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of the construction of a transmission line from
Brookfield, Missouri, to Laclede, Missouri.

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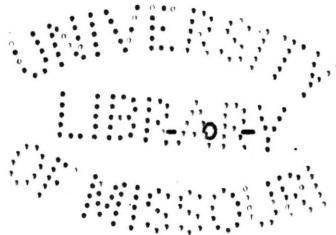
AN INVESTIGATION OF THE FEASIBILITY AND COST
OF THE CONSTRUCTION OF A TRANSMISSION
LINE FROM BROOKFIELD, MISSOURI
TO LACLEDE, MISSOURI.

THESIS
for
the DEGREE of
BACHELOR OF SCIENCE
in
ELECTRICAL ENGINEERING

UNIVERSITY OF MISSOURI

1911.

James Francis Rooker. 1887
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Introduction

There are a great many towns in the Northern part of Missouri that do not have either gas or electric lights for lighting their streets and buildings. These towns generally range in population from 500 to 2,000. When they look to the slightly larger towns that afford these conveniences they try to devise some way to obtain them for themselves.

The way that this end is most generally attempted is by the installation of a small steam-electric plant. The proposition of a gas plant for lighting and cooking is not generally attempted in a small place. As a rule the small steam-electric plant is not a paying proposition unless an extraordinary large rate is charged for the current.

The advent of the perfection of the internal combustion oil and gas engines has made a change in the financial efficiency of the small engine. By means of these engines electrical energy may be delivered at the bus-bars in small quantities at a very low rate. There seems to be no reason why these engines could not be operated successfully in small towns.

Another system by which it is possible to supply small towns with electrical energy for power and lighting is by transmitting it from larger towns. When a small town is within a radius of ten or twelve miles of a larger town, that already supports a lighting system, it is quite possible for it to build a transmission line and get power from there.

There are certain advantages of getting power by a transmission line which do not occur in the small plant. As a rule the small plant only gives night service and in many cases only from evening to midnight. Nearly always a larger plant gives twenty-four hour service and are willing to give the same service to the towns to which they sell current. This is an advantage because it allows the use of electric fans in midday and also the use of heating devices such as electric irons.

On the other hand, there is a corresponding disadvantage in the fact that it is not often possible to make long standing contracts with such larger plants and where the contract expires the small town is at the mercy of the larger town.

The object of this thesis is to investigate the feasibility and cost of the construction of a transmission line from Brookfield, Missouri to Laclede, Missouri for the purpose of supplying Laclede with electrical energy for lighting its streets and houses and small power uses as fans. It is possible for the town of Laclede to purchase the current from the Brookfield Electric Light Company at five cents per kw. hr. at the bus-bars at Brookfield. Laclede looks favorably towards the proposition and voted bonds for that purpose in August 1910.

Laclede, Missouri is a town of 850 population, located in Linn County in the North Central part of Missouri. It lies in an agricultural district and depends greatly for its support on the surrounding country. It is the junction point of the main line of the Hannibal and St. Joseph division of the Burlington Railroad and the Kansas City branch line of the same road. These two roads contribute much to the town.

The people of the town are thrifty and ready to do anything to help the town. There is more wealth in the town than most towns of its size. The people are very anxious at the present time to get some means of lighting other than they have.

Brookfield, Missouri is a town of 7,000 population, also located in Linn County. It is on the Hannibal and St. Joseph Railroad and is a division point. It supports the Brookfield Electric Light Company which is a private corporation. The capacity of the plant there is 175 kw. but the plant is not loaded to its maximum. In view of increasing their load they have consented to a proposition to sell Laclede power.

The Transmission Line.

The distance between the Brookfield station and the proposed Laclede substation is 31,050 feet. The most direct route lies along a highway. This road leads over a rolling country and there will be very little to interfere with the line. The line will cross one small stream at which the road bends and this will require several extra guys to keep the line as it should be. (See Plate IV). There is one place where telephone lines occupy both sides of the road and the Western Union Telegraph wires are close. The telegraph wires may be avoided but it will be necessary to move some of the telephone lines because of induction.

The transmission will be single phase, 60 cycles, and 6,600 volts. The plant at Brookfield generates 3 phase, 60 cycles, and 1100 volts. A step up transformer will have to be used at Brookfield. The proposition of a three phase transmission was first considered but for an almost entirely lighting load the extra cost of the third wire and the extra transformer would not be overcome by the added loss of the single phase.

The probable growth of the business is accounted for by making allowance for a position for the third wire and then two or three transformers in banks. Also as the business increases further the demand is provided for by making the transformers 13,200 or 6,600 volts on the primary.

The line will be constructed of #8 B and S hard drawn bare copper wire. The wire is supported on porcelain insulators tested for 14,000 volts. The line will be provided with special break joints to prevent accidents in case of a break at the cross roads.

The wires will be supported on 30' white cedar poles at all places except rail road or wagon road crossings and there the poles will be 40'. Each pole will be equipped with a 3'-two pin cross-arm placed 20" from the top of the roof of the pole. (See Plate I). This makes the wires 28" apart and when the third wire is desired a bracket may be placed on the top of the tops thus making that wire 20" from either of the others. All corner poles will be guyed with 1/4" stranded steel messenger. The guy rod shall be placed in the earth 7' and a giant strain insulator placed in each guy wire as prescribed

by law.

The voltage drop in per cent. was taken from
"Calculation of Transmission lines by L. W. Rosenthal.

V" = Voltage loss in per cent. and is found
from V" and per cent. table

$$V'' = \frac{M A W L}{E^2}$$

Where V" = Volts loss factor,
M = Wire factor (from tables),
A = Transmission factor (from tables),
W = Power at load in kw.
L = Length of line in miles,
E = Kilivolts between wires at load.

In this line

$$M = 3.32 (c - d),$$

$$A = .2 ,$$

$$W = 30,$$

$$L = 5.65,$$

$$E = 6.6,$$

$$V'' = 2.58 (c - d),$$

V = 2.75 from V" and tables.

Distribution System

The city distribution system shall be primary 2,200 volts and secondary 110 volts. There will be only one distribution district for the town that being sufficient to cover the whole town at present.

The primary lines shall be #8, B and S bare copper wire. The secondary lines shall be #s 4 and 6, B and S, bare copper except where it shall be liable to come in contact with any building and then it shall be covered with weatherproof insulation. As to whether the #4 or #6 copper is used will depend on the size of the transformer. The wires shall be supported on clear glass insulators tested to 2,200 volts.

The wires shall be supported on 30' white cedar pole except on the main business streets and railroad crossings. There 35 and 40 foot poles shall be used. Each pole carrying a primary shall be equipped with a 3' cross arm bolted to the pole at the top and if it carries secondary wires it shall have a 5 foot, four pin arm 20" below the primary arms. All poles shall be properly braced and guyed with 1/4"

stranded steel messenger fastened to a guy rod and carrying a strain insulator.

All service wires shall be run from the nearest pole to the house. The wire shall bear weather proof insulation and not be smaller than #10, B and S gauge. The exact length of these wires could not be estimated, but must be supplied by the company in case of construction.

The transformer shall be mounted on the pole about 20" below the primary arm. The arm to which the transformer is suspended must be bolted to the pole and though bolted to an arm on the back of the pole. Each transformer pole shall be stepped.

There shall be five transformers, installed at present. Numbers given here correspond to numbers given on the map of the town for location. (See Plate V).

Number 1	-	7 1/2 kw.
" 2	-	3 "
" 3	-	2 "
" 4	-	4 "
" 5	-	2 1/2 "

Street Lighting System.

This street lighting system should come under the head of the distribution. Due to the fact that the project is municipal I have considered it separately. One of the advantages looked to most by the town is the lighting of the streets and this they intend to do with the revenue from other sales of current.

The street lighting system will be series incandescent. The lamps to be used will be Madsa Tungsten with the large Edison base and about 50 watts per lamp.

345X
There will be one circuit starting and ending at the substation. The circuit will be constructed of #8 base hard drawn copper. The circuit will be operated by means of a switch from the station. The voltage of the line will be regulated by means of a tub-transformer.

The line will be run as near as possible where the other system is located. In case the same pole is used for both systems the street circuit will occupy the outside pins of the four pin arm that already carries the secondary. In case where it is necessary to set new poles there will be a two

pin arm where both wires of the circuit is carried. Where there is only one wire on the pole it will be bracketed to the pole at the top. All poles used will be 30' and guyed as usual.

Substation

The substation shall be located in the east edge of the corporation. It shall be on land now cultivated and occupy only as small space in the corner. (See Plate II).

The substation shall be a brick and concrete structure 14' x 12' x 8'. (See Plate). The building shall be larger than is actually needed for the transformers but ample space is left for other transformers as the business increases. Also it shall be necessary in keeping up as small system to have a supply room and tool room and part of this will serve that purpose.

The foundation shall be concrete and also the floor. The walls shall be nine inch brick. The roof shall be made of a patent ruberoid roofing which is practically fire proof. There shall

be one door opening on the street and five windows.

The substation equipment shall consist of a switch board. There will be one panel for the lighting circuit and one for the street lighting circuit. (See Plate III). There shall be one potential transformer of 30 kw. capacity and one tub-transformer of 4 kw. capacity for the street circuit. There shall also be protective devices such as lightning arresters, ground detectors, etc. All inside wiring shall be well insulated from the building.

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COST of TRANSMISSION LINE.



252- 30' white cedar poles,	\$ 694.00
8-40' " " " "	54.00
263- 2pin, 3' crossarms and pins,	77.40
263- 5/8" X 12" machine bolts,	20.28
263- 1/2" X 4" lag screws	5.65
526- 3/8" X 4 1/2" carriage bolts,	10.50
526- 20" cross arm braces,	22.20
526- porcelain insulators,	15.75
11.76- miles #8 hard drawn copper wire	445.00
1080- ft. 1/4" stranded steel messenger,	10.80
16- storm insulators,	8.00
16- steel wire strand thimbles,	.44
42- guy clamps,	6.30
16- guy anchors 3/4" X 8',	4.20
5- gallon creosote paint,	5.00
Labor digging holes and setting poles,	566.00
.. stringing wire,	182.00
.. guying and framing poles,	156.00
.. distributing material,	<u>20.00</u>
Total,	2503.46

COST of DISTRIBUTION SYSTEM.

10-	35'	white cedar poles.	\$	50.00
105-	30'	" " "		289.00
110-	2	pin cross arms and pins,		32.20
60-	4	" " " " "		33.95
170-		sets of braces, bolts, etc.		37.80
50-		guy wire clamps and thimbles,		9.00
25-		guy rods,		6.55
1250-	ft.	stranded steel messenger,		12.50
10500-	ft.	or 525 lbs. #8 copper wire,		75.40
6500-	ft.	" 822 " #4 " "		118.00
20200-	ft.	" 1604 " #6 " "		230.50
3-		sets pole line arresters,		26.40
10-		Bryant cut outs,		10.00
340-		glass insulators,		81.56
25-		storm insulators,		12.50
1-	2 1/2	kw. transformer,		45.00
1-	4	" "		58.00
1-	7 1/2	" "		105.00
1-	3	" "		50.00
1-	2	" "		40.00

Labor digging holes and setting poles,	\$ 225.00
" stringing wires,	68.20
" guying and framing poles,	75.00
" distributing material,	<u>10.00</u>
Total	1646.16

COST of STREET LIGHTING EQUIPMENT.

(Poles that were counted in the distribution system are not counted here)

16- 30' white cedar poles,	44.00
12300- ft. or 615 lbs. #8 copper wire,	88.20
440- ft. 1/4" stranded steel messenger,	4.50
11- guy rods,	2.88
22- " clamps and thimbles,	3.96
20- side brackets,	0.75
200- glass insulators,	4.80
11- storm insulators,	5.50
Labor for setting poles,	35.00
" stringing wire,	45.00
" guying and framing poles,	15.00
17- bracket street lamps (complete)	<u>68.00</u>
Total,	317.59

COST of SUBSTATION.

6250- brick in place,	\$ 156.25
228- cuft. concrete construction,	91.20
1.7- squares of patent roofing,	8.50
Material such as lumber,	10.00
Hardware,	10.00
1- 3' X 7' door and frame,	13.00
5- 3' X 6' windows and frames,	50.00
Labor other than laying brick,	<u>20.00</u>
Total,	358.95

COST of SUBSTATION EQUIPMENT.

2- switchboard panels,	\$ 20.00
1- voltmeter,	40.00
2- ammeters,	80.00
1- ground detector,	10.00
1- oil switch,	35.00
1- lightning arrester,	50.00
1- totalizing wattmeter,	100.00
1- 4kw. tub-transformer,	250.00
2- 30 kw. 13200/6600-2200/1100 transformers,	<u>950.00</u>
Total,	1495.00

Total Cost,	\$ 6121.16
Allowing 15% depreciation on everything,	\$ 918.00
Labor per year,	<u>1000.00</u>
Total annual cost,	1918.00
Estimate,	
Power used in kw. hr. per year,	23000
Cost per kw. hr. for depreciatio, labor, etc	\$.0833
" " " " at bus-bars,	<u>.05</u>
Total cost,	.1333
Cost of street lighting system,	\$ 317.59
15% depreciation,	48.00
Cost for power for street lights,	<u>162.00</u>
Total annual street light cost,	210.00

By selling power at 15 cents per kw. hr. there would be made .0167 cents per kw. hr. and this would give \$260.00 which is more than enough to cover the cost of street lighting.

CONCLUSION.

From the foregoing estimates I should say that it would be a paying proposition for Laclede Missouri to light its streets and residences by buying power and constructing a transmission line

It is easily seen that by buying current at five cents per kw. hr. at the bus-bars and selling in Laclede at 15 cents per kw. hr. the service may be obtained. The price of 15 cents per kw. hr. is not an extraordinarily high rate for a small place and in small quantities.

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PLATE II.

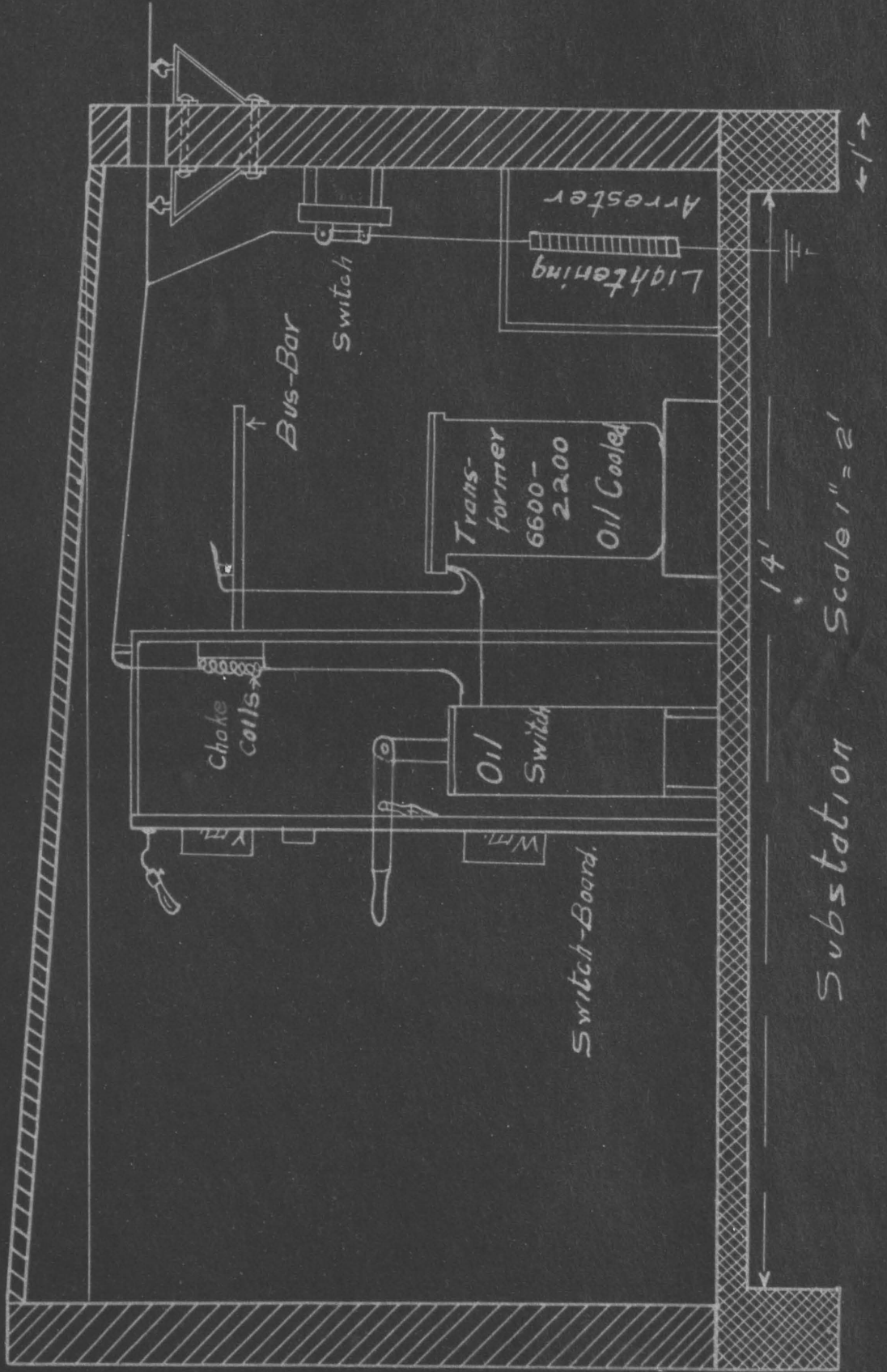
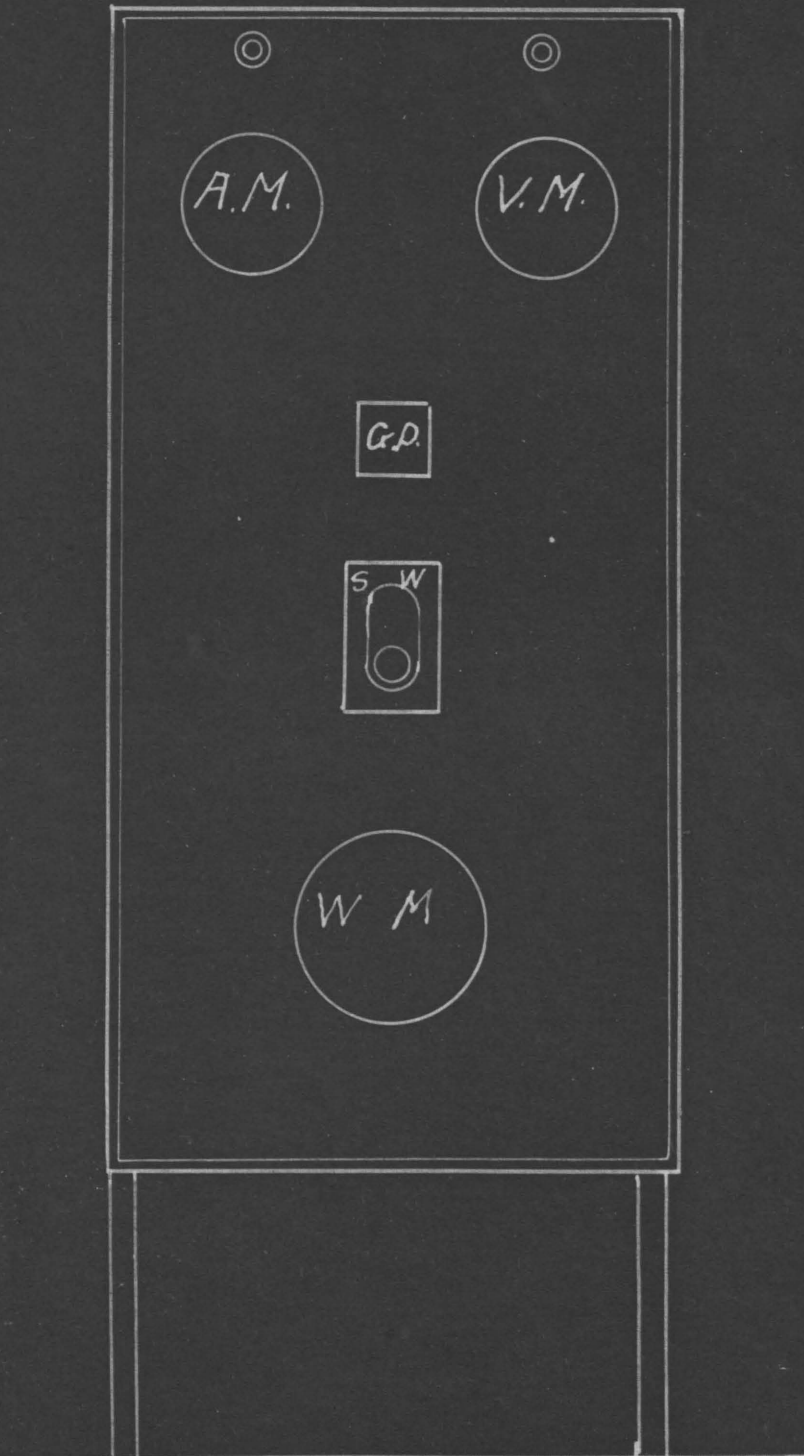
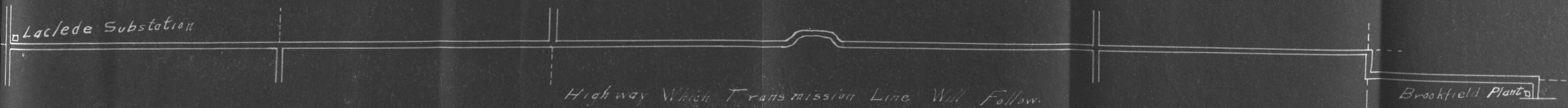


PLATE III.



Switch-board.

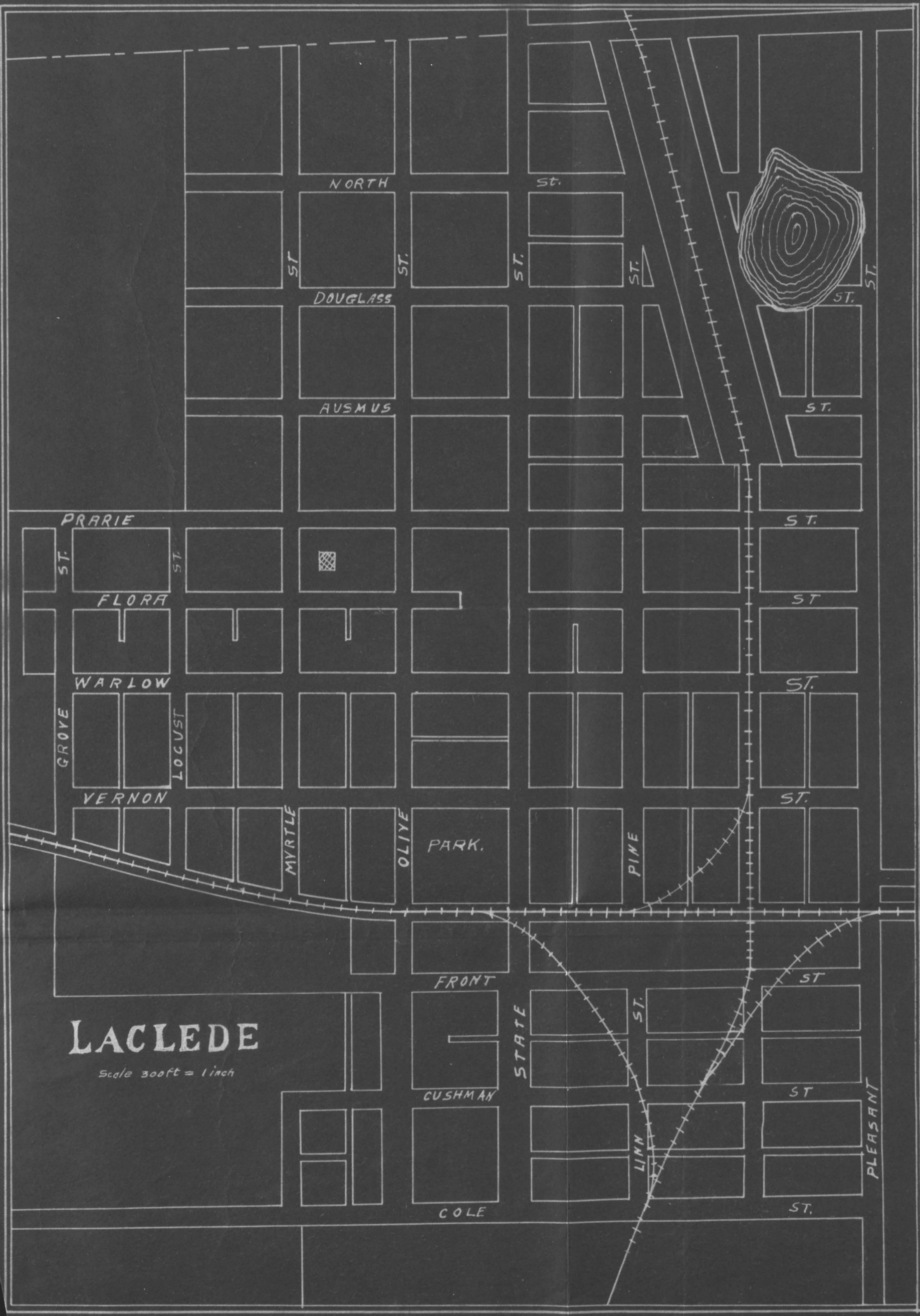
Laclede Substation



Brookfield Plant

Highway Which Transmission Line Will Follow.
Scale 4" = 1 Mile.

PLATE IV



LACLEDE

Scale 300ft = 1inch

NORTH

DOUGLASS

AUSMUS

PRARIE

FLORA

WARLOW

VERNON

PARK.

FRONT

CUSHMAN

COLE

STATE

PINE

LINN

PLEASANT

ST.

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GROVE

LOCUST

MYRTLE

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