protect our men from them and continually warn them of their presence.

When we enter into a discussion of the gases generated by exploding powder or dynamite, we get into a very large field. There have been volumes written on the different fumes liberated by the different powders. These gases are too numerous for us to attempt to describe or even enumerate. All of the dynamites used in this district are of a nitrate base, so we need to consider here only the main gases, which include those listed in the foregoing paragraphs, and in addition the oxides of nitrogen.

This last gas is usually generated as nitrous oxide which takes on oxygen from the air to form a nitrous peroxide which is very deadly. Very little data is available as to the percentages of nitrogen oxides allowable in mine air but it is the general conclusion that from 1/100 to 2/100 of 1 per cent are dangerous and that man cannot stand over 5/100 of 1 per cent. These gases are about ij/2 times as heavy as air, and are usually found in what might be termed fresh powder smoke. When mixed with traces of carbon monoxide the inhalation of these gases is often fatal to man.

We think it would be proper to add something concerning the physiological effects to men gassed by the four more deadly gases, namely, sulphur dioxide, hydrogen sulphide, oxides of nitrogen and carbon monoxide. We therefore quote from information obtained from Dr. R. R. Sayres, Chief Surgeon, U. S. Bureau of Mines,* and J. Barab, of the Hercules Powder Company.*

> "Sulphur dioxide is very irritating to the eyes and respiratory passages, one part in 500 being almost intolerable to breathe. Man sets up his own protection against this gas since he cannot breathe it.
>
> "Hydrogen sulphide (stink damp) is very poisonous and wherever it exists the possibility of poisoning is present. Tin's poisoning is of two types, namely, acute and sub-acute, causing asphyxiation and irritation (conjunctivitis, bronchitis, pharyngitis and depression of the central nervous system), respectively. Death from asphysia is caused by paralysis of the respiratory center, while death from sub-acute poisoning is associated with edema of the lungs. In low concentrations hydrogen suphide produce symptoms of headache, sleeplessness, dullness, dizziness and weariness. Pain in the eves, followed by conjunctivitis, is fairly constant; while bronchitis and pains in the chest are frequent. Further poisoning produces depression, stupor, unconsciousness, and death. The heart continues to beat after respiration has ceased.
>
> "In cases of poisoning by oxides of nitrogen fumes from explosions no symptoms may be evident and no poison or discomfort be felt for a time, yet within 12 to 18 hours after exposure the person exposed to the fumes may die from acute edema of the lungs, usually the common symptoms of coughing and vomiting, and dizziness are felt. The subject does not lose consciousness. He becomes pale or even gray or a bluish tinge comes over the skin. The upper air passages are sore. A few hours afterwards when it would seem that all symptoms had ceased and all fear of possible complications had passed, the individual who has breathed the gas begins to complain of severe compression of the chest and of respiration being painful. He becomes pale, temperature elevated, the pulse frequent and small, and the patient succumbs without loss of his intellectual functions. Some doctors claim that the deleterious action of nitrous fumes upon the human system is entirely due to their local corrosive action upon the respiratory mucous membrane. If the gassing has been thorough and most of lungs affected the patient usually succumbs. If the gassing has affected only portions of the lungs bronchitis or pneumonia may develop."

*"Fumes Encountered in Mining Operations and Handling Explosives," July 10, 1922.

*"Permissible Limits of Toxic and Noxious Gases, Etc.," U. S. Bureau of Mines, Serial No. 2734.

Dr. Sayres writes the following:

> "The treatment of poisoning by oxides of nitrogen will depend, of course upon the extent of gassing or injury. The first-aid treatment consists of keeping the patient at absolute rest and in a recumbent position and keeping him warm. Administration of oxygen is of advantage if there is cyanosis, that is, if the patient looks blue or gray. He should be placed under the care of a physician at once, preferably in a hospital where the physician will endeavor to limit the amount of pulmonary edema, to relieve the anoxemia, support the heart and circulation, relieve any pain or distress, and prevent infection and pneumonia.
>
> "Carbon monoxide is probably as deadly as any gas and the occurrence of it has increased throughout the years until at present it is found not only in the mines but in many other industries, even in our homes. Carbon monoxide exerts its extremely dangerous action on the body by displacing the oxygen from combination with the hemoglobin of the blood. The symptoms of carbon-monoxide poisoning can be divided into two stages," says Dr. Sayres: "the first beginning with normal and ending in syncope (fainting), and the second a depression of the central nervous system beginning in fainting extending through coma, and ending in loss of breath.
>
> "Stage 1. Tightness across forehead, dilation of cutaneous vessels, headache (frontal and basal), throbbing in temples, weariness, weakness, dizziness, nausea and vomiting, loss of strength and muscular control, increased pulse and respiratory rates, collapse. All of these are greatly increased and accelerated with exercise on account of the additional need of oxygen in the tissues. Men at rest have often been exposed to carbon monoxide all day

without noticing any marked ill-effects, but on walking home or exercising have experienced severe symptoms, even to unconsciousness.

"It is seldom that all these symptoms are experienced by the same individual. Also in some cases the poisoning may proceed up to the stage of syncope without the victim feeling any of the subjective symptoms, this frequently occurring if the poisoning has been rapid.

"Stage 2. Increased pulse and respiratory rates, fall of blood pressure, loss of muscular control, especially sphincters, coma, usually with intermittent convulsions, Cheyne-Stokes, respiration, slowing of pulse, respiration slow and shallow;, cessation of respiration, death."

Dr. Sayres gives the following as the steps in the effective treatment of acute poisoning by noxious gases in mine air:

1. The victim should be removed to fresh air as soon as possible.
2. If breathing has stopped, or is weak and intermittent, or present in but occasional gasps, artificial respiration by the Schaefer method should be given persistently until normal breathing is resumed, or until after the heart has stopped.
3. Circulation should be aided by rubbing the limbs and keeping the body warm with blankets, hot-water bottles, hot bricks or other devices, care being taken that these are wrapped or do not come in contact with the body and produce burns. This aids in tiding the body over a period of low vitality. Other stimulants such as hypodermics of caffein, sodium benzoate, or camphor in oil, should not be administered except by a doctor after he has considered the possibility of over-stimulation and consequent collapse.
4. The patient should be kept at rest, lying down in order to avoid any strain on the heart. Later, he should be treated as a convalescent and given plenty of time to rest and recuperate.
5. After-effects of poisoning by such gases should be treated symptomatically.
6. It should be emphasized that inhalations, for a period of 20 to 30 minutes, of oxygen, or a 5 per cent mixture of carbon dioxide in oxygen if available, will when given immediately lessen the number and severity of symptoms of carbon monoxide poisoning, as well as decrease the possibility of serious results."

We wish to close this article by emphasizing the dangers of poisoning by carbon monoxide and the oxides of nitrogen. A man in the presence of carbon monoxide is liable not to realize his danger when he feels he wants to rest and gradually loses consciousness as if in sleep. This is the gas which has caused so many fatalities when the engine runs in a closed garage. It occurs in large quantities in the gas from blast furnaces and may be present in the smoke of any combustion. One poisoned by the nitrogen oxides may not appear to be greatly distressed or in bad shape until death. Poisoning by the latter gas is not so common as with the former but such cases may occur as frequently if there is exposure to powder smoke. We must not forget to suspect its presence, especially in cases of poisoning from powder fumes.

We should bear in mind at all times the steps of treatment as given by Dr. Sayres in cases of poisoning and summon a physician at once.

EFFECT OF ATMOSPHERIC CONDITIONS ON IRON ORE ANALYSIS.*

BY O. A. SUNDNESS, CHISHOLM, MINN.**

Very little mention has been made of the hygroscopic nature of our Mesabi range iron ores and the effect of atmospheric conditions on the chemical results attained in our laboratories. All chemists will admit that there is some influence from atmospheric moisture and some take proper precautions to protect their ore pulps while others merely place a moisture absorbing agent in the balance itself. This act is of doubtful value if it is the only preventive used. Inadvertance on the part of the chemist toward the effect of moisture in the air, especially during the summer months, is undoubtedly the basic reason for the inability of some laboratories to check each others results, as well as for their difficulty in getting duplicate results on the same sample when analyzed at different periods of the day or night.

*Skillings' Mining Review, December 27, 1930.

**Chief Mining Engineer and Chemist, Snyder Mining Co.

HUMIDITY VARIES WITH TIME.

A series of four tests is submitted with this article to illustrate the importance of atmospheric influences as affecting the chemical determination of iron. Before discussing the results it may be well to call attention to the diurnal and annual cyclical variations in the atmospheric humidity in which we live. As a general statement, the relative humidity is at its highest during the early hours of daylight. As the day progresses and the heat of the sun begins to make itself felt, the relative humidity drops rapidly until three or four o'clock in the afternoon. The effect of the sun's heat is then dissipated and the cycle completes itself by steadily rising until morning. This diurnal cycle may show considerable variation in amount from day to day as influenced by intense heat or by rains during the twenty-four hour period. The peaks and valleys of the hygrometric curve are also leveled off to a large extent in the winter months, especially when we work in tightly closed buildings with artificially low humidity due to dry heat. We all recognize the various degrees of humidity when we speak of an oppressively hot day, or when we say that our automobile engine functions better in the moist

night air; still, some laboratories handle their iron ore pulps in paper bags or in envelopes with no heed as to what happens to the thoroughly dried, or you may call it a thirsty pulp, when thus openly exposed to the moisture bearing air.

Temperature and Moisture.

Curves A, B, C, D and E are submitted to illustrate the variations in daily temperature and atmospheric moisture mentioned in the preceding paragraph. Information as to hourly variations in relative humidity were not available to the writer so curve "A" was developed from Mesabi range air for the dates shown by readings of a Tycos wet and dry bulb hygrometer. September 23 is an example of a typical summer day; temperature ranging from 75 to 90 degrees Fahrenheit; relative humidity high in the morning, low in the afternoon but rising a little earlier than usual because of rain and then rising steadily until morning; atmospheric moisture content or absolute humidity quite high throughout the 24-hour period. These data may be compared with September 26 and 27 when a cold snap was being experienced. Doors and windows in laboratory were closed thus excluding natural influences and steam heat was being used. Room temperature approximated 75 degrees, relative humidity quite low and without any great variations while the atmospheric moisture content was barely one-half as compared to September 23.

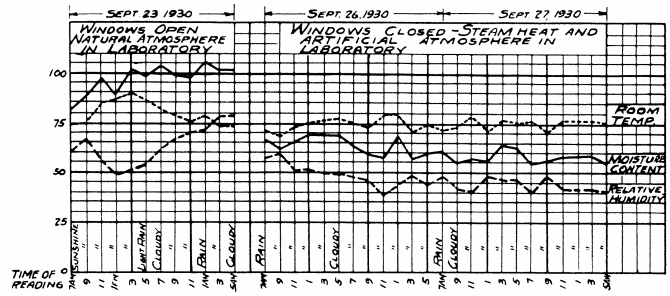
Curves "B" and "C" were plotted from information furnished by Mr. H. W. Richardson of the Duluth Weather Bureau. Curve "B" shows the variation in noon temperature for the months of February and July, 1930; while curve "C" shows the variations in relative humidity at noon each day during the same months.

Relative Humidity.

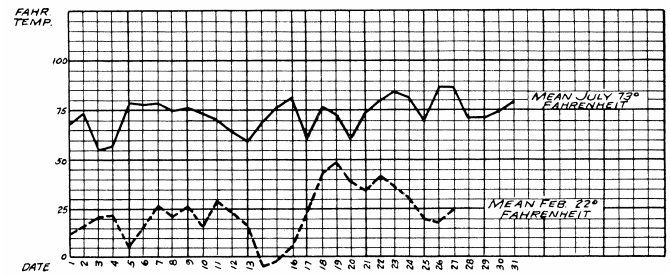
Relative humidity may be defined as the ratio of the amount of moisture actually contained in a given volume to the amount which would be present under a condition of saturation. Absolute humidity is the amount of moisture that is actually contained in a unit volume. Curve "D" was then developed from curves "B" and "C" in conjunction with a table showing the saturation content of air at various temperatures. This curve indicates that while the relative humidity of February is higher than July, still, because of the higher temperature existing in July, there is an enormous increase of water in the July air over the available moisture in the February air.

Curve "E" illustrates the annual variations by months during the year 1929 in mean temperature, relative humidity and atmospheric moisture content or absolute humidity. Attention is called to the fact that from May to October the water content of the air is very high as compared to the winter months and this fact should be given due consideration in attempting to check any results which are indicated in the following hygrometric tests and which were developed during the month of August, 1930.

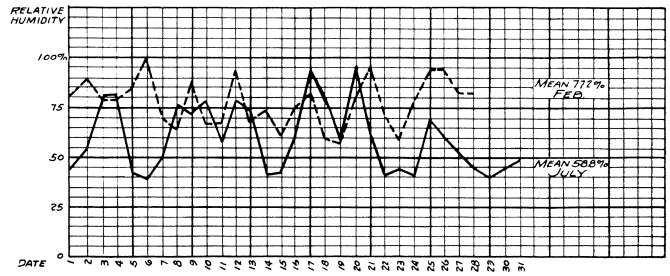
In each of the above curves the temperature is plotted in degrees Fahrenheit, the relative humidity as percentage and the actual moisture content or absolute humidity as pounds of water per 100,000 cubic feet of air.



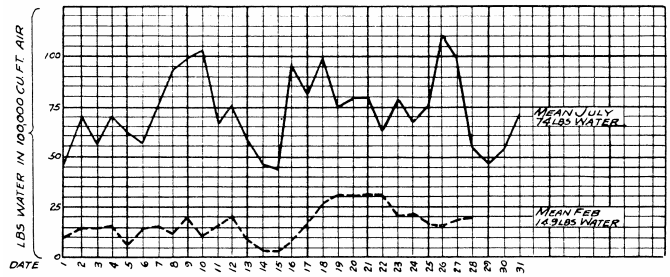
Hourly Variations in Temperature - Relative Humidity - Moisture Content
Curve "A"



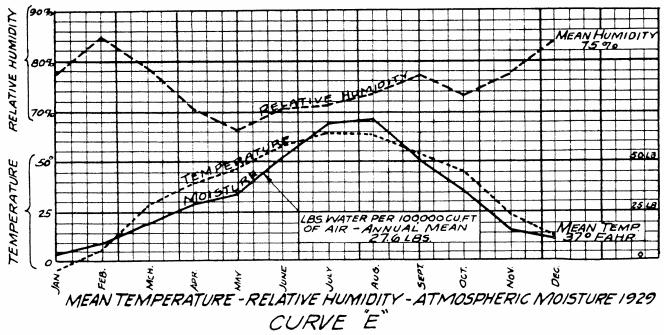
Noon Temperature Feb. and July 1930
Curve "B"



Noon Relative Humidity Feb. and July 1930
Curve "C"



Noon Atmospheric Moisture Content Feb. and July 1930
Curve "D"



SELECTION OF SAMPLES.

The ore samples for the hygrometric tests were taken from distinctive layers in a typical Mesabi range orebody. This orebody contains two merchantable layers and two non-merchantable layers in the intermediate Paint Rock horizon, and three merchantable high grade layers below the Paint Rock. A general description and the analysis of the samples taken are as follows:

SAMPLE "A"

Merchantable upper layer of orebody directly below glacial drift. Granular texture rather than painty, good black color.

Fe	P	Mn	SiO_2	Al_2O_3	Loss	Moist.
62.48	.060	.15	4.00	3.72	2.45	11.80

SAMPLE "B"

Non-merchantable layer below "A." Painty and soft in texture. Brown color.

Fe	P	Mn	SiO_2	Al_2O_3	Loss	Moist.
43.93	.157	1.48	11.40	11.76	10.50	26.80

SAMPLE "C"

Merchantable ore below "B." Painty and soft in texture. Dark purple color.

Fe	P	Mn	SiO_2	Al_2O_3	Loss	Moist.
60.53	.047	1.05	5.40	3.64	2.15	22.90

SAMPLE "D"

Non-merchantable ore below "C." Painty and sticky in texture. Brown color.

Fe	P	Mn	SiO_2	Al_2O_3	Loss	Moist.
36.45	.057	2.03	16.30	17.08	11.20	23 00

SAMPLE "E"

Bottom of paint rock layer below "D." Soft and sticky in texture. Pinkish red color with white seams.

Fe	P	Mn	SiO_2	Al_2O_3	Loss	Moist.
53.04	.098	.52	9.50	7.07	4.85	23.70

SAMPLE "F"

Limonite layer below "E." Soft powdery texture with hard dense seams. Bright canary yellow color.

Fe	P	Mn	SiO_2	Al_2O_3	Loss	Moist.
59.23	.067	.23	2.80	1.51	9.80	13.80

SAMPLE "G"

High grade bessemer hematite below "F." Granular texture. Deep black color when moist turning grayish on drying out.

Fe	P	Mn	SiO_2	Al_2O_3	Loss	Moist.
67.04	.027	.29	1.70	.54	1.35	7.00

SAMPLE "H"

High grade non-bessemer below "G." Granular seams and sticky seams. Yellow and brown in color.

Fe	P	Mn	SiO_2	Al_2O_3	Loss	Moist.
61.34	.083	.27	2.90	2.22	6.45	17.50

These samples were taken to the crusher house where they were handled in conformity with standard Mesabi range practice. They were put through crushing rolls, mixed, quartered down to size, dried at 212 degrees Fahrenheit, ground to 100 mesh in a Braun pulverizer, put through a 100 mesh sieve and then placed in tightly stoppered bottles for transportation to the laboratory.

HYGROMETRIC TESTS.

Ten grams of the ore pulp were then carefully weighed from each bottle for the hygrometric test in the laboratory. These samples were placed in small manila envelopes to approximate conditions existing in some laboratories and to facilitate handling and weighing, containing envelopes having been previously weighed. Each envelope and its contents were then weighed at two hour intervals and the resulting gains, which were due to moisture absorption, are plotted as curves in tests No. 1, No. 2 and No. 3. In order to correct for gain or loss in the containing envelope, four empty envelopes were also weighed at two hour intervals for test No. 1, and the total variation in weight from the original weight was divided by four. This result was then added to, or subtracted from, the total gain in each sample to compensate for variations due to the containing envelope. On test No. 2 three empty envelopes were weighed and in test No. 3, one empty envelope was carried along with the test.

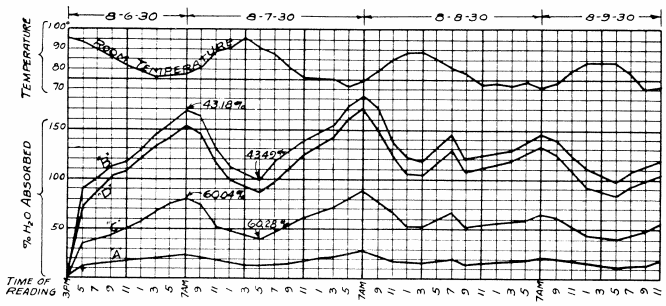
MEANS LOSS OF IRON.

It does not require close scrutiny of these curves to realize the importance of the matter. When we stop to consider the fact that the absorption of 1.0 per cent moisture by an iron ore pulp in the laboratory means the loss of approximately 0.5 per cent dried iron, the seriousness of the situation is brought home. For an example we refer to test No. 1. Ore "B" as noted in the above tabulation had a value of 43.93 per cent dried iron at 3:00 p. m. when the test was started. At 7:00 o'clock the following morning, after standing at room temperature in the balance room sealed in an envelope, this ore had absorbed 1.70 per cent moisture, and, by calculation would run only 43.18 per cent dried iron. By 5:00 o'clock the following afternoon, after being subjected to dropping humidity during the heat of the day, it contains only one per cent moisture and would analyze 43.49 per cent dried iron. Take also ore "C"; in a dry condition at 3:00 p. m. it had a value of 60.53 per cent dried iron; at 7:00 o'clock the following morning with an 0.8 per cent moisture content its value would be only 60.04 per cent dried iron while at 5:00 p. m., carrying only 0.4 per cent moisture its value would be 60.28 per cent dried iron. No hygrometric readings were taken with this test but the upper curve indicates the room temperature.

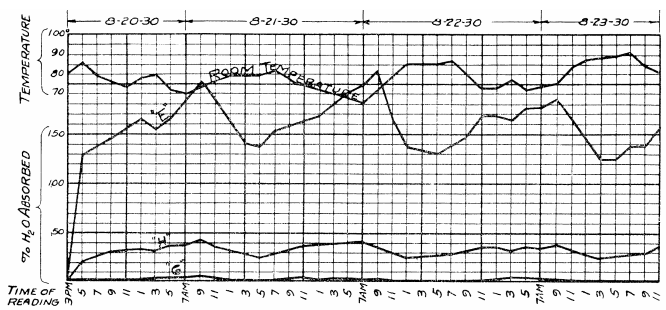
Test No. 2 on ores "E," "G" and "H" is similar to test No. 1. It was worked out several days later and the temperature curve is lower than in test No. 1. The daily drop in humidity takes place at 9:00 a. m. in test No. 2 instead of 7:00 a. m. as in test No. 1.

Test No. 3 on ore "E" was worked out a few days after test No. 2 with about the same room temperature. Hygrometric readings were also taken each time the ore

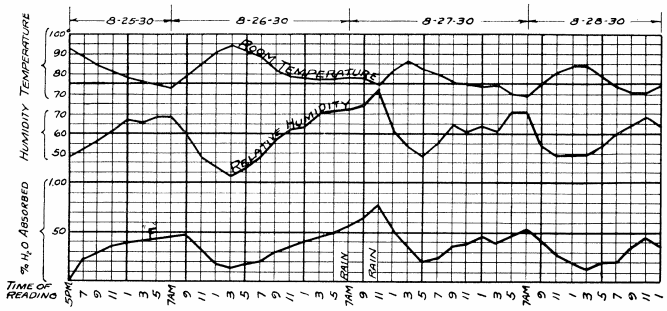
envelope was weighed. This test shows that the amount of moisture absorbed varies closely with the relative humidity. It also shows the effect of rains on the second morning when the drop in humidity did not take place until 11:00 a. m., while on the first and third mornings it took place at 7:00 a. m.



MOISTURE ABSORPTION BY 10GMS 100MESH IRON ORE PULP SEALED IN ENVELOPES
TEST No. 1



MOISTURE ABSORPTION BY 10GMS-100MESH IRON ORE PULP SEALED IN ENVELOPES
TEST No. 2

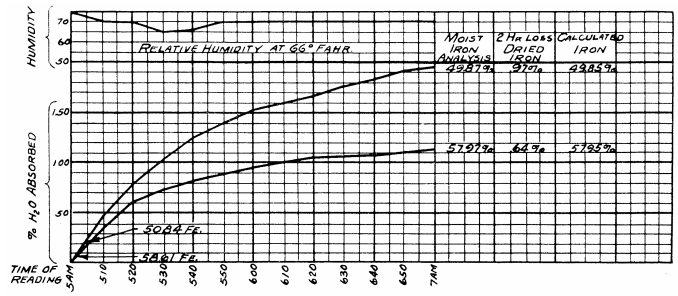


MOISTURE ABSORPTION BY 10GMS-100 MESH IRON ORE PULP SEALED IN ENVELOPES
TEST No. 3

The above three tests indicate that an unprotected iron ore pulp will absorb moisture from the air in varying amounts depending upon the moisture content or humidity of the air, and upon the individual affinity for moisture of each particular grade of ore under consideration.

RATE OF ABSORPTION.

In these three tests the greatest absorption by all of the ores, for any two hour period, took place during the first two hours of exposure. This holds true regardless of whether the test is started during the ascending portion of the hygrometric cycle, or the descending portion of the cycle. The above tests were purposely started near the end of the descending portion of the cycle so as to make a less complicated or more uniform curve. The rapid rise immediately after exposure indicates that there is a certain state of balance, or an equilibrium, between the various grades of iron ore pulps and the atmosphere, which state the freshly dried pulp rapidly tries to reach. This equilibrium is a different percentage of moisture content for each grade of ore, but when once reached the absorption then varies with the atmospheric humidity. The initial as well as the maximum absorption is greatest in the complex hydrated oxides of slaty decomposition in the upper portion of the orebody, while, in the simple oxide sample "G" (high grade hematite) the effect is nearly negligible.



MOISTURE ABSORPTION BY 10GMS-100 MESH IRON ORE PULP ON OPEN WATCHGLASSES
TEST NO. 4

In order to determine the rate of absorption during the first two hours, and, to illustrate the economies of the hygroscopic qualities of iron ores, test No. 4 was conducted on two run-of-mine samples. The 100 mesh iron ore pulps were carefully dried at 212 degrees Fahrenheit, thoroughly mixed and triplicate iron determinations were made on each ore with the results as noted at the beginning of each curve. Ten grams of pulp were then weighed from each sample, placed on watchglasses and left exposed to the balance room atmosphere. Whether the pulp is sealed in an envelope or left on an open watchglass seems to have but little effect on its moisture absorption. Weighings were then made every ten minutes for a two hour period with results as indicated by the curves; ore No. 1 finally absorbing 1.95 per cent moisture and ore No. 2 absorbing 1.15 per cent moisture. At the end of the two hour period triplicate irons were weighed from each of the two tests with results as noted at the end of each curve. The difference between the first iron determination and the second iron determination, which is due to moisture absorption, is a .97 per cent loss in dried iron for ore No. 1 and a .64 per cent loss for ore No. 2. The second iron determination is subject to mathematical check by using the original correct iron determination and applying to it the correction for accumulated moisture at the end of the two hour period as follows:

Iron No. 1—50.84% x (100%—1.95%) equals 49.85% calculated iron.
Ore No. 2—58.61% x (100%—1.15%) equals 57.95% calculated iron.

In these two ores, which carry from 15 to 20 per cent moisture, we now have a loss of from .50 to .75 per cent when considered as natural iron. The unit value of these ores which are in the double penalty class approximates 17 cents per unit, hence the moisture absorption is

responsible for a loss of from 9 cents to 13 cents per ton when the ore is sold.

Loss Varies.

Test No. 4 indicates what happens to these ores in a two hour period with a relative humidity of approximately 70 per cent and a room temperature of 66 degrees Fahr. If a longer period of time should pass before the iron determination is made, or, if the atmospheric condition should be more humid than indicated in test No. 4, these losses would be proportionately greater. Conversely, if less time elapses, or if the air is drier, the losses will be correspondingly lower.

The significant fact in test No. 4 is that sufficient moisture is absorbed in 20 minutes to cause serious loss of iron in an unprotected iron ore pulp. This is probably the minimum elapsed time for any sample, from the pulverizer in the crusher house to the iron flask in the laboratory, if more than three or four samples are handled at the same time.

FEDERAL GOVERNMENT IMPROVEMENT OF THE ST. MARY'S RIVER CANAL—MICHIGAN.

BY ARNOLD A. BELL, IRONWOOD, MICH.*

The history surrounding the use of the St. Mary's River as a transporting waterway between Lake Superior and Lake Huron dates back to 1799, when the first lock was built by the Northwest Fur Company. This lock later was destroyed by the United States troops. The first true ship canal was built on the American side of the river in 1853 by the State of Michigan. For the use of this canal a toll was charged to cover operating and repair expenses.

In 1881 control of this waterway was transferred to the United States Government, and the canal has since been free for public use to all nations. All improvements of deepening and widening the canal since that time have been financed by the United States, as provided by the treaty of the War of 1812. The United States Government made the first appropriation for improving the river channels in 1856.

The Lake George route, or longer canal, since discarded by' much of the shipping, was improved for 12 feet draft between 1857 and 1869. The depth was increased to 16 feet in 1883. The Hay Lake route was improved for a depth of 20 feet mean stage water by the year 1894. At that time also the Middle Neebish channel was opened to commerce. This channel comprises the present day direct and shorter route.

Betterment of the channels has been continued since that time so that the dredged areas now total 95 miles in length, with the least width of 300 feet, and a swept depth of 21 feet. The West Neebish channel was opened to traffic in 1908. At the present time down-bound traffic uses the West Neebish channel and up-bound traffic, the Middle Neebish route. This division of traffic facilitates shipping operations, due to the narrowing of the channels passing Neebish Island.

The most recent improvement contract was let in 1927 by the Government to the Standard Dredging Company of New York, and the Great Lakes Dredge & Dock Company of Chicago. The Standard Dredging Company contract called for the widening and deepening of the present Middle Neebish 300-foot channel to 500 feet, and a swept depth of 22 feet. There was an estimated yardage of 1,630,700 yards of rock ledge, hard-pan, sand, clay, gravel and boulders. Six hundred ninety-four thousand yards of this was ledge rock, 215,300 yards of hard-pan, 721,400 yards of sand, gravel and boulders. The quantities have over-run considerably and probably will be around a total of 2,000,000 yards.

The contract to the Great Lakes Dredge & Dock Company called for the removal of approximately 500,000 yards of hard-pan, gravel and boulders. The location of this contract is five miles further down stream from the Middle Neebish channel.

Dredging and the deepening of channels is a very important class of work, and the cost exceeds most any other kind of excavation, yet very little publicity has been given such an operation. Recent developments in methods and equipment by the two contractors operating in the St. Mary's River channel at present, particularly the Standard Dredging Company of New York, may justify a semi-detailed description of this dredging project as a subject of interest.

In general, dredging work is divided into three main operations, namely: drilling and blasting, dredging and cleaning up. A separate general discussion is made of each.

*Technical Representative. E. I. du Pont de Nemours & Co.

Drilling and Blasting Operation.

A Standard Drill boat on this project is equipped with four or five submarine piston drills. The nature of submarine drilling necessitates that these piston drills be of the reciprocating type. The drilling is always done from one side or end of the boat. If on the side, the boat is moved laterally. It is realized that in operating such a battery of drills, one drill—either because of better material or operation—will complete the drilling before the others. As a result, in order to overcome lost time, it is common practice to load and blast a hole as soon as it has been drilled. In this operation the boat is not moved nor is there any delay in the drilling by the other machines on the boat. Obviously this manner of blasting will not always produce the best, results, as the amount of explosive charge must be kept down so as not to injure the drill boat or other machines drilling.

The submarine piston type drills use solid 2½-inch drill steel with a four-inch bit. Sectional steel has not been found to be satisfactory. The ledge rock in the St. Mary's River channel is a very sharp, clear sandstone,

apparently soft, but it has been very difficult to drill because of its grindstone action on the drill bits. The constant delay due to changing steel for resharpening adds materially to the cost.

In view of this drilling problem that exists—not only here but elsewhere—the Standard Dredging Company have recently developed a new drill machine, patented under the name of the Grant Drill. A detailed description of this drill is not permitted.

It is a Mogul submarine type of piston drill. Four-inch hollow drill steel is used. The six-inch bit shank is detachable and has a hollow center core. This bit shank, originally 30 inches long, is of special steel. Peculiarly, it is not treated to obtain hardness or toughness, but rather so that it shall possess a certain degree of malleability, which, in this particular material, increases its resistance. In drilling, water under approximately 150 pounds pressure is applied through the steel. Unquestionably, this idea is an improvement over the usual method of applying water through a separate jet, as is being done in the old types of drills.

The Standard Dredging Company equip their drill boats with only one of these Grant drills, and this is placed on the end of the boat. This outfit is capable of drilling twice as many six-inch holes per shift as the older type of Drill boat carrying five machines and drilling four-inch holes.

Using this Drill boat, blasting is done only at the end of the shift. Each hole is charged at the completion of drilling, with an average load (about two pounds) of 50 per cent Gelatin per cubic yard. For loading, a submarine charger is used. This charger is a tube six or eight feet in length and four inches in outside diameter, which will allow it to slip easily into the six-inch casing that is used in drilling. With the charger placed into the hole, a plunger is used to force the cartridges out the bottom end. A water jet is used constantly in the hole while loading is going on, in order to keep it clean. The diameter and length of the charging tubes vary with the diameter and depth of the hole. The deeper a hole, the longer a tube to permit loading a heavier charge.

The charge is primed with four-foot No. 8 electric blasting caps. Two are used in each hole. To the four-foot legs is spliced a duplex No. 14 insulated iron wire that is kept on a reel to permit the boat to move over its drilling range without breaking connections. Iron wire was substituted for copper wire because of less expense, and was also found to be sufficiently effective. At the end of the shift the Drill boat is pulled to a safe distance and all the wares gathered in parallel connections and the blast fired by the dynamo on the boat.

In submarine drilling a terminology of 6 and 8, and 8 and to is used to indicate the spacing and depth to the holes. The old type of piston drill uses a 6 and 8 spacing. That is, the holes and rows are spaced six feet apart and each hole is drilled eight feet below the grade desired. The depth below grade is strictly adhered to, irrespective of the nature of the material. No chances are taken that the area blasted will not give the full required swept depth when dredged.

It is quite necessary that a drill boat be properly located at all times. This is done by shore and anchored buoy ranges. Some of these floating targets are unique in design. These ranges are laid out originally by triangulation. Frequently the boat engineer will check his position through the use of the sextant.

Dredging.

The bulk of all dredge work on this project is done by the use of dipper dredges having six- or eight-yard buckets. Depending on the material, the Standard Dredging Company have moved 10,000 yards in twenty-four hours. Up-to-date dredges represent a considerable investment in money, the Great Lakes Dredge & Dock Company using the latest type of dredge, electrically driven, and having an eight-yard bucket. It represents an investment of one million dollars. These dredges generate their own power.

By virtue of the longitudinal dimensions of the St. Mary's River channel work, the dredging operations are planned and records kept in much the same manner as on a shovel operation in an open-pit. Twenty-five feet is the width of the dipper cut, and it is made working with the current wherever possible. This facilitates handling the clumping barge that is alongside the dredge.

Full pay is accorded the contractor for everything to grade and one-half pay for two feet over depth. This fact will generally control the maximum amount of material moved. Quite often, however, digging is carried down to ten feet below the desired grade, this being necessary in sand and fine gravel where there is a tendency toward back-filling.

The clumping barges have a capacity of six hundred cubic yards and have drop bottoms. In all inland water dredging projects, the Government provides clumping waters. It is preferable to have these so located-that full advantage can be taken of the current with a load.

Clean-Up.

The clean-up operation follows the dredging of any area. Two methods are used by the Standard Dredging Company, depending upon the nature of the bottom.

Where the dredge work had been in sand and gravel, winrows are left on the bottom which vary in height and extent. To level down these winrows, a rock drag, forty feet long and weighing thirty tons, which is equipped with dipper teeth, is suspended from a tow barge so that it will rake the bottom at approximately one foot over depth, when towed. This rock drag is a development of the Standard Dredging Company, and has proved very successful in leveling off the channel floor.

In areas where there had been considerable rock work another method is used in cleaning up. For this work barges are equipped with clam shell and orange-peel

buckets for the picking up of any fragments of rock that are above grade and which the dipper dredge could not handle. Inasmuch as one boulder remaining above grade would be a serious hazard to shipping, the bottom is swept with careful detail. From the edge of the barge a railroad rail thirty feet long is suspended to a depth equal to the desired grade. With the rail in this position the barge is moved laterally. In addition, a diver is employed, who sits on the submerged rail and signals the crew above the moment the rail strikes an object which would indicate that the object would be above grade. Upon a signal from the diver, the orange-peel or clam shell is lowered and by a system of signals the diver directs the loading from his position on the channel floor. Due to the fact that the diver depends upon daylight to see, this clean-up operation cannot be carried on after dark. Rock fragments as large as twenty tons are handled in this manner.

The Standard Dredging Company have tried bulldozing these boulders under water, but such practice consumed more time than the present method employed.

COSTS.

The cost of submarine rock excavation for inland waters will range from $2.75 to $10.00 per yard, depending upon the headwater and the nature and depth of the material to be moved. Inasmuch as no chances are taken in blasting, regardless of whether the material is hardpan or rock, the explosives cost is much higher than similar work in a land operation. The two contractors on the St. Mary's project use a standard explosive charge, regardless of the material, for holes of the same depth.

THE ANNUAL PRODUCTION OF COPPER AND THE AVERAGE YEARLY PRICE OF COPPER.

BY EDWARD KOEPEL, FREDA, MICH.*

After reviewing the statistics which had become available on the subject of the copper production of the world, the writer conceived the idea that a graph of the copper industry, showing the production of copper from year to year, the market price for the metal, the tonnage of exports and imports of the metal, and other related data, would be not only interesting, but helpful and instructive as well.

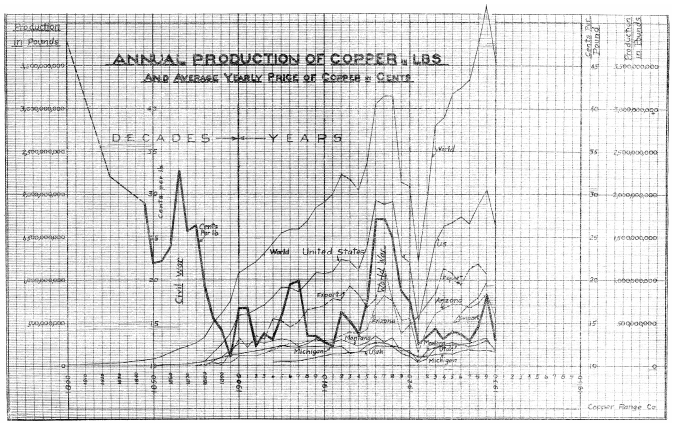
The accompanying graph of the annual production of copper. and the average yearly price of copper, covering a period of one hundred thirty years, was prepared in the office of the Copper Range Company, Stamp Mill Branch, at Freda, Michigan.

Much of the early data obtained on the subject was expressed in various units of weight and value, namely, in metric tons, in long tons, in short tons, in pounds sterling per long ton and also in cents per pound. To plot these data, the figures relating to the production of copper were converted to pounds in weight, and the figures relating to the price of the metal were converted to cents per pound in value.

To facilitate publication, the graph was shortened by plotting the fifty years from 1800 to 1850 in ten year periods. The years from 1850 to 1900 were plotted in five year periods. This flattened out the average yearly price per pound of copper during the fifty years between 1850 and 1900. During the Civil War the price of copper reached 55 cents per pound and the average price for the year 1864 was 47 cents per pound. In 1894 the average price of copper was nine and one-half cents per pound.

From a study of the graph, it will be observed that there has been a constantly expanding ratio of production for the last one hundred and thirty years. For the last one hundred years, the advance in the rate of production has been equivalent to an increase of 100 per cent every eighteen years. It will also be observed that the United States of America has contributed a tonnage equal to nearly one-half the total world's production of copper.

*Mill Superintendent, Champion Copper Co.



Until the year 1880, the Lake Superior district in Michigan was the most important source of production in the United States. In 1887, the production of copper in the State of Montana exceeded that of Michigan. In 1907, the State of Arizona surpassed Montana and became the largest producer of copper in the United States. It has held that position up to the present time, supplying nearly 50 per cent of the copper produced in the United States.

For the year 1929, the graph also shows that the quantity of copper imported into the United States from other countries was about one hundred million pounds less than the quantity of copper exported, a fact which indicates that the total of two billion fifty-two million six hundred ninety-six thousand pounds of copper produced in the United States in that year was all consumed at home except the one hundred million pounds by which the exports exceeded the imports, with the further exception, however, that owing to a decline in the demand for copper during the year 1929 the surplus of metal on hand was, no doubt, materially increased.

The copper production of the world, of the United States, and of the States of Arizona, Michigan, Montana, and

Utah, is plotted in hue lines. Exports and imports of copper by the United States are also plotted in fine lines. The average yearly price of copper in cents per pound is plotted with a heavy line.

DISCUSSION OF MR. HOLMAN I. PEARL'S PAPER.

BY W. O. HOTCHKISS, HOUGHTON, MICH.*

(See Page 85)

I have read Mr. Pearl's paper with much interest. It presents with a most pleasing clarity one of the very useful and economical methods of getting information about the geology of rocks which are obscured by a cover of glacial drift or other material, as are most of the rocks of the Lake Superior district.

The familiar fact that the magnetic needle is attracted by magnetite has resulted in a certain amount of misunderstanding of the cause of the variation of dip needle readings over different geological formations. The most common conception is that deflections of the needle are due to magnetite in the rocks. This may or may not be true.

We may consider the rocks as conductors of magnetic force, just as wires conduct electricity. If we connect two electrodes by parallel wires of iron and copper with equal cross sections, and pass a current, we know that more of the current will go through the copper wire than through the iron wire.

An analogous condition exists in the rocks. Certain rocks "conduct" magnetic force more readily than others. If the rock is solid magnetite it "conducts" very readily. If it is quartzite it "conducts" very poorly. If it is marble it "conducts" also very poorly compared to magnetite, *but in different degree from the quartzite*. Thus different rocks which contain no magnetite may have differing magnetic permeabilities, and affect the magnetic needle differently.

In an otherwise uniform magnetic field, as that of the earth, the kind of rock influences the "amount of magnetic force conducted" and more magnetic force goes through a good conductor than through an equal area of a poor conductor. The analogy of the iron and copper wires and the electric current is a very good one.

Consequently it is not necessary to have magnetite in a rock to be able to follow it with refined magnetic observations. As a matter of fact, a bed of rock with a very low permeability occurring in a series of beds of much higher permeability may be just as useful to the geologist working out the structure—just as easily followed with the dip needle—as would a bed of high permeability in a series of beds exhibiting low permeability.

It needs to be emphasized that magnetic observations are oftentimes of great utility to the geologist in areas where the rocks contain little or no magnetite. While the degree of variation is less in such areas, variation is usually present and can be detected by more refined observations than the ordinary clip needle will permit. So if we think of such observations as measuring *magnetic permeability* we will escape the too common erroneous impression that magnetic variations are due entirely to the differing magnetite content of the rocks.

*President Michigan College of Mining and Technology.

ESTIMATED IRON ORE OUTPUT IN THE UNITED STATES FOR 1930.

(By the Bureau of Mines, Department of Commerce)

The iron ore mined in the United States in 1930, exclusive of ore that contained 5 per cent or more of manganese in the natural state, is estimated by the United States Bureau of Mines, Department of Commerce, at 58,359,000 gross tons, a decrease of 20 per cent as compared with that mined in 1929. The ore shipped from the mines in 1930 is estimated at 55,094,000 gross tons, valued at $145,888,000, a decrease of 27 per cent in quantity and of 26 per cent in total value as compared with the figures for 1929. The average value of the ore per gross ton at the mines in 1930 is estimated at $2.65; in 1929 it was $2.61. The stocks of iron ore at the mines, mainly in Michigan and Minnesota, apparently increased from 7,067,206 gross tons in 1929 to 10,430,000 tons in 1930, or 48 per cent.

The Bureau of Mines estimates are based on preliminary figures furnished by producers who in 1929 mined about 99 per cent of the total iron ore. They show the totals for the principal iron-ore producing states, and, by grouping together certain states, the totals for the Lake Superior district and for groups of southeastern, northeastern and western states.

LAKE SUPERIOR DISTRICT

About 84 per cent of the iron ore shipped in 1930 came from the Lake Superior district, in which approximately 49,378,000 gross tons was mined and 46,411,000 tons was shipped, decreases of 21 and 29 per cent, respectively, as compared with the quantities mined and shipped in 1929. The ore shipped in 1930 was valued at the mines at $126,026,000, a decrease of 28 per cent. These totals include the ore from mines in Southern Wisconsin and ore shipped by rail as well as by water from all mines, but exclude manganiferous ores amounting to approximately 801,500 gross tons in 1930 and 1,058,953 tons in 1929 that contained 5 per cent or more of manganese in the natural state. The former ore is chiefly hematite. The stocks of iron ore in this district apparently increased from 6,108,499 gross tons in 1929 to 9,175,000 tons in 1930, or 50 per cent. The shipments of iron ore by water from the Lake Superior district in 1930 (including manganiferous iron ores), according to the Lake Superior Iron Ore Association, amounted to 46,582,982 gross tons, a decrease of 29 per cent as compared with these shipments in 1929. The average value of the ore at the mines in the Lake Superior district in 1930 was $2.72 a ton; in 1929 it was $2.68.

SOUTHEASTERN STATES

The Southeastern States, in which the Birmingham district is the largest iron-ore producing area, mined approximately 5,937,000 gross tons of iron ore in 1930, a decrease of 13 per cent as compared with 1929. The shipments of iron ore from mines in these states in 1930 amounted to 5,851,000 gross

tons, valued at $11,349,000, decreases of 16 and 17 per cent, respectively, in quantity and value as compared with 1929. The ore is mainly hematite; brown ore and magnetite come next in order. The average value of the ore produced in these states in 1930 per gross ton was $1.94; in 1929 it was $1.96. The stocks of iron ore at the mines in this group of states, mainly in the Birmingham district. increased from 827,486 gross tons in 1929 to 914,000 gross tons in 1930.

NORTHEASTERN STATES

The Northeastern States, which include the Adirondack district, New York, and the Cornwall district, Pennsylvania, in 1930 mined 2,245,000 gross tons of iron ore, an increase of 2 per cent. The iron ore shipped from mines in these states amounted to 2,033,000 tons, valued at $7,345,000, decreases of 12 and 2 per cent, respectively, in quantity and value as compared with 1929. The stocks of iron ore in this group of states increased from 119,056 gross tons in 1929 to 328,000 tons in 1930. The average value of the ore in these states in 1930 per gross ton was $3.61; in 1929 it was $3.24. Most of this ore is magnetite?

WESTERN STATES

The Western States that ordinarily produce iron ore, named in order of their importance, are Wyoming, Utah, New Mexico, Colorado and Washington. Occasionally Arizona, California, Idaho, Montana and Nevada contribute small quantities. In 1930 the Western, States mined and shipped approximately 799,000 gross tons of iron ore, valued at $1,168,000, a decrease of 33 per cent in the quantities mined and shipped and of 31 per cent in value of shipments as compared with 1929. The ore comprises hematite, magnetite, and brown ore.

IMPORTS AND EXPORTS

The imports of iron ore reported for the eleven months ended November 30, 1930, amounted to 2,599,204 gross tons, valued at $7,676,638, or $2.95 a ton. The imports for the year 1929 were 3,139,334 gross tons, valued at $8,145,354, or $2.59 a ton. The reported exports of iron ore for the eleven months ended November 30, 1930, amounted to 752,082 gross tons, valued at $2,733,423, or $3.63 a ton, as compared with exports for the entire year 1929 of 1,304,417 tons, valued at $4,774,842, or $3.66 a ton. These statistics of imports and exports were compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

The following table shows the quantity and value of the iron ore mined and shipped in the United States by the principal producing states. The figures for 1929 are final, but those for 1930 are subject to revision:

ESTIMATES OF IRON ORE MINED AND SHIPPED IN THE UNITED STATES IN 1930 AND ACTUAL OUTPUT IN 1929.

(By the Bureau of Mines, Department of Commerce)

District	Ore mined (gross tons)		Ore Shipped			
			1929		1930	
Lake Superior—	1929	1930	Gross tons	Value	Gross tons	Value
Michigan	15,456,397	13,668,000	16,838,568	$ 47,597,976	11,262,000	$ 32,248,000
Minnesota	45,760,858	34,385,000	46,470,243	121,776,312	24,000,000	90,598,000
Wisconsin	1,608,571	1,325,000	1,789,721	4,848,978	1,149,000	3,180,000
	62,825,826	49,378,000	65,098,532	$174,223,266	46,411,000	$126,026,000
Southeastern States—						
Alabama	6,453,075	5,710,000	6,637,299	$ 12,575,113	5,607,000	$ 10,586,000
Georgia	59,316	53,000	59,316	175,145	53,000	149,000
Missouri	168,934	127,000	171,456	661,055	127,000	482,000
North Carolina	30,655	.....	30,575	106,411	.....	.....
Tennessee	102,171	28,000	101,796	234,827	28,000	75,000
Virginia	.....	19,000	232	631	36,000	57,000
	6,814,171	5,937,000	7,000,674	$ 13,753,182	5,851,000	$ 11,349,000
Northeastern States—						
New Jersey	281,327	390,000	285,115	$ 1,157,848	387,000	$ 1,686,000
New York	822,261	890,000	875,564	3,941,985	752,000	3,647,000
Pennsylvania	1,092,013	965,000	1,151,130	2,382,839	894,000	2,012,000
	2,195,601	2,245,000	2,311,809	$ 7,482,672	2,033,000	$ 7,345,000
Western states	1,192,122	799,000	1,191,719	1,689,520	799,000	1,168,000
Grand total	73,027,720	58,359,000	75,602,734	$197,148,640	55,094,000	$145,888,000

COMPARATIVE STATEMENT OF IRON ORE SHIPMENTS FROM UPPER LAKE PORTS TO CLOSE OF SEASON 1929 AND 1930.

(Extract from Report of Lake Superior Iron Ore Association—By Permission)

Port and Dock—	Season 1929	P. C. of Total	Season 1930	P. C. of Total
Escanaba—C. & N. W.	4,445,775	6.82	2,923,131	6.28
Escanaba—C. M. & St. P.	1,902,798	2.92	1,173,682	2.52
Marquette—D., S. S. & A.	875,843	1.34	550,684	1.18
Marquette—L. S. & I.	3,572,545	5.48	2,410,986	5.17
Ashland—C. & N. W.	5,358,139	8.22	3,660,562	7.86
Ashland—Soo Line	2,261,921	3.47	1,400,812	3.01
Superior—Great Northern	17,355,736	26.62	12,450,361	26.73
Superior—Soo Line	1,373,871	2.10	1,013,623	2.17
Superior—Northern Pacific	893,532	1.37	689,569	1.48
Duluth—D. M. & N.	20,562,705	31.54	14,001,327	30.06
Two Harbors—D. & I. R.	6,601,735	10.12	6,308,245	13.54
Total	65,204,600	100.00	46,582,982	100.00
1930 decrease	.....	.....	18,621,618	28.56

Season—		Season—	
1921	22,300,726	1926	58,537,855
1922	42,613,229	1927	51,107,136
1923	59,036,705	1928	53,980,874
1924	42,623,572	1929	65,204,600
1925	54,081,298	1930	46,582,982

TONNAGE OF LAKE SUPERIOR IRON ORES ON HAND AT FURNACES AND LAKE ERIE DOCKS JANUARY 1ST, 1930 AND 1931.

	Central District Furnaces	Eastern Furnaces	Lake Front Furnaces (a)	All-Rail Furnaces	Total
Ore on hand at furnaces January 1st, 1931	15,660,324	510,556	15,956,988	490,298	32,618,166
Ore on hand at furnaces January 1st, 1930	14,684,883	795,909	15,368,092	654,423	31,503,307
Ore on Lake Erie docks January 1st, 1931	6,294,302	36,207	.....	.....	6,330,509
Ore on Lake Erie docks January 1st, 1930	6,022,317	120,247	.....	.....	6,142,564
Total ore on hand at furnaces and Lake Erie docks January 1st, 1931	21,954,626	546,763	15,956,988	490,298	38,948,675
Total ore on hand at furnaces and Lake Erie docks January 1st, 1930	20,707,200	916,156	15,368,092	654,423	37,645,871
Total number of furnaces represented above, 1931	121	29	90	11	251
Total number of furnaces represented above, 1930	127	31	90	11	259
Number in blast on last day of December, 1931	36	8	34	6	84
Number in blast on last day of December, 1930	64	15	53	7	139
Decrease December 31st, 1931	28	7	19	1	55

(a) Including Canadian Furnaces.

BALANCE OF IRON ORE ON DOCK AT LAKE ERIE PORTS APRIL 1, 1930—RECEIPTS FOR THE SEASON—BALANCE ON DOCK JANUARY 1ST, 1930 AND 1931.

	Dock Balance April 1st, 1930.	Receipts for Season, 1930.	Dock Balance Jan. 1st, 1930.	Dock Balance Jan. 1st, 1931.
Buffalo, North Tonawanda, Port Colborne	16,377	2,898,965	32,817	3,644
Erie	120,396	1,063,813	121,810	66,943
Conneaut	1,569,503	7,651,381	1,871,955	1,946,397
Ashtabula	1,490,726	5,718,879	2,062,972	2,238,737
Fairport	346,113	1,923,509	400,107	455,431
Cleveland	1,032,415	7,374,894	1,123,802	1,102,998
Lorain	119,336	2,532,098	120,157	165,664
Huron	357,561	883,114	364,959	321,796
Toledo	39,837	1,733,191	43,985	28,899
Total	5,092,264	31,779,844	6,142,564	6,330,509

TONNAGE OF LAKE SUPERIOR IRON ORES CONSUMED, 1929 AND 1930.

	Central District Furnaces.	Eastern Furnaces.	Lake Front Furnaces.	All-Rail Furnaces.	Total
Total ore consumed, year 1930	22,463,423	796,524	20,937,960	994,273	45,192,180
Total ore consumed, year 1929	32,144,132	1,381,230	28,547,183	1,573,053	63,645,598

BENEFICIATED ORE—SEASON 1930.

Method of Beneficiation—	Minnesota	Michigan & Wisconsin	Total
Washing	4,947,841		4,947,841
Jigging	923,810		923,810
Drying	126,003		126,003
Sintering	320,939		320,939
Total concentrated	6,318,593		6,318,593
*Crushing and screening	7,572,876	4,464,964	12,037,840
Total beneficiated	13,891,469	4,464,964	18,356,433

*Improves physical structure only.

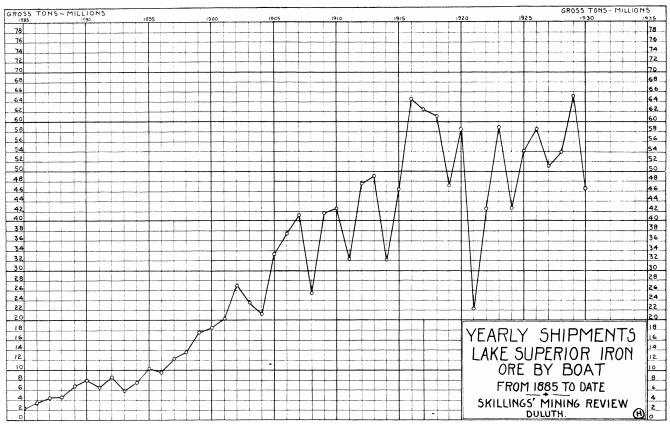
WORLD'S COPPER PRODUCTION.

The following table gives in short tons world output for the various countries as determined by the American Bureau of Metal Statistics. In the table the output is ascribed to place of smelting and no attempt has been made to trace the ore to point of origin:

	Year 1930		
United States	820,000	Tons***	
Mexico	58,535	"	
Canada	113,004	"	
Chile and Peru	280,554	"	
Japan	87,924	"	
Australia	14,658	"	
Germany	65,060	"	
*Other Europe	152,900	"	****
**Elsewhere	177,000	"	****
World's total for 1930	1,769,635	"	***
World's total for 1929	2,136,405	"	
World's total for 1928	1,916,471	"	

*Partly estimated. Includes production of blister copper in countries other than Germany, whereof Spain, Russia, Jugoslavia and Great Britain are the more important.
**Partly estimated, except as to December.
***Revised totals, secondary excluded.
****Revised totals.

[Iron Ore Shipments by Water, 1885 to 1930 (Chart)]



The Lake Superior iron ore shipments by boat to lower lake ports for 1930 are 46,582,982 gross tons compared with tonnage of 65,204,600 shipped during 1929. This shows a decrease for 1930 of 18,621,618 tons or 28.56 per cent. The grand total tonnage shipped from the Lake Superior district from 1850 to December 31, 1930 (taken from Lake Superior Iron Ore Association report) is 1,514,241,283 gross tons. This includes 3,022,898 tons from the Mayville and Baraboo, Wisconsin, districts.

[Summary of Facts of Michigan Iron Ore Production, Costs, Valuations and Reserves, by Department of Conservation, Michigan Geological Survey]

TABLE I.

SUMMARY OF FACTS OF MICHIGAN IRON ORE PRODUCTION.

Underground and Open Pit Mines.

(Department of Conservation—Michigan Geological Survey)

	1925	1926	1927	1928	1929
Tons of ore mined	14,504,495	15,246,932	15,129,164	13,699,017	15,227,331
Tons of ore shipped	15,065,130	16,810,160	14,518,480	14,332,872	16,880,448
State and local taxes paid by active mines	$3,601,962.47	$3,679,316.00	$3,882,061.58	$3,444,425.48	$3,436,658.17
State and local taxes per ton mined	$0.2483	$0.2413	$0.2566	$0.2405	$0.2260
Average number of days worked	269	278	268	247	284
Average number of men employed	11,953	11,302	10,421	9,266	8,996
Average daily wage	$4.80	$4.856	$4.828	$4.704	$4.915
Average yearly earning	$1,291.20	$1,350.22	$1,293.95	$1,161.80	$1,395.77
Tons per man per day		4.85	5.05	5.26	5.84

*Tables 1 to 12 on iron ore and copper production were compiled by F. G. Pardee, mine appraiser, and W. Osgood, Geologist and are printed by permission.

TABLE II.

DICKINSON COUNTY.

(Department of Conservation—Michigan Geological Survey)

Average Per Ton Costs—Underground Mines.

ITEMS—	1928		1929		5-Year Average	
Cost of Mining—						
Labor	1.4836		1.3912		1.5447	
Supplies	.4111		.4198		.4290	
Total	1.8947	1.8947	1.8110	1.8110	1.9737	1.9737
Deferred mining cost		.0145		.0289		.0105
Taxes—						
General property	.2199		.2088		.2259	
State corporation	.0025		.0021		.0035	
Federal corporation	.0000		.0000		.0000	
Total	.2224	.2224	.2109	.2109	.2294	.2294
General Overhead—						
General office	.0346		.0268		.0334	
General superintendence	.0252		.0235		.0255	
Fire insurance	.0032		.0025		.0024	
Contingent	.0086		.0077		.0082	
Depreciation	.0957		.0839		.0868	
Total	.1673	.1673	.1444	.1444	.1553	.1553
Transportation—						
Rail freight	.8217		.8222		.8217	
Boat freight	.6320		.6249		.6181	
Cargo insurance	.0016		.0012		.0011	
Total	1.4553	1.4553	1.4483	1.4483	1.4409	1.4409
Marketing—						
Selling and operator's commission	.0411		.0437		.0376	
Analysis	.0028		.0032		.0030	
Total	.0439	.0439	.0469	.0469	.0406	.0406
Total ore cost		3.7981		3.6904		3.8504
Lake Erie value per ton		4.3354		4.5613		4.2751
Gross ore profit*		.5373		.8709		.4247
Other Ore Costs—						
Royalty	.3054		.3038		.2708	
Interest on borrowed money	.0363		.0313		.0341	

*This figure does not represent true profit, as much ore is sold at a discount.

TABLE III.

GOGEBIC COUNTY.

(Department of Conservation—Michigan Geological Survey)

Average Per Ton Costs—Underground Mines.

ITEMS—	1928		1929		5-Year Average	
Cost of Mining—						
Labor	1.0868		.9687		1.1240	
Supplies	.5251		.5296		.5166	
Total	1.6119	1.6119	1.4983	1.4983	1.6406	1.6406
Deferred mining cost		.1274		.1192		.1153
Taxes—						
General property	.3264		.2879		.3005	
State corporation	.0049		.0036		.0049	
Federal corporation	.0000		.0000		.0002	
Total	.3313	.3313	.2915	.2915	.3056	.3056
General Overhead—						
General office	.0255		.0314		.0317	
General superintendence	.0223		.0202		.0221	
Fire insurance	.0050		.0038		.0040	
Contingent	.0100		.0087		.0094	
Depreciation	.1808		.1312		.1538	
Total	.2436	.2436	.1953	.1953	.2210	.2210

Transportation—						
Rail freight	.8229		.8204		.8216	
Boat freight	.8350		.8356		.8382	
Cargo insurance	.0016		.0017		.0016	
Total	1.6595	1.6595	1.6577	1.6577	1.6614	1.6614
Marketing—						
Selling and operator's commission	.0270		.0238		.0240	
Analysis	.0032		.0038		.0039	
Total	.0302	.0302	.0276	.0276	.0279	.0279
Total ore cost		4.9039		3.7896		3.9718
Lake Erie value per ton		4.5872		4.6006		4.6149
Gross ore profit*		.5833		.8110		.6431
Other Ore Costs—						
Royalty	.3606		.3583		.3592	
Interest on borrowed money	.0827		.0785		.0713	

*This figure does not represent true profit, as much ore is sold at a discount.

TABLE IV.

IRON COUNTY.

(Department of Conservation—Michigan Geological Survey)

Average Per Ton Costs—Underground Mines.

ITEMS—	1928		1929		5-Year Average	
Cost of Mining—						
Labor	.7768		.7784		.8154	
Supplies	.4683		.4631		.4850	
Total	1.2451	1.2451	1.2451	1.2451	1.3004	1.3004
Deferred mining cost		.1169		.0746		.0962
Taxes—						
General property	.1854		.1693		.1732	
State corporation	.0031		.0058		.0053	
Federal corporation	.0000		.0000		.0007	
Total	.1885	.1885	.1751	.1751	.1792	.1792
General Overhead—						
General office	.0602		.0565		.0540	
General superintendence	.0366		.0348		.0336	
Fire insurance	.0032		.0030		.0038	
Contingent	.0088		.0061		.0056	
Depreciation	.1216		.1023		.1067	
Total	.2304	.2304	.2027	.2027	.2037	.2037
Transportation—						
Rail freight	.8216		.8214		.8208	
Boat freight	.6430		.6344		.6403	
Cargo insurance	.0021		.0017		.0018	
Total	1.4667	1.4667	1.4575	1.4575	1.4629	1.4629
Marketing—						
Selling and operator's commission	.0667		.0688		.0706	
Analysis	.0049		.0080		.0060	
Total	.0716	.0716	.0768	.0768	.0766	.0766
Total ore cost		3.3192		3.2282		3.3190
Lake Erie value per ton		4.0336		4.3000		4.1097
Gross ore profit*		.7144		1.0718		.7907
Other Ore Costs—						
Royalty	.3049		.3123		.3083	
Interest on borrowed money	.0210		.0185		.0285	

*This figure does not represent true profit, as much ore is sold at a discount.

TABLE V.

MARQUETTE RANGE.

(Department of Conservation—Michigan Geological Survey)

Average Per Ton Costs—Underground Mines.

ITEMS—	1928		1929		5-Year Average	
Cost of Mining—						
Labor	1.0728		.9785		1.1284	
Supplies	.6588		.6339		.6292	
Total	1.7316	1.7316	1.6124	1.6124	1.7576	1.7576
Deferred mining cost		.0827		.0927		.0738
Taxes—						
General property	.2584		.2313		.2720	
State corporation	.0223		.0188		.0213	
Federal corporation	.0006		.0000		.0055	
Total	.2813	.2813	.2501	.2501	.2988	.2988
General Overhead—						
General office	.0839		.0964		.0706	
General superintendence	.0840		.0721		.0818	
Fire insurance	.0020		.0010		.0022	
Contingent	.0196		.0035		.0048	
Depreciation	.0932		.1006		.0874	
Total	.2827	.2827	.2736	.2736	.2468	.2468
Transportation—						
Rail freight	.6798		.6600		.6704	
Boat freight	.7188		.7288		.7229	
Cargo insurance	.0028		.0023		.0026	
Total	1.4014	1.4014	1.3911	1.3911	1.3959	1.3959
Marketing—						
Selling and operator's commission	.0846		.0896		.0840	
Analysis	.0080		.0056		.0069	
Total	.0926	.0926	.0952	.0952	.0909	.0909
Total ore cost		3.8723		3.7151		3.8638
Lake Erie value per ton		4.5685		4.8394		4.6478
Gross ore profit*		.6962		1.1243		.7840
Other Ore Costs—						
Royalty	.1396		.1537		.1534	
Interest on borrowed money	.0121		.0132		.0298	

*This figure does not represent true profit, as much ore is sold at a discount.

TABLE VI.

SILICEOUS OPEN PITS.

(Department of Conservation—Michigan Geological Survey)

Average Per Ton Costs.

ITEMS—	1928		1929		5-Year Average	
Cost of Mining—						
Labor	.1659		.1682		.1896	
Supplies	.2664		.2321		.2688	
Total	.4323	.4323	.4003	.4003	.4584	.4584
Deferred mining cost		.0629		.0334		.0443
Taxes—						
General property	.0525		.0377		.0365	
State corporation	.0078		.0041		.0101	
Federal corporation	.0000		.0000		.0021	
Total	.0603	.0603	.0418	.0418	.0487	.0487
General Overhead—						
General office	.0339		.0226		.0316	
General superintendence	.0321		.0179		.0262	
Fire insurance	.0037		.0008		.0015	
Contingent	.0021		.0002		.0001	
Depreciation	.0981		.1130		.0978	
Total	.1699	.1699	.1545	.1545	.1572	.1572
Transportation—						
Rail freight	.6694		.6518		.6971	
Boat freight	.7364		.7413		.7475	
Cargo insurance	.0026		.0009		.0019	
Total	1.4084	1.4084	1.3940	1.3940	1.4465	1.4465
Marketing—						
Selling and operator's commission	.0819		.0890		.0855	
Analysis	.0061		.0094		.0133	
Total	.0880	.0880	.0984	.0984	.0988	.0988
Total ore cost		2.2218		2.1224		2.2539
Lake Erie value per ton		2.2094		2.2894		2.3076
Gross ore profit*		-.0124		.1625		.0537
Other Ore Costs—						
Royalty	.1234		.0834		.1003	
Interest on borrowed money	.0031		.0017		.0121	

*This figure does not represent true profit, as much ore is sold at a discount.

TABLE VII.

STATE.

(Department of Conservation—Michigan Geological Survey)

Average Per Ton Costs—Underground Mines.

ITEMS—	1928		1929		5-Year Average	
Cost of Mining—						
Labor	1.0237		.9521		1.0662	
Supplies	.5291		.5240		.5237	
Total	1.5528	1.5528	1.4761	1.4761	1.5899	1.5899
Deferred mining cost		.1014		.0898		.0898
Taxes—						
General property	.2533		.2287		.2462	
State corporation	.0085		.0079		.0096	
Federal corporation	.0000		.0000		.0015	
Total	.2618	.2618	.2366	.2366	.2563	.2563
General Overhead—						
General office	.0522		.0551		.0478	
General superintendence	.0427		.0381		.0397	
Fire insurance	.0034		.0027		.0034	
Contingent	.0119		.0065		.0070	
Depreciation	.1312		.1099		.1173	
Total	.2414	.2414	.2123	.2123	.2152	.2152

Transportation—						
Rail freight	.7871		.7687		.7842	
Boat freight	.7320		.7440		.7448	
Cargo insurance	.0020		.0019		.0018	
Total	1.5211	1.5211	1.5146	1.5146	1.5308	1.5308
Marketing—						
Selling and operator's commission	.0559		.0585		.0544	
Analysis	.0048		.0055		.0051	
Total	.0607	.0607	.0640	.0640	.0595	.0595
Total ore cost		3.7392		3.5934		3.7415
Lake Erie Value per ton		4.3959		4.5838		4.4381
Gross ore profit*		.6567		.9904		.6966
Other Ore Costs—						
Royalty	.2779		.2778		.2838	
Interest on borrowed money	.0405		.0387		.0446	

*This figure does not represent true profit, as much ore is sold at a discount.

TABLE VIII.

STATE TOTALS.

(Department of Conservation—Michigan Geological Survey)

Iron Mine Valuations and Reserves.

	—1929—		—1930—	
	Tonnage	Total Value	Tonnage	Total Value
Dickinson county	4,886,465	$ 3,520,000	4,087,207	$ 3,330,000
Gogebic county	48,587,126	37,171,000	51,347,176	36,893,000
Iron county	58,035,954	20,835,000	57,260,057	21,162,000
Marquette range	57,920,862	28,232,000	55,655,383	28,523,000
Total	169,430,407	$89,758,000	168,349,823	$89,908,000

[Michigan Copper Production, Costs and General Facts Pertaining to Copper Mining Industry for 1929, Department of Conservation, Michigan Geological Survey]

TABLE IX.

MICHIGAN COPPER PRODUCTION IN 1929.

(Department of Conservation—Michigan Geological Survey)

	Pounds
Calumet & Hecla Consolidated Copper Company—	
Conglomerate mine	35,377,000
Osceola amygdaloid	18,237,000
Kearsarge amygdaloid	36,705,000
Calumet reclamation	25,991,000
Tamarack reclamation	7,520,000
Copper Range Company—	
Champion mine	20,660,701
Baltic mine	2,127,926
Trimountain mine	1,408,689
Isle Royale Copper company	10,864,085
Mohawk Mining company	20,043,265
Quincy Mining company	4,459,426
Seneca Copper company	2,999,882
Total	186,393,974

TABLE X.

GENERAL FACTS PERTAINING TO COPPER MINING INDUSTRY FOR 1929.

(Department of Conservation—Michigan Geological Survey)

Tons of Copper Rock Treated—	
Mines only	5,151,553
Mines and reclamations	7,595,553
Pounds of copper produced	186,393,974
Pounds of Copper produced per ton of rock treated—	
Mines only	29.677
Mines and reclamations	24.539
Average price received for sale of copper (cents)	17.8511
Gross value of copper produced	$30,222,947.27
Number of days worked	310
Tons per man underground per day	3.89
Tons per man per days surface and underground (this includes reclamations)	3.07
Average number of men employed	9,117

TABLE XI.

AVERAGE COST PER POUND OF MICHIGAN COPPER PRODUCTION FOR 1929.

(Department of Conservation—Michigan Geological Survey)

	Cost in Cents Per Pound Mines Only	
General Expense—		
General property tax	.4430	
State corporation tax	.0534	
Depreciation	1.4167	
General office	.1287	
Other general expense	.5328	
Total	2.5746	2.5746
Mining Cost—		
Labor	5.3984	
Supplies	2.8191	
Total	8.2175	8.2175
Treatment Cost—		
Transportation (rock to mill)	.4194	
Concentrating	1.2778	
Transportation to smelter	.0427	
Smelting and refining	.7376	
Total	2.4775	2.4775
Selling and delivery expense		.4240
Total gross cost		13.6936
Average price of copper		17.8511
Average profit		4.1575
Other Costs—		
Construction and installation of equipment	.5795	
Income tax	.3705	

TABLE XII.

AVERAGE COST PER POUND OF MICHIGAN COPPER PRODUCTION FOR 1925-1929 INCLUSIVE.

(Department of Conservation—Michigan Geological Survey)

	Cost in Cents Per Pound Mines Only	
General Expense—		
General property tax	.4838	
State corporation tax	.0531	
Depreciation	1.3479	
General office	.1250	
Other general expense	.4984	
Total	2.5082	2.5082
Mining Cost—		
Labor	4.8035	
Supplies	2.5514	
Total	7.3549	7.3549
Treatment Cost—		
Transportation (rock to mill)	.4290	
Concentration	1.1905	
Transportation to smelter	.0459	
Smelting and refining	.7571	
Total	2.4225	2.4225
Selling and delivering expense		.4285
Total gross cost		12.7141
Average price of copper		14.8655
Average profit		2.1514
Other Costs—		
Construction and installation of equipment	.5392	
Income tax	.2017	

BIOGRAPHICAL

FRANK PHILIP BOTSFORD

Frank Philip Botsford, who was for a number of years assistant manager in Minnesota for Pickands, Mather & Co., died July 4, 1930, at his home in Hibbing, Minn.

Mr. Botsford was born in L'Anse, Michigan, in 1878, the family moving to Hancock a few years later. He attended school in the latter city and later entered the Michigan College of Mining and Technology, from which institution he was graduated in 1900.

He started upon his mining career at the Arcadian mine, in the Michigan copper district, and in 1901 went to the Mesabi range to work as mining engineer for Pickands, Mather & Co. He worked at the Elba and Corsica mines, at the eastern end of the range. He advanced steadily and it was not long before he was serving as superintendent of the Syracuse-Bangor mine. He was promoted to assistant general superintendent for the company for the eastern district of the Mesabi and later held the title of general superintendent of the mines of the western Mesabi district. In 1928 he became assistant general manager in Minnesota.

Mr. Botsford was well and favorably known throughout the Lake Superior region as a highly efficient mine operator and organizer. He held membership in the Institute and numerous other organizations.

He left a wife and three daughters. Burial took place in Houghton.

E. LESLIE LAING

E. Leslie Laing was born in Gladstone, Michigan, May 27, 1889, and gained his early education in that city. He enrolled at the Michigan College of Mining & Technology and spent two years in study there. He went to Iron River and worked for the Monroe Mining Company. He returned to the Houghton school a short time later and received a degree in mining engineering in 1911.

In the same year he returned to Iron River and became associated with O. R. Hamilton, consulting engineer, and, when Mr. Hamilton entered the employ of the Oliver Iron Mining Company, Mr. Laing took over the office. He was engaged by numerous mining organizations and individuals to carry on engineering and geological work in the Iron River field. He was well acquainted with the mining properties and the possibilities for development. Just a year previous to his death he conducted a survey for gold and silver in Ontario, Canada, and he also made examinations of mineral holdings in other fields.

Mr. Laing was president of the First National Bank, Iron River, and president of the Commercial Club, Stambaugh. He held membership in the Lake Superior Mining Institute, the American Institute of Mining & Metallurgical Engineers and several branches of the Masonic order.

He died in a hospital in Chicago, where he was stricken while en route to Hot Springs, Ark., where he planned to spend a month's vacation. This was on March 3, 1930. Surviving were his wife, two sons and a daughter.

ALFRED MARTIN

Alfred Martin was born in Cornwall, England, in 1870 and there he engaged in mining at an early age. He came to the United States in 1888, coming directly to the Lake Superior district, where his uncle, the late Richard Boden, was located.

His first work here was at the old Brotherton mine, at Wakefield, and here he remained for two years, and then moved to the Sunday Lake mine, an adjoining property, taking a position as shift boss under the late Captain James Trezona. A year later he was promoted to the position of mining captain. In 1893 he was attracted to the Mesabi range, then being developed. The following year he started work at the Franklin mine, at Virginia, and remained for seven years. When the mine was taken over by the M. A. Hanna Company he was placed in charge.

When the same company decided to develop the Carpenter mine, on the Menominee range, in 1912, Captain Martin was transferred there. He lived in Crystal Falls until his death, November 9, 1929.

WILLIAM A. McGONAGLE

William A. McGonagle, for many years president of the Duluth, Missabe & Northern Railway, was born in Conshohoken, Pa., March 28, 1861, the son of a merchant. After completing his studies in the elementary schools of that place he entered the University of Pennsylvania. In 1881 he received the degree of Bachelor of Science in Civil Engineering.

He began his professional career in July of the same year when he entered the employ of the Northern Pacific Railway at Brainerd, Minn., as a draftsman. A short time later he was promoted to transit man on the location of the Little Falls & Dakota Railway, a branch of the Northern Pacific. He remained there until 1882, finishing as resident engineer in charge of construction.

He left the Northern Pacific to become associated with the engineering force of the Duluth & Iron Range Railway and worked on location between Tower and Two Harbors. His next important position was as assistant engineer in charge of building ore docks and terminal yards at Two Harbors. He later served as resident engineer and superintendent of bridges and buildings, and in 1901 was promoted to assistant chief engineer. One year later he was named assistant to the president of the Duluth, Missabe & Northern Railway, the late W. J. Olcott being the president at the time. In 1903 he was appointed first vice-president and general manager and in 1909 elevated to the presidency. In 1929 he was also made president of the Duluth & Iron Range Railway when the "Missabe" leased the latter.

Mr. McGonagle was long recognized as one of the leading men of the Northwest. He saw the start of the construction of the great iron ore railroads of Minnesota and played a prominent part in their construction and operation. He was energetic and aggressive and also very just, and his friends were many. He stood high in the councils of the United States Steel Corporation. His personal benevolences were many and he was presented with a bronze plaque by the American Legion post of his home city for distinguished service. He was a member of the Lake Superior Mining Institute, the New York Railroad Club and numerous social organizations.

He died in Duluth, August 2, 1930, leaving his wife, a daughter and a son. Mining and railway executives from many cities gathered in Duluth to be present at his funeral.

WILLIAM ALFRED PAINE

William Alfred Paine, senior partner of the banking and brokerage firm of Paine, Webber & Co. and president of the Copper Range Consolidated Mining Company, was born in Boston in 1855 and all of his life was spent in that city.

Before he was of voting age, Mr. Paine was a bank officer. On his twenty-fifth birthday he and another bank clerk, Wallace Webber, organized the firm of Paine, Webber & Co. The home office was in Boston, but the business expanded rapidly and offices were opened in many cities in the eastern half of the country. Several of these continue to operate in the Lake Superior district.

In 1898 Mr. Paine organized the Copper Range and allied companies and devoted much of his time to the activities of these. He spent considerable time each summer in Houghton assisting with the management of the mines and the Copper Range Railway.

He died September 24, 1929, at his home at Beach Bluff, Mass., at the age of 74. He left his wife, three daughters and two sons.

WILLIAM H. SELDEN

William H. Selden, one of the early explorers on the Michigan iron ranges, died December 17, 1929, and was buried at Deep River, Conn.

He was born in Deep River in 1853 and came to Michigan at the age of 20 to assist his father in surveying the Chicago & Northwestern Railway from Menominee to Escanaba, from Escanaba to Negaunee and from Negaunee west to Republic. Later he assisted in surveying from Powers to Quinnesec, when iron ore was found at the eastern end of what is now the Menominee iron ore range.

It is believed that Mr. Selden was the first white man to explore for and find iron ore in the Iron River district, at the western end of the Menominee range. It was in 1878 that he and his father reached Chicagoan Lake, where the elder Mr. Selden remained while the son pushed on farther to the west, where he found and opened the first mine, known as the Iron River. This property shipped 29,000 tons in 1882. He also discovered the Hiawatha mine, at Iron River.

Mr. Selden devoted most of an active life to the development of mineral deposits in the Iron River field and was highly successful in his enterprises. He was a member of the Institute.

FREDERICK WILLIAM SPERR

Professor Frederick William Sperr, who was for many years connected with the Michigan College of Mining & Technology and known to his students as “Captain,” was born in Jefferson, Ohio, June 4, 1856. His elementary education was received in Jefferson and his professional at Ohio State University, from which he received the degree of Engineer of Mines in 1883. Following his graduation he was for five years a mining engineer and mine operator in Colorado, Arizona and Mexico. From 1888 until 1894 he was assistant professor of mining engineering at Ohio State University. He served as special agent investigating the stone industry, methods of quarrying and dressing ornamental and building stone for the Tenth Census.

Professor Sperr’s connection with the Lake Superior district commenced in 1894, when he went to the Michigan College of Mining & Technology to take charge of the work in ore dressing and mining engineering. Upon his retirement from academic duties in 1926, he was appointed superintendent of grounds, an office which he was holding at the time of his death. He was recognized as a man of consequence in the mining world; a man whose merit equalled his reputation. He was greatly admired by the many who gained knowledge of mining affairs under his tutelage.

He was a member of the American Institute of Mining & Metallurgical Engineers for 44 years, and for many years active on its various committees. From 1898 until 1900 he served as secretary of the Lake Superior Mining Institute and its vice-president in 1910-11. He was also a member of the American Association for the Advancement of Science, the Society for the Promoting of Engineering Education, Gamma Phi Delta and Sigma Xi. He did much to advance the mining industry in the Lake Superior region through his advocacy of the adoption of safety first principles and through his share in prevailing upon the Federal Bureau of Mines to send its mine rescue car to the district for the giving of first-aid and safety-first instruction.

Professor Sperr died on November 19, 1929, and was buried in Jefferson. He left his wife and five sons.

PAUL H. TWEED

Paul H. Tweed, one of the best known business men of the Mesabi range, with headquarters at Nashwauk, died July 31, 1930, at the age of 52. Death came suddenly while he was at his summer cottage on Swan Lake.

Mr. Tweed was the first hardware merchant and the first recorder of the Village of Nashwauk. He also served as postmaster. He was president of the First National Bank of that village, a director of the board of education, a member of the light and water board, president of the Nashwauk Hardware Company and the Nashwauk Lumber & Coal Co. He played a prominent part in the business and civil life of the town and his services were constantly sought after because of his willingness to serve. His attention to public affairs was untiring.

He left a wife and six sons and two brothers, George P. Tweed and Chris E. Tweed.

JAMES G. VIVIAN

James G. Vivian, a pioneer mining man of the Minnesota iron ore ranges, died April 27, 1930, at Duluth. His age was 63. He was born in Linden, Wis.

Mr. Vivian, who was widely known in the Lake Superior region, went to the Vermilion range in 1885 and was identified for several years with the Minnesota Iron Company, in the days of the late Don Bacon. He went to the Mesabi range shortly after the first mines were opened there and was associated with Corrigan, McKinney & Co. Later he was connected with the firm of Wallace & Roberts in mine stripping operations.

Mr. Vivian was the organizer of the Duluth Diamond Drilling Company, in which he was associated with the late Ted Bush and S. E. Atkins. Mr. Atkins has continued under the name of S. E. Atkins Company. He held membership in the Institute.

He left his wife and a daughter.

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John N. Armstrong	1925	XXIV
D. H. Bacon	1923	XXIII
Clarence Morton Boss	1928	XXIV
George Brewer	1922	XXII
Edmund D. Brigham	1922	XXII
D. D. Brockway	1908	XIII
A. C. Brown	1922	XXII
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