THESIS

Test of 7.5 K.W. Kerr Turbine.

by

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THROOP COLLEGE OF TECHNOLOGY
Pasadena, California

1915

INDEX.

TEST OF 7.5 K.W. KERR TURBINE
at
Throop College of Technology.

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The object of this thesis was to make a series of tests on the 7.5 kw. Kerr steam turbine in the Mechanical Engineering Laboratory at Throop College of Technology, using saturated and superheated steam and with various back pressures. The following notes, drawings, curves, and data were compiled from six series of tests which were run with the following conditions:

Series No.I - - - - - - Saturated steam and 0" Vacuum.
Series No.2 - - - - 90 degrees superheat and 0" Vacuum.
Series No.3 - - - - - - Saturated steam and I4" Vacuum.
Series No.4 - - - - - - Saturated steam and I9" Vacuum.
Series No.5 - - - - 90 degrees superheat and I4" Vacuum.
Series No.6 - - - - 90 degrees superheat and I7" Vacuum.

METHOD OF PROCEDURE.

The 7.5 kw. Kerr steam turbine was direct connected to a 7.5 kw. Fort Wayne d.c. generator, and the loads were varied from I to I0 kilowatts by a water rheostat which was placed in series with the armature of the generator. A voltmeter and an ammeter were used to measure the amount of load delivered, the former being placed across the main leads of the generator and the latter in series with the armature and rheostat. The voltage was kept at I00 volts during all the tests. On starting a run the turbine was allowed to run for about one-half hour before any readings were taken in order to have all heat changes constant. All valves were examined to see that the steam and water were going to the right places. The gages which were graduated before the tests began were checked after all tests were completed. The quality of the saturated steam was determined by means of a throttling calorimeter which was placed in the steam line at the point where it entered the governor of the turbine. The degrees of superheat was determined by a thermometer placed also in the steam line just above the calorimeter. The pressure of the steam entering the different stages was measured by an indicator. The amount of steam used was determined by catching the condensed exhaust steam in a tank and weighing it. Each test was run for I hour, the readings being taken every I0 minutes.

APPARATUS AND EQUIPMENT.

The following list of apparatus and equipment was used during the series of tests and were connected as shown in the accompanying drawing:-

Kerr Steam Turbine, Kerr Turbine Co.
Wellsville, New York.
4 stage, 7.5 K.W. 3600 R.P.M. #7790.

Fort Wayne D.C. Generator, 7.5 K.W. #32407,
125 Volts, 60 Amperes, 4 Poles,
Compound wound.

General Electric D.C. Milli-Voltmeter, #252432,
Used with 100 ampere shunt.

Weston Voltmeter, #5374.

Schuchardt & Schutte Speedometer, #6361.

Crosby Indicator, #918 D.

American Throttling Calorimeter, #97.

American Steam Gage, #773616.

Crosby Vacuum Gage, #60863I.

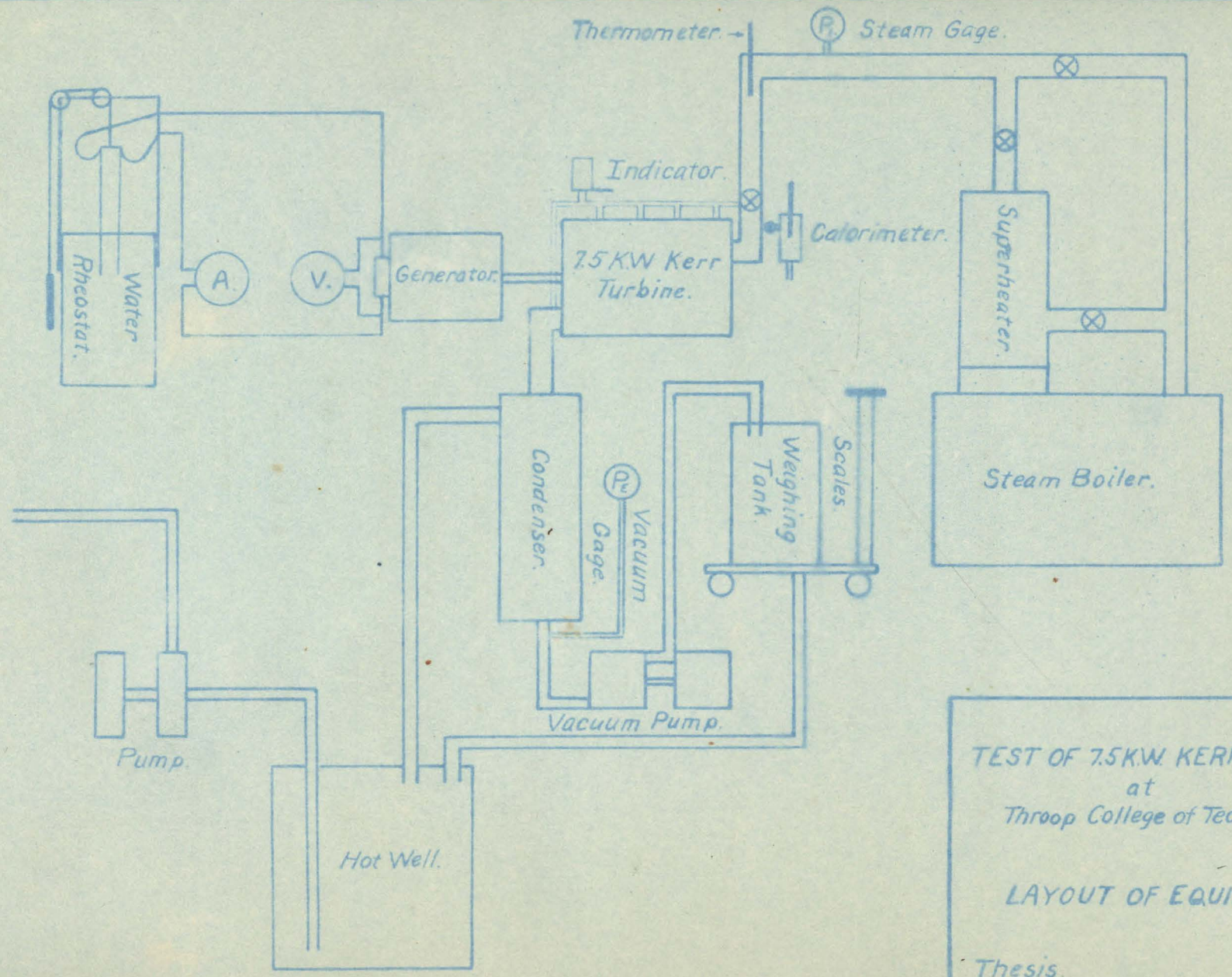
Superheater, T.C.T.

Surface Condenser, T.C.T.

Water Rheostat, T.C.T.

Weighing scales and tank.

Thermometers, 400° and 600° Fahrenheit.



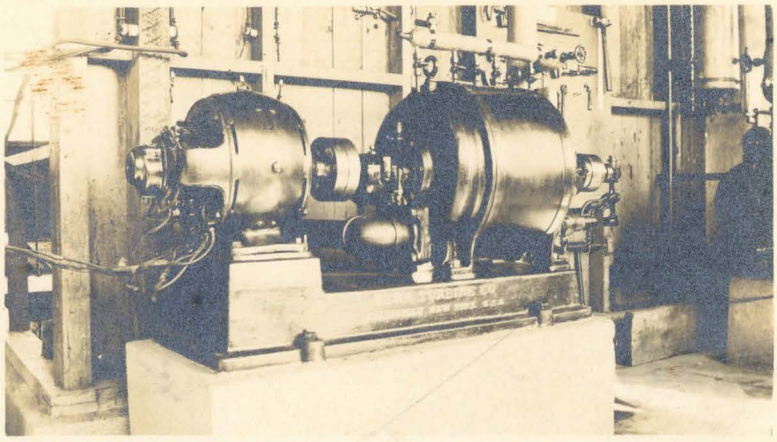
TEST OF 7.5 K.W. KERR TURBINE.
at
Throop College of Technology.

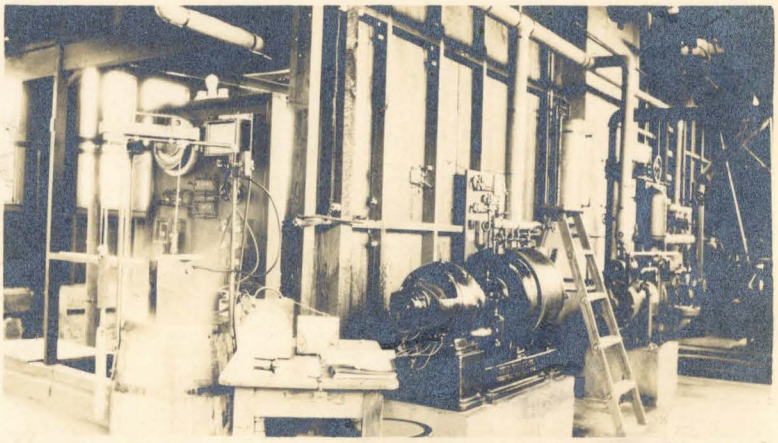
LAYOUT OF EQUIPMENT.

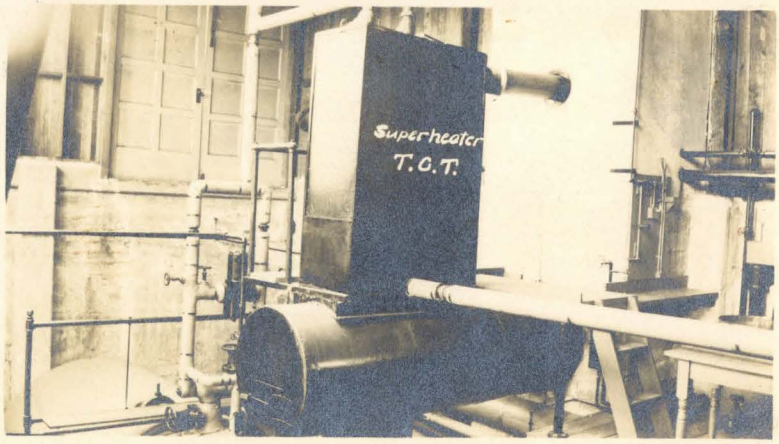
Thesis. H.A. Black.

6

PHOTOGRAPHS.







ABBREVIATIONS.

P-I	Pressure of steam at turbine governor.
V-E	Exhaust steam vacuum in inches of Hg.
P-E	Pressure of exhaust steam.
S-I	Steam pressure before entering the Ist. stage.
S-2	Steam pressure before entering the 2nd. stage.
S-3	Steam pressure before entering the 3th. stage.
S-4	Steam pressure before entering the 4th. stage.
Q-I	Quality of steam at P-I.
H-I	Total heat in steam at P-I.
S-H	Degrees of superheat in steam at P-I.
T-2	Temperature of steam in calorimeter.
T-I	Temperature of superheated steam at P-I.
H-T	Theoretical total heat in P-E, without friction.
H-E	Total heat in P-E, with friction.
E-A	Energy theoretically given out by the steam.
E-A	Energy actually given out by the steam.
K.W.	Kilowatts delivered by the generator.
DHP	Horse power delivered by the turbine.
GHP	Horse power delivered by the generator.
W-T	Total weight of steam used per hour.
W-HP	Weight of steam per GHP hour.
W-DHP	Weight of steam per DHP hour.
R.P.M.	Revolutions per minutes.
F.P.S.	Feet per second.

ABBREVIATIONS.

Eff.-G	% Efficiency of the generator.
Eff.-O	% Efficiency overall of turbine and generator.
Eff.- T	% Thermal efficiency of turbine on DHP.
Eff.-C	% Cyclic efficiency of the turbine.
Eff.-I	% Increase in Eff.-T over Series No.I.
Eff.-A	% Thermal efficiency of the ideal turbine.
Eff.-R	% Efficiency ratio of Eff.-T to Eff.-A.

FORMULAE.

$$Q\text{-}I = \frac{H\text{-}A + 0.48\,(T\text{-}2 - T\text{-}A) - Q\text{-}P}{L\text{-}P}$$

H-A = total heat of atmospheric steam.

T-A = temperature of atmospheric steam.

Q-P = heat of the liquid at P-I.

L-P = latent heat of the steam at P-I.

0.48 = specific heat of atmospheric steam.

Thus the formula becomes:-

$$Q\text{-}I = \frac{1149.8 + 0.48\,(T\text{-}2 - 210.6) - 324.2}{867.9}$$

S-H = T-I - T-P

T-P = temperature of saturated steam at P-I.

Thus the formula becomes:-

S-H = T-I - 352.7

$$P\text{-}E = \frac{B\text{-}R - V\text{-}E}{2.036}$$

B-R = average barometer reading,= 29.2 inches Hg.

2.036 = no. inches Hg. in 1lb. per square inch.

Thus the formula becomes:-

$$P\text{-}E = \frac{29.2 - V\text{-}E}{2.036}$$

E-T = H-T - H-E

E-A = 0.90 X E-T

10% of the energy is lost in friction.

FORMULA.

$$DHP = \frac{I.34 \times K.W.}{Eff.-G}$$

I.34 = no. of horse power in I kilowatt.

$$Eff.-O = \frac{2545 \times GHP}{W-T \times E-A}$$

$$Eff.-C = \frac{2545 \times DHP}{W-T \times E-A}$$

$$Eff.-T = \frac{2545 \times DHP}{W-T \times H-I}$$

2545 = no. of heat units in I horse power hour.

$$Eff.-A = \frac{E-A}{H-I}$$

$$Eff.-R = \frac{Eff.-T}{Eff.-A}$$

The following values were used with the above formula. They were determined from the efficiency curve given on pages I2 and I3.

K.W.	I	2	3	4	5	6	7.5	9	I0
GHP	I.34	2.68	4.02	5.36	6.70	8.04	I0.05	I2.06	I3.40
Eff-G	52.5	68.4	76.0	80.0	82.5	84.0	85.5	86.I	86.4
DHP	2.55	3.92	5.29	6.7I	8.I3	9.57	II.75	I4.00	I5.55

GENERATOR EFFICIENCY CURVE.

The work delivered by the turbine was used to drive the generator, and of this work only a part was delivered to the recording instruments, the remainder being lost in the generator. These losses should not be charged against the turbine; it is therefore necessary to know just how much they are. They were calaulated and the efficiency determined from them.

The following data were taken from the test made by W.L.Newton, Feb. 5, 1914, on the Fort Wayne D.C. Generator, #32407, to determine the efficiency of the generator at the various loads. The generator was run as a motor with the following readings:-

Volts	121.5 Volts.
Total current	7.40 Amperes.
Shunt field current	0.68 Amperes.
Shunt field resistance	173 Ohms.
Armature resistance	0.064 Ohms.
Series field resistance	0.005 Ohms.
Interpoles resistance	0.015 Ohms.
Resistance of arm. cur. path	0.084 Ohms.
Speed	3675 R.P.M.

There being no data available as to field current when running as a generator, it was assumed that it was the same as when running as a motor.

The readings of current and voltage varied very little with large variations in the speed, and as the speed of the generator during these series of tests covers a small range (3700 to 3650 R.P.M.), the readings corresponding to the average speed of 3675 R.P.M. were used.

Input, I2I.5 X 7.40 - - - - - - - - - 900 Watts.

Voltage - - - - - - - - - - - - - - - - - II0 Volts.

Current - - - - - - - - - - - - - - - - - 8.I6 Amperes.

Shunt field copper losses (SF.L.) - 80.0 Watts.

Arm. cur. path losses (Cu.L.) - - - - -5.6 Watts.

Total copper losses (T.L.) - - - - - 85.6 Watts.

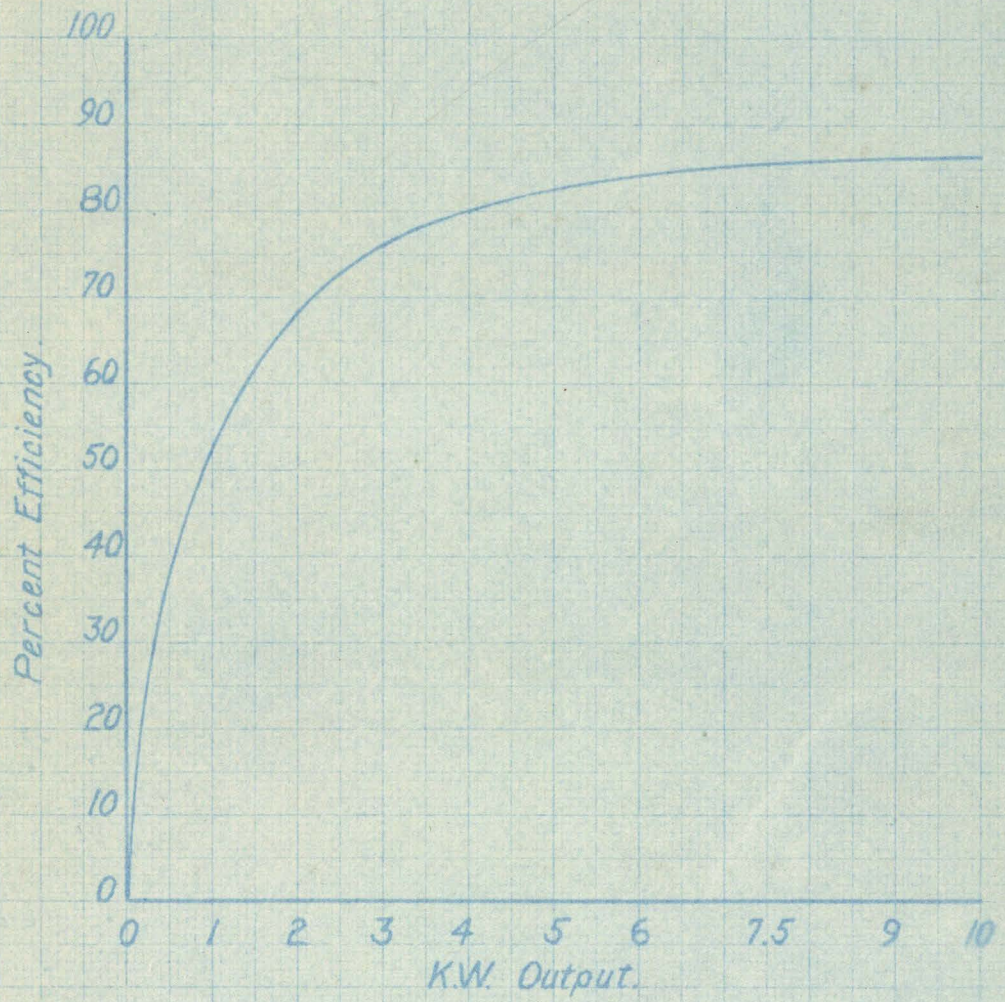
Stray power losses (Sp.L.) - - - - 8I4.4 Watts.

The efficiency of the generator run at 3675 R.P.M. was then found as follow:-

K.W.	I	2	3	4	5	6	7.5	9	I0
SF.L.	80	80	80	80	80	80	80	80	80
Sp.L.	8I4	8I4	8I4	8I4	8I4	8I4	8I4	8I4	8I4
Cu.L.	7	28	63	II2	I74	250	39I	562	692
T.L.	90I	922	957	I006	I068	II44	I285	I456	I586
Output	I000	2000	3000	4000	5000	6000	7500	9000	I0000
Input	I90I	2922	3957	5006	6068	7I44	8785	I0456	II586
Effi-G	52.5	68.4	76.0	80.0	82.5	84.0	85.5	86.I	86.4

EFFICIENCY CURVE.

Fort Wayne D.C. Generator.
#32407.
110 Volts. 68.2 Amperes. 7.5 K.W.
3675 R.P.M.
Direct Connected to Kerr Steam Turbine.



Thesis.

H.A. Black.

RESULTS OF TESTS.

From the log-data given in the appendix of this report the following values and calculation were worked out. The values of the total heat of the steam at the various qualities and degrees of superheat were taken from "The Mollier Diagram" of the Marks and Davis Steam Tables and Diagrams. No data could be obtained to determine the loss of energy due to the friction of the steam passing thru the nozzles. It was assumed that 10% of the available energy was lost, this going back into the steam in the form of heat, thus increasing the quality of the exhaust steam. The assumption was also made that the steam followed the adiabatic expansion as it passed thru the nozzles. It was found impossible to determine how this loss was distributed in the four stages. The absolute pressures in the different stages were found by adding to the pressures measured on the indicator cards the pressure corresponding to the barometer reading. As the water rate and the efficiencies are bases of comparison of operation they were determined in each case. The curves of these values were drawn to show graphically the gains made in the use of superheat and a vacuum over the common use of saturated steam, non-condensing.

RESULTS OF SERIES No.I.

K.W.	I	2	3	4	5
P-I	I39.3	I39.3	I39.3	I39.3	I39.3
S-I	42.05	49.02	56.55	64.42	7I.80
S-2	23.42	26.I8	29.30	32.30	35.65
S-3	I8.I8	I9.05	20.55	22.30	23.68
S-4	I5.30	I5.92	I6.55	I7.30	I7.80
P-E	I4.30	I4.30	I4.30	I4.30	I4.30
Q-I	97.2	97.I	97.6	97.7	98.0
H-I	II67.0	II67.0	II7I.0	II72.0	II74.5
H-T	I005.5	I006.0	I0I0.0	I0II.0	I0I2.2
E-T	I62.5	I6I.0	I6I.0	I6I.0	I62.3
E-A	I46.3	I44.9	I44.9	I44.9	I46.I
H-E	I02I.7	I022.7	I026.I	I027.I	I028.4
W-T	384.5	455.0	5I6.0	58I.0	655.0
W-HP	287.5	I69.9	I28.4	I08.4	97.8
W-DHP	I5I.0	II6.0	97.6	86.5	80.5
Eff.-O	6.07	I0.40	I3.7I	I6.25	I8.50
Eff.-C	II.57	I5.20	I8.05	20.35	22.45
Eff.-T	I.45	I.88	2.23	2.5I	2.69
Eff.-A	I2.55	I2.4I	I2.35	I2.34	I2.46
Eff.-I	0	0	0	0	0
Eff.-R	II.55	I5.II	I8.06	20.36	2I.60

RESULTS OF SERIES No.I.

K.W.	6	7.5	9	I0	Ave.
P-I	I39.3	I39.3	I39.3	I39.3	I39.3
S-I	80.80	95.80	I07.42	II7.I8	
S-2	39.58	44.55	50.55	55.80	
S-3	26.30	29.I8	32.I8	35.05	
S-4	I9.30	20.I8	2I.80	24.05	
P-E	I4.30	I4.30	I4.30	I4.30	I4.30
Q-I	98.2	99.I	99.0	98.8	97.8
H-I	II67.0	II84.5	II83.I	II8I.5	II75.2
H-T	I0I4.0	I020.0	I020.0	I0I8.2	I0I3.I
E-T	I62.0	I63.5	I63.I	I63.3	I62.I
E-A	I45.8	I47.I	I46.8	I47.0	I45.9
H-E	I030.2	I037.4	I036.3	I034.5	I029.3
W-T	727.0	794.0	889.0	962.0	
W-HP	90.5	79.0	73.6	7I.8	
W-DHP	76.0	67.5	63.4	6I.8	
Eff.-O	I9.35	2I.90	23.55	24.I5	
Eff.-C	23.05	25.60	27.40	28.00	
Eff.-T	2.86	3.I9	3.30	3.49	
Eff.-A	I2.40	I2.4I	I2.40	I2.43	I2.42
Eff.-I	0	0	0	0	
Eff.-R	23.05	25.65	26.60	28.05	

RESULTS OF SERIES No.2.

K.W.	I	2	3	4	5
P-I	I39.3	I39.3	I39.3	I39.3	I39.3
S-I	4I.55	47.30	5I.80	56.30	7I.30
S-2	2I.I9	23.50	25.42	27.25	33.50
S-3	I7.32	I8.02	I8.95	I9.78	22.90
S-4	I5.45	I5.40	I5.88	I6.28	I7.62
P-E	I4.30	I4.30	I4.30	I4.30	I4.30
S-H	9I.7	90.3	88.4	90.3	93.3
H-I	I244.0	I243.0	I24I.8	I244.0	I244.5
H-T	I067.5	I067.0	I066.0	I067.0	I068.5
E-T	I76.0	I76.0	I75.8	I76.0	I76.0
E-A	I58.4	I58.4	I58.2	I58.4	I58.4
H-E	I085.6	I084.6	I083.6	I084.6	I086.I
W-T	307.0	355.5	40I.0	438.0	542.0
W-HP	229.0	I32.7	99.7	8I.8	8I.0
W-DHP	I20.2	90.5	75.8	65.3	66.6
Eff.-O	7.02	I2.I5	I6.II	I9.70	I9.86
Eff.-C	I3.38	I7.78	2I.20	24.60	24.I0
Eff.-T	I.70	2.26	2.70	3.I4	3.07
Eff.-A	I2.73	I2.73	I2.74	I2.73	I2.72
Eff.-I	I7.2	20.2	2I.I	25.I	I4.I
Eff.-R	I3.33	I7.73	2I.20	24.62	24.I0

RESULTS OF SERIES No.2.

K.W.	6	7.5	9	I0	Ave.
P-I	I39.3	I39.3	I39.3	I39.3	I39.3
S-I	8I.05	96.20	II2.30	I24.30	
S-2	37.68	4I.50	47.80	52.98	
S-3	24.55	26.85	30.I5	33.25	
S-4	I7.92	I8.68	20.40	22.08	
P-E	I4.30	I4.30	I4.30	I4.30	I4.30
S-H	92.6	90.2	90.3	90.7	90.9
H-I	I244.0	I243.0	I243.0	I243.5	I243.3
H-T	I068.0	I067.0	I067.0	I067.2	I067.2
E-T	I76.0	I76.0	I76.0	I76.3	I76.I
E-A	I58.4	I58.4	I58.4	I58.7	I58.4
H-E	I085.6	I084.6	I084.6	I084.8	I084.9
W-T	6I6.0	730.5	8I3.5	867.5	
W-HP	76.8	72.8	67.5	64.7	
W-DHP	64.4	62.2	58.0	55.8	
Eff.-O	20.96	22.I0	23.90	24.85	
Eff.-C	25.00	25.82	27.75	28.82	
Eff.-T	3.I8	3.29	3.54	3.64	
Eff.-A	I2.73	I2.73	I2.73	I2.75	I2.73
Eff.-I	II.2	3.I	7.3	4.3	
Eff.-R	24.98	25.8I	27.79	28.56	

RESULTS OF SERIES No.3.

K.W.	I	2	3	4	5
P-I	I39.3	I39.3	I39.3	I39.3	I39.3
S-I	32.05	39.30	45.05	55.30	62.80
S-2	I4.42	I8.30	20.90	25.30	29.05
S-3	II.30	I2.80	I4.42	I6.42	I8.I8
S-4	8.72	I0.48	I0.30	II.I8	I2.I8
P-E	7.44	7.44	7.44	7.44	7.44
Q-I	97.5	98.I	97.2	98.3	98.I
H-I	II70.0	II75.5	II68.0	II78.5	II75.5
H-T	969.5	975.0	967.0	975.5	975.0
E-T	200.5	200.5	20I.0	203.0	200.5
E-A	I80.5	I80.5	I80.9	I82.7	I80.5
H-E	989.5	995.0	987.I	995.8	995.0
W-T	276.5	343.0	4I4.5	472.5	545.5
W-HP	206.5	I28.0	I03.0	88.I	8I.5
W-DHP	I08.5	87.4	78.3	70.3	67.2
Eff.-O	6.83	II.04	I6.69	I5.85	I7.30
Eff.-C	I3.05	I6.I2	I7.98	I9.8I	2I.00
Eff.-T	2.0I	2.48	2.80	3.08	3.23
Eff.-A	I5.42	I5.37	I5.50	I5.50	I5.37
Eff.-I	38.6	3I.9	25.6	22.7	20.I
Eff.-R	I3.00	I6.I3	I8.05	I9.88	2I.00

RESULTS OF SERIES No.3.

K.W.	6	7.5	9	I0	Ave.
P-I	I39.3	I39.3	I39.3	I39.3	I39.3
S-I	7I.05	83.68	96.05	I05.I8	
S-2	33.35	39.I8	42.55	47.30	
S-3	20.62	24.05	26.92	29.30	
S-4	I3.68	I6.05	I7.I8	I9.05	
P-E	7.44	7.44	7.44	7.44	7.44
Q-I	96.0	97.6	98.9	98.8	97.8
H-I	II57.0	II74.5	II82.2	II8I.8	II73.7
H-T	958.5	972.0	978.5	978.0	972.I
E-T	I98.5	202.5	203.7	203.8	20I.6
E-A	I78.7	I82.7	I83.3	I83.4	I8I.5
H-E	996.6	992.2	998.9	998.4	992.4
W-T	60I.5	7I9.5	788.0	86I.0	
W-HP	74.9	7I.5	65.4	64.3	
W-DHP	62.9	6I.I	56.2	55.4	
Eff.-O	I9.05	I9.5I	2I.25	2I.60	
Eff.-C	22.68	22.80	24.70	25.I0	
Eff.-T	3.5I	3.55	3.83	3.89	
Eff.-A	I5.45	I5.55	I5.55	I5.55	I5.46
Eff.-I	22.7	II.3	I6.I	II.5	
Eff.-R	22.70	22.80	24.60	25.00	

RESULTS OF SERIES No.4.

K.W.	I	2	3	4	5
P-I	I39.3	I39.3	I39.3	I39.3	I39.3
S-I	23.I8	34.68	4I.92	47.95	56.I8
S-2	II.92	I6.05	I8.42	22.05	26.20
S-3	7.55	9.90	II.55	I4.30	I6.90
S-4	5.92	7.I0	8.55	9.05	I0.80
P-E	4.97	4.97	4.97	4.97	4.97
Q-I	97.0	97.0	96.0	95.4	95.6
H-I	II65.5	II65.5	II57.0	II52.0	II54.0
H-T	944.0	944.0	937.0	933.0	934.0
E-T	22I.5	22I.5	220.0	2I9.0	220.0
E-A	I98.3	I98.0	I98.0	I97.I	I98.0
H-E	967.2	967.2	952.0	954.9	956.0
W-T	229.5	300.0	36I.5	430.0	499.5
W-HP	I7I.0	II2.0	89.9	80.2	74.5
W-DHP	90.0	76.5	68.3	64.0	6I.4
Eff.-O	7.46	II.50	I4.33	I6.I0	I7.28
Eff?-C	I4.22	I6.8I	I8.84	20.I5	20.95
Eff.-T	2.43	2.86	3.23	3.45	3.60
Eff.-A	I7.02	I7.00	I7.I4	I7.I0	I7.I6
Eff.-I	67.5	52.0	44.0	37.4	33.8
Eff.-R	I4.26	I6.82	I8.85	20.I8	2I.00

RESULTS OF SERIES No.4.

K.W.	6	7.5	9	I0	Ave.
P-I	I39.3	I39.3	I39.3	I39.3	I39.3
S-I	63.70	77.30	93.30	97.68	
S-2	29.95	36.50	42.68	46.05	
S-3	I8.50	22.32	26.80	28.75	
S-4	II.90	I4.05	I7.42	I8.50	
P-E	4.97	4.97	4.97	4.97	4.97
Q-I	97.6	98.5	98.3	98.6	97.I
H-I	II7I.0	II79.2	II78.5	II80.0	II67.0
H-T	947.5	953.5	952.5	954.0	944.4
E-T	223.5	225.7	226.0	226.0	222.6
E-A	20I.I	203.I	203.4	203.4	200.3
H-E	969.9	976.I	975.I	976.6	966.7
W-T	562.5	657.0	769.5	832.5	
W-HP	70.0	65.4	63.8	62.I	
W-DHP	58.7	56.0	54.9	53.5	
Eff.-O	I8.I2	I9.20	I9.68	20.20	
Eff.-C	2I.60	22.45	22.85	23.42	
Eff.-T	3.70	3.87	3.95	4.03	
Eff.-A	I7.I6	I7.23	I7.28	I7.22	I7.I5
Eff.-I	29.4	2I.3	I9.7	I5.5	
Eff.-R	2I.58	22.42	22.84	23.40	

RESULTS OF SERIES No.5.

K.W.	I	2	3	4	5
P-I	I39.3	I39.3	I39.3	I39.3	I39.3
S-I	27.80	35.42	44.55	5I.00	58.92
S-2	I4.30	I8.25	20.32	23.35	26.85
S-3	I0.20	II.72	I3.95	I5.I2	I7.I8
S-4	8.20	8.95	9.80	I0.62	II.55
P-E	7.44	7.44	7.44	7.44	7.44
S-H	90.9	90.2	88.7	90.9	90.2
H-I	I243.4	I243.0	I242.0	I243.4	I243.0
H-T	I025.5	I025.0	I024.0	I025.5	I025.0
E-T	2I7.9	2I8.0	2I8.0	2I7.9	2I8.0
E-A	I96.I	I96.2	I96.2	I96.I	I96.2
H-E	I047.3	I046.8	I045.8	I047.4	I046.8
W-T	242.0	297.0	359.5	408.0	46I.0
W-HP	I80.6	II0.9	89.5	76.0	68.9
W-DHP	94.8	75.8	68.0	60.7	56.7
Eff.-O	7.I9	II.70	I4.54	I7.05	I8.80
Eff.-C	I3.70	I7.I0	I9.I0	2I.32	22.82
Eff.-T	2.I6	2.7I	3.02	3.38	3.62
Eff.-A	I5.79	I5.79	I5.80	I5.79	I5.79
Eff.-I	49.0	44.I	35.4	34.7	34.6
Eff.-R	I3.69	I7.I7	I9.I2	2I.40	22.95

RESULTS OF SERIES No.5.

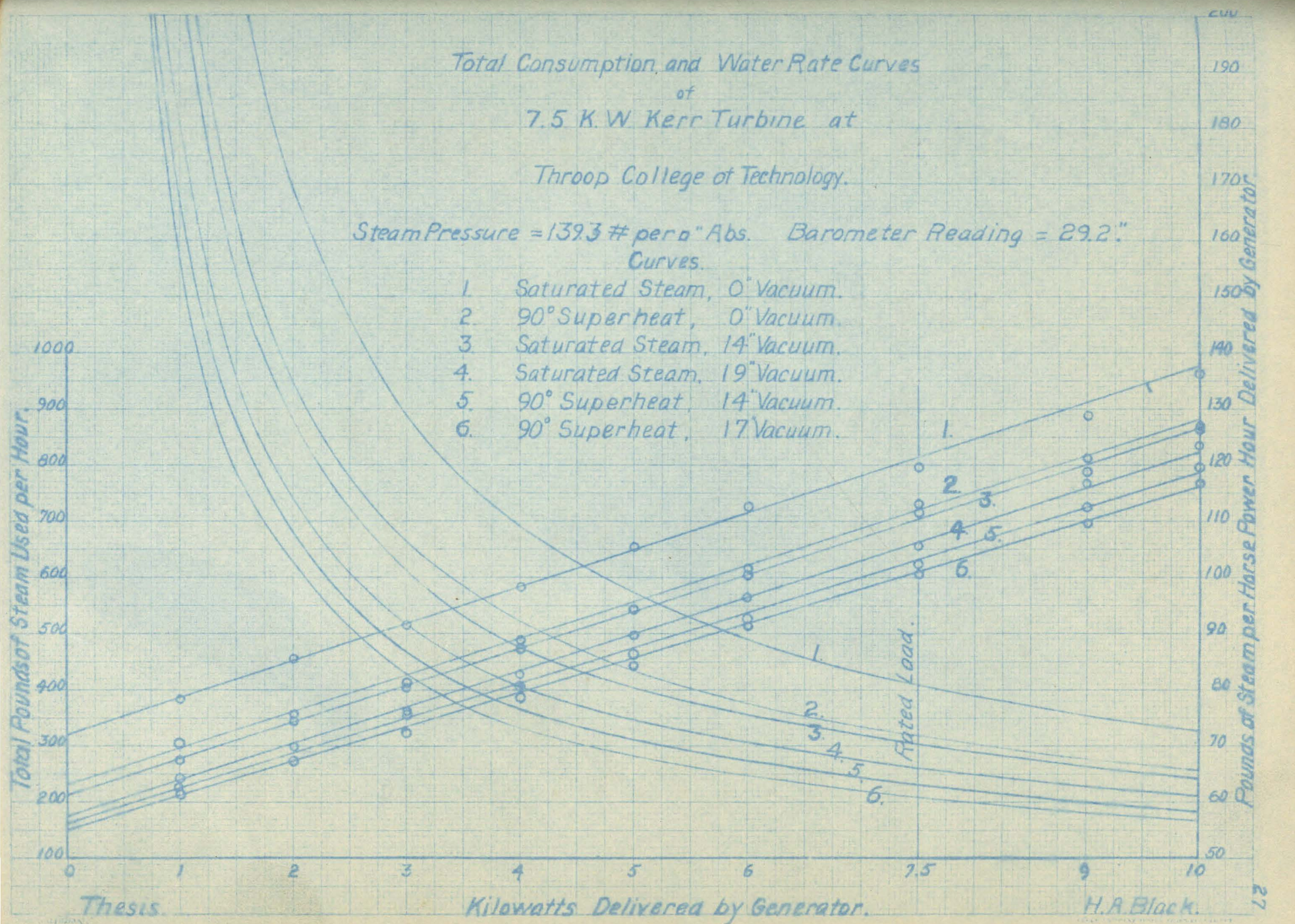
K.W.	6	7.5	9	I0	Ave.
P-I	I39.3	I39.3	I39.3	I39.3	I39.3
S-I	65.68	80.20	94.30	I03.68	
S-2	30.30	36.80	42.68	46.30	
S-3	I7.22	23.38	26.05	29.92	
S-4	I2.60	I4.92	I7.I8	I9.55	
P-E	7.44	7.44	7.44	7.44	7.44
S-H	9I.7	9I.0	89.9	90.I	90.4
H-I	I244.0	I243.5	I242.5	I243.7	I243.I
H-T	I026.5	I025.5	I025.0	I025.0	I025.2
E-T	2I7.5	2I8.0	2I7.5	2I8.7	2I7.9
E-A	I95.7	I96.2	I95.7	I96.8	I96.I
H-E	I048.3	I04I.3	I046.8	I046.9	I047.0
W-T	528.0	623.5	725.0	795.0	
W-HP	65.8	62.0	60.I	59.3	
W-DHP	55.2	53.0	5I.8	5I.I	
Eff.-O	I9.85	20.95	2I.65	2I.86	
Eff.-C	23.6I	24.58	25.I5	25.38	
Eff.-T	3.70	3.87	3.96	4.0I	
Eff.-A	I5.7I	I5.79	I5.7I	I5.80	I5.77
Eff.-I	29.4	2I.3	20.0	I4.9	
Eff.-R	23.5I	24.52	25.20	25.40	

RESULTS OF SERIES No.6.

K.W.	I	2	3	4	5
P-I	I39.3	I39.3	I39.3	I39.3	I39.3
S-I	26.92	34.42	42.I8	5I.68	54.42
S-2	I2.55	I5.60	I7.75	20.48	25.I5
S-3	8.80	I0.65	I2.I8	I4.I8	I6.40
S-4	6.92	8.08	8.55	9.60	II.I0
P-E	5.95	5.95	5.95	5.95	5.95
S-H	89.6	87.4	89.6	88.7	89.9
H-I	I242.5	I24I.5	I242.5	I24I.7	I242.6
H-T	I0II.0	I0I0.0	I0II.0	I0I0.0	I0I0.6
E-T	23I.5	23I.5	23I.5	23I.5	232.0
E-A	208.3	208.3	208.3	208.5	208.8
H-E	I034.2	I033.0	I034.2	I033.2	I033.8
W-T	2I2.0	272.0	324.5	383.0	447.0
W-HP	I58.2	I0I.4	80.9	7I.4	66.7
W-DHP	83.2	69.3	6I.4	57.0	54.9
Eff.-O	8.03	I2.52	I5.75	I7.80	I9.00
Eff.-C	I5.30	I8.30	20.70	22.50	23.05
Eff.-T	2.46	2.96	3.34	3.60	3.72
Eff.-A	I6.78	I5.80	I6.78	I6.79	I6.79
Eff.-I	69.5	57.5	49.8	43.5	38.2
Eff.-R	I4.68	I7.62	I9.9I	2I.44	22.I9

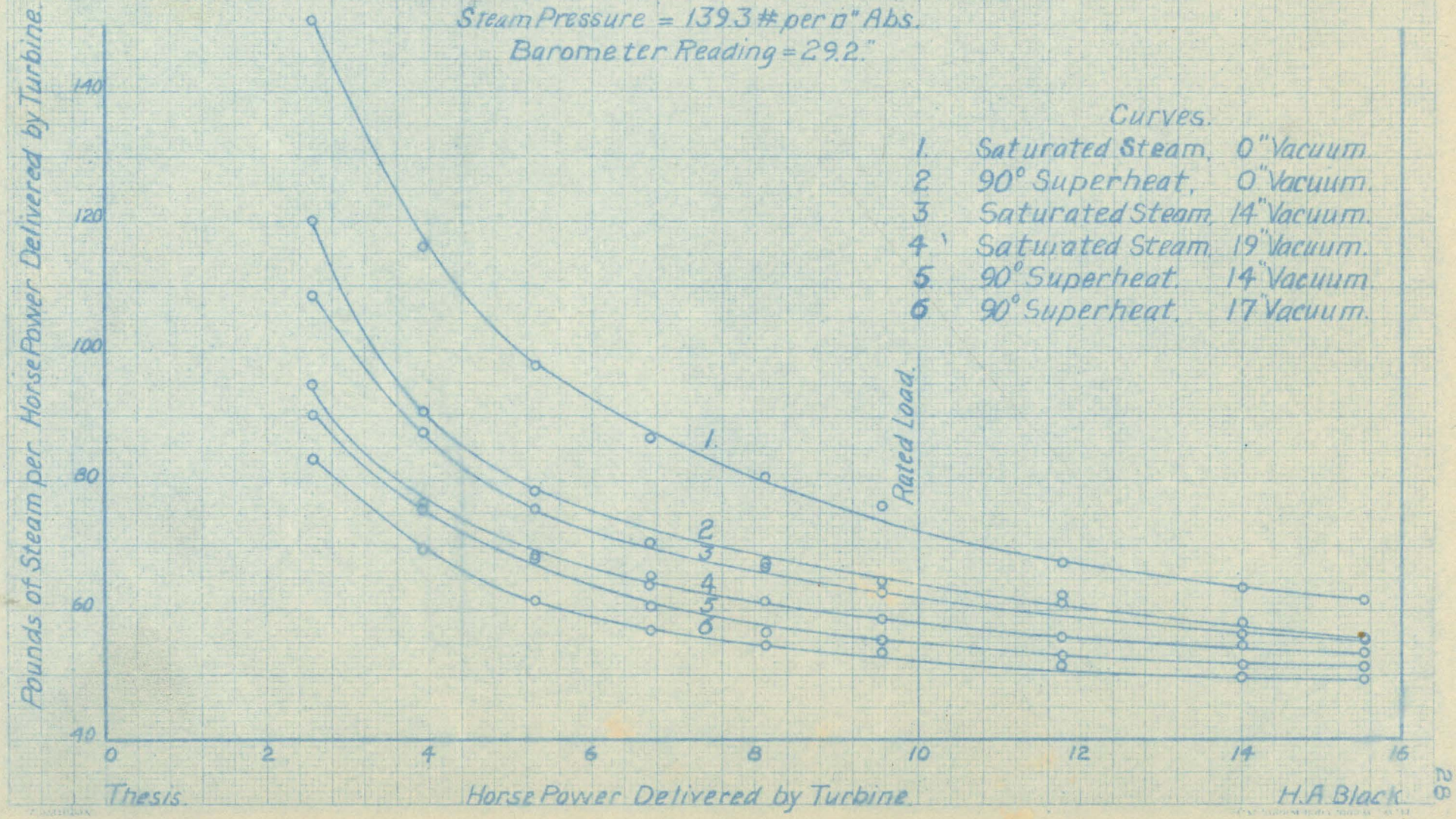
RESULTS OF SERIES No.6.

K.W.	6	7.5	9	I0	Ave.
P-I	I39.3	I39.3	I39.3	I39.3	I39.3
S-I	64.05	76.30	89.I8	97.80	
S-2	28.30	34.68	40.30	45.70	
S-3	I8.30	22.42	25.30	28.I8	
S-4	I2.30	I4.42	I6.30	I8.20	
P-E	5.95	5.95	5.95	5.95	5.95
S-H	89.6	89.9	90.3	90.2	89.5
H-I	I242.5	I242.6	I243.0	I243.0	I242.4
H-T	I0II.0	I0I0.6	I0II.0	I0II.0	I0I0.7
E-T	23I.5	232.0	232.0	232.0	23I.7
E-A	208.3	208.8	208.8	208.8	208.5
H-E	I034.2	I033.8	I034.2	I034.2	I033.9
W-T	5II.5	605.0	699.5	767.5	
W-HP	63.7	60.2	58.0	57.2	
W-DHP	53.5	5I.5	49.9	49.3	
Eff.-O	I9.92	2I.06	2I.85	22.I8	
Eff.-C	23.75	24.65	26.40	25.70	
Eff.-T	3.84	3.98	4.I0	4.I5	
Eff.-A	I6.78	I6.80	I6.80	I6.90	I6.79
Eff.-I	34.3	24.8	24.2	I8.9	
Eff.-R	22.89	23.50	24.4I	24.69	


Total Consumption and Water Rate Curves
of
7.5 K.W. Kerr Turbine at
Throop College of Technology.
Steam Pressure = 139.3 # per □" Abs. Barometer Reading = 29.2".
Curves.
1. Saturated Steam, 0" Vacuum.
2. 90° Superheat, 0" Vacuum.
3. Saturated Steam, 14" Vacuum.
4. Saturated Steam, 19" Vacuum.
5. 90° Superheat, 14" Vacuum.
6. 90° Superheat, 17" Vacuum.
Total Pounds of Steam Used per Hour.
Pounds of Steam per Horse Power Hour Delivered by Generator
Rated Load.
Kilowatts Delivered by Generator.
Thesis.
H.A. Black.
27

Water Rate Curve of

75 K.W. Kerr Turbine.

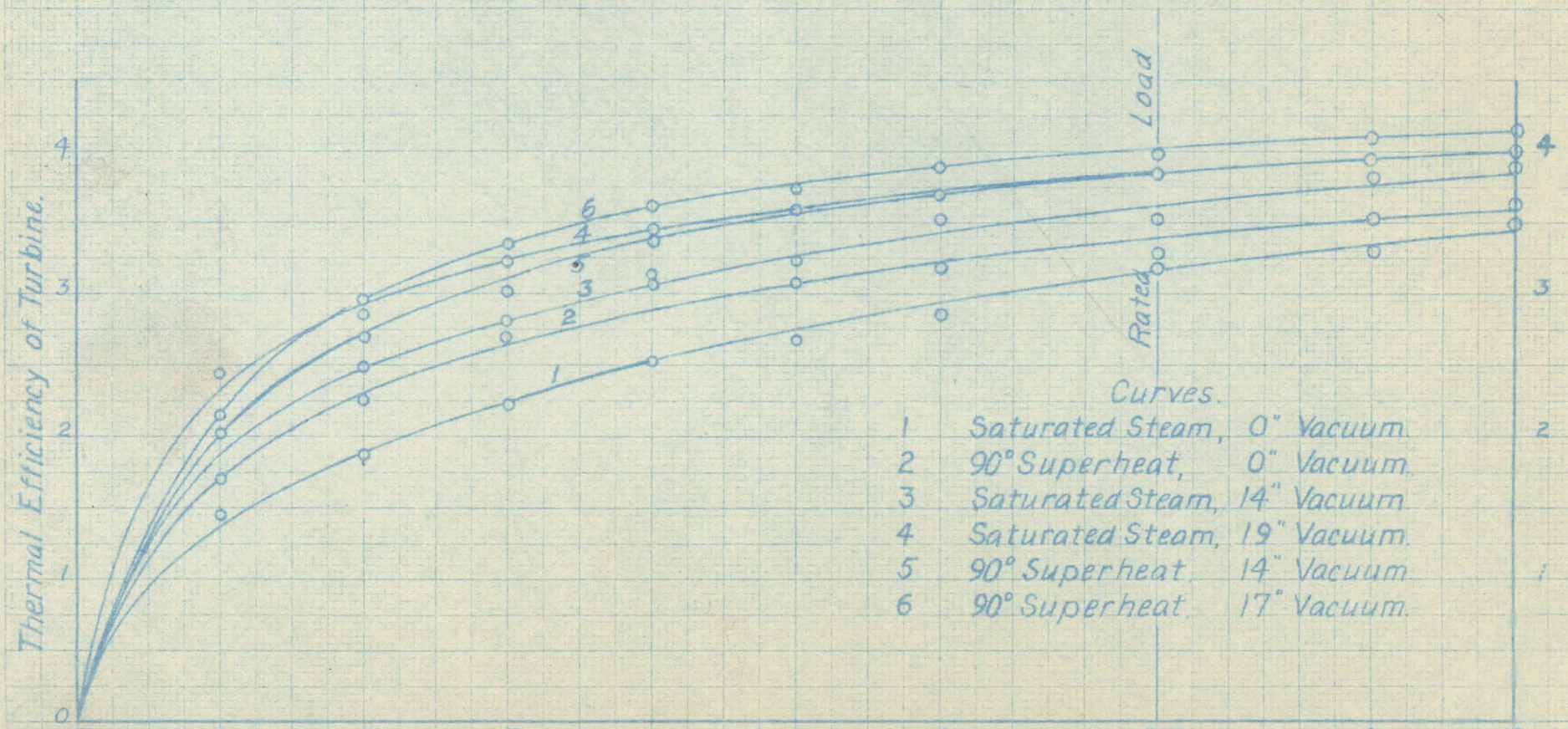


Thesis. H.A. Black.

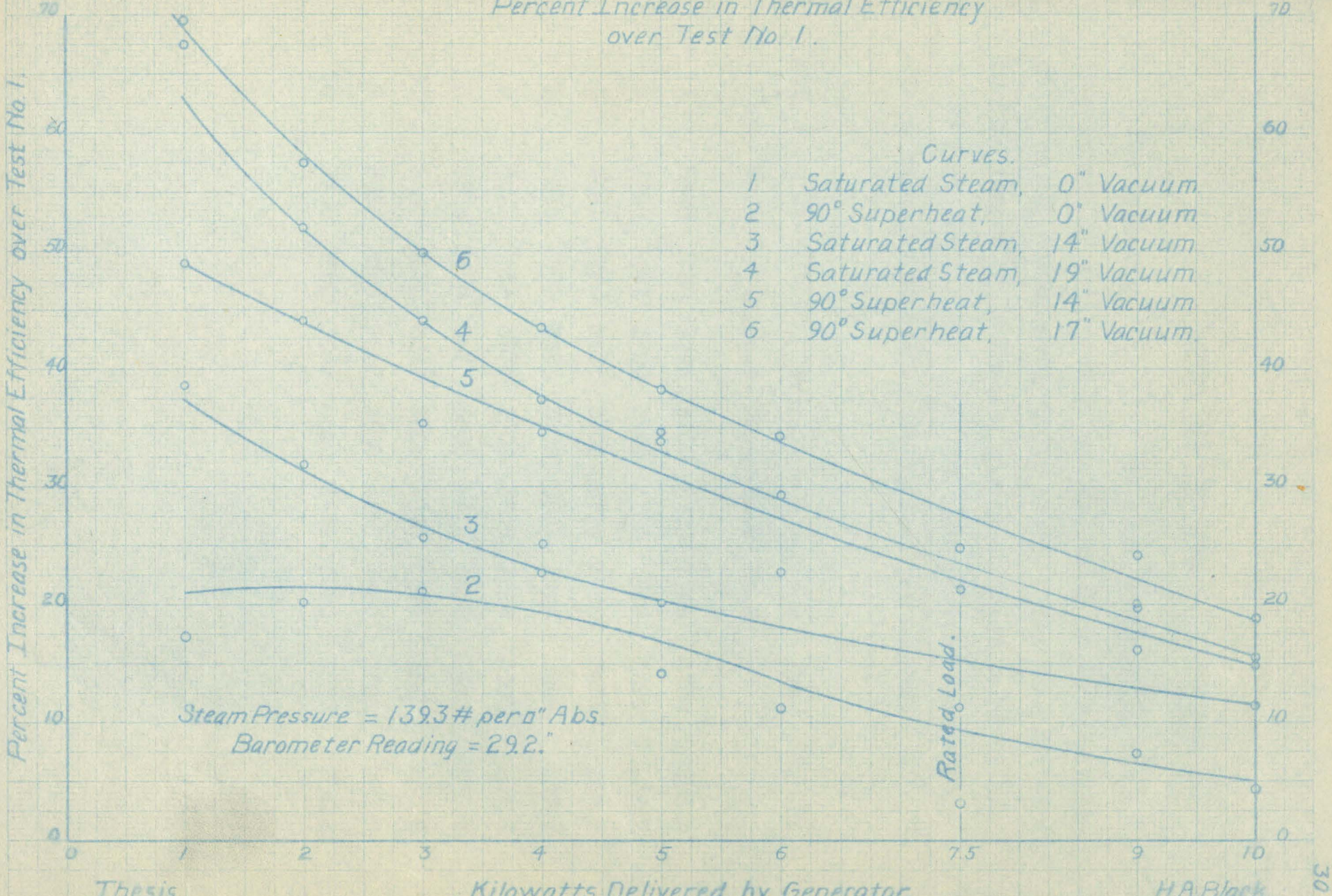
Thermal Efficiency Curves on Delivered Horse Power.

7.5 K.W. Kerr Turbine.

Steam Pressure = 139.3 # per □" Abs. Barometer Reading = 29.2"



Thesis H.A. Black.



Thesis. H.A. Black.

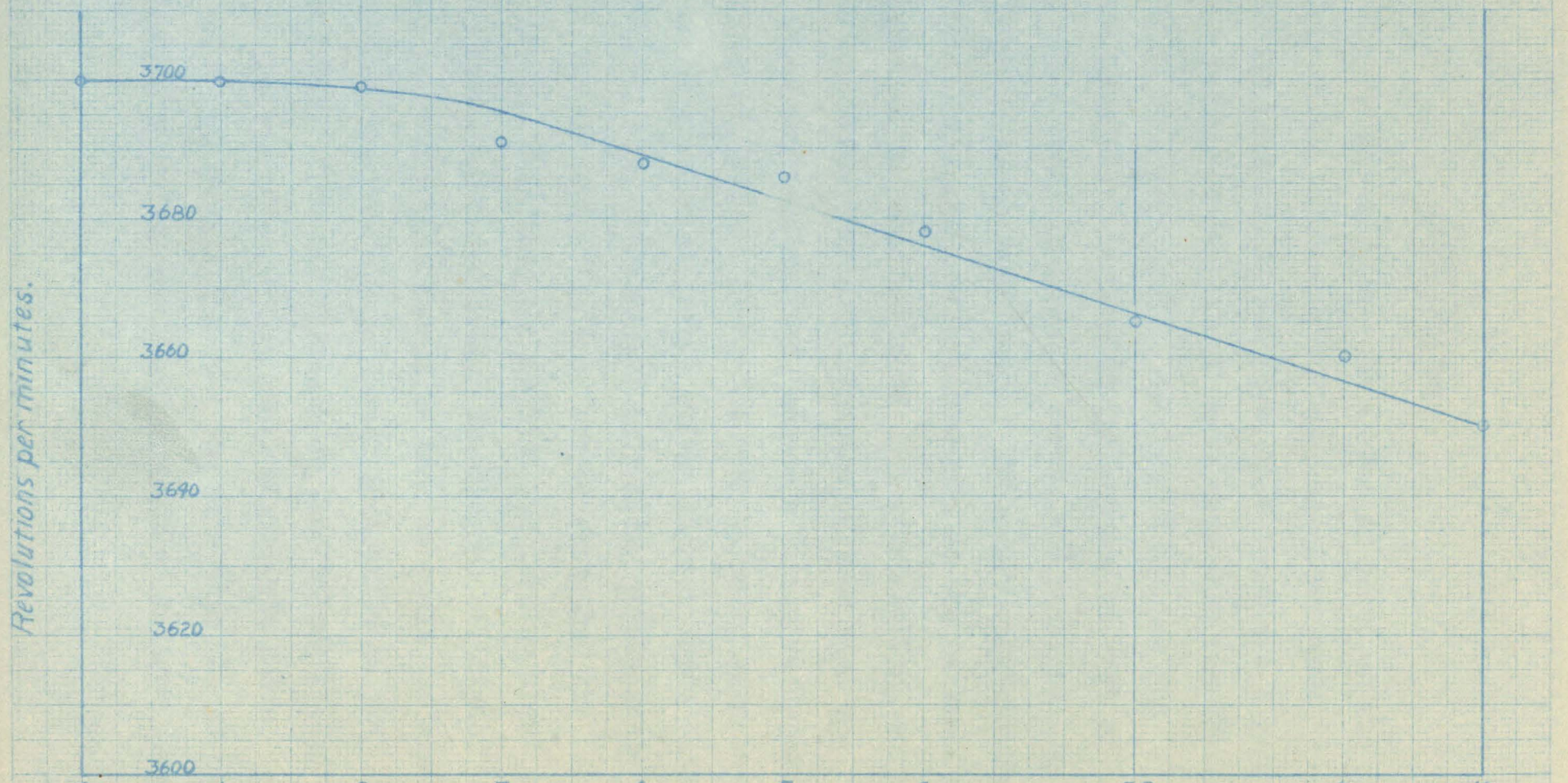
SPEED OF TURBINE.

The following data give the average R.P.M. at the various generator delivered kilowatts, which is shown graphically on the accompanying curve sheet. The diameter of the turbine runner is I6 inches, giving a linear velocity of 4.I89 feet per R.P.M. The last column gives the average linear velocity of the blades in feet per second.

K.W.	- - - - - - - Series.- - - - - - -						Ave.	F.P.S.
	No.I	No.2	No.3	No.4	No.5	No.6		
I	3700	3700	3700	3700	3700	3700	3700	258.3
2	3700	3697	3700	3700	3700	3700	3699	258.2
3	368I	3675	3675	3700	3700	3700	369I	257.7
4	3675	3690	3675	3700	369I	3700	3688	257.2
5	3675	3683	3675	3700	3689	3686	3686	257.I
6	3666	3675	3675	3690	3670	3676	3678	256.7
7.5	3660	3670	3667	3665	3663	3675	3665	255.8
9	3664	3660	3660	3660	3650	3660	3660	255.5
I0	3650	3650	3650	3650	3650	3650	3650	254.8

Speed - Load Curve. Ave. R.P.M.

Fort Wayne D.C Generator.



Thesis. H.A. Black.

CONCLUSIONS.

From the results of these six series of tests on the 7.5 K.W. Kerr steam turbine, a 4 stage, multi-pressure single velocity machine, it was found that there was a gain in the power delivered per lb. of steam used when superheat or a vacumm or both were used. However no attempt was made to determine the gain made in the economy of cost of operation. The total consumption curves are straight lines practically parallel to each other. The water rate curves show that the best economy of steam occurs at the maximum loads and that at the heavier loads they approach flat curves; this difference shows that a fluctuation of load when operating about rated and maximum load, causes a little variation in the economy of steam. The gains made by using superheat and a vacuum were somewhat larger at the lighter loads than at the heavier loads, the smallest gain being at the maximum loads. The thermal efficiency curves show that the greatest gain was made when the turbine was running about one-half to two-third rated load. The thermal efficiency rather than the water rate should be used as basis for comparison because it gives a more direct indication of the economy of fuel. Thus the increase in the thermal efficiency due to the use of superheat and a vacuum was shown graphically. The largest increase was made with the light loads, it being about 70% at I K.W. and I8% at maximum load

CONCLUSIONS.

in the case when 90 degrees superheat and I7 inches of mercury vacuum were used. The speed at maximum load being 99.5% of that at no load shows that the turbine is a constant speed machine.

APPENDIX.

The appendix contains all the original data as it was taken, according to the series of tests.

Series No.I.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = 0" Hg. Vacuum.

Test No.I.

I K.W. 9.I Amperes. Feb. 9, I9I5.

Time	S-I	S-2	S-3	S-4	T-2	R.P.M.	Wt.
9;39	28.0	9.0	4.0	I.0	254	3700	
9;49					254	3700	64.0
9;59	27.5	9.0	4.0	I.0	254	3700	63.0
I0;09					254	3700	65.5
I0:I9	28.0	9.5	4.0	I.00	248	3700	63.5
I0;29					244	3700	64.0
I0;39	27.5	9.0	3.5	I.0	242	3700	64.5
I:00	27.75	9.I2	3.88	I.00	249.9	3700	384.5

Test No.2.

2 K.W. I8.2 Amperes. Feb.9, I9I5.

I0:44	34.5	II.5	5.0	I.5	250	3700	
I0:54					252	3700	76.0
II;04	35.0	II.5	4.5	2.0	248	3700	75.5
II:I4					274	3700	75.0
II;24	35.0	II.0	4.5	I.5	246	3700	76.0
II;34					246	3700	77.0
II:44	36.0	I3.0	5.5	I.0	246	3700	75.5
I:00	35.I2	II.88	4.75	I.62	247.9	3700	455.0

Series No.I.

P-I = I25 lbs. per sq.in. gage. Volts = II0.

V-E = 0" Hg. Vacuum.

Test No.3.

3 K.W. 27.3 Amperes. Feb. 9, I9I5.

Time	S-I	S-2	S-3	S-4	T-2	R.P.M.	Wt.
II;55	42.0	I5.0	7.0	3.0	255	3680	
I2:05					256	3685	85.5
I2;I5	42.5	I5.0	6.0	2.0	257	3680	86.5
I2;25					256	3680	85.5
I2;35	43.0	I5.0	6.0	2.0	256	3685	86.0
I2;45					257	3680	85.5
I2;55	4I.5	I5.0	6.0	2.0	256	3680	87.0
I:00	35.I2	I5.0	6.25	2.25	256.0	368I	5I6.0

Test No.4.

4 K.W. 36.4 Amperes. Feb. 9, I9I5.

I;00	50.5	I8.0	8.0	3.0	262	3675	
I:I0					260	3675	97.0
I;20	50.0	I8.0	8.0	3.0	258	3675	96.0
I;30					257	3675	96.5
I;40	50.5	I8.0	8.0	3.0	257	3675	98.0
I;50					259	3675	97.0
2:00	49.5	I8.0	8.0	3.0	258	3675	96.5
I:00	50.I2	I8.00	8.00	3.00	258.7	3675	58I.0

Series No.I.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = 0" Hg. Vacuum.

Test No.5.

5 K.W. 45.5 Amperes. Feb. 9, I9I5.

Time	S-I	S-2	S-3	S-4	T-2	R.P.M.	Wt.
2:09	58.0	2I.5	9.0	3.5	262	3675	
2:I9					260	3675	II0.0
2:29	57.5	2I.0	9.5	3.5	26I	3675	I09.0
2:39					264	3675	I08.5
2:49	58.5	2I.0	9.5	3.5	264	3675	II0.0
2:59					264	3675	I08.5
3:09	56.0	2I.5	9.5	3.5	264	3675	I09.0
I:00	57.50	2I.25	9.38	3.50	262.7	3675	655.0

Test No.6.

6 K.W. 54.5 Amperes. Feb. 9, I9I5.

3:I4	67.0	25.0	I2.0	5.0	268	3665	
3:24					266	3665	I2I.0
3:34	65.0	26.0	I2.0	5.0	266	2665	I20.5
3:44					263	3670	I22.0
3:54	67.0	25.0	I2.0	5.0	266	3670	I2I.5
4:04					264	3665	I2I.0
4:I4	67.0	25.5	I2.0	5.0	265	3665	I2I.0
I:00	66.50	25.28	I2.00	5.00	265.4	3666	727.0

Series No.I.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = 0" Hg. Vacuum.

Test No.7.

7.5 K.W. 68.2 Amperes. Feb. I6, I9I5.

Time	S-I	S-2	S-3	S-4	T-2	R.P.M.	Wt.
8:54	85.0	30.0	I5.0	6.0	282	3660	
9:04					283	3660	I33.5
9:I4	80.0	30.0	I4.5	6.0	283	3665	I34.0
9:24					282	3660	I33.5
9:34	8I.0	30.0	I5.0	5.5	282	3660	I32.5
9:44					282	3665	I33.0
9:54	80.0	3I.0	I5.0	6.0	282	3660	I33.5
I:00	8I.5.	30.25	I4.88	5.88	282.3	3660	800.0

Test No.8.

9 K.W. 8I.8 Amperes. Feb. I6, I9I5.

II:2I	9I.5	36.0	I8.0	7.0	279	3660	
II:3I					280	2660	I50.0
II:4I	94.0	36.0	I7.5	7.0	28I	3650	I49.5
II:5I					280	3650	I48.0
I2:0I	95.0	36.0	I7.5	8.0	280	3660	I50.0
I2:II					280	2650	I48.5
I2:2I	92.0	37.0	I8.5	8.0	280	3650	I49.5
I:00	93.I2	36.25	I7.88	7.50	280	3654	895.5

Series No.I.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = 0" Hg. Vacuum.

Test No.9.

I0 K.W. 90.9 Amperes. Feb. I6, I9I5.

Time	S-I	S-2	S-3	S-4	T-2	R.P.M.	Wt.
I2:30	I04.5	43.0	22.0	I0.5	279	3650	
I2:40					278	3650	I62.0
I2:50	I0I.5	4I.0	I9.5	8.5	278	3650	I6I.0
I:00					278	3650	I57.5
I:I0	I03.5	4I.5	2I.5	I0.5	278	3650	I6I.0
I:20					276	3650	I59.5
I:50	I02.0	40.5	20.0	9.5	275	3650	I6I.0
I:00	I02.88	4I.50	20.75	9.75	277.4	3650	962.0

Series No.2.

P-I = 125 lbs. per sq. in. gage. Volts = 110.

V-E = 0" Hg. Vacuum.

Test No.1.

1 K.W. 9.1 Amperes. Mar. 16, 1915.

Time	S-1	S-2	S-3	S-4	T-1	R.P.M.	Wt.
9:11	29.0	7.8	3.0	1.2	445	3700	
9:21					460	3700	51.5
9:31	27.5	7.0	2.9	1.0	475	3700	48.5
9:41				460	460	3700	52.5
9:51	26.0	8.0	3.2	1.2	430	3700	51.5
10:01					420	3700	51.5
10:11	26.5	7.8	3.0	1.2	420	3700	51.5
1:00	27.25	7.65	3.02	1.15	444.4	3700	307.0

Test No.2.

2 K.W. 18.2 Amperes. Mar. 16, 1915.

10:15	34.0	10.0	4.0	1.5	450	3700	
10:25					440	3690	60.0
10:35	34.0	9.0	3.6	1.0	431	3690	60.0
10:45					442	3700	60.0
10:55	32.0	8.8	3.8	1.0	445	3700	58.5
11.05					450	3700	58.5
11:15	32.0	9.0	3.5	1.0	440	3700	58.5
1:00	33.00	9.20	3.72	1.10	443.0	3697	355.5

Series No.2.

P-I = I25 lbs. sq. in. gage. Volts = II0.

V-E = 0" Hg. Vacuum.

Test No.3.

3 K.W. 27.3 Amperes. Mar. I6, I9I5.

Time	S-I	S-2	S-3	S-4	T-I	R.P.M.	Wt.
II;I9	38.0	I2.0	5.0	I.8	430	3680	
II;29					434	3680	67.0
II;39	37.0	II.0	4.4	I.6	440	3680	65.5
II;49					444	3700	69.0
II;59	37.0	II.0	4.6	I.5	446	3700	67.0
I2;09					448	3700	66.0
I2;I9	38.0	I0.5	4.6	I.4	446	3690	66.5
I:00	37.50	II.I2	4.65	I.58	44I.I	3690	40I.0

Test No.4.

4 K.W. 36.4 Amperes. Mar. I6, I9I5.

I2;33	42.0	I3.0	5.6	2.0	445	3690	
I2;33					447	3690	74.0
I2;43	42.0	I3.0	5.2	2.0	465	3690	73.0
I2;53					454	3690	7I.5
I;03	42.0	I3.0	5.5	2.0	430	3690	73.0
I;I3					430	3690	73.0
I;23	42.0	I2.8	5.6	I.9	430	3690	73.5
I:00	42.00	I2.95	5.48	I.98	443.0	3690	438.0

Series No.2.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = 0" Hg. Vacuum.

Test No.5.

5 K.W. 45.5 Amperes. Mar. I6, I9I5.

Time	S-I	S-2	S-3	S-4	T-I	R.P.M.	Wt.
I:33	56.0	I9.5	8.2	3.5	435	3680	
I:43					438	3685	9I.0
I:53	59.0	I9.0	8.2	2.8	440	3685	90.0
2:03					444	3680	9I.5
2:I3	55.0	I8.5	9.0	3.0	444	3680	90.0
2:23					444	3685	90.0
2:33	56.0	I9.8	9.0	4.0	446	3685	90.0
I:00	57.00	I9.20	8.60	3.32	44I.0	3683	542.5

Test No.6.

6 K.W. 54.5 Amperes. Mar. I6, I9I5.

2:35	65.0	24.0	II.0	4.0	446	3675	
2:45					444	3675	I04.0
2:55	67.5	23.5	I0.5	3.5	440	3675	I0I.5
3:05					440	3675	I02.0
3:I5	67.0	22.5	9.5	3.5	438	3675	I04.0
3:25					436	3675	I02.0
3:35	67.0	23.5	I0.0	3.5	435	3675	I02.5
I:00	66.75	23.38	I0.25	3.62	439.9	3675	6I6.0

Series No.2.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = 0" Hg. Vacuum.

Test No.7.

7.5 K.W. 68.2 Amperes. Apr. 24, I9I5.

Time	S-I	S-2	S-3	S-4	T-I	R.P.M.	Wt.
8:20	8I.6	28.8	I3.2	5.0	435	3670	
8:30					438	3670	I20.0
8:40	82.0	25.5	I2.0	4.0	440	3670	I22.0
8:50					442	3670	I22.0
9:00	83.0	27.0	I2.5	4.0	445	3670	I2I.0
9:I0					450	3670	I22.5
9:20	8I.0	27.5	I2.5	4.5	450	3670	I22.0
I:00	8I.90	27.20	I2.55	4.38	442.9	3670	730.5

Test No.8.

9 K.W. 8I.8 Amperes. Apr. 24, I9I5.

9:25	99.2	33.0	I6.0	6.0	448	3660	
9:35					445	3660	I36.0
9:45	98.8	35.0	I6.2	6.4	444	3660	I34.5
9:55					442	3660	I36.0
I0:05	96.0	3I.5	I5.0	6.0	442	3660	I35.5
I0:I5					440	3660	I36.5
I0:25	98.0	34.5	I6.2	6.0	440	3660	I35.0
I:00	98.00	33.50	I5.85	6.I0	443.0	3660	8I3.5

Series No.2.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = 0" Hg. Vacuum.

Test No.9.

I0 K.W. 90.9 Amperes. Apr. 24, I9I5.

Time	S-I	S-2	S-3	S-4	T-I	R.P.M.	Wt.
I0:28	II0.0	38.6	I9.0	8.0	440	3650	
I0:38					442	3650	I44.0
II:48	II0.0	38.6	I8.8	7.4	442	3650	I45.0
II:58					444	3650	I46.0
II:08	II0.0	38.0	I9.2	8.5	444	3650	I44.0
II:I8					446	3650	I44.5
II:28	II0.0	39.5	I8.8	7.2	446	3650	I44.0
I:00	II0.0	38.68	I8.95	7.78	443.4	3650	867.5

Series No.3.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I4" Hg. Vacuum.

Test No.I.

I K.W. 9.I Amperes. Feb. I6, I9I5.

Time	S-I	S-2	S-3	S-4	T-2	R.P.M.	Wt.
I:49	I8.5	0.0	-3.0	-6.0	25I	2700	
I:59					257	3700	45.0
2:09	I8.5	0.5	-3.0	-5.8	255	3700	46.0
2:I9					256	3700	5I.5
2:29	I6.0	I.0	-3.0	-5.0	255	3700	42.5
2:39					255	3700	47.0
2:49	I8.0	I.0	-3.0	-5.5	256	3700	54.5
I:00	I7.75	0.62	-3.00	-5.58	255.0	3700	276.5

Test No.2.

2 K.W. I8.2 Amperes. Feb. I6, I9I5.

2:55	25.5	3.0	-I.5	-5.0	255	3700	
3:05					255	3700	54.0
3:I5	24.0	4.0	-I.5	-5.0	268	2700	57.5
3:25					266	2700	60.0
3:35	25.0	4.5	-I.5	-5.0	266	3700	58.0
3:45					262	3700	58.5
3:55	25.5	4.5	-I.5	-4.5	268	3700	58.5
I:00	25.00	4.00	-I.50	-3.82	262.9	3700	343.0

Series No.3.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I4" Hg. Vacuum.

Test No.3.

3 K.W. 27.3 Amperes. Feb. I9, I9I5.

Time	S-I	S-2	S-3	S-4	T-2	R.P.M.	Wt.
I2;58	30.5	6.0	0.5	-3.5	224	3675	
I;08					228	3675	7I.0
I;I8	30.5	5.5	0.0	-4.5	226	3675	68.0
I;28					270	3675	70.0
I;38	30.0	6.5	0.0	-4.0	265	3675	67.5
I;48					266	3675	69.0
I;58	33.0	7.5	0.0	-4.0	250	3675	69.0
I:00	30.75	6.60	0.I2	-4.00	247.0	3675	4I4.5

Test No.4.

4 K.W. 36.4 Amperes. Feb. I9, I9I5.

2;00	4I.5	II.0	2.0	-3.5	268	3675	
2;I0					280	3675	79.0
2;20	4I.0	II.0	2.5	-3.0	274	3675	79.5
2;30					266	3675	79.0
2;40	4I.5	I0.5	2.0	-3.0	250	3675	79.0
2:50					266	3675	78.0
3;00	40.0	II.5	2.0	-3.0	269	3675	78.0
I:00	4I.00	II.00	2.I2	-3.I2	267.6	3675	472.5

Series No.3.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I4" Hg. Vacuum.

Test No.5.

5 K.W. 45.5 Amperes. Feb. I9, I9I5.

Time	S-I	S-2	S-3	S-4	T-2	R.P.M.	Wt.
3.02	47.5	I4.5	2.5	-2.5	264	3675	
3;I2					279	3675	9I.0
3;22	48.0	I5.0	4.5	-2.0	28I	3675	90.5
3;32					28I	3675	9I.0
3;42	49.5	I4.5	4.0	-2.0	268	3675	92.0
3;52					245	3675	89.5
4;02	49.0	I5.0	4.5	-2.0	245	3675	9I.5
I:00	48.50	I4.75	3.88	-2.I2	266.0	3675	545.5

Test No.6.

6 K.W. 54.5 Amperes. Mar. 2, I9I5.

I;I0	58.0	I9.5	6.8	0.0	226	3675	
I;20					232	3675	99.0
I;30	57.0	I9.5	6.5	-0.5	2I7	3675	98.0
I;40					228	3675	I02.5
I;50	55.0	I8.2	6.0	-I.0	228	3675	I0I.5
2;00					2I4	3675	I0I.0
2;I0	57.0	I9.0	6.0	-I.0	2I4	3675	I0I.0
I:00	56.75	I9.05	6.32	-0.62	222.7	3675	60I.5

Series No.3.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I4" Hg. Vacuum.

Test No.7.

7.5 K.W. 68.2 Amperes. Mar. 2, I9I5.

Time	S-I	S-2	S-3	S-4	T-2	R.P.M.	Wt.
2;I5	68.0	25.0	I0.0	2.0	265	3665	
2;25					264	3665	II6.0
2;35	70.0	25.0	9.5	2.0	265	3675	II7.0
2;45					266	3675	II6.5
2;55	69.5	25.0	9.5	I.5	265	3660	II5.0
3;05					265	3660	II5.0
3;I5	70.0	24.5	I0.0	I.5	265	3660	II6.0
I:00	69.38	24.88	9.75	I.75	265	3667	695.5

Test No.8.

9.0 K.W. 8I.8 Amperes. Mar. 6, I9I5.

I2;I2	83.0	29.0	I3.0	3.0	279	3660	
I2;22					279	3660	I3I.0
I2;32	78.0	26.5	I2.0	2.5	278	3660	I3I.0
I2;42					278	3660	I3I.5
I2;52	82.5	29.5	I3.0	3.0	277	3660	I32.0
I;02					277	3660	I3I.5
I;I2	83.5	28.5	I2.5	3.0	276	3660	I3I.0
I:00	8I.85	28.25	I2.62	2.88	277.7	3660	788.0

Series No.3.

P-I = 125 lbs. per sq. in. gage. Volts = 110.

V-E = 14" Hg. Vacuum.

Test No.9.

10 K.W. 90.9 Amperes. Mar. 6, 1915.

Time	S-1	S-2	S-3	S-4	T-2	R.P.M.	Wt.
1;15	90.0	33.5	15.0	4.0	277	3650	
1;25					276	3650	143.0
1:35	91.5	32.5	15.5	5.0	274	3650	143.5
1;45					276	3650	144.0
1;55	90.0	32.5	14.0	4.5	275	3650	143.0
2;05					274	3650	144.0
2;15	92.0	33.5	15.5	5.5	275	3650	143.5
1:00	90.88	33.00	15.00	4.75	275.3	3650	861.0

Series No.4.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I9" Hg. Vacuum.

Test No.I.

I K.W. 9.I Amperes. Apr. 20, I9I5.

Time	S-I	S-2	S-3	S-4	T-2	R.P.M.	Wt.
8:35	9.5	-2.0	-7.0	-8.5	248	3700	
8:45					242	3700	43.5
8:55	9.0	-2.5	-7.0	-8.0	240	3700	32.5
9:05					246	3700	38.0
9:I5	8.5	-2.5	-6.5	-8.5	250	3700	42.0
9:25					248	3700	35.0
9:35	8.5	-2.5	-6.5	-8.5	246	3700	38.5
I:00	8.88	-2.38	-6.75	-8.38	245.7	3700	229.5

Test No.2.

2 K.W. I8.2 Amperes. Feb. 23, I9I5.

2:35	I9.5	I.8	-5.6	-7.0	26I	3700	
2:45					26I	3700	50.5
2:55	20.5	2.0	-4.0	-7.2	260	3700	50.0
3:05					232	3700	50.0
3:I5	20.0	I.5	-4.0	-7.4	232	3700	50.5
3:25					232	3700	49.5
3:35	2I.5	I.7	-4.0	-7.2	232	3700	49.5
I:00	20.38	I.75	-4.40	-7.20	245.7	3700	300.0

Series No.4.

P-I = I25 lbs. per sq.in. gage. Volts = II0.

V-E = I9" Hg. Vacuum.

Test No.3.

3 K.W. 27.3 Amperes. Apr. 20, I9I5.

Time	S-I	S-2	S-3	S-4	T-2	R.P.M.	Wt.
9:45	26.5	4.0	-3.0	-6.0	226	3700	
9:55					230	3700	55.5
I0:05	27.0	4.0	-3.0	-5.5	230	3700	65.0
I0:I5					226	3700	59.0
I0:25	26.5	3.5	-3.0	-5.5	226	3700	60.5
I0:35					224	3700	6I.0
I0:45	30.0	5.0	-2.0	-6.0	223	3700	60.5
I:00	27.62	4.I2	-2.75	-5.75	226.4	3700	36I.5

Test No.4.

4 K.W. 36.4 Amperes. Mar. 9, I9I5.

8:45	34.6	7.2	0.0	-5.4	2I4	3700	
8:55					2I4	3700	72.0
9:05	29.5	7.I	-0.3	-5.6	2I5	3700	7I.0
9:I5					2I4	3700	72.0
9:25	36.0	8.7	0.2	-5.0	2I5	3700	70.5
9:35					2I4	3700	72.5
9:45	34.5	8.0	0.I	-5.0	2I4	3700	72.0
I:00	33.65	7.75	0.00	-5.25	2I4.3	3700	430.0

Series No.4.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I9" Hg. Vacuum.

Test No.5.

5 K.W. 45.5 Amperes. Mar. 9, I9I5.

II;26	39.0	II.0	2.0	-4.0	236	3700	
II:36					224	3700	83.5
II;46	43.0	I2.0	2.4	-3.6	2I8	3700	83.0
II;56					2I5	3700	83.5
I2;06	43.5	I2.6	3.0	-3.o	2I4	3700	82.5
I2;I6					2I4	3700	82.5
I2;26	42.0	I2.0	3.0	-3.4	2I6	3700	84.5
I:00	4I.88	II.90	2.60	-3.50	2I9.6	3700	499.5

Test No.6.

6 K.W. 54.5 Amperes. Mar. 9, I9I5.

I2;29	50.5	I5.3	4.0	-2.5	242	3690	
I2;39					258	3690	92.5
I2;49	48.6	I5?3	4.0	-2.4	264	3690	95.0
I2;59					264	3690	94.0
I;09	50.2	I6.2	4.2	-2.5	258	3690	90.0
I;I9					25I	3690	97.0
I;29	48.3	I5.8	4.6	-2.2	250	3690	94.0
I:00	49.40	I5.65	4.20	-2.40	255.3	3690	562.5

Series No.4.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I9" Hg. Vacuum.

Test No.7.

7.5 K.W. 68.2 Amperes. Mar. 9, I9I5.

Time	S-I	S-2	S-3	S-4	T-2	R.P.M.	Wt.
2:40	59.0	22.0	8.6	-0.5	273	3675	
2:50					272	3665	I08.0
3:00	65.5	22.2	8.0	-0.5	273	3660	I08.0
3:I0					270	3660	II0.5
3:20	63.5	22.6	8.5	0.0	270	3665	I09.0
3:30					270	3665	I09.0
3:40	64.0	22.0	7.0	0.0	270	3665	III.0
I:00	63.00	22.20	8.02	-0.25	27I.I	3665	657.0

Test No.8.

9 K.W. 8I.8 Amperes. Apr. 20, I9I5.

I0:55	8I.0	30.0	I3.0	3.0	265	3660	
II:05					266	3660	I27.0
II:I5	78.0	28.0	I2.0	2.5	266	3660	I30.0
II:25					266	3660	I28.5
II:35	78.0	27.5	I2.0	2.0	266	3660	I28.0
II:45					266	3660	I27.5
II:55	79.0	28.0	I3.0	5.0	266	3660	I28.0
I:00	79.00	28.38	I2.50	3.I2	265.7	3660	769.5

Series No.4.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I9" Hg. Vacuum.

Test No.I0.

I0 K.W. 90.9 Amperes. Mar. 9, I9I5.

Time	S-I	S-2	S-3	S-4	T-2	R.P.M.	Wt.
3:45	84.0	32.5	I5.0	4.5	275	3650	
3:55					275	3650	I39.0
4:05	84.5	3I.5	I4.5	4.0	275	3650	I39.0
4:I5					275	3650	I39.0
4:25	84.0	3I.5	I4.0	4.0	274	3650	I4I.5
4:35					270	3650	I35.5
4:45	8I.0	3I.5	I4.3	4.3	270	3650	I38.5
I:00	83.38	3I.75	I4.45	4.20	273.4	3650	832.5

Series No.5.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I4" Hg. Vacuum.

Test No.I.

I K.W. 9.I Amperes. Mar. 29, I9I5.

Time	S-I	S-2	S-3	S-4	T-I	R.P.M.	Wt.
9:05	I3.8	0.0	-4.0	-6.0	460	3700	
9:I5					435	3700	40.0
9:25	I2.2	0.0	-4.4	-6.3	430	3700	40.5
9:35					450	3700	40.5
9:45	I4.4	0.0	-4.0	-6.I	445	3700	40.5
9:55					440	3700	40.0
I0:05	I3.6	0.0	-4.0	-6.0	445	3700	40.5
I:00	I3.50	0.00	-4.I0	-6.I0	443.6	3700	242.0

Test No.2.

2 K.W. I8.2 Amperes. Mar. 29, I9I5.

I0:I0	2I.0	2.6	-2.4	-5.5	450	3700	
I0:20					440	3700	49.0
I0:30	2I.0	2.8	-2.4	-5.0	450	3700	49.5
I0:40					450	3700	49.5
I0:50	2I.0	3.2	-2.5	-5.5	450	3700	50.0
II:I0	2I.5	3.2	-3.0	-5.4	430	3700	49.5
II:00					440	3700	49.5
I:00	2I.I2	3.95	-2.58	-5.35	442.9	3700	297.0

Series No.5.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I4" Hg. Vacuum.

Test No.3.

3 K.W. 27.3 Amperes. Mar. 29, I9I5.

Time	S-I	S-2	S-3	S-4	T-I	R.P.M.	Wt.
II;I3	29.5	5.8	-0.2	-4.5	460	3700	
II;23					435	3700	62.5
II;33	32.0	6.I	-0.2	-4.5	430	3700	55.0
II;43					450	3700	63.5
II;53	30.0	6.2	-0.5	-4.5	440	3700	54.5
I2;03					440	3700	65.0
I2;I3	29.5	6.0	-0.5	-4.5	440	3700	59.0
I:00	30.25	6.02	-0.35	-4.50	44I.4	3700	359.5

Test No.4.

4 K.W. 36.4 Amperes. Mar. 29, I9I5.

I2;I5	35.5	8.8	0.5	-4.0	445	3680	
I2;25					430	3680	68.0
I2;35	36.8	9.0	I.0	-3.5	455	3700	69.0
I2;45					450	3700	67.0
I2;55	36.0	8.8	0.8	-3.2	450	3700	68.0
I;05					440	3690	68.5
I;I5	38.5	I0.0	I.0	-4.0	435	3690	67.5
I:00	36.70	9.05	0.82	-3.68	443.6	369I	408.0

Series No.5.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I4" Hg. Vacuum.

Test No.5.

5 K.W. 45.5 Amperes. Mar. 29, I9I5.

Time	S-I	S-2	S-3	S-4	T-I	R.P.M.	Wt.
I;I8	44.0	I3.0	3.0	-2.5	444	3690	
I:28					446	3680	76.5
I;38	46.2	I3.6	3.4	-2.5	450	3690	76.5
I;48					445	3700	77.5
I:58	42.5	II.6	2.5	-3.0	440	3680	77.0
2;08					435	3690	76.5
2;I8	45.8	I2.0	2.2	-3.0	440	3680	77.0
I:00	44.62	I2.55	2.78	-2.75	442.9	3689	46I.0

Test No.6.

6 K.W. 54.5 Amperes. Mar. 29, I9I5.

2;20	52.5	I6.0	5.0	-I.2	440	3680	
2;30					446	3675	88.5
2;40	5I.0	I6.I	4.9	-2.0	450	3680	88.0
2;50					450	3675	87.0
2;00	50.5	I6.0	4.8	-I.8	445	3675	89.0
3;I0					440	3680	87.5
3;20	5I.5	I5.9	5.0	-I.8	440	3680	88.0
I:00	5I.38	I6.00	4.92	-I.70	444.4	3678	528.0

Series No.5.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I4" Hg. Vacuum.

Test No.7.

7.5 K.W. 68.2 Amperes. Mar. 29, I9I5.

Time	S-I	S-2	S-3	S-4	T-I	R.P.M.	Wt.
3:25	66.0	23.0	9.0	0.0	450	3650	
3:35					450	3650	I03.5
3:45	65.6	22.0	9.0	I.0	440	3675	I04.5
3:55					444	3670	I04.0
4:05	67.0	23.0	9.0	0.5	440	3675	I05.0
4:I5					442	3670	I03.0
4:25	65.0	22.0	9.3	I.0	440	3650	I03.5
I:00	65.90	22.50	9.08	o.62	443.7	3663	623.5

Test No.8.

9 K.W. 8I.8 Amperes. Apr.6, I9I5.

2:30	80.0	29.0	II.0	2.5	450	3650	
2:40					440	3650	I20.0
2:50	82.0	29.0	I2.5	4.0	439	3650	I20.0
3:00					445	3650	I2I.0
3:I0	80.0	27.5	II.5	2.5	440	3650	I2I.0
3:20					442	3650	I22.0
3:30	78.0	28.0	I2.0	2.5	442	3650	I2I.0
I:00	80.00	28.38	II.75	2.88	442.6	3650	725.0

Series No.5.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I4" Hg. Vacuum.

Test No.9.

I0 K.W. 90.9 Amperes. Apr. 6, I9I5.

Time	S-I	S-2	S-3	S-4	T-I	R.P.M.	Wt.
3;3I	90.0	30.0	I5.0	4.0	450	3650	
3;4I					446	3650	I33.0
3;5I	89.5	34.0	I6.5	6.0	435	3650	I32.5
4;0I					438	3650	I32.0
4;II	90.0	32.0	I6.0	6.0	450	3650	I32.0
4;2I					440	3650	I32.0
4;3I	88.0	32.0	I5.0	5.0	440	3650	I32.5
I:00	89.38	32.00	I5.62	5.25	442.8	3650	795.0

Series No.6.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I7" Hg. Vacuum.

Test No.I.

	I K.W.		9.I Amperes.			Apr. 23, I9I5.	
I:I5	I2.0	-2.0	-6.0	-7.5	440	3700	
I:25					440	3700	35.0
I:35	I2.5	-I.5	-5.5	-7.5	442	3700	35?5
I:45					442	3700	35.0
I:55	I3.0	-2.0	-5.5	-7.5	444	3700	36.0
2:05					444	3700	34.5
2:I5	I3.0	-I.5	-5.0	-7.0	444	3700	36.0
I:00	I2.62	-I.75	-5.50	-7.38	442.3	3700	2I2.0

Test No.2.

	2 K.W.		I8.2 Amperes.			Apr.23, I9I5.	
2:20	20.0	I.0	-3.8	-6.2	440	3700	
2:30					438	3700	46.0
2:40	I9.5	I.5	-3.5	-6.2	435	3700	45.0
2:50					440	3700	44.5
3:00	2I.5	I.5	-3.5	-6.0	444	3700	45.0
3:I0					444	3700	45.5
3:20	I9.5	I.2	-3.8	-6.5	440	3700	46.0
I:00	"o.I2	I.30	-3.65	-6.22	440.I	3700	272.0

Series No.6.

P-I = I25 lbs. per sq. in. gage Volts = II0.

V-E = I7" Hg. Vacuum.

Test No.3.

3 K.W. 27.3 Amperes. Apr.23, I9I5.

Time	S-I	S-2	S-3	S-4	T-I	R.P.M.	Wt.
3:30	28.0	3.5	-2.0	-6.0	442	3700	
3:40					444	3700	46.0
3:50	28.5	3.8	-2.5	-6.0	442	3700	54.5
4:00					444	3700	54.0
4:I0	27.0	3.5	-2.5	-5.5	442	3700	55.0
4:20					440	3700	53.5
4:30	28.0	3.0	-I.5	-5.5	440	3700	54.5
I:00	27.88	3.45	-2.I2	-5.75	442.3	3700	324.5

Test No.4.

4 K.W. 36.4 Amperes. Apr.23, I9I5.

II:25	38.0	6.5	0.0	-4.5	430	3700	
II:35					435	3700	63.0
II:45	38.0	5.0	-0.5	-5.0	440	3700	64.0
II:55					444	3700	64.5
I2:05	36.5	7.0	0.0	-4.8	446	3700	64.0
I2:I5					450	3700	64.5
I2:25	37.0	6.2	0.0	-4.5	445	3700	63.0
I:00	37.38	6.I8	-0.I2	-4.70	44I.4	3700	383.0

Series No.6.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I7" Hg. Vacuum.

Test No.5.

5 K.W. 45.5 Amperes. Apr. 25, I9I5.

Time	S-I	S-2	S-3	S-4	T-I	R.P.M.	Wt.
I2;30	39.5	I0.0	2.0	-3.0	444	3690	
I2;40					442	3690	74.5
I2;50	40.0	II.0	2.0	-3.5	444	3680	74.0
I;00					440	3680	74.0
I;I0	40.0	I0.5	2.0	-3.5	440	3690	75.0
I;20					444	3690	75.0
I;30	4I.0	II.5	2.4	-2.8	444	3680	74.5
I:00	40.I2	I0.75	2.I0	-3.20	442.6	3686	447.0

Test No.6.

6 K.W. 54.5 Amperes. Apr. 26, I9I5.

I;33	48.5	I4.0	4.0	-2.0	444	3675	
I;43					440	3675	85.0
I;53	50.0	I5.0	4.2	-2.0	442	3680	86.0
2;03					444	3680	85.5
2;I3	50.0	I4.5	4.0	-2.0	444	3675	86.0
2;23					442	3675	85.0
2;33	50.5	I3.5	3.8	-2.0	440	3675	84.0
I:00	49.75	I4.00	4.00	-2.00	442.3	3676	5II.5

Series No.6.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I7" Hg. Vacuum.

Test No.7.

7.5 K.W. 68.2 Amperes. Apr. 26, I9I5.

Time	S-I	S-2	S-3	S-4	T-I	R.P.M.	Wt.
2;40	63.0	20.5	8.5	0.0	444	3675	
2;50					446	3675	I0I.0
3;00	60.0	I9.5	8.0	0.0	442	3675	I00.5
3;I0					440	3675	I0I.0
3;20	62.0	2I.0	8.0	0.5	440	3675	I0I.0
3;30					442	3675	I0I.5
3;40	63.0	20.5	8.0	0.0	444	3675	I00.0
I:00	62.00	20.38	8.I2	0.I2	442.6	3675	605.0

Test No.8.

9 K.W. 8I.8 Amperes. Apr. 30, I9I5.

II;I5	74.0	26.0	II.0	2.2	440	3660	
II;25					435	3660	II6.0
II;35	75.0	26.0	II.0	2.0	440	3660	II7.0
II;45					444	3660	II6.0
II;55	75.5	25.8	I0.8	2.0	446	3660	II6.5
I2;05					446	3660	II8.0
I2;I5	73.0	26.2	II.0	I.8	450	3660	II6.0
I:00	74.88	26.00	II.00	2.00	443.0	3660	699.5

Series No.6.

P-I = I25 lbs. per sq. in. gage. Volts = II0.

V-E = I7" Hg. Vacuum.

Test No.9.

I0 K.W. 90.9 Amperes. Apr. 30, I9I5.

Time	S-I	S-2	S-3	S-4	T-I	R.P:M.	Wt.
I2.20	84.0	32.0	I4.0	4.0	445	3650	
I2:30					445	3650	I28.5
I2;40	83.5	3I.5	I4.0	4.0	444	3650	I28.0
I2;50					444	3650	I27.0
I;00	85.0	30.5	I3.5	3.8	442	3650	I28.5
I;I0					440	3650	I28.0
I;20	8I.5	3I.0	I4.0	3.8	440	3650	I27.5
I:00	83.50	3I.40	I3.88	3.90	442.9	3650	767.5