THESIS

on

Power Plant Design

Submitted to the Faculty

of the

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for the degree of

BACHELOR OF SCIENCE

in

Electrical Engineering

by

H.M.Propst

E.A.Sorensen

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APPROVED Redacted for privacy

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Department of Electrical Engineering

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Dean School of Engineering

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Introduction.

During the last five years the demand for electrical energy in the state of Oregon,and throughout the entire country,has increased to such an extent that electrical generating stations have become an important factor in the economic development of the common wealth.

Considering the great need for cheap power,which is mostly in the form of electrical energy, and that this state has abundant water power,the design of a hydro-electric generating station with transmission an distributing system seems to the writers of this thesis to be quite timely.

June I4,

Site.

The site of the proposed power plant is at Waterloo on the falls of the south fork of the Santiam River, twenty two miles south of Albany, Linn County Oregon.

Electricity is to be generated to supply the city of Albany and the smaller surrounding towns.

The present flow of water in the ditch at Albany is not sufficient to meet the increasing demand for power, hence an auxiliary steam plant is required, which makes the operation and maintanence costly. By constructing the generating station at the Waterloo Falls the use of steam will be unnessary.

The proposed plant will be so situated that energy can be supplied to Albany and transmission lines can be erected to Lebanon and the other small towns. The capacity of the generating machines will be sufficient to operate cars and trains on all of the proposed electric railroads in the vicinity.

The falls are in the bend of the river and have a width of approximately one hundred and fifty feet at the crest.

The banks at the falls are thirty five or forty feet high and are formed of igneous rock. The bed of the stream is very rough and is also formed of igneous rock making a solid foundation for the building and dam.

Back of the falls is a large area which could be very easily utilized for pondage and would be sufficient if the plant were enlarged to maintain the supply of water throughout the summer months.It is so located that no damage could be done by flooding as no homes or farms exist in this area.

Flow and,Conditions of Stream.

The river heads seventy five miles south-east of Sweethome,in the Cascade Range. It is a mountainous stream having a broad water shed,and on account of its many small tributaries the heavy rain fall during the winter months cause oftimes severe floods; consequently construction is attended with considerable risk.

The stream is free from ice throughout the year but some reliable means will have to be made in the construction to protect the station from the floating drift wood gathered by the floods.

Power Capacity of the Stream.

The stream has six hundred and forty square miles of drainage area and the coefficient of discharge at low flow forty-seven hundred. Thus with the thirty foot head the minimum rate of discharge will be three hundred cubic fedt per second.

The horse power of this stream is equal to rate of flow in cubic feetper second multiplied by the weight of one cubic foot of water multiplied by the head in feet and divided by five hundred and fifty; and has a value of one thousand one hundred and ninety.

The electric power realized is seventy-two per cent of the hydraulic energy. So that twelve and one half second feet with one foot fall, represents one electric horse power. Six hundred kilowatts of generated electricity is required, which corresponds to eight hundred horse power. Therefore with the seventy-two per cent efficiency one thousand one hundred and ten horse power of hydraulic energy must be utilized. Thus with the usual amount, of overload of twenty-five per cent, the turbine units must have a total capacity of one thousand one hundred and fifty horse power. This also makes an allowance of twenty-five horse power for exciters.

Considering the capacity of the stream and the amount of power that must be generated, the best combination of units would be three two hundred and fifty kilowatts each having an exciter of eight kilowatts and driven by three three hundred and eighty-five horse power turbines.

The modren practice is to use twin turbines, which combination does away with end thrusts. It is found that a twin turbine of twenty-two inches in diameter will develop under these conditions three hundred and ninety-six horse power. This is the nearest to the required horse power of the standard size that can be used. And in accordance with the low head the turbine chosen will be of the drownded type.

The Dam.

The dam will be built at rhe edge where the water breaks over the falls and be of concrete. The best cross-section for this height of dam has a width of five feet at the top, giving a cross-section of eighteen cubic yards. Hence the structure will contain one thousand one hundred forty cubic yards.

Headgate.

The headgate that gives the best service for a medium heads is made of plank three inches thick bolted through a stem and braces which are placed at an angle of thirty degrees with the stem.

The gate is raised and lowered by means of a hand worm gear.

Power House.

In the construction of power houses the main object is to keep the cost of construcion and maintainence a minimum. Another important factor isto construct a building that will be saleable.

The power house under consideration will be of concrete foundation with the floor reinforced with steel I beams. The walls are to be of solid concrete and the roof is to be of galvanized iron and supported by steel structure, thus making the building fire proof.

Transmission Line

In order to transmit the power from Waterloo to Albany, there will be necessary twenty-two miles of pole line. The route of the transmission line follows comparatively level ground. The poles are to be fo fir, thirty-five feet long set five feet in the ground, are to number forty-five to the mile.

The wire used is number six B. S. gauge and placed forty-eight inches apart.

Substation.

In order to have an economic system the substation should be located at or near the center of gravity of the electrical distribution. This places the site on the corner of second and Ferry St. On account of the danger of fire from the high tension the incoming mains, the building will be made of non-combustible material; having a concrete floor reinforced by steel I beams; concrete walls, and a steel roof.

It is provided with the following equipment; one fifteen foot switchboard consisting of five three foot panels; three step down transformers of two hundred kilo watts capacity, two constant current transformers, of ten kilowatts output each, and one one hundred kilowatt rotary converter for street car service.

Distribution System.

In considering the distribution system one of the main objects is to keep the regulation as good as possible for the cost of installation. With this object the layout of the circuits and the size of units are determined.

It is found that with the elevn hundred volts No. 8 and No. 6 wire could be used on thefeeders with a three per cent regulation.

By running the No. 6 wire for feeders the cost of copper is not materially increased sufficiently to balance the mechanical increase of strenght. This also gives a regulation slightly better than three per cent.

For the mains the regulation should not exceed one and one half per cent. It is found that No. 8 B. S. wire is sufficiently large to keep the drop within the desired limit.

The transformers are to be located so as to balance up theload as much as possible. It is found that one placed at the center of gravity of a section of sixteen blocks of strictly residence district, is very satisfactory.

In order to keep the regulation of the incandescent light circuit as high as possible, the motors are to be connected to a separate circuit on account of lower power factor. The voltage on this is to be two hundred twenty except to the carriage factory and saw mill at a distance of about a mile, the pressure to be used here to be twenty-two hundred volts.

The series arc lights are to be also on separate circuits and will require constant current. There are to be of these two circuits, the transformers being connected in open delta, with twenty lamps per circuit. The lamps are to be on the corners of every other block each way, except in the business district as shwon on blue ptints.

Costs.

Land-----------------------------------$2000

Dam Erected-------------------- ------ 6000

Power House

Concrete Foundation------------------$2250

Building Complete and Erected--------10200

Crane------------------------------ 210

Total----------$12660

Power House Equipment

Three three hundred eighty-five horse power Turbines and Governors------$5625

Three two hundred fifty kilowatt Generators and Exciters----------- 6822

Switchboard------------------------ 1800

Total----------$14247

Transmission Line

Copper------------------------------$4620

Poles Erected---------------- ----- 5695

Step up and Step down Transformers--- 7200

Total----------$17515

Substation

Building Complete-------------------$3000

Substation Equipment

Two ten kilowatt Constant Current
Transformers---------------------$ 480

Rotary Converter-------------------- 2000

Total----------$2480

Distributing System

Copper for Feeders------------------$ 945

" " Mains--------------------- 1853

" " Power Circuit-------------- 2154

" for Arc "----------------- 313

Fifteen Pole Transformers------------ 3787

Street Car Circuit------------------ 300

Total----------$9352

Total Cost---------------$67254

Operating Expenses

Superintendent's Salary	$1800 per year
Three Station Operators	2000
Two Substation Operators	1800
Two Line Men	1440
Total	$7040

Depreciation

Buildings	$ 201
Generators	341
Transformers	202
Total	$744

Arc Lamps	$ 2880
Incandescent	15000
Power Motors	21528
Street Car	1000
Total	$40408

Summary

Gross Receipts	$40408
Operating Expenses	7040
Depreciation and Maintainence	2314
Interest	4296
Taxes	1430
Net Profit	25695

Conclusion.

The writers of this thesis have carefully considered this subject, of proposed plant for Albany, have placed all costs sufficiently high, have placed all receipts nearer the minimum than the average, and have found that this new system would be a financial success as well as consistent with good engineering.

This new project would cost as shown above approximatelyseventy-five thousand and could be incorporated for one hundred thousand or one hundred fifty thousand dollars.

DATA SHEET I.

Discharge Table.

Taken From U.S. Geological Survey

Gage Height	Discharge	Gage Height	Discharge
2.40	1730	4.70	6580
2.50	1870	4.80	6850
2.60	2020	4.90	7120
2.70	2180	5	7400
2.80	2340	5.10	7690
2.90	2510	5.20	7980
3.	2680	5.30	8280
3.10	2860	5.40	8580
3.20	3050	5.50	8880
3.30	3240	5.60	9190
3.40	3440	5.70	9500
3.50	3640	5.80	9810
3.60	3850	5.90	101300
4.40	5780	7.40	15020
4.50	6040	7.60	15680

	Discharge in Sec. Ft.				Run Off.	
Month	Max.	Min.	Mean	P Sq. M.	Depth in on dranage area	Total acre feet
Jan.	25300	1730	7060	11	12.68	434000
Feb.	63700	5780	23800	37.2	38.74	1320000
March.	15400	2680	4430	6.9	7.98	27200

DATA SHEET 2

Load on the Transformers.

Sections	No. of Blocks	No. of Lamps	K.W.
I	I6	4I8	I3
2	I6	635	22
3	I6	380	I0
4	I6	5I5	I7
5	I0	I636	42
6	I7	407	I5
7	I2	830	52
8	8	I670	43
9	I6	3I0	I0
I0	I6	485	I6
II	I4	325	6.9
I2	I2	86	I2
I3	I2	229	I4
I4	8	200	9
I5	2		35

DATA SHEET 3

Data on the Size of Wires

Circuit I

Section	Length	K.W.	Cir. Mills.	Size of wire B&S.
8	420	43	I1620	9
I3	3I02	69	I9620	7
Average			I5620	8

Circuit 2.

Section	Length	K.W.	Cir.Mills.	Size of wire B&S.
5	924	42	23200	6
I4	420	8	3600	I4
Average			I3400	9

Circuit 3

Section	Length	K.W.	Cir. Mills.	Size of wire B&S.
2	I5I8	22	19750	8
4	924	I7	9460	II
Average			I4605	9

Circuit 4.

Section	Length	K.W.	Cir. Mills.	Size Of wire B&S
7	420	52	I3000	9
IO	I980	I6	I8690	8
I2	2970	I2	22680	6
Average			I8I23	7

Circuit 5

Section	Length	K.W.	Cir.Mills.	Size of wire B&S
6	660	I5	I0220	IO
9	I980	IO	I6400	8
II	3I02	6.9	2I560	6
Average			I6055	8

Circuit 6

Section	Length	K.W.	Cir. Mills.	Size of wire B&S.
I	2462	23I7	I0000	IO
3	I254	IO	7450	II
Average			I3035	9

DATA SHEET 4

Data on the Size of Wire.

Section I.

Section	Length	K.W.	Cir.M ills	Size of wire B & S
I to A.	462	2.I7	I0000	I0
I to B.	I98	2.76	5465	I2
I to D.	396	5.47	I9I50	7
Average				I4

Sec. 3.

Section	Length	K.W.	CIr. Mills	Size of wire B & S
3 to A.	462	3.5I	I6200	8
3 to B.	I98	I.3	2576	I6
3 to D	396	5.47	2I640	6
Average				I4

Section 4

Section	Length	K.W.	Cir. Mills	Size of wire B & S
4 to/E.	330	5.38	I7750	8
4 to G.	I98	4.86	9640	10
4 to H.	462	5.44	25I00	6
Average				I2

Section 5

Section	Length	K.W.	Cir. Mills	Size of Wire B & S
5 to L.	330	6.3	208000	7

Section 6

Section	Length	K.W.	Cir. Mills	Size of Wire B & S
6 to Depot	792	I.85	I4650	8
6 to D.	396	2	7220	II
6 to E.	I32	2.59	3420	I3
6 to F.	I98	3.22	6370	II
6 to G.	462	4.32	I9900	7

Section 7.

Section	Length	K.W.	Cir. Mills. 7	Size of W. B & S
7 to H.	528	5.48	29000	8
7 to I.	I98	5	9900	IO
7 to J.	60	30.99	I8975	8
Average				I2.

Section 8.

Section	Length	K.W.	Cir. Mills	Size of Wire. B & S
8 to K.	I98	30.99	6I300	3
8 to L.	99	37.59	37200	4

Section I4.

Section	Length	K.W.	Cir. Mills	Size of Wire B & S
I4 to K	66	67	4420	I4
I4 to L.	330	58	I9I500	0000

DATA SHEET 5

Induction Motor Circuits.

	Length	K.W.	Cir. Mills.
2200 Volts			
Sub. to (L&5)	I5I8	60	28I00
" " (M&I7&I8)	2376	65	48300
" " (First)	I98	2I5	II900
" " (Saw Mill)	5280	75	II2000
" " (H&2I)	4092	I50	I90500
220 Volts			
" " (H&I5 to First)	I98	30	18400
" " (M&I7&I8 to First	I98	65	40400
" " (L&I5&I6)	I00	40	
" " (J to 9)	I98	I0	
" " (L to 9)	I50	I0	
" " (L to 7)	I00	25	

		Size	K.W.	Lbs.
Running First St.	3960	4		498
" to Saw Mill.	5280	000	I68	2722

B & S	Substitute	Weight	Volts
4	4	356	2200
4			"
9			"
0			"
0000			"
7	6	I3	220
4			"
8			"
8			"
8			"
8			"

DATA SHEET 6

The Total Load.

Kind of Load	K.W.
Incandescant	300
Arcs	20
Motors	515
Total	835.

DATA SHEET 7.

The Main Feeder,

Block	Length	K.W .	Cir.Mills.
8	200	5I	3600
7	330	80	5500
4	II88	39	9745
3	204	23	I6480
6	I578	3I.9	I7280

DATA SHEET 8

Length and Weight of Secondaries.

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Transformers	B & S	Length	Lbs.
I	6	50I6	396
2	6	5346	423
3	8	52I4	28I
4	6	6600	52I
5	6	3894	30I
6	8	7722	4I6
7	8	6I38	33I
8	6	3234	258
9	8	7722	4I6
I0	8	7722	4I6
II	8	5082	28I
I2	8	6072	33I
I3	8	23I0	I24
I4	8	2640	I42

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Using No8 wire	66776	9266

Three wires 9266 x 3 is 27798 lbs.

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Electrical

Centers of Gravity of Sections.

Sec I.	I.	2.	3.	4.	A.	B.	C.	D.
	I.87	.87	.88	.88	.62	.62	.94	I.89
	.94	.62	.64	.88	.62	.62	.62	.87
	.62	.62	.64	.88	.3I	.64	.64	.88
	.62	.62	.3I	.62	.62	.88	.88	I.25
	4.05	2.73	2.47	3.63	2.I7	2.76	3.08	4.87

Center 6.4 X 6 Y

Sec.2	I.	2.	3.	4.	E.	F.	G..	H.
	I.9	I.25	I.8	3.I	I.8	I.7	I.9	
	I.7	I.25	.88	I.25	.94	I.25	I.25	I.25
	I.8	I.25	.88	I.8	.88	.88	.88	I.9
		.94	.88	.64	.64	I.8	I.25	3.
	5.5	4.79	4.44	6.79	4.26	5.63	4.47	6.05

Center IO.8 X IO Y.

Sec 3	5.	6.	7.	8..	9	A.	B.	C.	D.
	I.25	.99	.62	.94	I.62	.77	.99	I.25	I.25
	I.25	.I8	I.36	I.25		.3I	.3I	.I8	.99
	.99	.3I	.3I	.3I	I.9	I.25	.I	.62	
	.77	.3I				.3I	.I8		.94
						.3	I.56		.94
						I.8	I.56		
	4.26	I.79	2.29	2.59	3.52	5.74	4.70	2.05	4.I2

Center 7 X [illegible].5 Y.

Sec. 4	5.	6.	7.	8.	9.	E.	F.	G.	H.
	.36	.99	I.25	I.65	.99	I.25	I.2	.9	.36
	.9	.99	.99	.94	.99	.99	.62	.99	.99
	I.2	.62	.99	I.25	I.	.62	.99	.99	I.25
	I.25	.99	.62	I.9	.62	.62	I.	.99	.99
	3.7I	3.35	3.75	5.94	3.60	5.38	4.06	4.84	5.44

Center IO.5 X IO Y.

Sec 5	5.	6.	7.	I.	J.	K.	L.
	.62	I5.6	I2.6	.99	.3I	.62	8.3
	.3I	I.2	20	I.56	5.6	I0.I2	6.3
	.99	II.2	I2.6	I.25	6.3	&	
	I.9I	I6.I6	23.97	3.8	I2.2I	II.44	I4.6

Center 20 X 20 Y.

Sec. 6.	I0.	II.	I2.	I3.	C.	D.	E.	F.	G.	B.
	I.25	I	.99	.99	.62	.62	.99	I.25	I.25	I.85
	I.25	.36	.62	.99	.99	.3	.36	.36	I.	
	.99	.36	.62	.62		.3	.62	.62	.99	
	.62	.3	.62	.62		.62	.62	.99	.99	
	.62	.99	.X							
		I.85								
	4.73	3.86	2.53	3.22	I.6I	I.30	2.69	3.22	4.23	I.85

Center 7 X 7 Y.

Sec.7.	I0.	II.	I2.	I3.	H.	I.	J.
	I2.6	II.3	6.3	.99	I.25	I.25	6.3
	I2.6	5.6	3.I	I.25	.99	I.25	5.6
	II.2	I.25	I.25	I.25	.99	I.25	3.I
					I.25	I.25	.99
	I3.85	I3.I5	I0.65	3.45	4.48	55	I5.99
Center		20 X				I2 Y	

Sec. 8	I0.	II.	I2.	I3.	K.	L.
	I6.8	I0.8	6	.99	6.3	9.9
	I2.3	I2.6	I2.5	.6	6.3	5.3
					6.3	3.
					.6	.99
	I6.2	I2.7	I0.6	2.89	I9.5	I9.29
Center		I9 X			2I.	Y.

Sec. 9.	I4.	I5.	I6.	I7.	D.	E.	F.	G.
	.62	.99	.62	.99	.62	.62	.62	.62
	.62	.62	.3	.62	.62	.62	.62	.99
	.62	.62	.3	.3	.3	.3	.3	.62
	.62	.62	.3	.3	.3	.6	.62	.99
	2.48	2.85	I.68	2.2I	I.84	2.I4	2.I6	3.24

Center. 5 X 4.5 Y.

Sec. IO.	I4.	I5.	I6.	I7.	H.	I.	J.	K.
	.99	I.09	.89	.6	.62	.62	.99	.99
	.99	I.25	.62	I.25	I.25	I.25	I.25	I.09
	.62	I.25	.62	I.25	.62	.62	.62	.99
	.62	I25	.62	I.25	I.25	I.25	I.25	.6
	3. 22	4.84	2.75	5.	3.74	3.74	4.II	3.67

Center. 8 X 8 Y.

Sec. II	I4.	I5.	I6.	I7.	L.	M.
	.99	.99	.99	.6	.99	.99
	.99	.62	.77	.3	.99	.62
					.99	.77
					.6	.3
	I.98	I.6I	I.76	.9	3.57	2.68

Center 3.5 X. 3.5 Y.

Sec. I2.	I8.	I9.	20.	D.	E.	F.	G.
	.62	.62	.3	.3	.3	.I7	.6
	77	.6	.3	.6	.6	.6	.6
	.3	.6	.3	.3	.3	.3	.3
	.3	.6	.3				
	I.99	2.42	I.2	I.2	I.2	I.67	I.5

Center. 3 X 2.8 Y.

Sec. I3.	I8.	I9.	20..	H.	I.	J.	K.
	.99	.77	.37	.99	.99	.99	.99
	.99	.79	.6	.99	.99	.79	.77
	99	.99	.6	.3	.6	.6	.37
	.99	.99	.3				
	4.06	3.54	I.85	2.I0	2.58	2.38	2.I3
Center	5.2 X				3.5	Y	

Sec. I4.	I8.	I9.	20.	L.	M.
	.99	.6	.6	.99	,99
	.99	.3	.6	.6	.3
				.6	.6
	2.I6	2.8	I.2	2.I9	I.89
Center	3 X			2 Y.	

Sec. I5	8.	9.	I.	J.	K.	L.
	9.8	9.9	I.25	II.8	II.8	9.8
	II.2	6.3	I.25	6.3	6.3	9.9
	II.8	6.3				
	I.25	I.25				
	25.05	23.55	2.50	I8.I	I8.	I.9
Center		24.	X.		25	Y.

WATTS LOAD,

Per Block.

I	2	3	4	5	6
I.9	I.25	I.8	3.I	.62	8.3
I.7	I.25	.88	I.25	.3I	.7
I.8	I.25	.88	I.8	.99	5.6
I.87	.94	.88	.64	.36	I.56
.94	.87	.88	I.25	.9	.99
.62	.62	.64	.88	I.2	.99
.62	.62	.64	.88	I.25	.62
	.62	.3I	.62	I.25	.99
				I.25	.99
				.99	.I8
				.77	.3I
					.3I

7 &	8	9	IO	II	I2	I3	I4	I5
6.3	5.6	9.8	9.9	5.4	3.I	.99	.99	.99
IO.I2	II.4	II.2	6.3	6.3	6.3	.6	.99	I.09
6.3	9.4	II.8	6.3	5.6	3.I	.99	.99	I.25
I.25	I.25	I.25	I.25	I.25	I.25	I.25	.6	I.25
I.25	I.35	.99	I.25	.99	.99	I.25	.62	I.25
.99	.99	.99	I.25	I.09	.99	.99	.62	.99
.99	I.25	I.09	I.25	.36	.62	.99	.62	.62
.62	I.9	.62	.99	.36	.62	.62	.62	.62
.62	.99	.62	.62	.3	.3	.62	.62	.62
I.56	I.25		.62	.94			.99	
				I.85				
.3I	.3I	.3I	I.8					

I6	I7	I8	I9	20
.99	.6	.99	.6	.6
.99	.6	.99	.77	.37
.62	I.25	.99	.79	.6
.62	I.25	.99	.99	.6
.62	I.25	.99	.99	.3
.62	.99	.62	.62	.3
.3	.62	.77	.6	.3
.3	.6	.3	.6	.3
.3	.3	.3	.6	.3


WILLAMETTE
RIVER
THE CITY OF
ALBANY

THESIS

TRANSFORMER SECTIONS.

CENTERS of GRAVITY.

Drawn by Horace M. Probst,
E. A. Sorenson,

Serial No

Place No. 2.


WILLAMETTE
RIVER.
THESIS
ARC CIRCUITS.
MOTOR CIRCUITS.
Drawn by
E. A. Sorenson,
Serial No.
Plate No. 3.

THESIS

PRIMARY CIRCUITS.

SECONDARY CIRCUITS.

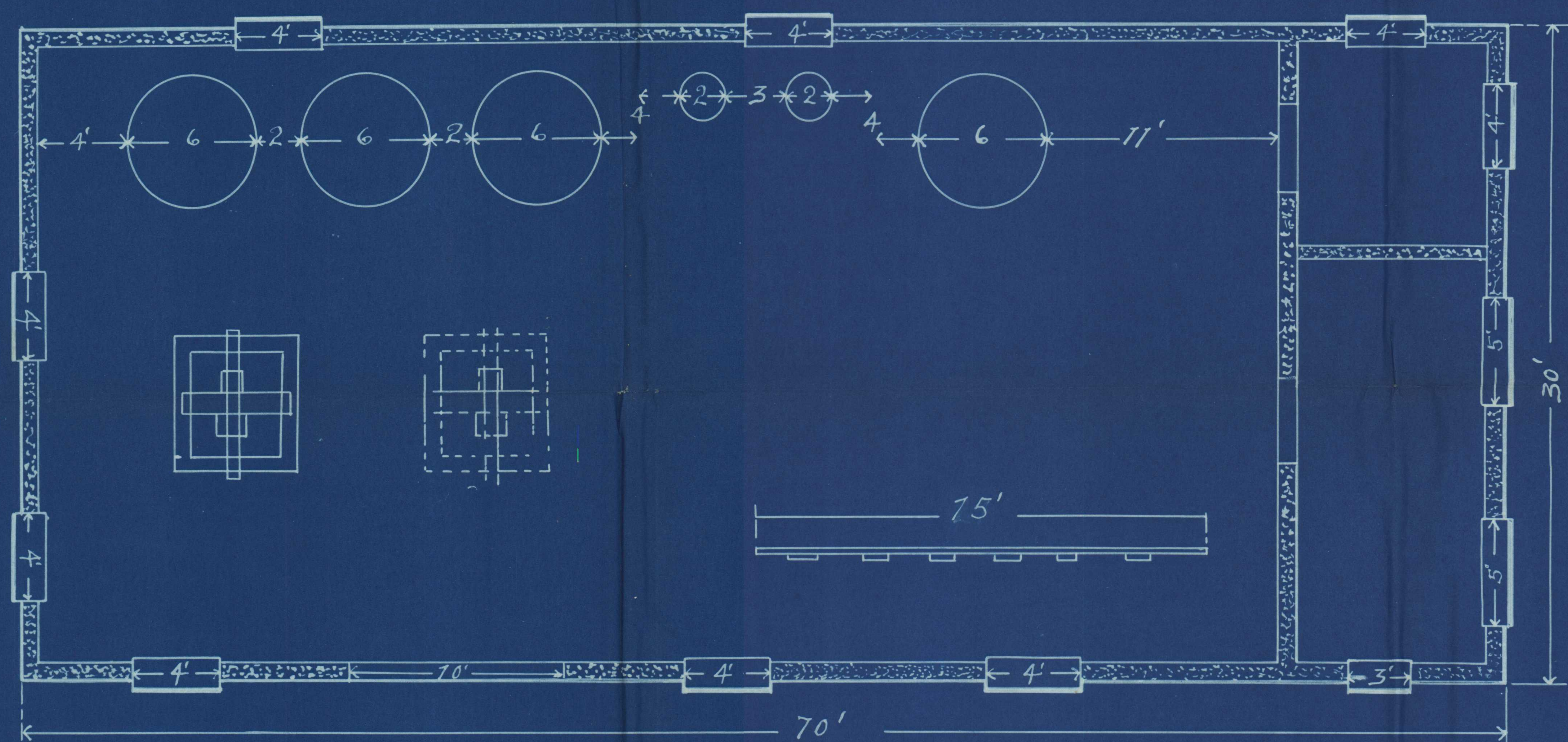
Drawn by

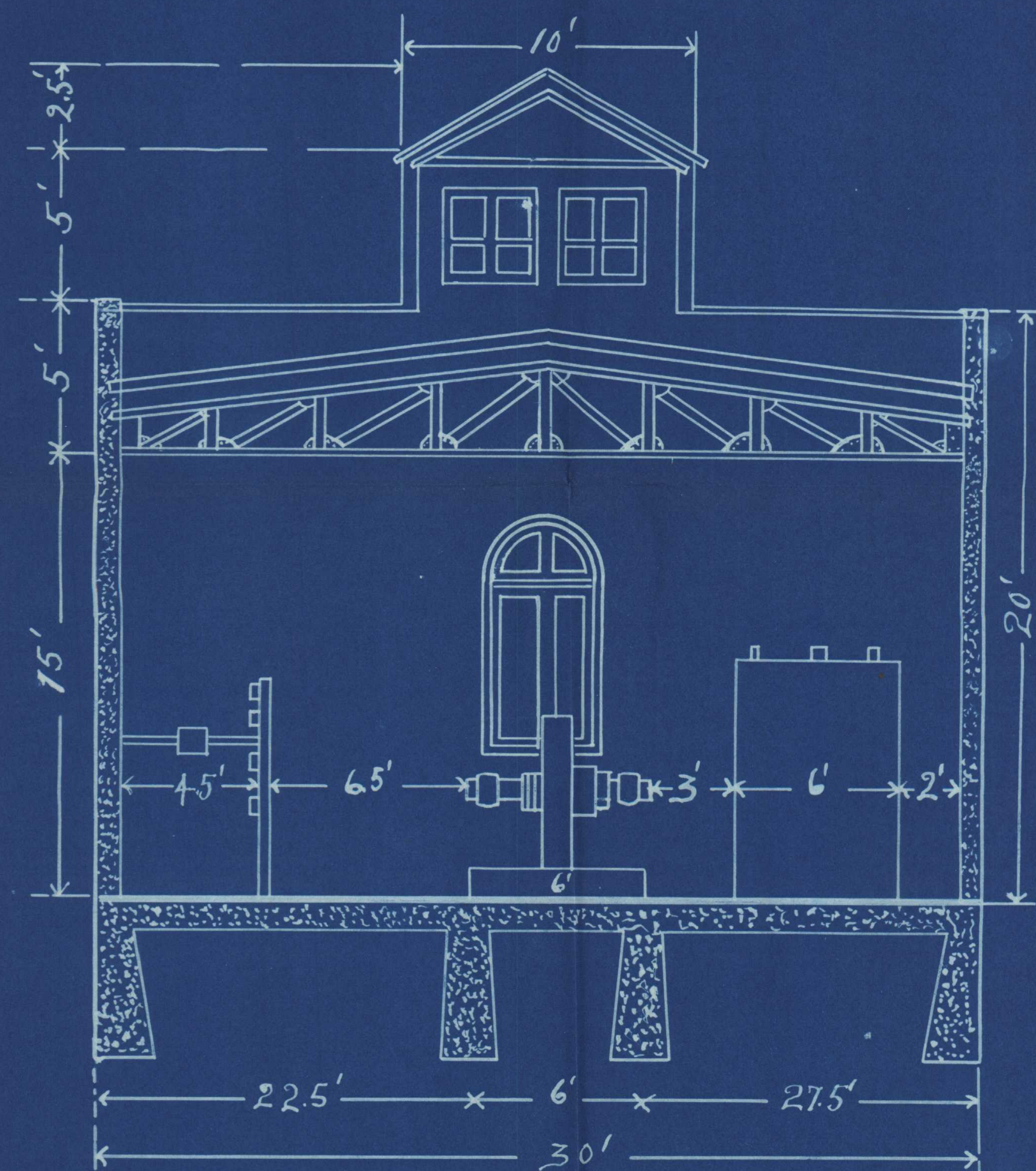
E. A. Sorenson.

Serial No.   Plate No. 4.

MAP of TRANSMISSION LINE.

Serial no Plate no 5





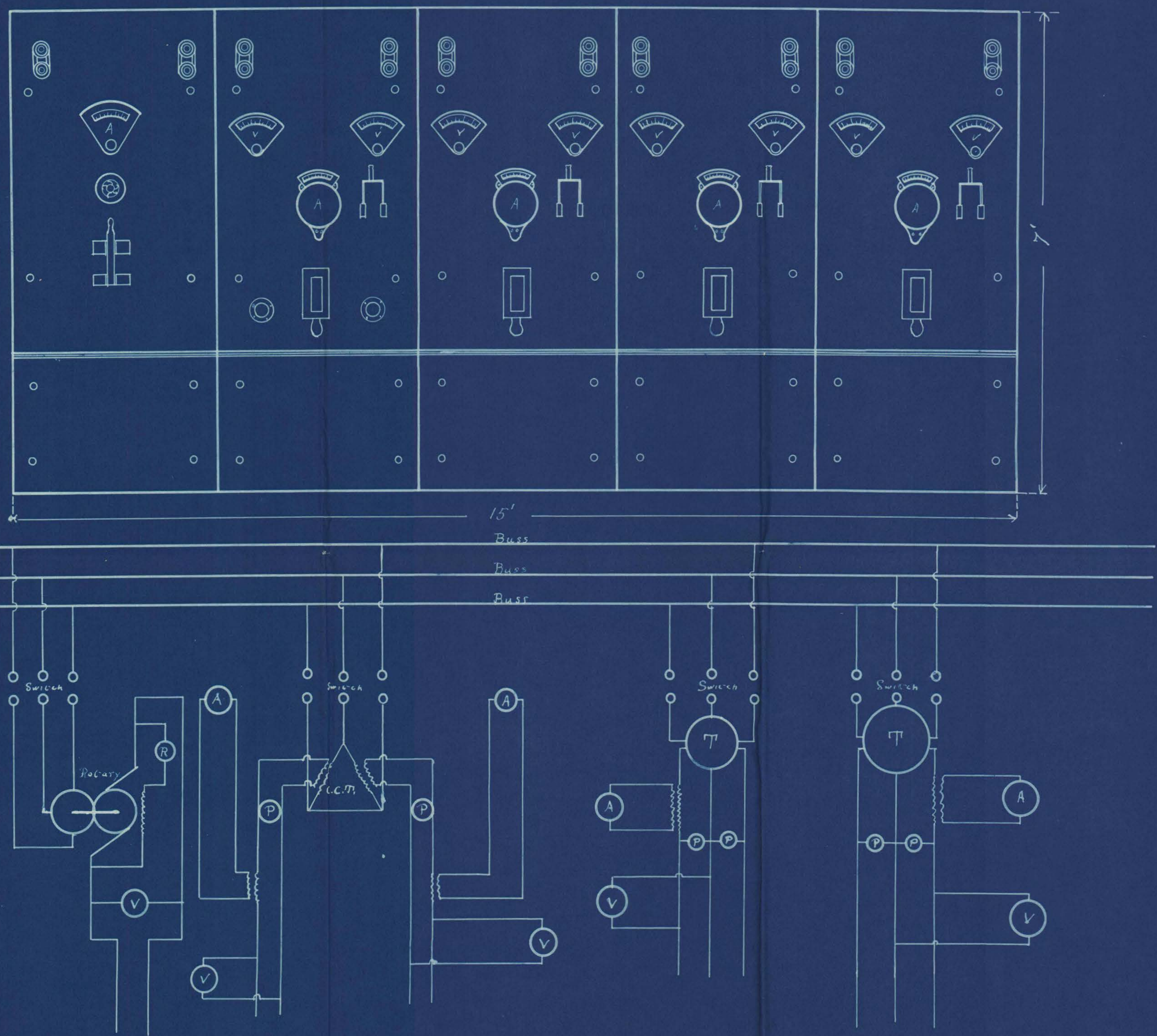
THESIS

SUB STATION

Drawn by Horace M. Probst
E. A. Sorenson.

Serial No Plate No 6

Scale one inch = five feet.



THESIS

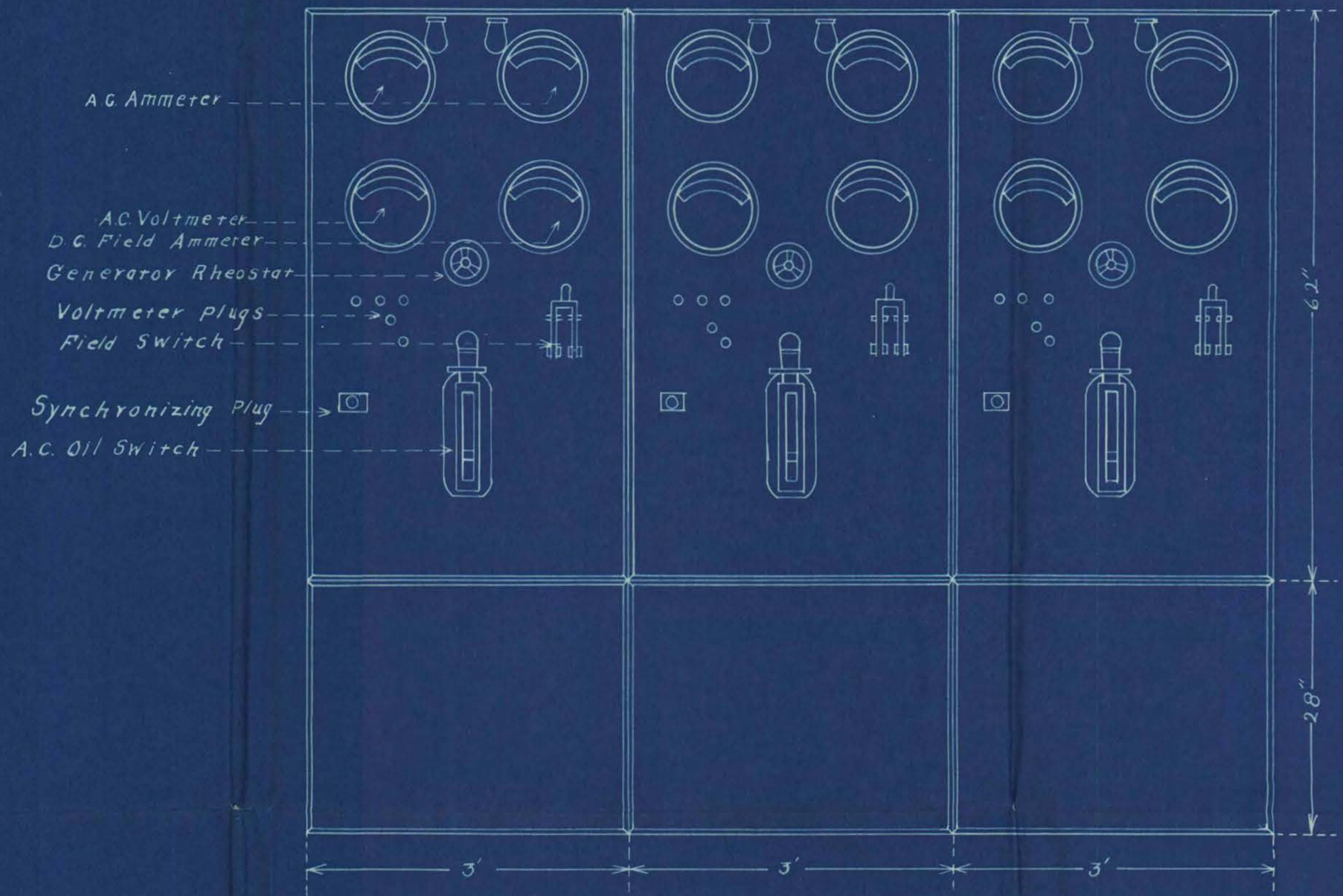
SUB STATION.

Designed by H.M. Propst
E.A. Sorenson

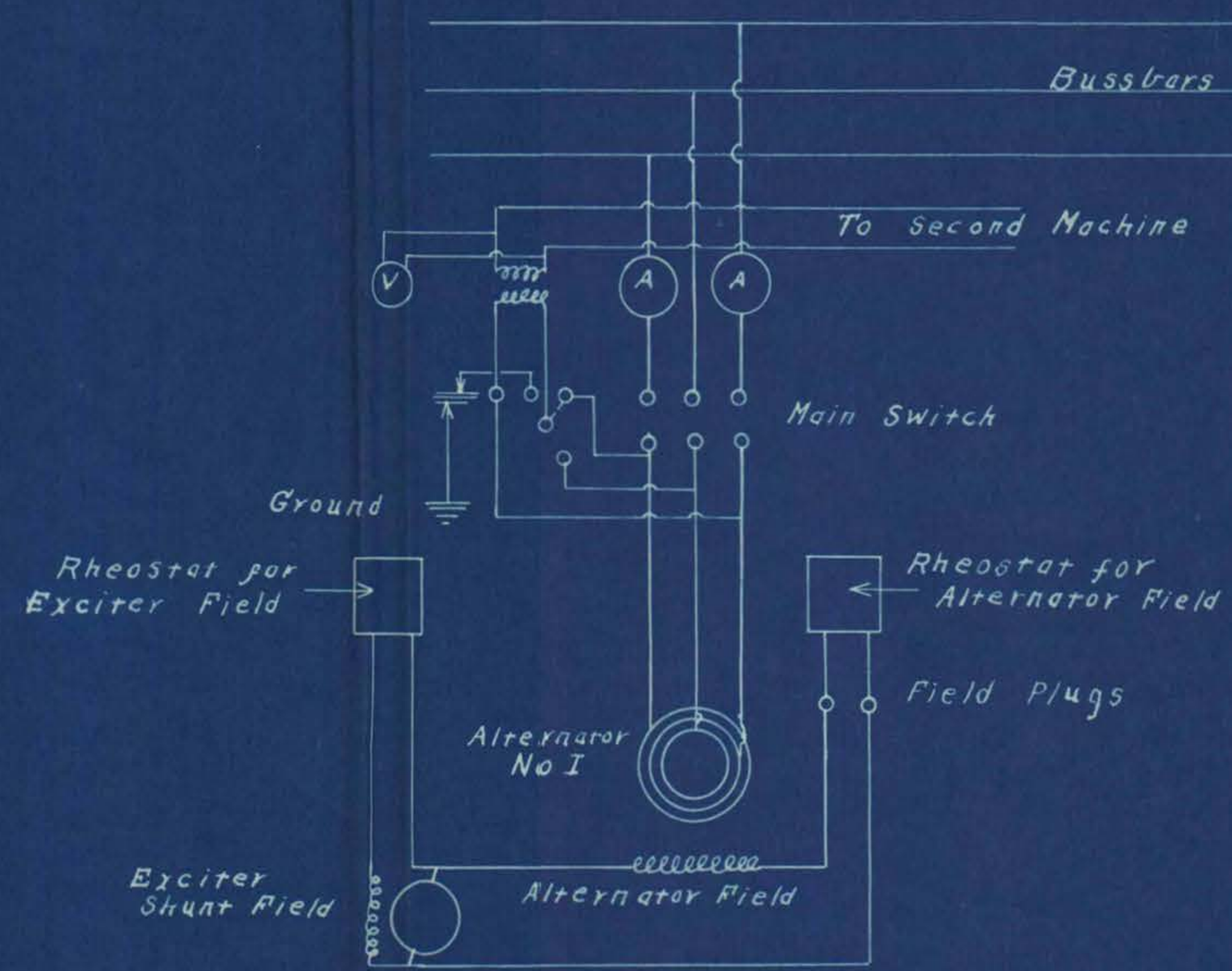
Drawn by H.M. Propst

Serial

Plate No 7



SWITCHBOARD
And
SWITCHBOARD CONNECTIONS



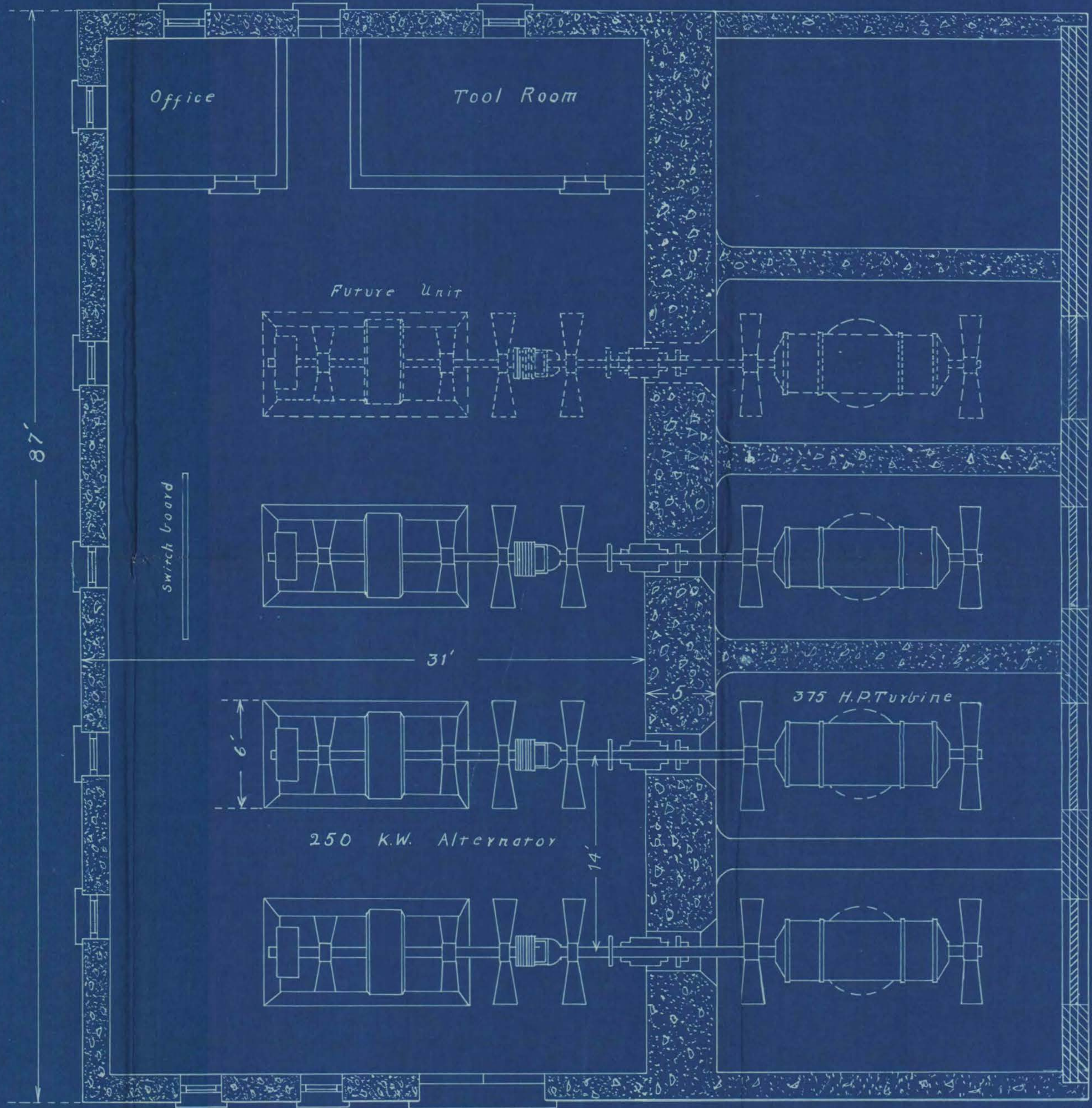
Connections of Second
and Third Machines
Dublicate of
First

POWER PLANT
FOR
ALBANY OREGON

Designed by H. M. Propst
E. A. Sorenson

Drawn by E. A. Sorenson

Serial No. Plate No. 8



PLAN

POWER PLANT
FOR
ALBANY OREGON

Designed by H. M. Propst
E. A. Sorenson

Drawn by E. A. Sorenson

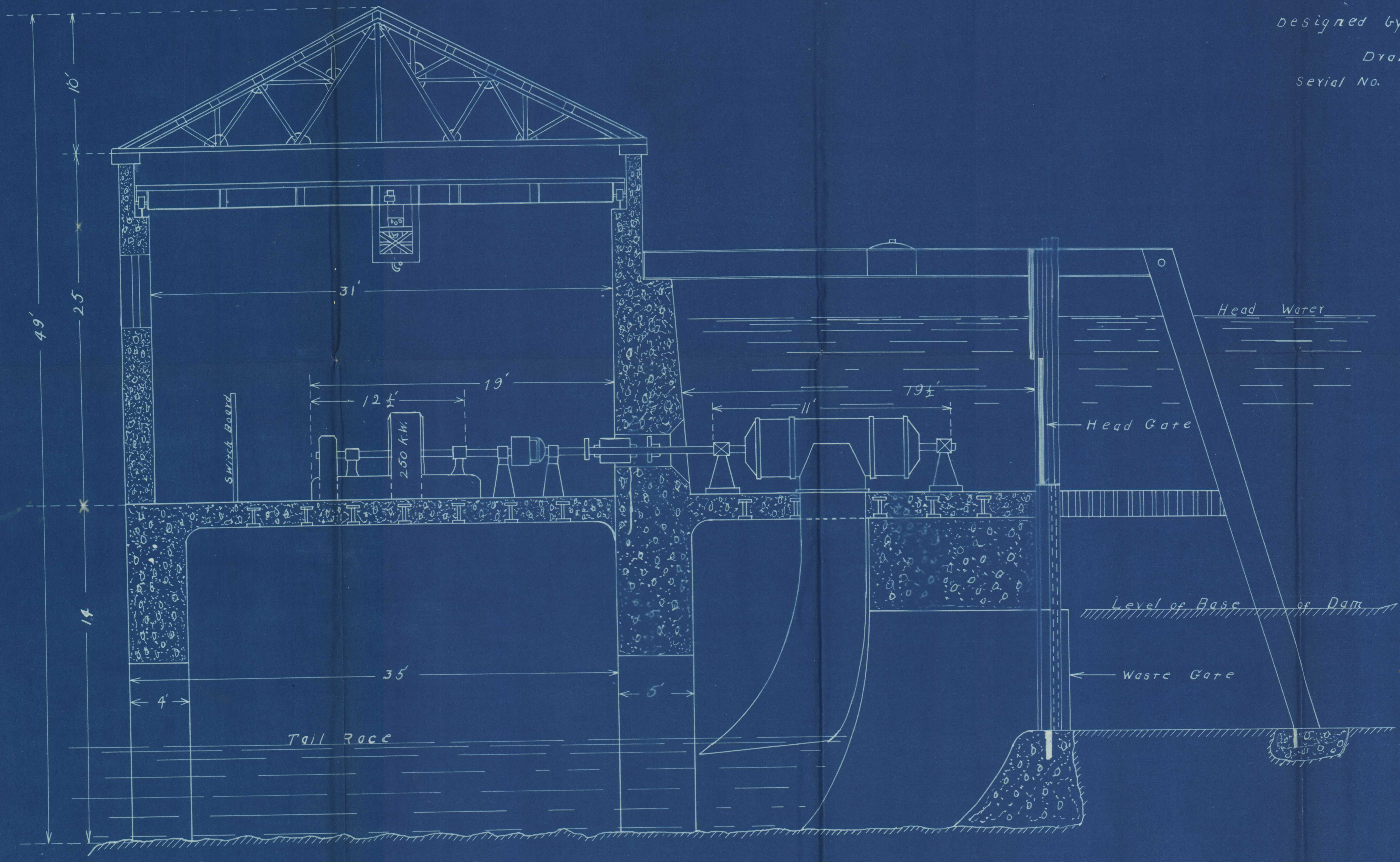
Serial No Plate No 9

POWER PLANT
FOR
ALBANY OREGON

Designed by H. M. Propst
E. A. Sorenson

Drawn by E. A. Sorenson

Serial No. Plate No. 10



TRANSVERSE CROSS-SECTIONAL ELEVATION