused by a top tram locomotive going over trestle and carrying the operator with it.

SLIGHT ACCIDENTS

The number of slight accidents reported in 1920 is the same as in 1919 when compared to the number of men employed, the rates being ^{about} 1.70 each

SAFETY INSPECTION

Safety Inspection reports of mines were made by the Safety Inspector, Workmen Committees, a Foreman Committee, a Committee on Mechanical and Surface Equipment, and the Committee on Rules and Regulations. The two Committees on Fatal Accidents investigated the places where fatal accidents occurred.

SAFETY INSPECTOR

Monthly inspections of the local mines were made by the Inspector, excepting in those months when inspections were made by Workmen and Foremen Committees, when he directed the work of these Committees. He also made three inspections of the Spies mine.

WORKMEN COMMITTEES

All local mines, with the exception of the Barnes-Hecker mine where development work only is in progress, were inspected by a Committee of three men selected from the men employed at each mine. There were 15 of these committees representing 45 employees. There have been 133 Workmen Committees employed during the past 10 years, representing 399 workmen or approximately an average of 40 workmen a year, who have inspected the mines in which they work.

FOREMAN COMMITTEE

Three shift bosses, Wm. Dabb of the Francis mine, John Nicholas of the Jackson and Negaunee mines and Ernest Norell of the Cliffs-Shaft mine were appointed to serve as a Foreman Inspection Committee. The mines in Marquette County were inspected in October and practically perfect reports were submitted.

COMMITTEE ON MECHANICAL and SURFACE EQUIPMENT

The Central Safety Committee designated Louis Keast of the Mechanical Department, James Tobin, electrician at the Cliffs-Shaft mine, and George Winters, surface foreman at the Athens mine, a Committee to inspect the mechanical and surface equipment. An inspection of local mines was made from October

SAFETY DEPARTMENT.

17th to October 19th and twenty-seven suggestions and recommendations were submitted and later put into effect.

Sixty-three foremen have served on Foreman Inspection Committee. A total of 462 employees have served the Company as safety inspectors since the inauguration of the Safety Department.

CENTRAL SAFETY COMMITTEE

This Committee held twelve sessions last year. All meetings were held at the General Office of the Company, with either Mr. Elliott or Mr. Jackson presiding as chairman. All injuries were carefully considered and classified and action was taken upon subjects of safety to which its attention was called. The important subjects are mentioned in this report under special safety precautions.

TABLE IV

The following table gives the number of foremen and workmen by mines, who have served on safety inspection committees since the beginning of safety work.

<u>Mines</u>	<u>Foremen</u>	<u>Workmen</u>
Angeline	0	3
Athens	3	3
Austin	1	12
Cliffs-Shaft	7	42
Francis	1	6
Gardner-Mackinaw	1	6
Gwinn	3	33
Holmes	1	9
Lake	6	42
Maas	6	30
Morris-Lloyd	5	42
Negaunee	8	42
Princeton	3	18
Republic	4	24
Salisbury	5	36
Stephenson	4	36
Miscellaneous	5	15
	63	399

GENERAL SAFETY PRECAUTIONS

General Rules and Regulations.

Only one new rule was adopted by the Central Safety Committee and that was a rule which requires all brakemen of underground locomotives to ride on motors and not on cars.