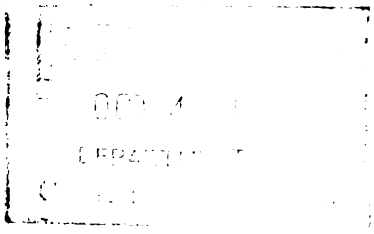
THESIS

STEAM TURBINE TEST

W. G. MAY B. CATALINE

M. A. C.

1910



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by

W. G. Kay D. Catalino

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THESIS

COMMERCIAL EFFICIENCY TESTS OF 10KW STEAM TURBINE

The object of these tests is to determine the commercial efficiency, some of the characteristics, and the relative power developed in the stages. The working conditions were kept as near constant as possible.

The machine tested was a twelve-inch six-stage Parsons steam turbine rated at ten horsepower at four thousand revolutions per minute.

The tests were made in the steam engine laboratory in the Mechanical building.

The auxiliary apparatus consisted of a horizontal surface condenser, vacuum pumps, weighing tanks and scales.

Steam was supplied to the turbine from the college power plant.

The power was absorbed by a water brake consisting of a small circular saw mounted on the main shaft and enclosed by a heavy galvanized iron casing. A steel arm was bolted to the casing and rested on a set of counter scales. Water entered the casing through a small slit in one side near the shaft and was thrown outward by centrifugal action filling the outer portion of the casing. The friction of the water against the surfaces constituted a resistance which absorbed the applied power. The amount of water entering was controlled by a needle valve, thus giving a very fine adjustment. The greater the depth of the

of the ring of water the greater the power absorbed. The heat generated by the friction was carried away by the water which escaped by means of an opening in the under side of the casing and through the base of the turbine.

The steam admission is controlled by a throttling governor of the centrifugal type with a balanced piston valve. The operation of the valve is such that in case the governor should break the valve would automatically close.

The governor weights consist of two semi-cylindrical pieces of steel which are thrown apart by the centrifugal action and at the same time act against a coiled spring on the shaft. Much trouble was experienced with the governor due to the catching or sticking of the spring at various points, thus giving a very irregular amount of steam admission. The variation of the speed with change of load showed that the steam admission was practically constant thus showing a very poor governor. The constant steam admission can be accounted for partially by the piping which allowed steam to enter the turbine without passing through the throttling valve of the governor.

The condensing water and the water for the brake was furnished part of the time from the college water system and part by the laboratory circulating pumps.

The condensed steam was pumped from the condenser by the vacuum pump directly into weighing barrels set upon weighing scales. When the run was completed the condensed steam was run into another barrel by shifting the conducting pipe. These barrels were emptied into the sewer system through the basement.

A very high vacuum could not be obtained owing to the inability of the vacuum pumps to operate successfully under the heavy steam condensation.

The speed was taken by means of a positive count speed counter.

The pressures were taken on each stage and also the steam main by means of gauges, vacuum and pressure being used on the low pressure side. Each gauge was calibrated by means of the Crosby Steam tester and weights for the pressures and by the mercury column for vacuums. A siphon was placed before each gauge so that the cold calibrations would be accurate.

The tests were of forty minutes duration during which time readings were taken every ten minutes. The steam pressure was maintained at about 80 pounds and the highest vacuum obtainable.

Tests were run at four different loads, first, with the first two stages in the turbine, then with four stages and then with six stages.

The horse power developed in these four tests for each two stages was nearly the same since the speed varied inversely as the loads seen by the following curves. The rated horse power was not developed under any condition, but this was due to insufficient vacuum, because of the incapacity of the pump.

When starting a new test the machine was allowed to run about fifteen minutes before readings were taken so that the conditions were constant.

CURVES

Calibration curves were plotted for each of the pressure and vacuum gauges and all the average or mean readings were corrected by these curves, thus giving accurate results.

To show the poor control of the governor curves with speed as ordinates and torque as abscissa were plotted. The speed varied in the six stages nearly inversely as the torque showing that very little if any change was made in the power developed and the very poor controll of the speed..

B..H..P..steam consumption curves were plotted to show the horsepower developed for the various arrangements of stages and so show the relative value of the stages to the turbine. The maximum horsepower developed for two stages was 4.65 which was about one-half the H..P..developed with 6 stages.. Stage pressure curves were plotted to show the expansion of the steam through the turbine. Stages were plotted as abscissa and pressures as ordinates..

A curve which shows the H. P. developed by the stages is plotted using as abscissa the two stages, 4 stages and six stages that were used and the ordinates were the maximum H. P.. developed by these stages.

A curve of B..H. P.. and speed is plotted which shows the drop in speed as the B..H..P.. is increased.. Finally the B. H..P. drops back as a result in the drop in speed due to over load of the brake.

GENERAL CONCLUSIONS

As a result of the tests the following conclusions are drawn.

As a heat engine the efficiency of the Kerr Turbine is very low when operating under a medium vacuum pressure and a steam pressure of 90#. This is shown in the tests where the lowest steam consumption per B. H. P. per hour amounted to 56.7# and it varied from that weight to 916# per B. H. P. per hour. Thus the commercial efficiency is very low and provided that the conditions obtainable were similar to those we had, the Kerr Turbine would be a very uneconomical means of driving power as compared with other heat engines.

The necessity of all of the stages for the most economical operation of the turbine is apparent since with the six stages in place the lowest steam consumption per B. H. P. is obtainable. The same amount of steam expanding more rapidly than when the six stages are in, as is the case when two or four stages were in does not exert the torque on the shaft since this load carried was much less in the latter cases. The velocity through the nozzles must be greater when running with a low number of stages, but the effect of the total kinetic energy of the steam upon the cups on the rotor is less as shown by the B. H. P. developed.

Therefore the most economical rate of expansion of steam occurs when the six stages are in the turbine and in this case the greatest power is developed.

The expansion of the steam through the stages is very

constant or regular as shown by the stage pressure curves. However, when the nozzles were removed in the lower stages there was still some expansion that took place due to the insufficient opening in the nozzle holes as shown by the stage pressure curves beyond the stages that were doing work. To make sure that no work would be done in the lower stages however the rotor disks in these stages were removed from the shaft.

The work done in each stage depends upon the effect of the kinetic energy of the steam upon the rotor disks of the stage. The kinetic energy depends upon the square of the velocity of the steam and the velocity varies as the difference in pressure in the different stages. Therefore, the relative amount of power developed in each stage can be approximately obtained by subtracting the ordinate of the next stage lower from the ordinate for that stage and comparing the square of these differences. By doing this we find that the power developed is distributed most regularly when the six stages a e in use and most irregularly when the two stages are used. Therefore, another value of the six stages when the expansion rate is fixed as it is now, is the equal or nearly equal distribution of the power developed over the entire turbine.

As before stated the governor is very poor and had practically no effect upon the steam consumption as shown by the B.H.P. speed curves. The speed dropped materially as the B.H.P. increased and then the B.H.P. decreased due to loss of speed and too great a friction in the brake.

Length of brake arm, 12.62"

Weight when resting on knife edges, 1.31#

$(W - 1.31)2\pi(3.1416) \times L \div 33{,}000 = H.P.$

$K = \frac{2\pi(3.1416)}{33000} = \frac{2(3.1416) \times 1.05697}{33000} = .00020033$

= the brake constant.

Test No. 1	2 stages
Load	.3#
Barometer	29.09"
Duration of test	40 min.
R. P. M.	6475
Pressure on main	90.5#
Pressure on exhaust	4.95# absolute
Temp. condensed steam	103°
B. H. P.	.259
Total steam condensed	123.5#
Steam per B. H. P. per hour	715#

Test No. 2	2 stages
Load	3#
Barometer	29"
Duration of test	40 min.
R. P. M.	5741
Pressure on main	89#
Pressure on exhaust	8.34# abs.
Temp. condensed steam	113°
B. H. P.	3.44
Total steam condensed	327#
Steam per B. H. P. per hour	1425

Test No. 3	2 stages
Load	5#
Barometer	29."
Duration of test	40 min.

R. P. M.	4650
Pressure on main	89.8#
Pressure on exhaust	8.59# abs.
Temp. condensed steam	110°
B. H. P.	4.66
Total steam condensed	348#
Steam per B. H. P. per hour	111.5#

Test No. 4	2 stages
Load	6#
Barometer	29.03"
Duration of test	40 min.
R. P. M.	2302
Pressure on main	8 .8#
Pressure on exhaust	8.83# abs.
Temp. of condensed steam	118°
B. H. P.	2.76"
Total steam condensed	345#
Steam per B. H. P. per hour	187.5#

Test No. 5	6 stages
Load	.2#
Barometer	29.91
Duration of test	40 min.
R. P. M.	6353
Pressure on main	90.5#
Pressure on exhaust	4.76# abs.
Temp. of condensed steam	134°
B. H. P.	.854

Total steam condensed	1[illegible]#
Steam per B. H. P. per hour	910#

Test No. 6	3 stages
Load	7#
Barometer	29.[illegible]"
Duration of test	40 min.
B. P. M.	5730
Pressure on main	83.7#
Pressure on exhaust	7.0[illegible]# abs.
Temp. of condensed steam	124.6°
B. H. P.	8.04
Total steam condensed	338#
Steam per B. H. P. per hour	62.[illegible]#

Test No. 7	3 stages
Load	10#
Barometer	29.[illegible]"
Duration of test	40 min.
B. P. M.	4630
Pressure on main	90.[illegible]#
Pressure on exhaust	7.[illegible]# abs.
Temp. of condensed steam	113.[illegible]°
B. H. P.	9.29
Total steam condensed	350#
Steam per B. H. P. per hour	56.7#

Test No. 8	3 stages
Load	13.4[illegible]
Barometer	[illegible].91
Duration of test	40 min.
R. P. M.	3440
Pressure main	90.2[illegible]
Pressure on exhaust	3.3[illegible] abs.
Temp. of condensed steam	118°
B. H. P.	9.23
Total steam condensed	360[illegible]
Steam per B. H. P. per hour	53.2[illegible]

Test No. 9	4 stages
Load	.2[illegible]
Barometer	29.38"
Duration of test	40 min.
R. P. M.	0413
Pressure on main	88.4[illegible]
Pressure on exhaust	4.52[illegible] abs.
Temp. of condensed steam	118°
B. H. P.	.350
Total steam condensed	13[illegible]
Steam per B. H. P. per hour	810[illegible]

Test No. 10	4 stages
Load	5½
Barometer	29.32"
Duration of test	40 min.
B. P. M.	3976
Pressure on main	89.4½
Pressure on exhaust	3.56½ abs.
Temp. of condensed steam	104.4°
B. H. P.	3.97
Total steam condensed	210½
Steam per B. H. P per hour	79.4

Test No. 11	4 stages
Load	5½
Barometer	29.32"
Duration of test	40 min.
B. P. M.	3820
Pressure on main	88
Pressure on exhaust	7.16½ abs.
Temp. of condensed steam	102°
B. H. P.	6.11
Total steam condensed	314½
Steam per B. H. P. per hour	77.3½

Test No. 13	4 stages
Load	10%
Barometer	29.32"
B. P. M.	2[illegible]33
Pressure on main	80.8%
Pressure on exhaust	3.3% abs.
Temp. of condensed steam	11[illegible]°
B. H. P.	5.04
Total steam condensed	5[illegible]%
Steam per B. H. P per hour	80.5%
Duration of test	40 min.

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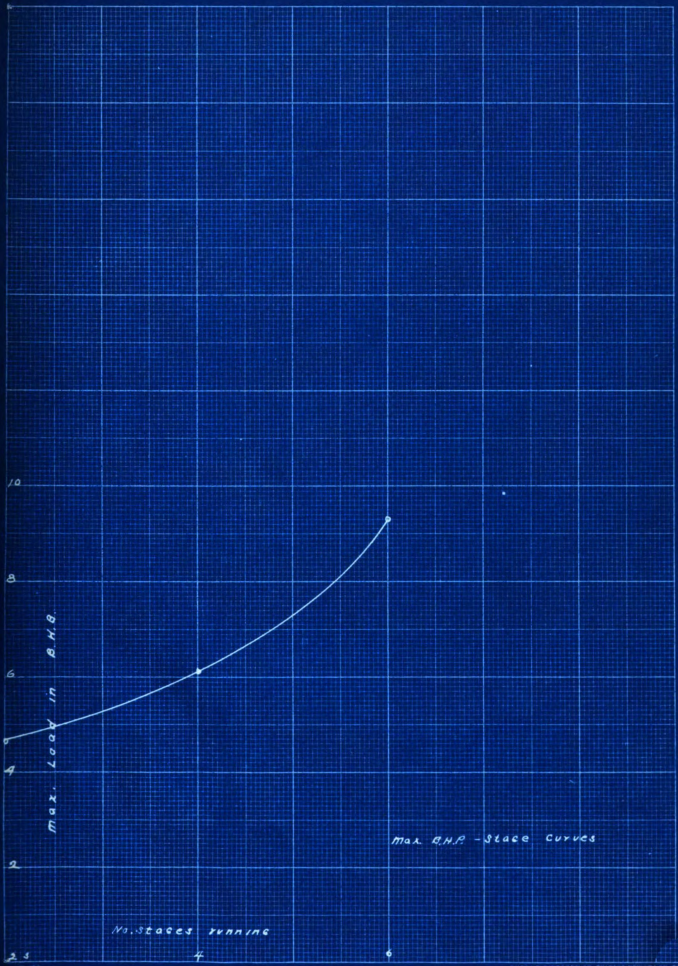
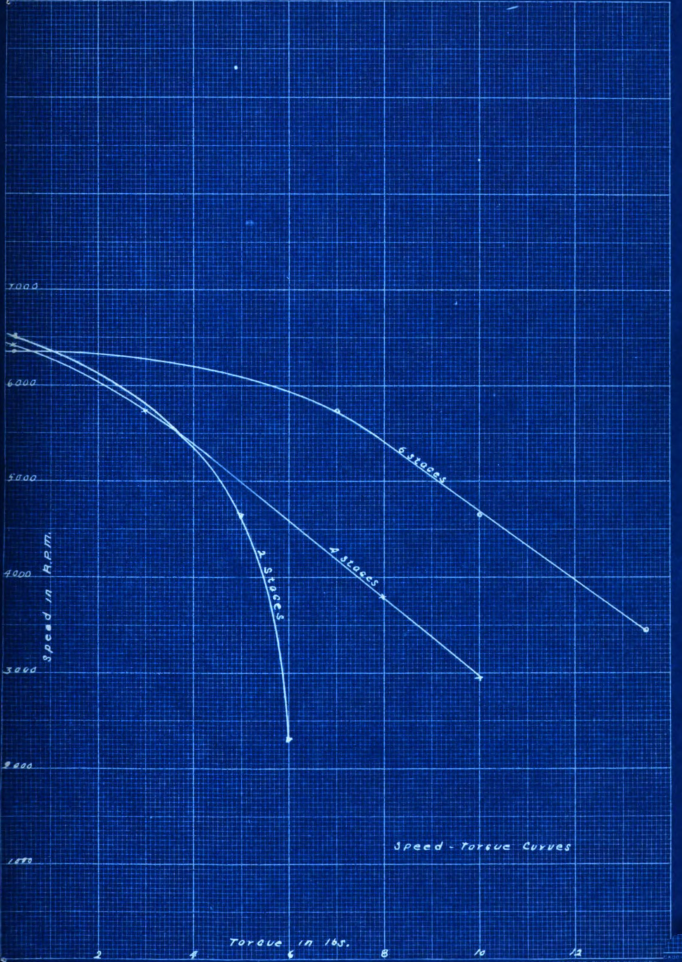
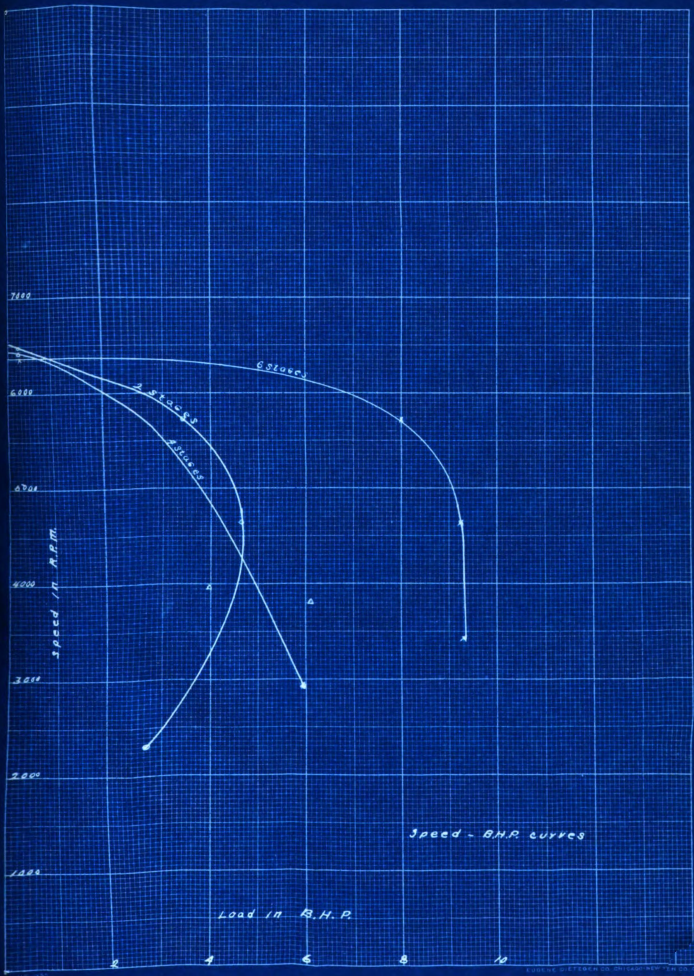
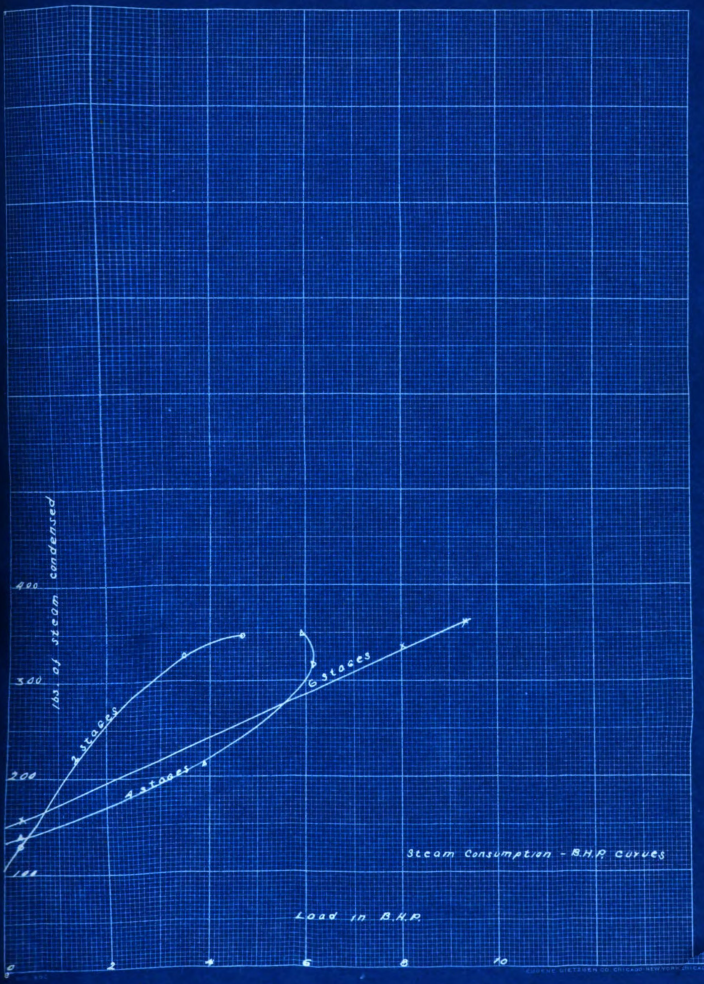
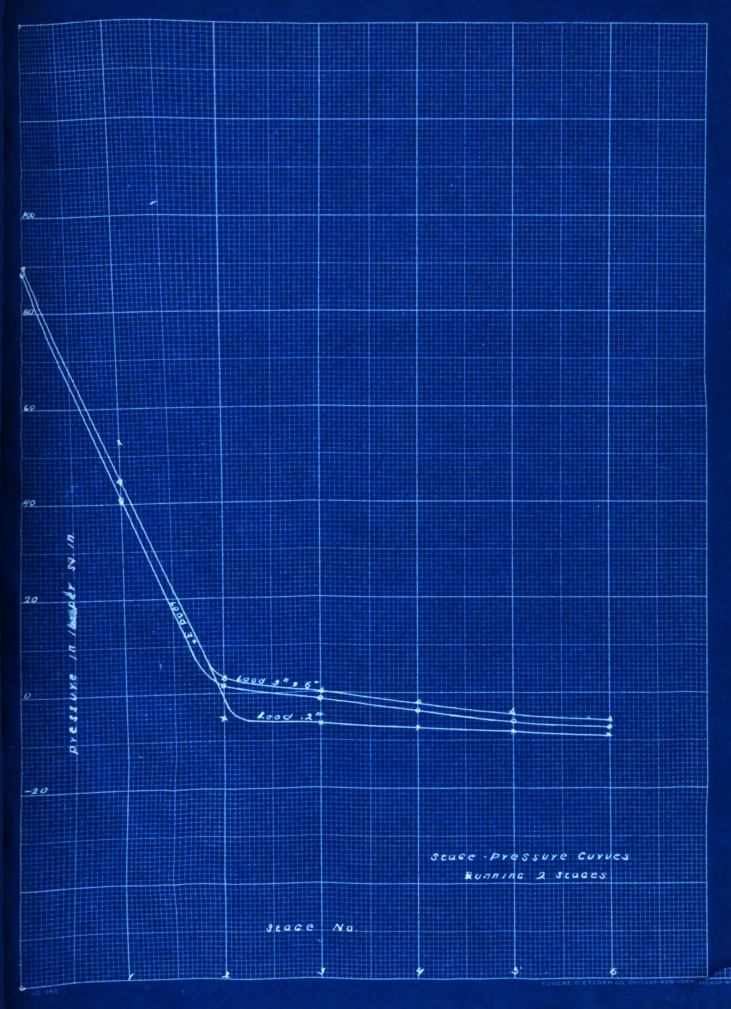
VII

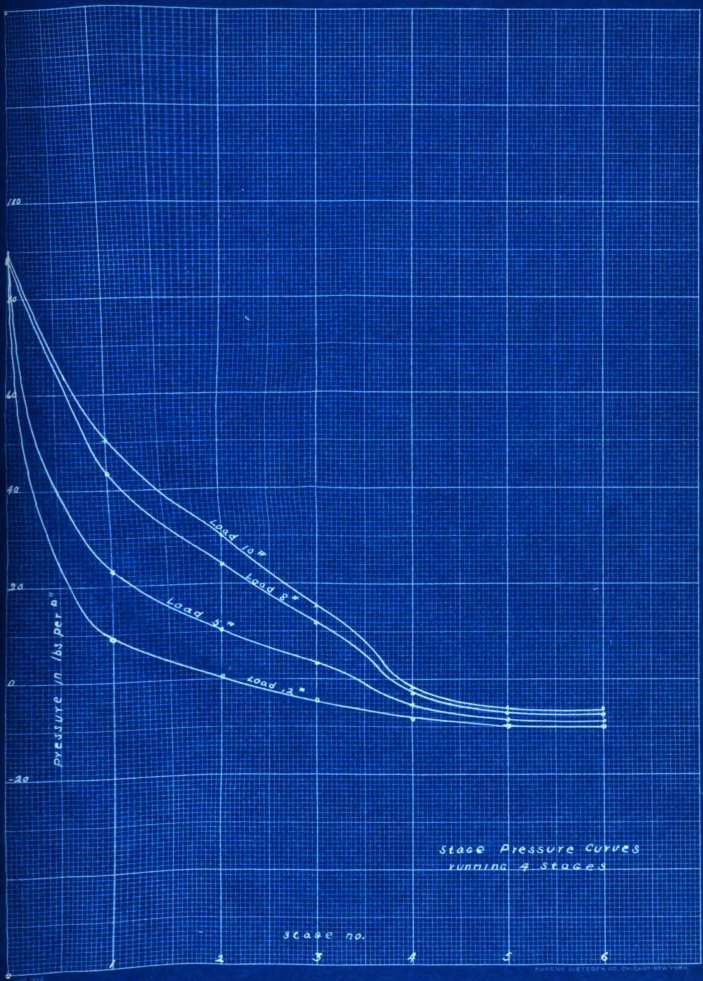

10
8
6
4
2
Max. Load in B.H.P.
Max. B.H.P. - Stage Curves
No. Stages running
2
4
6

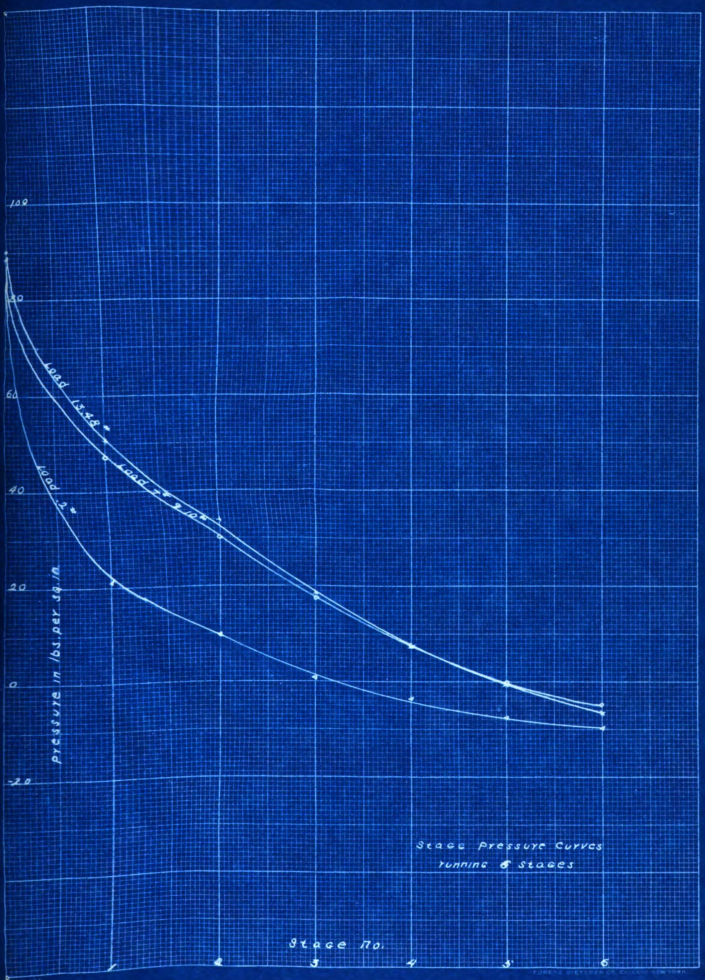

7000
6000
5000
4000
3000
2000
1000
Speed in R.P.M.
6 stages
4 stages
2 stages
Speed - Torque Curves
Torque in lbs.
2
4
6
8
10
12

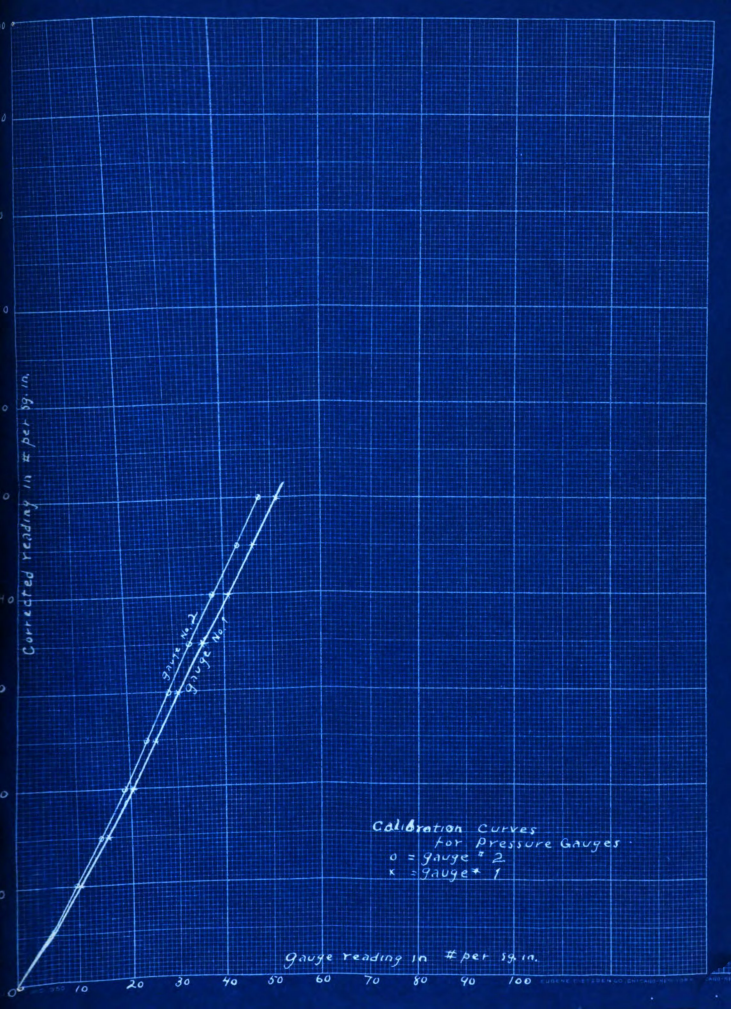

7200
6800
6400
6000
5600
5200
4800
4400
4000
3600
3200
2800
2400
2000
1600
1200
Speed in R.P.M.
6 Stroke
4 Stroke
4 Stroke
Speed - B.H.P. Curves
Load in B.H.P.
2
4
6
8
10


Pounds steam per B.H.P. per hr. condensed
400
300
200
100
2 stages
3 stages
4 stages
Steam Consumption - B.H.P. curves
Load in B.H.P.
0
2
4
6
8
10

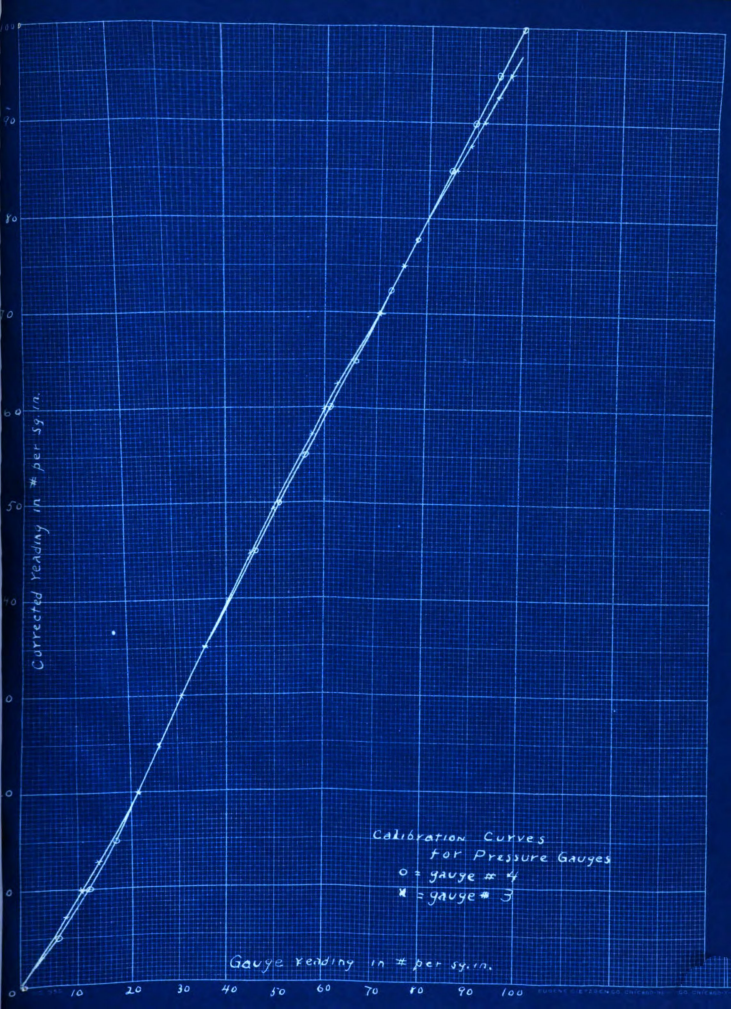

100
80
60
40
20
0
-20
Pressure in Inches of Water
Load 3" & 6"
Load 3"
Stage - Pressure Curves
Running 2 Stages
Stage No.
1
2
3
4
5
6

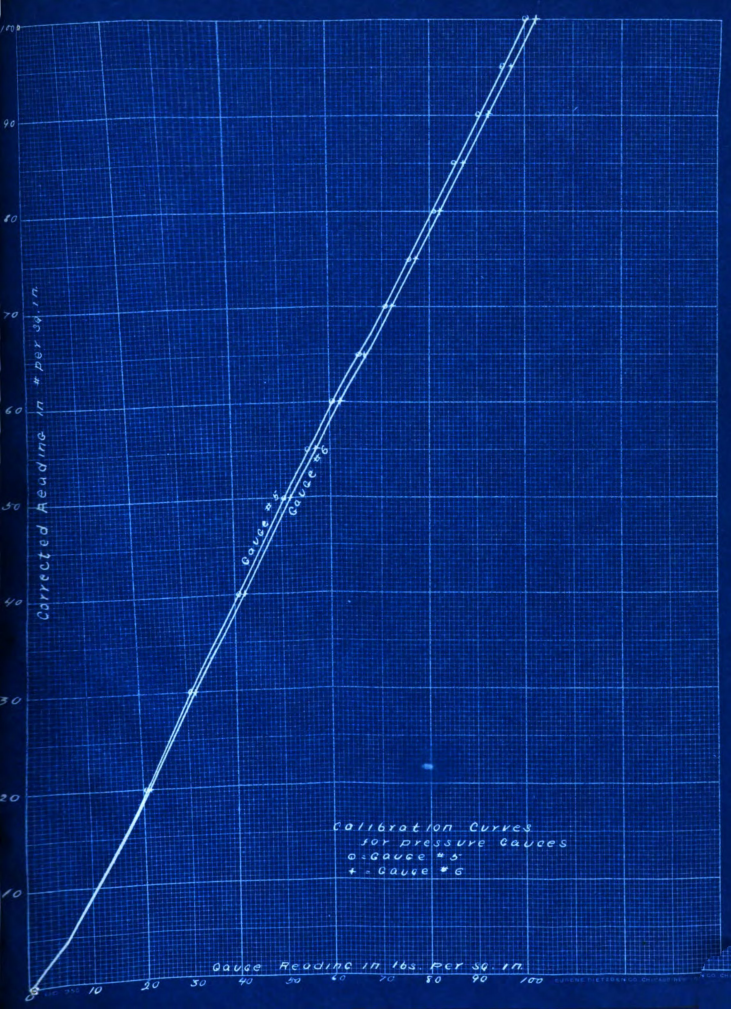

110
40
20
0
-20
Pressure in lbs per □"
Load 10"
Load 8"
Load 5"
Load 12"
Stage Pressure Curves
running 4 stages
Stage no.
1
2
3
4
5
6

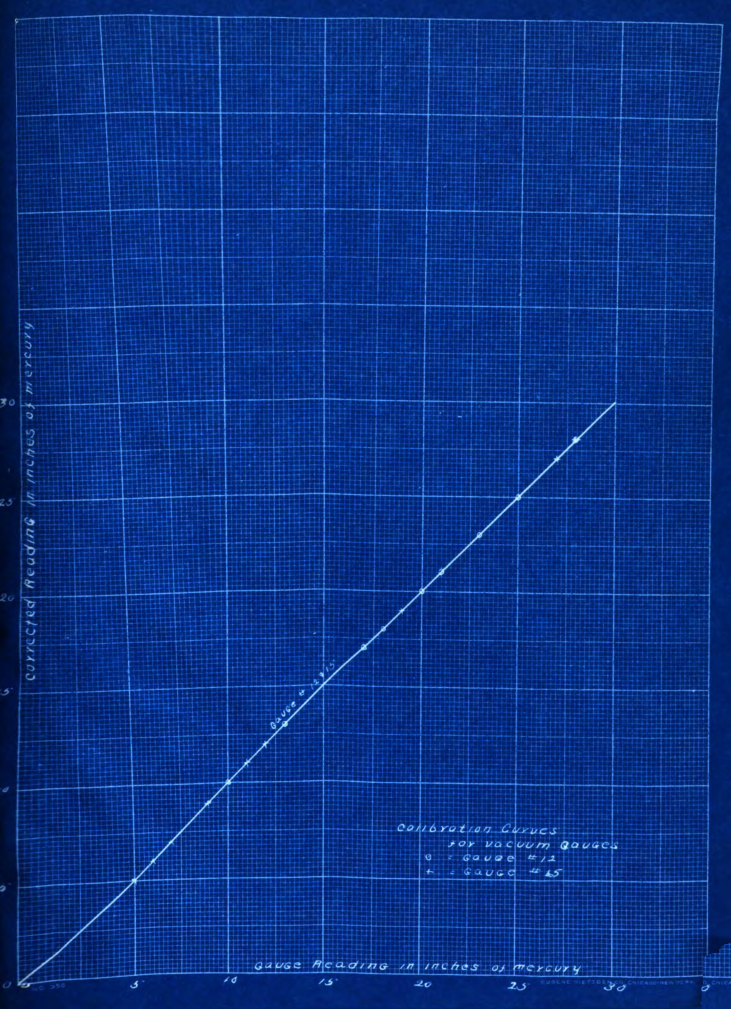

100
80
60
40
20
0
-20
Load 13.48"
Load 7"
Load 3"
Pressure in lbs. per sq. in.
Stage No.
1
2
3
4
5
6
Stage Pressure Curves
Running 6 Stages

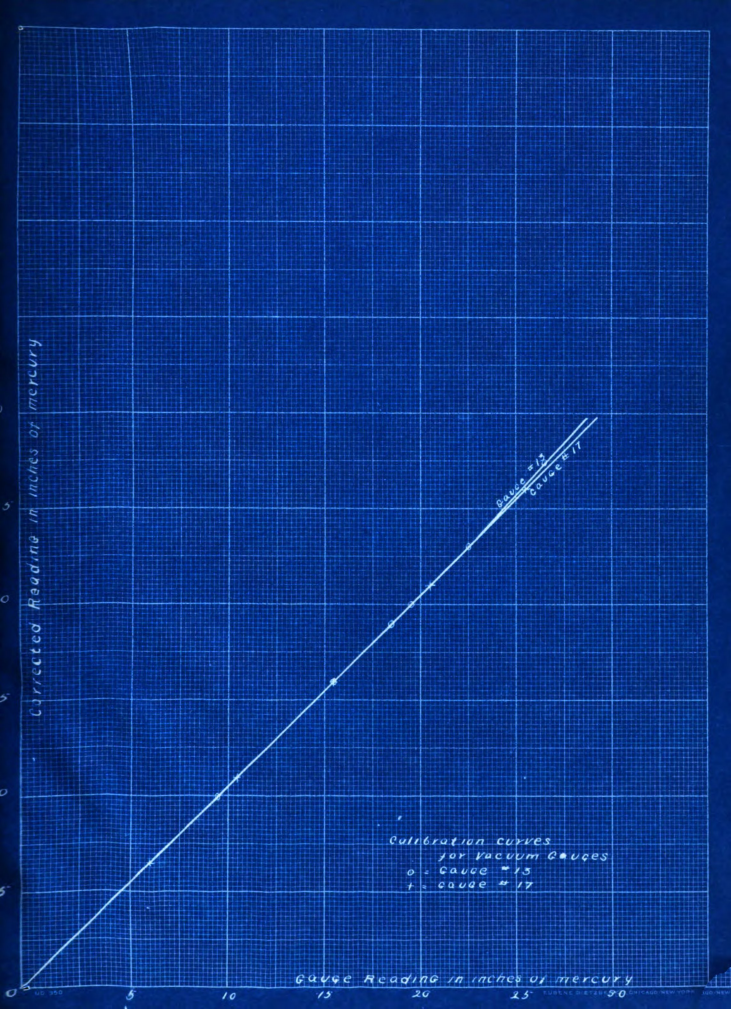


Calibration Curves
for Pressure Gauges.
o = Gauge # 2
x = Gauge # 1


Corrected Reading in # per sq. in.
Gauge Reading in # per sq. in.
0
10
20
30
40
50
60
70
80
90
100
Calibration Curves
for Pressure Gauges
o = gauge # 4
x = gauge # 3


Corrected Reading in # per sq. in.
Gauge Reading in lbs. per sq. in.
Gauge #5
Gauge #6
Calibration Curves
for pressure Gauges
o - Gauge #5
+ - Gauge #6
0
10
20
30
40
50
60
70
80
90
100


Corrected Reading in inches of mercury
Gauge Reading in inches of mercury
Calibration Curves
for Vacuum Gauges
o = Gauge #12
+ = Gauge #15
Gauge #15
0
5
10
15
20
25
30


Corrected Reading in inches of mercury
Gauge Reading in inches of mercury
Gauge #13
Gauge #17
Calibration curves
for Vacuum Gauges
o - Gauge #13
+ - Gauge #17
0
5
10
15
20
25
30

Test 2 Stages

Time	Load	Steam Pressures on Stages						No. of Steam Cond.	Press. Steam from gauge No 6	Temp Steam Cond.	R.P.M.
		Sta. #1 Gau. #4	Sta. #2 Gau. #17	Sta. #3 Gau. #	Sta. #4 Gau. 4/3	Sta. #5 Gau. #5	Sta. #6 Gau. #12				
2:55	.2	7"	14"	15"	16"	17"	18.5		94	106	6580
3:05	.2	6.5	13"	14.5	16	17	18		94.5	104	6470
3:15	.2	6.25	12.5	14	15.5	17	18		94	102	6450
3:25	.2	6.25	14	15.5	17	18	20		93	102	6444
3:35	.2	6	14	15.5	17.25	18	20	123.5	91	102	6430
mean	.2	6.4	13.4"	15"	16.4"	17.4"	19"	123.5	93.3	103	6475
Corr.	.2	5.5	12.9"	15"	15.9"	17.4"	19"	123.5	90.5	103	6475
8:45	3	42"	1.5"	2"	8.5"	11.5"	13"		90	112	5696
8:55	3	42	1.25	2	8.25	11.5	12.5		92	113	5726
9:05	3	43	1.5	2.5	8	11	12.5		92	110	5779
9:15	3	42	1	3	8	11	12.5		91	111	5773
9:25	3	42	1.5	2.5	8.25	11	13	327	91.5	112	5730
mean	3	42.2"	1.35"	2.4"	8.2"	11.2	12.3	327	91.3	112	5741
Corr.	3	41.2	1.35"	2.4"	7.7"	11.2"	12.3"	327	89	112	5741
7:30	5	46"	2.5"	1"	7"	10"	11.5"		90	118	4644
8:00	5	46	3.	0	6.5	10	11		94	120	4649
8:10	5	46.2	2.75	1	7	10	11.5		92	118	4664
8:20	5	44	3	1	7	10	11.5		91	118	4677
8:30	5	49	3	0	6.5	10	11.5	345	92	118	4653
mean	5	46.3	2.8	.6"	6.8	10	11.5	345	92	118	4656
Corr.	5	45.5	2.8"	.6"	6.3"	10"	11.5"	345	898	118	4656
3:55	6	45"	2.5"	1"	7"	10"	11.5"		91.5	118	2298
4:05	6	47.5	3.	0	7"	10	11.5		92.	118	2307
4:15	6	46	2.75	1	6.75	10	11.5		92.5	118	2326
4:25	6	46	3.	1.25	7	10	11.5		89	118	2293
4:35	6	46.5	3	0	6	10	11.5	345	93	118	2284
mean	6	46.3	2.8	.85	6.8	10	11.5	345	92	118	2302
Corr.	6	45.5	2.8"	.85"	6.3"	10"	11.5"	345	898	118	2302

Test 2 Stages

Time	Load	Steam Pressures on Stages						No. of Steam Cond.	Press. Steam Inlet Valve #6	Temp Steam Cond.	R.P.M.
		Sta. #1 Gov. #4	Sta. #2 Gov. #1	Sta. #3 Gov. #	Sta. #4 Gov. #3	Sta #5 Gov. #2	Sta #6 Gov. #1				
2:55	.2	7"	14"	15"	16"	17"	18.5		94	106	6580
3:05	.2	6.5	13"	14.5	16	17	18		94.5	104	6470
3:15	.2	6.25	12.5	14	15.5	17	18		94	102	6450
3:25	.2	6.25	14	15.5	17	18	20		93	102	6444
3:35	.2	6	14	15.5	17.25	18	20	123.5	91	102	6430
Mean	.2	6.4	13.4"	15"	16.4"	17.4"	19"	123.5	93.3	103	6475
Corr.	.2	5.5"	12.9"	15"	15.9"	17.4"	19"	123.5	90.5"	103	6475
8:45	3	42"	1.5"	2"	8.5"	11.5"	13"		90	112	5696
8:55	3	42	1.25	2	8.25	11.5	12.5		92	113	5726
9:05	3	43	1.5	2.5	8	11	12.5		92	110	5779
9:15	3	42	1	3	8	11	12.5		91	111	5773
9:25	3	42	1.5	2.5	8.25	11	13	327	91.5	112	5730
Mean	3	42.2"	1.35"	2.4"	8.2"	11.2	12.3	327	91.3	112	5741
Corr.	3	41.2	1.35"	2.4"	7.7"	11.2"	12.3"	327	89	112	5741
7:30	5	46"	2.5"	1"	7"	10"	11.5"		90	118	4644
8:00	5	46	3.	0	6.5	10	11		94	120	4649
8:10	5	46.2	2.75	1	7	10	11.5		92	118	4664
8:20	5	44	3	1	7	10	11.5		91	118	4677
8:30	5	49	3	0	6.5	10	11.5	345	92	118	4653
Mean	5	46.3	2.8	.6"	6.8	10	11.5	345	92	118	4656
Corr.	5	45.5	2.8"	.6"	6.3"	10"	11.5"	345	898	118	4656
3:55	6	45"	2.5"	1"	7"	10"	11.5"		91.5	118	2298
4:05	6	47.5	3.	0	7	10	11.5		92.	118	2307
4:15	6	46	2.75	1	6.75	10	11.5		92.5	118	2326
4:25	6	46	3.	1.25	7	10	11.5		89	118	2293
4:35	6	46.5	3	0	6	10	11.5	345	95	118	2284
Mean	6	46.3	2.8	.85	6.8	10	11.5	345	92	118	2302
Corr.	6	45.5	2.8"	.85"	6.3"	10"	11.5"	345	898	118	2302

Test 4 Stages

Time	Load	Steam Pressures on Stages Sta. #1 Sau. #4	Sta. #2 Sau. #1	Sta. #4 Sau. #17	Sta. #5 Sau. #13	Sta. #6 Sau. #15	Sta. #8 Sau. #12	Wt. of Steam Con.	Press. in Steam main	Temp of Sand Steam	A.R.M.
8:55	.2	10"	1"	7"	18"	19"	20"		93#	130°	6410
9:05	.2	10	0	8	18	19	19		93	120	6487
9:15	.2	7.5"	0	8.5"	18.5	19	19.5		90	114	6421
9:25	.2	7.5"	1	9	18.5	19.5	20		88	110	6412
9:35	.2	8	0	9	19"	19.5	20	138#	89	108	6415
Mean	.2	8.6"	.4"	8.3"	18.4"	19.2"	19.7"	138#	90.6#	116°	6413
Corr.	.2	8.1"	4"	7.8"	17.9"	19.2"	19.7	138#	88.4#	116°	6413
11:10	5	23"	12"	2"	15"	17.5"	18"		90#	110°	4000
11:20	5	24	12	4.5	14	16.5	18		85	102	3935
11:30	5	24	11	3	15.5	17	18		84	104	3966
11:40	5	25	12	3	15.5	17.5	18		100	104	3981
11:50	5	24	11.5	3	16	17.5	18	210#	99	104	3981
Mean	5	24"	11.7"	3.1"	15.2"	17.2"	18"	210#	91.6#	104.4°	3976
Corr.	5	23	10.7"	3.1"	14.7"	17.2"	18"	210#	89.4#	104.4°	3976
10:25	8	44"	22.5"	10"	12"	13.5"	15"		90	100	3811
10:35	8	45	24	10	12	14	15		93	95	3830
10:45	8	44	25	11.5	11	13.5	14		90	100	3838
10:55	8	43	24	12	10	12.5	14.5		86	108	3814
11:05	8	46	26	13	11	13.5	15	318#	90	108	3804
Mean	8	444"	24.3"	11.3"	11.2"	13.4"	14.7"	318#	89.8	102	3820
Corr.	8	43.6"	24	11.3"	10.7"	13.4"	14.7	318#	88	102	3820
9:40	10	30"	29.5"	15"	7.5"	10"	12"		89	130	2794
9:50	10	32	30	15	8	10.5	12		93	115	3036
10:00	10	30	30	15	8	11	12.5		90	110	2980
10:10	10	31	30.5	15	8	11	12.5		94	105	2980
10:20	10	32	30	15	8	11	12.5	350#	94	105	3031
Mean	10	31	30	15"	7.9"	10.7"	12.3"	350#	92	115°	2968
Corr.	10	30"	30"	15"	7.4"	10.7	12.3"	350#	898	115°	2968

Test 6 Stages

Time	Load	Steam Pressures On Stages						W.E. of Steam Cond.	Press. Steam Gauge #6	Temp Cond Steam	R.P.M.
		Sta. #1 Gau. #5	Sta. #2 Gau. #4	Sta. #3 Gau. #7	Sta. #4 Gau. #3	Sta. #5 Gau. #2	Sta. #6 Gau. #1				
1:45	.2"	19"	11"	0	6"	14"	18.5"		94"	128°	6275
1:55	.2	20	12	.5"	5"	13.5	18.5"		94"	124°	6300
2:05	.2	24	11	0	8.5"	15"	20"		91"	123°	6325
2:15	.2	20	10	.5"	8"	14.5	19'		87"	122°	6464
2:25	.2	28	13	1"	7.5	14.5	20"	1.5"	98"	122°	6400
Mean	.2	22.2"	11.8"	.5"	6.9	14.3"	19.2"	1.5"	92.8"	124	6353
Corr.	.2	21	10	.5"	6.4	14.3"	19.2"	1.5"	90.5	124°	6353
9:00	7"	49"	32"	18"	8"	0	14"		92	126°	5740
9:10	7	48	31	17.2	7.5	0	14.5"		90	126°	5730
9:20	7	47	30	17	7.25	0	15		88	126°	5730
9:30	7	48	31	18	7.75	0	14.5		93	124°	5740
9:40	7	47	30.5	17.2	7.25	.5"	14.5	3.5	92	122°	5750
Mean	7	47.8"	30.8"	17.5"	7.55"	.1"	14.5"	3.5	91	124.5°	5738
Corr.	7	47	30	17.5"	7.55"	.1"	14.5"	3.5	88.7	124.5°	5738
8:10	10	49.5"	32	18	8"	0	14"		94"	110°	4630
8:20	10	49	31.5	17.5"	7.5	.5	14"		90	118°	4660
8:30	10	48.5	31.5	17.2	7.5	0	13.5		93.5	120°	4610
8:40	10	49	31.5	17.5	7.75	.5	13.5		92.5	122°	4630
8:50	10	49.5	32	17.5	8.	.5	13.5	3.5	94	123°	4620
Mean	10	49.1"	31.7	17.5"	7.7"	.3"	13.7"	3.5	92.8"	118.6°	4630
Corr.	10	48	30.5	17.3"	7.7"	.3"	13.7"	3.5	90.5	118.6°	4630
3:00	13.48	51.5"	37"	18"	8	0	12"		93	116°	3430
3:10	13.48	52.	38.5"	18.5"	8	.5"	11.5"		95	116	3430
3:20	13.48	51.5	36	18	8	.0	12		94	116	3480
3:30	13.48	49.5	31	17	7.25	.0	12		92	116	3417
3:40	13.48	49.5	31	17	7.25	.0	12	3.6	92	116°	3440
Mean	13.48	50.8	34.7	17.7	7.55	.1"	12"	3.6	93.2	116°	3440
Corr.	13.48	50"	34"	17.7"	7.55"	.1"	12°	3.6	90.9	116°	3440

Gauge #1		Gauge #2		Gauge #3		Gauge #4		Gauge #5		Gauge #6	
Gauge Read.	True Read.	Gauge Read.	True Read.	Gauge Read.	True Read.	Gauge Read.	True Read.	Gauge Read.	True Read.	Gauge Read.	True Read.
5.2"	5"	4.8"	5"	"	5"	12"	10"	21"	20"	21"	20"
10.4	10	9.7	10	10.8	10	21.2	20	31	30	31	30
15.4	15	14.2	15	16	15	26.	25	40.5	40	42	40
20.5	20	18.7	20	21.6	20	31.	30	45.5	45	52	50
23.5	25	23.3	25	26.4	25	36.	35	50.5	50	57	55
30.5	30	28.1	30	31.	30	40.8	40	55.5	55	62	60
35.5	35	32.7	35	35.6	35	45.8	45	60.5	60	66.5	65
40.5	40	37.7	40	40.4	40	51.	50	66	65	71.5	70
45.5	45	42.7	45	43.2	45	56.	55	71	70	77	75
		47.7	50	50.2	50	60.8	60	76	75	82	80
				55.1	55	66.2	65	81	80	87	85
				60.	60	70.6	70	85	85	92	90
				65	65	75.2	75	90	90	97	95
				70	70	79.8	80	95	95	102	100
				75	75	84.7	85	100	100	107	105
				80.2	80	89.6	90	105	105	112	110
				86.	85	94.3	95	110	110	117	115
				91.5	90	99.2	100	115	115	122	120
				96.8	95						

Gauge #12		Gauge #13		Gauge #15		Gauge #17		Gauge #13		Gauge #17	
Gauge Read.	True Read.	Gauge Read.	True Read.	Gauge Read.	True Read.	Gauge Read.	True Read.	Gauge Read.	True Read.	Gauge Read.	True Read.
28"	28"	26.4	27.4"	28"	28"	25.7"	26.2	5"	5"	5"	5"
25	25	22.5	23	27	27	20.5	21.	10	10	10	10
23	23	19.5	20	25	25	15.5	16	15	15	15	15
21	21	18.5	19	21	21	10.5	11	20	20	20	20
20	20	13.5	16	19	19	6.	6.5	25	26	25	25
18	18	9.5	10	17	17			30	30	30	30
17	17	5.5	6	12	12			35	35	35	35
13	13			11	11			40	40	40	40
10	10			9	9			45	45	45	45
5	5			7	7						
				6	6						
				5	5						