THESIS

TESTS OF AN
8 H. P. GASOLINE ENGINE

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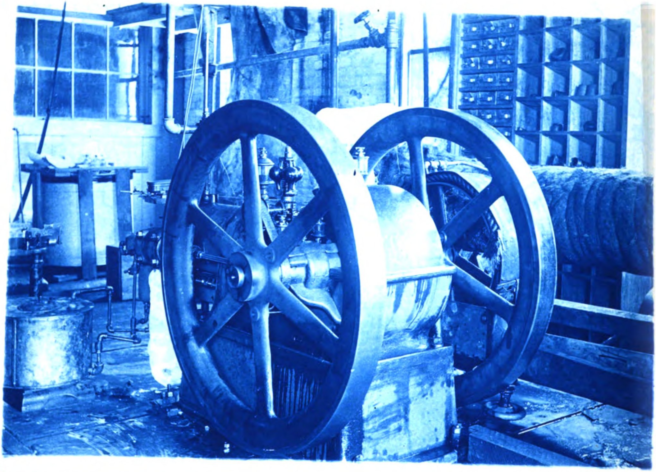
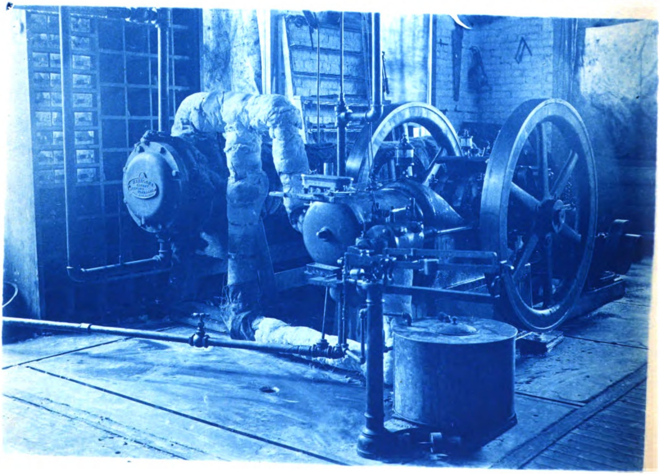
1904

This thesis was contributed by

Mr. P. B. Chase

under the date indicated by the department stamp, to replace the original which was destroyed in the fire of March 5, 1916.





THESIS.

Tests of an 8 H. P. Gasoline Engine.

by

P. B. Pierce and

Arthur Adleman.

Class '04.

THESIS

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PURPOSE OF THE TESTS:

The purpose of these tests was; to determine a heat balance for the engine, its brake and indicated horse-power, its mechanical and thermal efficiencies, and the amount of gasoline used per brake and indicated horse-power per hour.

ENGINE:

The engine used was an Olds Gasoline Engine built by the Olds Gasoline Engine Works, of Lansing, Mich. and sent out by them purposely for these tests. It was a 7 x 10, horizontal, four stroke cycle type, rated at 8 B. H. P.. It had an automatic poppet valve for the take in valve and a valve with positive action for the main exhaust valve. The auxiliary exhaust was a valveless port inside the cylinder so placed that it was uncovered by the piston at the end of its outward stroke. The governor was an ordinary ball governor, working on the hit and miss plan. When the engine ran over speed the governor held the main exhaust valve open and the sparker at rest.

The brake used was the well-known Prony pattern. It consisted of an arm, one end cut to nearly fit the wheel, one end of an 8" leather belt was fastendd into this circular opening, the belt then passing around the wheel being fastened to a screw bolt by which it might be tightened. Inside the belt and pressing against the pulley were six 1" ropes fastened with the belting to the brake arm. The brake was lubricated and the pulley kept cool by running water from the mains between ropes and pulley and belting. It ran off at the bottom. This brake was found to work with very uniform friction.

INDICATOR:

The indicator used was a new Thompson Gas Engine indicator with a 1/4" piston and 200 # spring. The rig was a reducing wheel of our own construction, shown in Plate . This rig shows no geometrical error and gave us no trouble whatever during the tests.

EXPLOSION COUNTER:

The number of explosions were taken every five minutes from a counter which was attached to the sparker. It was watched and not known to miss an explosion.

REVOLUTION COUNTER:

The total number of revolutions was registered by a counter attached to the piston rod of the gasoline pump. This rod made one stroke for two revolutions so that the number of revolutions equals the registered number multiplied by two. Readings were taken every five minutes and R. P. M. =

$$\frac{\text{total revolutions}}{\text{no. of min. run}}.$$

JACKET WATER:

Water from the mains was passed through the jacket, the temperature being taken just before entering and again just

after leaving the jacket. The water was run into a barrel and weighed. From the change in temperature and the total weight the B.T.U. absorbed by jacket was computed.

EXHAUST GASES:

The heat lost in exhaust was measured by using a Wheeler Surface Condenser of 50 H. P. capacity connected to the exhaust outlet by a short pipe shown in photographs. The whole was well covered to prevent radiation. Water from the mains was circulated through the condenser and was then run into barrels and weighed. The temperature of this water was taken before entering condenser and again upon leaving it, so that knowing the weight of water and change of temperature we determined the amount of heat given up by exhaust. The temperature of the exhaust gas was kept as nearly that of the incoming air as possible so that the heat given to the condenser water is practically the heat exhausted.

Mercurial thermometers were used to determine all temperatures referred to. They were placed in thermometer cups which were filled with oil and were also encased in brass tubes to keep the cool air from them and to prevent breaking.

GASOLINE:

The gasoline was drawn from a small galvanized iron tank, which was placed upon a set of scales weighing to .01 of a pound, so that the weight of gasoline used could be determined to .01 #. Readings were taken every five minutes.

Calometer tests upon samples of the gasoline used were made by the Chemical Department to determine the heat value of 1".

Test No. 1, heat value of 1" = 19494 B.T.V.

Test No. 2, heat value of 1" = 19563 B.T.V.

The latter result was taken in computation as it was thought to be the more accurate.

CALIBRATION OF INSTRUMENTS:

All scales used were carefully balanced, tested with a set of Crosby Dead Weights and found to be correct.

The thermometers were compared and a pair that would read alike selected for obtaining temperatures of jacket water, another pair for condenser water, etc.

The indicator spring was calibrated by the use of a steam log and Crosby Dead Weight set to measured pressure. It was found to be 4 % weak or the supposed 240 # spring was really a 230.4# spring.

Test No. 1.

To determine the brake and indicated horse-power of the engine; its mechanical and thermal efficiencies; the gasoline used per brakes and indicated horse-power per hour, and a heat balance. Preparatory to the tests the engine was run two hours under the same load and conditions as during the test. This gave opportunity to regulate the jacket and condenser waters and brake load, so as to have constant conditions when the test began. Brake load was kept constant during the test.

Log of Results for Test No. 1.

		Gasoline in lbs.		Explosions		Revolutions from strokes of pump.	
No.	Time	Gross	Net	Gross	Net	Gross strokes	Net Rev.
0	2:20	22.25		35066		45929	
1	2:25	21.7	.55	35754	688	46668	1478
2	2:30	21.12	.58	36444	690	47407	1478
3	2:35	20.58	.54	37130	686	48145	1476
4	2:40	20.04	.54	37824	694	48883	1476
5	2:45	19.47	.57	38520	696	49623	1480
6	2:50	18.91	.56	39208	688	50364	1482
7	2:55	18.34	.57	39899	691	51106	1484
8	3:00	17.75	.59	40593	694	51847	1482
9	3:05	17.19	.56	41283	690	52586	1478
10	3:10	16.65	.54	41969	686	53327	1482
11	3:15	16.08	.57	42662	693	54069	1484
12	3:20	15.48	.60	43359	697	54809	1480
			6.77				

Net Revolutions = (net strokes of pump) x 2.

Log of Results for Test No. 1, continued.

		Temperatures of				Temperatures of	
		Condenser cooling water		Jacket cooling water		Ingoing air	Exhaust gas
No.	Time	Before	After	Before	After		
0	2:20	54	66	53.5	150.5	77	77
1	2:25	53.5	65	53	139	77	77
2	2:30	54	65	53	130.5	76.5	78
3	2:35	54	65	53.5	137.5	76	79.5
4	2:40	53	64	54	143	76.5	80.5
5	2:45	53	63	54	145	76	80
6	2:50	53	63.5	53.5	146	77	81
7	2:55	53	63	54	133.5	76	82.5
8	3:00	53.5	63	54	135	75.5	84
9	3:05	53.5	64	54	135	75.5	84.5
10	3:10	53	63	53.5	132.5	75	84
11	3:15	53	62.5	53.5	131	76	84
12	3:20	52	62	53.5	137	76	84
		53.2	63.7	53.6	138.1	76.1	81.2

Log of Results for Test No.1, continued.

No.	Weight of Jacket Water Initial	Final	Net	Weight of condenser Water Initial	Final	Net
0	139			99		
1		188.5	49.5		253	154
2		234	45.5	79	415	1 2
3		277.5	43.5		235	156
4		320	42.5	79	422	187
5		360.5	40.5	82	311	232
6	108	409	48.5	75	305	223
7		160	52.0	81	300	225
8		209.5	49.5	76	302	221
9		258.5	49.0	82	296	220
10		309	50.5	73	310	238
11		355	46.0	82	320	247
12		398	43.0		340	258

Time of test	60	min.
Amount of gasoline used	6.77	#
Amount of jacket water used	560	#
Temp. of jacket water before being used	53.6	
Temperature of jacket water after being used	133.1	
Amount of water used in condenser	[illegible]513	#
Temperature of condenser water before being used	53.2	
Temperature of condenser water after being used	63.7	
Brake load corrected	25	#
Total number of revolutions	177[illegible]	
Total number of explosions	8[illegible]	
Average M.E.P.	[illegible].08	#
R.P.M.	296	

$$B.H.P. = \frac{2\pi R.N.W.}{33000}$$

R = length of brake arm.

N = number of revolutions.

W = brake load corrected.

R was made 63.025 inches so that

$$B.H.P. = \frac{\text{Brake load} \times R.P.M.}{1000}$$

B. H. P. $= \frac{25 \times 296}{1000} = 7.4$

I. H. P. $= \frac{P.L.A.N.}{33000}$

P. = Av. M.E.P.

L. = length of stroke in ft.

A. = area of piston in sq. in.

N. = No. of explosions per min.

I. H. P. $= \frac{82.08 \times 10 \times 38.5 \times 8283}{12 \times 33000 \times 60} = 11.$

Mechanical Eff. $= \frac{B.H.P.}{I.H.P.} = \frac{7.4}{11} = 67.3\ \%$

Heat supplied 6.77 x 19583 = 132,576.9 B.T.V.

Heat turned into work in cyl. = I. H. P. x 33000 x

time in min. $\div$ 778 $= \frac{11 \times 33000 \times 60}{778} =$ 27927.22 B.T.

Thermal Eff. $= \frac{\text{Heat turned into work in cylinder}}{\text{Heat supplied}} =$

$\frac{27{,}927.22}{132{,}576.9} = 21.08\ \%$

Heat used in jacket water = Change in temperature x

weight of water used = 84.5 x 560 = 47,320 B.T.V.

Heat given to exhaust gases = Change in temperature of condenser water x weight of water used = 10.5 x [illegible] = 26630.22

Air was taken into cylinder at a temperature of 76.1 F. and exhausted at a temperature of 81.2 F. By taking the volume of the cylinder, and considering that it took air at every explosion; knowing the weight of a cubic foot of air we can compute number of pounds of air used, which when multiplied by the sp. heat of air and difference in temperature between the air taken in and gas exhausted, gives the number of B.T.U. to be added to the heat given to cooling water in condenser in order to obtain heat of exhaust. This method is not absolutely correct but as this correction forms only a very small per cent. of the heat exhausted the error is not large.

Total number of explosions 8,[illegible]3.

Weight of 1 cu. ft. of air .0737 #

Vol. of cyl. 385 cu. in.

Sp. heat of air 2,375.

$$\frac{2375 \times .0737 \times 2293 \times 5.1}{1728} = 26,793.22$$

Heat of exhaust = 26630.22 + 163 = 26793.22

Heat lost in radiation and imperfect combustion = (Total heat supplied) - (Heat turned into work + heat given to jacket water + heat in exhaust) = 30,536.5 B.T.U.

Total heat supplied B.T.U. 132,576.9 = 100 %

Heat turned into work B.Y.U. 27,927.22 = 21.00 %

Heat lost in jacket B.T.U. 47,3[illegible]0 = 35.7 %

Heat lost in exhaust B.T.V. 26,793.22 = 20.2 %

Heat lost in radiation and imperfect combustion

B.T.V. 30,536.5 - 23.03 %

Gasoline used per B.H.P.H. = $\frac{6.77}{7.4}$ = .915 # = .154 gal.

Gasoline used per I.H.P.H. = $\frac{6.77}{11}$ = .615 # = .104 gal

Tests No. 2 and 3.

These tests were run without the condenser and were made in one run. In No. 2 the pin valve was open too wide so as to admit a surplus of gasoline and in No. 3 the valve was closed to the lowest point that would give a good explosion. This was for the purpose of finding out whether the drip return was efficient enough to regulate the mixture or if the air would take up more gasoline than it would burn.

No. 2.

Time of test	60	min.
Amount of gasoline used	[illegible].78	#
Amount of jacket cooling water used	459	#
Temp. of jacket cooling water before using	58.2	
Temp. of jacket cooling water after using	145.2	
Total number of revolutions	[illegible]7798	
Brake load corrected	27	
Total number of explosions	8272	
Average M.E.P.	21.8	#

F.H.P. = 296.6

B.H.P. = $\dfrac{27 \times 296.6}{1000}$ = 8.008

I.H.P. = $\dfrac{81.6 \times 10 \times 38.5 \times 8262}{12 \times 33000 \times 60}$ = 10.95

Mechanical Eff. = $\dfrac{8.008}{10.95}$ = 73.1 %

Heat delivered to engine during test =

8.78 x 19583 = 171,938.7 B.T.U.

Heat turned into work =

$\dfrac{10.95 \times 33000 \times 60}{778}$ = 27869.9

Thermal Eff. = $\dfrac{27869.9}{171938.7}$ = 16.2 %

Heat given to jacket water = 87 x 459 = 39933 = 23.2 %

Gasoline used per hour 8.78 = gal.

Gasoline used B.H.P. per hour = $\dfrac{8.78}{8.008}$ = 1.09 # = .184 gal.

Gasoline used I.H.P. per hour = $\dfrac{8.78}{10.95}$ = .80 # = .135 gal.

Test No. 3.

Time of test	20 min.
Amount of gasoline used	2.28 2.28 #
Amount of jacket cooling water used	153 #
Temp. of cooling water before using	57.4 °
Temp. of cooling water after using	154.5 °
Total explosions	2792

Log of Results for Test No. 2.

		Gasoline in lbs.		Explosions		Revolutions from strokes of pump		Wt. of Jacket Water	
No.	Time	Gross	Net	Gross	Net	Gross strokes	Net Rev.	Before	After
0	2:00	22.48		47048	667	60828		59	128
1	2:05	21.8	.68	47715	667	61570	1484	59	136
2	2:10	21.05	.75	48393	678	62315	1490	58.75	149.75
3	2:15	20.32	.73	49085	692	63056	1482	58	147.5
4	2:20	19.65	.67	49777	692	63800	1488	57.5	136
5	2:25	18.90	.75	50478	701	64542	1484	57.5	134.5
6	2:30	18.12	.76	51152	674	65283	1482	58.	149
7	2:35	17.4	.72	51818	666	66030	1494	58.5	151
8	2:40	16.65	.75	52504	686	66765	1470	58.5	154
9	2:45	15.95	.70	53210	706	67510	1490	58.5	150.5
10	2:50	15.2	.75	53909	699	68255	1490	58.5	147.5
11	2:55	14.43	.77	54602	693	68994	1478	58	147.5
12	3:00	13.7	.73	55310	708	69727	1466	57.5	147.25
					8262 Total		17798 Av.	58.2 Av.	145.2 Av.

Net rev. = (net strokes of pump) x 2.

Log of Results for Test No. 2, continued.

		Temperature Jacket Water		
No.	Time	Initial	Final	Net
0	2:00	112		
1	2:05		152	40
2	2:10		185	33
3	2:15		224	39
4	2:20		269	45
5	2:25		309	40
6	2:30		346	37
7	2:35		380	34
8	2:40		414	34
9	2:45	117	452	38
10	2:50		158	41
11	2:55		196	38
12	3:00		236	40
				459 Total.
(Test No. 3.) 0	3:15	125		
1	3:20		159	34
2	3:25		199	40
3	3:30		240	41
4	3:35		278	38
				153 Total.

Log of Results for Test No. 3.

		Gasoline in lbs.		Explosions		Revolutions from strokes of pump		[illegible] Jacket Water	
No.	Time	Gross	Net	Gross	Net	Gross strokes	Net Rev.	Before	After
0	3:15	24.65		[illegible]		71510		57.5	150.5
1	3:[illegible]0	24.08	.57	[illegible]	70[illegible]	72[illegible]51	14[illegible]	58	160
2	[illegible]	23.47	.61	[illegible]	707	72988	1474	57.5	156
3	3:30	22.77	.50	[illegible]	687	73730	1484	57	1[illegible].25
4	3:[illegible]	22.37	.60	[illegible]	692	74466	1472	57	153
			2.28				5912 Total	57.4 Av.	154.5 Av.

Net Rev. = (net strokes of pump) x 2.

Test No. 3, continued.

Brake load corrected [illegible]

Total revolutions [illegible]

Av. M.E.P. [illegible].31

R.P.M. [illegible]5.6

B.H.P. = $\frac{7 \times [illegible]}{100}$ = 7.[illegible]

I.H.P. = $\frac{80.31 \times 10 \times 38.[illegible] \times [illegible]792}{1[illegible] \times 33\,000 \times [illegible]}$ = 1[illegible].8

Mechanical Eff. = $\frac{7.[illegible]}{10.[illegible]}$ = 7[illegible].9

Heat delivered to engine = 2.[illegible] x 19[illegible] = 44[illegible]49.2.

Heat turned into work $= \frac{10.8 \times 33000 \times 20}{778} = 9162.7$

Thermal Eff. $= \frac{9162.7}{440492} = 20.7$ %

Heat given to jacket cooling water $= 97.1 \times 153 =$

14856.3 = 33.2 % of heat furnished.

Gasoline used per hour $= 3 \times 2.28 = 6.84$ #

Gasoline used per B.H.P. per hour $= \frac{6.84}{7.98} = .85$ # $= .144$

Gasoline used per I.H.P. per hour $= \frac{6.84}{10.8} = .63$ # $= .107$

Test No. 4.

This test was run for the purpose of finding the mechanical and thermal efficiencies under light load.

Time of test	20	min.
Amount of gasoline used	1.61	#
Amount of jacket cooling water used	126	#
Temperature of jacket cooling water before using	57.4	
Temperature of jacket cooling water after using	145.6	
Total number of explosions	1825	
Total number of revolutions	6004	
Brake load connected	15	#
Average M.E.P.	79.5	
Average R.P.M.	300.2	

B.H.P. $= \frac{300. \times 15}{1000} = 4.5$

I.H.P. $= \frac{79.5 \times 10 \times 38.5 \; 1825}{12 \times 33000 \times 20} = 7.05$

Mechanical Eff. $= \frac{4.5}{7.5} = 63.7 \%$

Heat delivered to engine $= 1.61 \times 19583 = 31528.6$

Heat turned into work $= \frac{7.05 \times 33000 \times 20}{778} = 5981.2$

Thermal Eff. $= \frac{5981.2}{31528.6} = 19 \%$

Heat given to jacket cooling water $= 88.2 \times 126 =$

11113.2 B.T.U. = 35.2 % of heat furnished.

Gasoline per hour $= 3 \times 161 - 4.83$ #

Gasoline used per B.H.P. per hour $= \frac{4.83}{4.5} = 1.07$ # $= .181$

Gasoline used per I.H.P. per hour $= \frac{4.83}{7.05} =$ [illegible] $= .115$

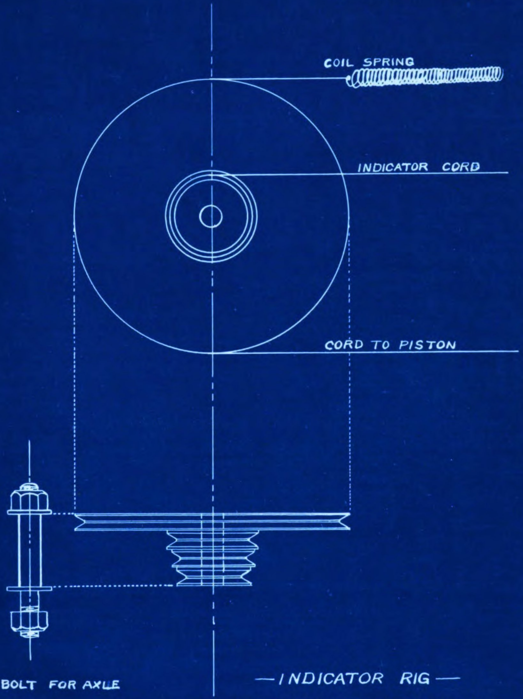
Log of Results for Test No. 4.

		Gasoline in lbs.		Explosions		Revolutions from strokes of pump		Wt. of Jacket Water	
No.	Time	Gross	Net	Gross	Net	Gross strokes	Net Rev.	Before	After
0	3:50	21.16		60837		76724		58	154
1	3:55	20.77	.39	61299	462	77476	1504	58	158
2	4:00	20.39	.38	61749	450	78224	1496	57	142.5
3	4:05	19.98	.41	62203	454	78973	1498	57	132.5
4	4:10	19.55	.43	62662	459	79726	1506	57	141
			1.61 Total		1825 Total		6004 Total	57.4 av.	145.6 av.

		Temp. of jacket water		
		Initial	Final	Net
0	3:50	115		
1	3:55		141	26
2	4:00		177	36
3	4:05		214	37
4	4:10		241	27
				126 Total

Net revolutions = (Net strokes of pump) x 2.

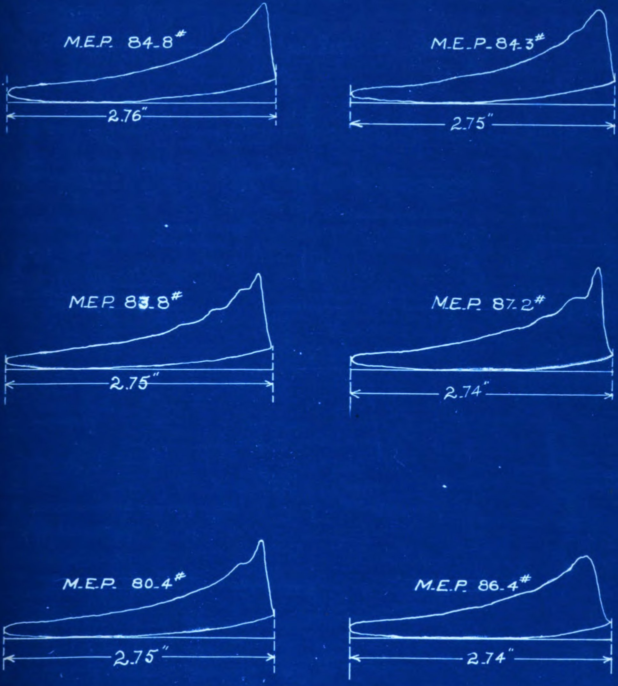
PLATE I



—INDICATOR RIG—

A REDUCING REEL MADE OF PINE AND SUPPORTED BY AN IRON BRACKET BOLTED TO THE BED OF ENGINE

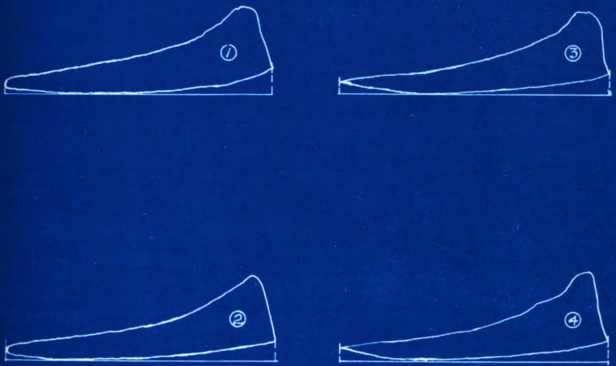
PLATE II.



SAMPLE · CARDS TAKEN DURING TESTS

230.4# SPRING

PLATE III.



CARDS 1 AND 2 WERE TAKEN WITH AUXILIARY EXHAUST PORT OPEN.

CARDS 3 AND 4 WERE TAKEN WITH AUXILIARY EXHAUST PORT CLOSED.