The Use of Pulverized Coal

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By H. R. COLLINS†

Methods of preparation of pulverized coal detailed and the advantages in the adoption of the system enumerated. The principal features of modern practice are presented in condensed form, and the economies said to result from the substitution of pulverized coal discussed, with details of savings effected in various types of furnaces.

THE purpose of pulverizing coal before burning it is to make available every heat unit that it contains. Machinery has been developed which will pulverize coal in one operation, delivering it to bins in front of the furnaces at an expenditure of about 17 hp.-hr. per ton, in a medium-sized plant. The cost of the operation depends upon the amount of moisture that must be expelled before pulverizing, the wages of labor, and the price of coal delivered at the plant. At a small plant, requiring a pulverizer with a capacity of only ½ ton per hour, the cost per ton pulverized will naturally be greater than at a plant requiring the largest pulverizer, possessing a capacity of seven tons per hour.

Preliminary Crushing and Drying

The first step is to reduce large lumps to a size suitable for drying uniformly, before passing to the pulverizing mills; this is done in rolls, at a single pass. The second step is the elimination of moisture, in order to facilitate pulverizing to great fineness, while also increasing the heating effect and the temperature attainable when the coal is burned. There are other mechanical advantages in the handling of dried coal. Driers are now manufactured which are able to eliminate moisture without distilling any of the volatile combustible matter in the coal. They are fired by hand or with pulverized fuel. The heat first surrounds the shell of the drier, being confined within a chamber where complete combustion takes place; the heated gases are then led through a duct to the discharge end of the drier and enter the inside of the shell at a temperature not exceeding 300° F. This temperature is maintained by the operator and is indicated by a pyrometer. Volatile combustible matter is not likely to be distilled until the temperature rises above 400° Fahrenheit.

Elimination of Iron and Pulverizing

On discharging from the drier, the coal is usually passed over a magnetic separator in order to prevent pieces of iron from going to the pulverizer. Two types are used: a magnetic pulley which automatically discharges its collection of iron, and a lifting type, from which the iron is removed by hand when convenient. In the operation of pulverizing, the coal should preferably be reduced until 95% will pass through a 100-mesh and 70% through a 200-mesh sieve. Such a product is obviously an almost impalpable powder. After pulverizing, the fuel is conveyed by one of several methods to the point where it is to be used. In several installations the pulverized coal is conveyed a distance of over 900 ft. Where possible, a bin should always be installed at the furnace, in order to guard against interruption of supply.

Feeders are practically indispensable for regulating the passage of the fuel from the bin to the burner. They are now made of simple design and are highly efficient. They deliver the pulverized coal in definite quantities into an air current of fixed volume, where the air disseminates the pulverized fuel, surrounding every particle and putting it into condition to develop all its energy. The first to ignite are the volatile gases; these raise the temperature to the ignition point of the solid carbon, and before leaving the zone of heated air every particle has released its last heat unit. It is entirely possible to obtain temperatures ranging between 1900° and 3500° F.; the highest temperature (3500°) I have observed was in an openhearth, when the average temperature of the furnace itself at some time ranged from 3100° to 3200° Fahrenheit.

Advantages in Pulverizing Coal

To justify the expense of erecting a special building and installing special machinery to pulverize coal, the following advantages in its use may be enumerated:

1. Conservation of the country's fuel, by utilizing every heat unit in the coal, made possible by this method of consumption.

2. Reduction of labor for handling coal to the point of consumption, handling by the fireman, and the removal of ash and unconsumed fuel from the ashpits; practically all this expense is avoided when fuel is burned in pulverized form. All the coal is received at one point, and thereafter it is handled entirely by automatic machinery, the human element being thereby eliminated, except for supervision, adjustment, and necessary repairs.

3. From actual experience with many grades of coal, I believe that every carbonaceous fuel in solid form, from lignites to the graphitic anthracites of Rhode Island, will yield its maximum measure of heat if burned in a truly pulverized condition.

4. Coal in pulverized form can be injected into a furnace on a column of air at very low velocity, thus allowing the expanding gases to liberate their heat without erosion of the refractories.

5. Pulverized fuel permits the maintenance of a constant temperature in a furnace when the relative amounts of fuel and air have once been set and the body of the furnace has been brought up to the desired temperature. It will continue thereafter under what is known as a test condition. Furnaces can be operated in this manner hour after hour, as shown by charts of recording pyrometers. The correct relationship between the amount of pulverized fuel and the volume of air, for any desired temperature, can be controlled automatically, after adjustment to the particular grade of

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coal in use, thus using a minimum of excess air. Gas analyses have been obtained showing as high as 17% of CO_2.

Pointers in Pulverized Coal Practice

Many questions are asked on the subject of pulverized coal, and I have arranged the answers to them in the following order:

1. *Grades of Coal Used Successfully*—For kilns, boilers, or metallurgical furnaces, coals of about 35% volatile, 50% fixed carbon, 8% or less ash, and 2% or less sulphur, are preferable.

2. *Experience with High-Ash and High-Sulphur Coal*—Coals analyzing 25% ash and 5% sulphur have caused no trouble in kilns, boilers or metallurgical furnaces. Experience shows that sulphur is entirely consumed by burning in suspension, none of it being absorbed by the metal or other liquid bath, as occurs in the usual copper reverberatory furnaces used for melting electrolytic copper.

3. *Provisions for Storage*—Storage bins for pulverized coal should be dust-tight and have steep hoppers, enabling old coal to leave the bin completely; accumulations of old coal are liable to fire, smolder, and coke, causing more or less annoyance.

4. *Why Coal Should Be Dried Before Pulverizing*—(*a*) To facilitate the pulverizing operation, giving the finest product with the least power consumption. (*b*) To permit high temperatures with the least consumption of fuel. Drying of the coal also promotes uniformity of temperature. (*c*) Dried coal will flow more easily from bins and through the feeders and burners. Coal should be dried to 1% of moisture, or less when possible, except that lignites can be readily handled with 5 to 8% combined moisture.

5. *Fineness of Grinding*—The finer the coal the more rapid its combustion, with relatively higher efficiency. It is commercially and economically possible to grind coal so that at least 95% will pass a 100-mesh sieve and 70% will pass a 300-mesh sieve.

6. *Cost of Handling, Grinding, and Upkeep*—The cost of preparing pulverized coal depends largely on the price and on the moisture content of the coal to be used. On the basis of 200 tons per day of coal containing 7.5% moisture, at present rates of wages and supplies and with coal ranging in price from \$1 to \$8 per ton, the cost of pulverizing will be between 30 and 40c. per ton, not including overhead charges, interest, depletion or depreciation.

7. *Danger From Dust Particles Floating in the Air*—A mixture of coal-dust particles in air will not ignite until it reaches a certain density; on the other hand, a mixture that it too rich in coal dust has a tendency to smother flame. Dust clouds should naturally be avoided outside the furnace chambers, and all sparks or flames should be kept away. Pulverized coal should be conveyed from mills to bins in as compact condition as possible; air currents should not be used to convey pulverized coal if any other method can be devised. Leakages should be stopped, to prevent uncleanness and accumulations in inaccessible places. Carelessness in the handling of pulverized coal and poorly designed plants are the only causes of so-called explosions.

8. *Essentials of a Good Feeder*—It must absolutely control the flow of pulverized coal to the burner, and prevent any rush or flooding of the fuel. This is essential for the positive control of predetermined temperatures.

9. *Essentials of a Burner*—A good mixing projector, or burner, should be so designed that it will receive the pulverized coal in regulated quantities, break up the stream of fuel, and so distribute it that each particle is surrounded by the correct proportion of air. It must also project the fuel into the furnace at the velocity required by the operation, and must be so proportioned as to deliver the necessary volume of air at the proper velocity. Four types of burners are employed: (*a*) Induction type, in which a high-velocity jet induces and entrains the necessary additional air, and projects it into the furnace at low velocity; this type has the high-velocity air under control as well as the induced air. (*b*) Positive type, in which the high-velocity air induces and entrains the fuel and projects it into a positive, larger column of low-velocity air, thereby breaking up the fuel stream evenly, and disseminating it through the larger column of low-velocity air before it enters the furnace. The larger column of low-velocity air is usually preheated, in stoves located in a chamber through which the waste gases from the furnace pass; temperatures of preheating range from 100° to 600° F. in the better-designed system of stoves. Both columns of air are positive, being generated by fans or pressure blowers, and gates regulate the quantity. (*c*) Single type, in which the high-velocity air first induces and entrains the fuel stream, after which a high-pressure jet of air, applied usually in the center of the stream, gives a sharp projection of flame and quick distribution of the fuel through a larger volume of preheated air at low velocity. This type of burner is usually adjustable in direction. The heated air ranges in temperature from 2200° to 1300° F., as in openhearth practice; usually 10 to 15% of the air enters with the fuel, and 85 to 90% from regenerators. The stack draft through the regenerative chambers is regulated by a valve. (*d*) Single type, in which the high-velocity air induces and entrains the fuel and projects it into the furnace, as in rotary-kiln practice, under usually 5 to 6 oz. pressure from a fan. The additional air required for combustion is induced by stack draft, and enters around the hood and through the kiln discharge opening.

10. *Air Pressure and Effect of Stack Draft*—Air pressures of ½ oz. entering the combustion chambers of some types of furnaces, from air and fuel mixing burners, up to 2 lb. in pressure jets of other types, have been in successful and constant use for years. Stack draft should be of only sufficient intensity to create a partial vacuum in the furnace, thereby helping the fuel and air into and not out of the chamber; its strength must be enough, however, to extract all the products of combustion.

11. *Design of Furnace*—Fuels low in volatiles but high in fixed carbon, as anthracite and coke breeze, require a special furnace in which the incoming fuel and air pass through the flame and the products of combustion, in a water-cooled, arched firebrick chamber, on their way to the furnace or boiler. When the volatile constituents of the fuel range from 1 to 3.5%, it is difficult to support combustion unless a temperature above 900° to 1000° F., the flash-point of carbon, is

maintained. The water-cooled arch, rear wall, and side walls are made of a special form of firebrick, which slips in place over the water tubes. After circulating through the tubes, the water passes to the hotwell or heater at approximately 190° F., entailing no appreciable loss of heat. Lignites and bituminous coal require no special furnace. As the volatiles ignite between 600° and 700° F., from the radiant heat of the walls, the flame is self-supporting, and every heat unit in the fuel is liberated before coming into contact with any cold surface.

12. *Ash or Furnace Slag*—Anthracite, coke breeze and lignite ash do not slag. Bituminous coal ash will slag on the bottom of the furnace chamber if not blanketed with cooler air, properly admitted, and if allowed to remain too long in the furnace. Most of the ash from pulverized coal passes away through the breeching to the cyclone, where the ash is separated from the gases. That portion which settles to the floor of the furnace should be removed from time to time; the quantity is small and light.

13. *Furnace Temperatures and Slag Formation*—Temperatures between 1800° and 3500° F. can be maintained in the flame. Slag forms more readily at high temperatures, necessitating proper blanketing with cooler air, always remembering the advisability of obtaining the maximum percentage of CO_2. From 16.5 to 17% of CO_2 is frequently obtained under operating conditions.

14. *Checkerwork in Metallurgical Furnaces*—Experience seems to point to the necessity for vertical baffle walls where the waste gases enter the regenerative chambers. Turning the direction of the gases up and down several times tends to discharge the dust tangentially, allowing the major part to settle in the bottom of the passages, whence it is easily removed through proper cleaning doors at the sides, not interfering with the operation of the furnace. The gases then filter through checkerwork, properly spaced and installed. The narrow side of the brick tile should be laid vertically and on rider walls, to permit the use of longitudinal scrapers to remove the ash which may have passed by the vertical baffle walls. This arrangement will undoubtedly give the regenerating chambers a life equal to the best record ever attained, as the narrow edge of a vertical tile presents little surface for the flocculent ash to rest on and thus close the gas passages.

15. *Furnace Life*—The life of furnaces in which pulverized fuel is used is equal to that of hand-fired, stoker, oil, or gas-fired furnaces. By absolute control of the quantity of coal and air, the velocity of the expanded gases can be reduced until erosion of refractories becomes hardly discernible.

16. *Economy of Pulverized Coal*—In this connection, all the benefits of pulverized coal should be taken into account: labor saving, increased fuel efficiency, ability for closer adjustment, and absence of smoke.

Comparative Costs and Economies

The efficiency of hand firing depends upon the skill and reliability of the fireman. With the best of attention, a loss of 20% heating value is frequent, and it often reaches as high as 40%, taking into consideration the analysis of the ash and of the flue gas. Stoker firing is relatively more efficient and more regular than hand firing, but the feeding of moist coal wastes part of the heat in the most undesirable place. Losses also occur in breaking and removing the clinker, in the discharge of unburned fuel, and in the flue gas.

Producer-Gas Firing: Referring to W. H. Blauvelt's results[1] and as quoted in Kent, page 819, it will be noted that 131,280 cu.ft. of gas was produced from one ton of coal, and contained 20,311,162 B.t.u., or 155 B.t.u. per cubic foot, or 2270 B.t.u. per pound of gas. The composition of the coal from which this gas was made was as follows: water, 1.26%; volatile matter, 36.22%; fixed carbon, 57.98%; sulphur, 0.70%; ash, 3.78%. One ton contains 1159.6 lb. carbon and 724.4 lb. volatile combustible, the energy of which is 31,302,200 B.t.u. Hence, in the process of gasification and purification, there was a loss of 35.2% of the energy of the coal. Producers are built today which will do slightly better than this.

Oil and Natural-Gas Firing: Coal, properly pulverized and burned, is on exactly the same basis as far as thermal capacity is concerned; and the price of the coal prepared and delivered into the furnace is directly comparable, on the heat-unit basis, with the cost of fuel or gas delivered into the furnace, plus the slight additional cost for ash removal.

Savings by the adoption of pulverized fuel in the operation of various types of furnaces have been attained as follows: heating and busheling furnaces, 20 to 25%; puddling furnaces, 30 to 50%; openhearth furnaces, compared with gas producers, 30 to 40%; copper reverberatory, smelting ore, 30 to 45%. In other furnaces, the consumption has been reduced to the following figures: continuous billet heating, 160 lb. of coal per ton of billets; desulphurizing iron ore in rotary kilns, 296 lb. of coal per ton of ore; drying and nodulizing iron ore in rotary kilns, on basis of 30% free moisture and 11% combined moisture, 477 lb. of coal per gross ton of ore. The figures given are from actual operations over extended periods, and confirm the contention that coal burned in true pulverized form is the only method by which every unit in the fuel can be made to develop its full value.

The Metallurgy of Antimony in France*

In considering the metallurgy of antimony, it is to be remembered that all conditions are subject to the constant fluctuations of the world market for the metal. Before the war the metallurgy of antimony had received little attention. It was the rule to treat, by a simple process of liquation, only the richest ores, and at points best situated for economical reduction, notably in England. Later, in France, where the deposits were relatively lean, a simple method of volatilizing roasting was adopted which converted the antimony contents into the oxide Sb_2O_3, which was then either sold direct or converted to regulus by reduction in small reverberatory furnaces. Despite the discovery of an important deposit of rich gold-bearing stibnite

[1]Trans. A. I. M. E. (1889), 18, 614.

*Abstract of report by M. Itiver, "L'Echo des Mines et de la Metallurgie," Mar. 10, 1918.

Six-cent Copper from Calumet & Hecla Tailings

Over 50,000,000 Tons of Sand, Accumulated During Half a Century, Being Treated by Tabling, Flotation, and Leaching

By C. H. Benedict

Metallurgist, Calumet & Hecla Consolidated Copper Co., Lake Linden, Mich.

THE CALUMET & HECLA MINING CO. was organized in 1871 as a consolidation of four companies, two of minor importance, together with the Calumet Mining Co., formed in 1865, and the Hecla Mining Co., organized about a year later. Both these latter companies found profitable ground at once and began the erection of stamp mills. The Calumet Mining Co. first erected its mill at the mine, but in a few years moved to its present site on Torch Lake adjoining the site on which the Hecla Mining Co. had already built its original mill and which is about four miles from the mine. These mills have been in existence then, at the same site, for upward of fifty years and have been depositing their tailings continuously into Torch Lake during that period.

Torch Lake is one of a series of inland lakes in the Keweenaw peninsula of upper Michigan, but is distinguished by being on the same level as Lake Superior, with which it has navigable connection; and it is distinguished further by the fact that it is quite deep relative to its area. At the time the mills were erected on the shore of this lake there was no thought of anything except the desire to find room for the sand tailings, but considering the development of the mine and of the art of metallurgy in the fifty years following the foundation of the mills, no better site could have been found anywhere. The shore adjacent to the lake is relatively flat, so that all buildings are at approximately the same level, but the sloping hills running down toward the shore permit of a uniform grade to a gravity railroad, and a trestle of moderate length gives the necessary elevation for gravity run to the ore bins and stamps.

The mills were built close to the shore of Torch Lake, and for some years there was sufficient elevation so

Dredge and portion of pontoon line

that the tailings ran into the lake by gravity, but as the deposit increased in area the shore gradually receded and it was necessary to provide some means of giving the tailing sufficient elevation to reach the lake. For this purpose a device was developed unique in this country at that time, and even yet but few are in use outside of the Lake Superior copper district. This is

Shore plant, showing storage pool and swinging suction line

known as a sand wheel, a slowly revolving wheel with depressions or buckets in the periphery which take their load at the bottom and discharge tangentially on approaching the top. Starting with a 30-ft. wheel the diameter of successive wheels was increased to 40, then to 50, and finally to 65 ft., to reach the desired elevation.

Originally two mills were built, known as the Calumet mill and the Hecla mill, and there are two distinct tailing piles with their centers about three-quarters of a mile apart and with clear water between, the two almost inclosing a bay from which is drawn the water for the pumping station. These tailing piles covered an area of about 152 acres at one time and vary in depth from nothing at the shore line to 120 ft. The reclamation plants are erected centrally to the north of the Calumet pile, and it is this pile that is now being reclaimed. The Hecla bank was all of it conglomerate up to about 1900, but since that date the south or extreme end has been mostly amygdaloid tailings of much lower grade, and there will be a boundary line between the conglomerate and the amygdaloid, which, as dredged, will be a mixture of the two. When this mixed material is to be reclaimed it will result either in the inclusion of low-grade material which would not pay by itself to reclaim or in the exclusion of some conglomerate tailing which by itself would be profitable.

At the beginning of mining operations in the late 60's the ore was running better than 100 lb. to the ton by assay and the metallurgical methods were naturally crude compared to present-day standards. The ore increased in richness for some years after the opening of the mines, and tailing losses of 20 lb. to the ton and more were not out of the ordinary. In those years the smelters required a very high-grade product, and as the fine copper could not be concentrated profitably to smelter requirements, practically no effort was made to save the slimes until about 1884, when buddles or circular slime tables were introduced. Neither was any effort made, except spasmodically, to do any grinding other than that by the original stamp, which crushed all material to pass through a $\frac{1}{8}$-in. round opening screen. This made for very rich tailings, and it was not until

Fig. 1—Map of Calumet & Hecla units at Lake Linden

about 1898, with the introduction of Wilfley tables, soon followed by fine grinding in Chilean and later in Hardinge mills, that any serious attempt was made to reduce the losses of fine inclosed or attached copper. The introduction of this more modern machinery was coincident with a rapid falling off in the quality of the ore sent to the mill, owing partly to the lessening in grade of the deposit underground and partly to the fact that lower-grade ore could be treated economically. A further decided drop in the copper losses followed the installation of a regrinding plant in 1908 and made it appear that the tailings subsequent to that date might not be profitably reworked, although they still contained about 9 lb. of copper to the ton. These tailings were accordingly segregated on one portion of the Calumet pile. With the discovery of the leaching process in 1912 and the adaptation of flotation a few years later it became evident that these apparently worthless tailings were of economic value. In the year just passed the work was almost entirely on these later fine, low-grade tailings, and the curious fact is that while the recovery per ton was less, the cost per pound of copper recovered was as low as on the richer coarse tailings of previous operations. This is because the regrinding cost is entirely eliminated.

That these tailings had commercial possibilities was recognized for a great many years before any effort at recovery was begun. Until the development of modern fine-grinding machinery, coincident as it was in the Lake Superior district with the introduction of the low-pressure turbine and consequent cheap electric power, it was not felt that the time was right for beginning operations. Then, at first, the plans were only for finer grinding and Wilfley table treatment, and it was the expectation that the recovery might not exceed 40 per cent. Even this was attractive, and work was begun in 1912. The regrinding plant was not yet in operation, however, before the leaching process was developed, which promised to double the anticipated recovery. Construction work was started in 1914 on the leaching plant, designed to treat sand, and experimentation was continued on the treatment of the slime by the same process. The rapid development of flotation, however, and its adaptation at the Calumet & Hecla to native copper, made it advisable to discontinue work on the leaching of slime, and a flotation plant was erected for this material. This again increased the recovery, so that about 85 per cent of the values contained in these tailing piles will probably be obtained by the present process. Inasmuch as the recovery on the ore originally was about 75 per cent, over 95 per cent of the metal contents of the Calumet & Hecla conglomerate lode as mined will be obtained as refined copper, a record probably unique in the history of any copper-mining operation.

Model showing status of sands for reclamation plant. The white represents lake bottom, and the dark, reclaimable sands.

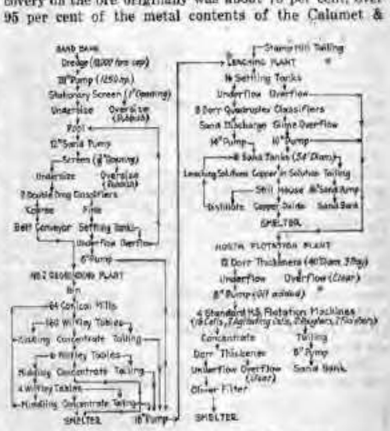


Fig. 2—Flow sheet of reclamation plant

Although the commercial possibilities of these deposits had been recognized long before recovery plants were erected, their treatment was not sufficiently imminent to prevent surface contamination. All the rubbish of the stamp mills and from the adjacent towns was deposited on top of these sand banks, and although this rubbish does not constitute a large percentage of the total weight, it amounts to thousands of tons of every conceivable kind and size of material, and any plan for the reworking of the sand had to take into account a mixture of ashes, hoop iron, wire cable, launder plates, and submerged logs. After five years of operation the suction dredge originally chosen has been in commission without at any time having had serious difficulty in operation.

The reclamation plant as at present constituted consists of five units separately housed as follows:

1. Dredge.
2. Shore pumping plant and classifying house.
3. Regrinding plant.
4. Leaching and distillation plant.
5. Flotation plant.

Fig. 1 shows a diagram of the units of this plant in connection with the other mill buildings. Fig. 2 is a flow sheet.

1. *Dredge*—It was recognized at once that a suction dredge would be the only possible means of reclaiming these tailings, because of the depth of the deposit and the severity of the climate. It was not feasible to develop a dredge by experimentation on a small scale, because from the very nature of the problem large-scale operation only was possible. No dredge had ever been designed to dig 110 ft. below the water level. A bucket dredge was considered entirely unfit, because of the depth, and also because of the fact that although a bucket dredge might handle rubbish to good advantage, the sharp coarse sand would be very hard upon the innumerable bearings. Further, it was thought impossible to operate such a dredge in winter time in the Lake Superior district, with the thermometer frequently reaching 20 deg. below zero.

The dredge finally adopted was developed with the aid of the Bucyrus Company, of South Milwaukee. It is a steel-hull dredge 56 ft. wide and 110 ft. long, with an overhanging deck 8 ft. wide. As originally installed, having in mind the amount of oversize rubbish to be handled, the dredge was provided with two dredging pumps. The first discharged into a 14-in. revolving screen for removing rubbish, the undersize going to a sump from which a second pump elevated the material and discharged it through the pontoon line.

After experiencing considerable trouble with the elimination of the oversize rubbish in this way, a method was finally devised of using but a single pump for dredging the sand directly from the pile and discharging it through the pontoon line to a stationary screen at the shore plant. This eliminated entirely the revolving screen on the dredge and the second dredge pump, and resulted in a tremendous saving of power and maintenance. It is surprising what large pieces of timber, rope, and even steel plate can be picked up by the pump and carried through 3,000 ft. of the 20-in. discharge pipe to the receiving pool on shore without choking pump or pipe.

In winter time 2 ft. of ice on the lake is usual, 20 deg. below zero is not uncommon, and usually for two to three weeks the temperature is continuously below zero. However, these conditions have caused no delay in the eight years of operation, and the dredge has less difficulty and loss of time in mid-winter than the railroad that brings ore from the mine to the mill. At first, efforts were made to cut the ice from about the dredge and haul it away. When the revolving screen was discontinued, however, so that the second dredging pump was not required, this pump was connected to a pipe surrounding the dredge and discharged water through a series of nozzles about 10 ft. above the deck of the dredge. The agitation from this water was sufficient to keep the ice from forming freely and also to melt such ice as had been formed adjacent to the dredge. For the last four years it has not been necessary to break or remove ice by other means, and the cost of operating this pump for a few hours each day is small.

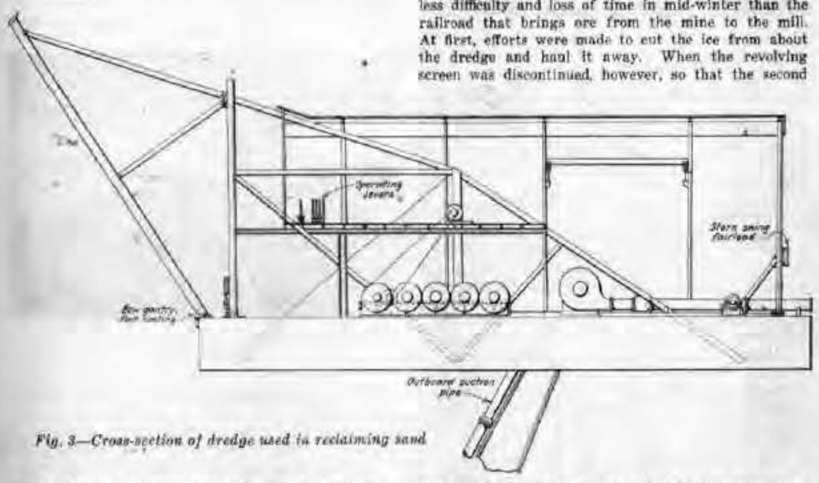


Fig. 3—Cross-section of dredge used in reclaiming sand

Fig. 3 shows a cross-section of this dredge. The dredge pump itself has a 20-in. diameter inlet and outlet, with impellers 55 in. in diameter, operating at 360 r.p.m., and is equipped with a 1,250-hp. motor. The pump casing is split vertically and is lined throughout. Various types of material for liners have been used, and although the best results are obtained with manganese steel, chilled cast iron made in the local foundry is much the cheapest material per ton dredged. In addition to the main dredge pump, and an auxiliary pump for supplying water to prevent ice formation, there is a 4-in. centrifugal pump for service water and an 8-in. centrifugal pump for supplying water at 75-lb. pressure for agitating the sand. The dredge suction is supplied with nozzles reaching out in all directions

Flotation plant, showing row of Dorr thickeners. At the right are the backs of the flotation machines.

along the periphery of the suction mouth; these nozzles discharging water under pressure keep the sand in agitation and break down the bank in advance of the digging ladder. The pipe for supplying this water is carried on the digging ladder and connected to its pump through a rubber sleeve. This type of agitation has proved satisfactory and at no time has the lack of a rotary cutter been felt.

When the dredge gets into certain portions of the bank there is a tendency for the material to hold up beyond the natural angle of repose, and consequently caves of considerable magnitude occur. Only once has a cave-in proved serious, the digging ladder being caught under an avalanche of sand. To release it, it was necessary to abandon the regular suction of the dredge and install a new suction, using the original dredge pump, operating the temporary suction independently by means of tackle from above, lowering it gradually through the accumulated sand, and adding additional pipe with depth until the ladder was finally freed. The ten-day delay because of this accident, and a second shutdown of three weeks when the dredge was dry-docked and the hull scraped and painted, have been the only interruptions to continuous service during eight years of operation.

The suction ladder consists of two longitudinal latticed girders thoroughly fastened and well braced. It is 141 ft. from center of suspension to the end of suction, and will permit of dredging to a depth of 110 ft. It carries the outboard suction of lap-welded pipe and also an 8-in. water pipe for supplying water under pressure for breaking down the sand. The center of the dredge pump is on the same center line as the pivot of the suction ladder, and the suction pipe is connected to the pump by an elbow, swiveled on this same center line. Near the outer end of the suction ladder the lower block of the hoisting tackle is attached, and the upper block is attached to the bow gantry, forming part of the hull.

The dredge is not self-propelling, but is operated by swinging lines fastened to anchors in the water and deadmen along the shore. There are two four-drum winches for operating the lines, two drums of which are for the ladder swing, two for the bow-line swing, two for the stern-line swing, one for the stern line, and one for hoisting the suction ladder. The bow swing lines are $\frac{7}{8}$ in. diameter, the ladder and stern lines are $\frac{3}{4}$ in. and the ladder hoist rope is 1 in. diameter, all plow steel. All pumps and winches are electrically driven, but there is a small boiler on the dredge to provide steam for heat and also for operating capstans when the electric power is cut off.

Electricity is supplied to the dredge at 2,300 volts, the power lines being supported on towers attached to the pontoons carrying the discharge pipes. The main dredging pump motor is 1,250 hp. rating and consumes about 900 kw. when working through its maximum discharge pipe of 3,000 ft. length. An additional 200 kw. is consumed by the 8-in. and 4-in. water pumps. Water rheostats control the speed of the pump with a variation of about thirty revolutions, from a minimum of 335 r.p.m.

Inboard and outboard pipe is of 21 in. diameter outside and the discharge line consists of the same kind

Regrinding plant, showing 64 8-ft. x 18-in. Hardinge mills

of pipe, mostly in 60-ft. lengths, carried on steel or wood pontoons. The pontoon pipes are connected by means of rubber sleeves, and although other types of flexible connections have been tried, especially ball joints, everything has been abandoned in favor of the rubber sleeve. The sleeves are held on by split steel bands, which arrangement, in connection with the beaded ends of the pipe, gives a simple flexible joint, and one that does not cause much trouble.

The pontoon line discharges at a fixed point on the shore into a stationary screen 16x20 ft., with round openings 1 in. in diameter. This discharge is placed so that the sand runs from the screen into a pond or reservoir which supplies the pumps in the shore plant about to be described. Not much rubbish accumulates on the screen, but it may consist of large pieces, including many relics of the early days. A chain 6 ft. long was once removed from the screen; also pieces of cast iron, innumerable rocks, and logs up to 16 in. in diameter.

The dredge has a rated capacity of 10,000 cu.yd. per day, which has been realized. No facilities have ever been at hand to make a definite test of its efficiency, and there is so much variation in the size and nature of the sand to be pumped, the length of discharge line, the condition of the impeller and pump casings, and depth of suction, that a test would be of little value. In the winter about sixteen hours, including delays, are required to do the necessary work, and sometimes during the summer, when the pontoon line is 3,000 ft.

long and the sand is fine and scattered, continuous operation is necessary.

No effort is made to synchronize the operation of the dredge with the plants on shore, which must run uniformly twenty-four hours per day. The capacity of the reservoir in front of the shore plant is such that the dredge can shut down two or three days at a time without the plants being short of sand. A dredge is necessarily intermittent in its operation, even when working under the best of conditions, and under the varying conditions met in this operation there is no possibility of supplying sand in either uniform quantity or dilution.

The general method of operating the deposit and the measurement and control of the work is carefully studied from day to day. Fortunately the United States Government had made accurate soundings in Torch Lake before the mills were operating for any length of time, so that the extent of the deposit both laterally and in depth is accurately known. A sectional model (shown in the illustration) has been made, consisting of vertical wooden pegs fastened into a horizontal board representing a base line. These pegs indicate conditions for each 50-ft. station and by means of different colors show lake bottom, lake level, and recoverable sand. Frequent soundings keep this model up to date, and operators on the dredge know at all times at what depth to expect sand and to what extent. Ranges along the shore and floating buoys assure accurate knowledge as to the position of the dredge, and a section of the model in the pilot house provides complete information as to conditions of deposit. The original lake bottom is fortunately a compact sand that resists dredging with this type of machine, and much of the area is as clear of tailing after dredging as a surface operation could be. In addition to this model, which is changed to show existing conditions, there is a cross-section for every 100 ft. which shows the progress from month to month.

Row of tanks in leaching plant. First tank has launder and distributor in place. Second tank is uncovered. Others have covers in place.

A problem at first was to find room for current tailing. For this reason the outer and more recent deposit has been dredged up to this time. In winter when the climatic conditions are at their worst the dredge is moved close to shore to shorten up the pontoon line and minimize operating difficulties; in summer more distant material is attacked. The operation is from its nature a "one-stope mine," but the quality of the sand does not vary greatly from day to day, although the proportion of coarse to fine does show a wide fluctuation. This results in operating difficulties felt more particularly in the flotation plant.

The cost of this operation for 1923, including all replacements and renewals, was 6.30c. per ton dredged. This is made up roughly of 32 per cent for labor, 14 per cent for pump renewals, 40 per cent for power, and 14 per cent for other supplies. These costs are for an average discharge line of about 2,000 ft., and vary somewhat with the size of sand, length of line, and other factors. The costs are showing a downward tendency from year to year as capacity is being increased and as greater experience is being acquired.

2. *Shore Pump Plant and Classifying House*—This plant is built upon a concrete dock constructed by driving piles through the sand down into the original lake bottom and upon these piles putting a cap of concrete 3 ft. 6 in. thick. The shore plant contains a 12-in. Morris centrifugal pump for the elevation of the sand, stationary screens for removing fine rubbish, drag-belts for separating the coarse sand that requires regrinding, from the fine, pumps for handling this fine sand, and a belt conveyor for conveying the coarser sand from this plant to the top of the regrinding plant. In the pond or reservoir in front of the shore plant into which the dredge sand is discharged is a semicircular row of piles having a radius of 35 ft. on which is constructed a track. Supported on this track and pivoted in front of the plant is a structural steel bridge 55 ft. long, which carries the suction pipe of the pump in the shore plant. This suction pipe works on swivel joints, so that it can travel through an angle of about 150 deg. and its outer or suction end can be raised or lowered vertically through an angle of 90 deg. The effect of this is to get a storage capacity for this suction pump in the shape of a "V" section along about one-half of the circumference of the 55-ft. circle and to a depth of 30 ft. below the water line. Thus is obtained a storage reservoir equivalent to about 20,000 tons' sand capacity, from any part of which the sand may be reclaimed, depending upon the position of the suction pipe carried on this swinging bridge. In reality it is a stationary dredge working under uniform conditions as to length of suction line, so that uniform capacity is obtained and the re-treatment plants are kept operating under uniform conditions, a necessity for efficient metallurgical practice.

To guard against delays in the shore plant, the original design called for two pumps so placed that

Leaching plant, showing tank filling

by swinging a suction elbow through 180 deg., one pump could be replaced by the other. Delays have been so infrequent, however, that such changing of parts as is necessary can be done during the regular six-hour shutdown once a week, so that only a single pump has been necessary. This pump has a 12-in. suction and discharge, is split horizontally and lined throughout. The impeller is 40 in. in diameter, running 375 r.p.m. direct connected to a 200-hp. motor. The discharge of this pump goes into a large receiving box fitted with an overflow for the excess water, and as this water carries considerable fine sand it is returned to the storage pool. Circulation of water is very useful in winter, as the agitation caused thereby aids in keeping the pool free from ice. The receiving box is provided with four openings, gate controlled, through which the sand and water flow to stationary screens with ⅜-in. diameter openings. These screens are for the purpose of removing the finer particles of rubbish. The undersize of these stationary screens is fed to two double drag-classifiers, each fitted with two 20-in. belts, these belts being provided with 6x4-in. angle

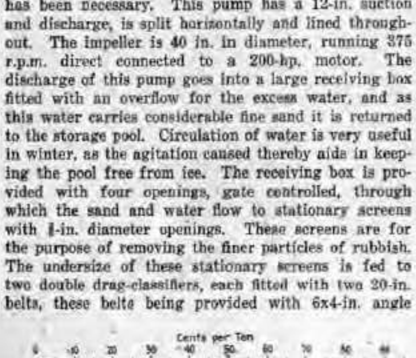


Fig. 4—Reclamation plant costs, 1915 to date

irons, 24 in. long, as drags. The discharged product of these drag belts is fed by chutes to a 22-in. belt conveyor, and the overflow, after suitable dewatering, is pumped directly to the same sand- and slime-classifying system that takes also the tailing of the regrinding plant.

The cost of operation of this plant for 1923 was 2.47c. per ton, including belt conveyor delivery to the regrinding plant. Of this cost 45 per cent was for labor, 30 per cent for power, and 25 per cent for supplies, chiefly pump repair parts and pipe.

3. *Regrinding Plant*—The material treated in the regrinding plant is the coarse sand classified out by the drag-belts in the shore plant and fed to the top of the plant by means of a belt conveyor. This belt conveyor is 275 ft. between centers, runs at a speed of 500 ft. per minute, and has an inclination of 2½ in. to the foot. It discharges into a receiving bin, which has sufficient storage to supply the mills for about thirty minutes. In the bottom of this receiving bin are discharge openings, from which the relatively dry sand is run at a uniform rate and fed by means of water jets into launders running down either side of the plant and discharging into dewatering boxes for feeding the conical mills.

The building itself is 122x481 ft. and contains 64 Hardinge mills, 8 ft. x 18 in., driven individually by 40-hp. motors connected by means of flexible couplings to herringbone pinions driving corresponding herringbone gears. Each mill revolves at 26 r.p.m., is lined with either Belgian silex or domestic quartzite, and uses flint pebbles for the grinding medium. The conical mills were among the first built by by the Hardinge Company and are low in capacity. At a corresponding plant now being built for the Tamarack sand, Hardinge mills are being used as before, but they have a cylindrical length of 6 ft. instead of 18 in., are driven with 100-hp. motors and give about three times the capacity of the shorter mill. These conical mills and motors are carried on a structural steel framework or floor about 12 ft. above the Wilfley table floor. The mills are in two rows of thirty-two each and are served by a fifteen-ton traveling crane which can pick up a full mill. All relining is done at the end of the plant, where piers are provided for this purpose. By the use of two extra mills it is usually possible to take a worn-out mill and replace it within an hour by a newly lined spare.

The mills are fed by a gate in the overhead launder handled by a lever from the conical-mill floor. The material cut out in this manner is run into a dewatering box, from which a plug discharges the thickened product into the feed scoop of the conical mill. The discharge of the mill is run into a distributing launder and fed directly to Wilfley tables, the product of two mills going to five Wilfleys. The concentrates from the Wilfleys are reconcentrated on other tables, and the final concentrate is pumped into elevated bins for dewatering, afterward fed by gravity into concentrate cars. Table middlings are returned to the conical mills for finer grinding. The tailing from the Wilfley tables joins the fine product from the drag-belts in the shore plant, and this combined material is pumped by means of a 16-in. centrifugal pump to a classifying section in the leaching plant where sand for leaching is separated out from the slime for flotation.

Special Considerations Govern Grinding Practice

This regrinding plant has a capacity of about 3,000 tons per twenty-four hours. The capacity per mill is low and the grinding efficiency is not the best, but efforts to improve conditions have not been successful. All grinding is single-pass, which would not seem to be according to best practice, but such experimentation as has been done with closed-circuit grinding on native copper ores, both in this plant and in other sections of the district, has not met with great success. A little thought as to the difference between native copper ore with its flat metallic particles compared to more friable crystalline ores met with in other metallurgical fields will be enlightening. With ordinary ores, in closed-circuit work the particles finally overflow the classifier or pass through a screen of the size adopted and thus are ready for further metallurgical treatment. On native copper ores, however, the very particles which are to be eliminated from the circuit as soon as possible are the ones that resist comminution. The result is that the native copper builds up in the circuit to an alarming extent—so much so, in fact, that the abrasive loss due to the sliming of this concentrated copper becomes a serious question in subsequent treatment, particularly as flotation recovery is not so satisfactory as it might be.

The use of steel liners and balls also comes to mind, but they have not proved advisable. The conglomerate ore probably resists comminution to a greater extent than any other ore treated in this country. Tests indicating this have been made by various independent investigators, notably Lennox, who found for this ore a "comparative crushing resistance" of 1.33 as against a low of 0.37 on Ray ores and 0.38 on Utah. For this reason consumption of pebbles is large—about five pounds to the ton—and such steel and cast iron balls as have been tried show a loss almost as great. With pebbles delivered at ½c. a pound, amounting to 4c. per ton of sand crushed, and with steel costing 3½c. per pound, or 14c. per ton of sand crushed, there has never been any inducement to add the necessary equipment for changing over to steel balls in view of an increased operating cost of 10c. per ton.

The cost of operation for this plant, in cents per ton, for 1923 was as follows:

General expense		1.82
Sand conveying and distribution		1.86
Grinding		21.27
Attendance	1.17	
Power	11.69	
Pebbles and lining	9.18	
Other supplies	.89	
Table treatment		4.90
Total		32.95

Metallurgical results for the same year follow:

Tons treated	866,524
Assay feed, per cent copper	0.723
Assay tailing, per cent copper	0.468
Pounds refined copper	4,458,100
Pounds copper per ton sand	5.14
Cost per pound copper, excluding smelting and selling, cents	6.40

4. *Leaching Plant*—An article describing this plant appeared in the *Engineering and Mining Journal* of July 14, 1917, written at a time when the plant had been in partial operation for about a year. Since the publication of that article the plant has been doubled in size and the cycle time decreased, so that a daily capacity of 6,000 to 7,000 tons has been reached for months at a time, this tonnage depending more upon the capacity of the plants preceding the leaching process than of the leaching plant itself.

Time of Leaching Now Reduced

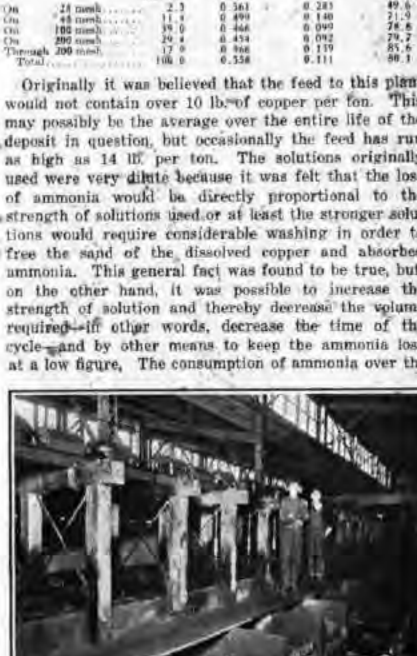
As at present installed, the leaching plant has sixteen leaching tanks in two rows of eight each, each tank having a capacity of 1,000 tons of sand. Originally the cycle was four days in length, but changes in strength of leaching solution and plant improvements have cut this down to as low as forty-eight hours, which would permit of a tonnage of 8,000 tons per twenty-four hours.

The material entering this plant consists of a combination of the fine material classified out by the drag belts at the shore plant, of the tailing of the regrinding plant, and the current fine tailing from the stamp mills. As this material enters the plant it is led into sixteen "V" shaped settling tanks each 19½ ft. long, 10½ ft. wide, and 6½ ft. deep. The overflow from these settling tanks contains upward of 95 per cent minus-200-mesh material. The thickened product from these tanks is drawn off by means of plugs to eight quadruplex Dorr classifiers the slime overflow of which joins the original overflow from the "V" tanks after thickening and is treated by flotation. This overflow contains about 93 per cent minus-200-mesh material. The sand discharge from the classifiers is treated by leaching, and although it contains about 15 per cent of minus-200-mesh product, is comparatively free from colloids. A characteristic sizing of the feed and tailing of this plant with assays is given below:

Leaching plant, showing "V" settling tanks, Dorr quadruplex classifier, and leaching tanks with covers in place. Colored lights against column in foreground are signals flashed from plant to plant to show load conditions.

	Per Cent Total Material	Assay Feed, Per Cent Copper	Assay Tailing, Per Cent Copper	Per Cent Recovery
On 28 mesh	2.3	0.361	0.283	49.6
On 48 mesh	11.4	0.499	0.140	71.9
On 100 mesh	39.0	0.466	0.099	78.8
On 200 mesh	29.4	0.454	0.092	79.7
Through 200 mesh	17.9	0.966	0.139	85.6
Total	100.0	0.558	0.111	80.1

Originally it was believed that the feed to this plant would not contain over 10 lb. of copper per ton. This may possibly be the average over the entire life of the deposit in question, but occasionally the feed has run as high as 14 lb. per ton. The solutions originally used were very dilute because it was felt that the loss of ammonia would be directly proportional to the strength of solutions used or at least the stronger solutions would require considerable washing in order to free the sand of the dissolved copper and absorbed ammonia. This general fact was found to be true, but, on the other hand, it was possible to increase the strength of solution and thereby decrease the volume required—in other words, decrease the time of the cycle—and by other means to keep the ammonia loss at a low figure. The consumption of ammonia over the



Flotation plant, showing Minerals Separation machines life of the plant has been approximately ½ lb. per ton of sand treated.

The classification between leaching and flotation slime, obtained by the Dorr classifiers, has been very satisfactory. The quadruplex classifier has given a capacity as high as 1,100 tons of sand actually delivered in twenty-four hours, and it is not sensitive to fluctuations of load. When working at this capacity the percentage of plus-200-mesh material in the overflow increases and the Dorr thickeners give considerable difficulty, but the classification for leaching is at all times satisfactory.

The cost of this leaching operation for 1923 in cents per ton follows:

General expense	3.07
Sand classification and distribution	1.49
Leaching	13.91
Distillation	11.71
Total	31.28
Ammonia (included in above)	3.68

The metallurgical results for 1923 were:

Tons treated	1,664,120
Assay feed, per cent copper	0.553
Assay tailings, per cent copper	0.195
Assay oxide, per cent copper	62.32
Pounds refined copper	13,625,000
Pounds copper per ton sand	8.19
Recovery, per cent	79.5
Cost per pound copper, excluding smelting and selling, cents	4.19

5. *Flotation Plant*—The feed to the flotation plant consists of the overflow of the "V" tanks mentioned above and of the Dorr classifiers. It is very dilute and subject to wide fluctuations in quantity and accordingly in dilution. The Dorr thickeners do not respond readily to fluctuations in feed, and overloading, with its attendant difficulties, is frequent and a source of inefficient operation.

The plant comprises settling units consisting of twelve three-tray Dorr thickeners with diaphragm pumps, four 16-cell 24-in. impeller Minerals Separation flotation machines, a 25-ft. Dorr thickener for concentrates, an 8x8-ft. Oliver filter, and the necessary incidental pumps and compressor.

The thickeners are in two rows of six each, with the feed launder in the center and an adjustable gate in the launder at each machine. The first eight thickeners were of the open type, but four more were required and these are of the connected type. The latter are much heavier in construction and far superior for the fluctuating conditions to which they are subjected. They show an increased capacity over the open type of about one-third, but the best capacity over the twenty-four hours for the twelve thickeners is about 1,800 tons.

The pulp is thickened to a consistency of about three parts of water to one of solids and pumped by means of an 8-in. centrifugal pump to a distributing box feeding the four flotation machines. The flotation oils are added at this same pump. The pulp is fed into the third cell of the machine, and this and the fourth cell are used for agitation only. Cells five to sixteen inclusive make middlings, which is returned to cells one and two for final concentration, the tailings of these joining the original feed at cell three. A final cleaning up of tailings is made by a series of air cells following the Minerals Separation machines.

For flotation a mixture of various coal-tar products is found most effective. The mixture at present used consists of coal tar from a local gas plant, coal tar creosote from the Barrett company, a residual coal tar oil from the Semet-Solvay company, and wood creosote from the Cleveland-Cliffs company, with a little pine oil added as required for frothing. Special flotation reagents have shown no advantage over the oils mentioned. Neither heat nor acid is found necessary, and the consumption of oil is about 1¼ lb. per ton of slime treated.

The plant is very compact and efficiently operated, two men only being required for shift work. The extraction is low, about 65 per cent, but native copper does not float so readily as the sulphide, and little that is coarser than 200 mesh is recovered. A characteristic sizing of feed and tailing is as follows:

	Per Cent Total Material	Feed Assay, Per Cent Copper	Tailing Assay, Per Cent Copper	Per Cent Recovery
On 200 mesh	5.97	0.289	0.243	15.90
Through 200 mesh	94.03	0.516	0.157	69.60
Total	100.00	0.503	0.162	67.80

The cost of flotation, in cents per ton, for 1923, with metallurgical data, follows:

General expense	3.78
Slime conveying and distribution	2.00
Flotation	5.47
Royalty	4.29
Total	15.54
Feed to machines, per cent copper	0.453
Tailing of machines, per cent copper	0.144
Concentrates, per cent copper	28.58
Pounds refined copper	2,135,500
Pounds copper per ton slime	5.76
Recovery, per cent	67.80
Cost per pound, excluding smelting and selling, cents	3.70

Summary of Results

The details of operation of the various plants as given above are for the individual units, and the costs and metallurgical data for the leaching and flotation plants include figures pertaining to current stamp-mill product treated in those plants. The portion of the product from these plants to be credited to current mine production is arrived at by difference of assay of feed and tailing. All material is treated finally by leaching or flotation, and as the leaching is a batch operation, each tank containing 1,000 tons, the weight of this product is accurately determined. The weight of material treated by flotation is determined by sampling, the difference between feed and tailing assay, divided into copper recovered, giving the tonnage.

In addition to the cost of the individual units of the reclamation plant as given above, this department bears its proportion of total administrative costs at mine and mill based on number of men employed. For 1923 the complete cost of this operation in cents per ton of sand treated was as follows:

General administration and miscellaneous	4.1
Dredge	6.3
Shore plant	3.5
Regrinding	16.4
Leaching	21.1
Flotation	3.4
	58.1
Tons treated	1,743,100
Assay feed, per cent copper	0.608
Assay tailing, per cent copper	0.124
Copper produced, pound	16,901,200

The total tonnage reclaimed from the beginning of operation up to Jan. 1, 1924, was 7,955,500 tons with a copper recovery of 82,102,924 lb., being 10.32 lb. to the ton, obtained at an operating cost of 6.32c. per lb. As these tailing piles were constituted at the beginning of operation they contained 46,683,000 tons of conglomerate tailing, of which 34,470,000 tons was estimated as available for treatment, with the probabilities that the final figures would exceed this estimate. It is evident that this deposit will constitute a profitable operation for many years and an important source of revenue to the Calumet & Hecla Consolidated Copper Co.

4.4 – Interview Summaries

INTERVIEW SUMMARIES
TORCH LAKE WATERFRONT INDUSTRIAL ACTIVITIES

Introduction

Research on the Torch Lake industrial facilities benefits from oral interviews of individuals familiar with milling, smelting, and refining processes. A handful of individuals are still alive in 2014 with first hand knowledge of these facilities. Three have been interviewed so far; two who worked in C&H facilities along Torch Lake and a third with first hand knowledge of the post-production phase of demolition and Superfund remediation. Additional interviews are scheduled for later this summer and fall. All interviews were recorded and transcribed. However, the interviewees have not yet given permission to distribute the transcripts, and they are identified by initials only. These interviews are also part of two other projects on the Torch Lake industrial waterfront funded by Michigan Sea Grant and by the Keweenaw National Historic Park. When these projects are completed, the permissions for public use will be complete and the interview transcripts will be on file in the MTU Archives and at the Keweenaw National Historic Park Archives.

Interviewee #1: TK
Conducted by Emma Schwaiger, IA MS Program,
July 1, 2013
Primary Topic: C&H Power Plant; Smelter yard waste

The interview started with questions about his family and his relationship with the area. He is not very connected to the Torch Lake area because he lives in Atlantic Mine and does not frequent the area. He has lived in the Keweenaw his entire life (born in 1920) minus about 10 years which he spent away working in Detroit or serving in the service during WWII. He worked at C&H from 1953 until the company closed in 1969.

His first job title was a maintenance engineer where he did preventative checks of the machines in the area around Lake Linden. He does remember changing the oil in some of the machines but does not know what they did with that oil afterwards or how it was disposed.

His second job was working as the superintendent of the Lake Linden Power Plant where he had no formal training. He said that the previous managers were fired because they had differing opinions from the company and he was brought in to replace them. He does not know the whole electrical system because that was managed by the electrical superintendents but does know that the voltage of power they sent out was around 13,800 volts. He knows that Quincy used power from C&H and that it did not go into their old power house in Mason because the mills had closed by this time and the power was only being used to power the dredge and reclamation facilities. He believes that there was a separate sub-station at Mason but does not know where exactly it was.

The Power Plant in Lake Linden used pulverized coal which was delivered at the coal dock by the Smelter. The coal was pulverized at the building and then stored in bins above the boilers and dropped in at a controlled rate. He believes that the fly ash produced from burning the coal was deposited into the air through the stack if it was in small enough particles, and the larger particles that did not escape were collected every so often and then simply dumped into Torch Lake.

His third job with C&H was working at Calumet in the foundry and reworking the ventilation system. The air was full of smoke from the workings at the foundry and he made a circulation system that would flush out the air and replace it with cleaner air for the workers.

He remembers driving by the large scrap piles near the smelter complex and says that they would get large car-loads of copper wiring from somewhere (possibly scrap yards) and they would pile them up and burn them. This would get rid of the insulation covering the wire and then they would take the remaining copper and leach it at the leaching plants, send it through the flotation plants, or simply re-smelt it if they could.

The closing of the company marked the end of his job and he moved on to the Michigan Tech Wood Resources division. He was disappointed that C&H closed as he thought they could have gone on for quite a few more years as they were working on opening up two more underground mines at Kearsarge and Centennial and had already begun working on surface plants at both. He stated his own theory on why the mines were shut down. He believes that the Board of Directors was full of the manufacturers down in Detroit and Alabama at the Wolverine Tube and other facilities and that they were not happy with the cost of maintaining the mines and chose to close them; they were too profit driven.

He does not know of anyone who would be able to help us on this project because all of the people he knew that worked there have passed away. He would be willing to do a follow-up interview in a few weeks if necessary.

Key Points: Separate electrical sub-station at Quincy, pulverized coal, fly ash, and the oil that was changed in the machinery was all disposed of (probably into the lake), and scrap was burned in large piles at the smelter site.

<u>Interviewee #2: SH</u>
Conducted by Emma Schwaiger (IA MS Program, MTU)
January 30, 2014
Primary Topic: Dismantling and cleaning up of Lake Linden building sites; children's play areas

SH has worked for the Village of Lake Linden and knows some about what went on during the days of the Superfund Project of covering the sands and about what did/did not get done. She was also instrumental in getting the campground in Lake Linden and getting that end of the lake cleaned up so that the grounds looked nice. However, there are still pollution issues that were not solved when the campground and park went in.

She has lived in the Lake Linden/Hubbell area for almost all of her life. Her father worked for the C&H facilities along the lakeshore, probably the Ahmeek Mill and the C&H Smelter. When she was a kid the children did not play in the water or along the lakeshore near the industrial buildings. If they played, they would take the bus over to the Dreamland Hotel out on Bootjack, or sometimes they would sneak onto the slag pile in Hubbell and play. Another spot was up on the railroad tracks above the industrial shoreline.

In the 1980s there was already some landscaping going on to try and remove some of the large buildings and make it more of an open space for people to use. A lot of this waste material went onto the Lake Linden dump, which was located on the sands behind Lake Linden. Another thing left by C&H was the infrastructure. The culverts between the hills which carried the railroad cars were left by C&H and were not looked after by anyone once the company left. This caused an issue in the late 1980s or early 1990s as one of the culverts caved in and a large area of Lake Linden was at risk of flooding. This caused an emergency and people came out and worked all night to clear a path and make sure the water did not harm anyone or any large structure, including the school.

She would like to see the shoreline continue to progress and to be cleaned up so people can use the area for recreation and enjoyment. She also admits that when the EPA first came in and started to do things she agreed with their decisions, but now, when she looks back, she has questions as to why they cleaned up some areas and not others, and also why they did things a certain way when there were other alternatives.

Key Points: Campground location was not done by the Superfund and may need further sampling and cleanup, the children of the employees working on the lakefront did not play in the water on the western side of the lake and for the most part stayed away from the area altogether, C&H left more behind than just pollution; there is infrastructure all over the region that is deteriorating from neglect and another disaster is waiting to happen, and people in the area that once agreed with the EPA are now second-guessing the work that they did, especially with new reports about pollution and the new knowledge that other chemicals (like PCBs) are still effecting the area.

<u>Interviewee #3: JB</u>
Conducted by Emma Schwaiger (IA MS Program, MTU)
May 8, 2014
Primary Topic: Hubbell Dump & Beach Area

JB is very interested in closing down the Hubbell Beach area because of the harmful effects it could have on children. She believes that there is lead in the 'slag' and the water that can contaminate the children and lead to autism and other health issues. Her husband used to work in the C&H Smelter and he always said that the things they put into the lake were really bad and that they would melt their shovels, so people should not be playing on or near the material. She did not, however, seem to know that there was a difference between slag and stamp sand tailings; she lumped them all together under the term 'slag' and said that the Hubbell Beach area was next to the slag dump as well as the Hubbell Dump. The Hubbell Dump started in the area just north of the Hubbell Beach where the land juts out into the lake and had some trees growing on the south side. There is also a pipe that runs out from the dump and empties into the lake, which she sees as contributing even more pollution.

The Hubbell Dump consisted of slag as well as refrigerators, freezers, ovens, other old appliances, bed frames, and other municipal wastes. She said that, if you sit on the Hubbell Beach and look at that piece of land, you can still see pieces of these materials sticking out of the bank. All of these trash items, combined with the slag, makes for a messy landscape and a contamination hazard. She believes that lead is the top priority in the Hubbell area and that the beach should be closed off until water tests have been done to make sure the lead is not contaminating anyone. She said that the MDCH has refused to do any water testing in the Hubbell Beach area because they have already tested the Lake Linden area. She wants this area tested as well, along with the pipe on the end of the dump area, and the small stream that runs out there as well. If these tests come back negative for lead, then the beach area can be opened up.

A sign should also be placed at all beach areas to inform people of the possible risks associated with Torch Lake and where they can get more information.

She believes that most locals understand that Torch Lake is full of toxins and is more concerned about unsupervised children and also visitors to the area. She, herself, never would let her kids play in Torch Lake and always instilled in them the sense to not play in the lake when she was not around. However, not all parents think the same way she does about protecting their children, and visitors have no knowledge of what went on around the lake to know about all of the chemicals that are now in it. She believes that having pamphlets at visitor areas would not do anything since the parents and families of today are such an online generation and do not look at handouts like they used to; posting signs is the only way to worn them.

Having more local meetings in the areas around Torch Lake would also help get the point across that Torch Lake is dangerous. She did not like the meeting that MDCH had at the Lake Linden/Hubbell School. She was told that there would be a meet and greet, but showed up to the meeting and was provided no refreshments, and then lectured to about how great the MDCH is and how much they have gotten accomplished. She does not think they did anything good at all because their data was from 5 years ago, was not gone very scientifically, and they are just now publishing it without actually answering anyone's questions. She believes that the community needs round-table type meetings where they can ask questions, get answers, and start a good discussion about what is actually going on. These should take place in each community on the lake and in places that are easily accessible to older people (the school had way too many stairs and it was hard to find the presentation space). Refreshments should also be served so people feel like they are being taken care of.

Lead testing should be done on all children in the local area if their parents want it, free of charge. She said that the only children who currently get tested are those on Medicaid, and she thinks that all should have that opportunity, not just those on government support. Having it be a part of a school science class, as well as teaching the kids about other health risk factors, would make it beneficial on many levels. Michigan Tech should help support some of these science projects, and they should also take an interest in offering the community discounts on family passes to the SDC so that the kids can have something to do in the summers besides play in pollution. She thinks that having some buses take kids from the HS to the SDC and back, and having Tech students volunteer to be chaperones on the buses and in the gyms and other activity rooms, would be a great solution instead of having them play on the slag piles until they can get a pool and community center of their own.

Overall, she wants all beaches in the area to be closed until testing at each individual location has proved it to be 100% safe. She is really concerned about the children playing and is worried about the future health effects that may come of it. She thinks that lead is the top pollutant that we should be trying to clean up as that, to her, causes the most damage. We need to make sure that not only the locals, but also visitors, understand the risks associated with the lake and that signs be placed to inform and give a website where they can read further information about the dangers. She also does not think that the fish advisories are known to people that do not look into Torch Lake issues like she does online and that the government needs to do a much better job of making sure people are informed.

Key Points: Thinks there are pollutants that can cause harm to people and wants all the local beaches closed. Smelter material was disposed of at the Hubbell beach area, which would melt the workers' shovels so she known it is bad. Wants the MDCH & others to do water and soil testing and close the beaches until it is proven to be 100% safe, wants warning signs up telling people about the risks of the water & pollution, wants free lead testing available to all local residents, and more community meetings to inform locals of the problems with the lake.

4.5 – Substation #9 – Lake Linden

<u>Houghton County Courthouse (6/21/2013)</u>

Substation #9 in Lake Linden

58340 Gregory Street OR 9th Street Substation
Lake Linden, MI 49945
Location: Schoolcraft Township
Current Use: Storage Facility

Current Owner: Betsy Olson West
PO Box 55416
Saint Petersburg, FL 33714


STORAGE
RENTAL
CALL DAN
296-0725

1. Prosper, Robert & Wife / Smith, Samuel L. & Wife
   Mtg, 2/1/1869, Recorded 2/12/1869
   Vol. C, Page 166

2. Smith, Samuel L., et al. / Prosper, Robert
   D of M, 3/14/1883, Recorded 8/6/1883
   Vol. G, Page 483

3. Prosper, Robert & Wife / Peninsula Electric Light & Power Co.
   Q. C. D., 7/11/1889, Recorded 11/11/1890
   Vol. 31, Page 177

4. Houghton County Electric Light Co. / Boston Safe Deposit & Trust Co.
   Mtg, 9/1/1902, Recorded 9/6/1902
   Vol. HH, Page 378

5. Houghton County Electric Light Co. / City National Bank & Trust
   Mtg, 9/1/1942, Recorded 12/3/1942
   Vol. P4, Page 431

6. Upper Peninsula Power Company / City National Bank & Trust
   Mtg, 5/1/1947, Recorded 6/12/1947
   Vol. R4, Page 451

7. City National Bank & Trust / Houghton County Electric Light Co.
   D of M, 6/11/1947, Recorded 6/12/1947
   Vol. R4, Page 447

8. Houghton County Electric Light Co. / Upper Peninsula Power Company
   Deed, 6/11/1947, Recorded 6/12/1947
   Vol. 148, Page 321

9. Upper Peninsula Power Company
   Notice of Claim, 1/27/1948, Recorded 1/27/1948
   Vol. MR/22, Page 281

10. U.P. Power Company / Village of Lake Linden
    Q. C. D., 10/29/1969, Recorded 11/10/1969
    Vol. 20, Page 717

11. Village of Lake Linden / Betsy Olson West
    Q. C. D., 11/13/1990, Recorded 12/7/1990
    Vol. 109, Page 337

12. Betsy Olson West / First National Bank
    Mtg, 11/21/1990, Recorded 12/7/1990
    Vol. 112, Page 479

13. Betsy Olson West / First National Bank
    Mtg, 12/21/1993, Recorded 1/27/1994
    Vol. 163, Page 713

14. Betsy Olson West / First National Bank
    D of M, 7/11/1996, Recorded 7/18/1996
    Vol. 192, Page 683

15. Betsy Olson West / First National Bank
    Mtg, 10/19/2004 (362MT-00874)
    Vol. 362, Page 874

16. Betsy Olson West / First National Bank
    D of M, 3/24/2009 (2009R-01652 MD)
    No Volume Listed

HOUGHTON COUNTY TREASURER
906 482-0560 PHONE 906 482-7040 FAX

-- TAX HISTORY --

TAX YEAR	PRE %	SEV	TAXABLE	BASE TAX	DELINQUENT BASE TAX DUE	INTEREST &/or FEES DUE	TOTAL DUE	LAST PMT
2012	0.00	12,132	7,712	349.37	0.00	0.00	0.00	12/10/12
2011	0.00	12,132	7,510	329.55	0.00	0.00	0.00	12/30/11
2010	0.00	12,132	7,385	325.35	0.00	0.00	0.00	12/21/10
2009	0.00	12,132	7,408	328.95	0.00	0.00	0.00	12/28/09
2008	0.00	12,132	7,096	329.49	0.00	0.00	0.00	06/11/09
2007	0.00	12,132	6,937	307.39	0.00	0.00	0.00	12/19/07
2006	0.00	12,132	6,690	300.76	0.00	0.00	0.00	01/05/07
2005	0.00	11,182	6,477	291.85	0.00	0.00	0.00	12/19/05
2004	0.00	9,203	6,332	279.67	0.00	0.00	0.00	01/05/05
2003	0.00	8,786	6,190	269.87	0.00	0.00	0.00	12/15/03
TOTAL DELINQUENT TAXES DUE FOR THIS PARCEL					0.00	0.00	0.00	

WEST BETSY

Property Address: LAKE LINDEN

SCHOOLCRAFT TOWNSHIP

Property Number: 012-055-039-00

DESCRIPTION OF PROPERTY:

SC2-5-14 SEC 5 T55N R32W PART OF GOV'T LOT 1 DESC AS FOLL, COM AT A PT 33' E & 813' S OF NW COR RUN TH E 50' S 100' W 50' N 100' TO THE POB. .11 A.

KATHLEEN A BEATTIE, TREASURER
HOUGHTON COUNTY COURTHOUSE
401 E HOUGHTON AVENUE
HOUGHTON MI 49931

DATE PREPARED
06/21/13

History Fees: 0.00

CARD # 31-12-055-039-00 **COMMERCIAL REAL ESTATE RECORD CARD** NO. OF CARDS CARD NO.

OWNERSHIP RECORD AND DESCRIPTION Betsy OLSON West
238 EAST 82ND ST #2A
New York, NY 10028

SC2-5-14 ~~Village of Lake Linden~~

~~Lake Linden, Mi. 49945~~

SC2-5-14 .11 A. 5 55 32
Part of Gov't Lot 1 desc as foll: Com
@ a pt 33' E & 813' S of NW cor run th
E 50' S 100' W 50' N 100' to the POB.

B

BUILDING PERMIT RECORD

DATE	AMOUNT		PURPOSE

OWNERSHIP RECORD

	DATE	VOL	PAGE	CONSIDERATION
VLs & L.L.	10-29-69	20	414	
West	11-13-96	109	337	10,000

Copper Country Arts

EXPLANATION FOR LAND ADJUSTMENT

Leased to Jack Anderson

APPRAISAL SUMMARY

YEAR 72	3000
LAND	640
BLDGS.	9750
TOTAL	10390

ASSESSMENT SUMMARY

YEAR 73	5200
LAND 75	5300
BLDGS. 77	5300
TOTAL 78	EX

APPRAISAL SUMMARY

YEAR 81	—
LAND 82	—
BLDGS. 84-86	—
TOTAL 87	—

ASSESSMENT SUMMARY

YEAR 95	5180
LAND 96	5804
BLDGS. 97	5804
TOTAL 99	7,008

APPRAISAL SUMMARY

YEAR 01	8,026-
LAND	
BLDGS.	
TOTAL	

ASSESSMENT SUMMARY

YEAR	
LAND	
BLDGS.	
TOTAL	

LAND RECORD AND COMPUTATION OF VALUE

FRONT	REAR	FRONT FIGURED	DEPTH AVE.	F. F. PRICE	DEPTH PER CENT	ACTUAL F. F. PRICE	SUB TOTAL	CORNER INFL.	$ ADJUSTMENT	TOTAL
		50	100	15.00	86	12.90			—	645

DISTRICT TREND	IMPROVING	STATIC ✓	DECLINING	WARD	ZONE	
DRIVEWAY	RIBBON		SLAB	GRAVEL	STONE	
ROAD	PAVED ✓		GRAVEL	DIRT	SIDEWALK	
UTILITIES	NO GAS	NO WATER	NO ELECTRIC	NO SEWER	NO TELEPHONE	
TOPOGRAPHY	LOW LEVEL	HIGH	ROUGH	BRUSH	LANDSCAPING POOR	AVE. — GOOD

GEM SURVEYS — ST. CLAIR, MICHIGAN

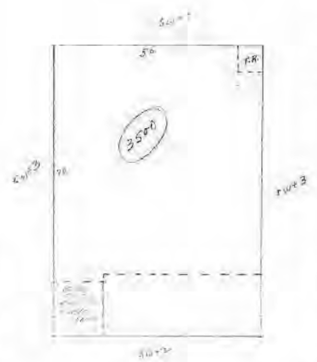
										Dep.		Dep.	Adj.	
1	Carri- Conservators	1S	A	BRK	SK	3500	Cm	1920±	F	27,848	50	13,924	70	9747
2														
3														
4														
5														

REASON FOR ECON. OR FUNC. DEPR. TOTAL 9747

FOUNDATION	
Concrete Walls	
Con. Blk. Walls	
Brick Walls	
Stone Walls	✓
Tile Walls	
BASEMENT AREA	NO
¼ | ½ | ¾ | F	
EXTERIOR WALLS	
Solid Com. Brick	✓
Com. Br. on Tie. or C.B.	
Face Br. on Com. Br.	
Fce. Br. on Tie. or C.B.	
Face Br. Ven.	
Com. Br. Ven.	
Concrete Blk.	
Rein. Concrete	
Cut Stone Facing	
Terra Cotta Facing	
Stone or T.C. Trim	
Stucco on Tile or C.B.	
Stucco on Frame	
Siding or Shingles	
Metal	
Plate Glass Front	
ROOF TYPE	
Flat	
Hip or Gable	
Bow String	
Gambrel	✓
ROOFING	
Tar & Gravel	
Composition	
Metal	
Rein. Conc.	
Insulation	✓

FLOORS	B	1	2	3	4	5	6
Concrete		✓					
Earth							
Pine Pervad [illegible]			✓				
Hardwood							
Single Fl.		0					
Wood Joist							
Hardwood on Concr							
Rein. Concrete							
Conc. on O.T.J.							
Terazzo							
Tile							
Rooms		1					
INTERIOR FINISH ON EXTERIOR WALLS							
Pine							
Hardwood							
Lath and Plaster							
Wallboard							
Unfin. Int.		✓	✓				
CEILING FINISH							
Lath and Plas.							
No Ceiling		✓	✓				
PARTITIONS							
L. & P.							
Plast. Bd.		✓					
Tile or C.B.							
Bvarrd		✓					
HEATING							
Steam							
Air Cond.							
Hot Water or Vapor							
Hot Air							
Pipeless							
Suspnd (3 Fn) 300K		✓					
No Heating							
~~Oil~~ Burner Gas		✓					
Coal Stoker							

PLUMBING	
Bathrooms	
Toilet Rooms 6 XL	✓
Water Closet	
Lavatory	
Sink	
Urinals	
No Plumbing	
1-30 GAL HWT	✓
TILING NO	
Bath Rm. Fl. & Wains.	
Toilet Rm. Fl. & Wains.	
Bath Room Flr.	
Toilet Room Flr.	
LIGHTING	
Higrade	
Ave. 10-8'-DBL	✓
~~Poor~~ 10-4'-DBL	
STRUCTURAL	
Fire-Proof Const.	
Rein. Conc. Beams & Col's.	
Steel Beams & Col's.	
Timber Beams & Col's.	
Steel Trusses	
MECHANICAL	
Sprinkler Syst.	
Passenger Elev.	
Freight Elev.	
Dumb Waiter	
MISCELLANEOUS	
Steel Frame Sash	
Wood Frame Sash	
Fire Escapes	
Vaults	
Skylights	
Remodeled	
12 X 14 - OH DR	✓



10' 10' 10' 10' 12' 16' 8.5'

FLAT EXPENSE ITEMS	
Land	
Vacancy	
Heating	
Water	
Electricity	
Janitor	
Management	
PERCENTAGE ITEMS	
Taxes	
Insurance	
Maintenance	
Depr. Allowance	
Contingencies	
Total Cap. Rate	
Ratio Expense to Income	
Total Flat Expenses	
Gross Annual Income	
Less Flat Expenses	
Balance For Cap.	
Cap. Rate	
Reflected Cap. Value of Bldg.	

BUILDING COMPUTATION	
Verticals	9312
Horizontals	17,325
Flats	121[illegible]
3500 ft @ 7.96	
Replace Val.	27,84[illegible]

Location: Excel. Good Fair Poor

VERTICALS	BASE	INT. END	TOTAL	
WALLS				
F- 240 L.F. @	44.70	-5.90	38.80	9312
R- L.F. @				
RT.- L.F. @				
L- L.F. @				
PL. GL.- L.F. @				
L.F. @				
L.F. @				
TOTAL				9312

HORIZONTALS	ADD	DED
BASE	5.05	
BSM.	-2.25	
FLOOR Carpet + Paint	+.10	
CEILING	-.38	
PAR. UP Gypsum	+.50	
PAR. DWN	+.15	
HEAT	+.48	
Ins. Frame	+1.00	
LIGHTS	+.30	
TOTALS	4.95	

FLATS	
PLUMBING	87[illegible]
OH. DR	33[illegible]
TOTAL	121[illegible]

Measured by Listed by Priced by Checked by AC Final by 3500 S.F. @

Assessment Roll
County: 31- HOUGHTON Unit: SCHOOLCRAFT TOWNSHIP
FOR THE YEAR 2014

Property Number 31- +	Sch. Dist.	* Class * Prev	Curr		Previous Assessment	Current Assessment	Board of Review	Loss	+/- Adjustment	New	**** Headlee **** Additions	Losses	Rsns for Change	July/Dec Tribunal
012-055-039-00	31130	201	201		12,132	12,132		0	0	0	0	0		
				S.E.V. -->	12,132	12,132								
				Capped -->	7,712	7,712								
Acreage: 0.0000				Taxable -->	7,712	7,712			0					

WEST BETSY
PO BOX 55416
SAINT PETERSBURG FL 33714

SC2-5-14 SEC 5 T55N R32W PART OF GOV'T LOT 1 DESC AS FOLL, COM AT A PT 33' E & 813' S OF NW COR RUN TH E 50' S 100' W 50' N 100' TO THE POB. .11 A. (Property address:)

Totals for all Parcels: Count= 1, Cur. S.E.V.=12,132, Prev. S.E.V.=12,132, Cur. Taxable=7,712, Prev. Taxable=7,712

Almar Professional Land Services, Inc.
Corporate Office: 450 Hillside Dr., Suite A-160 • Mesquite, NV 89027
Toll Free 877-868-6611 • Toll Free Fax 866-221-2671 • Website: www.almarpls.com
Midwestern Office: Baraboo, WI • Southeastern Office: Navarre, FL

Gov't Lot 1
Sec 5 Township 55
R 32 W

v.1.0.4905.19873

4.6 – MTU Archives C&H Collection – Files Consulted

	A	B	C	D
1	MTU Archives - C&H Boxes & Folders Completed for PHASE 1 - Updated July 4, 2014			
2	4.3.4a MacNaughton Numeric File: 1-625, Various Companies & Topics	43	50	Generators
3		43	118	Materials
4		43	126	Gereral Electric
5		43	131	General electric proposal
6		43	135	Defective Motors
7		43	139	Transformers
8		43	142	Motors
9		43	157	Contracts
10		43	166	Motor generator sets for substation
11		43	178	general electric equipment
12		43	181	Contracts
13		43	183	Tank Oil
14		44	194	Motors
15		44	199	Transformer problems
16		44	202	Transformers
17		44	206	Motors
18		44	208	Blueprints
19		44	227	Blueprint Corrections
20		44	230	Water & Sewage System
21		44	235	Water Pipes
22		44	236	Filtration Plant
23		44	238	W.E. Baker and Co.
24		44	258	Deeds and Blueprints
25		44	276	Electric Hoist Equipment
26		44	285	Water
27		44	286	Water Alarms
28		45	311	Houghton County Electric Light Co.
29		45	312	Edison Illuminating Company
30		45	316	Portage Coal and Dock Co.
31		45	388	Milling
32		45	419	Freight
33		45	420	Report on Water Works System to State Board of Health
34		46	432	Electrolytic plant
35		46	447	Turbo Alternator
36		46	457	Electric Lights in Company Houses and Houses on Company Property
37		46	458	Maps
38		46	461	Electrolytic plant
39		46	464	Freight

	A	B	C	D
40		46	466	Milling
41		47	472	Dredges for regrinding plant
42		47	490	Leaching process
43		47	505	Torch Lake Canal
44		47	522	Freight
45		47	524	Leaching process
46		47	525	Electrolytic plant
47		48	532	Turbo Generator
48		48	556	Electrolytic plant
49		48	557	Freight
50		48	563	Turbo Generator
51		48	576	Leaching process
52		48	580	Flotation process
53		48	590	Flotation process
54		49	607A	Electrolytic plant
55		49	607	Electrolytic plant
56		49	608	Leaching
57		49	616	Freight
58		49	625	Copper-oxide precipitate
59	4.3.5 McNaughton Numeric File: #1-102, Various Companies and Topics, 1903-1917	208	14	Union Coal Dock
60		208	47	Electric Power for Subsidiary Companies
61		208	49	Superior Mining Co. and Houghton County Light Co. Contracts
62		209	10	Union Coal Dock Reports
63		209	34	Mutual Water, Light, and Power Co.
64	4.3.6 McNaughton Numeric File: #1-208, Various Companies and Topics, 1907-1919	209	53	Report on Calumet and Lac LaBelle Traction and Power Co.
65		211	47	Power Plant Records
66	4.3.7 MacNaughton Numeric File: #1-141, Various Companies and Topics, 1910-1914	55	8	Tamarack Sands
67		55	11	Use of Dock by L.S. Smelting Co.
68		55	48	Freight
69		55	49	Lease Osceola to Houghton Co. Traction Co.
70		55	72	Electrolytic plant
71		56	28	Maps
72	4.3.11 McNaughton: Various Companies and Topics, 1909-1910	54	76	Mutual Water Co.
73	4.3.19 McNaughton: Alphabetical, A-Z, 1923-1924	71	11	Houghton Co. Light and Traction Co.
74	4.3.20 McNaughton: Alphabetical, A-Z, 1925-1926	72	2	Houghton Co Electric Light Company
75	4.3.25 McNaughton: Alphabetical, A-Z, 1937-1938	75	74	Revere Copper and Brass
76	4.3.29 President's Office Alphabetical, M-S, 1904-1964	76	2	Mutual Water Light & Power
77	4.3.31 Engineering Department, Alphabetical, A-Z, 1912-1916	41	7	#2 Coal Dock
78		41	8	#2 Coal Dock - Blueprints and Notes
79		41	11-12	Dredge

	A	B	C	D
80		41	13	Electrolytic Plant - Reports and Sketches
81		41	28	Regrinding Plant #1
82		41	29	Sand Leaching Plant
83		42	1-2	Regrinding Plant #2 and substation
84		42	10-11	Tamarack Regringing Plant
85	4.3.32 Engineering Department, Alphabetical, S-W, 1911-1969	124	4	Sketches
86		124	7	Secondary Copper Department
87		127	5	Cuprous Oxide Plant
88		127	6	Dock
89		40	5	Secondary Copper
90		40	7	Sketches
91	4.4.33 (4.3.25) McNaughton: Alphabetical, A-Z, 1937-1938	75	39	Smelting Works
92	4.4.34 (4.3.26) McNaughton: Alphabetical, A-Z, 1939-1941	75	76	Smelting Dept.
93	4.3.35 Lovell Alphabetical, A-Z, 1940-1951	58	34	Houghton Co Electric Light Company
94	4.3.36 Lovell Alphabetical, A-Z, 1945-1951	59	39	Electrical Dept
95		59	24	Power Plant
96	4.3.40 Engineering Miscellaneous, 1953-1968	138	3	Chemical Plants, Milling and Reclamation
97		138	13	Smelter Blueprints
98		138	17	Drawings - Osceola
99		138	18	Ahmeek Process and Practice Analysis
100	4.4 Generalized Office Files	215	19-23	Union Coal Dock
101		216	1-3	Union Coal Dock
102	4.4.14 (4.3.7) MacNaughton Numeric File: #1-141, Various Companies & Topics, 1910-1914	55	12	Slag Smelting
103		55	27	Smelting
104	4.4.38 (4.3.30) President's Office Alphabetical, A-Z, 1910-1969	82	13	Hydrology of Waste Disposal
105		86	20	Smelter Scrap
106		86	21	Smelter-Spectographic & X-Ray Equipment
107		86	22	Smelter Flow Sheets
108		86	23	Smelter-Misc.
109	4.4.40 (4.3.32) Engineering Department, Alphabetical, S-W, 1911-1969	127	30	Slag-Disposal
110	4.4.40.1 Smelting Works	124	5	Slag Granulating
111		124	14	Secondary Copper Dept.-Ash Screening Plant
112		124	26	Brick Dust Mill Air Separating Sys.-Blueprints
113		125	15	Furnace #20-Pulverized Coal
114		126	13	Coal Pulverized Pit -& Blueprints, Drawings, Telegrams, etc.
115		126	14	Coal Pulverized Pit -& Blueprints, Drawings, Telegrams, etc.
116		126	15	Coal Pulverized Pit -& Blueprints, Drawings, Telegrams, etc.
117		126	16	Coal Pulverized Pit -& Blueprints, Drawings, Telegrams, etc.
118		126	17	Coal Pulverized Pit -& Blueprints, Drawings, Telegrams, etc.
119		126	18	Coal Pulverized Pit -& Blueprints, Drawings, Telegrams, etc.

	A	B	C	D
120		126	19	Coal Pulverized Pit -& Blueprints, Drawings, Telegrams, etc.
121		126	20	Coal Pulverized Pit -& Blueprints, Drawings, Telegrams, etc.
122		127	1	Coal Pulverized Pit -& Blueprints, Drawings, Telegrams, etc.
123		127	2	Coal Pulv. pit., Sketches and Data
124	4.4.48 (4.3.40) Engineering Miscellaneous, 1953-1968	138	3	Chemical Plants, Smelter Projects, Smelter Secondary Reports
125	4.4.5 (4.3.4a) MacNaughton Numeric File: 1-625, Various Companies & Topics	45	377	Smelting
126		46	454	Smelting
127		48	534	Smelting
128		48	541	Pulverized Fuel for Smelting
129		48	562	Re: Smelting Works
130	5.6 Tax Records (non-property)	227	2	Mutual Water Light & Power
131	5.9 (Subseries 5.9) Agreements and Contracts, 1910-1978	181	5	Copper Slag Agreements & Contracts
132		181	6	Copper Slag Agreements & Contracts
133		181	7	Copper Slag Agreements & Contracts
134		181	8	Copper Slag Agreements & Contracts
135		181	9	Copper Slag Agreements & Contracts
136	5.10.2 Asset Valuation and Insurance Appraisals, 1906-1965	207	8	Lake Milling, Smelting, and Refining Co.
137		207	2	C&H Coal Dock
138		207	5	Tamarack Rec and Water Works
139	5.11.2 Purchasing Department Administrative Files, 1906-1933	35	11	Mutual Water Light & Power
140		35	17	Power Plant
141	5.12.3 (5.12.3) Boiler Inspection Reports, 1913-1942	37	13	Smelting Works
142	6.3.4 (6.3.4) Chemical Engineering Branch Files, 1925-1969	201	25	Soot Removers
143		199	20	Fly Ash
144		201	21	Slag Utilization
145	8.3.2 Lake Chemical Co, 1941-1965	27	36	Invoices to UPPCO
146	9.5 (Subseries 9.5) Reclamation 1920-1972	571	6	Slag Leaching Process
147	9.7.1 C&H Smelting Works-Stamp Mill Shipments to Smelter	524	21	Report on Copper Bearing Brick and Ash Residues at Smelter
148		524	35	Smelter Copper Inventory
149		569	4	C & H Mining Company-Slags
150		571	25	Copper in Slag-Correspondence., Reports, Articles
151	11.4.1 Light and Power, 1910-1952	208	49	Superior Mining Co & Houghton County Electric Light Co
152		208	47	Electric Power for Subsidiary Companies

4.7 – C&H Mining Co. Timeline – Torch Lake Facilities (1887 – 1968)

Calumet and Hecla Mining Company Timeline - Torch Lake Facilities

1887
- New Smelting Works under construction on Torch Lake

1891
- Completed building intended for new pumping plant in Lake Linden
- Completed 50 ft sand wheel for the Calumet Mill
- In the process of erecting 50 ft sand wheel for the Hecla Mill

1892
- New boilers installed at mills
- Purchased steam fire engine for mills
- Hecla sand wheel completed
- Automatic sprinklers installed in milling complex
- Hecla Mill addition underway

1893
- Addition for mill boiler house planned
- Hecla Mill addition completed
- Calumet Mill
    - 11 Leavitt heads with steam cylinders
    - 14 & 21.5 x 24 inch stroke
    - Washers, Huntington & Haeberle grinding mills and slime tables
    - Westinghouse driving engine 200HP
- Hecla Mill
    - 11 Leavitt heads, equipped similar to Calumet Mill
    - Preparing to place solid anvils under all stamps
- Boiler House
    - 11 boilers – Kendall & Roberts, 4730 HP
- Torch Lake
    - Freight house, warehouse, docks, railroad tracks, machine shops, carpenter shop, blacksmith shop, barns, coal dock, and coal shed
- Torch Lake Water Works
    - Pumping machine, 60 million gallons per day
- Mills and docks lighted by electricity
- Smelting Works
    - Covers about 30 acres, connected to mills by short railway
    - 4 stone furnace buildings – 80 x 130 ft
    - Water source from artesian well

1895
- Foundations laid for addition to mill boiler house and stack
- $30,000^3$ yards of Torch Lake canal dredged
- Experimental Electrolytic Plant built in Buffalo, NY

1896
- Electric Light Plant House at mills completed
- Boiler house erected
- In the process of extending coal docks

1897
- Boilers at the Water Works boiler house moved to new Boiler House near mills

1898
- Foundations laid for another coal dock

1899
- New coal dock almost finished
- Torch Lake canal dredged again
- Boilers overhauled

1900
- New coal dock completed
- Foundations laid for Hecla addition
- 4 boilers added to Boiler House
- Smelter – new mineral house and boiler house with 2 boilers

1901
- Contracted with General Electric to power new part of Hecla Mill with electricity

1902
- Torch Lake canal well lighted
- Hecla Mill addition finished
- New steel electric power house has been erected
- Tunnel for the electric cables to connect the Power House to the mills has been completed
- Smelter – 5 furnaces rebuilt
- Buffalo, NY – Electrolytic Plant completed

1903
- Hecla Mill addition is producing

- Electric Power House is in commission
- Large filter plant erected, 500,000 gallons daily

1904

- 5 Calumet Mill heads remodeled

1905

- Calumet Mill remodel completed
- Hecla Mill remodel started
- 2 large engine additions to Electric Power Plant in process

1906

- Hecla remodel completed
    - 23 stamps total capacity between both mills
- Addition to Electric Power Plant complete, 9,000 HP engines
    - 2 independent cable lines connect the Power Plant with the mine

1907

- Foundation for regrinding mill #1 started
- Foundation for new Boiler House at mills started
- Engine and generator of 2,000 KW at Electric Power Plant at mills

1908

- New Boiler House complete
- Regrinding Plant #1 building erected

1909

- Erected power line to Lake Superior Water Works to pump water from the lake to the mills
- Regrinding Plant #1 complete

1910

- ½ of old mill boiler house has been torn down

1911

- Land East of Calumet Mill being cleared for further development

1912

- Recrushing building #2 complete – 123 x 432 ft
- Foundation for new Electrolytic Plant building finished at Torch Lake – 155 x 270 ft

1913

- All buildings for new Recrushing Plant complete
- All smelting at Buffalo discontinued

1914

- Tube Mills in new Recrushing Plant started
- Dredge tested
- Ground broke for new Leaching Plant

1915

- Fire protection system remodeled
- Dredge, Classifying House & Conveyor, and No. 2 or New Recrushing Plant in operation
    - Went into commission in June on small scale, full scale in September
- Leaching Building complete – Ammonia

1916

- Oil flotation experiments underway
- Leaching began in July

1917

- Electric Power House fireproofed
- Flotation experiments successful
- Both mill heads remodeled
- Slime machines remodeled

1918

- Flotation plant to treat slimes from Regrinding Plant should be in commission in summer
- Regrinding Plant #1 remodel complete
- Dredge remodeled

1919

- Mills now equipped with tanks for settling slimes
- 2/3 of slimes from Regrinding Plant are treated by flotation, building need extending
- Tamarack mill is abandoned and will be dismantled

1920

- Last of round slime tables replaced by Wiffleys
- Chilean Mills to be replaced by Hardinge Conical Mills
- Boiler House reconstruction

    - Concrete foundation and side walls coated with concrete
- Tamarack Mill dismantled
- Foundations for new Tamarack Reclamation Plant are complete

1921
- All operations suspended in April except Power Plant and Boiler House
- Tamarack Reclamation Plant construction halted
- High prices for work caused a work stoppage

1922
- Work resumed on April 1
- Hecla Mill remained closed
- Calumet Mill has 9 of 11 units working
- Boiler House remodeled
- Tamarack Reclamation Plant construction resumed in Spring
    - Dredge ordered
    - Buildings complete
- Electrolytic Plant closed in December and may not re-open

1923
- Consolidation of Ahmeek, Allouez, Calumet and Hecla, Centennial, and Osceola mines
- Hecla stamp mill remained closed
- Tamarack reclamation plant construction continued
- Electrolytic plant not in commission since 1922

1924
- Hecla flotation plant dismantled
    - Two of the four machines to be taken to the Tamarack reclamation plant
- Tamarack reclamation plant ready to go into commission in the spring
- Smelter center plant for furnishing pulverized fuel, 12 tons of coal per hour

1926
- Smelter – second refining furnace under construction at the close of 1925 was completed and went into operation during the year, electrically operated 40 ft Clark casting machine, 800 KW turbo generator being installed

1927
- Pump installed on Ahmeek sands to elevate the tailings from the mill
- Lake Linden stamps had two boilers and a 500HP capacity
- Refining furnace went into operation in July – 11 x 23 ft
- Melting furnace now being installed – 20 x 70 ft, 225 tons per day

- New mineral storage building being installed
- Lake Milling and Smelting #2 mill closed but still operable

1928
- Lake Linden dredge began operating on Hecla mill sands
- Melting furnace in operation
- 800HP waste heat boiler installed and furnishing steam for the turbo-generator and for all other purposes required
- Reinforced concrete foundation and compartment walls for mineral storage building complete

1929
- Lake Milling #2 at Hubbell back to work
- Lake Linden power plant obsolete electrical equipment has been scrapped and a 2000KW low pressure unit is being installed
- New mineral house is open
    - 10 main compartments, 15,000 tons material
    - 7.5 ton overhead electric crane carrying a clam shell bucket for handling the mineral
- Steel and glass addition to main furnace building, houses turbo-generator
- Auxiliary gas driven centrifugal pump, 3500 gal/min, installed at pump house in the event of interruption to power for electric pumps
- Small, hand-dipped furnaces being dismantled at the smelter
    - Furnaces supply steam to a turbo-generator that furnishes electric current for power and lighting

1930
- Turbines at Lake Linden shut down, reclamation plants went down in mid-summer
- 2000KW low pressure unit operational at the power plant
- New boiler and power plant being erected at the Ahmeek Mill – Stone and Webster Engineering Corporation
- Boiler – steam for existing stamps and pumps and for new turbines of 8,750KW capacity
- Power plant has two turbines
- Smelter main furnace building was extended 45 ft north
- Lake Milling stamp mill shut down in December

1931
- Neither the Calumet nor the Tamarack reclamation plants were operated
- Ahmeek boiler and power plant went into commission in January
- Lake Milling did not operate

1932
- Neither reclamation plant operated

1933
- Ahmeek mill did not operate

1934
- Electric power was still being generated for Conglomerate lode operations by the Ahmeek power plant

1935
- Lake Linden reclamation plant went back into commission in July after 4.5 years

1936
- Tamarack reclamation plant being reconditioned
- Ahmeek mill back in operation

1937
- Tamarack reclamation plant back in operation by mid-May

1940
- Hecla mills and sand wheels were scrapped

1941
- Tamarack boiler shut down, steam now being supplied from Ahmeek boiler plant
- Ahmeek – boiler plant water treatment equipment installed
- Osceola mill and boiler house scrapped
- Lake Milling #2 still sitting idle

1942
- The leaching process in use on copper-bearing sands is adaptable to the recovery of copper from scrap of various kinds, including the treatment of scrap from copper and brass coated steel. C&H has successfully treated at Lake Linden leaching plant, yielding the original steel as scrap for steel mills and copper recovered as oxide which is refined at the smelter. They go through 2,500 tons of scrap metals per month.

1943
- Tamarack reclamation plant remodeled for most economical treatment of low-grade amygdaloid sands

1944

- Treated 31,604 tons of steel scrap clad with gilding metal from which there was recovered 11,503,688 lbs of copper
- Tamarack leaching producing copper oxide for Navy
- After treating small quantities of scrap copper for about ten years, the company has embarked on a comprehensive study of the possibility of using present idle leaching plant capacity for the treatment of various grades of copper bearing material in substantial tonnages
- Lake Linden reclamation plant remodeled for amygdaloid tailings
- Reconstruction of the discontinued leaching plant machinery now in progress to adapt it to the production of copper oxide from secondary copper products
- Calumet mill remodeled for conglomerate rock from Allouez, but it was discontinued
- Smelter – process for removing arsenic from soda slag by leaching the later with soda solution is now in regular operation
- New refining furnace installed at the smelter

1945
- End of war meant demand by Navy ended
- Treatment of scrap copper rapidly expanding
- Reclamation plants still open and working on tailings
- Ahmeek mill is still stamping
- Smelter refined copper on toll for the Metals Reserve Company (war effort) and treated a substantial tonnage of secondary copper
- Lake Chemical Company (C&H with The Harshaw Chemical Co. of Cleveland, OH) organized
    - Copper Oxychloride Sulphate (COCS)
    - Copper Hydrate
    - Leased space from the Tamarack reclamation plant building
- Lake Milling and Smelting company liquidated

1946
- Smelter had two furnaces rebuilt
- Secondary Copper Department of C&H in the developmental stage
    - Salvage and sale of various by-products including steel, cast-iron, lead, tin, aluminum, brass, and plastics
- Both reclamation plants are still open
- Ahmeek mill still open
- Lake Chemical production began in August
- Several new products still in experimental stages, may be added the following year

1947

- Successful operation of the secondary copper business requires maintenance of a substantial inventory
- Company's inventory of copper in the Secondary Department was placed on the "last-in, first-out" basis
- Installation of new generating facilities at our Lake Linden power plant is planned, should be completed in early 1949
    - Two new 1000HP diesel-electric locomotives and a diesel-electric locomotive crane
- Ahmeek mill – two new ball mills and flotation units installed
- Smelter installs new refining furnace
- Lake Linden reclamation plant shuts down for the winter season
- Tamarack reclamation plant remains open
- 1400 carloads of scrap metal reprocessed and 35,721,486 lbs of copper produced

1948
- Wolverine Tube Division in Decatur, AL has their new tube mill in partial operation
- Lake Linden power plant addition at the Calumet Division is nearing completion
- Lake Linden reclamation plant was originally scheduled to close in fall of 1948 but it is still open

1949
- Treatment of secondary materials, developed during the war, will be continued on a smaller and more selective basis
- New Lake Linden power plant of the Calumet Division is in full operation and gives evidence of meeting every expectation
- Annual Report has interior pictures of the power plant

1950
- Seven mines operated at capacity over the year
- A new power plant which was put into operation late in 1949 has performed satisfactorily and resulted in a considerable reduction of costs

1951
- Seven mines and two reclamation plants are still in production
- Secondary copper activities were severely curtailed
    - Unable to buy any sizable quantities of scrap at prices that would enable us to break even on reconversion and sale at the price fixed for refined copper

1952

- Undertaken to un-water and rehabilitate the Osceola mine, should take two years
- Government subsidy on three mines (No. 4 North Kearsarge, No. 4 Peninsula, and No. 1 Iroquois) enabled them to remain open
- Both reclamation plants working until the strike on September 8
- Lake Linden reclamation plant not re-opened until the next spring
- Shortage of scrap copper still affecting the reclamation activities

1953
- Seven mines, one reclamation plant, two leaching plants, a smelter and refinery, chemical plant, foundry, and bit plant are still operable
- Still working on un-watering Osceola
- Lake Linden reclamation plant exhausted tailings, closed in 1953
- Leaching plant is still in operation

1954
- Still copper scarcity for secondary operations
- Still working on Osceola
- Annual Report has interior pictures of the power plant

1955
- Mining is operational at the Osceola mine
- Tamarack reclamation plant now reprocessing Ahmeek sands

1956
- Two smelter furnaces shut down
- All reclamation done on the Ahmeek sands
- Tamarack leaching closed, all leaching activities now done at the Lake Linden facilities
- Scarcity of secondary copper still affecting the company
- Two major furnaces at the smelter rebuilt

1957
- Five-day work week is enacted

1959
- Reprocessing the Cliff Mine sands

1960
- Lideox, a highly conductive lithium deoxidized copper, was introduced

1963
- Selective mining has kept costs low

- Copper chemicals for industrial and agricultural customers are important products of the Calumet Division

1964
- Mines still producing, but at a loss

1965
- C&H starts production from the Kingston mine
- Preserving labor force by continuing operation of the high cost mines still in effect
- Most mines should be closed by 1967
- August 21, no agreement on a new contract, all operations stop because of the strike
    - Strike lasted until October 31
- Two furnaces rebuilt at the smelter

1966
- Shortage of skilled mining employees
- Senica mine is now closed
- Centennial #2 should shut down early in 1967

1967
- Performance of Calumet Division is disappointing
- For internal purposes the Calumet Division copper is transferred to the Wolverine Tube Division at the producers' price
- Most of the copper produced was sent to Wolverine Tube Co., some still used for the production of chemicals
- Three mines are still in operation (Centennial #6, Kingston, and Osceola)

1968
- Acquisition of all of the outstanding stock of Calumet and Hecla, Inc.
- Strike happened in August at the C&H facilities on Torch Lake
    - Caused the Wolverine Tube Division to buy copper from the world market

1969
- The strike ended in a deadlock, caused $13 million write-down of assets
- The company announced on April 8, 1969, that the operations of the Calumet Division would be closed down

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Source: Calumet and Hecla Mining Company Annual Reports (1923-1967) and Universal Oil Products Annual Reports (1968-1969), Michigan Tech Archives & Copper Country Historical Collections, Michigan Technological University, Michigan