T H È S I S

A DISCUSSION AND PLANS FOR REMODELING THE HYDRAULIC LIGHTING PLANT AT CHAPMAN, KANSAS

by

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'08.

A Discussion and Plans for Remodeling the Hydraulic Lighting Plant at Chapman, Kansas.

When a hydro-electric generating plant it to be designed and installed the problem must be taken up with the greatest possible tact and detailed consideration. The first item of importance which must be taken into consideration is the probable amount of power that can be sold and the competition which is to be met in the sale. Having decided that there will be sufficient demand for power to warrant the installation of the plant, and that from such sale a profitable income can be secured, the next question is, will the stream, when dammed, furnish the required amount of power? An estimate will have to be made upon the flow of the stream. The U. S. Geographical Survey Maps are invaluable, when available, for getting the primary idea of the topography and the probable drainage basin. The facts are not really very difficult to get at but guess work is emphatically out of the question and heresay evidence even more worthless than useless.

The power should be figured on minimum flow of water, since a "shut down" is one of the most objectionable occurrences which could happen. It results in dissatisfaction and loss of trade or consumption of power.

Coming now to the consideration of the plant in question, it appears that the estimate of the steady power which can be obtained from this particular stream was greatly exaggerated in favor of installation. In fact at certain times of the year the flow is insufficient to furnish the necessary power to the consumers.

Such a plant without an auxiliary source of power is practically worthless as far as house lighting is concerned, and is a useless expenditure of money.

This plant has been trying to operate under these conditions with the result that it has been running the company in debt to operate it. As the plan is now run, the generating machinery and the translating devices are about 1/4 or 1/3 loaded which means a very low efficiency of operation.

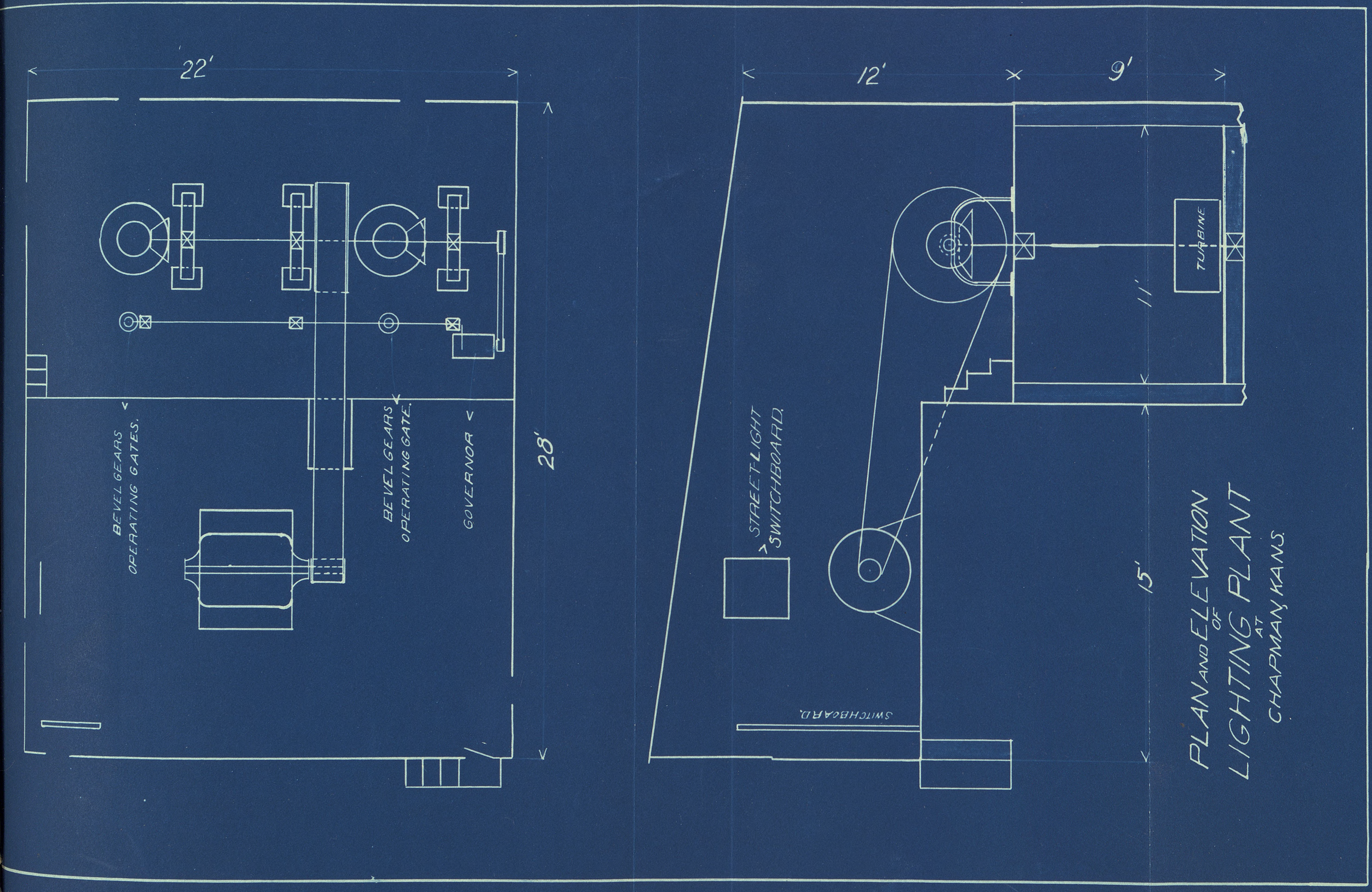
The reason for the small load is as stated before, that the company cannot furnish and cannot promise the same to prospective buyers, hence they refuse, and justly too, to have any electrical apparatus installed.

The people of this town are as a whole very enthusiastic over the electric lights and it appears that the present load can be doubled and more when the company insure to its customers steady power and light.

It now seems that it will be a profitable investment for the company to install auxiliary power and to improve the plant and translating devices in general, making it more efficient than it is at present.

This auxiliary power will need to be large enough to carry the full load but will be run only for a total of about three months out of the year. The running of the auxiliary power plant will be intermittent as sufficient water can be stored in the mill pond to run at least four nights out of each week during times of least flow.

Having once installed this new power, inducements can be offered which will bring the load on the plant up to nearly its


22'
28'
BEVEL GEARS OPERATING GATES.
BEVEL GEARS OPERATING GATE.
GOVERNOR
12'
9'
TURBINE
11'
15'
STREET-LIGHT SWITCHBOARD.
SWITCHBOARD.
PLAN AND ELEVATION OF LIGHTING PLANT AT CHAPMAN, KANS.

rated capacity, thus greatly increasing the efficiency of the plant and increasing the income from it. As the load materially increases these inducements can be with-drawn and thus shut off that portion of the load which does not give a profitable return.

The system of distribution is rather inefficient as it now stands and can be materially improved by some rearrangement of transformers and wiring. This overhauling need not entoil much additional expense as the apparatus is already on hand. It will be the purpose of this research to determine the improvements to be made, their probable cost and the feasibility of remodeling the system.

The Chapman Hydro-electric Lighting Plant is situated on Chapman Creek, one and a fourth miles north-east of the city of Chapman, Kansas.

The station consists of a 100 K W belt driven generator type A.T.B. General Elec. Co. Manufacture, two 125 H.P. Sampson water turbines, governed by a Woodward water wheel governor. This governor is a splendid regulator, giving a speed regulation almost as good as the steam engine. The speed regulation under test did not vary over five per cent from no load to full load.

The turbines are connected to a main driving shaft by means of two sets of bevel gears. These gears are of a comparatively large size having wooden cogs and can be repaired easily, since these cogs can be removed from the main body of the gear. The other equipment consists of a switchboard, including a house lighting panel and a street lighting panel, the house lighting panel being the main switchboard.

The creek on which the plant is situated is somewhat irregular in its flow since it drains a rather narrow strip of country. The storage of large quantities of water is impossible.

Since the plant has been installed there have been certain times in the year during which the flow of water has been large. This was during the fall months of September and October and the spring months of May and June. During the other months the flow has been rather uncertain and in the months of March and August the flow is especially small, and the plant could be run only four or five nights out of each week, making no allowance for dry loads which might occur.

During the periods of low water practically no water flows over the dam. This is because the flow of the stream is not sufficient to furnish the required amount of water to the turbines and keep the head constant. During a night's run the water head becomes so low that it requires the intervening time between runs for the dam to fill up. When the wheels are run with a low head, the amount of water is very large. With such a variation of head the regulator is greatly effected. In fact the governor will not work well when the head is low or under such varying conditions of head. The only way regulation can be maintained at all under such conditions is for the switchboard man to keep his eye constantly on the voltmeter and his hand on the rheostat.

It has been found from experience obtained during the time in which the plant has been in operation that the water supply has been sufficient to carry the load about three-fourths of the time for only night running or about one-half of the time for continuous running. This would leave the remaining part to be supplied by some other power.

The steam engine is probably the most reliable source of power that could be installed. It is comparatively simple in construction and could be tended by a man who would not demand a very high salary. The first cost of installation, however, is large. Then, too, since the engine will not be run constantly it will be necessary to let the steam go down in the boiler and then rebuild the fires and get up steam again. This will necessitate a large comsumption of coal and time. The gas-producer plant is now becoming into existensive use and great claims are being made as to its economy over the steam and the gasoline engines.

In comparing steam and gas engines we give the following data, taken from commercial tests. The gas producer will not use more than 1000 pounds of coal per day of ten hours run. This means a bill of $3.50 for coal and about 35 cents for oil making $3.85 against a bill of about $9.20 for coal supplied to the steam boiler. It will take from 75 to 100 lbs. of coal to generate enough gas to start the machine and about 30 minutes time to do it. It would take 300 - 400 pounds of coal to get up steam in a 100 H. P. boiler and about two hours time to do it. The time and expense of generating gas or steam means much in the case in hand.

The gas producer will not require as much careful attention as will the steam boiler. It will be necessary for the engineer to watch the electrical apparatus and hence the less attention the prime mover takes the more attention can be given to the electrical apparatus.

When the cost of installation is considered the gas plant is found to be much the cheaper of the two. First, because of the first cost of the two, second the gas plant will not require such a large space as will the steam boiler and engine, and third the storage bins for coal will not need to be nearly so large.

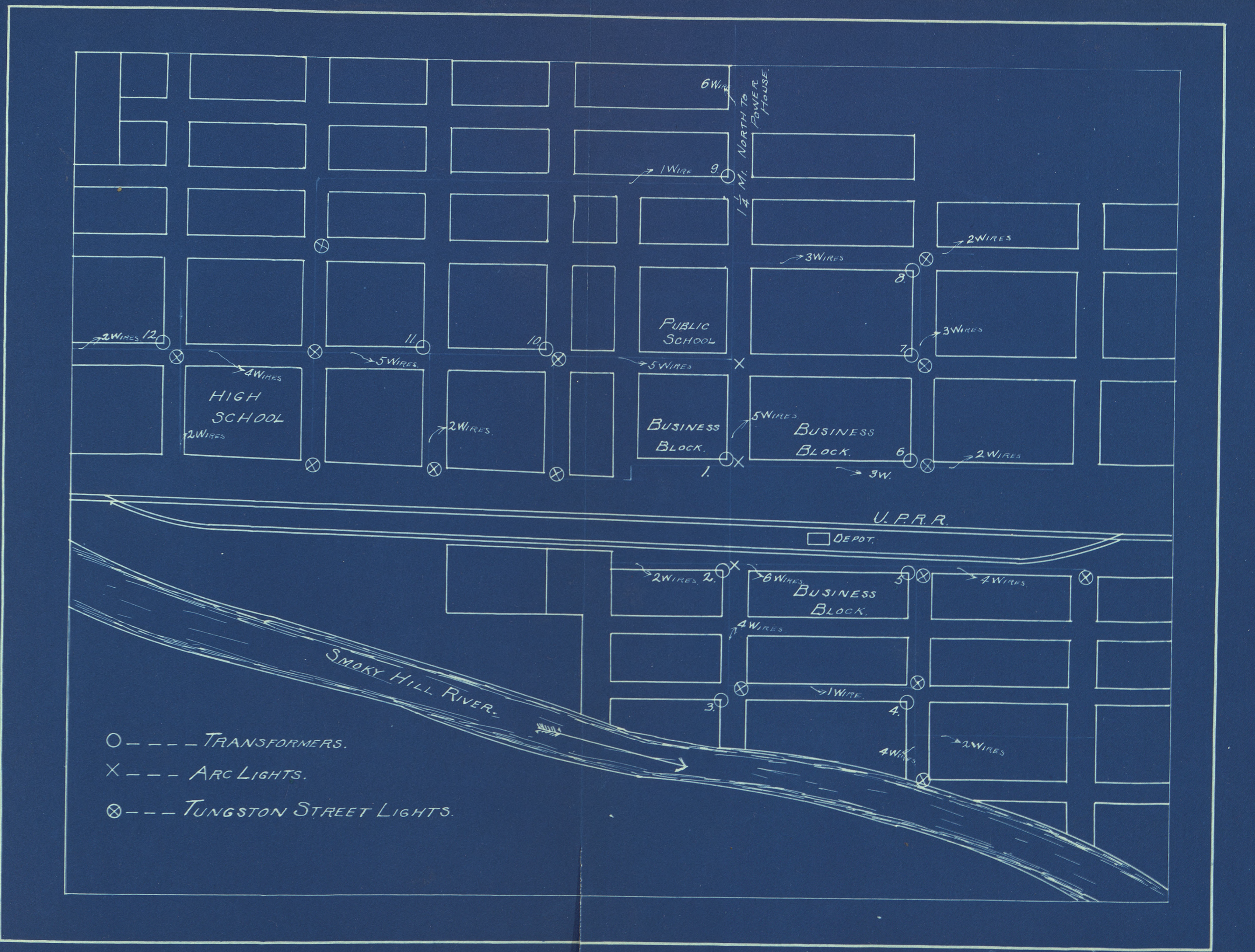
Taking up the comparison of the two remaining powers, (Gas and Gasoline) we have, in regard to the gasoline engine, first the cost of installation for a 100 H. P. engine of the standard type is $5500. Now the cost of fuel for the gasoline engine is $6.66 per month, figuring gasoline at 16 cents per gallon, the average load assumed being 40 H. P., making about $800 for the three months. These figures are taken from tests furnished by the Weber Gas Engine Co.

The gas engine using gas from the gas-producer plant costs about the same as does the gasoline engine of the same rating. The plant costs about $300. This would make the first cost of installation about $5800. Say for additional space about $6000 or $ 500 more than the gasoline installation.

The cost of fuel at the plant will be $4.60 per brake horse power month or $14.40 for the three months, making a saving of about $6 on each H. P. month consumed. The above figures are guaranteed by the Weber Gas Engine Co.

Another matter which must be considered carefully is the regulating qualities of the two engines. Results obtained with the gas engine are much better than those from gasoline power. The guaranteed regulation of the gas engines is two per cent from no load to full load. No company will guarantee this regulation for the gasoline engine.

Considering everything, the gas engine with the producer plant is the best obtainable for the conditions under which the machine must work.



6 Wire
1¼ Mi. North to Power House.
1 Wire
9
2 Wires
3 Wires
8.
3 Wires
7.
Public School
2 Wires
12
11.
10.
5 Wires
5 Wires
4 Wires
High School
2 Wires
2 Wires
Business Block.
5 Wires
Business Block.
6
2 Wires
1.
3W.
U.P.R.R.
Depot.
2 Wires
2.
6 Wires
5
4 Wires
Business Block.
4 Wires
Smoky Hill River.
1 Wire
3.
4.
4 Wires
2 Wires
O----Transformers.
X---Arc Lights.
⊗---Tungston Street Lights.

Distribution.

The lighting system of the Chapman Electric Lighting Company is a simple one but due to poor installation is not as efficient as the ordinary commercial installation should be. To transmit the power from the plant to the city one and a quarter miles away, three number four wires and one number eight wire, Brown and Sharp guage, are used.

On the phase used for house lighting the pressure is maintained at approximately 2280 volts, while on the street lighting phase the voltage is stepped down by two constant potential transformers, so connected that they give a pressure of about 550 volts.

The system as it is now used is a two phase system, one phase; namely, that used for house lighting being loaded about three times as heavy as the phase used for street lighting. This unbalancing of load results in loss of efficiency of the system as well as in additional amount of copper in installation.

As the generator is a three phase machine the best and most efficient method would be to operate the entire system as a three phase system and balance the load as nearly as possible.

Install one large transformer near the center of maximum load which will be in the business block of the city and from which the business district can be lighted. Use one phase for street lighting, connect one phase to the large transformer for lighting the business district, and use the remaining phase for the scattered load consisting of house lighting, thus the load on the three phases will be fairly well balanced and the transmission losses reduced to a minimum.

As the system is now installed, the high and low potential wires and arc light circuits are carried on the same poles. There is at times considerable crowding of lines, and although the high potential wires are kept well separated they are really very close since these lines are tapped off from the high potential lines, and in some cases are as close as six inches to primary wires.

The plot of the town contained in this discussion shows the town to be a very compact one and the problem of distribution can be solved easily and a large line loss prevented. The heaviest part of the load is taken off where transformer number one, (referring to plat of the town) is located. This in the heart of the maximum load and the transformer now installed has only 75 K. W. capacity and is about twenty per cent overloaded. This transformer should be replaced by the large transformer installed in the substation in the suggested plans for distribution.

It was found that the majority of the twelve remaining transformers in the system were only about one-half to one - fourth loaded, this particular one being about twenty per eent overloaded. It was estimated that the efficiency of the system ~~would~~ is not be over seventy per cent, which is, of course, very low as compared to the normal efficiency of the transformer which is about 97 per cent.

The transformers now installed range from 1 K. W. to 7.5 K. W. and are twelve in number. Their capacity and location can be found from following transformers' table and town plot.

The out-put of the plant at present is about 30 K. W., making a light load on most of the transformers, cutting down their efficiency and giving a low power factor.

The problem on this line, as on all other lines, is to secure good regulation and high efficiency at minimum cost of installation. For the two latter purposes, the transformers should be kept loaded to their fullest possible capacity. As in most cases, only part of the lights are on at the same time, It has been found allowable to over load the rated capacity of a transformer from ten to twenty-five per cent with lights, depending also upon the occupation of the inhabitants of the locality. This method gives high efficiency at low cost of installation, but care and judgment must be exercised so as not to overload to such an extent that when dark weather prevails the regulation will be poor.

In the town of Chapman the arrangement could be greatly improved upon by replacing several of the small transformers with one large transformer, and saving the small ones for future developement in the out-skirts of the town. At any rate, even if a few small transformers need lay idle the gain in efficiency of transformation will be enough to warrant such changes.

The changes that it will be advisable to make are about as follows: (Referring to map showing plat of wiring in the city) Take out numbers 6 - 7-10 - and 11 and replace by a 5 K W transformer located at 8. Replace transformer number 1 by a 20 K. W. placed in substation and take out transformer number 3 and number 5 connecting their load to number 1 at substation.

This would leave in 6 transformers with a 20 K. W. in the district of maximum load. The other transformers being well distributed over the town. With a small number of transformers lines, the danger from high potential lines is decreased. The insulation of any transformers is liable to break down and in such a case may result in injury to the consumer. The insulation of the large transformers offers a lighter resistance and also if the number of tranformer is decreased to 1/2 the danger is also decreased proportionally.

The power factor of the system will be raised and the no-load losses deminished by such change. A rough estimation of the efficiency of the system under the proposed plan of distribution would approximate 92%.

The efficiency of the whole system must be given very careful consideration bedause less of the auxiliary power will be needed and often times the water power will be sufficient to carry the required load when it will not be able to do so under present conditions.

The transformers installed are of the ration of 20 : 1, the secondary voltage being 110 volts.

Present, TRANSFORMER INSTALLATION.

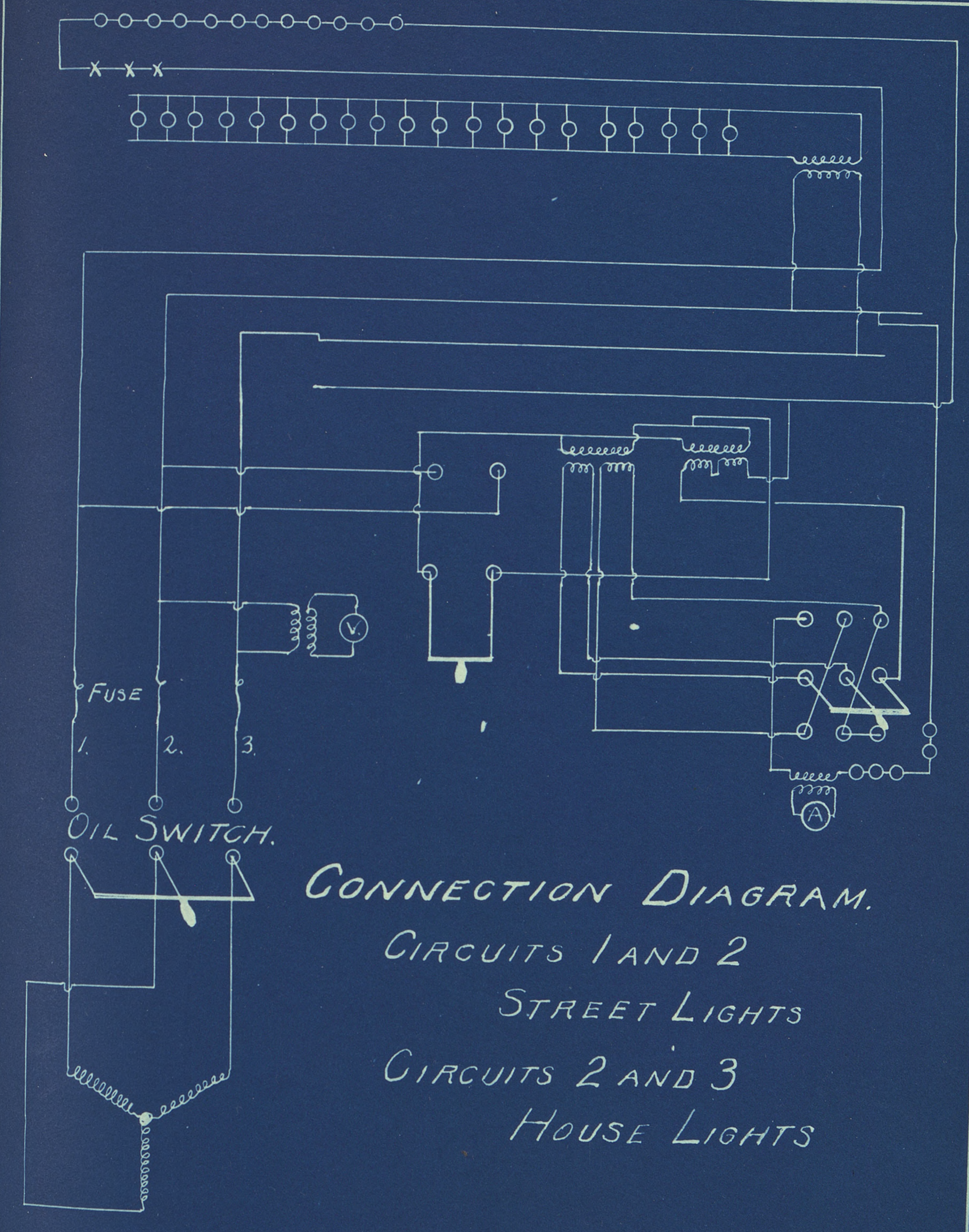
No. of Trans. as given on plot of town.	Capacity of Trans in K.W.	Capacity in C. P. lamps.	Per cent load, lamps.	Over-load		No Load	
				Lamps	%	Lamps	%
1	7.5	150	200	50	20		
2	5	100	40	0	0	60	60
3	2	40	25	0	0	15	38.5
4	2	40	36	0	0	4	10
5	5	100	38	0	0	62	62
6	2	40	10	0	0	30	75
7	1	20	6	0	0	14	70
8	2	40	26	0	0	14	70
9	2	40	8	0	0	32	80
10	2	40	32	0	0	8	20
11	2	40	20	0	0	20	50
12	2	40	12	0	0	28	70

Average per cent unloaded 55%.

Average per cent overloaded 20%.

Total load in lamps 450.

Total load in K. W. 24 3/4.



CONNECTION DIAGRAM.

CIRCUITS 1 AND 2
STREET LIGHTS

CIRCUITS 2 AND 3
HOUSE LIGHTS

Switch Board.

The present switch board connections are as shown in the diagram of the connections. The switch board is composed of two parts, one part having the instruments on it which record the voltage of house lighting circuit; the other part having switches and an ammeter to determine the current of the street lighting circuit. The present switchboard has not enough instruments upon it to enable the operator to tell what is going on, on the line.

A wattmeter and an Ammeter should be installed on the house lighting part of the switchboard and the voltmeter provided with plugs so that the voltage of the different circuits could be determined.

Summary.

The lighting station as it now stands cost in the neighborhood of $12,000. A cost almost $4,000 more than would have been necessary to have obtained a similar installation with a capacity sufficient to meet the present demands. The extra cost was due, principally, to poor judgment in installation.

The income of the plant is, at the present date, $150 per month. This income can be increased to $300 per month if continuous service can be insured. To insure continuous service, an additional investment of $6500 will be necessary.

Suppose that with this additional investment the income of the plant per annum is $3,600; from this the yearly expenses must be deducted, which may be estimated as follows:

Maintainance supplies, etc per year; say 5% of income	$180
Fuel and oil, referring to preceding figures	250
Labor, 1 man at plant $50 per month	600
Labor, 1 manager at $75	900
Depreciation; 8% of income	288
Drayage from station to plant	75
Total..	$2293

$3600 -- $2293 equals $1307.
Capitol invested--- 18500.
Income------------- 1307.00, which gives an income of 7.002 per cent on the investment.

The Chapman Electric Lighting Co. has gone into the hands of a receivor at the present date and the stock is worth, approximately, 70 cents on the dollar so that whoever purchases the plant as it now stands without remodeling will pay out about $7,500. The remodeling will cost, approximately, as stated above, $6,500, making a total cost of $14,000 with an income of $1500 per year. The purchaser would receive 10 per cent upon his investment. This is with present load. There are splendid prospects for increasing the load at least 50 per cent.

We would therefore say in conclusion that to buy the plant and remodel it, would be a good investment, and one that should interest anyone having the required capital to invest.

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