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T H E S I S

DESIGN OF A 75 K. W. POWER STATION

by

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DESIGN OF 75 K. W. POWER STATION.

The first consideration in installing a power plant is the cost. Whether or not the money invested will bring returns, is the proposition that outweighs all others. This resolves itself into the supply and demand for power and the cost of producing the power and installing the necessary machinery. In the design of this plant the cost of installation has been the foremost consideration, the cost of producing coming as an afterthought.

The supply is taken care of with but little thought. Estimating the probable demand as based on other towns of like size and selecting machines that are rated to deliver the required output. The maximum capacity of these machines is the output during the peak of the load, while all first class machines are designed to carry from 25 to 30 per cent overload for a short time, should it be necessary.

The demand for power is something that is beyong the control of the designing engineer, but to give good service and that at as low a cost as possible to the producer, must be his aim. Here, again comes in the consideration of cost. The plant should be built to give satisfaction to the consumer and to furnish power at a price that will compete with other kinds of power and lighting. To furnish power and light at a competing price the machines installed must be of the highest efficiency obtainable and the distributing apparatus of such a design as to make the loss of energy minimum.

The transmitting of energy will be the deciding factor in the selection of the electric machines. Whether direct or alternating current machines shall be used and if alternating, the frequency best adapted to the demands etc.

The amount of money invested, depends to a great extent, upon the size of the plant, and the demand for current, as well as upon the service, provided, in a small plant such as this, it will hardly be good practice to put in mechanical stokers, because of the fact that the money invested would not bring adequate returns, although the operating expenses would be reduced thereby. The same reasoning will govern the selection of a smoke-stack whether it shall be built of brick or of steel. In a similar manner other features of the power plant are to be decided upon, while the selection of the building material is governed more or less by local conditions. In selecting electric machines, nothing but first class machines are to be installed. All authorities on engineering subjects agree that this is the best business policy and the cheapest in the long run.

Summing up all considerations the cost of installing must be a compromise between the cost of production and good service on one hand and the amount of money on which the plant will pay dividents.

Building

Material

234 perch stone at $3 per perch	$690.
414 perch stone at $3 per gables	132
Roof of Elaterite at $4.50 per square	135
3000' roof sheathing (ship-lap) $25	90
80 2x6 20' rafters $25	40
23 2x8 32' floor joist	25
44 2x6 32' ceiling joist	35
14 windows 30x34 -- 2 light--	40
1200 sq..ft. flooring -yellow pine-	35
Doors	25
Nails & Hardware	100
Carpentry work	125
Total-----------------------------	$1472.

Equipment

Mechanical

2 - 60 H. P. Boilers - W.T.-	1300
Boiler foundation	
10000 brick	85
7 cu. yd. sand	7
18 bu. lime	8
7 bbl. cement	8
1 - 100 H.P. corliss engine 14x36-12' wheel.	1550
Engine foundation	
14400 brick	122.40
11 cu. yd. sand	11.00
30 bu. lime	25.00
11 bbl. cement	13.00
Pump	115.00
Pipe	
50' - 6" steam pipe	
20' water supply	
12' exhaust	200.00
Heater - 150 H.P. open Feed Water	200.00
Generator Belt 70' x 14" D.E.	250.00
Idler for belt	25.00
Chimney iron, 60' x 2'	125.00
Cost of installation	200.00
Total-----------------------------	

Electrical

One (1) 75 K.W., 60 cycle, 2300 V. 3 phase revolving field alternator, 900 R.P.M.

One (1) 2.5 K. W. 125 V., D. C. Exciter, (Comp. Wound.) exciter belt 25 ft. x 4 in. $1225.00

One (1) Blue Vermont Marble Generator, Exciter and Feeder Panel

Following instruments to be mounted on Panel.

3 Ammeters (0-25)	
1 A. C. voltmeter (0-150)	
1 D. C. " "	
2 Incandescent light ground Detectors.	
3 30 amp. 2300 V. fuse holders and rec.	
1 3 pole - 2300 V. 25 Amp. oil switch	
1 Potential Transformer (20-1)	
Synchronizing Plugs	
1 Double Pole 124 V. 20 amp. D. C. switch	
1 Current Transformer	
Alternator Field Rheostat	
Exciter Field Rheostat	$200.00
Generator Foundation Material	
Cost of installation	150.00

One (1) Arc Light Panel with followinginstruments:

Mounted	
1 Oil Break Switch	
1 A. C. Ammeter (0-10)	
2 Primary fuse holders and fuses	
1 Ammeter plug and Receptacles	
1 Constant Current Transformer	$ 50.00

Outside Wiring

1200 ft. #4 rubber insulated wire for arc light cir.	
17300 #4 " " " to Transformers	
34250 ft. #4 " " " from "	
25000 ft. #4 " " " " Feeders to Houses.	
Total--	$1700.00
Poles;	
10--30 ft.--6 in top	
140 25' -- 6 in top	600.00
90 4 pin -- 5 ft. H. P. cross arms	
60 2 pin -- 3 ft. " " "	60.00
300 braces 2 in x 1/4 in x 2 ft.	54.00
300 lags for braces and poles	12.00
300 bolts for cross arms	8.00
(600 1 1/2 inch. Locust pins	
(600Deep Grove Double Petticoat Insulators	300.00
Braces, Guys, Anchors, etc.	550.00
Transformers 5, 7.5, 7.5, 15, 20	187.50
10 arc lights - 200 c p series.	

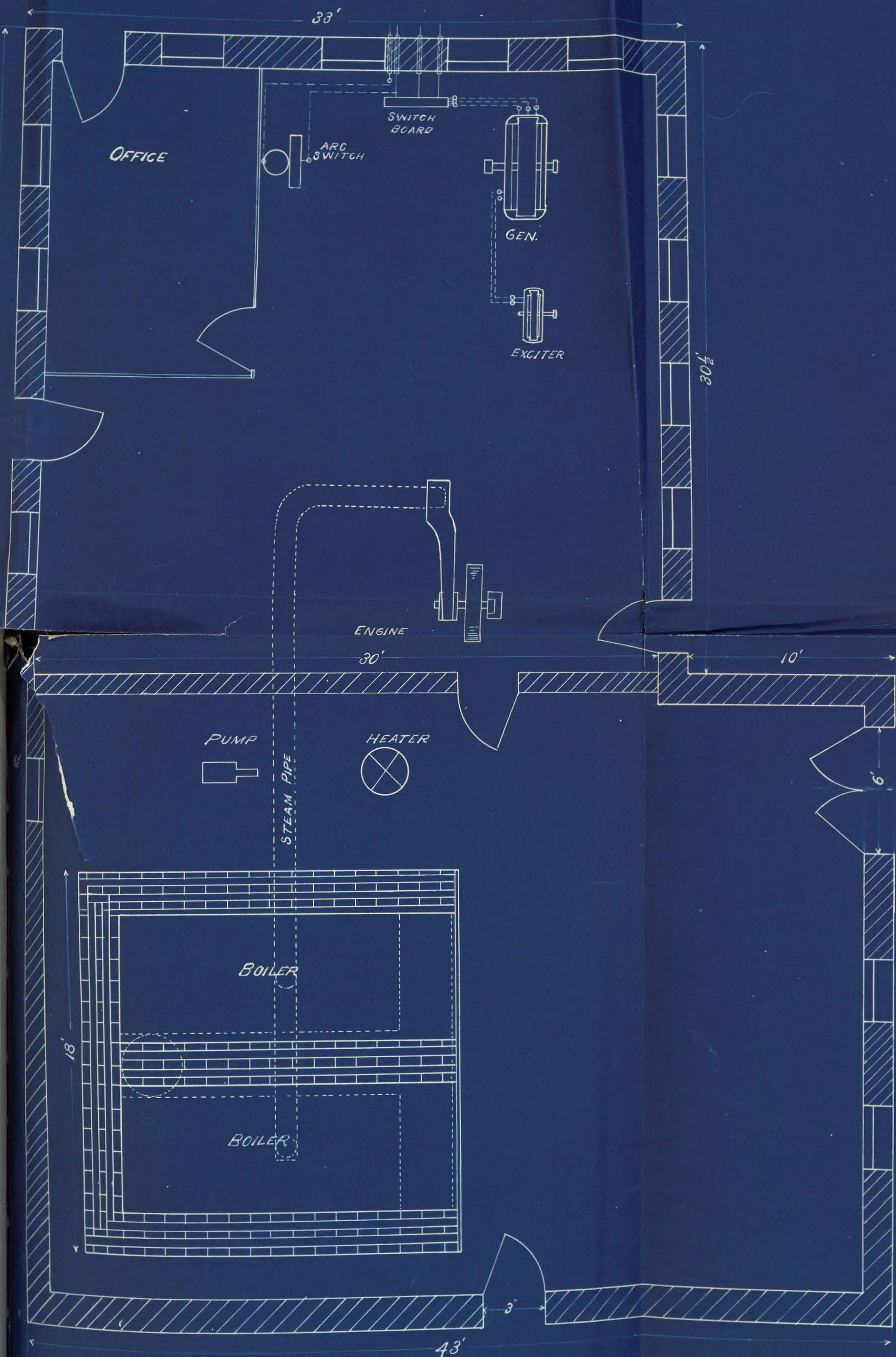
Cords and pulleys for arc lights	$ 25.00
2 30 ampere recording wattmeters	
4 20	
14 10	
80 5	1000.00
Cost of installation	145.00

Miscellaneous

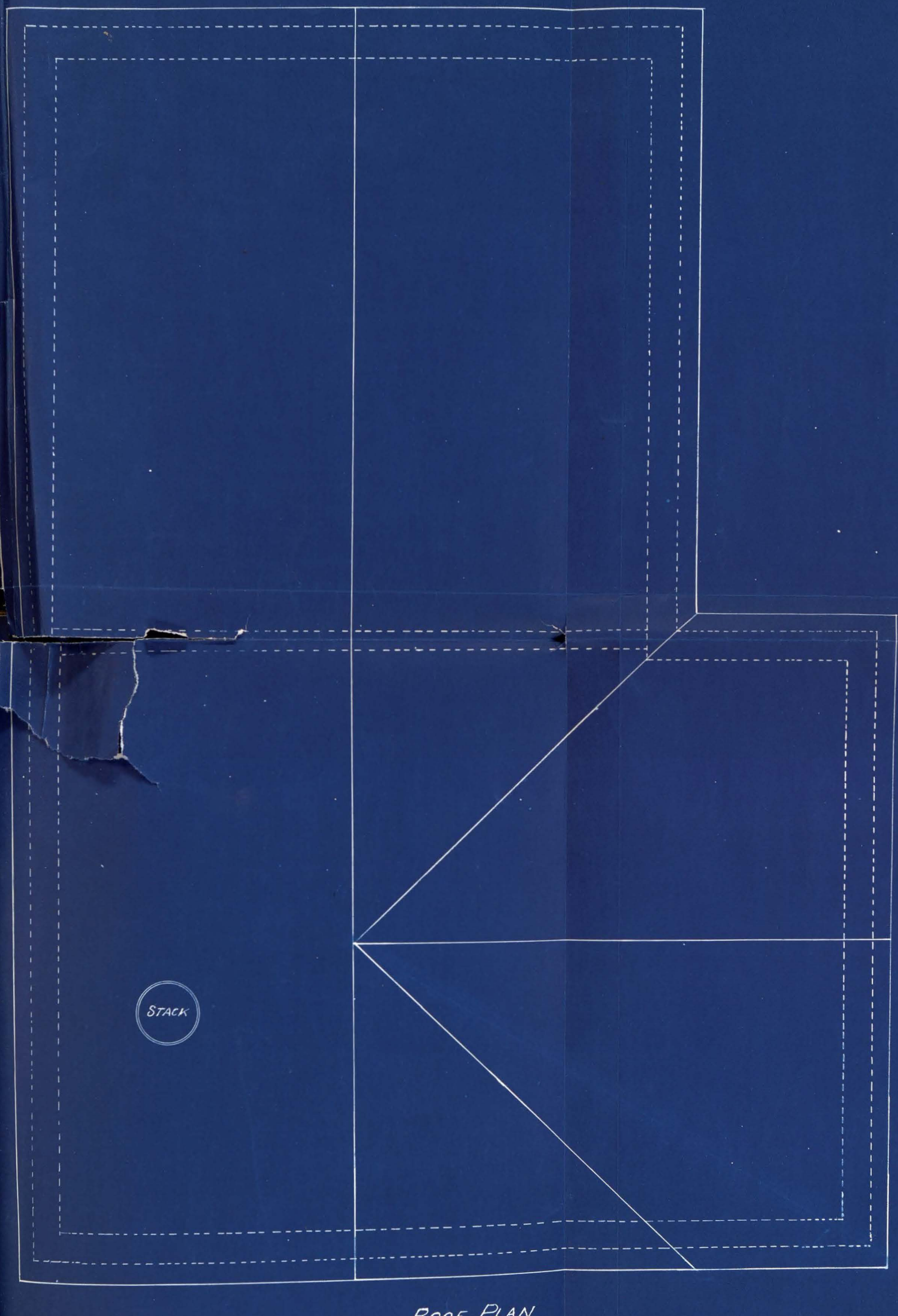
10 lbs. W. P. Tape	
10 lbs. solder wire	
12 sticks soldering paste	
Assortment of fuse wire	5.00

Summary of Cost.

Building Material	$1470.00
Mechanical Equipment	4244.40
Electrical Equipment	1625.00
Wiring	1730.00
Poles, etc.	3571.50
Wattmeters, etc.	1175.00
Total Cost-------------	$13817.90

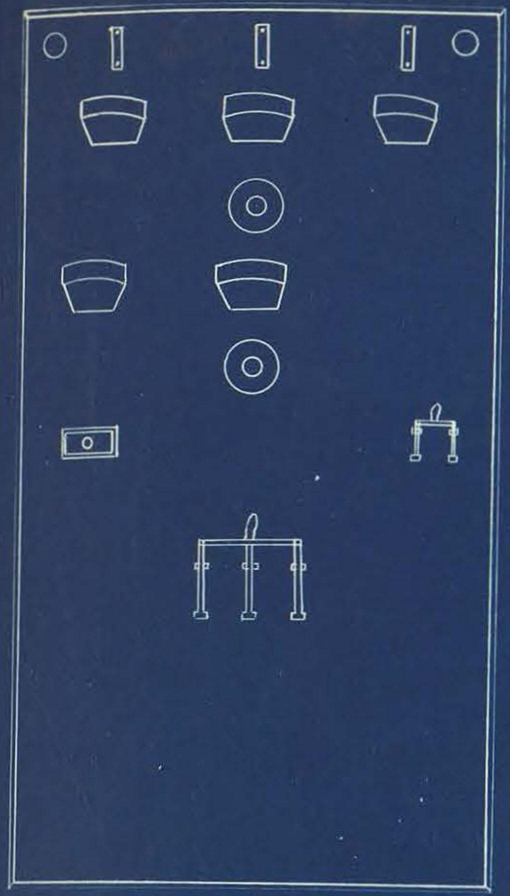


FLOOR PLAN
SCALE ¼" = 1'

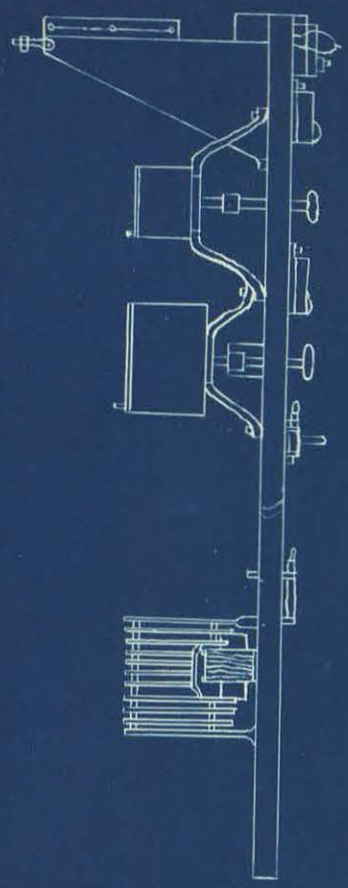


ROOF PLAN
SCALE $\frac{1}{4}$" = 1'

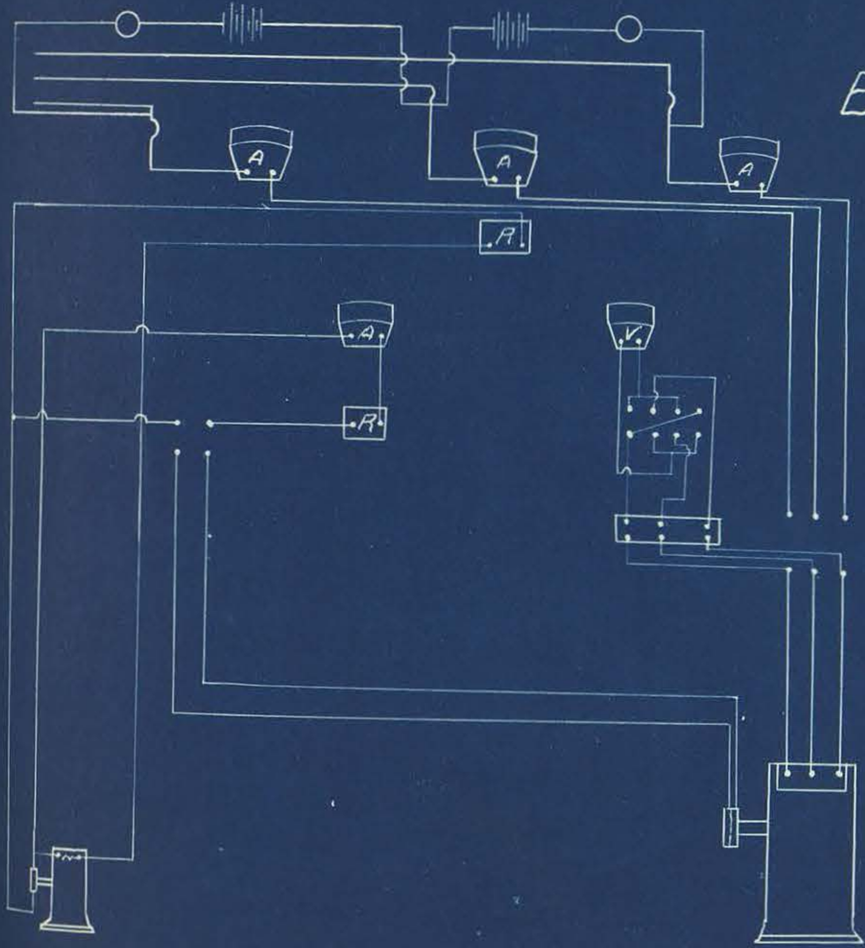
FRONT VIEW

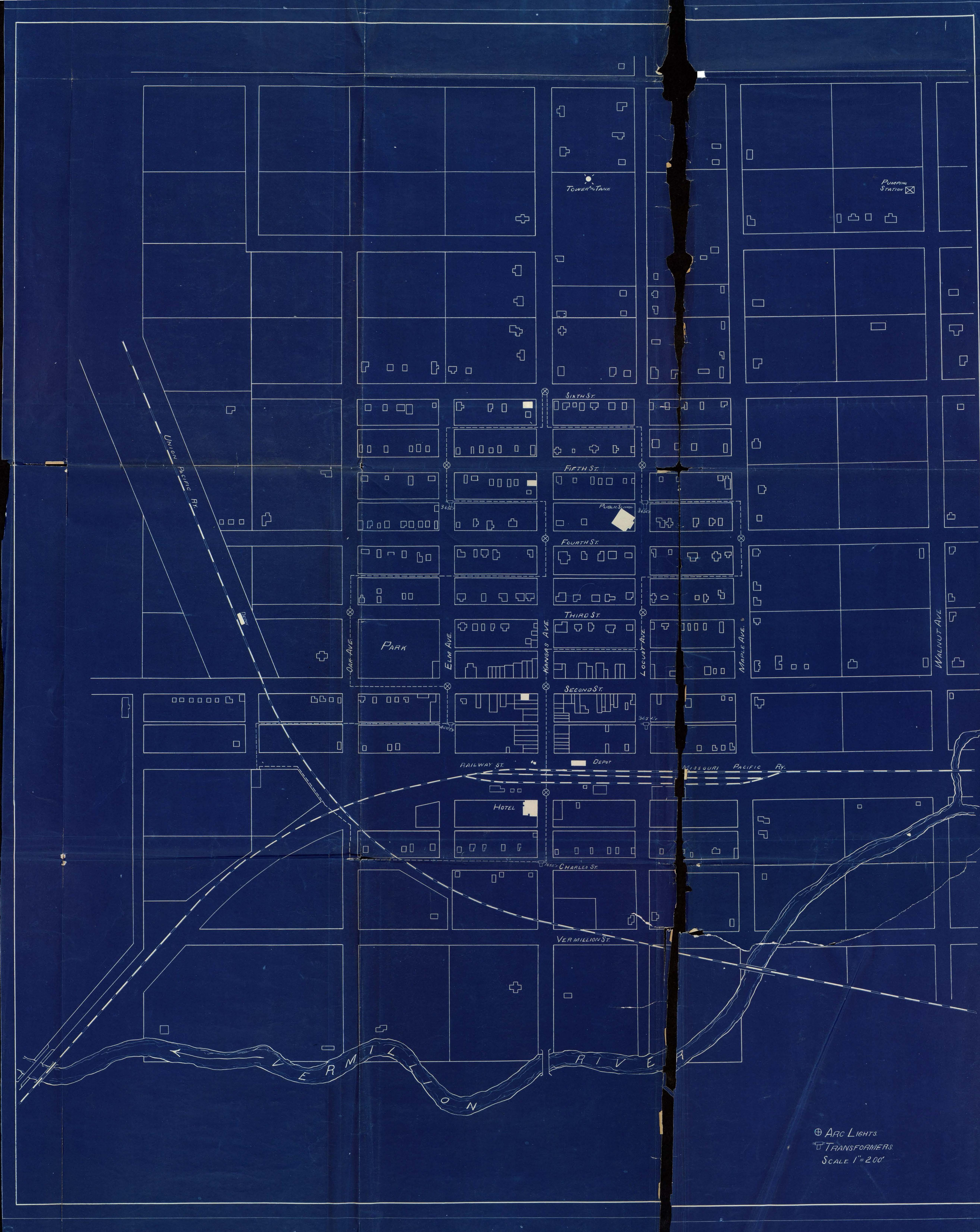


SIDE VIEW



BACK VIEW





Tower and Tank
Pumping Station
Sixth St.
Fifth St.
Fourth St.
Third St.
Second St.
Public School
Union Pacific Ry.
Park
Oak Ave.
Elm Ave.
Kansas Ave.
Locust Ave.
Maple Ave.
Walnut Ave.
Railway St.
Depot
Missouri Pacific Ry.
Hotel
Charles St.
Vermillion St.
Vermillion River
Arc Lights
Transformers
Scale 1" = 200'

Discussion.

The first thing to be considered in installing a power station is the building and site upon which to locate the building. There are numerous considerations that enter into the location of the station and its construction. The most prominent factors governing the location of the building are the following: Local conditions, location with reference to center of distribution, water supply, coaling facilities, and the cost of the building site.

Local conditions enter in the location in various ways. Land suitable for the station might have an advantage in one or two of the above factors and be wanting in the other attributes. The points considered the most were the location with reference to distribution and the coaling facilities. The ground finally selected was located fairly near the center of distribution and coal can be delivered to the station from either of two railroads with equal cost and ease. The ground can be purchased at a reasonable cost and the water supply will be adequate without going to a great depth. The materials selected for the construction of the building is governed by the location, durability of the materials, and the cost of keeping building after constructed in repair. As building stone is quarried near the town; can be purchased at a reasonable price the building material chosen was stone. The quality of the rock is first-class and when laid up in the rough, presents a good external appearance and makes a durable structure. Also the cost of keeping the building in repair is a minimum.

Stone masons can be hired as cheaply as carpenters and the cost of the stone is less than the cost of lumber; all things considered; and also the fire risk is less.

The walls of the building are to be laid of rough stone and are to be 18 inches in thickness. On the inside the rooms will not be ceiled and the walls will be of the same stone as the external walls. The flooring will be of yellow pine, cement floors having too great an initial cost for the size of the station. The interior of the building is to be divided off into an office, generator room, and boiler room. By keeping the engine and generator in a room separate from the boilers, much dirt and dust can be kept from the machines. By using as little lumber as possible on the inside construction, danger from fire is greatly lessened. Slow burning construction is to be used wherever possible. Draughts and recesses for the accumulation of refuse are to be avoided as much as possible.

The roof of the building is to be made of elatente roofing, a rubber compound to be covered with tar and fine gravel.

The building is cheap in its initial cost and danger from fire is eliminated to a great extent by its use. Good light can be procured by having plenty of windows. The building has been planned so that future additions can be made at a minimum cost.

Additions, as needed, can be built on either of the two sides of the boiler room and on the one side of the generator and engine room. On account of the construction of the roof of the boiler room, it can be enlarged at a minimum cost if an addition is built on the east end.

The next thing to be considered is the mechanical and electrical equipment of the station. The machines used are to be of modern up-to-date types of standard make. On the mechanical side, the boilers selected are two 60 H. P. water tube boilers. The boiler capacity was figured for about 25% increase over the engine capacity. Two boilers of 60 H. P. were chosen in preferance to one 120 H. P. boiler because one of the 60 H.P. boilers can carry the load for a time while the other is undergoing needed repairs. Also the cost of the two boilers does not greatly exceed the cost of one boiler of the same rated output and the small increase in cost is compensated for by the prevention of shut-downs during the time of load.

The boilers are to be mounted on brick foundations, giving solidity and eliminating all jars and strains to which the boilers may be subjected.

The prime mover selected is a 100 H. P., 14x36, Corliss engine, having a 12 foot fly-wheel. These engines give efficient service wherever installed and the cost for repairs is a minimum. The pump and heater are to be located in the boiler room between the boilers and the well. A compound pump was chosen and the heater is to be a 150 H. P. open feed water.

The smoke stack is to be made of steel and will be two feet in diameter and sixty (60) feet high. For a station of this size an iron chimney is preferred rather than a brick one, because of the difference in the initial cost. The prime mover drives the generator by means of a leather belt, 70'x14". A belt idler is to be used, as by this means the distance from the generator to the engine can be decreased and this in turn decreases the size of the building and its cost; not much power is lost by the use of the idler and good belt contact is insured by its use.

The generator installed is to be a three phase machine of 75 K. W. capacity, 60 cycles. Current to be produced at 2300 volts pressure, rotating field and speed of 900 r. p. m. The generator is to be belted to the prime mover.

The reason for using belt connected rather than a direct connected is that belt driven gives little trouble and the loss of power does not exceed 3 to 5 per cent.

The alternator is separately excited by a 2.5 K. W. commound would D. C. generator driven from the alternator shaft by a belt.

The cost of a prime mover for the exciter alone in a station of this size would not be good practic and the variations in the speed of the engine will not be great enough to destroy the voltage regulation of the alternator as governed by the exciter.

The generator, exciter, and feeder panel is to be of marble and have mounted upon it the following instruments: Three (0--25) A. C. ammeter; one A. C. voltmeter (0-150); one D. C. voltmeter (0-150); two incandescent lamps ground detectors; three 2300 volt fuse boxes; one 2300 volt-25 amp oil switch; one potential transformer (20-1); Sychronizing plugs; one double pole 125 volt; 20 amp D. C. switch; alternator field rheostat;and exciter field exciter rheostat.

The ammeters and voltmeters are to be of the Weston make and by use of the syuchronizing plugs the one voltmeter can be made to read the voltage over any phase.

The arc light panel is to have mounted upon it an oil break switch, one A C ammeter (0-10), fuse holders, ammeter plug, and a constant current transformer. By means of the oil break switch the arc light circuit can be broken at the station without interfering with the house light load.

Inside wiring is to be concealed as much as possible and all leads and wires on inside of station are to be made easy of access. Where the wire passes thru the floor, high grade porcelain insulators are to be used and the wires are to be insulated with rubber and lead. Porcelain insulators are to be used where the wires pass thru walls of the building and the insulators are to be inclined slightly toward the ground to avoid passage of water thru the insulators. Two lightning arresters are to be located in the lines where they pass from the building. They are to be the Horn type and are to be thoroughly grounded by means of iron straps.

The outside wires are to be #4 B. & S. as this size gives a minimum voltage drop for energy impressed and this size will be sufficient for strength.

For distribution lines are to be run from the station. Three of these for the three phases and the fourth to be tapped from one of the outside phase wires in the station, thus enabling the operator to cut out the arc lights and still maintain a balanced load. The wires will be strung on pine poles about 400 feet apart. The poles are to be 30 feet in height and set five feet in the ground. The parts of the poles set in the ground are to be treated with a wood filler and preserver before they are set. The cross arms and pins are to be of wood, five and three feet in length respectively. The five foot arms are to carry four wires and the three foot arms to carry two wires. The insulators are to be of glass and of the double petticoat type. Different colored glass insulators are to be used to distinguish the high voltage from the low voltage lines.

The transformers used are to be of the oil-cooled type and are to be fastened to the poles about ten feet above the ground.

The transformers used are to be located with reference to the load they carry. The size of the transformers was figured on the basis that one-third the lights will be in use at one time, due allowance being made for over-load.

Ten series arc, 2000 c p are to be used for the street lighting and they are to be located with reference to the greatest benefit to be derived from them by the public.

Recording wattmeters are to be installed in each building using the electric current.

In all calculations and estimations in the installing of the different machines and apparatus, we have been governed by the amount of energy that can be sold, the efficiency of the service and whether the type of machine or method of installation will pay on a basis of dollars and cents. The first cost of everything was made as low as possible because in a station of this size the initial cost is the deciding factor as to whether the station will pay the operators for the money invested.

Walker and Donley.