

TEST OF THE WATAUGA POWER COMPANY'S
HYDRO-ELECTRIC PLANT

by

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A THESIS SUBMITTED FOR
THE DEGREE OF BACHELOR OF SCIENCE
MECHANICAL ENGINEERING COURSE

University of Tennessee

1925

Tests of hydraulic power plants relate either to the entire plant extending from head water to tail water, or to any elementary part or parts of the plant desired. The test covered by this paper was a field test covering the turbines alone. The stimulus involved in the choosing of this subject as one for a thesis was the fact that there has never been a test of any kind made on this plant.

The Watauga Power Company owns and operates one hydro-electric power plant located on the Watauga River seven miles east of Elizabethton, Tennessee. This plant has a capacity of 2,000 kilowatts. The equipment consists of two horizontal 1000 kilowatt generators manufactured by the Westinghouse Electric Manufacturing Company. They are driven by two horizontal S. Morgan Smith turbines. The dam is 284 feet long and 55 feet high. (See Figure 1) This plant furnishes the cities of Bristol, Va-Tenn. Elizabethton and Bluff City, Tennessee, with electric power. The plant was built and put into operation in 1915 and has been delivering power to the above named cities since that date.

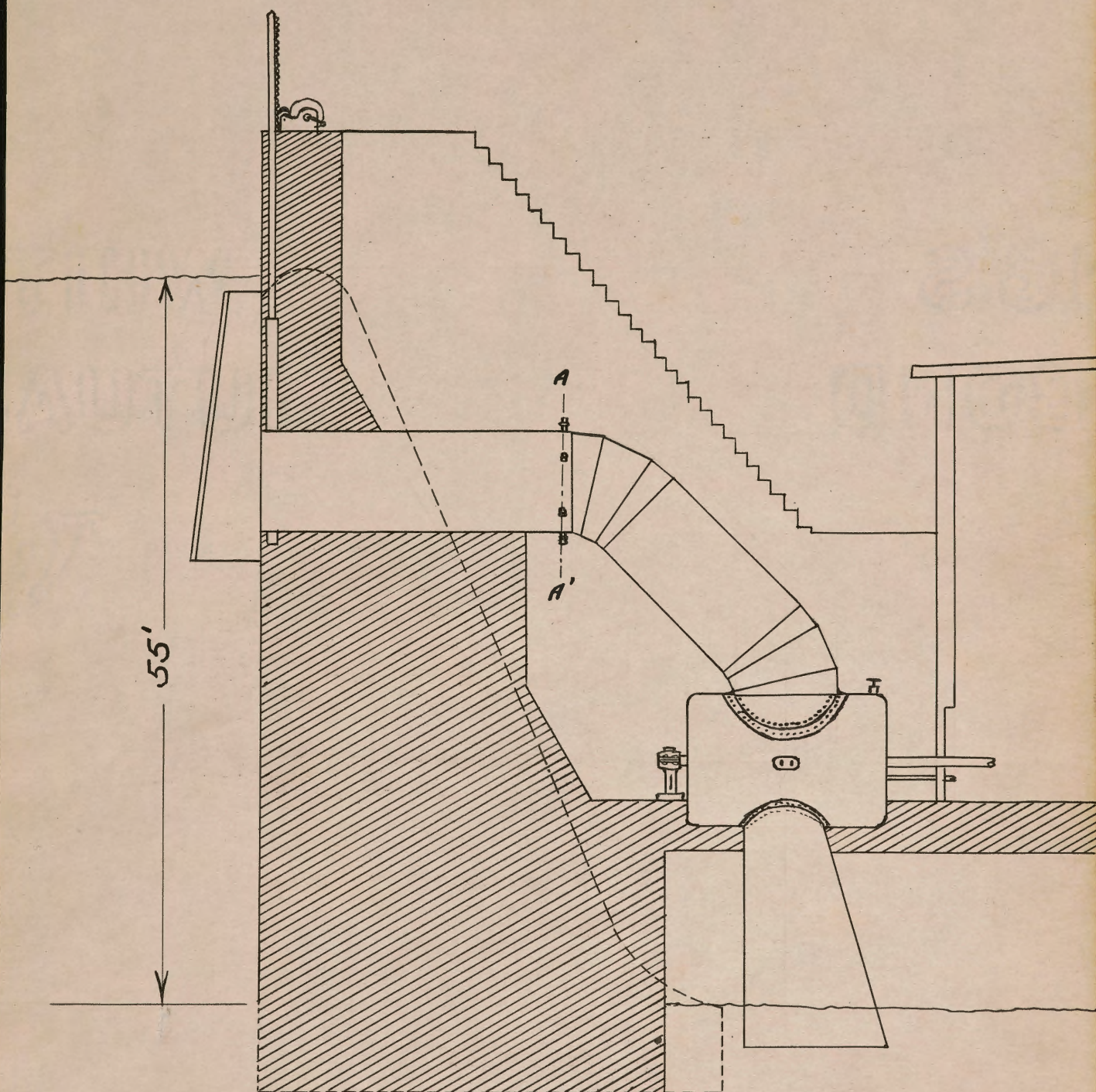


Figure 1

In the past there has been very little thought devoted to the testing of hydraulic machinery in the field. But in our present day people are coming more and more to see the benefits to be derived by these tests. It is of great advantage for the owner or operator of a plant to know just how efficiently his plant is running.

The possibilities of hydro-electric power plant testing are unlimited. The methods and porcedure specified in the test code of the American Society of Mechanical Engineers seems to be the best available on this subject and were therefore adhered to very closely in this test.

The general theory of hydro-electric power plant testing is: Obtain a constant load on the electric generator, being able to maintain this load over a certain period of time. Then with the head remaining as nearly constant as possible, measure accurately the quantity of water the turbines are passing. Run the wheel in this manner long enough to obtain a sufficient number of readings to give a good average and also to bring in all possible actual operating conditions. From the

the data thus obtained, the results are calculated as will be shown later.

The method of procedure in running the test is as follows: The velocity of the water was measured with a pitometer at section AA' in the penstock as shown in Figure 1 . The penstock is 90 inches in diameter and the length of the pitometer used was 45 inches. Six corporation cocks were placed at angles 60 degrees apart around the penstock, thereby allowing the total cross section of the penstock to be traversed. The head on the turbines was determined by a transit, taking some outside point as a bench mark and taking readings on two known points in the head water and tail water.

The two generators are delta connected machines and are run in parallel. There is a Lombard oil governor on each machine. By setting the governor on one machine so that ^{the} load is constant, then the governor on the other machine does double duty and the second machine takes care of the variations in the load. This enables the first machine to carry a constant load, and an accurate test be made of it.

The constant for the pitometer used was .72 and the efficiencies of both generator and exciter were given by the Westinghouse Electric & Manufacturing Company as

MACHINE NO 1

	Load		
	500 kw	750 kw	1000kw
Generator	92.4%	94.52%	95.45%
Exciter	86.95%	88.9%	89.6%

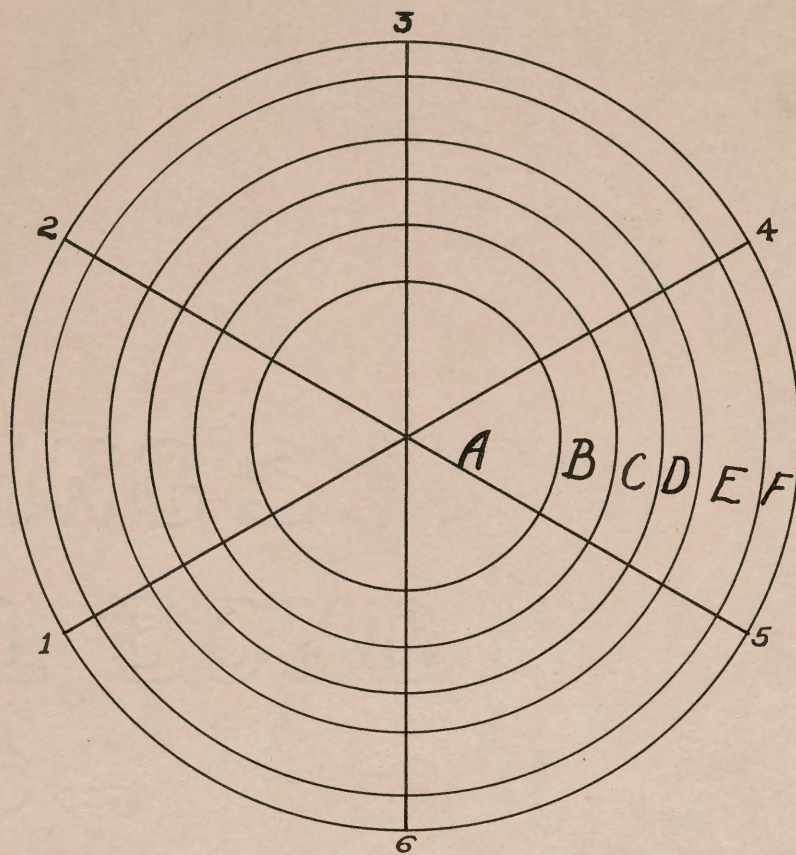
MACHINE NO 2

Generator	92.15%	94.34%	95.33%
Exciter	86.2%	88.4%	89.2%

The importance of this test lies in the fact that the efficiencies obtained will be of great value to the plant owners in that they contemplate installing a third unit at an early date.

The A. S. M. E. power test code was adhered to closely in this test.





Ring	Inside radius	Outside radius	Area Sq.in.	Area Sq.ft.
A	0"	17.06"	915.21	6.54
B	17.06	24.11	907.92	6.47
C	24.11	29.51	907.92	6.47
D	29.51	34.01	907.92	6.47
E	34.01	41.67	1815.84	12.90
F	41.67	45.00	907.92	6.47

	Ring	Area	Defl.	Defl.	Velocity	Velocity	Discharge
		Sq.ft.	Z"	Z'	head		Cu'/sec.
Run No.1 Mch.No.2	Load-500KW	A	6.54	4.00	.332	.598	4.47 29.21
		B	6.47	3.80	.316	.570	4.37 28.26
		C	6.47	3.68	.306	.552	4.18 27.03
		D	6.47	3.75	.312	.562	4.34 28.05
		E	12.90	3.52	.293	.528	4.21 54.30
		F	6.47	1.25	.104	.187	2.52 16.30
							TOTAL---- 183.15
Run No.2 Mch.No.2	Load-750KW	A	6.54	7.19	.599	1.079	6.00 39.30
		B	6.47	7.25	.604	1.089	6.04 39.08
		C	6.47	7.00	.583	1.050	5.93 38.40
		D	6.47	7.25	.604	1.089	6.04 39.08
		E	12.90	7.16	.597	1.075	6.01 77.50
		F	6.47	2.66	.222	0.400	3.66 23.65
							TOTAL----- 247.01
Run No.3 Mch.No.1	Load-500KW	A	6.54	4.44	.370	.666	4.72 30.80
		B	6.47	3.91	.326	.587	4.43 28.63
		C	6.47	4.08	.341	.613	4.53 29.30
		D	6.47	4.375	.364	.655	4.68 30.30
		E	12.90	3.91	.326	.587	4.43 57.20
		F	6.47	1.52	.126	.227	2.76 17.84
							TOTAL---- 194.07
Run No.4 Mch.No.2	Load-850KW	A	6.54	8.065	.672	1.22	6.39 41.85
		B	6.47	7.91	.659	1.188	6.30 40.75
		C	6.47	7.50	.625	1.126	6.15 39.80
		D	6.47	9.33	.777	1.400	6.84 44.25
		E	12.90	9.33	.777	1.400	6.84 88.25
		F	6.47	3.29	.274	.493	4.07 26.36
							TOTAL---- 281.26
Run No.5 Mch.No.1	Load-750KW	A	6.54	7.25	.605	1.090	6.05 39.60
		B	6.47	6.875	.573	1.032	5.88 38.00
		C	6.47	6.66	.555	1.000	5.79 37.42
		D	6.47	6.83	.569	1.025	5.86 37.90
		E	12.90	6.83	.569	1.025	5.86 75.60
		F	6.47	3.19	.266	.479	4.00 25.38
							TOTAL---- 254.38
Run No.6 Mch.no.1	Load-1000KW	A	6.54	10.80	.900	1.620	7.36 48.20
		B	6.47	10.41	.858	1.545	7.20 46.60
		C	6.47	10.50	.875	1.575	7.26 47.00
		D	6.47	10.41	.858	1.545	7.20 46.60
		E	12.90	10.41	.858	1.545	7.20 92.90
		F	6.47	4.56	.380	.684	4.78 30.91
							TOTAL---- 312.21

Exciter	Discharge Cu ¹ /sec.	0183.15	247.01	194.07	281.26	254.38	312.21
	Effective Head (ft)	56.62	55.34	55.16	55.87	55.71	55.54
	Water H.P.	1156.00	1552.00	1218.00	1783.00	1611.00	1970.00
	Volts	82.50	93.35	86.78	91.78	92.55	97.65
	Amperes	111.80	114.90	107.70	110.00	116.50	115.80
	Kilowatts	9.23	10.71	9.35	10.09	10.78	11.27
Generator	Output(H.P.)	12.38	14.37	12.54	13.52	14.45	15.11
	Input(H.P.)	14.38	16.23	14.42	15.18	16.25	16.89
	Volts	2209.69	2217.79	2220.00	2230.40	2232.00	2224.70
	Amperes	194.75	243.13	200.43	267.70	274.70	321.10
	Kilo Volt Amp.	746.00	934.00	770.00	1034.00	1063.00	1238.00
	Kilowatts	482.30	759.31	483.60	837.20	770.50	994.50
	Output(H.P.)	647.50	1020.00	648.00	1122.00	1032.00	1334.00
	Input(H.P.)	703.00	1080.00	701.00	1178.00	1090.00	1400.00
	Total input Gen.& Ex.	717.38	1096.23	715.42	1193.18	1106.25	1416.89
	Plant Efficiency (%)	56.00	65.70	53.30	63.00	64.00	67.70
	Turbine Efficiency (%)	62.00	70.60	58.80	67.00	68.50	72.00
		Run No. 1 Mch. No. 2 Load-500KW	Run No. 2 Mch. No. 2 Load-750KW	Run No. 3 Mch. No. 1 Load-500KW	Run No. 4 Mch. No. 2 Load-850KW	Run No. 5 Mch. No. 1 Load-750KW	Run No. 6 Mch. No. 1 Load-1000KW

APPROVAL

The foregoing thesis is hereby approved as a creditable study of an engineering subject, carried out and presented in a manner sufficiently satisfactory to warrant its acceptance as a prerequisite to the degree for which it has been submitted. It is to be understood that by this approval the undersigned does not necessarily endorse or approve any statements made, opinions expressed, or conclusions drawn therein, but approves the thesis only for the purpose for which it is submitted.

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