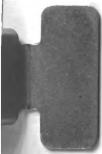




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INVESTIGATION AND PLANS FOR REMODELING
THE POWER PLANT

AT

ALMA COLLEGE

THESIS

SUBMITTED FOR THE DEGREE OF
BACHELOR OF SCIENCE

By

H.E. Aldrich.

L.P. Dendel.

MICHIGAN AGRICULTURAL COLLEGE

June 1914.

THESIS

1.
East Lansing, Michigan.

June 1, 1914.

The Board of Directors of Alma College,
Alma, Michigan.

Gentlemen:-

We have the honor of submitting herewith to you a detailed report of our investigation of the present power plant at Alma College, together with proposed plans to remodel the plant with the view of making it a central heat, water, and lighting station for the college.

Our first step in the investigation was to obtain from the Secretary, Prof. A. P. Cook the amount paid out per year for electric light and water. Working from this as a basis, we have proposed to save the college a considerable sum of money, by installing a steam generating set, the exhaust from which passes into the heating system. Thus the electricity could be generated and the water could be pumped at a very low cost and both electricity and water bills could be eliminated. Again, the college at present is inefficiently lighted, and in the advent of cheap current, the lighting could be brought up to standard at less expense than with the present system.

By repairing the heating system we have also proposed to effect a saving of at least 25% in the coal bills.

The total saving alone, we think, aside from the aesthetic improvement to the college would be enough to warrant the feasibility of the proposition.

Very respectfully yours,

H. E. Aldrich.
L. P. Dendel.

PRESENT CONDITIONS AT ALMA COLLEGE.

The present plant consists of four 35 H.P. Harvey low pressure, return tubular boilers. These boilers supply steam at 10 $\frac{1}{2}$ pressure for heating purposes only, and supply all buildings, except the museum which is not heated. The condensation drains back into two closed tanks, buried behind the boilers, and together with a small amount of make-up water is forced into the boilers by the means of traps.

It was found that it took 10-15 $\frac{1}{2}$ pressure to operate the traps and that 5 $\frac{1}{2}$ would be sufficient to operate the heating system if it were not for operating the traps. So when the fireman found the water getting low in the boilers, he would fire up until sufficient steam pressure was obtained to operate the traps and again fill the boilers. This at a glance is seen to be a very wasteful method as it does not allow the keeping of an even fire, and the fire alternately dies down and is forced up.

The pipes carrying the steam and condensation are encased in hollow logs, wrapped with iron bands. These logs have become rotten and water soaked and serve as a very poor heat insulator, a large part of the heat lost being expended in evaporating the water absorbed by the casing. The loss is so great that in the winter time, the heat escaping thru the ground, keeps the snow melted for a space of about 10 feet wide along the ground above the pipes. To have estimated this loss, conservatively, at 55%.

The present cost of light and power at the college is 9.14 per K.W.-hr. amounting to about \$260.00 per year. All

of the buildings however are inefficiently lighted, 25 watt tungstens and 50 watt carbons being used. Single phase alternating current is supplied from one of the city plants at 1100 volts, and by means of two 10-1 transformers is reduced to 110 volts at the lamps. One transformer supplies Wright Hall and is located near the East entrance to that building. The other transformer is located directly north of the Administration Building and Library. The Museum is wired but not connected to the current supply. At best it may be said that the service rendered is very unsatisfactory, the voltage at the lamps varying considerably, usually being so low as to make the filaments burn red instead of white.

The water bill at the college amounts to about \$250 per year. As the city water is not drinkable, two double cylinder, double acting water motors of the Vail and Kines type have been installed to furnish water for cooking and drinking purposes. One of these is installed in Wright Hall and supplies water from a well to a pressure tank which in turn supplies water to the kitchen and a drinking fountain on each floor. The other water motor is in the basement of Pioneer Hall and supplies drinking fountains in Pioneer Hall and the Administration Building. This is easily seen to be a very inefficient system as a water motor wastes about half as much as it pumps. City water is used for bathrooms, sprinkling, etc.

GENERAL DATA

Kind of coal	1 lump.
Cost of coal /ton delivered	\$ 3.15.
Coal used per year	900 tons.
Day man, 12 months @ \$60/mo.	\$ 720.00.
Night man, 3 months(winter) @ \$40/mo.	\$ 120.00.
Cost of electricity per K.W.-hr.(10% off) ..	9¢.
Number of resident students	225.
City lighting circuit ...2.phase, 133cycles, 1100 V.	
Average depth of pipe line	4 feet.
Water used per year	4,500,000 gala.
Water bill	\$ 250.00.
Light bill	\$ 800.00.
Harvey Boilers	4 - 12' x 42" shell, 54-3" tubes.
Cost of gravel	\$1-1.30/cu.yd.
Valuation of present plant	\$ 6000.00.

LIGHTING AND POWER LOAD

These figures represent the maximum possible load figuring 40 watts per socket.

	SOCKETS	MOTORS	WATTS
Pioneer Hall	100		4,000
Administration Building	125	4-16" fans	5,750
Wright Hall	300	2-H.P.	13,500
Library	50		2,000
Gymnasium	50		2,000
Museum	30		<u>1,200</u>
Total			28,450

PROPOSED INSTALLATION

It is proposed to install a high pressure boiler, in place of one of the low pressure ones in use at present, and a direct-connected steam driven, single phase alternator to furnish current for lighting and power, the exhaust steam from the engine passing into the heating system. The process of expanding through the engine would take about 150 British Thermal Units out of the steam or about 15% of the available heat, the remaining 85% being given up to the heating system. At the same time the high pressure boiler could also be connected to the heating system by means of a reducing valve and that regulated so the boiler could always be operating at full capacity and hence at its highest efficiency. The high pressure steam would also be extremely valuable for cleaning the flues of the other boilers, as low pressure steam is very unsatisfactory for this purpose.

The lighting load of the college is of a very peculiar nature. The load comes on from three to six o'clock in the afternoon and lasts until about eleven or twelve, but practically all of the load is on during this time. From the data as shown above we have estimated a generator of 25 K.V.A. capacity to be of ample size.

As there are practically no lights on after twelve o'clock except the hall lights, we propose to switch over onto the city line at that time and cut out the generating unit until the load begins to come on again the next afternoon.

The city line would also be used during the summer as it would be inadvisable to keep the boiler and generating unit in operation for the small and occasional load. By using the city line for reserve, it is not necessary to install a reserve boiler. It is planned to generate the current at 440 volts and by means of two transformers, one at Wright Hall and one at the plant, reduce the voltage to 110 at the lamps. By using No. 5 wire the greatest allowable drop in voltage is $2\frac{1}{2}\%$. The current furnished by the city will be reduced to 440 volts at the plant and then pass through the aforementioned transformers to the lamps.

In remodeling the water system, we intend to cut off all the city water and use well water for everything. The two water motors will be replaced by larger automatic electric motor pumps of sufficient size to furnish water for all purposes. A compression tank will also have to be supplied to be used in connection with the pump under Pioneer Hall.

Our first step to increase the efficiency of the heating system is to do away with the traps. We have planned to install a boiler feed pump of such size as to take care of supplying water to all four boilers. By dispensing with the traps, an even fire may be kept and a lower pressure used on the mains, which of course reduces the back pressure on the engine.

The boilers are in fairly good condition but the pipe line must be re-covered with heat insulating material.

We propose to support the pipe line on rollers, 30 ft. apart, in a large square cement conduit with 4" walls. The details of the same are shown in the blueprints. The pipe itself is to be covered with a diatomaceous material, a substance which is an excellent insulator of heat. Provision will also be made for the extending the pipe line over to the museum.

The present power plant building will be used for the boilers, but an addition will be built on the east side of the main building at the south-east corner. This addition will be large enough to accomodate two generating units. Only one, however, will be provided for the present; but it was thought advisable to allow space for two, as the college intends to acquire such new buildings in the next ten years, as to require a duplicate unit. At that time, another low pressure boiler will have to be replaced by a high pressure boiler. The stack was found to be in excellent condition and had a strong draft. Owing to the quick sand the stack was placed on piles and the building and boilers on a timber crib.

INSTALLATION COSTS OF CONDUIT

Conduit costs are based upon the following prices of materials.

Natural cement per bbl.....	.75
Sand and gravel per cu.yd.	1.25
Crushed stone per cu.yd.	.60
Drain tile, 3", per M ft.	15.00
Wood covering per M ft.....	50.00
Excavations per cu.yd.	.40
Mixing and handling cement per cu.yd.	1.25
Setting forms per cu.yd.	.50
Diatomaceous covering for pipes	
8" per ft.	.44
4" " " 	.25
3" " " 	.18
2½" " " 	.16
2" " " 	.14
Rollers and anchors each	.50
Concrete of the proportion 1, 2, and 5	

Wright Hall Conduit.

Concrete, including mixing, handling and placing

47 cu.yds. @ \$4.00/cu.yd.	188.00
Excavating 210 cu.yds. @ 40¢	84.00
Wood covering, 945 ft. @ \$50/M	47.25
Distomaceous material, 8", 630 ft. @ 44¢	277.00
Drain Tile, 630 ft. @ \$15/M	9.50
Crushed stone, including handling and placing, 630	
ft. @ 6¢	38.00
Labor @ 15¢/ft.	<u>95.00</u>
Total cost of conduit	\$ 738.75

Library Conduit.

Concrete, including mixing, handling and placing

14.2 cu.yds. @ \$ 4.00/cu.yd.	56.80
Excavating 76.0 cu.yds. @ 40¢	30.40
Wood covering, 344 ft. @ \$50/M	17.20
Distomaceous covering 4", 230 ft. @ 25¢	56.00
" " 3", " " @ 18¢	41.40
Drain tile, 230 ft. @ \$15/M	3.44
Crushed stone, including handling & placing, 230 @ 6¢	13.80
Labor for tile, wood and pipe covering @ 15¢/ft..	<u>34.50</u>
Total cost of conduit	\$ 253.54

Administration Building Conduit

Concrete, including mixing, handling and placing	
4 cu.yds. @ \$4.00/cu.yd.	16.00
Excavating, 22 cu.yds. @ 40¢	8.80
Wood covering 97.5 ft. @ \$50/M	4.83
Diatomaceous covering, 4", 65 ft @ 25¢	14.25
" " 2", 65 ft.@ 14¢	9.10
Drain tile, 65 ft. @ \$15/M	.90
Crushed stone, including handling and placing, 65' @ 3.00	3.00
Labor @ 15¢/ft.	<u>9.75</u>
Total cost of conduit	\$ 37.68

Pioneer Hall Conduit

Concrete, including mixing, handling and placing	
7.1 cu.yds. @ \$4.00/cu.yd.....	28.40
Excavating, 38 cu.yds. @ 40¢	15.20
Wood covering, 172ft. @ \$50/M	8.60
Diatomaceous covering, 2 1/2", 115 ft. @ 16¢	18.45
" " 2" , 115 ft. @ 14¢	16.10
Crushed stone, including handling and placing 115' @ 6.00	6.90
Drain tile, 115 ft. @ \$15/M	1.70
Labor @ 15¢/ft.	<u>17.25</u>
Total cost of conduit	\$ 112.62

Administration Bldg to Gymnasium Conduit	
Concrete, Including mixing, handling and placing	
1.5 cu.yds. @ \$4.00/cu.yd.	\$ 6.00
Excavating, 23 cu.yds. @ 40¢	9.20
Wood covering 40 ft. @ \$60/M	2.40
Diatomaceous material, 4", 65 ft. @ 25¢	14.25
Drain tile 65 ft. @ \$15/M	.90
Crushed stone, including handling and placing 65' @ 6¢ .	3.90
Labor @ 15¢/ft.	<u>5.75</u>
Total cost of conduit	\$ 46.13

COST OF PLANT AND CURRENT

Generating set, exciter, and transformers	\$ 1551.00
Boiler	406.00
Feed pump	175.00
Tank	25.00
Motor water pumps - 2	563.50
Injector	25.00
Switchboard	150.00
Piping and other mechanical equipment	580.00
Building	500.00
Conduits	1218.70
Wire and wiring	<u>60.00</u>
Total cost	\$ 5344.00
Engineering fees 10%	<u>534.40</u>
Total first cost	\$ 5878.40

FIXED CHARGES ON WHOLE PLANT

Depreciation @ 5%	\$ 505.00
Taxes @ 1½%	172.50
Insurance @ ½%	50.50
Interest @ 5%	<u>505.00</u>
Total	\$ 1433.00

OPERATING CHARGES ON WHOLE PLANT

Coal @ \$3.10/ton	\$ 2092.50
Labor	1000.00
Oil, waste, etc.	<u>50.00</u>
Total	\$ 3222.50

Total cost of operating plant per year	\$ 4650.00
City lighting bill	<u>200.00</u>
Total cost of light, heat and water per year	\$ 4850.00

COST PER YEAR OF PRESENT SYSTEM

Fixed charges on old plant valued at \$6000.00	
Depreciation @ 5%	\$ 300.00
Taxes $1\frac{1}{2}\%$	90.00
Insurance $\frac{1}{2}\%$	30.00
Interest 5%	<u>300.00</u>
Total	\$ 720.00

OPERATING CHARGES - OLD PLANT

Coal @ \$3.10 per ton - 900 tons	\$ 2790.00
Labor	<u>840.00</u>
Total	\$ 3630.00

FIXED CHARGES AND TOTAL COST

Fixed charges	\$ 720.00
Operating charges	3630.00
Light bill	800.00
Water bill	<u>250.00</u>
Total cost per year at present	\$ 5400.00
Cost under new installation	<u>4850.00</u>
Amount saved per year	\$ 550.00

SPECIFICATIONS

GENERATOR:

440 Volts, 27 K.V.A. Single Phase Alternator with 22 poles, direct connected, guaranteed efficiency at full load 89.8%; at $\frac{1}{2}$ load 89.5%; at $\frac{1}{4}$ load 87.5%, speed 327 R.P.M.

ENGINE:

Medium speed automatic steam engine, 10" x 8", and approximate weight connected 6800 pounds.

BOILER:

45 H.P. Return Tubular Boiler, 100# working pressure, shell 48" x 12', built in strict accordance with the Hartford Steam Boiler Insurance Company's specifications, complete with full front; stack saddles; grates; rear arch bars; rear ash door and frame; pop-safety valve and nipples; water column and end connection with three gauge cocks, steam gauge, and syphon, blow off valve, feed valve, and check valve.

PUMPS:

2 - pumps driven by $2\frac{1}{2}$ H.P. Motors, single phase motors to be mounted on the frame of same, 60 cycle, for automatic control apparatus, 3 x 4 Duplex Power Pump, capacity of pump to be 36 gal/min or 2160 gals/hr, Automatic control to be regulated by pressure, self starter with magnetic blow outs and relay.

FEED PUMP:

$8\frac{1}{2}$ x $5\frac{1}{2}$ x 10 pump, full brass fitted, capacity 4000 G.P.H.

EXCITER:

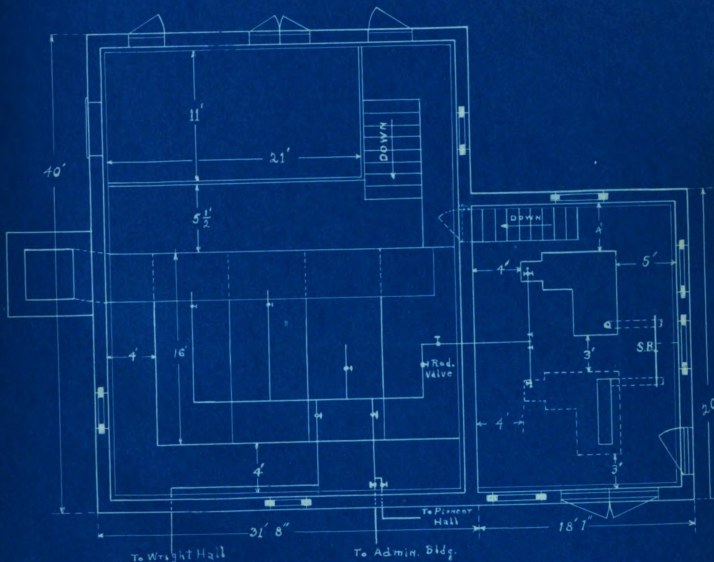
3 K.W., 1300 R.P.M., with field rheostat for both generator and exciter.

CONDUIT:

To be made as shown by blue prints.

TRANSFORMERS:

1 - 15 K.W. 440 volt-110 volt step down transformer, suitable for lighting load; 1 - 10 K.W. 440 volt-110 volt step down transformer, suitable for lighting load.



To Wright Hall

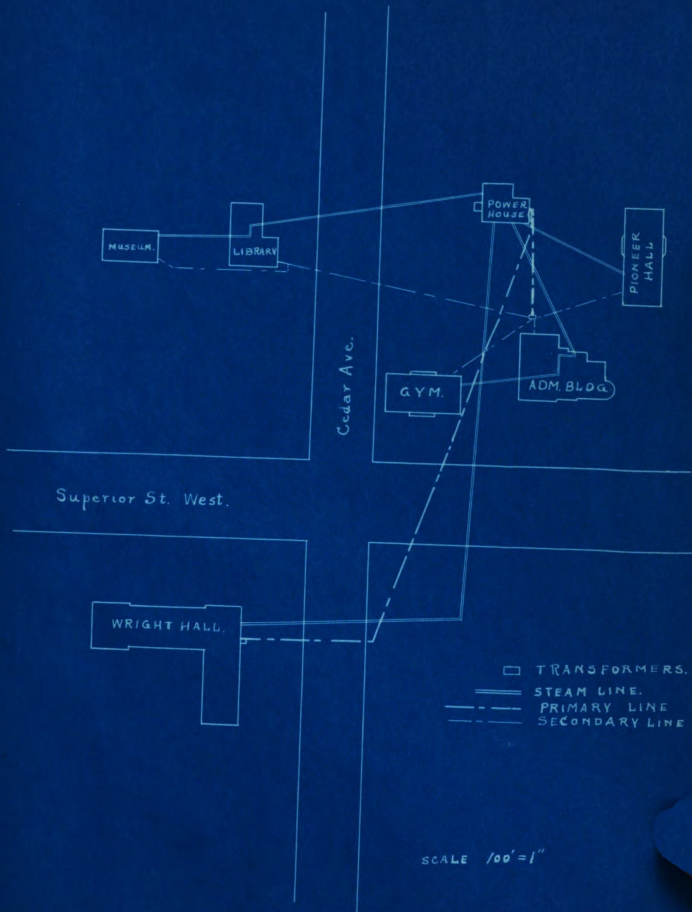
To Admin. Bldg.

To Pioneer Hall

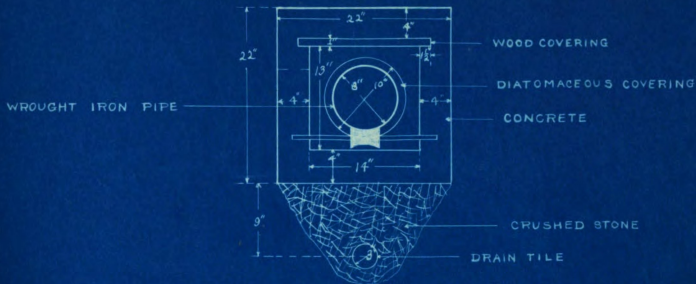
MAIN BUILDING REPRESENTS PRESENT PLANT
RIGHT WING SHOWS PROPOSED ADDITION

SCALE $\frac{1}{8}$ INCH = 1 FT.

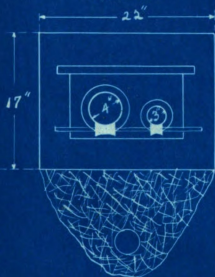
L.P.D. 5/15/14



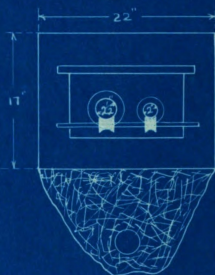
NO 1.



NO 2



NO 3.



NO 4



PIPE SUPPORTS AND ROLLERS TO
BE PLACED AT 20 FT. INTERVALS

- NO 1 WRIGHT HALL CONDUIT
NO 2 ADM. BLDG. AND LIBRARY
NO 3 PIONEER HALL CONDUIT
NO 4 GYMNASIUM CONDUIT

CONCLUSION

We would recommend that the college put in the proposed service at once, not only for the saving of \$530 per year but for the better service that would be possible. A still greater saving would appear if we did not take into consideration the depreciation as is often done under such conditions. It is very evident that the college is losing a great deal of money at present in their heat distribution so that detail cannot be elicited. Since our estimates are very conservative, you will find the savings much greater than herein stated.

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