REVIEW AND TEST OF THE NAPERVILLE, ILLINOIS, ELECTRIC LIGHT PLANT

BY

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Thomas Peebles
Alfred Nicholas Sommer

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE
IN MECHANICAL ENGINEERING

IN THE
COLLEGE OF ENGINEERING
OF THE
UNIVERSITY OF ILLINOIS
PRESENTED JUNE, 1906

UNIVERSITY OF ILLINOIS

June 1, 1906

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

CHARLES HOWARD BENT ALFRED NICHOLAS SOMMER
THOMAS PEEBLES

ENTITLED REVIEW AND TEST OF THE NAPERVILLE, ILLINOIS,

ELECTRIC LIGHT PLANT

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Mechanical Engineering

L. P. Breckenridge.

HEAD OF DEPARTMENT OF Mechanical Engineering

NAPERVILLE ILLINOIS ELECTRIC LIGHT PLANT.

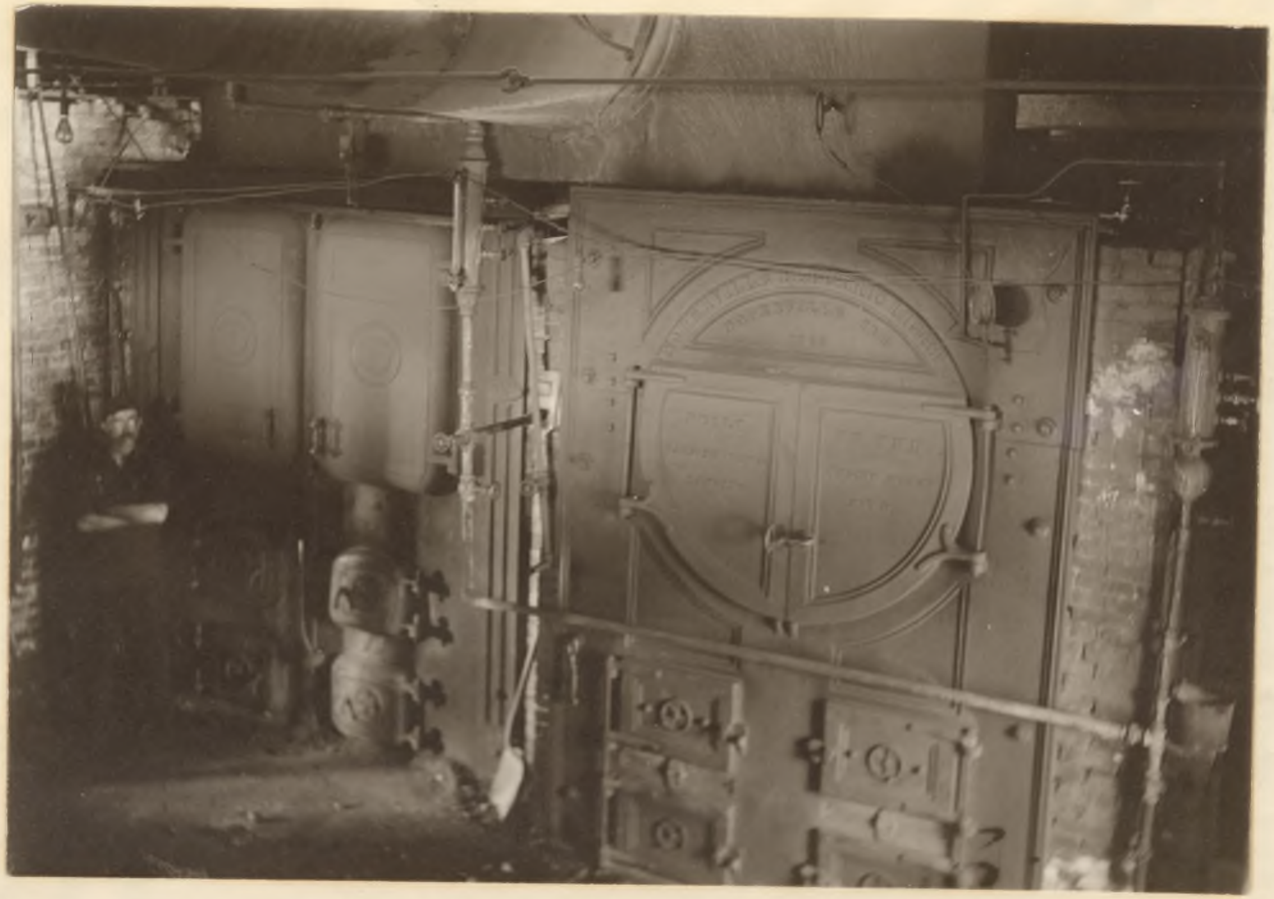
REVIEW AND TEST OF THE NAPERVILLE ILLINOIS ELECTRIC LIGHT PLANT.

LOCATION:-

Naperville, Illinois, is a town of about three thousand inhabitants, situated on the Chicago, Burlington and Quincy railroad, twenty-eight miles southwest of Chicago. The plant is owned and operated by the city and is in the southwest part of the business district on the DuPage River. It furnishes electric light for (the) street and residence lighting, and pumps the water for the city water works system. A siding from the railroad furnishes an easy means for conveying fuel to the plant.

DESCRIPTION OF PLANT:-

The plant was built in 1888 and consisted of one (1) seventy-five horse power New York Safety Fire Tube Boiler, one (1) one hundred horse power Lansing Automatic Cut off Engine, and two (2) Warren Generators. In 1900 a one hundred horse power New York Safety Fire Tube Boiler, a two hundred and ninety horse power Bates Cross Compound Corliss Engine, a one hundred Kilowatt Warren Generator ~~and~~ a condenser were added. In 1905 the water works system was installed and an addition built to the plant to hold the extra equipment. This addition contained a double acting Ingersoll Sargeant Air Compressor and a Compound Duplex Snow Pump. The plant has a floor area of about 6286 square feet and about one third of this total is used for the boiler room. The level of boiler room



BOILER ROOM NAPERVILLE, ILLINOIS, ELECTRIC LIGHT PLANT.

floor is about a foot lower than the engine room floor. The feed water pumps and condenser are in a pit in the engine room the level of which is four feet below the engine room floor.

DESCRIPTION OF EQUIPMENT:-

The present equipment of the plant is as follows:-

Boiler Room:-

1 75 H.P. New York Safety Boiler.

Type, Horizontal Tubular.

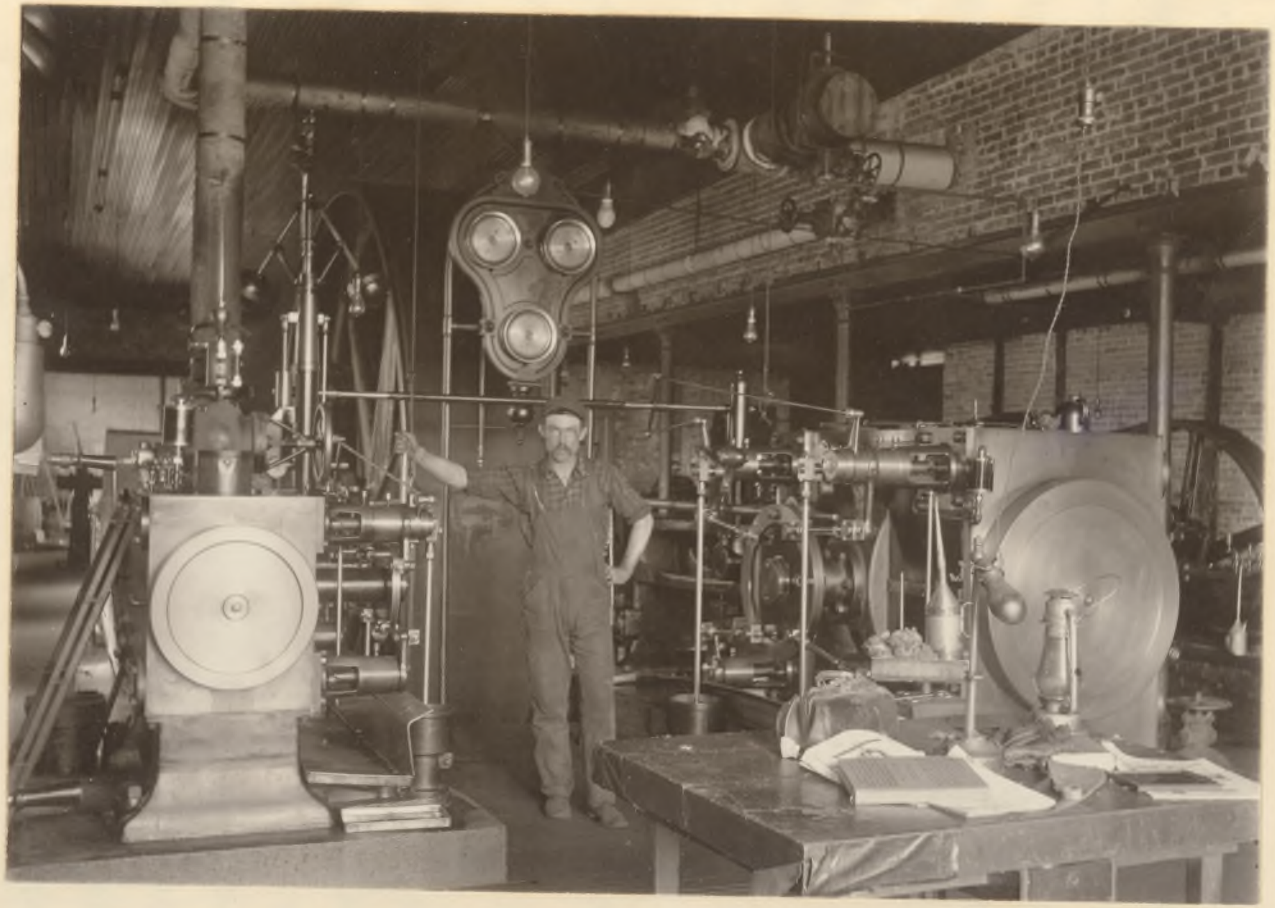
Outside dia. of shell	54 inches.
Length	16 feet.
Number of flues	36
Inside diameter	4 inches.

1 100 H.P. New York Safety Boiler.

Type, Horizontal Tubular.

Outside dia. of shell	60 inches.
Length	16 feet.
Number of flues	60
Inside diameter	3-1/2 inches.

Both boilers are fitted with plain grates and are supplied with natural draft by a chimney eighty-five feet high and forty-two inches in diameter. They were designed for a pressure of one hundred and twenty pounds but the inspectors have set the safety valve at one hundred and five pounds. The safety valves opened three times during our test at exactly one hundred and five pounds. The average working pressure being from ninety to one hundred

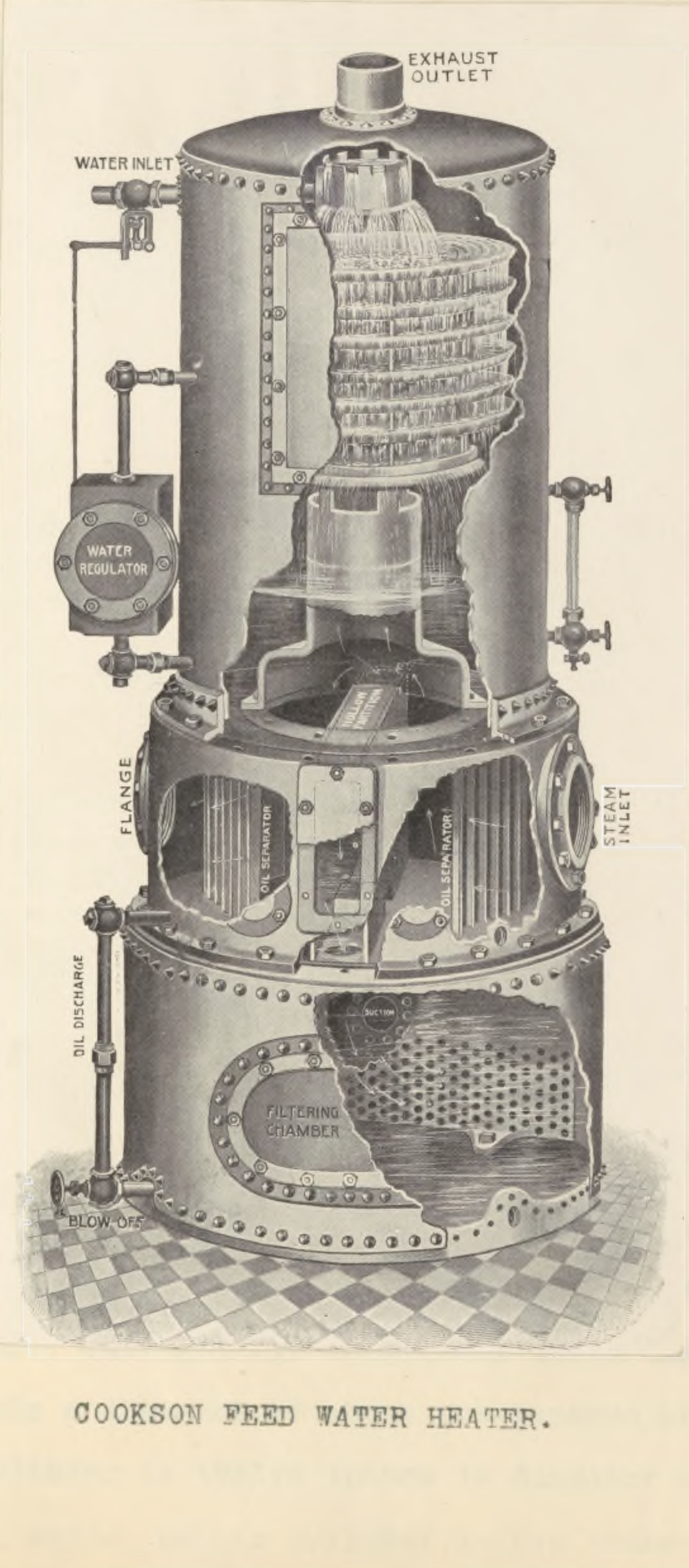


ENGINE ROOM, NAPERVILLE, ILLINOIS, ELECTRIC LIGHT PLANT.

pounds. The safety valves are seldom released. The gage glasses are at the upper right hand corner of each boiler and they were tested every little while to see that they were working properly. The average height of water in gage glasses was about three inches. The steam is carried into the engine room by a six inch main and the calorimeter was in the main above boiler number two. The flue gas was taken from the stack leading from the boilers to chimney by means of suction and analyzed in the boiler room. The draft was measured by means of a water gage placed in door at base of chimney. All readings were taken every twenty minutes. The boiler pressure gage (Crosby) was above the door leading from engine room to boiler room. The flue gas temperatures were taken from special thermometer placed in stack leading from boilers to chimney.

ENGINE ROOM:-

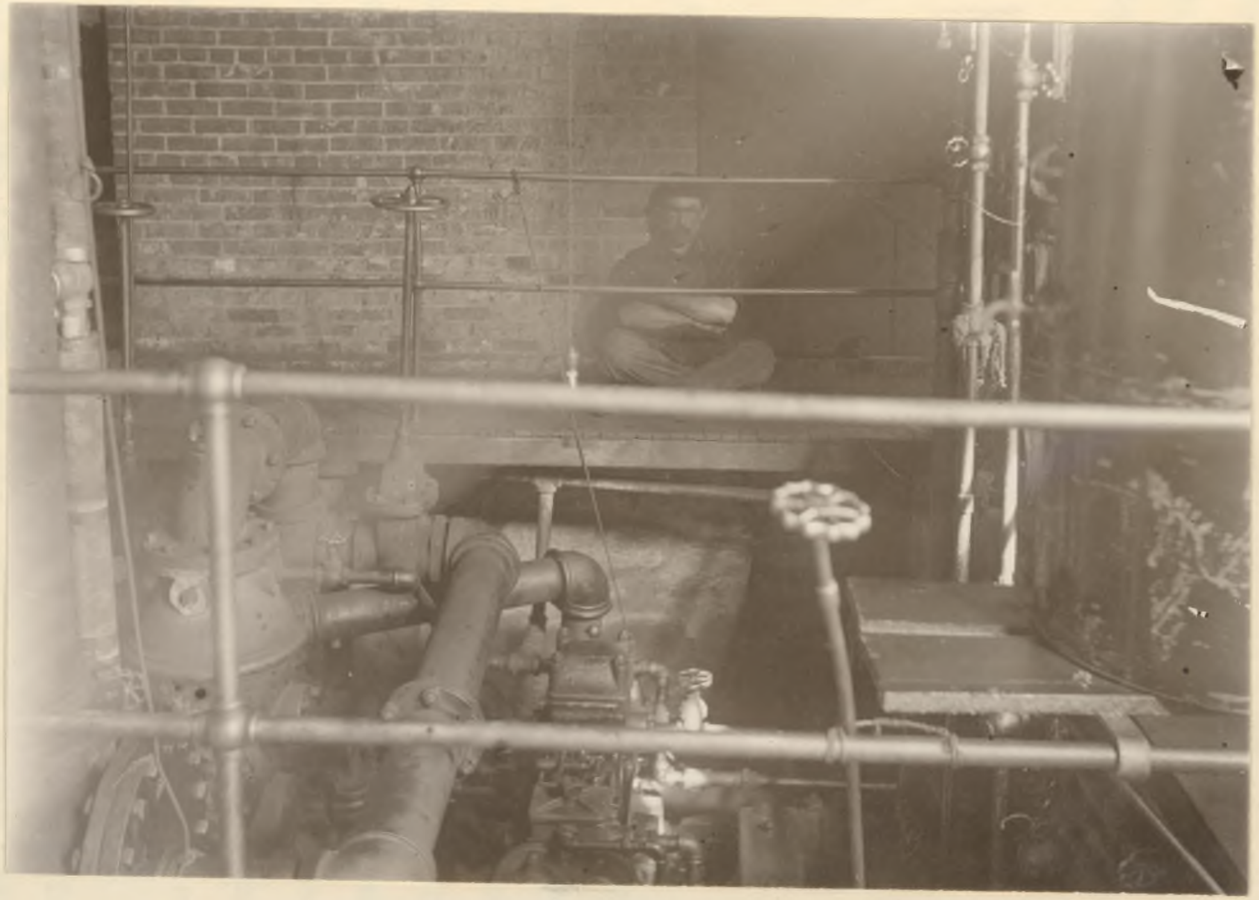
One Cross Compound Bates Corliss Engine rated at two hundred and ninety horse power. This power is developed when engine is taking steam at ninety pounds, cutting off at one sixth stroke, exhausting against a condenser pressure of three pounds. The fly-wheel which is eighteen feet in diameter carries a belt which drives a jack shaft. A hundred kilowatt Warren Induction Generator is driven by a belt from this jack shaft. One Lansing Automatic Cut off Tandem Engine. This engine makes two hundred and forty revolutions per minute and develops one hundred and twenty horse power when working between a boiler pressure of ninety pounds and condenser pressure of three pounds. This engine has two fly-wheels, each of which is belted to a generator.



COOKSON FEED WATER HEATER.

A Wheeler jet condenser is used in connection with the Bates and Lansing engines. Water is pumped from the DuPage River a distance of about one hundred feet and is discharged again into the river through a discharge pipe (b) Fig. 2. The pipe (c) leads from the discharge pipe to the hot well. An automatic valve allows enough water to enter (c) to keep the hot well full. Water is drawn from hot-well by pump (d) and dumped into a one hundred and twenty-five horse power Cookson Feedwater Heater which uses the exhaust from three pumps. The water is heated to about one hundred and eighty degrees Fahrenheit and runs by gravity into the pump (f) which supplies the boilers. By an auxiliary system of piping any one of the three pumps may be used to feed the boilers in case of accident. It was found necessary to use this auxiliary system during one of the tests, due to the stopping of the main pump by using too much boiler compound. The dotted lines Fig. 2. show the method of weighing feed water. A calibrated tank was placed at (g) and the water was discharged from there to tank (h) from whence it was pumped to the boilers. Two and one half inch pipes were used for connecting feed water heater, pumps and boilers. The level of tank (h) and the feed water pump were about the same, so the pump did not have to lift the hot water.

A six inch steam pipe carries steam from the main to the pump and air compressor which supply the city water. A single stage Ingersoll Sergeant Air Compressor lifts the water to a surface reservoir a distance of about one hundred and fifty feet. The steam cylinder is twelve inches in diameter and fourteen inches long, while the air cylinder is ten inches in diameter and



PIT SHOWING FEED WATER PUMPS.

fourteen inches long. The compressor has two fly-wheels and runs about one hundred revolutions per minute. A Compound Duplex Snow Pump forces the water to a stand pipe one hundred and sixty-five feet high. The pump has tandem steam cylinders and a single water cylinder. They are of the following dimensions:

High Pressure Steam	12	inches	diameter.
Low " "	18	"	"
Water Cylinder	12	"	"
Stroke	18	"	

ORDINARY CONDITIONS OF OPERATION:-

The plant is run by two men, one being in charge in the day time and the other at night. The day man starts work at about eight thirty in the morning and after seeing that the engines and pumps are in good shape he puts in most of his time on the line. At five o'clock he gets up steam pressure and by six o'clock he has the Corliss Engine running. About seven o'clock the night man reports and keeps the Corliss Engine running until the load becomes light when he starts the high speed engine, after shutting the Corliss down. This is usually about ten o'clock. After midnight practically the only load is that of the street lamps so he runs the pump and air compressor until both the standpipe and reservoir are full of water. This usually takes about three hours. As the pump consumes a great amount of steam these are usually the busiest hours. By five o'clock the engines are shut down and the fires banked for the day. The hours may vary somewhat according to the season and weather conditions.

OBJECT OF TEST:-

The object of this test was to determine primarily the grade of coal which gave the best results, that is, the coal which evaporated one thousand pounds of water at the lowest cost. This side of the test was given the most attention as it seemed that the greatest possibility of economy lay in the boiler room. Secondarily,- To note the performance of the engines. No attempt had ever been made before this to get at the evaporative value of the coal under the boilers. Usually the buyer just bought the particular coal which he did because the dealer happened to have that kind for sale or it was easily obtainable. We decided to make tests on the three following kinds of coal which the city supplied us with especially for these tests. The latter of these is what they usually use.

Streator Slack	at	$1.90 per ton.
Indiana Mine Run	at	2.55 per ton.
Carterville 1-1/2" (Screenings.)	at	2.25 per ton.

The prices include ten cents per ton for unloading into boiler room. Our test of forty-eight hours was run on each the Streator Slack and Carterville Screenings and a twenty four hour test on the Indiana Mine Run.

PERSONNEL:-

These tests were run by Thomas Peebles, Alfred Sommer and Howard Bent. The engineer, Mr. Ricker, who is a very practical man, aided us materially in getting ready for the tests and was very much interested in our results. The fireman, N. A. Murray, assisted us in taking our data, as he worked while our tests were in progress. The city furnished us with coal and all necessary piping for these tests. The University of Illinois loaned us all other necessary apparatus.

DISCUSSION OF RESULTS:-

Table II shows the results of the tests, the Carterville Screenings giving the best results. Besides being the most economical coal it burns very evenly and forms less clinker than Streator Slack. This is important because one man operates the whole plant and can not give much time to cleaning the fires. Instead of firing a small amount and doing it often, it is necessary for him to fire a large amount whenever he has time. Under these conditions Carterville Screenings give the better results.

Both the above coals are considerably more economical than Indiana Mine Run. It does not burn better than Carterville Screenings and on account of its greater cost, per thousand pounds of water evaporated, would not be considered an economical and satisfactory fuel for this plant.

KIND OF COAL.	COST PER TON.	COST OF EVAPORATING 1000# WATER FROM AND AT 212 DEGREES.
Carterville Screenings	$2.25	$.161
Streator Slack	1.90	.166
Indiana Mine Run	2.55	.184

RESULTS OF BOILER TRIALS

Made at Naperville, Illinois, Electric Light Plant.

Dimensions and Proportions.

Kind of Boilers.

#1 & #2 New York Safety Boilers.

Kind of Furnace.

Tupper straight bar.

Method of Starting and Stopping Tests.

Alternate.

Type of Boilers.

Horizontal Tubular.

	Boiler #1.	Boiler #2.
Grate area. Sq. ft.	18.83	21.70
Width of grate, ft.	4.34	5.00
Length of grate, ft.	4.34	4.34
Height of furnace, inches.	18.00	18.00
Width of air space in grate, inches	1/4	1/4
Length of flue to chimney, ft.	18.00	2.00
Water heating surface, sq. ft.	712.00	1000.00
Outside diameter of shell, inches	54.00	60.00
Length of shell, ft.	16.00	16.00
Number of tubes,	36.00	60.00
Diameter of tubes, (inside) inches	4.00	3.50
Length of tubes, ft.	16.00	16.00
Superheating surface,	0.00	0.00
Ratio of water heating surface) to grate surface)	38.08	46.50

Ratio of minimum draft area to grate surface 1- - - - - -	4.19
Height of chimney above grate, ft.	81.00
Area of chimney, sq. ft.	9.50
Kind of draft,-	Natural.

Date of Trial. June 20-21-22, 1905.

Engine running June 20 from 7. p. m. to 4. a. m., June 21, and from 7. p. m. June 21 to 4. a. m. June 22, 1905.

Fires banked between 4. a. m. and 7. p. m. June 21st.

Average Pressures.

Steam pressure by gauge, lbs.	94.20
Force of draft, inches of water.	.50

Average Temperatures.

Of fire room, degrees,	93.00
Of steam, degrees	333.80
Of feed water entering boiler, degrees	165.00
Of escaping gases from boiler, degrees,	563.00

Fuel.

Weight of coal as fired, lbs.	10375.00
Percentage of moisture in coal,	4.65
Total weight of dry coal consumed, lbs.	9893.00
Total ash and refuse in dry coal, per cent,	10.10
Total ash and refuse, lbs.	999.00

Total combustible consumed, lbs.	8894.00

Kind of Coal: Carterville, Ill., Screenings.

Proximate Analysis of Coal.

Fixed Carbon, per cent.	52.71
Volatile matter, per cent	35.00
Moisture, per cent	4.65
Ash	7.64
Total...........	100.00
Sulphur, separately determined%	.65

Fuel per Hour.

Dry coal, lbs.	550.00
Combustible consumed, lbs.	494.00
Dry coal per sq. ft. of grate area, lbs.	13.70
Combustible, per sq. ft. of water (heating surface, lbs.	.305

Calorific Value of Fuel.

Of dry coal, per lb.	B.T.U.	12,250
Of combustible, per lb.	B.T.U.	13,650

Quality of Steam.

Percentage of moisture, per cent	.72
Quality of steam, " "	99.28

Water.

Total weight fed to boilers, lbs.	61290.00

Actually evaporated,	60849.00
Factor of evaporation,	10851.00
Equivalent water evaporated into dry steam (from and at 212 degrees,	66027.00

Water per Hour.

Evaporated (corrected for quality) lbs.	3380.50
Equivalent evaporation from and at 212 degrees, lbs.	3612.30
Equivalent evaporation from water at 212 degrees per sq. ft. of water heating surface.	2.11

Horse Power.

Horse power developed,	104.70
Builder's rated horse power,	175.00
Percentage of rated horse power developed,	59.80

Economic Results.

Water apparently evaporated under actual conditions (per lbs. of coal as fired.	5.91
Equivalent evaporation per lb. of coal as fired,	6.267
Equivalent evaporation per lb. of dry coal	6.57
Equivalent evaporation per lb. of combustible,	7.31

Cost of Evaporation.

Cost of coal per ton in boiler room	$2.25
Cost of fuel for evaporating 1000lbs. of water	.19
Cost of fuel for evaporating 1000 lbs. of water (from and at 212 degrees----	.161

Analysis of Dry Gases.

Carbon dioxide (CO_2) per cent	3.96
Oxygen (O) per cent	14.48
Carbon monexide (CO) per cent	.46
Efficiency of Boiler, per cent	51.70

T E S T NO. II.

Date of Trial.

June 28, 29 and 30, 1905. Engine running 28th from 7. p. m. to 4. a. m. June 29th, and from 7. p. m. June 29th to 3.40 a. m. June 30th. Fires banked between 4. a. m. and 7. p. m. June 29th.

Average Pressures.

Steam pressure by gauge, lbs.	92.10
Force by draft, inches of water	.52

Average Temperatures.

Fire room, degrees,	94.50
Steam, degrees	321.70
Feed water entering boiler, degrees	176.00
Escaping gases from boiler, degrees	576.00

Fuel.

Kind of coal, Streator Slack.

Weight of coal as fired, lbs.	11958.00
Moisture in coal, per cent	6.86
Total weight of dry coal consumed, lbs.	11138.00
Total ash and refuse, lbs.	1972.00
Total combustibel consumed, lbs.	9166.00
Ash and refuse in dry coal, per cent	17.70

Proximate Analysis of Coal.

Fixed Carbon, per cent	49.72
Volatile matter, per cent	32.44
Moisture, per cent	6.86
Ash, per cent	11.18
Total, per cent........	100.00
Sulphur, separately determined %	3.08

Fuel per Hour.

Dry coal, lbs.	631.00
Combustible consumed, lbs.	556.00
Dry coal per sq. ft. of grate area, lbs.	15.70
Combustible consumed per sq. ft. of water heating (surface, lbs.	.325

Calorific Value of Fuel.

Of dry coal per lb. B.T.U.	11410.00
Of combustible per lb.B.T.U.	13910.00

Quality of Steam.

Moisture in steam, per cent	.82
Quality of steam, per cent	99.18

Water.

Total weight fed to boilers, lbs.	62883.00
Actually evaporated, lbs.	62367.00
Factor of evaporation	1073.00

Equivalent water evaporated into dry steam from

(Water, Cont'd.)

--- and at 212 degrees, lbs.	66920.00

Water per Hour.

Evaporated (corrected for quality) lbs.	3535.00
Equivalent evaporation from and at 212 degrees, lbs.	3805.00
Equivalent evaporation from and at 212 degrees per (sq. ft. of water heating surface, lbs.	2.12

Horse Power.

Horse power developed	105.20
Builder's rated H.P.	175.00
Percentage of rated H.P. developed,	60.00

Economic Results.

Water apparently evaporated under actual conditions (per lb. of coal as fired---	5.26
Equivalent evaporation per lb. of coal as fired.	5.62
Equivalent evaporation per lb. of dry coal	6.03
Equivalent evaporation per lb. of combustible	6.84

Cost of evaporation.

Cost of coal per ton in boiler room,	$1.90
Cost of fuel for evaporating 1000# of water	.186
Cost of fuel for evaporating 1000# of water (from and at 212 degrees,	.166

Analysis of Dry Gases.

Carbon dioxide (CO_2) per cent	4.32
Oxygen (O) " "	11.54
Carbon monoxide (CO) " "	.34
Efficiency of Boiler, per cent	47.41

T E S T, NO. III.

Date of Trial.

July 5th and 6th, 1905. Engine running July 5th from 7. p.m. to 4. a. m. July 6th, 1905.

Fires banked from 4. a. m. July 6th to 7. p. m. July 6th, '05.

Average Pressures.

Steam pressure by gauge, lbs.	94.00
Force of draft, inches of water,	.50

Average Temperatures.

Fire room, degrees	92.00
Steam, degrees	333.70
Feed water entering boiler, degrees	181.00
Escaping gases from boiler,	574.00

Fuel.

Weight of coal as fired, lbs.	5405.00
Moisture in coal, per cent	3.10
Total weight of dry coal consumed, lbs.	5237.00
Total ash and refuse, lbs.	523.00
Total combustible consumed, lbs.	4714.00
Ash and refuse in dry coal, per cent	9.99

Kind of coal,-

Indiana Mine Run.

Proximate Analysis of Coal.

Fixed carbon, per cent	55.3
Volatile matter, per cent	35.21
Moisture, per cent	3.10
Ash, per cent	6.39
Total, per cent........	100.00
Sulphur, separately determined %	.72

Fuel per Hour.

Dry coal, lbs.	581.90
Combustible consumed, lbs.	523.80
Dry coal per sq. ft. of grate area, lbs.	14.47
Combustible per sq. ft. of water heating surface, lbs.	.306

Calorific Value of Fuel.

Of dry coal per lb. B.T.U.	12627.00
Of combustible, per lb, B.T.U.	13900.00

Quality of steam.

Moisture in steam, per cent,	.66
Quality of steam, per cent	99.34

Water.

Total weight fed to boilers, lbs.	31236.00
Actually evaporated, lbs.	31030.00
Factor of evaportaion,	1066.00
Equivalent water evaporated into dry steam from and at 212 degrees, lbs.	33078.00

Water per Hour.

Evaporated, (corrected for quality) lbs.	3447.00
Equivalent evaporation from and at 212 degrees, lbs.	3675.00
Equivalent evaporation from and at 212 degrees per (sq. ft. water heating surface, lbs.	2.15

Horse Power.

Horse power developed,	106.50
Builder's rated horse power	175.00
Percentage of rated horse power developed,	60.70

Economic Results.

Water apparently evaporated under actual conditions (per lb. of coal as fired.	5.78
Equivalent evaporation per lb. of coal as fired	6.12
Equivalent evaporation per lb. of dry coal	6.31
Equivalent evaporation per lb. of combustible	7.02

Cost of Evaporation.

Cost of coal in boiler room,	$2.55
Cost of fuel for evaporating 1000 lbs. of water,	.222
Cost of fuel for evaporating 1000 lbs. of water (from and at 212 degrees.	.184

Analysis of dry Gases.

Carbon dioxide (CO_2) per cent	4.00
Oxygen (O) per cent	13.27
Carbon monoxide (CO) per cent	.21
Efficiency of Boiler, per cent	50.20

PERFORMANCE OF THE CORLISS ENGINE:-

This engine is rated at 290 H.P. when making 72 R.P.M. and taking steam at 90# gauge pressure. As it is never called upon to develop within 60 H.P. of its rated capacity it manifestly can not give its best performance under the conditions existing at the Naperville plant. A glance at any card shows that the engine is too large for the work it has to perform.

The indicated H.P. runs all the way from 150 to 235 and on only one card did it reach the latter figure; the average power for the total time during which cards were taken being 169 indicated H.P.

DISCUSSION OF CARDS:-

Cards No's. 1, 2, 3 and 4, while they are not average cards of the first day's run, still are representative ones, in that they show about the relative amount of work done in both ends of the high and low pressure cylinders. They also give an indication of how the load varied during the evening; the cards taken at 8.40 p. m. showing the maximum load carried and the one shown from 10.10 shows how much the load had decreased. Cards No's. 5, 6, 7 and 8 show a more equal division of work done in two ends of the high pressure cylinder due to a resetting of the valves. They were taken on the following day. It was evident from the cards taken on the first day that the crank end of the high pressure cylinder was not doing its share of the work, so its admission was set for a little later in the stroke with a later cut-off. The improvement is evident from the table. Cards Nos. 9, 10, 11 and 12 may again be called representative cards of the trial of June 28th, 1905. Here the cut-off had been changed from 1/6 of the previous trial to 1/7. With this setting of the valves the steam is given more chance to expand in the high pressure cylinder. This naturally cut down the percentage of the total work done in the low pressure cylinder and increased that done in the high pressure cylinder somewhat.

This was a more economical arrangement. During the first day's trial the engine was not running much better than a simple condensing engine, with the steam just flowing through the low pressure cylinder and doing most of the work in the high pressure cylinder.

With so much variation in the load, and at that never running at full load, we found it impossible to get a very satisfactory adjustment of the valves. However, from the table it is seen that the water rate was slightly improved.

TABLE I.

SAMPLE RESULTS OF ENGINE TEST.

No. Card	Time Date	Length	Area	End	M.E.P.	H.P.	Total H.P.
	6:20,05						
1	8.40	3.7	1.05	Crank	31.2	93.	
2	"	3.6	.49	Head	4.1	23.6	
1	"	3.7	1.12	Head	33.4	104.	
2	"	3.6	.39	Crank	3.25	19.5	236.1
	6:20,05						
3	10.10	3.7	.60	Crank	17.9	54.	
4	"	3.6	.38	Head	3.16	18.2	
3	"	3.7	.88	Head	26.2	82.	
4	"	3.6	.36	Crank	3.	17.9	172.1
	6:21,05.						
5	9.20	3.7	.90	Head	26.8	78.	
6	"	3.6	.38	Crank	3.16	18.2	
5	"	3.7	.88	Crank	26.2	82.1	
6	"	3.6	.41	Head	3.4	20.8	198.1
	6:28,05						
9	8.10	3.7	.90	Crank	26.7	80.5	
10	"	3.6	.43	Crank	3.6	20.5	
9	"	3.7	1.00	Head	29.7	91.	
10	"	3.6	.43	Head	3.6	21.	213.
	6:21,05						
7	9.50	3.7	.75	Crank	22.3	67.	
8	"	3.6	'29	Crank	2.42	13.9	
7	"	3.7	.78	Head	23.2	72.7	
8	"	3.6	.32	Head	2.67	16.	169.6
	6:28,05						
11	8.50	3.6	1.13	Head	33.5	100.	
12	"	3.6	.42	Head	3.5	20.	
11	"	3.6	.89	Crank	26.4	80.3	
12	"	3.6	.41	Crank	3.4	19.6	209.9

10-04-3M-S

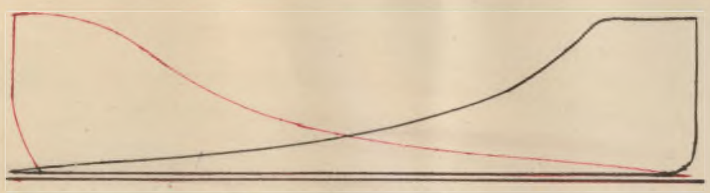
Engine Corliss
Cylinder High
End
Scale 110

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING DEPARTMENT
Diagram taken at Naperville E. L. Plant

Date 6/20, 05
Time 8:40
R. P. M. 71
Observer

Lyne 1½-inch Drum

CRANK HEAD



#1

10-04-3M-S

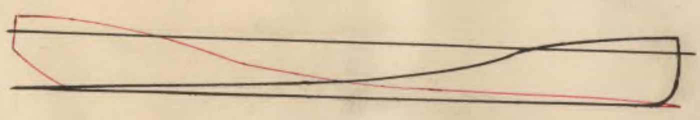
Engine Corliss
Cylinder Low. P.
End
Scale 30#

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING DEPARTMENT
Diagram taken at Naperville E. L. Plant

Date 6/20, 05
Time 8:40
R. P. M. 71
Observer

Lyne 1½-inch Drum

CRANK HEAD



#2

10-04-3M-S

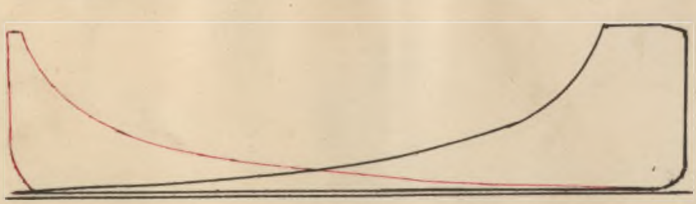
Engine Corliss
Cylinder High
End
Scale 110#

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING DEPARTMENT
Diagram taken at NAPERVILLE E. L. Plant

Date 6/20, '05
Time 10:10
R. P. M. 71
Observer

Lyne 1½-inch Drum

CRANK HEAD



#3

10-04-3M-5

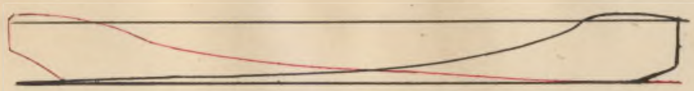
Engine Corliss
Cylinder Low
End
Scale 30#

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING DEPARTMENT
Diagram taken at
Naperville E. L. Plant

Date 6-20-05
Time 10:10
R. P. M. 71
Observer

Lyne 1½-inch Drum

CRANK HEAD



\# 4

10-04-3M-5

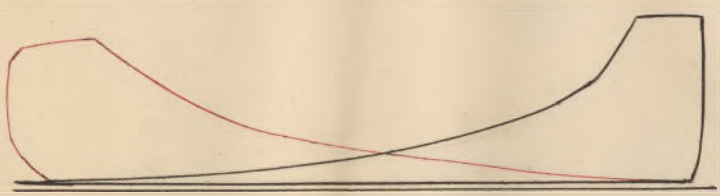
Engine Corliss
Cylinder High. P.
End
Scale 110

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING DEPARTMENT
Diagram taken at
Naperville E.L Plant

Date 6-21-05
Time 9:20
R. P. M. 72
Observer

Lyne 1½-inch Drum

CRANK HEAD



\# 5

10-04-3M-5

Engine Corliss
Cylinder Low
End
Scale 30#

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING DEPARTMENT
Diagram taken at
Naperville E.L. Plant

Date 6-21-05
Time 9:20
R. P. M. 72
Observer C.H.B.

Lyne 1½-inch Drum

CRANK HEAD

\# 6

10-04-3M-5

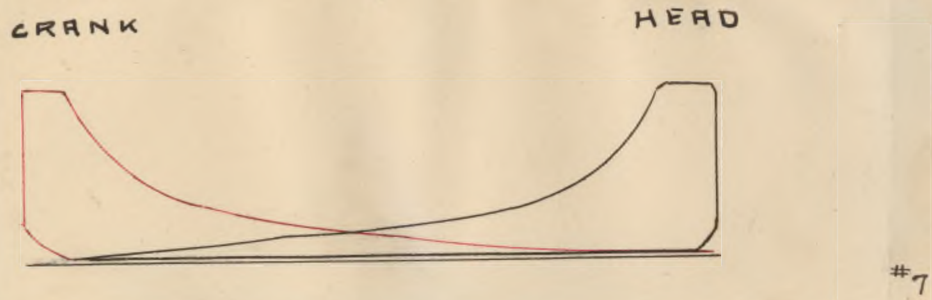
UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING DEPARTMENT

Engine Corliss
Cylinder High
End
Scale 110

Diagram taken at Naperville Plant

Date 6/21/05
Time 9.50
R. P. M. 72
Observer C.H.B.

Lyne 1½-inch Drum



10-04-3M-5

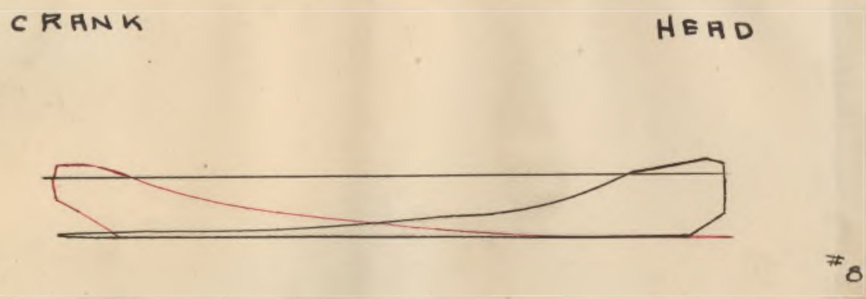
UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING DEPARTMENT

Engine Corliss
Cylinder Low. P.
End
Scale 30#

Diagram taken at NAPERVILLE E.L. Plant

Date 6/21/05
Time 9.50
R. P. M. 72
Observer C.H.B.

Lyne 1½-inch Drum



10-04-3M-5

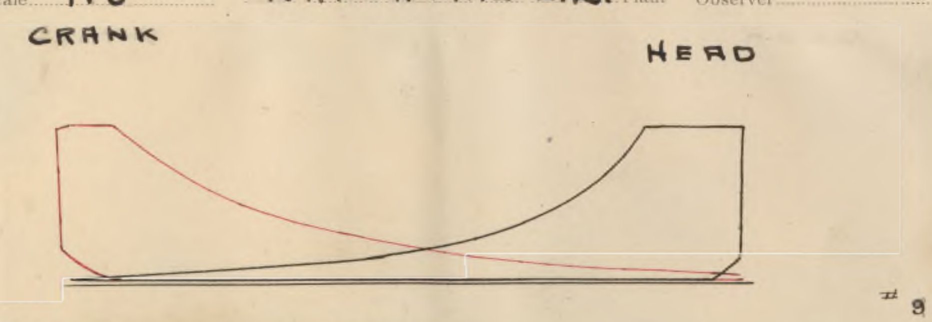
UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING DEPARTMENT

Engine Corliss
Cylinder High
End
Scale 110

Diagram taken at NAPERVILLE E.L. Plant

Date 6-28-05
Time 8.10
R. P. M. 72
Observer

Lyne 1½-inch Drum



10-04-3M-S

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING DEPARTMENT

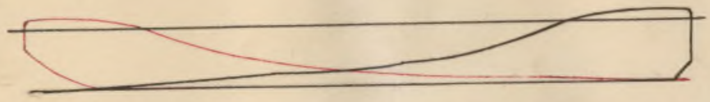
Engine Corliss
Cylinder Low
End
Scale 30#

Diagram taken at
Naperville E L Plant

Date 6-28-05
Time 8.10
R. P. M. 72
Observer

CRANK HEAD

Lyne 1½-inch Drum



10

10-04-3M-S

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING DEPARTMENT

Engine Corliss
Cylinder High
End
Scale 110

Diagram taken at
Naperville E. L. Plant

Date 6-28-05
Time 8.50
R. P. M. 72
Observer

CRANK HEAD

Lyne 1½-inch Drum

11

10-04-3M-S

UNIVERSITY OF ILLINOIS
MECHANICAL ENGINEERING DEPARTMENT

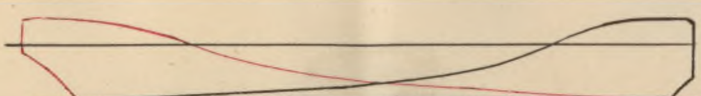
Engine CORLISS
Cylinder LOW
End
Scale 30#

Diagram taken at
Naperrille E. L Plant

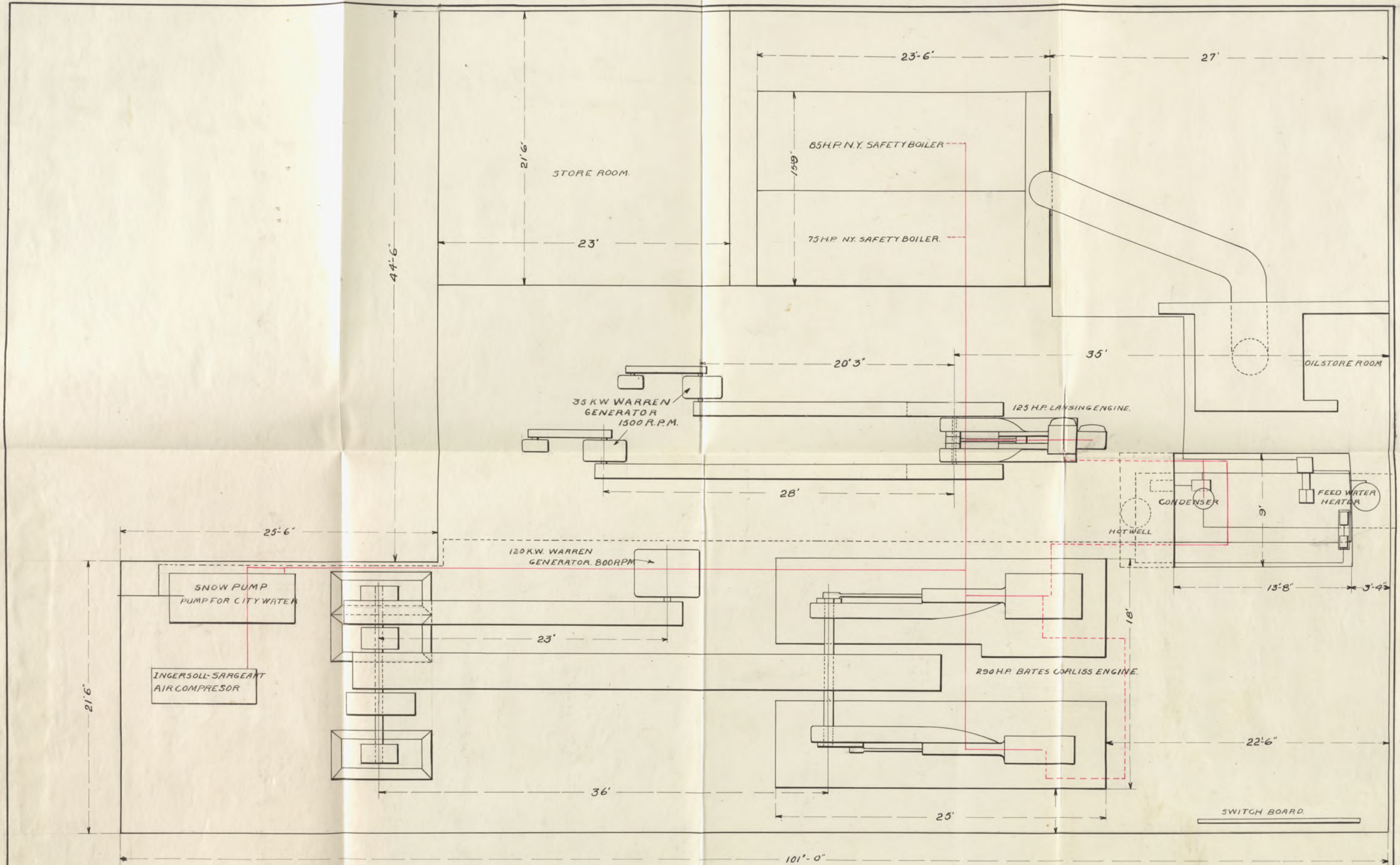
Date 6-28-05
Time 9:50
R. P. M. 72
Observer

CRANK HEAD

Lyne 1½-inch Drum



12



GROUND PLAN OF THE NAPERVILLE ILLINOIS ELECTRIC LIGHT PLANT

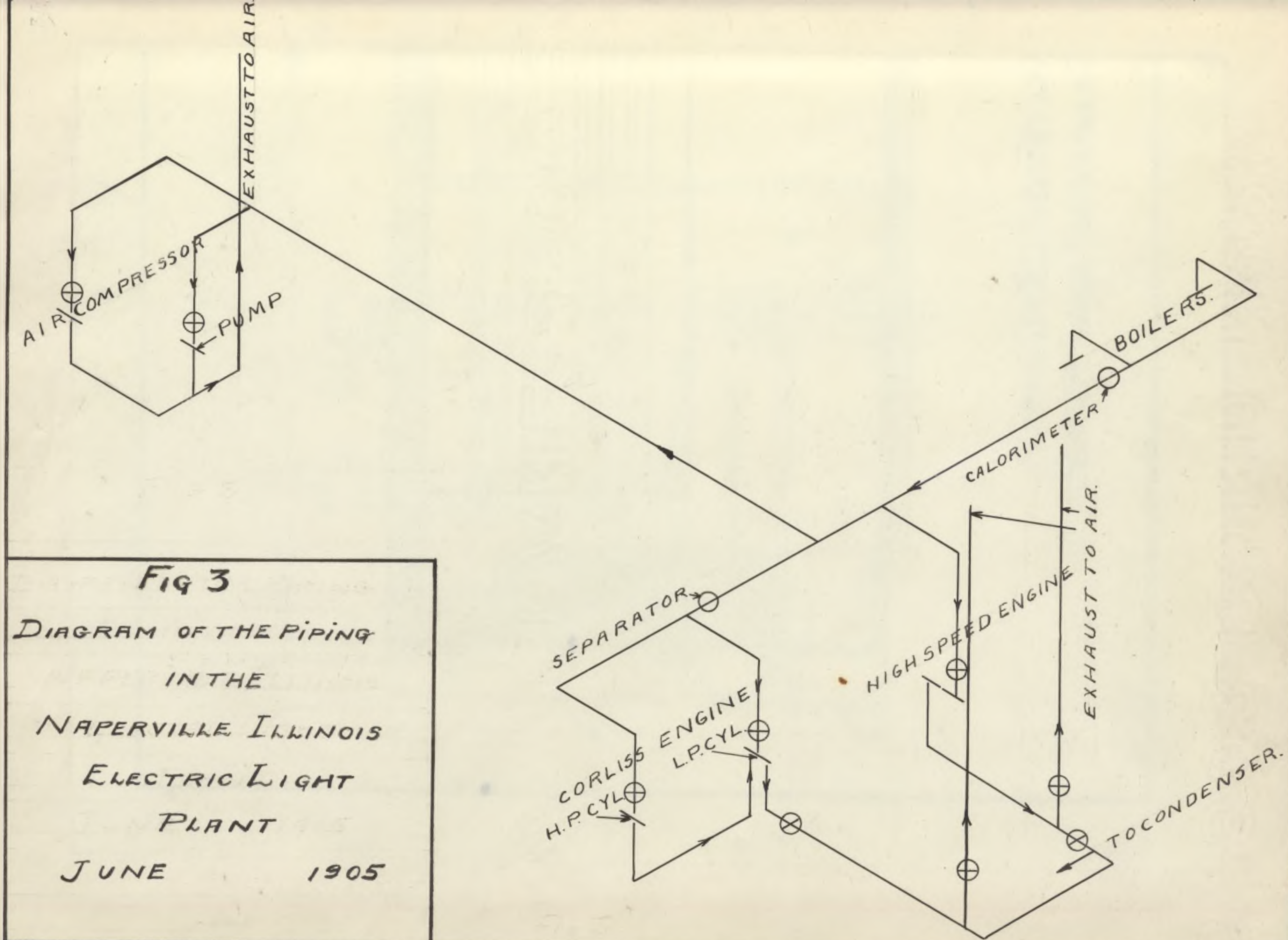


FIG 3

DIAGRAM OF THE PIPING
IN THE
NAPERVILLE ILLINOIS
ELECTRIC LIGHT
PLANT
JUNE 1905

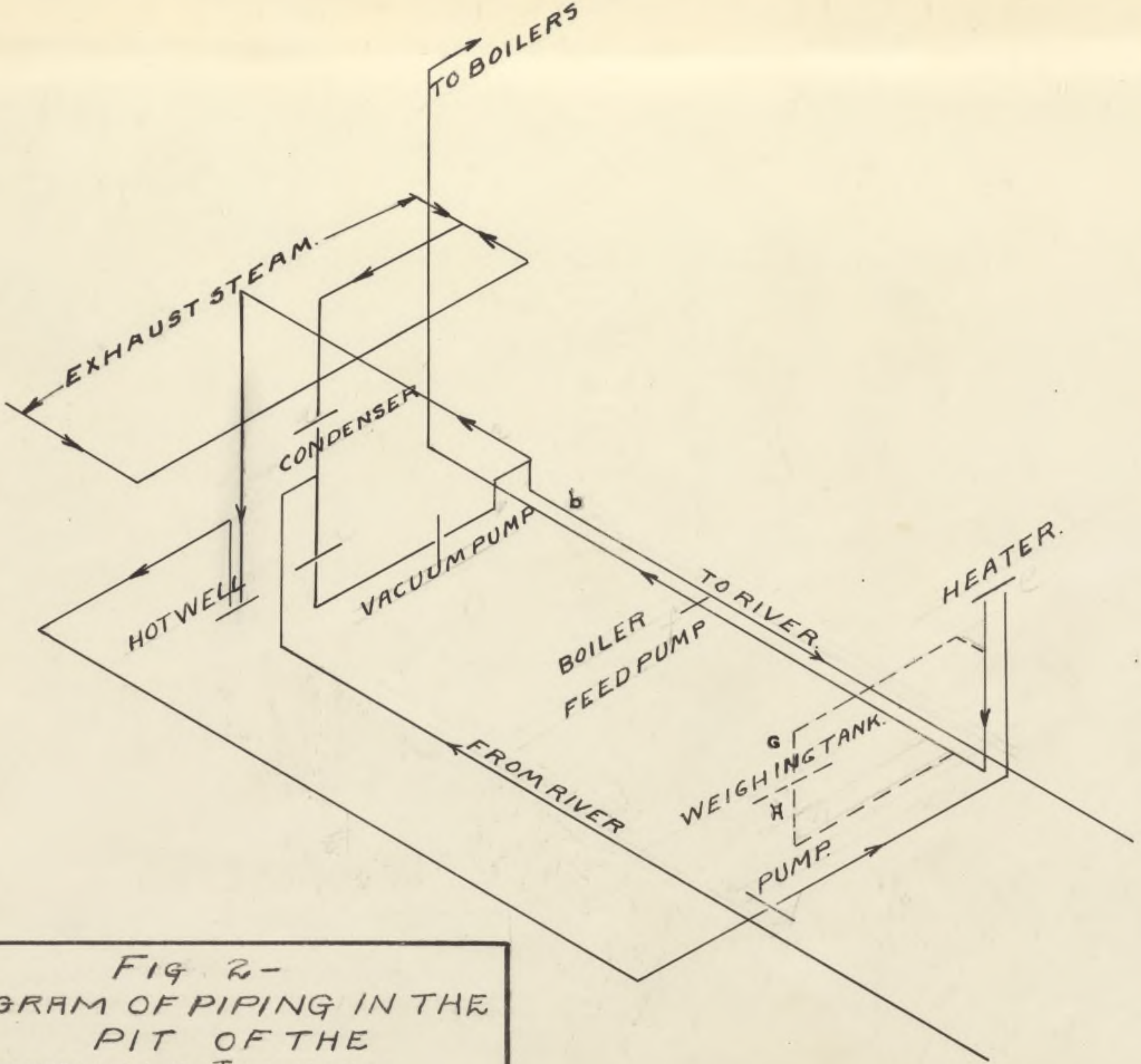


FIG 2-
DIAGRAM OF PIPING IN THE
PIT OF THE
NAPERVILLE ILLINOIS
ELECTRIC LIGHT PLANT
JUNE 1905