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11. ACCIDENTS AND PERSONAL INJURY

c. Safety Inspection (Continued)

TABLE XVI

NUMBER OF INSPECTIONS MADE DURING THE BLASTING PROCEDURE IN VARIOUS MINING CONTRACTS

MINE	NO. OF INSPECTIONS	NO. OF VIOLATIONS REPORTED
Athens	14	4
Cambria-Jackson	60	47
Cliffs Shaft	227	8
Lloyd	22	9
Maas	77	7
Mather Mine "A" Shaft	397	26
Mather Mine "B" Shaft	291	6
Negaunee Shaft *	0	0
Spies-Virgil	60	12
TOTALS	1,148	119

* Sinking Shaft
(Boss Always Present)

11. ACCIDENTS AND PERSONAL INJURY

c. Safety Inspection (Continued)

Rules & Regulations

A total of 88 surface and 461 underground rule books were passed out during the year. Most of these were to new employees but some were to men who were transferred from surface to underground or vice versa.

Mesaba Range open pit and plant rules and safe practices are being checked at the present time by the safety department of supervisors on the Range. Because of fast changing conditions it is difficult to make up rules which do not become obsolete in a short time.

Underground and surface rules for the Michigan Mines will be overhauled during 1953.

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11. ACCIDENTS AND PERSONAL INJURY

c. Safety Inspection (Continued)

TABLE XVII

RULE BOOKS DISTRIBUTED AT MICHIGAN MINES AND PLANTS

Mine Or Plant	SURFACE	UNDERGROUND	TOTAL
ATHENS	2	24	26
CAMBRIA-JACKSON	0	52	52
C. P. & L. CO.	10	0	10
CLIFFS SHAFT	0	29	29
ENGR. & GEOL. DEPTS	0	0	0
HUMBOLDT	6	0	6
LLOYD	0	5	5
MAAS	0	28	28
MATHER MINE "A" SHAFT	4	127	131
MATHER MINE "B" SHAFT	5	165	170
NEGAUNEE SHAFT	2	18	20
OHIO	23	0	23
SPIES-VIRGIL	3	13	16
STHSE & SHOPS	28	0	28
TILDEN	0	0	0
MISCELLANEOUS	5	0	5
TOTALS	88	461	549

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11. ACCIDENTS AND PERSONAL INJURY

c. Safety Inspection (Continued)

Inspection Reports From Mines & Plants

Many of the safety inspections at the various properties are made by supervisors or men appointed by the superintendent. These are some of the most important safety inspections made for the safety of the men and from information I have been able to gather our company demands more often and rigid inspections than any other company in the district.

These inspections include:

HOISTING ROPES (Daily)
SKIP & CAGE ROADS (Twice A week)
SAFETY CATCHES ON CAGES (Monthly)
LADDER ROADS (Weekly)
SLACK ROPE ALARM (Monthly)
HOISTING ENGINES (Monthly)
FIRE EXTINGUISHERS (Twice A Year)
FIRE EQUIPMENT (Four Times A Year)
FIRE PREVENTION (Once A Year)
BLASTING INSPECTIONS (Six Times A Year - Each Contract)
OLD STOPE INSPECTIONS (Cliffs Shaft Mine)
FIRE PATROL INSPECTIONS (Underground)

Reports of the above inspections are sent to the Safety Department and checked by them.

Following are tables showing the kind and number of safety inspection reports made by the mine and plant foreman, which were received and checked by this department.

TABLE XVIII

Type Of Inspection	Ag-new	Athens	Camb. Jack.	Cliffs Shaft	Lloyd	Maas	Mather Mine, A-Shaft	Mather Mine, B-Shaft	Neg. Shaft	Sar-gent	Spies-Virgil	Total
HOISTING ROPES	48	255	245	468	360	231	257	249	259	48	223	2643
SKIP & CAGE ROADS	51	77	116	82	30	33	35	44	11	0	41	520
LADDER ROAD	52	39	10	82	10	33	38	43	0	44	41	392
CAGE SAFETY CATCHES	11	10	7	31	15	9	9	9	3	0	12	116
SLACK ROPE ALARM	0	10	7	12	2	8	8	1	2	0	11	61
HOIST INSPECTION	0	24	12	24	36	36	36	24	13	0	20	225
FIRE EXTINGUISHER	2	2	2	2	2	2	2	2	2	2	2	22
FIRE EQUIPMENT	0	0	0	0	0	0	0	0	0	0	0	0
FIRE PREVENTION	2	27	12	18	0	20	5	12	30	12	11	149
HOIST ENGR. SPEC. REPORT	44	0	0	0	0	0	0	0	0	42	0	86
C. O. ALARM	0	0	0	0	0	10	0	0	0	0	0	10
TOTALS	210	444	411	719	455	382	390	384	320	148	361	4224

Mine Or Plant	Fire Extinguishers	Fire Prevention	Fire Equipment	Total
CANISTEO	3	11	4	18
C. P. & L. CO.	16	8	0	24
GENERAL OFFICE	1	0	0	1
HAWKINS	4	38	4	46
HIBBING OFFICE	1	0	0	1
HILL TRUMBULL	4	17	4	25
HOLMAN CLIFFS	5	20	4	29
PELLETIZING PLANT	1	1	0	2
PRINCETON	2	4	0	6
OHIO	2	0	0	2
RENTED BUILDINGS	1	0	0	1
RESEARCH LABORATORY	2	1	0	3
STHSE. SHOPS & GARAGE	1	6	0	7
TILDEN	2	13	0	15
WANLESS	1	8	4	13
TOTALS	46	127	20	193

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11. ACCIDENTS AND PERSONAL INJURY

c. Safety Inspection (Continued)

TABLE XIX

TYPES AND TOTALS OF FIRE EXTINGUISHERS INSTALLED AT VARIOUS PROPERTIES

Mine Or Plant	2½ Gal. Soda-Acid	2½ Gal. Non-Freeze	2½ Gal. Foam Type	1 - 1½ Qt. Vaporizing	1 - 3½ Gal. Vaporizing	15 lb. Dry Powder	20 - 30 lb. Dry Powder	4 lb. Dry Powder	Automatic Carbon Dioxide	10 - 15 - 30 lb. Carbon Dioxide	150 lb. Dry Powder - Engine	TOTAL
AGNEW	4			3	1	1	11					20
ATHENS	18			22	1	4	4					49
CAMBRIA-JACKSON	14			9	2		10					35
CANISTEO				51		9	7					67
CLIFFS SHAFT	22	1	2	39	3		11					78
DIAMOND DRILLS					1		6	2				9
GEN. STHSE. & SHOPS	16	20	1	53	3			1				94
HAWKINS	13	1		35	3	4	8					64
HILL TRUMBULL	3			33	1	13	7					57
HOLMAN CLIFFS	6	3		62	1	6	23					101
LLOYD	7	2	1	23	4	4						41
MAAS	5			22	6		7					40
MATHER MINE "A" SHAFT	9	6		49			47					111
MATHER MINE "B" SHAFT	30			36		1	33	3				103
NEGAUNEE SHAFT	7	3		17	3	2	5					37
SARGENT	2			12	1	1	2					18
SPIES-VIRGIL	5	12		20	4	6	5					52
TILDEN	1	5		39	1	3						49
WANLESS		1		13	3	2	1					20
McCLURE PLANT, CP&L CO.				3	2		2					7
CARP PLANT, CP&L CO.				4	1		2			1		8
HOIST PLANT, CP&L CO.				2	2		2					6
REPUBLIC PLANT CP&L CO.				1	1		1			1		4
ESCANABA PLANT CP&L CO.				1	1		1			1		4
AuTRAIN PLANT, CP&L CO.				1	2		1			1		5
DIESEL PLANT, CP&L CO.			5	3							1	9
HIBBING OFFICE	4		1	3	1							9
ISHPEMING GEN. OFFICE	7			8								15
RENTED HOUSES	1			17								18
PRINCETON	1			3	1							5
GWINN SUB STATION				3								3
STEAM PLANT, CP&L CO.				14					5			19
RESEARCH LABORATORY	4			5			6					15
PELLETIZING PLANT				1			3					4
OHIO	6			18			8	2				34
MISCELLANEOUS												0
TOTALS	185	54	10	625	49	56	213	8	5	4	1	1210

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11. ACCIDENTS AND PERSONAL INJURY

c. Safety Inspection (Continued)

Disciplinary Action

There were 220 cases of disciplinary action taken during the year which is one more than during 1951.

Again the greatest number of actions taken were because of men losing too much time (59); second was reporting for work under the influence of liquor (34); third was for sleeping on the job (29); fourth for violations of rules (22); fifth for carelessness in performing work (18) and sixth for violation of the "no smoking" rule (17).

When the new ruling or agreement was made with the union on "no smoking", change of penalty to two weeks for the first offence instead of discharge, we believed there would be a great increase in violations and this has proved true. During 1950 there were 6 violations reported, in 1951 there were 15 violations and in 1952 there 17 violations. It is entirely possible that some supervisors may have closed their eyes to some violations because the penalty was severe and are now reporting all they see because the man has two chances before he is discharged. Time will catch up with some of these men.

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11. ACCIDENTS AND PERSONAL INJURY

c. <u>Safety Inspection</u> (Continued)

TABLE XX

CAUSES AND NUMBER OF DISCIPLINARY ACTIONS

Mine Or Plant	Excessive Absenteeism Due To Alcoholism	Reporting To Work Under The Influence Of Liquor	Becoming Under Influence Of Liquor On Job	Violation Of Rules	Violation Of "No Smoking" Rule	Losing Too Much Time	Leaving Job Without Authority	Insubordination	Sleeping On The Job	Horse-Play	Carelessness In Performing Work	Fighting Underground	Loafing At Work	Playing Cards Underground	Stealing Company Property	TOTAL
ATHENS		4	2		2	6		2	3		1			3		23
CAMBRIA-JACKSON					2	1		1								4
CLIFFS SHAFT	2	1			4	2			2			1			1	13
CANISTEO		1		2		8		1	1	2						15
CHEMICAL LABORATORY		1														1
DIAMOND DRILLS							4	1								5
GENERAL STOREHOUSE		1														1
GENERAL SHOPS	1															1
HAWKINS		4		3		6	1		2		8					24
HILL TRUMBULL		2				11					1					14
HOLMAN CLIFFS													1			1
HUMBOLDT								1								1
LLOYD	1	2			1	1										5
MAAS		3				3				1					1	8
MATHER MINE "A" SHAFT	1	7		7	4	10	2	1	14	3	8		1			58
MATHER MINE "B" SHAFT	2	7		10	3	5	1	1	5						1	35
NEGAUNEE SHAFT						2		1	1							4
OHIO		1							1							2
PELLETIZING PLANT						1										1
SARGENT						1										1
SPIES-VIRGIL					1											1
WANLESS						2										2
TOTALS	7	34	2	22	17	59	8	9	29	6	18	1	2	3	3	220

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11. ACCIDENTS AND PERSONAL INJURY

c. Safety Inspection (Continued)

Central Safety Committee

This committee met 11 times during the year instead of the usual 12 times. There was no meeting in August mainly because of lack of important safety business and the labor troubles which had occurred. At all meetings accidents were classified and means to prevent others were discussed. Other subjects which were discussed are listed briefly:

January 11 - Fire prevention surveys to be made by the Safety Department.

February 14 - First Aid Classes for all foremen and others who wish to attend.
The American Mine ventilation doors came in for considerable discussion and some mines will try using them.

March 7 - Colored tamping shell to indentify shells from dynamite.
Proper blocking of mill raises.
Safety meetings at various properties.
First Aid Training set for April 14-25.
Change in compensation laws.
Training of Fire Fighting Crews at each property.
Timber Hooks for unloading timber from Railroad cars.

April 18 - New medical set-up at the hospital.
Committee appointed to make recommendations for Lloyd Mine shaft sinking.
Safety Department requested to get information on Cage Safety Catches from the Ontario Department of Mines.
Dust respirators discussed - Dustfoe #55, R-2000 and R-5050 to be kept in stock.
Mine Rescue equipment to be kept at all mines including All Service and Self Rescuers.

May 16 - Self Rescuers and All Service Gas Masks ordered for all underground mines.
Report by committee on Lloyd shaft sinking along with recommendations - Approved by Committee.

June 6 - Dana Cory reported on investigation of fires in combination battery and trolley locomotives.
Safety Department gave details of accident which caused death of three men at the Davidson Mine, Pickand Mather Co. at Iron River, Michigan. Stope pillar was blasted causing stope to collapse. Sulphor in stope was burning and ash caused death

(Continued on next page)

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11. ACCIDENTS AND PERSONAL INJURY

c. Safety Inspection (Continued)

Central Safety Committee (Cont'd)

June 6 - of the three men who had failed to leave mine as per orders.
Radio cage phones for mines.
Safety Department asked to get information on serious cave-in at an Ironwood mine.

July 11 - Distribution of Self Rescuers at underground mines.
Training in Self Rescuers and Mine Rescue Training.

September 29 - Michigan Mine legislation discussed.

October 24 - Felt hard toe shoes and overshoes to be kept in stock at storehouse for sale to surface employees.
Laundry service at mines - Turned down by committee.
New disciplinary action report blank approved.
Checking system on lost or stolen tools or equipment approved.
Payroll savings plan.
Recommended and approved that all visiting persons or workers such as geologists and engineers coming to open pit properties must first report to mine office to avoid walking into blasts.

November 10 - Instructions in safety to new employees and employees changing to new jobs by supervisors.
Accidents at Sample Crushing Plant and Cliffs Power & Light Co.
Failure of Lake Superior & Ishpeming Railroad switching crews to sound warnings at mines. Letter to Manager.
Procedure of union to make complaints about jobs.
Safety Department to purchase strip-film on Heavy Duty Truck Operation Safety.
New canvas liners for basket type stretchers.
Liners to be kept in stock by Safety Department.

December 12 - Powder storage in contracts must be improved.
Safety factors on hoist ropes.
Various types of hose clamps. Recommendation by Chief Mechanical Engineer approved.
Safety prizes for mines - Safety Department instructed to find what other companies in district are doing.

Safety Department

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11. ACCIDENTS AND PERSONAL INJURY

c. Safety Inspection (Continued)

Lake Superior Mines Safety Exchange

This organization includes eleven of the major ore mining companies in the district. It is a means of exchanging ideas on safety and any other matters of importance. Each company is permitted to ask for discussions on two safety problems each three months. A questionaire is sent to each member and they in turn answer the question if possible and a discussion is then held at a meeting usually held the day or evening previous to a Lake Superior Mines Safety Council meeting.

Lake Superior Mines Safety Council

January 10, 1952	-	Hibbing, Minnesota
February 7, 1952	-	Caspian, Michigan
March 6, 1952	-	Ironton, Minnesota
April 10, 1952	-	Ironwood, Michigan
May 8, 1952	-	Duluth, Minnesota (Executive Committee)
May 22-23, 1952	-	Duluth, Minnesota (Annual Meeting)
July 11, 1952	-	Duluth, Minnesota (Executive Committee)
August 22, 1952	-	Duluth, Minnesota (Executive Committee)
August 23, 1952	-	Virginia, Minnesota
September 11, 1952	-	Ely, Minnesota
November 13, 1952	-	Grand Rapids, Minnesota
December 10, 1952	-	Ishpeming, Michigan

Company employees who presented safety papers and talks at safety meetings:

Arne Hill, Superintendent, Sargent and Agnew Mines - "Safety in Sub-Level Caving" - Mesaba Range.

C. R. Sundeen, Superintendent, Maas Mine - "Safety in Shaft Sinking" at the Negaunee Mine.

T. W. Hill and A. J. Stromquist, Safety Engineer and Director of Safety, Respectively - "A Mechanical Loader Accident".

Dana Cory, Chief Electrical Engineer - "Underground Communication Systems".

Harry C. Swanson, Superintendent, Mather Mine "B" Shaft - "Falls of Ground" (Panel Discussion).

T. W. Hill, Safety Engineer - "Review of Accidents In The Lake Superior District".

H. H. Korpinen, Superintendent, Mather Mine "A" Shaft - "Block Caving With Circular Steel Transfer Drifts".

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c. Safety Inspection (Continued)

Lake Superior Mines Safety Council (Cont'd)

H. C. Swanson, Superintendent, Mather Mine "B" Shaft - "Safety In Block Caving Through Use Of Concrete".

N. P. Arnold, Superintendent of Maintenance - "Safety Standards As Applied To The Mining Industry".

Attendance at the annual meeting held in Duluth was 815 which is the largest in the councils history. Attendance at all Range meetings was also higher than the previous year.

National Safety Council

Our company is a charter member of the National Safety Council, Mining Section.

The mining section is now giving better service than it ever did and our staff representative is doing a fine job of giving us material which applies to our work. Strip film with either sound records or printed narration, sound and silent movies and posters are being made up each year.

The annual meeting held in Chicago, October 20-24 attracted over 14,000 people. The mining section meetings were well attended with over 100 persons attending each meeting.

Mr. Harry C. Swanson, Superintendent, Mather Mine "B" Shaft took part in a panel discussion on "Falls of Ground."

I was elected General Chairman of the Mining Section for the next fiscal year.

Our company was represented by six employees from the Marquette Range and four from the Mesaba Range.

Safety "Banner Flag"

The Cliffs Shaft Mine won the underground Safety "Banner Flag" for the year of 1952 with a frequency rating of 31.32 and a severity rating of 0.415.

The Ohio Mine won the "Flag" for open-pit operation with a frequency rating of 0.00 and a severity rating of 0.00.

The "Banner Flag" for miscellaneous operations went to Central Shops with a frequency of 8.38 and a severity of 0.069.

Safety Department

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11. ACCIDENTS AND PERSONAL INJURY

c. Safety Inspection (Continued)

TABLE XXI

SAFETY BONUSES PAID TO FOREMEN

Mine Or Plant	AMOUNT	NO. OF MEN PARTICIPATING	AMOUNT OF PENALTIES IMPOSED
ATHENS	$ 782.11	20	$ 61.43
CAMBRIA-JACKSON	527.24	11	21.31
CLIFFS SHAFT	1,119.40	18	15.40
DIAMOND DRILLS	42.88	2	-----
LLOYD	251.79	6	24.09
MAAS	844.77	14	-----
MATHER MINE "A" SHAFT	1,521.30	34	-----
MATHER MINE "B" SHAFT	1,050.42	23	65.40
NEGAUNEE SHAFT	209.80	7	-----
SPIES-VIRGIL	242.00	7	12.00
C. P. & L. CO.	83.71	3	1.62
TOTALS	$6,675.42	145	$201.25

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11. ACCIDENTS AND PERSONAL INJURY

c. Safety Inspection (Continued)

TABLE XXII

OCCUPATIONS OF MEN PARTICIPATING IN BONUS

Title	ATHENS	CAMBRIA-JACKSON	CLIFFS SHAFT	C. P. & L. CO.	LLOYD	MAAS	MATHER MINE "A" SHAFT	MATHER MINE "B" SHAFT	NEGAUNEE SHAFT	SPIES-VIRGIL	EXPLORATORY DRILLING DIVISION	TOTAL
SHIFT BOSS	14	8	14		3	11	28	15	4	5		102
MAINTENANCE FOREMAN							1					1
TIMBER FOREMAN	2	1	1		1	1	1	1				8
SURFACE FOREMAN	1	1	1		1	1	1	2	1	1		10
MECHANICAL FOREMAN	1	1	1		1	1	1	1	1	1		9
UNDG. MECH. FOREMAN			1				1	1	1			4
ELECTRICAL FOREMAN				2			1	1				4
STEAM PLANT FOREMAN				1								1
DRILL FOREMAN											2	2
TRAMMER BOSS								2				2
DISPATCHER	2											2
TOTALS	20	11	18	3	6	14	34	23	7	7	2	145

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11. ACCIDENTS AND PERSONAL INJURY

d. Ventilation

All mines are equipped with main mine fans, booster fans and auxiliary fans to the extent that when used, maintained and installed properly we should have excellent conditions in all mines. A brief summary of ventilation in the various mines follows:

ATHENS MINE

Because of the considerable amount of development work being done the ventilation has been and will be only fair until the proper ventilation raises and drifts have been completed. When all development work between the Athens Mine and the Negaunee Shaft has been completed the ventilation system may have to be changed completely but should be better than it ever was in the past because of a second shaft through which the air can be exhausted.

AGNEW MINE

This mine is partly ventilated by natural means and partly by fans. Being a shallow mine there are very few ventilation problems that come up.

CAMBRIA-JACKSON MINE

Ventilation has been good most of the time. Plans to place the Jeffery main mine fan on the Mather "A" 3rd level to blow to the Cambria 7th level, have been completed and work started. This will give the mine considerably more air than before.

CLIFFS SHAFT MINE

The Jeffery Aerodyne, Jr. fan is handling about 130,000 c.f.m. and conditions are good in the mine. At times it is necessary to install a booster fan for increased ventilation of certain sections of the mine.

LLOYD MINE

A Sturtevant and a Buffalo fan are used to ventilate this mine. One fan is located on the 4th level and the other on the 8th level. They handle about 16,200 c.f.m. This is a little less air than we would like to have but the life of the mine is short and it would not pay to install larger fans. The air has been well distributed.

MAAS MINE

The main mine fan is a Jeffery 8H-72 and is located on surface at Negaunee #2 Shaft. It is capable of 125,000 c.f.m. and has operated in #4 blade position handling about 80,000 c.f.m. During a period of repair work in the air shaft an American Blower was installed on the Negaunee 14th level to care for Maas Mine ventilation. This fan has a 100,000 c.f.m. capacity. Ventilation in the Maas Mine has been generally very good.

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11. ACCIDENTS AND PERSONAL INJURY

d. Ventilation (Continued)

MATHER MINE "A" & "B" SHAFTS

These two mines have been well ventilated with a LaDel H56-36 fan located on the 6th level on the boundary line between the two properties. Ventilation has been generally good. At times because of considerable development work many auxiliary fans have been used. Air coming from "B" Shaft to "A" Shaft is washed and tests show this method to be successful.

SARGENT MINE

This mine is shallow and is depending on natural ventilation which is good. Auxiliary fans are used extensively for dead-end places.

SPIES-VIRGIL MINE

Here ventilation has been good with a system easy to operate because of the method of mining. The Jeffery 8H-42 fan is at present handling 30,000 c.f.m. and is capable of twice that amount under present conditions.

During the year department personnel together with either the mine safety inspector or the mine engineer made 18 ventilation surveys at the various mines.

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11. ACCIDENTS AND PERSONAL INJURY

d. Ventilation (Continued)

Dust Sampling & Analyses

One man works almost continuously on this job. During the year 338 samples were taken and analyses made and the average counts for all properties were the best since dust sampling was started in 1933.

As the tables show our higher counts are in raising and scraping in transfer drifts.

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11. **ACCIDENTS AND PERSONAL INJURY**

d. Ventilation (Continued)

The tables on this and following pages give location and various occupations where dust counts were taken; also, total averages of counts since 1933, when the first counts were taken.

TABLE XXIII

DUST SAMPLES COLLECTED - ROCK AND ORE WORK

Mine Or Plant	1952 In Ore	1952 In Rock	1952 Total	1933 - 1952 Total
ATHENS	8	8	16	814
CAMBRIA-JACKSON	18	12	30	339
CLIFFS SHAFT	31	2	33	1817
LLOYD	5	4	9	747
MAAS	23	16	39	769
MATHER MINE "A" SHAFT	10	25	35	820
MATHER MINE "B" SHAFT	20	39	59	324
NEGAUNEE SHAFT	0	27	27	812
PRINCETON *	0	0	0	85
RESEARCH LABORATORY	14	0	14	27
SPIES-VIRGIL	4	5	9	174
TILDEN	0	0	0	80
MISCELLANEOUS	0	0	67	0
TOTALS	133	138	338	6,808

* Now Closed Down

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11. ACCIDENTS AND PERSONAL INJURY

d. Ventilation (Continued)

TABLE XXIV

VARIOUS OCCUPATIONS WHERE DUST SAMPLES WERE COLLECTED

Occupation	ATHENS	CAMBRIA-JACKSON	CLIFFS SHAFT	LLOYD	MAAS	MATHER MINE "A" SHAFT	MATHER MINE "B" SHAFT	NEGAUNEE SHAFT	RESEARCH LABORATORY	SPIES-VIRGIL	TILDEN	TOTAL
DRILLING	11	18	17	3	22	18	29	14		6		138
SCRAPING	5	10	4	4	16	11	18	1				69
LOADING CARS (USING LOADERS)		2				2	15	4		3		26
TIMBERING					1		2					3
HAND SHOVELING					1							1
BARRING BACK			1			1						2
BLOWING CARS	1			1								2
GENERAL MINE AIR	5	2			3	2	8		3	1		24
CHARGING HOLES	1					2	1					4
CRUSHING ORE			11			5	11		6			33
MIXING AND POURING CONCRETE				1			7					8
LAYING TRACK						1	2					3
USING HYDRO-MUCKER				2		3		8				13
PELLETIZING									5			5
TOTALS	23	32	33	11	43	45	93	27	14	10	0	331

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11. ACCIDENTS AND PERSONAL INJURY

d. Ventilation (Continued)

TABLE XXV

AVERAGE LIGHT FIELD COUNT OF ALL SAMPLES TAKEN

Mine Or Plant	1933	1934	1935	1936	1937	1938	1939
ATHENS		32.90	14.12	28.32	26.69	12.85	12.59
CAMBRIA-JACKSON *							
CLIFFS SHAFT	17.94	14.56	8.29	8.98	15.53	9.86	10.36
LLOYD		9.90	12.42	39.25	20.25	10.84	13.47
MAAS		7.46	27.55	35.75	150.98	11.24	36.90
MATHER MINE "A" SHAFT							
MATHER MINE "B" SHAFT *							
NEGAUNEE		53.80	17.77	33.25	59.06	56.26	25.49
PRINCETON *							
SPIES-VIRGIL					70.61	26.99	1.80
TILDEN				67.52	285.27	74.60	60.40
GARDINER MACKINAW		27.77		8.61	48.53		
MISCELLANEOUS			8.66	3.00	6.80	14.73	

* Not In Operation During This Period

(Table Cont'd. - Next Page)

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11. ACCIDENTS AND PERSONAL INJURY

d. Ventilation (Continued)

TABLE XXV (Cont'd.)

AVERAGE LIGHT FIELD COUNT OF ALL SAMPLES TAKEN

Mine Or Plant	1940	1941	1942	1943	1944	1945	1946
ATHENS	9.89	7.28	25.80	4.90	8.33	6.64	4.17
CAMBRIA-JACKSON				12.10	6.21	17.05	11.99
CLIFFS SHAFT	7.77	8.18	7.55	5.99	6.23	8.18	6.34
LLOYD	11.73	8.05	6.95	5.01	14.45	6.49	9.38
MAAS	8.71	17.29	8.46	12.48	8.78	8.17	9.29
MATHER MINE "A" SHAFT		2.42	5.58	6.64	7.57	8.39	7.72
MATHER MINE "B" SHAFT *							
NEGAUNEE	10.79	14.02	17.02	4.65	11.81	11.92	6.67
PRINCETON				10.59	6.32	8.48	
SPIES-VIRGIL	8.40	6.97			5.59	14.22	3.59
TILDEN		49.60				24.18	66.92
GARDNER MACKINAW **							
MISCELLANEOUS			3.00				

* Not In Operation During This Period

** No Longer In Operation

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11. ACCIDENTS AND PERSONAL INJURY

d. Ventilation (Continued)

TABLE XXV (Cont'd.)

AVERAGE LIGHT FIELD COUNT OF ALL SAMPLES TAKEN

Mine Or Plant	1947	1948	1949	1950	1951	1952
ATHENS	7.39	7.49	7.07	4.71	4.15	2.71
CAMBRIA-JACKSON	9.30	13.81	6.86	9.50	8.32	4.54
CLIFFS SHAFT	8.64	5.12	6.26	3.46	4.90	2.76
LLOYD	11.17	12.97	11.72	11.32	6.28	4.72
MAAS	6.08	21.08	10.55	4.45	4.84	4.93
MATHER MINE "A" SHAFT	10.88	9.50	8.40	7.01	8.75	5.86
MATHER MINE "B" SHAFT	2.23	4.16	2.46	6.68	5.04	5.40
NEGAUNEE	7.05	5.48			2.27	1.70
PRINCETON *						
RESEARCH LAB.					5.81	5.57
SPIES-VIRGIL	11.65	5.24	10.12	18.78	6.05	5.29
TILDEN	33.65	2.93	4.38	3.74	6.34	
GARDNER MACKINAW *						

* No Longer In Operation

Safety Department

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11. ACCIDENTS AND PERSONAL INJURY

d. Ventilation (Continued)

TABLE XXVI

COMPARISON OF DUST COUNTS IN RAISING TO DRIFTING

Mine	Average In Raising	Average In Drifting	General Average
ATHENS		2.80	2.71
CAMBRIA-JACKSON	11.06	4.17	4.54
CLIFFS SHAFT	1.26	2.81	2.76
LLOYD	25.20	1.75	4.72
MAAS		5.07	4.93
MATHER MINE "A" SHAFT	16.16	3.21	5.86
MATHER MINE "B" SHAFT	5.07	3.68	5.40
SPIES-VIRGIL		3.42	5.29
NEGAUNEE SHAFT		1.86	1.70

Safety Department

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11. ACCIDENTS AND PERSONAL INJURY

d. Ventilation (Continued)

TABLE XXVII

AVERAGES IN ORE COMPARED TO AVERAGES IN ROCK

Mine	Average In Ore	Average In Rock	General Average
ATHENS	4.16	2.32	2.71
CAMBRIA-JACKSON	5.71	3.31	4.54
CLIFFS SHAFT	2.72	3.37	2.76
LLOYD	8.10	1.61	4.72
MAAS	4.69	9.51	4.93
MATHER MINE "A" SHAFT	3.95	5.11	5.86
MATHER MINE "B" SHAFT	5.91	3.63	5.40
NEGAUNEE SHAFT		1.70	1.70
RESEARCH LAB.	5.57		5.57
SPIES-VIRGIL	8.59	3.34	5.29
TILDEN	-	-	-

Safety Department

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11. ACCIDENTS AND PERSONAL INJURY

d. **Ventilation** (Continued)

TABLE XXVIII

COMPARISON OF AVERAGE DUST COUNTS IN VARIOUS OPERATIONS

						Shafts					
Operation	ATHENS	CAMB. JACK.	CLIFFS SHAFT	LLOYD	MAAS	"A" MATHER	"B" MINE	NEG. SHAFT	RES. LAB.	SPIES VIRGIL	TILDEN
RAISING IN ROCK						16.16	5.07				
RAISING IN ORE		11.06	1.26	25.20							
DRIFTING IN ROCK	2.32	3.31	3.37	1.75	5.81	3.57	3.39	1.86		3.34	
DRIFTING IN ORE	3.56	5.89	1.70		4.05	1.81	4.48			3.82	
SLICING IN ORE											
STOPING IN ORE			2.30							10.18	
CONCRETING							4.01				
BLOWING OUT CARS											
SUB LEVEL CAVING	4.59	5.12		3.83	5.53	4.00	7.81				
BLOCK CAVING	3.24					4.12					
SINKING SHAFT				1.46		2.06		1.46			
CRUSHER & CONVEYOR BELT SYSTEM						16.95					
CRUSHING ORE			3.63						8.55		
PELLETIZING									4.29		

Safety Department

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11. ACCIDENTS AND PERSONAL INJURY

e. Mine Safety & Mine Rescue Courses

Mine Rescue Training

The U. S. Bureau of Mines assisted in training 98 employees in Mine Rescue. During the strike periods the department personnel conducted refresher courses of from 4 hours to 8 hours duration for Mine Rescue men. We have about 218 men trained in Mine Rescue of which 20 are on the Mesaba Range.

First Aid Training

During April month with the assistance of the U. S. Bureau of Mines, we trained 226 employees in First Aid to the injured. At various times during the year department members conducted refresher courses and the new Nielson Method of artificial resperation. Employees of the Cliffs Power and Light Company also attended classes. Plans for First Aid training at the new open pit mines have been made and training starts soon.

Mine Fires - Underground & Surface

Below are listed fires which were reported to this department. In most cases the fires were put out with First Aid fire extinguishers but in some cases required considerable work and use of respiratory equipment.

NEGAUNEE SHAFT

Battery locomotive, short circuit. Respiratory equipment used. Considerable damage to locomotive. Operations halted for 12 hours in Athens Mine because of gases and about same length of time at the Negaunee Shaft. Fire put out with Dry Chemical Fire Extinguishers and water.

MATHER MINE "B" SHAFT

Two fires in combination Battery-Trolley Locomotives. Cause-radiant heat from charging resistance. Both fires put out with dry chemical and later water. O_2 apparatus used by crew to carry Self-Rescuers to eight men who were back of the fire. These men were taken through the smoke using the Self-Rescuers and experienced no trouble. This was the first fire on April 11th. No respiratory equipment was used during the April 18th fire. Considerable damage to batteries of both locomotives.

MAAS MINE

Timber squeezed an electric jumper cable which was attached to the trolley cable. Short circuit caused small fire. Extinguished by shift boss.

Safety Department

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11. ACCIDENTS AND PERSONAL INJURY

e. Mine Safety & Mine Rescue Courses (Continued)

Mine Fires - Underground & Surface (Cont'd)

MAAS MINE

Plank fell on electric heater. Plank was charred but found before fire had started.

MAY22nd - OLD CRUSHER PLANT

Fire in debris from cutting torch. Put out with fire extinguisher and water. Negaunee Fire Department called to finish the job. No damage.

CLIFFS SHAFT MINE

Flooring in small shanty on the 15th level caught fire from an electric light bulb which was attached to an extension. Evidently the bulb had fallen to the floor at the time of blasting in #41 contract. The contract miners smelled the smoke, found the fire and put it out by removing the plank and threw them into some water near by. Damage only slight.

June 22nd

Short circuit at sub-station. Grass in area caught fire. Ishpeming Fire Department put out fire. Only slight damage.

CLIFFS SHAFT MINE

April 29th - Fire under crushing plant in straw and planks caused by sparks from a cutting torch. Put out with fire extinguisher. No damage.

MATHER MINE "A" SHAFT

December 17th - a welder was cutting away a part of a cat-walk over the 7th level crusher box. Hot sparks dropped onto the crusher deck directly below and started a fire in oil which had been flushed from the crusher motor. Fire extinguished with Karbaloy Fire Extinguisher immediately. No damage.

December 22nd - in a top timber transfer a rubber glove had been placed on top of a light bulb and caught fire. Extinguished by a foreman before damage was done.

CAMBRIA-JACKSON MINE

June 22nd - Grass fire. Put out by Negaunee Fire Department. No damage.

September 27th - Grass fire South end of timber field. Fire put out by policeman. No damage.

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11. ACCIDENTS AND PERSONAL INJURY

e. Mine Safety & Mine Rescue Courses (Continued)

Mine Fires - Underground & Surface (Cont'd)

DIESEL POWER PLANT

December 8th - Fire caused by one of the diesel motors. Ishpeming Fire Department called. Damage considerable.

NEGAUNEE MINE

April 29th - Grass fire West end of timber field. Cause unknown but probably children. Negaunee Fire Department put out fire. No damage.

HILL-TRUMBULL MINE

February 1, 1952. Washing Plant - Destroyed wooden forms, and damages to concrete walls.

Caused by overheated space heaters.

February 16, 1952. Pumphouse - 5' x 5' complete loss of building and workmen's clothing.

Caused by overheated stove.

November, 1952. Bulldozer - caught fire while mechanics were repairing it in shop. (Main Shop) No damage.

Caused by using gasoline to clean parts. Safety rule was broken.

December, 1952 Bulldozer - caught fire while mechanics were making repairs on machine in dump service garage.

No damage - cause unknown.

AGNEW MINE

January 17, 1952 Motor barn - stockpile 12' x 30' complete loss.

Caused by overheated stove.

SARGENT MINE

During Strike. Head frame and Hoist house at timber shaft. - 5:00 A.M. complete loss. Building 10' x 10'.

Caused by lightning shorting wires.

There were other fires, how many we cannot say, but all were discovered in the incipient stage and put out. Fire extinguishers certainly have paid for themselves many times over.

11. ACCIDENTS AND PERSONAL INJURY

e. Mine Safety And Mine Rescue Courses (Cont'd)

TABLE XXIX

MINE RESCUE TRAINING
BY U. S. BUREAU OF MINES
MICHIGAN MINES

MAY AND JULY - 1952

Mine	No. Of Men
ATHENS	18
MATHER MINE "A" SHAFT	49
MATHER MINE "B" SHAFT	11
TOTALS	78

MINNESOTA MINES

MARCH - 1952

AGNEW	9
SARGENT	11
TOTALS	20

Other Mine Rescue Training Conducted By Members Of The Safety Department

Safety Department

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11. ACCIDENTS AND PERSONAL INJURY

e. Mine Safety And Mine Rescue Courses (Cont'd)

TABLE XXIX-A

FIRST AID TRAINING
BY U. S. BUREAU OF MINES
MICHIGAN MINES

APRIL - 1952

Mine Or Plant	No. Of Men
ATHENS	16
CAMBRIA-JACKSON	13
CLIFFS POWER & LIGHT	10
CLIFFS SHAFT	33
GENERAL SHOPS	7
MAAS	14
MATHER MINE "A" SHAFT	44
MATHER MINE "B" SHAFT	58
NEGAUNEE SHAFT	16
RESEARCH LABORATORY	4
MISCELLANEOUS	11
TOTAL	226

Other First Aid Training Conducted By Members
Of The Safety Department.

Safety Department

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11. ACCIDENTS AND PERSONAL INJURY

e. Mine Safety And Mine Rescue Courses (Cont'd)

TABLE XXX

FIRST-AID SUPPLIES DISTRIBUTED

MATERIAL	NO. DISTRIBUTED
Tyro-Thri-Cin Pads (Band-Aids)	70,597
Ounces Of Merthiolate	205
1" Roller Bandage	184
2" Roller Bandage	196
3" Roller Bandage	163
Rolls Of Adhesive Tape	161
Picric Acid Gauze Pads (For Burns)	262
Plain Gauze Pads	616
Leather Finger Cots	249
Merthiolate Applicators	3128
Ounces Of Aromatic Spirits Of Amonia	28
Ounces Of Absorbent Cotton	31
Tubes Of Surfacaine	7
Triangular Bandages	12
Pairs Of Scissors	6
Bottles, 1 Oz. (Medicine)	45
2" Compress Bandages	196
3" Compress Bandages	94
5/8 Oz. Tubes Of Boille Ointement	79
TOTALS	76,259

Safety Department

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11. ACCIDENTS AND PERSONAL INJURY

f. Miscellaneous

The department arranged for floats in the VJ-Day parade with a second prize going to one of them. A Drill Jumbo was mounted on a truck and two miners in working clothes operated the drills with power from a portable compressed air machine. The other float was a new Euclid truck. We also had all retired and active employees who had worked 40 or more years without injury riding in autos with large signs on each side of the auto telling the public the fact that people can work without injury.

Fire prevention and protection surveys were made of all active properties.

Furnished an exhibit for the Timber Producers Association at Escanaba, Michigan.

Athens Mine received a "Certificate of Honor" from the Joseph A. Holmes Safety Association for working 11 years without a fatality.

Spent some time with the Michigan Legislative Safety Committee which inspected the Mather and Ohio Mines.

Tables 31,32 and 33 are comparisons of available accident statistics.

Tables 32 and 33 were made available to the Michigan Safety Committee of which I was Chairman and is about as interesting as I have ever seen. These figures show the one or two year accident statistics do not mean too much.

The 15 year periods shown in these tables places the Cleveland-Cliffs Iron Company in a very favorable position.

TABLE XXXI

COMPARISON OF FREQUENCY, SEVERITY RATINGS
TAKEN FROM AVAILABLE STATISTICS

	FREQUENCY	SEVERITY	1951 - LAKE SUPERIOR DIST. FREQUENCY	1951 - LAKE SUPERIOR DIST. SEVERITY
1951 National Rating, All Mining, Including Coal	28.16	5.46		
1951 " " , Coal Mining	34.12	6.77		
1951 " " , Other Mining (Not Including Coal)	22.09	4.14		
1951 " " , Metal Mining	25.89	5.05		
1951 Lake Superior District Mines (24 Companies Reporting)	14.86	2.50		
1952 Lake Superior Mines Safety Exchange (10 Co.'s) No C.C.I.	8.57	3.192		
1952 Lake Superior Mines Safety Exchange " " + C.C.I.	13.19	3.520		
1952 The Cleveland-Cliffs Iron Co., Compensable Injuries	15.87	4.981		
1952 The Cleveland-Cliffs Iron Co., All Injuries	33.72	5.026	14.86	2.50
1952 The Cleveland-Cliffs Iron Co., Open-Cut Mining	16.06	4.260	8.84	1.63
1952 The Cleveland-Cliffs Iron Co., Concentrating Plants	27.23	.640	5.69	0.13
1952 The Cleveland-Cliffs Iron Co., Top Slicing	34.55	15.020	34.97	12.18
1952 The Cleveland-Cliffs Iron Co., Sub-Level Caving	42.80	7.294	20.79	3.06
1952 The Cleveland-Cliffs Iron Co., Stoping	42.66	1.014	20.00	4.29
1952 The Cleveland-Cliffs Iron Co., Block Caving	55.80	10.952	56.26	4.40
1952 The Cleveland-Cliffs Iron Co., Shaft Sinking	45.41	2.296	22.04	0.67
1952 The Cleveland-Cliffs Iron Co., General Shops	8.38	.069	7.89	0.89
1952 The Cleveland-Cliffs Iron Co., C.P.&L. Co.	15.99	.474		
1952 The Cleveland-Cliffs Iron Co., General Roll	0.00	.000		

TABLE XXXII

COMPARISON OF ACCIDENT STATISTICS FOR MICHIGAN METAL MINES FOR THE PERIOD 1937 - 1951 INCLUSIVE

Companies	Man-Hours Worked	Number Of Accidents	Number Of Fatalities	Days Lost Or Charged	Frequency Rate	Severity Rate	Fatality Rate
Calumet & Hecla	61,820,500	762	19	254,169	12.3	4.11	0.30
Cleveland-Cliffs Iron Co.	90,866,869	2,460	38	323,142	27.1	3.56	0.42
M. A. Hanna Company	22,080,044	371	16	122,364	16.8	5.54	0.72
Inland Steel Company	22,739,324	463	12	149,326	20.4	6.57	0.53
North Range Mining Co.	10,982,541	376	12	86,791	34.2	7.90	1.09
Oliver Iron Mining Div.	15,267,332	204	9	87,839	13.4	5.74	0.59
Pickands Mather & Co.	62,383,519	1,028	44	345,080	16.5	5.53	0.70
Republic Steel Corp.	19,842,080	300	23	164,848	15.1	8.31	1.16
TOTALS	305,982,209	5,964	173	1,533,559	19.5	5.01	0.57

TABLE XXXIII

COMPARISON OF ACCIDENT STATISTICS FOR METAL MINES
IN MICHIGAN AND MINNESOTA FOR THE PERIOD
1937 - 1951 INCLUSIVE

Companies	Man-Hours Worked	Number Of Accidents	Number Of Fatalities	Days Lost Or Charged	Frequency Rate	Severity Rate	Fatality Rate
Cleveland-Cliffs Iron Co.	111,842,226	2,957	43	372,592	26.4	3.33	0.38
M. A. Hanna Company	51,706,936	793	24	206,027	15.3	3.98	0.46
Inland Steel Company	25,976,775	572	14	169,857	22.0	6.54	0.54
North Range Mining Co.	11,749,167	394	14	99,256	33.5	8.44	1.19
Oliver Iron Mining Div.	196,197,308	1,271	67	701,325	6.3	3.57	0.34
Pickands Mather & Co.	74,890,894	1,229	46	400,951	16.4	5.35	0.61
Republic Steel Corp.	26,799,656	363	26	187,836	13.5	7.01	0.97
TOTALS	499,162,962	7,579	234	2,137,844	15.2	4.28	0.47

ANNUAL REPORT OF THE MINING ENGINEERING DEPARTMENT FOR THE YEAR ENDING DECEMBER 31, 1952

The four volumes that accompany this report contain photographic views, maps of both the surface and underground workings, open pit cross-sections and records of drilling of all the mines operated by The Cleveland-Cliffs Iron Company. and its affiliated companies. The 1952 yearly mining progress or development is shown colored in red on the maps of the underground projects. The cross-sections of the open pit mines are colored to show the unmined formations, in addition to the portions of the pit volumes that were removed during 1952. The records of drilling and exploration are shown by drill logs and surface maps on which the drill hole locations are indicated. A number of photographs or views are incorporated in these volumes to pictorially show the construction progress at the various current operations of The Cleveland-Cliffs Iron Company.

Two sets of four bound volumes each were compiled; one for the Cleveland office and the other for the Michigan Engineering Department at Ishpeming. One additional volume of the Minnesota Mines was bound and forwarded to the Minnesota office at Hibbing. Other booklets of looseleaf nature were prepared and distributed as indicated below. The following table shows the company for which the booklets were prepared and the mine or mines in which that company has interest

Company	Mines: For Itself	Mines: As Operating Agent
The Cleveland-Cliffs Iron Company	Agnew	Athens
	Alworth	Atkins
	Cambria-Jackson	Bunker Hill
	Canisteo	Hill-Trumbull
	Cliffs-Shaft	Hill-Walker-Potter
	Hawkins	Holman-Cliffs
	Lloyd	Humboldt
	Maas	Mather
	Negaunee	Ohio
	Republic	
	Sally	
	Sargent	
	Spies-Virgil	
	Tilden	
	Wanless-Woodbridge	
The Mesaba-Cliffs Mining Company		
Partners: Hanna Iron Ore Company		Hill-Trumbull
Inland Steel Company		Holman-Cliffs
Jones & Laughlin Steel Corporation		
Pittsburgh Steel Company		
Wheeling Steel Company		
The Athens Iron Mining Company		
for Pickands Mather & Company		Athens
The Negaunee Mine Company		
Partner: Bethlehem Steel Company		Mather Mine
		"A" Shaft
		"B" Shaft
Humboldt Mining Company		
Partner: Ford Motor Company		Humboldt

Additional looseleaf booklets were prepared for the following companies or fee-owners and contain maps of the mines in which they were interested.

Company	Mines
Arthur Iron Mining Company	Atkins, Hill-Trumbull, North Star and Bingham Lease of Holman Cliffs
Inland Steel Company	Atkins
International Harvester Company	Agnew, Hawkins and Sargent
Teal Lake Iron Mining Company	Cambria-Jackson

Similar looseleaf books were prepared for the various Company officials, as follows:

Company		Mine
Grover J. Holt, Manager Minnesota District		Agnew, Alworth, Atkins, Canisteo, Hawkins, Hill-Trumbull, Holman-Cliffs, Sally, Sargent and Wanless-Woodbridge
Arnold E. Hill, Superintendent		Agnew, Alworth
Giulio D. Giuliani	"	Atkins, Wanless-Woodbridge
Ronald B. Pearson	"	Canisteo
William LeClaire	"	Hawkins
Hugh J. Leach	"	Hill-Trumbull
John J. Foucault	"	Holman-Cliffs
Arnold E. Hill	"(Underground)	Sargent
Paul P. Swanson	"(Open Pit)	Sargent
T. A. Kauppila	"	Athens, Negaunee
William R. Atkins	"	Cambria-Jackson, Lloyd
Onni Marjama	"	Cliffs-Shaft
LeRoy Hosking	"	Humboldt
Curtis R. Sundeen	"	Maas
Hugo H. Korpinen	"	Mather
Kenneth C. Olson	"	Ohio, Tilden
Harry Swanson	"	Republic
John M. Haivala	"	Spies-Virgil

B. MAP REPORTS

At the end of each month, the Mining Engineers assigned to the soft ore properties, inspect the underground workings and post the monthly mining progress, the advance of the development contracts and the exploration drill holes. Two sets of these monthly progress maps are made; one set to be used by the Manager and the other set sent to the Superintendent for his use. Numerous prints of the various sub-level maps upon which there was active mining operations are printed, trimmed and folded to pocket size. These maps are carried by the mine captain, foremen and shift bosses who use them to assist them in their day to day production planning.

The next few paragraphs describe the monthly, quarterly and tri-annual map reports sent out by the Engineering Department.

ATHENS MINE

Two sets of monthly progress maps, with mining advancement colored in red, were sent to the Pickands Mather & Company throughout the year.

The Corbit Lease fee-owner trustee was given a set of prints semi-annually, showing work done within the boundaries of that lease.

CLIFFS-SHAFT MINE

One set of geological maps of the Bancroft and Section 10 Leases were forwarded to the Duluth office of the Oliver Iron Mining Company after each of the tri-annual surveys, showing the work done during that four-month period in color. The final issue of these progress maps for the year 1952 also showsthe ore areas that were used in calculating the estimate of ore reserves as reported to the Michigan State Tax Commission.

HUMBOLDT MINE

Quarterly progress maps, showing mining, development or related operations, were sent to Mr. Harry B. Weber, fee-owner of the Weber Lease.

MATHER MINE

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

MICHIGAN STATE TAX COMMISSION

During the first part of September, copies of all maps upon which there was any active workings were sent to Mr. Harry J. Hardenberg, Deputy State Geologist. Upon these maps are shown the known ore areas which are used in calculating ore reserve tonnages. A supplementary map report was sent to the Michigan State Tax Commission at the end of the year, reporting any large increase in ore reserves discovered since the appraisal date of October 1st. At the end of the year, two sets of annual report maps were prepared, showing the areas used in calculating the ore reserve estimates. These sets, one for the Cleveland office and the other kept in the Ishpeming Engineering Department, are made and used as a permanent record of ore reserve tonnages, as reported to the Michigan State Tax Commission.

C. MINING LEASES

The following mining leases were executed and placed on file in the Engineering Department during 1952:

Lease No. 101

The Pittsburgh & Lake Superior Iron Company to The Cleveland-Cliffs Iron Company, dated January 1, 1952, expires December 31, 2002, covering the SW$\frac{1}{4}$ of Section 22, 47-26, Marquette County, Michigan.

Lease No. 102

Elizabeth Joan Vogeler, et al. to The Cleveland-Cliffs Iron Company, dated April 1, 1952, expires March 31, 2002, covering the NW$\frac{1}{4}$ of NW$\frac{1}{4}$, SW$\frac{1}{4}$ of NW$\frac{1}{4}$ and SE$\frac{1}{4}$ of NW$\frac{1}{4}$, all in Section 13, 43-35, Iron County, Michigan.

<u>Lease No. 103</u>

Elizabeth Joan Vogeler, et al. to The Cleveland-Cliffs Iron Company, dated June 1, 1952, expires May 31, 2002, covering the NE$\frac{1}{4}$ of NW$\frac{1}{4}$ of Section 13, 43-35, Iron County, Michigan.

<u>Lease No. 104</u>

Viner Eliasson, et al. to The Cleveland-Cliffs Iron Company, dated August 1, 1952, expires July 31, 2002, covering the NE$\frac{1}{4}$ of Section 13, 43-35, Iron County, Michigan.

<u>Lease No. 105</u>

County of Houghton to The Cleveland-Cliffs Iron Company, dated January 1, 1952, for a term of 50 years with an option for a 50-year extension, covering the N$\frac{1}{2}$ of NE$\frac{1}{4}$, SW$\frac{1}{4}$ of NE$\frac{1}{4}$, NW$\frac{1}{4}$, NE$\frac{1}{4}$ of SW$\frac{1}{4}$ and W$\frac{1}{2}$ of SE$\frac{1}{4}$ of Section 13, 43-32 and SE$\frac{1}{4}$ of NE$\frac{1}{4}$ of Section 24, 43-32, all in Iron County, Michigan. (The surface of the above descriptions was deeded to The Cleveland-Cliffs Iron Company by deed, dated June 3, 1952 from the County of Houghton.)

<u>Lease No. 106</u>

County of Houghton to The Cleveland-Cliffs Iron Company, dated January 1, 1952, for a term of 50 years, with an option for a 50-year extension covering the SE$\frac{1}{4}$ of NW$\frac{1}{4}$ and NE$\frac{1}{4}$ of SW$\frac{1}{4}$ of Section 8, 47-28; SW$\frac{1}{4}$ of NE$\frac{1}{4}$ of Section 13, 47-28; SE$\frac{1}{4}$ of NE$\frac{1}{4}$, N$\frac{1}{2}$ of SE$\frac{1}{4}$ and NE$\frac{1}{4}$ of SW$\frac{1}{4}$ of Section 31, 48-28 and SE$\frac{1}{4}$ of SE$\frac{1}{4}$ and SE$\frac{1}{4}$ of SW$\frac{1}{4}$ of Section 19, 48-29, all in Marquette County, Michigan. (The surface of the above descriptions was deeded to The Cleveland-Cliffs Iron Company by deed, dated June 3, 1952 from the County of Houghton.)

<u>Lease No. 107</u>

Semer Land Company to The Cleveland-Cliffs Iron Company, dated August 1, 1952, expires July 31, 2002, covering the S$\frac{1}{2}$ of NW$\frac{1}{4}$, NW$\frac{1}{4}$ of SE$\frac{1}{4}$ and SW$\frac{1}{4}$ of NE$\frac{1}{4}$ of Section 5, 62-14, Vermilion Range, Minnesota.

<u>Lease No. 108</u>

Agreement between The Cleveland-Cliffs Iron Company and Mather Iron Company, dated August 3, 1951, covering the N$\frac{1}{2}$ of NE$\frac{1}{4}$ and the SE$\frac{1}{4}$ of NE$\frac{1}{4}$ of Section 26, 48-31, Baraga County, Michigan, known as the Webster Mine. This provides The Cleveland-Cliffs Iron Company with an operating agreement for mining upon said lands in conjunction with the Ohio Property.

D. <u>THE FORCE</u>

The personnel of the Engineering Department staff has been slightly increased during 1952 to take care of the needs of our expanding Mining Department. The development of the low grade ore properties, specifically the Ohio, Humboldt and Republic Mines, plus the use of Engineering personnel in matters such as, time study, analysis map use, recording of stope analysis and draw charts, called for additional technical men.

On September 1st, Mr. Kenneth C. Olson, senior Mining Engineer, was appointed Operating Engineer in charge of the Ohio Mine operations.

The summer field season, which runs from June 15th to September 15th, not only gives us an opportunity to do field mapping and sampling but also gives us a chance to evaluate the capabilities of each field party member in looking forward to possible permanent technical employees. The field survey work necessary for the exploration of low grade ore possibilities was carried out by five two-man parties. Two of these parties were based in a tent camp in the Fence Lake Area, one two-man party at the Central Range Basin, one at the North Lake Project and the remaining party housed at a camp in the Cascade Area.

In as much as the source of our Surveyor Helper personnel is that of high school graduates, we have had some turnover of men due to the fact that this age group is presently being inducted into the Armed Services. The following men were inducted into the Armed Services during 1952:

Name	Leaving Date
Clyde H. Dodge	February 28th
Ronald C. Foisie	March 31st
John P. Clark	August 8th
Michael A. Zychowski	November 28th

Mr. George B. Manzoline, Draftsman, was transferred from the Mining Engineering Department to the Mechanical Department on March 17th, where he is presently doing architectural drawing and design.

Mr. Ralph K. Oja, Surveyor, rejoined the Engineering Department on December 8th, after completing a two-year hitch in the Army Air Corps.

The following table shows the personnel of the Department, their position and the period of employment:

Name	Position	Entered	Left	1952 Employment
Carl Brewer	Recorder			12 Months
Grant T. Hollett	District Engineer			12 Months
Eric G. Beinlich, Jr.	Engineer	July 1st		6 Months
Keith R. Busby	Engineer			12 Months
Harley E. Clickner	Engineer	June 9th		7 Months
Robert G. Fountain	Engineer			12 Months
Oiva W. Hakala	Engineer			12 Months
Allen H. Heikkinen	Engineer	August 6th		5 Months
R. Charles Kincaid	Engineer			12 Months
Eino A. Koski	Engineer	March 18th		9½ Months
Lionel N. Larson	Engineer			12 Months
John F. Magnuson	Engineer			12 Months
Leamon G. McGee	Engineer	July 17th		5½ Months
Kenneth C. Olson	Engineer		September 1st	8 Months
Bernhardt H. Petersen	Engineer			12 Months
Thomas B. Reifsnyder	Engineer	May 22nd		7 Months
Dale S. Strand	Engineer	June 30th		6 Months
Robert L. Sundeen	Engineer			12 Months
Victor E. Swan	Engineer			12 Months
P. Daniel Isaacson	Asst. Engineer			12 Months
C. Arthur Koski	Asst. Engineer			12 Months
F. Alfred Koski	Asst. Engineer			12 Months
W. Harlow Stannard	Chief Draftsman			12 Months
Lembit L. Liivoja	Draftsman	January 11th		11½ Months
Anselm H. Mantyla	Draftsman			12 Months
George B. Manzoline	Draftsman		March 17th	2½ Months
Donald R. Nankervis	Draftsman			12 Months

Name	Position	Entered	Left	1952 Employment
Donald W. Carlson	Clerk			12 Months
Jean C. Jensen	Stenographer			12 Months
Clifford H. Amel	Surveyor			12 Months
Robert E. Anderson	Surveyor			12 Months
Clarence P. Ayotte	Surveyor			12 Months
Charles W. Cornish	Surveyor			12 Months
Paul G. Jacka	Surveyor			12 Months
Herbert S. Kelly	Surveyor			12 Months
Donald E. Lampi	Surveyor			12 Months
Alfred B. Nault	Surveyor			12 Months
Ernest A. Oja	Surveyor			12 Months
Ralph K. Oja	Surveyor	December 8th		1 Month
Russell J. Paull	Surveyor			12 Months
John R. Sleeman	Surveyor			12 Months
Harold A. St. John	Surveyor	October 6th		3 Months
Robert R. Swanson	Surveyor	November 3rd		2 Months
Allan E. Wakkuri	Surveyor			12 Months
Clyde C. Anderson	Helper			12 Months
Allan L. Bjork	Helper	April 3rd		9 Months
Donald P. Chartier	Helper	September 10th		4 Months
James C. Cleven	Helper	September 18th		3½ Months
Clyde H. Dodge	Helper		February 28th	2 Months
David W. Dompierre	Helper	April 1st	September 12th	5½ Months
Ronald C. Foisie	Helper		March 31st	3 Months
Clifford A. Frenn	Helper	September 16th		3½ Months
Robert L. Lahde	Helper	March 24th		9 Months
William M. Leaf	Helper			12 Months
William R. Lehmann	Helper	February 27th		10 Months
Carl F. Lemin	Helper	February 15th		10½ Months
Robert A. Marietti	Helper	February 26th		10 Months
Louis R. Miller	Helper			12 Months
Paul E. Poutanen	Helper			12 Months
Joseph J. Scoleri	Helper			12 Months
Arnold A. Sundell	Helper			12 Months
Richard L. Swanson	Helper	June 17th		6½ Months
James M. Taipale	Helper	April 22nd	September 11th	4½ Months
Nicholas W. Tasson	Helper			12 Months
Arnold E. Townsend	Helper	August 18th		4½ Months
Wilburt H. Thomas	Helper			12 Months
Francis A. Wills	Helper	April 7th	September 4th	6 Months
Raymond S. Windsand	Helper			12 Months
Michael A. Zychowski	Helper	September 16th	November 28th	2½ Months

The following table shows the summer field crew personnel, their position and their period of employment:

Rogers J. Corcoran	Helper	August 7th	September 15th	1½ Months
Wayne R. Dolezal	Surveyor	June 9th	August 29th	3 Months
Robert D. Fraser	Surveyor	June 19th	September 11th	3 Months
Marvin E. Kiel	Surveyor	June 10th	August 29th	3 Months
Keith W. Johnson	Helper	June 17th	September 12th	3 Months
Wallace L. Larsen	Surveyor	June 10th	August 22nd	3 Months
Claude Latour	Surveyor	July 17th	September 19th	2 Months
Roy E. Margenau, Jr.	Surveyor	June 16th	September 5th	3 Months

Name	Position	Entered	Left	1952 Employment
Donald M. Peterson	Helper	June 17th	September 12th	3 Months
David W. Satterley	Helper	July 28th	August 29th	1 Month
Wayne W. Sternitsky	Surveyor	June 9th	July 31st	2 Months

The following table shows the length of service in the Engineering Department of those employed at the end of the year:

Name	Date Entered	Length of Service
Carl Brewer	August, 1906	34 Years, 3 Months
Grant T. Hollett	August, 1940	12 Years, 4½ Months
Eric G. Beinlich, Jr.	July, 1952	6 Months
Keith R. Busby	October, 1951	1 Year, 3 Months
Harley E. Clickner	June, 1952	7 Months
Robert B. Davis	August, 1951	1 Year, 4 Months
Robert G. Fountain	August, 1951	1 Year, 4 Months
Oiva W. Hakala	July, 1951	1 Year, 6 Months
Allen H. Heikkinen	August, 1952	5 Months
R. Charles Kincaid	July, 1951	1 Year, 6 Months
Eino A. Koski	March, 1952	9½ Months
Lionel N. Larson	October, 1951	1 Year, 2½ Months
John F. Magnuson	March, 1950	2 Years, 10 Months
Leamon G. McGee	July, 1952	5½ Months
Bernhardt H. Petersen	November, 1950	2 Years, 1½ Months
Thomas B. Reifsnyder	May, 1952	7 Months
Dale S. Strand	June, 1952	6 Months
Robert L. Sundeen	December, 1950	2 Years, ½ Month
Victor E. Swan	April, 1951	1 Year, 9 Months
P. Daniel Isaacson	November, 1950	7 Years, 4½ Months
C. Arthur Koski	June, 1941	8 Years, 1 Month
F. Alfred Koski	January, 1936	11 Years, 9 Months
W. Harlow Stannard	November, 1940	12 Years, 2 Months
Lembit L. Liivoja	January, 1952	11½ Months
Anselm H. Mantyla	July, 1948	4 Years, 5½ Months
Donald R. Nankervis	March, 1951	1 Year, 10 Months
Jean C. Jensen	July, 1951	1 Year, 5½ Months
Clifford H. Amel	May, 1944	8 Years, 7½ Months
Robert E. Anderson	July, 1948	4 Years, 6 Months
Clarence P. Ayotte	April, 1948	4 Years, 8½ Months
Charles W. Cornish	January, 1951	2 Years
Paul G. Jacka	April, 1951	1 Year, 8½ Months
Herbert S. Kelly	May, 1948	4 Years, 7 Months
Donald E. Lampi	April, 1951	1 Year, 9 Months
Alfred B. Nault	September, 1946	6 Years, 3½ Months
Ernest A. Oja	March, 1943	9 Years, 10 Months
Ralph K. Oja	February, 1947	3 Years, 9 Months
Russell J. Paull	March, 1947	5 Years, 9 Months
John R. Sleeman	February, 1947	5 Years, 10½ Months
Harold A. St. John	October, 1952	3 Months
Robert R. Swanson	November, 1952	2 Months
Allan E. Wakkuri	January, 1951	1 Year, 11½ Months
Clyde C. Anderson	December, 1950	2 Years, 1 Month
Allan L. Bjork	April, 1952	9 Months
Donald P. Chartier	September, 1952	4 Months

Name	Date Entered	Length of Service
James C. Cleven	September, 1952	3½ Months
Clifford A. Frenn	September, 1952	3½ Months
Robert L. Lahde	March, 1952	9 Months
William M. Leaf	July, 1950	2 Years, 6 Months
William R. Lehmann	February, 1952	10 Months
Carl F. Lemin	February, 1952	10½ Months
Robert A. Marietti	February, 1952	10 Months
Louis R. Miller	August, 1945	7 Years, 3½ Months
Paul E. Poutanen	January, 1951	1 Year, 11½ Months
Joseph J. Scoleri	May, 1951	1 Year, 7½ Months
Arnold A. Sundell	February, 1951	1 Year, 11 Months
Richard L. Swanson	June, 1952	6½ Months
Nicholas W. Tasson	November, 1951	1 Year, 1½ Months
Wilburt H. Thomas	January, 1951	2 Years
Arnold E. Townsend	August, 1952	4½ Months
Raymond S. Windsand	December, 1947	5 Years, ½ Month

In the above table, the "Length of Service" covers only that period the men were employed in the Engineering Department. Some of them have been in other Departments and at the mines at one time or another.

The following table shows the number of days worked, days overtime, sick and absent during the year, of all those who were in the Department:

Name	Days Worked	Overtime	Sick	Absent
Carl Brewer	224		30	
Grant T. Hollett	244			10
Eric G. Beinlich, Jr.	125½	3½		8
Keith R. Busby	274	18		2
Harley E. Clickner	140½			3
Robert B. Davis	249	4		12
Robert G. Fountain	245	1	3	7
Oiva W. Hakala	198½	10	54½	11
Allen H. Heikkinen	101			
R. Charles Kincaid	264½	23½		6
Eino A. Koski	207	9½		6
Lionel N. Larson	254½	11½	2	13½
John F. Magnuson	256	11		13
Leamon G. McGee	117½	½		
Kenneth C. Olson	202½	13½	2	1
Bernhardt H. Petersen	258½	7½		5
Thomas B. Reifsnyder	156½	3		
Dale S. Strand	132	1		
Robert L. Sundeen	260	14	1	14
Victor E. Swan	247	3½	12	2
P. Daniel Isaacson	279½	31½		10
C. Arthur Koski	258	11	½	10½
F. Alfred Koski	257	18		16
W. Harlow Stannard	242½			12½
Lembit L. Liivoja	253	5		
George B. Manzoline	52			
Anselm H. Mantyla	239½	1	3	12½
Donald R. Nankervis	262	15½		7

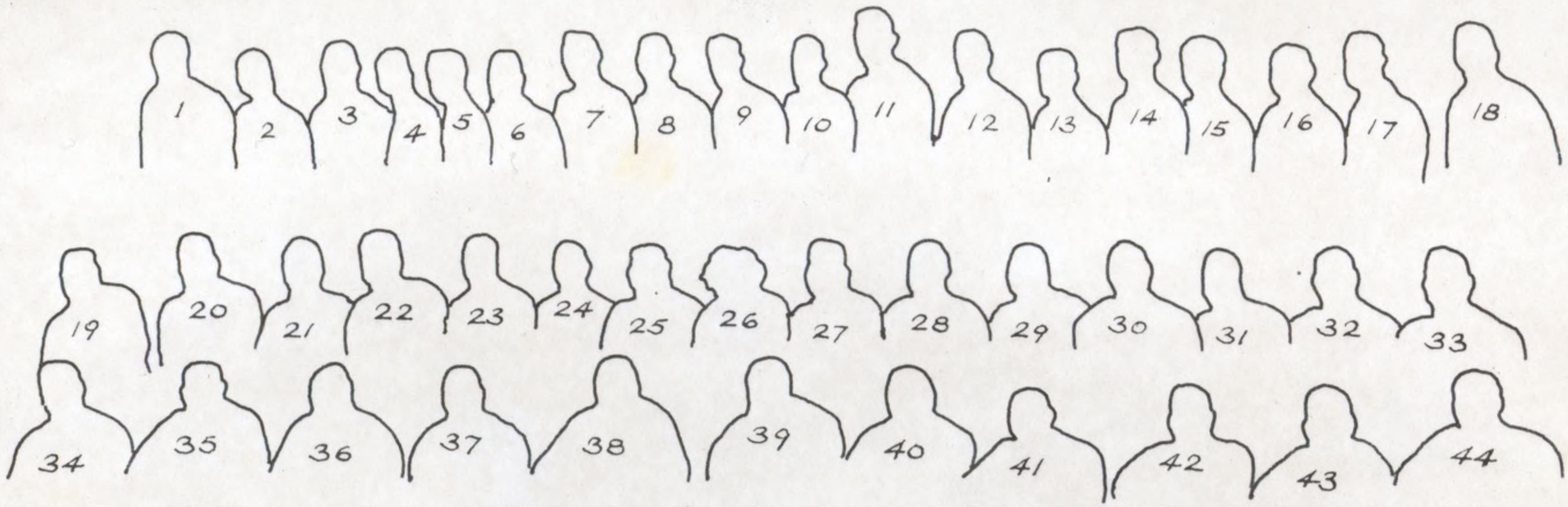
Name	Days Worked	Overtime	Sick	Absent
Donald W. Carlson	244			10
Jean C. Jensen	257	7½		4½
Clifford H. Amel	249½	6½		10
Robert E. Anderson	227½	3	30	10
Clarence P. Ayotte	280	40	4	10
Charles W. Cornish	269	29	1	10
Paul G. Jacka	245	13		22
Herbert S. Kelly	229½	15½	29	11
Donald E. Lampi	251½	7½		10
Alfred B. Nault	272½	28½		10
Ernest A. Oja	228		18	8
Ralph K. Oja	16	1		
Russell J. Paull	260	16		10
John R. Sleeman	265-3/4	21-3/4		10
Harold A. St. John	64	5		
Robert R. Swanson	39½	½		
Allan E. Wakkuri	278½	29½	1	5
Clyde C. Anderson	258½	19½	2	12
Allan L. Bjork	190	4		2
Donald P. Chartier	74			3
James C. Cleven	75½	4½		
Clyde H. Dodge	41½	6½		
David W. Dompierre	116	1		1
Ronald C. Foisie	61½	7½		3
Clifford A. Frenn	70			
Robert L. Lahde	186	7	6	9
William M. Leaf	256-3/4	12-3/4		10
William R. Lehmann	226	18		6
Carl F. Lemin	215½			5
Robert A. Marietti	217½	13		15½
Louis R. Miller	243½	7	7½	10
Paul E. Poutanen	213½	19½	40	20
Joseph J. Scoleri	274½	25½		5
Arnold A. Sundell	274½	25½		5
Richard L. Swanson	142½	9½		3
James M. Taipale	99			1
Nicholas W. Tasson	195½	2	45	15½
Arnold E. Townsend	94½	2½		1
Wilburt H. Thomas	261	30		19
Francis A. Wills	112½	8		1
Raymond S. Windsand	258½	16	1	10½
Michael A. Zychowski	47			3
Rogers J. Corcoran	27	1		
Wayne R. Dolezal	64	5		
Robert D. Fraser	66	4		
Marvin E. Kiel	62½	5		
Keith W. Johnson	64½	2½		
Wallace L. Larsen	47½	5		
Claude Latour	48	2		
Roy E. Margenau, Jr.	58			
Donald M. Peterson	61		1	
David W. Satterley	27½			
Wayne W. Sternitsky	41	3		

The following table shows the distribution of time spent underground, in the field and in the office:

Name	Underground	Field	Office	Total
Carl Brewer			224	224
Grant T. Hollett	2	92	150	244
Eric G. Beinlich, Jr.	50½	47-1/4	27-3/4	125½
Keith R. Busby	98	26	150	274
Harley E. Clickner	52	40	48½	140½
Robert B. Davis	130	20	99	249
Robert G. Fountain		47	198	245
Oiva W. Hakala	58½	32½	107½	198½
Allen H. Heikkinen		96	5	101
R. Charles Kincaid	99	19	146½	264½
Eino A. Koski	47	71	89	207
Lionel N. Larson	2½	187	65	254½
John F. Magnuson	141	24	91	256
Leamon G. McGee		87½	30	117½
Kenneth C. Olson	30	67½	105	202½
Bernhardt H. Petersen	109	12	137½	258½
Thomas B. Reifsnyder	59½	26	71	156½
Dale S. Strand		86	46	132
Robert L. Sundeen	107		153	260
Victor E. Swan		175½	71½	247
P. Daniel Isaacson	127½	24	128	279½
C. Arthur Koski	138	33-1/4	86-3/4	258
F. Alfred Koski	4	144	109	257
W. Harlow Stannard			242½	242½
Lembit L. Liivoja			253	253
Anselm H. Mantyla			239½	239½
George B. Manzoline			52	52
Donald R. Nankervis			262	262
Donald W. Carlson			244	244
Jean C. Jensen			257	257
Clifford H. Amel		168	81½	249½
Robert E. Anderson	107½	29½	90½	227½
Clarence P. Ayotte	163½	27	89½	280
Charles W. Cornish	169	27	73	269
Paul G. Jacka	1	192	52	245
Herbert S. Kelly	92	15½	122	229½
Donald E. Lampi	67	128½	56	251½
Alfred B. Nault	129	46	97½	272½
Ernest A. Oja		162	66	228
Ralph K. Oja	10		6	16
Russell J. Paull	120	66½	73½	260
John R. Sleeman	110	40	115-3/4	265-3/4
Harold A. St. John		23	41	64
Robert R. Swanson	1	38½		39½
Allan E. Wakkuri	168	26	84½	278½
Clyde C. Anderson	117½	70	71	258½
Allan L. Bjork	65	36	89	190
Donald P. Chartier	1	71	2	74
James C. Cleven	44	3	28½	75½
Clyde H. Dodge	27		14½	41½
David W. Dompierre	38	28½	49½	116
Ronald C. Foisie	40		21½	61½

Name	Underground	Field	Office	Total
Clifford A. Frenn		66	4	70
Robert L. Lahde	82	35	69	186
William M. Leaf	106	40	110-3/4	256-3/4
William R. Lehmann	98	47	81	226
Carl F. Lemin		182	33½	215½
Robert A. Marietti	112½	31	74	217½
Louis R. Miller			243½	243½
Paul E. Poutanen	118½	30	65	213½
Joseph J. Scoleri	133	46½	95	274½
Arnold A. Sundell	142½	32½	99½	274½
Richard L. Swanson		134½	8	142½
James M. Taipale		91	8	99
Nicholas W. Tasson		110	85½	195½
Arnold E. Townsend	32½	16	46	94½
Wilburt H. Thomas	147	26	88	261
Francis A. Wills	45	27	40½	112½
Raymond S. Windsand	112	72½	74	258½
Michael A. Zychowski		47		47
Rogers J. Corcoran		27		27
Wayne R. Dolezal		61	3	64
Robert D. Fraser		65	1	66
Marvin E. Kiel		60	2½	62½
Keith W. Johnson		62	2½	64½
Wallace L. Larsen		45	2½	47½
Claude Latour	17	22	9	48
Roy E. Margenau, Jr.		56	2	58
Donald M. Peterson		59	2	61
David W. Satterley		26	1½	27½
Wayne W. Sternitsky		39	2	41

The following sheet shows in tabular form, the personnel of the Engineering Department and their classification, as of December 31, 1952:



1. Leamon G. McGee
2. William R. Lehmann
3. C. Arthur Koski
4. Allan L. Bjork
5. David W. Dompierre
6. Raymond S. Windsand
7. Louis R. Miller
8. Clarence P. Ayotte
9. David W. Satterley
10. Richard L. Swanson
11. Paul G. Jacka
12. Keith W. Johnson
13. Donald E. Lampi
14. William M. Leaf
15. Donald R. Nankervis
16. Anselm H. Mantyla
17. Lembit L. Liivoja
18. Wilburt H. Thomas
19. W. Harlow Stannard
20. Robert L. Sundeen
21. Robert B. Davis
22. Oiva W. Hakala
23. Eino A. Koski
24. Keith R. Busby
25. Grant T. Hollett
26. Jean C. Jensen
27. R. Charles Kincaid
28. Eric G. Beinlich
29. Dale S. Strand
30. Robert G. Fountain
31. Clyde C. Anderson
32. Francis A. Wills
33. Arnold A. Sundell
34. Victor E. Swan
35. Clifford H. Amel
36. Robert E. Anderson
37. John R. Sleeman
38. Herbert S. Kelly
39. Alfred B. Nault
40. Allen H. Heikkinen
41. F. Alfred Koski
42. Joseph J. Scoleri
43. James M. Taipale
44. P. Daniel Isaacson

Not Present—

Harley E. Clickner, Lionel N. Larson, John F. Magnuson, Kenneth C. Olson, Bernhardt H. Petersen, Thomas B. Reifsnyder, Ernest A. Oja, Allan E. Wakkuri, Charles W. Cornish, Russell J. Paull, Robert L. Lahde, Carl F. Lemin, Robert A. Marietti, Paul E. Poutanen, Nicholas W. Tasson, Arnold E. Townsend, Claude Latour, Rogers J. Corcoran, Roy E. Margenau, Jr., Donald M. Peterson.

ENGINEERING DEPARTMENT PERSONNEL - 1952

	ATHENS	CAMBRIA JACKSON	CLIFFS SHAFT	HUMBOLDT	LLOYD	MAAS	MATHER "A"	MATHER "B"	NEGAUNEE
MINE ENGINEER	B. H. Petersen	R. L. Sundeen	R. B. Davis	L. N. Larson	J. F. Magnuson	K. R. Busby	O. W. Hakala	R. C. Kincaid	E. A. Koski
ASST. MINE ENGINEER	E. G. Beinlich		C. A. Koski			H. E. Glickner	P. D. Isaacson		
SURVEYOR	J. R. Sleeman	H. S. Kelly		C. H. Amel	H. S. Kelly	R. E. Anderson	C. P. Ayotte C. W. Cornish R. K. Oja	A. B. Nault A. E. Wakkuri	R. J. Paull
HELPERS	W. M. Leaf	R. L. Lahde	A. L. Bjork	R. L. Swanson	R. L. Lahde		P. E. Poutanen W. H. Thomas R. A. Marietti	A. A. Sundell J. J. Scoleri W. R. Lehmann J. C. Cleven	C. C. Anderson R. S. Windsand

	OHIO	REPUBLIC	SPIES	TILDEN	CLIFFS 8TH ADDITION	HUMBOLDT BOUNDARIES
MINE ENGINEER	D. S. Strand	L. G. McGee	T. B. Reifsnyder	D. S. Strand	V. E. Swan	A. H. Heikkinen
SURVEYOR	P. G. Jacka	R. R. Swanson		P. G. Jacka	D. E. Lampi E. A. Oja	
HELPERS	C. F. Lemin	D. P. Chartier	A. E. Townsend	C. F. Lemin	H. A. St. John	C. A. Frenn M. A. Zychowski

OFFICE

OFFICE ENGINEER	R. G. Fountain
ASST. ENGINEER	F. A. Koski
DRAFTSMEN	W. H. Stannard (Chief) L. L. Liivoja A. H. Mantyla D. R. Nankervis
DEPT. CLERK	J. C. Jensen
PRINTER	L. R. Miller

SUMMER FIELD PARTIES
(June 15th to September 15th)

Party No.	Name	District
1	Paul G. Jacka Richard L. Swanson	Section 4,5,6, 47-27
2	Robert D. Fraser	Cascade
3	Wayne R. Dolezal	Central Range Basin
4	Wallace L. Larsen	Fence Lake
5	Marvin E. Kiel	Fence Lake

F. COSTS

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

	1950	1951	1952
Salaries	$100,143.54	$159,185.49	$252,469.75
Auto Expense	3,580.32	4,054.85	4,007.82
Furniture and Fixtures	653.56	396.01	158.60
Heat, Light and Power	556.29	631.20	691.57
Insurance	148.02	179.01	230.72
Postage	94.34	93.02	113.95
Rentals			15.00
Repairs	3,640.80	332.78	85.96
Stationery and Printing	243.07	540.43	1,479.46
Supplies	10,250.34	15,475.61	13,308.93
Taxes	49.18	48.89	48.55
Traveling and Entertainment	866.70	3,177.55	4,581.24
Telephone and Telegraph	241.57	384.68	503.42
Papers and Periodicals	3.00	69.20	88.41
Unemployment Insurance Tax	1,164.79	1,545.71	2,492.34
General - Unclassified	1,068.00	1,094.45	3,913.43
Old Age Benefits Tax	1,343.98	2,061.07	3,243.66
Depreciation	64.00	108.00	78.00
Equipment		6,144.51	548.87
Group Annuity Premiums	695.95	1,760.82	1,719.71
Personal Injury Expense			7.50
TOTALS	$124,807.45	$197,283.28	$289,786.89

H. AUTOMOBILES

The Ford Tudor sedan furnished by Four Wheels, Inc., was released to Mr. John M. Haivala on June 21, 1952. A 1952 Ford Ranch Wagon was purchased by the Engineering Department and received on June 20, 1952. The latter has been operated for the balance of the year by the surface survey crews. The development of the low grade ore properties at the West end of the Range required additional transporation facilities, so on October 16, 1952, the Engineering Department was again supplied with a 1952 Ford Mainliner, furnished by Globe Auto Leasing, Inc. The Chevrolet Carry-All #1 (1949 model) was operated throughout the year by the Cliffs 8th Addition crew. The Chevrolet Carry-All #2 (1950 model) was operated throughout the year, mainly by the Humboldt Mine survey crew.

The following table shows the mileage covered in 1952, the total mileage to the end of the year or date of disposal, and the date the cars were received in the Department:

Car	Miles		Date	Date
	1952	Total	Received	Disposed of
Ford Sedan (1951 model)	15,745	30,780	7/3/51	6/21/52
Ford Mainliner (1952 model)	3,201	3,201	10/16/52	
Ford Ranch Wagon	6,762	6,762	6/20/52	
Chevrolet Carry-All #1	26,200	36,933	6/13/49	
Chevrolet Carry-All #2	19,894	32,334	6/1/50	

I. MINES

The following brief summary itemizes the special work done at the various properties during the year:

GENERAL

The Michigan mines were idle during the period, June 2nd to July 26th, as a result of a strike of the United Steelworkers of America, CIO. The Engineering Department's efforts were confined to check surveys, both level and transit on surface and underground.

ATHENS MINE

(a) The shaft was plumbed from 6th to 10th Levels to insure the accuracy of the surveys on the 10th Level connecting drift to the Negaunee Mine.

(b) Complete subsidence surveys were made in the spring and fall. An additional 24 iron pins were added to the grid system North of Ann Street.

(c) A stockpile survey was made in August to establish a skip factor for wet ore being hoisted from the Bunker Hill property.

(d) Plans were made for the re-routing of Partridge Creek in an effort to reduce water seepage through the cave into the mine. A semi-circular, corrugated, galvanized steel flume was selected as the means of carrying the water over and around the surface cave area. Lines and elevations for the new route were put in, and construction was expected to commence early in 1953.

(e) Timbered bents were designed and erected to replace the North permanent stockpile trestle which collapsed apparently due to surface subsidence and shifting. Three sets of railroad tracks underneath the trestle and the necessary clearances needed by the engine and ore cars made the design and erection of the bents an exceptionally difficult job.

(f) Considerable time was spent making a time study of the Canadian Copco drill machines, mounted on the standard mine jumbo, operating in the 10th Level connecting drift to the Negaunee Mine.

CAMBRIA-JACKSON MINE

(a) Mining Sub Levels between 7th and 8th Levels were planned and laid out and the development of these Sub Levels was directed.

(b) In conjunction with the mine geologist, the 6th and 7th Levels' Exploration drifting and drilling program were planned and directed.

(c) New ore pockets were designed and constructed on the 6th Level plat.

(d) Experiments were made on new type auger steel and related drilling equipment.

(e) The Mining Engineer conducted a shift bosses' school; instructing them in the use of the Brunton compass, scale, protractor and maps.

CLIFFS-SHAFT MINE

(a) Sample procedure as proposed by Mr. John Hollister has been carried through. A monthly report giving the average iron percent of all ore broken in each contract is compiled by the Mining Engineer.

(b) Considerable work was done by the survey crew in staking and grading the Cliffs-Shaft and Engineering Building parking lots, as well as the extension of Euclid Street to US-41.

(c) The shift bosses were individually instructed in the use of scales, protractors and reading of the underground mine maps.

(d) "A" and "B" Shafts were plumbed from surface to 5th, 10th and 15th Levels. Check surveys were run in preparation for "C" Shaft development.

(e) Replacement of wooden sets with steel sets and grouting of "B" Shaft required some planning and surveying by the Engineering Department personnel.

(f) The tri-annual survey of mining and development contracts has been supplemented by the surveying of all two-shift contracts (about 25% of all contracts) every two months. These maps are prepared for mine operating personnel only.

(g) Routine surveying of mining and development contracts and diamond drill holes was carried out when needed throughout the year.

HUMBOLDT MINE

(a) The preliminary work of developing the proposed mill site was done for the O. W. Walvoord Company, the mill designers. This work consisted of establishing base line control, bench marks, center lines, contours, profiles and the final staking out of the proposed mill to see how it would fit the actual field conditions.

(b) Three drill machines were tested on the property to determine their adaptability and operating efficiency in the pit area. The machines tested were:

1. Linde Air Company's Jet Piercing Rig
2. Joy Manufacturing Company's TWM-1
3. Chicago Pneumatic's C. P. 70 N. D. C.

Complete drilling data was tabulated and operating costs calculated for each machine. Blasting tests were also made using the holes drilled during the testing of the Joy machine.

(c) Surveys of all boundary lines and the setting of brass cap monuments on the Humboldt Mining Company lands and Weber Lease have been completed in addition to several lines on auxiliary lands that will be necessary for future operations.

(d) Highway US-41 has been relocated, graded and partially surfaced. Surfacing operations were discontinued due to the failure of the cement company to provide an adequate supply of cement. Five houses in the pit area were moved to new locations on the relocated highway.

(e) Permanent power lines have been constructed from the Clarksburg substation to a temporary substation at the plant site. The temporary substation is servicing the mill area, permanent pit and Lake Lory lines.

(f) Layout of the office and shop buildings was done for Klippen-Holm, the contractor placing the footings and concrete walls. Structural steel erection was started by Arrowhead Steel Buildings, Inc. late in the year.

(g) Layout and grading of the dike system around the tailings basin has been completed. The area enclosed is 104 acres, having a storage capacity of 242,100,000 gal. of water. Water from the basin will be reused in the mill as required.

(h) Lake Lory has been sounded to determine the depth and volume of the lake. A proposed pumphouse location has been chosen as well as a make-up water pipe location from the mill to the tailings basin.

(i) A 500 gpm pump was installed in one of the old Baron Shaft caves and the water level lowered 18 ft. in an effort to drop the water table in the pit area where quicksands became apparent in several places well above the general swamp level.

(j) The pit base line and pit sections have been run for stripping estimates and pit planning. Stripping was carried on using a P&H 1500-4 cu. yd. shovel and four 22-ton Euclid trucks. A total of 133,700 cu. yds of surface material was moved. This material was used for back fill in the warehouse and stocking areas and for the construction of dikes and roads.

LLOYD MINE

(a) In order to provide the Lloyd and Morris Mines with an adequate water supply system, a 1450' 4" water line was planned, laid out and installed to connect the mine water system to the Ishpeming Township and City of Ishpeming water systems. The new line was installed to bypass the old line to the North Lake Location and the old water tank. The old method of water supply from the Morris Mine deep wells and the Lloyd 2nd Level was discontinued. As part of this program, all of the existing water lines were surveyed and posted on the surface maps.

(b) A comprehensive study of the Lloyd discharge system was also made to determine the probability of the recirculation of the mine discharge water.

(c) During the year, four additions to the existing surface buildings were erected; a tractor garage adjacent to the truck garage, a welding shop, a car repair building addition to the shops building and an equipment storage shed addition to the steel storage shed.

(d) A new rock trestle and two new ore stocking trestles were erected and the stocking area to the East of the shaft was graded. This grading will provide gravity feed of the ore cars to the shovel and pockets.

(e) After a complete geological study and the preparation of ore estimates, the decision was made to sink the Winze shaft an additional 150' and to develop the 10th Level.

MAAS MINE

(a) The development program carried out on the 7th Level during the entire year was controlled throughout by lines and grades set by the survey crew.

(b) The method of developing and undercutting the first block cave on the 7th Level was drafted and closely supervised by the Mining Engineer.

(c) As the geographical location of the rehabilitation work done on the No. 2 Air Shaft, Negaunee Mine, was not convenient for supervision by the underground staff, the Mining Engineer, in conjunction with the Mechanical Department, undertook the planning and general supervision of this project. As part of the project, the survey crew laid out a new foundation and checked the installation of the auxiliary fan on the 14th Level, Negaunee Mine.

(d) A check survey was carried from the 6th Level to the 7th Level through the 7102 Air Raise to check the accuracy of the shaft plumbing done in 1951.

(e) With the cooperation of the Geological Department, a detailed study and report were made on the method and costs of exploring the area between the present Maas ore body and the Eastern boundary of the Mather Mine, i.e., on Pioneer and Arctic Lands.

(f) Assistance was given the Geological Department in the planning, supervision and analysis of two drilling programs during the year. One program explored the area immediately West of the 6th Level workings while the other probed the extension of the ore body South into the Pioneer and Arctic Lease.

MATHER MINE

"A" Shaft

(a) On surface, the Engineering Department crew ran a centerline, profile and cross-sections for a road between "A" and "B" Shafts.

(b) Footings and piers for a cement batching plant, adjacent to the headframe, were laid out and the construction supervised.

(c) A stockpile estimate was made of the North and South trestles to determine the amount of ore in stock.

(d) The 5th Level check survey was advanced and elevations were checked. Considerable time was spent on a rock pass drift and preliminary installation work of the crusher and trench on the main line was undertaken.

(e) A shaft plumbing from 6th to 7th Level was completed. Using this data, a check survey was made on the 7th Level which will connect with "B" Shaft 7th Level early in 1953.

(f) Between 7400 and 7500 Cross-cuts, five drifts were driven simultaneously from each side, holing through with a high degree of accuracy for both line and elevation.

(g) Numerous checks were made on the alignment of the steel in the shaft sinking project below the pentice. When the shaft sinking was completed, a raise was brought up to the $9\frac{1}{2}$ Level. The $9\frac{1}{2}$ Level trench was driven and a prefabricated steel pocket, a recent innovation, was installed. This type of development work required close attention by Engineering Department personnel.

(h) In conjunction with the Safety Department, a ventilation survey was made of the entire mine.

(i) Statistical data pertinent to ore analysis (iron-silica-sulphur content) was collected by sampling cars from each of the producing areas and compiled on a ton-iron unit basis. After a great deal of mathematical manipulation, a bi-monthly and monthly cumulative average is obtained.

"B" Shaft

(a) The West extension of the stocking trestle required the assistance of the Engineering Department staff to install the concrete footings, plumb the columns and line up the conveyor belt.

(b) The construction of the Butler Pin Concrete Batching Plant was supervised by Engineering Department personnel. The railroad car loading pocket also required Engineering Department assistance during its construction.

(c) Profiles and cross-sections were made and a center line was surveyed for the Mather "A"-"B" private road.

(d) During the fall, the stockpile was surveyed and the tonnage calculated.

(e) The shaft was plumbed during the year and courses and coordinates were carried from the 8th to 10th Level. Check surveys and elevations were made on the 7th and 8th Levels to confirm previous results.

(f) The Engineering Department staff assisted in the planning and excavating of the 10th Level pumphouse and the installation of the concrete footings.

(g) Samples from all the development headings were taken. These analyses were posted on a special set of maps.

(h) Two ventilation surveys were made by members of the Safety Department and the Engineering Department staff.

NEGAUNEE MINE

(a) Lines and elevations were given for the construction of the footings for the conveyor galleries and the walls enclosing the crusher and apron feeders.

(b) Construction lines were given for the erection of two cage hoist idler stands.

(c) A surface storm sewer was planned and installed under the guidance of the Mining Engineer and surveyors.

(d) Numerous plumbings were made to establish bearings and coordinates on the 10th, 12th and 14th Levels (Athens).

(e) Plans for the 6th and 14th Levels' sumps (Athens) and skip pit were designed by the Mining Engineer.

(f) The plats and trenches on the new levels were cut out under Engineering Department supervision.

OHIO MINE

(a) Plan maps of the Webster Pit were revised continually during the stripping and hauling operations.

(b) Sections were made of the Webster Pit operations and new reserve estimates computed.

(c) Staking of blast holes and calculation of powder requirements were made for the Webster Pit operations.

(d) Complete check surveys were made in the Webster-Portland-Ohio-Beaufort Area.

(e) Stripping outlines were checked in the Norwood-Beaufort Area.

(f) A survey of the tailings pile was made for determining future needs of the extension of the conveyor system.

REPUBLIC MINE

(a) The Engineering pertinent to the layout of the mine and buildings began in mid-July.

(b) The area enclosed by the coordinates 600 N. - 2200 N. and 2400 E. - 3600 E., Sections 7 and 8, T. 46 N., R. 29 W. was contoured on a 2' interval basis. N-S and E-W base lines were established. Elevations were established on all iron pins in the plant area.

(c) Grading began on the railroad from the Humboldt Mine to the Republic Mine on September 16th and continued until the end of the year. Track laying began on October 1st and reached a point below the mill site on December 8th. The overall length of the railroad grade is approximately 9 miles.

(d) The sites for all the buildings were cleared of brush and trees after building location had been established.

(e) Lindberg and Sons, Contractors, began grading and earth moving on the mill site, primary crusher shaft, secondary crusher location and conveyor tunnel in mid-December. The overburden at the mill site was also removed preparatory to blasting rock to rough grade. This work required day to day survey control by Engineering Department personnel.

SPIES MINE

(a) A check survey was run on the 8th Level during the strike to confirm the results of previous work.

(b) The routine work of underground surveying, mapping, stockpile surveying, preparation of tax maps, etc. was taken care of by the Mining Engineer and his helper.

(c) Drill Hole locations and survey work for both surface and underground drilling were taken care of as called for by the Engineering Department personnel.

(d) Stope analyses, cross-section and sub-level maps were aids used in planning the development of the 8th Level by the Engineering staff.

(e) A profile was run on the 3200 E. coordinate in the W$\frac{1}{2}$ of the NE$\frac{1}{4}$ and SE$\frac{1}{4}$ of Section 25, T. 43 N., R. 35 W., for future exploration work. This property, known as the Wheat, is Land Offer No. 2747.

TILDEN MINE

(a) Surveys of the churn drill holes in the Summit and West Pits were run and locations plotted in order to plan a blasting program that will be carried out in 1953.

(b) Ore reserve estimates were reviewed.

J. MISCELLANEOUS

ORE ESTIMATES

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

	Tons	
Mine	As of 8/31/51	As of 8/31/52
Athens	1,806,463	1,843,314
Bunker Hill	488,352	1,557,536
Cambria-Jackson	896,658	749,483
Cliffs-Shaft	2,100,419	2,000,991
Lloyd	136,951	359,475
Maas	3,753,152	4,100,950
Mather		
"A" Shaft	6,454,213	4,764,777
"B" Shaft	10,197,317	12,857,649
Spies	310,352	266,774
Total Developed Ore	26,143,877	28,500,949
Undeveloped Reserves		
Sec. 3, 47-27	302,378	302,378
Grand Total All Ores	26,446,255	28,803,327

STOCKPILES

Estimates of the ore in stock were made by the Engineering Department at the Athens, Cliffs-Shaft, Lloyd, Maas, Mather "A", Mather "B" and Spies Mines during October.

The following table shows the comparison of ore in stock on November 1, 1951 and November 1, 1952:

Mine	Nov. 1, 1951	Nov. 1, 1952
Athens	13,012	9,457
Cambria-Jackson	0	0
Cliffs-Shaft	77,903	111,484
Lloyd	144,167	167,493
Maas	21,681	47,299
Mather		
"A" Shaft	24,388	218,968
"B" Shaft	75,274	110,487
Spies	17,046	48,800
Tilden		15,857
Totals	373,471	729,845

COAL PILES

At the request of Mr. Paul L. Barkman of our Coal Department, three members of the Engineering Department went to Escanaba and Green Bay, during the week of April 14th, to cross-section and calculate the coal quantities in stock at these docks.

SHAFT GAUGING

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

Mine	Date
Athens	January 6th
	June 12th
	December 14th
Cambria-Jackson	January 13th
Cliffs-Shaft	April 25th
Lloyd	May 2nd
	December 6th
Maas	January 20th
	June 10th
Mather	
"A" Shaft	April 27th
"B" Shaft	May 11th
Negaunee	May 25th
	November 8th
Spies	May 17th
	November 2nd

CLIFFS 8TH ADDITION

(a) The storm sewer system was designed and laid out.

(b) Alley and street grades were supplied for the contractor, A. Lindberg and Sons.

(c) The curb and sidewalk installation by the Pajula and Maki Concrete Construction Company required day to day survey control.

(d) The area adjacent to the North boundary of the 8th Addition was contoured and several profiles were supplied to Harold S. Starin, Architect, in order that he might design an elementary school.

(e) In order to promote sales, two houses were selected as model homes, the lots being landscaped, the interiors finished and the rooms furnished by local merchants, so that potential buyers might visualize a completed residence. Members of the Engineering Department acted as guides during the weekend sales campaign, August 16th and 17th.

(f) Grades for individual lots were supplied for those home owners who were interested in landscaping their premises.

LAKE ANGELINE BASIN AND BARNUM PIT

Surveys were made of a proposed drainage ditch which would carry the overflow from the North end of the Barnum Pit to the Carp River. The ditch was excavated early in 1952 and provided the necessary channel to maintain a constant water level in the Lake Angeline Basin.

U.S.G.S. SURVEY

In cooperation with the U.S.G.S. mapping program, GS-OI, the Engineering Department marked numerous section corners for aerial photography work during the early spring. This was done to assure us that upon publication of the maps, these land boundaries would be established correctly and be more valuable to our organization. At various times during the year, we were called upon to supply data, that is, coordinate values of our triangulation stations, elevations of section corners and positions of boundary lines.

REMODELING OF CENTRAL OFFICE AND ENGINEERING BUILDING ADDITION

The foundation for the Engineering Building Addition was completed and the work of framing the walls and roof was well under way by the end of the year.

The remodeling of the bowling alley into an office supply storage space and the rejuvenation of the men's and women's toilet facilities was started at the close of 1952.

SUMMER FIELD CREWS

The practice of hiring undergraduate Engineers and Geologists for summer field mapping and sampling had proved so successful during 1951, that we continued in this method of field exploration work by having five crews working during the summer of 1952. Each crew is made up of an Engineer, who is responsible for the locations or survey details, and a Geologist, who handles the mapping of outcrops and other pertinent land features. These five field crews were assigned to the following areas from June 15th through September 15th:

Crew #1 - Section 4, 5 and 6, 47-27
Crew #2 - Cascade District
Crew #3 - Central Range Basin
Crews #4 and #5 - Fence Lake

HOLIDAYS

The following holidays were granted during the year:

January 1st	- New Year's Day
May 30th	- Memorial Day
July 4th	- Independence Day
September 1st	- Labor Day
November 27th	- Thanksgiving Day
December 24($\frac{1}{2}$),25,26	- Christmas

Respectfully submitted,

Grant T. Hollett

Grant T. Hollett
District Engineer

GTH:JJ
5-15-53

RESEARCH LABORATORY

ANNUAL REPORT - YEAR 1952

The Annual Report for 1952 in subdivided into five main sections. These sections are included as separate reports related to different phases of the work conducted by the Metallurgical Department. The specific sections are (1) General Testing Program, (2) Operation of the Pelletizing Pilot Plant, (3) Agglomeration Research and Magnetic Oxide Conversion, (4) Research and Development work and flotation projects and (5) Plant Control work and testing projects related to the Ohio Mine.

The Annual Report for the Research Laboratory is intended only to briefly discuss the various programs studied during the year. No attempt is made in this report to present test data, conclusions or recommendations that culminated from any specific investigation. The Yearly Summary Report for 1952 which is a summary of the test results for the year provides the detailed information. There were undoubtedly several small scale projects completed that are not mentioned in the report. Due to the large number of the small scale projects worked on they are only discussed in a general manner and no specific reference is given.

Part I of the Annual Report includes the major projects worked on as part of the general schedule for the Research Laboratory. The work conducted has been classified in several groups; namely, Major Projects, Exploration Surface Samples, Service Projects and Research and Development. Some of the various phases of the program discussed in this section will necessarily overlap the programs discussed in other parts of the report. For the most part, however, each investigation is discussed under the proper section and classification.

PART I
GENERAL TESTING PROGRAMS

MAJOR PROJECTS:

Pilot Mill Tests:

Considerable work has been carried out through the year in the pilot mill section utilizing a flowsheet that duplicates that of the Humboldt Plant. During the summer approximately 200 tons of low grade ore from the Humboldt Pit area was trucked into the Tilden crusher, crushed to approximately 3 to 4" and then trucked to a stockpile area at the rear of the Laboratory. This sample of the Humboldt crude was collected from three different areas in the pit and was very representative of the formation that will eventually be treated at the Humboldt Mine. Approximately 80 tons of Republic crude iron formation taken from the dumps in the area was also collected and trucked into the Laboratory stockpile area. These stockpiles of ore were used as a source of feed in conducting tests utilizing the pilot mill circuit. The feed was crushed to minus 3/8" and stored in bins for use as needed.

The pilot mill circuit which follows the proposed flowsheet for the Humboldt Plant involves ball mill grinding, classification, desliming employing cyclones, conditioning at high solids with flotation reagents in a 2 cell conditioner, flotation and mineral separation in several stages utilizing 6 Denver Sub A No. 8 flotation cells and filtering of the flotation concentrates. Basically, this is the flowsheet that was utilized throughout the testing program, however slight variations in the flowsheet were adopted from time to time.

During the year approximately 190 tons of Humboldt crude iron formation was utilized in operating the pilot mill circuit. Roughly 40 tons of lean iron formation from the Republic area was also processed. The flotation concentrates produced from operation of the circuit were stockpiled at the rear of the Laboratory for use in agglomeration test work. The concentrates produced from the small scale mill circuit during 1952 were roughly 110 tons.

Each component part of the flowsheet required considerable time and study in an attempt to pinpoint variables and produce optimum results. The grinding circuit had perhaps the most intense program of study and evaluation. All of the testing during the year was conducted employing a Dorrco hydroscillator in the grinding circuit. A complete study and evaluation of this classifier was completed and such important factors determined as operating characteristics and relative efficiencies compared to conventional classifiers. Detailed studies were also made of desliming techniques employed and the variables present in the system. The objective here was to determine the minimum amount of slimes that could be discarded without impairing the efficiency of the flotation separation. The greater portion of the work during the year centered around the flotation circuit which up to the present time had been the one stage of the process which had received the least amount of study. Some of the factors investigated in the flotation circuit were the various reagents that could effectively be used, possibility of eliminating an acid circuit for flotation, the study of the cleaning stages required to obtain a good metallurgical balance, influence of pulp dilutions and others. Detailed description of the investigations of the flotation circuit is given in Part IV. The filter circuit study which had been fairly well completed was also investigated further. Here such factors as types of filter cloth that could be utilized, effect of feed dilution, effect of slimes present in the concentrate and other variables were studied.

The testing program was designed to study the variables present in the circuit and to note their effect on the final metallurgical balance. Most of the testing during the year could be classified as refinement work which was directed towards pinpointing the most important variables. Important correlations also could be made as a result of operating the pilot mill by the batch scale testing and the pilot mill testing. One can readily see that this type of investigation has no definite end point. As new equipment or changes in technique are applied, numerous tests are required to accurately check and evaluate the data. It is realized that much of the test work will cover only the more important phases of the flowsheet and that final evaluation of the variables present will only be determined at the operation of the mill at the Humboldt Mine.

Cliffs Shaft Mine:

During the year an intense investigation of the sampling of the underground and surface samples of the Cliffs Shaft lump ore was conducted. This investigation was a continuation of the initial program that was inaugurated in the summer of 1951. The initial study revealed that discrepancies between the Laboratory sample analyses and shipping car analyses existed. The investigation conducted during the year was designed to study the sampling techniques employed at the Cliffs Shaft Mine and present the facts as they existed. A long range program was set up whereby close supervision would be exercised over the underground and surface sampling.

During the year two sample checking periods were set up, one being during the months of April and May and the second period being carried out during the months of August through December. During these periods a complete study was made of the sampling procedures employed and integrated factors.

Several modifications of the sampling techniques were put into practice under close supervision. Periodically the underground sampling as well as surface sampling would be checked by the Laboratory sampler. Several times during the periods check samples were taken by the Laboratory sampler and these results compared with those obtained from the mine samplers. Throughout the entire program sample analyses were accumulated from the mine reports and the Laboratory sampler's check analyses. The data accumulated was studied and tabulated. The investigation also included a study of each individual mine sampler and the accuracy in sampling. A study of the crushing room practices in preparing and pulverizing samples was also conducted.

This study involves considerable detailed work and it is extremely difficult to summarize a program of this nature. Much of the data has been tabulated in the form of graphs and charts that can be easily correlated and compared. This sampling investigation has revealed indications as to the reliability of the sampling at the Cliffs

Shaft Mine. A metallurgical report will be issued in the near future covering this investigation.

Michigamme Mine:

During the year the drilling campaign was completed in the North Michigamme Area in Sections 19 and 20, 48-31. Final composites were built up which included the treatable formation encountered in each drill hole within the proposed pit area and subjected to concentration tests. The tests performed on the final composites were magnetic tube tests, froth flotation tests, gravity concentration tests and magnetic oxide conversion tests. Various concentrating schemes were employed in an attempt to determine the most feasible flowsheet for treatment of this lean iron formation on a commercial basis.

Michigamme River Exploration:

Final test work was completed on the composites built up from the treatable formation encountered in the drill holes for the Standard, Magnetic, Metropolis and Norman properties. The test work included magnetic tube tests and froth flotation tests.

Land Offers & Outside Explorations:

During the year numerous priority samples identified under various Land Offers or Outside Explorations were submitted to the Research Laboratory for testing. The majority of the samples submitted under these classifications represented the Canadian Exploration Program. Another series of more important samples submitted were those from the South American Development Program. Most of these samples submitted are scheduled for preliminary testing which involves a crude assay, magnetic tube tests if warranted and possible flotation and gravity concentration tests.

RESEARCH AND DEVELOPMENT PROGRAM:

Research and Study:

Considerable time was devoted by the Laboratory's technical staff to studying various techniques and processes that have potential application to the treatment of the low grade iron ores. Much of this time which is distributed to the Research and Study account includes reading of technical books and papers, administration details and general technical investigations that cannot be directly charged to any one program.

Microscopy Section:

During the summer a graduate student from the University of Minnesota was working in the Microscopy Section at the Research Laboratory. The work conducted during the summer was devoted almost entirely to preparing specimens of Humboldt drill core, microscopic identification and preparing photomicrographs. A limited amount of work was also completed on representative pieces of Republic drill core and special South American samples.

The work completed this summer resulted in the accumulation of invaluable data relative to the mineral characteristics of the Humboldt formation. With a qualified technician supervising the work in the Microscopy Section it afforded an excellent opportunity to set up standard procedures, line up the equipment required and organize the section. With the Microscopy Section will organiz ed it was possible to conduct work on a small scale utilizing non-technical personnel who had been trained in the proper procedures.

North Lake Project:

During the year the Exploration Diamond Drilling Program was commenced for Sections 4, 5 and 6, 47-27. The initial phase of the program was begun in order to determine an indication of the tonnage of lean iron formation available in this area, the mineral characteristics and the concentrating characteristics of the formation.

The split core samples were submitted to the Research Laboratory and processed according to a standard procedure and subjected to concentration tests. The preliminary phase of the testing program was conducted to determine the homogenuity of the formation and general response to concentration by magnetic oxide conversion followed by magnetic separation and a possible flotation of the magnetic concentrate. The program, at the outset, was not designed to obtain optimum results or determine the most feasible concentration scheme but rather to classify the material and determine any variations in concentrating characteristics by utilizing a standard testing procedure. A more detailed description of this program is included in Part III.

Empire:

During the early part of the year the test work was completed on the surface samples collected in Section 19, 47-26. Each sample was subjected to froth flotation tests and if the sample contained an appreciable amount of magnetite was also tested in the magnetic circuit. After the preliminary test results had been accumulated for each individual sample, composites were built up using as a guide the geological locations, mineral characteristics and concentrating characteristics. The composites were subjected to a more intense program of investigation to determine the concentrating schemes that appeared feasible. Several locations in the area were isolated based on their concentratability and further work will be directed towards the more favorable locations.

During the year Diamond Drill Hole No. 1 in Section 19, 47-27 was started having the purpose being twofold; first to investigate the formation for high grade ore at depth and second to provide drill core samples of the lean iron formation for metallurgical test work. The drill cores have been submitted to the Laboratory, processed and composites built up. As time permits the representative composites will be subjected to concentration tests.

EXPLORATION SURFACE SAMPLES:

North Jackson Area:

During the summer of 1950 approximately seventy samples were collected from the North Jackson area Section 1, 47-27. The samples were processed as received and crude analyses obtained. Due to the full schedule at the Research Laboratory no test work was conducted on these samples until the latter part of 1952. At present work is being conducted on these samples which involves a preliminary testing program subjecting each sample to froth flotation tests and magnetic tube tests if warranted.

Cedar Lake Area:

Sixty-three samples were collected in Section 12, 47-27 during the summer of 1950. The samples were processed as received and tested during 1952. Each sample was subjected to froth flotation tests and magnetic tube tests if warranted. On the basis of the preliminary testing, seven of the samples were classified as "Concentratable," four classified as "Favorable," four classified as "Possible" and forty-seven classified as "No Good." One sample was misplaced.

Isabella Area - Cascade District:

Test work was completed during the year on the surface samples collected in Sections 29 and 32, 47-26. Test work was conducted on the following samples. Twenty-six samples collected during the summer of 1950, seven composites built up from the 1950 samples and thirty-seven samples collected during the summer of 1951. Tests conducted included gravity concentration, magnetic separation and froth flotation. The concentrating characteristics indicated that the samples required fine grinding (150 mesh or lower) to substantially liberate the mineral and silica. Also the soft fraction present in the ore resulted in high slime losses. Of the seventy samples and composites tested, they were classified as follows. Eight were classified as "Concentratable," seventeen were classified as "Favorable," eighteen were classified as "Possible" and twenty-seven were classified as "No Good."

Bellevue Area:

Thirteen samples were collected during the summer of 1950 in Section 18, 47-26. The samples were processed as received and stored until test work could be scheduled. Test work was completed during the year which included Davis magnetic tube tests and froth flotation tests. The samples did not respond favorably to concentration by froth flotation. However the samples do contain an appreciable amount of magnetite. A classification based on preliminary magnetic tube tests is as follows. Thirteen samples can be classified as "Possible" while the remaining four samples were classified as "No Good."

SERVICE PROJECTS AND RESEARCH & DEVELOPMENT:

Drill Core:

The practice of submitting drill core sections of lean iron formation from underground drill holes and exploration drill holes was continued. The core samples were submitted by the Geological Department representing iron formation having an iron content in range from 20 to 50%. Intrusive material containing less than 20% Fe is usually screened out by the Geological Department and this type of material not submitted. These samples are given a high priority rating and are processed daily by the Research Laboratory. This processing involves cataloging the samples, crushing to 1/4", mixing and riffling out a head sample for analyses and compositing consecutive footages of similar material to be stored. This routine work constitutes a large portion of the Laboratory crushing room's schedule as the processing, handling, and compositing of these samples require considerable time and effort. During 1952, 488 drill holes were represented by core samples submitted to the Research Laboratory. This number of drill holes resulted in the submission of 4,210 samples which in turn were combined into roughly 300 composites.

These composites are valuable in that they represent types of lean iron formation existing throughout the active areas of the Marquette Range. Undoubtedly some of these composites will never be tested. However, it is felt that some of the composites will be extremely useful in evaluating the concentrating characteristics of the various types of lean iron formation existing on the range. As time progresses there will be a great need for eliminating composites that have little or no value and possibly combine similar composites into larger ones to ease the storing problem which each year becomes more troublesome.

Holman Mine - Crude Ore:

During the year approximately forty-five tons of Holman Mine crude ore was shipped down to the Research Laboratory for classification tests. The ore was screened as received over 1/8" and the minus 1/8" crude fraction was subjected to classification tests employing the Dorrco hydroscillator. The purpose of the testing program was to evaluate the use of the hydroscillator in affecting a classification at 35 to 48 mesh. This classification would roughly duplicate that being practiced at the mine utilizing double classification. Several pilot mill tests were conducted adjusting hydroscillator variables to obtain optimum results. Test results indicated that the total size separation that could be affected in the laboratory size hydroscillator was 48 mesh. It appears possible that several minor changes in the hydroscillator would effect a coarser and more efficient separation. The results obtained to date indicate that the hydroscillator separation did not appreciably improve the results obtained at the mill through double classification.

Colorado Fuel & Iron Company:

Two samples were submitted by the Colorado Fuel & Iron Company for concentration tests. One sample represented the type of ore from the Sunrise Wyoming Area, the other sample was representative of a deposit in Utah. The two samples were subjected to gravity concentration tests, magnetic tube tests, froth flotation tests and magnetic oxide conversion tests. The sample from Wyoming was amenable to gravity concentration employing heavy media separation on the coarse fraction and heavy liquid separation on the fine fraction. The sample from Utah responded favorably to concentration by magnetic separation and magnetic oxide conversion.

These samples were tested to determine the concentrating characteristics and to form some preliminary conclusions as to the feasibility for commercial treatment.

Time Charges for 1952:

The following is a tabulation of the distribution of hours spent in the Laboratory on various projects. The total number of hours spent this year was 47,958 as compared with 31,369 hours during 1951. On glancing through the distribution sheet, one can easily determine which projects represented the major part of the research program. Some of these would be flotation study, Empire Mine, Humboldt Mine, Ohio Mine, Republic, and Pelletizing Research. A distribution time sheet will be included with each annual report to depict the trend of various testing programs in order to establish the time allotted for each project and to reveal the increase in hours worked as the Metallurgical Department expands due to more accelerated and comprehensive programs.

Also included on separate pages following the time distribution is a table listing the memoranda and reports issued in 1952.

Chemical Charges:

The following sheets reveal the distribution of chemical determinations made by the Chemical Laboratory during 1952. The assays in 1952 totaled 40,428 as against 22,098 for 1951 which again reflects the increase in programs being conducted at the Research Laboratory. The distribution of chemical analyses as well as the time distribution presents an overall picture of the number of projects and various studies carried out at the Research Laboratory during 1952.

TIME DISTRIBUTION - 1952

Account	Hours
Athens Mine	129
Bellevue	175
Calumet & Hecla Project	166
Cambria-Jackson Mine	199
Cascade	677
Cedar Lake	940
Cliffs Group Ore Misture Problem	78
Cliffs Shaft Mine	930
Colorado Fuel & Iron Company	321
Core Storage Building	73
D. D. H. 1	30
" 7	6
" 8	11
" 9	25
" 19	3
" 20	169
" 21	217
" 22	197
" 35	6
" 42	11
" 43	232
" 45	65
" 46	146
" 47	138
" 48	131
" 49	118
" 50	89
" 58	7
" 62	66
" 63	7
" 65	22
" 68	38
" 69	6
" 70	8
" 71	18
Eaton Sample	47
Empire Mine	1147
Flotation Study	7811
Fluo-Solids Tests	20
Gwinn District	3
Magnetic Mine	30
Mather Mine "A" Shaft	633
Mather Mine "B" Shaft	596
Metropolis	187
Extension to Mezzanine	55
Microscopy Section	1230
Michigamme River Area	19
North Jackson	63
Outside Explorations	554
Pelletizing Research	4462
Reduction-Oxidation Process	131
Research & Study	2011
Riverside	6

Account	Hours
Humboldt Mine	5738
Holman (Hydroscillator Test)	608
Installation of Jaw Crusher	65
Inco Pelletizing	1034
Land Offer 2468	14
" " 2639	1
" " 2644	27
" " 2664	11
" " 2732	3
" " 2721	2
" " 2745	5
" " 2748	2
" " 2769	24
" " 2777	8
" " 2781	29
" " 2792	35
" " 2799	85
" " 2815	190
" " 2818	18
" " 2822	15
" " 2831	20
" " 2836	75
" " 2837	193
" " 2851	14
" " 2855	3
" " 3001	7
" " 3002	4
" " 3004	4
" " 3012	4
" " 3016	3
" " 3020	9
" " 3028	4
" " 3034	12
" " 3037	3
" " 3045	11
" " 3067	4
Lloyd Mine	1541
Maas Mine	9
Magnetic Oxide Conversion	1995
Spies Mine	227
Standard	163
Teal Lake	70
Tilden	288
Webster-Ohio-Norwood	291
Webster	295
Michigamme	840
Norman	56
Ohio Mine	3792
Pelletizing Pilot Unit	563
Pitmon-Erck Process	1870
Republic	3209
Richmond	4
South Jackson	3

METALLURGICAL REPORTS - 1952

Report No.	Subject
61	Michigamme River District
62	North Michigamme District
63	Cuyuna Range
64	Cliffs Shaft Mine
65	Metropolis Exploration Drilling Campaign
66	Standard Exploration Drilling Campaign
67	Norman Exploration Drilling Campaign
68	Magnetic Exploration Drilling Campaign
69	Bellevue Area
70	Cascade Area
71	Empire Area
72	Eaton Sample
73	Republic Final Report
74	Minerals Separation Report
75	Microscopic Investigation - Humboldt Formation
76	Colorado Fuel & Iron Company's Samples
77	Fatty Acid Study - Humboldt & Republic
78	Ungava Bay Samples
79	Cedar Lake Area
80	Humboldt Final Report
81	Traveling Grate Investigation

METALLURGICAL MEMORANDA - 1952

Memo No.	Subject
47	Canadian Samples Mx-1497, -1498 & -1501
48	Special Mather Mine "A" Shaft Samples
49	Sections 19 & 24, 46-26
50	Outside Exploration 1014
51	Outside Exploration 1013
52	Webster Heavy Liquid Tests
53	Webster Heavy Liquid Tests
54	Land Offer 2781
55	Canadian Samples Mx-1134, -1135, & -1136
56	Mather Mine "A" Shaft Rock Pile
57	Webster Heavy Liquid Tests
58	Land Offer 2745
59	Land Offer 2721
60	Land Offer 3001
61	Land Offer 3016
62	Outside Exploration 1035
63	Ohio Mine Testing
64	Land Offer 3012
65	Richmond Area
66	North Michigamme Area
67	Outside Exploration 1030
68	Sample MxC-1
69	Ohio Mine Samples for June
70	Outside Exploration 1036
71	Land Offer 28222
72	Land Offer 2799
73	Outside Exploration 978
74	Republic Batch Tests
75	Outside Exploration 2836
76	Outside Exploration 2831
77	Outside Exploration 1041
78	Ohio Mine Samples - August

Memo No.	Subject
79	Outside Exploration 1031
80	Land Offer 3002
81	Outside Exploration 1036
82	Mather Mine "B" Shaft High Sulphur Ore
83	Land Offer 3037
84	South American Samples
85	Outside Exploration 1048
86	Land Offer 2792
87	Land Offer 2836
88	Land Offer 2831
89	Land Offer 2851
90	Land Offer 2855
91	Outside Exploration 3020
92	Land Offer 3045
93	Outside Exploration 1023
94	Land Offer 3034
95	1952 Field Samples
96	Ohio Heavy Media Reject Pile
97	Ohio Mine Memorandum - September
98	Benson Mine Concentrate
99	Ore Mixture Problem - Cliffs Group and Humboldt
100	Cliffs Shaft Lump Ore Structure
101	Land Offer 2837
102	Effect of Overburden Dilution on Flotation - Humboldt
103	D. D. H. 62, Section 9, 47-27
104	D. D. H. 21, Section 11, 47-27
105	D. D. H. 22, Section 11, 47-27
106	Ohio Mine Samples - Flotation Study

Cliffs Shaft Chemical Laboratory

Total number of determinations analyzed in 1952 from RESEARCH samples

Maas	208
Athens	119
Bunker Hill	244
Cliffs Shaft	1,154
Lloyd	2,007
Tilden	180
Cambria-Jackson	449
North Jackson	108
Mather "A"	2,108
Mather "B"	1,420
Spies	540
Michigamme	1,130
North Michigamme	13
Ohio	3,570
Cedar Lake	833
Belleview	207
Teal Lake	56
Hilltop	27
Riverside	21
Webster	1,651
Empire	1,502
Metropolis	912
Standard	242
McGillis	10
Richmond	29
Vermillion	80
Calumet & Hecla	18
G 12-13-14-15-16-17	60
Experiments & Investigations	569
Magnetic Roasting	662
Pelletizing Research	2,111
Flotation Study	8,995
Magnetic Oxide Conversion	199
Land Offer 2644	304
" " 2701	8
" " 2745	15
" " 2748	10
" " 2769	7
" " 2781	30
" " 2792	18
" " 2799	198
" " 2815	136
" " 2822	35
" " 2831	45
" " 2836	151
" " 2851	11
" " 2855	5
" " 3001	6
" " 3002	44
" " 3004	7
" " 3012	12
" " 3016	2
" " 3028	4
" " 3034	3
" " 3045	9

Colorado Fuel & Iron Company		13
Outside Exploration	1013	8
" "	1014	8
" "	1023	19
" "	1030	45
" "	1031	1,804
" "	1035	33
" "	1036	263
" "	1041	393
" "	1048	20
E. & A. 521		316
E. & A. 531		223
Section 3 Hole 46		6
Section 4 Hole 42		7
" 4 " 43		498
" 4 " 45		123
" 4 " 46		344
" 4 " 47		120
" 4 " 48		290
" 4 " 49		212
" 4 " 50		240
Section 5 Hole 35		4
" 9 " 59		3
" 9 " 62		87
" 9 " 61		42
" 9 " 63		12
" 9 " 64		38
" 9 " 65		2
" 9 " 66		164
" 9 " 67		18
" 9 " 68		188
" 9 " 69		2
Section 11 Hole 20		388
" 11 " 21		542
" 11 " 22		419
" 11 " 47		150
Section 13 Hole 7		58
Section 19 Hole 1		139
" 19 " 9		36
" 19 " 11		194
Section 29 Hole 2		2
" 29 " 3		429
" 29 " 4		24
Section 27 Hole 5		8
	Total	40,428

PART II

OPERATION OF PELLETIZING PILOT UNIT

This section of the Annual Report will briefly cover the progress and projects of the Pelletizing Pilot Unit from January 1st through December 31st, 1952.

Unlike the first year of operation, the Pilot Unit operated on a semi-continuous basis. Delays and down times were noticeably decreased during the past year. This does not necessarily mean that the operation functioned smoothly, as development of the unit still had to cope with many problems. The innumerable variables inherent to the art of pelletizing were thoroughly investigated and evaluated. Technical reports and memoranda have been issued, or will be issued, concerning every phase of the investigations and, therefore, will not be included in the scope of this report.

A total of 1,199 net tons of iron ore concentrates were received at the Pilot Unit in 1952. Of this amount, International Nickel Company shipped 1,049 net tons of hematite and magnetite concentrates, and the remaining 150 net tons were received as Benson magnetite concentrates from Orefraction, Incorporated. Pellet shipments to various steel companies totalled 1,139 net tons, of which 336 tons went to Inland Steel Company, 218 tons to Jones & LaughlineSteel Corporation, 224 tons to International Harvester Company, and 64 tons to Timken Roller Bearing Company. Inland Steel, Jones and Laughlin and International Harvester used the pellets in open hearth furnaces, whereas Timken's shipment was used as feed ore in the electric furnaces. Memoranda have been issued concerning the results and observations of the steel tests. Furnace fines (minus 1/4" material) totalling 297 net tons were shipped to the docks and included in a cargo of Cliffs Group Ore.

Pelletizing operations were suspended at the Pilot Unit on December 19th, 1952. It was generally conceded that the specific objectives of this investigation were completed and that temporary abandonment of shaft furnace pelletizing was justified in favor of agglomeration with the traveling grate mechanism. Laboratory investigation of the principles of traveling grate pelletization were undertaken during the latter part of 1952 and will be included in another section of this report.

Revisions:

Several Revisions of major importance were undertaken and completed in 1952. These revisions were concerned primarily with the furnace section. Although revisions and alterations were made to other sections of the plant proper, they appear of a minor nature and will not be mentioned herein.

A workable scheme for breaking and discharging clinkered masses of pellets was introduced to the pelletizing furnace in May, 1952. This breaker was of a toothed roll type, similar in design to that in use at the Ashland Plant of the Pelletizing Enterprise. The method was effective and remained in the furnace until the end of the pelletizing investigation period.

The combustion chamber had been a constant source of trouble and delay since the beginning of operations at the Unit. The refractories on the flat arch roof of the chamber were continuously falling. To effectively remedy this condition, the roof was removed and replaced with a spring arch roof with elimination of the manhole at the top. Increased furnace efficiency resulted from the aforementioned change.

Pilot Unit Operation:

Practically all time at the Pilot Unit was devoted to the pelletization of International Nickel Company's artificial hematite and magnetite concentrates. INCO was represented by their technical personnel at Ishpeming throughout the more important phases of the investigation. The INCO technicians acted as liason between the research directors at Copper Cliff and the operators at Ishpeming. This scheme worked out to mutual satisfaction of The Cleveland-Cliffs Iron Company and International Nickel Company.

The first half of 1952 was devoted to pelletization of INCO hematite concentrates. The pelletization of this type of ore was difficultly achieved in the shaft furnace at Ishpeming. Numerous variables were investigated to determine the optimum conditions necessary to produce a satisfactory agglomerate. Among these were: (1) moisture content of pellet charge, (2) distribution of coal in the individual pellet, (3) varying amounts of coal in the pellet, (4) various methods of coal addition to the pellet charge, (5) various methods of making reagent additions, (6) varying amounts of bentonite in the green pellet, (7) different feeding schemes and feeding devices, (8) temperature at which pellets were fired, (9) throughput rate of pellets, and numerous other variables necessary for satisfactory pelletizing. To complete such a study with interpretation of results required a considerable period of time.

The artificial hematite concentrate, as contrasted to the natural and artificial magnetites, posed separate and distinct problems. Hematite is inert and not oxidizable, therefore the fuel value of magnetite was not realized when pelletizing hematite ores. The thermal requirements were, therefore, obtained from the products of combustion or a fuel additive. The fuel additive, in all cases, was pulverized or crushed anthracite or bituminous coal. The varying schemes of coal additions were investigated, namely, rerolling the green pellets in coal, adding crushed coal in varying proportions to the charging boxes, or adding coal in varying amounts directly onto the charging hearth of the furnace.

The furnace was extremely difficult to control with pulverized or crushed varieties of coal as an additional source of fuel. The use of coal as an additive invariably caused clinker formation in different zones of the furnace.

Tests conducted on hematite concentrates without the use of coal entailed many problems. The thermal requirements for pelletizing were obtained from the combustion chamber only, and large gas flows were required to literally drive the heat across the furnace hearth. Heat penetration and BTU input were limiting factors with this scheme.

All tests conducted with INCO hematite concentrates had a very high fuel-ore ratio and low production rates.

The latter part of 1952 was devoted to pelletization of the natural and artificial magnetites. The natural magnetite pelletized at the Ishpeming furnace was from the Benson Mine in Upper New York State. The artificial magnetite used was obtained from the International Nickel Company of Canada. The 1952 shipments from INCO were of a high nickel variety as compared to the finer structured, low nickel concentrates shipped in 1950.

The actual firing of the natural magnetite pellets was conducted with relative ease. The thermal requirements were much lower and the capacities per square foot of hearth area were somewhat higher than that obtained with artificial hematites.

Although INCO magnetites did not respond to pelletizing as readily as did the natural magnetite, pellets were produced with satisfactory characteristics. The thermal requirements approached those of the natural magnetite and the capacities per square foot of hearth area were approximately the same. Exacting furnace control was extremely necessary for successful pelletization of INCO magnetite. The optimum pelletizing conditions for this type of ore were difficultly achieved with the one ton capacity furnace, and only seldom were such optimum conditions reproducible.

Pilot Unit operations were suspended with the work stoppage in June and July, 1952. INCO's technical representatives returned to their home office, and Cleveland-Cliffs' supervisory personnel were concerned with necessary maintenance and revisions at the Pilot Unit.

Disposition of Plant, Equipment & Materials:

With the suspension of operations on December 19th, 1952, the personnel at the Pilot Unit were transferred, laid off, and in some cases, retained for necessary dismantling and clean-up details at the Pilot Unit.

Dismantling of equipment at the Pilot Unit was started late in December, 1952. It is intended to dismantle and overhaul all equipment that has been in operation at the plant. All salvageable equipment and material will be retained for further use in the anticipated new grate agglomeration unit.

The materials, such as ore concentrates, pellets and pellet fines, will be held at the stocking area west of the plant. The exact disposition of this material is not presently known, but it is conceivable that some of the INCO material will be used in the traveling grate studies. The fired pellets will presumably be shipped to the steel mills for further testing in the open hearth or electric furnaces.

PART III

AGGLOMERATION & PYROLYSIS INVESTIGATIONS

AGGLOMERATION RESEARCH:

Laboratory Investigations - Shaft Furnace Firing of Pellets:

A survey of the shaft furnace firing operation was conducted to determine the consecutive treatments which green pellets normally undergo during induration. This survey provided data which described the pellet temperature variation with time and the gas composition and gas velocities which pellets are subjected to during firing. These data were procured during runs carried out with pellets of magnetite and hematite, and more or less ideal conditions of operation were assumed during these periods. The conditions of this operation were incorporated in a laboratory apparatus for determining the pelletizing characteristics of iron ore concentrates. This was designed and operated so as to simulate the firing conditions normally imposed on green pellets during the shaft furnace firing. Part of this unit was operated during 1951, but several modifications were made during 1952, and the greater part of the test program was conducted after these modifications. A program of material tests was used during this period, and these tests in turn were used for equating the values assigned to materials that have undergone the laboratory investigations.

The influence of some variables associated with pelletizing have been evaluated along with a measurement of the pelletizing characteristics of seven different types of ore. These included:

1. A hematite calcine of pyrrhotite concentrates from International Nickel Company.
2. A magnetite calcine of pyrrhotite concentrate from International Nickel Company.
3. A magnetite concentrate from Jones & Laughlin Steel Corporation.
4. A magnetite concentrate from Erie Mining Company.
5. A hematite flotation concentrate from Cleveland-Cliffs.
6. An artificial magnetite concentrate produced from Item No. 5.
7. An artificial magnetite concentrate produced from magnetically converted taconite from Cleveland-Cliffs.

Some of the most prominent variables that have been qualified by this apparatus included:

1. The functions of additives such as borax, limestone, and bentonite.
2. The function of regrinding some of the coarser concentrates.
3. The function of disposing fuel in, or coated upon, green pellets.
4. The function of magnetically converting hematite to magnetite prior to pelletizing in order to utilize the inherent fuel of magnetite.

One of the developments of this investigation was prepared as a prospectus for patent application. This was compiled for the use of limestone as an additive for strengthening pellets. It was proposed that for a reagent cost of twelve cents per ton of pellets, the impact resistance could be enhanced 220%, the crushing resistance 330%, and the abrasion resistance 330%.

Pelletizing of Copper Concentrates:

A consulting project was undertaken for Calumet & Hecla Consolidated Copper Company wherein preliminary pelletizing tests were to be conducted on copper concentrates from their mill. Essentially, the problem was to determine a process for agglomerating flotation and table concentrates and flue dust so that the mixture could be more favorably utilized in the reverberating smelter. The laboratory test results concluded that an adequate product could be formed by pelletizing the copper concentrates and dust in a rotating drum and drying the product prior to smelting. The functions of various additives were discussed along with procedures for forming pellets in a continuous operation. Shaft furnace firing of the product was not advised in light of the pyrolitic reactions of the concentrate.

Development of the Grate Firing Process:

A laboratory batch type grate firing box was designed and erected for testing the agglomeration of iron ore by the grate firing operation. This unit, with the essential components, was fully instrumented so as to enable the variables of grate firing to be determined and the unit was capable of testing the sintering operation by up or down draft, or the art of pelletizing and grate firing by up or down draft. During operation, this laboratory unit was used for investigating the following functional components of grate firing preformed pellets by updraft: 1, Pellet additives, both quantity and quality; 2, pellet moisture; 3, pellet sizes and size range; 4, pellet fuel - quantity, quality and disposition; 5, ignition bed depth; 6, ignition bed solid fuel; 7, ignition gas - time and intensity; 8, ignition draft flow; 9, time factor between ignition and firing; 10, updraft flow, differential or constant; 11, feed rate of pellets, intermittent or constant.

After controlling these variables and investigating the independent function of each, the test run data were equated to tonnage production. This evaluation provided information relative to the following items: 1, the quantity of additives per long ton of feed; 2, the quantity of heat provided as ignition gas, ignition coal, and pellet feed coal per long ton of feed; 3, the electrical energy required for primary air, secondary air, and updraft air per long ton of feed; 4, the blowing rate of updraft in CFM at NTP per square foot of windbox area; 5, the unit capacity of the system in tons per square foot per day; 6, the product evaluation in percentage minus 28 mesh material production from a standardized tumbling drum tester.

All of these requirements were calculated to the basis of one long ton of feed, and were equated to the basis of one long ton of product, assuming that all minus 3 mesh material would constitute returns or a recycled product. During 1952 a total of 27 test runs was reported. The noteworthy results indicated that a considerable degree of reproducibility was attained after the art of grate firing was completely mastered. This information in turn provided the essential information that a grate firing process exists for agglomerating hematite by updraft. These operating data were translated for a continuous operation. It appeared from the data procured in 1952 that approximately two million BTU's of thermal energy and two KWH of electrical energy would be required for producing one long ton of indurated product.

Shaft Furnace Design for Hematite Ores:

Previous reports from Cleveland-Cliffs' Research Laboratory have indicated some of the basic pelletization characteristics of hematite and magnetite concentrates determined from both laboratory and pilot plant tests. A general review of the findings is given in the following paragraphs which describe the technology of the pelletizing process.

As green pellets descend into the shaft of a pelletizing furnace, they are subjected to three consecutive operations which are performed by the ascending gases. These are: 1, Drying; 2, firing, and 3, cooling. The operations are performed in transverse zones of the furnace shaft and the zones are established by the feed rate and chemistry of the pellets, the temperature and flow rate of the gases, and the furnace design. Green pellets should dry at a rate low enough to prevent pellet decrepitation from water expulsion, and at a rate rapid enough to prevent moisture condensation from mushing pellets together. Pellets should be fired at a temperature high enough to incorporate inter-particle consolidation, and low enough to prevent inter-pellet consolidation. The cooling rate is not too critical for pellets other than the factor of enabling good heat transfer between fired pellets and cooling air.

There is no basic difference between the optimum drying rates of hematite and magnetite pellets. The tolerable drying rate is a function of the humidity of the drying gas, and the moisture content and degree of compaction of the green pellet. There is no basic difference between the optimum firing temperature of hematite and magnetite pellets. The optimum temperature will generally range from between 1250 and 1350° C, and is specific for every kind of ore concentrate regardless of the quantity of FeO in the ore. There is no marked difference in the optimum firing rates, and there is no difference in the optimum cooling rates for hematite and magnetite pellets. The basic difference between the practicability of pelletizing either kind of ore in a shaft furnace is denoted by the chemistry of the ore. Magnetite is a fuel, and as such will burn in a stream of hot oxidizing gases. During the ignition-combustion cycle within the furnace shaft, magnetite enables a more or less hot zone to be "floated." This is the fundamental property of magnetite which enables it to be pelletized more economically than hematite.

Magnetite combines with oxygen according to the following reaction:

$$2\ Fe_3O_4 \text{ Plus } 1/2\ O_2 \qquad 3\ Fe_2O_3\ ; \quad H \text{ equals } -61{,}364 \text{ K. cal. at } 1000^\circ \text{ C}$$

$$\text{or } 239 \text{ BTU/lb. of } Fe_3O_4$$

By using the stoichiometric quantity of air, this heat of reaction in an insulated system will bring the temperature of the reactants from 1000° C to a product of 1381° C. This phenomenon undoubtedly is the most vital factor of pelletizing. It is inherent to magnetite and enables the excess oxidizing gases of about 1900° F to propagate a temperature of about 2400° F across a wide hearth of pellets. It is not entirely dependent on the gas-solid heat transfer within the furnace shaft.

Hematite is not oxidizable. If a temperature of 2400° F is to be attained in a bed of hematite, the heat must be obtained from an outside source such as hot gases or a fuel additive. The problem of transferring a 2400° F temperature to a wide bed of pellets by hot oxidizing gases is a major engineering problem. It can naturally be accomplished, but the heat transfer is so slow that the furnace capacity and thermal requirements of the ore appear prohibitive from an economical standpoint when contrasted to the magnetite phenomenon. Substituting coal in hematite for the good, clean exothermic heat of magnetite seems to be a logical resort. If the coal is to provide the temperature boost for hematite that magnetite ordinarily imparts, the coal must oxidize from the hot gases, or it will certainly reduce the hot pellets. Localized channels of oxidizing gases burn the coal vigorously, whereas ever-present stagnant zones of the furnace allow iron ore reduction to proceed. With proper engineering development, a shaft furnace might be able to cope with this problem. Until this development comes about, however, the shaft furnace will be very difficultly controlled with the use of coal and hematite pellets in lieu of magnetite pellets. This factor contributes markedly to the expense of pelletizing hematite.

A report presented as a summary of pelletizing operations for 1951 showed the results of preliminary tests carried out by pelletizing magnetite and hematite concentrates. The data revealed that green pellets of hematite could probably be pelletized at 80% the rate of magnetite pellets, and that hematite pellets would probably have a thermal requirement of about 200% the requirement of magnetite pellets. Subsequent tests have shown that the trends of the relative capacity and cost figures were in the right direction. A present evaluation of data shows that for producing the same quality product, pellets of hematite ore containing 16% water would have about 50% the unit capacity of magnetite pellets containing 9% water. These same hematite pellets would require approximately 220% of the fuel that magnetite pellets would require. These ratios are naturally approximate but, nevertheless, grim. Development could probably lower the ratios, but the thought would be idle speculation. The pelletization characteristics of every iron ore concentrate has peculiarities which are inherent with the ore. Certain generalizations can be made, but experience has dictated the necessity of accepting generalities with reservation.

The most logical furnace design for pelletizing hematite would utilize the transverse velocities of 2400° F normal to the stock descent. The existing shaft furnace at the Ishpeming Pelletizing Unit did not incorporate this mechanism to a great extent. This furnace allowed vertically ascending heat transfer air to intercept the transverse velocities of hot gases from the combustion chamber and virtually quench the hot zone with a thermal diluent. This vitiating factor contributed to the abnormally large thermal requirement and low capacity for pelletizing hematite. It was concluded that a furnace design for increasing the transverse velocity should have both gas components, heat transfer air and combustion products, flow in a horizontal vector through the vertical bed of pellets.

In an endeavor to approach these conditions, several modifications were used in the existing shaft furnace: 1, the use of a 12" shuttle pipe to bypass air directly from the cooling portion of the furnace stock into the combustion chamber and, 2, the use of a 30" x 9" refractory tunnel in the same gas route. These modifications were used in an attempt to shunt the heat transfer gases into the combustion chamber where their flow would be imparted in a transverse manner to the furnace stock. Preferential flow should have been prominent through these shunting devices, but a quantitative measurement as determined by gas analysis indicated that only 2% of the air bypassed through the pipe, and only 19% shunted through the pipe-tunnel combination. It was concluded that a thorough revision of furnace design would be necessary in order to effectively bypass the heat transfer air.

Two alternate designs for meeting this problem were presented to the Babcock-Wilcox engineers in the fall of 1952. These consisted of (1) a design similar to both the original C. V. Firth furnace and the Bethlehem Steel Company's furnace. These units incorporated the use of heat transfer air as secondary air to the combustion chamber and tended to impart the full velocity of hot gas transverse to the path of descending pellets. (2) A novel design in which the combustion chamber gases are admitted transversely to the stock in a high narrow neck and the heat transfer gases are shunted around to the preheating zone. This design would gain the merit of a narrow pelletizing zone without the disturbance from uprising vectors caused by the heat transfer air. This unit could conceivably cope with dusty heat transfer air which could be vicious on the refractory wall of a 2400° F combustion chamber. The Babcock-Wilcox engineers voiced interest in these applications and discussed some of the limitations. The entire redesign scheme was tabled pending the outcome of the traveling grate for agglomerating hematite pellets.

MAGNETIC CONVERSION-CONCENTRATION:

Laboratory Magnetic-Conversion Concentration Tests:

A laboratory unit was designed for testing the relative response of various lean iron ores by magnetic conversion-concentration. The complete system consists of separate units for performing standardized conversion, milling and concentration tests. The conversion apparatus consists of 4" alloy retorts which have external provisions for admitting metered reducing gases through rotary gas ports while the retorts rotate inside of electrically heated ovens. An automatic temperature controller in conjunction with a variac is used for maintaining the retorts to any reacting temperature up to 900° C, within plus or minus 3%. The roasted products are milled in a laboratory ball mill up to a predetermined mesh of grind, and concentration is carried out by standardized Davis tube tests.

Through the judicious interpretation of random conversion tests, the variables which affect the response of an ore toward magnetic conversion were isolated and controlled. This lead to the formulation of a standardized schedule for converting, milling and concentrating ore samples. This schedule follows on the next page of this report.

Standardized Test Schedule

Ore Sample:	200 grams, plus or minus 2 grams, minus 20 mesh ore as stage-crushed through a rolls crusher.
Reducing Gas:	100% hydrogen admitted in a uniform flow which, after 30, plus or minus .3 minutes, will total two times the stoichiometric equivalence required to reduce the Fe_2O_3 content to Fe_3O_4.
Temperature:	500° C, plus or minus 10°.
Time:	30 minutes, plus or minus .3.
Reactor:	3" dia. x 4" length retort rotating at 4 rpm.
Metallurgy:	Ball milling the retort product as a batch until a minus 150 mesh product (80% minus 325 mesh) is produced. Standardized Davis tube tests performed on product.

The following list contains the number of samples tested by this technique during 1952. Each of these tests were duplicated at least two times in order to verify the metallurgical results.

Area	Location	No. Samples Tested
North Lake	Lloyd Mine	44
	Outcrops	13
	Drill Hole	25
Tilden	Outcrops	5
Humboldt	Outcrops	1
	Drill Hole	1
Republic	Drill Hole	1
Michigamme	Drill Hole	3
Minnesota	Concentrator Rejects	5
	Outcrop - Dump	3
	Land Offers	2
Special Projects	Colorado Fuel & Iron Co.	1

In addition to the survey samples, a considerable amount of research work was conducted on specific samples with regard to possibilities of fine grinding, coarse cobbing, etc. The application of a magnetic conversion-concentration flowsheet for processing Humboldt crude was the culmination of research work conducted on Sample H-67D, representing the Humboldt formation. This application was reported on in the comparison between magnetic conversion and flotation processes as applied to the beneficiation of low grade specular hematite. A definite improvement in the metallurgy was indicated from the utilization of magnetic concentration in lieu of flotation for processing this type of material.

Commercial Units for Magnetic Conversion:

Shaft Furnaces:

An investigation of shaft furnaces for conducting magnetic conversion has provided information relative to the design and operation of six different units. These furnaces are designated on the following page of this report.

Showa Steel Works, Anzan, Manchucko

Stribergs, Hofors, Sweden

Butler Brothers - MEX, Cooley, Minnesota

Battelle Memorial Institute, Columbus, Ohio

Pickands, Mather & Company, Hibbing, Minnesota

This survey concluded that the Pickands, Mather & Company development had the most favorable design and operation characteristics with regard to thermal efficiency and unit capacity. A tentative design of a pilot plant furnace for The Cleveland-Cliffs Iron Company was proposed with this investigation.

Rotary Kilns:

The use of rotary kilns for magnetic conversion at Gijon, Spain, and at Wattenstadt, Germany, was reported on. The application of rotary kilns for magnetic conversion was elaborated on in subsequent reports which concluded that this type of unit was inadequate for conducting the essential unit operations of conversion.

Fluo-Solids Reactor:

The discussion of fluo-solids reactors was covered in several memoranda which described the operations in general and as applied to magnetic conversion. Four samples of lean ore representing reserves of Cleveland-Cliffs were tested with a fluo-solids reactor by The Dorr Company. The laboratory results indicated that the fluo-solids reactor would be adequate for converting lean hematite from two Minnesota areas, the North Lake formation, and the Republic formation.

ORE EVALUATION & IRON ORE REDUCTION:

Ore Evaluation:

During the winter of 1952, Cleveland-Cliffs' Ore Sales Department requested technical assistance for a problem of iron ore evaluation. The problem consisted of evaluating the difference in value to a steel plant in three different iron ores running (1) 3% silica, (2) 2% silica, and (3) 1% silica. Certain effects of residuals such as nickel in iron ores were to be qualified along with the effects of silica.

In qualifying the factors which indirectly influence the higher value low silica ores, such items as those listed below were discussed with reference to basic open hearth steel making:

1. Less limestone would be required for the same basicity of slag.

2. A smaller slag volume would be produced.

3. Refractory maintenance would be decreased.

4. Hot metal with a higher silica and consequential lower sulfur could be tolerated.

A series of materials balance calculations showed how slag flushing could be eliminated through the use of low silica ores for charge and feed purposes in basic open hearth steel making. These calculations involved the silica balances from ten actual furnace heats, five of which used 40% hot metal with ore of 6% silica, and five of which used 60% hot metal with the same ore. By assuming a slag composition of 15% silica for nominal phosphorous absorption, the calculations showed how slag flushing was necessitated with the 60% hot metal addition. Be equating these 60% hot metal heats with the usage of ores containing 3% and 1% silica, it was shown that a slag volume of 13% would come about with the 1% silica ore, thus eliminating the necessity of slag flushing. This elimination could introduce a saving to a steel plant by increasing production and iron and manganese recoveries.

The ore values could be assigned from the four listed factors and from the elimination of slag flushing. The evaluation report pointed out that the values could only be determined from open hearth tests and data received from the tests would be specific for each steel plant. Open hearth tests and test evaluations were the concluding recommendations.

The undesirable effect of nickel in sheet steel stock was pointed out as the most critical item of concern for this residual in open hearth ore. The increase in hardenability caused by nickel and the cumulative effect of nickel in the presence of chromium and manganese result in what is known as "spring-back" during deep forming. This phenomenon has caused consumers of deep formed steel plate to specify residuals limits which range from .10 to .15%. In that scrap cannot be sampled nor chemically controlled with regard to sources of residuals in open hearth steel, it behooves ore processors to control the nickel content for open market products.

Iron Ore Reduction:

A literature study of sponge iron processing has shown the application of the Wiberg-Soderfors method to be one of the most promising processes. A 60 ton per day shaft furnace at Sandviken is producing sponge iron from light burned sinter and pellets at a reported cost of about $30.00 per ton. This product is used in the acid open hearth and electric induction and arc furnaces with reported satisfaction.

The direct reduction of fine iron ore has been given consideration by the Ford Motor Company. There have been indications that two different processes are under development. One of these is apparently the sponge iron or the liquid smelting of green pellets in a shaft furnace. The other application is the use of the Babcock-Wilcox cyclone burner for directly smelting fine iron ore. A discussion of this unit with the Ford and Babcock-Wilcox engineers has led to the following conclusions:

1. The discovery of smelted iron constituents of coal ash in the slag of Babcock-Wilcox's cyclone burner has shown that Fe - C - O equilibria can be established within the unit so as to smelt pulverized iron bearing materials.

2. The introduction of fine iron ore with the tertiary supply of air while burning pulverized coal in the cyclone burner can conceivably bring about iron production in a continuous device.

3. This application can utilize the high specific surface of pulverized ore, though the utilization may be gained at a loss of thermal efficiency.

PART IV

RESEARCH & DEVELOPMENT WORK & FLOTATION PROCESSES

Empire Area Project:

The preliminary Empire Area project, Sections 19 & 20, T47N-R30W, was completed early in 1952. Most of the outcrop samples were found to be very fine grained, with magnetite the major iron bearing mineral in many of the samples. Fine grinding followed by magnetic separation produced suitable concentrates from many of the samples; flotation results were generally poor.

Michigamme River District:

Work on a group of surface samples collected from the Michigamme River District was completed early in 1952. The samples were collected from the Metropolis, Magnetic and Michigamme ores representing Sections 20, 27, 34 & 35, T47N-R30W, and Sections 1, 2, and 12, T46N-R30W. The test work indicated that all but two of the 18 samples showed good response to concentration by froth flotation.

Cascade District:

Early in 1952 work on the surface samples from the Isabella Area, Cascade District, was completed. Only a very few of the surface samples showed good response to concentration by froth flotation. Composites built up from the 1950 surface samples were treated with heavy liquids followed by froth flotation on the sink products. It was felt that pre-connentration by gravity separation might eliminate some of the contaminants detrimental to a good response to froth flotation. However the procedure showed no beneficial effects on the flotation process.

The two main obstacles encountered in concentrating the Cascade surface samples were the apparent fine particle size necessary for liberation, and the apparent softness of the iron minerals which created large portions of minus 20 micron size material from grinding.

The test results indicate that the mineralogy of the Cascade Area is complex. The samples which responded favorably to froth flotation were scattered among those which did not respond favorably.

Ishpeming-Negaunee District - Cedar Lake Area:

Sixty-two samples from Sections 11 and 12 were subjected to preliminary froth flotation tests. The test results indicate that seven of the samples were classified as "Concentratable," four as "Favorable,", four as "Possible," and forty-seven as "No Good." Most of the samples responded poorly to concentration by froth flotation and only a few are strongly magnetic. The test work further indicates that a majority of the samples are hard and fine grained, requiring a fine grind for liberation.

All the samples which responded favorably to concentration by froth flotation were located in the northwest portion of Section 11.

Michigamme Area:

Froth flotation and Davis magnetic tube tests were conducted on composites built up from drill hole core footages from the Michigamme Area.

Three final composites were then built up from the individual drill hole composites. These are listed on the following page of this report.

Mi-68A - Includes three holes in Section 19 and is representative of the western end of the formation.

Mi-68B - Includes seven holes in Section 19 and four in Section 20, and is representative of the eastern end of the proposed mining area.

Mi-68C - Made up of the proper portions of Composites Mi-68A and Mi-68B, plus intrusive and lean material which would be difficult to eliminate in a selective mining operation.

Extensive tests were conducted on the final representative diamond drill hole composites. The tests conducted included froth flotation, magnetic separation, gravity concentration and magnetic oxide conversion, followed by magnetic separation. The results from this test program will be completed shortly and a final preliminary report on the Michigamme Area will be forthcoming.

Flotation Study Project:

1. Fatty Acids:

Fatty acids supplied by Armour and Company, General Mills, Inc., and American Cyanamid Company were used in this investigation. Almost any fatty acid product containing high proportions of oleic and linoleic acid proved to be a promoter for specular hematites, but not for other types of iron ores. Best results were obtained when the fatty acid was used in the raw state; no other additives were used.

Selectivity was best for reagents containing the highest proportions of oleic acid, but practical metallurgical results were best for reagents containing nearly equal proportions of oleic and linoleic acids. Results fell off sharply for reagents which contained more than 2% rosin acids or more than 5% palmitic acids. Other normal impurities, such as stearic acid, has no apparent effect at normal temperatures. Of the pure fatty acids, only oleic and linoleic acids had a marked collecting effect for the specular hematite, although other reagents were non-selective collectors.

Several oleic-linoleic reagents, costing about eight cents per pound, proved to be the most economical to use. The requirements for flotation seem to be about 0.6 pound per ton of crude ore.

2. Mill Testing:

The results of batch flotation testing were verified by conducting tests in the pilot mill with the various fatty acids and with water from Lake Lory, Lake Milwaukee, and Ishpeming tap water (Lake Sally). The pilot mill tests were also helpful in determining such important factors as retention time, conditioning time, percent solids, and information on the use of the densifier and cyclone for desliming. The information derived was reported to the design engineer for use in designing the Humboldt and Republic Mills.

3. Water for Flotation:

Samples of water from the proposed sources for the Humboldt Mill (Lake Lory) and for the Republic Mill (Lake Milwaukee) were obtained, analyzed and used for flotation. Flotation with fatty acids is known to be adversely affected by hard water, such as Lake Angeline. The water from Lakes Lory and Milwaukee proved to be very soft, but contained colloidal organic material, probably iron tannates, which color the water yellow. Water from wells in the area was considerably harder, and is probably not suitable for fatty acid flotation. The organic coloring in the lake waters had some adverse effect upon flotation, but the effect was not considered serious enough to consider water treatment before opening the mills, when the problem will be given more consideration.

Methods of treating water, such as demineralization, softening, coagulating, and clarification were studied and the waters produced were used for flotation. The information derived was reported on and is available for future use.

4. Reagent Testing Program:

A program of reagent testing was carried on throughout the year, concurrently with other projects. The reagents tested included several supplied by the Emulsol Corporation, petroleum sulfonates from various sources, and a large number of fatty acids supplied by various manufacturers.

Petroleum Sulfonates: Petroleum sulfonates, particularly those supplied by L. Sonneborn Sons, Inc., were tested and new information on the use of those materials was obtained. These reagents were found non-competitive with the fatty acid materials later developed for the flotation of specular hematite ores. California Research Corporation's Reagent 51946-R, a sulfonated aromatic hydrocarbon, was also tested. Results were not much different from those obtained with regular sulfonates.

Emulsol Reagents: Various surface active reagents supplied by the Emulsol Corporation, particularly Emcol 4150, were extensively tested. The results obtained were good metallurgically but the problem of breaking the tough froth formed was not solved, and this investigation was dropped when the fatty acid investigation began to show results.

5. Ohio Mine Samples:

A brief study was made to determine the amenability of three Ohio Mine samples to concentration by froth flotation. The three samples on which the study was conducted were the hydrosizer from the Ohio Mine Plant, the primary spiral feed plus 48 mesh, and the primary spiral feed minus 48 mesh.

Various reagents and flotation procedures were tested, and it was found that American Cyanamid R-899 procedure and a quartz flotation procedure with amine acetates gave the best results. However, the American Cyanamid procedure required thorough desliming and an abundant reagent promotion, while the amine acetate procedure was poor mechanically with a tough, voluminous froth. Because neither of these procedures appeared to be economically feasible, the project was discontinued.

6. Flotation of Magnetic Oxide Conversion Concentrates:

A study was initiated to determine a suitable procedure for beneficiating magnetic concentrates produced from the magnetic oxide conversion process. The magnetic concentrate produced by magnetic separation of magnetic oxide conversion of Lloyd Mine Sample L-34 contains approximately 57% Fe and 17% SiO_2. It was felt that some simple flotation procedure might be found which would raise the iron content and lower the silica content to a desirable point.

Various procedures and reagents were tested and it was found that a procedure using amine acetates was the best. Several tests are now in progress to determine the most suitable amines and optimum reagent balances. A report on this study is forthcoming.

7. Others:

Several minor flotation studies were conducted during the year. Among these were a study of the effects on froth flotation of Humboldt overburden sands and clays, a brief study of pilot mill reagents and water, a brief study of Minerals Separation's High Lime flotation procedure, and settling tests to determine the size and nature of the Humboldt and Republic tailings ponds.

OHIO MINE CONCENTRATING PLANT OPERATION

The Ohio Mine went into production during the 1952 season. The plant operated from May 7th through June 2nd, and from August 11th through October 28th. Production from June 2nd through July 25th was halted because of the work stoppage, and from July 26th through August 10th because of revisions and repairs to the plant. Ore was treated from the East Pit (Webster Ore), only.

The plant produced 59,507 tons of concentrate during its first season. The shipping analysis of the product assayed 54.08% Fe, .190% Phos., 12.21% SiO_2, and .030% Sul. The overall weight recovery was 29.80%. Of this total, the heavy media concentrate assayed 54.75% Fe, 11.65% SiO_2, with a crude weight recovery of 8.05%. The heavy media circuit produced 43,440 tons and the spiral circuit produced 16,067 tons.

The feed rate to the plant from the surge pile was 86.84 tons per hour (gross) and 120.61 tons per hour (net). Concentrate was produced at 25.88 tons per hour (gross).

Delays consumed 27.96% of all operating time of the plant. The major sources of trouble were due to inexperience in starting and operating this type of mill, difficulties with the Hydrocone crusher, and difficulties with plant operation in unseasonably cold October weather.

The media loss for the season was .955 lbs. ferrosilicon per ton of heavy media feed, and 2.822 lbs. ferrosilicon per ton heavy media concentrate.

Production:

The concentrating plant treated 199,698 tons of crude ore during the season. From this, 59,507 tons of concentrate were produced. This total breaks down as follows:

Season Production

	Tons	% Wt. Crude	% Fe	% SiO_2	TPH Gross	TPH Net
Crude to Plant	199,698		42.79	29.01	86.84	120.61
Crude to H.M. Section	128,349	64.27	40.61	32.73	55.82	77.52
Crude to Spiral Section	61,051	30.57	47.47	23.03	26.55	38.95
Fines to Tailing Pond	10,398	5.16	46.13	22.56		
Total Conc. Produced	59,507	29.80	54.49	12.75	25.88	
H.M. Conc. Produced	43,440	21.75	54.75	11.65	18.89	
Spiral Conc. Produced	16,067	8.05	53.77	15.74	6.99	

The above figures do not present a true picture of the capacities and capabilities of the plant. They include figures from the first month of operation when production and operating time were low, and the assay of the concentrate was poor. The figures for the last two months of the season approach a truer picture. September was the month of highest production. Its operating data were as follows:

	Tons	% Wt. Crude	% Fe	% SiO_2	TPH Gross	TPH Net
Crude to Plant	69,581		42.71	29.09	115.97	131.96
Crude to H.M. Section	48,801	70.13	42.17	30.61	81.34	92.55
Crude to Spiral Section	20,084	28.87	48.11	22.23	33.47	38.09
Fines to Tailing Pond	696	1.00	46.26	22.03		
Total Conc. Produced	23,587	33.90	55.14	11.93	39.31	
H.M. Conc. Produced	18,098	26.01	55.02	11.38	30.16	
Spiral Conc. Produced	5,489	7.89	55.53	13.73	9.15	

October was the month in which the best grade of concentrate was produced. Its tonnage output was hampered by poor weather. The operating data for October were as follows:

	Tons	% Wt. Crude	% Fe	% SiO_2	TPH Gross	TPH Net
Crude to Plant	61,699		42.58	28.39	101.48	138.25
Crude to H.M. Section	37,882	61.44	40.74	31.28	62.34	84.93
Crude to Spiral Section	18,881	30.56	49.77	19.64	31.02	43.06
Fines to Tailing Pond	4,936	8.00	48.76	19.51		
Total Conc. Produced	16,889	27.39	55.15	10.59	27.79	
H. M. Conc. Produced	11,520	18.68	54.93	9.62	18.96	
Spiral Conc. Produced	5,369	8.71	55.61	12.66	8.83	

Delays:

The concentrating plant operated with delays amounting to 27.96% of the total working time. Of this total, almost one-half of all delays occurred in May, the startup month. About one-fourth of all delays occurred during October when cold weather seriously hampered operations.

Many of the delays which were encountered were of a correctable nature. In other words, they were eliminated or greatly improved during the season, or they will be rectified before the coming season. Into this category falls all equipment which has been altered to fit plant requirements, all changes in plant design, and all improvements in the basic techniques of operation.

Metallurgy:

Testing during the year was limited by the time consumed in the supervision of operations and production necessary with first season plants. Control work on all portions of plant products will be more complete for the 1953 season. Metallurgical work centered mainly on 1) eliminating "jackpots" in the heavy media circuit, 2) removing of a coarse final concentrate from the primary spirals, 3) improving the classification of spiral concentrates, 4) testing on other methods of concentration for fines, 5) improving operation of the spirals, 6) testing the efficiency of the Crockett magnetic separators, and 7) testing attachment losses on heavy media products.

General:

A comparison of plant results with the original test work which led to the development of the Ohio Mine is presented below. The data are taken from 1) Metallurgical Report No. 7, dealing with heavy media and heavy liquid tests on individual Webster trench samples, 2) similar test work on Sample W-130, a composite of Webster trench samples, and 3) actual results as recorded in concentrating plant monthly reports.

The abovementioned data are presented on the following page of this report.

Metallurgical Report No. 7

		% Wt.	% Fe	% SiO_2
Combined H.M. & H. L. Concentrates	Trench A	43.17	55.10	10.70
(Sink 2.8-3.0 on -3/4" +1/8" Fraction)	Trenhh B	30.75	56.99	8.02
(Sink 2.97 on -1/8" +65 Mesh Fraction)	Trench C	30.29	56.83	8.75
	Average	35.63	56.05	9.48

Sample W-130

Various Combined Concentrates:

	% Wt.	% Fe	% SiO_2
1) Sink 2.9 -3/4" +8 Mesh	22.50	55.58	10.19
Sink 2.97 -8 M. +150 M.	14.96	53.71	11.83
Total	37.46	54.83	10.84
2) Sink 2.9 -3/4" +8 Mesh	22.50	55.58	10.19
Sink 2.8 -8 M. +150 M.	15.68	51.44	14.67
Total	38.18	55.33	12.03
3) Sink 3.0 -3/4" +8 Mesh	9.46	57.90	6.84
Sink 2.97 -8 M. +150 M.	14.96	53.71	11.83
Total	24.42	55.33	9.90
4) Sink 3.0 -3/4" +8 Mesh	9.46	57.90	6.84
Sink 2.8 -8 M. +150 M.	15.68	51.44	14.67
Total	25.14	53.87	11.72

Plant Operating Data

		% Wt.	% Fe	% SiO_2
Total Season	- H.M. Concentrate @ 2.8-3.0	21.75	54.75	11.65
	Spiral Concentrate	8.05	53.77	15.74
	Total	29.80	54.49	12.75
September	- H.M. Concentrate @ 3.0	26.01	55.02	11.38
	Spiral Concentrate	7.89	55.53	13.73
	Total	33.90	55.14	11.93
October	- H.M. Concentrate @ 3.0	18.68	54.93	9.62
	Spiral Concentrate	8.71	55.61	12.66
	Total	27.39	55.15	10.59

It is apparent that the heavy media results are similar, in most respects, in both plant and laboratory. It is in the performance of the spirals that the discrepancy exists. The weight recovery is approximately seven to eight percent below what heavy liquid tests can do. Recovery of this fraction is the objective of testing at the Research Laboratory. This would bring total recovery figures close to those predicted in Metallurgical Report No. 7.

The 1953 season will undoubtedly show a higher production over the first year of operation on the East Pit. The opening of the West Pit will present a different problem when this ore is treated. The experienced crew should be able to make the transition without too much difficulty, although such a change always creates new difficulties.

L. J. Erck,
Chief Metallurgist

Six - 4/28/53

1 - Cleveland Office
1 - Ishpeming Office
1 - Mr. Grover J. Holt
1 - Mr. E. L. Derby, Jr.
1 - Research Laboratory