Nov. 1950

Copy to L C Klein
" " O A Rockwell
R K. Powell

R E P O R T

THE GREASE RECLAMATION PLANT

To
RESEARCH COMMITTEE
CALUMET AND HECLA CONSOLIDATED COPPER COMPANY
CALUMET, MICHIGAN

By
L. C. KLEIN
CHEMICAL SUPERINTENDENT
CALUMET AND HECLA CONSOLIDATED COPPER COMPANY
CALUMET, MICHIGAN

MARCH 24, 1947

GREASE RECLAMATION PLANT

History of Development

Late in 1944 samples of spent wire drawing lubricant were obtained from the Copperweld Steel Corporation for experimental purposes. This material is a sludge from lubricant storage vats in copper wire drawing mills, where the lubricant is circulated to the wire-drawing dies then returned to a vat where the fine copper particles accumulating in the dies is settled out, and the lubricant recirculated. The lubricant usually used for this purpose is a composition of animal tallow, with or without the addition of other animal or vegetable fats and oils, and in some cases mineral oils. The sludge from these tanks may contain from 20%to 60% oxide and metallic copper, the balance consisting of spent drawing lubricant containing copper chemically combined with it in the form of the metallic soap, and varying amounts of moisture. Since much of this material has been stored in dumps around the wire drawing plants for years, the greater part of it is generously contaminated with wire, waste, scrap iron, and other shop refuse. The material is solid or semi-solid at lower temperatures, but above 90° F. it becomes fluid.

While this spent lubricant was valuable to the extent that it often contained over 50% copper, smelters and other scrap processors were reluctant to process it because of the almost explosive combustion of the grease on charging it in furnaces, and because of the generally obnoxious nature of the material. Since this material could be purchased at a lower price per pound of contained copper than most other grades of copper scrap, and there being on the average over a pound of lubricant associated with each pound of copper, there occurred the possibility that the grease might be separated from the copper by chemical or physical means, or both, and regenerated in such a way that the grease might be reused in compounding fresh wire drawing lubricant, or that use might be made of its saponifiable content in the soap, fatty acid, or allied industries.

Subsequent laboratory experiments indicated that the grease could be separated from the copper in several ways. For example it could be dried to remove its moisture content and then separated by extraction with organic solvents. After the solvent was recovered the grease could be acid treated to remove the copper dissolved in the grease. Another method involved the saponification of the fat with an alkali, filtering off the metallic copper and recovering the saponified portion as an industrial soap. The saponification liquors could be worked to recover the glycerine content. Still another process would involve the emulsification of the fat with very weak solutions of alkalis, filtering to remove the metallic copper, and then treating the filtered emulsion with an acid to break the emulsion and remove the copper dissolved in the grease. Another possibility was the treatment with complex organic chemicals to form the fatty acids, and subsequent distillation under a vacuum to separate them. These acids, particularly stearic acid, are frequently used in making candles.

Of the methods described none but the one involving emulsification of the fat appeared attractive, particularly because of the elaborate and costly equipment involved.

In February, 1946, attention was brought to the work of the American Chemical Service Co., Hammond, Indiana, who were processing similar material for the Western Electric Company. On being contacted, this company divulged their method of processing, there being no conflicting interests involved. Their method consisted of treating the spent wire drawing lubricant with a water solution of sulfuric acid and heating to boiling, then filtering, and washing the residue with hot water until free of grease, on a vacuum filter. The filtrate, containing the grease, was allowed to cool until the grease solidified. The grease was then separated from the acid solution, washed with hot water to remove all traces of acid and soluble copper, then allowed to cool again until the grease solidified, and could be separated from the wash water. The acid solution from the filtration contained copper sulfate in solution, this coming from the copper dissolved in the oil. This copper was recovered by running the solution on scrap iron, the copper being separated by displacement.

The method of the American Chemical Service Co. was tried on a laboratory scale, and proved to produce a satisfactory grease product, and a copper concentrate assaying from 65% to over 75% copper. Samples of grease recovered by the process and sent to soap makers and fatty acid manufacturers brought satisfactory comments in most cases, although some soap manufacturers objected to even a trace of copper in the grease.

On the results of laboratory experiments it was decided to build a commercial unit to process about six tons of the spent lubricant per day, using for the most part materials available around the works for handling the corrosive liquors. This unit was to be a pilot plant in many respects, inasmuch as the corrosion problems, the handling problem, and particularly the filtering problem were a bit out of the ordinary. The filtration in this process is a difficult one because the acid solution and the grease form two layers. For example, the water solution is first filtered through the filter medium, and then the grease. This constitutes a difficult and time consuming operation. An analagous situation would be trying to filter a heavy oil through a cloth bag that had been wet with water, or filtering water through a bag that had been soaked in oil. In this operation not only the filter cloth, but several inches of fine copper filter cake must be permeated by successive layers of oil and water. The corrosive problem was not limited to the action of sulfuric acid and copper sulfate, but included the grease which caused the rapid deterioration of the wood filter grids and rubber hoses used in the process.

The Plant

The plant was located in the old Cupola Building at the Smelter. Although somewhat confined as to space this location was decided upon because steam and hot water were available there together with rail and handling facilities for moving materials in and out of the building.

Equipment for the plant consisted of the following items:

1. A lead-lined steel agitated tank 54" in diameter and 8' high.

2. A cylindrical vacuum filter tank, lead-lined steel, 8' in diameter by 4' high, having a false bottom formed by a wood filter grid. Accessory equipment to this filter is a copper receiving tank, a Nash Hytor vacuum pump to provide up to 15" of vacuum, and a pump to deliver the filtrate to a separating tank.

3. A lead-lined separating tank, 3½' by 10' high.

4. A steel grease receiving tank equipped with steam coils.

5. A Shriver plate and frame filter press.

6. An 8000-gallon steel grease storage tank equipped with steam coils.

7. A 5000-gallon cast iron acid storage tank.

8. A lead-lined wood cementation tank.

9. A sulfuric acid measuring tank.

Operation

About 120 gallons of water are placed in the agitated tank, and to it is added about 13 gallons of 57° sulfuric acid. The solution is heated to boiling by introducing live steam, and then 3 barrels, about 1200 pounds, of spent lubricant is introduced rather slowly into the tank. The material is handled by shoveling, and must be carefully picked over in the operation to exclude any wire, iron, paper, gloves, stones, and other refuse that it contains. After the addition the mixture is agitated and heated for about 20 minutes, or as much longer as is required to heat the mix to boiling. The mixture is then let down, by gravity, to the filter tank, and this process repeated until the filter tank has been filled. As many as 7 batches have been placed in the filter in one day without discharging the residue; however, in this case about 20 hours was required to filter and wash the residue. Later practice has been to treat one or two batches completely and discharge the residue from the filter before beginning another batch. Discharging the filter is accomplished by men getting into the tank with rubber boots on, and shoveling the degreased copper residue into a mineral car body.

The filtrate from the filter tank is pumped to the separating tank. This tank will normally hold the filtrate from an entire day's run, but in cases when it does not, the lower, water-acid-copper sulfate, layer is slowly run off at intervals into the cementation tank, where the copper is separated from the solution and the spent solution is discharged to the sewer. When filtration is completed, the lower layer from the separating tank is entirely run off, and the grease layer is washed with hot water until the grease is free of copper and acid. The grease is then run over to the intermediate grease storage tank by introducing hot water at the bottom of the separating tank and forcing the grease to rise in the tank to an overflow from which it runs by gravity to the storage tank.

In the intermediate storage tank the grease is reheated, and any water separating from it is drained off at the bottom of the tank. The grease is then refiltered through a plate and frame filter to remove any remaining fine copper that might have gone through the first filter, and is pumped either to a wood receiving tank until its quality is determined, or directly to the 8000-gallon grease storage tank to await shipment.

Experimental Work

A considerable amount of experimental work has been carried on since the beginning of the plant in an effort to simplify handling of material, and to increase the capacity of the plant. For example, steam heating plates were installed to warm up the barrels in which the material comes into the plant in the hope that much of the picking and pounding necessary to get some of the material out of the barrels would be eliminated. Next, two rectangular tanks were fitted with steam coils and the material placed in these in an attempt to liquify the grease and treat only the grease thus obtained, eliminating the need for shoveling out the filter tank as frequently as is now necessary, and to increase capacity. Next, a steel acid egg was constructed so that a quantity of acid could be transported from the acid storage tank to the plant, thus eliminating the need for daily hauling acid to the plant in barrel lots. The acid egg has a capacity of 500 gallons, and holds sufficient acid for over a week's operation. Experiments were also made with different materials for handling the corrosive liquors used in the process, particularly in the case of pumps and pipe lines. Both bronze and lead pumps were tried, having been made at the local foundry. Neither lived a long life. There is currently being installed a Durichlor pump obtained from War Surplus. Piping which for a while gave corrosion troubles has of late given practically no trouble. Copper, brass, monel, and stainless steel pipe all are proving serviceable, and where failures occur, it is almost always the result of electrolysis caused by the joining of unlike metals. While copper and brass theoretically should be attacked to some extent by the copper sulfate-sulfuric acid solutions, the corrosion seems to be sufficiently slow to warrant its use wherever practical.

Costs

Pounds spent wire drawing lubricant purchased:	813,163
Pounds of contained copper:	294,874
Average per cent copper in material purchased:	36.26
Average cost per pound of copper:	$0.1107
Total cost of material delivered:	$32,645.11
Pounds material treated to Feb. 28, 1947:	305,408
Pounds concentrate recovered:	215,200
Average per cent copper in concentrate:	54.28
Pounds copper recovered:	116,803
Pounds of grease recovered, approximate:	64,640
Pounds of grease shipped:	51,640
Pounds of grease on hand Feb. 28, 1947, approximate:	13,000
Credit for grease shipped @13¢ per pound:	$6,713.20
Value of grease on hand @13¢ per pound:	$1,690.00
Total value of grease produced:	$8,403.20
Construction charges, labor and materials:	$3,326.49
Labor charges to Feb. 28, 1947:	
Direct ----- $6,331.98	
Mechanical - 1,316.13	$7,648.11
Supplies to Feb. 28, 1947, approximate:	$1,520.00
Total operating cost, approximate:	$9,168.11

Analysis of Costs

Above is a brief statement of the direct costs applied to the project. While the statement indicates that the unit operated at a decided loss, considering that overhead and supervisory salaries have not been taken into account, on the other hand, the figures are misleading inasmuch as a considerable amount of the labor and materials charged against operating were expended on experimental work and accessory purchases and probably should have been charged against other accounts. No accurate breakdown can be made of these charges.

No credit has been given the operation for putting 116,803 pounds of copper in condition for furnacing. Since this copper was bought at a figure considerably below the average buying price for No. 1 copper scrap, it seems at least a portion of the difference between the two costs should be credited to the operation.

Contributing to the high direct labor cost was the high rate of absenteeism in the early months of operation, which resulted in abnormally large overtime payments.

Because of the disagreeable working conditions on this job, the men handling the grease are paid incentive wages. When in full time operation the plant employs six men. Three of these men receive a wage incentive of 6 cents per hour over surface pay, or 88 3/4 cents per hour. They are held responsible for the operation of the plant on their shift. The other 3 men receive a 3-cent per hour differential or 85 3/4 cents per hour. The men are all supplied with coveralls, gloves, rubber boots, and goggles.

Discussion

The results obtained so far from the operation of the grease reclamation plant have on the whole been discouraging, despite the fact that the price received for the grease at the present time is considerably more than it was at the time the plant was designed. The greatest bottleneck in the operation is the filter that is being used. While at times the filtration proceeds rapidly, at other times the filtration is sluggish and time consuming, so that it is difficult to maintain a uniform schedule of operation. The variation in filtering rates seems to be attributable to the different character of spent lubricant as received from different manufacturers. Much is lacking in the present method of handling the materials into the agitating tank, and also in the present method of discharging the filter. The material must be shoveled in both cases, and the location of the tanks is such that the men must work in cramped positions. As a result of the nature of the work the men do not have the healthiest attitude toward their job, and are prone to be lax in their duties when not directly supervised.

To date the process has, but on few occasions, produced a concentrate as high in copper as is consistently obtained in laboratory separations. While in the laboratory a concentrate is obtained with a copper content of from 65% to over 75% copper, the average concentrate from the plant up to the end of February was 54.28% copper. This indicated that much of the grease is not being recovered, and it is due to the fact that insufficient washing is given the material before it is discharged from the filter. This has been a necessary evil for the most part in order to maintain some kind of a production schedule.

Much of the early trouble in the plant was with failures of materials used in pumps and pipe lines, and the occasional puncturing of the lead lining in the lead-lined agitated tank and filter. To a great extent these failures have now been eliminated, and with the installation of the new

Durichlor pump the pumping problem should be eliminated. However, as a result of these various failures the plant was idle for possibly six weeks since the time the operation started. Part of this lost time was also due to lack of steam on occasions when the furnaces were under repair. In one instance this necessitated moving an old steam locomotive into the plant to generate sufficient steam to keep the process in operation. While stainless steel would have been the ideal material of construction for the tanks, pumps, and piping for this plant the high cost of this material did not, and does not now, seem to warrant its use. Copper equipment has been proving serviceable wherever used. Lead-lined equipment has proved successful so far as its resistance to the corrosive liquors is concerned. Failures have usually resulted from its being punctured on shoveling out the filter tank, or from coarse material such as iron or rocks getting into the agitated tank.

Recommendations

The suggestion has been made that the plant either be moved to a more suitable location and redesigned, or that its operation be discontinued. On the basis of information gained during the some seven months of intermittent operation, very few basic changes are indicated other than the possible streamlining of handling methods. While the present filter has not performed satisfactorily, no other standard filter appears to be suitable for the job, and while one or two odd types of filters might be suitable, their use cannot be recommended without actual tests having been made. In this case the problem seems to confine itself to increasing the present filtering capacity, either by providing a second filter, or by making a preliminary separation of much of the coarse copper and refuse by melting the spent lubricant in a tall tank and allowing the coarse material to settle out, and then treating only the grease that separates out in the plant.

There seems no need for abandoning the present plant for the time being, since it is now fully equipped, and with a few changes to increase capacity might well be used to finish processing what material is still on hand. With fair success this can be accomplished in three to four months of warm weather when the material can be more easily handled. After this accumulation has been processed, the plant may be reappraised and if the material is still available in quantity, and at a satisfactory price, if the price of grease remains high, and if operating costs are within reason, the possibility of moving the plant and remodeling it can be more safely considered. Since the plant was designed, in part, to serve a dual purpose, in the event that the grease operation be discontinued, part of the facilities may be used to recover the copper from smelter flue dust.

Recommendations for changes to be made to the present plant setup to increase capacity are as follows:

1. The installation of a tank 52" in diameter by 10' to 12' high, made of steel, equipped with steam heating coils and a manhole near the bottom. Into this would be charged the original material, about 25 barrels to a batch. The material would be heated until melted, and all of the coarse copper settled out, along with the wire and other material that must be hand-picked before charging into the agitated tank. After settling the grease would be pumped, or run by gravity into the agitating tank. After sufficient coarse material accumulates in the tank it will be drained of grease, and the residue steamed to free it of most of the grease. The residue would then be discharged by hoeing the copper out of the manhole into a mineral car body. The tank should be located in an open area, and the material dumped directly into it from the container in which it is brought to the plant, this being accomplished by hoisting the container over the tank by means of a chain block or hydraulic lifting device. This arrangement should result in less sludge accumulating in the filter, with a resulting faster filtering rate, and less time consumed in discharging the filter tank. Estimated cost--$250.

2. If filtering capacity is still inadequate using the above equipment, the installation of a second filter, similar in design to the present one, and operating from the same vacuum system. Each filter would be charged every second day, so that ample time could be allowed for thorough washing, and a strict cycle maintained. Estimated cost--$350.

3. A full-time working foreman should be placed in charge of the plant on the day shift. He would be responsible for scheduling the work, and seeing that equipment is maintained properly.

4. The material should be delivered to the Cupola Building in some kind of bucket that could be readily dumped, rather than in barrels.

5. A weekly log should be kept of material treated, grease recovered, and copper recovered, with notations as to the number of hours of operating and repair labor involved.

6. The grease should be shipped in 4000-gallon tank cars whenever possible, instead of the conventional 8000- or 10,000-gallon cars.

BY-PRODUCTS RECOVERED BY SECONDARY DEPT.

The treatment of secondary materials at the Smelter is becoming an increasingly complicated operation. In the early days materials of relatively high purity, such as clean copper scrap and copper or brass clad steel scrap, was easily processed by direct smelting or by removing the copper or brass from steel by the ammonia leaching process. During the war, however, vast quantities of scrap were generated in which the copper was associated with other metals and non-metallic materials having scrap values sufficiently high to warrant the development of separation processes. Typical of this class of materials that is now being processed in large tonnage by the Secondary Department is Navy degaussing cable which was used on merchant and naval vessels during the war to protect them from magnetic mines. The cable provided a system which neutralized the attraction of steel hulls for this type of mine.

The degaussing cable varies considerably in size and composition but is usually about two inches in diameter and consists of a fabric outer covering over an armor of heavy steel wire. The steel wire is woven over a lead sheathing under which the copper wire or conductor is located. Some forms of cable are clad with aluminum or bronze and may be insulated with neoprene rubber or vinylite, all of which have some scrap value.

The cable is received at the plant on large wooden reels measuring from 4 to 6 feet in diameter. The first step in processing is to shear the cable into suitable lengths with mechanical shears. The outer fabric is then cut and the steel armor removed by hand and segregated for sale as scrap. The lead sheaths are then passed through a stripping machine which cuts the lead armor lengthwise on opposite sides and allows the two halves to fall apart. The lead is likewise segregated and accumulated in carload lots for sale to lead processors. The core of the cable, which contains the insulated copper wire, is sent to the furnaces for direct melting. Cable which is sheathed with aluminum or bronze and insulated with neoprene or vinylite is processed in identically the same manner.

Telephone communication cable is likewise a source of copper and by-product metals. This type of cable may contain hundreds of relatively fine insulated copper wires inside of a lead sheath. The lead sheathing for this kind of conductor is usually alloyed with 1% of antimony or 1% of tin, as both elements harden lead and provide a somewhat more rigid sheath for the copper wires. These different alloys must be separated and identified in order to receive the highest salvage value.

Occasionally miscellaneous scrap is received which contains lead or solder that cannot be separated from the copper-bearing scrap by mechanical methods. This type of material is processed through a small "sweating" furnace where just sufficient heat is applied to melt the lead or solder without melting the copper, and the white metals are accumulated in a pool at the bottom of the furnace. This metal is cast into pigs which are sold for re-processing into solder or for other uses requiring lead tin alloys.

Stripping machine for recovering lead and copper from cable.

Scrap lead recovered from cable.

SCRAP YARD
Steel, Lead and Copper recovered from battleship cable.

Sweating furnace for melting lead.

Unloading Scrap Wire and Cable.

Scrap battleship cable on reels.

Box 201 - Folder 21
"Slag Utilization"

December 1, 1950

Mr. H. L. Humes, Vice President
Baldwin-Hill Company
500 Breunig Avenue
Trenton, New Jersey

Dear Mr. Humes:

I am indeed sorry that so much time has been required to accumulate data on slag production and had it not been for your visit with our Mr. J. S. White the Richardson file would probably have remained in the mothball fleet.

Current production of waste slag from melting furnace operations amounts to 1500 to 1700 tons per month. The fluid slag is granulated in water, trommeled to remove brick and chunks, which produces a product passing through a 1/4" mesh screen. The material could be easily handled from a pulverizer and loaded into gondola cars by diverting the slurry from the slag line which carries the product into the lake. We do not believe that the cost of loading this material would be other than nominal.

We have not as yet been able to develop rates on the product to Huntington, Indiana, but as a means of comparison the rate into Milwaukee is 32¢ per cwt (70,000 lbs. minimum) and for lump slag 22¢ per cwt.

The composition of our slags is not too uniform and although we have made completes from time to time the weighted average is about as follows:

SiO_2	53.8%
Al_2O_3	10.2%
FeO	13.8%
CaO	9.5%
MgO	11.5%
Cu	1.0%
Total	99.8%

In practically all analyses the five major components vary in a range ≠ or - 5%. Copper is always present to the extent of .5 to 1%, together with small percentages of lead and nickel.

There is some question in the minds of our operating personnel whether our waste slags, with their varying composition and viscosities, are suitable for production of a satisfactory wool fiber, but I assure you that we are interested in exploring any end use to which these products might be adapted.

We will appreciate having your comments, particularly as they pertain to chemical composition and physical properties, and if the product appears to have merit we will then welcome an opportunity to discuss the subject further with you.

Yours very truly,

G. L. Craig
Director of Sales
and Research

GLC:hek

cc: JSWhite

COPY

VERN E. ALDEN COMPANY
ENGINEERS
33 NORTH LA SALLE STREET
CHICAGO 2

J.O. 342

November 15, 1954

Mr. P. H. Ostlender
Project Engineer
Calumet Division
Calumet & Hecla, Inc.
Calumet, Michigan

Report on Lightning Protection
For the Electrical Transmission System of
Calumet & Hecla, Inc.

Dear Mr. Ostlender:

Following your inquiry letter to us dated April 6, 1953, Purchase Order No. 14418 was issued to cover the subject report.

We are sending you herewith five copies of this report. The completion of this report was delayed until the Osceola Unwatering Project was fairly well complete as was suggested in your letter.

A minute survey of your lines and substations was made and this report embodies our findings and our recommendations for certain improvements.

We will be pleased to review this report with you after you have had an opportunity to study it.

Yours very truly,

F. D. Troxel
Project Engineer

Encl

J.O. 342 November 12, 1954

REPORT ON LIGHTNING PROTECTION FOR THE ELECTRICAL TRANSMISSION SYSTEM OF CALUMET & HECLA, INC.

1. During past years there have been a considerable number of outages of the electrical transmission system which were traceable to lightning disturbances. This study was made in accordance with the instructions in your purchase order No. 14418 and was made in an effort to find the points in your electrical transmission system which are susceptible to lightning troubles and to determine what could be done, at not too great a cost, to correct these conditions, and thus provide more reliable service from the electrical transmission system.

2. In an electrical transmission system such as exists here, the principal forms of lightning protection which might be considered are:

   A. The use of modern lightning arresters correctly applied.

   B. The use of overhead ground wires and lightning rods properly installed.

   C. The maintaining of low resistance ground connections for the arresters, the overhead ground wires and the lightning rods.

3. We have looked at each of your substations individually and find that in general there are many old lightning arresters

now in service on your system. Many of these arresters are undoubtedly useless as lightning arresters and, perhaps, even worse than no lightning arrester at all. In general this report recommends the replacement of all these old arresters with new modern arresters. The new arresters should be as follows:

15 kv station type grounded neutral service
Westinghouse Type "SV" outdoor Style No. 1533116 or equal.

2300 V Line type ungrounded neutral service
Westinghouse Type "LV" Style No. 1535071 or equal.

At certain points on your system some of the old arresters have already been replaced and these, of course, do not have to be replaced again. This report discusses in detail the conditions which exist at each substation on your system. At a few points where overhead lightning rods or ground wires are not now installed, it is suggested that they be added. In general in protecting equipment from lightning disturbances, it is well to place the lightning arrester as close to the equipment being protected as is possible. On your system, for the most part, the major equipment which is being protected is transformers and for that reason the arresters in each case should be placed as close to the transformers as is possible.

4. This report is a part of the general effort to raise the level of the reliability of your entire electrical system and other items, germane to this program, have been carried out in the past year or so. These items included the reconditioning of the 13.2 kv breakers and relays in the Lake Linden power house, revision of relay settings, automatic transfer of auxiliary supply, replacing poles on lines, etc. This work has progressed along with the work on the Osceola project. In our report to you dated February 8, 1949 we made an engineering study of each of your substations. This report covered principally the possible short circuit conditions on your system at the various points and the interrupting abilities of the breakers at the various points. In this report we made a series of recommendations. While reviewing your system in connection with this lightning study, we checked to see if the recommendations contained in the report dated February 8, 1949 had been carried out. In many cases these recommendations had not been carried out. In the earlier report certain hazards were pointed out and recommendations made to remove these hazards. As long as these conditions exist, they are a hazard to the reliable operation of this system just as are the hazards from lightning disturbances. We suggest that the report dated February 8, 1949 be reviewed and the things recommended therein, which have not been done, be carried out as soon as possible.

5. Any overhead 2300 volt or lower voltage lines which are exposed to lightning surges should be equipped with modern lightning arresters at both ends of each line. All electrical equipment and lighting circuits should be solidly and permanently connected to ground.

6. Below are listed in detail our recommendations in regard to each of the substations. You will note that in certain cases we are referring to substations which no longer carry much load. However, as long as these substations are connected to your system they constitute just as much a hazard to the reliable operation of your system as if they were carrying a heavier load. In cases where certain substations are no longer carrying any load, we would suggest that that substation and as much of the line as possible, that originally supplied such a substation, be disconnected from your system.

   A. Quincy Substation - This substation is relatively new. The equipment for the most part is relatively modern. Modern G.E. type lightning arresters are installed. The substation is located in a low spot which should be relatively free from lightning occurrence. There is no record of a lightning stroke at this location. The ground resistance is quite low. Therefore, we would suggest no changes insofar as the lightning protection for this particular yard is concerned even though there are no ground wires above the substation proper. In our report dated February 1, 1949, we stated that the breaker which is installed on the high tension side of this transformer had an interrupting capacity of 50,000 kva and that the short circuit current that might flow in case of a short at the terminals of the transformer, would be about 91,000 kva. We suggested that this breaker be removed from service since it constitutes a serious hazard to the reliable operation of the system and is a source of fire hazard as well. This breaker has not been removed and we again recommend that it be removed just as soon as practical. When the breaker is removed, it will be necessary to change the settings of the relays for the Quincy Line at the Ahmeek Power House since the clearing of a fault will depend upon the operation of these relays.

B. Tamarack Reclamation Substation - In this substation there are two banks of transformers. These transformers are each 1,000 kva in capacity, arranged in two banks of three each, one stepping down to 440 volt and the other to 2300 volt. All of this equipment is located indoors. Both transformer banks are supplied by one feeder from the Ahmeek Power Station. There are located here, three old style G.E.Co.'s oxide film type of lightning arresters. These arresters are quite old and are obsolete. Most arresters of this type have been removed from power systems many years ago since it was found that the discs in the arresters deteriorated after a period of time and that it was impossible to determine their condition in any satisfactory manner. Furthermore, the porous block type of arrester has been developed since and it is a much better arrester in every respect. We would recommend that these arresters be removed and be replaced with modern arresters. In our report dated February 1, 1949 we stated that the three oil circuit breakers located in the circuit on the high tension side of these transformers each had an interrupting rating of 25,000 kva and that the possible short circuit current that might flow with a short circuit at the high tension terminals of these transformers could be about 136,000 kva. We, therefore, recommended that these breakers be all removed from service just as soon as possible. This has not been done. We recommend again that these breakers be removed just as soon as practical as they constitute a serious fire and system reliability hazard. Furthermore this substation is located in a room which has a door which leads to the Reclamation Plant. If the oil in these transformers or the breakers should get out of the tanks and catch fire, as it does when there is a fault in the equipment, this flaming oil could flow out through this door onto a wooden platform, down a wooden stairs, thereby starting what could be a serious and costly fire. We would recommend that a curb be placed immediately at this door entrance so that this flaming oil could not flow out onto the wooden platform and stairs. Furthermore certain of this equipment is located on an elevated platform which has a stairway at one end. If a fault occurs when a man was at the opposite end of this platform he would be trapped. We would suggest that at least an escape ladder of some sort be provided at the opposite end of this elevated platform.

C. No. 2 Regrinding Plant Substation - This substation was originally supplied by two lines from the Lake Linden power house bus. Two transformer banks were installed, one 3750 kva in capacity and another 6000 kva. The load at this time, however, has been very much reduced and at present only one line is connected from Lake Linden to the substation. All of the transformer capacity is, however, yet in service. Apparently there is a good chance that all of this equipment will be taken out of service before long due to the regrinding plant operation being discontinued. If this is true, of course, it is not desirable to spend any money here. However, if this equipment is to continue to be energized, even though it is not carrying any load for any length of time, we would suggest that the old lightning arresters on the one line that is in service be replaced with modern type of arresters. In our report dated February 1, 1949 we stated that the breakers which are in the high tension side of the feeds to these two transformer banks each had an interrupting rating of about 25,000 kva. The short circuit current that might flow is something in the order of 232,000 kva. We, therefore, recommended that these breakers be removed from service immediately. This has not been done. If this equipment is to remain energized we would recommend again that these breakers be removed just as soon as possible. All of this equipment is quite old and it is a source of hazard to the whole system. The equipment, however, is located in a separate building and if it caught on fire it probably would not do much damage to other buildings. When the high tension breakers are removed, the relay settings at the Lake Linden bus should be changed.

D. The Smelter Substation - The smelter substation has three 1000 kva single phase transformers. These transformers were formerly fed through breakers on the high tension sides from a line from the Lake Linden Power House. These breakers have been removed in accordance with the recommendations of our report dated February 1, 1949. The incoming line to this substation is provided with old G.E. lightning arresters which should be replaced with the new modern type. The ground resistance at this station is low and with the new lightning arresters, a minimum amount of lightning disturbance would be anticipated. We, however, would recommend that lightning rods be placed above the switchyard structure in the usual manner that has been done on many of the substations on the C&H system.

E. Coal Dock Substation - The coal dock substation is an outdoor substation. The transformer bank formerly had an oil circuit breaker on the high tension side but this breaker has been removed in accordance with the recommendation of our report of February 1, 1949. The incoming line is provided with old style Westinghouse lightning arresters and these should be replaced with new style arresters. We would also suggest that lightning rods be added above this switchyard. This substation is fed from the same breaker and line that feeds the smelter. The relay settings for this breaker in the Lake Linden Power House are satisfactory as indicated on the last relay settings list which we gave Calumet & Hecla.

F. Ahmeek Power Plant - All the lines going out of the Ahmeek Power Plant are equipped with modern lightning arresters. These arresters are mounted on a modern steel pull-off structure. The pull-off structure does not have lightning rod protection above it but it is set adjacent to the rather tall power house smokestack which is equipped with lightning rods and this affords good protection from direct lightning strokes. We would, therefore, suggest no changes at this point. The ground resistance at this point is very low which also will lead to good operation from these lightning arresters.

G. Lake Linden Power Plant - All of the lines going out from the Lake Linden Power Plant are equipped with modern arresters. These have been replaced in recent years. The switching equipment in the Lake Linden Power Plant is all relatively modern and has recently been reconditioned and tested. The relays have been carefully cleaned and adjusted. The relay settings have been checked in accordance with the system as it is at present. Therefore, no further work would need to be done at the Lake Linden Power Plant and a minimum of trouble should be expected from lightning at this point.

H. All of the transmission lines at Substation "B", both the 60 cycle and the 25 cycle, have been provided with modern lightning arresters. Ground resistance at this point is low. Overhead lightning rods have been provided. Therefore it would appear that no work need to be done at this point in order to have a good level of lightning protection.

I. Lines to Osceola No. 13 and No. 6 Shafts and to Tamarack No. 5 - These lines and the associated substations have recently been built and they are equipped with modern lightning arresters and other lightning protection features. All of this should give good lightning protection for these lines and the substations.

J. Calumet Waterworks Substation - All of the lightning arresters at Calumet Waterworks are old arresters. These should be removed and replaced by modern arresters. There are two sets, one for each of the two transformer banks. Lightning rods should be added over the switchyard. The ground resistance at this point is rather low and with the addition of the two items mentioned above a good level of protection would be assured. The arresters on both ends of the 2300 V line to the Tamarack Water Works should also be replaced.

K. Centennial Substation and Adjacent Lines - The area around the Centennial Substation has the record of having more lightning difficulties than any other spot on the C&H system. This is probably due to exceedingly high ground resistance and to, perhaps, a rather exposed natural position. We would recommend that the two old lightning arresters on the line to the transformer bank be removed and that the one modern arrester be retained. We would suggest the addition of a modern arrester at the point where this connection to the transformer bank cuts into the main line. We would suggest that another arrester be placed about one thousand feet away on the line to Substation "B" and that another be placed about one thousand foot distance in the opposite direction from this tap point. Anything that can be done to lower the ground resistance of all of these arresters should be done. Modern lightning arresters should be provided on the 2300 V. distribution system. With the addition of these arresters and a low ground resistance we would think that the protection afforded was about as good as possible.

L. Alloway No. 3 Substation - There are modern arresters at this substation and we would suggest no change here.

M. Ahmeek No. 2 Substation - There are choke coils in the connection to the transformer bank to Ahmeek No. 2. These choke coils serve no useful purpose and in fact are a hindrance insofar as lightning protection is concerned. They should be removed. The lightning arresters at this point are very old and should be replaced with modern arresters.

N. Ahmeek No. 3 and No. 4 Substation - The lightning arresters at this point on both the incoming lines and outgoing lines are all very old and should be replaced with modern arresters. All of these new arresters should be located out of doors.

O. Seneca No. 2 Substation - The lightning arresters at this point are very old and should be replaced with modern lightning arresters. Lightning rods should be placed above the substation.

P. Iroquois Substation - The lightning arresters at this substation are very old and should be replaced with modern arresters. Lightning rods should also be placed over the substation.

Q. Trap Rock Valley Line and Substation - This line and substation have been built recently and are provided with modern arresters, etc. and should be relatively free from lightning troubles.

The estimated cost of carrying out the foregoing recommendations is as follows:

42 -	15 kv lightning arresters @ $200. ea. installed =	$8,400.
12 -	2300 V. lightning arresters @ $10.ea. installed =	120.
5 -	Sets of lightning rods above substations =	500.
	Total =	$9,020.

We feel that if the recommendations which are made in this report are carried out that the reliability of your electrical transmission system, insofar as lightning disturbances are concerned, will be much improved. We will be happy to discuss this report with you, after you have had an opportunity to review it, if you so desire.

Signed: F. D. Troxel

F. D. Troxel
Senior Electrical Engineer

REPORT ON STATUS OF RECOMMENDATIONS

OF Vern E. Alden Co.'s Engineering Studies

of Feb. 1, 1949 and Nov. 17, 1954

CONTENTS

This report lists by substations, the status of Vern E. Alden's recommendations contained in their two reports:

Engineering Study of Distribution Substations
February 1, 1949

Lightning Protection for Elec. Transmission System
November 17, 1954

Submitted to

F. H. OSTLENDER

by

A. J. KLEVEN

January 6, 1955

Note: This status report does not take into consideration the advisability of installing some of the recommended equipment in the light of the life of some of the properties involved nor does it reflect some changes that have been made in the distribution system since the 1949 report. This report, therefore, can only serve as information for further studies.
A.J.K.

The following is a list of recommendations taken from Vern E. Alden Company reports of February 8, 1949, and November 12, 1954, and what has been done toward carrying them out.

Quincy Substation

Recommendations:
Remove 13.2 KV Breaker.
Set relays at Ahmeek to clear fault when breaker is removed.
Work done on recommendations:
There seems to be some question as to the interrupting capacity of this breaker. V. E. Alden's report says 50,000 KVA and a letter attached to the report from C. K. Nauman of General Electric addressed to J. E. Breth claims 250,000 KVA.
New bushings have been installed in the 13.2 KV breaker and it is still in service.

Tamarack Reclamation Substation

Recommendations:
Remove three 13.2 KV Breakers from service, one on line from Ahmeek and two on high side of transformers.
Set relays at Ahmeek to trip on fault on either low voltage bus at Tamarack.
Overhaul 2.3 KV Breakers.
Install reactor on high side of transformer banks.
On 2300 Volt bank, reactor specifications - 4.1% reactance, 132 amps, 13.8 KV on 3000 KVA base.
On 460 Volt bank, reactor specifications - 30% reactance, 132 amps, 13.8 KV on 3000 KVA base.
Build curb to prevent oil from transformers from flowing down wooden stairs.
Provide escape ladder from elevated platform on opposite side from stairs.
Replace old G.E. lightning arresters.
Work done on recommendations:
The trip circuit has been taken out of the 13.2 KV breaker at Tamarack.
No other changes have been made.

No.2 Regrinding Plant Substation

Recommendations:
Remove 13.2 KV breakers.
Put both transformer banks on one circuit.
Change relay settings at Lake Linden plant when breakers are removed.
Replace old lightning arresters if station is to continue energized.
Work done on recommendations:
Breakers have been taken out of service.
Two transformer banks have been put on one circuit.

The Smelter Substation

Recommendations:

Separate breakers at Lake Linden for Coal Dock and Smelter.
Remove 13.2 KV breaker at Smelter.
Set relays at Lake Linden to trip on fault on low voltage bus at Smelter.
Install a reactor on the high side of transformers to limit short circuit current as the 2.3 KV breakers have too low interrupting capacity.
Reactor specifications - 9% reactance, 132 amps, 13.8 KV on a 3000 KVA base.
Clean and overhaul low voltage equipment.
Replace old G.E. lightning arresters.
Install lightning rods above station.

Work done on recommendations:

13.2 KV breaker removed from service.

Coal Dock Substation

Recommendations:

Remove remaining 13.2 KV Breaker.
Feed substation from separate breaker at Lake Linden.
Set relays at Lake Linden to trip with a fault on low voltage bus at Coal Dock.
Clean and overhaul 2.3 KV breakers.
Replace old Westinghouse lightning arresters.
Install lightning rods above station.

Work done on recommendations:

13.2 KV Breaker has been removed.
Indoor transformer banks have been replaced with a new outdoor bank.
S & C fuses with 209,000 KVA interrupting capacity have been installed on new transformer bank.
Cleaning and overhauling 2.3 KV breakers is being done.
Sub is fed from same breaker and line which feeds Smelter, and the relay settings at Lake Linden are satisfactory.

Calumet Substation

Recommendations:

New 13.2 KV breakers.
Operate on 600 KVA bank with 1500 KVA bank as spare.
Overhaul 2.3 KV breakers.

Work done on recommendations:

13.2 KV in Calumet Substation used only in emergency.
600 KVA bank removed.
1500 KVA bank used only in emergency.

Calumet and Tamarack Water Works Substation

Recommendations:

Check equipment.
Replace lightning arresters on both transformer banks.
Install lightning rods over the switchyard.
Replace lightning arresters on both ends of 2.3 KV line to Tam. Water Works.

Work done on recommendations:

None of the recommendations carried out so far.

Centennial Substation

Recommendations:

Check 13.2 KV Breaker and relays.
Remove old lightning arresters on line to transformer and retain modern station arresters.
Install modern arresters at point where connection to transformer bank cuts into main line.
Install lightning arresters 1000' along line to "B" Station from tap point and 1000' along line in opposite direction from tap point.
Drive additional ground rods to lower ground resistance.
Put lightning arresters on 2.3 KV distribution system.

Work done on recommendations:

Lightning arresters installed on line to compressors.

Allouez No.3 Substation

Recommendations:

Install modern lightning arresters.

Work done on recommendations:

No changes have been made.

Ahmeek No.2 Substation

Recommendations:

Remove choke coil in connection to transformer bank.
Replace lightning arresters.
The relays at this station should be changed.

Work done on recommendations:

No changes have been made.

Ahmeek No.3 & 4 Substation

Recommendations:

Replace lightning arresters on all incoming and outgoing lines.
Locate all arresters outside.

Work done on recommendations:

No changes have been made.

Seneca No.2 Substation

Recommendations:

13.2 KV breaker at No. 3 & 4 Ahmeek on Seneca line should be removed or replaced.
Replace lightning arresters.
Install lightning rods over substation.

Work done on recommendations:

No changes have been made.

Iroquois Mine Substation

Recommendations:

Put 13.2 KV breaker in service if it is in good condition.
Replace lightning arresters.
Install lightning rods over substation.

Work done on recommendations:

No changes have been made.
The 13.2 KW breaker is not in operating condition.

The substations listed below have modern lightning protection and modern equipment and no changes are suggested.

Lake Linden Power Plant

Ahmeek Power Plant

"B" Station

Trap Rock Valley Substation

No.13 Osceola Substation

No.6 Osceola Substation

No.5 Tamarack Substation

Box 201 - Folder 23
"Smelting & Refining

Research Activities Committee Members
essrs. T. P. Condon
R. J. Marcotte
R. L. Pierce

February 1, 1957

The current Smelter inventory carries approximately 3,300,000 pounds of assorted materials classified as wastes, residues, ashes, brick, etc. containing some 600,000 pounds of recoverable copper. A part of this inventory is salable but transportation, processing, and penalties reduce the return to a point where only a very small part of the values come back to the Division. Certain of the items can be classified only as wastes which will either remain in stockpile indefinitely, used for fill, or pushed into the lake.

A number of years ago, processing equipment was installed in the cupola building for reworking slags and other materials to concentrate the metallic content into products that could be returned to the furnaces. These facilities have not been used in recent years.

A study has been made to determine if the facilities, as presently arranged or modified, could be used for processing certain of the so-called waste products generated in the smelting and refining operation. Two reports have emerged from this study, viz., A. B. Landstrom's report of October 19, 1956 covering the mineral dressing and Lee Crouse's report of January 19th covering costs and other economic considerations. Copies of these reports are attached.

In reviewing the cost data, it should be borne in mind that no cost consideration is given to the use of these facilities for processing materials that will be generated in the future. The study is limited to the present inventory. It will also be noted that the costs incurred in putting the inventory items into their present form have been taken into the cost study. At the time this project was initiated, it was assumed that any previous costs incurred had already been written off and that the materials would be brought into the new processing operation without penalty.

It is estimated that the combined capital and expense expenditures required to provide the proposed facilities will be $2,725. Of this, $1,500 is in the capital category and $1,225 in expense items. The only new equipment required is a two inch Wilfley solids pump. All of the other equipment