Supplies are usually considered practically a constant factor in the cost of production. They are, at least, less affected by a study of the details than labor.

The importance of having excessive capital tied up in supplies is recognized, but it is doubtful if the interest on the amount necessary to carry an adequate stock of those in general use, would meet the loss due to the delays caused by continually running short of material. The amount of supplies which is necessary to carry, is affected by the standardization of equipment. For instance, nearly every manufacturer of power drills is glad to have his machine given a fair trial. If this trial were made on ground which were fairly uniform, a careful record kept of the performance of each machine and a comparison made of the records, it would probably result in one machine of each type being selected as a standard and a basis established for the purchase of power drills. The adoption of one brand of steel usually insures more uniform results in the forge and consequently a better bit sent underground.

Fuel, one of the principal items of supplies, is now purchased by most operators on an analysis basis, after determining the fuel best suited for each condition.

One company has reduced the cost of their lubricating oil by using a commercial grade of a thick oil, adding other lubricants to meet various conditions.

A study of explosives, their application and instructions in their use may result in a saving of a cent or two per pound in this item or a pound or two of explosive per foot of drift.

The use of carbide lamps underground has demonstrated that they not only cost less but give a better light and are smokeless.

Labor—

During the past ten years, it has been necessary for the mining industry to meet an increase of wages, varying from 8 to 21 per cent, a decrease of 20 per cent in the working hours and in many instances, a decrease in the price received for their product. The one object of labor is to receive larger wages and one of the main objects of the operator is to get lower costs. The question naturally presents itself, how can this condition be met to the satisfaction of both parties? There can be but one answer to this and that is by increasing the efficiency of labor.

The conditions which have a direct bearing on the efficiency of labor are so varied, that an exhaustive treatment can not be brought within the confines of one paper. Not only each district hut each mine presents a different proposition in itself and a study of the details of the operating conditions is the only manner by which we may arrive at any definite solution. From our practical knowledge we may be able to sense a tiling as being right or wrong. This judgment may err 5, 10 or 15 per cent one way or the other and may represent the margin between a profit and loss, but from a set of figures compiled from a time study of the complete cycle of operations, from breaking the ore until it is loaded on surface, one is able to determine to what extent and at which point it is possible to make changes and the exact result of these changes. It enables the work to be so co-ordinated that each man is given an opportunity of doing a days work and is not being held, up by some other operation. It also provides an intelligent basis for making contracts and if the average man does not make the minimum wage, it is his fault rather than an error in judgment on the part of the foreman.

A time study to be of practical value, must be enough in detail and cover a sufficient period of time to enable one to get a fair average of the time required on each operation, and one which does not give this information is worse than useless as it permits false conclusions to be drawn. To get positive results from this work it is absolutely essential that the co-operation of the entire executive force be maintained and if there is any inclination on the part of a boss or foreman not to co-operate in the work, there remains but one of two courses to pursue, either discontinue the work along these lines or dispense with that persons services.

No trouble should be experienced in getting the men interested in the work for as soon as they realize that it mean an increase in their wages, they are only too glad to make an extra effort. The men should be dealt with individually as far as possible. The force of this is apparent when a man is taken from day labor and given contract work. He immediately realizes that a premium is being offered for better work, and can see some tangible reason for making a greater effort. It is generally recognized that any system of efficiency that does not provide for a division of the benefits to be derived from any changes which affects labor, will prove a failure, and while a large percentage of the men working underground may not be able to speak English fluently, there are few who, at the end of the month, do not know approximately what they have made and a settlement on any other basis will not prove conducive to the best results.

There are conditions in which it is rather difficult to figure a contract basis. For example, in the Lake Superior Copper District, the cost of copper per pound depends upon the quality of rock hoisted as well as the quantity. This necessitates underground sorting, which item is a large proportion of the underground expense. When this operation is placed on a contract basis, the quality of the rock decreases and the quantity increases as well as the cost of copper per pound.

To a certain extent, efficiency work is a matter of education. While a practical training is absolutely necessary to one who in any way has charge of men or is planning work, it is of prime importance that they be able to appreciate the value of figures. The result of a time study placed before some of the older mining captains would produce about the same feeling toward them as the man lost in the woods has toward his compass. He will agree that they ought to be right, “but that they are certainly off this time.”

In the majority of cases the men themselves may be taught to accomplish the same or greater results with an expenditure of less physical force. This can not be clone by simply explaining the method but must be demonstrated. It may be necessary to take four or five cuts out of a drift before you can convince a gang that they are not placing their holes to the best advantage. This part of the system of education is usually left to the boss, whose territory is so great that he cannot give sufficient time to any individual gang or operation, to get the best results and too often his attitude toward the men may be that if they do not get the best results, they are on a contract and they, not he, will be the losers.

There are many other conditions which have a direct bearing on the efficiency of labor, some of which are of such nature that the results can not be measured in dollars and cents for instance, one large copper mine in the Southwest employs an expert to provide ventilation form stopes where the air is too hot or impure. Sociological and welfare work, which might be considered a dead expense, undoubtedly has a direct bearing on the efficiency of labor, in tending to preserve the health, loyalty and continuity of an organization. If it were possible to determine to what extent the cost per ton of ore or per pound of copper were affected by this expenditure, it would doubtless show a balance on the credit side.

MINE LAWS, SPECIAL RULES AND THE PREVENTION OF ACCIDENTS.

BY E. B. WILSON, SCRANTON, PA.*

To cover exhaustively the subjects of this paper would require that a large hook be written, even then it is improbable that the continually changing conditions about metal mines could be anticipated so as to present all the various mailers which culminate in accidents; the unforseen possibilities that may arise for changes and additions to mine laws; or the necessity for formulating new rules. The very uncertainly of things makes this paper of a general nature, nevertheless, there are specific matters that come under these captions to which attention is directed.

That there may be no misunderstanding, this paper is not a criticisnn, but one in which are stated conditions as they are recorded. In the writer's opinion therefore no individual operator can assume complacency in this matter, but rather all should unite to remedy the conditions collectively.

In most mining states laws have been passed to compel mine operators to do certain things and post certain rules, and, to see that the provisions in these laws are carried out, state mine inspectors are appointed or elected, whose power also consists in recommending safety measures, and pointing out dangers. In some coal mining states the inspectors are able to close mines and bring suits if operators do not comply with their suggestions.

*Editor, The Colliery Engineer.

In going over the various state mine laws in operation and proposed, one will find a list of subjects adopted years ago, but now suited only for use in kindergarten mining. There are also “Dont’s” for operators and everyone else about a mine which to say the least are insults to average mining intelligence, but there are also some features in these various state laws which are good and might be adopted more extensively to advantage. Copies of these laws may be obtained by writing to the Secretaries of the various metal mining states, and a proposed uniform metal mining law may be obtained by writing to James F. Callbreath, Secretary, American Mining Congress, Washington, D. C.

Inspectors have had laws enacted which proved burdensome without corresponding decrease in fatalities, they have also created considerable friction by their suggestions and demands for their enforcement, but, as a rule, when they receive their office by appointment, and not by election, they work as harmoniously with the operators as the nature of their oath will permit.

The selection of a state mine inspector is a matter of considerable importance as his first duty consists in providing for the maximum protection to mine workers. Violations of mine laws by operators, mine officials or mine workers, whereby the lives and health of men are jeopardized, must be prosecuted, therefore a mine inspector must be conversant with conditions existing in mines, and besides having an extensive practical experience must possess moral courage and a mental temperament that will ensure the avoidance of hasty and ill-advised action.

If inspection is to be properly performed, competent inspectors must be obtained free from any influence that will detract from the powers vested in them. The proper way in the writer's estimation to obtain competent inspection is by appointment by the Governor, he however to be limited in his appointments to men who have passed a civil service examination before an examining board composed of three mining engineers, three mine bosses and three miners. The examining board may select from the candidates who have passed both a written and oral examination with a percentage of 90, those who have temperaments and moral characters that may be depended on and recommend them for appointments.

In the anthracite fields of Pennsylvania men have been elected inspectors not because of character or ability but because they were politicians. Most of those who vote for mine inspectors, being farmers, laborers, business and professional men, are incompetent to judge as to the fitness of candidates for mine inspectors, in fact may never have seen or heard of them before their names were placed on the ballot.

This is not all, if an elected inspector wants to retain his office he must be “suave”; a “trimmer” at all times; spend most of his time electioneering for himself and party and

not offend any of his constituents or they will defeat him at the polls.

A good inspector should be kept in office so long as he is physically able to perform his duties, and if a poor inspector is appointed his removal should be recommended by the examining board that had him appointed. The constant change in inspectors made possible by the elective law, or by executive appointments, if not surrounded by civil service limitations, frequently makes the laws farcial to an extent which gets on the public nerves. After following both the appointment and the election plans of creating inspectors, I am convinced that the plan here proposed will prove more satisfactory to miners, operators and the public than, any other that has been advanced.

Large coal companies not satisfied with periodic state mine inspection, hire company inspectors who examine the mine and appliances and suggest both changes and improvements that make for safety. Provided the right kind of a man is employed, a company inspector will save his wages readily by acting as an efficiency engineer. In positions of this kind only experienced men with liberal educations should be employed, and if a concern is not large enough to hire such a man two or three should club together for the purpose. That he may not conflict with the Superintendent and Foreman a perfect understanding as to each one's duties should be stated in writing. Further he is not to give orders either above or below ground and should write his suggestions in triplicate for the benefit of the Manager, Superintendent and Foreman.

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Fig. 1

In the absence of state mine laws to govern metal mining, it certainly is advisable that the operator appoint a safety committee, make a uniform set of mine rules, make use of danger signs, and also issue from time to time Safety Pamphlets for the miners all over the fields, calling attention to the accidents that have happened and how they may be avoided.

Where there are state mine laws both the miner and the operator must observe them, and in addition the miner must abide by the rules of the company. It is undoubtedly true that the number of accidents may be decreased by united efforts to teach the miners to care for themselves and by using strict disciplinary measures to regulate carelessness and evasion of rules. It is not enough to make one set of rules for the guidance of the miner, special sets of rules must be formulated for those men who follow distinctive lines of work inside and outside the mine.

In case of an accident the cause should be investigated and wherever possible a rule formulated in such a way that a similar accident will not be likely to occur. Although this may produce radical changes in the work and the discharge of several men for infringement of the rules, nevertheless it has been found to add to efficiency and eventually decrease accidents.

The most difficult cases to contend with will be those of old miners who have worked for years doing things certain ways. They are "bull-headed" and will tell how long they have mined, etc. However, they must understand that they are to do things differently if they want to continue at work. These men may purposely do things they are told in a wrong way, but a lay-off with the reprimand that they are not good miners will bring them to reason.

In mining two parties are concerned in an undertaking in which a contract is implied if not signed, sealed, acknowledged and recorded. Both miner and operator are under obligations by this contract to refrain from doing or leaving undone those acts which will work injury to the other. This being a. recognized fact the next step is for the contracting parties to work in harmony for mutual benefit, in other words, place confidence in each other.

Mr. Thomas Lynch, head of the H. C. Frick Coke Company seems to have gained the confidence of his men, by appointing a safety committee of miners who investigate whenever a miner anticipates danger and who immediately recommend that conditions be made safe. A comparison between the fatal accidents in Great Britain and the H. C. Frick Company per million tons of coal mined is 4.52 to 1.88. The H. C. Frick Coke Company produced in 1912, twice as much coal per fatal accident as the bituminous fields of Pennsylvania, Ohio, Illinois, and West Virginia. The success of Mr. Lynch in decreasing accidents is due to his making the men. responsible for them, and by the strict enforcement of mine rules.

Michigan employed 31,584 metal miners in 1911, of which number 134 were killed or 4.24 per thousand employed.

Minnesota employed 16,548 metal miners of which number 76 were killed or 4.59 out of every 1,000.

As Michigan and Minnesota employ 29 per cent of the 165,979 metal miners in the United States it naturally follows that there would be more accidents in these two states, but we find on further analysis of the Census Bureau Reports that Houghton County, Michigan, had 563 deaths recorded during the period extending from 1894 to 1908, inclusive, yet in every one of these 14 years the death rate was less per thousand men employed than in the iron mines of the state. The average by counties was as follows: Dickinson County,

4.01; Houghton County, 2.94, and Marquette County, 4.32.

The writer has no statistics relative to the Minnesota Mine accidents for the 14 years mentioned, however, the data compiled by Albert H. Fay and printed in the Bureau of Mines Technical Paper 40 is sufficient to show that the fatal accident list is much too high being 4.59 per 1,000.

Taking Mr. Fay's figures, the total number of fatal accidents in 1911 in Michigan and Minnesota ore mines were 157, while those seriously injured numbered 1,839. These are tabulated for ready reference as follows:

Accident Table Lake Superior Ore Mines 1911.

Cause.	Killed.	Per cent of total.	Seriously injured.	Per cent of total.
Falls of rock or ore.....	65	41	611	33
Timber or hand tools.....	3	2	192	10
Explosives	13	8	45	2
Haulage	4	3	392	21
Falling down chute, or winze, raise or stope...	10	6	92	5
Falling down shafts	27	17	18	1
Run of ore from chute or pocket	6	4	70	3
Drilling machines			132	7
Electricity	1	0.6	2	0.1
Machinery other than drills and locomotives	5	3	60	3
Mine fires	8	5		
Natural gas	1	0.6		
Miscellaneous	10	6	199	11
Objects falling down shafts	3	2	21	1
Hoisting rope breaking....	1	0.6	1	0.1
Overwinding			4	0.2
	157		1,839	

It is customary for statisticians to tabulate accidents which occur on the surface separately from those which occur underground and also to sub-divide the accidents under heading. In the accident table, only underground and shaft accidents are given.

In 1911 there were 32,793,130 tons of iron ore and 10. 978,827 tons of copper rock mined in the Lake Superior region, but for every 278,802 tons of ore raised one life was lost and for every 23,802 tons a man was seriously injured.

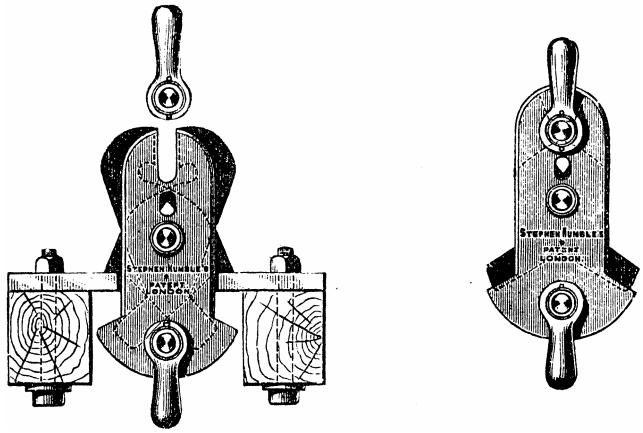


Fig. 2. Safety Hooks

Accidents above ground seem to be due to carelessness, although frequently it is commendable if misguided carelessness when to save property or time the employe risks safety. It should be thoroughly instilled into men's heads that no piece of property is worth so much as his life. Outside accidents happen through machinery; haulage arrangements, tramming, coupling and dumping cars; falls from head frame and staging; while carrying tools or materials; into chute or ore bin and getting caught with running ore; and in getting on or off the cage or bucket at the surface. Overwinding is not so common as it once was, since at a large number of small operations Humble or Akron safety or detaching hooks have been adopted and at large mines overwinding devices are used that take control of the hoisting engine if the engineer is incapacitated or fails to pay attention to the work or the indicator fails to register correctly.

That the top of all shafts, slopes and machinery is to be fenced goes without saying, and so far as my observation goes this is done at the Lake Superior mines without laws. Shaft gates should be arranged to open automatically whenever the landing is at the surface. Where, however, the landing or dump is above the ground, the surface gates should be kept locked. There is danger from pieces of ore falling from the dump where self-dumping cages and buckets are in use, and people should be warned from standing near the shaft collar when dumping is carried on above ground. Skips usually dump so far into the chute that with ordinary care no ore falls outside the chutes.

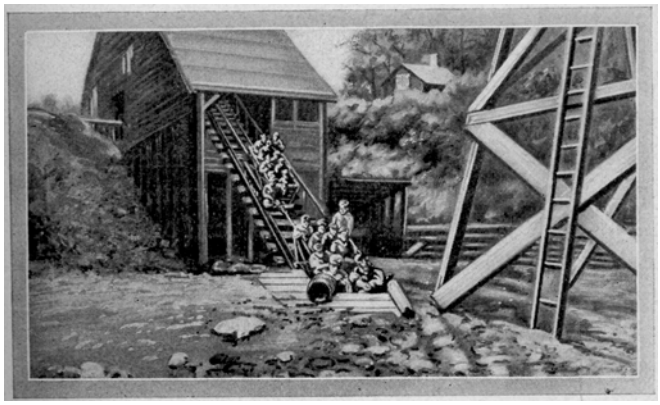


Fig. 4. Fancy Skip Riding, Two Skips on One Rope

Getting off or on the bucket, skip or cage when in motion is a frequent cause for injury. No one should be allowed to ride on cages carrying supplies except the man in charge and he should be instructed how to fasten the material so it will not move on the cage or project beyond the sides.

At a mine in one of the eastern states, the men ride down the slope on skips. In addition to their overcrowding the skip they ride on the outside and on the rope steadying themselves by placing their feet on the rail. While the speed of hoisting is not fast, there are any number of chances for accidents. The number of men that shall ride in a skip or cage should be posted at the top and bottom of the mine and at each level. The man that gets on after this limited number is reached should be laid off and for a second offense discharged.

Hoisting ropes should be inspected each morning before the men go down and each evening before the men come up. This is readily done by letting the rope run slowly through the gloved hands of two men. Ropes are subject to greatest wear near the cage fastenings and the clamps or sockets should be examined each morning and evening, also bridle chains should be used. Occasionaly a timber or tool may drop from a cage, etc., or a trammer may push a car from a level into the shaft and follow it down, or as in Colorado men may be killed by being struck with a descending cage or bucket; however, to guard against the numerous kinds of accidents that might happen in a shaft, rules should be posted stating what may not be done. It is considered advisable to give publicity to shaft accidents and show how they may be avoided. This is best accomplished by an operator's Publicity Pamplet.

One fruitful source for accidents in the Lake Superior metal mines is falling down shafts, 17 per cent of the fatal accidents being due to that cause. It is hard to account for this if the levels, stations and shaft collars are properly fenced and run-arounds provided. It may possibly be due to falling from ladders. It certainly is not due to overwinding or the hoisting ropes breaking, for such accidents are reported separately.

There were three killed by objects falling down shafts and 21 injured. The table fails to specifically state whether the objects were loose rock from the sides of the shaft or material falling from buckets, skips or cages overloaded.

In this connection no one should be permitted to stand directly under a shaft opening, and not close to the shaft on a level. The shaft walls should be examined at regular intervals from top to bottom and loose rock taken down or timbers repaired as delay may prove serious. Universal danger signs should be freely used to warn people of a danger zone.

When shafts are being repaired, the men should be provided with strong platforms braced rigidly to the top members of the cage. A swinging platform below the cage is not safe.

Palling down chutes, winzes, raises and stopes, killed 10 and wounded 92 men. Ladders should be provided in raises and winzes and kept in repair. Chain ladders will be found serviceable in this connection and when provided with stretchers of great help in avoiding accidents. Hoisting men out of winzes by a windlass is not so safe as making use of ladders. In raises care should be taken to see that the timbers supporting the staging have proper footings even if it requires cutting hitches. Chicken ladders well made will answer for stope climbing if properly fastened at the top and bottom. Where winzes connecting levels are used for ventilation and exit, good ladders should be provided, all other openings on levels should be boarded over to prevent falls, and those used as traveling ways should be fenced on the upper level. The number of winzes on each level equipped with ladders will of course be only those used for traveling ways.

When there is a ladder compartment the ladders should not have an inclination above 60 degrees and should have substantial landings at least every 20 ft. The rungs of the ladders should be inspected and repaired quickly when broken, likely to break, or missing. Men carrying more than one tool should not be permitted to climb ladders. At about 25 ft. from the surface a bulkhead should be placed over the ladder compartment; from this bulkhead a level should be driven and in. the case of comparatively level surface ground a riser made. There are a number of reasons for this level among which are: prevention of material falling on men's heads; improved ventilation; in case of fire in the head house or near it, the men will not be overcome with gases, and besides forming a partly second opening it gives the men a chance to rest.

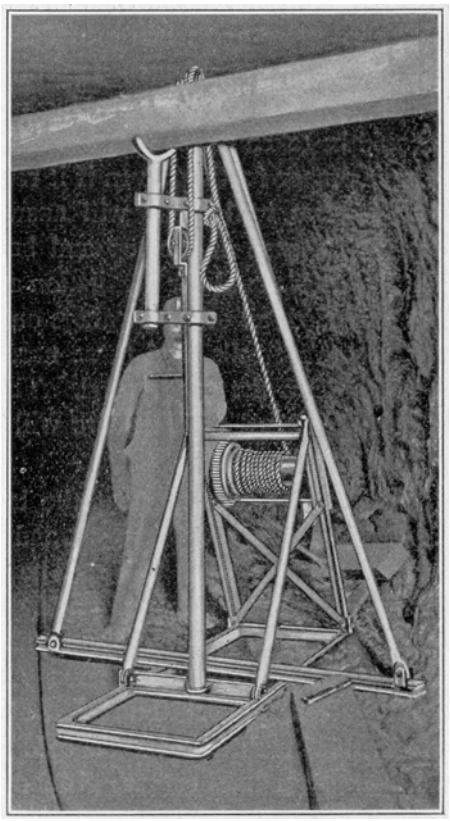


Fig. 5. Collapsible Timber Derrick

While there were but four fatal haulage accidents in the Lake Superior mines there were 392 serious injuries. It would appear from this that more are injured by haulage arrangements in ore mines in proportion to the number of men employed than in coal mines where haulage is longer and where many more cars are in use. There being no data to go by, the only suggestion to be offered is a warning to men not to ride on loaded cars or jump from moving cars. Rules made to cover haulage matters underground should be strictly enforced.

As in coal mines it is found that rock-falls are the most prolific cause of accidents underground and the most difficult to prevent. The manager can go only so far as

to furnish materials that men may protect themselves; however, with the aid of inspectors men may be educated to protect themselves. In this connection inspection will disclose whether the sides of the level are in order, and another frequent source of injury will be removed namely falls of rock when traveling through levels.

While there were three deaths from timbers and hand tools, 192 men were seriously injured by them. There is no branch of metal mining so important to successful operation as timbering and possibly no part of the industry has been neglected to such an extent as that of handling timber. Recently a collapsible timber setting derrick (Fig. 5) has been placed on the market and this may prove useful for raising and placing stulls and stemples, also in placing collars in timber sets. The Eureka Timber Hook (Fig. 6) or "toad" for short, may be used on the end of sticks to lift them or snake them along. Sometime probably small electric crabs will be devised to assist in handling timber in the mines; then there will be fewer falls of timber and fewer injuries from tools, and falls from staging.

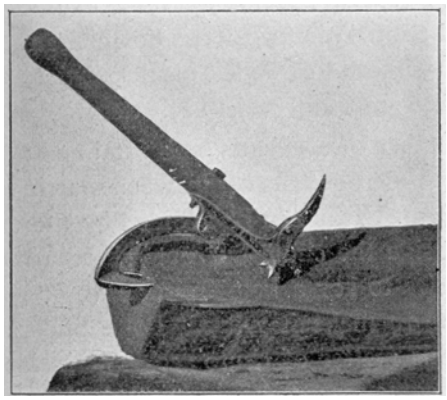


Fig. 6. Eureka Timber Hook

In the Lake Superior region 13 were killed from explosives and 45 seriously injured, which shows that in this respect the operators are aware of the importance of properly handling this material. In Colorado in 1911, 43 were killed and 247 injured by explosives, and in 1912, 47 were killed and 435 injured. Some of the common accidents result from thawing dynamite over a candle, in a stove, by using too hot water or placing it on too hot sand; picking out missed shots; drilling into missed fire charges; using metal tools for ramming charges in holes; remaining too long after lighting fuse; returning too soon after blast had been lighted; flying rock from blast, men not being in place of safety; explosions from unknown causes; picking or mucking dirt in which was unexploded powder or caps; carelessness in handling and carrying caps and drilling in blownout shot holes.

Underground magazines are unsafe. Within the past few years one blew up in Park City, Utah; another on Treadwells Island, Alaska, and one in California. There have been others likely. No definite reasons for these explosions have been advanced, although lightning went down the same coal mine twice in two years and exploded black powder, also dynamite in holes which were connected to a battery.

Quite a number of accidents both fatal and non-fatal occur in chutes where men get drawn in when starting the ore running after a jam. This can be avoided by the use of ladders outside and inside the chute but not where a man stands on the ore and tries to bar a hole from above or gets below the jam and starts to make it move. Lake Superior mines are not alone in this matter of chute accidents inside and outside the mine, and some means should be devised to prevent them, for so long as rock will jam and arch, the chutes must be barred. A few dollars expended on a chute might possibly do away with these accidents.

While no fatal accidents are recorded from drilling machines 132 serious injuries are recorded. It is sometimes hard work to haul machines up a stope and sometimes difficult to keep them there, consequently every man for himself on this proposition until some one devises a remedy. Machinery other than drills and locomotives is responsible for the deaths of 5 and the injury of 60 men. Not knowing the kind of machines connected with these accidents, one naturally wonders how men got against them or into them if they were fenced as machines should be.

Mine fires are miserable affairs and have caused great damage and expense more particularly in metal mines. It is possible that most of them can be avoided by using foresight, making rules and demanding their rigid enforcement. No steam pipes or electric wires should be allowed to come in contact with mine timbers. Miners should not be permitted to leave their candles or lamps burning in the mine, and should not attach them so close to timbers that the flames will scorch. Punk easily catches fire and in course of time creates a blaze. Pyrite can be ignited for which reason the lamps should be as carefully kept from pyritic rocks as from wood. Old timbers which have been replaced by new ones or are no longer needed should be removed from the mine. The reasons are they may trip some one, they are liable to catch fire; they will transmit fungii to sound timbers and will vitiate the mine air.

Rules of the mine should be printed and each man presented with a copy. Shaft rules and signals should be posted in the shaft house and at the landings.

To protect life and avoid accidents all hands from the manager to the nipper should regulate their actions to conform to the rules of the mine and neither do or leave undone anything liable to cause an accident.

THE PREVENTION OF OVERWINDING.

A device to prevent overwinding demands that the control of a hoisting engine be taken out of the hands of the engineer if the cage passes a certain point, say 3 or 4 feet above the landing. Such a device must shut off the steam and apply the brake instantly so that the cage shall not travel more than from 10 to 15 feet before it is

brought to a stop, and held in suspension above the shaft. C. R. Welch has made a simple device of this kind which consists of a few valves, levers, a ram, some pipes and a weight.

There is a revolving hub having projected arms which travels to the right on a threaded shaft when the cage is ascending and to the left when it is descending. The length of the horizontal movement of the hub is proportioned to the exact distance from the bottom to the top landing, and should the cage travel 3 or 4 feet above the top landing, the arms on the revolving hub will strike a lever which opens a valve and sends steam to a ram whose piston puts on the brake and closes the throttle almost instantaneously, thus preventing overwinding. The engineer has no volition in the matter, the control of the engine is out of his hands, and before he can recommence hoisting he must reset the device which prevents overwinding.

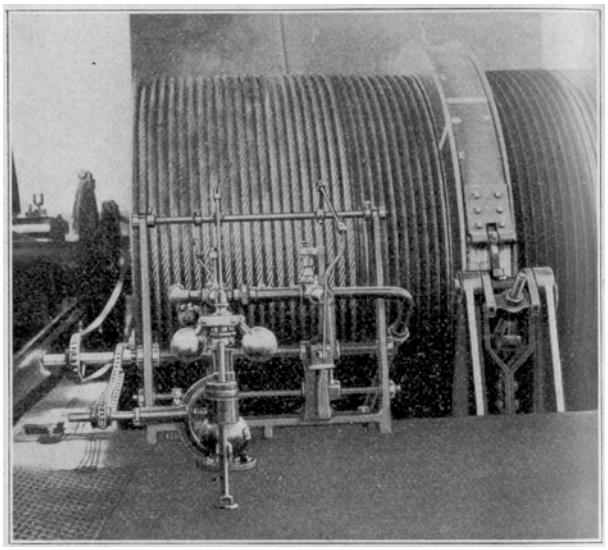


Fig. 7. Overwinding Device.

There is a regulator on this machine which, should the engineer fail to slow down as the cage reaches a certain point-near the top of the shaft, will by the increased speed of rotation raise a weight and shut off the steam, also apply the brake.

The apparatus which is shown in Fig. 7 occupies little space on the floor and is a positive check on overwinding. The only possible way to prevent its stopping the engine in case of overwinding would be to shut the steam off from it. Its very simplicity recommends it. When hoisting in balance, the two drums being fixed on the same shaft, but one overwinding device is needed because both cages travel specified distances relative to each other.

If, however, one drum is fixed and the other loose, or if drums are loose on the shaft to hoist from different levels, two devices are required, one for each drum. The drum shaft is connected to the overwinding device by a sprocket chain, and the regulator to the overwinding device by another sprocket chain. In case the drums were loose on the shaft the overwinding sprocket would be fastened to the drum.

SAFETY GATES FOR SHAFTS.

To prevent shaft accidents at the surface a gate of simple construction is used by the D. L. & W. Coal Company, that may be raised or lowered into position before the shaft opening, by the cage as it comes to or leaves the surface landing. (See Fig. 8). It is a double gate, that is, it is constructed the same for each side of the shaft and is raised by the top of the cage striking against the two wooden cross pieces “A” fastened to both gates.

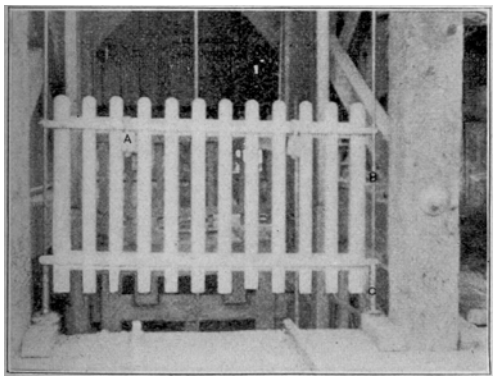


Fig. 8. Safety Gate, D. L. & W. Coal Co.

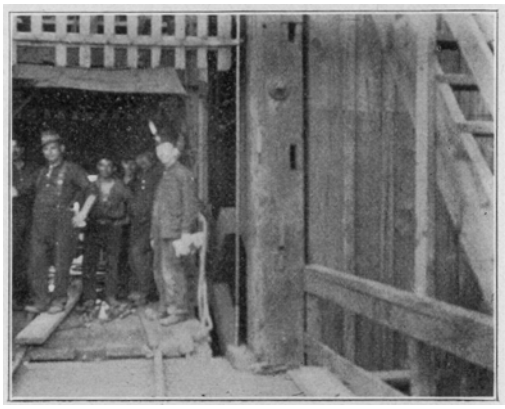


Fig. 9. Safety Gate Raised, D. L. & W. Coal Co.

Fig. 9 shows the gate raised. Two iron guide rods “B” one each side of the gate keep the gate from swinging or swaying when the cage strikes the cross beams and also causes it to seat properly. To take up the shock of seating there are two coil springs “C” which answer every purpose. Because the cuds are hoarded there is no way for a person to fall into this shaft unless he climbs the gates.

Another safety gate is shown in Fig. 10. This gate is used at Pennsylvania. Coal Company's No. 1 Dunmore shaft where the landing is on a high steel trestle and landers must at times cross the cage opening. The horizontal gate is raised and lowered by the top of the cage and both gates are always over the openings except when one of the cages is at the landing. The shaft collar at the surface of this mine is fenced on four

sides and these fences must be removed by some one in authority before a person could fall down the shaft. It will be noted that these gates are worked automatically so that only some one vested with authority to make use of the cage can raise them.

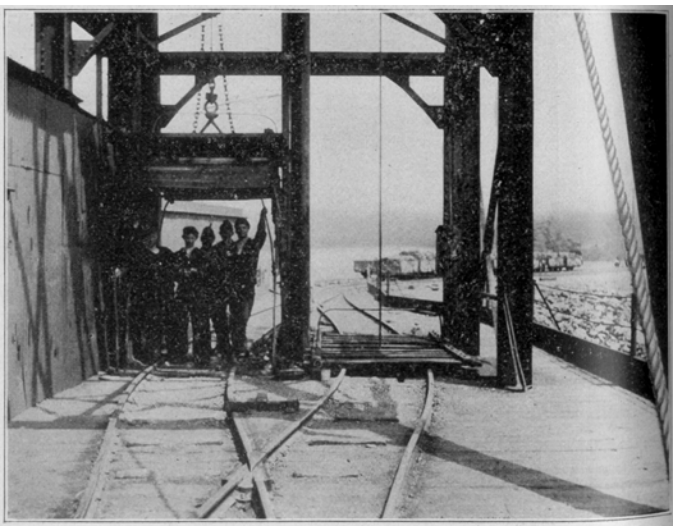


Fig. 10. Safety Gate, Pennsylvania Coal Co.

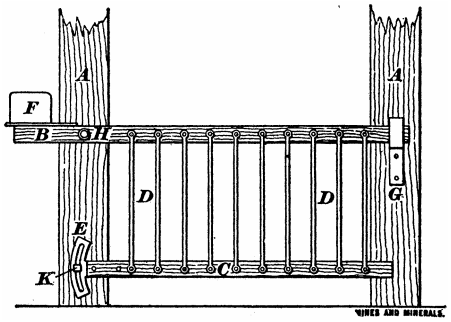


Fig. 11. Safety Gate, Strong Shaft, Victor, Colo.

The shaft gate shown in Fig. 11 is in use at the Strong shaft, Victor, Colo. The bar "B" is made of 4 in x 8 in. timber or of any other convenient size. It is pivoted at "H" by a bolt upon the head-frame leg "A" and at the opposite end fits into the rest or catch "G" of ½ in. x 3 in. iron. "F" is a counterweight of the proper heaviness and distance from "H" to permit of the gate being raised or turned on the pivot "H," by a very light upward pull.

Suspended from the bar "B" by means of the rods "D*" etc., is the lower bar "C" which may be made of lighter material than "B." The rods "D," etc., are flattened at the upper and lower ends and bolted to both "B" and "C" so that they may turn freely.

Attached to the inner side and on the left end of the bar "C" is a slotted plate of thin iron, through which the bolt "K," set in the leg" "A" passes.

When the bar "B" is raised by an upward pull near "G" it revolves on the bolt "H," and rods "D," etc., turn on their upper and lower pivots and the plate "E" turns downward on the bolt "K," the whole gate being raised and folded like a ferry boat gate. The arrangement is very simple and can be made by any mine carpenter at a reasonable cost.

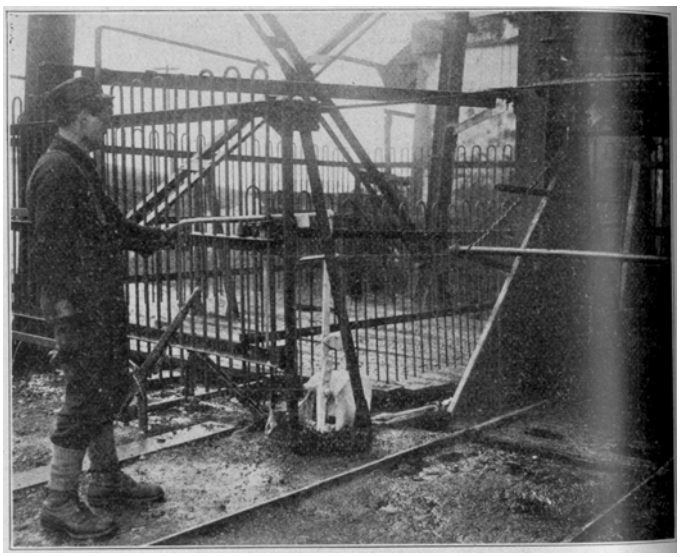


Fig. 12. Shaft Gate Locking Device, H. C. Frick Coke Co.

As gates of this description can be interfered with, the H. C. Frick Coke Company have adopted safety catches and locking device.

With the shaft gate locking device shown in Fig. 12, it is impossible to open the gate in the railing about the top of the shaft unless the cage is there. The latch can be raised only by a system of levers operated by a handle extending through the fence just beside the gate; and it is only when the cage is in position at the surface that the proper bearing is afforded to the levers so that the latch can be lifted. On the shaft framing at the ground level is fastened a horizontal plate—an T-shaped lever turns about a pin in this plate. The lever arm is ordinarily back from the shaft out of the way of the cage, but when the cage is present one arm may be turned so as to bear against the side of the cage; the other arm being connected by a straight rigid link to the lower end of an upright lever, to the upper end of which is fastened the rod and handle to operate the gate latch, and. which ordinarily, when the cage is not present, turns about a pin held by a heavy weight about 10 inches from the lower end. If now the upright lever is pulled with the cage away from the landing the L-shaped arm is simply turned forward and one arm extends out over the shaft; but if the cage is present the L arm can turn only until it hits the side of the cage when the lower end of the upright lever is prevented from further movement by the rigid link and the weight is lifted by any further pull. The gate latch is connected by a simple system of levers to this weight, holding the gate locked except when this weight is moved by the lever only when the cage is present.

It is proposed to connect this device also to operate a car step so that it will not be possible for a car to run to the shaft except when the gate is open, the cage in position and ready for the car. The car stop prevents heavy cars from running into the gate.

The D. L. & W. Coal company have a combination of a gate which is lifted up by the cage and for a special reason can be made to swing open when the cage is not at the landing. It may be understood that in some instances this double arrangement may be valuable but as a rule the positive opening and shutting of the gate by the cage will prevent accidents.

The writer has been unable to find or hear of any automatic shaft gates used on levels underground. In the anthracite fields the gates on levels swing on hinges, and are operated by the lander who opens and shuts the pair on his side of the shaft and by the loader who does the same on his side.

CONCENTRATING AT THE MADRID MINE.

BY BENEDICT CROWELL, CLEVELAND, OHIO.

The Madrid mine, Virginia, Minn., has an output of about 400 tons per day. The ore requires concentration to produce a commercial grade, both as to the chemical analysis and the physical structure of the ore. The problem of cheaply concentrating this small output seems to have been successfully met by the introduction of the Wetherbee concentrator, which has been working sucessfully for some time past.

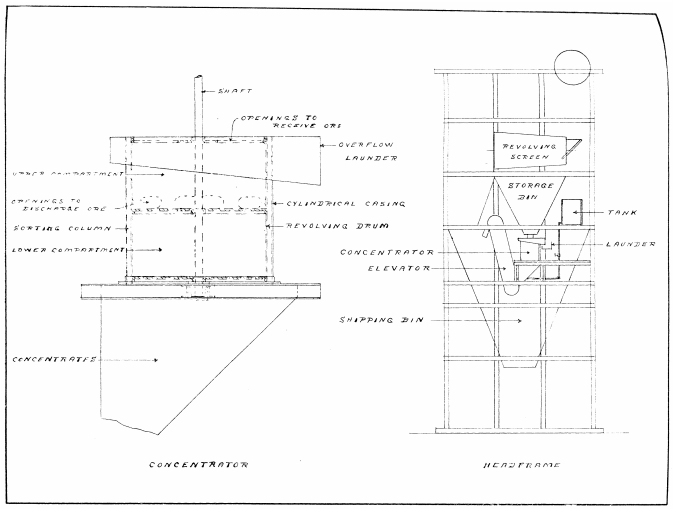
The concentrator is installed in the headframe, just below a pocket which receives all of the material that passes through a one-half inch screen. This amounts to about 50 per cent. of the ore hoisted. The coarse ore does not require treatment, and goes direct to the shipping pocket. The concentrator receives the material that has passed through the one-half inch screen, and discharges the concentrates which have been unwatered by a perforated bucket elevator into the same pocket that receives the coarse ore.

The concentrator is 3 feet in diameter, and is 6 feet high. It requires less than 1 horse power to operate and receives 6.5 gallons of water per minute, the water being pumped as needed from the sump in, the mine to a small storage tank in the head frame. It is operated less than one-half of the time to take care of the output of the mine, and requires only one man in addition to the regular lander.

The output is desirable, both as to analysis and structure. It carries less moisture than the original ore, as all of the material that has been removed will pass through a 100 mesh screen, and this material increases the power of the ore to hold moisture. The concentrates average about 57.50 per cent. iron, and the tailings about 40.00 per cent. iron. The recovery is about 84 per cent. of the material treated, or 92 per cent. of the total hoist.

The machine consists of a cylindrical drum and a cylindrical casing, the axis of the drum and of the casing being concentric and vertical. The drum is driven from above, and is made with two compartments, the lower of which is an air chamber that causes the drum to just float in water. The upper compartment receives the material to be washed, and discharges it by centrifugal force through openings into the annular space between the drum and casing. The casing has an overflow launder at the top, and is bolted at the bottom to a water tight compartment, that is connected with the boot of the elevator. The water required enters at the base of the machine, and rises through the annular space between the revolving drum, and casing, and discharges into the overflow launder at the top of the casing.

The principle of the machine is based on the following theory: Supposing a particle of ore and a particle of quartz were allowed to settle in still water for a certain length of time, and that the particle of ore settled 4 inches, while the particle of quartz was settling 2 inches—it is evident that in order to separate these two particles by an upward flow of water, that a velocity of somewhere between 2 and 4 inches would be required or, say 3 inches a second. Assuming that these same two particles were placed in the machine, and the revolving drum given such a velocity that the quartz particle remained in suspension, traveling in the same horizontal plane, the ore particle, in the same length of time, would settle, say 1 inch. It is then evident that the slightest upward. flow of water would wash out the particle of quartz, and would still allow the particle of ore to settle and that we have secured the same result by the use of the machine with an upward flow, of say, one sixteenth of an inch a second, that we did before with a flow of 3 inches a second, or in other words, with the use of one forty-eighth of the amount of water. The fact that the whirling current can be controlled independent of the velocity of the upward rising current allows an exact and independent control over the material that goes into the overflow or into the concentrates by changing either the speed of the drum, or the amount of water used.



The capacity of this machine has not yet been tested at the Madrid mine, owing to the inability of the mine to hoist enough ore to make such a test. Twenty-five tons per hour has been put through, however, which is equivalent to say, 500 tons per day. The larger size

machines, now being constructed, will greatly increase this output.

The Wetherbee concentrator was designed primarily to treat the sandy ores on the Western Mesaba range, and a number of tests have demonstrated that these ores can be concentrated up to nearly 60 per cent., the tailings consisting of fine material, that wall pass through a 100 mesh sieve, running about 40 per cent, in iron, in other words, material that would make flue dust.

MINING METHODS ON THE MISSABE IRON RANGE.

BY COMMITTEE, CONSISTING OF WILLARD BAYLISS, E. D. M'NEIL AND J. S. LUTES.

The ore bodies of the Missabe Range are essentially flat deposits, of great area as compared to their depth. As an illustration, one of the larger deposits, located near Chisholm, has been proved by the drilling on contiguous forty-acre tracts to be two and one-half miles in length, and to average three-quarters of a mile in width. Within this area, however, there are seine isolated barren portions where ore concentration has not taken place. This ore body is overlaid in some places by slate or taconite and glacial drift; in others, by glacial drift alone. The average of 202 drill holes through to the bottom of the ore was 58 ft. of ore and 76 ft. of glacial drift and rods above. The depth of ore ranged from 5 to 243 ft., while the glacial drift and rock ranged from 11 to 215 ft.

Taking the whole range into consideration, it may be said that the ore bodies are generally less than 200 ft. thick, with a maximum of 500 ft.

MINING METHODS IN PRESENT USE.

There are three general methods in use at the present time in mining these ore bodies, viz:

1. *Underground Mining*—The ore being mined by hand and hoisted through a shaft, the underground openings being supported by timber.

2. *Open Pit Mining*—Where the material above the ore body is first removed and the ore then mined by steam shovels and loaded direct into standard-gauge railroad cars.

3. *Milling-Pit Mining*—-A combination of the two former methods, the material above the ore body being first removed, after which the ore is mined through underground openings and hoisted through a shaft.

SELECTION OF METHOD OF MINING.

The selection of the method of mining to be adopted involves a great many considerations and calls for experienced engineering and business judgment. Regardless of the method to be adopted, its selection should be preceded by thorough drilling to determine the limits and size of the ore body and the grades of the ore. Maps showing the top and bottom contours of the ore, and cross-section maps showing relative thickness of stripping and ore are indispensable. It is not the intention of this paper to go into the subject of the costs of mining, hut in order to show the basis on which calculations are made, we quote the following from "IRON MINING IN MINNESOTA," by Charles E. Van Barneveld.*

*Published by Authority of the Board of Regents of the University of Minnesota. Copyrighted, 1913.

"*Operating Estimates*—When a property has been drilled and estimated, the engineer makes further estimates to determine the method of mining best suited to the ore body under consideration. The following basis has been established for comparison of underground and open pit mining costs:

TABLE NO. 1.

Stripping ordinary glacial drift, 30 cents a cubic yard.

Stripping ordinary paint-rock, 30 cents a cubic yard.

Stripping ordinary broken taconite, 75 cents a cubic yard.

Stripping ordinary solid taconite, $1.00 a cubic yard.

Steam shovel mining, ordinary ground, 15 cents a ton.

Underground mining, ordinary conditions, 75 cents a ton.

One cubic yard of ore is roughly 2 tons.

Sometimes a glance at the ore estimate will suffice to classify part or all of an ore body. Often a calculation must be made as exemplified by this case: A drill hole shows 50 ft. of ordinary glacial drift and paint rock, 15 ft. hard taconite, 36 ft. merchantable ore. All other things being equal, is this in open-pit or an underground proposition?

Reducing the consideration to a column of one yard square at the drill hole, a comparison may be made using the data in Table No. 1.

Underground Mining—

Cost of mining a column of ore 1 yd. square and 36 ft. high at 75 cents a ton (1 cu. yd. equals 2 tons), 36/3x2x$0.75=.....	$18.00
Open Pit Mining—	
Stripping a column 1 yd. sq. and 50 ft. high of glacial drift at 30 cents a cu. yd., 50/3x$0.30=.....	5.00
Stripping 15 ft. solid taconite at $1.00, 15/3x$1.00=..	5.00
Steam shovel mining 36 ft. ore at 15 cents per ton, 36/3x2x$0.15=...	3.60
Total cost of open pit work.....	$13.60
Difference in favor of open pit.....	4.40

* * * *

This offers a ready method of preliminary comparison to be supplemented by more exact figures when special considerations enter. It is of course understood that such questions as adverse or favorable topography, accessibility of dump room, quick-sands, swamps, etc., have a special bearing on each individual case that does not admit of generalization.

The economical limit of stripping is at present considered to lie within the following proportions:

1. One yard of overburden to 1 ton of ore.

2. Not to exceed 2-ft. depth of overburden to 1-ft. depth of ore. Hard slates and taconite cost from 2 to 3 times as much to strip as ordinary glacial drift and it is customary when applying these figures to consider 1 ft. of such material as equal to 3 ft. of overburden.

3. A maximum stripping depth under any considerations of 150 feet."

In general, underground methods are used for those ore bodies lying under slates or taconite, or deep glacial drift. It is an alternative method, adopted only when the other two methods are out of the question. About the only consideration in its favor is that production can be obtained quicker and with less initial cost than with the other methods.

Open pit mining is used for the larger bodies of ore lying under comparatively shallow surface material and where the operating company is able to make the large initial expenditure in stripping. Besides permitting the lowest operating cost, it has many other advantages. The capacity for production from an open pit is enormous as compared to a shaft. One forty acre tract opened up as an open pit, provided the approach can lie on adjoining land, operating with two shovels and five locomotives, can send forward 9,000 tons daily, while the same area being operated as an underground mine, hoisting through one shaft, would ordinarily produce about 2,000 tons daily.

The milling pit method of mining is adopted generally for the smaller bodies of ore lying under comparatively shallow surface material. The amount of initial expenditure foist ripping is much less than for an open pit, where the cost of the approach is a large item. The cost of production from a milling pit lies between that of open pit and underground mining.

UNDERGROUND MINING.

There is one prevailing method of underground mining in use on the Missabe Range at the present time. This is the Top Slicing or Caving Method. The main points of this method are as follows:

A top slice over the whole area of the ore body is removed, using timber to the full height of the ore. As fast as the various rooms of this top slice are worked out, the bottoms are covered with boards, and the timber is blasted down, allowing the overburden to cave and fill up solidly the space formerly occupied by the ore.

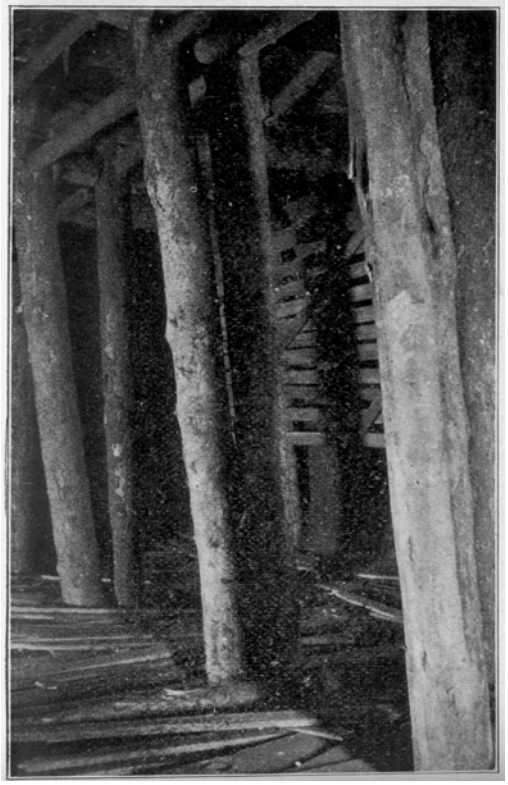
When the top slice is out, another slice over the whole area is taken out just below it, also using timber the full height of the slice, up to the boards of the slice above. Rooms are blasted in as fast as they are mined out and the cave follows. Successive slices are taken in like manner to the bottom of the ore body. The use of timber to the full height of the ore in each slice, thus insuring a very high percentage of extraction, is the most important feature of this method. The cross-cuts to the various rooms are always in solid ground, providing a safe retreat for the miners.

The general practice in opening up and mining an ore body to be worked on the Top Slicing system may now be briefly considered.

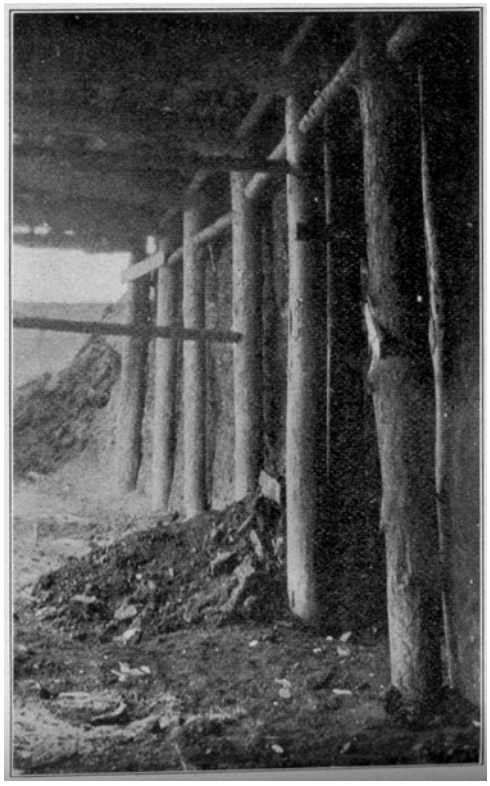
Size and Location of Main Shaft—For an ore body of considerable size, a shaft 8 by 20 ft. outside is largely used. There are two skip compartments, 5 by 6 ft., and one ladder and pipe compartment, 6 by 7 ft. with 6 in. dividers. The sets are of 12 by 12 in. timber. The shaft is located near the deepest part of the ore body, either in the ore itself or in the adjacent rock. From this position the drainage of all the ore to be mined through the shaft may be taken care of.

Timber Shafts—Usually the sinking of a timber shaft, somewhere near the main shaft, is begun at the same time as the latter. From one to three additional shafts, depending on the size of the mine, are sunk at advantageous points. The size may be 6 ft. square, or 6 by 9 ft.

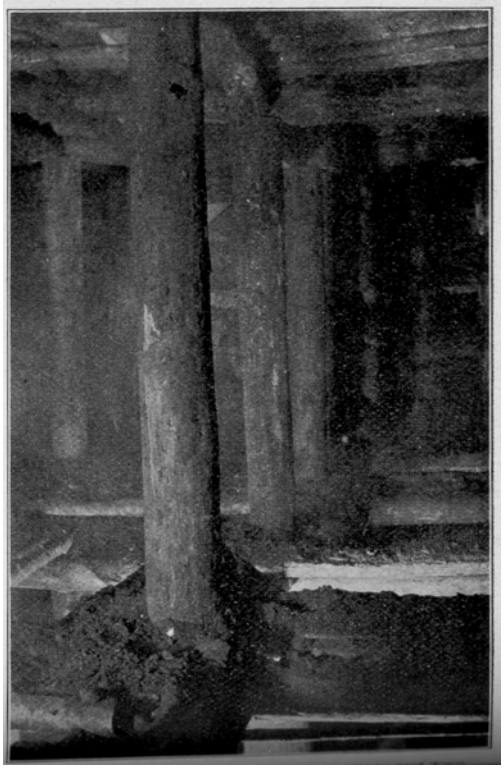
Location of Main Drifts—A close study of the bottom contour map is necessary to decide this point. Where the drilling has been sufficient, one or more troughs of deep ore will be found running through the ore body, generally from northwest to southeast, or from west to east, with the deepest part of the trough at the easterly end. It is in these troughs that the main drifts are located. The chief considerations are to have them near the bottom rock and still have them extend as near to the limits of the ore body as possible. The idea is to make the motor tramming long and the hand tramming short. When an ore body is 50 ft. thick or more, it is good practice to locate the main level high enough up in the ore body so that it will extend a considerable distance from the shaft, another main level being opened up nearer the bottom later. If the ore trough is wide enough, two parallel drifts, from 60 to 100 ft. apart, are driven, connected by a loop near the shaft. The advantage of two drifts is in opening up the ground quicker for drainage; small drifts across connecting them improve the ventilation; if one strikes rock unexpectedly it can be discontinued temporarily, while the other continues ahead, from which exploration of the rock encountered can be made. The main drifts are timbered with sets 5 ft. apart, using 8 or 9 ft. posts and 10 or 12 ft. caps, with lagging over the back. Vertical raises, 4 ft. square and without cribbing, are put up every 50 ft. along the main drifts and carried up to the top of the ore.



Top Slicing Method—Room Two Sets Wide, Showing Bottom Covered and Sides Partly Boarded Up.



Drift Slice, Top Slicing Method

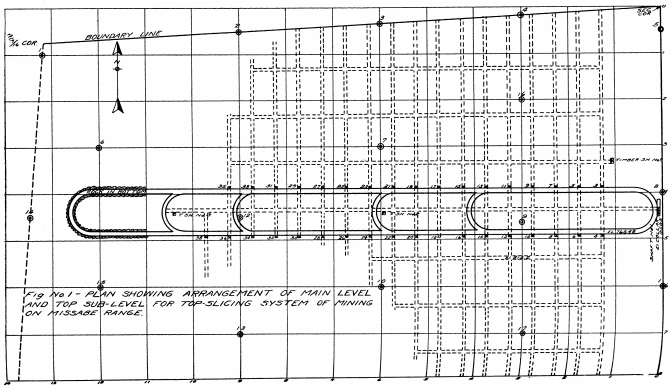


Square-Set Slicing, Room Two Sets Wide and Two Sets High.

Top Sub-Level—(See Fig. 1, which also shows plan of main drifts and raises.) The Top Sub-Level is located at such an elevation that the average height of the ore to be removed will be from 12 to 14 ft., so that most of it can he taken out with drift sets. From each raise 5 by 6 ft. drifts, untimbered, are driven parallel with each other and at right angles to the main drifts, until they reach the limit of the ore body or the boundary line of the property. Here the storing or slicing of the ore begins.

Slicing Details—Fig. No. 2 shows plan of two adjoining rooms each 50 ft. long and 15 ft. wide, opened up at the boundary line, together with a cross-section through one of them. When the boundary line was reached by cross-cut No. 1, the first drift slice was started by blasting out all the ore at set marked No. 1, and sets of timber, (12 ft. posts and 7 ft. caps), with the caps parallel with the cross-cut, put in place, using 6 ft. lagging overhead. Set No. 2, also in the cross-cut, is the next to be taken and securely timbered and spragged, thus making the entrance secure. These four sets of timber at the entrance of the two slices of a room or stope are usually referred to as the “open sets.” The first slice on the long side of the 50 ft. room is now completed by taking out sets 3 to 9. The track is continued from the cross-cut into this slice as it advances. The next sets to be taken out depend upon whether the timber is taking much weight or not. If it is not, sets 10 to 16 are consecutively mined out, completing the long side of the room. The short side of the room is now taken out in the order indicated (sets 17-18-19-20). On the other hand, if the room is heavy and timbers are taking considerable weight, the order of removing the sets must be changed. A safe exit for the miners must be maintained and it

would be inadvisable to weaken the entrance to the room by taking cut set No. 10 at this time. The slice would be worked out, from the far corner retreating toward the cross-cut. Instead of taking set No. 16 first, however, the miners make their attack on set No. 15, because it would blast out a little easier and there would be more room for them to shovel into the tram car standing on track in set 7 or 8. Therefore the sequence of sets taken out would be 15-16-14-13-12-11. Set No. 10 is left standing to protect the entrance while the short side of room (sets 17-18-19-20) is next mined out, and is the last set to be taken. This order of working out a room is not invariable, many changes being made depending on differing conditions. Under a strong back, or with solid ore on both sides of a room, the ore would be taken out two sets wide from the cross-cut back to the far end. Again, when the preceding room has not filled up solid with the cave, sets 10 to 16 would be taken first, leaving one set of solid ground against the unfilled cave, after which sets 9 back to 3 would be taken.



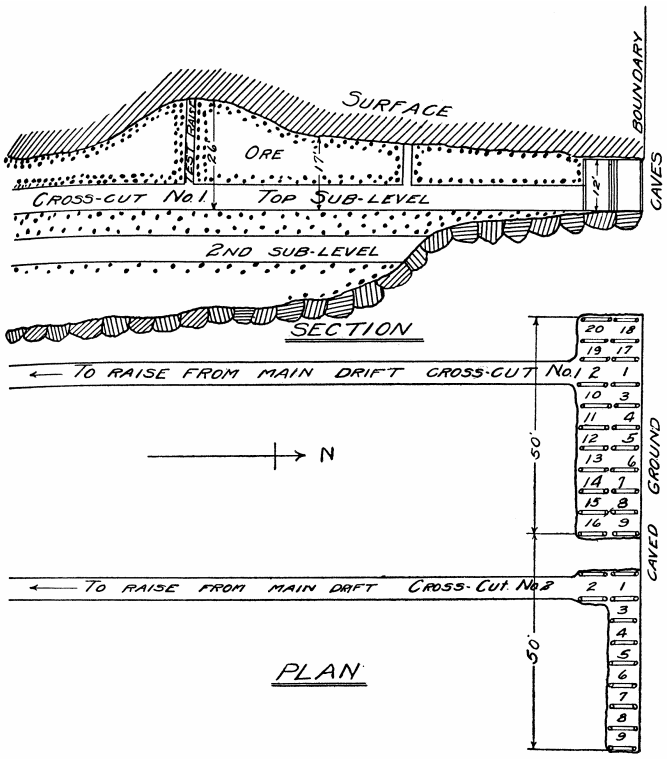


Fig. No. 2. Top Slicing on Missabe Range

The reason for having a long side and a short side to a room is that only one set of curved rails need be laid to get tram car to convenient shoveling distance for all the sets. The track is laid in only one of the slices. The ore from the short side is shovelled into car standing in the cross-cut.

When a room is worked out, the side and ends next to the solid ore are boarded up with cull boards to prevent the sand from mixing with the ore of the next room when it is mined. The bottom is also covered with boards if there is a slice to be taken out underneath. The double row of posts in the center, and those along cave side, throughout the length of the room, are blasted out and the caved ground follows and fills the room. There is usually no difficulty at this point, the room soon being filled up solid against the boards so that another slice may be started alongside after a few hours.

The height of the ore on the top sub-level varies considerably on account of the rolling back. The length of posts used in the successive slices must be changed accordingly. The limit to successful slicing with drift sets is reached when posts 16 ft. long are necessary. Rather than use such long posts to any considerable extent recourse is usually had to using square set timber, two sets high, which would take out the same height of ore.

Square-Set Slicing—In the cross-section in Fig. 2, a test raise is indicated which shows a roll in the back making maximum height of ore 26 ft. above the top sub-level. Rather than open up a sub-level of very limited area in the upper half of this roll, in order to remove the ore with drift timber, it is the usual practice to mine it all out on square-sets. The change from drift slicing to square-set slicing would begin where the height of ore shows 17 ft. The first square-set slice would he taken in the solid, that is, leaving one set of ore standing between it and the last drift-slice. This is to insure getting the line of the square sets straight and at right angles to the cross-cut. The two sets in height of this slice are both mined out and timbered as the slice advances. The pillar left standing next to the drift-slice is then mined out and timbered, the order of removal of the sets depending on whether the ground is heavy or not. The long side and the short side of the room being mined out, the side and ends next to ore are boarded up in same manner as a drift slice, except that lagging instead of boards is used on the bottom set. This is because they are stronger than boards and there is more pressure from the cave on account of room being higher. The span between sets is also greater. The rooms are blasted in as soon as the timbers show that much weight is on them which usually occurs when they are two sets wide. The blasting is done in such a manner as to leave the timber undisturbed which stands against the solid ore.

In the succeeding square-set rooms the first slice is taken out along the cave, the caps connecting with the timber of the previous room. There are usually 5 sets on one side of the cross-cut, and one set on the other, which, with the set occupying the cross-cut itself, makes the total length of room 7 sets or 51 ft. 8 in. A cap of odd

length is used in connecting timbering of rooms joining each other on their ends.

Bottom posts are 8 ft. over-all, with 4 in. tenon. Regular top-posts are 8 ft. over-all with two- 4-in. tenons. Top. posts of lengths varying from 4 to 12 ft. are used on the top set where the back is irregular. The regular cap is 7 ft long.

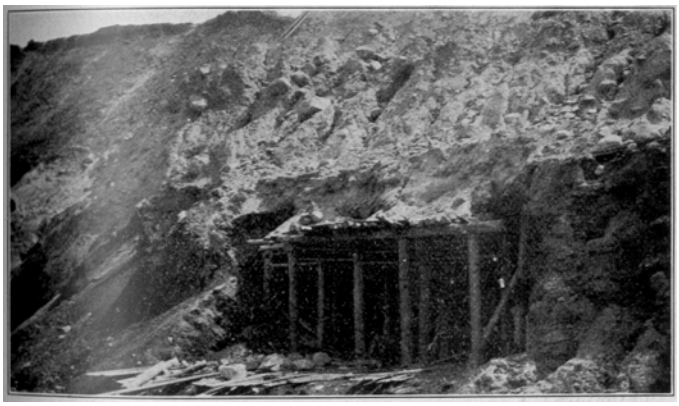
There is very little square-set slicing on the Missabe Range at the present time exceeding four sets in height. Higher than this a great deal of trouble is experienced in keeping the rooms in shape on account of the pressure of the caves. Where the ore on the top sub-level is found to exceed this height it is divided by opening up another local sub-level and mined out with drift timber.

Square-set slicing should be distinguished from the well-known square-set system of mining, where alternate pillars of ore were left standing between large square-set rooms, to be mined out after the latter were caved and filled.

Prop Slicing—There are extensive stretches of ground in many of the Missabe mines where the ore is overlaid by firm taconite or slate. In such cases the top slice can be taken out with the use of props, spaced irregularly as required. The maximum height of props used is 20 ft. Often the ore does not exceed this height and, consequently, can all be mined out in one slice. Where such conditions occur the cost of mining is considerably lessened.

Second and Lower Sub-Levels—When the ore in any part of the top sub-level has been mined out back to 20 ft. from the raise from main level drift, a second sub-level is opened up by starting another cross-cut from the raise, directly under the one above, and of the same dimensions, 5 by 6 ft. Parallel cross-cuts on the same level are driven from each raise as other places above are finished. The distance below the bottom of the top sub-level at which these cross-cuts are started depends on the total thickness of the ore down to the main level, measured from bottom to bottom. This total height is divided so that the sub-levels will be from 11 to 15 ft high. Where 11 ft. must be selected there would be 5 ft. of solid ground over the back of the second sub-level cross-cut up to the boards of the top slice above. The ground is usually firm enough so that these cross-cuts will stand without being timbered. They are driven to the boundary line or until they strike the bottom rock, when slicing begins and is carried on in the same manner as on the top slice. The rooms are timbered right up to the bottom boards of the slice above.

In conclusion, the Top-Slicing or Caving method of mining can be adapted to all conditions met with in underground mining on the Missabe Range. It is favored alike by fee-owner and operator, for in these days of rapidly diminishing ore reserves, wasteful methods of mining are no longer tolerated. In any method of mining, the safety of the miner should lie the first consideration; the conservation of the ore, the second. This system has both of them to recommend it.



Top Slicing at Edge of Leonard Open Pit.

Open-Pit or Steam Shovel Mining.

Open-pit or steam shovel mining applies to that system of mining where the ore from an open pit is loaded by steam shovels direct into railroad cars. It has been likened to loading a stockpile, beginning at the top.

The first shipments from some Missabe Range mines have been fully as simple as stockpile loading but as depth is reached, approaches, grades of incline, and lay-out of tracks to reach the various parts of the ore body require skillful engineering.

As mentioned elsewhere in this article, this system is the cheapest method and is adopted wherever it appears practicable. Recent practice shows the use of open-pit mining for ore deposits that were formerly considered underground propositions. In fact, some mines that were opened as underground propositions have been changed to the open system, notwithstanding the fact that a considerable tonnage of ore had already been removed and that stripping and mining both presented conditions less favorable than before underground mining was undertaken.

Among the mines originally operated by underground mining and later changed to open-pit methods is the Commodore Mine at Virginia. It consists of one forty and is surrounded by the Lincoln, Union, Lone Jack and Missabe Mountain properties. Seven hundred thousand tons had been mined through underground operations when it was decided to change to open pit mining. Adequate and suitable dumping grounds were difficult to obtain and to complete the stripping necessitated dumping 800,000 yds, on the Commodore forty, over one-half of which composed the stripping area of the open pit. The waste dump finally reached a height of 87 ft. and the height from top of ore at deepest stripping point to top of dump was 201 ft., showing that some of this stripping material was elevated in its transportation 201 ft., which was accomplished without going off the mine forty, except at the ends of two tail tracks where they ran on to adjoining property. The tracks from shovel to dump consisted of four switch-backs on a 5 per cent grade.

The equipment was standard gauge dump cars and Shay geared locomotives of eighty tons weight on drivers. These locomotives are slower than the rod engines but have more tractive power, particularly on starting their loads on heavy grades and curves. In mining at this property both the rod type and Shay geared locomotives are used and a comparison of the two types under similar conditions shows the rod engines more satisfactory on good tracks and low grades, but on grades over 3 per cent and particularly where necessary to start the loads on heavy grade the geared locomotives had the advantage.

Limited area, depth and shape of ore deposit, yard facilities, etc., have made conditions at this property for steam shovel mining more severe than most open pits on the Range. The accompanying map shows the surface and pit lay-out. The approach is laid cut on a 3 per cent grade which is equalized to allow for resistance on curves. During one season considerable loading was done on a 7 per cent grade, the Shay locomotives being able to start and haul three loads and the rod engines two loaded ore cars of forty tons each. A few years ago it was the practice to lay out open pits with grades not over two and one-half per cent, and with curves not exceeding twenty degrees. While it is very desirable to keep within these limits of grades and curves, nearly every mine has found it possible and necessary to exceed practical railroad conditions.

The actual loading of the ore by steam shovels is practically the same all over the Range. At some mines all the ore must be blasted in order to loosen it for better loading, while at other mines the shovels are able to handle the ore without any blasting.

Hull-Rust and Mahoning Mines, Hibbing, Minn.

Monroe Mine

Sixty to eighty-pound rails are used for mine tracks, the heavier steel being favored. The temporary loading tracks have to be changed for each succeeding shovel cut. At some mines, and especially where the loading tracks are straight and of the lighter rail section, it is the practice to jack up the track to be moved and then line or heave it over with bars. At other mines new track is laid behind the shovel and in place for the next cut, the previous track being taken up.

There are several important special features in connection with open-pit mining of which mention should be made.

At the Biwabik mine which has the distinction of being the first mine on the Missabe Range to use the steam shovel, much of the ore, a high grade Bessemer, requires crushing. Recently a new crusher of the gyratory type, with a 48-in. receiving opening, has been put in operation. It has a capacity of 1,000 tons per hour and is the largest gyratory crusher that has ever been installed.

On the western end of the range, many of the ore bodies contain layers of fine sand, lean ore and broken taconite which must, be separated from the ore in order to make it merchantable. After several years of experiment a large concentrator was erected on the east side of Trout Lake, at Coleraine, by the Oliver Iron Mining Company, which has been in successful operation since 1909.

The Wisconsin Steel Company erected a concentrator at Nashwauk, consisting of two units, which began operations in 1912.

At the Leonard, Shenango, Commodore and some other pits, low grade material containing 35 to 49 per cent iron is being stockpiled. This material is unmerchantable at the present time and being mostly paint-rock it will probably not yield to concentration.

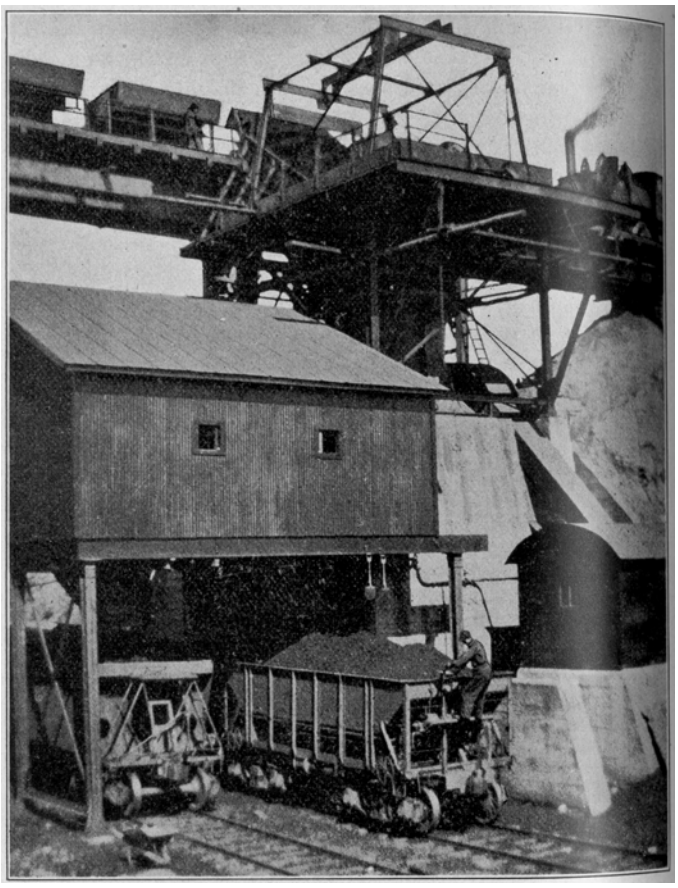
At the Brunt mine, at Mountain Iron, a drying plant is in operation for removing the excess moisture from the ore. The moisture is being reduced from 18 to 20 per cent down below 8 per cent, resulting in considerable saving in freight charges and rendering the ore more acceptable to the furnacemen.

Another drying plant is in course of erection at the Whitesides Mine.

Milling System of Mining.

The Milling System is adapted for mining of the ore from deposits favorable for stripping but where the size of the deposit, or its location, is such as to make it impracticable to mine as a steam shovel proposition.

The relative depth of surface and ore, or rather the relative proportion of over-burden to be removed to the amount of ore uncovered, the size and shape of the ore deposit, the space and facilities for trackage approaches, and relative outlay for equipment and development, are the determining factors for choosing between the milling and steam shovel methods. What is termed the “Milling System” on the Missabe Range is in reality a form of what is termed “Underhand Stoping” on the older ranges, and the development is by shafts, tramming levels, etc., much the same as in underground mining. The overburden is removed from the surface of the ore which permits of the use of underhand stoping by working the ore into chutes, from which it is drawn out on the tramming levels and handled in the same manner as in other underground mining systems.



Crushing Plant at the Biwabik Mine.

In opening up a proposition on the Milling System, the area to be stripped, the stripping approaches, location f shaft, shaft house, tracks and mine buildings are decided upon. The work of stripping or removing the overburden is usually the first work started, and while this is progressing the working shaft is sunk, tramming levels opened up and raises driven to the top of the ore deposit. Raises are usually 4 by 5 ft. or 5 ft. square, and are put up at intervals of from 30 ft. to 40 ft., and are equipped with chutes at the bottom. When ready to start mining, milling or underhand stoping is started by drilling holes around the tops of the raises and blasting them so that their burden will fall into the raises. After blasting, the loose dirt is usually picked down or loosened, or at least as much of it as will readily run into the raise, after which blasting is again resorted to. It is customary to drill what are usually called collar holes first, and then carry the slope up the bank by successive blasting and picking down the loose dirt as long as it will run into the raises. The Missabe Range ores are of such character as to break up quite fine and run readily at an angle of 45 degrees, and in dry weather the ore will run on a slope of 38 degrees. Results are best after the mills or funnels have been enlarged, and the larger the mill the better. When blasting large quantities of ore, and particularly when starting mills, the ore from the blasted holes falls to the bottom of the raises with such force that it often packs so hard that it will not run out of the chutes, and causes what is termed a “hang-up.” This necessitates the use of chute bars to loosen the ore and get it running. It often happens that the ore continues to hang tip higher than can be reached with bars, when other means must be employed. At the Monroe mine where the raises were very high, a system of sub-drifts were driven above the working level, connecting all the raises. This plan gave an opening for barring a hang-up raise through openings in the lagging or raise cribbing. At the Albany mine the main level drifts were made two sets high opposite the raises or chutes. This permitted the use of longer bars and facilitated the process of barring. At the Iroquois mine they placed a chain or wire rope through the raise, and when hung up the rope or chain was pulled up by a small hoist and pulled down by a number of men standing on the level.

Jordan Milling Pit, 1903.

At the Jordan Mine the trouble with hang-up raises was obviated to a large extent by working down to the back of the tramming level the first two mills, and after that the raises were holed through into the sides of the slopes. The raises being from 30 to 40 ft. apart would hole through into the milling slopes when 30 to 40 ft. high. The first raises were 85 ft. high and caused a great deal of trouble with hangups. The subsequent raises being from 35 to 40 ft. high were much freer from hang-ups than the longer raises. By starting milling on the lower sides of the raises where they holed through into the slopes, the distance from the collar of the raise to the chute was seldom over 30 ft., and a hang-up could be broken down by barring or drilling from the top, if the trammers failed to get it running by barring from below.

Another plan adopted to some extent was to make the raises larger at the bottom and tapering upward, but the construction of the chutes permits the ore to accumulate back in the corners and the raise openings soon become smaller. While the hang-ups occur from the impact of the falling burden, resulting usually from blasting into the raises, the trouble from this source is contributed to by

the raise opening becoming smaller and smaller, from moist ore accumulating and caking quite hard all around the raise. From time to time it is necessary to clean out the sides of the raises for a distance above the chutes.

The production by the Milling method is usually irregular and varies from day to day, being influenced largely by weather conditions, as well as by the steadiness of the labor employed. During a spell of nice weather and with full crew of men, the daily production may be at the maximum, but a heavy rain drives home the men working in the mills and washes out the slopes, making holes and gullies in the mills, and blocking the chutes with loose ore and water. If much water collects in the mills and chutes, any attempt to open and draw the chutes results in a rush of sloppy ore and water, filling the level and necessitating cleaning up before tramming can be resumed. If the chutes are opened up more than two or three inches there is no closing them if the rush starts. In addition to the chute and level trouble, the slopes in the mills are so uneven and irregular that for several days much of the ore that is loosened by blasting or picking down, fills up the holes and gullies instead of running into the chutes. Dry ores naturally run much better in the mills than wet ones, and some ores that would run readily on a 45 degree slope during dry weather become soaked and will scarcely run on a 50 degree slope when wet.

When the mills are worked down close to the back of the level, short raises are put up in the ridges and much of the remaining ore is milled in that way. At some mines steam shovels have been used to dig the ore in the hog-backs or ridges and drop it into the mills. This process, was further developed, using the steam shovel to load the ore into cars which were either dumped direct into the skip pocket, or through a transfer chute and then re-trammed to the shaft. The Milling System is also used for the lower parts of ore bodies opened up for steam shovel mining, when the depth renders the use of locomotives impracticable. This system permits the recovery of all the ore, is more economical than underground mining and is, perhaps, a little safer. It is subject to the accidents incident to the limited underground work and blasting in the open, but the greater danger is from men being carried into chutes by slides. This is guarded against to some extent by the use of ropes.

The Milling System has been used at the Norman, Auburn, Fayal, Adams, Sharon, Jordan, Albany, Monroe, Duluth, Leonard, and a few other mines.

WASH ORES OF WESTERN MISSABE RANGE AND THE COLERAINE CONCENTRATING PLANT.

BY JOHN UNO SEBENIUS, DULUTH, MINN.*

CHAPTERS.

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Illustrations:

Exhibits, 1 Map showing the location of the Coleraine Washing Plant with reference to the mines in the district, from which, the crude ore for this plant is obtained.

2 Typical Cross Section of Western Missabe ore body.

3 Vertical section of Coleraine Washing Plant.

4 Flow Sheet of Coleraine Washing Plant.

Exhibits, A, B and C:
Photographic reductions, respectively of, early experimental washing plants at Arcturus, Holman and Trout Lake—(Oliver Iron Mining Company.)

Views, Photographs Nos. 1 to 13 inclusive, showing outside view of Coleraine Plant itself and the Electric Sub-Station.

Photographs 14 and 15, showing exterior and interior views of Power Station.

Photographic reductions, respectively of the Power Plant and the surface water supply line.

Before entering into a discussion of the so-called wash ores of the Western Missabe Range and their treatment as practiced in the Coleraine washing plant, it seems best, for the better understanding of the occurrence and character of the ore, and of the various problems presented in its treatment and the construction of the concentrating plant first to refer briefly to some of the geological facts concerning the formation of the ore.

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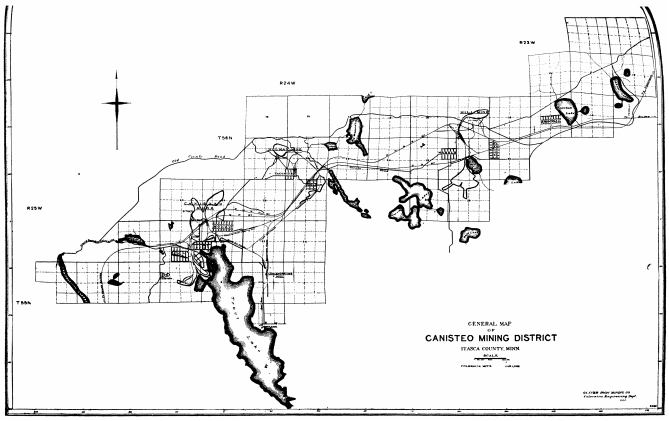
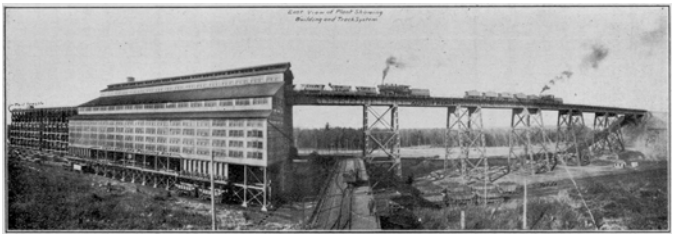
GEOLOGY.

Briefly, the iron formation on the Missabe Range extends for a distance of 125 miles having an approximate average width of about two miles. While the actual ore areas on this range are of considerable extent, they occupy only a small percentage of the total area. Recently, very complete investigations, both as to the occurrence of the ore and the process through which it has been developed, have been made by men engaged for this work by the various mining concerns and the United States Government.

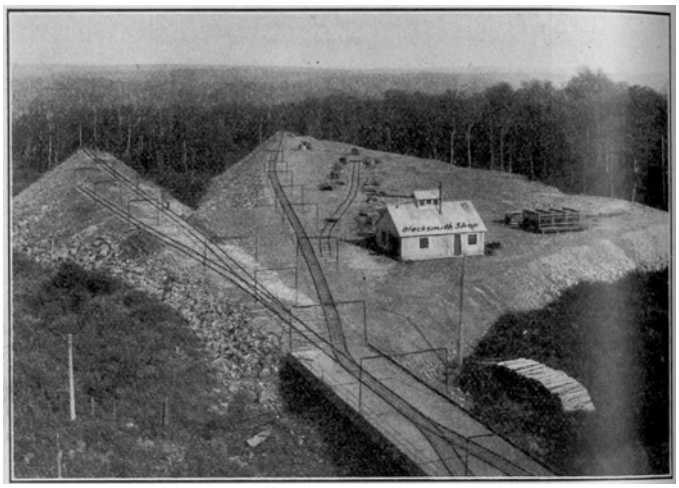


These investigations have shown that almost the entire iron formation such as seen today on the Missabe Range has been developed through a process of leaching of a hydrous iron silicate known as "greenalite." Where his process of leaching and subsequent enrichment was most effective, the result is our high grade merchantable ores; but where conditions for this process of change and disintegration were not entirely favorable, nature did not carry out its work to completion. Hence on the Missabe Range we find gradations all the way from the original "greenalite" as the extreme on one hand to- the high grade ore on the other. The conditions affecting the efficiency of the process for the time it prevailed were largely such as offered the underground waters, which acted as the main agency in this important change, opportunities for perfect percolation and circulation. In viewing the Range with these conditions in mind it seems that over the eastern portion, extending from the eastern limit as far west as a mile east of the D. & I. R. R. R. track, conditions were evidently not favorable for a perfect change, and we therefore now find a hard lean iron formation practically barren at present, as far as known today, of merchantable deposits of any size, together with some lean silicious material; whereas in the middle portion of the Range, extending over an area lying approximately between Sec. 22, 59-4 and the center of Sec. 23, 57-22, we find merchantable ore bodies of large size occurring in a rich largely altered formation, together with a considerable amount of low grade merchantable and non-merchantable silicious ore material as a connecting link between the formation itself and the high grade ores. Again, on the western end of the range, extending from the central part of Sec. 23, 57-22 to about twenty miles west of the Mississippi river, the same altered iron formation occurs as in the central portion, and in it similar large ore areas, but here, instead of the merchantable ores, the non-merchantable silicious ores predominate, and in these ores are large quantities of a great variety of the altered material resulting from an incomplete process of disintegration and enrichment.



Therefore, instead of the clean-cut features of a standard Missabe ore body, we see here a small amount of merchantable ore underlaid or surrounded by every derivative of the "greenalite" formation, and in some instances masses so great that they form veritable rock beds, layers and islands in this silicious ore material. Thus we find here extensive deposits of taconite lying above, within and under the ore material. These layers of silicious material within the deposit are divided from each other by a rather large body or zone of more or less clayey and sticky paint-rock material which was originally a layer of slate occurring in the original deposit.

As a further complication, there was found in the drilling, right under the surface and on top of some of the large ore areas, an entirely different deposit of ore material. This was afterwards found to be a cretaceous deposit containing fossils of various kinds and an ore material generally, of high phosphorous content.



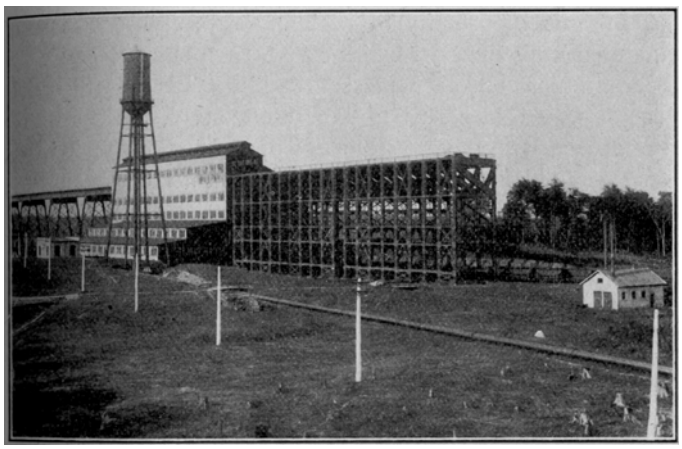
Rock Dumps and Track Arrangement Connecting Same With the Plant.

STRUCTURE.

After these ore areas had been explored and determined and it was thought that possibly the ores were suitable for concentration it became necessary to make a classification of the various materials encountered with a view to arriving at the physical structure of the deposits:

(1) in order that mining methods could be worked out adapted to the sizes and conditions of the ore bodies; (2) in order that machinery suitable for handling these possible wash ores might be constructed or found.

On account of the fact that churn drilling had to be resorted to in exploring these ore deposits, which method of drilling destroys the physical structure of the layers or ore material encountered, and since in addition to these results of drilling we had only a few shallow test-pits and shafts mainly on the Arcturus property to work from, it was at first very difficult to get at the structure; but this was finally worked out and I attach hereto a section showing substantially the structure of these Western Missabe Range ore deposits. The reader will note in the center of this section the large paint rock layer separating the masses of ore material into two layers or zones. Each of these zones is a separate member of the formation, divided by the paint rock layer referred to above, and in these zones occurs the silicious wash material, generally speaking, in layers; and where of a standard character, made up of large and small pieces and grains of high grade ore arranged in seams alternating with seams of fine sand. Interbedded in these standard wash ore areas, however, are layers of hard taconite and all the other gradations of material encountered, varying from hard taconite to material so soft that it can be crushed in the hand, in fact derivative layers of the original material referred to above. Over it all lies a deposit of cretaceous ore material and over this again the overburden or surface material, consisting of clay, sand, gravel and boulders.



West View of Washing Plant Showing Tail Track, Water Supply Line and Tank; Electric Sub-Station.

MINING METHODS.

After the physical structure of these ore deposits was known it became apparent that the only way they could be attacked commercially was by the open-pit method. This method, after the overburden had been removed, would afford us (1) the opportunity to stockpile or otherwise dispose of the cretaceous material which had been found unsuitable for concentration or other present day methods of treatment; (2) it would enable us to have the exact conditions of the ore deposit before us at any stage of the work; (3) it would enable us to handle to the best advantage the large quantity of ore material which could be treated; (4) it would afford us opportunity to sort out the waste material varying in composition and structure and entirely unfit for concentration lying within the wash ore zone, from the material remaining for concentration within that same zone.

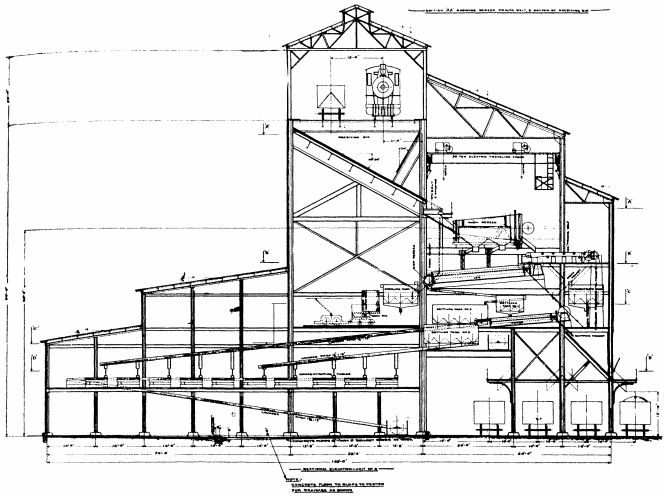
MAIN POINTS BEARING UPON THE COMMERCIAL UTILIZATION OF THE WESTERN MISSABE SILICIOUS DEPOSITS.

In approaching the problem of utilizing commercially the ore material from the vast deposits developed, we were confronted with the following conditions and facts:

First—A very heavy overburden as compared with the depth of the available ores or the ores directly and easily amenable to concentration.

Second—The occurrence very generally of a more or less thick layer of cretaceous material which was unmerchantable and further unfit for present methods of concentration, but which on the other hand, could not be wasted, as it carried considerable iron, and therefore must be removed and stockpiled at a considerable expense.

Third—Although there were in these deposits large tonnages of ore amenable to concentration, there was also found with them a large quantity of material entirely unfit for concentration, rough and hard in character and so large in size that it had to be sorted out either by hand or machinery, as the occasion would demand, at a considerable expense over and above the ordinary method of handling and disposing of such material.

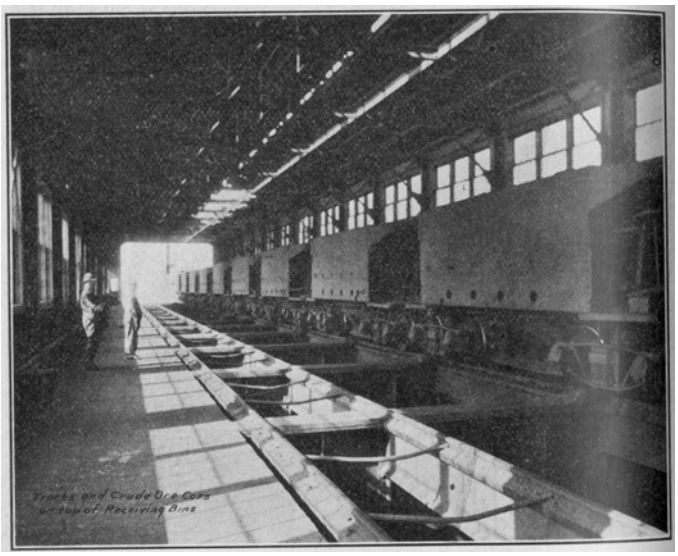


Section AA Showing Screen, Picking Belt, and Bottom of Receiving Bin.

Fourth—Furthermore, in this material, in and between the layers of standard wash ore, there occurred a vast quantity of material which was neither washable ore nor hard rock, in fact, consisting of every gradation possible between these extremes, and which could readily be sorted out. On account of its character and occurrence

we were confronted not only with the necessity of handling this material and the expense connected therewith, but were forced to so construct our plant that a considerable portion of this could be advantageously dealt with in the mill operation. This particular requirement for the mill meant a high degree of strength, ability and efficiency in the machines selected.

Fifth—Whereas most of the ore in the washable material was rather coarse, there was nevertheless quite large amount of fine rich ore which on account of its exceeding fineness was not diserable from a furnace standpoint but which nevertheless had to be saved as it already had borne a share of mining and transportation expenses, and for economical reasons alone could not be wasted when once delivered to the plant.

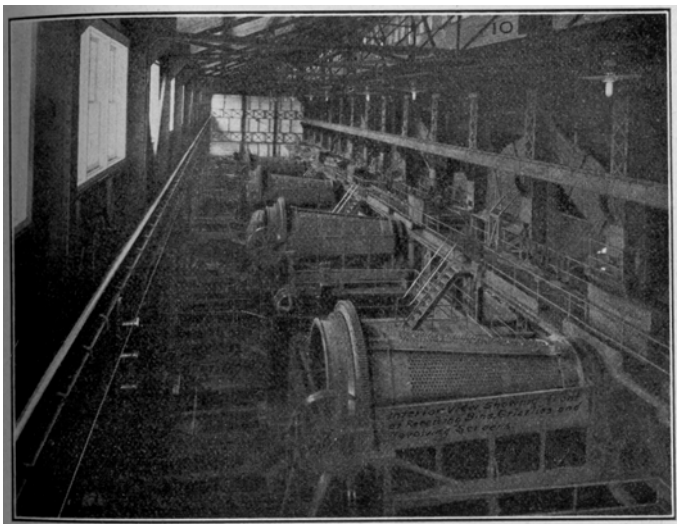


Tracks and Crude Ore Cars on Top of Receiving Bins.

Sixth—The occurrence of the above mentioned paint rock. This material, having been derived from an original slate layer, was in its nature stickey and difficult to handle, when wet, contained a considerable amount of moisture, and was not amenable to concentration; but on the other hand its chemical composition was such that portions of it could be shipped direct, while the remaining portion, which had to be removed to get at the underlying wash ores, could not be wasted and had to be stockpiled at some additional expense, because this material at some future day might become merchantable.

Seventh—Practical economic and lease conditions demanded a large tonnage, much greater than generally had been handled up to that time by mills elsewhere in the country.

Eighth—Large areas required, with extensive track systems to provide for the disposition of great quantities of overburden to be removed and for the stockpiling of low grade material not amenable to concentration.



Interior View, Showing Front of Receiving Bins, Grizzlies and Revolving Screens.

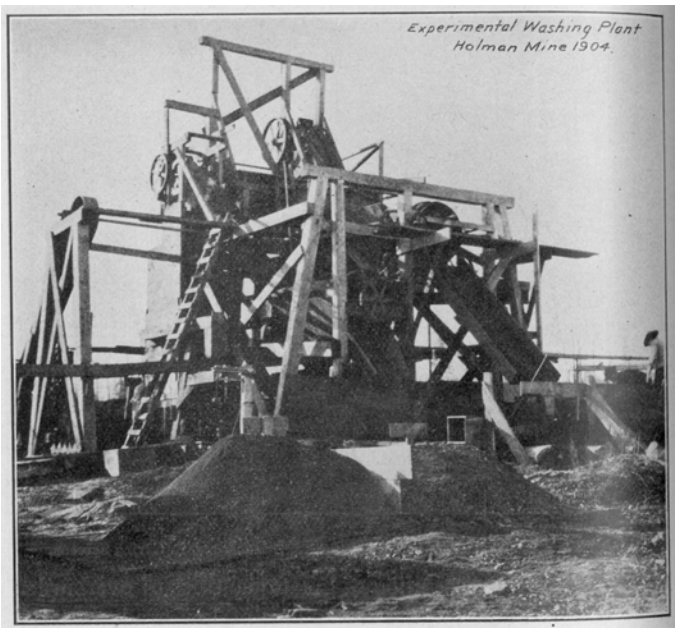
Concentration of the Western Missabe Silicious Ores.

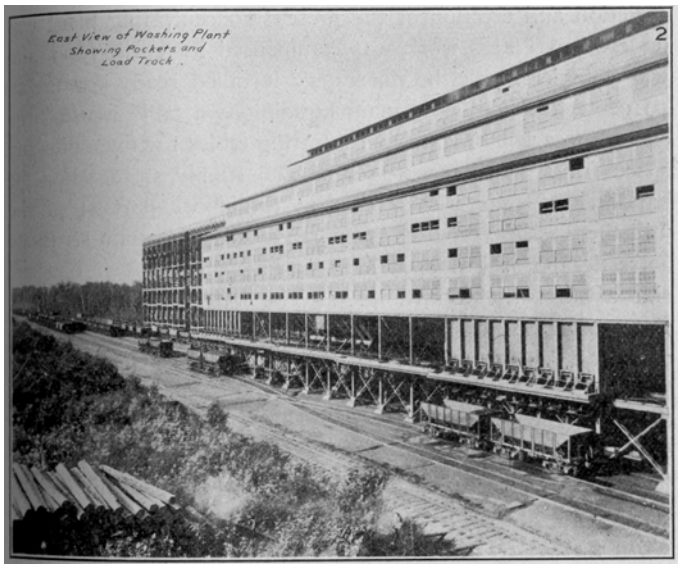
In 1901 and 1902 Mr. Walter Barrows, Jr., Mr. Chas. A. Purdon and associates, after obtaining certain exploration data from, the Arcturus property, and additional information by drilling, desirous of ascertaining whether this ore was amenable to some sort of concentration, sent a car-load of ore to Cedartown, Georgia, or treatment. The result seemed so satisfactory that they installed on the property at their expense a small concentrating plant consisting of conical screens and a set of McLanahan jigs. In 1903 and 1904 a small plant (see photo) of somewhat similar construction, but without jigs, was installed and operated at what is now known as the Holman mine, by Mr. Congdon and associates. While these two smaller plants clearly indicated that something could be done at least with some portions of the vast ore bodies contained in the district, they also showed that these screens and jigs would not meet the requirements, first on account of the variety of material to be treated, and second on account of the large quantities that had to be handled. For this reason the officers of the Oliver Iron Mining Company appointed a committee to make a thorough study of the concentration problem here presented, ascertain what was done elsewhere, and if possible find machinery which would meet the requirements.

After due consideration of all the facts and after an extensive trip over the western and southwestern portion of the United States the commission prepared its report recommending a scheme which seemed to them to offer a solution of the problem in hand.

As suggested by the committee an experimental plant was decided on and erected in 1906 in the vicinity of the Canisteo deposits. (See photo.) In 1907 and 1908 experimental work was conducted in this plant with the machinery originally installed as well as with additional different concentrating machines which from time to time

were tried out at the suggestion and request of manufacturers.





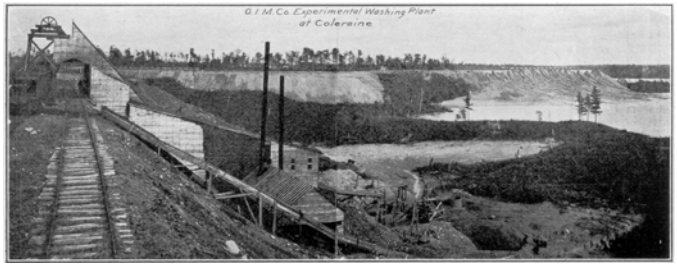
After a long, expensive and exhaustive investigation, and compilation and study of the results obtained, it was conclusively proved, 1st, that these ores could 'be economically and successfully treated and on a large scale made to render a merchantable product of a good desirable physical structure; 2nd, that machinery substantially such as suggested by the committee with some changes and improvements would successfully treat these ores.

TROUT LAKE CONCENTRATING PLANT.

(A) MAIN BUILDING AND SERVING TRACKS.

With these and other facts and data at hand the construction and erection of the present concentrating plant was undertaken. This work was commenced in April, 1909, and was complete with the machinery installed ready for use in 1910. Attached to the main building is a table house large enough to accommodate concentrating tables for five units and space for a small machine shop and supply store. For the handling of the railroad cars in the upper portion of the mill there is provided on the north side of the main structure a trestle approach 650 ft. long, and on the south or opposite side a tail track 300 ft. long. The latter is so constructed as to permit its being incorporated directly in a possible future extension of the plant. The building, viaduct approach and tail trestle, as well as the table house, are constructed of steel, the total amount used being 6,100 tons. The building is covered by corrugated steel sheeting over 2x6 in. wood sheeting fastened directly to the structural steel. The north end of the trestle approach is connected with the main road-beds forming the track system for delivery of the crude ore to the plant over an embankment of a maximum height of no feet containing over 2,000,000 cu. yds. of dirt. On the east side of the building is arranged a system of concentrate tracks connecting with ample storage yards for both loads and empties. The delivery tracks over the crude-ore bins are 90 feet above the tracks receiving the concentrates.

While not intended for winter operation, the mill building is equipped with a high pressure heating system, the steam for which is supplied by a small boiler plant located in the immediate vicinity of the mill.



All inside wiring is placed in conduits. A traveling crane electrically operated over a track extending the entire length of the building provides for handling the heavy machinery.

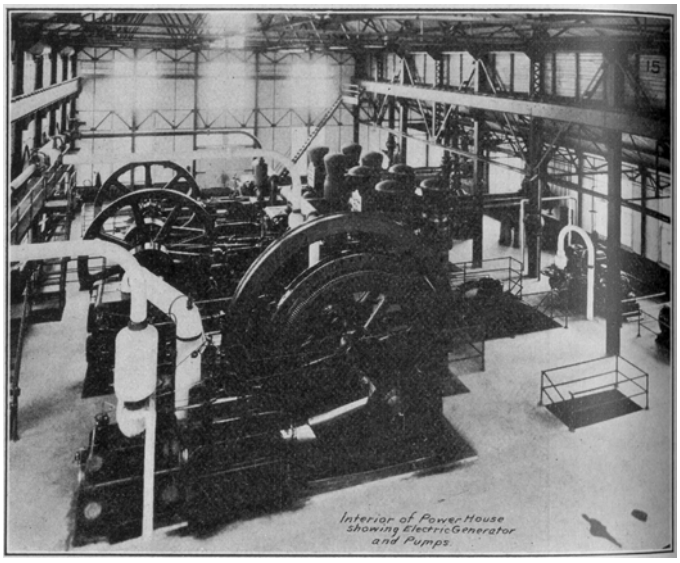
(B) POWER PLANT AND TRANSMISSION.

The power plant of the mill is located on the shore of Trout Lake, 7,000 ft. distant from the main mill building. Clear water could not be obtained nearer the mill on account of the tailing discharge into the lake.

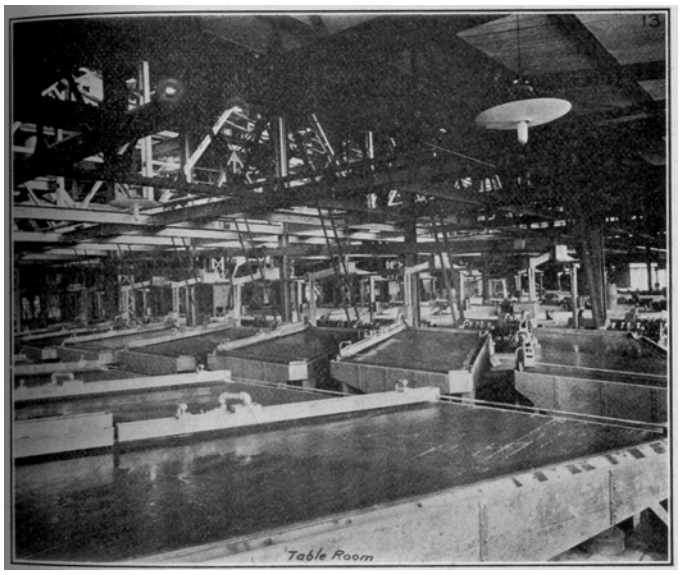
Boiler House—The power is generated in a battery of six, 72”x18', horizontal return tubular boilers housed in a building with a 120x53 ft. steel frame, brick nogged and covered with corrugated steel. Draught for these boilers is obtained through a chimney of hollow radial tile 150 ft. high.

Engine and Generator House—This building is of the same general construction as the boiler house, size 82 by 132 ft. In it is housed one 26x52x48 in. horizontal cross compound Reynolds Corliss engine, direct connected to a 1,250 kw. 3-phase 60-cycle alternating

current generator producing a current at 6,600 volts, equaling 1,675 horsepower.

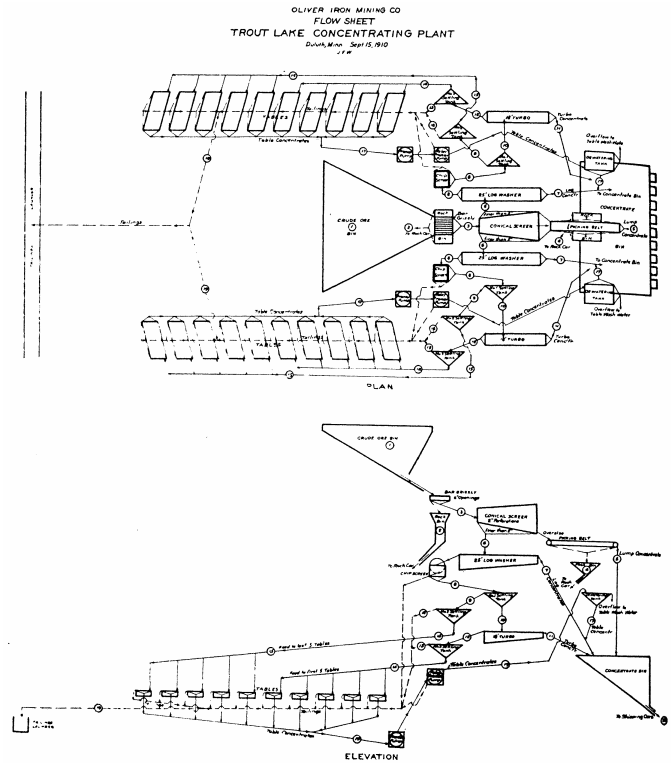


In this building are also installed two 26x52x48 in. Prescott compound pumping engines, of the fly-wheel type, each with a 24-hour capacity of 10,000,000 gals., total lift being 240 ft. Each of these pumps is capable of furnishing the water necessary to operate the mill. As the five concentrating units contained in the mill described require individual consumption of 1,300 gals., per min. per unit, the power requirement of each pump is about 400 horsepower.



The electric current generated is transmitted over surface lines to a transformer station located near the mill, where its pressure is stepped down to 440 volts—the working pressure required for the plant. Power transmission in the mill is so arranged that each working unit and the main group of machines in the units themselves are independently operated by commensurate motors. All buildings are electrically lighted.

Water Supply—Water is obtained from the lake throng a 40-in., 400 ft. long, steel intake pipe and is conducted through a 30-in. lap-welded steel pipe to a 100,000 gal. cylindrical steel tank at the mill. The water pressure on the various floors of the mill varies from 20 to 75 pounds per square inch.

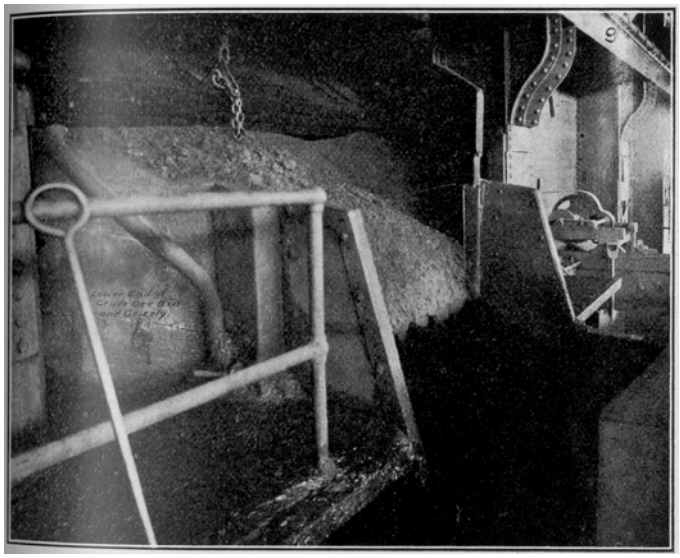


(C) CONCENTRATING MACHINERY AND APPLIANCES.

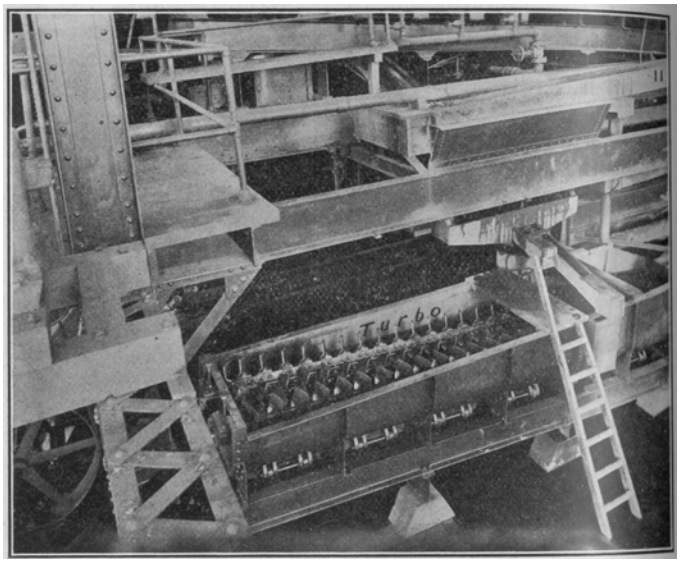
As the mill stands today the plant contains five independent units and appliances. Each individual unit is made up of two half units which are dependent on one another only in bin and screening capacity. This arrangement was adopted to prevent delay in the entire mill and in each separate unit—should break-downs occur. Installment of individual units was necessitated by lease conditions requiring that ore from each property be handled separately. All units are entirely similar in construction, but were installed at various times, the first and second units being erected in the spring of 1910, the third in the fall of the same year, the fourth and fifth completed at the beginning of the season 1911. Precaution was taken to eliminate from the mill construction all light and unreliable machinery such as link belts, chain elevators, conveyors and automatic feeding appliances.

Each individual unit is made up as follows: At the top of the mill and directly under the crude ore tracks, for each unit there is a receiving bin with a capacity of about 500 tons crude ore. At the discharge end of this receiving bin is a grizzly—steel rails spaced 12-in. centers—and also a hydraulic nozzle connected to the water system. Under the grizzly is a rock pocket. The hydraulic nozzle is capable of discharging into the recovering bin at the direction of an operator, a heavy stream of water under a pressure of 33 pounds per square inch. The bin extension under the grizzly is through an apron directly

connected with one conical, revolving screen or trommel having 2-in. perforations. Passing through the center and along the entire length of this trammel is a spray pipe. The size of the trommel is: Length 20 ft., diameter at the small end 4 ft., at the larger end 8 ft.

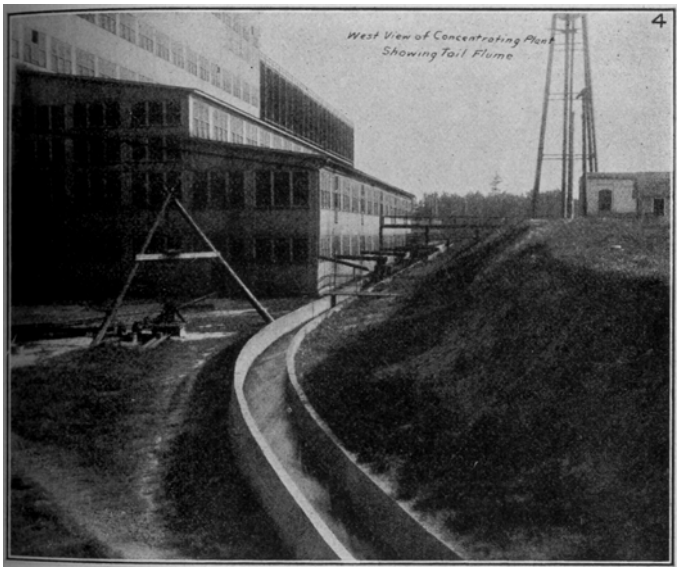


Lower End of Crude Ore Bin and Grizzly

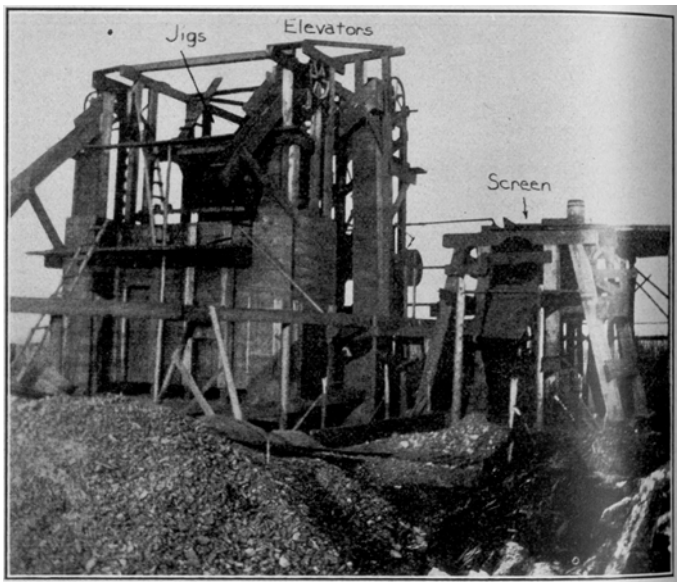


Turbo.

Directly below the large end of the trommel is placed a conveyor belt 36 in. wide and 20 ft. long to- take the over-size material from this screen. Directly below the trommel is constructed a bin or junction-box divided into two compartments into which falls the under-size material. On each side of this bin and below the same and at proper distances and elevations are placed two log washers each taking one-half of the undersize material delivered into the junction box from the trommel. The size of these log washers is: Length 25 ft., width 6 ft. 8 in., depth 3 ft. They are placed at an incline of 1 in. to the foot, and are each provided with twin logs with chilled cast iron paddles. Their bottom is constructed so as to provide for three hutches covered with perforated steel plates through which a strong current of water under a pressure of 50 lbs. to the square inch is forced. The waste material coming over the overflow end of the log washers contains chips, waste and other material, and for this reason a chip screen has been placed directly behind each log washer. Directly under these log washers are placed three steel settling tanks, Nos. 1, 2 and 3, at different elevations. Located directly under No. 1 tank on each unit is placed one smaller log washer locally known as a "turbo." The size of these turbos is as follows: Length 18 ft., width 4 ft, depth 1½ ft. These turbos are of the same general construction as the larger log-washers, being provided with a rising water column forced under pressure through hutches and hutch-plates.



The tanks above referred to are "V" shaped. Tank No. 1 is 5 ft. in width by 8 ft. in length and 4½ ft. deep. Tanks Nos. 2 and 3 are 6 ft. in width, 16 ft. in length and 5½ ft. deep. All are provided with spigots for the discharge of the accumulated material.



Arcturus Experimental Washing Plant, Front View.

In the table house at some distance below these three steel tanks are located four batteries of five Overstrain

tables, arranged in two parallel series. Each of the twenty concentrating tables is 14 ft. in length and 6 ft. wide along end lines, and is provided with riffles, which on some tables are constructed of wood and on others of rubber.

To convey the table concentrate from the table house, two 54-in. Frenier spiral sand pumps are installed in each one-half unit. These pumps discharge into a de-watering tank located immediately above the bin into which is assembled all the concentrate from all machines constituting the unit. This de-watering tank is also of steel "V" shaped, top width 7 ft., length 12 ft., and depth 5½ ft.

The conveyor belt above referred to is known as the "picking belt." On each side of it is located a steel chute leading to what is known as a "rock pocket" made of steel. This discharged into cars below. These cars are hauled by an electric locomotive to a rock dump a short distance beyond the confines of the plant, over a track system overloading the main shipping tracks on the east side of the plant.

The concentrate receiving bin is large enough to accommodate the entire unit, built of wood and lined with steel plates, and has a capacity of about 90 tons. This receiving bin is provided with discharge lips through which this concentrate passes into railroad cars on the tracks below.

The following arrangement gives the power distribution for the unit: One 100 h.p. motor is used for driving the cone-shaped trommel, two log washers and two turbos. One 15 h.p. motor is used for driving the concentrating table and chip screen. One 20 h.p. motor drives the four Frenier pumps serving the unit.

The concentrating equipment in each unit thus includes:

One receiving bin.

One grizzly.

One conical screen.

One belt conveyor, or picking belt.

Two 25-ft. log washers.

Two 18-ft. log washers.

Six steel settling tanks.

Two table wash-water tanks.

Twenty Overstrain concentrating tables.

Four Frenier pumps.

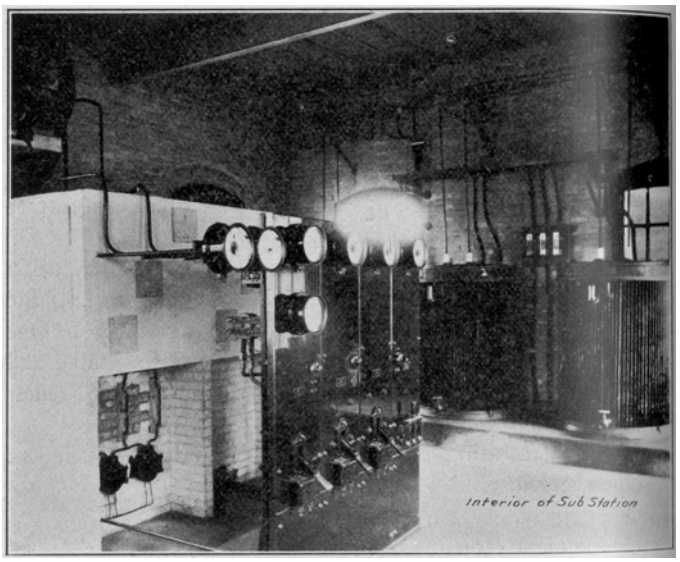
Two steel de-watering tanks.

Two rock pockets.

One concentrate bin.

PROCESS OF CONCENTRATION.

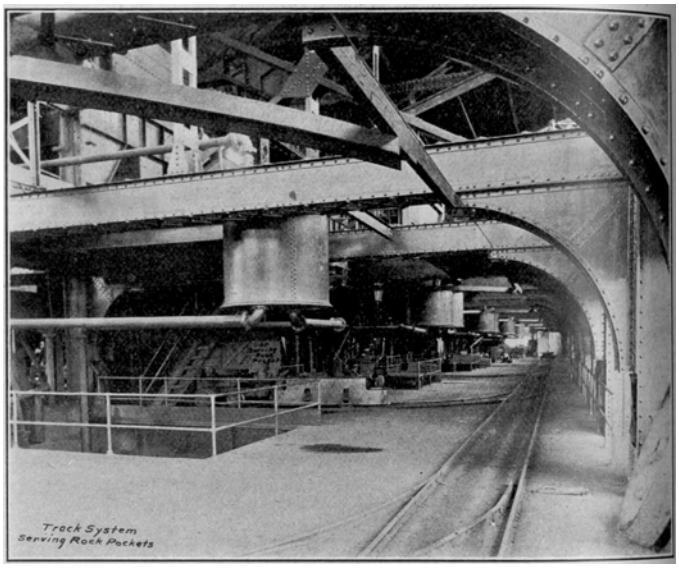
At the mines the crude ore is loaded directly into hopper cars of an average capacity of 40 tons of this material. The cars are of pressed steel, of Sommers and Pressed Steel Car Company design. Train loads of these cars are hauled over the receiving tracks and over the viaduct approach to the top of the mill and there dumped directly into the receiving bins. In these receiving bins the ores are attacked by a stream of water from the hydraulic nozzle above referred to and sluiced down through the opening in the lower end of the bin over the grizzly bars, which eliminates the larger pieces of taconite included in the shipment. This rock is raked from the top of the grizzly by hand into the rock pocket provided for each unit. The material passing through the grizzly is conducted over the connecting' apron into the revolving trommel. The over-size material in this trommel advances through it and is in passage subjected to a thorough rolling and rubbing process as well as a heavy spray of water from the spray-pipe arranged for this purpose. After being thus abraded and washed off, the content of this trammel passes on to the picking belt provided in front and is here hand sorted. The rock material is thrown into the chutes leading to the rock pocket whence it is loaded into cars and by an electric locomotive hauled to the rock dump. The coarse material remaining on the picking belt falls directly into a steel chute which conveys it to the concentrate bin immediately below. The material obtained is known as belt product and consists of lump ore concentrate of sizes larger than 2 in.



The material passing through the conical screen or trommel falls directly into the underlying junction-box, half of the material going to each of the two log washers provided on other side of this junction-box. In these log washers the material is subjected to a combined stirring and abrasive action produced by the paddles of the twin logs revolving therein, in water which enters the log washer under pressure through the three bottom hutches. This introduction of water under pressure into the bottom of the log washer is a decided improvement

over earlier constructed log washers, and is an important provision in that it prevents dead material from lying at the bottom of the box, assists in the thorough stirring and washing of all the material passing through the machine, and gives life and activity to the entire operation. The action of the log washer in this process is that of a large, efficient, ever-ready classifier-concentrator and disintegrator. By stirring effect of the paddles, the friction between them and the pieces with which they come in contact, as well as between the pieces themselves in this ever-moving mass under strong water action, all the more or less disintegrated pieces are broken up into their component parts—grains of sand and pieces and particles of ore.

In the operation the heavy flow of water introduced into the machine, both with the material itself as well as from the bottom, carries the sand towards and over the tail-board at the lower end of the machine. The heavy material, on the other hand, consisting largely of iron ore varying in size from 2 in. to grains, is forced by the action of the paddled twin logs towards the raised or upper end and there discharged as log product into the concentrate-receiving bin.



The overflow from the log washer is then passed through the chip screen for the purpose of removing pieces of wood waste and other foreign substances. From the chip screen the material is led into what is known as the first set of settling tanks, one on each side of the unit. The heavier material is allowed to settle and the spigot product is fed to the two turbos below.

As stated before the “turbo” is similar in construction to the large washer, but smaller. The operation is also similar.

The overflow from the settling tanks is passed into a second pair of tanks. The overflow from these is carried out of the mill and the spigot product is conveyed into the table room and there distributed over two sets of five Overstrom tables, each set serving one tank.

The concentrate obtained in the upper end of the turbos is fed directly into the concentrate receiving bin of the unit. The overflow from the turbos is passed into a third pair of settling tanks. The overflow from these is passed out of the mill. The spigot product is carried into the table house and there dealt with in a manner similar to that in which the spigot product from the second pair is handled.

The concentrate from the twenty tables serving each unit is conveyed through the four Frenier pumps serving the unit into the de-watering tank, the spigot product of which falls directly into the concentrate receiving bin beneath.

All tailings from the settling tanks and tables are discharged into Trout Lake below the mill through a 4-ft. wood bottom concrete flume.

Safety Devices.

The great amount of thought which has been put into safety devices, and the minute detail into which those in charge have gone, make impossible complete description in a paper of this kind. Therefore only the more prominent features will be described, and perhaps the most simple course to follow will be the one most commonly used, that is, the route of the ore.

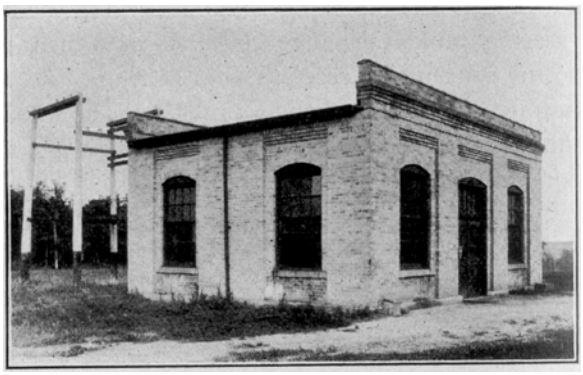
The first application of a safety feature is in preventing the crude ore from falling through the approach trestle from the cars to the ground. The great height of this trestle would make an injury from this source very serious. This is prevented by a decking which also eliminates danger of fire from the sparks of passing locomotives. A structural steel hand-railing extends the entire length of the trestle on both sides and is supplemented by a toe-board at its bottom.

Within the building, at the receiving bins, the most apparent features are, first, the peculiar arrangement of railings and walks which compels the workman unconscious to guard himself from passing trains, and second, the covered stairways and landings by which the sluicer helpers are enabled to work beneath the tracks with safety and freedom.

Within the mill proper, at a point where the ore is washed from the bins into the revolving conical screens, are placed large heavy hinged, gate and a stationary wall which serves as a sort of breastwork in front of the sluicer. The stationary walls afford the worker safety from sudden slides of ore while sluicing, and the hinged door protects him from the same danger when are is being dumped into the bin.

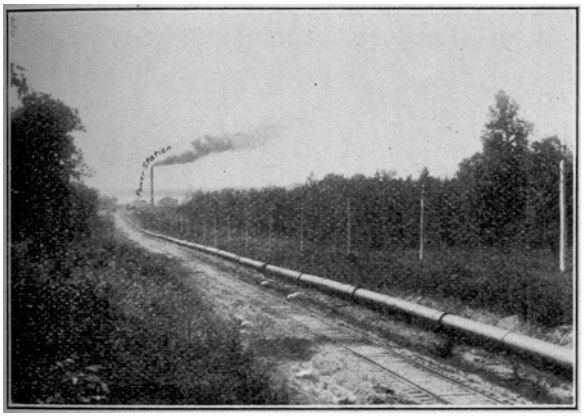
At the picking belts are provided hopper located conveniently near both the belt and the men. While these are built up high enough to greatly facilitate removing the waste rock from the belt, their primary purpose is to prevent the men from falling into the pockets beneath. The chutes from these pockets which receive the waste rock were provided with the customary quarter-pan or pocket stops, but as these did not prevent

small pieces from rolling out beneath them down on to the heads of passers-by, it was necessary to provide an additional means to prevent this. Such a device consisted of a special counterbalance gate or dam made of steel plate. The peculiar location of the stop itself 'and the point from which it was to be operated made this a difficult problem. The electric tram cars which carry the rock from these chutes to the dumps are provided with automatic gongs which ring when the cars are in motion and warn the workmen of their approach.



Electric Sub-Station

The next point of possible danger in the course of the ore is the discharge from the log washers. The problem here was somewhat difficult, for in order to inspect properly the concentrated product the workmen had to stand between large revolving gears on one side, and the moving blades of the washers on the other. However, the difficulty was solved by means of gear housing and platforms in such a manner as to make this point very accessible and at the same time remove both danger and fear of injury.

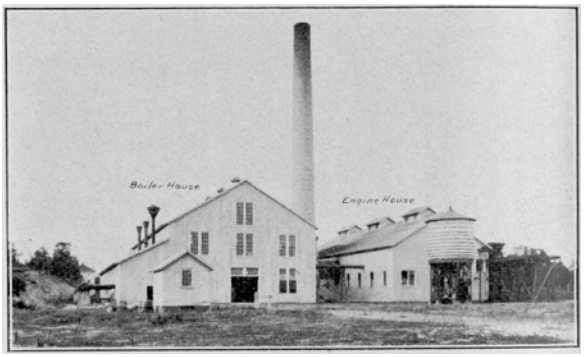


Water Supply Line

On the table floor, the driving-head gear of the machines presented the chief source of danger. To obviate this, frames built of pipe and covered with removable steel plates were placed around the driving mechanism. This secured safety and accessibility. Shifting levers for the belts, so designed as to he simple and free from projecting parts, were attached to these frames.

In the basement the only point which was considered dangerous, and this on account of darkness rather than location, was the driving mechanism of the Frenier pumps. The installation of steel geared housings, wooden troughs for belts and a generous lighting system, did away with all danger at this point.

There are many miscellaneous devices which though not so intimately connected with the operation of the mill, are none the less necessary. The most important of these are the coverings of every gear, belt, pulley, and moving part throughout the mill, and the safety collars on all shafting. Enameled iron signs warning operators are placed at every conceivable point of danger. Signal bells are sounded when starting all mill machinery, so that every working man may protect himself if in danger or invisible to the operator. Permanent stair-like platforms, were constructed beneath the receiving bins, to enable workmen safely to remove the bolts that hold the wearing plates when repairing them. Stairways were everywhere provided rather than ladders, and all of them were covered at the backs, thereby preventing material from falling or being kicked through them on to the head of persons beneath. But perhaps the greatest of all provisions for the protection of the working man in his routine duty about the mill is the most carefully planned and permanently constructed system of railed walks. These lead everywhere. They are rigid and strong to the last degree. Their railings are of steel pipe, their stringers and joists are of steel beams. Their treads are of the heaviest matched flooring, and their sides are protected by the ever-efficient, though obscure, toe-board. Records show that in this item alone, 32,300 lineal ft. of 1¼ in. standard pipe with the necessary fittings, and 12,450 lineal ft. of 2x8 in. surface pine boards have been used. Not the least of the factors which makes this provisione one of the most worthy of the safety device is the sense of security, which the workmanship apparent in it engenders.



Power Plant

In conclusion, it must not be supposed that the apparent completion of these safety devices has tended to eliminate interest in safety measures. On the contrary the interest is even greater, because it has been shown that the effort, money and vigilance expended in this direction produces the most gratifying results.

PRODUCTION.

	Tons.
Plant produced in 1910 with 2 units in operation....	610 000
Plant produced in 1911 with 5 units in operation....	1,978,000
Plant produced in 1912 with 5 units in operation...	2,555,000
The construction of the plant including power installation, water supply and necessary track arrangements, involved an expenditure of approximately	$1,500,000

The total amount of concentrate produced by the various machines in the unit depends largely on the character of the crude ore treated. The following table will, however, give a general idea thereof:

	Per Cent.	
Belt product	3 to 35	Depending on character of crude ore.
Two logs product.....	60 to 85	
Two turbos product.....	2.5 to 10	
Twenty tables product.....	1.5 to 6.5	

Concerning the size of the product obtained, it may be stated that the belt product is all larger than 20 mesh. Of the log product 90 per cent. is coarser than 40 mesh and 4 per cent. finer than 100 mesh. Of the turbo product 15 per cent, is coarser than 40 mesh and 32 per cent, finer than 100 mesh. Of the total table product 85 per cent. is finer than 100 mesh and 50 per cent. is finer than 200 mesh.

These figures will indicate the care which has been take in the processes, in the construction of the plant and of various machines therein, to effect a saving commensurate with good practice, economy and furnace requirements.

The above is a general and practical statement devoid of complicated calculations and demonstrations, entering into the solution of the problems connected with the handling of the wash ores on the Western Missabe Range, involving the construction of, and the processes devised for, the Coleraine Washing Plant.

In conclusion I wish to state that while it would be desirable and interesting from a scientific and economical standpoint in a subject of this nature, to enter into, for instance, the specific performance of each machine, the possibility of improving and of simplifying both method and machinery, to consider the question of recovery and the ratio of concentration, and finally to demonstrate the extent to which this plant as a unit has served its purpose as a medium through which this non-merchantable ore is made merchantable, it is impossible to touch upon these subjects within the scope of this paper, as time and conditions will not permit it.

The items referred to above may be proper subjects for another paper on a future occasion.

Lastly, while this plant today does its work as well and even better than expected, at some future day no doubt it will be changed and improved, or others will be built to take its place to meet conditions not here presented, but fully known from investigations made, which conditions it is neither practicable nor advisable to approach nearer at the present time.

THE APPLICATION OF MINING MACHINES TO UNDERGROUND MINING ON THE MESABI RANGE.

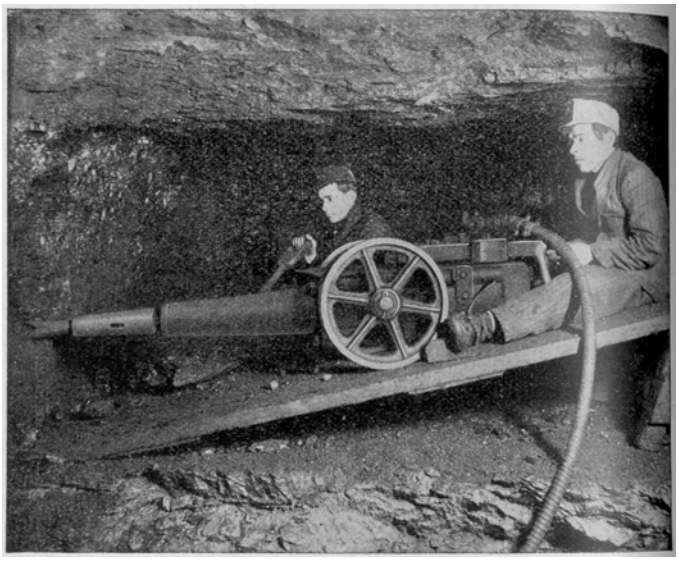
BY H. E. MARTIN AND W. J. KAISER.

The application of machines to underground mining on the Mesabi Range is a radical departure from the methods in use at the present time, and while it is difficult to foretell the ultimate results, their use cannot but be beneficial both to the miner and the mining companies.

Since mining was started on the Mesabi Range some twenty odd years ago, improvements and changes have been made in practically every method and device except those used in the actual mining of underground ore. During the past few years open pit mining has grown from a comparative infant to its present huge proportions. Heavier steam shovels, larger engines and standard equipment have been adopted, as well as various changes in methods employed. In our underground mines, the most efficient machinery has been installed for handling the ore once it has left the miners hands. The miners, however, still drill by hand, muck their own dirt and otherwise mine as they have done since the start. The number of miners on this range has not grown in proportion to the amount of development, and in consequence the production from underground mines has not been as large as it should be. How to increase the production, using the limited number of miners available, is then the question of vital interest. Could power machines be successfully used, it would necessarily mean a division of labor into two classes, miners and muckers, and the output per miner would be largely increased. The common laborers, becoming more proficient, would eventually graduate into the miners class, thus increasing their number. With these ideas in view, it was decide to experiment with machines on the soft ores of this range.

As used at the Harold Mine, of the Hibbing District, the machines consist of an ordinary Sullivan air-pick or coal puncher, and a Jeffries air-auger. The pick machine is the largest type manufactured by the Sullivan Machinery Company having a depth of undercut of five and one-half feet. The bore of cylinder is 5⅛ inches, pressure required 80 pounds, and total weight 825 pounds. To understand thoroughly the application of these machines to our mining methods, it may be well to mention first the several operations incident to taking out a set of ground by ordinary means. The miners first drill a round of holes in the breast, each hole approximately five feet in depth and varying in number from three to five, depending upon the height of post, character of ground and whether drifting into the solid or along side of caved ground. The upper holes are usually fired first and the bottom holes after the top dirt is mucked out. The amount of dynamite used depends upon the conditions mentioned above and varies from 15 to 30 sticks, each stick being about ½ pound. After the upper holes are fired the miners secure the back by poling from the last

set of timber into the breast. The ore broken in this blast is then loaded and trammed, and the bottom holes are fired. After all the ore is mucked out, the miners trim the breast, back and sides and the set is ready for timber. Under ordinary conditions the amount of time spent in these several operations is approximately as follows:



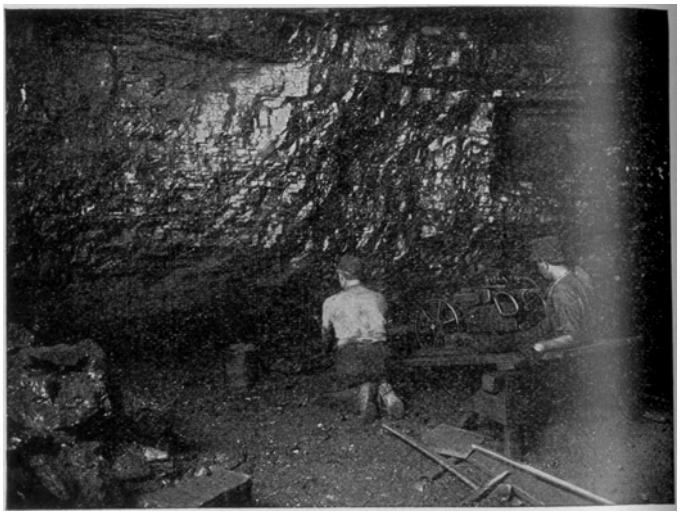
Sullivan 700 lb. Pick Machine in a four-foot vein of coal, Pennsylvania. Runner sits on board, guiding machine by handles and foot-clog.

Drilling, 17 per cent; blasting, 4 per cent; clearing of smoke. 3 per cent; tramming, 7 per cent; trimming, 9 per cent; timbering, 20 per cent; and mucking, 40 per cent.

The number of men required for one machine crew, is two machine men, three miners and six muckers. This ratio was experimentally determined and is of the most importance to the efficient working of the machines, in that there should be no delay of miners, muckers or machine men waiting upon each other. The minimum number of working places or rooms required to take care of one machine has been found to be five, though a larger number will insure no delays and make for higher efficiency.

The actual taking out of a set of ground with the aid of the machines is as follows:

The set is first under-cut with the puncher to a depth of five feet, the cut extending from the solid rib to within six inches or so of the opposite side, thus leaving a small pillar six inches wide and the full length of the set. The purpose of this small pillar being to support the ground against premature caving. Two holes are then drilled with the air-auger, about one foot from the solid rib and spaced about two and six feet respectively from the back. In case the slice was driven into the solid four holes would be necessary, two on each side. Two short holes are drilled in the small pillar supporting the set by the miners. Boards are now placed in the cut and under the set to be broken out, a small amount of ore picked down upon them to hold them in place, and the holes are loaded and fired. Being able to place boards beneath the set before it is broken, is an advantage rather hard to estimate but of considerable moment to those using the shovels, giving them as it does a smooth surface from which to shovel. The miners now secure the back by poling and the room is ready for the mockers. After the ore is mucked out, the miners square up the set, place the timber and another cycle of operations is started.



Sullivan 825 lb. Pick Machine in a Southern Illinois mine, 8-foot coal. This shows the undercut completed at left, and a fresh "board" started to the right.

The average time for under-cutting one set of ground excluding delays, has been 59 minutes, for moving from place to place and setting machine, 26 minutes. To drill one foot of ground with the air-auger has averaged 2.8 minutes, time setting up 1.4 minutes per foot. These results can and no doubt will be considerably lessened, as the machine men become more proficient.

The advantages which can be claimed for the machine, aside from any possible reduction in the cost of producing the ore, are employment of one-half common labor, using approximately one-half the amount of dynamite, less liability of posts being blasted out and consequent caving of rooms, and always having a smooth surface to shovel from. To the successful working of the machines, several conditions are necessary. The rooms served by the machine must be easy of access from one to another, their height should not be less than seven or eight feet and no bottom stoping should be necessary. In other words they can be applied to ordinary slicing and square-setting.

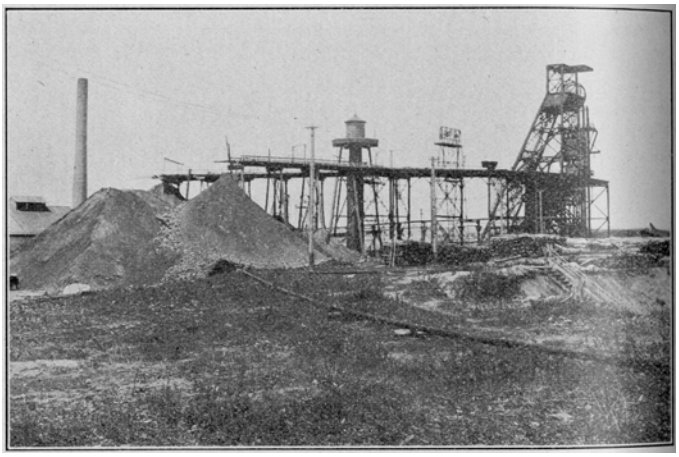
The results obtained so far have not been as satisfactory as could be wished, primarily due to the labor situation, muckers not being obtainable in sufficient number to keep the machine and miners busy at all times. At the start many delays were occasioned by not having a sufficient number of places opened up for the machine. However, during the first five weeks of work, the average number of tons per man per day was twelve, an amount considerably above the average for most places in our underground mines. Taking these points into consideration, it can be conservatively said, that it is not a question of what the machines can or will do but

merely one of organization and hence their future on the Mesabi Range seems assured.

OPENING THE LEONIDAS MINE AT EVELETH, MINNESOTA.

BY H. E. LOYE, EVELETH, MINN.*

At the Leonidas mine of the Oliver Iron Mining Company at Eveleth, Minnesota, two ore bodies were found separated by rock 250 ft. in thickness. The upper body averaging 49 ft. in thickness, will be mined in greater part by the open pit method, the lower body averaging 76 ft. in thickness, by the underground method.



Leonidas Mine, Eveleth, Minn.

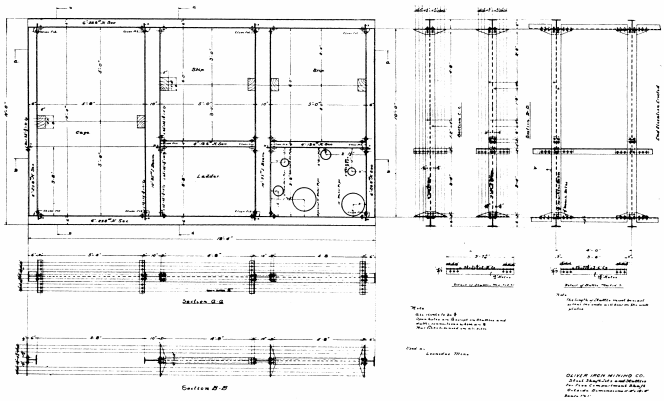
On account of the long period of time required to mine this lower deposit, it was desirable to have the shaft and stations as permanent as possible, and also as shaft stations are the parts most subject to fire, and as in this case there will be only one outlet for a number of years, it was very important to have the shaft and stations as nearly fireproof as possible. With this in view, it was decided to use only steel and concrete in the construction; steel sets made by the American Bridge Co., backed by reinforced concrete slabs made with Universal Portland cement.

*Chief Engineer, Oliver Iron Mining Co., Adams District.

The shaft, which is 10 ft. by 17 ft. 4 in. in the clear, contains five compartments; two skip compartments 6 ft. by 5 ft., pipe and ladder compartments each 3 ft. 8 in. by 5 ft. and a cage compartment 10 ft. by 5 ft. 8 in., as shown in Plate 1. The wall and end plates are made of 6-in. 23.8-lb. H sections, the main dividers of 10-in. 25-lb. I-beams, the smaller dividers of 4-in. 13.6-lb. H sections and the studdles of 3½ in. by 3 in. by ⅜-in. angle irons. Sets were placed 4 ft. center to center and 2-in. planking used for temporary lathing, to be replaced later by reinforced concrete slabs, the planking resting in the hollow of the H section and being flush on the inside of the shaft so as to prevent lodgment of material. In sinking, the sets were kept from 12 to 16 ft. above the bottom of the shaft to avoid any breakage by blasting. The hearing pieces used were 12-in. 31.5-lb. I-beams, 19 ft. 6 in. long, 4 in a set, placed under the end plates and dividers with their ends concreted into' the hitches, as shown on Plate 2. Five sets of these bearers were put in as follows: At collar, at 113 ft., at 213 ft., at 313 ft. and at 438 ft.

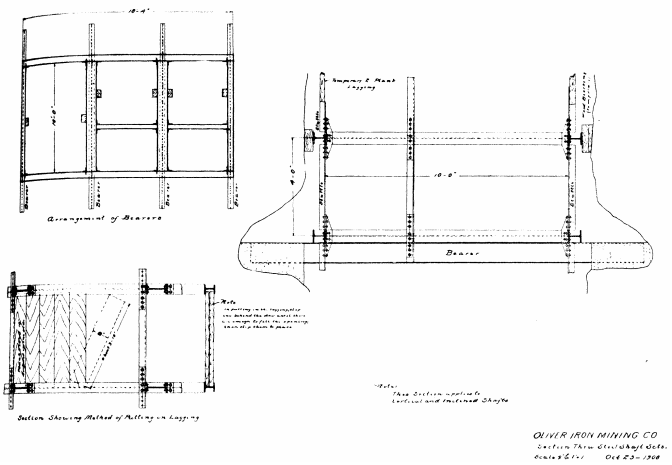
In sinking the shaft, 72 ft. of surface or glacial drift was passed through, the remainder of the shaft being sunk through taconite. Water was encountered at a depth of 30 ft. and the flow became so heavy at a depth of 268 ft. that a temporary pump station was cut, 8 ft. by 16 ft. by 41 ft. in the clear with a sump 10 ft. by 12 ft. by 7 ft. Two 9 and 18 by 8 by 18-in. Prescott compound duplex pumps and a 14 by 9 by 18 in. Prescott duplex pump were installed in this pump-house with four 14 by 8 by 12 in. Prescott sinking pumps shambling the water to them. At this time 1,500 gallons per minute were being handled. The column and steam pipes were carried down the shaft according to the permanent lay-out as shown in Plate I, so that when the shaft was completed it was only necessary to carry the piping down from the 348 foot pump station. By the time the shaft was 356 ft. in depth, 2,400 gallons per minute were being handled requiring six sinking pumps in the shaft, one throwing to surface, and as the flow was increasing, it was necessary to put in another temporary pump station, at a depth of 348 ft. This is 10 ft. by 18 ft. by 61 ft. in the clear, with a sump 14 ft. by 16 ft. by 6 ft. In this station was installed one 12 and 24 by 12 by 24 in. and one 12 and 24 by 10½ by 24 in. Prescott compound duplex pumps and the two 9 and 18 by 8 by 18 in. Prescott compounds were moved down from the upper station. This equipment, using six sinking pumps, sufficed to complete the shaft although the flow ran up to 3,500 gallons per minute before the shaft was finished. When the permanent pump station was being cut the flow ran up as high as 4,000 gallons per minute and to handle this required the addition of a 14 by 9 by 18 in. Cameron pump which with one of the sinking pumps was put in on the entry level and both discharged to surface, the other five sinkers shambling to the 348 foot pump-house.

PLATE I.



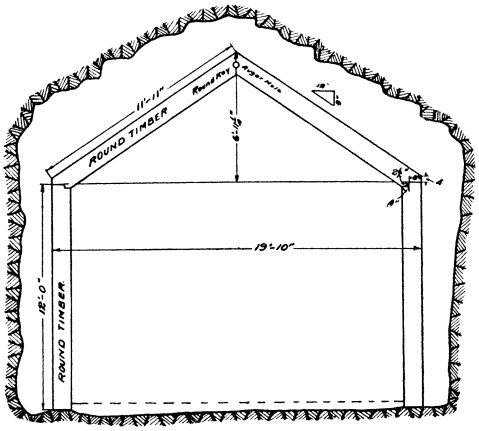
Steel Shaft Sets and Stuttles for Five Compartment Shaft

PLATE 2



Section Through Steel Shaft Sets

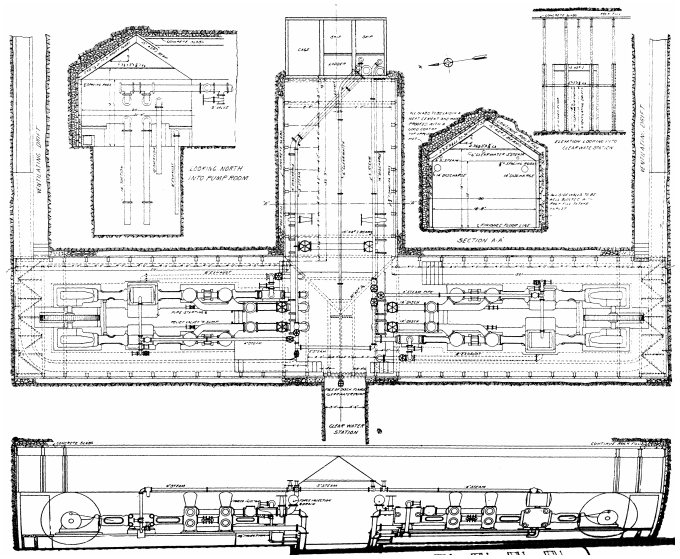
PLATE 3.

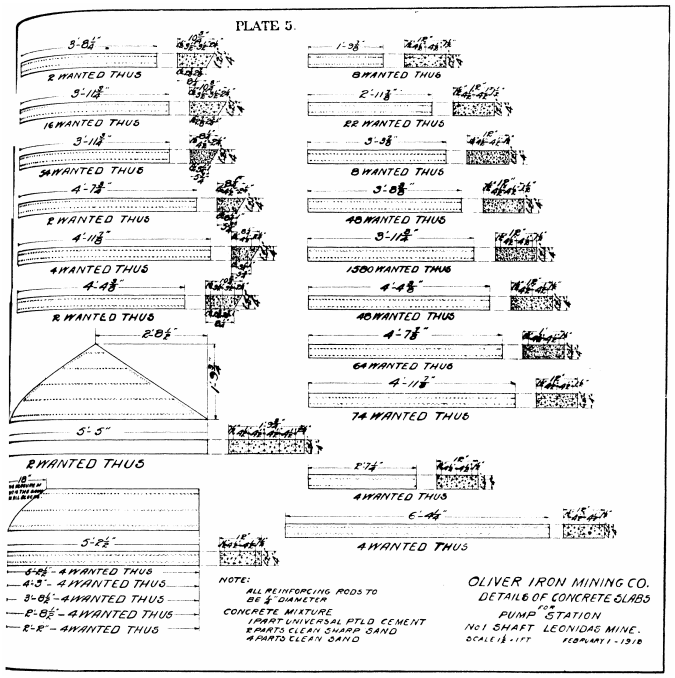


TEMPORARY TIMBERING.
LEONIDAS PUMP ROOM.
437 FT. LEVEL No 1 SHAFT.
SCALE $\frac{1}{4}$" = 1'. SEPT 24 – 1913.

The sinking of the shaft was greatly impeded by the flow of water, the miners working in from 12 to 24 in. of water all the time. The great number of pumps in the shaft took up much room and made the shaft exceedingly warm. This shaft drained the Adams and Spruce ore bodies, leaving them dry by the time the shaft was 300 ft. in depth. In sinking from this point to the bottom, if one of the pumps broke down, it was necessary to stop work to enable the other pumps to handle the flow, and this caused many delays.

After completing the shaft to a depth of 448 ft., the entry to the permanent pump station was started at a depth of 438 ft. The rock-work in the entry and pump-house was driven in two stopes, the upper running from 5 ft. in height on the side to 13 ft. in the center, was kept 10 to 12 ft. ahead of the lower which was 8 ft. in height, the opening being 24 ft. wide by 21 ft. high in the center, as shown on Plate 3. The entry is 32 ft. long and the pump-house opening is 119 ft. As the steel for the sets could not be delivered in time, temporary wood sets, as shown in Plate 3, were used, placing them between where the steel sets would come and with the outside line of the wood posts 1 in. in the clear of the inside line of the steel sets. This facilitated the work of putting in the hold-down bolts and small piers for the steel posts and the erection of the steel work. When the rock-work of the main pump-house was completed, the steel sets were placed, as shown in Plate 4, working from each end towards the center and then through the entry to the shaft, affording an easy way of completing the rock-fill behind the concrete slabs. The start was made by removing two wood sets at the breast and putting in three steel sets, the first two being cross-braced. Then the concrete slabs, as shown in Plate 5, which had previously been dipped in hot tar and dried on surface, were laid in place in neat cement behind the steel and as each slab was placed, it was back-filled with broken rock tamped in. The slabs were stepped up three to a set so that there were fifteen slabs in the center of the breast set when the three sets of steel and slabs were ready to proceed further with the work. The steel gang then removed one wooden set at a time, replacing it with a steel set, the slab work being raised three slabs all around for each steel set placed. This necessarily left the back open for quite a distance but if the back showed any weakness props were put in either from the steel sets or from the floor. Before the steel and concrete were placed it was almost impossible to see from the center to either end of the pump house on account of the amount of water falling from the back but after these were in place the room was practically dry.





To keep down the water pressure behind these walls short pieces of one inch pipe were placed under the slabs just below the floor level and these were connected to a pipe under the concrete floor leading to the sump. Pipes were also laid under the floor from the sump to each fly wheel pit so as to be able to drain the pits, but valves were placed on these pipes and are kept closed so that in case of water rising up in the station it will not back up into the pits. On the top of the concrete slabs in the back, tar paper was used to shed the water until the cement could set, the back-filling being placed in on top of the paper. Although in some places holes opened up in the back as high as 10 ft. above the sets, still nothing but rock was used for back-filling. When the station had dried up, the slabs were given two coats of white cold water paint and the steel two coats of turpentine asphaltum.

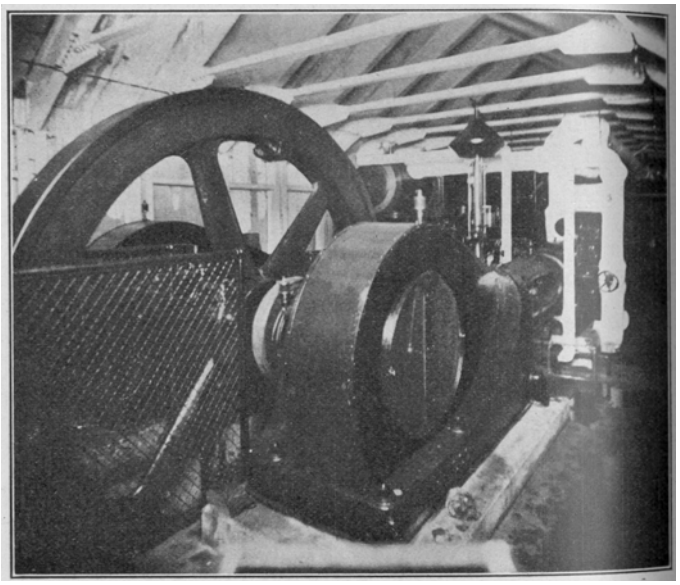


Plate 6. Engine End of South Pump.

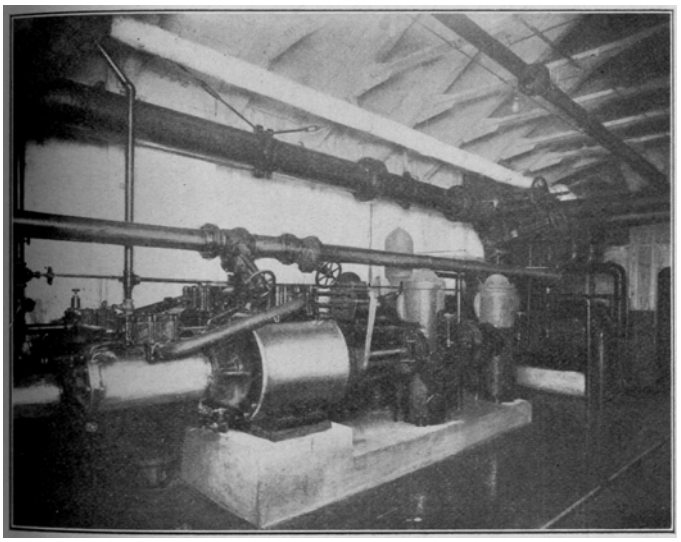


Plate 7. Emergency Pump in Entry Drift.

As soon as the steel sets had been placed in the clear of the pump foundations, the templets for these were placed and work started. These foundations were finished and had set sufficiently before the slab work was completed so that the pumps could be installed at once on the completion of the pump-house supportings.

The pumping engines are two 16 and 32 by 8 by 36 in. Prescott corliss cross compound condensing, Missabe type, crank and fly wheel, with horizontal jet condenser with a normal capacity of 1,500 gallons per minute and a maximum capacity of 2,200 gallons per minute against a head of 450 ft. Plate 6 shows the engine end of one of these pumps. This type of pump was selected on account of its economical operation, its guaranteed duty being 135,000,000 ft. pounds of delivered work per 1,000 pounds of dry steam consumed by the engine, when furnished with steam at 125 pounds gauge pressure and with a vacuum of 26 in. of mercury. Each engine is supplied by a 5-in. steam line and discharges into an independent 14-in. column pipe. The steam pipes and discharge pipes are cross connected in the entry and provided with valves so that either engine can take steam from either steam pipe and either pump discharge into either column pipe. This arrangement, as shown on Plate 4, prevents flooding of the mine due to one pump and the steam or discharge pipe of the other pump being out of commission at the same time. An auxiliary pump was installed in the entry drift for use in case of emergency as there is always the possibility of something going wrong with a new installation. This is a 12 and 24 by 10½ by 24 in. Prescott cross compound capable of pumping 1,200 gallons per minute against a 450 ft. head and is shown in Plate 7. A trench just under the floor of the entry connects the shaft and the sump so that the water in the shaft can flow into the sump without running over the entry floor. Plate 8 shows the water end of North pump and the entry drift from shaft.

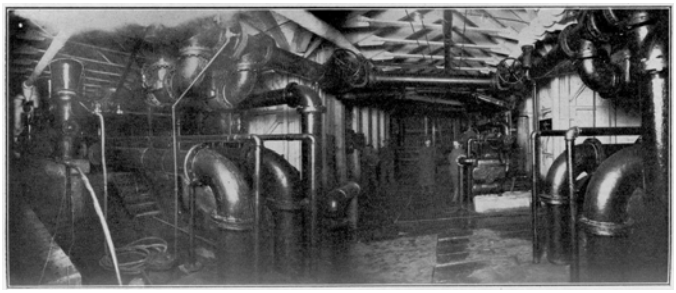


Plate 8. Water End of North Pump and Entry Drift

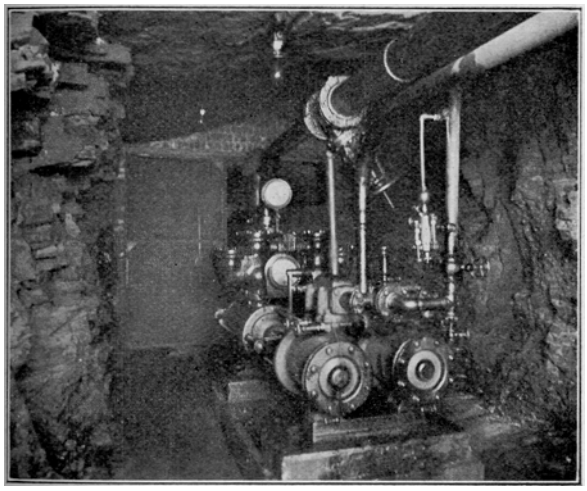


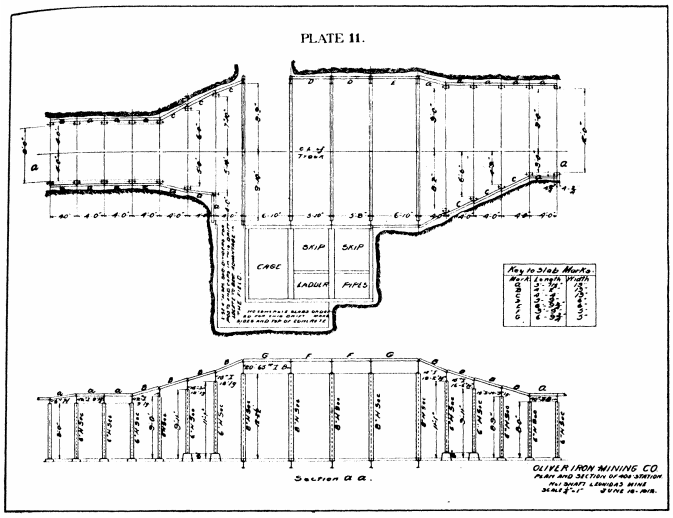
Plate 9. Clear Water Drift and Pump

A drift 50 ft. in length was driven to the west directly opposite the entry and at the breast a sump was put down 6 ft. by 6 ft. by 20 ft. deep. The drift is now practically dry, as shown by Plate 9, but there is an excellent flow of pure water from the breast, as shown in Plate 10, which was taken from the doorway in the wire partition shown in Plate 9. In this drift was installed the pump for supplying clean water for domestic and drinking purposes. This is an Epping-Carpenter pot-form pump 10 by 6 by 12 in. capable of pumping 350 gallons per minute against a 500 ft. head. The end of the drift has a heavy wire netting partition across it so that no one can get near the supply of water.

The ventilating drifts were driven in rock on an incline of 50 degrees, from each end of the pump station up to the main tramming level 30 ft. above. These drifts required no supports. Iron stairways with railings were placed in them affording a good passage-way between level and station. The water from the level above is conducted along the drifts from the breasts in box launders covered over for walk-ways, then down these ventilating drifts in 12-in. pipes into concrete launders below, the launders emptying into the main sump. Board partitions are placed in the box launders and screens over the tops of the pipes to keep the mud, rocks and sticks out of the sump.

Plate 10. Breast of Clear Water Drift

After completing the pump station, the main level station was started at a depth of 405 ft. below the collar or 33 ft. above the pump station. The level station is 19 ft. 6 in. by 47 ft. by 12 ft. high, in the clear, and has steel sets with concrete slabs for lagging on sides and back. On account of the ladder way being on the other side of the shaft from the station, a passageway around the shaft was made using steel sets and concrete slabs, while the temporary wooden laths in the shaft at the station were replaced by steel plates. Plate 11 shows the station lay-out, and Plate 12 shows a reproduction of a picture of the station.



Plan and Section of 405 ft. Station

The main drifts leading north and south from the main station and then turning to the east a short distance in, have steel sets and concrete slab lagging for some distance from the shaft. The one leading north has sets 8 ft. by 8 ft. in the clear, made from 6-in. 23.8-lb. H sections lined with 4 in. by 12 in. reinforced concrete slabs (Plate 5) extending for 84 ft. from the shaft station. The drift leading south has steel sets 12 ft. by 8 ft. in the clear, with 6-in. 23.8-lb. H sections for posts and 10-in. 25-lb. I-beams for caps with 4 in. by 12 in. reinforced concrete slabs (Plate 5) for lining a distance of 210 ft.

from the shaft station. This drift is double tracked with drainage launder between the tracks covered over for a walk-way. Motor haulage will be used on this level.

When the level drifts were well under way, the opening for the pockets was cut and the steel put in. The main pocket is 8 ft. by 24 ft. by 9 ft. deep with the bottom; on an angle of 47 degrees. Chutes with finger stoppers lead from this main pocket to an auxiliary pocket for each skip, each pocket holding one skip of ore when full. These are filled from the main pocket while the skip is being hoisted and as soon as the skip is in place for loading, the tiller wheel opening the door is thrown over and the ore falls into the skip, the door closing of its own weight. A skip can be filled almost; before the engineer can reverse his engine. Plate 13 shows the arrangement of these pockets.

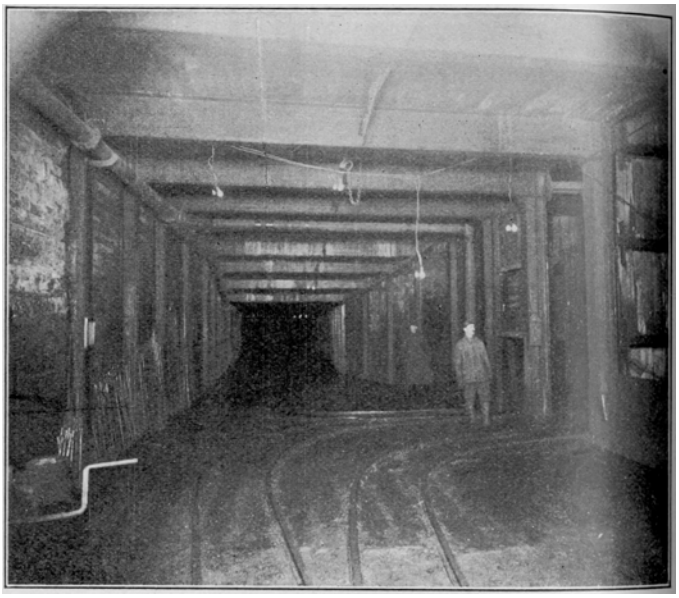
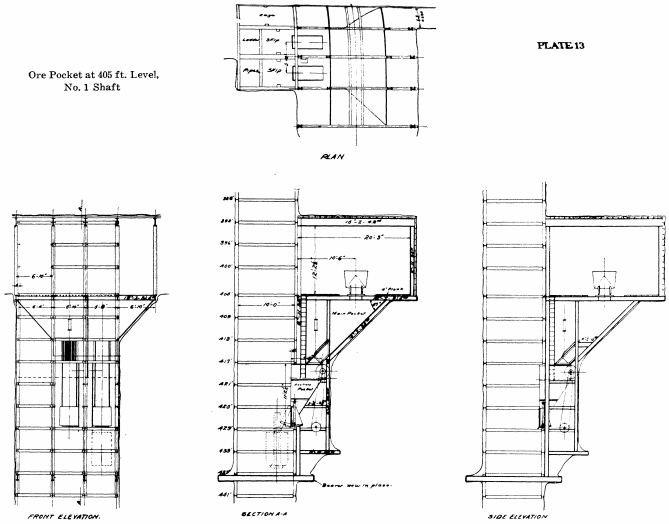
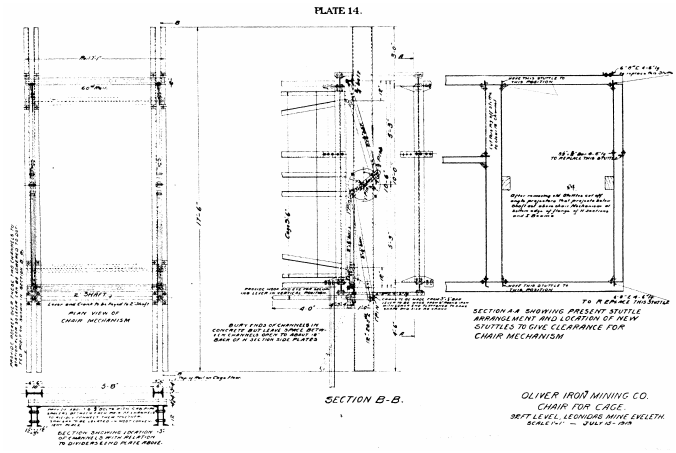
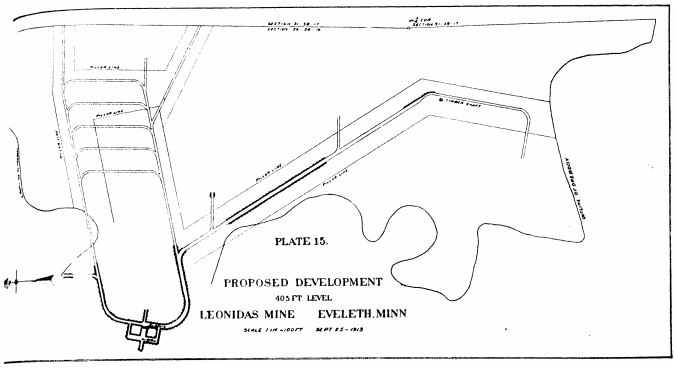


Plate 12. Shaft Station 405 ft. Level





The ore, outside of the pit limits in the upper ore body, had been planned to be mined out from the open pit but it was decided to mine this ore through, the shaft and thereby save a number of years in the mining of the ore. Accordingly a level was driven at a depth of 92 ft. from the collar. Steel sets with concrete slabs in the back were used for the station which extended back the full width of the shaft for 16 ft. The drift extending on from the station has steel sets same as in the south drift of the 405 ft. level, 12 ft. wide but with concrete slabs in the back only. These extend for 125 ft. from the station. As it was necessary to hoist the ore from this level on the cage and it was found that, without chairs, the cage settled so much when the loaded car was being pushed on it that occasionally one stood on end, it was necessary to design chairs to suit the equipment. The chairs used are shown in Plate 14. These chairs have to be held in place for the cage to rest on and when the cage is lifted off, they move back out of place, leaving the shaft clear. Motor haulage will be used on this level.

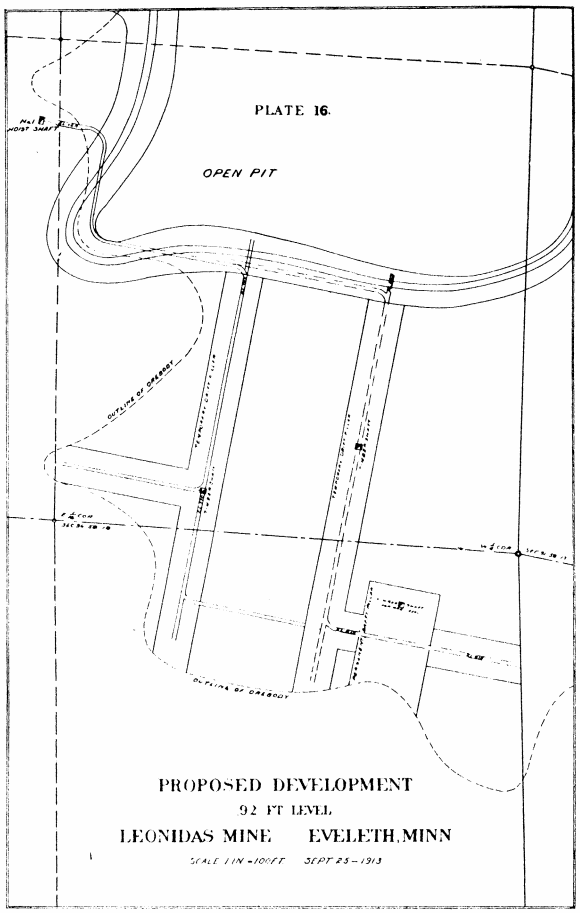


The lay-out of the main tramming drifts on the main level, (405 ft. level), is shown in Plate 15. The lay-out of the main tramming drifts on the 92 ft. level is shown in Plate 16.

The wires of the lighting system are carried in conduits throughout and every endeavor was made to have the conduits water tight. The positive line down the shaft is a No. 10 double-braid, rubber covered, crown cable and the various circuits below are of No. 12 duplex rubber covered wire.

The pump station has 18 60-Watt Mazda lamps with 10 in. aluminum reflectors, the entry drift 5 and the clear

water station 3 lamps of the same size. These light up the station in excellent shape.



The main station has 4 100-Watt Mazda lamps with 12 in. aluminum reflectors. The lights in the tramming drifts are 16 candlepower carbon lamps and are placed every 50 ft. along the drift.

THE NEW CHANGE HOUSE AT VULCAN MINE.

BY FLOYD L. BURR, VULCAN, MICH.*

No meeting of the Institute and volume of its Proceedings seems to be entirely complete without a paper describing the latest and best miner's “dry” or change house. Therefore for the sake of such completeness, I shall attempt a short description of a change house recently built at the East Vulcan Mine of Penn Iron Mining Company.

Early in the spring of 1912, the old imperfect and inadequate, wooden structure known as the “dry” burned down, and brought to the point of early decision the previously considered project of building a new and modern change house.

At this time and in previous years, a large amount of study and thought had been given to the question as to what would constitute an ideal change house. The principal requirements named in the order of their relative importance seem to be: Perfect facilities for the drying, warming and otherwise caring for the miner's digging clothes, suitable provision for washing off the dirt accumulated on the hands and face during the day's toil underground; a comfortable and convenient place for changing from street clothes to underground clothes or vice versa; satisfactory provision for the safe and convenient storage of the miner's street clothing during his absence underground; good emergency hospital facilities; and toilet arrangements comprising sanitary closets, urinals and shower baths. Good lighting, heating, ventilation, plumbing, fire resistance, and good construction generally, are to be considered necessary features in the attainment of the principal requirements just mentioned. They are means toward an end.

*Structural Engineer, Penn Iron Mining Co.

The matters of permanence and economy of operation and maintenance, have to do both with general policies of management and with local conditions, such as the value, size and permanence of the mine for which the equipment is planned. Of course there must always be in the mind of the designer a continuous conflict between the awful ogre, cost and the beautiful goddess, perfection.

The decision was to build a permanent, substantial, convenient, sanitary change house of fire resistant construction at minimum cost without considerable attention to architectural beauty. Minimum cost implies minimum size of building. It was considered necessary to provide for at least 250 men with the possibility of taking care of 250 men if occasion should require.

The first mentioned requirement of caring for the underground clothing was given much consideration, many schemes being drawn up and rejected for one reason or another. The scheme finally adopted is in a general way one that has a wide use in some parts of Europe and in a few places in America. By this scheme the clothes are hung upon suitable hooks which are afterwards hoisted up out of reach to dry and aerate. One of the most extensive and widely known installations of this sort in America is located at the Marianna Coal Mine in Washington County, Pennsylvania. During the consideration of the design, a visit was paid to Marianna and the change house inspected. Through the courtesy of friends and associates, various descriptions of such installations from English and French technical journals were available. From all this data, however, only the general idea of hoisting the clothes was copied.

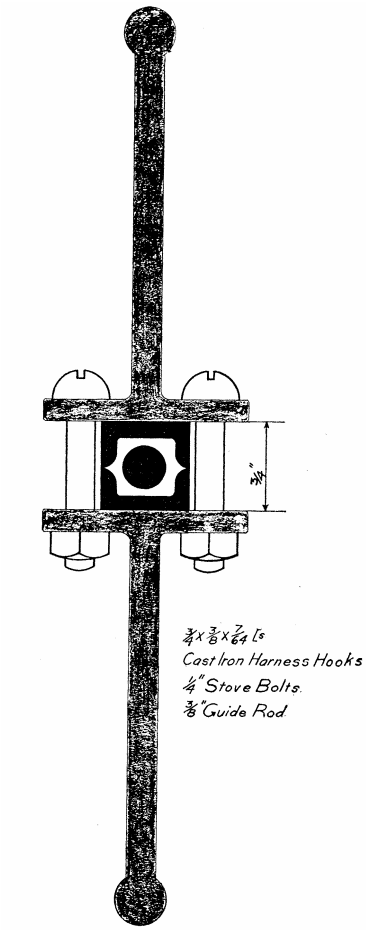
In all the previous installations of which we have knowledge one man's clothes are hung upon a single multi-pronged hook which is attached to a simple chain, not confined against swinging, and hoisted up to a more or less high ceiling. These chains or hoists have been arranged in blocks comprising at least five rows between aisles. Their use has not been confined to the mine clothes; on the contrary the street clothes also are hung up, which practice often brings one man's street clothes

adjacent to and in contact with another man's underground clothing.

According to the design adopted a cupola or monitor, extending the full length of the locker room, has been built and up into this drying chamber the clothes are hoisted. Near the base of this monitor are coils of steam pipes from the region of which quantities of dry warm air rise through and about the clothing. The monitor is surmounted at its center by a large ventilator which provides for the escape from the building of this air now laden with moisture and disagreeable odors from the clothing. The monitor is about four feet wide inside and provides for only two rows of hoists which places each row adjacent to an aisle. No street clothing is hung on these hoists, lockers being provided for them.

The supports for the mine clothes, we have chosen to call hook racks. A hook rack consists of a hollow central stem to which are attached twelve or sixteen large hooks. This central stem is made up of two channels placed flange to flange and held in that position by the pressure of the hooks which are bolted together in pairs, enclosing the stem. The stem being hollow, a space is provided which is occupied by a round steel guide rod up and down which the rack can be made to travel at the will of the operator. This guide rod is about 22 feet long and extends from an attachment at a point about a foot above the floor up to a point about a foot below the ceiling of the drying chamber or monitor. The hooks can turn about the guide rod but, of course, they are confined by it against swinging. This arrangement confines the rack to space allowed for it and prevents adjacent racks and their hoisting chains from becoming entangled. For the sake of economy each rank is assigned to two or three men and to neutralize the excessive hoisting load a counter-weight is attached to the chain. Suitable hooks are provided for holding the chain at any desired point in its travel and there are padlocks to lock it against the evil designs of “the other fellow.” These devices are attached to a horizontal 3 by 3¼ in. steel angle located at a height of about four feet above the floor. The horizontal area contiguous to each hook rack is a rectangle 21 by 24 in. and the one double row includes a total of 84 racks. These racks have been in use now for several months and seem to fulfill their purpose well, though it is not claimed that the scheme is ideal.

Lockers are provided for the street clothes. To economize in floor and wall space, it was decided to use double-tier lockers and in order to have them of proper height and yet be able to reach into the upper tier of lockers successfully, it was necessary to have a seat run along the front of the lockers nineteen inches above the floor and to use this seat as a step. The lockers are home-made and consist of cylinders 24 in. in diameter and 46 in. high, revolving about a central spindle. Each locker is provided with a series of 6 3-pronged hooks but has no shelf on account of limited vertical dimensions due to the double-tier arrangement. They are doorless and are closed by revolving them until the opening comes adjacent to the wall along which they are arranged. They may be locked in this closed position at the pleasure of the men who possess the keys. This type of locker is the invention of the author of this paper and his intention is to apply for letters patent upon the idea.



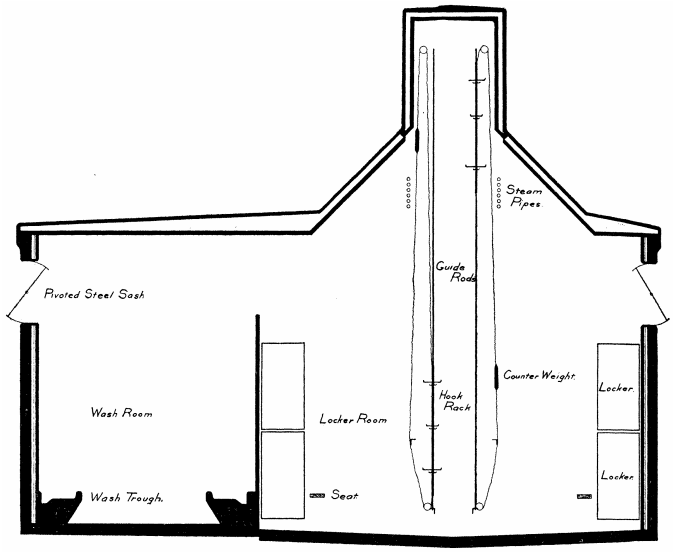
Cross Section Through Hook Rack.

The available wall space gives room for 64 lockers in each tier or a total of 128 lockers. There is ample room in each locker for two men's street clothes at one time while three men would not be badly crowded. The lockers are strong and to illustrate their strength, it might be mentioned that upon several occasions a large man has been enticed into one of the lockers and the unsuspecting victim given a free merry-go-round ride therein.

The lockers and hook-racks occupy a rectangular room 17 ft. 8 in. wide and 80 ft. 4 in. long. Pivoted-ventilator steel sash windows at about 9 ft. above the floor are arranged along one side and at both ends of this room. At each end of the room is an emergency-exit door opening outward.

Connected by an open doorway with the locker room and separated from it by a partition reaching only to within some four feet of the ceiling is the wash room. This room is about 9 ft. 8 in. wide and 36 ft. 6 in. long, and contains about 70 lineal feet of wash-trough arranged on the two sides and one end of the room. The men use this trough only as a sink or support for

pails, each man providing himself with a paid to be used as a wash basin. This is standard practice at all the changing houses at the Penn Mines. The trough is made of concrete and is so shaped as to form at the back a gutter the bottom of which slopes to catch basins discharging, into the sewer and into which gutter each man dumps his pail of wash water after the completion of his ablution. The bottom of the main portion of the trough slopes slightly toward the gutter so that water dumped upon it goes immediately into the gutter and one man's wash water does not inconvenience his neighbor. Hot and cold water is on tap at three foot intervals along the length of the trough. A coil of steam pipes attached to the wall just above the water pipes gives heat to the room.

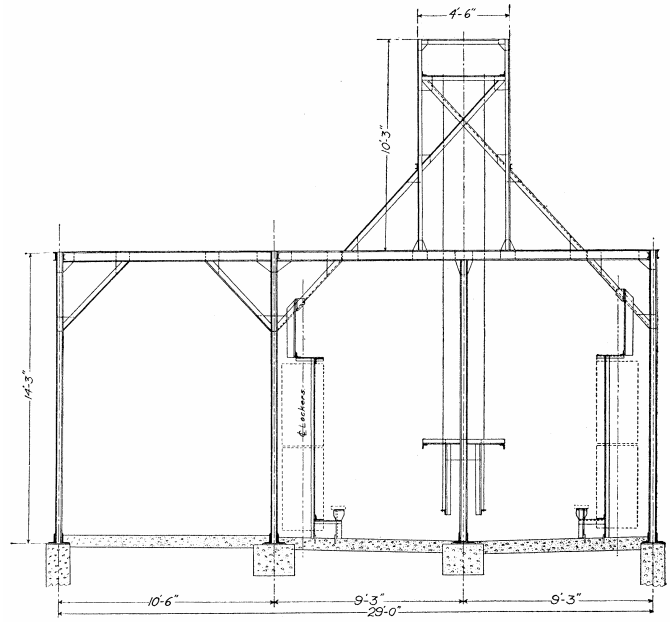


Cross Section Through Wash Room and Locker Room

In working out the floor plat only a small space seemed to be available for first aid purposes. This room is 9 ft. 3 in. wide by 9 ft. 11 in, long and may prove to be rather cramped when equipped with the hospital apparatus needed for such a place. However, there is a very high ceiling and by a proper use of the space overhead, the floor area may be conserved and found sufficient when the equipment is in. In order to give the room sanitary qualities, a heavy coating of enamel has been applied to the floor, walls and cealing.

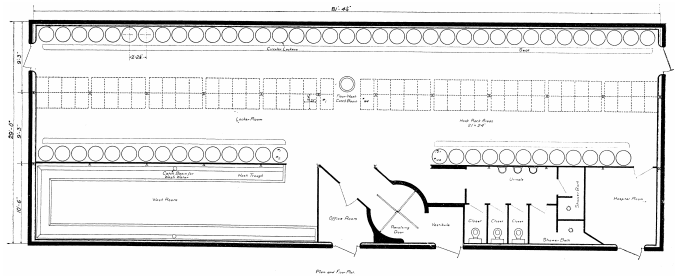
The irregular shaped office room is also something in the nature of a left-over and there was some doubt of its being adequate, the floor area being only about 45 feet. However since it has been in use, it seems to be large enough for its purpose. The shift bosses go into it to write their daily reports but its greatest use is by the dry man who uses it to dispense carbide as well as for an office where he stands in taking the numbers of the men going on shift.

The toilet room is of ample size and contains two shower baths, three urinals and three closets. Each shower room has a vestibule where the bather may disrobe and hang up his clothes. The fixtures are of the ordinary type without mixing chambers. The urinals are high grade and arranged for ample flushing. The closets are high grade, automatic in action and are equipped with white enamel iron tanks. They have proven to be extremely satisfactory in use, and as yet no difficulty has been experienced in keeping them perfectly clean. They flush in every way similarly to an ordinary non-automatic, low tank closet, except that the removal of the occupants weight from the seats takes the place of the usual act of pulling a chain, pushing a button, or otherwise voluntarily operating a lever. In the opinion of the writer of this paper, they are far superior to the closed or air-pressure-tank type of automatic closet.



Cross Section Showing Structural Steel Frame Work

Considerable thought was given to the subject of a proper entrance to the building. The shortcoming of most existing change houses was recognized in that there is no adequate provisions against a current of cold winter air blowing in through open doors upon men half naked in the operation of changing and washing. It was decided to have a revolving door, built of steel and asbestos, this has been built at our own shops and is about to be set up.



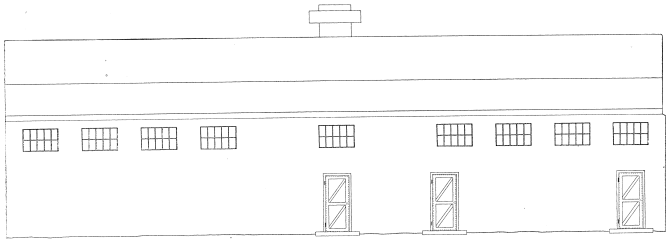
One of the conditions most essential in a modern change house is perfect cleanliness and it was necessary in the design to so arrange that the dry man could clean up each morning with a minimum expenditure of time and labor and with a maximum degree of perfection. The floor o»f the building which, of course, is of concrete, is so built that it slopes from every

point in the building down to a large central catch-basin located in the center of the locker room. There is an exception to this statement in that the floor in each of the shower-bath rooms slopes locally to a small catch basin. This large catch basin is so- provided with trap, screen, and flushing arrangements that the dryman may with impunity wash all dirt and litter down to it. Sticks, matches, tobacco bags, discarded hats, all land at the catch basin, and, of course, there are large quantities of ore and jaspar that go the same way. The building is so piped that at five different points a one-inch hose may be readily attached for this floor washing. One 25 ft. length hose is sufficient to reach every part of the building.

Compressed air is piped into the building and is on tap at several points where a small hose may be attached for blowing dust from the tops of lockers or other points of lodgment

The building is heated by steam, piped in from the boiler house. The coils located in the various rooms are each provided with valves so that the temperature of the different rooms may be regulated separately. The steam pipe located in the monitor are in four coils, thus allowing special regulation there, to suit the season, or special conditions. All water of condensation is discharged through a steam trap to a concrete tank located over the revolving door-way, and hot water is drawn from this tank for the wash room and shower baths.

The illumination of the building is very satisfactory, due to the high windows and to white-washed walls and ceiling Electric incandescent lamps are provided in plentiful number for night illumination. It may be mentioned that there are a few in the entrance way and main aisle that stay on all night while the great majority are switched on only at times when the men are in the building. The lights are arranged on several sub-circuits for the sake of economical control. The main switches and all the sub-switches are located in the office room excepting one located in the hospital room to control the lights there.



Elevation of South Side

The building is of fire resistant construction throughout. It is not fire-proof in a strict sense because many steel members are exposed, but considering the contents of the building there is practically no risk of any fire sufficient to injure the structure. The nucleus of the building is a structural steel frame of somewhat unusual design. The outer columns are merged into a 6 in. concrete wall and the roof beams support a concrete roof. Inside of the 6 in. concrete wall is a 2 in. air space, a layer of No. 1 tarred felt, a ½-in. air space, and last of all a 1-in. slab of cement plaster. The roof consists of asphalt mastic wall board, another air space, and at the bottom a 2-in. slab of concrete. The partitions consist of cement plaster walls 2 in. thick. Some of these partitions reach entirely up to the ceiling, while others of them reach only part way up. All the concrete and plaster work is reinforced with “Trussit” and “Self-Centering,” furnished by the General Fire-Proofing Company. The steel window sash came from the Trussed Concrete Steel Company. Wooden storm sash are provided, to be used in winter. They are applied inside the regular sash. The roof inclusive of sides and top of monitor is water-proofed by the application of Carey’s Flexible Cement Roofing, with a surfacing of asphalt. The exterior of the walls is uniformed and slightly tinted by the application of “Trus-Con Stonetex.” The interior of all walls and ceiling except in the hospital room are treated with white-wash. For the lower five feet of the walls the white-wash was stained red by the use of powdered hematite. All the exposed steel work is painted black.

The normal capacity of the building is taken as 252 men but it might be possible to take care of more should occasion arise. A little calculation may be in order. The 84 hook racks will each hold the underground clothing of three men, making the total capacity as regards hook-racks to be 252 men. The 128 circular lockers will each normally be issued to two men, one man on day shift and one man on night shift, which would total 256 men, approximately the same as the hook racks accommodate. However these lockers will easily old two men's clothes at one time and on a pinch three men can crowd their clothes in. Therefore it would be practicable to assign each locker to- two men on each shift and each locker would thus take care of the street clothes of four men. By thus assigning the lockers, only 63 of the 128 would be needed to equal the capacity of the hook-racks, and 65 lockers would be empty. Now there are a good many miners who work in dry places who could get along with the circular lockers for both street and mine clothes. Two men could easily occupy a locker together in this way and the 65 lockers could thus be made to accommodate at least 130 men. By this arrangement the capacity would be 252 plus 130 or 382 men. In computing the cost per man, however, a capacity of 252 men is considered.

The work of construction has all been done by the regular mine force and, as is usual when done in that way, has dragged along so that even yet there are a few things to do, such as hanging permanent doors in place of rough temporary ones, supplying seats and hooks in shower bath rooms, and equipping the hospital. Estimating the cost of the few items yet to be finished, the total cost amounts to $10,325.00. This cost includes excavation, grading, building and construction, piping, sewerage work inside and outside of building, wiring, experimental work, and equipment. For a capacity of 252 men this amounts to a cost of about $41.00 per man.

DISCUSSION

MINING METHODS ON MISSABE IRON RANGE.

(Discussion of the Paper of Willard Bayliss, E. D. McNeil, and J. S. Lutes, Committee, p. 133).

WILLIAM KELLY, Vulcan Mich: The paper just read gives us an exceedingly clear idea of the varying conditions which are met with in mining on the Missabe and the modifications of the general methods which have been worked out in practice to meet these conditions. The statements are so clearly made that there is little room for discussion.

One matter not touched on that might give additional value to the paper is the percentage of ore recovered or conversely the loss of ore in the methods that are being used on the Missabe Range. I am very strongly of the opinion that the underground methods used here result in the saving of a very high percentage of the original amount of commercial ore in the ground, and if this is the case, and an estimate can be made, the figures should have a place in this paper so that the methods perfected in this district may receive the credit to which they are justly entitled.

PENTECOST MITCHELL, Duluth, Minn: I think that Mr. Kelly's suggestion is a good one, and that matter ought to be brought out. At various times estimates have been made and checked up very closely by some of the mining companies and the representatives of the fee owners.

REPORT OF COMMITTEE ON THE PRACTICE FOR THE PREVENTION OF ACCIDENTS.

(Discussion of the Paper, p. 31).

WILLIAM KELLY, Vulcan, Mich: Mr. President, I take it that this report is merely a report of progress, and that we can look forward to a more extended report later. Am I correct in that hope and expectation?

SECRETARY: I will say that the Committee has prepared this classification in the hope that it would get the matter started, and they are very anxious to receive suggestions regarding the classification. They believe that it would be advisable to make reports conform to the reports of the Bureau of Mines, and this paper sets forth the classification adopted by the Bureau at the present time. If any of the mining companies desired to carry the detail a little further they could still use the general captions and elaborate their reports to suit requirements.

PEARSON WELLS, Ironwood, Mich: I notice that one of the objects of the Committee was to do some work on uniform mine accident laws. I have here a copy of the report on that subject by the Committee appointed by the American Mining Congress. The Technical Society of Colorado went over these proposals for uniform mining laws and changed them to a considerable extent. I would like to put this into the hands of the Chairman of the Committee, but since he isn't here I will hand it to the Secretary. I think the Committee can find something of value in it. The Colorado Committee was to report to the American Mining Congress and also to the American Institute of Mining Engineers, and discussion, suggestions and criticisms by other bodies interested in mining, and from mining men in general, were invited by the original Committee.

(The report referred to is the "Proceedings of the Colorado Scientific Society, Vol. X, pp. 279-414," July, 1913).

MINE LAWS, SPECIAL RULES AND THE PREVENTION OF ACCIDENTS.

(Discussion of the Paper of E. B. Wilson, Scranton, Pa., p. 108).

EDWIN HIGGINS, Ironwood, Mich: On page in of this volume there appears a cut of a danger sign. The only reference to it in the text is where the writer states:

"In the absence of state mine laws to govern metal mining, it certainly is advisable that the operator appoint a safety committee, make a uniform set of mine rules, make use of danger signs, and also issue from time to time safety pamphlets for the miners all over the fields, calling attention to the accidents that have happened and how they may be avoided."

There is a publication to come out shortly by the Bureau of Mines, on the use of mine signs in metal mines, and an important feature of that paper will be the recommendation of three universal signs. The Bureau has requested me, if possible, to get some discussion or some expression of opinion on these signs which it will recommend. Unless there is some objection to them by some mining body or institution in some part of the metal mining country, these signs will be recommended by the Bureau as universal signs. They are as follows:

1. Universal danger sign: A circular red ball painted on a white background.

2. Universal safety sign: An arrow painted in any distinctive color. This may be used also to indicate the direction to outlet shafts, main drifts, etc.

3. Universal sign indicating ladderways: A ladder painted in a dark color on a light colored background.

PEARSON WELLS, Ironwood, Mich: This suggestion came up at the last meeting of the Mine Association of the Gogebic Range. Although we haven't come to any definite conclusion on the matter, I think that the Association will be in favor of adopting anything that the Bureau recommends. I say this for the benefit of the operators on the other ranges. I can't say definitely that

we will resolve to adopt it on the Gogebic Range, but it certainly looks like a good thing to us because the more general these things can be made the better it is for all concerned. Our men are migrating from place to place a great deal, and if we can educate them up to the universal signs it is bound to help a great deal on all the ranges. Mr. Higgins tells me that the Mining Association in the Iron Mountain district also look upon these universal signs favorably, in fact, I believe they have resolved to accept what the Bureau proposes.

SAFETY IN THE MINES OF THE LAKE SUPERIOR IRON RANGES.

(Discussion of the Paper of Edwin Higgins, Ironwood, Mich., p. 63).

A. H. FAY, Washington, D. C.: Three years ago I visited the iron ranges of Minnesota and Michigan and in passing through a number of machine shops and also around the headframes, hoisting plants, etc., I noticed that some of the companies were putting up guard rails and other safety devices on machinery, stairways and ladderways. This, however, was only in a few places. These guard rails and other safety devices were still fresh from the planning mill with scarcely a grease mark on them, indicating that the work was of recent date. I find today that practically all of those have been replaced by pipe and substantial frames of various kinds. This is not only at a few mines, but at many. The gearing of lathes has been enclosed; wire netting has been placed in front of other dangerous machinery; emery wheels have been covered with sheet iron; and band and circular saws have been encased. Stairways of heading frames, and in shops as well, have been provided with hand rails, and shaft openings provided with automatic gates or covers. In addition to all of these mechanical improvements there has been in progress a campaign of education among the miners, foremen, and operators all of which has resulted in a decrease in the fatality rate in the Lake Superior district. This decrease is show in the following tabulation of fatalities for 1911 and 1912.

FATALITY RATES IN MICHIGAN AND MINNESOTA COMPARED FOR THE YEARS 1911 AND 1912.

	Number Killed.	Number Killed Per 1,000 Employed.
Michigan iron mines, 1911	69	4.67
Michigan iron mines, 1912	52	3.62
Michigan copper mines, 1911	63	3.80
Michigan copper mines, 1912	44	2.96
Michigan total for all mines, 1911	134	4.24
Michigan total for all mines, 1912	96	3.25
Minnesota iron mines, 1911	76	4.57
Minnesota iron mines, 1912	50	3.02

It will be noted from the above table that the fatality rate has been decreased practically one unit in each case, and it is hoped that with the good work that is being done in the iron and copper mines of Lake Superior district that a still further reduction in the fatality rate may be obtained:

PENTECOST MITCHELL, Duluth, Minn: The figures submitted by Mr. Fay are very interesting, and I think they should be included in our proceedings here this evening as showing the progress that has been made during the last few years. I think this has been general over the whole Lake Superior country.

BIOGRAPHICAL

BIOGRAPHICAL NOTICES.

CHAS. T. HARVEY.

Born in 1829, in Connecticut. In his youth he worked as a clerk for Josiah Wright, in a grocery store, and later on he became traveling salesman for the Fairbanks Scales Company. In 1852 he came to Marquette, an invalid, seeking health after a severe attack of typhoid fever at his home in Connecticut. At that time he represented, as western agent, the Fairbanks Scales Company and looked after their business when he first came.

During his visit at Marquette he saw, as had many others, the necessity for the locks at Sault Ste. Marie and busied himself immediately in starting such a project. Standing six feet two inches, with great personal magnetism, he soon overcame all opposition to such a project in the state legislature, and organized the Sault Ste. Marie Canal & Land Co., with the necessary capital to complete the canal.

A government land grant of 750,000 acres was given for the building of the canal, and Mr. Harvey was placed in charge of the project and personally superintended the construct ion of the canal, which was completed in 1855.

In 1857 Mr. Harvey organized the first company to build a blast furnace in northern Michigan. It was called the Pioneer furnace and was located in Negaunee. This company was later on absorbed by the present Pioneer Iron Company, with furnace at Marquette.

He also obtained a charter for the building of a railway from Ishpeming to Escanaba in the early sixties and which is now the Peninsula division of the C. & N. W. R'y.

Later he was awarded a state appropriation for the best rapid transit system in New York city, which was the elevated street railway.

Throughout his life he was continually promoting enterprises of great public importance but from which he gained but little for himself. His ability in such matters and good judgment in their direction won wealth to many but in which he seldom shared. He died in New York city March 14, 1912.

Louis W. Powell.

Louis Weston Powell was born at Wytherville, Va., and was a graduate of Washington and Lee University. For a time he was employed in the iron mines, at Virginia, coming to the Palms mine, at Bessemer in 1896.

In 1900 he became connected with the Oliver Iron Mining Company, at Duluth, as assistant to the president. He remained with this Company, as assistant general manager, until 1906, at which time he became general manager for the Calumet & Arizona Mining, Company, at Bisbee, Arizona. In 1910 he resigned this position and was interested for a number of years, until his death, in promoting different mining companies in Mexico and the Southwest. At his death, which occurred in New York on October 24, 1913, he was president of the Elenita Development Company, vice president of the Cananea Copper Company, and a director in other copper mines.

Dr. George Koenig.

Born in Germany, 1845. Educated in Heidelberg. He came to America in his youth and taught chemistry for twenty years in the University of Pennsylvania. He established the first course in mining ever taught in the United States. In 1892 Dr. Koenig joined the Michigan College of Mines, at Houghton, as professor of chemistry.

He had a kindly humor and his lectures were very popular with the students because he illuminated them with quiet fun at times.

He died January 14, 1913, at Philadelphia, of arterio sclerosis.

His works on chemistry are used as text books at the Michigan College of Mines and other colleges.

A. Lanfear Norrie.

Born in 1858; his early home was in New York city. He received part of his education in England. Came to the Northern Peninsula in 1885 and, having some capital, commenced to explore on the then new Gogebic range. He located the Norrie mine in 1885 and 1886 and then retired from his mining work, living principally in New York city. He died there December 22, 1910.

Graham Pope.

Mr. Pope was born in the city of Boston, Mass., October 12, 1840. He was educated in the public schools there and, for a year following his student life, worked in a nautical and scientific instrument shop. He then took a position in a large mercantile house and there gained a business education.

In 1861 Mr. Pope came to Houghton and entered the employ of the Isle Royale Mining Company with the intention of following mining work thereafter. He was made treasurer and manager of the Houghton Copper Works in 1871 and continued this work for two years until the concern bad to close in 1873 for lack of capital. Then for a few years Mr. Pope was engaged on tribute mining, until 1878, when he became a member of the firm of Pope, Shepherd & Co., later becoming sole owner.

In 1892 Mr. Pope again entered the mining field, as manager of the Franklin Mine, and again gave up mining in 1899 owing to the pressure of his private affairs. He also closed his mercantile business and retired to private life.

During the Civil war Mr. Pope was a lieutenant in Company I, Twenty-Third Michigan Volunteer Infantry, and was largely instrumental in recruiting this Houghton county company. He was the donor of the soldiers' monument in Houghton, dedicated May 30, 1912.

Mr. Pope was president of 1 lie Lake Superior Mining Institute for the year 1900 and was always an enthusiastic supporter and member of the same.

In 1864 he married Miss Alice H. Fielder, of Houghton, who died in 1876, and they are survived by one son and three daughters. He died Sunday, July 8, 1912. An active. aggressive man, throughout his entire life, which was nearly all spent in the upper peninsula; he also possessed those qualities that drew from his associates their honor, respect and affection. At his death there were few in the Lake Superior region that stood as high in the estimation of those engaged in the business of mining.

Edwin J. Hulbert.

Born at Fort Brady, Sault Ste. Marie, April 30, 1829. He was a son of John Hulbert, of Sault Ste. Marie, and a nephew of Henry W. Schoolcraft, the historian, he was employed in 1857 on the survey of the state road from Copper Harbor, by way of Eagle Harbor Cliff and Houghton, to Ontonagon and, during that time, the first discoveries of conglomerate boulders were made.

He purchased lands which he thought contained copper veins and, in 1864, discovered the Calumet conglomerate lode in a pit sunk by John Hulbert, Jr., and Amos Scott. No. 4 shaft, Calumet mine, marks the site of the pit in which the discovery was made.

Mr. Hulbert had the first survey made for the Portage Lake canal, the work being done by W. H. Hearding, then of Houghton. For this survey he personally paid. The work was afterwards completed by the government. During his discovery of the Calumet & Hecla conglomerate, Mr. Hulbert acquired large tracts of land in the vicinity of the original pit, the Tamarack Mine being situated upon some of them.

For various reasons he lost almost all his holdings and, not wishing to remain in the United States, moved to Rome, Italy, where he died October 20, 1910.

ANSON B. MINER.

Born in Illinois in 1846. He entered a Chicago banking institution at an early age in the capacity of office boy. He soon gained a knowledge of the banking business and advanced rapidly until he was appointed as cashier, a position which he filled until 1874, when the bank was burned out and he was forced to journey to the West because of ill health. He returned to Chicago after an absence of several years and took a position with the First National Bank, remaining there until 1883 when he went to Ishpeming as cashier of the First National Bank of that city. The bank was reorganized later, the name being changed to the Miners' National Bank, and Mr. Miner was named as cashier and managing director.

He was one of the keenest bankers in the Upper Peninsula and his advice was sought by many. He took a great deal of interest in the mining business of the country and never failed to attend the sessions of the Institute.

Mr. Miner was married to Miss Colter, of Ontonagon, at Ishpeming, and one daughter, Mary Miner, was born to them. He died at Ishpeming on January 13, 1913, after a short illness.

JOHN MCENCROE.

Born at Detroit, Michigan, in 1834. Twenty years later lie left his native city and. started for the Upper Peninsula, shopping first at Sault Ste. Marie, where he spent a few months, and then journeyed to Marquette. At this place he secured work on the Marquette, Houghton & Ontonagon Railway, which was then being built. In 1856 he went to work at the Eureka Mine, located a short distance from Marquette. The property was operated by A. B. Ward and the ore was of the bog variety and was sent to the Wyandot furnace for smelting. The mine soon played out as the deposit was small.

In 1858 Mr. McEncroe went to Ishpeming to enter the employ of the Lake Superior Iron Company and he remained in the service of that company for 53 years, being placed on the pension roll a few years prior to his death, he was one of a little band of ten working under Gilbert D.. Johnson the Company's first superintendent. His first work was that of a miner, working in the open pits, for which he received seventy-five cents per day. In 1860 he was promoted to the foremanship of one of the pits. In 1865 he was made foreman of all of the pits and all of the surface work.

In 1873 Mr. McEncroe was made mining captain of all of the Company's hard ore mines, a position which, lie held continuously until he retired, with great credit to himself and profit to his employers. Captain McEncroe needs no greater compliment to his ability as a miner; to his organization of a working force, or to his character as a stable citizen than the simple statement that he had been engaged with one company for fifty-three years. He entered the Lake Superior field when there were but a few mining properties and the methods of extracting ore were crude, and the experiences that he often related of the early days on the Marquette range were highly interesting.

He was the oldest resident of Ishpeming, Mich., at the time of his death, which occurred on April 23, 1913.

PAST OFFICERS.

PRESIDENTS.

Nelson P. Hulst	1893	George H. Abeel	1903
J. Parke Channing	1894	O. C. Davidson	1904
John Duncan	1895	James MacNaughton	1905
William G. Mather	1896	Thomas F. Cole	1906
William Kelly	1898	Murray M. Duncan	1908
Graham Pope	1900	D. E. Sutherland	1909
W. J. Olcott	1901	William J. Richards	1910
Walter Fitch	1902	F. W. Denton	1911
Pentecost Mitchell.	1912		

(No meetings were held in 1897, 1899 and 1907.)

VICE PRESIDENTS.

	1893.	
John T. Jones F. P. Mills	J. Parke Channing	Graham Pope M. W. Burt
	1894.	
John T. Jones F. P. Mills	R. A. Parker	Graham Pope W. J. Olcott
	1895.	
F. McM. Stanton Geo. A. Newett	R. A. Parker	Per Larsson W. J. Olcott
	1896.	
F. McM. Stanton Geo. A. Newett	J. F. Armstrong	Per Larsson Geo. H. Abeel
	1898.	
E. F. Brown James B. Cooper	Ed. Ball	Walter Fitch Geo. H. Abeel
	1900.	
O. C. Davidson T. F. Cole	M. M. Duncan	J. H. McLean F. W. Denton
	1901.	
J. H. McLean M. M. Duncan	Nelson P. Hulst	F. W. Denton William Kelly
	1902.	
William Kelly Nelson P. Hulst	Fred Smith	H. F. Ellard Wm. H. Johnston
	1903.	
H. F. Ellard Fred Smith	James B. Cooper	Wm. H. Johnston John H. McLean
	1904.	
H. F. Ellard Wm. H. Johnston	Fred Smith	John H. McLean James B. Cooper
	1905.	
M. M. Duncan Fred M. Prescott	F. W. McNair	John H. McLean J. B. Cooper
	1906.	
M. M. Duncan J. M. Longyear	Fred M. Prescott	F. W. McNair F. W. Denton
	1908.	
J. M. Longyear F. W. Denton	David T. Morgan	D. E. Sutherland Norman W. Haire
	1909.	
W. J. Richards Charles Trezona	D. T. Morgan	D. E. Sutherland Norman W. Haire
	1910.	
W. J. Richards John M. Bush	Frederick W. Sperr	Charles Trezona James H. Rough
	1911.	
E. D. Brigham John M. Bush	Frederick W. Sperr	C. H. Munger James H. Rough
	1912.	
E. D. Brigham Geo. H. Abeel	W. P. Chinn	C. H. Munger W. H. Jobe

MANAGERS.

	1893.	
John Duncan Walter Fitch	William Kelly	James MacNaughton Charles Munger
	1894.	
Walter Fitch John Duncan	M. E. Wadsworth	C. M. Boss O. C. Davidson
	1895.	
F. P. Mills Ed. Ball	M. E. Wadsworth	C. M. Boss O. C. Davidson
	1896.	
F. P. Mills Ed. Ball	C. H. Munger	Graham Pope William Kelly
	1898.	
M. M. Duncan J. D. Gilchrist	T. F. Cole	Graham Pope O. C. Davidson
	1900.	
E. F. Brown Ed. Ball	James B. Cooper	Walter Fitch George H. Abeel
	1901.	
James B. Cooper James MacNaughton	(One Vacancy)	James Clancey J. L. Greatsinger
	1902.	
James Clancey J. L. Greatsinger	Amos Shephard	Graham Pope T. F. Cole
	1903.	
Graham Pope Amos Shephard	W. J. Richards	T. F. Cole John McDowell
	1904.	
John McDowell Wm. J. Richards	Graham Pope	Thomas F. Cole Amos Shephard
	1905.	
John C. Greenway John McDowell	William Kelly	H. B. Sturtevant Wm. J. Richards
	1906.	
John C. Greenway Jas. R. Thompson	William Kelly	H. B. Sturtevant Felix A. Vogel
	1908.	
James R. Thompson Felix A. Vogel	John C. Greenway	J. Ward Amberg Pentecost Mitchell
	1909.	
F. E. Keese W. J. Uren	L. M. Hardenburg	J. Ward Amberg Pentecost Mitchell
	1910.	
Frank E. Keese Charles E. Lawrence	William J. Uren	L. M. Hardenburg William J. West
	1911.	
Charles E. Lawrence Peter W. Pascoe	J. B. Cooper	William J. West L. C. Brewer
	1912.	
Peter Pascoe M. H. Godfrey	J. B. Cooper	L. C. Brewer J. E. Jopling

TREASURERS.

C. M. Boss 1893
A. C. Lane 1894
Geo. D. Swift 1895-1896
A. J. Yungbluth 1898-1900
Geo. H. Abeel 1901-1902
E. W. Hopkins .....1903-....

SECRETARIES.

F. W. Denton 1893-1896
F. W. Denton and F. W. Sperr.....1898
F. W. Sperr 1900
A. J. Yungbluth .....1901-....

LIST OF PUBLICATIONS RECEIVED BY THE INSTITUTE.

American Institute of Mining Engineers, 99 John Street, New York City.

Mining and Metallurgical Society of America, 505 Pearl Street New York City.

American Society of Civil Engineers, 220 West 57th Street, New York City.

Massachusetts Institute of Technology, Boston, Mass.

Western Society of Engineers, 1734-41 Monadnock Block, Chicago.

The Mining Society of Nova Scotia, Halifax, N. S.

Canadian Mining Institute, Ottawa.

Canadian Society of Civil Engineers, Montreal.

Institute of Mining Engineers, Neville Hall, Newcastle-Upon-Tyne, England.

North of England Institute of Mining and Mechanical Engineers Newcastle-Upon-Tyne, England.

Chemical, Metallurgical and Mining Society of South Africa, Johannesburg, S. A.

American Mining Congress, 1510 Court Place, Denver, Colo.

State Bureau of Mines, Colorado, Denver, Colo.

Reports of the United States Geological Survey, Washington, D. C.

Geological Survey of Ohio State University, Columbus, O.

Geological Survey of New South Wales, Sydney, N. S. W.

Oklahoma Geological Survey, Norman, Okla.

University of Oregon, Library, Eugene, Oregon.

Case School of Applied Science, Department of Mining & Metallurgy, Cleveland, Ohio.

University of Illinois, Exchange Department, Urbana, Ills.

University of Missouri, Columbia, Mo.

University of Michigan, Ann Arbor, Mich.

Iowa State College, Ames, Iowa.

The Mining Magazine, 178 Salisbury House, London, E. C.

Mines and Mining, 1824 Curtis Street, Denver, Colo.

Engineering-Contracting, 355 Dearborn Street, Chicago, Ills.

Mining & Engineering World, Monadnock Block, Chicago, Ills.

Mining Science, Denver Colo.

Mining & Scientific Press, 667 Howard Street, San Francisco, Cal.

The Mexican Mining Journal, Mexico City, Mexico.

Stahl und Eisen, Dusseldorf, Germany, Jacobistrasse 5.

[Lake Superior Iron Ore Shipments]

LAKE SUPERIOR IRON ORE SHIPMENTS FROM THE DIFFERENT RANGES FOR YEARS PRIOR TO 1909, 1909, 1910, 1911 AND 1912, AND GRAND TOTAL FROM 1855 TO 1912, INCLUSIVE.

(Compiled from Report Published by Iron Trade Review).

		Prior to 1909.	1909.	1910.	1911.	1912.	Grand Tot.
Marquette Range	(Tons.....	87,647,810	4,256,172	4,392,726	2,833,116	4,202,308	103,332,141
	(Per cent	21.5	10.0	10.1	8.6	8.7	18.
Menominee Range	(Tons.....	66,337,670	4,875,385	4,237,738	3,911,174	4,711,440	84,073,407
	(Per cent	16.3	11.4	9.9	11.9	9.8	14.5
Vermilion Range	(Tons.....	28,017,170	1,108,215	1,203,177	1,088,930	1,844,981	33,262,473
	(Per cent	6.9	2.6	2.6	3.4	3.8	6.5
Gogebic Range	(Tons.....	56,732,446	4,088,057	4,315,314	2,603,318	5,006,266	72,745,401
	(Per cent	14.	9.5	10.0	8.0	10.4	12.5
Mesabi Range	(Tons.....	167,548,343	28,176,281	29,201,760	22,093,532	32,047,409	279,067,325
	(Per cent	41.1	66.1	67.2	67.4	66.5	48.2
Cuyuna Range	(Tons.....				147,431	305,111	452,542
	(Per cent				.4	.6	.1
Miscellaneous	(Tons.....	797,868	82,759	91,682	115,629	104,031	1,191,969
	(Per cent	.2	.2	.2	.2	.2	.2
Total tons.....		407,081,316	42,586,869 Increase over 1908 63.6%	43,442,397 Increase over 1909 2.0%	32,793,130 Decrease from 1910 24.5%	48,221,546 Increase over 1911 47.0%	574,125,258