THE CONSTRUCTION OF AN EXPERIMENTAL APPARATUS FOR TESTING THE POWER PLANT OF THE STANLEY STEAM AUTOMOBILE AND SOME TESTS MADE WITH IT.

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REPORTS OF TESTS

In order that these reports may be more readily stated, the various items will be numbered thus: (27).

The meanings of these numbers, as well as the calculations of test No.2, which will serve to illustrate the manner of calculating all of the tests, are given on the following pages.

OBSERVATIONS

(1) Length of test.

(2) Counter readings at beginning and end of test.

(5) Deadweight on rope brake.

(6) Right counterbalance reading.

(7) Left " "

(9) Weight of condensate for test.

(11) " " kerosene " "

(14) Temperature of feedwater entering boiler, Fahrenheit.

(15) Boiler pressure, gage.

(16) Corresponding boiling temperature, Fahrenheit.

(17) Superheater terminal pressure, gage.

(18) " " temperature, centigrade.

(19) Steam chest pressure, gage.

(20) " " temperature, centigrade.

(21) Exhaust pressure, inches of mercury.

(22) " temperature, Fahrenheit.

DATA, AND SAMPLE CALCULATIONS FOR RUN NO.2

(3) Average R.P.M.

4518 ÷ 6 = 225.9, use 226 R.P.M.

(4) Corresponding miles per hour.

226.104 = 23.5

(8) Net brake pull.

62.0 - 3.50 = 58.5 Lbs.

(10) Water rate, or Lbs. steam per hour.

$$\frac{40 \times 60}{20} = 120$$

(12) Kerosene per hour.

2 Lbs.11oz. in 17 min. = $\frac{2.69 \times 60}{17}$ = 9.50 Lbs.

(13) Gasolene per hour.

15 oz. in 5 hr.10 min. = $\frac{.938 \times 60}{310}$ = .182 Lbs.

(23) Heat of feedwater entering boiler.

From Goodenough's Tables q = 171.96 at 204°,
use 172 B.T.U. per Lb.

(24) Heat of steam leaving boiler, assuming it to be dry and saturated.

590 Lbs. per sq.in gage = 605 Lbs. per sq.in. abs.
H = 1199.7, use 1200 B.T.U. per Lb.

(25) Heat of steam leaving superheater.

63.3 Lbs. per sq.in gage = 78 Lbs. per sq.in. abs.
78 Lbs. per sq.in abs. and 575°F. = 1319 B.T.U. per Lb.

(26) Heat of steam in steam chest.

61.7 Lbs. per sq.in gage = 76.4 Lbs. per sq.in. abs.
76.4 " " " " and 550°F. = 1307 B.T.U. per Lb.
ϕ = 1.762 (Peabody)

DATA, AND SAMPLE CALCULATIONS FOR RUN NO.2
(Cont.)

(27) Heat of water, at boiling temperature corresponding to pressure in exhaust pipe.

$p = 14.7 + .258 \times .491 = 14.82$ Lbs. per sq.in. abs.

$q = 180 + \frac{12}{29} = 180.41$, use 180 B.T.U. per Lb.

(28) Heat input to water and steam in boiler, assuming steam to be dry and saturated.

1200 - 172 = 1028 B.T.U. per Lb.

(29) Heat input to water and steam in boiler and superheater.

1319 - 172 = 1147 B.T.U. per Lb.

(30) Heat supplied to steam chest, actually.

1307 - 172 = 1135 B.T.U. per Lb.

(31) Heat supplied to steam chest, if feedwater were at the temperature corresponding to pressure in the exhaust pipe.

1307 - 180 = 1127 B.T.U. per Lb.

RESULTS, AND SAMPLE CALCULATIONS FOR RUN NO.2

(32) Boiler horse power developed.

= (Heat of steam leaving superheater - Heat of feedwater) x Lbs. per hour / 33520

$$\frac{(1319 - 172) \times 120}{33520} = 4.10$$

(33) Fuel B.T.U. per hour.

= Lbs. gasoline per hour x heat of combustion of 1 Lb.
+ " kerosene " " " " " " " " " ,

$$= \frac{.182 \times 19700}{} + 9.50 \times 18900 = 183090$$

(34) Lbs. of water evaporated per Lb. kerosene.

$$\frac{120}{9.50} = 12.6$$

(35) Efficiency of boiler and superheater.

$$\frac{(1319 - 172) \times 120}{\text{Fuel B.T.U. per hr.}} = 75.0\%$$

(36) Heat transferred to water and steam, in boiler and superheater per hour, per sq.ft. of heating surface.

$$\frac{1147 \times 120}{104 + 2.6} = 1290 \text{ B.T.U.}$$

(37) Brake horse power developed by engine.

Constant x net brake pull x R.P.M.

.000288 x 58.5 x 226 = 3.82

(38) Lbs. of steam per brake horse power ~~per~~ hr.

$$\frac{120}{3.82} = 31.4$$

RESULTS, AND SAMPLE CALCULATIONS FOR RUN NO.2
(cont.)

(39) Lbs. of kerosene per brake H.P. hr.

$$\frac{9.50}{3.82} = 2.49$$

(40) Heat consumption of engine per brake H.P. hr.

$$1127 \times 31.4 = 35400$$

(41) Thermal efficiency of engine, based on brake H.P.

$$\frac{2545}{35400} = 7.20\,\%$$

(42) Efficiency of Rankine cycle $= \dfrac{H_1 - H_2}{H_1 - q_2}$

$$\frac{1307 - 1156}{1307 - 180} \quad (H_2 \text{ at } \phi = 1.768 \text{ and } p_2 = 14.82 \text{ Lbs. per sq.in abs.})$$

$$= 13.4\,\%$$

(43) Ratio of thermal to Rankine efficiency.

$$\frac{7.20}{13.4} = .538$$

(44) Fuel B.T.U. per brake H.P. hr.

$$\frac{\text{Fuel B.T.U. per hr.}}{3.82}, \qquad \frac{183090}{3.82} = 48000$$

(45) Overall thermal efficiency of plant.

$$= \frac{2545}{\text{Fuel B.T.U. per brake H.P. hr.}}$$

$$\frac{2545}{48000} = 5.30\,\%$$

RUN NO.2

OBSERVATIONS

(1) 20 min.

(2) 21322 - 25840

(5) 62 Lbs.

(6)
1.00
1.25
1.25
1.50
1.25
1.25
7.50

(7)
2.50
2.25
2.25
1.75
2.50
2.25
13.50
7.50
6)21.00
3.50 Lbs.

(9) 40 Lbs.

(11) 2.69 Lbs. in 17 min.

(14)
202
199
205
212
202
200
6)1220
203.7, use 204°F.

RUN NO.2
OBSERVATIONS

(15) 580
580
580
580
580
580
580 + 10 = 590 Lbs. per sq.in. gage.

(16) 487° F.

(17) 61.5
60.0
62.0
62.5
61.5
62.0
6)369.5
61.6 + 1.7 = 63.3 Lbs. per sq.in.

(18) 307
299
295
311
300
298
6)1810
301.7°C. = 575°F.

RUN NO.2
OBSERVATIONS

(19) 60.0
58.5
60.5
61.0
60.0
60.0
6)360.0
60.0 + 1.7 = 61.7 Lbs. per sq.in.

(20) 289
280
285
292
290
285
6)1721
287°C = 550°F.

(21) .25
.30
.25
.25
.25
.25
6)1.55
.258"Hg.

(22) 268
270
270
270
272
274
6)1624
270.6 = 271°F.

RUN NO.2

DATA

(3) 226 R.P.M.

(4) 23.5 M.P.H.

(8) 58.5 Lbs.

(10) 120 Lbs.

(12) 9.50 Lbs.

(13) .182 Lbs.

(23) 172 B.T.U.

(24) 1200 B.T.U.

(25) 1319 B.T.U.

(26) 1307 B.T.U.

(27) 180 "

(28) 1028 "

(29) 1147 "

(30) 1135 "

(31) 1127 "

RUN NO. 2

RESULTS

(32) 4.10

(33) 183,090

(34) 12.6 Lbs.

(35) 75.0 %

(36) 1290 B.T.U.

(37) 3.82 Brake H.P.

(38) 31.4 Lbs. steam per Brake H.P.

(39) 2.49 Lbs.

(40) 35400 B.T.U.

(41) 7.20 %

(42) 13.4 %

(43) .538

(44) 48000 B.T.U.

(45) 5.30 %

RUN NO.3
OBSERVATIONS

(1) 12 min.

(2) 28980 - 32167

(5) 120 Lbs.

(6)
8.0
9.0
8.5
9.0
8.0
42.5

(7)
6.0
7.0
6.5
6.5
7.0
33.0
33.0
42.5
5)75.5
15.1 + 2.5 = 17.6 Lbs. Counterpull.

(9) 40 Lbs. 12 oz.

(11) 3 Lbs. 3 oz.

(14)
205
203
207
206
204
5)1025
205° F.

RUN NO.3

OBSERVATIONS

(15)

580
575
575
580
575
5)2885

577 + 10 = 587 Lbs. per sq.in. gage.

(16) 602 Lbs. per sq.in. abs. = 487°F.

(17)

85.5
84.5
86.5
85.0
86.0
5)427.5

85.5 + 1.8 = 87.3 Lbs. per sq.in. gage.

(18)

313
315
315
311
317
5)1571

314.2°C. = 597°F.

RUN NO.3
OBSERVATIONS

(19) 83.5
82.5
85.0
83.0
84.5
5)418.5
83.7 + 1.8 = 85.5 Lbs. per sq.in. gage.

(20) 296
299
303
300
301
5)1499
299.8°C. = 572°

(21) .40
.35
.35
.40
.35
5)1.85
.37" Hg.

(22) 272
273
276
274
273
5)1368
273.6 = 274°F.

RUN NO.3

DATA

(3) 266 R.P.M.

(4) 27.6 M.P.H.

(8) 102.4 Lbs.

(10) 204 Lbs. per hr.

(12) 15.94 Lbs. per hr.

(13) .182 " " "

(23) 173 B.T.U.

(24) 1200 "

(25) 1329 "

(26) 1315 "

(27) 181 "

(28) 1027 "

(29) 1156 "

(30) 1142 "

(31) 1133 "

RUN NO.3

RESULTS

(32) 7.03 Boiler H.P.

(33) 305,090 B.T.U.

(34) 12.8 Lbs.

(35) 77.0 %

(36) 2210 B.T.U. per hr.

(37) 7.83 Brake H.P.

(38) 26.05 Lbs. steam per brake H.P. hr.

(39) 2.04 Lbs.

(40) 29600 B.T.U.

(41) 8.60 %

(42) 15.40 %

(43) .558

(44) 41500 B.T.U.

(45) 6.13 %

RUN NO.4
OBSERVATIONS

(1) 18 min.

(2) 35615 - 41280

(5) 195 Lbs.

(6)
13.5
18.5
14.5
13.0
13.0
72.5

(7)
13.5
20.5
18.0
15.0
13.0
80.0
80.0
72.5
5)152.5
30.5 + 1 = 31.5 Lbs. Counterpull.

(9) 97 Lbs.

(11) 5 Lbs. 15 oz. in 16 min.

(14)
200
205
200
208
207
5)1020
204°F.

RUN NO.4

OBSERVATIONS

(15) 570
565
575
575
575
5)2860

572 + 10 = 582 Lbs. per sq.in. gage.

(16) 485° F.

(17) 120.5
119.0
122.5
120.0
122.5
5)604.5

120.9 + 2.1 = 123 Lbs. per sq.in. gage

(18) 314
302
313
305
303
5)1537

307.4°C. = 585°F.

RUN NO.4
OBSERVATIONS

(19) 117.5
117.5
120.0
117.0
120.0
5)592.0
118.4 + 2.1 = 120.5 Lbs. per sq.in. gage.

(20) 297
298
306
297
298
5)1496
299.2°C. = 571°F.

(21) 1.00
.95
.80
.95
.90
5)4.60
.92" Hg.

(22) 258
256
257
256
256
5)1283
256.6 = 257°F.

RUN NO.4

DATA

(3) 815 R.P.M.

(4) 32.8 M.P.H.

(8) 163.5 Lbs.

(10) 323 Lbs. per hour.

(12) 22.25 " " "

(13) .182 " " "

(23) 172 B.T.U. per Lb.

(24) 1200 " " "

(25) 1320 " " "

(26) 1313 " " " $\phi = 1.712$

(27) 182 " " "

(28) 1028 " " "

(29) 1148 " " "

(30) 1141 " " "

(31) 1131 " " "

RUN NO.4
RESULTS

(32) 11.05 Boiler H.P.

(33) 405590 B.T.U.

(34) 14.5 Lbs.

(35) 85.8 %

(36) 3270 B.T.U.

(37) 14.95 Brake H.P.

(38) 21.6 Lbs.

(39) 1.49 Lbs.

(40) 24500 B.T.U.

(41) 10.4 %

(42) 16.9 %

(43) .615

(44) 28400

(45) 8.96 %

RUN NO.5

OBSERVATIONS

(1) 15 min.

(2) 45702 - 48975

(5) 260 Lbs.

(6)
27.0
29.0
27.0
29.0
28.0
140.0

(7)
26.0
28.0
30.0
27.0
29.0
140.0
140.0
5)280.0
56.0 Lbs. Counterpull.

(9) 75 Lbs.6oz. in 15 min.

(11) 5 Lbs.5oz. " " "

(14)
187
203
204
204
203
5)1001
200.2, use 200°F.

RUN NO.5

OBSERVATIONS

(15) 570
560
570
570
570

5)2840

568 + 10 = 578 Lbs. per sq.in. gage.

(16) 485°F.

(17) 150.5
148.0
139.0
138.5
148.0

5) 724.0

144.8 + 2.7 = 147.5 Lbs. per sq.in.gage.

(18) 322
320
308
313
317

5)1580

316°C. = 600°F.

RUN NO.5

OBSERVATIONS

(19) 148.5
146.0
136.5
137.0
146.0
5)714.0

142.8 + 2.7 = 145.5 Lbs. per sq.in. gage.

(20) 310
308
298
303
306
5)1525

305°C. = 581°F.

(21) .80
.70
.80
.75
.70
5)3.75

.75" Hg.

(22) 258
258
254
256
254
5)1280

256° F.

RUN NO.5

DATA

(3) 218 R.P.M.

(5) 22.7 M.P.H.

(8) 204 Lbs.

(10) 301.5 Lbs.

(12) 21.25 Lbs.

(13) .182 Lbs.

(23) 168 B.T.U. per Lb.

(24) 1200 " " "

(25) 1325 " " "

(26) 1315 " " " $\phi = 1.702$

(27) 181 " " "

(28) 1032 " " "

(29) 1157 " " "

(30) 1147 " " "

(31) 1134 " " "

RUN NO.5

RESULTS

(32) 10.4 Boiler H.P.

(33) 405,590 B.T.U.

(34) 14.2 Lbs.

(35) 85.8 %

(36) 3270 B.T.U.

(37) 12.90 Brake H.P.

(38) 23.4 Lbs. per Brake H.P.

(39) 1.65 Lbs.

(40) 26600 B.T.U.

(41) 9.56 %

(42) 17.5 %

(43) .546

(44) 31400 B.T.U.

(45) 8.10 %

COMPARISON OF RESULTS
(1)
Results from boiler plant

	(2)	(3)	(4)	(5)	
(32) Boiler H.P.	4.10	7.08	11.05	10.4	
(33) Fuel B.T.U. per hr.	183,090	305,090	423,590	405,590	
(34) Evaporation per lb.kerosene.	12.6	12.8	14.5	14.2	Lbs.water
(35) Efficiency.	75.0	77.0	87.3	85.8	%
(36) Heat transmitted per sq.ft. total heating surface per hr.,p.	1290	2210	3480	3270	B.T.U.

COMPARISON OF RESULTS

Results from engine (2)

	(2)	(3)	(4)	(5)	
(3) R.P.M.	226	226	315	218	
(37 Brake H.P.	3.82	7.38	14.95	12.90	
(38) Water rate.	31.4	26.05	21.6	23.4	Lbs. per B.H.P. hr.
(39) Kerosene per brake hr.	2.49	2.04	1.49	1.65	Lbs.
(40) Heat used per " H.P. hr.	35400	29600	24500	26600	B.T.U.
(41) Thermal efficiency.	7.20	8.60	10.4	9.56	%
(42) Rankine "	13.4	15.40	16.9	17.5	%
(43) Cycle "	53.8	55.8	61.5	54.6	%

COMPARISON OF RESULTS
(3)

Plant results.

		(2)	(3)	(4)	(5)	
(44)	Fuel B.T.U. per brake H.P. hr.	48000	41500	28400	31400	
(45)	Overall efficiency.	5.30	6.13	8.96	8.10	%