THESIS

The Effect of Compression on the Fuel Consumption of a Gasoline Engine

by

Everett S. Gardiner

Class of Nineteen hundred and fourteen

Department of Mechanical Engineering

THROOP COLLEGE OF TECHNOLOGY

Pasadena, California.

- 1914 -

T A B L E O F C O N T E N T S

I

INTRODUCTION

The title of this thesis was originally: "The Effect of Compression on the Consumption of an Internal Combustion Engine Using Gasoline, Kerosene, Distillate and Alcohol." And it was thought that it comprised a field sufficiently broad to insure the expenditure of the efforts of two men.

Curves of the various fuels were to be obtained from: the compression pressures as abscissae and pounds of fuel per delivered horsepower per hour as ordinates. These curves were to be plotted from the results of a least two tests at an interval of one delivered horsepower apart ranging from zero to the maximum output of the engine; this series being repeated at each of the four or six compressions obtainable. Thus with a five brake horsepower engine, which was used, there would be two tests at each horsepower, at each compression, and with each fuel; making in all; assuming five different compression pressures ranging between forty-five pounds per square inch (Gage) and one hundred and ten pounds per square inch (Gage) two (tests) X five(horsepower) X five (compression pressures) X four (fuels) equals two hundred (Total number of tests).

This figure is conservative as it would

have required more than two tests in many cases in order to get anything like checking results.

All tests were to be of not less than an hour's duration and in some cases it was hoped to run longer ones in order to procure more accurate indicated horsepower readings.

The curves thus obtained and plotted would show at what power the maximum economy occurred for each fuel. Such curves are not to be found at this time in any source obtainable.

- - - - - - - - - - -

The engine, that was used, had a compression pressure of fifty-nine and three tenths pounds per square inch (absolute) and a series of twelve tests were run, as previously suggested, at that pressure. The pressure was then changed, by lengthening the connecting rod, to sixty-seven and three tenths pounds per square inch (absolute); and a similar series of fourteen tests was run at this pressure.

Owing to the construction of the cylinder it was impossible to increase the compression pressure further, using the same method, because the piston already covered one-half of the exhaust port when it was on dead centre. Thus in order to procure the desired results it would have been necessary to have procured another, differently designed, cylinder, As it was,

results were obtained from the two different pressures which with the curves will be found in another section of the thesis.

- - - - - - - - - - - -

During the first few tests which were run on the engine, several difficulties were encountered:
(1) The carburetor was filled with water and other foreign matter left over from a year ago so that it was necessary to remove the instrument, clean it thoroughly, and replace it before satisfactory tests could be made.
(2) The "make and break" mechanism of the ignition system was also out of order and this necessitated the design and manufacture of a contrivance which had to be adjusted.
(3) The explosion counter had slipped out of place so that it did not record the impulses accurately.
(4) A rope prony brake, placed on either of the two fly-wheels, was used to absorb the power in all tests; but various arrangements had to be contrived to get the brake to remain constant at the different loads. At the higher loads, a two strand hemp rope was used, but at the low loads a single cotton rope sufficed. At loads as low as one horsepower a single piece of number eighteen copper annunciator wire was found to

work most satisfactorily.

- - - - - - - - - - - -

CARBURATION

There were two different carburetors used in these tests, or more strictly speaking, one carburetor and one vaporizer. The engine was fitted with a vaporizer, the action of which was as follows: Gasoline was pumped from a tank to the vaporizer by a mechanically operated pump; here a constant level was maintained by the height of the overflow pipe above the floor of the vaporizer. The surplus ran back to the supply tank. The adjustment of the instrument was accomplished by the use of a needle valve, the discharge from it passing into the suction line.

The carburetor that was used was made by the Mayer Carburetor Company and was designed for use on four cylinder motor-car engines.

The results show that one instrument was equally as good as the other, as far as fuel economy is concerned. Accompanying the thesis are cuts of both arrangements.

II

- SPECIFICATIONS OF ENGINE -

(1) Type of Engine: Stationary, Horizontal, Single-acting, Gasoline.

(2) Number of Revolutions for one cycle: two

(3) Class of cycle: Four

(4) Method of Ignition: "Make and Break."

(5) Governing: Flywheel governor, centrifugal type, acting on "hit and miss" principle. Cam holds intake valve closed and exhaust valve open when miss occurs.

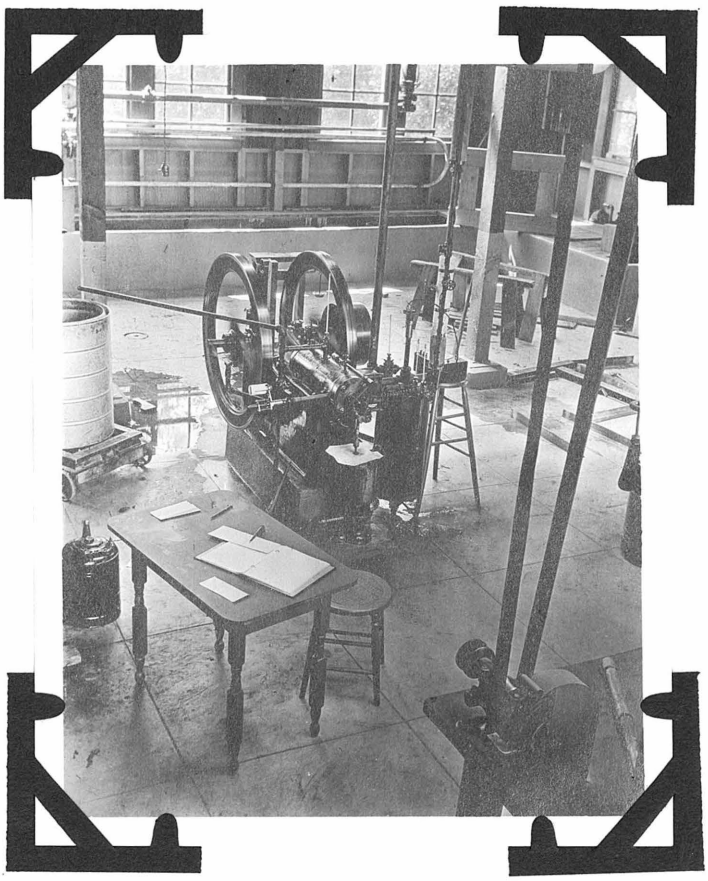
(6) Name of Builders: Fairbanks Morse Company.

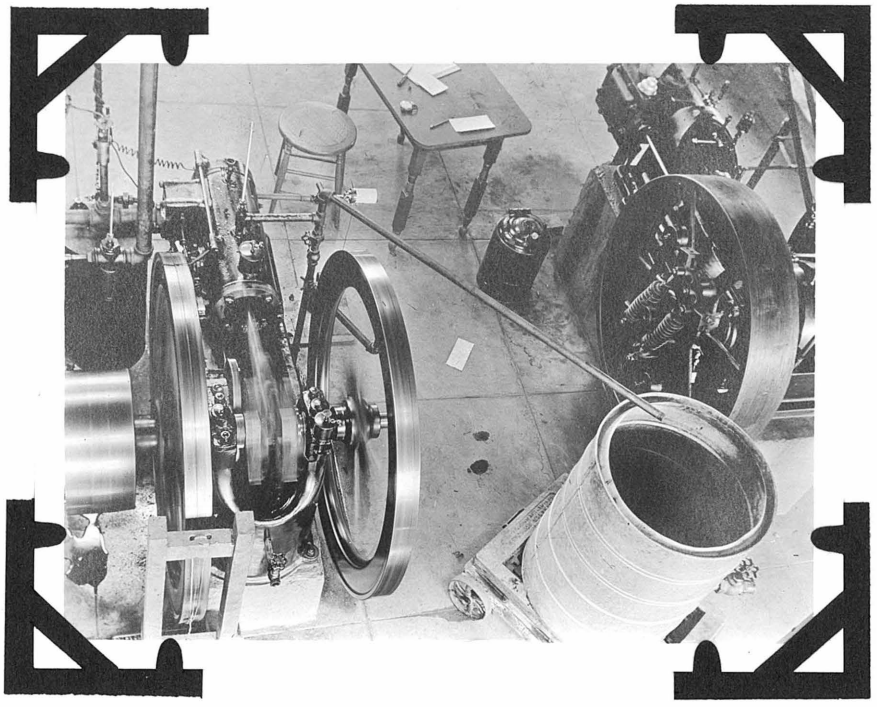
(7) Rated Capacity: Five horsepower at 325 revolutions per minute.

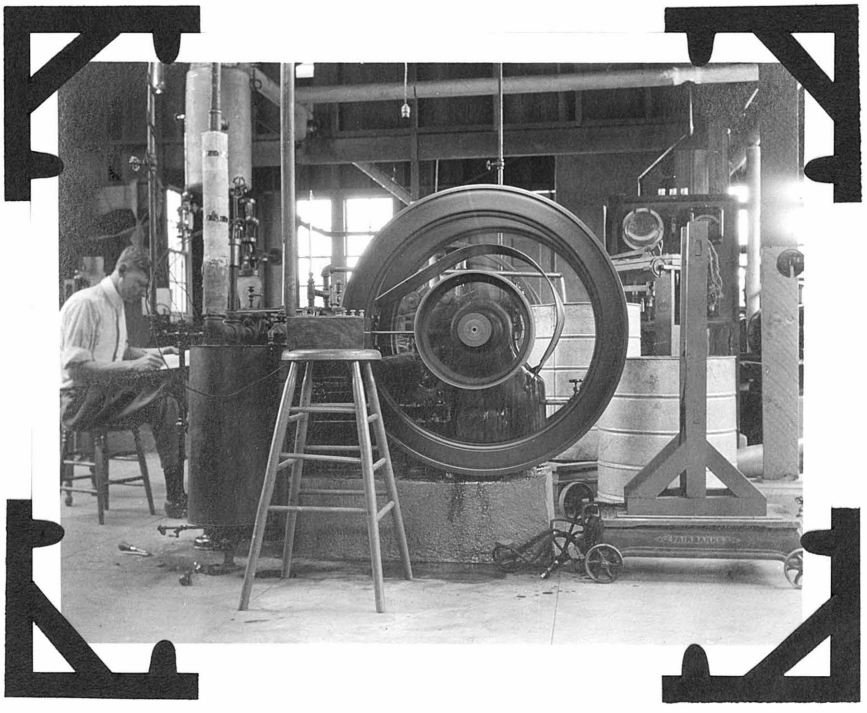
(8) Dimensions:
- (a) Diameter of cylinder: 5 inches
- (b) Length of stroke: 6 "
- (c) Area of piston: 19.6 square inches
- (d) Compression space:
  - (1) At 59.3 pounds per square inch absolute: Volume: .04853 cubic feet. Or 42.8% of the piston displacement.
  - (2) At 67.3 pounds per square inch absolute: Volume: .0399 cu. ft. or 35.1% of the piston displacement.
- (e) Compression pressure increase from 59.3 pounds per square inch absolute to 67.3 pounds per square inch absolute represents a percentage of

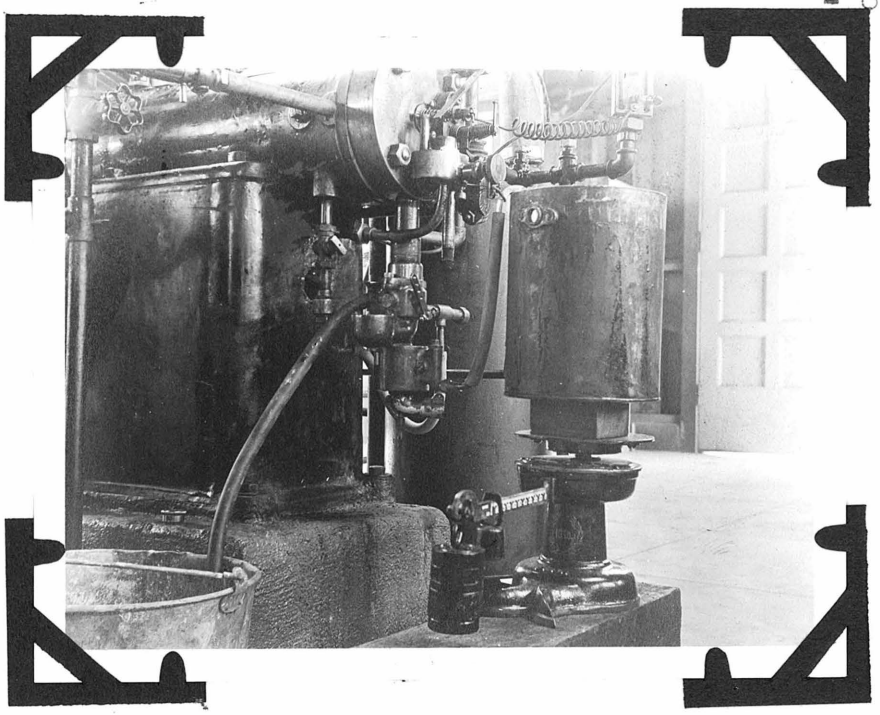
$$\frac{67.3 - 59.3}{59.3} = 13.4$$

(9) Date: May 1914

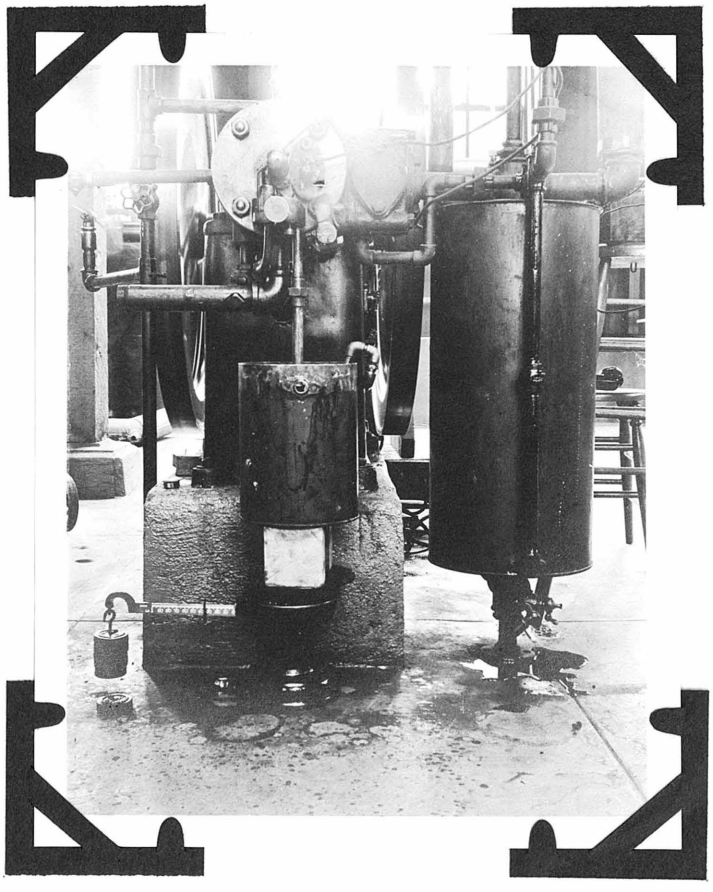






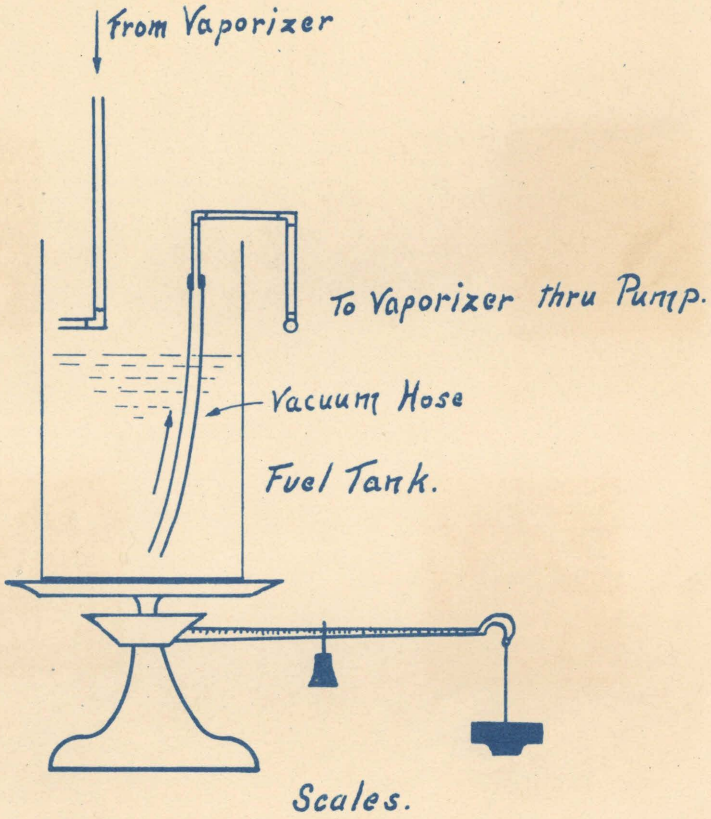


Mayer Carburetor



Vaporizer

Diagram Showing Method of Weighing Fuel. - 8-a -



Gas Engine Thesis
February 1914
E.S. Gardiner.

III

DESCRIPTION OF TESTS

The engine was run under load conditions until it became thoroughly heated before each test was started, in order to maintain the various temperatures as nearly as possible constant through the tests. Each test was started at a predetermined time so that the zero weights of the oil and water tanks might be determined, and the reading of the impulse counter taken. This done, readings were taken every five minutes of; (1) the temperature of the cooling water going into the cooler; (2) the temperature of the water out of the cooler and in the water jackets of the cylinder; (3) the temperature of the cooling water out of the jackets; (4) the temperature of the exhaust gases from the engine and from the cooler. All these readings were taken from thermometers excepting the exhaust gases from the engine; the temperature of these was determined from a Leeds Northrup Pyrometer.

On account of the "hit and miss" type of governor used on the engine the exhausr valve is held open during the idle strokes, thus the temperature reading on the Pyrometer at no load is not correct because of so few explosions.

Indicator cards were taken every five minutes with a Crosby New Indicator Number 2 using a spring calibrated to two hundred pounds per inch.

The speed was ascertained several times during each test, it being unnecessary to observe it at short intervals. The governor kept the speed practically constant at three hundred and thirty-five revolutions per minute, at all loads.

Two instruments were used to check the revolutions of the engine, namely; a Schuchardt & Schutte Tachometer number 6361, and a Veeder Revolution Counter.

V

- FORMULA SHEETS -

The average number of explosions per minute is calculated by dividing the total number by the duration of the test in minutes.

The indicated horsepower is $\frac{P\ L\ A\ N}{33000}$

P is the Mean Effective Pressure in pounds per square inch
L is length of stroke in feet
A is the area of the piston in square inches
N is the average number of explosions per minute

The delivered horsepower is $\frac{2\pi\ R\ N\ P}{33000}$

π is 3.14159
R is radius of wheel in feet
N is the number of revolutions per minute
P is the net pressure on the brake arm at a distance R from centre of shaft.

Mechanical Efficiency is $\frac{D.H.P.\ X\ 100}{I.H.P.}$

Heat consumed per hour is the product of the calorific value of the oil per pound and the total number of pounds used per hour.

Heat consumed per indicated horsepower per hour is the heat consumed per hour divided by the indicated horsepower.

Heat consumed per delivered horsepower per hour in the heat consumed per hour divided by the delivered horsepower.

Thermal Efficiency Ratio:

Per indicated horsepower $\frac{2545 \times 100}{\text{Line 51 (a)}}$

Per delivered horsepower $\frac{2545 \times 100}{\text{Line 51 (b)}}$

2545 is the equivalent of one horsepower per hour expressed in British Thermal Units.

Line 51 (a) is the number of British Thermal Units consumed by the engine per indicated horsepower per hour.

Line 51 (b) is the number of British Thermal Units consumed by the engine per delivered horsepower per hour.

Mean Effective Pressure is: the area of the card, in square inches, multiplied by the scale of the spring, in pounds per inch, divided by the length of the card, in inches.

- - - - - - - - - - - -

- POWER -

-INDICATED HORSEPOWER-

The Indicated horsepower was calculated from the mean effective pressure of diagrams taken every five minutes; and also the average number of explosions per minute.

-DELIVERED HORSEPOWER-

The power was absorbed from the engine by means of a rope brake placed on the flywheel. The zero weight of the brake was twelve pounds. The circumference of the flywheel was ten feet nine inches.

A table showing the relation between the delivered horsepower and the brake readings:

D.H.P.	P	Weight on scales
1	9.15	21.15
2	18.30	30.30
3	27.50	39.50
4	36.60	48.60
5	45.80	57.80

P is the net pressure on the brake arm at a distance R from the centre of the shaft.

The weight on the scales is P plus the zero weight of the brake.

VI

CALORIFIC VALUE OF FUEL

The higher calorific value of United States petroleum and its distillates, ranging from crude oil to gasoline, varies quite regularly with the Specific Gravity of the material, and is expressed approximately by the following formula, which may be assumed correct within two percent:

British Thermal Units per pound is equal to 18650 plus 40 (B - 10)

B is equal to degrees on the Baume Hydrometer.

(Taken from "Elements of Heat-Power Engineering" by Hirshfeld & Barnard Page 469.)

Calculated Calorific Value

18650 plus 40 (60 - 10) 20650 B.T.U. per pound

Experimental Value 20717 B.T.U. per pound

Percentage variation 0.324

Test No. 1 Parr Calorimeter

Wt. of glass bulb & gasoline	0.534
" " " " alone	0.139
" " gasoline alone	0.395

1 gr. $KClO_3$, 1 measure Na_2O_2

Minutes	Temperatures	Differences	
1	69.10°F.		
2	69.10		
3	64.11		
4	69.12		
5	69.125		
6	69.14		
7	69.14 fired	)	
8	74.15	)5 minute interval	
9	74.53	)	
10	74.56	)	
11	74.56	)	
12	74.57	)	
13	74.56	.01	
14	74.555	.005	
15	74.55	.005	
16	74.55	.000	
17	74.54	.01	.03
18	74.53	.01	
19	74.525	.005	
20	74.52	.005	

		CORRECTIONS	
Maximum temperature	74.57		
Initial "	69.14		
Rise in "	5.43	Fuse	.014
Radiation	.03	1 gr. $KClO_3$	.234
	5.4600	Glass:	
Corrections	.2897	(.03X1.39)	.0417
"r" in formula	5.1703		.2897

B.T.U. per pound is $\frac{r \times 0.73 \times 2135}{\text{Wt. of Oil (gr.)}}$

$$\frac{5.1703 \times 0.73 \times 2135}{.395} = 20400$$

Fuel used in tests: 16, 17, 18, 20.

Test No. 2 Parr Calorimeter

Fuel used in tests numbers 16, 17, 18, 20

Wt. of glass bulb & gasoline	.4610
" " " " alone	.1605
" " gasoline "	.3005

1 gr. $KClO_3$, 1 measure Na_2O_2

Minutes	Temperatures		Differences	
1	73.84°F.			
2	73.84			
3	73.84			
4	73.83			
5	73.825			
6	73.82			
7	73.81	fired		
8	77.40			
9	77.90			
10	77.95			
11	77.95			
12	77.95		.00	
13	77.94		.01	
14	77.91		.03	
15	77.90		.01	
16	77.89		.01	.06
17	77.87		.02	
18	77.86		.01	
19	77.85		.01	
20	77.84		.01	.06

		CORRECTIONS	
Maximum temperature	77.95		
Initial "	73.81		
Rise in "	4.14	Fuse	.014
Radiation	.06	$KClO_3$	.234
	4.200	Glass:	
Corrections	.296	(.03 X 1.6)	.048
"r" in formula	3.904		.296

$$\frac{3.904 \times .73 \times 2135}{.3005} = 20350 \text{ B.T.U. per pound}$$

Test No. 3 Parr Calorimeter

Fuel used in tests numbers 21 to 31 inclusive.

Wt. of glass bulb & gasoline	.463
" " " " alone	.1805
" " gasoline "	.2825

1 gr. $KClO_3$, 1 measure Na_2O_2

Minutes	Temperatures	Differences
1	67.45°F. fired	
2	70.70	
3	71.30	
4	71.45	
5	71.50	
6	71.50	.00
7	71.50	.00
8	71.50	.00
9	71.50	.00
10	71.50	.00

Maximum temperature	71.50	CORRECTIONS	
Initial "	67.45		
Rise in "	4.05	Fuse	.014
Radiation	0.00	$KClO_3$	.234
	4.05		
Corrections	.102	Glass:	
"r" in formula	3.948	(.03 X 1.8)	.054
			.102

Calorific Value per pound is $\frac{r \times 0.73 \times 2135}{\text{Wt. of Oil (gr.)}}$

$\frac{3.948 \times .73 \times 2135}{.2825} = 21750$ B.T.U. per pound

Test No. 4 Parr Calorimeter

Fuel used in tests numbers 21 to 31 inclusive.

Wt. of glass bulb & gasoline	.3655
" " " " alone	.1105
" " gasoline "	.2450

1 gr. $KClO_3$, 1 measure Na_2O_2

Minutes	Temperatures	Differences
1	71.30°F.	
2	71.30	
3	71.30	
4	71.30	
5	71.30 fired	
6	74.35	
7	74.75	
8	74.80	
9	74.80	
10	74.80	
11	74.79	
12	74.775	
13	74.76	
14	74.75	

Maximum temperature	74.80
Initial "	71.30
Rise in "	3.500
Corrections	.282
"r" in formula	3.218

CORRECTIONS

Fuse	.014
$KClO_3$	.234
Glass: (.03 X 1.1)	.033
	.282

Calorific Value per pound is $\frac{r \times 0.73 \times 2135}{\text{Wt. of Oil (gr.)}}$

$\frac{3.218 \times 2135 \times .73}{.245} = 20450$ B.T.U. per pound

Test No. 5 Parr Calorimeter

Fuel used in tests numbers 21 to 31 inclusive.

Wt. of glass bulb & gasoline	.6115
" " " " alone	.2525
" " gasoline "	.3590

1 gr. $KClO_3$, 1 measure Na_2O_2

Minutes	Temperatures	Differences	
1	74.07°F.		
2	74.07 fired		
3	78.30)		
4	78.80) 4 minute interval		
5	78.90)		
6	78.91)		
7	78.90	.01	
8	78.88	.02	
9	78.85	.03	
10	78.84	.01	.07
11	78.81	.03	
12	78.80	.01	.08

		CORRECTIONS	
Maximum temperature	78.91		
Initial "	74.07		
Rise in "	4.840	Fuse	.014
Radiation	.075	$KClO_3$	.234
	4.915		
Corrections	.324	Glass:	
"r" in formula	4.591	(.03 X 2.525)	.076
			.324

Calorific Value per pound is $\frac{r \times 0.73 \times 2135}{\text{Wt. of Oil (gr.)}}$

$\frac{4.591 \times .73 \times 2135}{.359} = 19950$ B.T.U. per pound

The average value of tests numbers 3, 4 and 5 is: 20717 B.T.U. per pound.

VII

DATA AND RESULTS OF TESTS

- A.S.M.E. Code of 1912, Complete Form -

No. of Test	1	8	9	10	11	12	14
Duration (min)	60	60	60	60	60	60	60
Spec. Gr. of Oil				.75	.75	.75	.75
Barometer "Hg.		29.23	29.23	29.17		29.17	29.54
TEMPERATURES: °F.							
Cooling Water:							
In Cooler	58	51	58	60	60	58	57
Out "	82.5	95	92	96	104	85	115
Out of Engine	109	136	150	141	162	118	180
Exhaust Gases:							
From Engine	296.6	292	507	670	756	749	736
" Cooler	63.4	69	68	71	74	67	76
Dry bulb	66.3	68	68	71	74	67	77
Wet "		60	61	66	68	60	63
% Humidity		63	68	71	74	67	45
TOTAL QUANTITIES:							
Oil Consumed lb.	2.44	2.15	3.77	4.41	5.03	4.35	4.6
Cooling Water "	412.5	2o3	367	610	549	963	422
INDICATOR DIAGRAMS:							
Pressures in lb. per sq. in. above atmosphere							
Maximum press.	290	275	260	247	237	234	274
Pressure at beginning of stroke:	232	275	260	245	237	234	233
At end of expansion:	52.5	49	44	41	38	40	40
Mean Effective Pressure	90.1	81.1	71.7	71.5	67	68.6	70.4

DATA AND RESULTS (Continued)

No. of Test	1	8	9	10	11	12	14
SPEED & EXPLOSIONS							
Rev. per minute	331	338	335	335	335	335	335
Average number Impulses/min.	41	31.5	83.7	125	151	146	139
POWER							
I.H.P.	1.83	1.27	2.98	4.42	5	4.96	4.84
D.H.P.	0	0	2	3	4.58	4.14	4.25
Friction H.P. by difference	1.83	1.27	.98	1.42	.42	.82	.59
Mechanical Eff.			67.1	67.8	91.6	83.4	87.9
% I.H.P. Lost in friction	100	100	32.9	32.1	8.4	16.5	12.2
ECONOMY RESULTS							
(51) B.T.U. Consumed per hr.							
(a) per I.H.P.							
(b) " D.H.P.							
lbs. oil used per hour	2.44	2.15	3.77	4.41	5.03	4.35	4.6
Per I.H.P.	1.33	1.69	1.27	.998	1.005	.875	.95
Per D.H.P.			1.88	1.47	1.1	1.05	1.08
EFFICIENCY							
Thermal Efficiency Ratio							
Per I.H.P.							
Per D.H.P.							
Work Done per Heat Unit 1980000 / Line 51(b) (Foot pound)							

DATA AND RESULTS (Continued)

No. of Test	15	16	17	18	20	21	22
Duration (min)	60	60	60	60	60	60	60
Spec. Gr. of Oil	.75	.73	.73	.73	.73	.745	.745
Barometer "Hg.	29.44	29.34	29.34	29.3	29.33	29.2	29.2
TEMPERATURES: °F.							
Cooling Water:							
In Cooler	59	63	61	62	62	63	64
Out "	111	121	128	102	106	91	91
Out of Engine	177n	193	210	143	165	120	122
Exhaust Gases:							
From Engine	701	450	723	327	414	240	255
" Cooler	77	86	88	74	76	69	69
Dry bulb	78	86	88	74	76	69	69
Wet "	63	70	70	65	67	58	58
% Humidity	43	44	39	62	63	58	58
TOTAL QUANTITIES:							
Oil Consumed lb.	4.73	2.35	4.12	1.84	2.38	1.82	1.92
Cooling Water	447.5	172.5	320.2	173	225.5	189	230.5
B.T.U./lb. Oil	(20400.)					(20720)	
INDICATOR DIAGRAMS: Pressures in lb. per Sq. in. above atmosphere							
Maximum pres.	249	241	240	194	216	308	313
Pres. at beginning of stroke:	244	241	240	167	183	231	262
At end of expansion:	40	44	38	46	45	50	49
Mean Effective Pressure	71	70.3	61.9	68.6	74	92.6	89.4

DATA AND RESULTS (Continued)

No. of Test	15	16	17	18	20	21	22
SPEED & EXPLOSIONS							
Rev. per minute	335	335	335	335	335	335	335
Average number Impulses/min.	137	75	141	57	83.2	27.3	31.1
POWER							
I.H.P.	4.81	2.61	4.32	1.93	3.04	1.24	1.37
D.H.P.	4.14	1	4	0	1	0	0
Friction H.P. by difference	.67	1.61	.32	1.93	2.04	1.24	1.37
Mechanical Eff.	86	46.4	92.6		32.9		
% I.H.P. Lost in friction	13.9	61.5	7.4		67	100	100
ECONOMY RESULTS							
(51) B.T.U. Consumed per hr.		47900	84000	37500	48500	37700	39800
(a) per I.H.P.		18300	19450	19420	15970	30400	29100
(b) " D.H.P.		47900	21000		48500		
lbs. Oil used per hour	4.73	2.35	4.12	1.84	2.38	1.82	1.92
Per I.H.P.	.983	.9	.954	.954	.784	1.47	1.4
Per D.H.P.	1.14	2.35	1.03		2.38		
EFFICIENCY							
Thermal Efficiency Ratio							
Per I.H.P.		.139	.131	.131	.159	.084	.087
Per D.H.P.		.053	.121		.052		
Work done per Heat Unit 1980000/Line 51 (b) (Foot pounds)		41.6	94.7		41		

DATA AND RESULTS (Continued)

No. of Test	23	24	25	26	27	28	29
Duration (min)	60	60	60	60	60	60	60
Spec. Gr. of Oil	.745	.745	.745	.745	.745	.745	.745
Barometer "Hg.	29.20	29.12	29.12	29.36	29.36	29.36	29.36
TEMPERATURES: °F.							
Cooling Water:							
In Cooler	62	64	63	60	60	60	61
Out "	84	105	106	88	105	107	100
Out of Engine	110	152	159	129	157	172	153
Exhaust Gases:							
From Engine	370	350	358	670	570	652	650
" Cooler	66	73	74	69	74	75	74
Dry Bulb	67	74	74	68	74	76	75
Wet "	59	63	63	59	62	63	63
% Humidity	62	54	54	58	51	47	51
TOTAL QUANTITIES:							
Oil Consumed lb.	3.18	2.41	3.07	4.06	3.53	4.04	3.89
Cooling Water	447	173.5	184	716.5	348.5	209.5	492.5
B.T.U./lb. Oil	(	2 0 7 2 0 for all					)
INDICATOR DIAGRAMS: Pressures in lb. per Sq. in. above atmosphere							
Maximum pres.	311	299	297	283	296	297	293
Pres. at beginning of stroke:	283	283	293	283	296	297	293
At end of expansion:	43	44	44	40	41	40	40
Mean Effective Pressure	83.6	76.6	81.1	75.6	79.4	75.8	76.4

DATA AND RESULTS (Continued)

No. of Test	23	24	25	26	27	28	29
SPEED & EXPLOSIONS							
Rev. per minute	335	335	335	335	335	335	335
Average number Impulses/min.	60.8	48.8	52.4	137	105.4	124.5	124.5
POWER							
I.H.P.	2.52	1.89	2.1	5.14	4.14	4.72	4.71
D.H.P.	1	1	1	3	3	4	4
Friction H.P. by difference	1.52	.89	1.1	2.14	1.14	.72	.71
Mechanical Eff.	39.7	53	47.6	58.4	72.4	84.7	84.9
% I.H.P. lost in friction	59.5	47	52.4	41.6	27.5	15.2	15.1
ECONOMY RESULTS							
(51) B.T.U. Consumed per hr.	65900	49900	63600	84100	73100	83600	80500
(a) per I.H.P.	26150	26400	30300	16380	17700	17700	17100
(b) " D.H.P.	65900	49900	63600	28050	24400	20900	20150
lbs. Oil used per hour	3.18	2.41	3.07	4.06	3.53	4.04	3.89
Per I.H.P.	1.26	1.28	1.46	.79	.85	.85	.82
Per D.H.P.	3.18	2.41	3.07	1.35	1.18	1.01	.97
EFFICIENCY							
Thermal Efficiency Ratio							
Per I.H.P.) x 100 for %	.097	.096	.084	.155	.144	.144	.149
Per D.H.P.)	.039	.051	.04	.091	.104	.122	.126
Work done per Heat Unit 1980000/Line 51 (b) (Foot pounds)	30.1	39.7	31.1	70.5	81.2	94.8	98.4

DATA AND RESULTS (Continued)

No. of Test	30	31	32	33	34
Duration (min)	60	60	60	60	60
Spec. Gr. of Oil	.745	.745	.735	.735	.735
Barometer "Hg.	29.33	29.33	29.325	29.325	29.27
TEMPERATURES: ° F.					
Cooling Water:					
In Cooler	60	60	61	62	62
Out "	93	104	104	106	102
Out of Engine	133	161	163	166	149
Exhaust Gases:					
From Engine	725	747	454	445	345
" Cooler	72	75	75	76	73
Dry Bulb	72	77	76	76	73
Wet "	61	64	65	65	64
% Humidity	53	47	55	55	62
TOTAL QUANTITIES:					
Oil Consumed lb.	4.16	4.54	3.15	3.16	2.32
Cooling Water	619	530	266	248.5	185.5
B.T.U./lb. Oil	20720				
INDICATOR DIAGRAMS:					
Pressures in lb. per Sq. in. above atmosphere					
Maximum pres.	293	289	304	310	305
Pres. at beginning of stroke:	293	289	304	310	285
At end of expansion:	40	39	40	40	45
Mean Effective Pressure	74.5	73.5	77.5	75.8	84.4

DATA AND RESULTS (C ontinued)

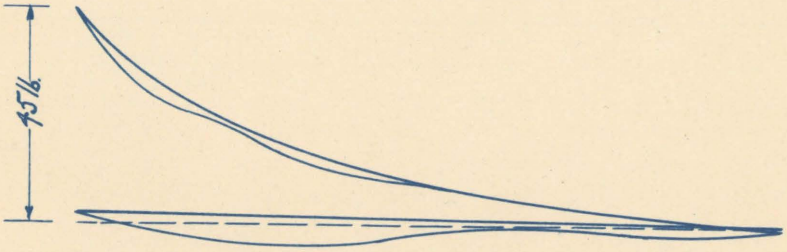
No.of Test	30	31	32	33	34
SPEED & EXPLOSIONS					
Rev.per minute	335	335	335	335	335
Average number Impulses/min.	151.3	153.6	76.3	75.5	45.8
POWER					
I.H.P.	5.6	5.59	2.93	2.83	1.93
D.H.P.	5	5	2	2	1
Friction H.P. by difference	.6	.59	.93	.83	.93
Mechanical Eff.	89.4	89.5	68.3	70.6	51.9
% I.H.P. lost in friction	10.7	10.56	31.8	29.4	48.1
ECONOMY RESULTS					
(51) B.T.U. Consumed per hr.	86200	94000			
(a) per I.H.P.	15390	16820			
(b) " D.H.P.	17230	18800			
lbs.Oil used per hour	4.16	4.54	3.15	3.16	2.32
Per I.H.P.	.74	.813	1.076	1.12	1.2
Per D.H.P.	.833	.907	1.576	1.58	2.32
EFFICIENCY					
Thermal Efficiency Ratio					
Per I.H.P.) x 100 for %	.165	.151			
Per D.H.P.)	.148	.135			
Work done per Heat Unit 1980000/Line 51 (b) (Foot pounds)	11.5	10.5			

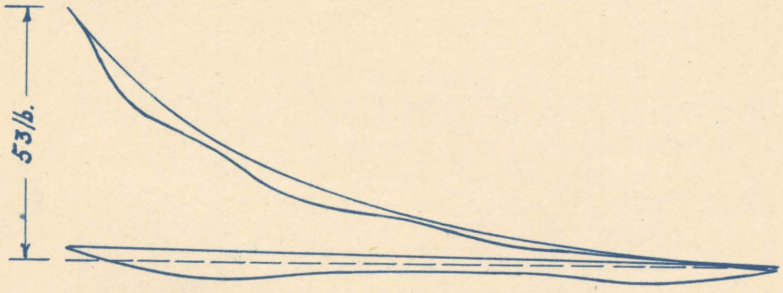
VIII

GRAPHICAL REPRESENTATION OF RESULTS

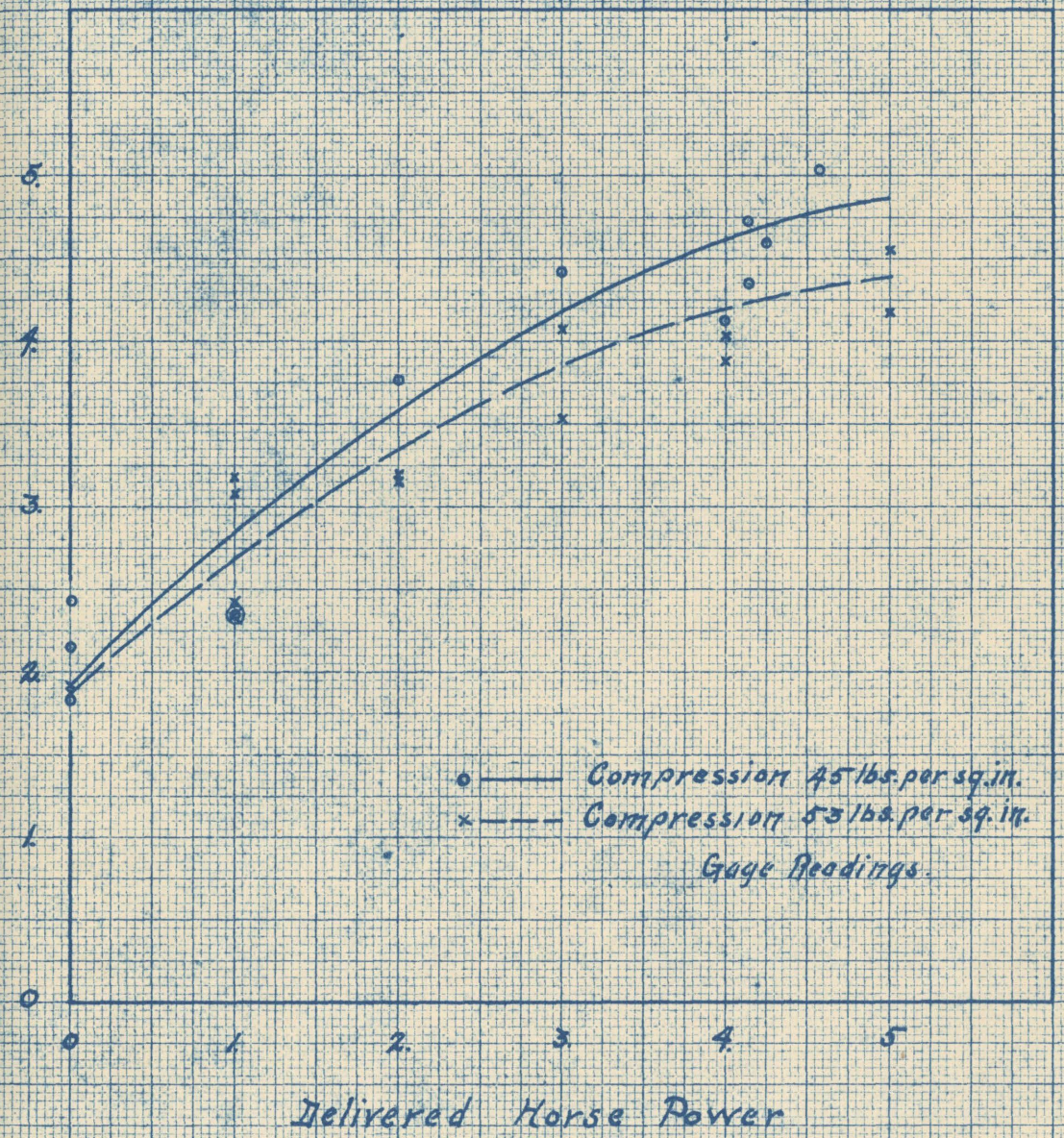
Compression Curves

Spring 40 lb. per in.



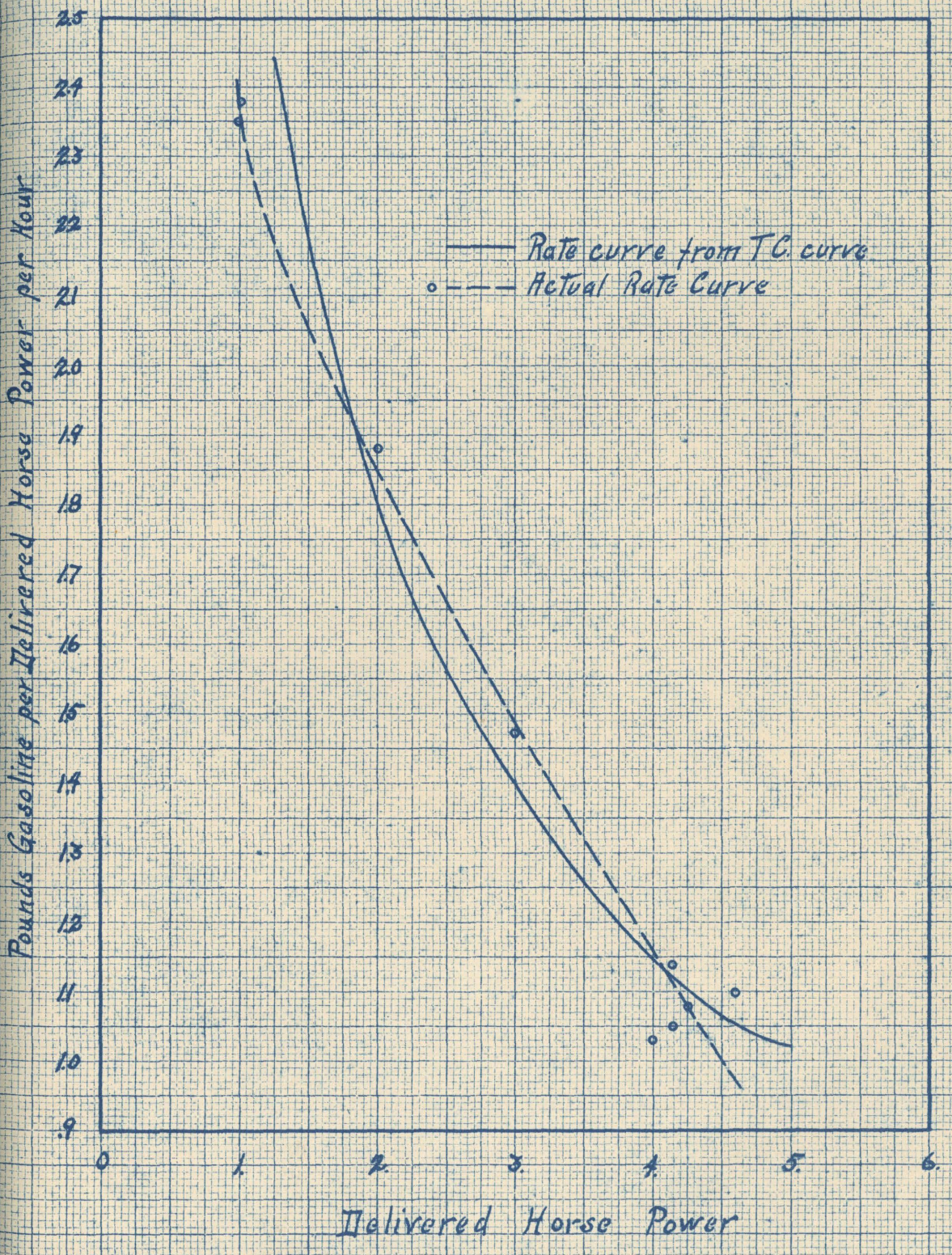


Total Consumption Curves

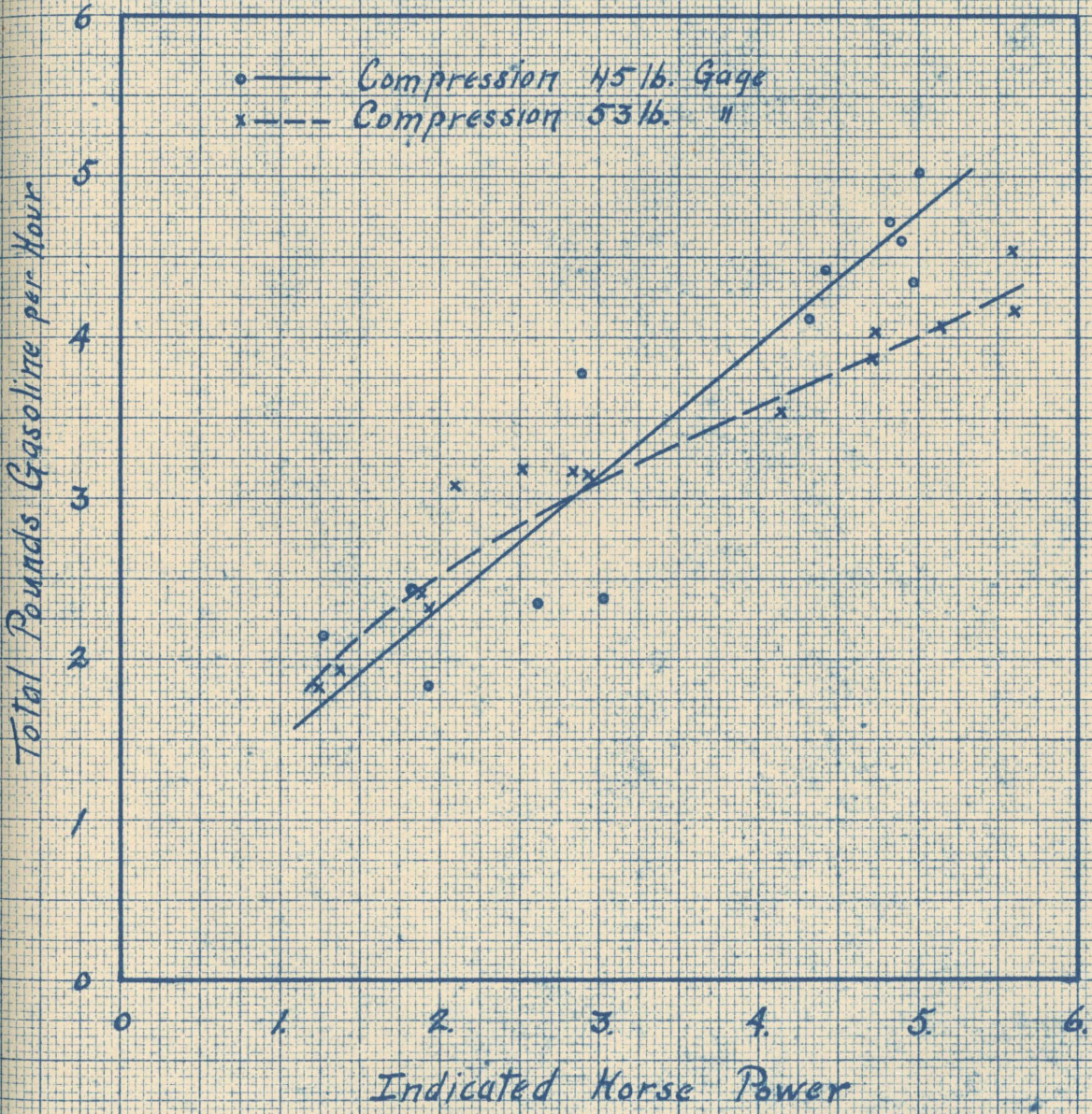


Rate Curves Based on Delivered Horse Power

Compression 45 lbs. Gage.



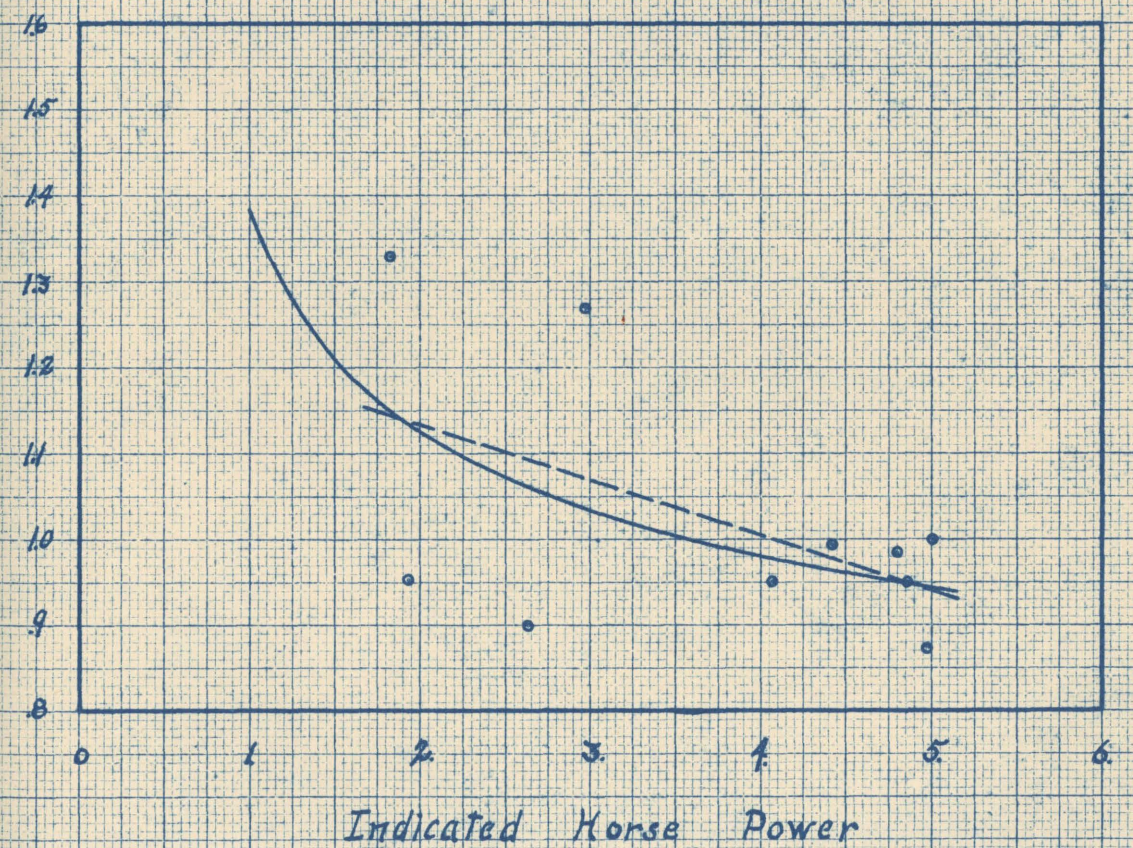
Total Consumption Curves Based on I.H.P.



Rate Curves Based on Indicated Horse Power:

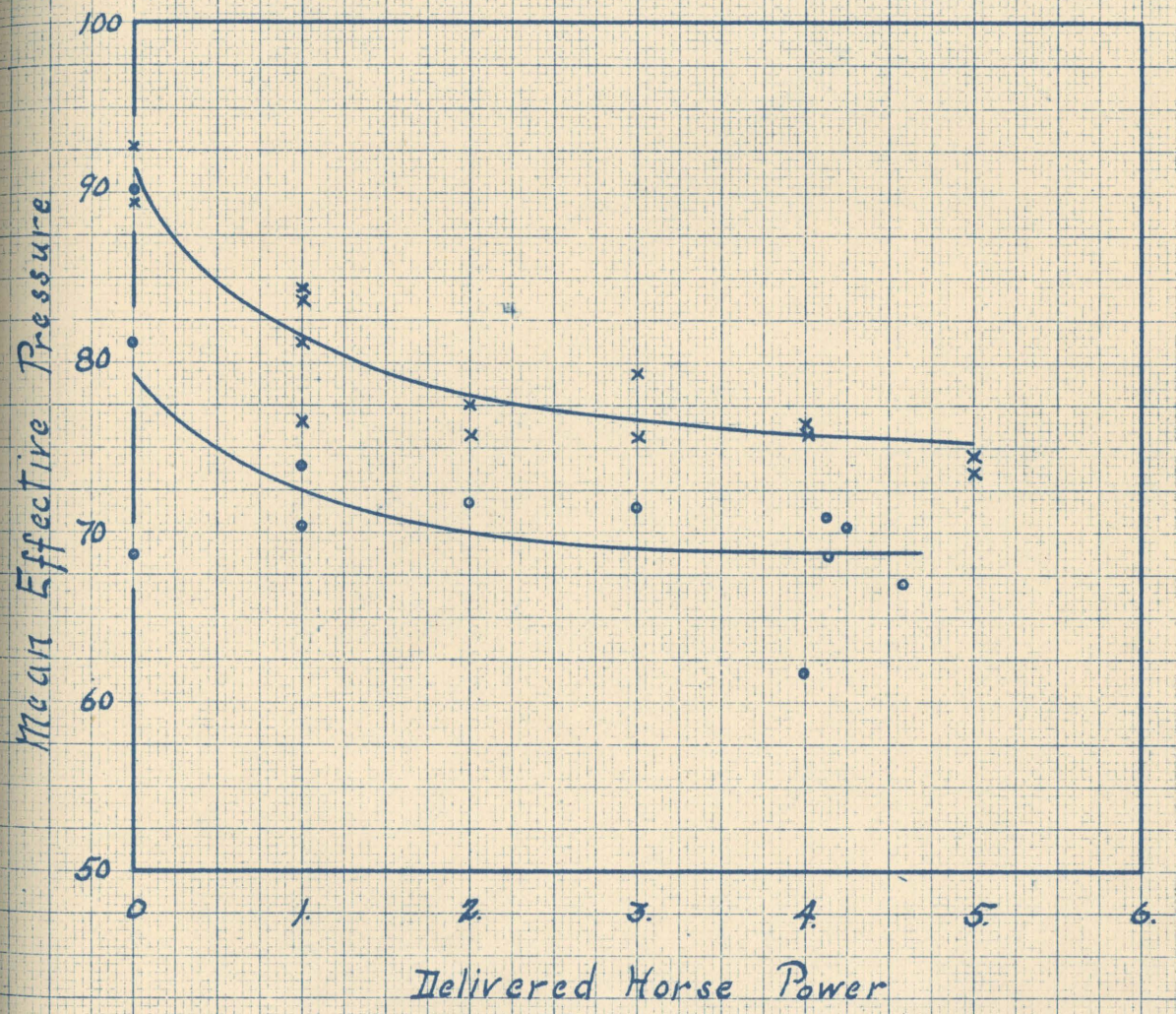
Compression 45 lbs. Gage.

——— Rate curve from T.C. curve.
o---- Actual Rate curve.



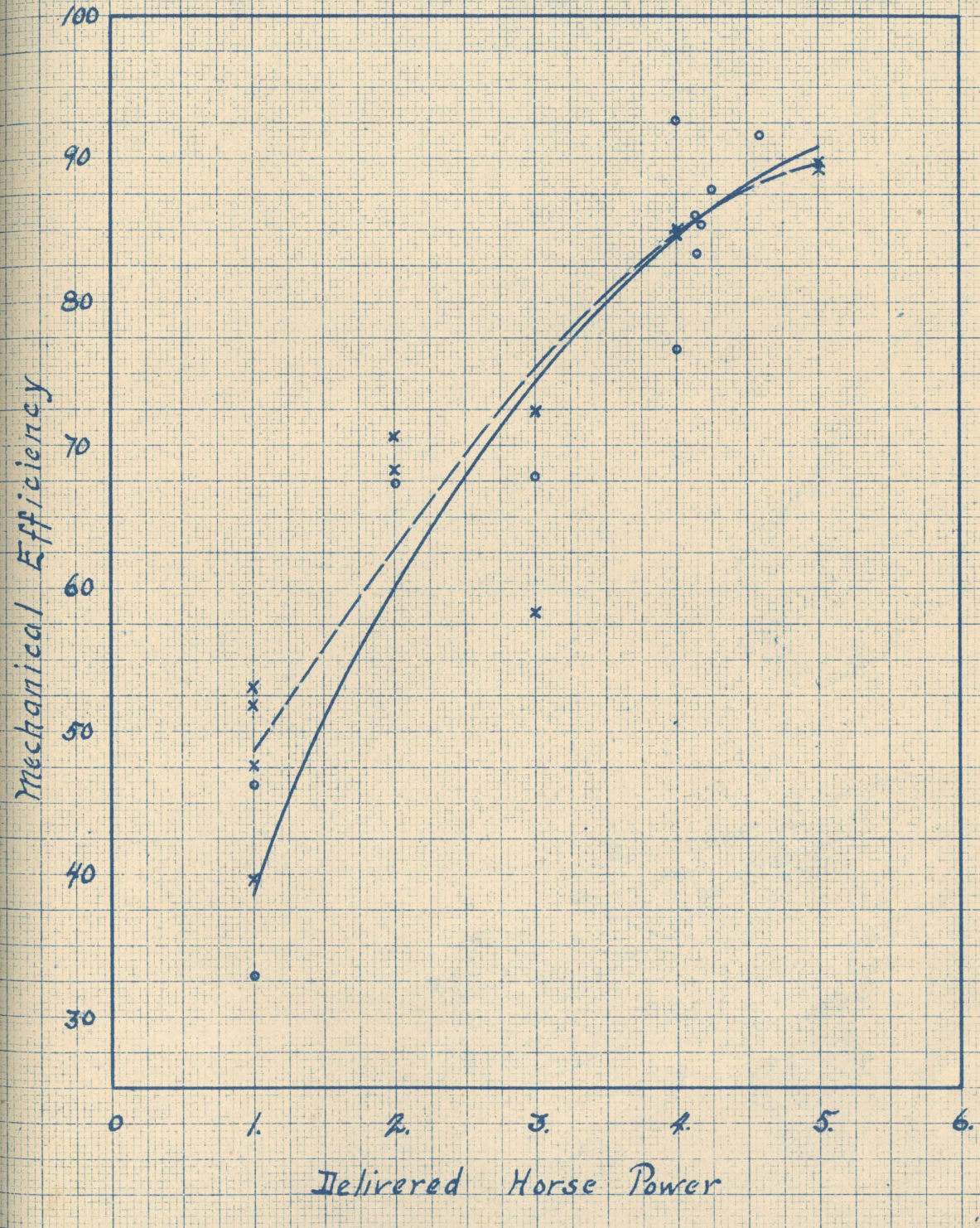
Mean Effective Pressure Curves

° At 45 lb. [gage] Compression
× At 53 lb. " "



Mechanical Efficiency Curves

o —— At 45 lb. (Gage) Compression
x – – – At 53 lb. " "

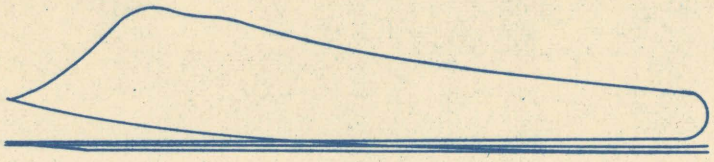


Indicator Cards

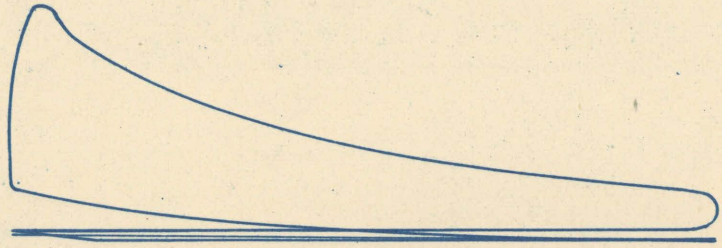
Showing Affect of Advancing Spark

Spring: 200 lb. per in.

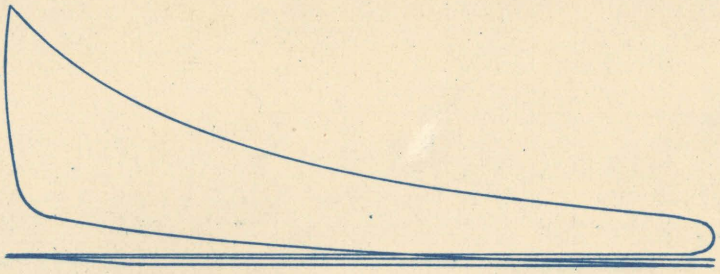
1.



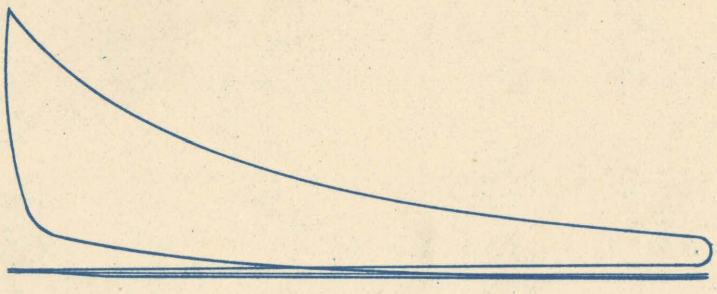
2.



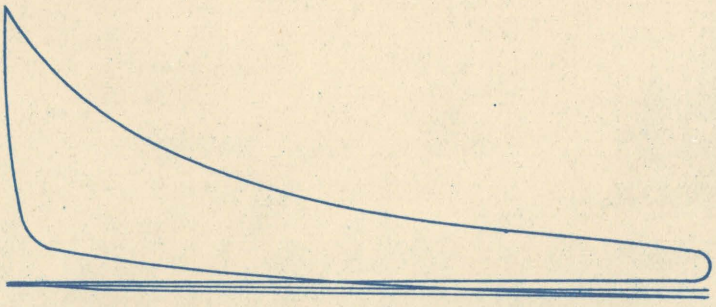
3.



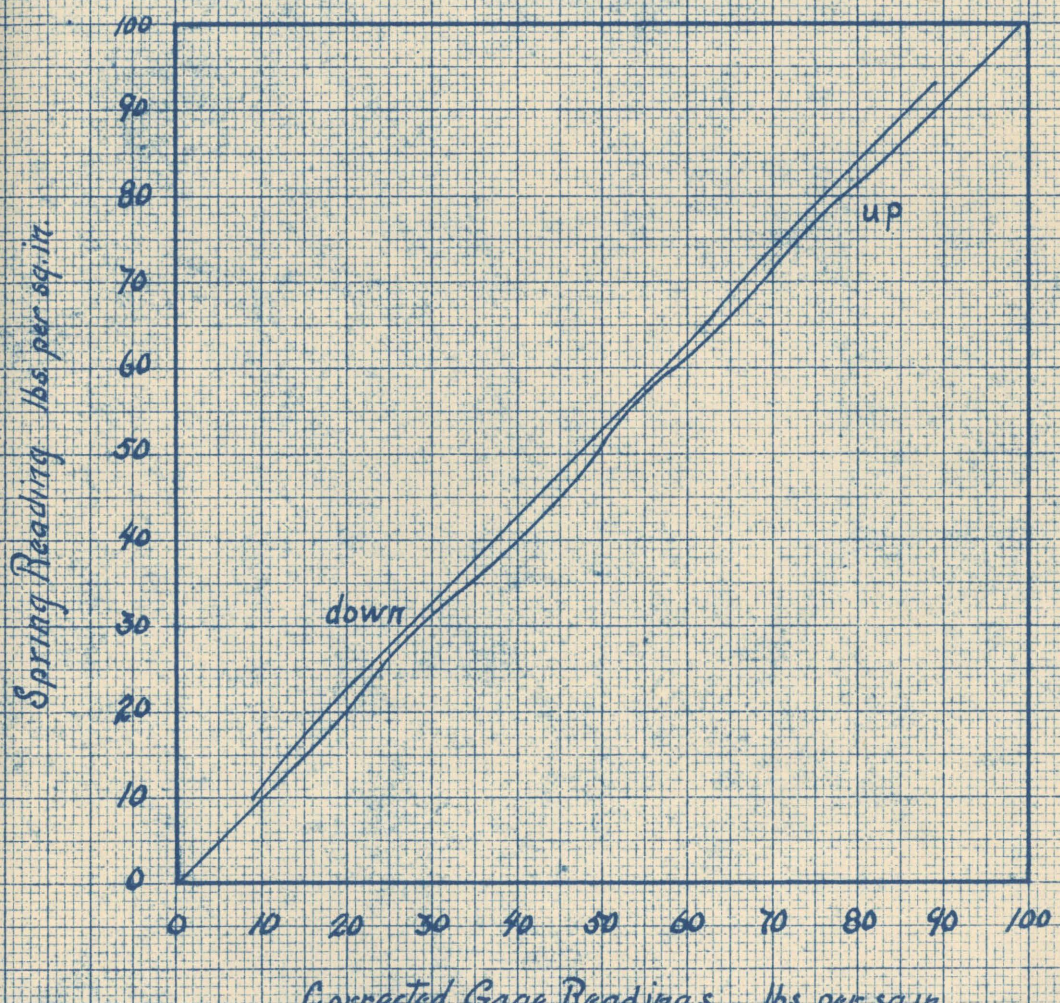
4.



5.



Calibration of 100 lb. Indicator Spring



Readings Doubled when used as Gas Engine Indicator Spring.

IX

ORIGINAL DATA

- TAKEN AS TESTS WERE MADE -

" " "" " "

Test numbers one to twenty inclusive were run on the engine with a compression pressure of 59.3 pounds per square inch absolute; and test numbers twenty-one to thirty-four inclusive were run with a compression pressure of 67.3 pounds per square inch absolute.

		(TEMPERATURES °F)				
No.	Time	In Cooler	Out Cooler	Exh. Gas From Eng.	Exh. Gas From Cooler	Cool. Water From Engine
1	10:45	57.5	79	170°C	63	104
2	50	"	78	"	"	105
3	55	"	"	160	62.5	104
4	11:00	"	79	170	62.5	106
5	05	57	80	"	63	"
6	10	57.5	76.5	"	62	101
7	15	"	78.5	140	"	103
8	20	58	82	130	63	110
9	25	59	85	"	64	112
10	30	57.5	86	"	"	"
11	35	58	87	"	"	115
12	40	60	89	120	65.9	119
13	45	"	91	"	67	122
Averages:		58	82.5	147°C	63.4	109

INDICATOR DIAGRAMS

	(PRESSURES)					
No.	Maximum.	Begin Strk.	End Expansion.	Length.	Area.	M.E.P.
1	308	268	50	3.73	1.66	
2	320	240	"	3.72	1.63	
3	300	224	"	3.72	1.68	
4	274	220	54	3.76	1.66	
5	320	280	"	3.72	1.55	
6	310	257	56	"	1.64	
7	274	174	50	"	1.8	
8	303	256	"	"	1.73	
9	278	240	52	"	1.76	
10	250	110	56	"	1.63	
11	268	214	58	"	1.76	
12	278	264	52	3.74	1.66	
13	280	264	54	"	1.68	
Aver.	290	232	52.5	3.73	1.68	90.1

Dry Bulb 66.3°F. Water Weights Full 583.5 lb.
Wet " Empty 171
% Humidity Net 412.5
Barometer
Rev. per min. 331 Gasoline " Start 4.43
Finish 1.99
Load 0 H.P. Net 2.44
Gross Pres. 0
Zero 12 Explosions Counter
Net 0 Finish 9663
Start 7202 Per min.
Net 2461 41

I.H.P. is $\frac{90.1 \times 10 \times 19.6 \times 41}{12 \times 33000} = 1.83$

		TEMPERATURES °F.				
		In	Out	Exh. Gas	Exh. Gas	Cool. Water
No.	Time	Cooler	Cooler	From Eng.	From Cooler	From Engine
1	2:25	59	98	310	68	145
2	30	60	102	290	70	151
3	35	62	105	280	73	156
4	40	60	102	290	72	149
5	45	"	101	"	71	142
6	50	"	96	"	70	128
7	55	59	87	280	66	118
8	3:00	"	83	"	65	114
9	05	58	"	"	66	"
10	10	"	86	"	64	123
11	15	62	95	"	68	138
12	20	63	99	"	70	144
13	25	62	101	"	72	145
Average:		51	95	292	69	136

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in.gage.)

No.	Maximum.	Begin Strk.	End Expansion.	Length.	Area.	M.E.P.
1	270	270	50	3.72	1.4	
2	280	280	45	"	1.55	
3	270	270	47	"	1.5	
4	280	280	50	"	1.54	
5	270	270	50	"	1.4	
6	260	260	"	"	1.38	
7	300	300	"	"	1.49	
8	280	280	"	3.73	1.57	
9	270	270	48	"	1.52	
10	255	255	50	"	1.57	
11	270	270	"	"	"	
12	300	300	"	"	1.61	
13						
Aver.	275	275	49	3.72	1.51	81.1

Dry Bulb 68° F. Water Weights: Full 216
Wet " 60 Empty 13
% Humidity 63 Net 203
Barometer "Hg 29.23
Rev. per min 338 Gasoline " Start 9.98 lb
Finish 7.83
Load in H.P. 0 Net 2.15 lb.
Gross Pres. 0
Zero 12 Explosion Counter: Finish 83832
Net 0 Start 81943 Per min
Net 1889 31.5

I.H.P. is :

$$\frac{81.1 \times 10 \times 196 \times 31.5}{12 \times 33000} = 1.269$$

(TEMPERATURES° F.)

No.	Time	H_2O In Cooler	H_2O out Cooler	Exh. Gas From Eng.	Exh. Gas From Cooler	Cool. Water From Engine
1	4:15	58	92	500	67	137
2	20	"	93	520	"	138
3	25	"	"	"	66	139
4	30	"	96	"	68	149
5	35	"	101	510	"	154
6	40	"	103	"	70	157
7	45	"	"	"	"	158
8	50	"	"	500	"	154
9	55	"	100	"	69	151
10	5:00	"	99	"	"	"
11	05	57	100	"	68	152
12	10	58	101	"	69	155
13	15	"	"	"	"	156
Average:		58	92	507	68	150

INDICATOR DIAGRAMS

(PRESSURES IN lb./sq. in. gage.)

No.	Maximum.	Begin Strk.	End Expansion.	Length.	Area.	M.E.P.
1	250	250	43	3.73	1.38	
2	250	"	"	3.72	1.19	
3	"	"	"	3.73	1.33	
4	"	"	47	3.74	1.36	
5	"	"	43	"	1.45	
6	260	260	"	"	1.49	
7	270	270	"	"	1.29	
8	250	250	"	"	1.23	
9	270	270	"	"	1.39	
10	280	280	40	"	"	
11	265	265	50	"	1.34	
12	275	275	43	"	1.32	
13	260	260	45	"	1.49	
Aver.	260	260	44	3.74	1.34	71.7

Dry Bulb 68° F.
Wet " 61
% Humidity 68
Barometer "Hg 29.23
Rev. per min 335

Load in H.P. 2
Gross Pres. 30.3 lb.
Zero 12
Net 18.3 lb.

Water Weights: Full 379.5 lb.
Empty 12.5
Net 367 lb.

Gasoline " Start 9.50 lb.
Finish 5.73
Net 3.77 lb.

Explosions: Finish 91341
Start 86314 Per min.
Net 5027 83.7

I.H.P. is:

$$\frac{71.7 \times 10 \times 19.6 \times 83.7}{12 \times 33000} = 2.98$$

		(TEMPERATURES °F.)				
		H_2O in	H_2O out	Exh. Gas	Exh. Gas	Cool. Water
No.	Time	Cooler	Cooler	From Eng.	From Cooler	From Engine
1	1:45	60	100	640	72	149
2	50	"	97	700	71	145
3	55	"	"	710	"	"
4	2:00	"	"	730	72	144
5	05	"	98	725	"	143
6	10	"	99	"	"	149
7	15	"	98	690	"	146
8	20	"	95	680	71	
9	25	"	94	630	"	138
10	30	"	92	625	70	135
11	35	"	93	"	71	"
12	40	"	92	620	70	132
13	45	"	91	"	"	"
Average:		60	96	670	71	141

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin Strk.	End Expansion.	Length.	Area.	M.E.P.
1	260	260	41	3.76	1.45	
2	275	260	45	"	"	
3	260	"	40	"	1.33	
4	250	240	"	"	1.35	
5	245	245	38	3.77	1.14	
6	250	250	40	"	1.28	
7	260	260	"	3.75	1.32	
8	240	240	42	3.72	1.43	
9	230	230	45	3.76	1.38	
10	"	"	42	3.74	1.46	
11	250	250	"	3.75	1.4	
12	255	255	40	"	1.24	
13	210	210	"	"	1.2	
Aver.	247	245	41	3.75	1.34	71.5

Dry Bulb 71° F. Water Weights: Full

Wet " 66 Empty

% Humidity 77 Net 610 lb.

Barometer "Hg. 29.17

Rev. per min. 335 Gasoline " Start 9.95

BRAKE READING Finish 5.54

Load in H.P. 3 Net 4.41 lb.

Gross Pres. 39.5

Zero 12 Explosions: Finish 107030

Net 27.5 lb. Start 99537 per min.

Net 7493 125

I.H.P. is:

$$\frac{71.5 \times 10 \times 19.6 \times 125}{12 \times 33000} = 4.42$$

(TEMPERATURES °F.)

No.	Time	H_2O in Cooler	H_2O out Cooler	Exh. Gas From Eng.	Exh. Gas From Cooler	Cool. Water From Engine
1	3:35	60	106	740	75	165
2	40	"	105	730	74	162
3	45	"	"	750	"	164
4	50	"	"	"	75	163
5	55	"	109	"	76	173
6	4:00	"	110	775	"	171
7	05	"	106	"	75	165
8	10	"	104	"	74	161
9	15	"	"	"	"	160
10	20	"	102	760	"	157
11	25	"	101	750	73	158
12	30	"	"	"	"	155
13	35	"	"	"	"	158
Average		60	104	756	74	162

INDICATOR DIAGRAMS

(PRESSURES in Lb./sq.in. gage.)

No.	Maximum.	Begin Strk.	End Expansion.	Length.	Area.	M.E.P.
1	240	240	36	3.76	1.75	
2	232	232	"	"	1.32	
3	232	"	40	3.75	1.54	
4	256	256	"	"	1.64	
5	232	232	"	"	1.79	
6	"	"	37	"	1.74	
7	235	235	34	3.76	1.32	
8	240	240	38	3.75	1.59	
9	"	"	40	"	1.37	
10	"	"	"	"	"	
11	234	234	"	"	1.65	
12	240	240	37	"	1.6	
13	232	232	40	"	1.66	
Aver.	237	237	38	3.75	1.57	67

Dry Bulb 74°F.
Wet Bulb 68
% Humidity 74
Barometer "Hg.
Rev. per min. 335

BRAKE READING
Load in H.P. 4.58
Gross Pres. 53
Zero 12
Net 41 lb.

Water Weights: Full
Empty
Net 549 lb.

Gasoline " Start 9.85
Finish 4.82
Net 5.03 lb.

Explosions: Finish 21682
Start 12610 per min.
Net 9072 151

I.H.P. is:

$$\frac{67 \times 10 \times 19.6 \times 151}{12 \times 33000} = 5$$

(T E M P E R A T U R E S ° F.)

No.	Time	H_2O in Cooler	H_2O out Cooler	Exh. Gas From Eng.	Exh. Gas From Cooler	Cool. Water From Engine
1	10:45	58	84	750	67	113
2	50	"	83	"	"	114
3	55	"	84	760	"	117
4	11:00	"	83	745	"	"
5	05	"	"	"	"	116
6	10	"	"	750	66	"
7	15	"	"	745	67	117
8	20	59	84	"	"	118
9	25	"	85	740	"	120
10	30	58	86	760	68	122
11	35	"	87	"	"	125
12	40	"	"	750	"	123
13	45	"	86	740	"	122
Average		58	85	749	67	118

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin Strk.	End Expansion.	Length.	Area.	M.E.P.
1	234	234	40	3.73	1.72	
2	243	243	43	3.75	1.6	
3	230	230	37	"	1.63	
4	234	234	40	"	1.51	
5	232	232	45	"	1.59	
6	220	220	40	3.76	1.55	
7	232	232	39	3.75	1.57	
8	240	240	40	"	1.56	
9	"	"	"	"	1.57	
10	230	230	"	"	1.66	
11	240	240	"	"	1.58	
12	224	224	"	"	1.8	
13	240	240	"	"	1.56	
Aver.	234	234	40	3.75	1.61	68.6

Dry Bulb 67°F.
Wet " 60
% Humidity 67
Barometer "Hg. 29.17
Rev. per min. 335

BRAKE READING
Load in H.P. 4.14
Gross Pres. 50
Zero 12
Net 38 lb.

Water Weights: Full 1013
Empty 50
Net 963 lb.

Gasoline " Start 9.98
Finish 5.33
Net 4.35 lb.

Explosions: Finish 39263
Start 30513
Net 8750 per min. 146

I.H.P. is:

$$\frac{68.6 \times 10 \times 19.6 \times 146}{12 \times 33000} = 4.96$$

(T E M P E R A T U R E S °F.)

No.	Time	H_2O in Cooler	H_2O out Cooler	Exh. Gas From Eng.	Exh. Gas From Cooler	Cool. Water From Engine
1	2:00	57	119	740	75	179
2	05	"	117	730	"	175
3	10	"	116	725	74	173
4	15	"	118	"	75	"
5	20	"	117	745	"	172
6	25	"	120	"	76	179
7	30	"	113	"	77	186
8	35	58	118	"	79	196
9	40	"	"	"	80	194
10	45	57	109	720	76	178
11	50	"	107	715	75	174
12	55	"	109	725	76	180
13	3:00	58	112	750	77	184
Average		57	115	736	76	180

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin Strk.	End Expansion.	Length.	Area.	M.E.P.
1	272	235	40	3.76	1.65	
2	268	232	"	3.75	1.6	
3	278	232	"	"	1.63	
4	280	220	42	"	1.77	
5	265	232	40	"	1.71	
6	280	220	"	"	1.69	
7	276	228	42	"	1.92	
8	296	240	40	"n	1.57	
9	241	220	42	"	1.64	
10	260	224	40	3.74	1.51	
11	300	268	"	3.75	1.68	
12	280	230	"	"	1.51	
13	264	244	"	"	1.56	
Aver.	274	233	40	3.75	1.65	70.4

Dry Bulb 77°F. Water Weights: Full 440.5
Wet " 63 Empty 18.5
% Humidity 45 Net 422 lb.
Barometer "Hg. 29.54
Rev. per min. 335 Gasoline " Start 9.92
BRAKE READING Finish 5.32
Load in H.P. 4.25 Net 4.6 lb.
Gross Pres. 51
Zero 12
Net 39 lb. Explosions: Finish
Start per min.
Net 8342 139

I.H.P. is:

$$\frac{70.4 \times 10 \times 19.6 \times 139}{12 \times 33000} = 4.84$$

(TEMPERATURES °F.)

No.	Time.	H_2O in Cooler.	H_2O out Cooler.	Exh. Gas From Eng.	Exh. Gas from Cooler.	Cool. Water From Engine
1	2:30	60	114	710	79	188
2	35	"	113	"	"	185
3	40	"	"	700	"	186
4	45	"	117	"	77	170
5	50	61	"	"	76	172
6	55	59	109	"	78	178
7	3:00	60	111	"	"	181
8	05	"	112	"	"	185
9	10	59	114	"	79	190
10	15	"	108	"	77	170
11	20	"	103	"	75	164
12	25	58	"	"	75	166
13	30	59	104	"	"	168
Average		59	111	701	77	177

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin Strk.	End Expansion.	Length.	Area.	M.E.P.
1	250	250	38	3.77	1.24	
2	240	225	40	3.75	1.29	
3	250	250	"	"	1.34	
4	250	230	38	"	1.35	
5	"	250	42	"	1.36	
6	248	248	38	"	1.3	
7	250	250	41	"	1.38	
8	270	240	42	"	1.23	
9	240	240	"	3.76	1.35	
10	245	245	38	3.75	1.3	
11	250	250	40	3.76	1.33	
12	240	240	"	3.75	1.37	
13	250	250	41	3.76	1.4	
Aver.	249	244	40	3.75	1.33	71

Dry Bulb 78°F.
Wet " 63
% Humidity 43
Barometer"Hg. 29.44
Rev.per min. 335

BRAKE READING
Load in H.P. 4.14
Gross Pres. 50
Zero 12
Net 38 lb.

Water Weights: Full 477.5
Empty 30
Net 447.5 lb.

Gasoline " Start 9.71
Finish 4.98
Net 4.73 lb.

Explosions: Finish 86999
Start 78788
Net 8211 per min. 137

I.H.P. is:

$$\frac{71 \times 10 \times 19.6 \times 137}{12 \times 33000} = 4.81$$

		(- - - - TEMPERATURES °F. - - - -)				
		H_2O in	H_2O out	Exh. Gas	Exh. Gas	Cool. Water
No.	Time.	Cooler.	Cooler.	From Eng.	from Cooler.	from Engine
1	1:50	63	121	500	85	200
2	55	62	"	475	"	196
3	2:00	"	120	450	84	190
4	05	64	122	425	86	196
5	10	"	124	450	88	200
6	15	62	122	"	87	190
7	20	"	121	465	85	196
8	25	"	117	450	83	190
9	30	63	121	435	85	188
10	35	64	"	430	87	193
11	40	63	"	425	86	190
12	45	64	122	450	87	190
13	50	"	"	"	88	192
Average		63	121	450	86	193

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin Strk.	End Expansion.	Length.	Area.	M.E.P.
1	260	260	45	3.75	1.59	
2	232	232	40	"	1.42	
3	228	228	"	"	1.26	
4	262	262	45	"	1.45	
5	250	250	48	"	"	
6	240	240	42	"	1.18	
7	245	245	40	"	1.27	
8	235	235	"	"	1.17	
9	240	240	"	"	1.26	
10	225	225	38	"	1.27	
11	232	232	40	"	1.24	
12	230	230	"	"	1.16	
13	248	248	50	"	1.41	
Aver.	241	241	44	3.75	1.32	70.3

Dry Bulb 86°F.
Wet " 70
% Humidity 44
Barometer "Hg. 29.34
Rev. per min. 335

BRAKE READING
Load in H.P. 1
Gross Pres. 21.15
Zero 12
Net 9.15 lb.

Water Weights: Full 189
Empty 16.5
Net 172.5 lb.

Gasoline " Start 9.75
Finish 7.40
Net 2.35 lb.

Explosions: Finish 103201
Start 98712
Net 4489 per min. 75

I.H.P. is:

$$\frac{70.3 \times 10 \times 19.6 \times 75}{12 \times 33000} = 2.61$$

		(- - - - TEMPERATURES °F. - - - -)				
		H_2O in	H_2O out	Exh. Gas	Exh. Gas	Cool. Water
No.	Time.	Cooler.	Cooler.	from Eng.	from Cooler.	from Engine
1	3:20	61	136	715	92	210
2	25	"	117	725	82	218
3	30	62	120	"	84	210
4	35	"	127	"	89	208
5	40	61	123	"	85	209
6	45	62	129	"	90	210
7	50	61	128	"	88	"
8	55	"	127	"	87	"
9	4:00	"	128	"	88	"
10	05	"	130	735	"	"
11	10	"	131	"	89	"
12	15	"	"	"	"	"
13	20	"	"	"	"	"
Average		61	128	723	88	210

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	230	230	38	3.75	1.08	
2	240	240	38	"	1.1	
3	250	250	37	"	1.04	
4	250	250	38	"	1.25	
5	230	230	35	"	1.20	
6	240	240	38	"	1.11	
7	240	240	"	"	1.08	
8	"	"	"	"	1	
9	242	242	"	"	1.25	
10	240	240	40	"	1.3	
11	250	250	38	"	1.2	
12	"	"	40	"	1.28	
13	"	"	38	"	1.23	
Aver.	240	240	38	3.75	1.16	61.9

Dry Bulb 88° F. Water Weights: Full 347
Wet " 70 Empty 26.75
% Humidity 39 Net 320.25 lb.
Barometer "Hg. 29.34
Rev. per min 335 Gasoline " Start 9.93
BRAKE READING Finish 5.81
Load in H.P. 4 Net 4.12 lb.
Gross Pres. 48.6
Zero 12 Explosions: Finish 15217
Net 36.6 lb. Start 6777 per min.
Net 8440 141

I.H.P. is:

$$\frac{61.9 \times 10 \times 19.6 \times 141}{12 \times 33000} = 4.32$$

		(- - - - TEMPERATURES °F. - - - -)				
		H_2O in	H_2O out	Exh. Gas	Exh. Gas	Cool. Water
No.	Time.	Cooler.	Cooler.	from Eng.	from Cooler.	from Engine
1	1:50	63	97	350	73	138
2	55	62	98	"	"	"
3	2:00	"	99	345	"	142
4	05n	"	101	"	74	146
5	10	"	"	330	"	147
6	15	"	100	320	"	142
7	20	"	"	310	73	144
8	25	"	101	"	74	147
9	30	"	"	"	75	142
10	35	"	100	"	73	138
11	40	"	102	"	74	144
12	45	"	104	340	76	147
13	50	"	108	325	78	153
Average		62	102	327	74	143

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area	M.E.P.
1	200	100	43	3.75	1.38	
2	240	240	48	3.76	1.39	
3	180	180	40	"	1.22	
4	150	150	45	"	1.23	
5	190	190	"	3.74	1.24	
6	180	60	50	3.76	1.38	
7	210	210	48	"	1.25	
8	230	230	45	"	1.3	
9	210	210	48	"	1.2	
10	180	50	52	"	1.54	
11	200	200	50	"	1.24	
12	190	190	45	"	1.23	
13	160	160	"	"	1.29	
Aver.	194	167	46	3.76	1.29	68.6

Dry Bulb 74°F.
Wet " 65
% Humidity 62
Barometer"Hg. 29.3
Rev.per min. 335

BRAKE READING
Load in H.P. 0
Gross Pres. 0
Zero 12
Net 0

Water Weights: Full 203
Empty 30
Net 173 lb.

Gasoline " Start 9.66
Finish 7.82
Net 1.84 lb.

Explosions: Finish 20496
Start 17073
Net 3423 Per min. 57

I.H.P. is :

$$\frac{68.6 \times 10 \times 19.6 \times 57}{12 \times 33000} = 1.93$$

Test No. 20 Mch. 11, 1914. Mayer Carburetor used.

(- - - - TEMPERATURES °F. - - - -)

No.	Time.	H_2O in Cooler.	H_2O out Cooler.	Exh. Gas from Eng.	Exh. Gas from Cooler.	Cool. Water from Engine
1	2:55	62	104	400	76	136
2	3:00	"	"	"	"	144
3	05	"	105	"	"	152
4	10	61	106	420	"	158
5	15	"	108	445	77	168
6	20	62	"	425	"	172
7	25	61	107	420	76	169
8	30	"	106	"	"	167
9	35	"	105	410	"	164
10	40	62	"	"	75	163
11	45	61	"	"	"	"
12	50	62	"	"	76	160
13	55	"	"	"	"	"
Average		62	106	414	76	165

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	200	140	48	3.76	1.39	
2	"	150	45	"	1.28	
3	230	230	40	"	"	
4	215	75	45	"	1.39	
5	210	210	42	"	1.5	
6	205	190	"	"	1.49	
7	230	220	46	"	1.45	
8	"	230	"	"	1.41	
9	"	"	45	"	1.47	
10	220	170	"	"	1.43	
11	190	190	"	"	1.37	
12	210	150	"	"	1.30	
13	240	200	"	"	1.36	
Aver.	216	183	45	3.76	1.39	74

Dry Bulb 76° F.
Wet Bulb 67
% Humidity 63
Barometer "Hg. 29.33
Rev. per min. 335

BRAKE READING
Load in H.P. 1
Gross Pres. 21.15
Zero 12
Net 9.15 lb.

Water Weights: Full 321
Empty 95.5
Net 225.5 lb.

Gasoline " Start 9.69
Finish 7.31
Net 2.38

Explosions: Finish 33116
Start 28132
Net 4984 per min. 83.2

I.H.P. is:

$$\frac{74 \times 10 \times 19.6 \times 83.2}{12 \times 33000} = 3.05$$

COMPRESSION OF 53 lb./sq.in.gage STARTS HERE

Test No. 21 Mch. 25, 1914

		(- - - - TEMPERATURES °F. - - - -)				
		H_2O in	H_2O out	Exh.Gas	Exh.Gas	Cool. Water
No.	Time.	Cooler.	Cooler.	from Eng.	from Cooler.	from Engine
1	1:05	62	84	240	67	108
2	10	"	"	"	"	"
3	15	"	85	"	66	111
4	20	63	88	"	67	119
5	25	64	92	"	68	125
6	30	"	95	230	70	130
7	35	"	"	"	"	125
8	40	"	"	240	"	124
9	45	"	94	"	"	"
10	50	63	93	"	69	122
11	55	"	92	"	70	121
12	2:00	"	91	"	68	"
13	05	"	"	"	69	122
Average		63	91	240	69	120

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	330	270	50	3.75	1.79	
2	320	280	"	3.76	1.71	
3	310	210	"	"	1.77	
4	300	130	"	"	1.72	
5	310	220	"	"	1.75	
6	290	110	"	"	1.83	
7	315	240	"	"	1.66	
8	320	320	"	"	1.76	
9	300	300	"	"	1.7	
10	310	240	"	"	"	
11	290	230	"	"	1.85	
12	290	180	52	"	1.72	
13	325	270	50	"	1.73	
Aver.	308	231	50	3.76	1.74	92.6

Dry Bulb 69° F.
Wet " 58
% Humidity 58
Barometer "Hg. 29.2
Rev. per min. 335

BRAKE READING
Load in H.P. 0
Gross Pres. 0
Zero 12
Net 0

Water Weights: Full 215.5
Empty 26.5
Net 189 lb.

Gasoline " Start 9.68
Finish 7.86
Net 1.82 lb.

Explosions: Finish 35591
Start 33953
Net 1638 per min. 27.3

I.H.P. is:

$$\frac{92.6 \times 10 \times 19.6 \times 27.3}{12 \times 33000} = 1.24$$

(- - - - TEMPERATURES °F. - - - -)

No.	Time.	H_2O in Cooler.	H_2O out Cooler.	Exh. Gas from Eng.	Exh. Gas from Cooler.	Cool. Water from Engine
1	2:20	63	90	250	69	117
2	25	"	88	"	68	116
3	30	"	92	260	69	128
4	35	65	95	"	70	134
5	40	64	98	270	71	137
6	45	63	91	"	69	119
7	50	64	86	260	68	114
8	55	63	86	250	67	116
9	3:00	64	91	"	68	127
10	05	65	94	"	70	134
11	10	66	91	"	69	120
12	15	65	88	"	"	115
13	20	"	87	"	"	114
Average		64	91	255	69	122

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	320	260	48	3.76	1.63	
2	315	270	50	"	1.69	
3	310	310	48	"	1.56	
4	305	215	50	"	1.77	
5	320	270	"	3.75	1.68	
6	310	310	"	3.76	1.66	
7	310	220	"	"	1.77	
8	315	285	"	"	1.67	
9	320	265	48	"	1.7	
10	300	240	52	"	1.62	
11	290	190	50	"	1.63	
12	330	330	47	"	1.63	
13	325	240	45	3.78	1.66	
Aver.	313	262	49	3.76	1.68	89.4

Dry Bulb 69°F.
Wet " 58
% Humidity 58
Barometer "Hg. 29.2
Rev. per min. 335

BRAKE READING
Load in H.P. 0
Gross Pres. 0
Zero 12
Net 0

Water Weights: Full 257
Empty 26.5
Net 230.5 lb.

Gasoline " Start 9.14
Finish 7.22
Net 1.92 lb.

Explosions: Finish 37898
Start 36030
Net 1868 per min. 31.1

I.H.P. is:

$$\frac{89.4 \times 10 \times 19.6 \times 31.1}{12 \times 33000} = 1.375$$

(- - - - T E M P E R A T U R E S °F. - - - -)

No.	Time.	H_2O in Cooler.	H_2O out Cooler.	Exh. Gas from Eng.	Exh. Gas from Cooler.	Cool. Water from Engine
1	1:45	62	79	400	66	102
2	50	"	81	"	"	108
3	55	"	84	385	67	113
4	2:00	"	85	375	"	114
5	05	"	84	"	"	113
6	10	"	"	370	66	112
7	15	"	"	"	"	111
8	20	"	"	360	"	"
9	25	63	"	"	"	112
10	30	"	85	"	"	"
11	35	"	84	"	67	"
12	40	"	"	350	"	110
13	45	"	"	"	"	"
Average		62	84	370	66	110

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	310	260	45	3.76	1.6	
2	320	270	42	"	1.49	
3	300	300	"	"	1.59	
4	315	315	45	"	1.55	
5	320	320	41	"	1.53	
6	"	"	"	"	1.58	
7	"	280	42	"	1.46	
8	305	"	"	"	1.75	
9	320	320	"	"	1.7	
10	290	210	45	"	1.51	
11	300	175	"	"	1.62	
12	325	325	41	"	1.53	
13	300	300	"	"	1.51	
Aver.	311	283	43	3.76	1.57	83.6

Dry Bulb 67°F.
Wet " 59
% Humidity 62
Barometer"Hg. 29.2
Rev.per min. 335

BRAKE READING
Load in H.P. 1
Gross Pres. 21.15
Zero 12
Net 9.15 lb.

Water Weights: Full 477
Empty 30
Net 447 lb.

Gasoline " Start 9.71
Finish 6.53
Net 3.18

Explosions: Finish 43653
Start 39997
Net 3656 per min.
60.8

I.H.P. is:

$$\frac{83.6 \times 10 \times 19.6 \times 60.8}{12 \times 33000} = 2.52$$

(- - - - TEMPERATURES °F. - - - -)

No.	Time.	H_2O in Cooler.	H_2O out Cooler.	Exh. Gas from Eng.	Exh. Gas from Cooler.	Cool. Water from Engine
1	1:15	62	99	350	72	133
2	20	63	"	"	71	140
3	25	65	87	"	73	157
4	30	"	111	"	75	140
5	35	63	102	"	73	140
6	40	"	103	"	72	148
7	45	64	109	"	73	162
8	50	65	113	"	75	168
9	55	63	108	"	74	155
10	2:00	64	109	"	"	157
11	05	"	111	"	"	164
12	10	63	108	"	"	156
13	15	"	107	"	"	154
Average		64	105	350	73	152

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.-)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	280	280	45	3.76	1.38	
2	310	"	"	"	1.45	
3	"	310	"	"	1.54	
4	275	275	"	"	1.4	
5	320	320	48	"	1.51	
6	300	300	"	"	1.58	
7	280	220	45	"	1.45	
8	325	325	"	"	"	
9	350	350	38	"	1.42	
10	300	300	42	"	1.45	
11	260	230	"	"	1.36	
12	275	190	"	"	1.39	
13	300	300	"	"	1.32	
Aver.	299	283	44	3.76	1.44	76.6

Dry Bulb 74°F.
Wet " 63
% Humidity 54
Barometer "Hg. 29.2
Rev. per min. 335

BRAKE READING
Load in H.P. 1
Gross Pres. 21.15
Zero 12
Net 9.15 lb.

Water Weights: Full 190
Empty 16.5
Net 173.5 lb.

Gasoline " Start 10
Finish 7.59
Net 2.41 lb.

Explosions: Finish 47804
Start 44868
Net 2936 per min. 48.8

I.H.P. is:

$$\frac{76.6 \times 10 \times 19.6 \times 48.8}{12 \times 33000} = 1.89$$

(- - - - TEMPERATURES °F. - - - -)

No.	Time.	H_2O in Cooler.	H_2O out Cooler.	Exh. Gas from Eng.	Exh. Gas from Cooler.	Cool. Water from Engine
1	2:35	62	103	350	74	155
2	40	"	"	"	73	"
3	45	64	108	"	74	166
4	50	"	110	360	75	169
5	55	62	107	"	74	157
6	3:00	"	105	"	73	152
7	05	"	104	"	"	156
8	10	63	107	"	74	162
9	15	"	109	"	75	166
10	20	"	108	"	74	160
11	25	62	107	"	"	158
12	30	63	106	"	"	156
13	35	62	105	"	73	155
Average		63	106	358	74	159

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	280	280	42	3.77	1.48	
2	285	285	"	"	1.53	
3	"	"	"	3.76	1.4	
4	310	310	45	3.77	1.68	
5	300	300	42	"	1.51	
6	310	310	45	"	1.55	
7	290	290	"	"	1.43	
8	300	300	48	"	1.62	
9	310	260	45	"	1.61	
10	"	310	"	"	1.57	
11	280	280	"	"	1.44	
12	295	295	"	"	1.42	
13	310	310	"	"	1.68	
Aver.	297	293	44	3.77	1.53	81.1

Dry Bulb 74°F.
Wet " 63
% Humidity 54
Barometer "Hg. 29.12
Rev. per min. 335

BRAKE READING
Load in H.P. 1
Gross Pres. 21.15
Zero 12
Net 9.15 lb.

Water Weights: Full 200
Empty 16
Net 184 lb.

Gasoline " Start 9.81
Finish 6.74
Net 3.07 lb.

Explosions: Finish 52263
Start 49118
Net 3145 per min. 52.4

I.H.P. is:

$$\frac{81.1 \times 10 \times 19.6 \times 52.4}{12 \times 33000} = 2.1$$

		(- - - - TEMPERATURES °F. - - - -)				
		H_2O in	H_2O out	Exh. Gas	Exh. Gas	Cool. Water
No.	Time.	Cooler.	Cooler.	from Eng.	from Cooler.	from Engine
1	11:00	58	87	480	68	118
2	05	59	89	580	"	124
3	10	"	91	660	"	135
4	15	"	89	670	"	130
5	20	"	"	675	"	"
6	25	"	"	700	"	132
7	30	60	91	720	69	126
8	35	"	89	"	"	133
9	40	"	88	"	"	132
10	45	"	89	"	"	"
11	50	"	88	700	"	130
12	55	"	"	680	"	129
13	12:00	"	87	685	"	"
Average		60	88	670	69	129

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	300	300	45	3.76	1.56	
2	290	290	41	"	1.48	
3	280	280	"	"	1.4	
4	285	285	"	3.77	1.32	
5	280	280	"	3.75	1.49	
6	300	300	40	3.76	1.4	
7	280	280	"	"	1.41	
8	"	"	"	"	1.43	
9	270	270	38	"	1.44	
10	290	290	"	"	1.46	
11	285	285	"	3.77	1.38	
12	275	275	40	"	1.33	
13	280	280	"	3.76	1.36	
Aver.	283	283	40	3.76	1.42	75.6

Dry Bulb 68°F. Water Weights: Full 749.5
Wet " 59 Empty 33
% Humidity 58 Net 716.5 lb.
Barometer "Hg. 29.36
Rev. per min. 335 Gasoline " Start 10
BRAKE READING Finish 5.94
Load in H.P. 3 Net 4.06 lb.
Gross Pres. 39.5
Zero 12 Explosions: Finish 62687
Net 27.5 lb. Start 54461 per min.
Net 8226 137

I.H.P. is:

$$\frac{75.6 \times 10 \times 19.6 \times 137}{12 \times 33000} = 5.14$$

(- - - - TEMPERATURES °F. - - - -)

No.	Time.	H_2O in Cooler.	H_2O out Cooler.	Exh. Gas from Eng.	Exh. Gas from Cooler.	Cool. Water from Engine
1	12:20	60	102	650	72	164
2	25	"	103	630	73	154
3	30	"	96	580	71	170
4	35	"	102	575	72	168
5	40	"	106	560	74	173
6	45	"	108	"	"	176
7	50	"	109	550	75	178
8	55	"	"	"	"	179
9	1:00	"	108	"	"	173
10	05	"	106	"	74	172
11	10	"	"	"	"	171
12	15	"	105	"	"	169
13	20	"	"	"	"	"
Average		60	105	570	74	157

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	280	280	40	3.77	1.4	
2	300	300	"	"	1.32	
3	290	290	"	"	"	
4	310	310	45	"	1.51	
5	300	300	"	"	1.48	
6	320	320	40	"	1.58	
7	290	290	45	"	1.51	
8	"	"	"	3.76	1.48	
9	300	300	40	"	1.49	
10	280	280	42	"	1.42	
11	310	310	38	"	1.49	
12	280	280	"	3.77	1.47	
13	290	290	40	"	1.45	
Aver.	296	296	41	3.77	1.49	79.4

Dry Bulb 74°F. Water Weights: Full 365
Wet " 62 Empty 16.5
% Humidity 51 Net 348.5 lb.
Barometer "Hg. 29.36
Rev. per min. 335 Gasoline " Start 10
BRAKE READING Finish 6.47
Load in H.P. 3 Net 3.53 lb.
Gross Pres. 39.5
Zero 12 Explosions: Finish 70128
Net 27.5 lb. Start 63806 per min.
Net 6322 105.4

I.H.P. is:

$$\frac{79.4 \times 10 \times 19.6 \times 105.4}{12 \times 33000} = 4.14$$

(- - - - TEMPERATURES °F. - - - -)

No.	Time.	H_2O in Cooler.	H_2O out Cooler.	Exh. Gas from Eng.	Exh. Gas from Cooler.	Cool. Water from Engine
1	1:50	60	115	660	78	182
2	55	"	110	"	76	174
3	2:00	"	103	"	74	162
4	05	"	105	650	"	170
5	10	"	106	"	"	"
6	15	"	107	"	75	172
7	20	"	"	"	"	173
8	25	"	108	"	76	172
9	30	62	109	"	"	178
10	35	61	"	"	"	"
11	40	60	108	"	"	171
12	45	"	106	"	75	169
13	50	"	"	"	"	171
Average		60	107	652	75	172

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	300	300	40	3.77	1.34	
2	290	290	"	"	1.43	
3	"	"	"	"	1.36	
4	310	310	"	"	1.45	
5	300	300	"	"	1.47	
6	310	310	"	"	"	
7	"	"	"	"	1.48	
8	"	"	"	"	1.38	
9	290	290	"	"	1.46	
10	"	"	"	"	1.35	
11	"	"	"	"	1.45	
12	"	"	"	3.78	1.46	
13	300	300	"	"	"	
Aver.	297	297	40	3.77	1.43	75.8

Dry Bulb 76°F. Water Weights: Full 225.5
Wet " 63 Empty 16.5
% Humidity 47 Net 209 lb.
Barometer "Hg. 29.36
Rev. per min. 335 Gasoline " Start 9.91
BRAKE READING Finish 5.87
Load in H.P. 4 Net 4.04 lb.
Gross Pres. 48.6
Zero 12 Explosions: Finish 79495
Net 36.6 lb. Start 71954 per min.
Net 7541 125.8

I.H.P. is:

$$\frac{75.8 \times 10 \times 19.6 \times 125.8}{12 \times 33000} = 4.72$$

(- - - - TEMPERATURES °F. - - - -)

No.	Time.	H_2O in Cooler.	H_2O out Cooler.	Exh. Gas from Eng.	Exh. Gas from Cooler.	Cool. Water from Engine
1	3:10	61	104	650	75	150
2	15	"	99	"	73	147
3	20	"	"	"	"	153
4	25	62	104	"	74	164
5	30	"	103	"	75	154
6	35	61	99	"	74	150
7	40	"	98	"	73	"
8	45	"	99	"	74	152
9	50	"	100	"	"	"
10	55	"	"	"	"	153
11	4:00	"	"	"	"	154
12	05	"	101	"	"	155
13	10	"	"	"	"	"
Average		61	100	650	74	153

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	300	300	40	3.75	1.51	
2	300	"	"	3.78	1.37	
3	310	310	"	3.77	1.39	
4	280	280	"	"	1.41	
5	300	300	"	"	1.53	
6	290	290	"	"	1.46	
7	"	"	"	"	1.50	
8	280	280	"	"	1.44	
9	290	290	42	"	1.45	
10	"	"	40	"	1.33	
11	300	300	"	3.75	1.47	
12	280	280	"	3.76	1.50	
13	300	300	"	3.77	1.3	
Aver.	293	293	40	3.77	1.44	76.4

Dry Bulb 75°F.
Wet " 63
% Humidity 51
Barometer "Hg. 29.36
Rev. per min. 335

BRAKE READING
Load in H.P. 4
Gross Pres. 48.6
Zero 12
Net 36.6 lb.

Water Weights: Full 525.5
Empty 33
Net 492.5 lb.

Gasoline " Start 9.84
Finish 5.95
Net 3.89 lb.

Explosions: Finish 88288
Start 80816
Net 7472 per min.
124.5

I.H.P. is:

$$\frac{76.4 \times 10 \times 19.6 \times 124.5}{12 \times 33000} = 4.71$$

		(- - - - TEMPERATURES °F. - - - -)				
		H_2O in	H_2O out	Exh. Gas	Exh. Gas	Cool. Water
No.	Time.	Cooler.	Cooler.	from Eng.	from Cooler.	from Engine
1	10:10	61	92	725	71	130
2	15	60	"	"	"	131
3	20	"	"	"	"	132
4	25	61	93	"	72	"
5	30	60	"	"	"	134
6	35	"	"	"	"	"
7	40	61	"	"	"	"
8	45	60	"	"	"	"
9	50	"	"	"	"	"
10	55	"	"	"	"	"
11	11:00	61	"	"	"	"
12	05	"	"	"	"	"
13	10	"	"	"	"	"
Average		60	93	725	72	133

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	290	290	40	3.76	1.4	
2	300	300	"	"	1.51	
3	290	290	"	"	1.43	
4	280	280	"	"	1.4	
5	300	300	"	"	"	
6	290	290	38	"	1.27	
7	310	310	40	"	1.42	
8	290	290	"	"	1.45	
9	310	310	45	"	1.55	
10	290	290	40	"	1.33	
11	280	280	"	"	1.34	
12	"	"	"	"	"	
13	300	300	"	"	1.4	
Aver.	293	293	40	3.76	1.4	74.5

Dry Bulb 72°F. Water Weights: Full 752
Wet " 61 Empty 33
% Humidity 53 Net 619 lb.
Barometer "Hg. 29.33
Rev. per min. 335 Gasoline " Start 9.74
BRAKE READING Finish 5.58
Load in H.P. 5 Net 4.16 lb.
Gross Pres. 57.8
Zero 12 Explosions: Finish 100160
Net 45.8 lb. Start 91088 per min.
Net 9072 151.3

I.H.P. is:

$$\frac{74.5 \times 10 \times 19.6 \times 151.3}{12 \times 33000} = 5.6$$

(- - - - TEMPERATURES °F. - - - -)

No.	Time.	H_2O in Cooler.	H_2O out Cooler.	Exh. Gas from Eng.	Exh. Gas from Cooler.	Cool. Water from Engine
1	11:45	60	102	750	75	135
2	:50	"	"	760	"	138
3	55	"	"	"	"	159
4	12:00	"	"	750	"	160
5	05	"	"	"	"	"
6	10	"	101	"	74	159
7	15	"	102	"	75	160
8	20	"	103	"	"	164
9	25	"	107	"	76	171
10	30	"	108	735	77	164
11	35	"	109	"	78	175
12	40	"	"	"	77	176
13	45	"	"	"	"	"
Average		60	104	747	75	161

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	290	290	38	3.76	1.40	
2	"	"	40	"	1.50	
3	"	"	"	3.75	1.47	
4	280	280	"	3.76	1.41	
5	"	"	"	"	1.32	
6	300	300	38	3.77	1.37	
7	280	280	40	"	1.32	
8	"	"	"	"	1.39	
9	290	290	"	3.76	1.27	
10	300	300	38	3.77	1.35	
11						
12	290	290	40	3.76	1.41	
13	300	300	38	3.78	1.38	
Aver.	289	289	39	3.76	1.38	73.5

Dry Bulb 77° F. Water Weights: Full 559.
Wet " 64 Empty 29
% Humidity 47 Net 530 lb.
Barometer "Hg. 29.33
Rev. per min. 335 Gasoline " Start 10
BRAKE READING Finish 5.46
Load in H.P. 5 Net 4.54
Gross Pres. 57.8
Zero 12 Explosions: Finish 11245
Net 45.8 lb. Start 2032 per min.
Net 9213 153.6

I.H.P. is:

$$\frac{73.5 \times 10 \times 19.6 \times 153.6}{12 \times 33000} = 5.59$$

		(- - - - TEMPERATURES °F. - - - -)				
		H_2O in	H_2O out	Exh. Gas	Exh. Gas	Cool. Water
No.	Time.	Cooler.	Cooler.	from Eng.	from Cooler.	from Engine
1	2:05	62	103	460	75	167
2	10	61	108	"	77	173
3	15	60	104	500	75	155
4	20	"	101	450	74	158
5	25	61	103	"	"	164
6	30	"	105	"	76	168
7	35	"	108	"	77	170
8	40	62	110	"	78	171
9	45	61	107	"	76	161
10	50	"	103	"	75	156
11	55	62	101	"	74	154
12	3:00	"	103	"	75	160
13	05	"	"	"	"	"
Average		61	104	454	75	163

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	300	300	40	3.77	1.48	
2	320	320	"	"	1.59	
3	315	315	"	"	1.46	
4	290	290	"	"	1.42	
5	300	300	"	"	1.38	
6	"	"	"	"	1.46	
7	310	310	"	"	1.4	
8	300	300	"	"	1.51	
9	290	290	"	"	1.54	
10	320	320	42	3.78	1.42	
11	300	300	40	"	1.46	
12	315	315	38	3.77	1.44	
13	300	300	40	"	1.4	
Aver.	304	304	40	3.77	1.46	77.5

Dry Bulb 76°F. Water Weights: Full 282.5
Wet " 65 Empty 16.5
% Humidity 55 Net 266. lb.
Barometer "Hg. 29.325
Rev. per min. 335 Gasoline " Start 9.78
BRAKE READING Finish 6.63
Load in H.P. 2 Net 3.15 lb.
Gross Pres. 30.3
Zero 12 Explosions: Finish 16853
Net 18.3 lb. Start 12280 per min.
Net 4573 76.3

I.H.P. is:

$$\frac{77.5 \times 10 \times 19.6 \times 76.3}{12 \times 33000} = 2.93$$

(- - - - TEMPERATURES °F. - - - -)

No.	Time.	H_2O in Cooler.	H_2O out Cooler.	Exh. Gas from Eng.	Exh. Gas from Cooler.	Cool. Water from Engine
1	3:10	61	105	445	76	162
2	15	62	106	"	"	"
3	20	"	105	"	"	"
4	25	"	106	"	"	164
5	30	"	"	"	"	"
6	35	"	"	"	"	166
7	40	"	107	"	"	167
8	45	"	"	"	"	168
9	50	"	"	"	"	167
10	55	"	108	"	"	168
11	4:00	"	"	"	"	"
12	05	"	107	"	"	"
13	10	"	"	"	"	"
Average		62	106	445	76	166

INDICATOR DIAGRAMS

(PRESSURES in Lb./sq.in. gage.)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	310	310	40	3.77	1.45	
2	320	320	"	"	1.44	
3	290	290	"	"	1.45	
4	310	310	"	"	"	
5	300	300	"	"	1.41	
6	310	310	"	"	1.4	
7	330	330	"	"	1.41	
8	310	310	"	"	1.32	
9	330	330	42	3.79	1.47	
10	305	305	40	3.78	1.48	
11	320	320	"	3.77	1.44	
12	300	300	"	"	1.5	
13	290	290	"	3.78	1.43	
Aver.	310	310	40	3.77	1.43	75.8

Dry Bulb 76°F.
Wet " 65
% Humidity 55
Barometer "Hg. 29.325
Rev.per min. 335

BRAKE READING
Load in H.P. 2
Gross Pres. 30.3
Zero 12
Net 18.3 lb.

Water Weights: Full 265
Empty 16.5
Net 248.5 lb.

Gasoline " Start 9.86
Finish 6.70
Net 3.16 lb.

Explosions: Finish 21765
Start 17230
Net 4535 per min.
75.5

I.H.P. is:

$$\frac{75.8 \times 10 \times 19.6 \times 75.5}{12 \times 33000} = 2.83$$

(- - - - T E M P E R A T U R E S °F. - - - -)

No.	Time.	H_2O in Cooler.	H_2O out Cooler.	Exh. Gas from Eng.	Exh. Gas from Cooler.	Cool. Water from Engine
1	10:45	62	99	350	71	144
2	50	"	100	"	72	146
3	55	63	102	"	"	150
4	11:00	62	103	"	73	"
5	05	"	102	340	"	148
6	10	"	"	"	"	"
7	15	"	"	"	"	"
8	20	"	"	"	"	"
9	25	"	"	"	74	150
10	30	"	"	"	"	149
11	35	"	"	350	"	"
12	40	"	103	"	"	152
13	45	"	"	"	"	"
Average		62	102	345	73	149

INDICATOR DIAGRAMS

(PRESSURES in lb./sq.in. gage.)

No.	Maximum.	Begin strk.	End expansion.	Length.	Area.	M.E.P.
1	310	270	42	3.77	1.6	
2	300	280	45	"	1.61	
3	310	310	"	"	1.55	
4	300	230	"	"	1.59	
5	295	260	"	"	1.67	
6	310	250	"	"	1.52	
7	"	310	"	"	1.69	
8	300	260	"	"	1.49	
9	310	310	"	"	1.57	
10	"	"	"	"	1.7	
11	300	300	"	"	1.4	
12	"	"	"	"	1.69	
13	310	310	"	"	1.56	
Aver.	305	285	45	3.77	1.59	84.4

Dry Bulb 73°F. Water Weights: Full 202
Wet " 64 Empty 16.5
% Humidity 62 Net 185.5 lb.
Barometer "Hg. 29.27
Rev. per min. 335 Gasoline " Start 9.86
BRAKE READING Finish 7.54
Load in H.P. 1 Net 2.32 lb.
Gross Pres. 21.15
Zero 12 Explosions: Finish 27157
Net 9.15 lb. Start 24403 per min.
Net 2754 45.8

I.H.P. is:

$$\frac{84.4 \times 10 \times 19.6 \times 45.8}{12 \times 33000} = 1.928$$