THESIS

DESIGN OF

DAM AND POWER PLANT

BENZIE COUNTY MICH.

GLEASON ALLEN E. C. KIEFER

1913

This thesis was contributed by

Mr. Gleason Allen Mr. E. C. Kiefer

under the date indicated by the department stamp, to replace the original which was destroyed in the fire of March 5, 1916.

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Densio County, Michigan.

\- Thesis of -

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Design of Dam and Power

Plant, Benzie County, Michigan.

The object of this thesis is: 1st, To design a dam and power house to furnish power to Frankfort, Elberta, Beulah, and Benzonia: 2nd, To lay out the necessary transmission lines, and the distribution system for Frankfort: and 3rd, To estimate the cost of the entire development.

In attaining these ends we have divided the work into two general parts, namely:-

Part 1.

The design of the dam and Power House and the estimate for the same to be worked out by H. C. Kiefer.

Part 2.

The transmission lines to furnish power to Frankfort, Elberta, Beulah, and Benzonia, and the distribution system for Frankfort together with the estimate of the cost of the transmission lines and the distribution system for the four towns to be worked out by Gleason Allen.

Part 1.

The advisability of obtaining power from the Betsie River in Benzie County, Michigan, has been under consideration for a long time by various men of means. The attractive features of the project are: first, the steep slope of the stream, second, the steep banks, which means a small floodage area, and third, the steady flow of the river. Further, the fuel question for electric power is a feature attracting no small amount of attention. The power obtained can be used for lighting the towns of the surrounding country and also to run the various industries requiring power.

The survey for constructing the contour map as shown by sheet No. 1, was made by us during the Spring vacation of this year. We carried our levels along with running the traverse. The nature of the banks of the river are also shown for some distance below the dam. The field note books attached are considered as a part of this thesis.

The river has a comparatively steady flow as is shown by the precipitation table as recorded by the U. S. Department of Agriculture, Weather Bureau. From the above paper is taken the following extract; " The precipitation is greatest during the late spring and early summer and least during the winter, but with all is well distributed throughout the year. Summer drouths are comparatively rare, the most severe one of which there is record being in 1908, ---- During which time the average precipitation was between 0.5 and 0.75 of an inch".

Year	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
1897	3.03	1.77	2.12	3.[illegible]	3.48	2.31	1.90	2.07	2.[illegible]
1898	3.86	2.55	2.06	2.99	2.06	3.40	[illegible].94	4.07	1.40
1899	1.09	0.80	1.53	1.79	1.42	5.06	4.05	[illegible].94	1.53
1900	2.45	3.[illegible]	2.[illegible]	1.00	0.17	1.90	7.03	3.55	5.[illegible]4
1901	3.60	1.25	3.12	[illegible].4[illegible]	1.71	2.16	3.97	2.97	3.75
1902	2.[illegible]	1.0[illegible]	1.44	[illegible].97	3.5[illegible]	2.80	5.60	1.97	---
1903	2.[illegible]	1.60	3.65	1.87	2.53	2.51	2.39	3.2[illegible]	3.98
1904	2.42	3.1[illegible]	1.71	2.22	3.63	0.83	1.02	3.66	4.1[illegible]
1905	----	2.[illegible]5	1.79	1.[illegible]6	3.19	2.25	7.46	3.[illegible]1	1.9
1906	2.57	2.16	2.[illegible]6	0.39	1.42	2.78	1.39	[illegible].02	2.64
1907	3.66	1.44	2.30	2.33	2.06	3.23	3.39	1.20	3.79
1908	1.46	3.64	2.19	-----	-----	----	----	----	0.00

Year	Oct.	Nov.	Dec.	Annual.
1897	3.01	1.19	2.73	31.74.
1898	6.55	1.99	3.[illegible]	37.43.
1899	1.96	0.66	4.52	85.53.
1900	2.45	3.62	2.[illegible]3	33.95.
1901	4.30	2.04	2.5[illegible]	31.66.
1902	----	-----	1.55	-----
1903	1.32	3.62	2.3[illegible]	31.25.
1904	2.63	1.97	1.63	26.[illegible]2.
1905	3.1[illegible]	1.93	2.71	-----
1906	3.23	3.59	3.05	26.12.
1907	0.67	2.31	1.62	26.42.
1908	1.46	3.64	2.01	-----

Mean Jan	- 2.69	Aug.	2.43.
Feb.	[illegible]	Sept.	3.27
Mar.	2.15	Oct.	2.71
Apr.	1.69	Nov.	2.17
May.	2.44	Dec.	2.49
Jun	2.32	Ann.	29.65.
Jul	3.41		

The above table shows that at no time were there any two consecutive months with a minimum rainfall, the average minimum being 1.89 inches. From Merriman's Hand Book the percolation for ordinary soil with sod is about 66 %. This gives the minimum percolation as 1.25 inches. One inch of rainfall is equal to .9 of cubic foot per second per square mile. Therefore the run-off is 1.39 cubic feet per square mile.

From various records the length of the [illegible] River is about 63 miles, and having a run-off area of about 310 square miles of surface mostly sodded and only slightly cultivated, and with considerable timber.

31[illegible] x 1.39 equals 432 cubic feet per second, as the discharge of the river.

From our survey the cross sectional area of the river is 126.4 square feet, and with a slope of 0.45 feet per mile. From Kutter's formula and Chezy's coefficient,

V equals C $\sqrt{rs}$, where

V equals velocity and C equals Chezy's coefficient.

r-equals Hydraulic radius equals $\frac{\text{area}}{\text{wetted perimeter}}$

s-equals Slope of stream.

The velocity is given.

C equals 50

s " $\frac{8.45}{5280}$ equals .0016.

p " 46.8

r " $\frac{126.4}{46.8}$ equals 2.7.

V " $50\sqrt{2.7 \times .0016}$ equals 50 x .066 equals 3.3 feet per sec.

The discharge is given by the formula.

Q-equals av.

Q equals 126.4 x 3.3 equals 417.12 cusec.

Sheet No. 2 is a profile of the center line of the dam as obtained from data of the [illegible] County Power Company. The bank on the north side of the river being very flat and comparatively long it seems advisable to construct a combination concrete and earth fill dam. The nature of the subsoil also condemns an entirely concrete dam, because of the great expense.

In designing the dam the pressure of ice must be considered for so cold a country. From sheet No. 1, it is shown that a head of 25 feet can be attained without flooding a great area or backing the water onto any dam further up stream.

Using a head of 25 feet, it is deemed advisable to place the base of the dam about 6 feet in the clay bottom of the river, and further prevent percolation, and sliding by driving a double row of [illegible] sheet piling deep enough to reach the next clay strata below the gravel as shown on Sheet No. 2. [illegible] of the clay that is excavated here can be used on the earth fill portion. The spillway and power house are to be placed in the stream as shown by Sheet 4. A concrete core-wall with a 4 foot base, and a 2 foot crest, will be used in the earth fill portion; the wall being placed deep enough to get solid footing and prevent percolation. The up-stream face of both core wall and spillway are to be faced with a half inch of clear cement.

The spillway section is trapezoidal with a short apron of concrete, and a further length of apron built of paving brick on a 6 inch concrete foundation.

To obtain an economical design for the spillway section with a crest of 4 feet the following formula was used. (From American Handbook.)

b equals $\sqrt{A^2 \text{ plus } B}$ - A where,

A " 1/2 a.

B " a^2 plus (0.1 plus wd^2) d / vh, where,

H " ice pressure.

w " weight of cubic foot of water.

d " height of water above the base.

h " d equals height.

v " weight of 1 cu foot of masonry.

a " 4' ; H equals 4[illegible] #, w equals 62.5 #,

d equals [illegible]; v equals 145 #.

A equals 1/2 x 4 equals 2.

B " 2^2 plus (.6 x 4[illegible] plus 62.5 x [illegible]^2) / (145 x [illegible]) so equals

16 plus 7040 / 145 equals [illegible].

b equals 4 plus [illegible] -2 equals 23.1 -2 equals 21.1'.

Let l equal base width 6 feet below river bottom.

$$\frac{22}{[illegible]} = \frac{21.1}{l}$$

l equals $\frac{21.1 \times 35}{22}$ equals 25.5' equals base width.

The entire weight of a foot length of spillway is

$\frac{(25.5 \text{ plus } 4)}{2}$ 35 x 145 equals 74000 #.

$\frac{74000}{25.5}$ equals 2900 # per square foot.

The minimum bearing strength of wet clay is [illegible] # per square foot. (Merriman's Handbook). The above pressure per square foot comes within the minimum, therefore is O.K. The cross section was then further designed as shown on Sheet 4-A, and tested graphically and found to be O.K. as the resultant pressure falls within the middle third.

To avoid over flow of the earth fill, this portion of the dam is 5 feet higher than the spillway section. Retaining walls are used to hold the earth fill in place, and avoid its being carried over to the spillway or turbine tubes.

The form of turbine decided upon is an enclosed case turbine not requiring a penstock, and using a draft tube. The power necessary for the system, as shown in part 2 of this thesis, is 665 H.P. To accommodate this, two turbines of [illegible] H. P. each, making 164 K.W. and each using 249 cubic feet of water per second, were decided upon. This would allow a minimum spill of 117 cubic feet per second over the spillway. The turbines are to be direct connected to the generators for power and lighting purposes.

The power house is to be of concrete walls and floor with a frame roof and composition covering. A crane is to be provided for use in moving the machines if necessary. Sheet No. 4 shows the design of the power house and the location of machines and draft tubes. The draft tubes are to be long enough to be at all times not less than 6 inches below the surface of the tail-race.

The tail race is to be of concrete one foot thick, and on the same level as the apron of the spillway.

To avoid any settlement of the foundation of the power house the structure is to be built on wooden piles of not less than 10" in diameter at the top, and long enough to reach the next clay strata below the gravel, and placed with 3' centers.

The entrance is to be from the north side, a road being built on the down stream side of the earth fill. To get to the power house a road can be easily constructed from the main highway, which is only a short distance away.

All gravel and sand for the concrete can be obtained from the banks in the vicinity, none requiring over 1000 feet of haul. Earth for the earth fill can be procured with equivalent ease. This information was obtained from the Dansie County Power Company.

Estimates of Cost of
Dam and Power House.

Concrete of a 1 : 3 : 6 mixture cost $5.00 per cubic yard in place, including costs of of forms, etc., for work in the dam. The same mixture for the power house in place costs $6.00 per cubic yard.

The earth fill for the dam can be hauled and placed for 30 cents per cubic yard.

Excavation of earth at 30 cents per cubic yard. Timber for building costs about $16.00 per M. Timber for 10" piles in place at 60 cents per linear foot.

Floodage area:-

201.81 acres of land at $12 per acre -----------	$ 2421.72.
Concrete in spillway; 2133 cu yds at $5.00 -----	10665.00.
" " retaining walls; 4[illegible]0 cu. yds. at $5.00	2[illegible].
" " building; 452 cu yds. at $6.00 -----	2712.00.
Piling for power house in place ----------------	2[illegible].
Sheet piling for spillway in place -------------	175.00.
Cost of roof for building ---------------------	1[illegible].00.
Brick for spillway; 7.5 M at $10 per M. --------	75.00.
Removal of muck; 1[illegible] cu yds. at 50 cents -------	50.00.
2 turbines at $[illegible] ----------------------	1[illegible].
Total -------	$19878.72.

Conclusion.

The location of the power-house and spillway of the proposed plant of the Benzie County Power Company is practically the same as in this thesis except in regards to distances. They have made plans to utilize the entire minimum flow of the river thru their turbines, while we are only using enough water to supply our present peak load. For this reason our spillway is somewhat longer than their proposed plan.

Their plant takes in the idea of the use of a penstock and sluice gates. Between the power house and spillway is a chute about 4 feet wide for the purpose of running logs thru, if necessary.

Their power house and spillway is to rest on piles with 4 foot centers, but they do not use sheet piling on the up stream side of the spillway as proposed in this thesis. Further, we do not require bearing piles under the spillway section as the base width is great enough to accomodate the weight of masonry.

The slope of this earth fill, on the up stream side, is 3 to 1; where we use a 2 to 1. A 2 to 1 seemed reasonable as the fill will be a large percentage clay; the natural slope of which is 1 to 1, and further there is no action of running water on this section to wear the surface away.

Part 2.

Transmission Lines and Distribution System.

The location of the towns to be supplied are shown by print No. 5.

Frankfort is a town of 1500 population. By a canvass its probable lighting load was determined at 74 K.W., which minus 14 K.W. hotel load (Frankfort being a summer resort) give about 375 Watts per capita. This compares very well with Manistee, which with a similar system has an average load of about 36 Watts per capita. The power load at present will consist of 25 K.W. for the town pumping station and 26 K.W. for a flour mill, making the total load 125 K.W.

The other three town have a lighting load only, which is as follows:-

Town	Population	Load.
Elberta	650	35 K.W.
Beulah	400	[illegible] K.W.
Bensonia	600	30 K.W.

Transmission Lines.

Two transmission lines were laid out. One to supply Frankfort, and Elberta , and the other to supply Beulah and Bensonia. These lines are kept entirely separate so that trouble on one will not interfere with service on the other.

The total length of the lines are 17.[illegible]7 miles, They are to be three wire supplying 3 phase 60 cycle current at 7,2[illegible] Volts, poles spaced 125 feet apart.

Although 30 cycles and 7000 V are not generally considered as standards yet they are used extensively by the commonwealth power company with very good results and were chosen for that reason.

The sizes of the wires were figured from the formula,

$$C.M. \text{ equals } \frac{D \times W}{P \times E^2} K. \quad \text{where,}$$

W equals power transmitted in watts.

D " Distance one way in feet.

P " Percent loss in line of W.

E " Volts delivered between main conductors and phase.

K " Factor depending on power factor.

C.M. " Area of wire in circular Mills.

For a 3 phase system operating at 7000 V with an 85 % power factor and a 5 % drop this formula reduces to,

C.M. equals $D \times W \times .0060$. where,

C.M. " area of wire in circular Mills.

D " Distance one way in feet.

W " Power delivered in K.W.

It was in this form that the formula was used, provision being made for a 40 % increase in the Frankfort load, the Elberta load remaining constant, while the Beulah - Benzonia line was figured for a load of about twice that which it has at present.

A complete layout of the lines is shown by print No. 5 and the estimate of the cost construction as given below.

Frankfort Distribution System.

House Lighting and Power.

The distribution system for Frankfort was layed out in accordance with the practice of the Commonwealth Power Co. The lines were run three wire single phase 110 and 220 volts. The sizes of the outside conductors were figured from the same formulae as given above under transmission lines, which for single phase 220 V and 90 % power factor allowing a 3 % drop, reduces to,

C.M. equals D x W x 19, where,

C.M. " Area of conductor in circular Mills.

D " Distance one way in feet.

W " Power Transmitted in K.W.

The center wire was taken as one half of the size of the out side ones. A complete layout of the system is shown by print No. 6.

Street Lighting.

For a desirable street lighting system the choice lay between the use of series and multiple tungsten lamps. The latter was chosen because of the high first cost and unreliability of the former. The laying out of this system is proposed to be done by using the middle wire of the house lighting circuits as the return. This makes it necessary to run but one wire when the street lamps are adjacent to these circuits. If necessary to complete the return the middle wires of the various transformers may be connected together.

For controlling these lights time switches are provided.

A complete layout of the street lighting system is shown by print No. 2.

Generators.

It is figured that two 200 K.W. direct connected 3 phase 30 cycle, 72,000 V water wheel type alternators operating at about 270 R.P.M. would be the proper installation, since one unit will then take care of the entire load. This will result in a waste of water at low load but since the supply of water is twice that needed at present there is no need of economy in this direction. Provisions are to be made of the installation of larger machines when necessary.

Frankfort Estimate.

House Lighting and Power.

2760'	No.1	Ins wire plus 10%	= 970#	at 21 ¢	in place	$ 4.7[illegible]
7100'	No 2	" " " "	= 2050#	" 21 ¢	" "	4[illegible]1.5[illegible]
15040'	No 4	" " " "	= 2050#	" 21 ¢	" "	[illegible].8[illegible]
13300'	No 6	" " " "	= 1520#	" 23 ¢	" "	3[illegible].[illegible]
33340'	No 8	" " " "	= 2750#	" 23 ¢	" "	2[illegible]
700[illegible]'	No 10	" " " "	= 37[illegible]#	at 23¢	" "	[illegible]1.
352	Single phase meters	$[illegible] in place			------------	[illegible]10.
3	Three phase power meters	at $15.00			---------------	45.
4	20 K.W. transformers	at $171.00 in place			----------	[illegible]4.
8	10 K.W. "	at 117.00 in place			----------	[illegible].
3	5 K.W. "	at 69.50 in place			----------	2[illegible].50
130	30 ft. poles	at 8.00 in place			----------	1[illegible]
142	35 ft. poles	at 9.00 in place			----------	1278.00
365	4 pin cross arms	at 1.00 in place			----------	365.00
10	6 pin cross arms	at 1.30 in place			----------	13.
1600	Insulators at [illegible] dollars per 1000					[illegible]
					Total ---------	$10[illegible].5[illegible]

Frankfort Estimate (continued)

Street Lighting System.

20730'	No 8 line wire plus 10% equals 22800' at 23¢ in place	$ [illegible]
27	35 ft poles at 9.00 dollars in place	243.00.
35	30 ft poles at 8.00 " in place	280.00.
33	2 pin cross arms at 80 ¢ in place	26.40.
300	Insulators at $30.00 per thousand	9.00
50	Lamps at $1.00	50.00
11	Suspensions at $5.00 in place	55.00
39	Pole brackets at $5.00 in place	195.00.
5	Pole switches at $[illegible] in place	1[illegible]5.00
	Total ----------------------	$1400.40.

Total (street lighting and house lighting) $11000.75.

[illegible]berta Estimate.

House Lighting.

4[illegible]'	No 4 Ins wire plus [illegible]% = 723 lbs at 21¢ in place	[illegible]151.[illegible].
6[illegible]'	No 6 " " " [illegible]% = 74[illegible] " at 23 in place	27[illegible].[illegible].
10[illegible]	No 8 " " " [illegible]% = 15[illegible] " at 23 in place	[illegible].6 .
83	Single phase motors at [illegible] in place ------------	664. .
1	2[illegible] K.W. Transformer at $171.[illegible] in place ------------	171.[illegible] .
1	1[illegible] K.W. " at 117.[illegible] in place -----------	117.[illegible].
2	5 K.W. " at 69.5[illegible] in place -----------	139.[illegible].
2[illegible]	3[illegible] ft poles at $[illegible] in place --------------------	[illegible].[illegible].
[illegible]	35 ft poles at [illegible] in place --------------------	7[illegible].[illegible].
232	4 pin cross arms at $1.[illegible] in place ---------------	232.[illegible]
9[illegible]	Insulators at $3[illegible] per 1000 -----------------	27.[illegible].
	Total ------------------	$[illegible].63.

Street Lighting.

11,[illegible]'	No 8 Ins. wire plus 10 % = 91[illegible] lbs at 23 ¢	[illegible].3 .
2[illegible]	3[illegible] ft poles at $[illegible] in place -----------------	24[illegible].[illegible].
15	2 pin cross arms at 8[illegible] ¢ in place --------------	12.4 .
140	Insulators at $3[illegible] per 1[illegible] ---------------	42 [illegible].
26	Lamps at $1.[illegible] ------------------------------	26.[illegible] .
3	Time switches at $25.[illegible] in place --------------	75.[illegible] .
86	Brackets at $[illegible] in place ------------------	[illegible].
	Total ------------------	[illegible] 6[illegible].9 .

Total (House lighting plus street lighting) $[illegible].[illegible].

Rough Estimate.

House lighting system.

7500' No 6 Ins wire plus 10 % = 925 # at 23¢ in place $212.75.

15000' No 8 Ins wire " 10 % = 124[illegible] # at 23¢ in place 285.2[illegible].

12000' No 10 " " " 10 % = 673 # at 23¢ in place 134.7[illegible].

60 Single phase meters at [illegible] in place ------------ 40[illegible].

5 5 [illegible] transformers at $[illegible] in place -------- 367.5[illegible].

30 3[illegible] ft poles at $[illegible] in place ------------------ 24[illegible].

41 35 ft poles at $[illegible] in place ------------------ 36[illegible].

94 4 pin cross arms at $1.[illegible] in place ------------- 94[illegible].

4[illegible] Insulators at $[illegible] per 1[illegible] ----------------- [illegible].

Total ------------------$2[illegible]

Street Lighting.

[illegible]' No 8 Ins. wire plus 10 % = [illegible] # at 2[illegible]¢ in place 151.7[illegible].

19 3[illegible] ft poles at $[illegible] in place --------------- 1[illegible].

19 2 pin cross arms at [illegible]¢ in place -------------- 15.[illegible].

2[illegible] Insulators at $[illegible] per 1[illegible] --------------- 6.[illegible].

25 Lamps at $1.[illegible] ------------------------------- 25.[illegible].

25 Brackets at $5.00 in place ------------------- 125.[illegible].

3 [illegible] switches at $25.[illegible] in place ------------- 75.[illegible].

Total --------------------$ 55[illegible].

Total (Street lighting and house lighting) ----------$3725.17.

[illegible] Estimate.

House Lighting System.

16000'	No 6 Ins wire plus 10% = 1970# at 21¢ in place	$413.70.
32000'	No 8 Ins wire plus 10% = 2640# at 23¢ " "	607.20.
20000'	No 10 " " " " = 1480# " " " "	340.40.
90	Single phase house meters at $8.00 ----------	720.00.
8	5 K.W. phase transformers at $69.50 ----------	556.00.
52	30 ft poles at $8.00 in place ----------------	416.00.
60	35 ft poles at $9.00 in place ----------------	540.00.
150	4 pin cross arms at $1.00 in place -----------	150.00.
600	Insulators at $30.00 per 1000 ----------------	18.00.
	Total ----------------	$3761.30.

Street Lighting.

15000'	No 8 Ins wire plus 10% = 1[illegible]40# at 23¢ in place	$ [illegible]
200	Insulators at $30.00 per 1000 ----------------	6.00
27	Lamps at $1.00 -------------------------------	27.00.
27	Brackets at $5.00 in place -------------------	135.00.
3	Time switches at $25.00 in place -------------	75.00.
	Total ----------------	$ [illegible].2[illegible]

Total (House and Street Lighting) ---------------- $42[illegible].5[illegible]

Transmission Line.

570	30 ft poles at $8.00 in place ----------------------	4560.[illegible]
100	35 ft " " $9.00 in place ----------------------	900.
50	40 ft poles at $11.00 in " ----------------------	550.
82	6 pin cross arms at $130 in place ------------------	106.6[illegible]
638	4 pin cross arms at $1.00 " " ------------------	638.
2406	10000 V Insulators at $130 per 1000 ------------------	312.78
114,522'	No 8 bare wire 1[illegible] = 6,300# at 23¢ in place ---	1440.[illegible]
106,436	No 2 " " " = 39,[illegible]# at 21¢ " " ---	819[illegible].
	Total ------------------------	$ 10706.30

Power House and Dam.

Cost of Dam and Power House complete	(Kiefer's report)	18870.72
Cost of Turbines in place	(" ")	1000.00
2	250 K.W. alternators at $2,400 ------------------	4800.00
1	Switch board complete --------------------------	1200.00
2	5 K.W. exciters at $120.00 ----------------------	240.00
	Total ------------------------	$ 26110.72

Total Cost of Development.

Frankfort (complete)	----------------------------	$21080.76.
Alberta "	----------------------------	3055.53.
Beulah "	----------------------------	2725.17.
Benzonia "	----------------------------	4000.50.
Transmission Line	----------------------------	107[illegible]6.3[illegible].
Power House and Dam	----------------------------	20210.73.
Sundry Expenses	----------------------------	5[illegible].
Total	----------------$	7[illegible]676.[illegible]9.

Cost of Power per K.W. H.

Yearly expenses.

Fixed charges at 15 %	----------------------------	10[illegible]71.4[illegible].
1 Gen Supt. at [illegible] per month	----------------	1[illegible].
1 Clerk at [illegible] per month	------------------	6[illegible].
1 Eng.(Day) at $75 per month	----------------	9[illegible]
1 " (Night) at 22 1/2¢ per hr.	---------------	91[illegible]
2 Repair men at 22 1/2¢ per hr	--------------	1[illegible].
Sundry expenses	----------------------------	[illegible].
Total	-----------------$	161[illegible]0.4[illegible].

Allowing use of current on an average of 3.5 hours a day the cost of current per K.W. is $\frac{\$161[illegible]0.4[illegible]}{3.5 \times 365 \times [illegible]}$ = /K.W.H.

Conclusion.

In view of the fact that the Benzie County Power Company which is at present installing a plant similar to the one figured in this thesis, has a contract with the town of Frankfort whereby it agrees to supply a street lighting system at about 1.50 dollars per lamp per month and current for house lighting at 10 cents per K.W. it would seem that an installation as figured here would be a very good investment.