# DESIGN OF POWER PLANT

## AT URBANA, ILL.

FOR

# ILLINOIS TRACTION SYSTEM

BY

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## THESIS

FOR

## DEGREE OF BACHELOR OF SCIENCE

IN

ELECTRICAL ENGINEERING

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COLLEGE OF ENGINEERING

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

HENRY CHARLES FELLMAN and MICHAEL EDWARD HAGAN

ENTITLED DESIGN OF A POWER PLANT FOR URBANA, ILLINOIS

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

OF BACHELOR OF SCIENCE IN ELECTRICAL ENGINEERING

Morgan Brooks.

HEAD OF DEPARTMENT OF ELECTRICAL ENGINEERING

# DESIGN OF POWER PLANT

at

URBANA, ILLINOIS.

for

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## INTRODUCTION.

Object: With a view of satisfying the increased demand for light and power in the city of Urbana, the authors have endeavored to re-equip and arrange the present power station and power circuits of that city.

Limitations: The following restrictions were submitted by the Illinois Traction System to guide the authors in the design and equipment.

The power plant to be located on the present site of power plant.

Tracks to be left as at present, may assume entirely new construction.

Coal same as now used.

Water tube boilers preferred, with stokers and simple coal handling machinery.

A. C. current at 2300 volts and 60 cycles.

Capacity of Generator unit should be 375 K W and auxiliary railway uint of 200 K W at 550 volts.

Must be able to run in parallel with same current supplied from Champaign station.

Engine to run non-condensing exhausting into heating system against back pressure varying from 2 to 7 lbs.

Must arrange for some slight extension of engine and boiler capacity.

First cost must be carefully considered and made as low as possible, consistent with conditions existing.

## DESCRIPTION OF PRESENT PLANT.

Location: The Urbana Light and Power Plant is located on Water Street, one-half block east of Market. This position gives it immediate access to both the Big Four and Wabash Railroads, as well as a branch line of the Illinois Traction System, thus minimizing the danger of temporary shut-down due to strikes, labor troubles, or local disasters.

The present location is two blocks from the center of the business district, being ideally placed with respect to supplying steam heat to the business houses.

General Description: The plant is entirely contained in one building 43' X 115' This structure is divided into two main rooms, with fire wall between; namely, the boiler and engine room.

The space given for the boilers is located in the north end of the building and measures 40' X 43-1/2' inside dimension. The engine room is located just south of the boiler compartment and measures 40' X 68'. The flooring of the engine room is 3" above

that of the boiler room.

Boiler Room: The boiler room is anything but satisfactorily planned and arranged. The floor space is not divided with any show of economy. The boilers are four in number, fire tube, hand fed, and large for their capacity. Three of them are rated at 150 and the fourth at 125 horse power. Owing to the poor condition of these boilers the Fire Underwriters have allowed but 110 pounds presure on the three largest and 100 pounds on the small boiler. This, of course, has reduced their capacity considerable.

A space of about 12' in width is allowed in front of these boilers. This is hardly more than enough to properly attend to and clean the fires, nevertheless, this space is almost entirely filled with coal. No stokers or coal handling machinery is used. Such conditions not only hinder the fireman in the preformance of his duties, but also lowers the efficiency of the boilers because of the impossibility of proper handling.

The stack is located just north of the boiler room with no space between it and the boiler room wall. This renders any extension of the plant in this direction impractible, as the stack is new and would have to be destroyed. The stack measures 12' X 12' at the base is 86 ft. high and the flue is of 5' diameter.

Engine Room: The floor of the engine room proper is elevated three feet above that of the boiler room. This was so designed that a pit was formed along the east side of the room, the floor being level with the boiler room floor. In this are placed the feed water heater and one steam driven water pump. The heater is of vertical type and in poor condition. The pump, Dean Brother make, is new and in very good condition.

Three Warren Inductor Alternators, single phase, are directly connected to single acting steam engines. Two of these generators are 60 K W, one being connected to an Ideal, the other to a Chuse engine. Third generator, a 120 K W machine is connected to and driven by an Ideal engine.

Each of these alternators has a separate exciter of its own, which is connected by belts to the different engines.

Besides these three generators there is a direct current dynamo of Edison Bipolar type, which is also driven by the Chuse engine, a belt being placed on the fly wheel.

The switch board begins at the south west corner of the engine room and extends north along the

west wall of the building. There six panels in number, three of which are A. C. Generator Panels, two for circuits, and the sixth a D. C. Generator Panel.

The Illinois Traction System owns twelve feet east of the power house which istaken up by the railroad spur on which coal is shipped in, preventing any extension in this direction. The plant sets back twelve feet from the side walk and a small margin of two feet extends along the west side. At the rear of the structor there is about 125' extending north to the Wabash Railroad tracks. Expansion can, therefore, be made in this direction only, without the purchase of more land.

Distribution, Circuits: There are seven circuits in all, three incandescent and four arc light. The arc lights give good satisfaction, and good regulation is obtained due to the regulators placed in these circuits. No regulators have been placed in the incandescent circuits and much dissatisfaction has resulted due to poor regulation and excessive line drop.

One arc light circuit feeds the north-west district of Urbana. Another supplies the south-east portion, a third the business section of the city, and the fourth the south-west resident district. Approximately, twenty-five lights are in service in each circuit. The three incandescent circuits supply current

to the same districts as do the arcs mentioned above, and are installed on the same pole line.

The distribution of load may readily be seen from the accompanying table, which shows the number and the make of the transformers, also the number of houses and lights supplied by each.

# LIST OF TRANSFORMERS IN URBANA, ILLINOIS.

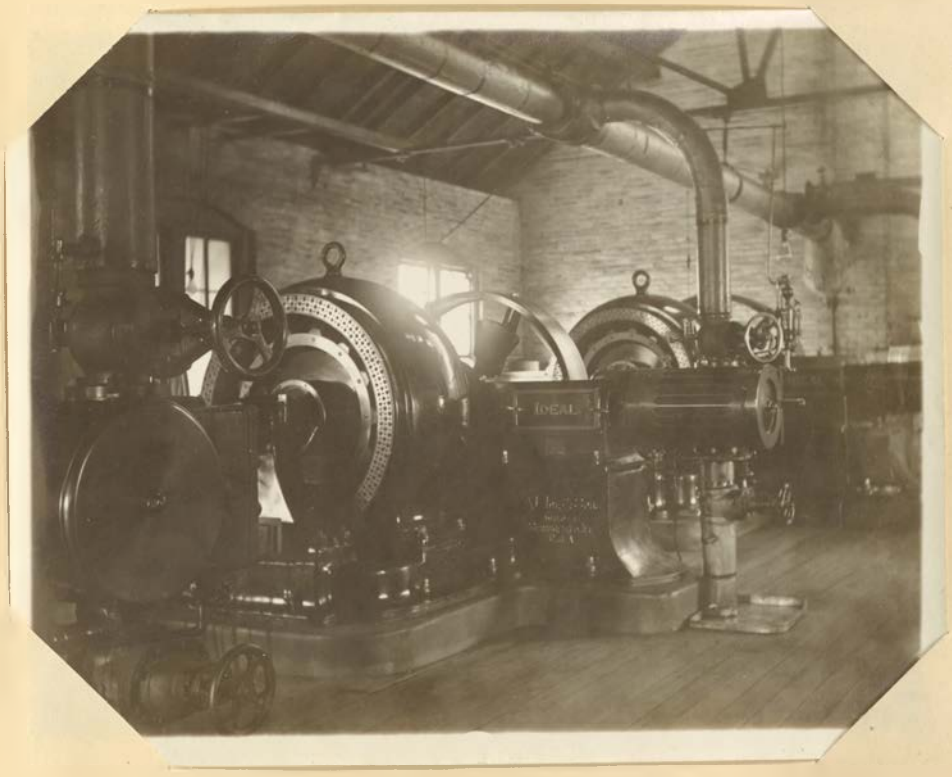
| No. on Map | Make | K. W. | No. Houses | Aprox. No. Lamps | Max. Load K. W. Aprox. | Remarks. |
|---|---|---|---|---|---|---|
| 1 | Westinghouse | 5 | 12 | 180 | 9.90 | O. K. |
| 2 | Peerless | 2-1/2 | 10 | 100 | 5.50 | O. K. |
| 3 | G. E. | 5 | 8 | 80 | 4.40 | O. K. |
| 4 | G. E. | 5 | 12 | 175 | 9.60 | O. K. |
| 5 | Westinghouse | 5 | 7 | 145 | 7.90 | O. K. |
| 6 | Westinghouse | 5 | 9 | 155 | 8.40 | O. K. |
| 7 | Westinghouse | 5 | 9 | 165 | 9.00 | O. K. |
| 8 | Peerless | 2 | 7 | 105 | 5.70 | R. by new 5 K. W. |
| 9 | Westinghouse | 5 | 12 | 180 | 9.90 | O. K. |
| 10 | G. E. | 5 | 10 | 150 | 8.25 | O. K. |
| 11 | Peerless | 3 | 7 | 105 | 5.70 | O. K. |
| 12 | Peerless | 1-1/2 | 5 | 50 | 2.75 | O. K. |
| 13 | Peerless | 1-1/2 | 6 | 60 | 3.30 | Replace by 24. |
| 14 | Peerless | 3 | 8 - C | 235 | 12.85 | Replace by 16. |
| 15 | Westinghouse | 5 | 17 | 200 | 11.00 | R. by New 10 K. W. |
| 16 | Westinghouse | 5 | 5 | 60 | 3.30 | Replace by 14. |
| 17 | G. E. | 10 | 8 - S. | 160 | 8.80 | O. K. |
| 18 | G. E. | 20 | 15 - C. | 550 | 30.00 | O. K. |
| 19 | Peerless | 1 | 5 | 50 | 2.75 | O. K. |
| 20 | G. E. | 5 | 10 | 100 | 5.50 | O. K. |
| 21 | G. E. | 5 | 5 | 50 | 2.75 | Replace by 36. |
| 22 | Westinghouse | 5 | 14 | 200 | 11.00 | R. by New 10 K. W |
| 23 | G. E. | 5 | 9 | 110 | 6.00 | O. K. |
| 24 | G. E. | 5 | 5 | 50 | 2.75 | Replace by 13. |
| 25 | G. E. | 1 | 4 | 45 | 2.42 | Replace by 42. |
| 26 | Peerless | 1 | 9 | 90 | 4.95 | Replace by 15. |
| 27 | G. E. | 5 | 5 | 75 | 4.1 | O. K. |
| 28 | Westinghouse | 5 | 3 | 70 | 3.85 | O. K. |
| 29 | Peerless | 1-1/2 | 5 | 30 | 1.65 | O. K. |
| 30 | Wagner | 4 | F. D. | 100 | 5.50 | O. K. |
| 31 | Westinghouse | 5 | 6 | 60 | 3.30 | O. K. |
| 32 | G. E. | 5 | 14 | 150 | 8.25 | O. K. |
| 33 | Peerless | 1 | 8 | 80 | 4.40 | Replace by 8. |
| 34 | G. E. | 5 | 8 | 95 | 5.20 | O. K. |
| 35 | G. E. | 5 | 11 | 130 | 7.20 | O. K. |
| 36 | Peerless | 3 | 5 - C. | 150 | 8.20 | Replace by 21. |
| 37 | Peerless | 1 | 5 | 50 | 2.75 | Replace by 39. |
| 38 | Peerless | 1-1/2 | 4 | 40 | 2.20 | O. K. |
| 39 | Peerless | 2 | 9 | 120 | 6.60 | Replace by 22. |
| 40 | Wagner | 10 | 7 - m. | 60 | 10.00 | O. K. |
| 41 | Peerless | 1 | 3 | 30 | 1.65 | O. K. |
| 42 | Peerless | 1-1/2 | Mill | 20 | 1.10 | Replace by 25. |
| 43 | Westinghouse | 5 | 2 - S. | 130 | 7.15 | O. K. |
| 44 | G. E. | 5 | P. F. | 80 | 4.40 | O. K. |
| 45 | Peerless | 1-1/2 | 5 | 45 | 2.42 | O. K. |
| 46 | G. E. | 2-1/2 | L. H. | 85 | 4.60 | O. K. |
| 47 | G. E. | 5 | 11 | 100 | 5.50 | O. K. |

LIST OF TRANSFORMERS IN URBANA, ILLINOIS.

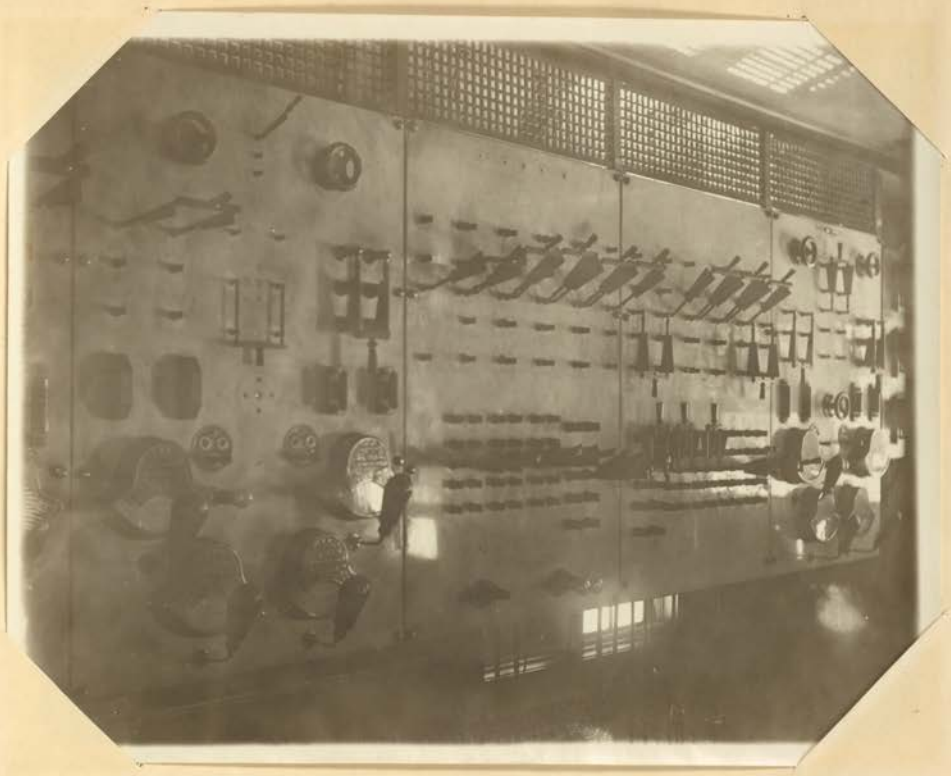
Continued.

| No. on Map | Make | K. W. | No. Houses | Aprox. No. Lamps | Max. Load K. W. Aprox. | Remarks. |
|---|---|---|---|---|---|---|
| 48 | G. E. | 5 | F. | 80 | 4.40 | O. K. |
| 49 | Peerless | 2 | 4 | 25 | 1.37 | O. K. |
| 50 | Peerless | 1/2 | 1 | 10 | .55 | O. K. |
| 51 | G. E. | 2-1/2 | 7 | 50 | 2.75 | O. K. |
| 52 | G. E. | 5 | 7 | 70 | 3.85 | O. K. |
| 53 | G. E. | 15 | Flat | 20 A. | 9.00 | O. K. |
| 54 | G. E. | 15 | Iron B | 370 | 20.00 | O. K. |
| 55 | G. E. | 2-1/2 | 3 | 40 | 2.20 | O. K. |

A view of the Present Power Plant.



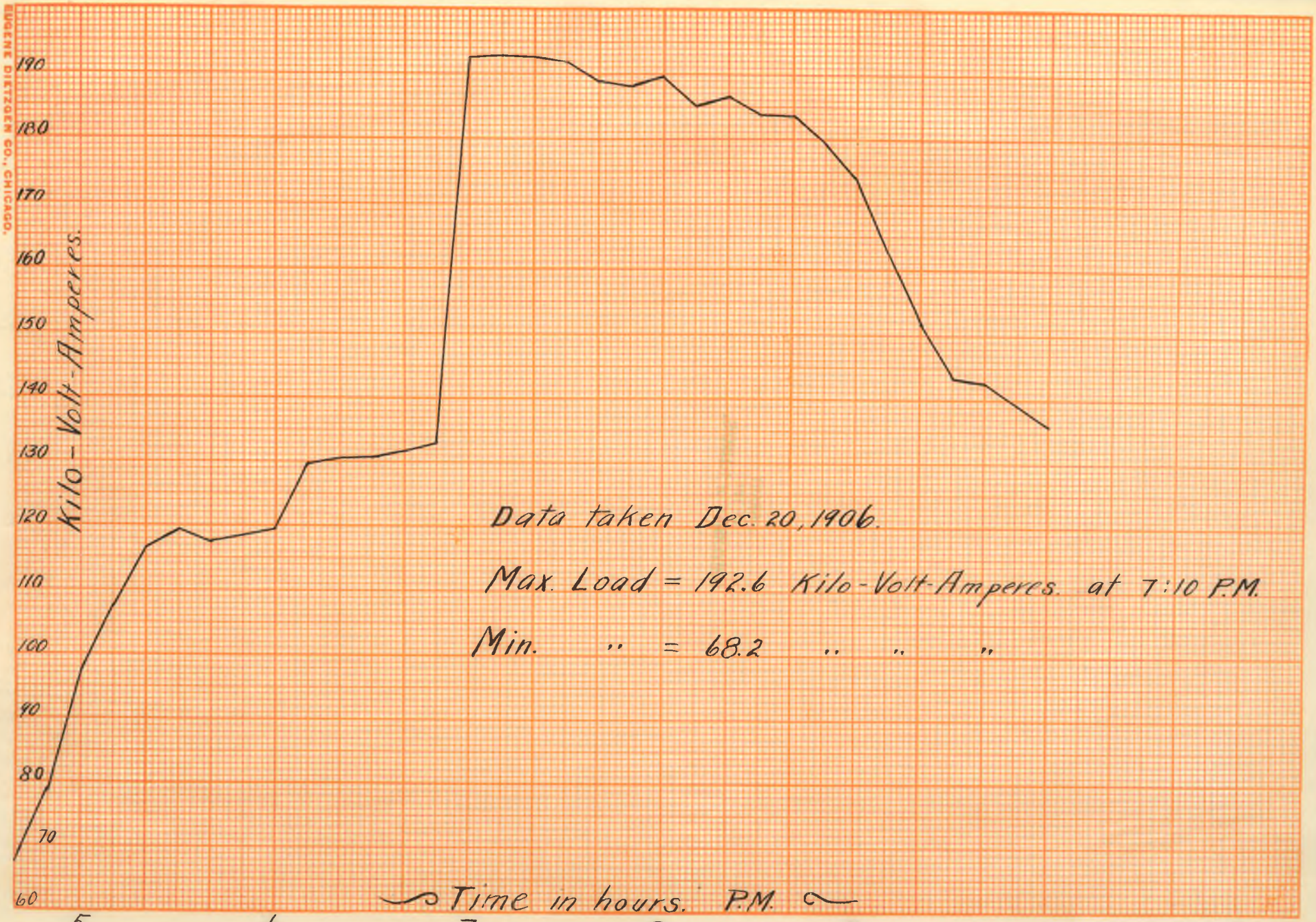

A View of the Interior of the Engine Room.

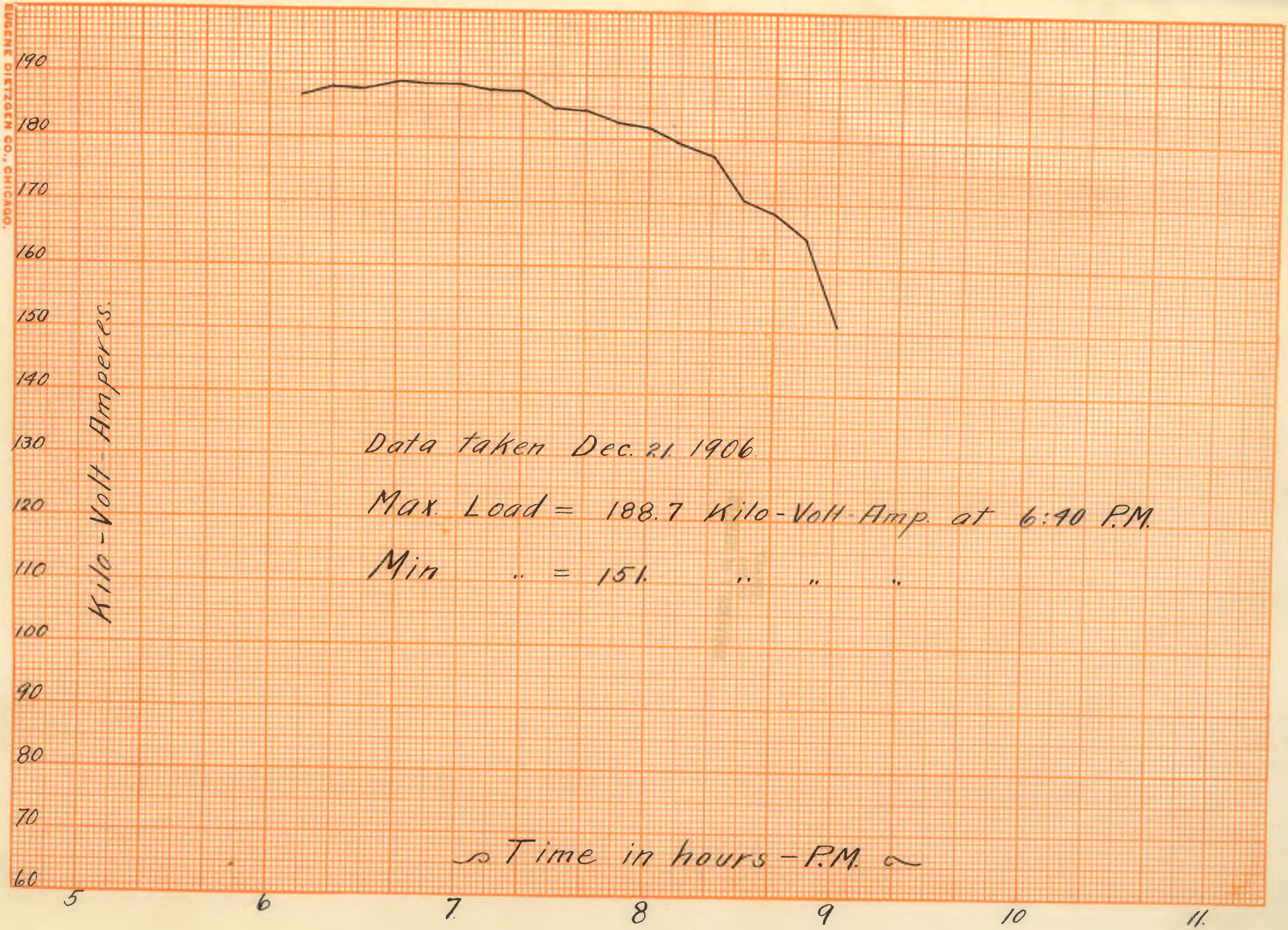


View Showing Switch Board.

Boiler Room, Showing Method of Handling Coal.

The accompanying curves show the variation of load with the time of the day. They were plotted from readings taken December 20th and 21st, 1906. It will be noticed that the increase of load starts at 4:40 in the afternoon and reaches its maximum at 7:00 o'clock in the evening.




EUGENE DIETZGEN CO., CHICAGO.
190
180
170
160
150
140
130
120
110
100
90
80
70
60
Kilo-Volt-Amperes.
Data taken Dec. 21. 1906.
Max. Load = 188.7 Kilo-Volt-Amp. at 6:40 P.M.
Min " = 151. " " "
Time in hours - P.M.
5
6
7
8
9
10
11.

Justification for New Plant: The city council of Urbana has agreed to extend the franchise of the Urbana Heat Light and Power Company for twenty years, provided the expenditure of Fifty Thousand Dollars be made upon the present plant and circuits to meet the increasing demand for electrical energy.

It has been considered by the company that the plant is inadiquate to supply the demand for light and power; that the apparatus is of old type and much worn; that the regulation is poor and that the boilers are old and unreliable, while coal is deposited and handled in a very unsatisfactory manner. It is such that the economy and efficiency of the plant is greatly reduced.

It has been the endeavor of the authors to show how these demands may readily be met in an econimical and practical way. A power plant has been designed requiring the installation of new and up-to-date apparatus, including boilers and coal handling machinery of approved type.

Strict attention has been kept to the restrictions imposed on page 3, the first cost being the controlling item. The Champaign Power House, new and up-to-date is now running daily at more than full capacity. The plant at Urbana could be made to operate

in parallel with that of Champaign, thus reducing the load of the latter and at the same time maintaining a high load factor at the Urbana plant.

Location: The new plant is to be located on the present site of the old plant, that is, on Water Street one-half block east of Market. This gives all the advantages mentioned in the foregoing pages, such as, centralization for the heating system, and nearness to railroads for the delivery of coal and the carrying away of ashes, etc.

Boiler Room: The proposed boiler room to remain in floor dimensions as at present---40' X 43-1/2'. The roof of this part of the building to be raised to accommodate the installation of coal deposite bins.

The boilers recommended are water tube 300 H.P. three in number. These to be placed facing the east. One battery of two boilers and an aisle of 4' between them and the third, which is a reserve boiler.

Rating: As stated above the boilers recommended are to beof water tube type and to have a capacity of 300 horse power each. Each must have 2,700 sq. ft. of heating surface and 50 sq. ft. of grate area.

The boilers are to be sustained independently of brick work and to be free to expand and contract with-

out affecting the same, and so that the masonry may be removed and replaced without disturbing any fittings or connections, which is accomplished by using wrought iron supporting beams and columns with cast iron bases properly secured.

Firing: The boilers are to be equiped with chain grates and hoppers to which the fuel is supplied by means of automatic coal handling apparatus.

Supply: The water used in the boilers is taken from the Urbana city mains and contains a considerable percentage of salts in solution.

Heater: An exhaust heater of the closed horizontal type and of approved design is to be used; this will take care of the objectionable ingredients in the feed water to be used.

Pumps: It is the intention to use a comparatively new steam driven pump in good condition now in use in the plant. The increased boiler capacity necessitates the addition of a second one, which it is deemed adviaable to be of the same type and size.

Fuel: The fuel used is the Illinois Butuminous coal from Danville and is of fairly good quantity.

Method of Handling: The dump cars carrying fuel are run in on a spur from the Illinois Traction System lines and the coal dropped into pits between the tracks.

From there it is conveyed by means of bucket carriers, arranged in an endless chain to the storage bins above and to the front of the boilers. The coal by means of the long feed pipes, passes by gravity to the grates as it is needed. The bins are 28' long 8' wide and 10' deep, are supported by cast iron columns, approved construction being followed throughout. A hopper for ashes with dimensions of 9' long 8' wide and 10' deep is adjoining that to be used for fuel.

Distribution of Ashes: The cinders and ashes are raked from under the boilers into the conveyor, which carries them up into the ash bin above. From there they pass by means of a chute into the cars and are carried away.

Stack: The chimney as it is at present is of ample size to take care of the increased boiler capacity of the plant. It is of brick with a squarebase and round cross sections above. At the ground it is 12' X 12' and 5' diameter of flue.

## ENGINE ROOM.

Engines: There are to be two in number. One is a Corless rated at 700 horse power with a capacity of supplying 1000 indicated horse power as a maximum load,

and the other a 100 horse power Chuse Engine, which is now running the 60 K. W. single phase generator and Edison bipolar dynamo.

The authors in designing the station and choosing the apparatus andmachinery have constantly kept in mind the variation ofload required, and have endeavored to show how the proposed plant may be installed and equipped without totally shutting down the plant.

Unit number two to be taken out first and the Corliss engine set and generator with exciter connected without taking out set one and three. With this new unit up and ready to run the unit designated as number one may be taken out while the new one carried the load.

The above scheme necessitates the changing in position of the pump and heater in use at present. These will be moved out of the way and set up temporarily during the process of installation. The new pumps and heater will be set up and connected before old ones are disconnected and set up permanently in a pit in the north west corner of the engine room.

Generators, Number: there are four generators recommended. Two of three phase and 60 cycles at 2300 volts. One generator to be 375 K. W. and driven by the Corliss, and the other of 75 K. W. capacity by the Chuse engine.

The third generator, a D. C. 200 K. W., 550 volt machine is also run by the Corless, and is for the supplying of current to the railway system. In addition there is a generator of 15 K. W. Edison bipolar type with a voltage of 220, which carries the motor load in Urbana. This will be kept in use so long as is necessary to change the direct current motors to induction motors.

Number of Exciters: There are exciters proposed, one for the 375 and one for the 75 K. W. alternators.

Kind: These exciters are ordinary multipolar direct current type and are of the proper size for the ~~for the~~ units just mentioned, being of 15 K. W. and of 5 K. W. capacity respectively.

## SWITCH BOARD.

Location: The switch board to be located on the east side of the building. In this position it shields no light and is well lighted from the front. It will be some distance from all the steam mains so that heat arising from same or leakage of steam will have no affect on the instruments and contact surfaces. Another advantage in favor of this position is the fact that the old board can be kept in service while the new one is being placed and connections made, thus causing no delay.

Kind and Size: The material for the switch board

panels is to be of white marble free from metalic stirae. The front side polished.

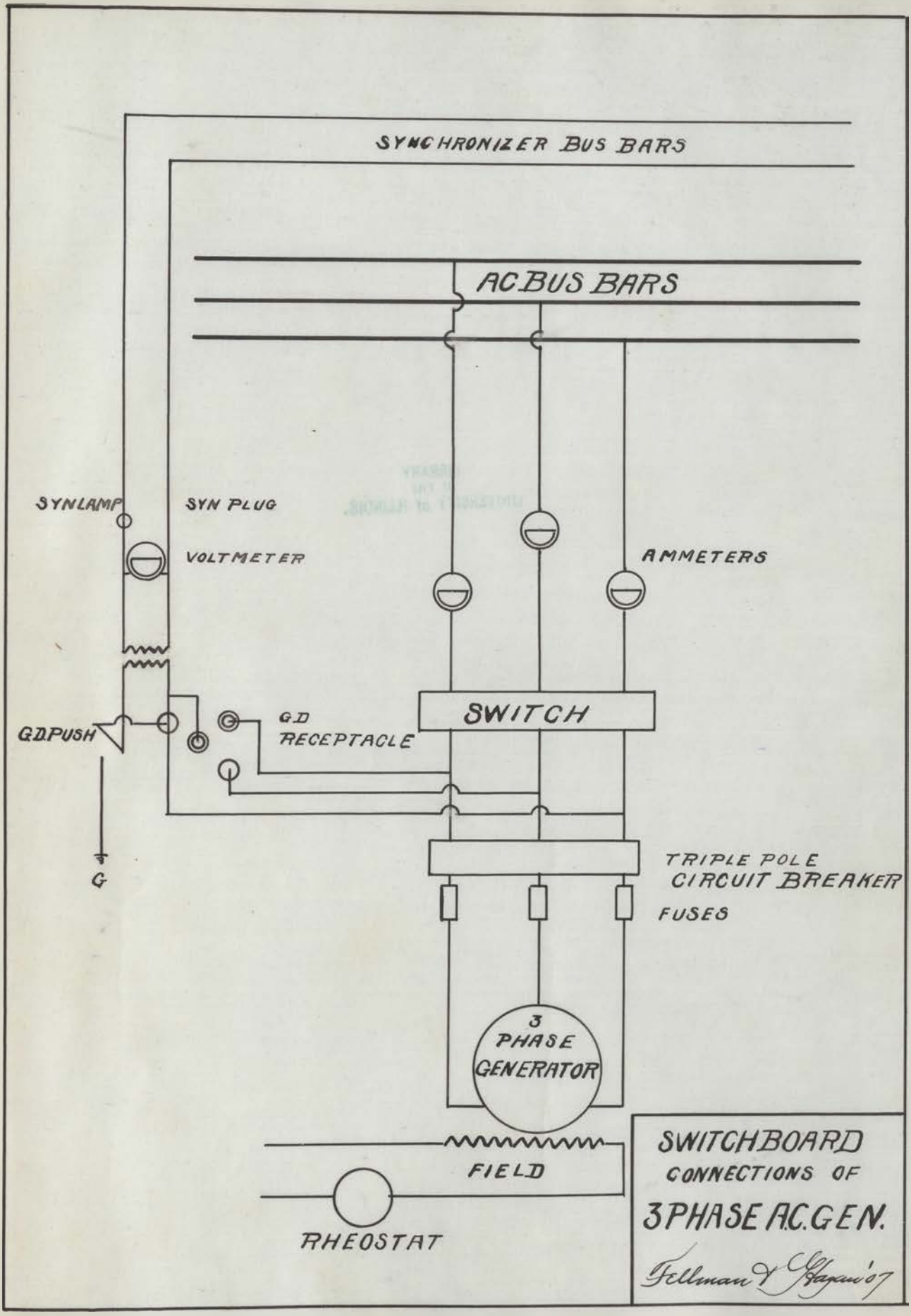
Number of Panels: There are to be three for the generators and one for the in-coming circuits from Champaign,and seven distributing panels.

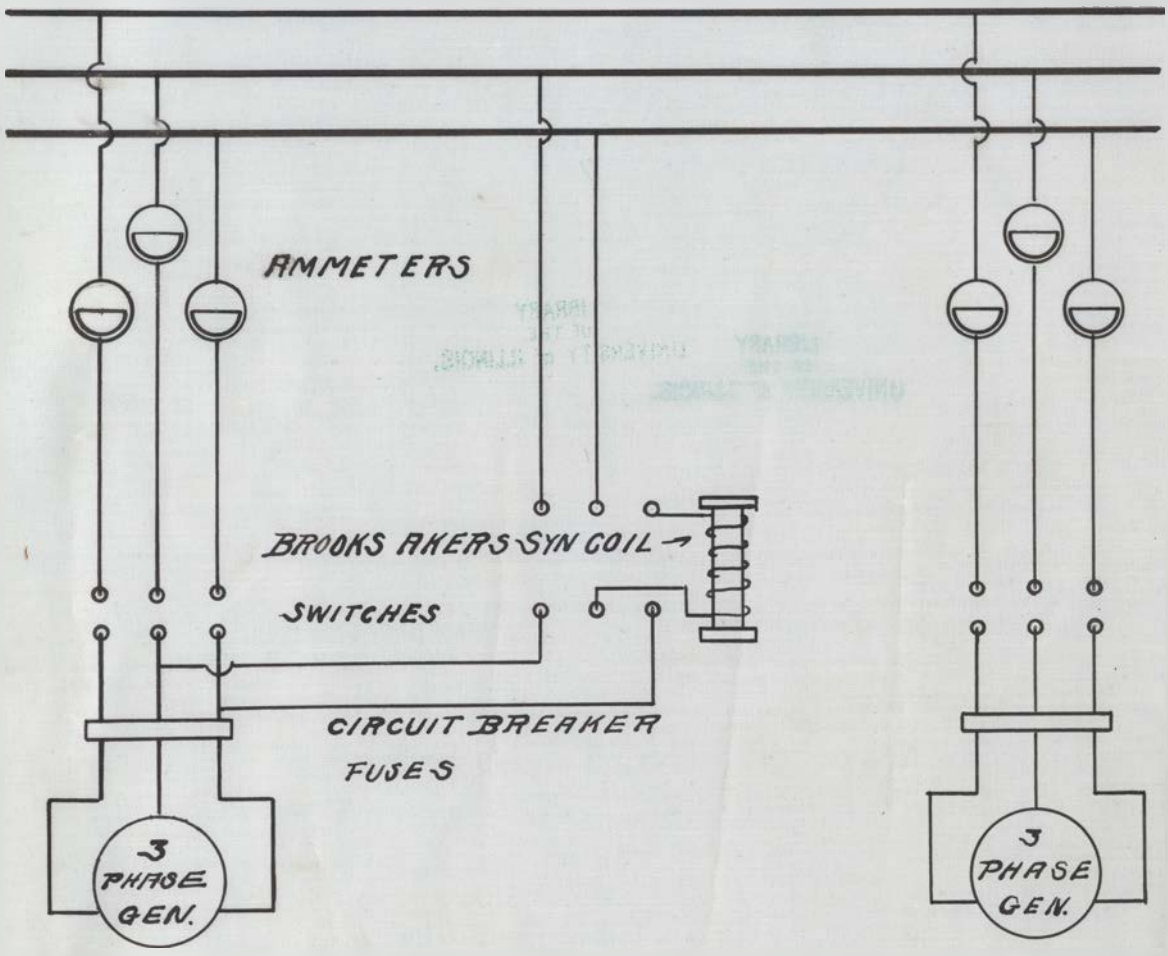
Description of Panels: The exciter panel to contain a D. C. voltmeter and Ammeter, Rheostat connections, and a two pole switch,panel, to be 16" wide. The 375 K. W. generator panel is to contain three ammeters, one for each phase, a recording wattmeter, voltmeter connections, and a three pole switch. Panel to be 24" wide.

The 75 K. W. panel is to contain an ammeter for each circuit, voltmeter connections, recording wattmeter, and synchronous connections. On this panel are also to be placed the exciter instruments for this macchine. That is, ammeter D. C. and voltmeter, and Rheostat connections. Panel to be 24" wide.

The third generator panel is that for the 200 K. W. railway generator. On this board will be placed the direct current instruments, as, ammeter, voltmeter, rheostat connection for field of generator, recording wattmeter, and suitable switches.

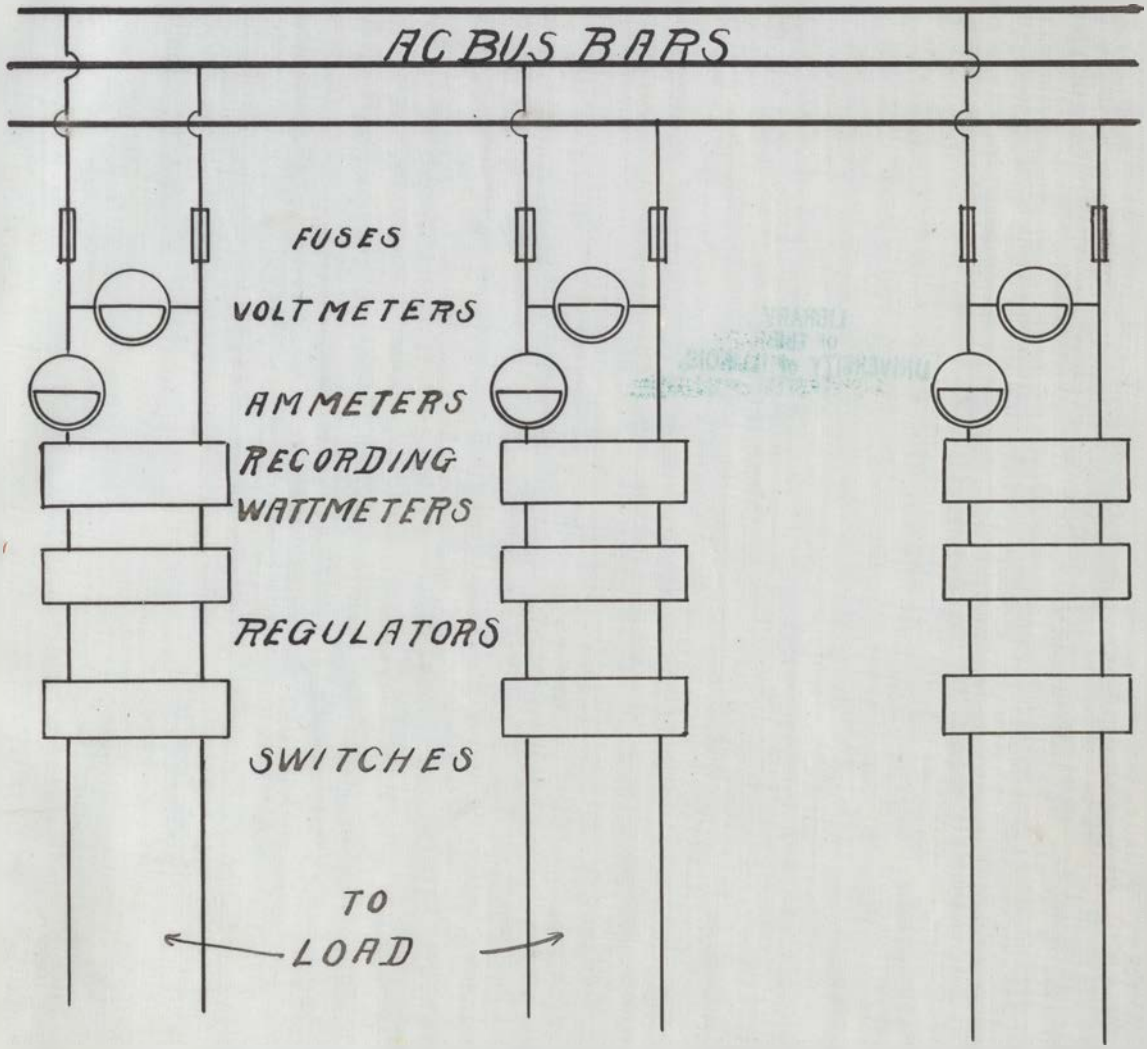
On each circuit panel will be placed the recording wattmeter, the ammeter, and voltmeter connections and the lightening aresters mounted on the back of the board near the bottom.


SYNCHRONIZER BUS BARS
AC BUS BARS
SYNLAMP
SYN PLUG
VOLTMETER
AMMETERS
SWITCH
G.D PUSH
G.D RECEPTACLE
G
TRIPLE POLE CIRCUIT BREAKER
FUSES
3 PHASE GENERATOR
FIELD
RHEOSTAT
SWITCHBOARD CONNECTIONS OF 3 PHASE A.C. GEN.
Fellman & Hagen '07




AC GENERATOR
CONNECTIONS
SYNCHRONIZING
CORELESS IND. DEVICE

Fellman Hayes




SWITCHBOARD
CONNECTIONS
LOAD PANELS

Fellman & Hagan

## DISTRIBUTION.

Circuits: There to be seven circuits in all, four arc light and three incandescent circuits.

Location: The direction of the circuits to remain as at present except new wire beingused where ever the engineer in charge deems necessary. The feeders from the station to transformers to be of wire of No. 6 B. and S. gage.

The transformers to be shifted and changed where same are too small and over-loaded or for any reason whatsoever unsatisfactory.

Plate 2 shows the theoretical ideal position for placing of the power house with respect to the best possible regulation and least line loss. By this method the centers of gravity of the different circuits were found and from this finally the center of distribution of the city.

It would not be advisable, however, to place the plant at the center of distribution, which figures to be two blocks west and one south of the building known as the Flat Iron Building. In this position it would nothave the good position it now has with respect to the receipt of coal; neither would it be so well placed to handle the steam heat proposition.

The center of gravity would be the theoretical

of installation and because of the very great elasticity of this system.

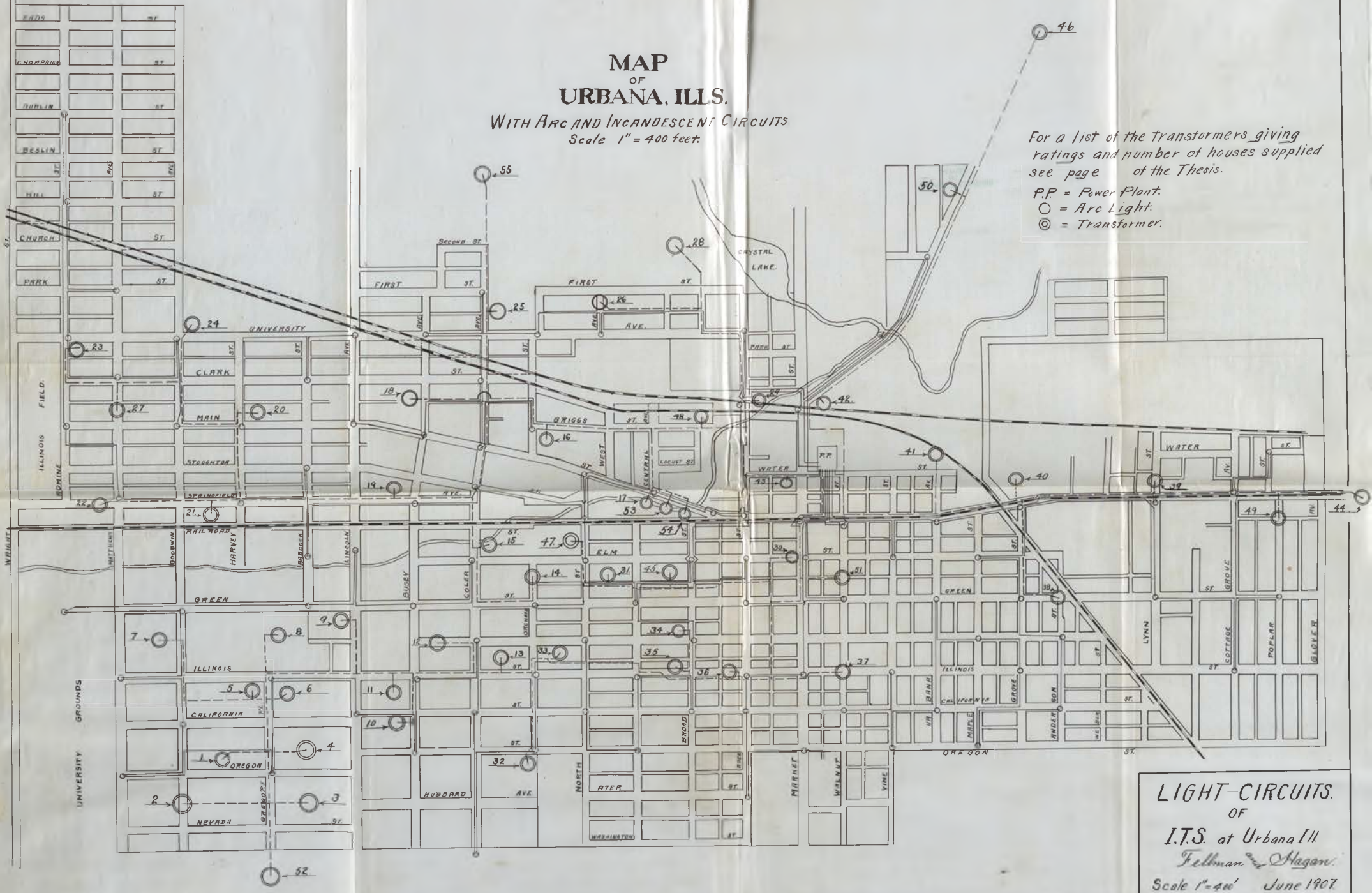
The total cost should not exceed $75000.00.

Henry Charles Fellman.

M. Edward Hagan.

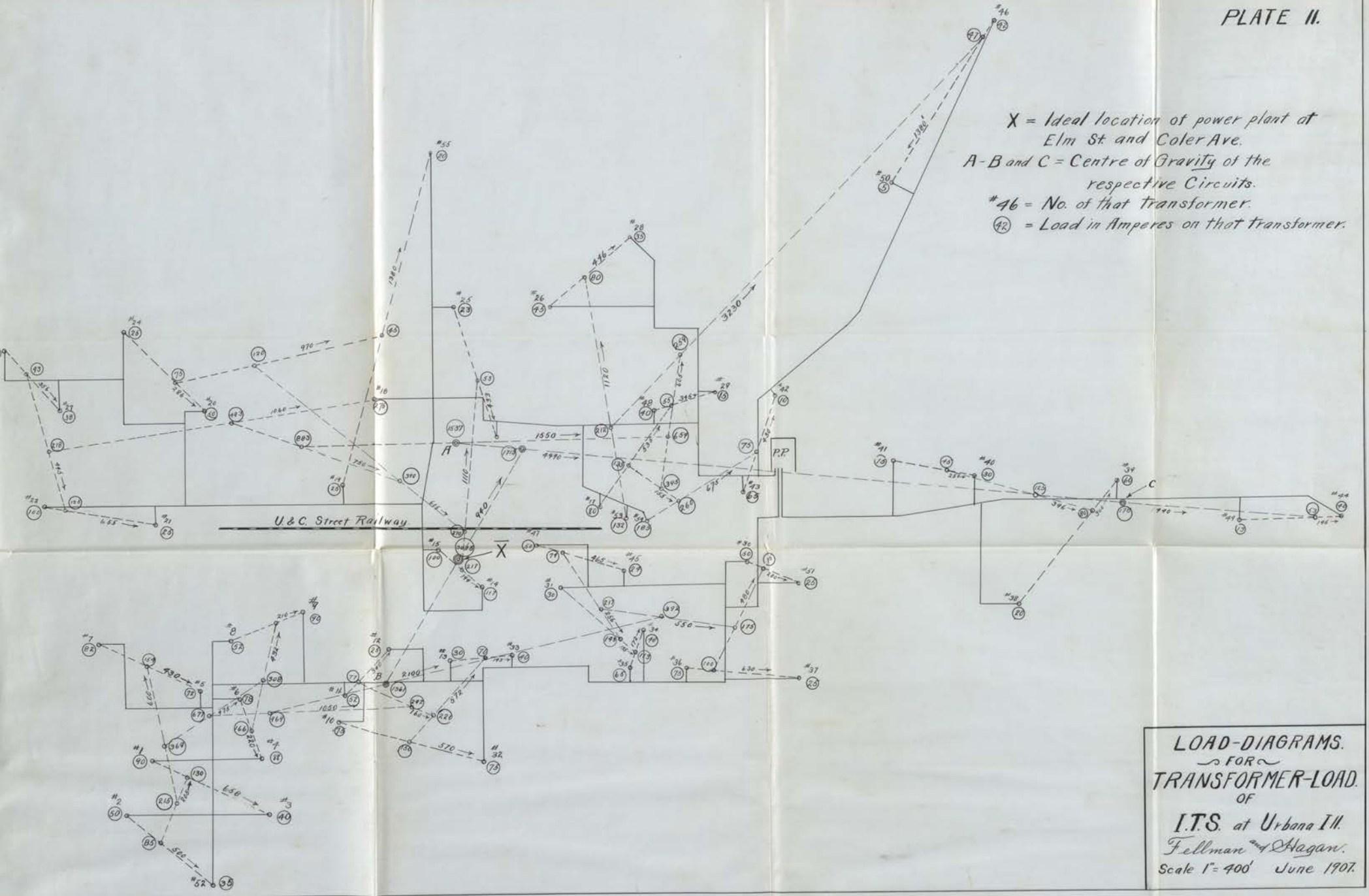
PLATE I.

# MAP
OF
# URBANA, ILLS.
WITH ARC AND INCANDESCENT CIRCUITS
Scale 1" = 400 feet.



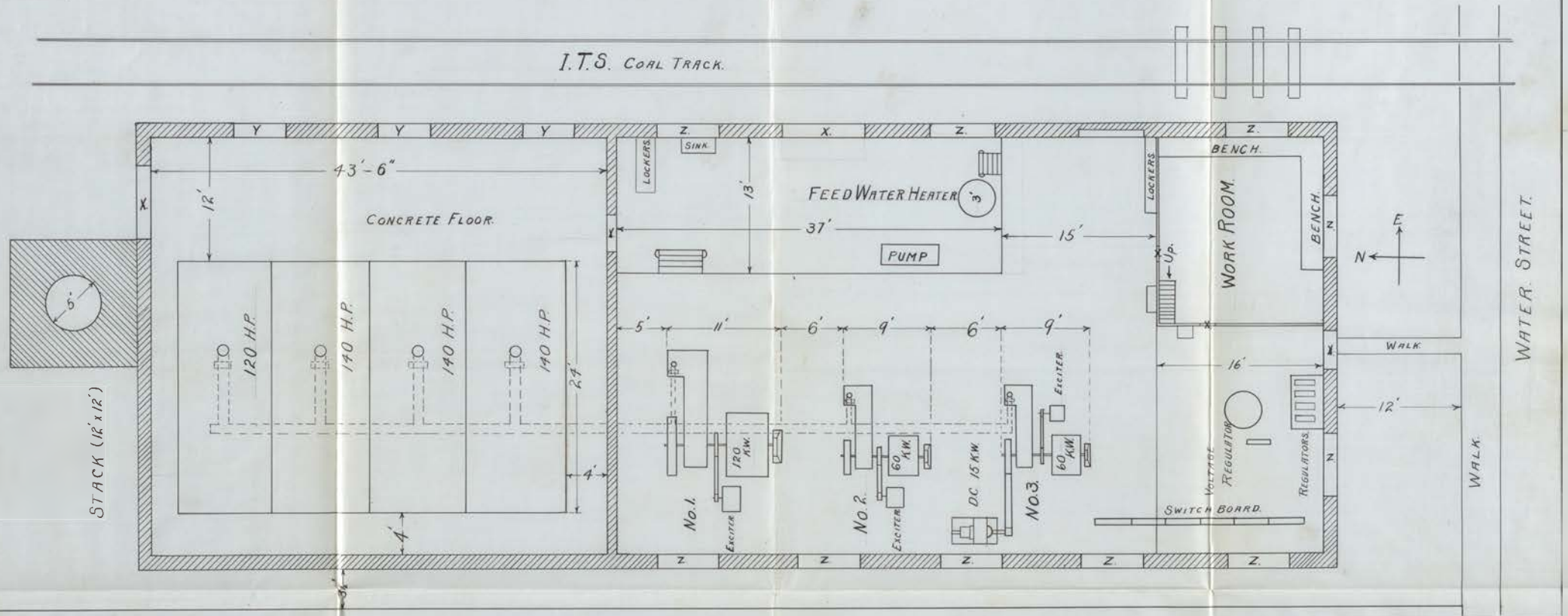

## LIGHT-CIRCUITS.
OF
I.T.S. at Urbana Ill.
Fellman & Hagan.
Scale 1"=400' June 1907

PLATE II.




LOAD-DIAGRAMS.
FOR
TRANSFORMER-LOAD.
OF
I.T.S. at Urbana Ill.
Fellman and Hagan.
Scale 1" = 400' June 1907.

PLATE III.



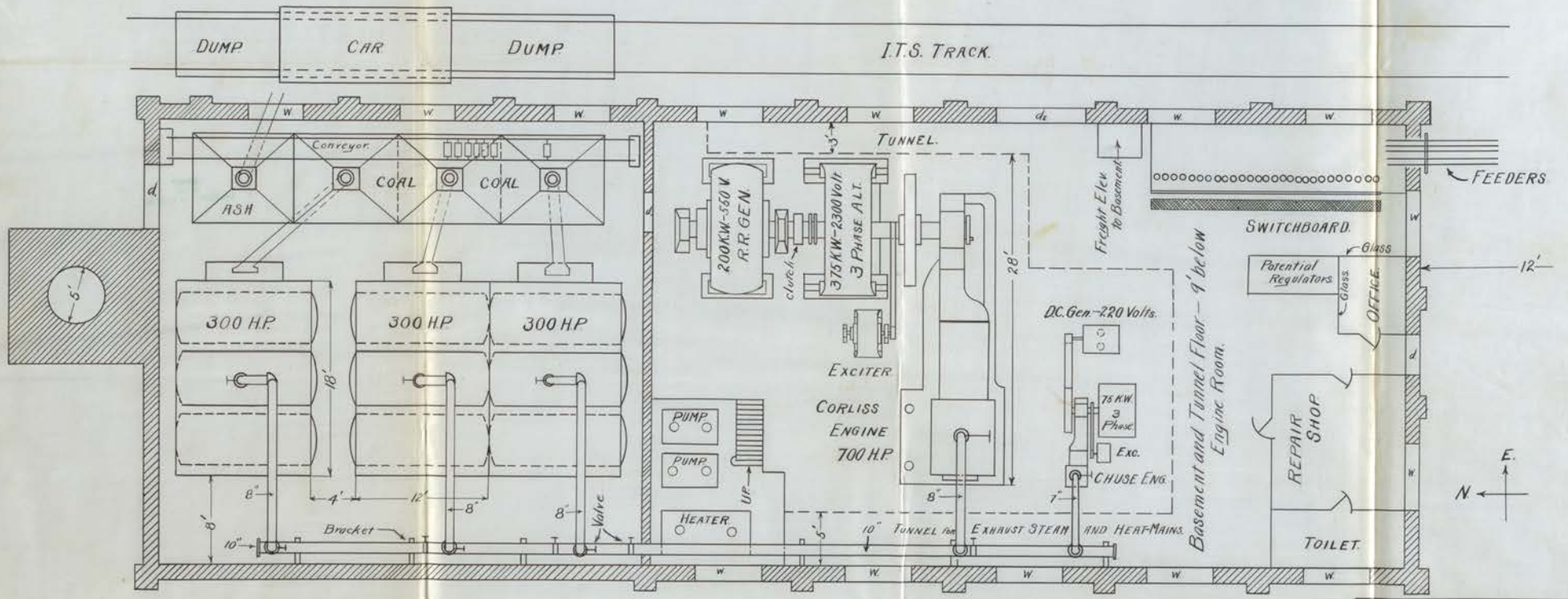

X. = DOORS

Y = COAL HOLES.

Z = WINDOWS.

PRESENT PLANT
OF
I.T.S. at Urbana Ill.
Fellman & Hagan.
Scale 1"=6' June 1907.

PLATE IV.




d = doors.

W = Windows.

$d_1$ and $d_2$ = Steel roller drop doors.

Water tube Boilers.

Steam driven Pumps. — Horizontal Heater.

Coal capacity shown = Three days supply.

# DESIGN OF PLANT FOR I.T.S. at Urbana Ill.

Fellman and Hagan.

Scale 1"=6' June 1907.