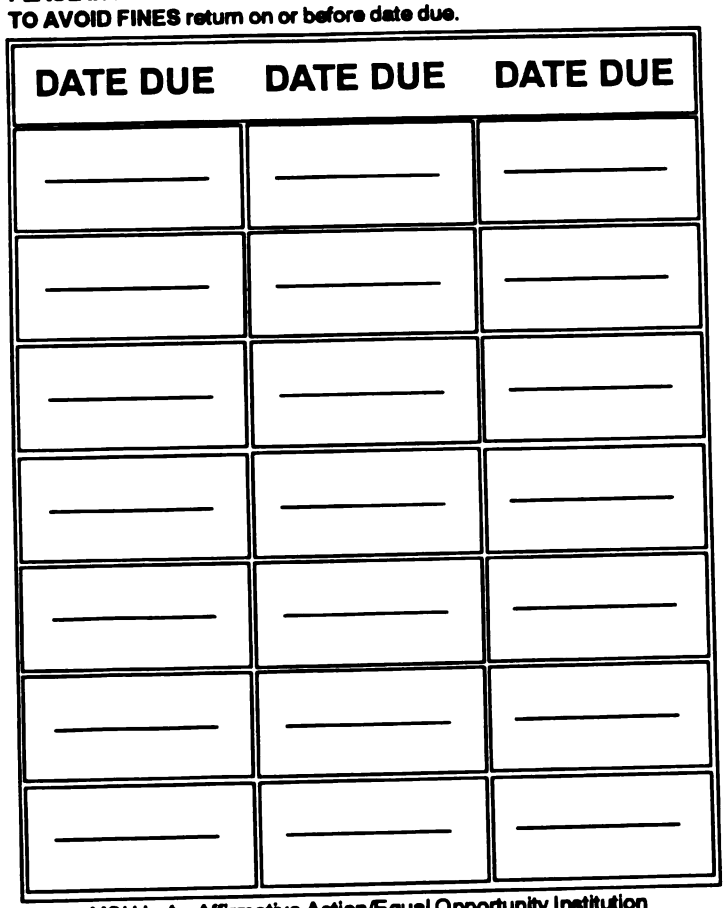


THESIS

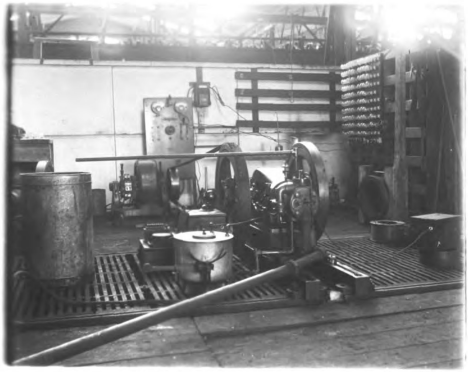
COMPARATIVE TEST OF GAS ENGINE GOVERNING

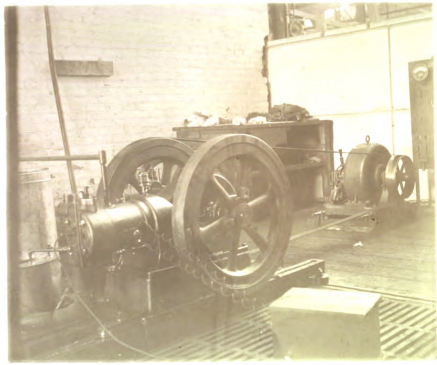
C. B. HAYES A. S. VAN HALTEREN

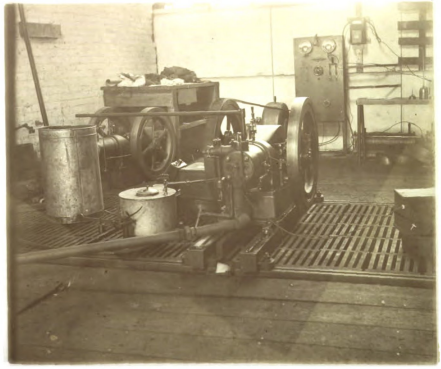
This thesis was contributed by

Mr. A. S. Van Haltern

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







THESIS

12-4-51

Objects.

The objects of this test were to determine the relative efficiency and the relative regulation of the Throttling and of the Hit and Miss types of governing when applied to the same engine.

Apparatus.

Engine.

A 6 H.P. (5 1/2" x 7 1/2") engine of the horizontal type made by the Olds Gas Power Company of Lansing was used. This engine as built for Hit and Miss governing is equipped with two 200 lb. fly wheels 32" in diameter, while for Throttling governing 350 lb. fly wheels of equal diameter are fitted to the same crank shaft. The engine as used throughout these tests was fitted with the latter. The old crank shaft was somewhat light for the heavy wheels as evidenced by the vibrations but no trouble was experienced from this source. The engine was built to run at 425 R.P.M. However, the efficiency curve of the generator used as a power absorber was plotted at 125 volts and, with the pulleys at hand, it was necessary to run the engine at 475 R.P.M. in order to bring the generator up to normal voltage. The ignition was of the jump spark type. Fuel was supplied to the cylinder with a

pump discharging into a reservoir in which a constant level was maintained by means of an overflow leading back to the supply tank. The gasoline was piped from this reservoir directly to the needle valve at the base of the carbureter. Jacket water was supplied from the main. Either type of governor was easily applied to this engine. Both were of the centrifugal single weight type mounted on fly wheel. The ball on the Throttling governor was about three times the weight of that on the Hit and Miss. A separate type of carbureter was used with each governor. For sketch see Plate VIII.

Switch board.

The voltmeter and the ammeter were both of the Weston switch board type. The limit of the voltmeter was 150 volts while that of the ammeter was 250 amperes. As no currents exceeding 30 amperes were used the range of the instrument was much greater than desirable. A shunt field rheostat was used for voltage control. The switch board was connected to a bank of about one hundred 16 c.p. 110 volt incandescent lamps which constituted the load.

Generator.

The generator used for load was a Crocker-Wheeler four-pole, compound wound, direct current 9 K.W. machine designed to give 125 volts at 950 R.P.M. The diameter of the

pulley was 16". For efficiency and B.H.P. curves see Plate III.

Reducing Motion.

A reducing motion of common type was used. A 3/8" steel rod was screwed into the piston and locked with a jam nut. This rod was led out parallel with the axis of the cylinder and bent to meet the horizontal link which in turn was pivoted to the vertical link. The last was pivoted to the engine base. Due to the high speed and the reduction of area by threading, the lead rod, after the engine had run a short time, whipped off at the point where it entered the piston. To remedy this a new rod was made by welding about 2 1/2" of 5/8" wrought iron rod to a 7/16" wrought iron rod and leading the latter to the link as before. This arrangement was rigid and proved very satisfactory.

Indicator.

A Thompson indicator was used with piston area of 1/4 square inch, making the 100# spring with piston area of 1/2 square inch equivalent to 200#. The connection to cylinder was made by a short pipe through back of combustion chamber about 3/8 of an inch above the spark plug (See Plate VIII). This arrangement allowed the spark to jump from spark plug to indicator pipe which was remedied by placing a glass tubing over the spark plug. The object of running pipe into cylinder

at this point was to avoid going through the jacket, although the latter would be advisable to avoid trouble with spark plug.

Tachometer.

A tachometer was used direct connected to engine with a flexible spring coupling consisting of a small generator so designed as to give voltage in direct proportion to speed, a milli-ammeter for reading the speed directly within 1 R.P.M., and a resistance which was previously determined. The tachometer showed variations on different loads very plainly, and during each cycle, although not the precise variation because of inertia of the needle.

Speed Indicator.

As a check for the tachometer and in order to determine the belt slippage, speeds were taken simultaneously from the engine and the generator with Starrett speed indicators.

Water Tank.

A cylindrical sheet iron tank was used for determination of the amount of jacket water used. This tank had an outlet at the bottom and an overflow near the top. The tank was calibrated and contained 218# between overflow and outlet.

Calibration of Instrument.

The voltmeter was calibrated by the potentionmeter method and the ammeter by direct comparison with a standard instrument. For calibration curves of both instruments see Plate I.

The indicator spring used was calibrated cold on a test pump since there was not a sufficiently high pressure at hand tc calibrate it hot. The spring was found to be slightly stiff but, as a spring is weakened 2 to 3% by heating, this error was practically compensated.

Quarter Load - Throttling Governor.

Time	Switch board			Jacket water		Gasoline		Revolutions					
	Voltmeter	Ammeter	Voltmeter Variations	Temperatures Initial	Temperatures Final	Weight	Temperature	Weight	Engine Tachometer	Speed Indicator	Generator Speed Indicator	M.E.P.	I.H.P.	B.H.P.
9-33	126	2.8	3	52	150		55	31.25	465					.88
9-43	126	2.8	6	52	156		56		470	466	925	54	5.66	.88
9-53	125	2.8	4	52	154		59		465	465	922	22	2.30	.873
10-03	125	2.8	6	52	154		60		465	470	926	64	6.76	.873
10-13	125	2.8	6	53	148		63		470	467	921	72	7.56	.873
10-23	126	2.8	8	53	156		63		470	467	934	38	3.98	.88
10-33	126	2.8	10	53	149		66		465	466	932	55.5	5.81	.88
10-43	126	2.8	6	53	150	218	68		465	461	929	65.5	6.8	.873
10-53	125	2.8	8	53	152		69		465	468	932	66	6.95	.873
11-03	125	2.8		53	147		70		465	467	932	65	6.8	.873
11-17	125	2.8		53	147	113	71	25.25	465			62.5	6.53	.873
Averages & Totals			6.3	53	151	331	64	6.00		466	929	56.5	5.92	.876

Average belt slip .322

Half Load - Throttling Governor

Time	Switch board			Jacket water Temperatures			Gasoline		Revolutions Engine					
	Voltmeter	Ammeter	Voltmeter Variations	Initial	Final	Weight	Temperature	Weight	Tachometer	Speed Indicator	Generator Speed Indicator	M.E.P.	I.H.P.	B.H.P.
1-50	124	11.1	6	52	167		70	29.25	475			62	6.82	2.82
2-00	124	11.6	6	52	149		70		472	468	935	68	7.15	2.94
2-10	123	11.1	5	52	131		71		470	470	937	56	5.92	2.79
2-20	123	11.1	4	53	167		72		472	468	934	64	6.73	2.79
2-30	124	10.6	5	53	170		73		475	470	931	72	7.62	2.69
2-40	123	11.1	4	53	149		75		470	470	937	64	6.76	2.79
2-50	127	11.6	4	53	152	218	75		470	469	934	60	6.34	3.01
3-00	126	11.6	3	56	158		76		472	471	937	68	7.21	2.98
3-10	127	11.1	4	51	183		77		470	470	936	58	6.13	2.88
3-20	125	11.1	5	50	193		76		470	470	933	66	6.98	2.84
3-30	125	10.4	4	50	140		77		475	471	937	66.5	7.05	2.66
3-40	125	11.1	2	51	149		77		470	470	937	68	7.19	2.84
3-50	124	11.6	6	51	147	218	78		472	470	932	60	6.34	2.94
4-00	125	11.6	3	52	165		77		470	471	933	57	6.04	2.96
4-10	125	11.1	2	52	165		78		470	470	935	61.5	6.50	2.84
4-20	124	11.1	3	52	158		78		470	471	933	55	5.83	2.82
4-30	124	11.1	3	52	158		77		470	470	933	62.5	6.61	2.82
4-40	124	11.1	2	53	165		78		470	470	933	57.5	6.07	2.82
4-50	124	11.1	2	51	163	218	78		470	471	936	61	6.47	2.82
5-00	124	10.6	5	51	162		78		470	471	936	62.5	6.62	2.69
5-10	124	10.6	6	51	169		78		470	471	934	65	6.88	2.69
5-20						166		17.50						
Averages & Totals			3.9	52	160	820	76	11.75		470	935	62.6	6.63	2.82

Average belt slip .53

Three-Quarters Load-Throttling Governor

Time	Switch board			Jacket water Temperatures			Gasoline		Revolutions					
	Voltmeter	Ammeter	Voltmeter Variations	Inlet	Exit	Weight	Temperature	Weight	Engine Tachometer	Speed Indicator	Generator Speed Indicator	M.E.P.	I.H.P.	B.H.P.
2-55	124	20.5	2	52	123		65	36.75	470	472	932	78	8.28	4.57
3-05	124	20.5	2	52	127		67		470	470	934	80	8.46	4.57
3-15	124	20.5	2	52	127		69		470	467	934	76	8.03	4.57
3-25	123	20	2	52	138		70		468	470	932	80	8.46	4.42
3-35	122	20.5	2	52	138	218	70		468	469	933	75.2	7.94	4.50
3-45	123	20.5	2	52	145		70		470	469	930	72	7.60	4.55
3-55	122	20.5	2	52	150		70		468	467	930	78	8.20	4.50
4-05	123	20.5	2	52	172		72		468	469	933	76	8.02	4.54
4-15	123	20.5	2	52	147		72		468	468	934	74	7.78	4.54
4-25	123	20.5	2	52	125		73		468	467	931	74	7.77	4.54
4-35	123	20.5	2	52	136		72		468	469	934	70	7.38	4.54
4-45	122	20.5	2	52	149		73		468	469	935	72	7.60	4.50
4-55	122	20.5	2	52	147		73		468	468	933	73	7.68	4.50
5-05	122	20.5	2	52	131	218	73		468	469	933	73	7.70	4.50
5-15	124	20.5	2	52	121		73		469	469	933	76	8.02	4.57
5-25	122	20.5	2	52	125		73		470	468	931	70	7.37	4.50
5-35	124	20.5	2	52	132		73		468	469	933	72	7.59	4.57
5-45	122	20.5	2	52	150	218	75		468	468	932	74	7.78	4.50
5-55	124	20.5	2	52	172	35	75	26.25	468			73.8	7.79	4.57
Averages & Totals			2	52	140	689	72	10.50		469	933	75.1	7.87	4.53

Average belt slip .342

Full Load - Throttling Governor

Time	Switchboard: Voltmeter	Switchboard: Ammeter	Switchboard: Voltmeter Variations	Jacket water temperatures: Inlet	Jacket water temperatures: Outlet	Jacket water temperatures: Weight	Gasoline: Temperature	Gasoline: Weight	Revolutions: Engine Tachometer	Revolutions: Speed Indicator	Revolutions: Generator Speed Indicator	M.E.P.	I.H.P.	B.H.P.
10-55	121	27.7	2					37.75	467					5.71
11-05	120	27.7	2	52	186		61		468	465	922	76	7.98	5.68
11-15	120	27.2	2	51	165		65		470	466	922	76.5	8.00	5.57
11-25	120	27.7	1	51	150		66		465	467	923	78	8.17	5.68
11-35	120	26.9	1	50	145		68		467	465	924	80	8.36	5.50
11-45	119	27.2	1	52	145		69		465	464	927	83.5	8.73	5.51
11-55	120	27.2	1	52	167	218	70		466	463	922	82.5	8.60	5.57
12-05	120	27.2	1	52	168		70		467	465	922	76	7.95	5.57
12-15	119	27.2	1	51	169		70		465	464	922	73	7.62	5.51
12-25	119	26.9	1	51	131		71		465	465	923	84	8.79	5.45
12-35	119	26.9	1	52	125	218	71		466	464	924	88	9.18	5.45
12-45	120	26.9	1	52	120		71		465	463	923	76	7.91	5.50
12-55	120	27.2	2	52	143	218	71		467	464	920	84	8.76	5.57
1-05	119	27.2	1	53	131		72		465	464	921	92	9.61	5.51
1-15	120	26.9	1	53	129		73		466	462	920	78	8.11	5.50
1-25	120	27.7	1	53	131	218	74		465	463	921	90	9.37	5.68
1-35	120	27.7	1	51	127		74		465	464	920	80	8.35	5.68
1-45	121	27.2	1	52	129		74		465	465	918	80	8.36	5.61
1-55	121	27.7	2	52	131		74		465	464	921	82	8.56	5.71
2-05	121	27.2	1	51	127	218	74		467	461	922	80	8.29	5.61
2-15	121	27.7	1	52	134	50	74		466			80	8.34	5.71
2-25								23.25						
Averages & Totals			1.1	52	143	1140	71	14.5		464	922	87.9	8.44	5.58

Average belt slip .647

Overload - Throttling Governor.

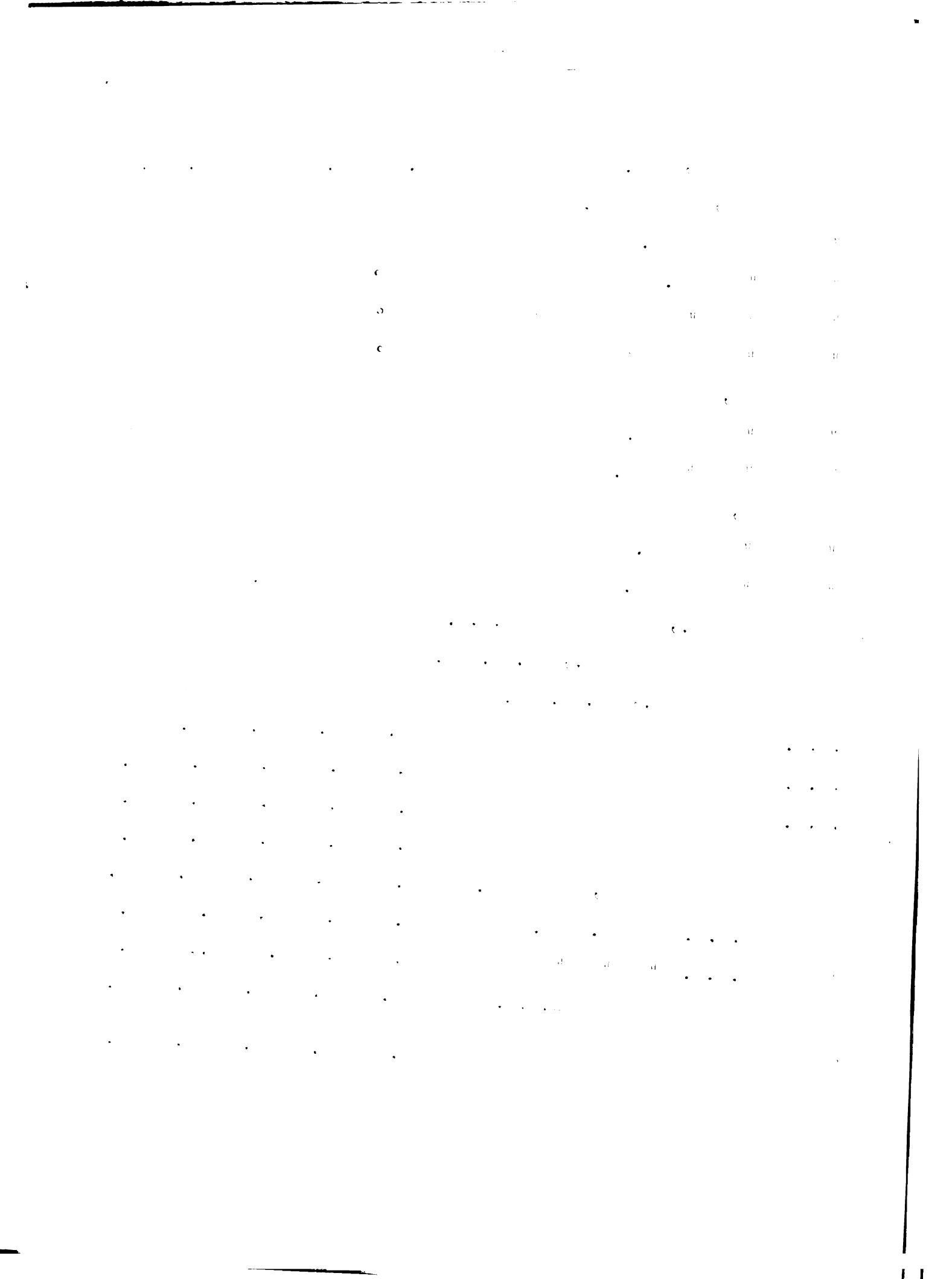
	Switch board			Jacket water Temperatures			Gasoline		Revolutions Engine					
Time	Voltmeter	Ammeter	Voltmeter Variations	Initial	Final	Weight	Temperature	Weight	Tachometer	Speed Indicator	Generator Speed Indicator	M.E.P.	I.H.P.	B.H.P.
6-15	116	34.5	2	51	104		65	34.87	460	452	894	90	9.16	6.65
6-25	118	34.5	1	51	127		65		460	457	901	92	9.37	6.76
6-35	117	34.5	1	50	129		65		460	455	892	90	9.23	6.70
6-45	118	34.5	1	52	118		66		460	459	903	88	9.08	6.76
6-55	117	34.5	2	51	121		66		460			90	9.23	6.70
6-59						109		29.75						
Averages & Totals			1.4	51	120	109	65	5.12		456	898	90	9.21	6.71

Average belt slip 1.54

Totals 1.4 51 120

Report of Test - Throttling Governing.

	Load				
	1/4	1/2	3/4	Full	Over
Duration trial, hrs.	1.66	3.5	3	3.5	.733
Jacket water, total lbs.	331	820	689	1140	109
" " per hr. "	198	234	230	326	149
" " temp. entering F°	53°	52	52	52	51
" " " leaving F°	151°	160	140	143	120
" " range F°	98°	108	88	91	69
Revolutions, total	46600	99000	84500	97500	20080
" " per hr.	27960	28200	28140	27840	27360
" " " min.	466	470	469	464	456
Explosions, total	23300	49500	42250	48750	10040
" " per hr.	13980	14100	14070	13920	13680
" " " min.	233	235	234.5	232	228
Thermal equiva., 1# gasoline B.T.U.	19290	19290	19290	19290	19290
Maximum effective press.,lbs.sq. in.	116	130	154	374	426
Compression press.,lbs.sq. in.	58	56	58	64	65
M.E.P. power stroke	56.5	62.6	75.1	87.9	90
I.H.P.	5.92	6.63	7.87	8.44	9.21
B,H.P.	.88	2.82	4.53	5.58	6.71
Friction horse power	5.04	3.81	3.34	2.86	2.50
Mechanical efficiency, per cent.	14.85	42.5	57.6	66.1	72.9
Gas per I.H.P. per hr. lbs.	.61	.51	.45	.491	.75
" " B.H.P. " " "	4.09	1.19	.773	.691	1.04
Thermal efficiency from I.H.P.	21.6	26.1	29.6	26.6	17.7
Efficiency of engine $\frac{\text{work done}}{\text{Heat in fuel}}$ %	3.23	11.1	17.2	17.8	17.3



Quarter Load - Hit and Miss Governor

	Switch board			Jacket water			Gasoline		Revolutions					
				Temperatures					Engine					
Time	Voltmeter	Ammeter	Voltmeter Variations	Inlet	Final	Weight	Temperature	Weight	Tachometer	Speed Indicator	Generator Speed Indicator	M.E.P.	I.H.P.	B.H.P.
3-00	126	3.3	6	52	140		66	37.75	475	472	937			1.03
3-10	126	2.9	6	52	104		66		478	475	948			.91
3-20	126	3.3	5	52	100		66		478	475	945			1.03
3-30	127	3.3	4	52	158		67		475	476	944			1.04
3-40	126	2.9	5	52	138		68		475	476	947			.91
3-50	126	3.3	5	52	145	218	68		478	479	957			1.03
4-00	126	3.3	5	52	134		68		480	479	957			1.03
4-10	126	3.3	5	52	136		69		478	477	952			1.03
4-20	126	2.9	5	52	140		69		478	477	952			.91
4-30	126	3.3	5	52	140		69		478	476	950			1.03
4-40	126	3.3	6	52	136		69		478	476	952			1.03
4-50	126	3.3	6	52	140		69		478	478	954			1.03
5-00	126	3.3	6	52	158	218	69		478	477	953			1.03
5-10	126	2.9	6	52	149		69		478	476	952			.91
5-20	126	3.3	6	52	149		69		478	476	953			1.03
5-30	126	2.9	5	52	125	109	69	31.75	475					.91
Averages & Totals			5.37	52	137		68.1	6.00		476	950			.993

Average belt slip .002

Half Load - Hit and Miss Governor.

	Switch board			Jacket water Temperatures			Gasoline		Revolutions Engine					
Time	Voltmeter	Ammeter	Voltmeter Variations	Initial	Final	Weight	Temperature	Weight	Tachometer	Speed Indicator	Generator Speed Indicator	M.E.P.	I.H.P.	B.H.P.
8-35	125	11.6	4	51	111		61	29.75	477	476	949			2.87
8-45	125	11.1	4	53	168		61		475	476	946			2.75
8-55	125	11.6	4	53	145		63		475	475	950			2.87
9-05	125	11.1	4	53	138		65		472	476	947			2.75
9-15	125	11.1	4	53	138		66		475	476	950			2.75
9-25	125	11.1	4	52	136		67		476	475	949			2.75
9-35	124	11.1	4	53	132	218	68		475	476	947			2.72
9-45	125	11.1	4	54	148		69		475	474	946			2.75
9-55	125	11.6	4	53	144		71		475	476	950			2.87
10-05	125	11.1	4	53	144		71		475	477	952			2.75
10-15	123	11.1	4	54	146		72		478					2.71
10-25	125	11.1	4	54	146		72		475	476	952			2.75
10-35	125	11.1	4	53	146	218	72		477	477	952			2.75
10-45	127	11.6	4	53	152		73		476					2.92
10-55	127	11.6	4	53	149		73		478	476	958			2.92
11-05	125	11.1	4	53	152		73		477					2.75
11-15	126	11.6	4	53	152		73		477	481	959			2.90
11-25	126	11.6	4	53	148		74		477	474	950			2.90
11-35	126	11.6	4	53	140	218	74	20.25	477	476	950			2.90
Averages & Totals			4	53.5	145.8		69.4	950		476	952			2.80

Average belt slip-0

Three Quarters Load - Hit and Miss Governor

Time	Switch board: Voltmeter	Ammeter	Voltmeter Variations	Jacket water Temperatures: Entra	Final	Weight	Gasoline: Temperature	Weight	Revolutions: Engine Tachometer	Speed Indicator	Generator Speed Indicator	M.E.P.	I.H.P.	B.H.P.
11-00	121	20	4	53	136		59	30.5	465	470	938			4.35
11-10	121	20	4	53	136		62		465	471	938			4.35
11-20	121	19.7	4	53	140		64		465	472	940			4.28
11-30	121	19.7	4	53	118		66		470	471	938			4.28
11-40	120	19.7	3	53	134	218	67		456	472	940			4.35
11-50	119	19.5	4	53	215		68		450	471	940			4.16
12-00	120	20	3	53	188		68		425	472	939			4.31
12-10	120	19.7	4	53	160		69		455	471	938			4.25
12-20	120	19.7	4	53	169		70		460	472	937			4.25
12-30	120	19.8	3	53	184		71		450	471	938			4.30
12-40	120	19.7	3	53	188		72		460	471	937			4.25
12-50	120	20	4	53	172		72		455	472	939			4.31
1-00	119	20	4	53	165	218	73		460	471	936			4.27
1-10	120	19.5	4	53	170		73		455	472	939			4.20
1-20	119	20	4	53	160		73		460	472	939			4.27
1-30	119	19.5	4	53	181		73		460	470	938			4.16
1-40	119	19.5	4	53	162		73		462	472	941			4.16
1-50	119	19.5	4	53	162		73		467	472	939			4.16
2-00	119	19.5	4	53	169	200	73	20.25	465	470	938			4.16
Averages & Totals			3.8	53	164		69.5	10.25		471	938			4.25

Full Load Hit and Miss Governor.

Time	Switch board: Voltmeter	Switch board: Ammeter	Switch board: Voltmeter Variations	Jacket water Temperatures: Initial	Jacket water Temperatures: Final	Jacket water: Weight	Gasoline: Temperature	Gasoline: Weight	Revolution Engine: Tachometer	Revolution Engine: Speed Indicator	Revolution Engine: Speed Indicator	M.E.P.	I.H.P.	B.H.P.
7-05	123	31.9	5	52	140		56	35.25	465	468	926			6.53
7-15	123	31.9	5.5	52	149		57		465	466	925			6.53
7-25	123	31.9	5.5	52	166		58		468	467	935			6.53
7-35	122	31.4	5.5	52	168		62		466	466	927			6.37
7-45	122	31.4	5	53	154	216	64		465	466	925			6.37
7-55	121	30.9	5	53	154		65		464	465	922			6.22
8-05	121	31.4	5.5	53	154		67		463	465	924			6.32
8-15	121	31.4	5	53	154		68		464	466	925			6.32
8-25	120	30.9	5	53	166		69		464	465	926			6.17
8-35	121	30.9	5	53	172	218	69		465	465	925			6.22
8-45	121	30.9	4	53	161		69		465	467	925			6.22
8-55	121	30.9	5	53	157		70		465	464	926			6.22
9-05	120	30.9	5	53	154		71	25.75	465	465	925			6.17
9-15	120	30.9	4	53	150	218	71		465	466	924			6.17
9-25	120	30.9	5	53	161		72		466	465	925			6.17
9-35	120	30.9	5	53	170		72	23.25	465	465	924			6.17
9-45	119	30.4	4	53	168		73		463	465	924			6.02
9-55	119	30.4	5	53	161	218	73		465	465	925			6.02
10-05	120	30.4	5	53	164		74		463	467	926			6.07
10-15	120	30.4	4	53	168		74		464	466	926			6.07
10-25	119	30.4	5	53	172		74		464	465	925			6.02
10-35	119	30.4		53	168	200	74	18.75	463					
Averages & Totals			4.9	52.9	160		68.5	16.50		465	925			6.23

Average belt slip .0054

Over Load - Hit and Miss Governor.

	Switch board			Jacket water Temperatures			Gasoline		Revolution Engine					
Time	Voltmeter	Ammeter	Voltmeter Terminals	Initial	Final	Weight	Temperature	Weight	Tachometer	Speed Indicator	Generator Speed Indicator	M.E.P.	I.H.P.	B.H.P.
3-45	121	37	4	53	185		73	27.25	460	469	927			7.29
3-55	121	36.5	4	52	200		74		455	467	928			7.18
4-05	120	37	4	52	152		74		450	468	929			7.21
4-15	121	37	4	52	149	218	74		450	467	925			7.29
4-25	121	36.5	4	52	157		74		450	468	927			7.18
4-35	121	37	4	52	155		74			468	927			7.29
4-45	121	37	4	52	157	141	74	21.50		468	926			7.29
Averages & Totals			4	52.1	165		73.9	5.75		468	928			7.25

Report of Test

Hit and Miss Governing

	Load				
	1/4	1/2	3/4	Full	Over
Duration of trial, hrs.	2.5	3.0	3.0	3.5	1.0
Jacket water total, lbs.	545	654	636	1072	359
" " per hr. "	218	218	212	306	359
" " temp. entering F°	52	53.5	53	52.9	52.1
" " " leaving F°	137	143.8	164	160	165
" " range F°	85	90.3	111	107.1	112.9
Revolutions total	71400	85680	84780	97650	28080
" " per hr.	28560	28560	28260	27900	28080
" " " min.	476	476	471	465	468
Thermal equivalent 1# gasoline B.T.U.	19290	19290	19290	19290	19290
D.H.P.	.993	2.8	4.25	6.23	7.25
Gasoline per D.H.P. per hr. lbs.	2.42	1.13	.804	.757	.793
Efficiency of engine $\frac{\text{work done}}{\text{Heat in fuel}}$ %	5.4	11.7	16.4	17.4	16.6

Remarks.

Preliminary run.

A two hour preliminary run was made to assure that the engine was running normally. The engine was new, having just been erected, and had never been worked out on the stand. This fact explains the high frictional horse power and consequent low mechanical efficiency of the early runs (See Plate VII) which respectively diminished and increased as the test progressed. On the preliminary run the engine was set to ignite at 30° before dead center. Even at this point, however, the cards showed late ignition. The spark was then set at 36° and the cards showed the ignition to be normal.

The effect of the temperature of cooling water was partially shown by the following experiment:

The engine was overloaded with the jacket water at about 212° F. The mixture was so proportioned as to cause the engine to miss fire about five times per minute. The jacket water was then gradually cooled. At about 100° F. the engine was exploding every cycle and the speed decreased until, finally, with the temperature at 55° the engine stopped. Since the mixture remained constant, this gradual decrease in the power developed by the engine was without doubt largely due to a decrease in the efficiency of combustion with the lowering of the temperatures, but the final stopping of the engine may have been partly due to the tightening of the piston with

the contraction of the cylinder.

The maximum power that could be obtained from the engine while running Throttling was 7 1/2 H.P. but when running on Hit and Miss governing 8 1/2 H.P. was developed with no difficulty other than a slight drop in speed.

It will be noticed that no cards were taken throughout the test of Hit & Miss Governing for the reason there was no indicator springs at hand of sufficient stiffness for the cylinder pressures, which were considerably higher than on the throttling test.

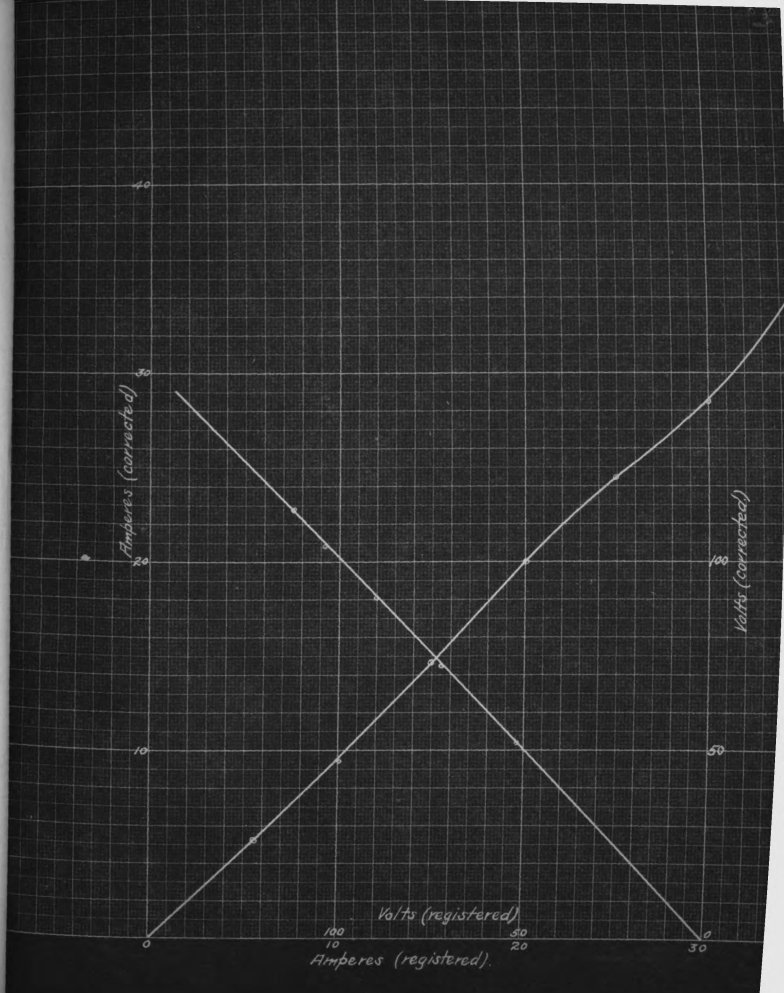

40
30
20
10
Amperes (corrected)
100
50
0
Volts (corrected)
Volts (registered)
100
50
0
10
20
30
Amperes (registered).

Plate I.

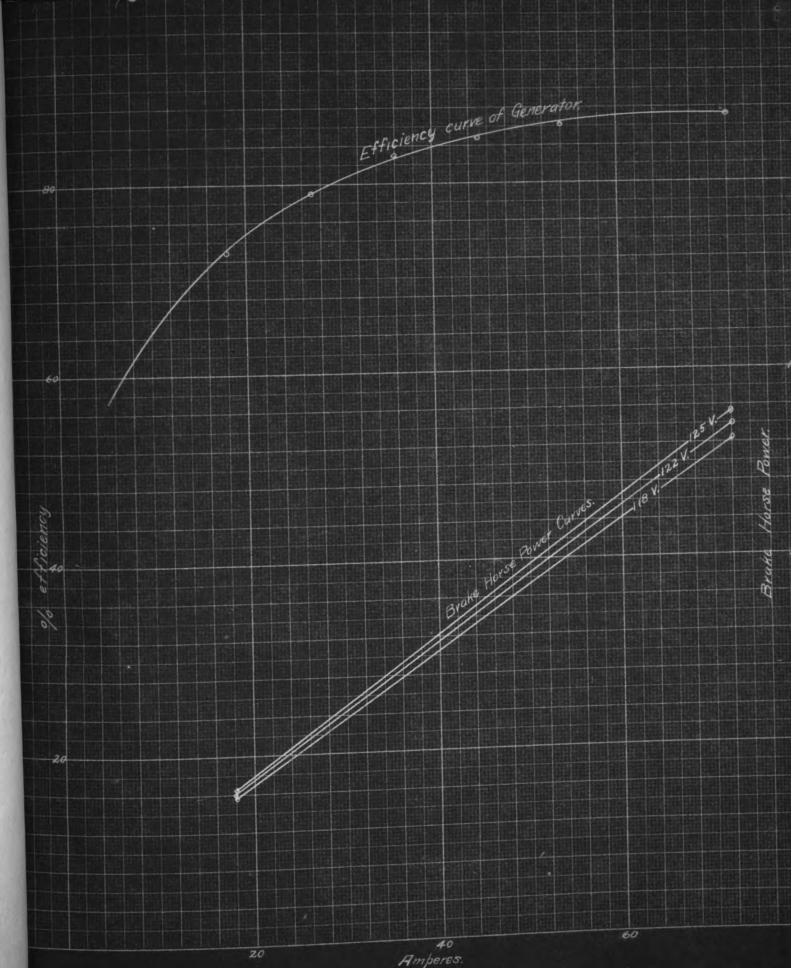
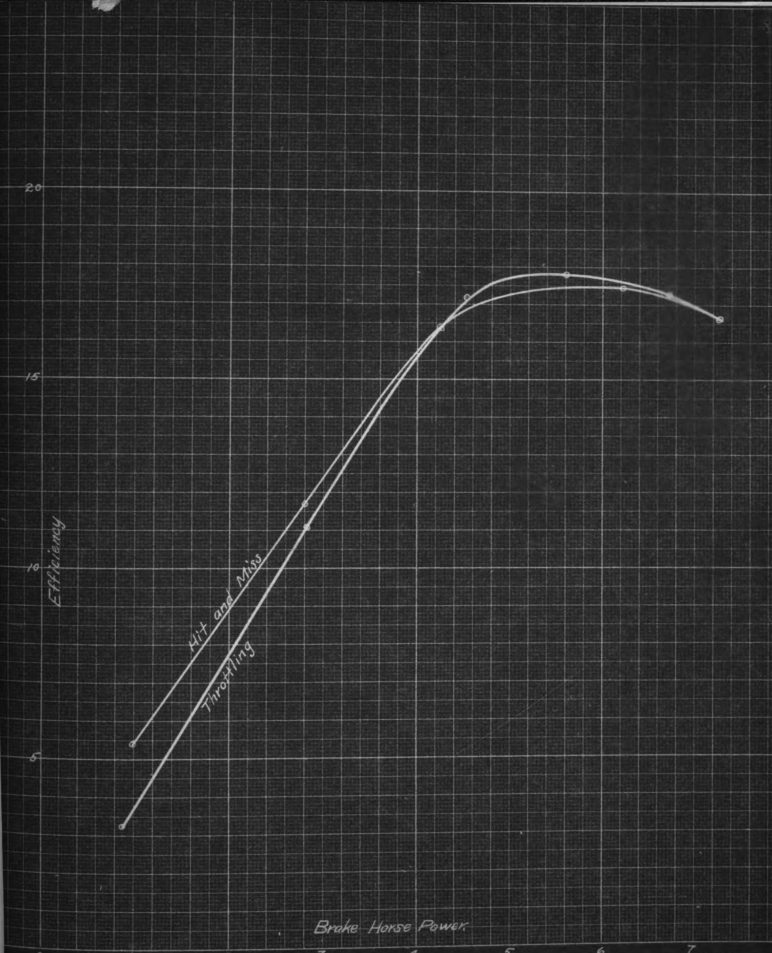
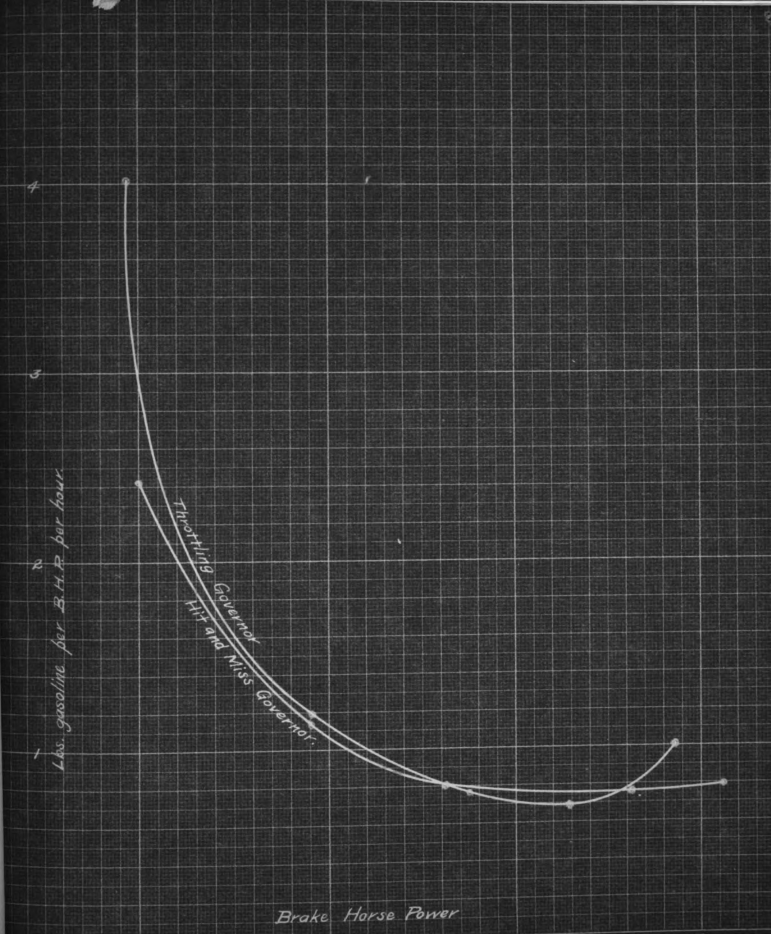

Efficiency curve of Generator.
80
60
40
20
% Efficiency
Brake Horse Power Curves.
118 V.
122 V.
125 V.
Brake Horse Power.
20
40
60
Amperes.

Plate II

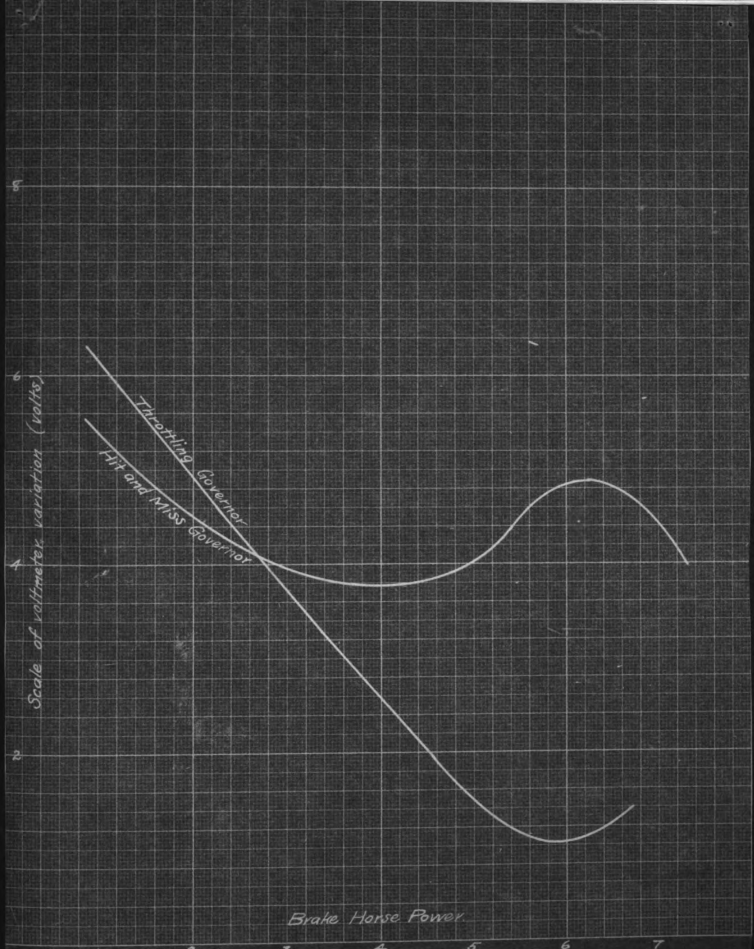


Efficiency Curve of Engine for
Hit and Miss and for Throttling Governing.



Consumption Curves for Hit and Miss and for Throttling Governing.

Plate IV.



Curves of Voltmeter Variation at Different Loads.

Plate V

All cards taken with 200 lbs. spring.

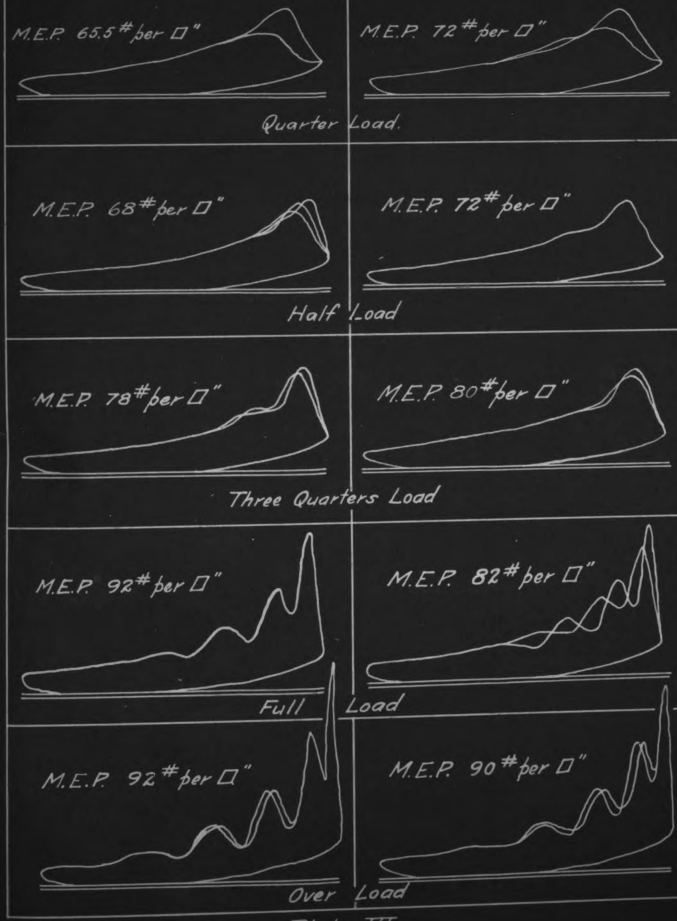
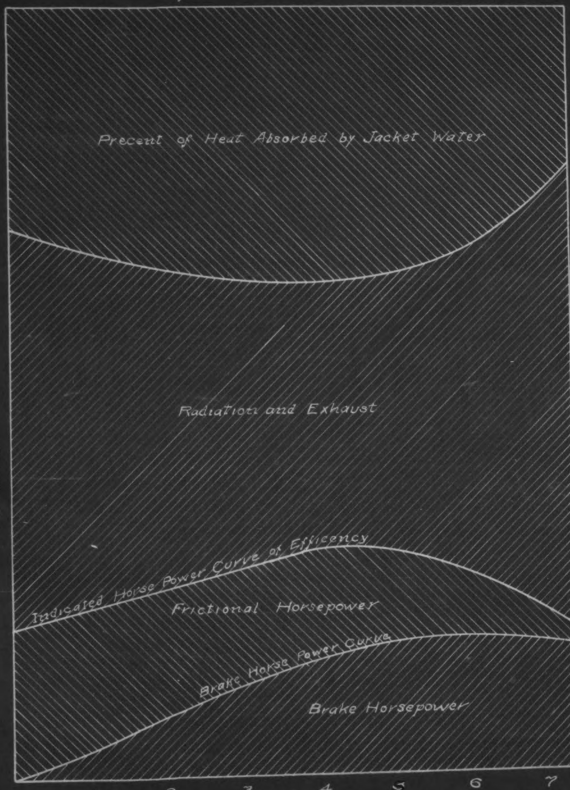


Plate VI.

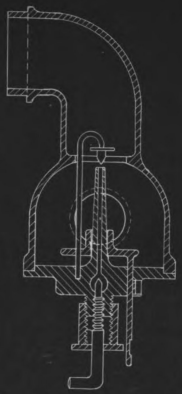


Heat Balance

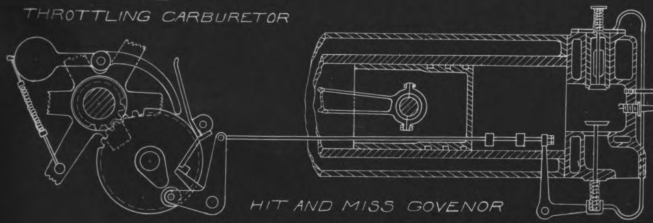
Plate VII

Plate VIII.

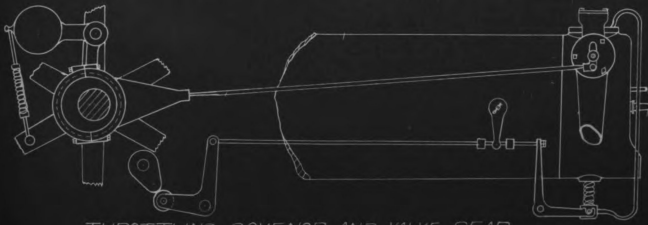
THROTTLING CARBURETOR



HIT AND MISS CARBURETOR



HIT AND MISS GOVENOR
AND VALVE GEAR IN POSITION TO MISS



THROTTLING GOVENOR AND VALVE GEAR.