TECHNICAL MEMORANDUMS

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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No. 363

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EXPERIMENTAL INVESTIGATION OF THE PHYSICAL PROPERTIES

OF MEDIUM AND HEAVY OILS, THEIR VAPORIZATION

AND USE IN EXPLOSION ENGINES

By Fritz Heinlein

PART II

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EXPERIMENTAL INVESTIGATION OF THE PHYSICAL PROPERTIES

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PART II.

Evaluation of the Experiments.

G = weight in grams of fuel introduced into vacuum,

V = vapor volume (cm^3) at temperature $t^{\circ}C$ uncorrected,

$V_{p,t}$ = vapor volume (cm^3) at temperature $t^{\circ}C$ corrected,

V_o = " " $V_{p,t}$ reduced to $0^{\circ}C$ and 760 mm Hg,

B = barometer stand at $0^{\circ}C$,

p = mercury level in barometer,

p_1 = " " " experiment tube,

p_t = vapor pressure in mm Hg

t = temperature of heating vapor,

t_1 = " " barometer,

t_2 = " " room.

The volume $V_{p,t}$ calibrated at $0^{\circ}C$, has increased at $t^{\circ}C$ by $V_{p,t}$ reading $\beta \times t$ ($\beta = 0.00025$, the coefficient of expansion of glass), so that for the $V_{p,t}$ reading, we must

now write $V_{p,t} = V_{p,t}$ reading $(1 + 0.00025\ t)$. The mercury column in the barometer tube must be reduced to $0^\circ C$, hence p to $p - (1 - 0.00081\ t_1)$. The mercury column in the experiment tube must likewise be reduced. It is here necessary to make the reduction in two parts, since the upper portion has the temperature t of the heating jacket, while the lower portion, outside of the heating jacket for a length of about 180 mm, may be assumed to have a temperature of about $\dfrac{t + t_2}{2}$. The reduction of $p_1 - 180$ mm gives $(p_1 - 180)(1 - 0.000181\ t)$ and $180\left(1 - 0.000181\ \dfrac{t + t_2}{2}\right)$. Moreover, in calculating the vapor pressures at high temperatures, the tension of the mercury must be taken into account, which can be obtained from the Landolt-Börnstein tables.

Experimental Results

In the following tables, the first column gives the temperatures t of the heating vapors; the second column gives the vapor pressures p_t which are the difference between the corrected mercury columns of the barometer and experiment tube. The third column gives the corrected vapor volume $V_{p,t}$ for every vapor pressure. The fourth column gives the calculated volume for 0.1 gram of the liquid, in order to have the same weight as the basis for all the fuels. Columns 5 and 6 give the volume $V_{p,t} = V_0$ reduced to $0^\circ C$ and 760 mm Hg, and the specific volume v_0, which is involved in the calculation of

the vapor density D (column 4) and is given only for the experimental conditions which produced complete evaporation of the fuel introduced.

In Figs. 3a-11b the pressure-volume curves are plotted for the different temperatures on the basis of the corresponding tables and the vapor-pressure curves derived from them. The explanation of this process has already been given. The weight G of the substance introduced into the vacuum is given at the head of each table. The vapor density D was calculated according to the formula

$$D = \frac{G}{0.001293} \; \frac{1}{V_{p,t}} \; \frac{760}{p,t} \; (1 + \alpha t).$$

TABLE III.

Gas oil. $G = 0.0378$ gram (.0013 oz.).

Temp. t		Vap. pres. p, t Hg		Vap. vol. $V_{p,t}$		$V_{p,t}$ for 0.1 g (.00353 oz.)	
°C	°F	mm	in.	cm³	cu. in	cm³	cu. in.
45	113	4.0	.16	26.0	1.59	68.78	4.20
Carbon		3.5	.14	49.0	2.99	129.64	7.91
disul-		3.0	.12	73.0	4.45	193.12	11.78
phide		2.0	.08	98.0	5.98	259.26	15.82
		2.0	.08	121.0	7.38	320.10	19.53
		1.5	.06	146.0	8.91	386.26	23.57
		1.5	.06	170.0	10.37	449.73	27.44
		1.0	.04	196.0	11.96	515.86	31.48
63	145.4	5.0	.20	26.5	1.62	70.10	4.28
Methyl		4.5	.18	49.5	3.02	130.94	7.99
alcohol		4.0	.16	73.5	4.49	194.44	11.87
		4.0	.16	99.0	6.04	261.90	15.98
		3.5	.14	121.5	7.41	313.75	19.15
		3.0	.12	146.5	8.94	387.77	23.66
		2.5	.10	170.5	10.40	451.05	27.52
		2.0	.08	195.5	11.93	517.19	31.56
		2.0	.08	219.0	13.36	579.36	35.35
98	208.4	12.0	.47	27.0	1.65	71.43	4.36
Water		12.0	.47	50.0	3.05	132.27	8.07
vapor		10.0	.39	74.0	4.52	195.76	11.95
		8.0	.31	100.0	6.10	264.05	16.11
		7.0	.28	122.0	7.44	322.07	19.65
		6.0	.24	145.0	8.85	383.05	23.37
		5.0	.20	171.0	10.43	452.03	27.58
		4.5	.18	196.0	11.96	518.05	31.61
		4.0	.16	219.0	13.36	579.04	35.33
130	266	49.0	1.93	35.0	2.14	92.6	5.65
Methyl		40.0	1.57	55.0	3.36	145.5	8.88
alcohol		31.0	1.22	78.0	4.76	206.3	12.59
		28.0	1.10	101.5	6.19	268.5	16.38
		23.0	.91	125.0	7.63	330.7	20.18
		20.0	.79	173.0	10.56	457.6	27.92

TABLE III (Cont.)

Gas oil. G = 0.0378 gram (.0013 oz.).

Temp. t		Vap. pres. p,t Hg		Vap. vol. $V_{p,t}$		$V_{p,t}$ for 0.1 g (.00353 oz.)	
°C	°F	mm	in.	cm³	cu.in.	cm³	cu.in.
162	333.6	93.0	3.36	22.5	1.37	56.8	3.47
Turpentine		84.0	3.31	40.0	2.44	105.8	6.46
		52.0	2.05	60.0	3.66	158.7	9.68
		39.0	1.54	81.0	4.94	214.2	13.07
		32.0	1.26	104.0	6.35	275.1	16.79
		30.0	1.18	124.0	7.57	328.3	20.03
Completely		29.0	1.14	158.0	9.64		
evaporated		27.0	1.06	173.0	10.56		

TABLE III (Cont.)

Temp. t	V_o at 0°C (32°F) 760 mm(29.89 in.) Hg		Sp. vol. v_o		Vapor density D
	cm³	cu.in.	cm³	cu.in.	
Completely	3.85	.23	101.8	6.21	7.59
evaporated	3.85	.23	101.8	6.21	7.59

TABLE IV.

Rositzer fuel oil. G = 0.0406 g (.00143 oz.).

Temp. t		Vap. pres. p,t Hg		Vap. vol. $V_{p,t}$		$V_{p,t}$ for 0.1 g (.00353 oz.)	
°C	°F	mm	in.	cm	cu. in.	cm	cu. in.
63	145.4	5.0	.20	18.0	1.10	44.3	2.70
		4.0	.16	41.0	2.50	100.9	6.16
		3.0	.12	65.0	3.97	160.1	9.77
		2.5	.10	89.0	5.43	219.2	13.38
		2.0	.08	113.0	6.90	278.3	16.98
		2.0	.08	137.0	8.36	337.4	20.59
		1.5	.06	162.0	9.89	399.0	24.35
97	206.6	12.0	.47	20.0	1.22	49.2	3.00
		8.0	.31	41.0	2.50	100.9	6.16
		6.0	.24	65.0	3.97	160.1	9.77
		4.5	.18	89.0	5.43	219.2	13.38
		4.0	.16	114.0	6.96	280.7	17.13
		3.0	.12	138.0	8.42	339.9	20.74
		2.0	.08	161.0	9.82	396.5	24.20
144	291.2	76.0	2.99	34.0	2.07	83.7	5.11
		53.0	2.09	53.0	3.23	130.5	7.96
		48.0	1.89	77.0	4.70	189.6	11.57
		45.0	1.77	100.0	6.10	246.3	15.03
		40.0	1.57	123.0	7.51	302.9	18.48
		35.0	1.38	145.0	8.85	357.1	21.79
Completely evaporated		30.0	1.18	172.0	10.50		
		26.0	1.02	217.0	13.24		
173	343.4	119.0	4.69	46.0	2.81	113.3	6.91
		105.0	4.13	85.0	5.19	209.3	12.77
		78.0	3.07	106.0	6.47		
Completely evaporated		69.0	2.72	130.0	7.93		
		56.0	2.20	160.0	9.76		

TABLE IV (Cont.)

Rositzer fuel oil.　G = 0.0406 g (.00143 oz.).

Temp. t	V_0 at $0^\circ C$ ($32^\circ F$) 760 mm (29.29 in.) Hg		Sp. vol. v_0		Vapor density D
	cm³	cu. in.	cm³	cu. in.	
Completely evaporated	$\{$4.44 $\{$4.85	.27 .30	109.3 119.2	6.67 7.27	6.80$\}$ 6.75$\}$ 6.78
173　343.4	—	—	—	—	-- --
	6.85	.42	163.8	10.00	4.83
Completely evaporated	$\{$7.21 $\{$7.21	.44 .44	177.4 177.4	10.83 10.83	4.35$\}$ 4.35$\}$ 4.35

TABLE V.

Solar oil. G = 0.9418 g (.03322 oz.).

Temp. t		Vap. pres. p,t Hg		Vap. vol. $V_{p,t}$		$V_{p,t}$ for 0.1 g (.00353 oz.)	
°C	°F	mm	in.	cm³	cu. in.	cm³	cu. in.
44	111.2	6.0	.24	42.0	2.56	100.4	6.13
		6.0	.24	66.0	4.03	157.8	9.63
		5.0	.20	90.0	5.49	215.3	13.14
		4.0	.16	114.0	6.96	272.7	16.64
		3.5	.14	138.0	8.42	330.1	20.14
		3.0	.12	162.0	9.89	387.5	23.65
		2.0	.08	183.0	11.17	437.8	26.72
63	145.4	10.0	.39	43.0	2.62	102.8	6.27
		9.0	.35	67.0	4.09	160.3	9.78
		8.0	.31	90.0	5.49	215.3	13.14
		7.0	.28	114.0	6.96	272.5	16.63
		6.0	.24	139.0	8.48	332.5	20.29
		5.0	.20	162.0	9.89	387.5	23.65
		4.0	.16	171.0	10.43	409.0	24.96
		3.0	.12	217.0	13.24	519.1	31.68
97	206.6	76.0	2.99	60.0	3.66	143.5	8.76
		63.0	2.48	80.0	4.88	191.3	11.67
		52.0	2.05	102.0	6.22	244.0	14.89
		44.0	1.73	125.0	7.63	299.0	18.25
		40.0	1.57	147.0	8.97	351.6	21.46
130	266	101.0	3.98	66.0	4.03	157.9	9.64
		93.0	3.66	83.0	5.06	198.5	12.11
		82.0	3.23	107.0	6.53	256.0	15.62
Completely evaporated		72.0	2.83	129.0	7.87	—	—
		64.0	2.52	152.0	9.28	—	—
		57.0	2.24	172.0	10.50	—	—
		50.0	1.97	196.0	11.96	—	—

.TABLE V (Cont.)

Solar oil.   G = 0.9418 g (.03322 oz.).

Temp. t	V_O at $0^\circ C$ $(32^\circ F)$ 760 mm(29.39 in.) Hg		Sp. vol. v_O		Vapor density D
	cm³	cu.in.	cm³	cu.in.	
Completely evaporated	8.28	.51	198.1	12.09	3.91
	8.67	.529	207.4	12.66	3.73
	{ 8.72	.53	208.0	12.70	3.69 } 3.69
	{ 8.72	.53	208.8	12.74	3.69 }

TABLE VI.

Paraffine oil. G = 0.0384 g (.00135 oz.)

Temp. t		Vap. pres. p,t Hg		Vap. vol. $V_{p,t}$		$V_{p,t}$ for 0.1 g (.00353 oz.)	
°C	°F	mm	in.	cm³	cu.in.	cm³	cu.in.
63	145.4	5.0	.20	38.0	2.31	98.9	6.04
		5.0	.20	62.0	3.78	161.4	9.85
		4.5	.18	87.0	5.31	226.5	13.82
		4.0	.16	113.0	6.90	294.2	17.95
		4.0	.16	135.0	8.24	351.5	21.45
		3.5	.14	158.0	9.64	411.4	25.10
		3.0	.12	183.0	11.17	476.5	29.08
		3.0	.12	208.0	12.69	541.6	33.05
75	167	8.0	.31	39.0	2.38	101.5	6.19
		8.0	.31	62.0	3.78	161.4	9.85
		6.0	.24	86.0	5.25	223.9	13.66
		5.0	.20	110.0	6.71	286.4	17.48
		5.0	.20	135.0	8.24	351.5	21.45
		4.0	.16	185.0	11.29	411.4	25.10
		3.0	.12	183.0	11.17	476.5	29.08
		3.0	.12	208.0	12.69	541.6	33.05
98.5	209.3	14.0	.55	39.0	2.38	101.5	6.19
		13.0	.51	62.0	3.78	161.4	9.85
		11.0	.43	86.0	5.25	223.9	13.66
		10.0	.39	110.0	6.71	286.4	17.48
		9.0	.35	158.0	9.64	411.4	25.10
		8.0	.31	183.0	11.17	476.5	29.08
		6.0	.24	208.0	12.69	541.6	33.05
118	244.4	15.0	.59	39.0	2.38	101.5	6.19
		14.0	.55	62.0	3.78	161.4	9.85
		12.0	.47	86.0	5.25	223.9	13.66
		11.0	.43	110.0	6.71	286.4	17.48
		10.0	.39	135.0	8.24	351.5	21.45
		9.0	.35	158.0	9.64	411.4	25.10
		8.0	.31	183.0	11.17	476.5	29.08
		6.0	.24	208.0	12.69	541.6	33.05
175	347	18.0	.71	41.0	2.50	106.7	6.51
		16.0	.63	65.0	3.97	169.2	10.33
		14.0	.55	89.0	5.43	231.6	14.13

TABLE VI (Cont.)

Paraffine oil. G = 0.0384 g (.00135 oz.).

Temp. t	Vap. pres. p, t Hg		Vap. vol. $V_{p,t}$		$V_{p,t}$ for 0.1 g (.00353 oz.)	
Completely evaporated	mm	in.	cm³	cu.in.		
	11.0	.43	114.0	6.96		—
	10.0	.39	138.0	8.42		—
	9.0	.35	163.0	9.95		—
	8.0	.31	183.5	11.20		—

TABLE VI (Cont.)

Temp. t	V_o at 0°C (32°F) 760 mm(29.29 in.) Hg		Sp. vol. v_o		Vapor density D
Completely evaporated	cm³	cu.in.	cm³	cu.in.	
	1.009	.0616	26.29	1.60	29.4
	1.111	.0678	28.93	1.77	26.7
	{1.183	.0722	30.82	1.88	25.0 } 25.0
	{1.184	.0723	30.82	1.88	25.0

TABLE VII.

Coal-tar oil I. G = 0.094 g (.003316 oz.).

Temp. t		Vap. pres. p, t Hg		Vap. vol. $V_{p,t}$		$V_{p,t}$ for 0.1 g (.00353 oz.)	
°C	°F	mm	in.	cm³	cu. in.	cm³	cu. in.
20.5	68.9	29.0	1.14	37.0	2.26	39.4	2.40
		23.0	.87	60.0	3.66	63.8	3.89
		21.0	.83	87.0	5.31	92.8	5.66
		19.0	.75	107.0	6.53	113.8	6.94
		17.0	.67	130.0	7.93	138.3	8.44
		14.0	.55	154.0	9.40	163.8	10.00
35	95	43.0	1.69	39.0	2.38	41.5	2.53
		37.0	1.46	62.0	3.78	65.9	4.02
		30.0	1.18	84.0	5.13	89.3	5.45
		27.0	1.06	106.0	6.47	113.8	6.88
		25.0	.98	130.0	7.93	138.3	8.44
		23.0	.91	154.0	9.40	163.8	10.00
		21.0	.83	178.0	10.86	189.3	11.55
44	111.2	61.0	2.40	43.0	2.62	45.7	2.79
		50.0	1.97	64.0	3.91	68.1	4.16
		42.0	1.65	87.0	5.31	92.5	5.64
		37.0	1.46	109.0	6.65	115.9	7.07
		32.0	1.26	132.0	8.06	140.4	8.57
		30.0	1.18	155.0	9.46	164.9	10.06
		27.0	1.06	180.0	10.98	191.5	11.69
63	145.4	91.0	3.58	50.0	3.05	53.1	3.24
		72.0	2.83	70.0	4.27	74.4	4.54
		59.0	2.32	91.0	5.55	96.8	5.91
		53.0	2.09	114.0	6.96	121.2	7.40
		46.0	1.81	136.0	8.30	144.7	8.83
		41.0	1.61	160.0	9.76	177.2	10.81
		37.0	1.46	188.0	11.47	194.7	11.88
		35.0	1.38	206.0	12.57	219.1	13.37
78	172.4	116.0	4.57	50.5	3.08	53.5	3.26
		93.0	3.66	69.0	4.21	73.4	4.48
		77.0	3.03	89.0	5.43	94.7	5.78
		68.0	2.68	111.0	6.77	118.1	7.21
		59.0	2.32	133.0	8.12	151.5	9.24
		54.0	2.13	156.0	9.52	165.9	10.12
		50.0	1.97	178.0	10.86	189.3	11.55

TABLE VII (Cont.)

Coal-tar oil I.   G = 0.094 g (.003316 oz.)

Temp. t		Vap. pres. p,t Hg		Vap. vol. $V_{p,t}$		$V_{p,t}$ for 0.1 g (.00353 oz.)	
°C	°F	mm	in.	cm³	cu. in.	cm³	cu. in.
98.5	209.3	140.0	5.51	58.0	3.54	61.7	3.77
		116.0	4.57	75.0	4.58	79.8	4.87
		89.0	3.50	95.0	5.80	101.0	6.16
		82.0	3.23	117.0	7.14	124.4	7.59
		76.0	2.99	138.0	8.42	146.8	8.96
Completely evaporated		69.0	2.72	160.0	9.76		
		62.0	2.44	178.0	10.86		
		54.0	2.13	207.0	12.63		
120	248	150.0	5.91	64.0	3.91	68.0	4.15
		131.0	5.16	79.0	4.82	83.6	5.10
Completely evaporated		118.0	4.65	99.0	6.04		
		99.0	3.90	119.0	7.26		
		86.0	3.39	139.0	8.48		
		74.0	2.91	162.0	9.89		
		66.0	2.60	185.0	11.29		
		59.0	2.32	207.0	12.63		
134	273.2	171.0	6.73	64.0	3.91	68.0	4.15
Completely evaporated		139.0	5.47	102.0	6.22		
		116.0	4.57	123.0	7.51		
		101.0	3.98	145.0	8.85		
		86.0	3.39	173.0	10.56		
		78.0	3.07	191.0	11.66		

TABLE VII (Cont.)

Coal-tar oil I.   G = 0.094 g (.003316 oz.)

Temp. t	V_O at $0°C$ ($32°F$.) 760 mm (29.29 in.) Hg		Sp. vol. v_O		Vapor density D
	cm³	cu.in.	cm³	cu.in.	
Completely evaporated	10.67	.651	113.5	6.93	6.82
	10.72	.654	114.5	6.99	6.79
	10.80	.659	114.9	7.01	6.74
120 248	–	–	–	–	–
	–	–	–	–	–
Completely evaporated	10.67	.651	113.5	6.93	6.82
	10.76	.657	114.4	6.99	6.77
	10.92	.666	116.1	7.08	6.67
	10.96	.669	116.6	7.12	6.64
	{11.13	.679	118.2	7.21	6.48 } 6.48
	{11.12	.679	118.2	7.21	6.48 }
134 273.2	–	–	–	–	–
Completely evaporated	12.51	.763	132.9	8.11	5.82
	12.59	.768	133.9	8.17	5.78
	12.60	.769	134.0	8.18	5.77
	{13.13	.801	139.6	8.519	5.55 } 5.55
	{13.14	.802	139.7	8.52	5.55 }

TABLE VIII.

Coal-tar oil II.   G = 0.0852 g (.003 oz.)

Temperature $t^{\circ}C$		Vapor pressure p,t Hg		Vapor volume $V_{p,t}$		$V_{p,t}$ for 0.1 gram (.00353 oz.)	
		mm	in.	cm³	cu.in.	cm³	cu.in.
32	89.6	3.0	.12	33.0	2.01	38.7	2.36
		2.5	.10	52.5	3.20	61.5	3.75
		2.5	.10	78.5	4.79	92.1	5.62
		2.0	.08	100.5	6.13	117.9	7.19
		2.0	.08	126.0	7.69	147.8	9.02
		1.5	.06	149.0	9.09	174.8	10.67
		1.5	.06	174.0	10.62	204.2	12.46
63	145.4	7.0	.28	28.0	1.71	32.8	2.00
		6.0	.24	50.0	3.05	58.6	3.58
		5.0	.20	75.0	4.58	88.0	5.37
		4.0	.16	100.0	6.10	117.3	7.16
		3.5	.14	124.0	7.57	145.5	8.88
		3.0	.12	149.0	9.09	174.8	10.67
		2.5	.10	173.0	10.56	200.3	12.22
		1.5	.06	197.0	12.02	231.2	14.11
72	161.6	9.0	.35	31.0	1.89	36.3	2.22
		8.0	.31	50.0	3.05	58.6	3.58
		7.0	.28	75.0	4.58	88.0	5.37
		6.0	.24	100.0	6.10	117.3	7.16
		6.0	.24	123.0	7.57	144.3	8.81
		4.0	.16	149.0	9.09	174.8	10.67
		3.0	.12	172.0	10.50	201.9	12.32
97	206.6	18.0	.71	30.5	1.86	35.8	2.18
		15.0	.59	53.0	3.23	62.2	3.80
		13.0	.51	77.0	4.70	90.3	5.51
		11.0	.43	101.5	6.19	119.1	7.27
		9.0	.35	125.0	7.63	146.7	8.95
		8.0	.31	148.0	9.03	173.7	10.60
		8.0	.31	173.5	10.59	203.6	12.42

TABLE VIII (Cont.)

Coal-tar oil II. G = 0.0852 g (.003 oz.).

Temperature ±°C		Vapor pressure p,t Hg		Vapor volume $V_{p,t}$		$V_{p,t}$ for 0.1 gram (.00353 oz.)	
°C	°F	mm	in.	cm³	cu. in.	cm³	cu. in.
110	230	28.0	1.02	32.5	1.98	38.1	2.32
		22.0	.87	55.0	3.36	64.5	3.94
		20.0	.79	78.0	4.76	91.5	5.58
		18.0	.71	103.0	6.29	120.9	7.38
		17.0	.67	126.0	7.69	147.9	9.03
		16.0	.63	150.0	9.15	176.0	10.74
		15.0	.59	175.5	10.71	205.9	12.56
		13.0	.51	199.0	12.15	233.5	14.35
173	343.4	65.0	2.56	36.0	2.20	42.2	2.58
		63.0	2.48	63.0	3.84	73.9	4.51
		59.0	2.32	87.0	5.31	102.1	6.23
		57.0	2.24	113.0	6.90	132.6	8.09
		53.0	2.09	137.0	8.36	160.8	9.81
		50.0	1.97	159.0	9.70	186.8	11.40
		42.0	1.65	183.0	11.17	214.8	13.11
		30.0	1.18	205.0	12.51	240.6	14.68

TABLE IX.

Kerosene.   G = 0.0456 g (.0016 oz.).

Temp. t°C		Vap. pres. p,t Hg		Vap. vol. $V_{p,t}$		$V_{p,t}$ for 0.1 g (.00353 oz.)	
°C	°F	mm	in.	cm³	cu. in.	cm³	cu. in.
33	92.4	4.0	.16	46.0	2.81	105.5	6.44
		4.0	.16	70.0	4.27	160.5	9.79
		3.0	.12	94.0	5.74	215.6	13.16
		3.0	.12	119.0	7.26	272.9	16.65
		2.5	.10	142.0	8.67	325.6	19.87
		2.0	.08	166.5	10.16	381.9	23.30
		1.0	.04	190.0	11.59	435.8	26.59
60	140	12.0	.47	48.0	2.93	110.1	6.72
		12.0	.47	72.0	4.39	165.1	10.07
		11.0	.43	95.0	5.80	217.6	13.28
		9.0	.35	120.0	7.32	275.2	16.79
		8.0	.31	144.0	8.79	330.2	20.15
		6.0	.24	168.0	10.25	385.3	23.51
		6.0	.24	192.0	11.72	440.3	26.87
73	163.4	19.0	.75	49.0	2.99	112.4	6.86
		18.0	.71	72.5	4.42	165.1	10.11
		17.0	.67	96.0	5.86	220.2	13.44
		13.0	.51	120.5	7.35	276.4	16.87
		11.0	.43	144.0	8.79	330.2	20.15
		10.0	.39	120.5	7.35	276.4	16.87
		10.0	.39	169.0	10.31	387.6	23.65
		10.0	.39	193.0	11.78	442.6	27.01
97	206.6	39.0	1.54	54.0	3.30	123.9	7.56
		32.0	1.26	76.0	4.64	172.0	10.50
		29.0	1.14	99.0	6.04	227.0	13.85
		27.0	1.06	123.0	7.51	282.1	17.21
		24.0	.94	157.0	9.58	337.1	20.57
		20.0	.79	171.0	10.43	392.2	23.93
		18.0	.71	195.0	11.90	447.2	27.29
120	248	73.0	2.87	81.0	4.94	185.8	11.34
		65.0	2.56	103.0	6.29	236.5	14.43
Completely evaporated		53.0	2.09	130.0	7.93		--
		49.0	1.93	160.0	9.76		--
		45.0	1.77	174.0	10.62		--

TABLE IX (Cont.)

Kerosene. G = 0.0456 g (.00161 oz.).

Temp. $t^{\circ}C$	V_o at $0^{\circ}C$ ($32^{\circ}F$) 760 mm(29.39 in.) Hg		Sp. vol. v_o		Vapor density D	
	cm³	cu.in.	cm³	cu.in.		
Completely evaporated	6.29	.38	144.3	8.80	5.36	
	7.01	.43	160.8	9.81	4.81	4.81
	7.01	.43	160.8	9.81	4.81	

TABLE X.

Benzol (benzene). G = 0.3038 g (.01089 oz.)

Temp. $t^{\circ}C$		Vap. pres. p,t Hg		Vap. vol. V_p,t		V_p,t for 0.1 g (.00353 oz.)	
$^{\circ}C$	$^{\circ}F$	mm	in.	cm³	cu.in.	cm³	cu.in.
22	71.6	74.0	2.91	71.0	4.33	23.9	1.40
		73.0	2.87	95.0	5.80	30.7	1.87
		72.5	2.85	118.0	7.20	38.2	2.33
		68.0	2.68	167.0	10.19	54.0	3.30
		66.0	2.60	190.0	11.59	61.5	3.75
		64.0	2.52	214.0	13.06	69.3	4.23
36	96.8	121.0	4.76	82.0	5.00	26.5	1.62
		120.0	4.72	106.0	6.47	34.3	2.09
		119.0	4.69	130.0	7.93	42.0	2.56
		118.0	4.65	154.0	9.40	49.8	3.04
		117.0	4.61	180.0	10.98	58.2	3.55
		116.0	4.57	203.0	13.39	65.7	4.01
43	109.4	171.0	6.73	96.0	5.86	31.1	1.90
		164.0	6.46	117.0	7.14	37.8	2.31
		159.0	6.36	140.0	8.54	45.3	2.76
		148.0	5.83	161.0	9.82	52.1	3.18
		144.0	5.67	185.0	11.29	59.9	3.66
		142.0	5.59	204.0	12.45	67.6	4.13
61	141.8	282.0	11.10	98.0	5.98	31.7	1.93
		268.0	10.55	127.0	7.75	41.1	2.51
		257.0	10.12	140.0	8.54	45.3	2.76
		354.0	10.00	166.0	10.13	53.7	3.28
		350.0	9.84	188.0	11.47	60.8	3.71
		244.0	9.61	210.0	12.81	68.0	4.15

TABLE X (Cont.)

Benzol (benzene).   G = 0.3088 g (.01089 oz.).

Temp. $t^\circ C$		Vap. pres. p,t Hg		Vap. vol. $V_{p,t}$		$V_{p,t}$ for 0.1 g (.00353 oz.)	
$^\circ C$	$^\circ F$	mm	in.	cm^3	cu.in.	cm^3	cu.in.
97	206.6	486.0	19.13	150.0	9.15	48.5	2.96
		439.0	17.28	166.0	10.13	53.7	3.28
Completely evaporated.		418.0	16.46	182.0	11.11	--	
		389.0	15.31	198.0	12.08	--	
		362.0	14.25	216.0	13.18	--	

TABLE X (Cont.)

Temp. $t^\circ C$	V_o at $0^\circ C$ $(32^\circ F)$ 760 mm(29.29 in.) Hg		Sp. vol. v_o		Vapor density D	
	cm^3	cu.in.	cm^3	cu.in.		
Completely evaporated	73.85	4.51	239.1	14.59	3.22	
	74.77	4.56	242.1	14.77	3.19	3.19
	75.91	4.63	245.8	15.00	3.19	

TABLE XI.

Gasoline. G = 0.1101 g (.00388 oz.).

Temp. t°C		Vap. pres. p,t Hg		Vap. vol. V p,t		V p,t for 0.1 g (.00353 oz.)	
°C	°F	mm	in.	cm³	cu. in.	cm³	cu. in.
18.5	65.3	63.0	2.48	23.0	1.41	20.9	1.28
		51.0	2.01	44.0	2.69	40.0	2.45
		44.0	1.73	65.5	4.01	59.0	3.61
		39.0	1.54	88.0	5.39	80.0	4.90
		38.0	1.50	111.0	6.80	100.9	6.18
		34.0	1.34	135.0	8.27	122.7	7.51
		33.0	1.30	159.5	9.77	145.0	8.88
		30.0	1.18	183.0	11.21	166.3	10.18
		30.0	1.18	206.0	12.61	187.2	11.46
37	98.6	110.0	4.33	35.0	2.14	31.8	1.95
		96.0	3.78	51.0	3.12	46.3	2.83
		80.0	3.15	73.0	4.47	66.3	4.06
		71.0	2.80	95.5	5.85	86.8	5.31
		61.0	2.40	118.0	7.23	107.2	6.56
		59.0	2.32	140.0	8.57	127.2	7.79
		53.0	2.09	166.0	10.16	150.9	9.24
		50.0	1.97	188.0	11.51	170.9	10.46
		48.0	1.89	211.0	12.92	191.8	11.74
44	111.2	129.0	5.08	39.0	2.39	35.4	2.17
		115.0	4.53	56.5	3.46	51.3	3.14
		91.0	3.58	77.0	4.71	70.0	4.29
		81.0	3.19	98.5	6.03	89.5	5.48
		72.0	2.83	119.0	7.29	108.1	6.62
		67.0	2.64	143.0	8.76	130.0	7.96
		64.0	2.52	167.0	10.23	151.8	9.29
		61.0	2.40	190.0	11.63	172.7	10.57
		59.0	2.32	213.0	13.04	193.6	11.85
63	145.4	144.0	5.67	67.0	4.10	60.9	3.73
		127.0	5.00	86.0	5.27	78.1	4.78
		111.0	4.37	106.0	6.49	96.3	5.90
		101.0	3.98	128.0	7.84	116.3	7.12
		91.0	3.58	150.0	9.18	136.3	8.35
		88.0	3.46	173.0	10.59	157.2	9.63
		82.0	3.23	195.0	11.94	177.2	10.85
		76.0	2.99	218.0	13.35	198.1	12.13

TABLE XI (Cont.)

Gasoline.　G = 0.1101 g (.00388 oz.).

Temp. t^oC		Vap. pres. p,t Hg		Vap. vol. $V_{p,t}$		$V_{p,t}$ for 0.1 g (.00353 oz.)	
^oC	^oF	mm	in.	cm³	cu. in.	cm³	cu. in.
97	206.6	246.0	9.69	70.0	4.29	63.6	3.89
		214	8.43	88.0	5.39	80.0	4.90
		190.0	7.48	101.0	6.18	91.8	5.62
		166.0	6.54	119.0	7.29	108.1	6.62
		144.0	5.67	130.0	7.96	126.3	7.73
		128.0	5.04	158.0	9.67	143.6	8.79
		113.0	4.45	180.0	11.02	143.6	8.79
		113.0	4.45	180.0	11.02	163.6	10.02
Completely evaporated		104.0	4.09	201.0	12.27	--	
		94.0	3.70	223.0	13.61	--	

TABLE XI (Cont.)

Temp. t^oC		V_o at 0^oC (32^oF) 760 mm(29.39 in.) Hg		Sp. vol. v_o		Vapor density D	
		cm³	cu. in.	cm³	cu. in.		
Completely evaporated		20.29	1.24	184.13	11.24	4.19	}4.2
		20.28	1.24	815.06	49.74	4.02	

TABLE XII.

Vapor Densities.

Fuel	Temperatures in degrees C.							
	97	120	123	130	134	144	162	173
Gas oil	--	--	--	9.74	--	--	7.59	--
Rositzer oil	--	--	--	--	--	6.78	--	4.35
Paraffine oil	--	--	--	--	--	--	--	25.0
Coal-tar oil I	--	6.48	--	--	5.55	--	--	--
Coal-tar oil II	--	--	--	--	--	--	--	--
Solar oil	--	--	--	3.69	--	--	--	--
Kerosene	--	--	4.91	--	--	--	--	--
Gasoline	4.2	--	--	--	--	--	--	--
Benzol	3.19	--	--	--	--	--	--	--

Table Giving Boiling Limits.
(See Figs. 3a to 11b inclusive)

	°C	°F
Gas oil	190 – 340	374 – 644
Rositzer fuel oil	140 – 325	284 – 617
Solar oil	155 – 275	311 – 527
Paraffine oil	200 – 370	392 – 698
Coal-tar oil I	90 – 225	194 – 437
Coal-tar oil II	120 – 300	248 – 572
Kerosene	150 – 208	302 – 406.4
Benzol	75 – 160	167 – 320
Gasoline	60 – 120	140 – 248

On the basis of the experiments we were able to investigate thoroughly the already described phenomena of the obtainable vapor pressures with increased volume and constant temperature. The vapor pressures, as represented by the vapor-pressure curves show, according to the explanation already given, no maximum vapor pressures (saturation pressures). We can therefore conclude that, even in the light-oil fuel mixtures, there is no saturation of the combustion air with the fuel vapors. In practice, with the adoption of the spraying carburetor, we have no longer striven to obtain complete evaporation and the corresponding saturation of the combustion air with the fuel vapors. It is sufficient for the functioning of the engine to obtain a fine atomization of the fuel and a partial evaporation which, however, must have proceeded far enough to enable the ignition of the mixture by the electric spark.

Knowledge of vapor pressures is absolutely necessary, however, for the theoretical investigation of the evaporation of fuels. The vapor-pressure curves, in spite of their having no absolute values, are therefore of decisive importance, because they were plotted for both light and heavy oils under like conditions. In seeking a way for the use of heavy oils in explosion engines, it is of less importance to determine the absolute values of the physical characteristics of the fuels than to obtain data for comparing the light and heavy fuel oils. For the subsequent theoretical investigation of the evaporation

of liquid fuels, I have taken as the basis the vapor pressures

for $V_{p,t}$ = 160 cm³ (9.76 cu.in.) and have, for this purpose,

once more plotted the vapor-pressure curves in Fig. 12.

With the same apparatus, the vapor densities of the fuels

could also be found in connection with the determination of the

vapor pressures. The weight of the liquid was found by weigh-

ing the fuel introduced into the vacuum. All the data required

for calculating the vapor densities were obtained by lowering

the surface of the liquid until the last traces of the liquid

had vanished and by reading the pressure, volume and tempera-

ture. The calculation was then made according to the well-

known formula for vapor density:

$$D = \frac{G}{0.001293} \ \frac{1}{V_{p,t}} \ \frac{760}{pt} (1 + \alpha t).$$

The decrease in the vapor pressure, at constant pressure and

volumetric increase, could not indicate complete evaporation

with absolute certainty, according to the previously described

behavior of the fuels, even when no liquid was still visible

to the eye. Especially with heavy fuels, particles of liquid

could still adhere to the inside of the vacuum tube, without

being perceptible to the eye. It was therefore necessary to

delay reading the vapor pressure, temperature and volume, until

complete disappearance of the liquid had been observed at the

previous low positions of the mercury reservoir. A second con-

trol was obtained by taking several readings after the apparent

disappearance of the liquid surface until two successive read-
ings gave the same (or practically the same) computed value for
the vapor density.

For a few fuels, it was possible to find the vapor densi-
ties at different temperatures and to note the fact that the
vapor density diminished as the temperature rose. This is ex-
plained by the dissociation of the vapors at high temperatures.
Table XII gives the vapor densities in a convenient form for
comparison. For coal-tar oil II, no determination of the
vapor density was possible up to the highest experimental tem-
perature of 173°C (343.4°F), because complete evaporation could
not be effected at this temperature.

The <u>specific heat</u> of the oils was determined at different
temperatures, whereby the upper temperature limit was the low-
est boiling point of the oil. Electricity was employed for
heating, the current passing through a heater in the double
bottom of the calorimeter. The temperature of the liquid was
kept uniform by a mixer with an up-and-down motion.

If i represents the current strength and e the volt-
age at the ends of the heater wires, then the work of the cur-
rent for a period of z seconds is e i z watt-seconds or
joules. Now a joule = 0.23899 lesser calories, so that the
heating energy, expressed in heat units, is

$$Q = 0.23899 \; e \, i \, z \quad \text{greater calories} \qquad (1)$$
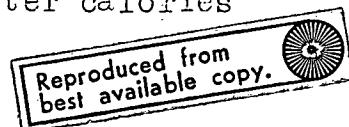
This added heat increases the temperature of the liquid, of the calorimeter, of the stirrer, and of the brass tube containing a thermo-electric couple for measuring the temperature. If W denotes the water equivalent of these parts, $t_2 - t_1$ the rise in temperature, c the specific heat of the liquid, and G the weight of the liquid, we have

$$Q = (c\,G + W)\,(t_2 - t_1) = 0.2389\,e\,i\,z \quad \text{also:}$$

$$c = \left(0.23899\,\frac{e\,i\,z}{t_2 - t_1} - W\right)\frac{1}{G} \qquad (2)$$

Experimental Arrangement (Fig. 13)

A brass calorimeter was nickel-plated and well polished on the outside, in order to lessen the heat radiation, and had a double bottom, in which a strip of nickeline with a resistance of about 30 ohms was wound about a sheet of mica. The connections of the delivery wires for the heating current were carefully soldered. Mica insulation in the bottom of the calorimeter prevented much outward loss of heat. A thermo-electric couple was soldered to the bottom of the calorimeter for control readings of the heat transition from the heater to the liquid. The calorimeter was closed at the top by a sheet-steel cover, through which passed a vertically moving stirrer b, which was made tight by a packing box. Another packing box enabled the introduction of a thin brass tube c, in which a small copper bulb, containing a thermo-electric couple for determining

the temperature, could be moved up and down. The temperature
of the liquid at different depths could thus be observed. No
difference in temperature at different depths was observed,
however, because the stirrer kept the liquid well mixed.

The calorimeter was placed in a Dewar vessel and the inter-
vening space filled with glass wool, in order to diminish as
much as possible the passage of heat between the calorimeter
and the surrounding media. Likewise the upward heat radiation
of the cover was reduced as much as possible by insulating with
glass wool. A constant outside temperature with a simultaneous-
ly higher temperature level in the high-temperature experiments
was maintained lastly by setting the Dewar vessel in a sheet-
iron cylinder which was electrically heated from the outside.*
The outer sheet-iron cylinder was filled with rape oil and the
Dewar vessel was sunk so deeply into the rape oil, that the
cover of the outer cylinder, which has a round opening in the
middle, came above the insulating glass wool on top of the cal-
orimeter. It was found quite possible to keep the temperature
of the rape oil constant by regulating the current for the out-
side heating.

For measuring the temperature of the calorimeter liquid,
of the base heater of the calorimeter and of the outside heater,
thermo-electric couples of copper constantan were used, which

*As a result of this arrangement, the downward heat conduction
from the bottom of the calorimeter is so small that it can be
disregarded. Its extremely small magnitude is, moreover, offset
by the "water equivalent" yet to be discussed.

had been previously calibrated with the laboratory thermostat and which enabled, by the mutual switching over of a pole switch, the convenient reading of the galvanometer or of the temperatures. The heating current for the calorimeter liquid was the laboratory battery with an E.M.F. of 60 volts and could be adjusted to the desired strength by switching in resistances. The current strength and tension of the current were determined with an ammeter and voltmeter with a shunt, which were compared, before using, with the standard laboratory instruments. The time was measured with a stop watch, which agreed with the laboratory electric clock, the sound of the latter being clearly audible once a minute, when it was operated by the master clock.

Performance of the Experiments

The calorimeter was filled with the oil to be tested, after having been previously weighed empty. The weight of the oil was found by subtracting the latter weight from that of the filled calorimeter. After the cover of the calorimeter was closed, it was placed in the Dewar vessel, the intervening spaces and the bottom were filled with glass wool and the Dewar vessel was put into the sheet-iron tank which was filled to overflowing with rape oil and was heated from without. The thermo-electric couples were now connected with the pole switches and the connections were made for the external and internal heating. In order to reduce the heat loss of the calori-

meter as much as possible, the external heater was adjusted to the temperature at which the preliminary period of the experiment was to begin. The greatest possible accuracy was attained in the calorimetric measurements through the heat loss determined for each experiment. The frictional heat generated by stirring was disregarded, because all the oils were thinly liquid and in preliminary experiments, both with and without a stirrer, no measurable quantity of heat was generated.

The determination of the heat transfer between the calorimeter and its surroundings would be the simplest if the change in its temperature were proportional to the time. Since this was not the case, it was necessary to divide the experiment into a preliminary period, a principal period and a subsequent period, and to determine the heat loss by computation.

We began with a preliminary period, without switching on the inside heater, and measured the temperature change per minute undergone by the calorimeter. The slight temperature changes thus produced were proportional to the time. After an interval, the inside heater was switched on and the principal period began. The temperature first changed more rapidly and then slower until, after the heater was switched off, the rate of temperature change again became uniform. The subsequent period then began and was likewise continued for a long time, like the period from the beginning of the real experiment to the inception of the uniform rate of change.

We thus determined the temperature exchange between the calorimeter and its surroundings, both in the vicinity of the lowest and of the highest experimental temperatures. If we then made the assumption (permissible for such small temperature differences) that the heat exchange of the calorimeter was proportional to the difference between the calorimeter temperature and the equilibrium temperature t_o, at which no temperature change would occur, we could calculate or graphically determine the principal period.

If the calorimeter temperature t (Fig. 14) is plotted against the time, α being the cooling factor and $d i$ the temperature change of the calorimeter per unit of time at 1^oC (1.8^oF) difference in temperature between the calorimeter temperatures t and t_o; then, according to Newton's law of cooling, we have

$$\frac{dt}{d\tau} = - \alpha (t - t_o),$$

α and t_o being determined from the preliminary and subsequent periods. The temperature change in the calorimeter resulting from the heat exchange between the time points 1 and 2 of the principal period is then

$$\Delta t = - \alpha \int_{\tau_1}^{\tau_2} (t - t_o) \, d\tau$$

The computation method employed for all the experiments is best shown by a numerical example.

TABLE XIII.

Gas oil.   G = 375 g (0.822 lb.).

Experiment period	Min- ute	Temperature		Tension volts	Volt- amperes	Temperature of outside heater	
		°C	°F			°C	°F
Preliminary	0	32.2	89.96	--	--	32.0	89.6
	1	32.1	89.78	--	--	--	
	2	32.0	89.60	--	--	--	
	3	31.9	89.42	--	--	--	
	4	31.8	89.24	--	--	--	
	5	31.7	89.06	--	--	--	
	6	31.6	88.88	--	--	--	
	7	31.6	88.88	--	--	--	
	8	31.5	88.70	--	--	--	
	9	31.5	88.70	--	--	--	
	10	31.5	88.70	--	--	--	
Principal	11	32.0	89.60	36.9	1.09	32.0	89.6
	12	33.6	92.48	36.9	1.09	--	
	13	35.0	95.00	36.9	1.09	--	
	14	36.9	98.42	36.8	1.08	--	
	15	38.5	101.30	36.8	1.08	--	
	16	40.0	104.00	36.8	1.08	--	
	17	41.6	106.88	36.8	1.08	--	
	18	43.3	109.94	36.8	1.08	--	
	19	44.7	112.46	36.8	1.08	--	
	20	44.8	112.64	36.8	1.08	--	
Subsequent	21	44.8	112.64	--	--	32.0	89.6
	22	44.7	112.46	--	--	--	
	23	44.5	112.10	--	--	--	
	24	44.3	111.74	--	--	--	
	25	44.1	111.38	--	--	--	
	26	43.9	111.02	--	--	--	
	27	43.7	110.66	--	--	--	
	28	43.6	110.48	--	--	--	
	29	43.5	110.30	--	--	--	
	30	43.4	110.12	--	--	32.0	89.6

In the preliminary period, the mean temperature exchange per minute is

$$\frac{31.5 - 32.2^{\circ}}{10} = -0.07^{\circ}C$$

at a mean temperature of

$$\frac{31.5 + 32.2}{2} = 31.85^{\circ}C$$

In the subsequent period,

$$\frac{43.4 - 44.8}{10} = -0.14^{\circ}C$$

at a mean temperature of

$$\frac{43.4 + 44.8}{2} = 44.1^{\circ}C$$

A temperature change of $44.1^{\circ}C - 31.85^{\circ} = 12.25^{\circ}C$ therefore causes a temperature exchange per minute of $-0.07 - (-0.14) = 0.07^{\circ}C$. The change per degree $\overline{C}$ is therefore

$$\alpha = \frac{0.07}{12.25} = 0.00571 \text{ (cooling factor)}.$$

From this the temperature is calculated, at which no exchange of heat would occur.

$$t_0 = 31.85 - \frac{0.07}{0.00571}$$

or,

$$t_0 = 44.1 - \frac{0.14}{0.00571}$$

$$t_0 = 19.6^{\circ}$$

For other temperatures the heat exchange is accordingly $(19.6 - t)$ 0.00571 degrees C. per minute. From this we can easily calculate the temperature losses or gains from the beginning of the principal period, the eleventh minute, till the heat exchange becomes constant, by finding the difference between the equilibrium temperature t_0 and the mean temperature for each minute of the principal period and multiplying it by the cooling factor α.

Minute	Mean temperature		Heat exchange
	$^\circ C$	$^\circ F$	
11	31.75	89.15	-12.15×0.00571
12	32.80	91.04	-13.20×0.00571
13	34.30	93.74	-14.70×0.00571
14	35.95	96.71	-16.35×0.00571
15	37.70	99.86	-18.10×0.00571
16	39.35	102.65	-19.65×0.00571
17	40.80	105.44	-21.20×0.00571
18	42.45	108.41	-22.85×0.00571
19	44.00	111.20	-24.40×0.00571
20	44.75	112.55	-25.15×0.00571

$$\Delta t = -\overline{187.75 \times 0.00571}$$

$$\Delta t = -1.07^\circ C.$$

i.e., as a result of the heat exchange, the temperature at the end of the 20th minute is $1.07^\circ C$ ($1.93^\circ F$) lower than it would

be without any heat exchange. In the latter case the final temperature would have been 44.8 + 1.07 = 45.87°C (114.57°F). The difference between this temperature and the temperature at the beginning of the principal period gives the temperature increase to be used in the computation.

The mean values were taken for the tension and the current strength, and the current consumption of the voltmeter was deducted.

The water equivalent of the apparatus was still required for the calculation of the specific heat according to formula (2). For finding this, the experiments were performed in exactly the same way as for determining the heat exchange, but with the difference that the calorimeter was filled with water whose specific heat was accurately known. The calculation was then made according to the formula

$$W = 0.3588 \frac{i \; e \; z}{t_2 - t_1} - G \; c \; \text{water.}$$

The water equivalents thus found were plotted against the temperature (Fig. 15) and were taken into account in calculating the specific heats of the fuels. The specific heats of the different fuels are given in Table XIV, together with the corresponding temperatures, and in Fig. 16 they are plotted against the temperatures.

TABLE XIV.

Specific heats.

Degrees C " F	30 86	35 95	40 104	45 113	50 122	55 131	60 140	65 149
Gas oil	--	0.528	--	--	--	0.543	--	0.552
Rositzer oil	--	0.554	--	--	0.564	--	--	0.580
Solar oil	--	--	--	0.458	--	--	--	0.485
Paraffine oil	0.474	--	--	0.487	--	--	--	0.507
Coal-tar oil I	0.553	--	--	0.550	--	--	0.561	--
Coal-tar oil II	--	--	--	--	0.460	--	--	0.491
Kerosene	--	0.583	--	--	0.588	--	--	--
Gasoline	0.568	0.578	--	0.586	--	--	--	--
Benzol	0.484	0.490	--	0.496	--	--	--	--

TABLE XIV (Cont.)

Degrees C " F	70 158	75 167	80 176	85 185	90 194	95 203	100 212	105 221
Gas oil	0.561	--	--	--	--	--	--	--
Rositzer oil	--	0.585	--	0.593	--	--	--	--
Solar oil	--	0.515	--	0.541	--	--	--	--
Paraffine oil	--	--	0.521	--	--	--	--	--
Coal-tar oil I	--	0.581	--	--	--	--	--	--
Coal-tar oil II	--	--	0.510	--	0.530	--	--	0.562
Kerosene	--	0.618	--	--	--	--	--	--
Gasoline	--	--	--	--	--	--	--	--
Benzol	--	--	--	--	--	--	--	--

The curves in Fig. 16 show an almost linear relation of the specific heats within the temperature range covered by the experiments.

The specific-heat values run in the order of magnitude given by Landolt-Börnstein for chemically pure benzol (benzene). There the specific heat of C_6H_6 was given by the different investigators as 0.406 - 0.434 at temperatures of 1 - 70°C (33.8 - 158°F).

Heat of Vaporization.

General statements concerning the method of determination.-
The determination of the heat of vaporization was necessary for the determination of the vaporization process of heavy oils and was carried out for the different oils, because the calculation of the heat of vaporization according to the Clausius-Clapyron equation, which gives the relation between the heat of vaporization and the change of pressure with the temperature, could not be applied to mixed liquids.

The vaporization heat of a liquid can be determined by two different methods. One either measures the quantity of heat given out per unit of mass by the condensation of the saturated vapor or observes how much heat is absorbed while a mass unit of the liquid is being changed to vapor at the same temperature

The second method was chosen for the experiments because it enabled (with further changes) the use of the apparatus already employed for the specific-heat determinations, and offered the additional advantage of enabling one to determine the heat of vaporization at constant temperature, which made the measurements independent of the capacity of the vaporization vessel.

Translation by Dwight M. Miner,
National Advisory Committee
for Aeronautics.
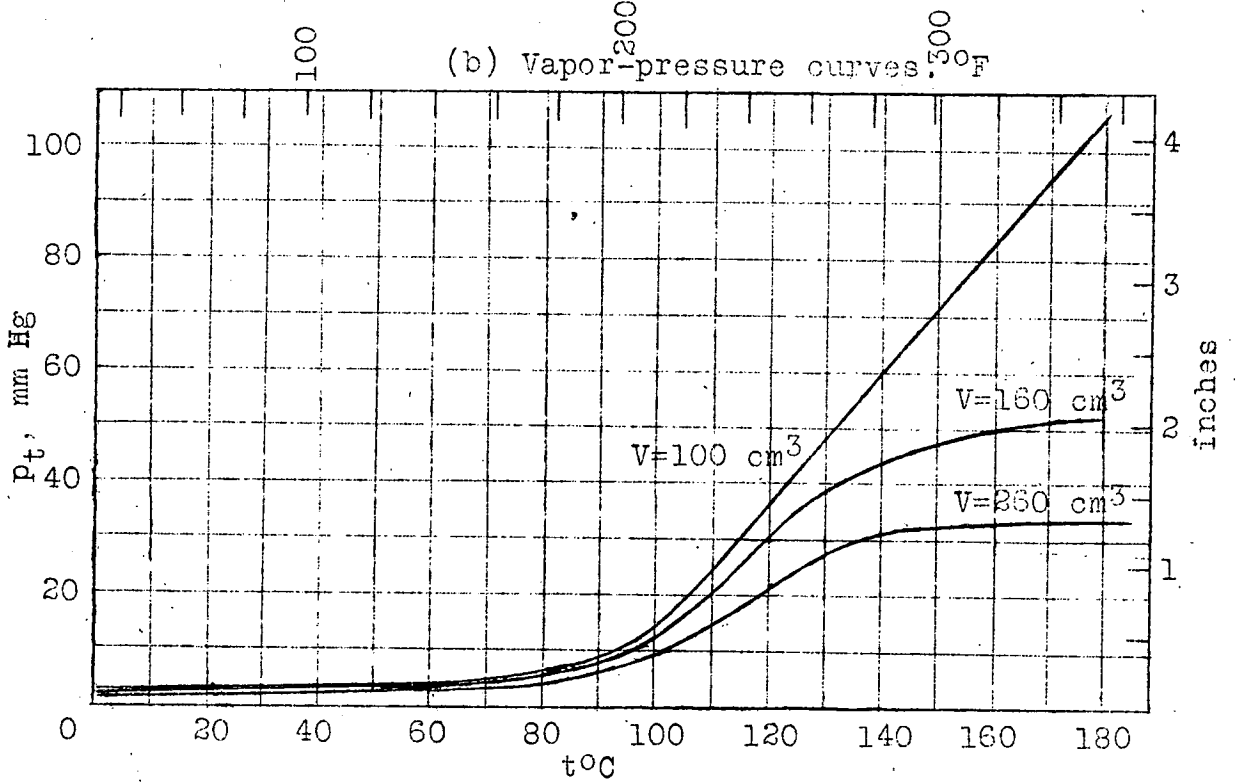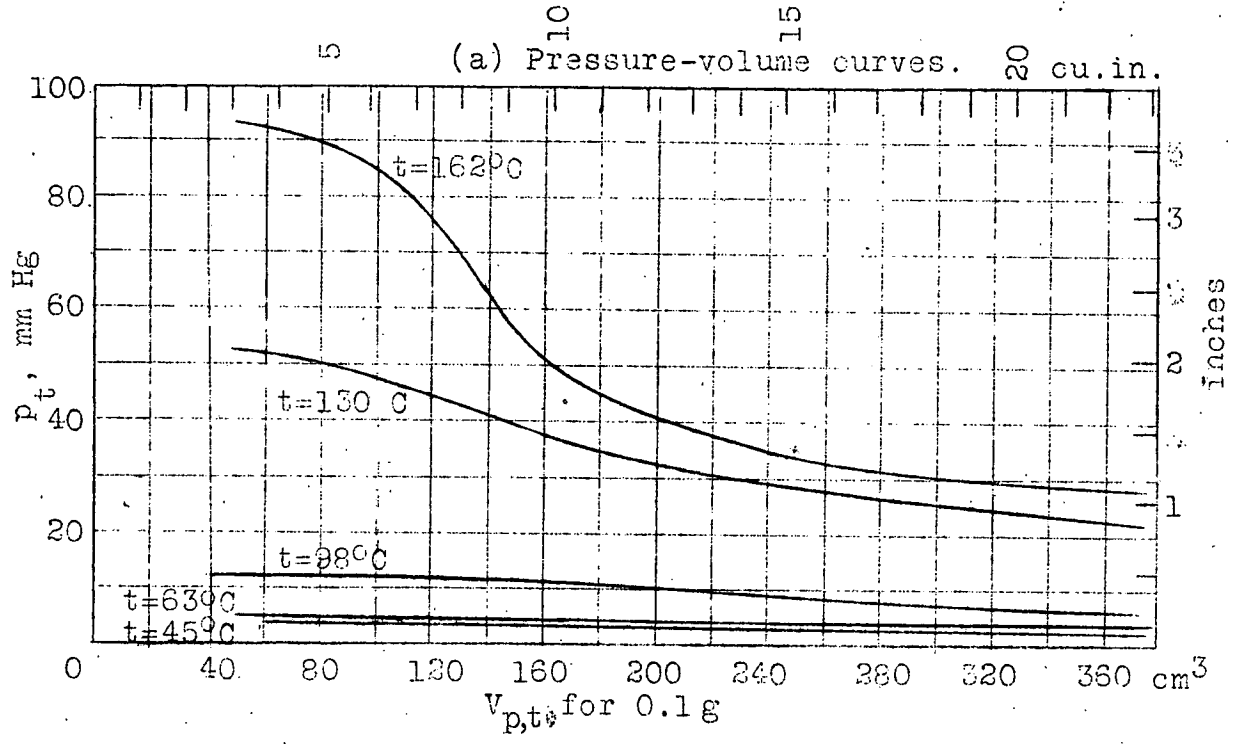
Fig.3 Gas oil.(Boiling limits 190-340°C)
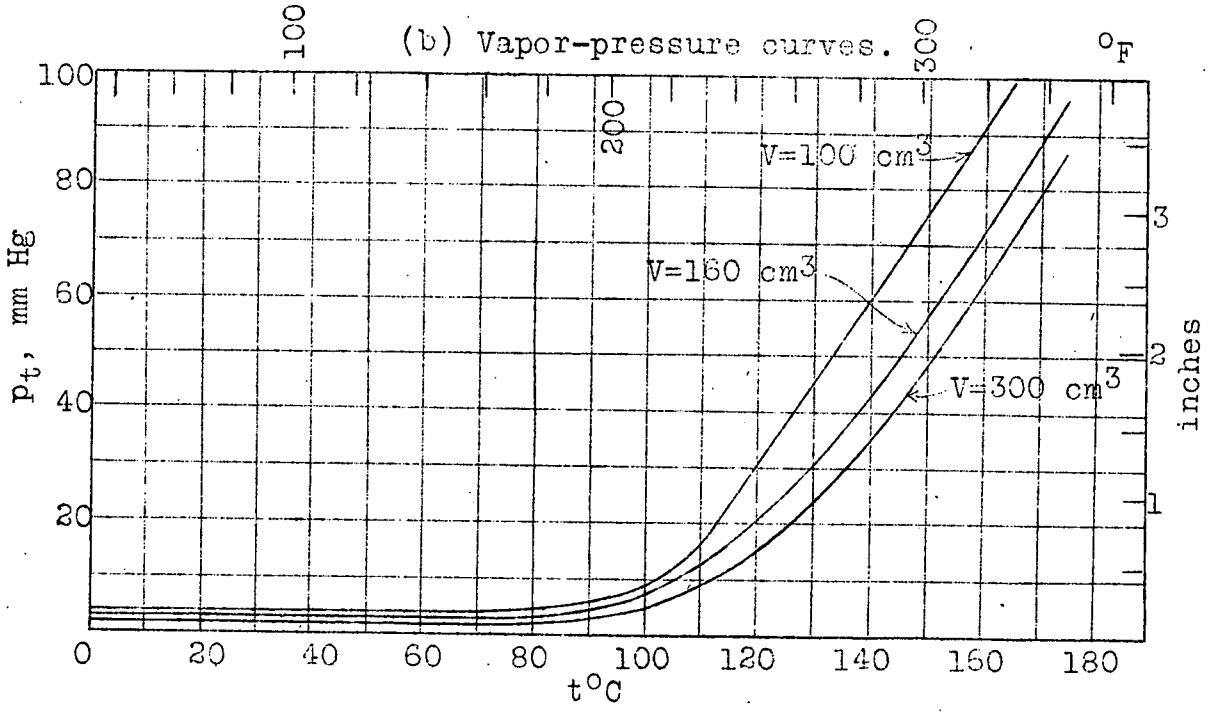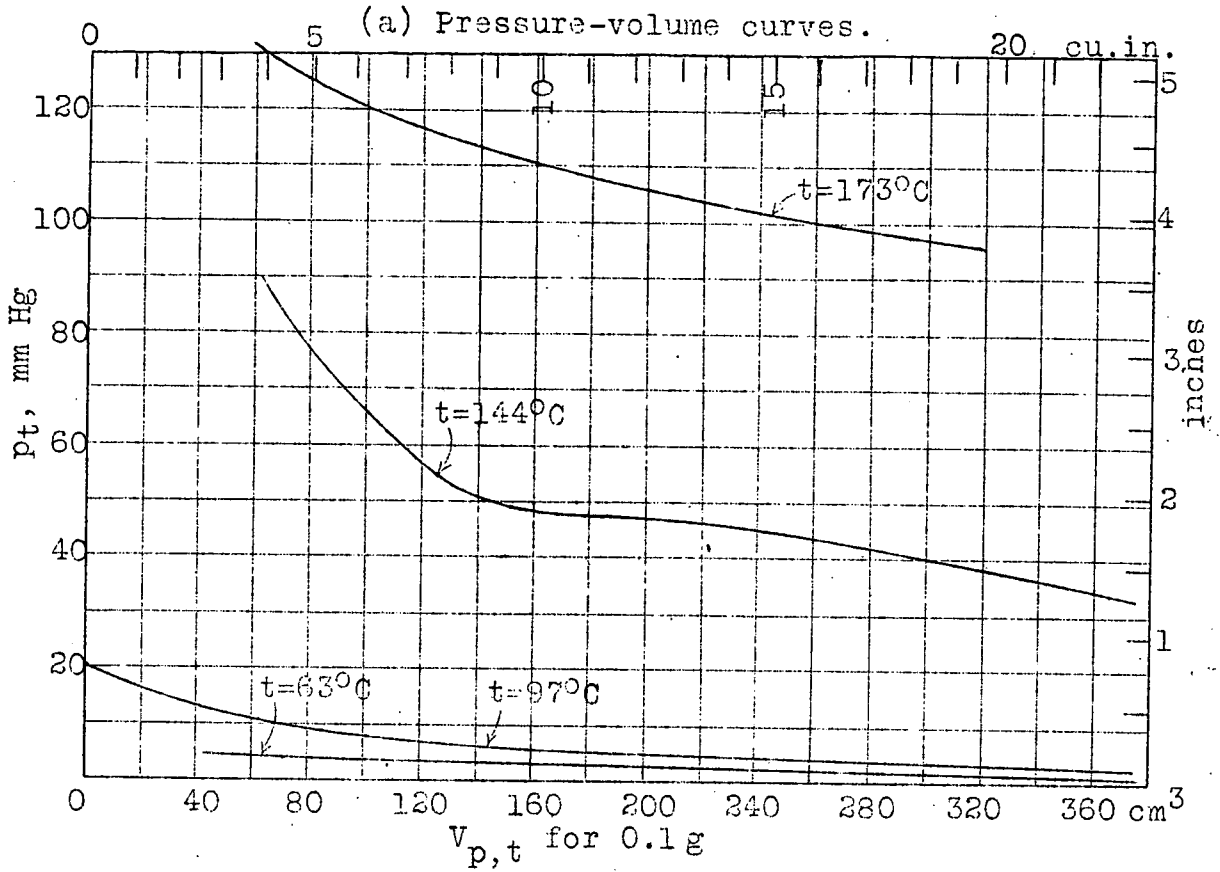
Fig.4 Rositzer fuel oil.(Boiling limits 140-325°C)
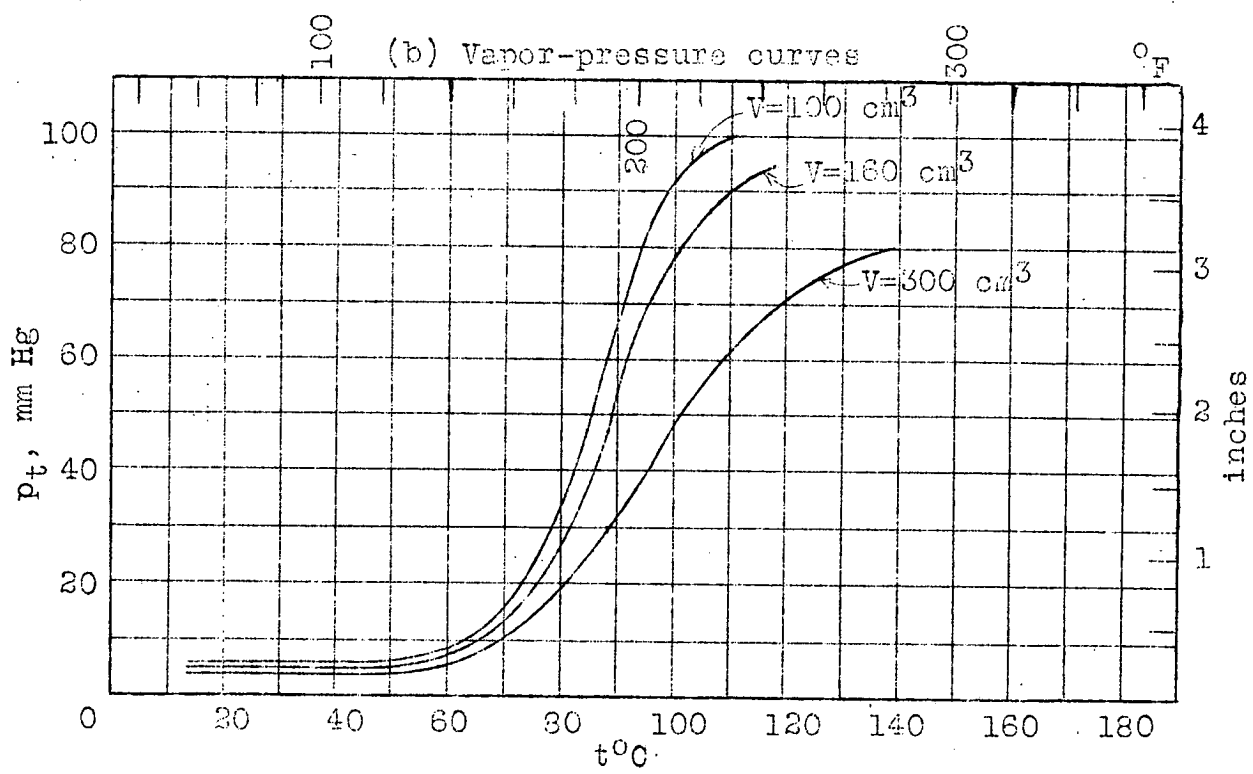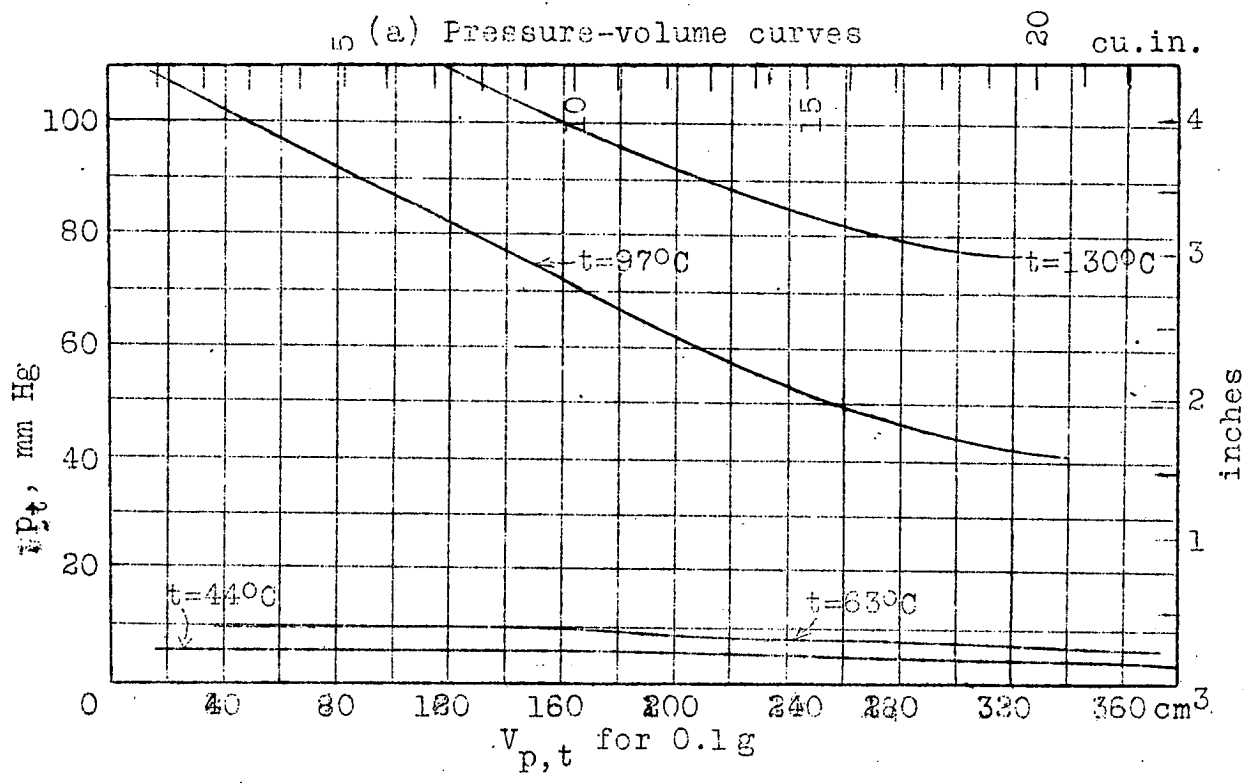
Fig.5 Solar oil. (Boiling limits 155-275°C)
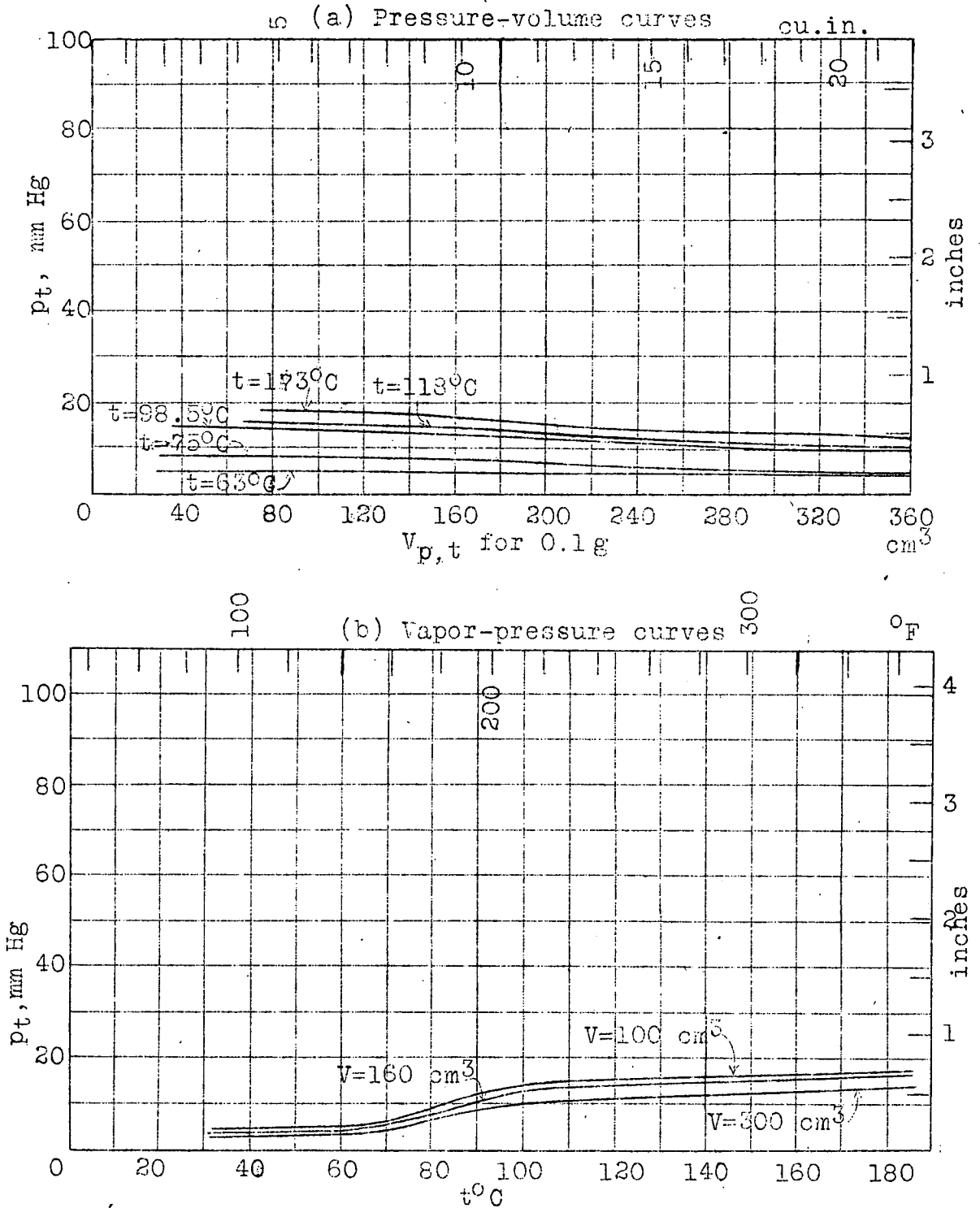
Fig.6 Paraffine oil.(Boiling limits 200-370°C)
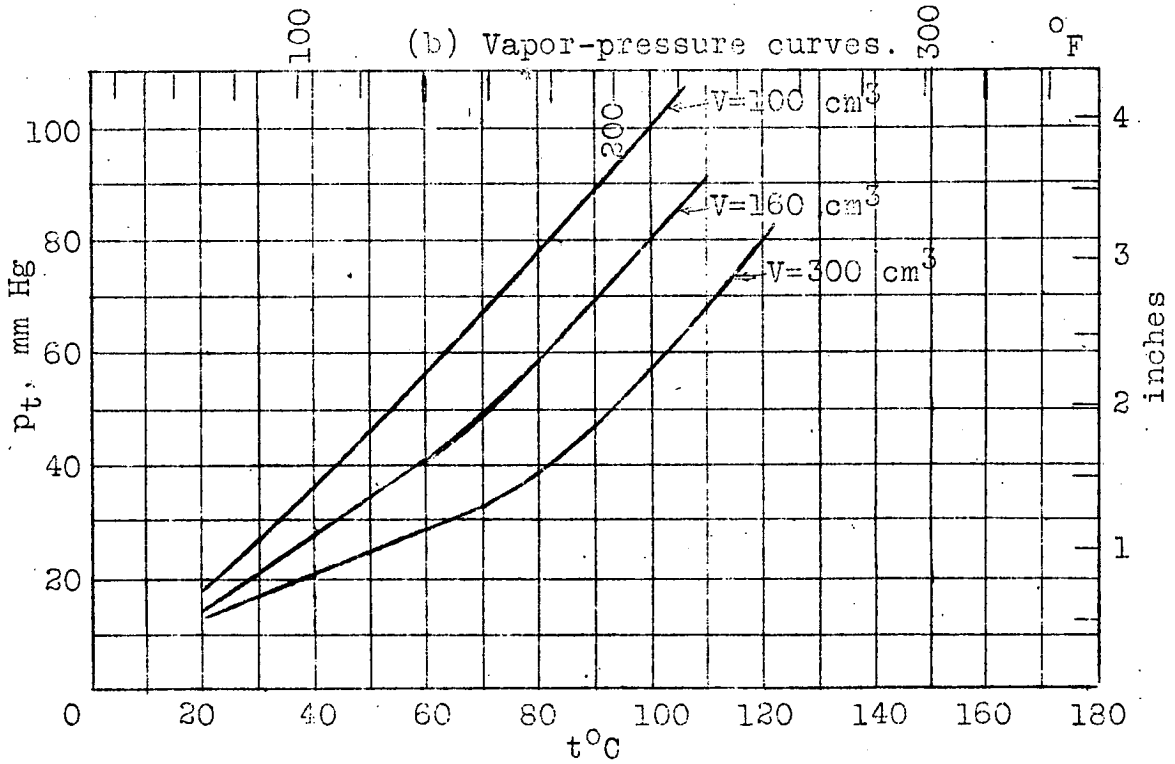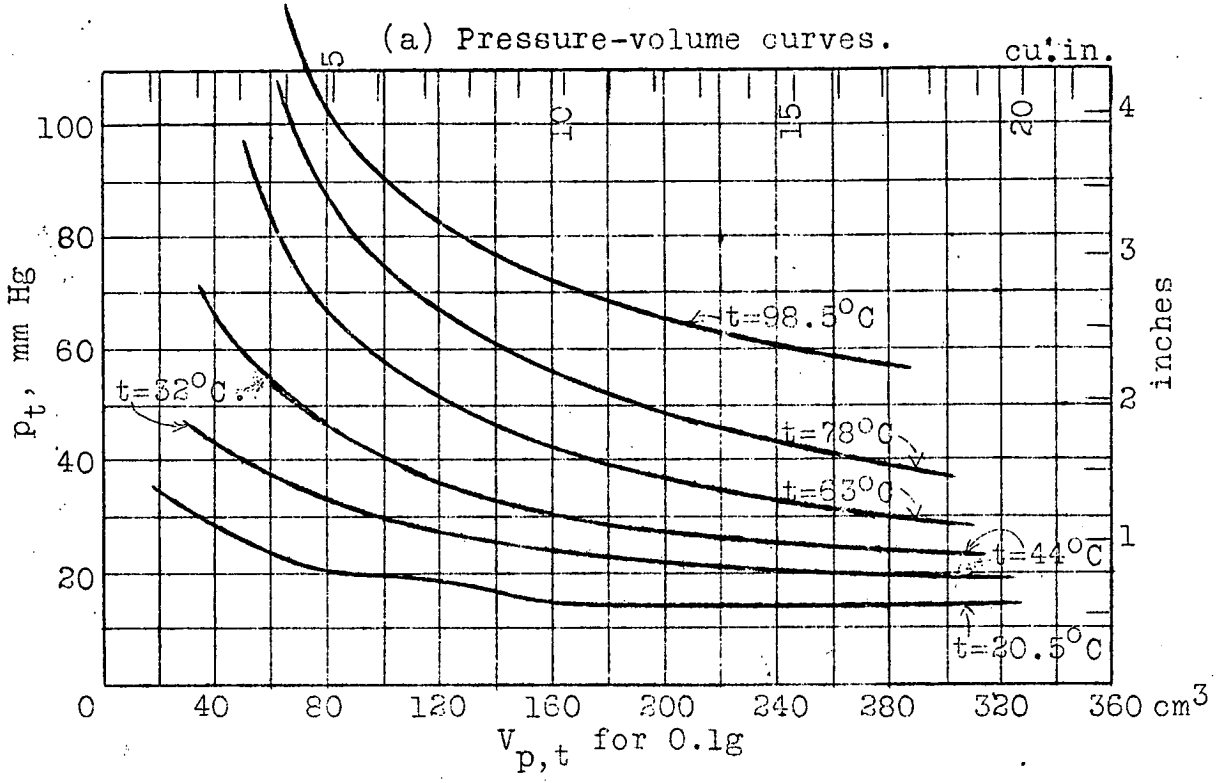
Fig.7 Coal-tar oil I.(Boiling limits 90-225°C)
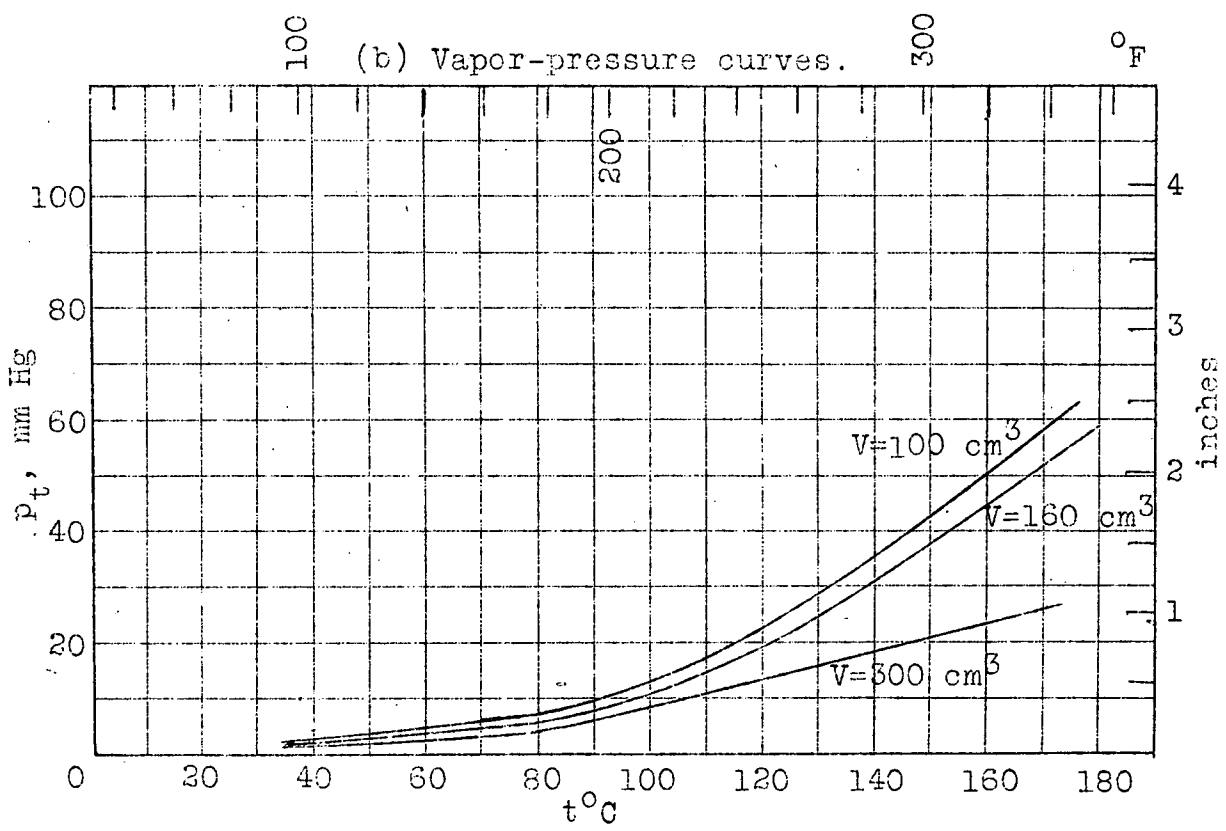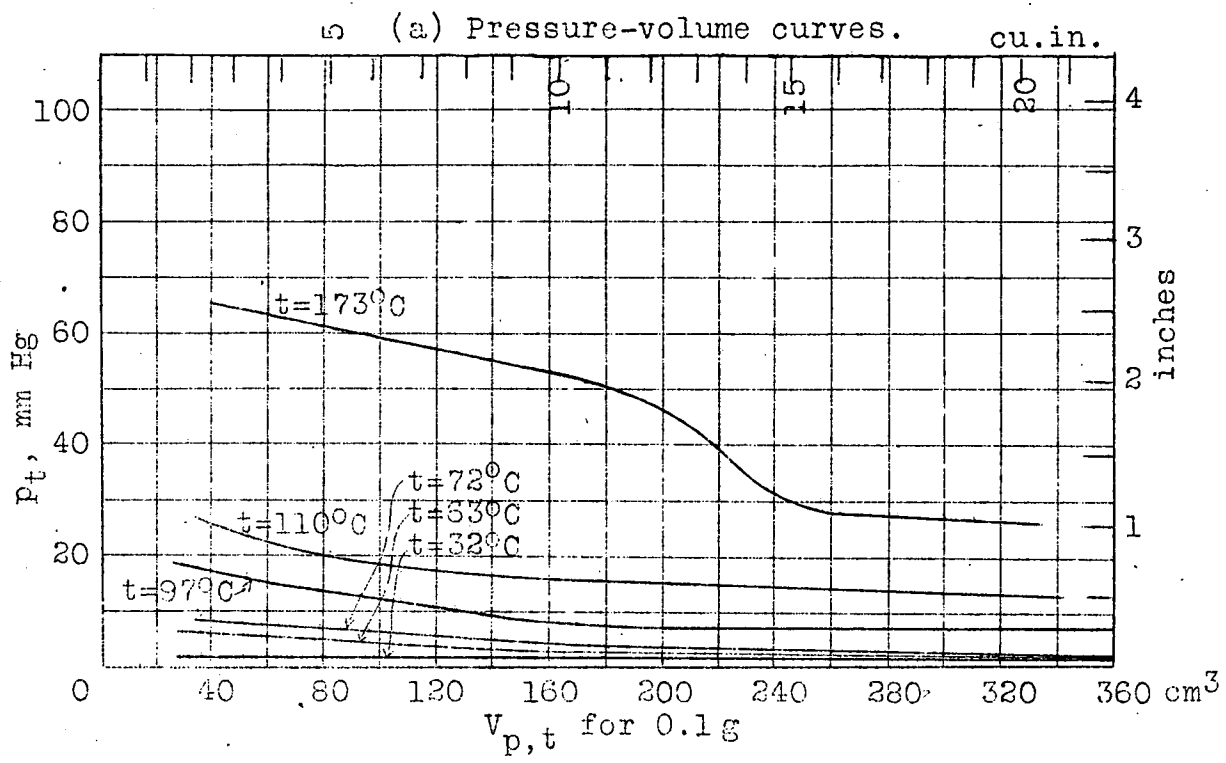
Fig.8   Coal-tar oil II.(Boiling limits 130-300°C)

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(a) Pressure-volume curves.   cu.in.


p_t, mm Hg

t=128°C

t=97°C

t=73°C

t=60°C

t=33°C

inches

0   40   80   120   160   200   240   280   320   360 cm³

$V_{p,t}$ for 0.1 g

(b) Vapor-pressure curves.   °F

p_t, mm Hg

V=100 cm³

V=160 cm³

V=300 cm³

inches

0   20   40   60   80   100   120   140   160   180

t°C
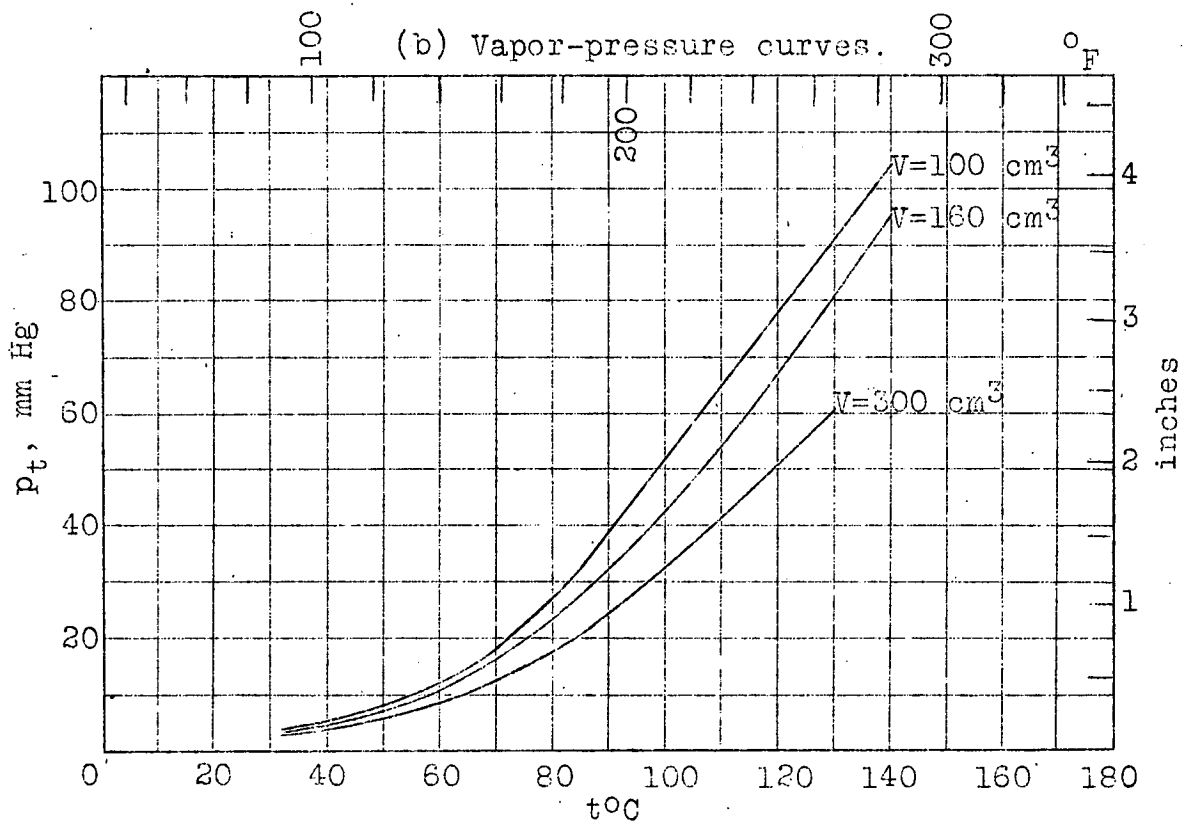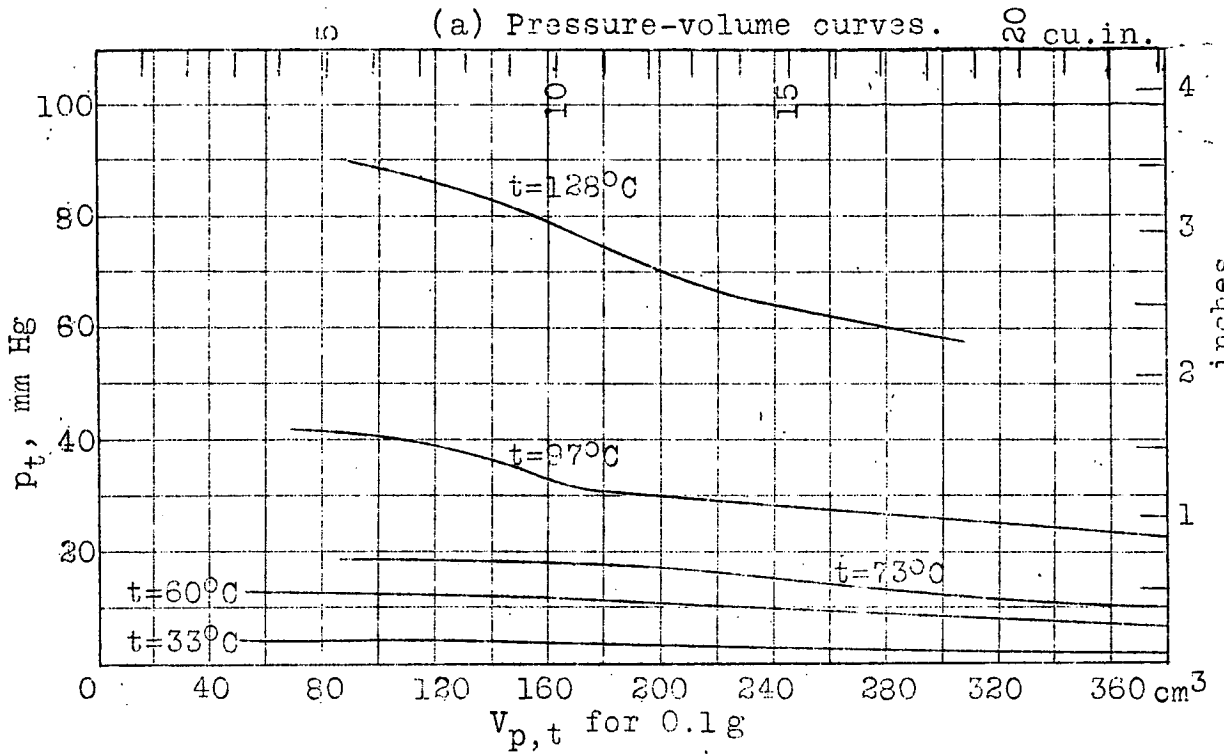
Fig.9   Kerosene.(Boiling limits 150-208°C)
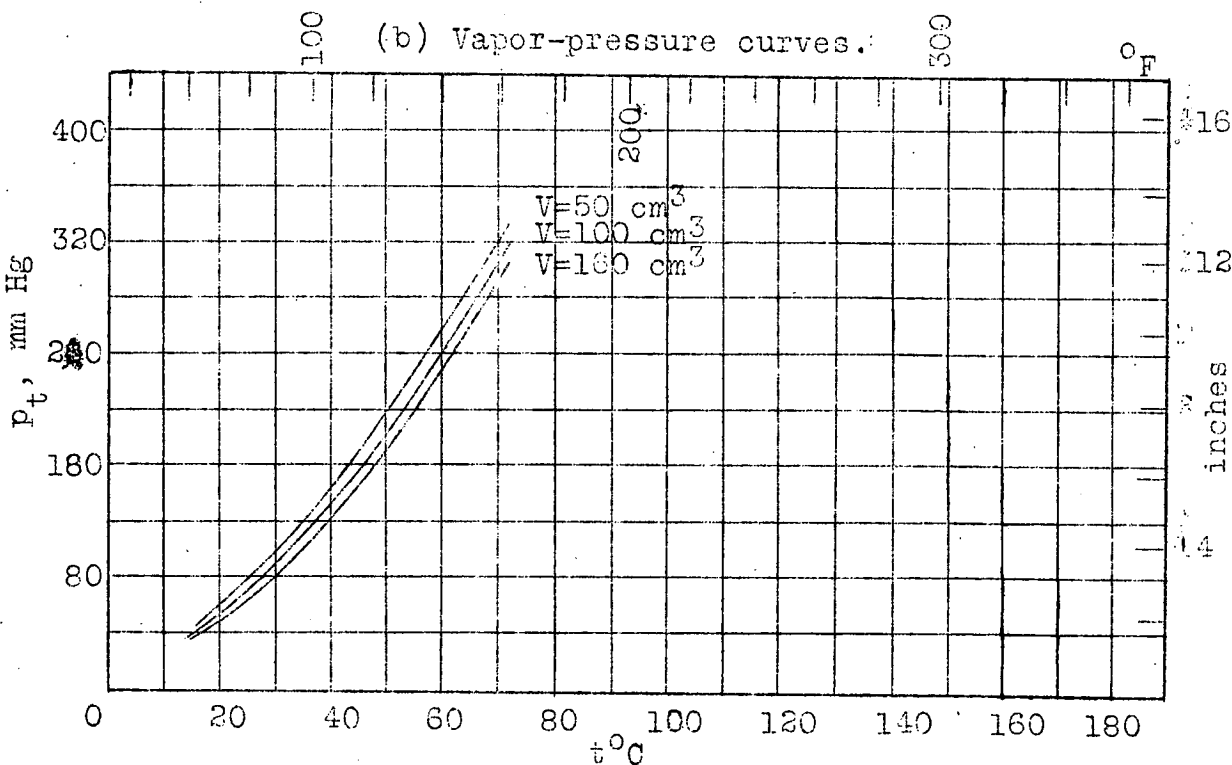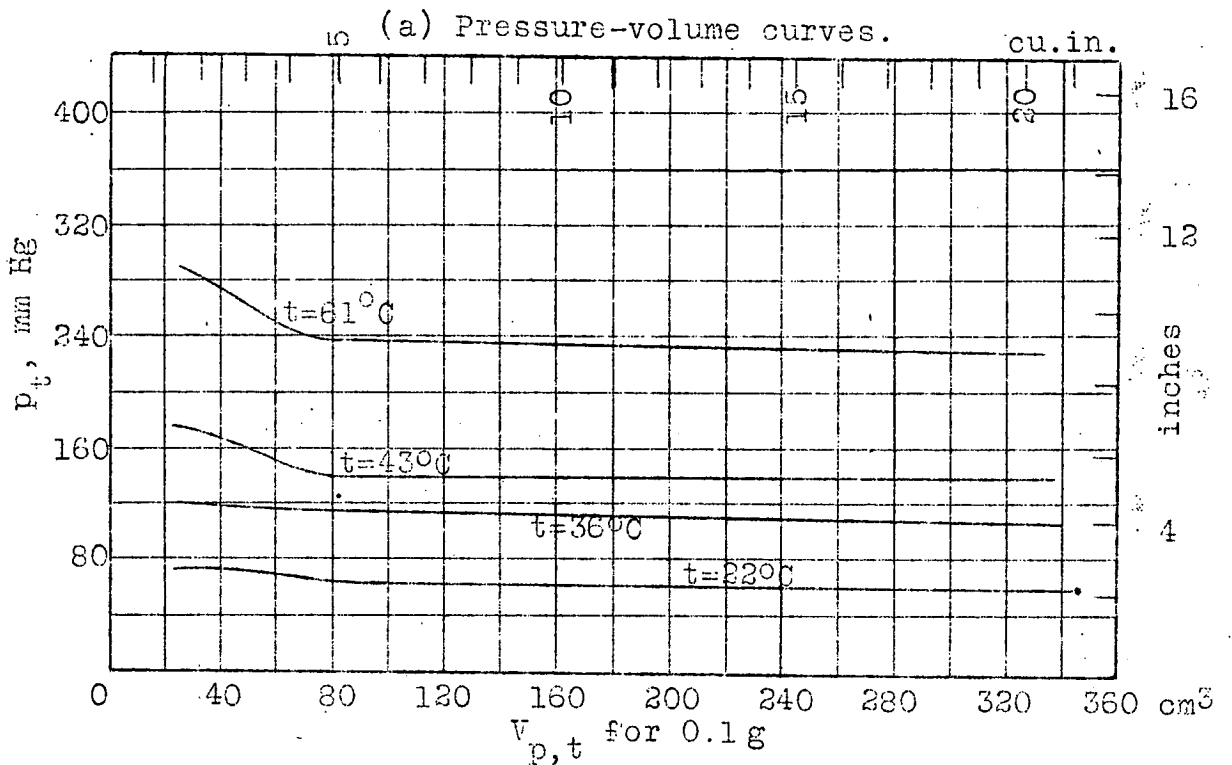
Fig.10　　Benzol.(Boiling limits 75-160°C)
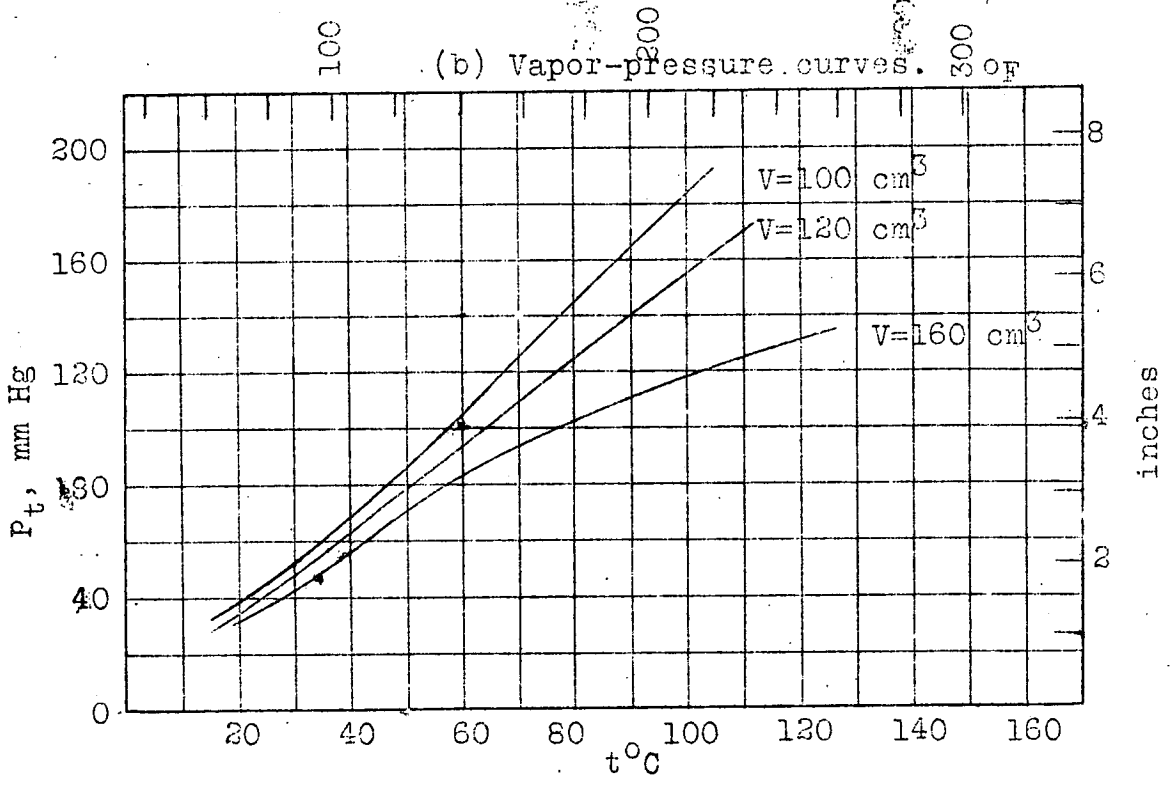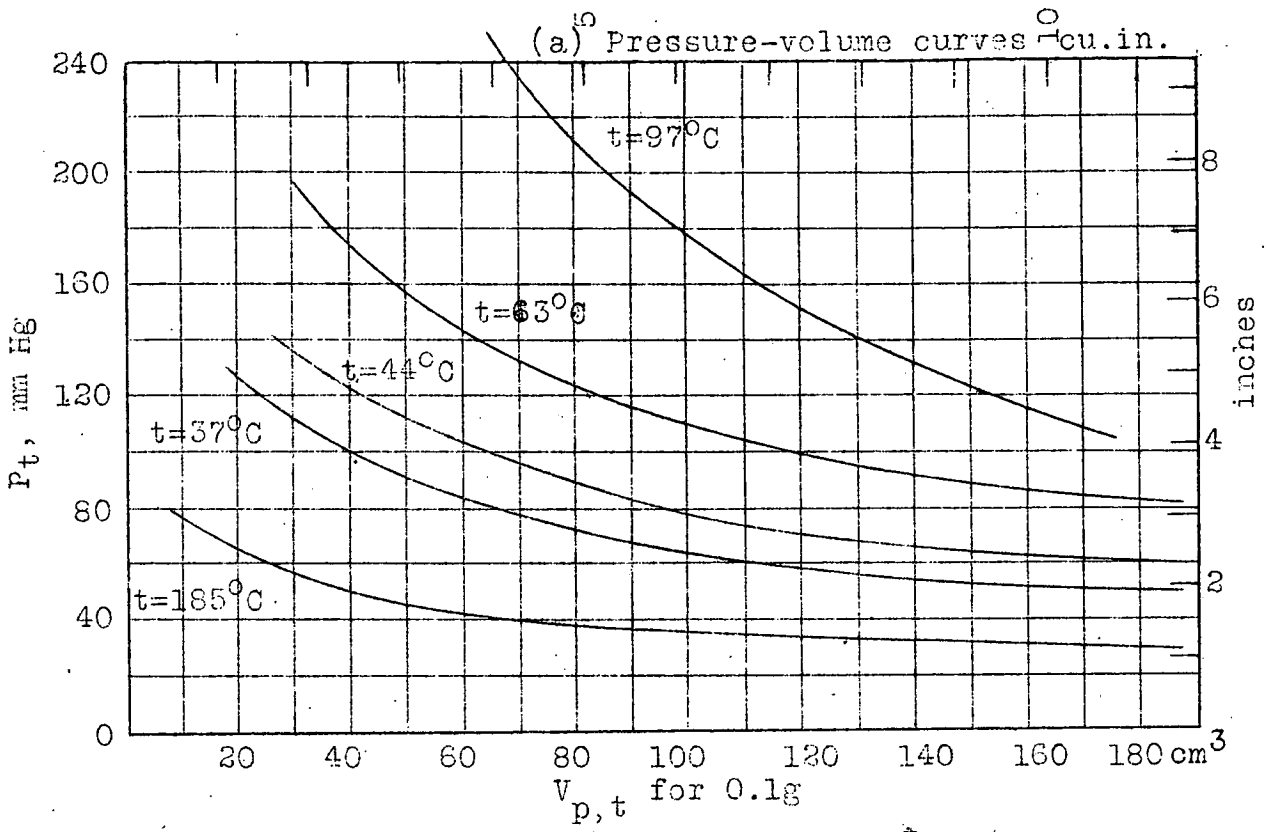
Fig.11   Gasoline.(Boiling limits 60-120°C)

1. Gasoline
2. Benzol   6 Rositzer fuel oil
3. Coal-tar oil I   7 Coal-tar oil II
4. Solar oil   8 Gas oil
5. Kerosene   9 Paraffin oil
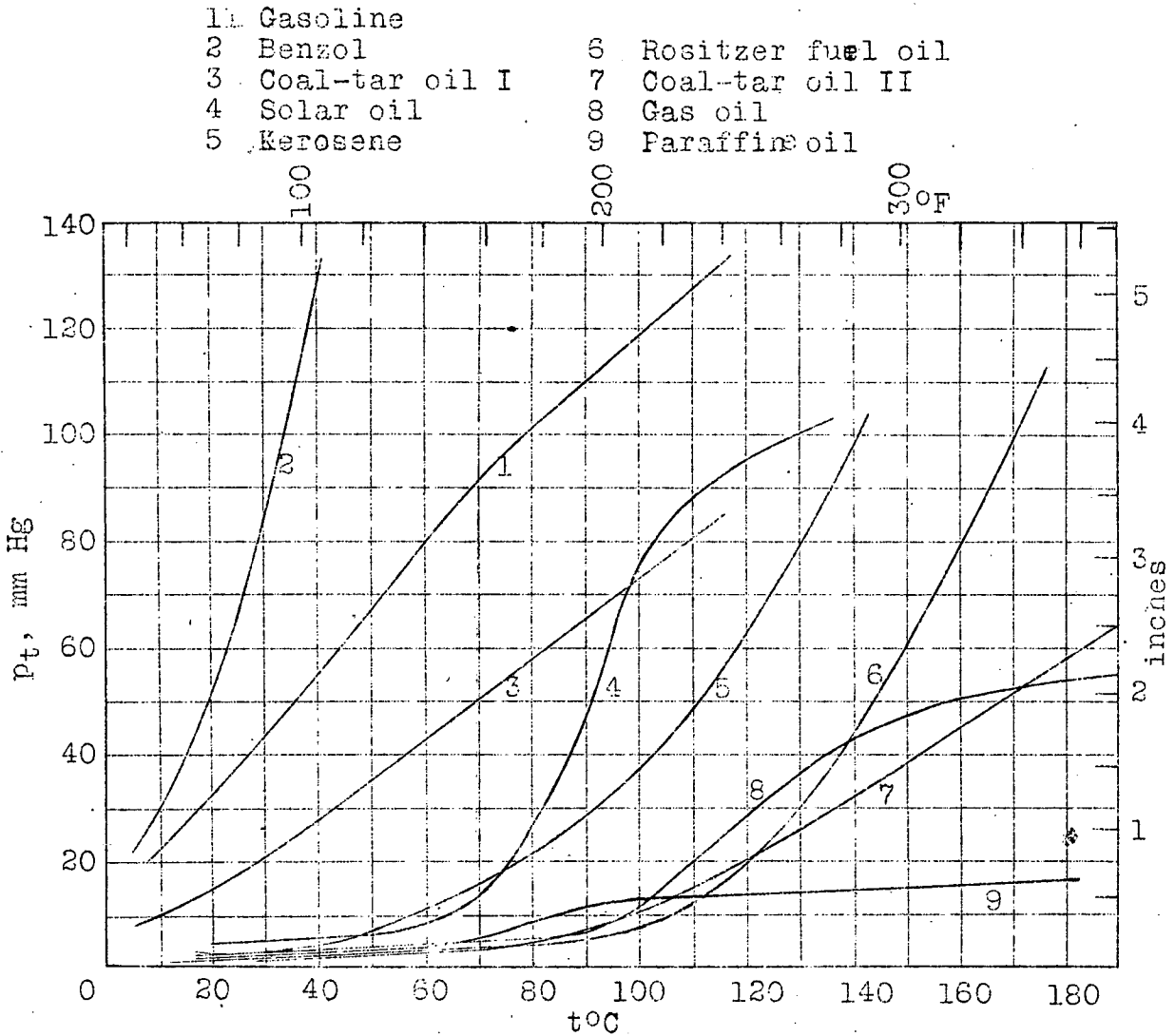
Fig.12   Vapor-pressure curves for 0.1 g fuel and
$V_{p,t} = 180$ cm³.

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Heater wires

Thermo-electric couple I

Thermo-electric couple II

Thermo-electric couple III

Oil overflow

Fig.13

Temperature, t

t_o

t_o

Period:

| Prelim-inary | Prin-cipal | Subse-quent |

τ_1 Time τ_2

Fig.14

Fig.15

1 Gasoline
2 Benzol
3 Coal-tar oil I
4 Solar oil
5 Kerosene

Fig.16

6 Rositzer fuel oil
7 Coal-tar oil II
8 Gas oil
9 Paraffine oil