A MAJOR THESIS FOR THE DEGREE

OF

MASTER OF SCIENCE IN AGRICULTURAL ENGINEERING

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[Methods and cost of developing farm water power]

SUBMITTED BY

HARRY MOORE WALLACE JR.

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VIRGINIA POLYTECHNIC INSTITUTE

1926

METHODS AND COST OF DEVELOPING FARM WATER POWER.

INTRODUCTION.

Country life today does not bring to mind the inconveniences and hardships with which our fathers contended. All kinds of conveniences may be had on the modern farm, through the use of water power.

Where there is a small stream or mountain brook that may be carried in a two inch pipe, luxuries and pleasures may be had at a small cost. A complete description of such a plant built in 1919 at the cost of $448.00 will be given in this study.

With the increasing cost of fuel and labor, a small water power is a valuable possession. One horse power by steam costs at least seventy dollars per annum under the most efficient methods. A gasoline engine is even more expensive for continuous service.

On this basis a water unit developing ten horse power is worth from seven hundred to one thousand dollars a year.

There are hundreds of water power installations in Virginia, and thousands of valuable water power sites that may be easily harnessed. The power may be used with very little cost for upkeep.

Electricity in Virginia homes is being used for lighting, cooking, pumping, washing, milking, refrigerating, sewing; to operate vacuum cleaners, electric fans, dish washers, separators, electric irons, electric motors and many other appliances.

After a survey of a site has been made, one naturally desires information on the cost of a power installation. On account of various requirements, such as: storage, batteries, governors, dams, and long flumes, none of which may be needed,

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it is impossible to state the cost per horse power of water units. With the type of power site known as shown by a survey, a close estimate of the cost and power available may be quickly made.

Water powers may be developed as water power plants, or hydroelectric plants. A hydroelectric plant transfers the power developed by a water power plant into electrical energy, by its electrical equipment.

OBJECT.

To obtain reliable information on the methods of developing small water powers, and the cost of such plants under various typical conditions.

CONDUCT.

METHODS OF CONDUCTING THIS STUDY, WITH EXPLANATION GIVING THE RESULTS OF THE QUESTIONNAIRS.

Letters were sent to known manufacturers of water wheels, asking them for names of other manufacturers of the same equipment. The list of manufacturers obtained in this way received individual letters asking for information on their equipment, and the location of their water wheels in Virginia. Over six hundred names of water wheel owners were obtained by this method.

Reference and textbooks were next obtained, and a complete course of study mapped out.

At that time the method of procedure was to make a study of only the plants in operation. A complete short questionnaire was worked up and sent to all the individual owners in Virginia.

Result of the questionnaire: Twenty-four per cent of these letters were marked dead or unknown. Thirty-one per cent were answered. The remaining forty-five per cent were not answered.

Only forty-one per cent of the answered questionnaires were of value due to the three following factors:

1. The questionnaires were partly filled out.
2. The builder had no idea of the cost of any part of the plant.
3. The plant was not built by the present owner, and no information could be obtained from the builder.

Some of the water power plants in Virginia have been in use over fifty years. Fourteen per cent of the answered questionnaires were answered in this way, which shows to some extent the life of even the older types of water units.

It was then evident that the information received in this way was not adequate to form an accurate working knowledge. This information could only be used as a guide.

Water powers were divided into seven typical divisions. Water power plants and hydro-electric plants were designed for these typical divisions, giving data or cost estimation as well as the cost of the elements of each plant.

This was done by aid of information received from the questionnaire, manufacturers, a study of plants in operation, making five actual surveys of power sites, the use of texts, and the cost of labor under present conditions.

The conclusionsreached in this study were checked by using engineering hand books to determine such problems as the amount of various kinds of labor a man can perform in a day.

#1.

SUBJECT AND CALCULATIONS.

Methods of Developing Small Water Powers, After the Power Site Has Been Surveyed.

NOTE--For making a survey of a water power see Farmers Bulletin No. 1430-By C. E. Sietz, J. S. Glenn, and A. M. Daniels.

METHODS OF DEVELOPING THE HEAD.

The pioneers of this country used a method in developing water powers that is very practical today. This method is to construct an open earth ditch or wood conduit on the side of a hill. The water is diverted into this ditch by a small diversion dam.

The water is carried in this open conduit to a point where the greatest amount of head, to the shortest distance, from the old stream bed can be obtained. The water is carried from this point in an open conduit on trestles or a closed pressure conduit. Site "C" pages (67 to) illustrate this method clearly.

CLOSED PRESSURE CONDUCTS.

2. Closed pressure conduits as riveted steel pipe, wood pipe or reinforced concrete pipe are always used in the development of large high head water powers. A larger dam is impracticable.

By using a closed pressure conduit, for small developements, the cost of a large dam can likewise be eliminated. The head lost by a properly designed closed conduit is not half that lost by an open ditch.

HIGH DAMS

3. High dams may be used economically to secure the desired head, as well as the desired storage. However it is only practicable to use such a dam where the span is relatively short, and

a good foundation, on the sides especially, can be secured.

An ideal location for such a dam is where a stream has cut a channel through a cleft, which would otherwise have caused a natural pond. Such a location is often found though usually the cut is too wide. Site A pages (56) represents a very good illustration of a low-high dam for this type of location.

DAM AND CONDUIT COMBINED.

4. Site "B" pages(56) shows a development using a fairly high dam and a long conduit. By this method the excessive cost of a high dam is somewhat eliminated. The construction of a dam with a certain height is practical to a certain point. Additional head is secured by the use of a conduit.

A HIGH DAM constructed at site "B" page (56) would cost ten times that of the dam higher up, and a long flume. The pond caused by the large dam would cover fifty acres of valuable land.

It is admitted that the water storage is great and that a very large wheel could be used, yet only a short time daily. The value of this storage as well as the large wheel naturally depends on the length of time the plant may be run. In that you cannot use over the 24 hour stream flow storage per day, the larger dam has no more value than the small dam above.

LONG GRADED TAILRACE

5.

The value of a well graded tail race, be it short or long, cannot be over emphasized. Many overshot wheels are dragging in back water causing considerable loss of head. The wheels for these installations were designed too large for the effective head.

This dragging may be eliminated by the construction of a long tail race emptying into the old stream bed, as soon as the proper grade is reached.

The construction of a two to three hundred foot tail race may be a means of securing from two to four feet of additional head at the least expense.

METHODS OF INCREASING THE FLOW

1. STORAGE DAM.

The use of a storage dam was partly explained above, in the discussion of dams, to secure the desired head.

Storage dams may be used entirely for storage alone. For storage alone the dam is usually of cheap construction, earth or crib, it having a height of two to five feet. It is located in a depression above or at the head of the site. The water being carried in on opened or closed pressure conduit to the wheel. Site "F" page (88) illustrates such a dam, and it may be noticed that this dam is located near the top of the hill yet by its location considerable head was lost.

By using a dam, be it for head and storage or storage alone, its value, assuming it is of sufficient size, it attributed to producing an increase in flow to run the desired size water wheel for a certain length of time. In this way the flow may be doubled for twelve hours over the straight stream flow for twenty-four hours.

2. BRINGING ONE SMALL STREAM INTO ANOTHER.

By diverting one stream into another as in Site "F" an increase of flow is secured

#5.

ELEMENTS OF A WATER POWER PLANT WITH COST.

INDEX.

#6.

BODY-A.

WATER WHEELS--THEIR USES AND COST.

The power of falling water is converted to usable power by means of water wheels.

Water wheels are generally classified as follows:

1. Reaction or pressure wheels (reaction turbine)
2. Gravity or current wheels.
   - (a) Overshot
   - (b) Undershot
   - (c) Breast
   - (d) Pitch back
3. Impulse or velocity wheels (Pelton)

The reaction, overshot and impulse wheels are generally used for the development of small water powers.

REACTION TURBINES.

Reaction turbines are cheaper than any other type of wheel. They will handle a greater quantity of water from a storage dam. The water may be drained from a dam very low. The size of the wheel and the low location, enables this feature to be of value.

Turbines are designed horizontally and vertically; have a high speed, and are easily regulated by a fly ball governor. Stock turbines are built for heads verying from two to eighty feet.

For high heads the Hunt-Frances runner is used. For medium and low heads the Hunt-McCormic runner is used.

Turbines have a disadvantage of a low efficiency. Manufacturers who manufacture both reaction turbines and overshot wheels estimate the turbine efficiency of from sixty to seventy-five per cent. The efficiency decreases in proportion to the decrease of flow.

#8.

POWER TABLE AND COST OF FITZ REACTION TURBINE WATER WHEELS

WITH DISCOUNT TAKEN OFF.

Size of Wheel	Cu.Ft per min.	HEAD IN FEET 2	5	8	10	15	20	25	30	40	50	60	COST
	Cu.Ft	63	100	126	141	172	200	224	244	282	315	345	
9	H.P.	19	.77	1.57	2.18	4.00	6.18	8.66	11.37	17.49	24.52	32.16	$170.00
	Cu.Ft	86	135	171	192	236	271	303	333	384	430	470	
10½	H.P.	.27	1.05	2.13	2.98	5.47	8.42	11.76	15.48	23.80	33.34	43.80	185.00
	Cu.Ft	112	117	225	250	308	354	397	435	501	560	614	
12	H.P.	.33	1.40	2.79	3.89	7.17	10.76	15.35	20.22	31.06	43.26	56.94	195.00
	Cu.Ft	142	225	283	316	389	459	502	550	634	707	776	
13½	H. P.	.44	1.74	3.51	4.93	9.03	13.95	19.47	25.59	39.36	55.10	72.27	200.00
	Cu.Ft	175	277	351	391	481	555	621	679	784	878	960	
15	H. P.	.54	215	4.37	6.07	1116	17.20	24.07	31.61	48.69	67.94	89.28	210.00
	Cu.Ft	211	336	424	574	581	671	750	823	949	1063	1165	
16½	H.P.	.66	2.61	5.27	7.35	1350	20.79	29.07	38.22	58.87	82.90	108.4	225.00
	Cu.Ft	252	399	505	565	692	800	894	977	1130	1260	1380	
18	H.P.	.78	3.10	6.27	8.72	1605	24.78	34.63	45.38	70.02	98.08	128.5	250.00
	Cu.Ft	343	543	687	769	942	1086	1215	1332	1537			
21	H. P.	1.07	4.22	8.52	11.93	1766	33.66	47.08	61.93	95.32			290.00
	Cu,Ft	448	709	897	1003	1229	1419	1587	1738	2007			
24	H. P.	1.40	5.51	11.12	15.56	2856	44.00	61.50	80.83	124.4			340.00
	Cu.Ft	568	900	1132	1264	1557	1797	2010	2202	2542			
27	H. P.	1.86	6.96	14.04	19.70	3619	55.71	77.73	102.3	157.6			400.00
	Cu.Ft	702	1112	1404	1569	1921	2220	2481	2718	3138			
30	H.P.	2.18	8.60	17.26	24.32	4467	68.82	96.13	126.3	194.5			460.00
	Cu.Ft	1011	1597	2022	2260	2770	3196	3578	3915	4519			
36	H. P.	313	12.37	25.08	35.04	6435	99.09	138.4	182.0	280.2			654.00
	Cu.Ft	1444	2284	2889	3232	3956	4570	5109	5598	6463			
42	H. P.	4.47	17.74	35.82	50.10	9204	141.6	197.9	260.3	400.7			875.00
	Cu.Ft	1884	2956	3739	4185	5125	5913	6610	7242	8361			
48	H.P.	5.84	22.97	46.35	64.80	1191	183.3	256.1	336.7	519.3			1,100.00
	Cu.Ft	2328	3729	4716	5274	6459	7456	8337	9133	10546			
54	H. P.	7.30	28.93	58.47	81.75	1500	231.1	323.0	424.7	653.8			1,350.00
	Cu.Ft	2901	4585	5815	6486	7944	9172	10255	11233	12972			
60	H. P.	9.00	35.53	72.10	100.5	1845	284.3	397.3	522.3	804.2			1,725.00

OVERSHOT WHEELS.

Overshot wheels have the highest efficiency of any type of water wheel developed. Their efficiency is from eighty to ninety per cent. When the flow decreases the efficienty stays the same. This is accounted for by the buckets being partly filled and a greater proportion of the water is carried to a lower level before emptying. These wheels are not easily clogged with trash. They are made for heads varying from four to sixty feet. There are over twelve hundred overshot wheels in the State of Virginia.

This type of wheel has the disadvantage of a high cost. Water in a pond cannot be lowered to as low a level as when using a reaction or impulse turbine. It has a low spud which makes it necessary to use high gearing.

FITZ OVERSHOT WHEELS

WITH SHAFTING AND GEARS.

Diameter in Ft.	Width in Ft.	Capacity In H. P.	Cu. Ft. Water Required per Min.	Price 1925.
4	2	.50	85	$216.00
4	4	1.00	170	330.00
5	2	.62	85	258.00
5	3	.95	125	338.00
5	4	1.30	170	516.00
5	5	2.00	250	676.00
6	2	.75	85	300.00
6	3	1.25	125	424.00
6	4	2.00	200	586.00
6	5	2.75	275	772.00
8	1½	1.00	85	444.00
8	2	1.65	120	512.00
8	3	3.00	200	744.00
8	4	5.00	365	944.00
8	6	10.25	750	1232.00
10	1	1.00	65	430.00
10	1½	2.00	110	516.00
10	2	5.00	270	730.00
10	2	5.00	270	630.00
10	3	8.00	430	(S.G.) 872.00
10	3	8.00	430	(M.W.) 882.00
10	4	11.00	560	1130.00
12	1	1.00	50	498.00
12	1½	3.00	145	558.00
12	2	6.00	270	886.00
12	3	9.00	400	1086.00
14	1	1.00	45	590.00
14	1½	3.50	140	786.00
14	2	7.00	270	1158.00
14	3	11.00	400	1300.00
16	1	1.00	42	572.00
16	1½	3.00	110	830.00
16	2	8.00	280	1258.00
16	3	12.00	420	1430.00
18	1	1.20	42	644.00
18	1½	5.00	160	1270.00
18	2	9.00	280	1480.00
20	1	1.33	40	800.00
20	1½	5.50	160	1500.00
24	1	2.00	45	1520.00
11	3	8.50	415	(Master Wheel) 996.00
24	3	11.00	320	(Segment Gear Drive) 1950.00

IMPULSE TURBINES OR PELTON WHEELS

Impulse wheels have an efficiency of 70 to 80 per cent, and are designed primarily for use under high heads. They have a high speed and are made for heads from 20 feet on up. For heads under 60 feet this type of wheel is seldom used for the development of small water powers. This is due to their cost and efficiency compared with other wheels at low heads. They however generally take the field above 80 feet of head.

Prices on individual wheels may be obtained on application.

Impulse

REACTION TURBINES OR PELTON WATER WHEELS

Indicating the Horsepower, Required Water Quantity in Cubic Feet per Minute and R. P. M. for Standard Single-Nozzle Wheels and Standard Type Motors.

Head in Feet	Cost / Size Wheel	$68.00 / 6 In.	$112.00 / 12 "	$200.00 / 15"	$245.00 / 18"	$345.00 / 24"	3'	4'	5'	6 '
20	H.P.	.05	.12	.20	.37	.66	1.50	2.64	4.18	6.00
8.66 #	Cu.Ft.	1.65	3.97	6.61	12.20	21.75	49.60	87.20	138.0	198.0
2152	R.P.M.	675	359	289	243	177	111	85	67	55
30	H.P.	.10	.23	.38	.69	1.22	2.76	4.88	7.69	11.04
13.00#	Cu.Ft.	2.20	5.06	8.36	15.09	26.83	60.80	107.3	169.2	243.0
2635	R.P.M.	826	439	352	298	216	135	103	82	68
40	H.P.	.15	.35	.59	1.06	1.89	4.24	7.58	11.85	16.96
17.34#	Cu.Ft.	2.47	5.78	9.74	17.50	31.20	70.00	125.2	195.6	280.0
3043	R.P.M.	956	508	407	344	251	157	119	95	78
50	H. P.	.21	.49	.84	1.49	2.65	5.98	10.60	16.63	23.93
21.67#	Cu.Ft.	2.78	6.47	11.09	19.68	35.00	78.95	140.0	219.5	316.1
3397	R.P.M.	1068	567	455	385	280	176	134	107	88
60	H. P.	.28	.65	1.10	1.96	3.48	7.84	13.94	21.77	31.36
26.00#	Cu.Ft.	3.08	7.15	12.10	21.56	38.30	86.23	153.3	239.4	345.2
3727	R.P.M.	1170	621	498	421	307	193	146	116	97
70	H. P.	.35	.82	1.39	2.47	4.39	9.88	17.58	27.51	39.52
30.34#	Cu.Ft.	3.30	7.73	13.12	23.30	41.45	93.20	165.8	259.5	373.0
4025	R.P.M.	1265	672	539	455	332	208	158	126	104
80	H.P.	.43	1.00	1.70	3.01	5.36	12.04	21.44	33.54	48.16
34.67#	Cu.Ft.	3.55	8.25	14.04	24.85	44.23	99.50	177.0	277.0	398.0
4303	R.P.M.	1350	717	576	486	354	222	169	135	111
90	H. P.	.51	1.20	2.03	3.60	6.39	14.40	25.59	40.04	57.60
39.01#	Cu.Ft.	3.74	8.80	14.88	26.40	46.81	105.6	187.6	293.6	422.2
4564	R.P.M.	1434	762	611	516	376	236	179	143	118

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REACTION TURBINES OR PELTON WATER WHEELS

Indicating the Horsepower, Required Water Quantity in Cubic Feet per Minute and R.P.M. for Standard Single-Nozzle Wheels and Standard Type Motors.

Head in Feet	Cost / Size Wheel	6 In.	12 In.	15 In.	18 In.	24 In.	3 ft.	4 ft.	5 ft.	6 ft.
	Cost	$68.00	$112.00	$200.00	$245.00	$345.00				
100	H.P.	.60	1.40	2.32	4.21	7.49	16.84	29.85	46.85	67.36
43.34#	Cu.Ft.	3.96	9.25	15.31	27.80	49.45	111.2	197.6	309.3	444.9
4811	R.P.M.	1512	802	644	545	396	249	189	151	124
110	H.P.	.69	1.62	2.74	4.86	8.64	19.44	34.58	54.11	77.76
47.67#	Cu.Ft.	4.14	9.72	16.45	29.19	51.86	116.7	207.5	325.0	467.1
5046	R.P.M.	1586	841	676	570	415	261	198	158	131
120	H.P.	.79	1.84	3.12	5.54	9.85	22.18	39.41	61.66	88.75
52.01#	Cu.Ft.	4.35	10.12	17.16	30.47	54.20	122.0	216.8	339.1	488.2
5271	R.P.M.	1657	869	706	596	434	272	207	165	137
130	H.P.	.89	2.08	3.53	6.25	11.11	25.02	44.56	69.53	100.08
56.34#	Cu.Ft.	4.52	10.57	17.93	31.76	56.47	127.2	225.8	353.4	509.0
5486	R.P.M.	1724	915	735	620	452	284	215	172	143
140	H.P.	.99	2.33	3.94	6.90	12.41	27.96	49.64	77.71	111.85
60.68#	Cu.Ft.	4.68	11.00	18.60	33.00	58.60	132.1	234.5	367.1	527.2
5693	R.P.M	1790	950	763	644	469	295	223	178	148
150	H.P.	1.10	2.58	4.37	7.75	13.77	31.01	55.08	86.22	124.04
65.01#	Cu.Ft.	4.85	11.36	19.23	34.12	60.58	136.6	242.5	379.4	546.2
5893	R.P.M.	1852	982	790	667	484	305	231	184	153
160	H.P.	1.22	2.84	4.82	8.54	15.17	34.16	60.68	94.94	136.65
69.34#	Cu.Ft.	5.04	11.74	19.92	35.30	62.65	141.2	250.8	392.2	564.7
6086	R.P.M.	1914	1016	816	688	502	315	239	190	158
170	H. P.	1.33	3.11	5.28	9.35	16.61	37.42	66.46	103.99	149.68
73.68	Cu.Ft.	5.18	12.10	20.53	36.40	64.64	145.7	258.3	404.6	582.7
6274	R.P.M.	1970	1046	840	709	517	324	246	196	163

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Indicating the Horsepower, Required Water Qantity in Cubic Feet per Minute and R.P.M. for Standard Single-Nozzle Wheels and Standard Type Motors.

Head in Feet	Cost / Size Wheel	$68.00 6 in.	$112.00 12 in.	$200.00 15 in.	$245.00 18 in.	$345.00 24 in.	3 ft.	4 ft.	5 ft.	6 ft.
180	H. P.	1.45	3.39	5.75	10.19	18.10	40.77	72.41	113.30	163.08
78.01#	Cu.Ft.	5.32	12.44	21.10	37.40	66.39	149.5	265.8	416.0	598.5
6455	R.P.M.	2024	1074	863	728	530	333	253	201	167
190	H. P.	1.57	3.68	6.24	11.05	19.63	44.21	78.53	122.87	176.86
82.35#	Cu. Ft.	5.46	12.80	21.73	38.46	68.36	153.8	273.3	427.8	615.6
6632	R.P.M.	2079	1104	887	749	544	342	260	207	171
200	H. P.	1.70	3.97	6.74	11.93	21.20	47.75	84.81	132.70	191.00
86.68#	Cu.Ft.	5.61	13.10	22.25	39.40	70.00	157.6	280.0	437.8	630.0
6804	R.P.M	2132	1138	910	767	559	351	266	213	175
210	H. P.	1.83	4.28	7.25	12.84	22.81	51.38	91.26	142.78	205.52
91.01#	Cu.Ft.	5.76	13.45	40.38	40.38	71.73	161.6	287.0	448.5	646.2
6972	R.P.M.	2186	1162	933	787	573	360	273	218	180
220	H. P.	1.96	4.59	7.77	13.77	24.46	55.09	97.85	153.10	220.36
95.35#	Cu.Ft.	5.88	13.78	23.33	41.30	73.41	165.4	294.1	459.8	661.0
7136	R.P.M.	2240	1190	955	805	587	369	280	223	185
230	H. P.	2.10	4.90	8.31	14.72	26.15	58.89	104.60	163.66	235.56
99.68#	Cu.Ft.	6.03	14.07	23.85	42.28	75.00	169.1	300.0	469.9	676.2
7297	R.P.M.	2291	1216	976	823	600	377	286	228	189
240	H. P.	2.24	5.23	8.86	15.69	27.87	62.77	111.50	174.45	251.10
104.02#	Cu.Ft.	6.16	14.47	24.38	43.15	76.65	172.6	306.6	480.0	690.5
7454	R.P.M.	2339	1243	997	841	612	385	292	233	193
250	H. P.	2.38	5.56	9.42	16.68	29.63	66.74	118.54	185.47	266.96
108.35#	Cu.Ft.	6.28	14.67	24.86	44.00	78.20	176.1	313.0	490.0	705.0
7607	R.P.M.	2387	1268	1019	858	626	393	298	238	197
260	H. P.	2.52	5.89	10.05	17.69	31.43	70.78	125.72	196.71	283.15
112.68#	Cu.Ft.	6.40	14.96	25.53	44.95	79.86	179.8	319.5	500.00	720.0
7758	R.P.M.	2435	1293	1038	876	638	401	304	243	201
270	H. P.	2.67	6.24	10.67	18.72	33.26	74.90	133.05	208.17	299.63
117.02#	Cu.Ft.	6.53	15.27	26.10	45.81	81.38	183.3	324.8	509.9	733.5
7906	R.P.M.	2482	1318	1059	894	650	408	310	247	205
280	H. P.	2.82	6.59	11.16	19.77	35.12	79.11	140.51	219.84	316.44
121.35#	Cu.Ft.	6.65	16.57	26.28	46.65	82.81	186.9	331.9	518.6	746.5
8051	R.P.M.	2530	1342	1083	911	663	416	316	252	208

Impulse

REACTION TURBINES OR PELTON WATER WHEELS

Indicating the Horsepower, Required Water Quantity in Cubic Feet per Minute and R.P.M. for Standard Single-Nozzle Wheels and Standard Type Motors.

Head in Feet	Cost / Size Wheel	6 in.	12 in.	15 in.	18 in.	24 in.	3 ft.	4 ft.	5 ft.	6 ft.
	Cost	$68.00	$112.00	$200.00	$245.00	$345.00				
290	H.P.	2.97	6.94	11.77	20.84	37.02	83.38	148.10	231.73	333.55
125.69#	Cu.Ft.	6.77	15.84	26.85	47.55	84.48	190.4	338.0	528.4	760.0
8194	R.P.M.	2574	1366	1101	926	675	424	322	257	212
300	H.P.	3.13	7.31	12.38	21.93	38.95	87.73	155.83	243.82	350.94
130.0 2#	Cu.Ft.	6.88	16.09	27.25	48.25	85.66	193.0	343.0	536.2	771.6
8334	R.P.M.	2620	1390	1121	942	686	432	327	261	216
310	H.P.	3.29	7.68	13.01	23.04	40.92	92.16	163.69	286.11	368.64
134.35#	Cu.Ft.	7.01	16.36	27.72	49.10	87.10	196.3	248.7	546.0	785.0
8471	R.P.M.	2665	1414	1140	958	697	439	333	265	220
320	H.P.	3.45	8.05	13.64	24.16	42.91	96.65	171.68	268.60	386.62
138.69#	Cu.Ft.	7.12	16.60	28.13	49.82	88.50	199.2	354.0	554.0	797.2
8607	R.P.M.	2705	1437	1156	973	708	455	338	269	223
330	H.P.	3.61	8.43	14.29	25.30	44.94	101.22	179.72	281.29	404.89
143.02#	Cu.Ft.	7.22	16.86	28.60	50.60	89.88	202.5	359.6	562.6	809.0
8720	R.P.M.	2746	1458	1172	987	720	452	343	274	227

NOTE:- Extra for suitable type speed governor together with jet deflector as a means of effecting speed regulation-------approximately $450.00 depending upon the exact engineering conditions obtaining, that is, with respect to head, horse power and speed. Governor not required for plant developing less than 10. Horse Power

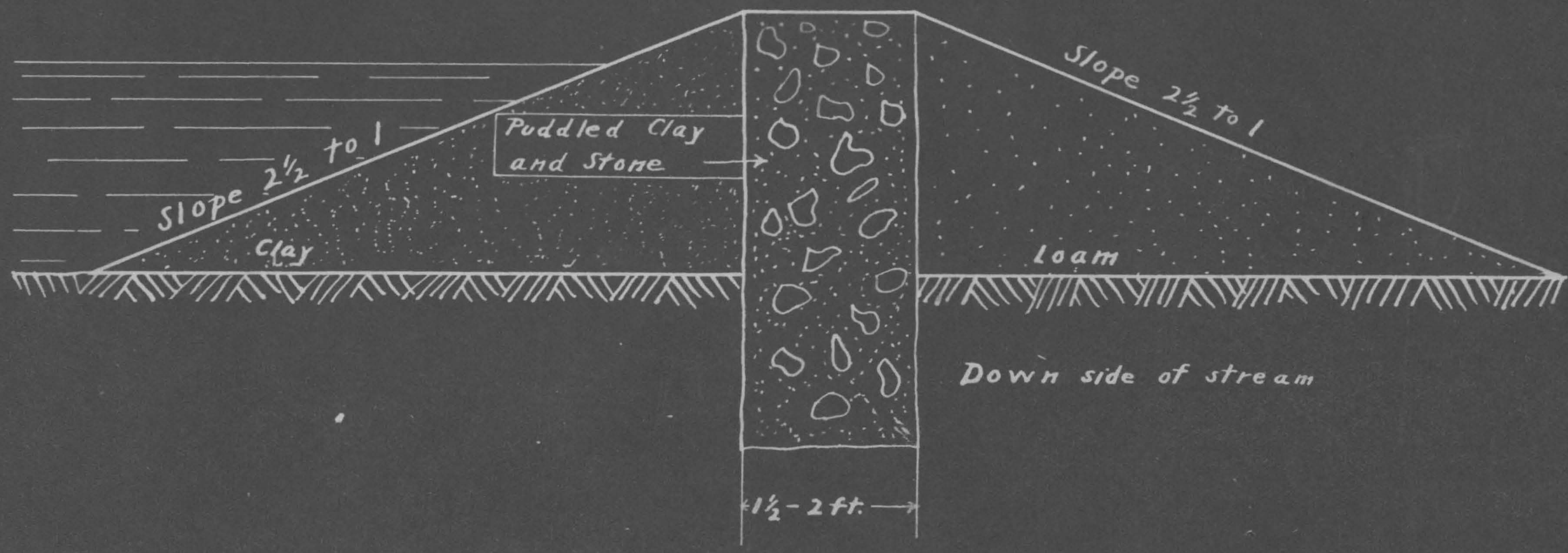
DAMS.

A diversion dam is a small dam used to divert a stream's course into a conduit.

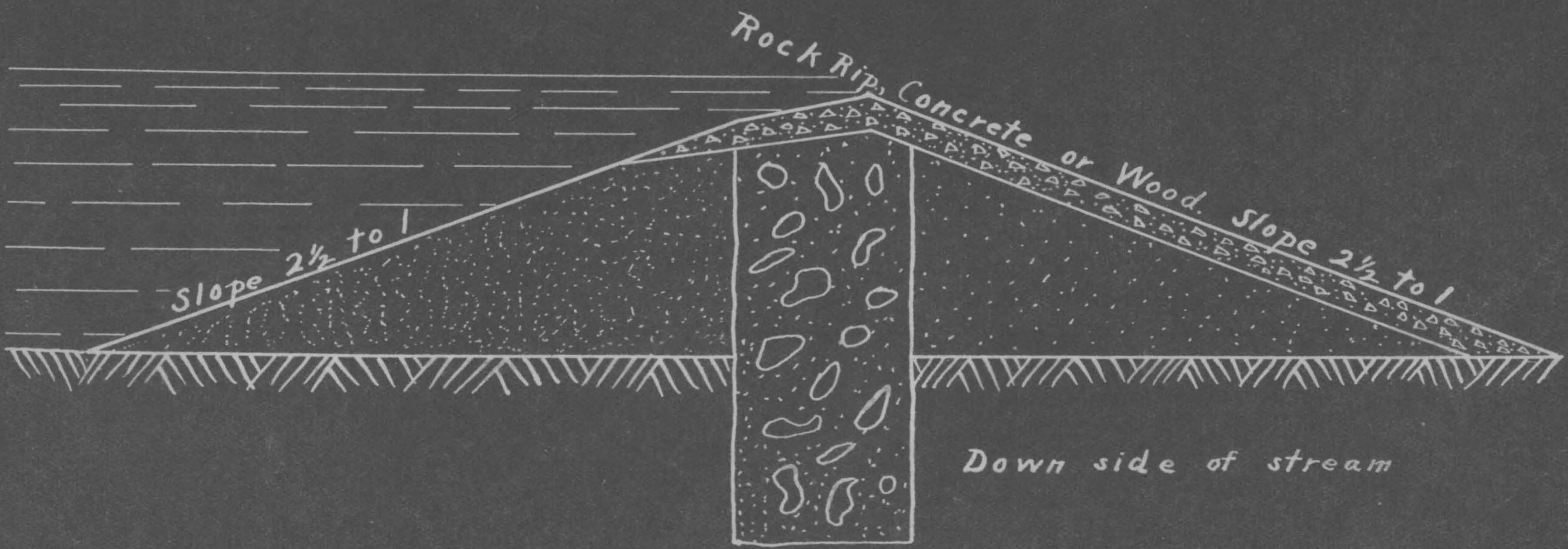
The materials used in constructing both small and large dams are, earth, wood, stone and concrete.

The spillway section of any dam should be built of concrete masonry, stone, wood or cribbing. The spillway section shown on page (21) may answer the purpose, though is not recommended.

Earth Dam



Spillway Section



COST OF EARTH DAMS.

Cost of an earth dam 100 ft. long, 5 ft high.

231 cu. yds of earth placed @ 30¢ per cu. yd	$69.30
50 cu. yds of puddled clay & gravel @ $1.00 per cu. yd.	50.00
TOTAL COST----------------------------	$ 119.30

Cost per lineal foot----$1.19

Cost per cu. yd of earth dam--51¢

NOTE: This work is done by scrapers carrying earth 100 ft. Cost per day of man scraper and team $5.00. Cost of helper per day $2.50. At this price a man and helper will move loam at 15¢; clay at 19¢ and earth with stone mixed 23¢ per cu. yd. For each 100 ft. lead (or distance) add 5¢ per cu. yd.

COST OF AN EARTH DAM SPILLWAY SECTION.

Cost of an earth dam spillway section 100 ft. long, 5 ft. high.

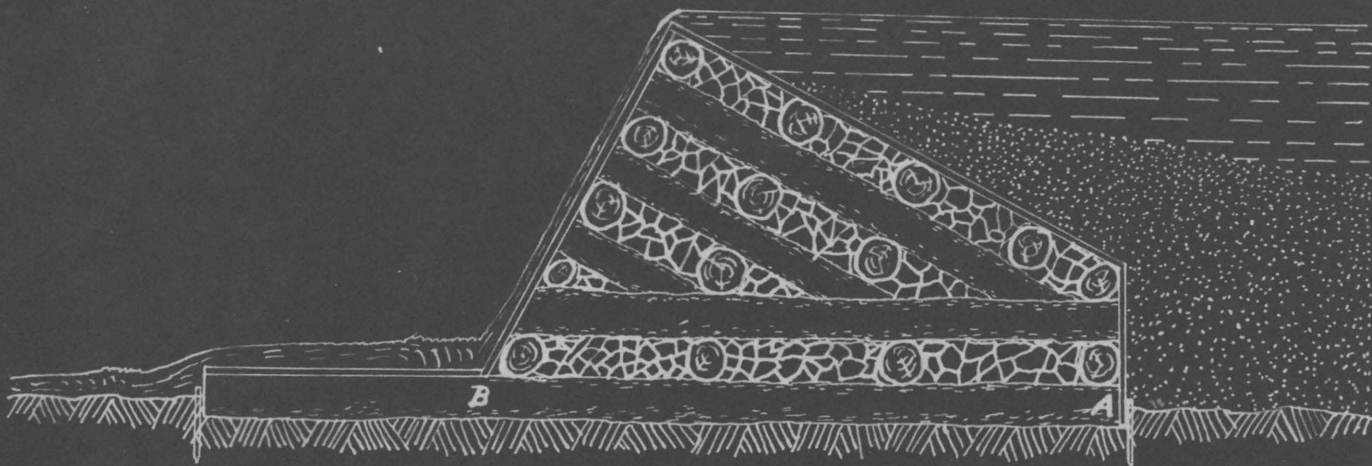
201 cu. yds of earth @ 35¢ per cu. yd	$70.35
30 cu. yrd of Rup-rap @ $8.00 per cu. yd	240.00
TOTAL COST OF 100 ft. Spillway section----------	$ 310.35

SUMMARY:

Cost per lineal ft----$3.10

Cost per cu. yd of spillway section--$1.35

Crib Dam



The construction of a typical crib dam is shown in Page

The cost of a dam of this design is given below:

COST OF CRIB DAMS

Dam 100 ft. long and 5 ft. high.

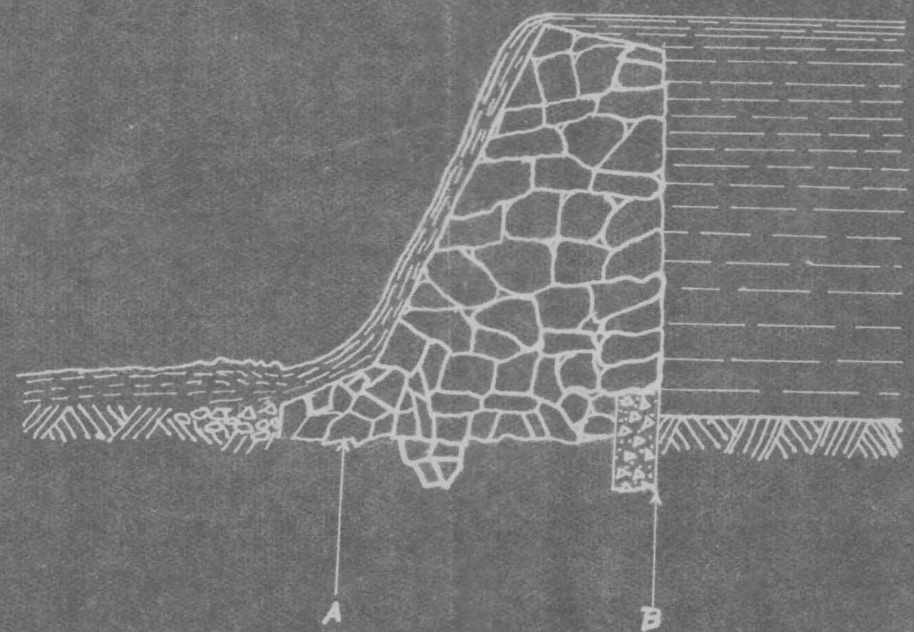
Longitudinal timbers 8,145 ft. B. M. @ $5.00 per 100 ft. B.M.	$40.75
Transverse timbers 5000 ft. B. M. @ $5.00 per 1000 ft. B. M.	25.00
Lumber 2,500 ft. B.M.@ $30.00 per 100 ft. B. M.	75.00
Quarrying rock, filling cribs and grading	160.00
Farm labor, carpenter work	50.00
Nails, spikes and iron	20.00
Total cost per 100 lineal ft.	$ 370.75

Cost per Lineal Ft. $3.70

Cost per cu. yd $4.00

NOTE:- Longitudinal and transverse timber figured at what it will cost a farmer to cut and haul this waste timber on his place giving it a value of fire wood. The base, from A to B should be over one and one-half times the height.

Stone Dam



(Blueprint of Stone Dam)

STONE DAM DESIGN AND COST.

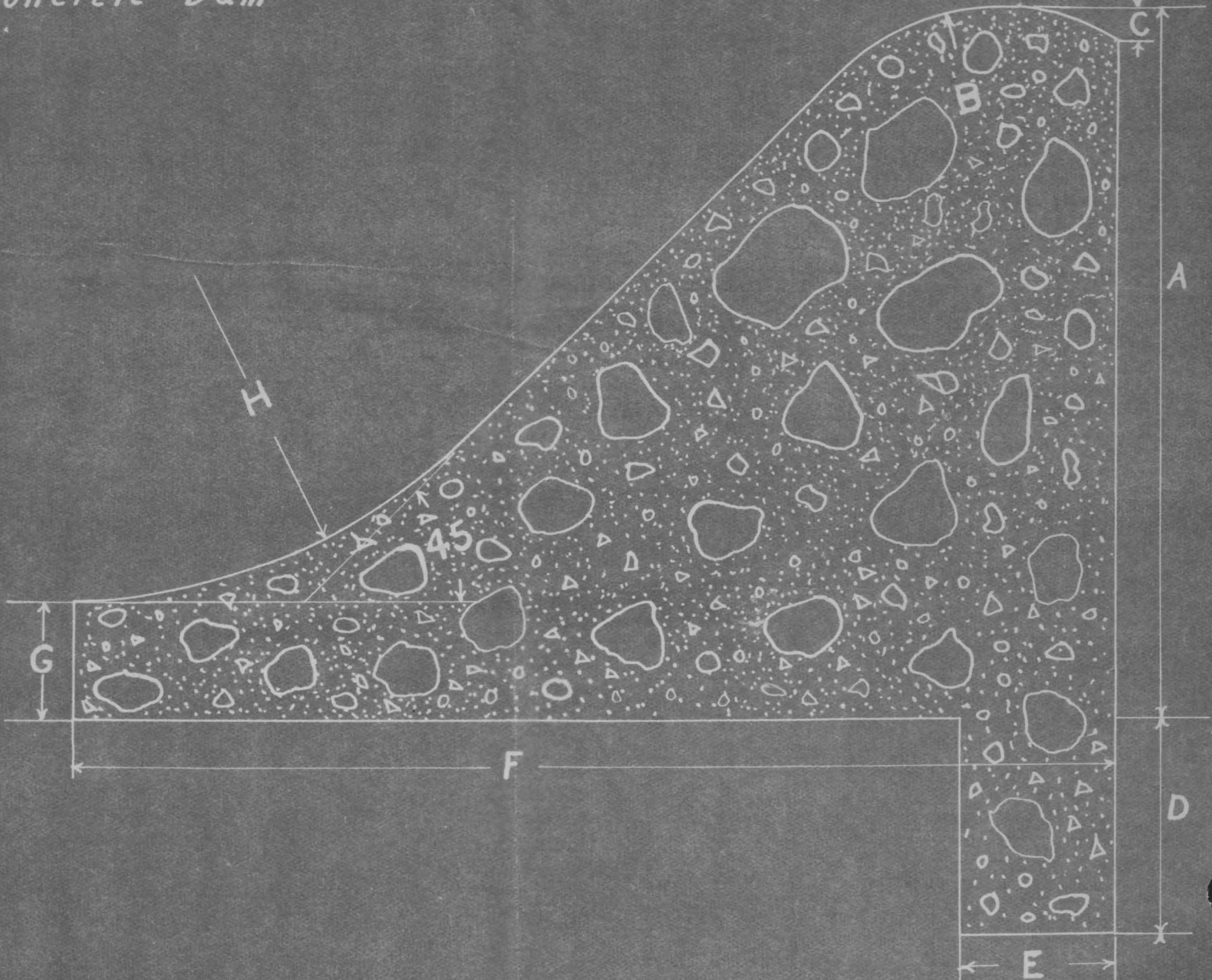
Cut stone and brick should not be used for dam construction as a more stable dam can be made by using rubble masonry.

The base of the stone dam page Fig. (25) A. to B. should be eight tenths its height laid in cement mortar. For this design the height should not exceed 10 feet.

COST OF STONE MASONRY DAM

Cost of Rock per cu. yd		$2.25
Cost of 1: 3 mixture mortar		
8 cu. ft. cement @ $1.00 per cu. ft.	$8.00	
27 cu. ft. sand @ $2.50 per cu. yd	2.50	
Total cost per yd----	10.50	
The amount of mortar required for irregular limestone and sandstone rubble is one cu. yd per cu. yd of masonry. Cost $10.50 ÷ 3		3.50
One mason with a helper, to mix mortar and get stone will lay 4 to 5 bu. yds of stone masonry per 8 hr. day.		
Cost of laying masonry. One mason $5.00. One helper $2.50--$7.50 divided by 4.5 percu. yd.		1.70
Water and extra expense per cu. yd		.20
Total cost per cu. yd of rock dam		$ 7.65

Concrete Dam



Blueprint concrete dam.

COST PER CU. YD OF 1:2:4 MIXTURE CONCRETE DAM.

6	cu. ft. (bags) cement	@ $1.00 per cu. ft	$6.00
12	cu. ft. Sand	@ $3.00 " " yd.	1.77
24	cu. ft. Rock	@ $2.00 " " "	1.33
	Labor to mix and place per cu. yd		2.00
	Average cost of form lumber and nails per cu. yd of concrete		1.02
	Carpenter labor on forms for above		.88
	Total cost per cu. yd of concrete		$ 13.00

By embedding 25% large stone as shown in blueprint for concrete dams a saving of $2.50 per cu. yd is made. $13.00 2.50

Cost per cu. yd of concrete for dam---------- $10.50

NOTE:- Under very suitable conditions small concrete dams may be built at $9.00 per cu. yd. All materials delivered at this price.

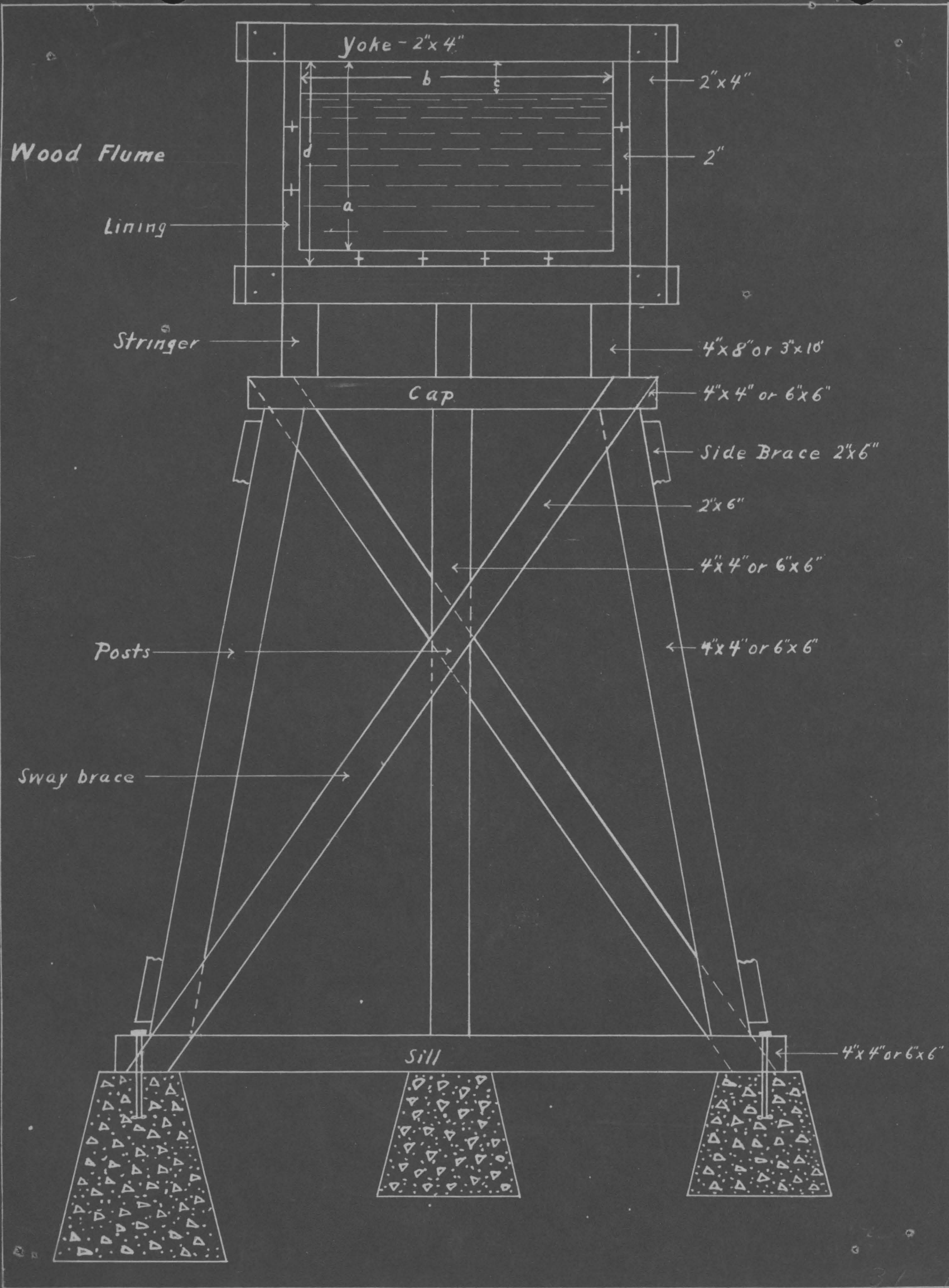
Blue Print

CONCRETE DAM.

The design of a concrete dam is shown in Page (28). The mixture should be 1-2-4. For this design the length should not be over 50 ft. and the heighth over 12 ft. Large stones may be embedded to a proportion not exceeding 30% of the total volume of the dam.

Table 4. Dimensions of sections for gravity concrete dam with cost.

A Height of dam	B	C	D	E	F	Cu.ft of concrete per lineal foot (approx.)	Cost per lin. ft. @ $10.50 per cu. yd.
3'	1'-0"	3"	1'-0"	0'-9"	5'-0"	10	$3.90
4'	1'-3"	3"	1'-0"	0'-9"	6'-0"	15	5.85
5'	1'-6"	3"	1'-3"	0'-11"	7'-3"	22	8.58
6'	1'-9"	3"	1'-6"	1'-1"	6'-6"	31	12.09
7'	2'-0"	3"	1'-9"	1'-3"	9'-9"	41	15.99
8'	2'-2"	3"	2'-0"	1'-6"	11'-0"	53	21.45
9'	2'-7"	3"	2'-3"	1'-9"	12'-6"	67	26.13
10 '	3'-0"	3"	2'-6"	2'-0"	14'-0"	34	32.76



Wood Flume
Yoke - 2"x 4"
b
c
d
a
2"x 4"
2"
Lining
Stringer
4"x 8" or 3"x 10"
Cap
4"x 4" or 6"x 6"
Side Brace 2"x 6"
2"x 6"
4"x 4" or 6"x 6"
Posts
4"x 4" or 6"x 6"
Sway brace
Sill
4"x 4" or 6"x 6"

FLUMES.

It is far more economical in most cases to construct a low diversion dam with a long flume winding around on the side of a hill, than to build a comparatively short flume with a high dam.

Earth flumes should have their base twice as wide as the depth of water. The sides should slope 1' ~~or~~ to $1\frac{1}{2}$'.

COST OF EARTH FLUMES PER CU. YD EXCAVATED.

Loam using plow and scrapers per cu. yd.	$0.12
Clay " " " " " " "	$0.16
Loam using pick and shovel " " "	$0.30
Clay using spade-- " " "	$0.20
Clay using pick and shovel " " "	$0.35
Loam using spade " " "	$0.20
Rocky, or through projecting ledges at stone per cu. yd.	$1.10
Stone " " "	$1.50

Wood flumes should have their base of lining (b page) twice the heighth of lining (a)

FLOW OF WATER IN OPEN WOOD FLUMES.

NOTE: Velocity in feet per second and quantity in gallons per minute, for various sizes and slopes.

FLUMES OF SMOOTH CONCRETE OR ROUGH LUMBER.

Cross Section in feet		1' x ½'	1½' x ¾'	2' x 1'	3' x 1½'	4' x 2'	5' x 2½'
Slope in inches per 100 feet							
	Velocity	1.2	1.6	1.9	2.6	3.2	3.7
3/4"	G. P. M.	270	1825	1725	5200	11475	20350
1/2"	Velocity	1.7	2.2	2.7	3.7	4.5	5.2
	G. P. M.	382	1130	2430	6500	16300	29250
3 "	Velocity	2.4	3.1	3.9	5.2	6.4	7.4
	G. P. M.	540	1560	3510	10500	22950	41625
4½ "	Velocity	2.3	3.8	4.8	6.4	7.8	
	G. P. M.	650	1920	4312	12900	23050	
6 "	Velocity	3.3	4.4	5.5	7.3		
	G. P. M.	742	2220	4950	14775		

FLUMES OF SMOOTH PLANED T & G LUMBER.

Cross Section in feet		1' x ½'	1½' x ¾'	2' x 1'	3' x 1½'	4' x 2'	5' x 2½'
Slope in inches per 100 feet							
3/4"	Velocity	1.7	2.3	2.7	3.6	4.4	5.0
	G. P. M.	382	1162	2430	7275	15750	28125
1/2"	Velocity	2.4	3.2	3.9	5.1	6.2	7.1
	G. P. M.	540	1620	3510	10275	22350	37750
3"	Velocity	3.4	4.5	5.5	7.2		
	G. P. M.	765	2252	4950	14550		
4½"	Velocity	4.1	5.5	6.7			
	G. P. M.	915	2775	6037			
6"	Velocity	4.8	6.4	7.7			
	G. P. M.	1072	3225	6937			

WOOD FLUME COST

SIZE 1' x 1'

FLUME	Number and Size	Number with 25% Waste Added	Estimated Cost
Number of Flume	1		
D x B in Ft.	1 x 1		
Span in ft.	16		
Thickness of lining in In. & Mat.	2(or $1\frac{1}{2}$)	120'	$5.40
Dimension of side yokes, inches	4 x 2		
Yokes spaced in ft.	4		
Top & Bottom yokes, inches	4 x 2		
Number of stringers	2		
Stringer dimensions, inches	3 x 8		
Material in board ft.		97'	3.00
Nails in pounds	10		.50
BENTS			
Dimensions of Caps & Sills, inches	4 x 4		
Number & Size of posts, inches	2-4 x 4		
Maximum height, feet.	10		
Dimensions of bracing, inches	2 x 6		
Lumber in Board feet		162'	4.90
Nails in pounds	8		.40
Diameter of anchor bolts, inches	5/8		.20
Total cost of lumber and nails (for 16' span)			14.40
Concrete piers and form labor			3.00
Labor for 1 bent & 16' of flume			8.00
Hauling @ $5. per 1000 ft. B. M.			2.00
Grand Total for 16 ft. section			27.40

NOTE:*

Lumber for lining of flume figured at $45.00 per 1000 ft. B.M.

All other lumber @ $30.00 per 1000 ft. B. M.
See blue print- b should be twice a; c should be 3 to 6 inches.

Use larger material in bents for a height over 10 feet.

SUMMARY:

Nails, bolts, concrete piers and hauling averaged per lineal foot of flume---$1.21

Labor per lineal foot------------------------------------- .50

Total cost of wood flume 1'x 1' -10 ft. high per lineal ft.-$ 1.71

c 33

WOOD FLUME

FLUME	Number and Size	Number with 25% Waste Added	Estimated Cost
Number of flumes	4		
D x B in feet.	1 x 2		
Span in feet.	16		
Thickness of lining in In. &Mat	2(or 1½)	160	$6.90
Dimension of side yokes, inches	4 x 2		
Yokes spaced in feet	4		
Top & bottom yokes, inches	2 x 4		
Number of stringers	2		
Stringer dimensions, inches	3 x 10		
Material in board feet	260	325	4.95
Nails in pounds	10		.50
BENTS			
Domensions of caps & sills, In.	4 x 4		
Number & size of posts, inches	2-4 x 4		
Maximum height, feet	10		
Dimensions of bracing, inches	2 x 6		
Lumber in Board feet.	120	162	4.90
Nails in pounds	8		.40
Diameter of anchor bolts, inches	½ (8)		.40
			18.05
Concrete piers and form labor			3.00
Labor for 1 Bent & 16' of flume			10.00
Hauling @ $5.00 per 1000ft.B.M.			2.00
Grand total for 16 ft. section			$33.05

NOTE: See blue print- b should be twice a; c should be 3 to 6 inches. Use larger material in bents for a height over 10 feet.

Lumber for lining of flume figured at $45.00 per 100 ft. B.M. All other lumber at $30.00 per 100 ft. B. M.

SUMMARY:-

Lumber, nails, bolts, concrete, piers and hauling averaged
per lineal foot of flume---------------------------------$1.44
Carpenter labor @ $5.00 a day----------------------------$ .62
Total cost of wood flume 1' x 2' -10' high per lin. ft. $2.06

WOOD FLUME

FLUME	Number and Size	Lumber with 25% Waste Added	Estimated Cost
Number of flumes	6		
D x B in feet	1 x 3		
Span in feet	16		
Thickness of lining in In.&Mat.	2(or 1½)		$9.60
Dimension of side yokes, inches	4 x 2		
Yokes spaced in feet	4		
Top & bottom yokes, inches	4 x 2		
Number of stringers	3		
Stringer dimensions, inches	3 x 10		
Material in board ft.	340	372	5.25
Nails in pounds	12		.60
BENTS			
Dimensions of caps & sills, in.	4 x 6		
Number & sizes of posts, inches	2-4 x 4		
Maximum height, feet	10		
Dimensions of bracing, inches	2 x 6		
Lumber in Board feet	120	162	4.90
Nails in pounds	8		.40
Diameter of anchor bolts, inches	½ (8)		.40
Total cost of lumber &nails (for 16' span)			21.15
Concrete piers and form labor			3.00
Labor for 1 Bent 16' of flume			11.00
Hauling @ $5.00 per 1000 ft.B.M.			2.25
Grand total for 16 ft. section			$ 37.40

NOTE: See blue print-b should be twice a; c should be 3 to 6 inches. Use larger material in bents for a height over 10 feet.

Lumber for lining of flume figured at $45.00 per 100 ft. B. M.
All other lumber @ $30.00 per 1000 ft. B. M.

SUMMARY:-

Lumber, nails, bolts, concrete piers and hauling averaged per lineal foot of flume---$1.65
Carpenter labor at $5.00 a day---------------------------------$ .69
Total cost of wood flume 1' x 3'-10 ft. high per lineal ft. $2.34

COST OF VARIOUS SIZES OF WOOD FLUMES

PER LINEAL FOOT.

Size of flume in ft.	Maximum height of bents in ft.	Span in ft.	Cost of all material, hauling &labor on concrete piers per lineal ft. with 25% waste added	Cost of labor to build flume per lineal ft.	Total cost per lineal ft.
1 x 1	10	16	$ 1.21	$ 0.50	$ 1.71
1 x 1	10	16	1.44	0.62	2.06
1 x 3	10	16	1.65	0.69	2.34
1½ x 2	10	16	1.61	0.69	2.30
1½ x 3	10	16	1.72	0.73	2.45
2 x 2	10	16	1.80	0.73	2.53
2 x 3	10	16	2.12	0.85	2.97
3 x 4	10	16	2.90	1.10	4.00

NOTE:-

Lumber for lining of flume figured at $45.00 per 1000 ft. B. M. All other lumber figured at $30.00 per 1000 ft. B. M. Carpenter labot at $5.00 a day.

CAST-IRON PIPE COST.

Size Pipe In Inches	Maximum Ft. Head	Thickness Inches Grade "C"	Approximate lbs. per Lin. Ft.	At $30.00 per Ton actual cost per Lin ft.	Total Cost per Lin.ft. to Lay 2' deep.
4	150	.36	18	$ 0.27	$ 0.58
6	150	.42	29	0.43	0.79
8	150	.48	44	0.66	1.03
10	150	.53	60	0.90	1.30
12	150	.57	76	1.14	1.58
16	150	.65	116	1.74	2.39
20	150	.72	160	2.40	3.34
24	150	.80	213	3.40	4.13
30	150	.91	30	4.50	5.80

REINFORCED CONCRETE PIPE COST

TABEE I By L. S. Gelser & Son, Inc. Fillmore, N. Y.
(Reinforced Sluice Pipe)

STYLE--Tongue and Groove, Two Foot Lengths. Mixture, 2½ parts sand and gravel, one part cement.

REINFORCEMENT--Six to nine No. 6 to No. 10 gauge wire hoops to length, according to size.

Size In.	Weight per lineal Ft.	Thickness inches	Delivered in car lots Price per lineal ft.	Delivered in less car lots Price per lineal ft.
8	45 lbs	1 5/8	$ .66	$ .72
10	58 "	2	.85	.94
12	92 "	2¼	1.18	1.29
15	109 "	2¼	1.38	1.52
18	157 "	2¾	1.72	1.90
24	245 "	3½	2.72	3.03
30	369 "	3¾	4.00	4.45
36	480 "	4¼	5.00	5.55
42	850 "	4½	7.70	8.55
48	1000 "	5	9.30	10.30
54	1200 "	5½	10.80	12.00
60	1500 "	6	13.00	14.50

Prices subject to change without notice.

REINFORCED CONCRETE CULVERT PIPE

REINFORCEMENT

Electric Welded Fabric. Wires cross each other at right angles. Welded at every joint.

MIXTURE

1. Part best Portland Cement
2 Parts clean washed Sand
4 Parts crushed Stone
Pure spring Water

COST

Size in	Weight per Lin.Ft.	Delivered in less carlots price per lineal ft.	D dia n in	A in	F dep in	C th in	E ft	Area circular reinforcement per lineal ft shell in sq.in	Area Long'nal reinforcement per cross section pipe sq.in.
12	95 lbs	$ 1.35	12	2½	2¾	2	4	.070	.196
15	130 "	1.65	15	2¾	2¾	2¼	4	.094	.196
18	180 "	2.10	18	3	2¾	2½	4	.123	.196
24	295 "	3.45	24	3½	3 1/8	3	4	.180	.196
30	400 "	5.05	30	4	3½	3½	4	2 x.162	.393
36	500 "	6.05	36	4½	3½	4	4	2 x.189	.614
42	850 "	9.75	42	5	3½	4½	4	2 x.221	.614
48	1000 "	11.10	48	5½	3½	5	4	2 x.258	1.200
54	1200 "	13.60	54	6¼	3½	5½	4	2 x.295	1.326
60	1500 "	16.00	60	6½	3½	6	4	2 x.330	1.326

One line of Reinforcement in pipe 12 to 24 inches, inclusive

Two lines of Reinforcement in pipe 30 to 60 inches, inclusive

PRICE OF SPIRAL RIVETED PRESSURE PIPE

Inside Dia. In.	Thickness U.S.Std. Gauge	Price per ft. Asphalt Coated	Price per ft. Galvanized	App. Wt. Lbs per Ft. Ashpalted	App. Bursting Strength Lbs. per Sq. in.
3	18	$0.39	$0.53	2.3	2000
4	16	.52	.73	3.7	1875
5	16	.63	.88	4.5	1500
6	(16	.74	1.04	5.3	12500
	(14*	.87	1.21	6.6	1560
	(12**	1.15	1.61	9.2	2170
7	(16	.87	1.22	6.2	1070
	(14*	1.01	1.41	7.7	1340
	(12**	1.34	1.88	10.7	1860
8	(16	1.00	1.40	7.1	935
	(14*	1.16	1.62	8.8	1170
	(12**	1.54	2.17	12.3	1640
9	(16	1.12	1.56	8.0	835
	(14*	1.30	1.81	9.9	1045
	(12**	1.74	2.45	13.9	1460
10	(16	1.24	1.73	8.8	750
	(14*	1.45	2.01	11.0	935
	(12**	1.91	2.69	15.3	1310
11	(16	1.35	1.90	9.7	680
	(14*	1.58	2.20	12.0	850
	(12**	2.08	2.92	16.6	1200
12	(16	1.48	2.07	10.6	625
	(14*	1.72	2.40	13.0	780
	(12**	2.27	3.19	18.2	1080
	(10	2.76	3.88	22.5	1410
13	(14	1.86	2.59	14.1	720
	(12*	2.46	3.45	19.7	1010
	(10**	2.99	4.22	24.5	1295
14	(14	2.00	2.91	15.9	670
	(12*	2.77	3.89	22.2	940
	(10**	3.38	4.75	27.6	1210

PRICE OF SPIRAL RIVETED PRESSURE PIPE

Inside Dia. In.	Thickness U.S.Std. Gauge	Price per ft. Asphalt Coated	Price per ft. Galvanized	App. Wt. Lbs. per Ft. Asphalted	App. Bursting Strength Lbs. per Sq. in.
15	(14	$2.17	$3.12	17.0	625
	(12*	2.97	4.16	23.7	875
	(10* *	3.62	5.10	29.6	1125
16	(14	2.36	3.33	18.1	585
	(12*	3.15	4.43	25.2	820
	(10* *	3.85	5.42	31.5	1050
	(8	4.66	6.54	38.1	1290
	(6	5.47	7.67	44.7	1520
18	(14	2.63	3.66	19.9	520
	(12*	3.40	4.84	27.6	730
	(10* *	4.22	5.95	34.5	940
	(8	5.09	7.16	41.6	1140
	(6	6.00	8.41	49.0	1360
20	(14	2.92	4.06	22.1	470
	(12*	3.82	5.37	30.6	660
	(10* *	4.68	6.59	38.3	840
	(8	5.65	7.94	46.2	1030
	(6	6.62	9.28	54.1	1220
22	(12	4.21	5.91	33.7	595
	(10*	5.15	7.26	42.2	765
	(8* *	6.22	8.73	50.8	940
	(6	7.28	10.21	59.5	1108
24	(12	4.47	6.41	36.5	540
	(10*	5.59	7.88	45.7	705
	(8* *	6.75	9.48	55.2	820
	(6	7.90	11.09	64.6	1015

NOTE: *Extra heavy
**Double extra Heavy
Working pressure should not be more than 25 per cent of the ultimate strength or bursting pressure

Above prices are for plain end pipe without flanges.

PRICE OF RIVETED STEEL PIPE

Dia. of Pipe in In.	Thickness by Stubb's	Equivalent in In.	Price per Lin.Ft.	Dia. of pipe in In.	Thickness by Stubb's	Equivalent in In.	Price per Lin.Ft.
12	No. 14	5/64	$2.65	22	No. 7	3/16	$7.00
14	14	5/64	3.00	24	14	5/64	4.40
14	12	7/64	3.35	24	12	7/64	5.00
14	10	9/64	3.75	24	10	9/64	5.70
16	14	5/64	3.25	24	8	11/64	6.50
16	12	7/64	3.75	24	7	3/16	7.50
16	10	9/64	4.30	30	14	5/64	4.90
16	8	11/64	5.00	30	12	7/64	5.50
18	14	5/64	3.60	30	10	9/64	6.30
18	12	7/64	4.10	30	8	11/64	7.00
18	10	9/64	4.50	30	7	3/16	8.00
18	8	11/64	5.25	36	12	7/64	6.95
20	14	5/64	3.75	36	10	9/64	7.65
20	12	7/64	4.25	36	8	11/64	8.50
20	10	9/64	4.85	36	7	3/16	9.50
20	8	11/64	5.40	42	8	11/64	9.80
22	14	5/64	4.10	42	7	3/16	10.90
22	12	7/64	4.60	48	7	3/16	12.50
22	10	9/64	5.25	54	7	3/16	14.00
22	8	11/64	6.00	54	3	1/4	17.75

PRICES OF WOOD PIPE

Diam.	Head	Shell	Wire	Spacing	Joint	Untreated Coated Weight	Untreated Price	Treated Coated Weight	Treated Price
				Prices per 100 ft. of Pipe f.o.b. Tacome					
2"	50	1"	#8	3"	Inserted	327#	$18.00	371#	$21.60
	100	"	"	2-1/4"	"	337	18.90	381	22.50
3"	50	1"	#8	3"	Inserted	426	22.50	481#	27.00
	100	"	"	2-1/4"	"	440	23.40	495	27.90
4"	50	1-1/16"	#8	3"	Inserted	563	27.90	641	35.10
	100	"	"	2-3/8"	"	579	38.80	657	36.00
5"	50	1-1/16"	#8	3"	Inserted	668	32.40	762	40.50
	100	"	"	2-3/8"	"	687	34.20	781	42.30
6"	50	1-1/8"	#6	3"	Inserted	852	39.60	968	48.60
	100	"	"	2-1/2"	"	870	41.40	986	50.40
8"	50	1-1/8"	#6	3"	Inserted	1081	49.50	1213	61.20
	100	"	"	2-1/4"	"	1119	52.20	1269	63.90
10"	50	1-1/8"	#4	3"	Inserted	1367	62.10	1551	76.50
	100	"	"	2-1/4"	"	1430	66.60	1614	81.00
12"	50	1-3/16"	#4	3"	Inserted	1680	71.10	1915	89.10
	100	"	"	2-1/8"	"	1769	76.50	2004	94.50
14"	50	1-3/16"	#4	3"	Inserted	1957	82.80	2228	102.60
	100	"	"	2"	I.J.R.B.2-7/16"	2097	91.80	2368	111.60
16"									
16"	50	1-1/4"	#2	3"	I.J.R.B.1-7/16"	2404	104.40	2729	127.80
	100	"	"	2-1/4"	" " " " 2-7/16"	2549	114.30	2874	137.70
18"	50	1-1/4"	#2	3"	I.J.R.B.1-7/16"	2674	117.90	3037	144.00
	100	"	"	2-1/16"	" " " " 2-7/16"	2880	133.20	3243	159.30
20"	50	1-5/16"	#2	3"	I.J.R.B.1-7/16"	3059	132.30	3485	162.00
	100	"	"	1-7/8"	" " " " 2-7/16"	3346	152.10	3772	181.80
22"	50	1-5/16"	#2	3"	I.J.R.B.1-7/16"	3360	141.30	3829	173.70
	100	"	"	1-11/16"	" " " " 2-7/16"	3761	167.40	4230	199.80
24"	50	1-5/16"	#2	3"	I.J.R.B.1- 1/2"	3641	155.70	4153	191.70
	100	"	"	1-9/16"	" " " " 2- 1/2"	4144	189.00	4656	225.00
26"	50	1-5/16"	#2	3"	I.J.R.B.1- 1/2"	4249	180.90	4921	221.40
	100	"	"	1-7/16"	" " " " 2- 1/2"	4719	213.30	5391	254.70
28"	50	1-5/16"	#2	3"	I.J.R.B.1- 1/2"	4550	189.90	5274	234.00
	100	"	"	1-5/16"	" " " " 2- 1/2"	5203	223.20	5927	267.30
30"	50	1-5/16"	#1	3"	I.J.R.B.1- 1/2"	4880	204.30	5655	251.10
	100	"	"	2"	" " " " 2- 1/2"	5660	243.90	6435	290.70

INSTRUCTIONS AND PRICE LIST FITTINGS AND VALVES

Fittings- Prices are subject to a maximum discount of 20% when shipped with pipe. If fittings only are ordered quote without discount. When shipped with pipe prices given are f.o.b. destination. If fittings alone are ordered add actual freight applying.

Valves - For valves list is subject to a discount of 25%. When shipped with pipe prices are f.o.b. destination. When shipped alone add actual freight applying.

Prices stated are for fittings with hub ends only. For flanged or threaded connections increase prices and weights as shown in list below. Order for fittings should state definitely kind of connection desired. Additions include all machine work necessary for flanged or threaded connections to metal pipe or casing

TIES	WEIGHT	PRICE	BENDS	WEIGHT	PRICE	Additions to list for flanged or threaded C.		Threaded	Flanged
2x2x2	25 lbs.	$ 2.50	2x2	20 lbs.	$ 2.00	2 inch	20 lbs.	$1.00	$2.50
3x3x3	40 "	4.00	3x3	30 "	3.00	3 "	25 "	1.75	3.00
4x4x4	55 "	5.50	4x4	40 "	4.00	4 "	30 "	2.50	4.00
5x5x5	65 "	6.50	5x5	45 "	4.50	5 "	40 "	3.50	5.00
6x6x6	80 "	8.00	6x6	65 "	6.50	6 "	50 "	4.50	6.00
8x8x8	140 "	14.00	8x8	90 "	9.00	8 "	60 "	7.00	8.00
10x10x10	200 "	20.00	10x10	150 "	15.00	10 "	80 "	9.00	11.00
12x12x12	300 "	30.00	12x12	210 "	21.00	12 "	110 "	12.00	14.00
14x14x14	400 "	40.00	14x14	300 "	30.00	14 "	140 "	16.00	20.00
16x16x16	650 "	65.00	16x16	450 "	45.00	16 "	170 "	20.00	24.00
18x18x18	750 "	75.00	18x18	600 "	60.00	18 "	200 "	24.00	28.00
20x20x20	1000"	100.00	20x20	800 "	80.00	20 "	240 "	28.00	32.00
22x22x22	1100"	110.00	22x22	900 "	90.00	22 "	320 "	36.00	40.00
24x24x24	1200"	120.00	24x24	1000 "	100.00	24 "	400 "	44.00	50.00

CROSSES	WEIGHT	PRICE	WYES	WEIGHT	PRICE	Fir Wood Plugs for Pipe &Fitting	
2x2x2x2	35 lb	$3.50	2x2x2	40 lbs.	4.00	2 inch	$ .50
3x3x3x3	60 "	6.00	3x3x3	50 "	5.00	3 "	.55
4x4x4x4	70 "	7.00	4x4x4	70 "	7.00	4 "	.60
5x5x5x5	90 "	9.00	5x5x5	90 "	9.00	5 "	.75
6x6x6x6	120 "	12.00	6x6x6	150 "	15.00	6 "	1.00
8x8x8x8	180 "	18.00	8x8x8	190 "	19.00	8 "	1.25
10x10x10x10	270 "	27.00	10x10x10	240 "	24.00	10 "	1.50
12x12x12x12	375 "	37.50	12x12x12	500 "	50.00	12 "	2.00
14x14x14x14	425 "	42.50	14x14x14	700 "	70.00	14 "	3.00
16x16x16x16	700 "	70.00	16x16x16	1100"	110.00	16 "	4.00
18x18x18x18	850 "	85.00	18x18x18	1300"	130.00	18 "	5.00
20x20x20x20	1150"	115.00	20x20x20	1700"	170.00	20 "	6.00
22x22x22x22	1400"	140.00	22x22x22	1900"	190.00	22 "	7.00
24x24x24x24	1600"	160.00	24x24x24	2100"	210.00	24 "	8.00

In ordering fir wood plugs be sure to specify whether for pipe or fittings.

REDUCERS	WEIGHT	PRICE
4 x 2	35 lbs.	$3.50
6x4	55 "	5.50
8x6	75 "	7.50
10x8	100 "	10.00
12x10	130 "	13.00
14x12	185 "	18.50
16x14	300 "	30.00
18x16	400 "	40.00
20x18	500 "	50.00
22x20	600 "	60.00
24x22	700 "	70.00

Oak Driving Plug complete with bands

2	
2 inch	$1.50
3 "	1.75
4 "	2.00
5 "	2.25
6 "	2.50
8 "	3.00
10 "	4.00
12 "	5.00
14 "	6.00
16 "	7.00

Gate valves tested to 300 lbs. hydraulic pressure

2 inch	42 lbs.	$10.00
3 "	64 "	14.00
4 "	94 "	19.00
5 "	116 "	27.50
6 "	155 "	32.50
8 "	195 "	54.00
10 "	240 "	90.00
12 "	391 "	125.00

Oak Driving Mauls for laying pipe (Ironed) Price $3.00

March 1, 1924.

AMERICAN CONTINUOUS STAVE PIPE

Prices & Weights per lin. ft. of Pipe

Dia. of Pipe	Head in Feet	Untreated Coated Weight	Untreated Coated Price	Creosoted Coated Weight	Creosoted Coated Price
18"	50	25#	$1.48	30#	$1.67
	100	29	1.83	34	2.02
	150	34	2.25	38	2.43
	200	38	2.64	43	2.80
24"	50	36#	$3.08	43#	$ 2.32
	100	42	2.58	49	2.82
	150	49	3.12	55	3.35
	200	55	3.68	62	3.92
30"	50	47#	$ 3.65	56#	$2.96
	100	56	3.35	64	3.65
	150	66	4.14	74	4.44
	200	75	4.91	84	5.21
36"	50	57#	$3.18	70#	$3.57
	100	70	4.21	80	4.58
	150	84	5.29	93	5.64
	200	97	6.20	107	6.56

The above prices are f.o.b. Virginia and includes the erection of the pipe.

POWER HOUSE

Size 6' x 8' x 10'

Tupe of structure- Wood frame-shed roof.

COSTS

Foundation-six inch, two and one half ft in height= 1.28 cu. yds. @ $10.00 per yd.	$12.80
Lumber -900 ft. B.M.@ $30.00 per 100 ft.B.M.	27.00
Door	2.25
Window (Small)	2.25
Roofing-Galvanized	6.00
Cost of materials & Labor on foundation	50.30
Farm Carpenter Labor	22.70
Total Cost of Power House	$ 73.00

HEAD GATES

Head gates should be located at the entrance of a channel or flume. The average head gate will cost about $15.00 installed.

GENERATORS

Direct-current shunt wound generators are generally used with storage batteries.

Direct-current, shunt-series wound generators may be used as a motor in starting the plant and then used to generate current for the battery.

Direct current compound-wound generators are used for plants without batteries.

Use a 32 volt generator when batteries are used due to extra cost of batteries for 110 volt plant. Use 110 volt generator for plant without betteries.

PRICES

The prices shown are for shunt or compound wound generators. Shunt series wound generators have a small additional cost. The price being made on application.

PRICES FOR SHUNT OR COMPOUND WOUND GENERATOR

K.W. Open 50° Cont.	F. L. R.P.M.	Amps.	Volts	Gen. Only	Gen. Complete	Extra for B.O.B. Rheo.	Allowance for Pulley	Base	F.O.B. Rheo.
.8	1800	23	36	$54	$64	$2.50	$2	$4	$4
.8	1800	13	60	54	66	2.50	2	4	6
1	1800	28	36	63	73	2.50	2	4	4
1	1800	16	60	63	75	2.50	2	4	6
1	1200	28	36	73	83	2.50	2	4	4
1	1200	16	60	73	85	2.50	2	4	6
1	950	28	36	80	92	2.50	2	4	6
1	950	16	60	80	92	2.50	2	4	6
1	550	28	36	140	154	2.50	2	6	6
1	550	16	60	140	154	2.50	2	6	6
1¼	1200	35	36	82	84	2.50	2	4	6
1¼	1200	21	60	82	84	2.50	2	4	6
1½	1800	42	36	70	80	2.50	2	4	4
1½	1800	25	60	70	82	2.50	2	4	6
1½	1200	42	36	100	114	2.50	2	6	6
1½	1200	25	60	100	114	2.50	2	6	6
1½	900	42	36	130	144	2.50	2	6	6
1½	900	25	60	130	144	2.50	2	6	6
1½	750	42	36	140	154	2.50	2	6	6
1½	750	25	60	140	154	2.50	2	6	6
1½	600	42	36	160	176	2.50	2	8	6
1½	600	25	60	160	176	2.50	2	8	6
2	1800	55	36	100	114	2.50	2	6	6
2	1800	33	60	82	94	2.50	2	4	6
2½	1200	69	36	130	144	2.50	2	6	6
2½	1200	42	60	130	144	2.50	2	6	6
2½	1000	69	36	154	170	2.50	2	8	6
2½	1000	42	60	154	170	2.50	2	8	6
3	1800	83	36	129	143	2.50	2	6	6
3	1800	50	60	129	143	2.50	2	6	6
3	1200	83	36	150	166	2.50	2	8	6
3	1200	50	60	150	166	2.50	2	8	6
3	600	83	36	203	224	2.50	4	11	6
3	600	50	60	203	224	2.50	4	11	6
3	500	83	36	234	255	2.50	4	11	6
3	500	50	60	234	255	2.50	4	11	6
4	1800	67	60	154	170	2.50	2	8	6
5	1200	83	60	182	193	2.50	4	11	6
5	850	83	60	226	247	2.50	4	11	6
5	525	83	60	315	338	2.50	4	13	6
5	425	83	60	340	364	2.50	4	13	7

GENERAL ELECTRIC GENERATORS

Type	Frame	K. W.	Speed	Price with pulley-base & Rheostat.
BD	35	7/8	1150	$116.00
BD	33	1 1/8	1750	102.00
BD	45	1 1/4	1150	138.00
BD	43	1 3/4	1750	126.00
CD	55	2	1150	210.00
CD	73	3	750	291.00
CD	65	6	1750	252.00
CD	73	9	1750	300.00

SWITCH BOARDS.

A switch board for a hydro-electric plant with out batteries consists of:

1-Voltmeter

1-Ammeter

1-Rheostat

2-Switches
1-Panel(Usually slate)

2-Fuses.

For a plant with batteries an automatic cut-in and cut-out switch is added.

The cost of a switch board will vary from $15. to $30.00.

GOVERNORS WITH COST.

A uniform flow of current is maintained by the following methods:

1. Storage batteries and Rheostat for plants producing one K.W. and less.

2. Resistant coils and double throw switches for Turbine installations developing from one to five K.W's. The same method is used for over-shot installations developing one to eight K.W's.

3. Governors should be used for Turbine installations developing 5 K.W's or 10 H. P. and overshot wheel installations developing above 8 K.W.'s or 25 H. P. used for saw mills, grist

mills, etc.

Governors for hydro-electric plants must be very sensitive. A governor dor a turbine hydro-electric plant as explained above will cost $485.00. For mills, etc. a governor will cost $350. A governor for overshot hydro-electric plants will cost $650.00. For saw mills, etc. $275.00.

If storage abtteries are used with an auxiliary generator on a power plant no governor is required for lighting.

NOTE:- This information was given by a number of manufacturers of water wheel equipment.

BATTERIES.

Batteries are not necessary for plants developing over one K. W., as this is sufficient for the average farm lighting plant.

For plants developing less than one K. W. batteries are essential to store up current in sufficient quantity, and to cut down the fluctuation of the current caused by the changing speed of the water wheel.

The cost of the lead 16 cell, 32 volt, 120 ampere, battery is $200.00

Same as above, 60 ampere battery-----$125.00.

SIZE WIRE FOR TRANSMISSION LINES.

For transmission lines wire should not be smaller than No.10 B & S. gauge. Wire smaller than this is mechanically weak and the voltage drop is very high.

The voltage drop for a transmission line may be easily figured by the following formula and table:

$$V = \frac{I \times 11 \times 2 \times L}{\text{Circular Mils}}$$

V= Voltage Drop

I= Current in Amperes

L= Single distance current is carried in feet.

EXAMPLE.

Voltage drop on a 500 foot line carrying a 120 volt 2 K.W. current.

$2000 \div 120 = 16 = I$, or amperes

Circular mils - Table = 16,510 for No. 8 wire

$$\frac{16 \times 11 \times 2 \times 500}{16{,}510} = 10.6 \text{ voltage drop}$$

At the end of the line the voltage would be 120 - 10.6 = 109.4 bolts.

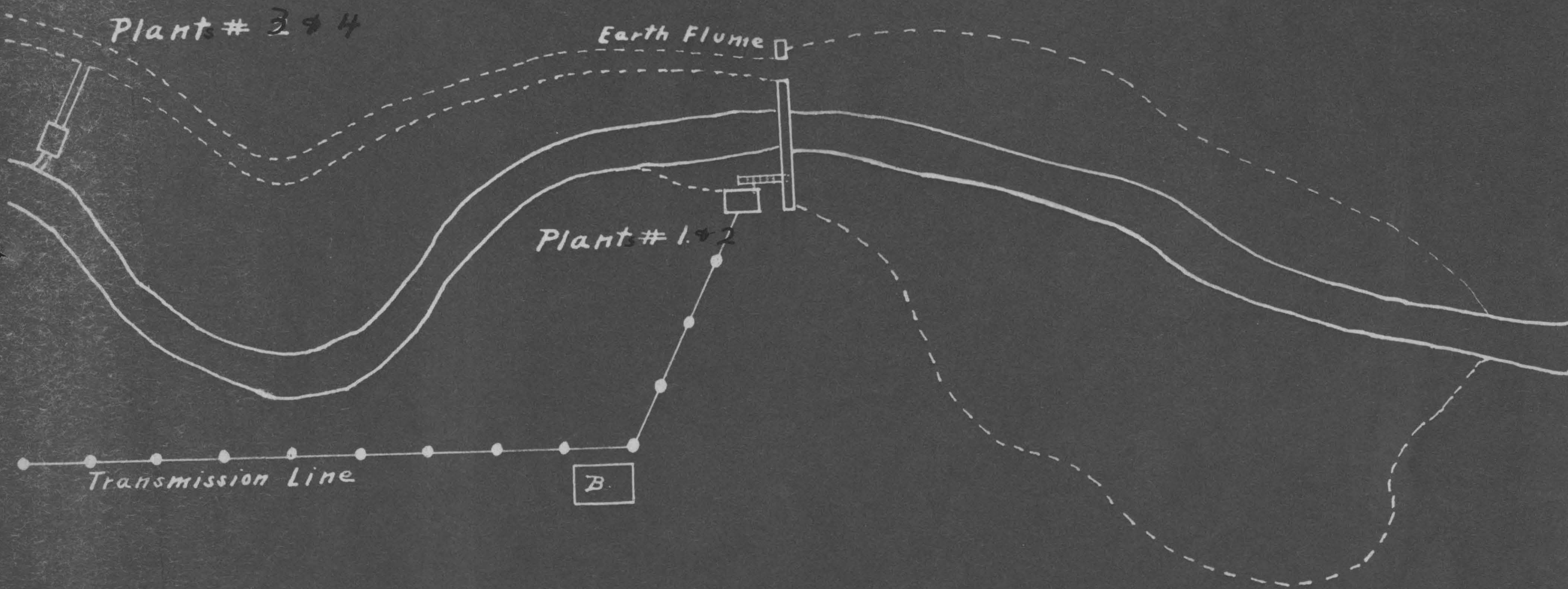
WIRE FOR HYDRO-ELECTRIC PLANTS

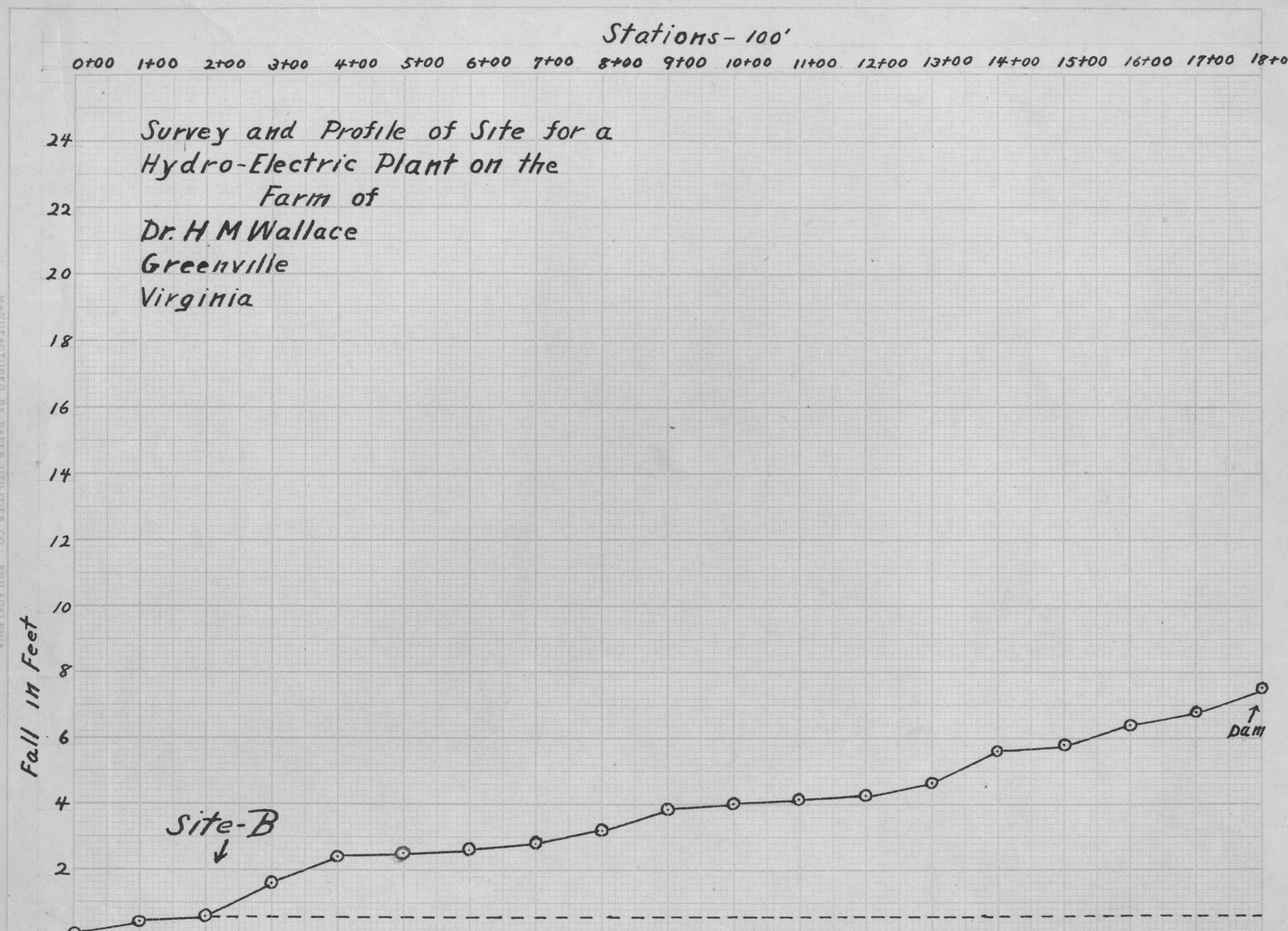
B. & S. Gauge Number	Circular Mils	Carrying Capacity: Rubber Covered Wires Amperes	Carrying Capacity: Weatherproof Wires Amperes
18	1,624	3	5
16	2,583	6	8
14	4,107	12	16
12	6,530	17	23
10	10,380	24	32
8	16,510	33	46
6	26,250	46	65
5	33,100	54	77
4	41,740	65	92
3	52,630	76	110
2	66,370	90	131
1	83,690	107	156
0	105,500	127	185
00	133,100	150	220
000	167,800	177	262
0000	211,600	210	312

COST OF TRANSMISSION LINE WIRE OF THE STANDARD RUBBER WEATHER PROOF COVERING.

Size-B. & S. Gauge	Cost per 1000 feet delivered
12	$16.00
10	20.00
8	30.00

Dr H.M. Wallace




Stations - 100'
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
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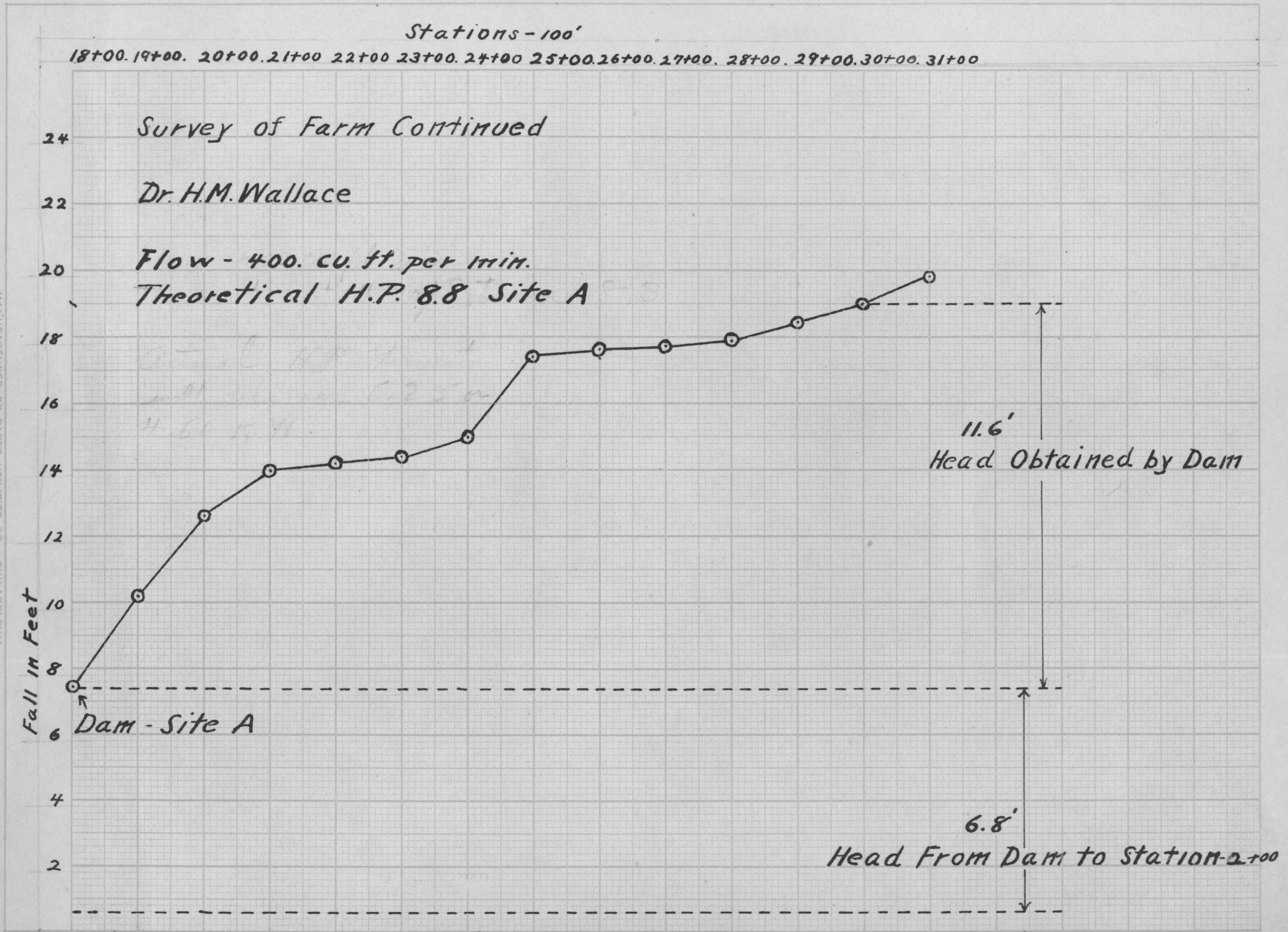
9+00
10+00
11+00
12+00
13+00
14+00
15+00
16+00
17+00
18+00
Survey and Profile of Site for a
Hydro-Electric Plant on the
Farm of
Dr. H M Wallace
Greenville
Virginia
24
22
20
18
16
14
12
10
8
6
4
2
Fall in Feet
Site-B
Dam

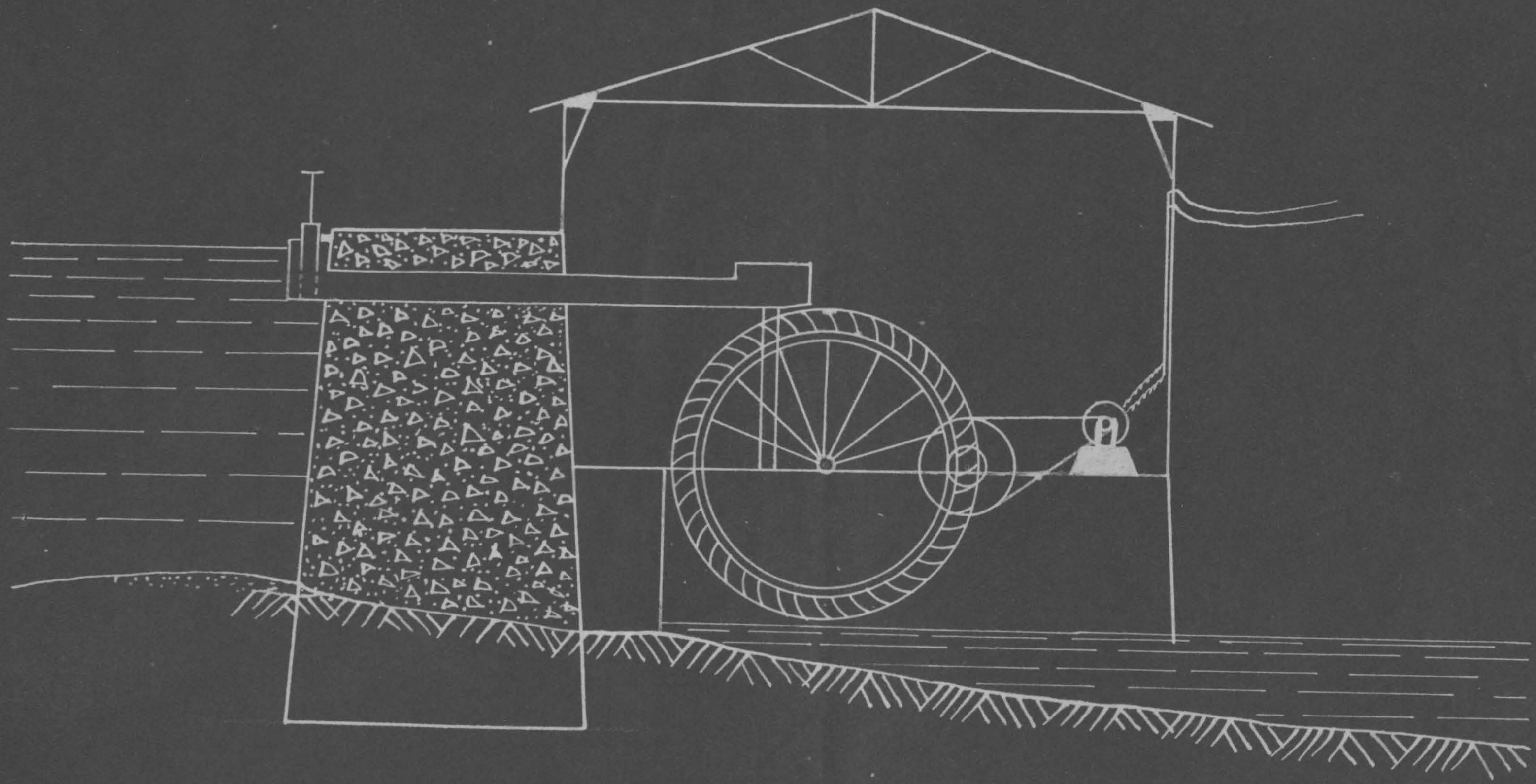
57



Stations - 100'
18+00. 19+00. 20+00. 21+00 22+00 23+00. 24+00 25+00. 26+00. 27+00. 28+00. 29+00. 30+00. 31+00
Survey of Farm Continued
Dr. H.M. Wallace
Flow - 400. cu. ft. per min.
Theoretical H.P. 8.8 Site A
Fall in Feet
2
4
6
8
10
12
14
16
18
20
22
24
Dam - Site A
11.6'
Head Obtained by Dam
6.8'
Head From Dam to Station-2+00

5.8

Typical Overshoot Installation



TYPICAL FARM HYDRO-ELECTRIC PLANTS WITH COST

The following are typical farm water powers. These powers were surveyed and plants designed to show the various factors which have to be met, and how they can be over come.

Each site represents a typical problem, or one of the seven divisions, that water power developments have been divided into.

Site A. (see pages 56 to 59) Farm of Dr. H. M. Wallace, Greenville, Va.

Head 11.6 feet

Flow 400 cu. ft. per min.

Dam crib (average 8' x 60') 11.6 high at middle of channel.

Distance to house 1800 ft.

Theoretical Horse Power- 8.8

Plant I. (site A)

Plant using straight stream flow, with an overshot water wheel

Theoretical Horse Power 8.8.

Power delivered 4 K. W. or 5.36 H. P. continuous 1 Y.

Cost of Hydro-Electric Plant $1,392.

Cost per K. W. $348.

Cost of 7.5 Horse Power Plant $1,195.

ESTIMATE-A.

Rought lumber @ $20.00 per 1000 ft. B. M.	$60.00
Farm labor & Hauling to build dam	105.00
Cost of dam	165.00
Forbey-steel tank and pipe	20.00
Overshot wheel 10' x 3'	900.00
Power House	60.00
Compound D. C. Generator 4 K. W. 125 volt	158.00
Pully	2.00
Base	8.00
Rheostat	6.00
Wire	3.00
Switch Board	20.00
Freight & incidentals	.50
	$ 139 2.00

PLANT 2 (Site A)

Plant using upper foot of storate dam, with a 6' x 10' overshot wheel.

Theoretical H. P. for 10 hours per day 17.

Power delivered 10 K. W. or 14 H. P.-10 hours

Cost of Hydro-electric Plant $1,959.

Cost per K. W. for 10 hours service per day $196.

Cost of a 14. Horse Power plant-10 hours per day $1,579.

PLANT 3 (Site A)

Plant using straight flow as "A" with a reaction turbine.

Theoretical H. P. 8.8.

Power delivered 3. K. W.

Cost of Hydro-electric Plant $662.

Cost per K. W. $221. continuous service.

Cost of 6 H. P. Power Plant $460.

Estimate "B"

ESTIMATE- B.

WITH TURBINE INSTALLATION USING STRAIGHT FLOW.

Crib Dam	$165.00
Pinstock & Power House	85.00
Turbine wheel 15" complete	210.00
Compound D. C. Generator 3 K. W. 125 volt	156.00
Pully	2.00
Base	8.00
Rheastat	6.00
Wire	3.00
Switch Board	20.00
Belt	7.00
	$ 662.00

PLANT 4 (Site A)

Plant using upper foot of storage dam as Plant 2 and a reaction turbine.

Theoretical Horse Power for 10 hours per day---17.

Power delivered 8 K. W.

Cost of Hydro-electric plant $996.

Cost per K. W.-$122 (for 10 hours service per day)

Cost of a 12 horse power plant 10 hours per day $690.00

PLANT 5 (site A)

Hoppes Hydro-Electric Plant using straight stream flow. pages 98-10

From sta. 18 + 00 to 25 + 00 see page (58)

No dam

Conduit 700' open earth flume + 30' steel riveted pipe size 14 inch.

Power delivered 3 K. W.

Cost of plant $1,275.50

Cost per K. W. $425. (for continuous service)

ESTIMATE.

[illegible]' diversion Dam	$10.00
30'-14" steel riveted pipe	100.50
700' open earth hume	140.00
Plant set on base	1025.00
Total.	$ 1275.50

PLANT 6 Site A

Object to design the least expensive plant for electric lights, electric iron and very small motor use (The plant must produce over one K. W. to eliminate the expense of storage batteries.

Wood Flume on the side of a hill from stalion 18+00 to 21+00 = 300 ft.

Head theoretical -6.6 feet.

Head actual 5' - 10½".

Size turbine to produce 3 H. P. at 6 ft. head= 16½"

Flow required 367 cu. ft. per min.

Size wood flume 2' x 1' with a slope of 2½ inches per 100 ft.= 7½ inches.

Cost of plant $828. (for 1¼ K. W. Plant)

Cost per K. W. continuous service-------$662.

ESTIMATE.

Open rough wood flume with no tressels required as it will rest on the sideof a hill.

Length 300 ft. size 2 ft. by 1 ft. @ 90¢ per ft.---------	$270.00
Penstock wood--	$ 95.00
Reaction turbine (16½ inch)--------------------------	$225.00
Power House--	60.00
Generator 1¼ K. W. Compound D. C. 130. volt-------------	138.00
Switch Board---	15.00
Beveled gears & Belt---------------------------------	25.00
	$ 828.00

Head-Theoretical 18.4'-Actual- 14'.

Flow 400 cu. ft. per min.

Dam-Crib (Average 7' x 60' - 11.6' High at middle of Channel 1. (same as Plant #1)

Flume 1,600 feet open earth

Theoretical H. P.

Object to obtain the greatest amount of power for 10 hrs. per day, using upper foot of pond and a reaction turbine.

PLANT 7 SITE B.

Plant with 21inch turbine wheel using 909 cu. ft. of water per min.

Theoretical H. P.- 24.

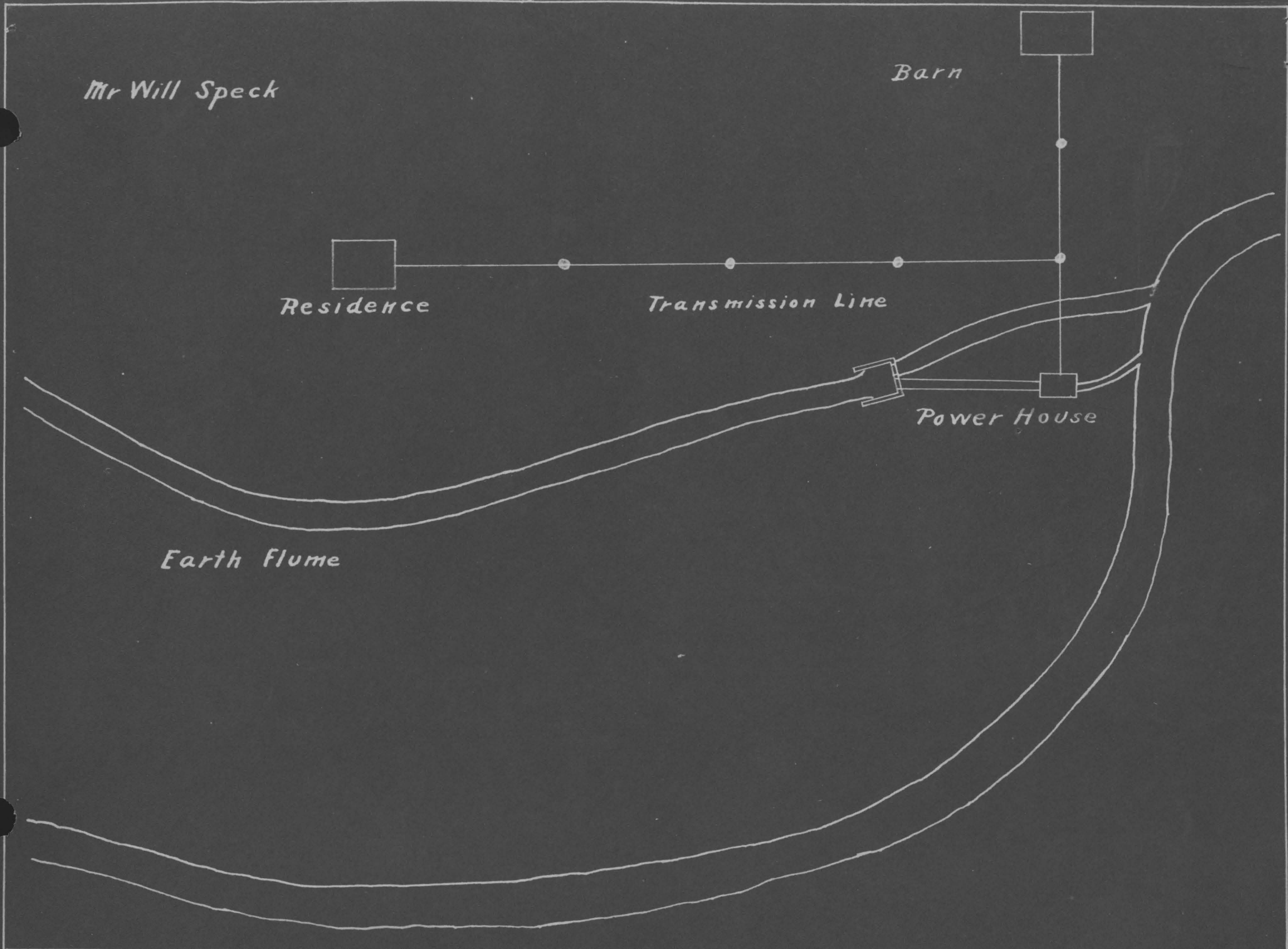
Actual H. P. 16.5, or 12. K. W.

Cost of Plant $1,523.

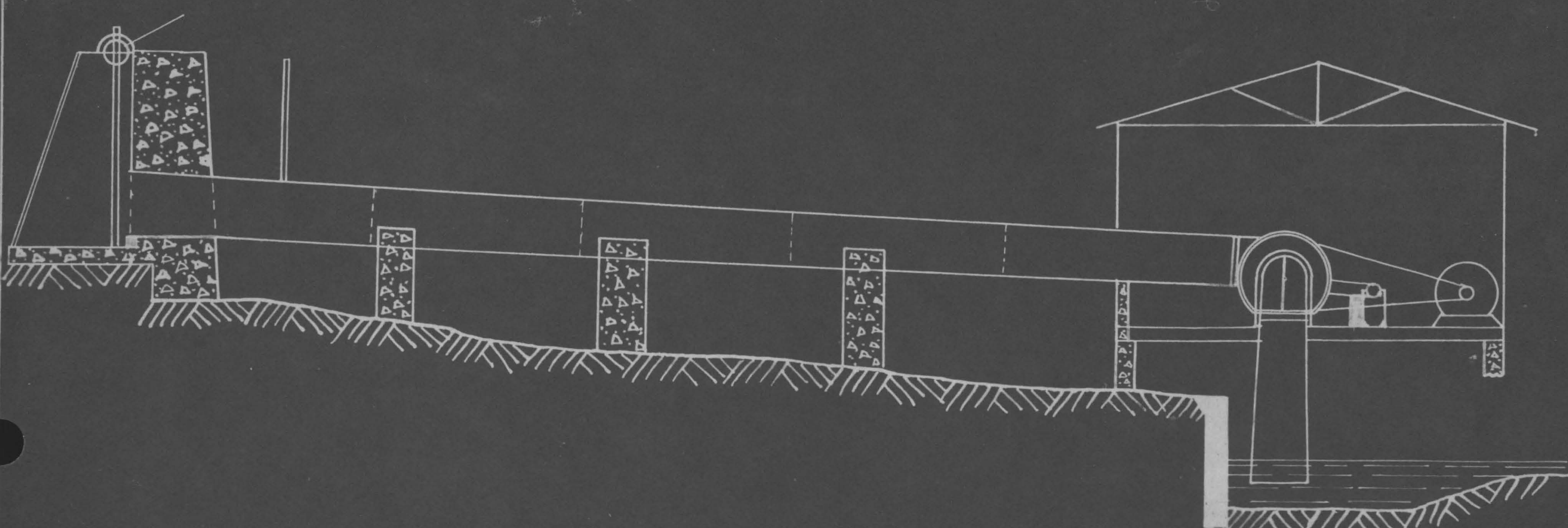
Cost per K. W. 10. hr. service per day $128.

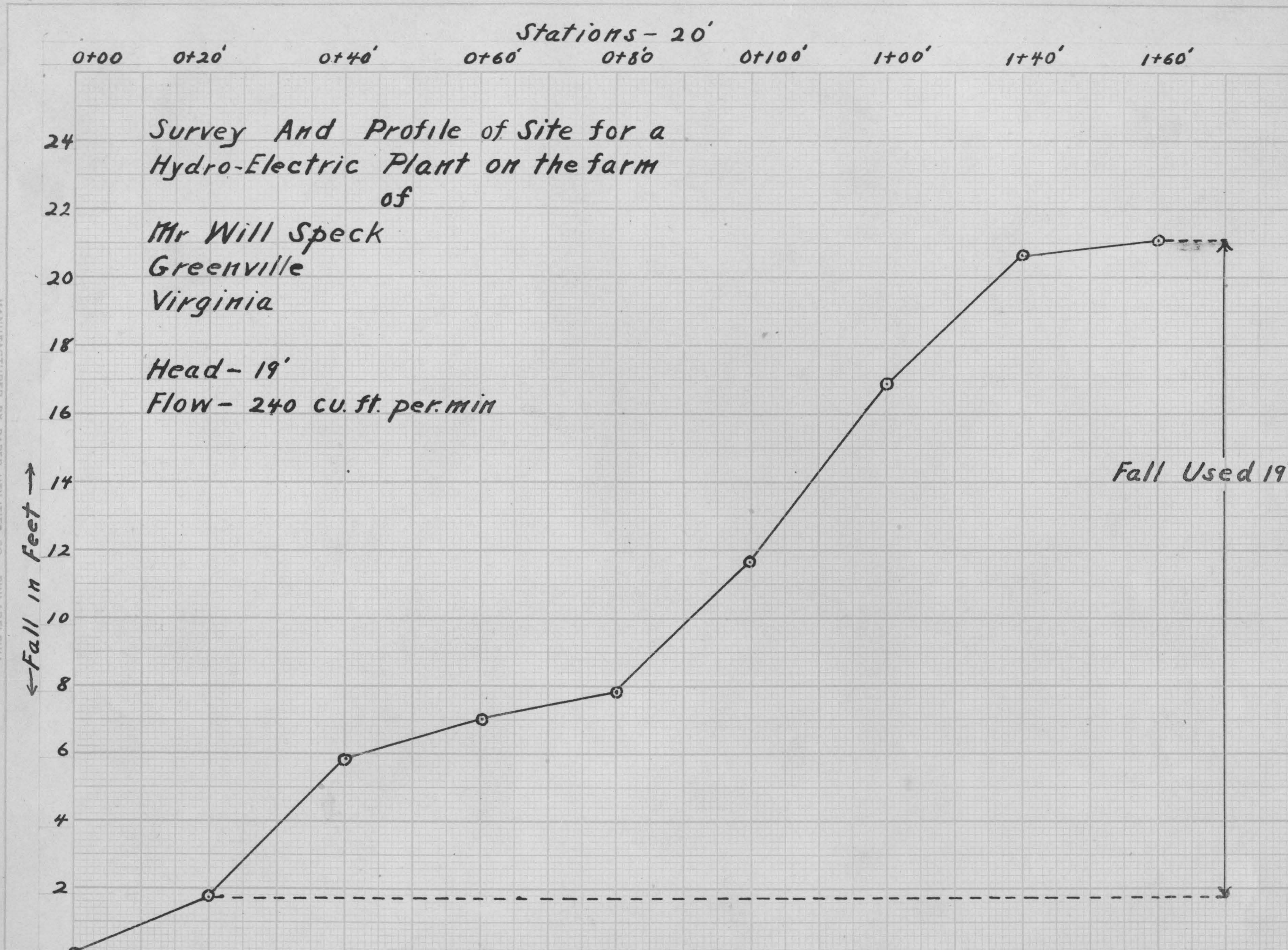
ESTIMATE

Crib Dam- -	$165.00
Earth flume (excavation 220 cu. yds. @ 90¢ cu.yd.	198.00
Penstock wood- - - - - - - - - - - - - - - - - - - -	120.00
Turbine-21 inch 70% efficient- - - - - - - - - - -	290.00
Power House- ---	80.00
Generator 12. K. W. Compound D.C.125 volt- - - -	400.00
Gearing (Beveled gears & Belt)- - - - - - - - -- -	75.00
Switch Board- -	40.00
Wire- -	5.00
Extra Labor in installing- - - - - - - - - - - - --	150.00
	$ 1523.00


Mr Will Speck
Barn
Residence
Transmission Line
Power House
Earth Flume

Typical Turbine Installation




Stations - 20'
0+00
0+20'
0+40'
0+60'
0+80'
0+100'
1+00'
1+40'
1+60'
Survey And Profile of Site for a
Hydro-Electric Plant on the farm
of
Mr Will Speck
Greenville
Virginia
Head - 19'
Flow - 240 cu. ft. per. min
←Fall in Feet→
24
22
20
18
16
14
12
10
8
6
4
2
Fall Used 19'

SITE "C" FARM OF Mr. Will Speck, Greenville, Va.

(See Pages 67-69)

Theoretical Head 19.2

Flow 240. cu. ft. per min.

Dam small diversion.

Conduit open earth 900 ft. long 60 ft. of steel riveted pipe.

PLANT 8. SITE "C".

Object to obtain the most electrical power at the lowest cost.

Theoretical Horse Power-----8.6

Ust straight stream flow with reaction Turbine.

Actual H. P. of 10½ inch reaction turbine-6

Electrical Power delivered= 4 K. W

Cost per K. W. (24 hour service) $179.

Cost of Hydro-electric plant (4 K. W. continuous service)	$717.50
Cost of a 6 Horse Power - - - - - - - - - - - - - - - - - - -	537.50

ESTIMATE PLANT 8 SITE "C".

Diversion dam- -	5.00
Earth flume repairs (old mill site)- - - - - - - - -	20.00
Over flow (concrete)- - - - - - - - - - - - - - - - -	20.00
Conduit 124 ft. 16 inch steel riveted pipe @ $2.25 per ft.	281.00
Draft tube 3 ft. @ $5.50 per ft.- - - - - - - - - - -	16.50
Turbine(reaction 10½ inch) & gearing - - - - - - - -	195.00
Belt- -	7.00
Generator Compound 4 K. W. 125 Volt- - - - - - - - -	158.00
Switch Board- -	15.00
Cost of 4 K. W. 24 hour service plant- - - - - - - - - -	$ 717.50

PLANT 9 SITE "C".

Object to install a unit hydro-electric plant for lights. Use Newport News Hydrolite (a unit plant consisting of re-action turbine generator (150 Watt or smallest size) switch board and 32 volt battery, see pages (101-104) description.

Hydrolite-150 Watts------------------------ $595.00

Power House-------------------------------- 60.00

Iron pipe 3" (172 gal. per min discharge)---

150 feet @ 46¢ per ft.--------------------- 69.00

150 watt plant Total--------------------- $ 724.00

PLANT 10 SITE "C".

Object--same as Plant 9.

Newport News Hydrolite (largest size) 500 watt or (7/10 H.P) 110. volt.

Plant complete-----------------------------------$ 1250.00

Power House------------------------------------ 60.00

Iron pipe 150 ft. 4 inch (discharge 380 gal)----- 88.00

Total Cost of 1/2 K. W. unit plant $ 1398.00

PLANT 11 SITE "C".

Object same as Plant 9

Plant-Pelton Hydrolite Set (a 1.5 K. W.) plant without storage batteries; seepages (92-97)

Head used 10 feet.

Flow used 193. cu. ft. per minute.

Complete Plant (only size made)-------------------$750.00

Power House--------------------------------------$ 50.00

Spiral Riveted pipe (8 inch 105. ft)--------------$120.00

TOTAL------- $920.00

PLANT 12 SITE "C"

Object same as Plant 9.

Plant-Rodney Hunt Niteload No. 24 (1.K.W.)

Plant with Batteries 32 volt) see pages 105-107

Head used 10 feet.

Flow used 100 cu. ft. per min.

Complete plant-------------------------------------	$620.00
Power House--	60.00
Pipe (6 inch spiral riveted 105 ft.)---------------	82.00
TOTAL-------	$762.00

PLANT 13 SITE "C"

Object same as Plant 9

Plant-Rodney Hunt Niteload No. 24 (Same plant as Plant 12 though using 19.ft. head and no batteries; Automatic control switch board; Plant delivered 2¼ K. W.

Head used 19

Flow 140 cu. ft. per min.

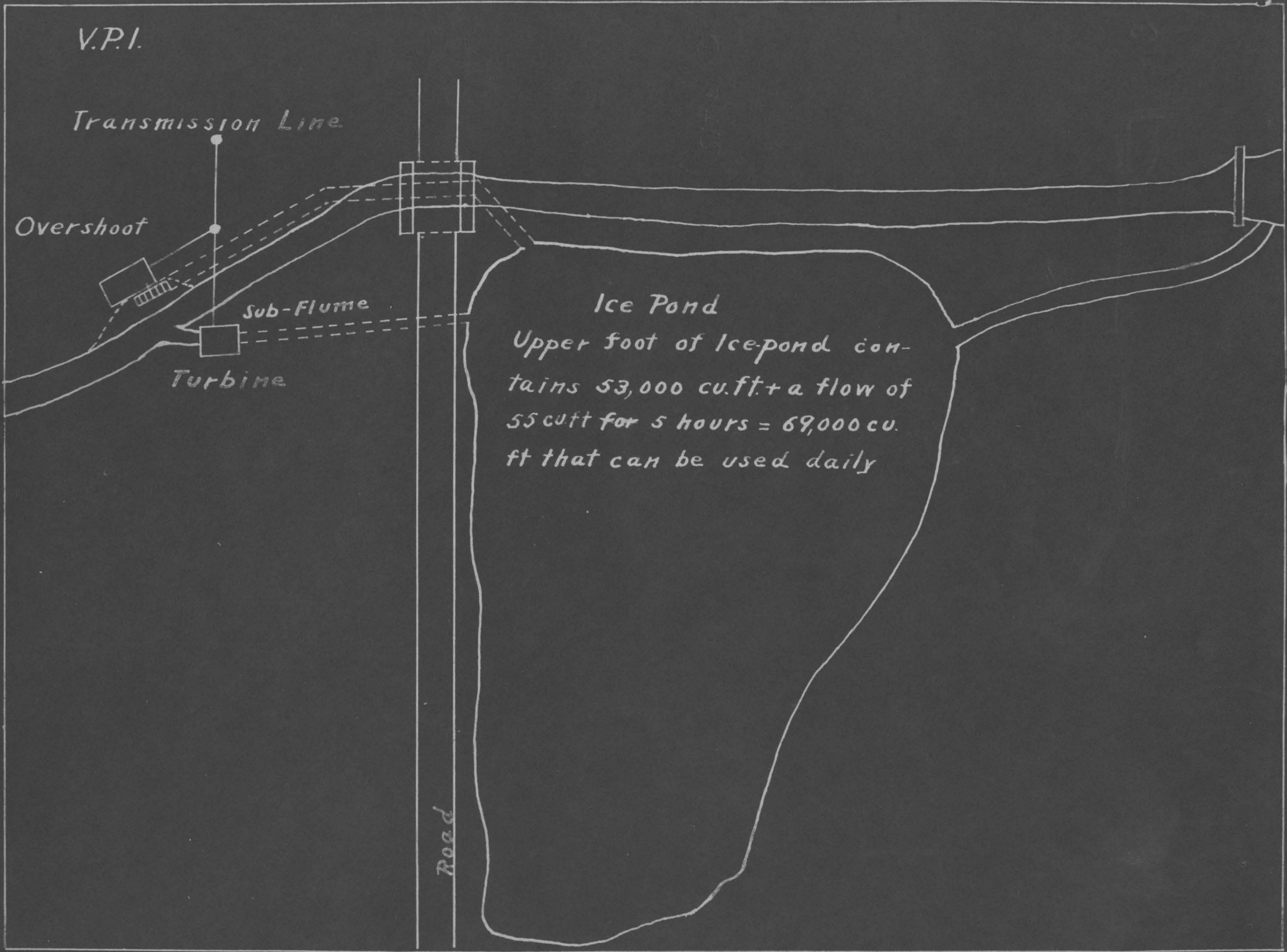
Complete Plant-----------------------------------	$595.00
Power House--------------------------------------	50.00
Pipe (6 inch spiral steel riveted 150 ft.)------	140.00
TOTAL---------	$ 785.00

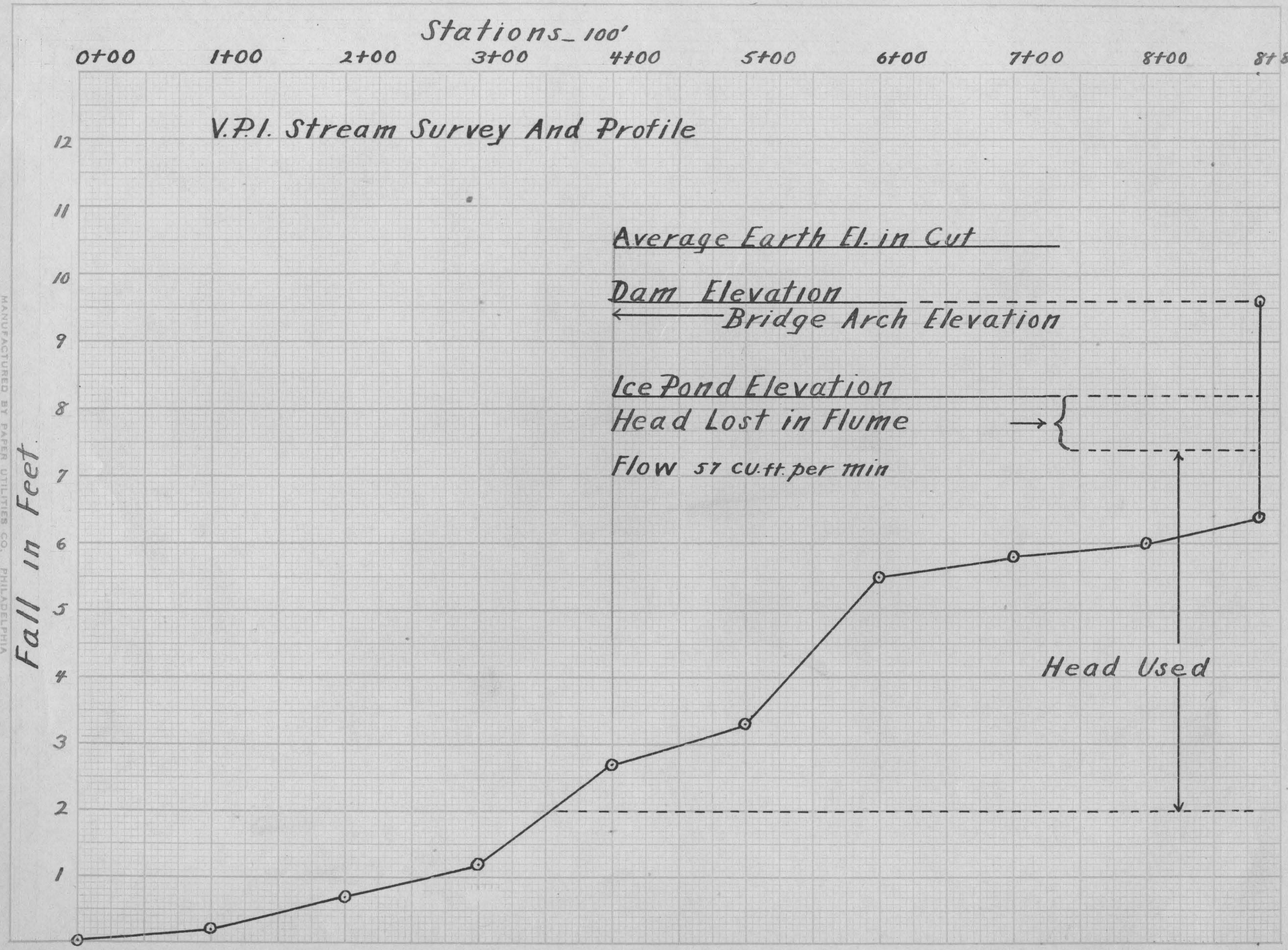
Quotation made by the Rodney-Hunt Machine Co. January 29, 1925. for Site "C".

1. Regulation Hunt-Francis cylinder gate turbine in cast iron case, complete with shaft, driving pulley and 1 KW electric lighting outfit with switchboard and storage batteries, price..............................$995.00

2. 9" Hunt-Francis Cylinder Gate turbine in cast iron case with 5 KW direct current generator and switchboard furnished with Type D Woodward mechanical governor and without storage battery. No storage batteries being required for this plant, price.................$1460.00

3. #24 Niteload water powered farm lighting unit with 1 KW generator, switchboard and storage batteries, price..$595.00


V.P.I.
Transmission Line
Overshoot
Sub-Flume
Turbine
Road
Ice Pond
Upper foot of Ice-pond contains 53,000 cu.ft.+ a flow of 55 cu.ft for 5 hours = 69,000 cu. ft that can be used daily


Stations_100'
0+00
1+00
2+00
3+00
4+00
5+00
6+00
7+00
8+00
8+82
V.P.I. Stream Survey And Profile
Fall in Feet
12
11
10
9
8
7
6
5
4
3
2
1
Average Earth El. in Cut
Dam Elevation
Bridge Arch Elevation
Ice Pond Elevation
Head Lost in Flume
Flow 57 cu.ft. per min
Head Used

SITE "D"--CAMPUS OF V. P. I

BELOW ICE POND--SEE PAGES (73-74)

Head 7.4 feet.

Flow 57. cu. ft. per min

Dam--Diversion

Conduit from ice pond (90' of 12" clay tile.) and 28 ft. of 8" x 14" wood flume

Ice Pond--Upper foot of which contains 53,000 cu. ft. of water This with a stream flow in 5 hours of 17,000 cu. ft= 70,000 cu. ft. which is the maximum storage that can be obtained. The stream will replace 82,000 cu. ft. per day.

EXPLANATION.

The ice pond will have to be used in all cases to secure 7.4 feet head due to the excessive cost of a long conduit, which would only give a 9 ft. head. The regular stream flow is insufficient for any stock wheel and the power this stream will deliver is too small for the use of an average family.

Storage of energy is therefore necessary to supply current in a quantity needed. Storage of energy may be accomplished by using storage batteries or the ice pond as a storage reservoir. In figuring the amount of power that may be obtained from a storage dam, care must be taken not to take out more water than the stream flow will replace by the time the plant will be used again.

The object of an installation is to develope enough current for the average home use. There are three plausable methods of developing this site, namely: PLANTS-14-15-16.

PLANT 14 SITE "D"

A one K.W.Hoppes Hydro-Electric Plant.

Plant without storage. The upper foot of the ice pond being used for the storage of water.

Head used 7.4 ft.

Flow 180 cu. ft. per min.

Power 1. K.W.for 7 hours.

No batteries.

ESTIMATE.

Flume-140 ft. of 10 inch spiral steelriveted pipe--	179.00 $1079.00
Concrete Foundation----------------------------------	20.00 200 .00
Plant (wrote for cost Fig. 3)------------------------	1200.00
TOTAL	$ 1399.00

NOTE:--

This plant will require daily attention in opening and closing the flow of water.

PLANT 15 SITE "D"

A $10\frac{1}{2}$ inch Turbine installation using the ice pond for water storage to run this wheel 7. hours.

This plant will deliver 1 K. W. for 7 hours. No governor or batteried.

ESTIMATE.

Dam wood diversion above ice pond--------------------	$30.00
Blasting and digging out for turbine------------------	25.00
Conduit 140 ft. of 8 inch spiral steel riveted pipe	131.00
Excavating for conduit (23 yds.)---------------------	14.00
Turbine $10\frac{1}{2}$ inch--------------------------------------	185.00
Power House--	50.00
Switch Board---------------------------------------	25.00
Generator Compound 1 KW 125 volt--------------------	102.00
Belt--	9.00
TOTAL-------------------	$ 571.00

NOTE:

1. This plant will require daily attention in opening and closing the water flow.
2. An overshot wheel would deliver this much power for $8\frac{1}{2}$ hours. Due to the cost of an especially designed wheel, this is not practical.

PLANT 16 SITE "D"

A small turbine installation 8 inch wheel using the straight stream flow and storage batteries.

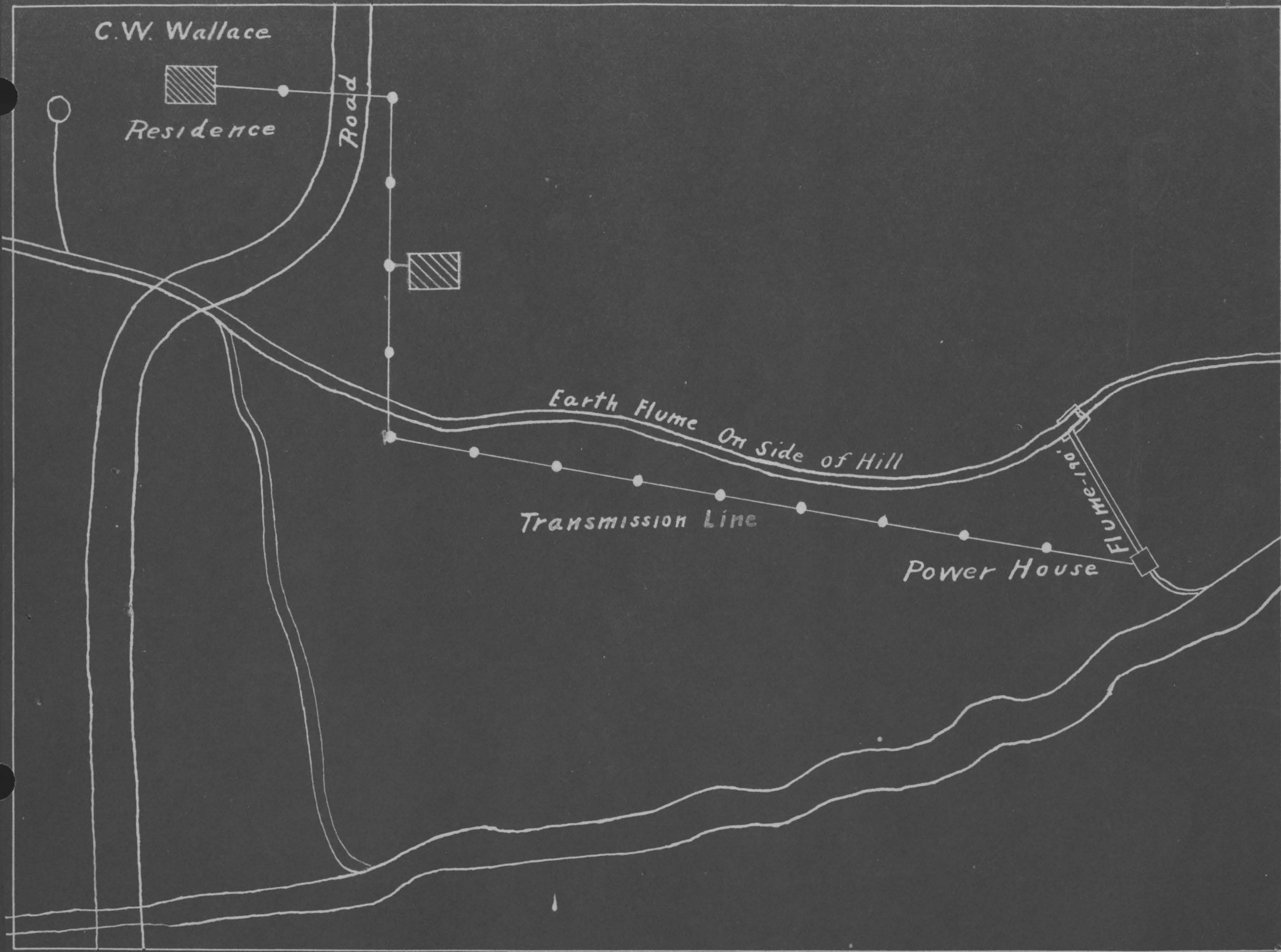
This turbine will deliver more current than is required to keep a set of batteries charged, therefore the use of a more efficient and expensive wheel, for instance an overshot wheel is not necessary.

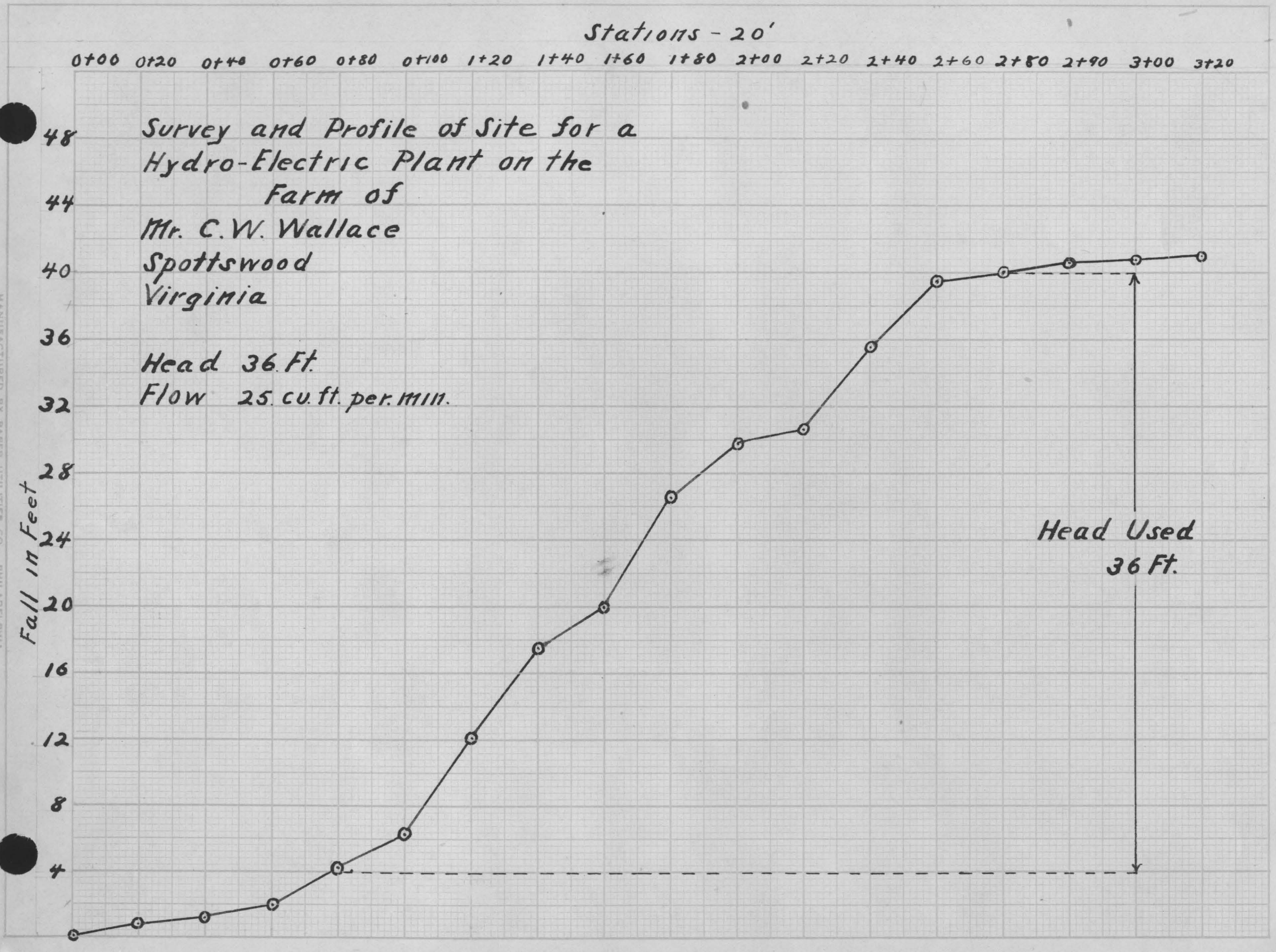
ESTIMATE

Dam-wood diversion above ice pond	$ 30.00
Blasting and digging for turbine	20.00
Conduit 140 ft. of 6 inch spiral riveted pipe	109.00
Penstock	20.00
Excavating for conduit	14.00
Turbine 8 inch	149.00
Power House	50.00
Switch Board	25.00
Generator 1/4 K.W shunt wound, 32 volt	47.00 45.00
Belt	9.00
Batteries	180.00
TOTAL	$ 653. 00

NOTE:

This plant has the disadvantage of battery replacement every four or five years. Due to an automatic switch board it will require little attention. The lights will not vary due to fluctuations in flow from generator.


C.W. Wallace
Residence
Road
Earth Flume On Side of Hill
Transmission Line
Power House
Flume-190'


Stations - 20'
0+00 0+20 0+40 0+60 0+80 0+100 1+20 1+40 1+60 1+80 2+00 2+20 2+40 2+60 2+80 2+90 3+00 3+20
Fall in Feet
48
44
40
36
32
28
24
20
16
12
8
4
Survey and Profile of Site for a
Hydro-Electric Plant on the
Farm of
Mr. C.W. Wallace
Spottswood
Virginia
Head 36. Ft.
Flow 25. cu. ft. per. min.
Head Used
36 Ft.

SITE "E"

Plant 17 On the Farm of Mr. C. W. Wallace, Spottswood, Va.

See Pages 79-80

Head-36 ft.

Flow-25 cu. ft. per min.

Conduit 1100 ft. open earth and 190 ft. 6 inch spiral riveted pipe.

EXPLANATION.

This stream is the flow from two springs. There is an open ditch 1300 feet long which takes the water around on the side of a hill to water the meadow.

By diverting this flow from the earth conduit to the old stream bed below, a head of 26 feet is obtained.

A very small turbine with storage batteries may be used to develop this power, yet the owner does not want a plant with storage batteries.

The theoretical Horse Power of the stream is 1.7.

PLANT 17 SITE "E"

Dam small diversion

Conduit 8" spiral steel riveted pipe 180 feet long.

Plant-1.34 H.P. Pelton-Impulse Turbine

Power Delivered 1.KW.

Total Cost of Plant.

ESTIMATE

Pelton water wheel & Electric control----------	$590.00
Generator 1.KW.-------------------------------	102.00
Power House-----------------------------------	75.00
Diversion Dam---------------------------------	15.00
Switch Board----------------------------------	20.00
Pipe 8" spiral steel 190 feet long------------	212.00
Belt--	7.00
TOTAL----------------	$ 1,021.00

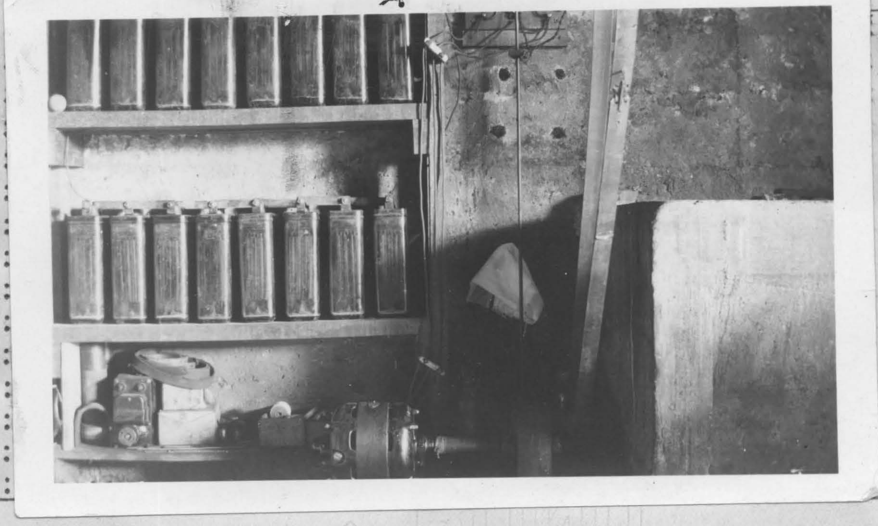
HIGH HEAD PLANT USING A SIX INCH

PELTON IMPULSE WHEEL OWNED BY

Pictures taken by H. M. Wallace, Jr. in basement of house.

see survey page (85-87)

A



Picture A, notice batteries, switch board and belt to overhead to counter shaft.

B

Picture-B- Notice generator and pelton wheel as well as the method of drive used.

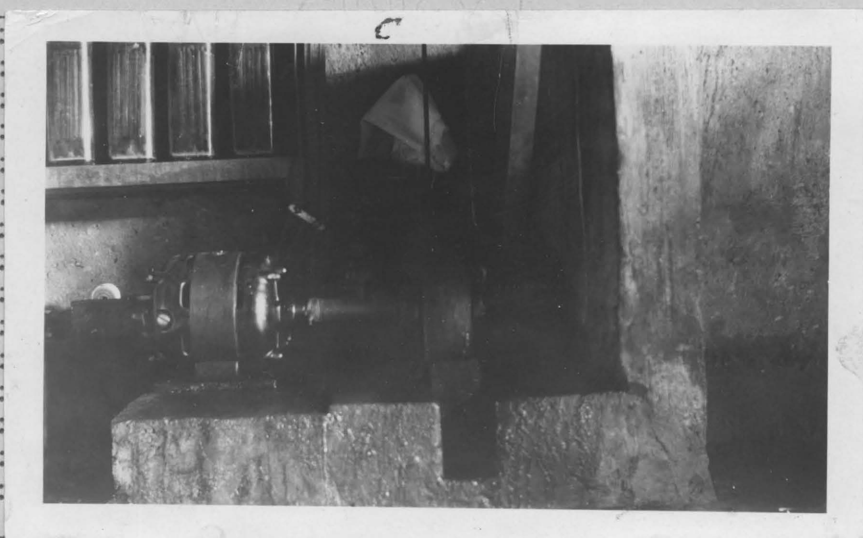
HIGH HEAD PLANT USING A SIX INCH

PELTON IMPULSE WHEEL OWNED BY

Pictures taken by H. M. Wallace, Jr. in basement of house.

See survey page (85)

C



DEPARTMENT OF AGRICULTURAL ENGINEERING,
THE VIRGINIA POLYTECHNIC INSTITUTE,
BLACKSBURG, VIRGINIA.

November 26, 1924.

5624

Newport, Va.

Dear Sir:-

We are making a study of the cost of developing small water power plants with the view of publishing a bulletin containing this information.

We understand that you have a water wheel installation on your property, and trust that you will give us some information in regard to it.

Kindly fill out the questions you can on the attached questionnaire and mail to the Department of Agricultural Engineering, Blacksburg, Virginia.

Thanking you in advance for your co-operation, we are,

Very truly yours,

DEPT. AGRICULTURAL ENGINEERING,

By:

Name Town: Newport R.F.D. Va.

1. When was your plant installed, 1919.

DAM

2. Kind of dam,-Concrete, rock, wood, crib, earth: Earth

3. Length of dam: 30 feet Height: 3 ft.

4. Actual cost of dam when installed: $18. Three laborers & Team

5. Give estimate of cost, including labor, if built under present condition: $20.

6. Whate type of millrace or channel for conveying water from dam to wheel is used.

Earth Ditch________:Wood Flume________:Steel riveted pipe______

Give length______:Width:________:Diameter: 2 inch ,frompipe 2".

7. Estimated cost when built: 1500 ft. @ 9¢- ~~$13,500~~. $135.00

8. Estimated cost to make under present conditions per 100 ft. in

length:$18.00
Pipe----------------$270.00

Team & four laborers 25.00
4 days.
$ 295.00 total.

GATE

9. Type of gate: 2" gate valve.

PENSTOCK

10. If turbine installation, type of penstock- wood, concrete or steel__

11. Estimate present cost of penstock:______________________

POWER

12. Flow of stream, cu. ft. per minute:______Gal.per minute: 30

13. Fall or head used; 110 feet.

14. Horse power of Plant_________or K.W. 7 Amps 32 volts.

15. Voltage: 32.

WHEEL

16. Type of wheel-overshott, turbine or pelton, 6 inch impulse turbine

17. Size of wheel, (diameter) 6 inch.

18. Actual cost of wheel $75.00

19. Name of Manufacturer: Pelton water wheel Co.

GENERATOR

20. Make of generator: Gen. Electric:Capacity: 500 wat.Cost: $25.00

DRIVE

21. Direct Yes; Generator mounted on turbine shaft: No.

22; Give cost of belt:

23. Do you use beveled or spur gear drive: No. Cost:

POWER HOUSE.

24. Type of house,-concrete, wood, or both: Basement of house.

25. Size of house: ______________________________

26. Estimated cost of house if built at present: No separate house.

27. Actual cost of switchboard: $15.00

28. What was the cost of installing equipment at power plant: $50.00

29. What was the cost of wiring house: did it myself: Outbuildings: Same.

30. What do you estimate was the actual cost of the plant (not including wiring or fixtures in home, etc.) $448.00

31. What do you estimate the total of the plant, including labor, would be under present conditions: $600.00

32. Cost of upkeep per year for:

(a) Oil: 40¢ (c) Repairs: $30.00

(b) Labor: $2.00 (d) Miscellaneous: __________

33. Does your plant need much attention: NO. Now many hours per year: TEN.

34. Has it been in continuous operation: YES

35. What have been the principal troubles with your plant: NO.

36. Are you satisfied with your plant: YES, if not, why not: __________

37. Do you think the installation of a hydro-electric plant a good investment: YES

38. How much do you think a farmer could afford to spend for a hydro-electric plant to furnish lights: $1,000. Power: __________

87

SITE "F" PLANT 18

A High Head Plant. Owner

Actual Head-----------------------------135.ft.

Head Used--------------------------------110.ft.

Flow------------------------------------ 30 gal. per minute

Conduit 1500 feet 2 inch iron pipe

Dam-Earth 30 ft. side & 3 feet high

Wheel-6 inch Pelton-Impulse turbine.

Power House-None-(Basement of house used)

Power 17. amp. 32 volts.

Cost--------------------------------$448.00

EXPLANATION Site F

This high head plant isrun by a spring located 1,500 ft from the house and 135 feet above the supply pipe at the wheel. The topography was such that a dam 30 ft. wide and 3 feet high could be located near the spring. This dam supplies enough water to operate a 6 inch impulse turbine 4 hours, this being the time required to charge the battery. The bettery is a 190 ampere, hour, 32 bolt lead storage battery.

The plant supplies the owner with electricity for lights, small heating units and power for operating a separator, churn, gringstone, washing machine, as will an air compressor pump for pumping up pneumatic tires on his truck. The plant was installed by the owner.

COST

Earth-dam 30 ft. wide, 3 ft. high	$ 18.00
Pipe-1500 ft., 2 inch iron pipe	135.00
Placing pipe	15.00
Storage batteries	150.00
Impulse water wheel, 6 inch	75.00
Generator-Compound 500 watt. D. C.	25.00
Switch Board	15.00
Drain pipe from wheel	15.00
Total cost installation in 1919	$448.00

Estimated cost installed 1926 -------------------- $600.00

(This is due to the cost of 2 inch pipe)

UNIT HYDRO-ELECTRIC PLANTS.

Unit hydro-electric plants are in an experimental stage. Several of the plants described later have not come on the market. For this reason prices for some of the plants could not be obtained.

A unit hydro-electric plant consists of a turbine wheel, generator, switchboard, governor or batteries and minor accessories built in one unit.

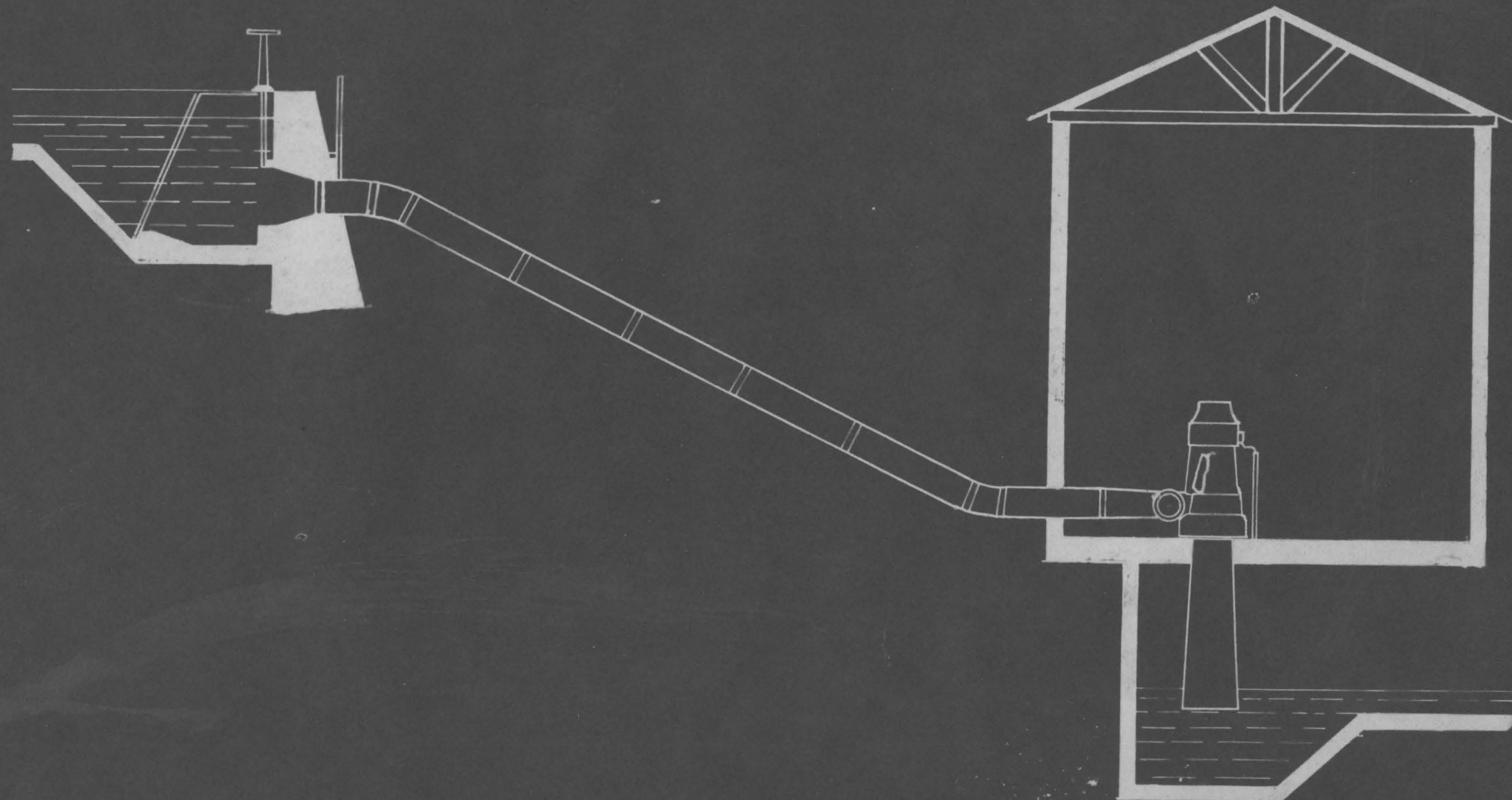
These plants are designed primarily for electric lighting and small motor use. At presnt no one water wheel manufacturer makes very many sizes and types of hydro-electric plants. For this reason it is harder to obtain the full available power with a unit hydro-electric plant than by designing a plant for a specific site. However one can obtain a unit plant that will give the available power very closely and usually the difference in power caused by using a smaller size water wheel will be of little importance. In many cases the development of all the available power will not be desired.

Unit hydro-electric plants are designed in a unit which eliminates the matching of parts; for example the selection of a generator for the speed of the water wheel under a certain load. The generator is usually directly connected to the turbine shaft which also eliminates the use of gears and belts. They are controlled automatically and require little attention. The cost of a power house is eliminated or cut in half as some plants require no house and others require a very small one for the plant and batteries. Lastly, the plant is very easy to install and may be installed by the average farmer.

Practically the only expense is the first cost, including installation. Little inspection is required other than replenishing the oil supply to the bearings and adding water to storage batteries, should the plant require storage batteries. Being entirely self contained and requiring no skilled attention, this equipment forms a splendid isolated lighting set, rendering possible the benefits of electricity for the home at a very low price.

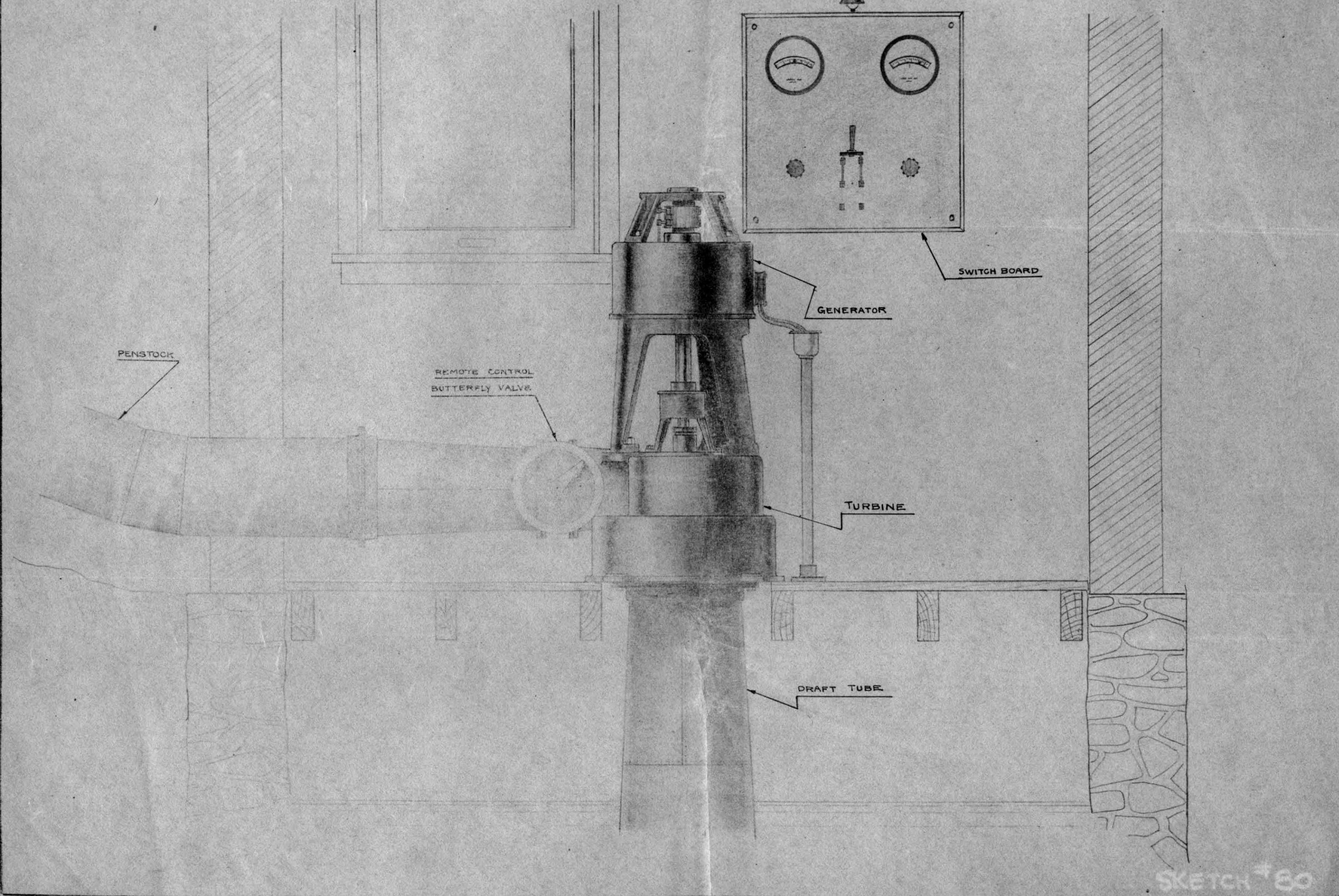
1. Pelton Hydrolite
2. Hoppes
3. Newport News.
4. Rodney Hunt
5. Northern Machine Corp.

The Pelton Hydro-Lite
-A Reaction Turbine-



PELTON HYDRO~LITE SYSTEM

2.5 H.P. 1800 R.P.M.
HEADS 10 TO 40 FEET



PELTON HYDRO-LITE SET

A Reaction Turbine Unit
See Pages (92-93)

GENERAL:

This hydro-lite set consists of a self-contained hydraulic turbine direct connected to a direct current electric generator. It is designed primarily for furnishing current for lighting and small motors for country homes, farms and camps, where a suitable fall and the requisite water quantity is obtainable within a comparatively short distance of the point where the electric energy is to be employed.

DESCRIPTION:

It is necessary to obtain a head of water, and this is usually provided for by throwing a dam across a brook or small stream and connecting to this supply of water a pipeline for conveying the water to the hydraulic turbine. Only a small house need be provided for the unit, or it could be placed in any outbuilding conveniently located to the source of water supply.

The equipment consists of three essential parts, viz: the hydraulic turbine with its control gate valve, the generator, and the switchboard. The turbine is of the new high speed design, the runner of which is mounted on one end of the generator shaft. Enclosing the runner is a solid cast iron casing of efficient design, and incorporated is a special type draft tube which conveys the water to the discharge pit or tailrace. The turbine guide vanes are of the stationary type, and in view of the special design no speed governor is employed, since the generator is provided with automatic features, permitting fairly constant voltage being maintained even the speed of the water wheel vary materially from normal, as would be the case with loads fluctuating from full to practically 10% load.

CONTROL VALVE:

The inlet to the turbine casing is provided with a control valve of the butterfly type, by means of which the turbine can be stopped or started. This valve is equipped with a special hydraulic operating device, electrically controlled, which permits its operation from a remote point, such as the receiving end of the transmission line. In this way the generating unit can be stopped or started by merely pushing a button and any number of push button stations can be provided for controlling the plant from various points. It is also possible to open and close the control valve at the turbine itself, either manually or electrically. Electric energy for operating the control is derived from a battery consisting of four (4) to six (6) dry cells located in the power house. If the remote control feature is not required, a reduction in price can be quoted. Omission of this requires that an attendant start and stop the turbine by means of manual operation of the turbine valve.

ELECTRIC GENERATOR:

The generator is of the compound wound, direct current type, the revolving parts being mounted on a vertical shaft which rotates in ball bearings, one of which is a thrust bearing for carrying the weight of the rotating parts and hydraulic thrust on the turbine runner, which is mounted on the lower end of the extended generator shaft. These ball bearings are practically self-lubricating and require very little attention.

SWITCHBOARD:

Each generating unit is supplied with a switchboard arranged for wall mounting and equipped with a voltmeter, ammeter, main line switch, fuses, and necessary control rheostat. The design of the generator is such that once the switchboard instruments have been adjusted no further attention is required as the unit then functions automatically.

ADVANTAGES:

1st. Due to the self-contained type of unit an inexpensive power house can be used and the complete equipment erected by the average layman. This results in low cost of installation.

2nd. Once the equipment is installed there is practically no expense for upkeep since the apparatus uses very little oil and a large amount of expense is saved due to the elimination of storage batteries, which have to be renewed frequently, and fuel which must be supplied to other types of generating equipment which are not operated by water power.

3rd. The absence of complicated wearing parts results in practically eliminating the item of repairs.

4th. The use of the 125 volt generator, which will deliver 110-volts at the end of the transmission line, permits the use of standard voltage lamps and other electrical equipment which can always be obtained at a lower figure than special equipment for lower voltages where storage batteries are used.

5th. The remote control stopping and starting feature permits the installation of the generating unit several thousand feet from the residence without any inconvenience since the machine can be stopped and started by merely pressing a button.

OPERATING CHARACTERISTICS:

Normal capacity of turbine - 2.5 HP.

Range of operating heads - 10 to 40 feet.

Normal full load speed of turbine depending upon head - 1800 to 2400 Rpm.

Maximum output of generator - 1.5 kilowatts.

Normal voltage - 125.

Maximum voltage for long transmissions - 140.

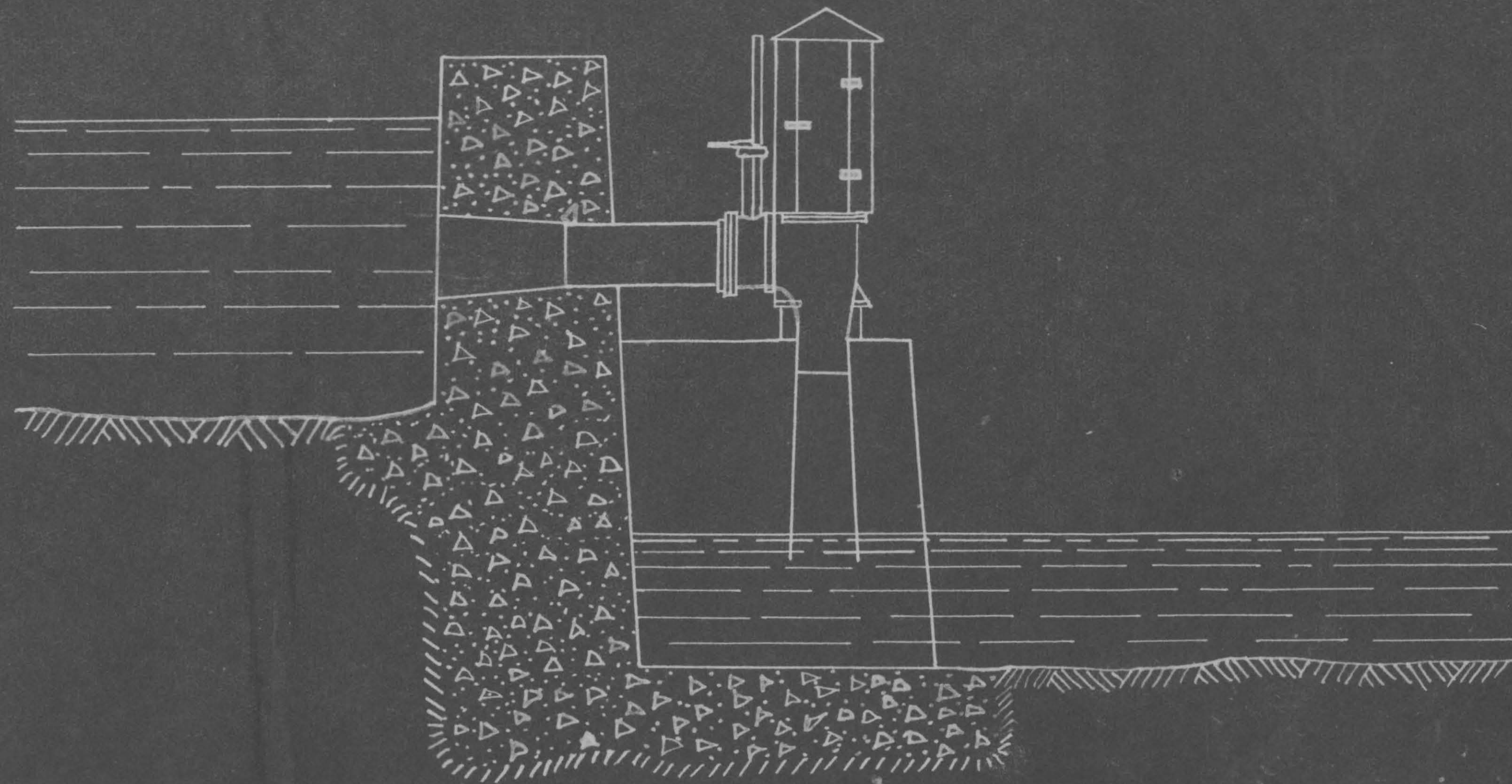
Current output - 12 amperes.

Water quantity for full output varies from about 3.2 cu. ft. per second for 10 ft. head to .8 cu. ft. per second for 40 ft. head.

PRICES:

Price, weight and delivery will be quoted upon application.

Hoppes Hydro-Electric Plant



HOPPES HYDRO-ELECTRIC PLANT.

This plant was developed for use by consumers of power in limited quantities, such as for farms, mills, country places, camps, etc., where water power is available either from small streams, wells, or water over the spillway.

The electrical equipment includes the generator, instrument board, volt meter, switch, rheostat and necessary insulators attached to the house; the generator is D.C., 125 volt, direct connected to the runner shaft. The speed varies depending upon the head and size up to 1700 R.P.M., and the capacity is 1, 3, 5 KW or larger. The turbine runner is of the propeller or reaction type depending on conditions.

The plant is supplied with a governor, which controls the speed by means of a valve, regulating the amount of water entering the turbine.

Prices are for the plant complete with generator and all parts up to and including the first elbow flange to which the pipe from the water race is to be connected. A butterfly valve near the flange is included.

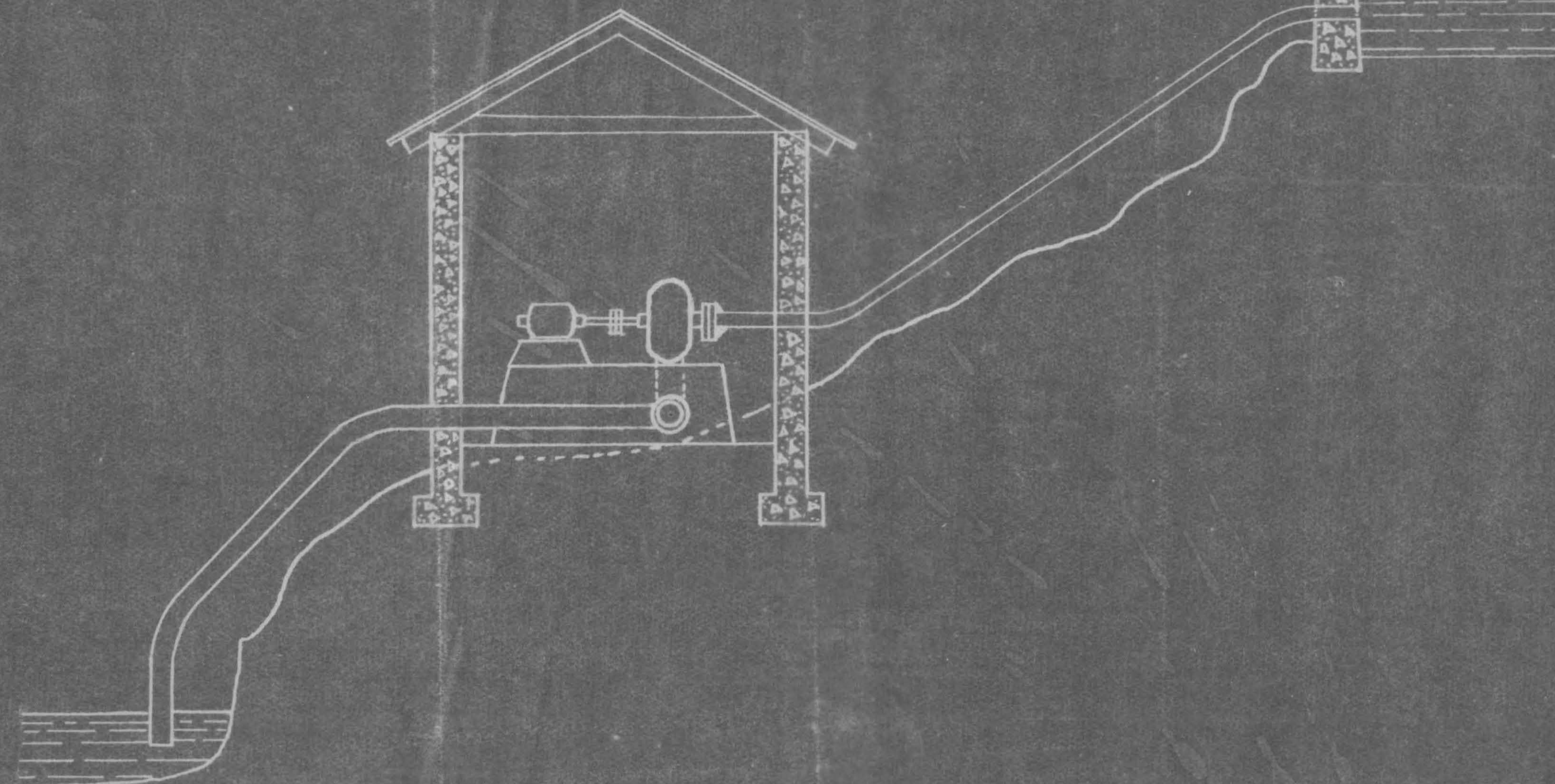
The cost of upkeep is almost negligible, as it requires no supervision, no batteries, fuel or other expensive items.

The plants are made vertical for direct connection to generator as shown, or horizontal for connection to a horizontal generator, direct or through belting. The best arrangement will depend on water conditions, and our propositions will be made to suit. These plants can be adapted to heads as low as 4 feet.

HOPPES HYDRO-ELECTRIC PLANT

Size	Head in feet	Water Cu.Ft. per minute	Diam of Pipe, inches	Weight
	8	240	12	1400
1 KW.	10	120	8	1300
8 Ampere	15	80	7	1200
125 volt	20	60	6	1150
	5	700	20	1800
3 KW.	10	350	14	1600
24 Amp.	15	235	12	1400
124 Volt	20	175	10	1300
	5	1200	26	2100
4 K.W.	10	600	20	1950
40 Amp.	15	400	16	1750
125 Volt	20	300	14	1600

Hydrolite Installation



NEWPORT NEWS HYDROLITE

GENERAL:

The Newport News Hydrolite is a plant which requires only a small stream, an Artesial well, or a large spring for operation. It consists of a turbine directly connected to a generator, storage batteries, and switch board.

THE STORAGE BATTERIES:

They furnish means of storing the surplus electricity generated during the entire 24 hours. For short periods they allow the use of several times the maximum output of the generator. They regulate the voltage of the Hydrolite, eliminating all forms of mechanical governors and such other parts as are liable to cause trouble. They enable many electrical devices to be operated with a very small water power, which, otherwise would be impossible. Batteries are Exide.

THE SWITCHBOARD:

The switchboards are designed for efficiency and simplicity, in fact the outstanding features of The Newport News Hyrdolite is its simplicity and ability to render continuous electrical service with low operating costs and little attention. A special feature of the switchboard is the auxiliary battery charging switch for charging radio or any other storage battery; the negative terminal of battery is connected to switchboard terminal marked (___), Positive Battery terminal is connected to Switchboard terminal marked (+) charging switch is turned to "ON"; battery is left on until it is fully charged, charging switch is turned to "OFF"; battery is then removed, all of which is very simple.

INSTALLATION:

The Newport News Hydrolite is easily installed, due to its construction and fixed alignment of parts. No special outlet or intake required; water is supplied to turbine thru standard pipe and fittings and outlet can be standard pipe or a combination of pipe and vitrified tile.

THE GENERATOR:

The generator is a special design manufactured by General Electric Company, Standard voltages are 32 and 110.

PRICE OF NEWPORT NEWS HYDROLITE PLANTS

The sizes of the plants at present carried in stock are 150-watt, 250-watt and 500-watt. These sizes correspond to the rated output of the generators. To develop full output the following supply of water is required at the net head shown:

Size Plant	Supply (Gallons per Minute)	Net head (feet)
150-Watt	133	26
"	172	18
"	225	12
"	270	10
250-Watt	155	36
"	197	24
"	262	16
"	310	13
500-Watt	188	52
"	241	36
"	318	24
"	380	20

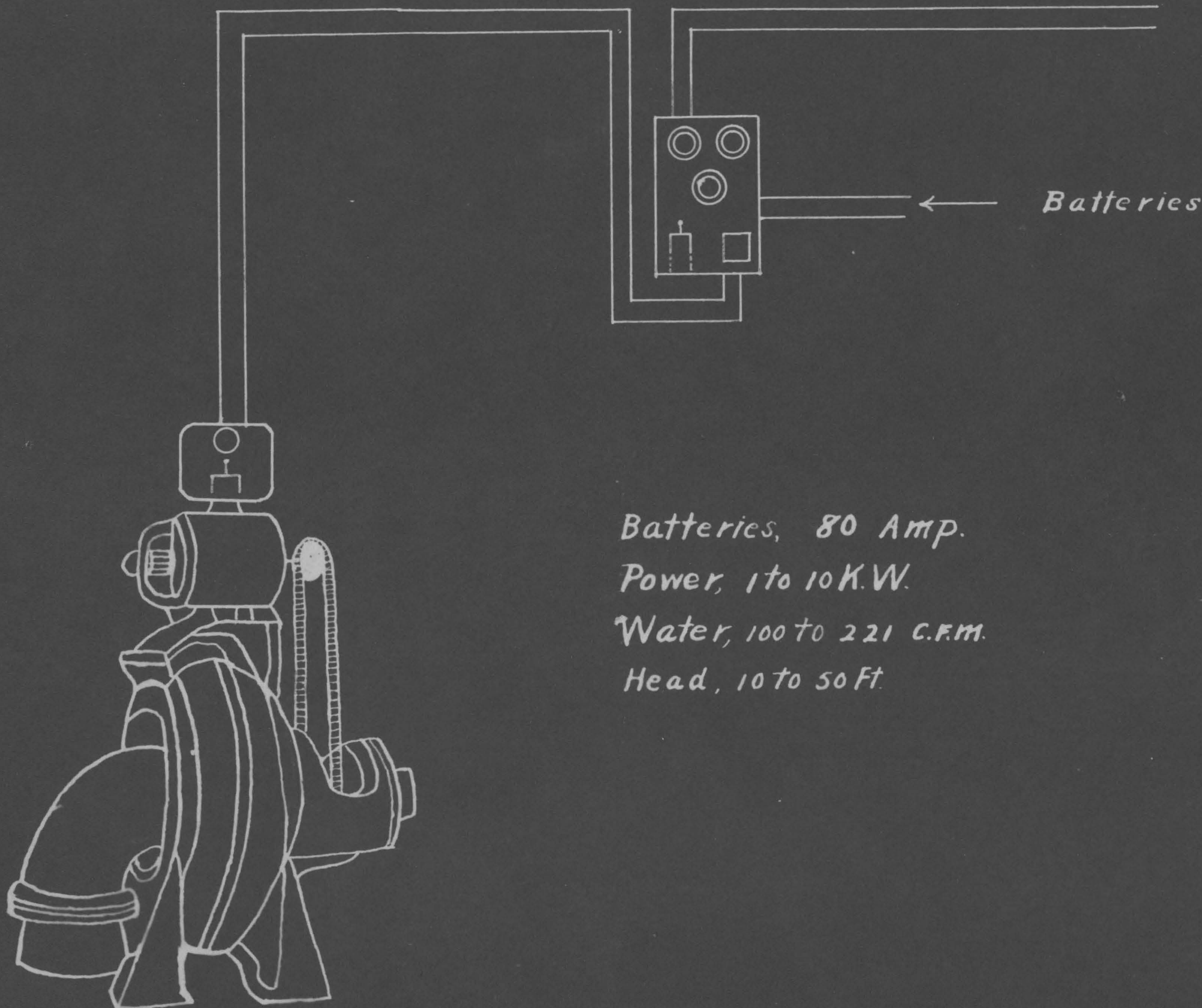
Larger sizes and plants designed to operate at lower heads will have to be specially assembled.

PRICE OF NEWPORT NEWS HYDROLITE PLANTS

The following are the daily output, the price and the shipping weight of the stock size plants:

Size Plant	Daily Output	Price (F.O.B. Newport News, Va.)	Shipping Weight
150-Watt,32-volt	3000 watt-hours	$565.00	1200 lbs.
250-watt,32-volt	5000 "	645.00	1400 "
500-watt,32-volt	10000 "	850.00	1800 "
500-watt,110-volt	10000 "	1200.00	3500 "

Miteload - Rodney Hunt Machine Co.



Batteries, 80 Amp.
Power, 1 to 10 K.W.
Water, 100 to 221 C.F.M.
Head, 10 to 50 Ft.

RODNEY HUNT NITELOAD

The #24 Niteload Farm Siting unit consists of a small reaction turbine without speed regulating gate, either chain driven or directly connected to a direct current generator.

This plant is essentially a storage battery plant, although it can be used without batteries if the equalizing system (double through switches and resistance coils) is used no governor is used. This plant has all of the advantages of being a simple compact unit.

(A) POWER TABLE NITELOAD NO.24

Head Feet	Power K.W.	Water C.F.M.	Speed R.P.M.
10	1	100	520
15	1½	122	640
20	2½	140	740
25	4	158	830
30	5	172	905
40	7½	200	1022
50	10	221	1165

Rodney Hunt Niteload Unit No. 24 is a standardized Hydro-electric unit or Water Power Farm Lighting Plant.

Heads of ten feet or more are very common in certain sections. The Niteload even under minimum head will develop sufficient power to light an ordinary homestead with all outbuildings, pump water, operate household appliances and a small 1/4 H.P. Utility Motor.

Operation is practically automatic. Common practice is to use storage batteries in connection with the Niteload to give uniform voltage and provide reserve power.

The turbine and generator should be installed where the best fall can be secured and the storage batteries loacted in a warm, well ventilated place as near as possible to the centre of lighting load distribution. The distance between the power plant and batteries can be as great as one mile if suitable size wire is used.

The Niteload is built to run all the time, charging the batteries at a constant rate. When the batteries have become charged the current is switched into a resistance in order to keep a constant load on the generator and prevent its burning out. This resistance can be a water heater, stove or the rehostat furnished with the switchboard. The switching over from charging to resistance is done automatically or manually depending on the style of switchboard purchased. All regulation is accomplished at the switchboard and it is not necessary to visit the power plant oftener than twice a month.

The Niteload has been built for continuous operation over a long term of years. It has very few parts, and all bearings are anti-friction type with special lubricating features. The following specifications show how rugged and substantial are all the component parts.

Turbine--Francis Type Runner. Mounted on three sets of ball bearings. Lubrication is needed only two or three times a year. Heavy Cast Iron Scroll Case with attached gate. Arranged for connection to 8-inch pipe.

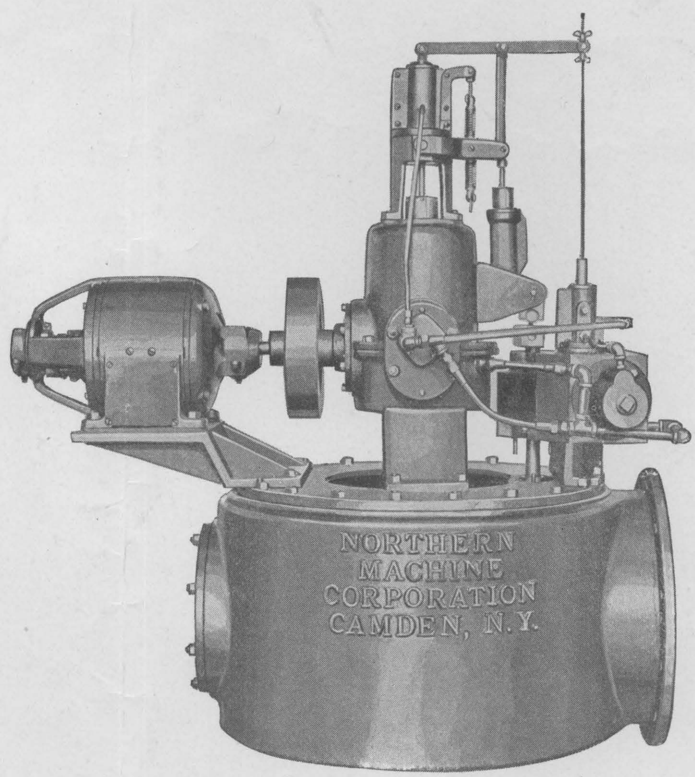
Generator--Specially wound constant voltage direct current generator. Either 32 or 110 volts. Guaranteed by the manufacturer. Generator drive is by silent chain covered by suitable guard. Quiet and efficient.

Switchboard--Fully equipped for charging storage batteries. Arranged for automatic control if desired.

Storage Batteries--Standard Farm Lighting Type. 80 Amp. hr. eight hour rating, regularly furnished. Larger capacity if desired at extra cost.

NORTHERN MACHINE CORP. HYDRO-ELECTRIC PLANT.

This plant has just been designed and no information on it could be obtained.



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SUMMARY

The average farm home requires one Kilowatt of power for lighting and minor domestic duties.

To eliminate the use of storage batteries a plant must develop one Kilowatt.

To develop one Kilowatt (1.34.H.P.) a water power should show two theoretical horse power available, for at least seven hours per day.

The straight stream flow of a water power may show one available horse power. This horse power may be increased to two and one half for eight hours by using a small storage dam.

Energy must be stored where the theoretical power is less than two horse power. It may be stored by the use of storage batteries or by a small storage dam.

A uniform flow of current is maintained by the following methods.

(a) Storage batteries and Rheostat for plants producing one Kilowatt and less.

(b) Resistant coils and double through switches for turbine installations developing from one to five Kilowatts. The same method is used for overshot installations developing from one to eight Kilowatts.

(c) Governors should be used for turbine installations developing over five Kilowatts, and overshot wheel installations developing above eight Kilowatts, or twenty five horse power to be used for mills.

Governors for hydro-electric plants must be very sensative. A governor for a turbine hydro-electric plant will cost $485.00. for mills; etc., a governor will cost $350.00 A governor for an overshot hydro-electric plant will cost $650.00 For saw mills, etc. $275.00

No governor is required when storage batteries are used with an auxilliary generator on a power plant.

In the development of water powers the reaction turbine and overshot wheel compete, for heads, varying from four to twenty-five feet. This is due to the high efficiency of the overshot wheel compared with the low cost of the turbine wheel. Above a head of twenty-five feet the cost of an overshot wheel is generally prohibitive and the reaction turbine takes the field. The reaction turbine is usually the most economical wheel to use except in a case where the high efficiency of an overshot wheel will eliminate the use of storage batteries.

From a head of fifty feet, the Pelton or impulse turbine wheel comes in, although this tupe of wheel is made for heads as low as twenty-feet. Above a head of eighty feet the impulse wheel has no competition.

The average cost of a commercial hydro-electric plant, or unit plant, is high compared with a designed plant developing the same amount of power, for the same location.

The average cost of a commercial plant, not installed, to develop one to three Kilowatts (depending on the amount of head available) is from $595.00 to $1025.00. This cost may be compared with a turbine generator, belt resistance coil and switch board at from $300.00 to $550.00.

A comparison in value between the two types of plants cannot be drawn from these figures. The commercial plant has the advantage of being built in a unit, it requires less attention and is easier to install.

The cost of installing a commercial plant will be from twenty-five to seventy-five percent less, due to the construction of pen-stock and power house for the designed plant. The average cost of installing a small designed plant is $143.00, which includes the power house.

The cost of any plant will depend largely on the cost of developing the power site.

Power sites vary so greatly in their requirements, as to large dams and conduits, that no definite figure can be given for the cost ofsuch developments. However, it may be stated that such cost varies approximately from $50 to $1,500. for developments up to ten horse power and from $350. to $5,000. up to 20 horse power.

The average total cost of an installed commercial plant for lights is $975.

The average total cost of a designed plant installed is $850.

<u>COST OF UPKEEP</u>

For the average farm hydro-electric plant without batteries $11.00 per year.

For the average farm hydro-electric plant with storage batteries--$49.00 per year.

For a ten horse power power plant--$20.00 per year.

The average life of a storage battery is four and one half years.

The average life of a water power plant is forty five years.

The average life of a hydro-electric plant is estimated at thirty five years.

The average life of a commercial hydro-electric plant is estimated at from twenty to thirty five years.

NOTE:

The above figures are used only in this summary. They are used to give a concrete idea of cost. The outstanding part of this thesis deals with designing plants for the seven typical divisions of water powers, including blue prints and data on estimating the cost of each element of the plant. This information cannot be summarized.

Through a study of the plants designed, and the estimating material given, a very close estimate of a plant for most any small water power can be obtained.

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