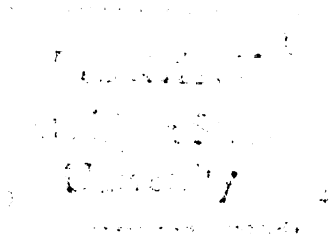

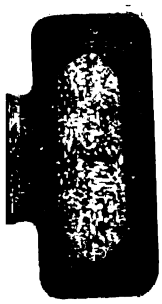

COST OF HANDLING COAL
IN STEAM POWER STATIONS

A Thesis Submitted To The
Faculty of
MICHIGAN AGRICULTURAL COLLEGE

By

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Candidates for the Degree of
Bachelor of Science

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OBJECT OF THESIS.

The object of the investigations was to make a careful study of the coal handling system in each of three power plants and to determine the cost of handling both coal and ashes in each plant.

STATIONS INVESTIGATED.

The following stations were investigated;

Municipal Power Plant, Lansing, Michigan,

M. A. C. Power Plant, East Lansing, Michigan,

Consumers Power Co., Wealthy Ave. Station, Grand Rapids, Michigan.

The following stations were visited but no investigation made;

Michigan Power Co., Lansing, Michigan,

Michigan Central Round House Coaling Station, Grand Rapids, Michigan.

SCOPE OF THESIS.

The investigation was to include a study of the apparatus, measurement of power consumed in its operation, the determination of labor costs, and a record of the time required for the various steps of the transfer of the coal and ashes.

Cost of handling was to be divided as follows;

Cost of unloading cars,

Cost of conveying to bunkers,

Cost of feeding to furnaces,

Cost of removing ashes.

These costs were not to include wear and tear and depreciation of machinery.

METHOD OF PROCEEDURE.

The first step in each case was to secure permission from the proper authorities to carry on the investigation in their plants. A half day was then spent in looking over the plant, noting the type of system used, its arrangement and operation. Following this study a method of running a test was devised.

Later, at a time when the plant was carrying as nearly as possible an average load, a 24 hour test was made. In all cases the motive power was electrical motors; hence, the power consumed was measured by cutting meters into the motor circuits. The amount of coal fed to the furnaces thru the 24 hours was considered to be the amount handled by the system during that period. In all cases the coal fed to the furnaces was weighed by means of a weighing car before being passed to the furnace hoppers. The weights were recorded and totaled.

The handling of the ashes in only one case allowed of accurate weights being kept. In the other two cases average weights per car or load were obtained and account kept of total cars dumped.

Data as to the capacity of the plant, wages of firemen, operators, helpers, and laborers was obtained from the Chief Engineer of each plant.

Sufficient measurements were made to enable a diagramatic sketch of each plant to be made.

Photographs of each plant, system and objects of interest were taken.

REMARKS.

The writers feel that the value of the work done cannot be adequately expressed in this report. The data obtained, in itself, is of value only as relating to the period of year and load carried during the test day. The greatest value was in the experience gained by coming into actual contact with power plant operation; by getting into overalls and jackets and thoroly examining the various plants; by talking to the operators, firemen, and laborers, thereby getting first hand information as to the advantages and disadvantages of the systems used; in fact, by getting a knowledge of power plants such as can be obtained only by practical experience.

The methods of running the tests were original with the writers, altho the method of dividing the costs was obtained from "Steam Power Plant Engineering" by Gebhardt.

Some difficulties were encountered but successfully overcome. Trouble was experienced in two cases due to difficulty in securing proper sized meters. At the Municipal Plant, it was required to keep the ash hopper locked during the period of the test to prevent the public hauling the ashes away. It was also required that the ashes be hauled to the city scale to be weighed .

CONCLUSION.

The writers are indebted to Messrs. Mefford and Keech, of the Consumers Power Company; Crane and Childs of the Municipal Plant; Bissell and Newell, of the College Plant, for courtesy shown in allowing the investigations and kindness in giving the required information during the tests.

MUNICIPAL PLANT Lansing, Michigan.

APPARATUS:

24" apron elevator from hopper beneath track to crusher.

Coal crusher.

24" bucket elevator.

18" x 6" distributing conveyor with sliding wearing shoes.

Reinforced concrete coal storage bin with down spouts to

, Weighing car, and also to

Storage room.

6- 400 H.P. Wickes vertical boilers with Dutch oven furnaces.

Vacuum system for removing ashes.

GENERAL DESCRIPTION.

The Municipal Plant is located on a spur of the L.S. & M.S. Railroad having connection also with the Pere Marquette and Michigan Central Railroads. This assures good service in getting the coal to the plant. It is required that the coal be shipped in hopper bottom cars.

The coal is dumped from the cars into a hopper below the tracks from which it is fed to the crusher by means of a 24" apron elevator. After leaving the crusher, it drops into the buckets of an elevator and is raised about 50feet to the distributing conveyor, by which it is carried to

the storage bin. It then passes thru down spouts to the weighing car, and after being weighed is dumped into the furnace hoppers.

The ashes drop from the grate into ash pits below the furnaces from which they are hoed and dropped into the suction pipe of the ash removing sydtem. A suction of 6 to 8 oz. per square inch is required to move the ashes. The ashes pass thru a mixing chamber where they are thoroly soaked with water and then dropped into the storage hopper. The ashes are placed at the disposal of the public, wagons being driven under the hopper and when the valve is opehed the ashes fall into the wagon.

When it is desired to place coal in storage, valves in down spouts leading to the storage room from the storage bin are opened and the coal allowed to drop into the storage room. When required for use, it is passed thru openings in the floor onto the reclaiming conveyor which dumps it into the bucket elevator for hoisting to the distributing conveyor.

The services of two coal passers and two firemen are required. The coal passers work a ten hour day. There are three shifts of eight hours each for the firemen.

The usual practice at this plant is to have the coal shipped in such quantities that it may be put into

the storage bin and used directly from that. Much time is required for unloading a car because the opening in the bottom of the hopper beneath the tracks is not of sufficient size to keep the apron elevator loaded.

RESULTS OF 24 HOUR TEST.

Date- 11:30 A. M., April 12 to 11:30 A.M., April 13, 1916.

Operating Conditions.

We selected Wednesday afternnon and Thursday morning as the time for the tests because, in the opinion of Mr. Childs, Chief Engineer, the plant was operating under a most nearly average load.

Data.

Total amount of coal fed to furnaces 47.2 Tons

Total amount of ashes removed 8.36 "

COST OF UNLOADING CARS, COAL BEING PLACED IN STORAGE BIN.

Test on car #33398 C. & O.
Weight of coal- 111000# = 55.5 Tons

Time required 3½ hours.

Power cost.

		Crusher	Elevator
Meter readings-	Final	24.4 KWHr.	7108.9 KWHr.
	Initial	11.1	7094.2
	Total	13.3 KWHr.	14.7 KWHr.
			28.0 KWHr.

Estimated cost of power .75¢ per KWHr.- Mr. Childs

Power cost per ton of coal handled = $\frac{28 \times 75}{55.5}$ = .35¢

Labor cost.

Wages	Chief helper	25¢ per hour	
	2 assistants	22.5¢ " "	(each)
	Total	70¢ " "	

Labor cost per ton of coal handled-

$$\frac{70 \times 3.25¢}{55.5} = 4.1¢$$

Total cost per ton of coal handled-

$$4.1¢ + .35¢ = 4.45¢$$

Test on car #------ Wt. of coal- 83400# = 41.7 Tons

Time required- 1 Hr. 11 Min.= 1.18 Hr.

Power cost.

		Crusher	Elevator
Meter readings-	Final	7083.0 KWHr.	5.4 KWHr.
	Initial	7075.5	0.0
		7.5 KWHr.	5.4 KWHr.
	Total		12.9 KWHr.

Power cost per ton of coal handled-

$$\frac{12.9 \times .75¢}{41.7} = .23¢$$

Labor cost.

Wages-	Chief helper	25¢ per hour
	Assistant	22.5¢ " "
	Total	47.5¢ " "

Labor cost per ton of coal handled-

$$\frac{47.5 \times 3.25¢}{41.7} = 1.35¢$$

Total cost per ton of coal handled-

$$1.35¢ + .23¢ = 1.57¢$$

COST OF FEEDING COAL TO FURNACES.

2 firemen required- 3 shifts of 8 hrs. per day

Estimating that 4/5 of the time spent in handling coal and 1/5 in handling ashes.

Labor cost.

Wages- Chief fireman 28.8¢ per hour

Second " 24.7¢ " "

Total 53.5¢ " "

Labor cost per ton of coal handled-

$$4/5 \times \frac{24 \times 53.5¢}{47.2} = 31.8¢$$

COST OF REMOVING ASHES.

Labor cost.

Per ton of ash handled- $1/5 \times \frac{24 \times 53.5¢}{8.36} = 30.7¢$

Power cost.

Meter readings- Final Suction fan 0012.0 KWHr.

Initial 0003.3

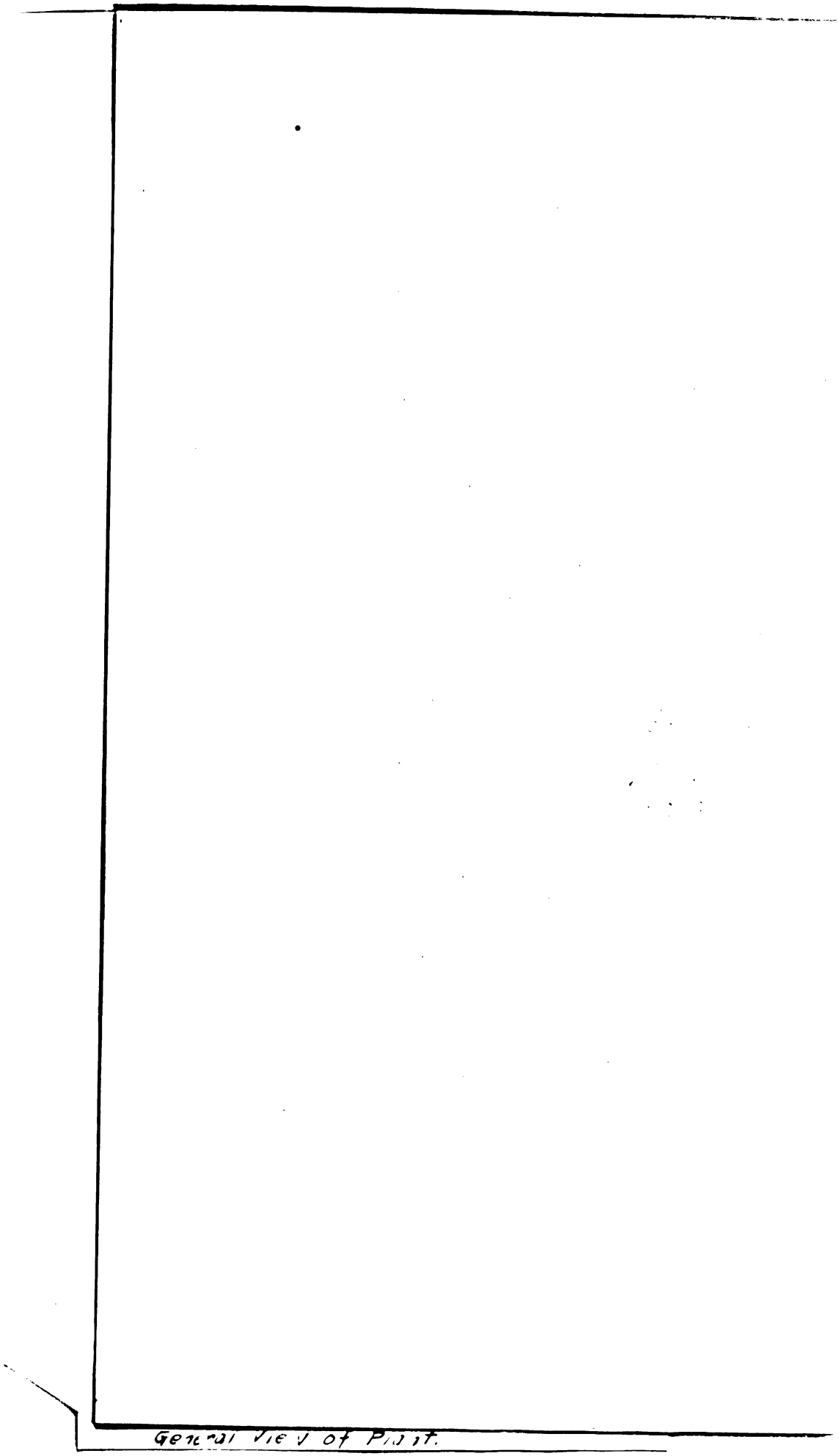
8.7 KWHr.

Per ton of ash handled- $\frac{8.7 \times .75¢}{8.36} = .73¢$

Total cost per ton of ash handled- 31.4¢

TABULATION OF COSTS- Per Ton.

Unloading cars	4.5¢
" "	1.6¢
Feeding furnaces	31.8¢
Removing ashes	31.4¢



General View of Plant.

City Light and Water Plant

COAL TICKET

Date_____191____

FIREMAN	A. M.	P. M.
	COAL LBS.	COAL LBS.

Unloading Coal.

General View of Plant

CONSUMERS POWER CO.,

Wealthy Avenue Station, Grand Rapids, Michigan.

APPARATUS:

Shaw electric traveling yard crane with single motor, clutch operated type trolley handling a two-cubic yard Brownhoist clamshell bucket.

Linkbelt, 18" four roller belt conveyor running above 8 storage bins, each with a down spout controlled by a simplex valve.

Weighing car.

8-600 H.P. Stirling boilers, equipped with Foster superheaters and Green chain grates.

Ash handling car.

GENERAL DESCRIPTION.

Coal is received at this plant over a spur from the main line of the Michigan Central Railroad, the cars being run directly beneath the crane runway. The coal is removed from the cars by means of the clamshell bucket and either dropped into the conveyor hopper or placed in storage. The services of a helper are required for cleaning up the car.

Coal from the conveyor hopper is carried by the belt and discharged into the storage bins by means of a movable tripper actuated by power from the belt.

From the storage bins, the coal is fed thru down spouts to the weighing car and after the weight is registered it is spread along the hopper arranged above the furnace. The correct weight of each car of coal is registered on a printed ticket which is punched by the movement of a lever on the scale weight.

The ashes drop from the grates into a sheet metal hopped from which they are allowed to drop into the ash car below by the operator. The ashes, while in the car, are soaked with water and then dumped into the ash pit outside the building, from which they are removed by the crane and dropped into an ash hopper at the opposite side of the runway. From here they are hauled away as desired.

The plant is coaled up ordinarily four times a day, at 7:30 and 10:30 A.M. and at 1:30 and 5:30 P.M.

The capacity of the storage in the yard under the crane is about 15000 tons.

The one objection noted to the system is that the speed of the bucket hoist is not sufficient for the speeds of the bridge and trolley. This necessitates a delay both in unloading cars and in filling the hopper.

RESULTS OF 24 HOUR TEST.

Date- 2:15 P.M., April 27 to 2:15 P.M., April 28.

Operating Conditions.

This plant is one of a number of steam and hydro-electric plants forming a chain about the state. Due to high water in the rivers and a consequent carrying of the load by the hydro-electric plants, this plant was running at about one-half normal capacity.

Data.

Total amount of coal fed to furnaces---- 72.03 Tons

Total amount of ashes removed---- 10.95 "

COST OF CONVEYING COAL TO BUNKERS AND REMOVING ASHES.

Power-

Meter reading,		Crane	Conveyor
	Final	00028 KWHr.	33819 KWHr.
	Initial	00000	33815
		28 KWHr.	4 KWHr.
	Total		32 KWHr.

Estimating the cost of power at .7¢ per KWHr.,

Power cost = 32 X .7¢ = 22.4¢ for 24 hours.

Estimating that 9/10 of the power was consumed in handling coal and 1/10 in handling ashes,

Cost per ton of coal handled= $9/10 \times \frac{22.4}{72.03} = .3¢$

Power cost per ton of ash removed= $1/10 \times \frac{22.4}{10.95} = .2¢$

Labor=

Wages= Crane Operator 30¢ per hour

Helpers 24¢ per hour

Ash passer= Day man 23¢ per hour

Night " 18.5¢ " "

Handling coal.

Estimating that the crane operator spent 9/10 of the time handling coal and 1/10 of the time handling ashes. Operator and helpers worked 10 hours per day.

Wage cost= Operator 9/10x10x30¢= 270¢

Helpers 2x 10 x 24¢= 480¢

Total 750¢

Cost per ton of coal handled= $\frac{750}{72.03}$ = 10.4¢

Handling ashes.

Wage cost= Operator 1/10x10x30¢ = 30¢

Ash passers 11x23¢= 242¢

13x18.5¢= 240¢

Total 512¢

Cost per ton of ash handled= $\frac{512}{10.95}$ = 46.5¢

Total cost of conveying coal to bunker and removing ashes.

	Coal	Ashes
Power	.3¢	.2¢
Labor	10.4¢	46.5¢
Total	10.7¢	46.7¢

COST OF FEEDING COAL TO FURNACES.

The exact wage rate of the firemen could not be obtained. We estimate it to be 22¢ per hour. There are two shifts; four men during a day of eleven hours, and three men during a night of thirteen hours.

Wages- Day shift $4 \times 11 \times 22¢ = 968¢$

Night " $3 \times 13 \times 22¢ = 858¢$

Total $1826¢$

Cost per ton of coal fed $= \frac{1826}{72.03} = 25.3¢$

COST OF UNLOADING CARS.

(1) Test on car #20393- Hocking Valley.
Weight of coal- 107800#= 53.9 Tons

Time required 40 minutes= 2/3 hours.

Power consumed 6.5 KWHr.

Power cost per Ton= $\frac{6.5 \times .7¢}{53.9} =$ .9¢

Labor cost per Ton= $2/3 \times \frac{(30 \div (2 \times 24))}{53.9} =$ .7¢

Total 1.6¢

(2) Test on car #15311 - C. I. & S.
Weight of coal- 97100#= 48.55 Tons

Time required 29 minutes= .48 hours

Power consumed 7 KWHr.

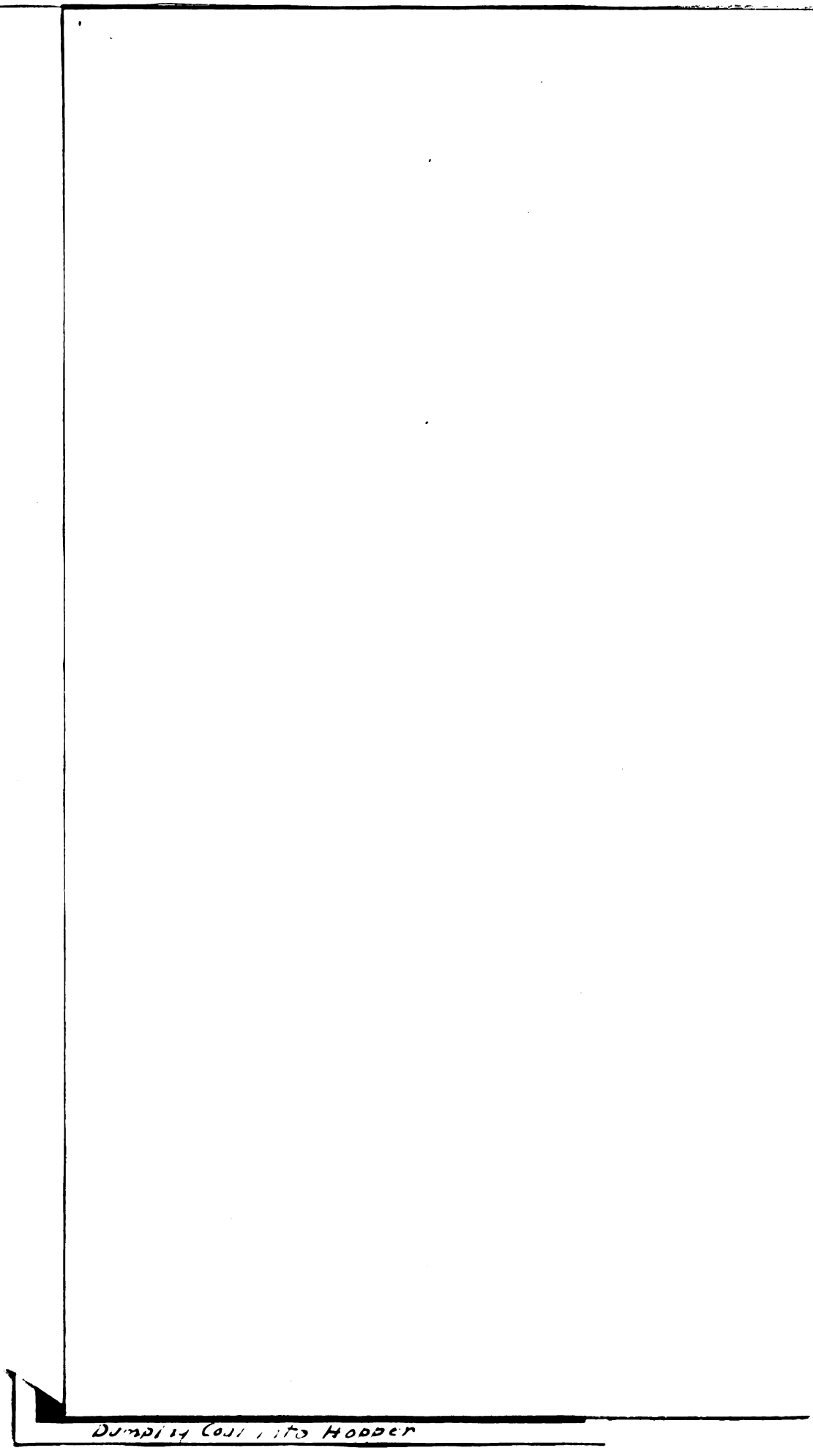
Power cost per Ton= $\frac{7 \times .7¢}{48.55} =$ .1¢

Labor cost per Ton= $.48 \times \frac{(30 \div (2 \times 24))}{48.55} =$ 1.1¢

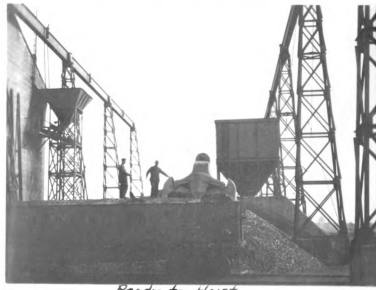
Total 1.2¢

TABULATION OF COSTS- Per Ton.

Unloading cars	1.2¢
" "	1.6¢
Filling bunkers	10.7¢
Feeding furnaces	25.3¢
Removing ashes	46.7¢


Dumping Coal into Hopper

General View of Plant.



Ready to Hoist.

Dumping Coal into Hopper

Michigan Central Roundhouse - Grand Rapids, Mich.

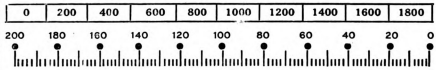
Michigan Power Co. Lansing, Mich.

Michigan Power Co. Lansing, Mich.

Bucket In Car.

Consumers Power Co. Grand Rapids, Mich.

THIS EDGE UP. PRINTED SIDE TOWARD BEAM.



Carrying Coal to Storage.

Ash Car

Dumping Ashes.

Engineer Crane Operator Belts Green.

M. A. C. PLANT East Lansing, Michigan.

GENERAL DESCRIPTION.

The College Power Plant is located on a spur of the Pere Marquette Railroad, this spur being joined to the main line at Trowbridge, where the Port Huron to Chicago division of the Grand Trunk Railroad crosses the Grand Rapids to Detroit division of the Pere Marquette. This affords convenient facilities for transporting coal to the plant.

This plant furnishes heat, light, and water for all buildings on the Campus. Both exhaust steam and live steam are used for heating purposes.

The boiler equipment includes; 4 Scotch Marine Boilers, 150 H.P. each; 1 -350 H.P. Freeman Combination Boiler; and 1 -150 H.P. Horizontal Tubular Boiler, all equipped with Jones underfeed stokers.

The coal is shoveled by hand from the cars to a storage shed, having a capacity of 1000 tons. When the shed is full, the remaining coal is shoveled into piles outside along the track wherever it is convenient.

An electrically driven elevator is located in the middle of the storage shed, on the side opposite the spur. It is driven by a 15 H.P. D. C. Motor, and has a capacity of 3000#.

The coal in the shed is shoveled by hand into a chute which empties into a 1-ton car standing on tracks on the elevator. Provision was made for using a crusher which would empty into the chute, but it has never been installed. When the car is filled with coal, it is raised by means of the elevator to the level of an overhead track, which extends from the elevator shaft to the storage hoppers at the top of the boiler room. The car is pushed by hand onto scales set in this track. After being weighed it is pushed to the hoppers and dumped. From the hoppers it drops by gravity thru down spouts to the stoker hoppers. After unloading the coal into the storage hoppers the car is pushed back to the elevator and lowered to the level of another track, located directly beneath the first track and parallel to it and extending thru the ash tunnel below the boiler room floor. Here the car is loaded with ashes which drop down from hoppers in front of the boilers. The car is then pushed back, elevated, weighed, and dumped into the ash hopper.

Coal from the outdoor piles is wheeled in barrows or wagons to a reclaiming hopper above the ash tunnel. It drops from here into the car below. One man is required to handle the cars of coal and ashes. At least two men are needed in the storage shed. These men work ten hours a day, seven days in the week.

The method of conducting the test was as follows; A watt-hour meter was calibrated and cut into the motor circuit. Readings at the end of each of two 24 hour periods were taken. Total weights of coal and ashes for the same 24 hour periods were obtained from the scale records.

RESULTS OF 24 HOUR TESTS.

Date- 5:00 P.M., April 19 to 5:00 P.M., April 21, 1916.

Data-

Totalaamount of coal fed to furnaces-

1st 24 hours	48840#
2nd 24 hours	41920#
	90760# = 45.4 tons

Total amount of ashes removed-

1st 24 hours	7900#
2nd 24 hours	6140#
	14040# = 7 tons

COST OF CONVEYING COAL TO BUNKERS AND REMOVING ASHES.

Power-

		Elevator
Meter reading,	Final	0274.9 KWHr
	Initial	0271.2
		3.7 KWHr.

Calibration of meter with shunt

Formula- $\frac{\text{meter watts x Rev. x 3600}}{\text{time in seconds}}$

10 revolutions of disk in 58 sec.

$\frac{10 \times 3600}{58}$ = 621 meter watts

Testing circuit was held at 200 volts and 25 amps.

200 x 25= 5000 true watts

Correction Factor = $\frac{5000}{621}$

$\frac{5000}{621}$ x 3.7 = 29.8 KWHr. used in 48 hours.

Approximate cost of current at time of test-

.75¢ per KWHr. -Mr. Newell

Power cost

39.8 x .75¢ = 22.4¢

Estimating that 4/5 of the power is consumed in handling coal and 1/5 in handling ashes.

Cost per ton of coal handled- $4/5 \times \frac{22.4}{45.4} = .4¢$

Cost per ton of ash handled- $1/5 \times \frac{22.4}{7} = .7¢$

Labor Cost.

Wages- Coal passer- Chief 35¢ per hour

Assistants 22.5¢ " "

Estimating that one assistant spent 8 hours per day handling coal and 2 hours handling ashes.

Wage cost- Chief $2 \times 10 \times 35¢ = 500¢$

1st Assistant $2 \times 10 \times 22.5¢ = 450¢$

2nd " $4/5 \times 2 \times 10 \times 22.5¢ = \frac{360¢}{1310¢}$

Cost per ton of coal handled- $\frac{1310¢}{45.4} = 28.8¢$

Cost per ton of ash handled-

$$\frac{1/5 \times 2 \times 10 \times 22.5¢}{7} = 13¢$$

COST OF FEEDING FURNACES.

Wage- Firemen 35¢ per hour

Estimating that 4/5 of the time is spent in handling coal and 1/5 in handling ashes.

Cost per ton of coal fed- $\frac{4/5 \times 2 \times 24 \times 35¢}{45.4} = 21.2¢$

Cost per ton of ash removed $\frac{1/5 \times 2 \times 24 \times 35¢}{7} = 34.2¢$

COST OF REMOVING ASHES.

Power and labor	-coal passers	.7¢
		13.0¢
	Firemen	34.2¢
	Total	47.9¢

TABULATION OF COSTS- Per Ton

Conveying coal to bunkers	13.4¢
FEeding coal to furnace	21.2¢
Removing ashes	47.9¢

COST OF UNLOADING CARS.

Data obtained from Mr. Newell

Result of test made April 14, 1906

282.3 tons of coal unloaded at cost of 9.74¢ per ton

Coal taken from car and carried to back of shed

Average cost from car to shed 7¢ - 7½¢ per ton

Average cost from cars to ground to storage-

25¢ - 30¢ per ton

Average cost from car to shed- handling frozen coal

25¢ - 30¢ per ton

This latter figure is usually taken as the cost of handling the coal during the months of December, January and February.

General View of Plant.

Ash Hopper and Elevator

Coal Storage Shed