

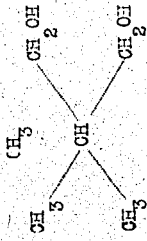
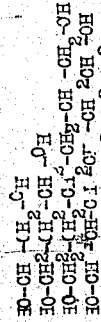
Figure 11 57082

Ester from three-and four valent alcohols Partial Esterification	Spec wt	Viscosity in cSt at C					m. 20.99	Set point °C
		20°	30°	40°	50°	99		
Trimethylolethane + 3 Mol: -C <sub>13</sub> -Acid	0.917	97.90	42.13	26.60	7.11	3.34	-28	
Trimethylolethane + 2 Mol: -C <sub>13</sub> -Acid	0.925	124.5	49.90	29.87	7.27	3.51	-27	
Trimethylolethane + 3 Mol-Leuna Carboxylic Acid	0.949	123	42.50	24.3	5.57	3.96	-48	
Trimethylolethane + 2 Mol-Leuna Carboxylic Acid	0.962	193	59.50	32.40	6.57	4.01	-44	
Trimethylolethane + 1 Mol-Leuna Carboxylic Acid	0.982	427	105	51.5	7.30	4.34	-33	
Pentaerythritol + 4 Mol i-C <sub>13</sub> -Acids	0.929	179.50	71.10	42.80	10.00	3.27	-28	
Pentaerythritol + 3 Mol i-C <sub>15</sub> -Acids	0.934	213.2	81.20	48.50	10.40	3.53	-27	
Pentaerythritol + 2 Mol i-C <sub>13</sub> -Acids	0.951	339.0	114.9	64.50	11.70	3.50	-26	

Figure 12

## Ester from divalent Alcohols

Spec wt.	Viscosity in c.St. at °C					Set Point °C
	20	38	50	99	20:99	
0.934	9.07	5.36	4.03	1.76	3.67	+18
0.919	11.77	6.85	5.17	2.28	3.51	+13
0.920	14.40	8.40	6.26	2.62	3.33	+6
0.916	15.40	8.88	6.53	2.71	3.31	-20
0.920	14.50	8.10	5.87	2.36	3.62	-85
0.936	12.80	6.99	4.83	1.98	3.86	<-22
0.920	16.60	8.88	6.18	2.37	3.73	<-72
0.915	18.20	9.20	6.50	2.48	3.70	<-72
0.920	17.60	8.77	6.05	2.16	4.15	<-72
0.930	22.00	11.97	8.2	2.94	3.64	<-72
0.926	2.53	12.20	8.60	3.20	3.44	<-72
0.922	28.60	14.80	9.97	3.40	3.63	<-72
0.930	32.90	15.40	10.00	3.21	3.90	<-59



1.4-Butyleneglycol

1.6-Hexyleneglycol

1.6-Methyl-hexyleneglycol

Dimethylolpropane

1.4-Butyleneglycol

1.6-Hexyleneglycol

1.6-Methyl-hexyleneglycol

Dimethylolpropane

+ n Octylic acid

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Figure 13 57098.

Ester of Dicarboxyls with branched and cyclic Alcohols compared with straight chain alcohols.	Spec Wt.	Viscosity in c.St.					m.	Set Point
		20°c	20°	33°	50°	99°		
Adipic Acid +n-Octanol	0.919	14.2	3.75	6.28	2.85	3.09	+10	
" " +i-Octanol								
" " -2 Ethyl-hexanol	0.925	13.2	7.33	5.85	2.26	3.45	<-72	
" " + Cyclohexanol	--	--	--	12.90	4.42	(3.24)	+40	
" " +m and n-Methylcyclo- hexanol	1.002	63.70	27.70	17.60	4.64	3.76	-52	
" " +i-Hexanol 2-Ethyl-butanol	0.946	3.76	5.35	4.06	1.77	3.6	<-72	
<del>6</del> Methyladipic Acid +n-Octanol	0.920	16.00	9.22	6.67	2.98	3.16	-36	
<del>3</del> Methyladipic Acid +i-Octanol	0.910	18.00	9.43	6.33	2.61	3.65	<-72	
<del>6</del> Methyladipic Acid + Cyclohexanol	1.025	71.0	27.27	16.40	4.43	3.95	-50	
<del>6</del> Methyladipic Acid +m and p- Methylcyclo- hexanol	0.993	66.9	25.73	15.60	4.23	3.99	-46	
<del>6</del> Methyladipic Acid +i-Hexanol	0.943	11.67	6.49	4.77	2.02	3.72	<-72	

Figure 14

57092

Ester from Dicarboxy-acids	Spec. Wt.	Viscosity in C.St. @ °C.					Set Point °C
		20°C	20	38	50	99	
Adipic Acid + N-Octanol	0.919	14.2	8.75	6.28	2.85	3.09	+ 10
- " + N-Dodecanol	-	-	-	12.40	4.53	(3.05)	+ 36
$\alpha$ -Methyladipic Acid + N-Octanol	0.927	16.80	9.33	6.66	2.66	3.48	- 32
$\alpha$ - " " + N-Dodecanol	0.913	36.13	17.30	12.10	4.28	3.23	+ 16
$\beta$ -Methyladipic Acid + N-Octanol	0.920	16.00	9.22	6.67	2.90	3.16	- 36
$\beta$ - " " + N-Dodecanol	0.893	35.90	18.60	13.20	4.71	2.96	+ 10
Adipic Acid + Leuna Alcohol 180/250	0.930	32.73	16.40	10.85	3.65	3.60	- 69
$\alpha$ -Methyladipic Acid + " " "	0.933	49.20	20.90	13.40	4.07	3.71	- 60
$\beta$ -Methyladipic Acid + " " "	0.913	49.60	21.20	13.60	4.16	3.67	- 59
Dimethyladipic Acid + " " "	0.932	58.70	24.20	15.50	4.29	3.85	- 57
Sebacic Acid + " " "	0.916	44.10	20.70	13.90	4.45	3.48	- 70
Adipic Acid + 1- $\epsilon$ -Oxoalcohol from Diisobutylene	0.918	24.00	12.70	8.70	3.21	3.43	- 72
$\beta$ -Methyladipic Acid + " " "	0.916	28.20	14.60	10.00	3.52	3.49	--70
Dimethyladipic Acid + " " "	0.916	30.73	15.00	10.41	3.53	3.59	- 68
Sebacic Acid + " " "	0.911	38.33	19.50	13.40	4.71	3.20	- 60

Figure 15

57096

Ester from multivalent alcohols and the half-ester (HE) of Adipic acid; $\text{ROOC}-(\text{CH}_2)_4-\text{COOH}$ R-Leunaalcohol. 1.0/1.80.	Spec. wt. 20°C	Viscosity in c.St. at °C				m	Set Point °C
		20°	30°	50°	90°		
Ethylene glycol + HE	0.992	43.53	20.10	13.50	4.50	3.48	-62
+ n-C <sub>8</sub> - Acid	0.934	9.00	5.36	4.03	1.76	3.67	+19
1,4-Butylene glycol + HE	0.993	57.70	26.80	17.20	5.38	3.35	-53
+ n-C <sub>8</sub> - Acid	0.919	11.77	6.85	5.17	2.29	3.38	+13
1,6-Hexylene glycol + HE	0.983	64.20	29.53	19.80	6.14	3.16	-19
+ n-C <sub>8</sub> - Acid	0.920	14.40	8.40	6.26	2.62	3.33	+ 8
1,6-Methyl-hexylene glycol + HE	0.995	87.30	40.20	25.30	7.23	3.23	-60
+ n-C <sub>8</sub> - Acid	0.916	15.40	8.08	6.53	2.71	3.31	-23
Dimethylolpropane + HE	0.982	64.00	27.90	17.80	5.30	3.46	-53
+ n-C <sub>8</sub> - Acid	0.920	14.50	8.10	5.87	2.36	3.62	-55
Trimethylol ethane + HE	1.011	226	81.25	47.07	10.75	3.30	-51
+ n-C <sub>8</sub> - Acid	0.844	36.?	17.75	11.96	3.86	3.58	-3(1)
Pentaerythritol + HE	1.021	482	177.7	101.1	19.50	3.04	-43
+ n-C <sub>8</sub> - Acid	0.959	50.73	23.60	15.69	4.73	3.50	+ 7(2)

Figure 16

Molecule enlargement by ethoxylation of Alcohols  
 C<sub>9</sub> Oxo-alcohol from Diisobutylene

	Spec Wt.	Viscosity in cSt. at °C					Set Point. °C
		20	38	50	99	20.99	
1 C <sub>9</sub> -Alcohol + 0 Mol C <sub>2</sub> H <sub>4</sub> O + Adipic Acid	0.918	24.00	12.70	8.70	3.21	3.43	< -72
" " + 1 Mol " " "	0.948	37.60	18.30	12.0	4.80	3.88	-65
" " + 2 " " "	0.976	59.00	27.40	18.30	5.74	3.26	-58
" " + 4 " " "	1.002	92.80	40.90	27.60	7.72	3.13	-52
" " + 6 " " "	1.021	124.60	54.10	34.80	10.00	2.97	-38
2 C <sub>9</sub> -Alcohol + 0 Mol C <sub>2</sub> H <sub>4</sub> O + Methyladipic Acid	0.916	28.20	14.60	10.00	3.52	3.43	-70
" " + 1 " " "	0.950	46.00	21.90	14.70	4.73	3.40	-60
" " + 2 " " "	0.974	66.10	29.07	19.50	6.16	3.24	-55
" " + 4 " " "	0.998	98.00	42.30	27.10	8.31	3.06	-50
" " + 6 " " "	1.038	180.0	75.20	47.01	12.50	2.92	-16
100% Alcohol 180/250 + 2 Mol C <sub>2</sub> H <sub>4</sub> O + Adipic Acid	0.972	53.90	24.60	15.70	4.96	3.46	-59
" " + 2 " " + Methyladipic Acid	0.980	78.50	32.80	21.40	6.25	3.38	-54
" " + 2 " " + sebacic Acid	0.969	119.20	50.60	31.30	8.96	3.10	-55

Fig. 23 57080

Surface Tension etc. of Different Materials  
against Mercury (@ 22°C) according to  
measurements by Wolf and Dunken Halle.

Materials	Surface Tension (dyn/cm)	Limiting Surface Tension (dyn/cm)	Surface Energy (erg/cm <sup>2</sup> )
<u>Hydrocarbons</u>			
Hexane	19.5	350	120
Cyclohexane	24.7	377	128
Benzene	23.6	366	143
<u>Alcohols</u>			
Methanol	22.5	384	119
Ethanol	22.4	383	120
n-Propanol	23.7	379	125
i-Propanol	23.7	384	117
n-Butanol	24.8	377	128
i-Butanol	20	384	116
n-Hexanol	26.4	372	134
n-Octanol	27	367	140
<u>Acids</u>			
Formic	37.4	395	124
Acetic	27.4	331	176
Propionic	26.5	333	174
n-Butyric	26.6	335	172
n-Valerianic	27.4	333	174
n-Hexylic	29.1	334	174
n-Heptylic	28.3	335	173
n-Octylic	28.7	334	175
n-Nonylic	28.9	332	178
<u>Esters</u>			
Methylacetate	24.9	388	117
Ethyl	23.8	334	120
n-Propyl	24.3	300	124
i-Propyl	23.1	369	134
n-Butyl	24.5	374	131
sec-Butyl	23.5	354	150
i-Butyl	22.3	355	143
n-Amyl	25.5	365	141
i-Amyl	24.8	345	160
n-Hexyl	26.3	365	141
n-Heptyl	27.1	357	150
n-Dacyl	28.7	343	166
n-Dodecyl	29.1	341	168

Differences in surface energy against water & metallic  
boundary surfaces according to experiments by

K.L. WOLF, HALLE

Substance	Boundary Surface Tension (dyn/cm) VS.		Surface Energy. (erg/cm <sup>2</sup> ) VS.	
	Water	Mercury	Water	Mercury
Hexane	51.25	380	40.0	190
Benzene	35.03	366	66.6	143
CCl <sub>4</sub>	43.26	353	56.1	149
C <sub>6</sub> H <sub>5</sub> Cl	37.41	350	68.5	163
CS <sub>2</sub>	48.36	341	55.8	170
Merkaptan	36.12	340	63.5	160
Octanol	3.52	367	90.8	140
Heptylic acid	6.56	335	94.6	173
Ester	approx. 25	approx. 350	approx. 75	approx. 150



Rupture Strength<sup>x</sup> and Surface Energy calculated by,

K.L. WOLF HALLÉ.

<u>Material</u>	<u>Rupture Strength</u> (Kg/cm <sup>2</sup> )	<u>Surface Energy</u> (Kg/cm <sup>2</sup> )
Cyclohexane	4 900	12 900
Benzene	5 600	14 500
CCl <sub>4</sub>	5 600	15 000
Ethanol	4 800	12 000
Propanol	4 700	12 900
Butanol	5 000	12 000
Hexanol	5 300	15 400
Propionic Acid	5 300	17 400
Butyric Acid	5 300	17 200
Hexylic Acid	5 600	17 400
Heptylic Acid	5 700	17 400
Water	14 400	16 700
Mercury	96 000	96 000
Brass	5 000	
Iron	4 000-7 000	

x ZerreiBfestigkeit.

Cold Properties of a M.G. Oil.

Oil Nr	Viscosity in c.St.			Ignition	Ignition	Stoppage free firing at
	-62°	-60°	-58°	Plates x Jammed at	Plates x Adjusted at	

463	-	34650	21500	-60°	-59°	-58°
494	16100	11380	8330	-62°	-61°	-60°
495	11220	8870	6130	-64°	-63°	-62.5°

x Zundplattchen

M.G. Oil

Figure 3B

53027

No.	Kind of Oil	Set point below	Viscosity in cSt		Pelé ht. at start finish	50 shots in no. of seconds	Endurance Test No. of shots	Cold start at -60°				
			+55°	+20°					+38°	+99° M		
376	1,4 Butandiol + LA 140-C	-76	2640	9.00	5.31	1.78	3.197	1.07	3.00	2.80	Jammed after 125	OK
369	Adipic-S + LA 140-C	-77	8160	14.5	7.87	2.34	3.137	1.211	2.8	-	" " 250	OK
370	Adipic-S + LA 165/250	-76	12220	21.1	10.5	2.82	3.136	1.539	3.0	2.80	" " 3000	OK down to
494	i-Butylphosphate	-78	2863	11.8	6.60	2.20	2.968	0.975	2.65	2.77	" " 2250	-
290 S	Ester 290 + 1% S dissolved	-76	18380	19.3	9.00	2.51	3.193	1.533	2.70	3.00	after 3000 difficult start	-
290 CS	Ester 290 + 2% as thiocretomaldehyde	-76	29180	17.7	9.20	2.51	3.23	1.584	3.00	-	Jammed after 250	-
401	E 376 + 2% S as R-600-S-G-O-(CH <sub>2</sub> ) <sub>4</sub> -O-C-S-S-O08R	-76	5510	9.11	5.51	1.82	3.122	0.949	3.00	-	" " 125	OK
402	E 376 + 4% S up to 401	-76	2801	9.44	5.79	1.92	3.143	1.066	2.80	3.00	" " 3000	-
403	E 376 + 2% S as R-60-O-CH <sub>2</sub> -CH <sub>2</sub> -S-S-CH <sub>2</sub> -CH <sub>2</sub> -O-COR	-76	6210	11.4	6.49	2.06	3.14	1.13	2.80	-	-	-
404	E 376 + 2% S as R-600-CH <sub>2</sub> -S-CS-O-(CH <sub>2</sub> ) <sub>4</sub> -O-CS-S-CH <sub>2</sub> -RCOO	-76	6820	10.6	6.14	1.97	3.176	1.131	2.84	-	-	-
405	E 376 + 2% S as R-O-CS-S-CO-(CH <sub>2</sub> ) <sub>4</sub> -CO-S-CS-OR	-76	7200	11.0	6.25	1.97	3.219	1.182	2.50	2.66	After 3000 OK	OK
441	E 376 + 2% S as R-O-CS-S-S-S-CS-OR	-78	2165	10.6	6.04	1.96	3.159	1.103	2.50	2.65	" 3000 OK	OK
442	E 376 + 2% S as R-O-CS-S-S-S-S-CS-O-R	-76	1672	10.6	6.04	2.02	3.259	1.352	2.50	2.50	" 3000 OK	OK

No.	Kind of oil	M. G. Oils		Figure 39		Endurance Test	Cold start. st. 60			
		Set Point below	Viscosity at	Tele height	50 Shots in number of seconds					
		-55°	+20°	+38°	+99°	M.				
40	M.G. Oil	-55	35.2	16.4	3.47	3.406	1.763	2.50	2.51	after 3000 Down to 25° OK
455	Adipin S + L.A. 140/200	-78	4020	13.7	7.56	3.33	3.074	1.156		
463	E 455+2% S as C <sub>5</sub> H <sub>11</sub> -O-OS-S-S-S-OS-O-C <sub>5</sub> H <sub>11</sub>	-78	10720	14.1	7.82	2.23	3.215	1.282	2.55	2.50
463	E455+3% S.	-78	11000	14.3	7.90	2.29	3.221	1.424	2.50	2.52
463	KW-Oil + 3% S.	-78	2765	12.0	6.96	2.17	3.129	1.145	2.50	2.50
495	KW-Oil + 5% S.	-78	3185	11.9	7.07	2.16	3.181	1.204	2.50	2.50
494	KW-Oil + E455 1:1 + 2.5% S	-78	5280	13.0	7.40	2.22	3.186	1.233	2.52	2.50

Figure 40

50764

## German Axle Oils

	Winter Oil 2/191 III	Winter Oil -2/1 III	Winter Oil 2/166 <sup>+</sup> III	Winter Oil 2/194 III	Winter Oil 2/61 III
Asphalt	0.08	0.7	1.0	0.02	0.5
Harse CHCl <sub>3</sub>	8.7	11.8	11.3	15.5	13.5
Carbene Py	3.4	3.0	1.8	1.6	1.6
H <sub>2</sub> SO <sub>4</sub> - Soluble 6x2 to 3 cm	18.2	16.7	20.9	18.0	11.7
Acetone - insol. 20°	3.3	6.9	10.4	4.6	9.8
Paraffin	2.0	2.2	2.9	4.5	3.9
H/C Oil	54.6	58.6	51.4	57.9	58.7

Figure 41

50765

Kind of Oil	Set Point °C	Viscosity in EP at					V.I.
		-30°	-20°	+38°	+50°	+99°	
1) 2/166	-40	16380	2583	10.97	6.00	1.713	75
2) 2/191	-34	37100	1710	8.61	4.81	1.600	75
3) 2/1	-45	7076	1311	8.24	4.78	1.638	98
4) 2/61	-44	5359	1248	8.27	4.85	1.643	98
5) 2/194	-38	not meas.	1482	8.21	4.83	1.658	104

## Blends

6)	2/166 + 2/191	1:1	-35	24630	2192	-	-	-	-
7)	2/1 + 2/61 + 2/194	1:1:1	-35	6574	1155	-	-	-	-
8)	2/61 + 2/194	1:1	-40	8300	1270	-	-	-	-
9)	2/1 + 2/194	1:1	-34	7273	1225	-	-	-	-
10)	2/1 + 2/61	1:1	-42	6093	1322	-	-	-	-
11)	Blend 1-5		-35	9593	1595	9.41	5.30	1.657	81
12)	Ester 436		-74	52.0	20.3	1.75	1.53	1.17	169
13)	Ml-5 + 12% Ester		-40	3235	729	6.75	4.03	1.543	95
14)	Blend 7 + 6% Ester		-41	3390	971	7.11	4.25	1.584	101
15)	" 7 + 12% "		-44	2285	660	6.07	3.74	1.521	102

Figure 42 54694

Capillary Action of natural axle oils

Kind of Oil	at+50°			at+20°			at-10°		
	1. Week	6. Weeks	Total Quantity	1. Week	6. Weeks	Total Quantity	1. Week	6. Weeks	Total Quantity
1.	379	265	1912	128	120	760	0.1	4.3	28
2.	299	101	1050	20	0.6	26	0	0.5	0.9
3.	389	325	2125	126	119	756	3.8	.9	52
4.	355	181	1517	90	81	529	0	1.3	4.5
5.	409	349	2232	122	117	741	0.4	4.4	25
Mixture 1-5	378	243	1807	81	22	245	0.1	2.	12
Mixture 1-5 + 12% Ester	511	359	2525	121	52	461	0.8	3.4	22
Mixture 1-5 + 10% Gasoil	433	240	1980	152	141	901	11	13	114

Figure 45 45115.

Test Nr	SS.970-SS.906 Mineral oil 1:1 and Ester addition.F	Running time in hours	Improvement over Redband	Oil consumption gm/hours	Viscosity E° at.99°	V.I.
464	Redband.D.	8.5	-	400	2.95	95
470	SS.970 a	11	29%	380	3.50	119
474	SS.970a + 5%F	10.5	23%	310	3.23	109
472	SS. 970a + 10%F	14	65%	335	3.05	109
475	SS.970 +10%F	12.5	47%	400	3.09	110
580	SS.970a +20%F	14	65%	320	2.50	103.
470	SS.904a	12	41%	310	3.08	116
518	SS.904a + 10%F	19.5	129%	400	2.62	114
324	SS.904a + 20%F	23.0	170%	405	2.34	112.

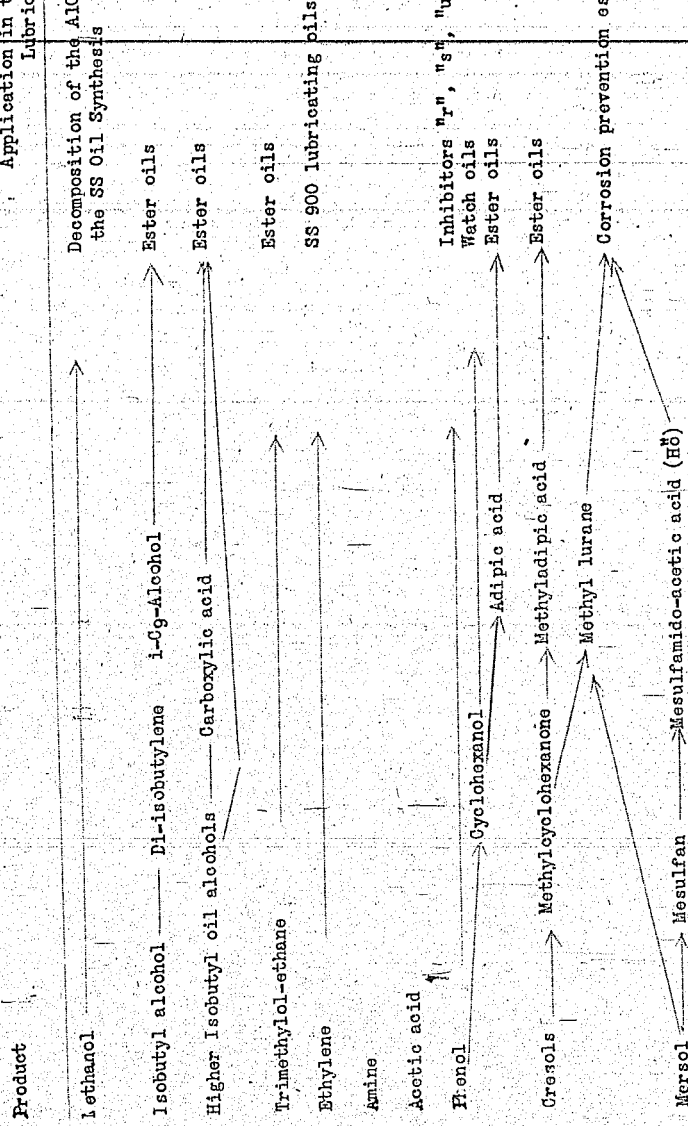
Nr.	Kind of Oil	Improvement in Running time compared with Stanavo
-----	-------------	---

- |    |   |      |
|----|---|------|
| 1. | Nienhagen Lube Distillate refined<br>with $AlCl_3$ + SS.1100 1:1  | 23%  |
| 2. | Mixed polymerisation of the above<br>Nienhagen Oil and Wax cracking<br>product 1:1                      | 48%  |
| 3. | Nienhagen Lube Distillate treated with<br>Propane and refined with $AlCl_3$ mixed<br>with SS.1100 1:1   | 25%  |
| 4. | Nienhagen Lube Distillate treated with propane<br>mixed polymerization with wax cracking<br>product 1:1 | 100% |

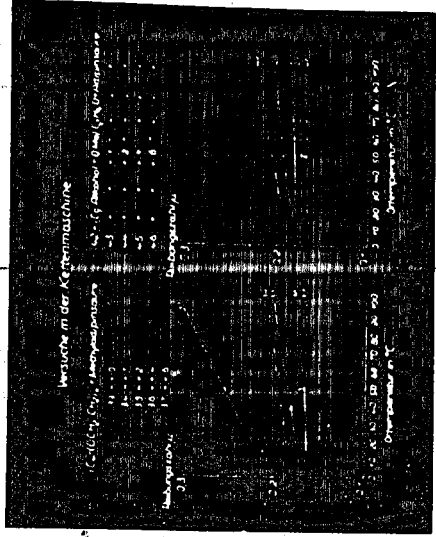
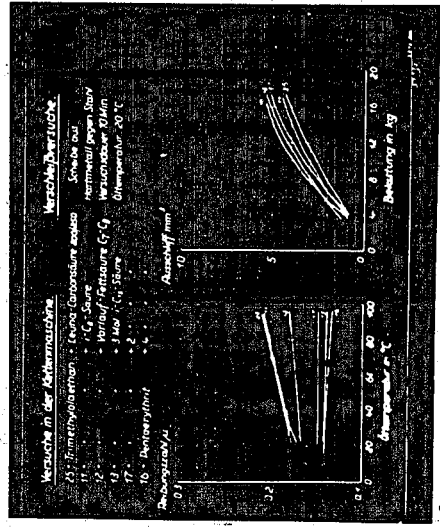
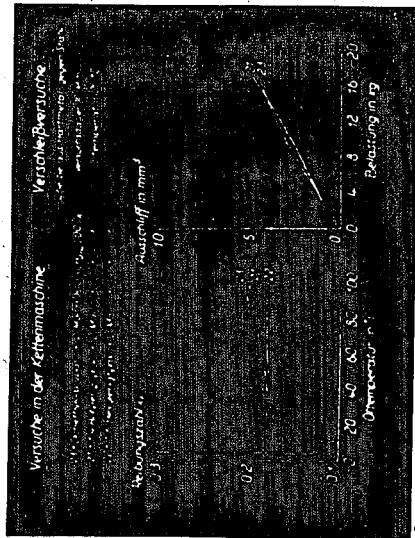
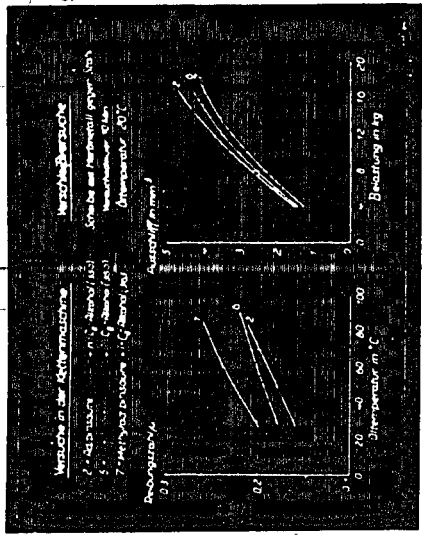
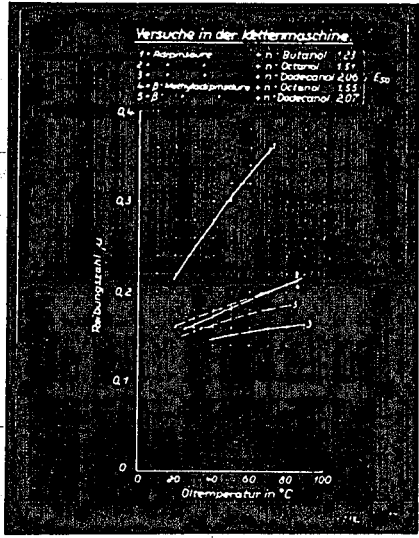
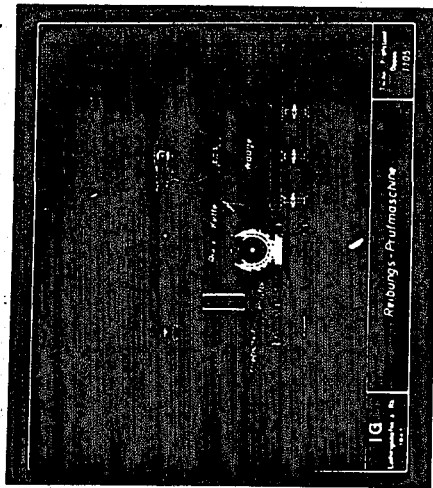
Figure 54

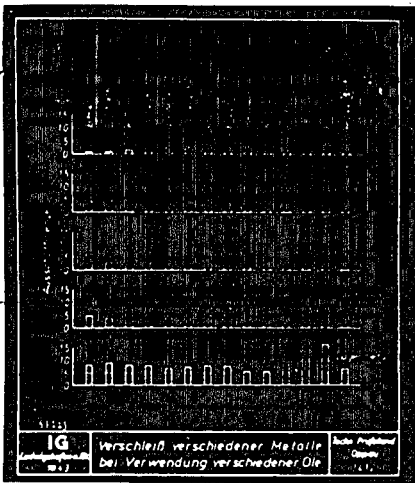
Application in the Field of Lubrication

Decomposition of the AlCl<sub>3</sub> sludge in the SS Oil Synthesis

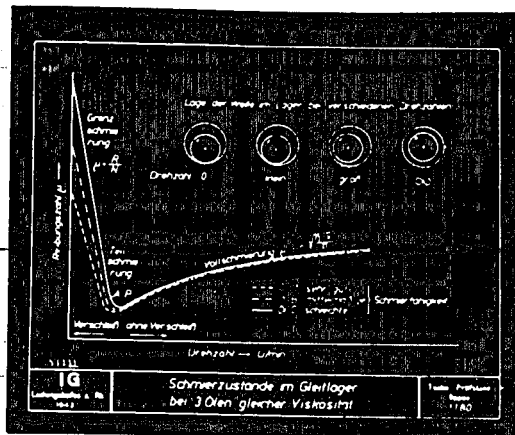




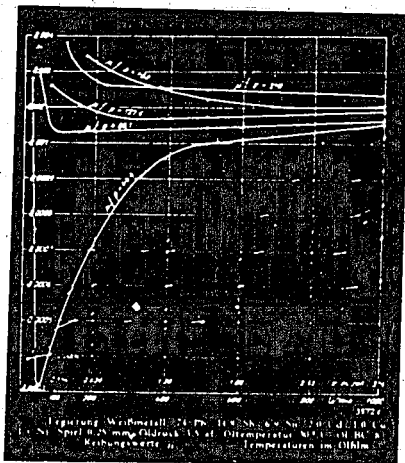




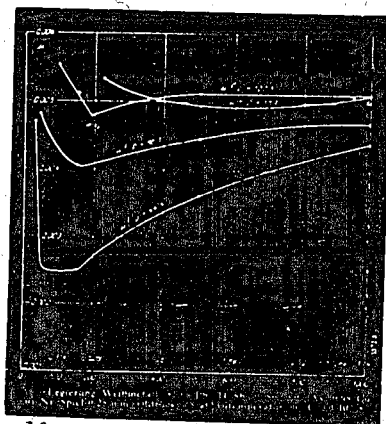
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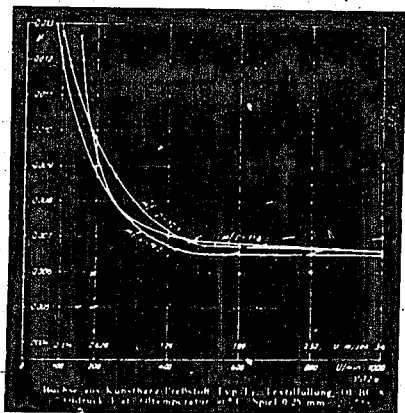
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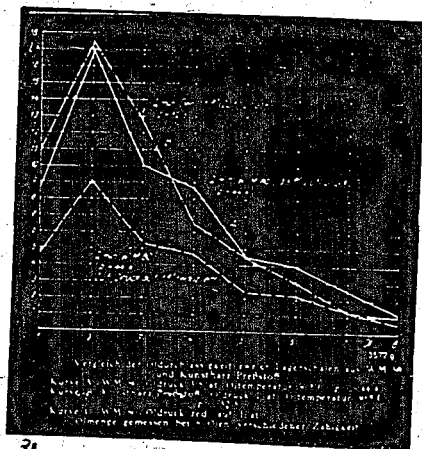
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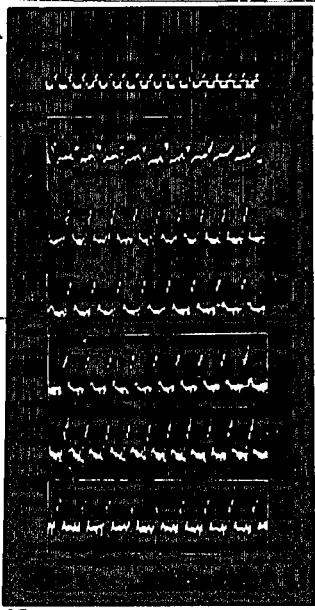
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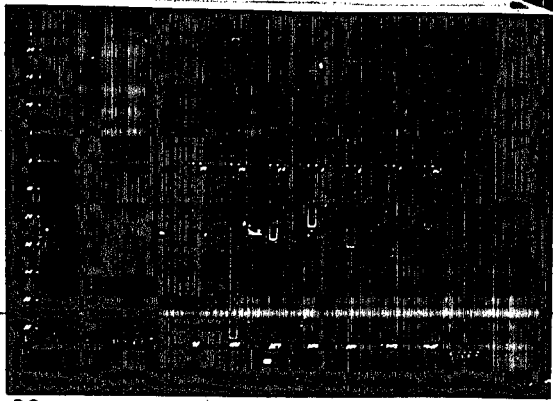
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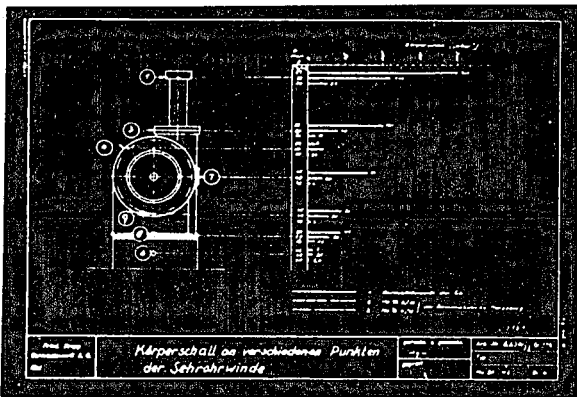
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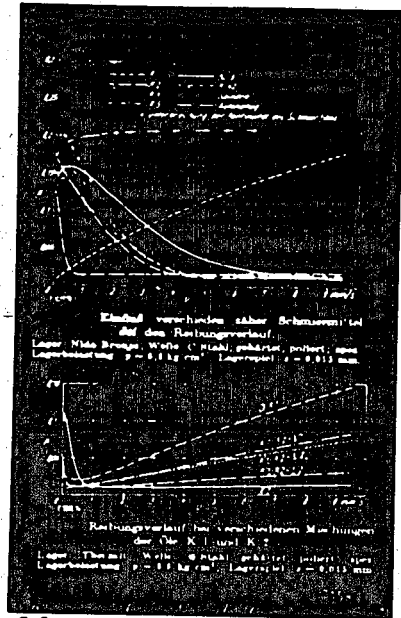
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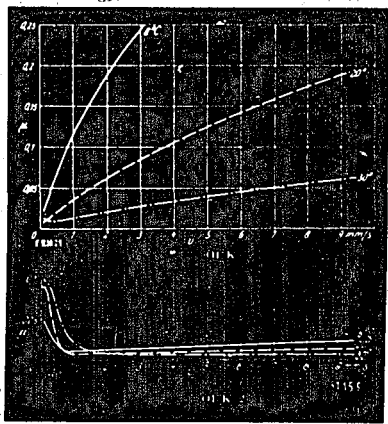
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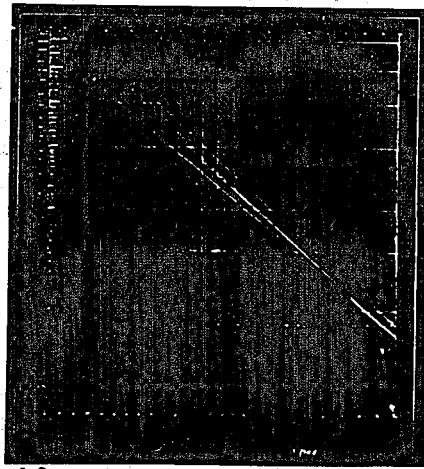
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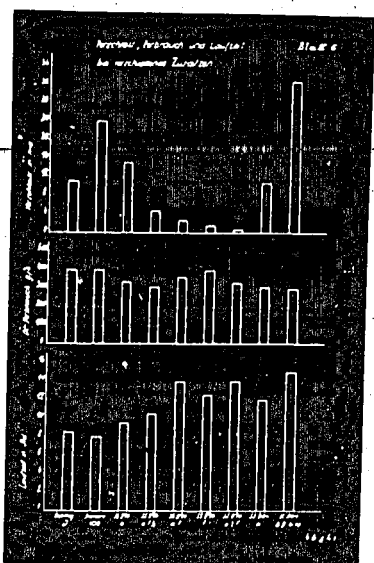
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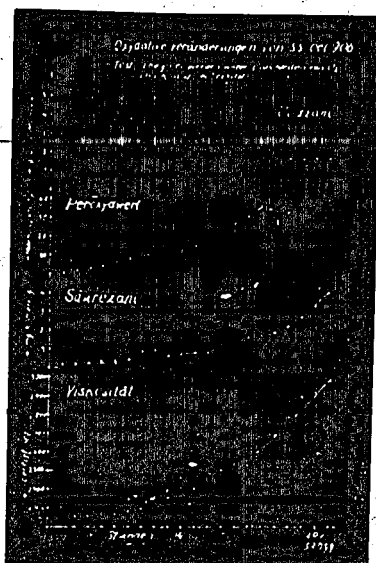
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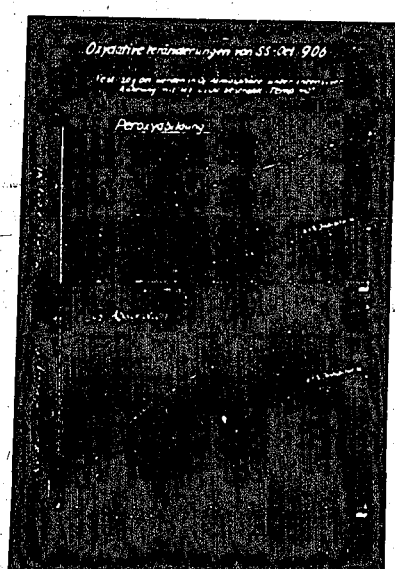
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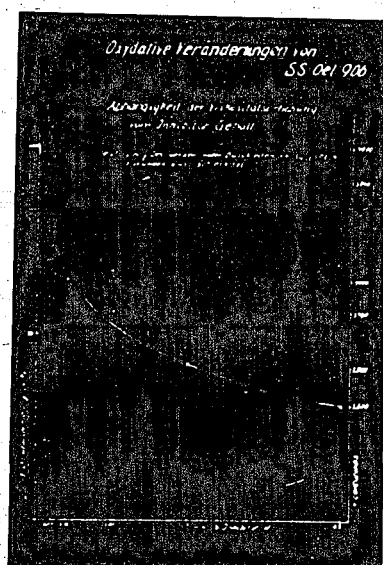
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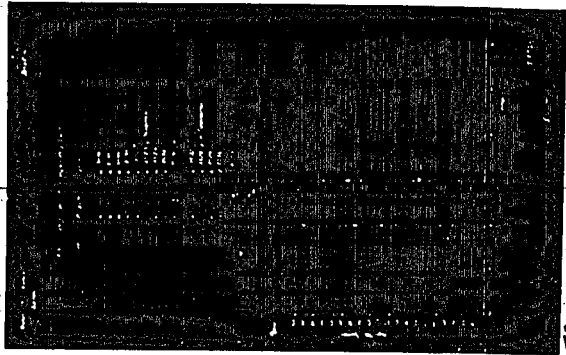
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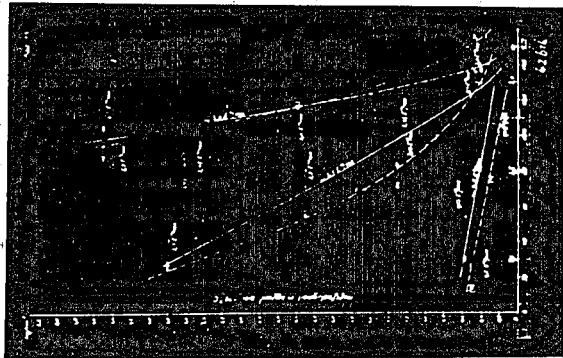
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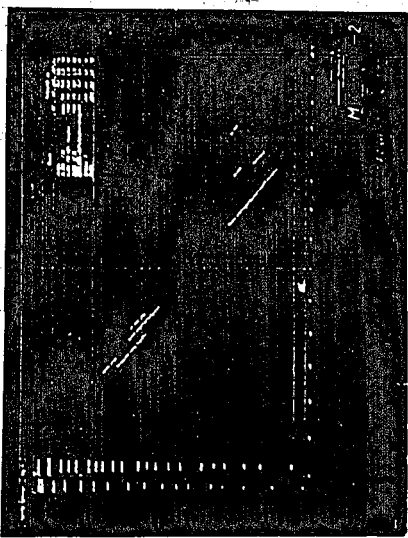
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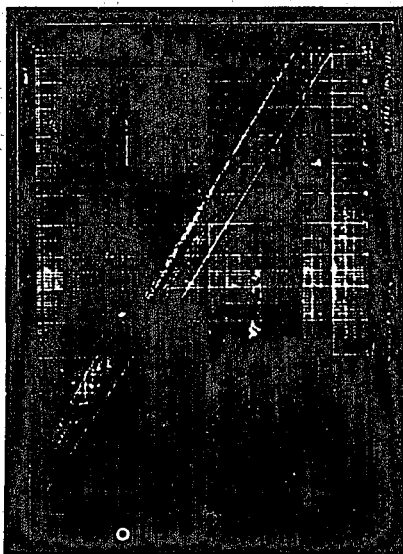
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49



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C.I.O.S. Microfilm 135.

ATTACHMENT X.ESTER OILS.

Ester oils are those synthetic esters which are produced from a basis of isobutyl oil, phenol and cresol. The following esters are being produced at the present time:

- Esteroil 504: Made from methyladipic acid and Leuna alcohol (Fraction 160° - 200°C).  
 Esteroil 515: Made from methyladipic acid and Leuna alcohol (Fraction 180° - 250°C).  
 Esteroil 455: Made from adipic acid and Leuna alcohol (Fraction 140° - 180°C).  
 Esteroil 426: Made from Leuna carboxylic acids (Fraction 200° - 250°C) and trimethylolethane.  
 Esteroil IT4: Made from Leuna carboxylic acid (Fraction 140° - 180°C) and trimethylolethane.  
 Mollith L.85: Made from Leuna carboxylic acid (Fraction 160° - 180°C) and trimethylolethane.  
 Esteroil 623: Made from methyladipic acid and  $\frac{1}{2}$  dimethylolpropane and  $\frac{1}{2}$  isobutyl oil (Fraction 180° - 250°C).

Production of the Ester Oils.

Acid and alcohol are well mixed in a stirrer vessel at ordinary temperatures; zinc oxide or toluene-sulphonic acid are added as catalysts. Zinc oxide is used for the trimethylolethane esters and toluene-sulphonic acid for the esters of adipic and methyladipic acids.

The mixture is then heated by gas from outside and raised to a temperature between 180° and 200°C.

The water liberated during the reaction is distilled off in the form of an azeotropic mixture with a middle oil fraction (180° - 220°C) which is kept in circulation. The reaction goes on for about 6 - 8 hours; it is finished when no more water is being formed.

The crude esters are washed with dilute caustic soda and then washed with water until they are neutral; the middle oil and low boiling impurities are removed by distillation up to the flash point of 210°C. Fuller's earth is then used to purify the esters.

For the manufacture of 100 kg. of ester oil the following are required:

- Esteroil 504: 56 kg. methyladipic acid,  
160 kg. Leuna alcohol (Fraction 160° - 200°C).  
 Esteroil 515: 50 kg. methyladipic acid  
164 kg. Leuna alcohol (Fraction 180° - 250°C).  
 Esteroil 455: 48 kg. adipic acid  
158 kg. Leuna alcohol (Fraction 140° - 180°C).  
 Esteroil 426: 90.4 kg. Leuna carboxylic acid (Fraction 200° - 250°C),  
6.5 kg. soap acid,  
24.5 kg. trimethylolethane.  
 Esteroil IT4: 96.1 kg. Leuna carboxylic acid (Fraction 160° - 180°C).  
30.8 kg. trimethylolethane.  
 Mollith L.85: 97.0 kg. Leuna carboxylic acid (Fraction 160° - 180°C).  
29.7 kg. trimethylolethane.  
 Esteroil 623: 57 kg. methyladipic acid,  
33 kg. isobutyl oil,  
9 kg. dimethylolpropane.

Applications and properties of the ester oils.

1. Esteroil 504 is used in the production of low temperature resistant axle oil for the Reichsbahn in "Y axle oil red". In the latter it is mixed with equal parts of the R oils of the SS oil production, after-treated with aluminium chloride. The low temperature axle oil should ensure perfect lubrication of the railway waggons at  $-40^{\circ}\text{C}$ .

Properties: E<sub>500</sub>  $\approx 3.4$   
E<sub>-400</sub>  $\approx 3300$   
Setting point  $\approx -60^{\circ}\text{C}$   
Flash point  $\approx +140^{\circ}\text{C}$ .

Esteroil 504 is also used in the manufacture of low temperature resistant writing ink.

2. Esteroil 515 and Esteroil 426 in the ratio 3 : 2 are used in the manufacture of low temperature aero-engine and low temperature automobile oil. The low temperature aviation oil is made by mixing:

25% ester mixture  
75% SS903 polymer

This allows aeroplanes to be started at  $-30^{\circ}\text{C}$ .

Properties: E<sub>990</sub>  $\approx 72.0$   
E<sub>-300</sub> ca. 3000.  
Setting point  $\approx -50^{\circ}\text{C}$   
Flash point  $\approx +220^{\circ}\text{C}$ .

The low temperature automobile oil is made by mixing:

50% SS903 polymer  
50% ester mixture

This allows motor cars to be started at  $-(35 \text{ to } 40)^{\circ}\text{C}$ .

Properties: E<sub>990</sub>  $\approx 1.6$   
E<sub>-300</sub> ca 2000  
Setting point  $\approx -50^{\circ}\text{C}$   
Flash point  $\approx +200^{\circ}\text{C}$ .

3. Esteroil 455 is used in the manufacture of "weapon oil blue" which can be used at  $-50^{\circ}\text{C}$ . It is employed in machine guns. "Weapon oil blue" is a mixture of:

4.6% esteroil 455  
4.7% high boiling fraction of the first run in the production of SS900  
2% SS906  
5% Amylcarbazate tetrasulphide.

Properties: E<sub>200</sub>  $\approx 2.0$   
E<sub>-500</sub>  $\approx 350$   
Setting point  $\approx -70^{\circ}\text{C}$   
Flash point  $\approx +120^{\circ}\text{C}$ .

4. Esteroil IT4 is used as an insulating oil for liquid cooled switches. It is less combustible than mineral oil, very resistant to cold, and it does not form soot in operation and has, therefore, a high sparking potential.

Properties: E<sub>200</sub> 4 - 7  
E<sub>-300</sub>  $\approx 800$   
Setting point  $\approx -50^{\circ}\text{C}$   
Flash point  $\approx 200^{\circ}\text{C}$ .

5. Mollith L.85 is used as a non-gelatinising softener for nitrocellulose.

Properties: E200 5-6%  
 Setting point <-60°C.  
 Flash point > 200°C.

6. Esteroil 623 is used as a substitute for rape-seed oil for the lubrication of heavily strained cutting machines and Räummaschinen (broaches?).

Properties: E200 8-12%  
 Setting point <-50°C.  
 Flash point > 200°C.

Manufacturing plant, partly under construction or being planned.

	<u>Leuna.</u>	<u>SCHKOPAU</u> <u>Leuna.</u>	<u>Auschwitz.</u>
Esteroil 504	1000 tons/year	-	2400 tons/year
515	1500 "	2400 tons/year	-
455	230 "	-	-
426	1000 "	-	1600 tons/year
IT4	200 "	-	-
Mollith L.85	1000 "	-	-
Esteroil 623	500 "	-	-



ESTER MANUFACTURE AT LEINA.

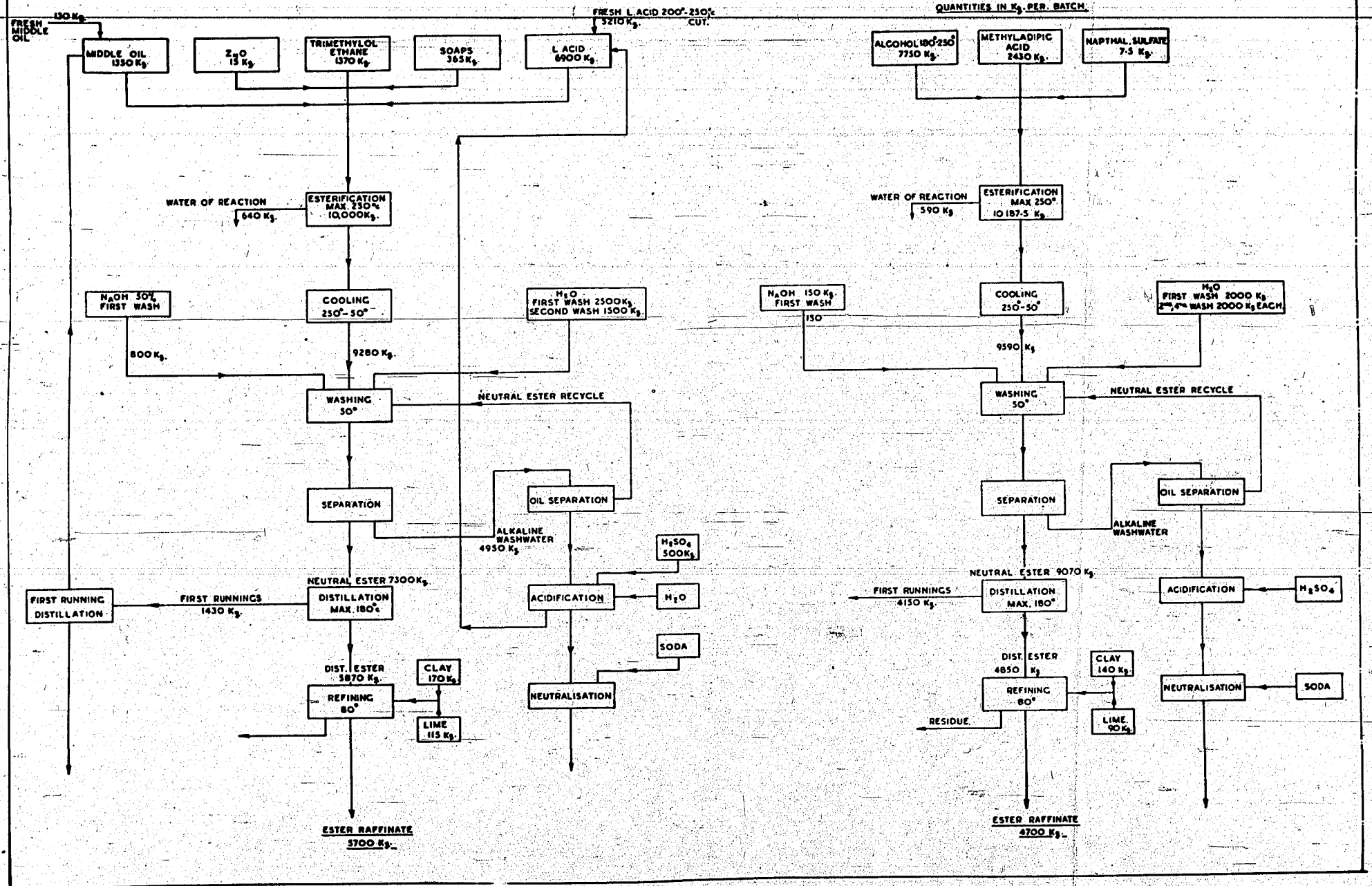
ESTER 426 (1840 x p.p.)

1-BATCH = 5.7 TONS PRODUCT IN 15 WORKING HOURS.

ESTER 312 (1350 x p.p.)

1-BATCH = 4.7 TONS PRODUCT IN 15 WORKING HOURS.

QUANTITIES IN K<sub>g</sub>. PER BATCH.



**ESTER 504 (150-3100-22)**

**ESTER MANUFACTURE AT LEUNA**

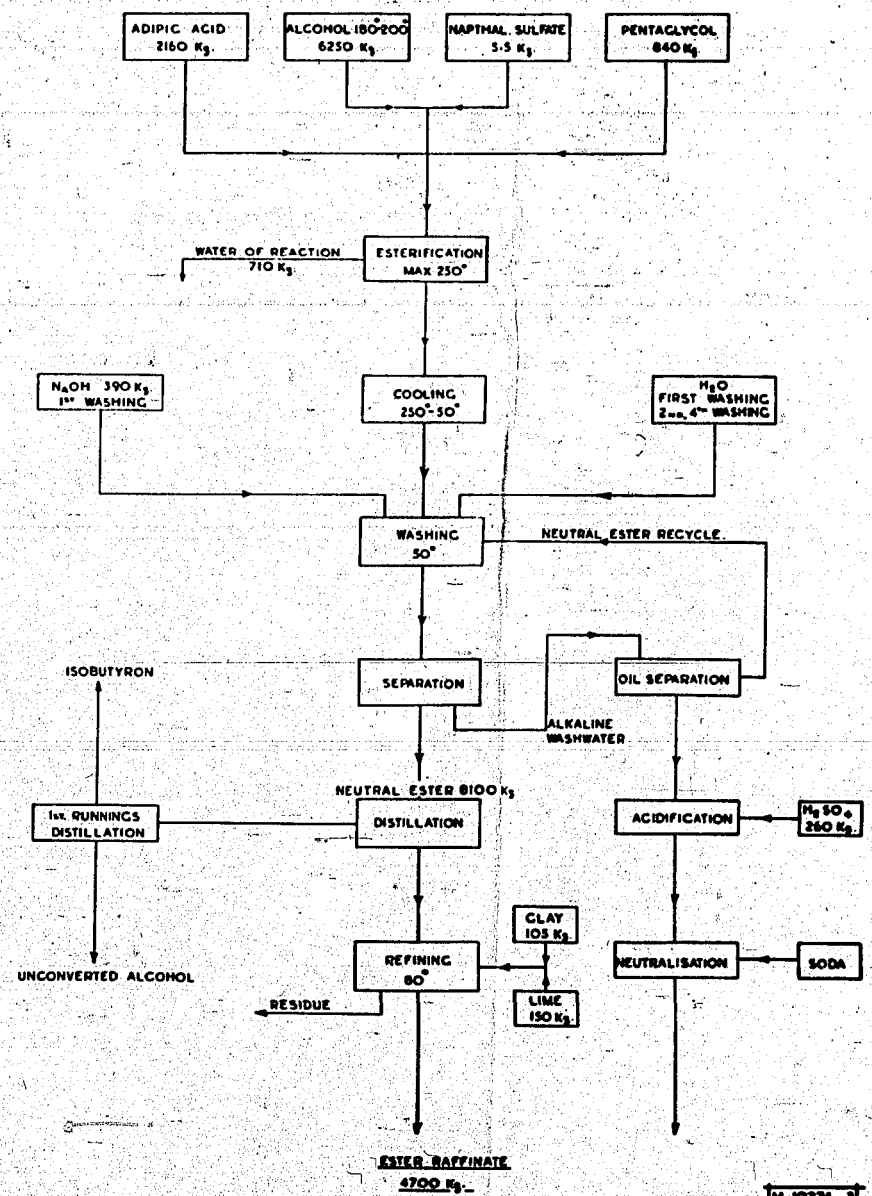
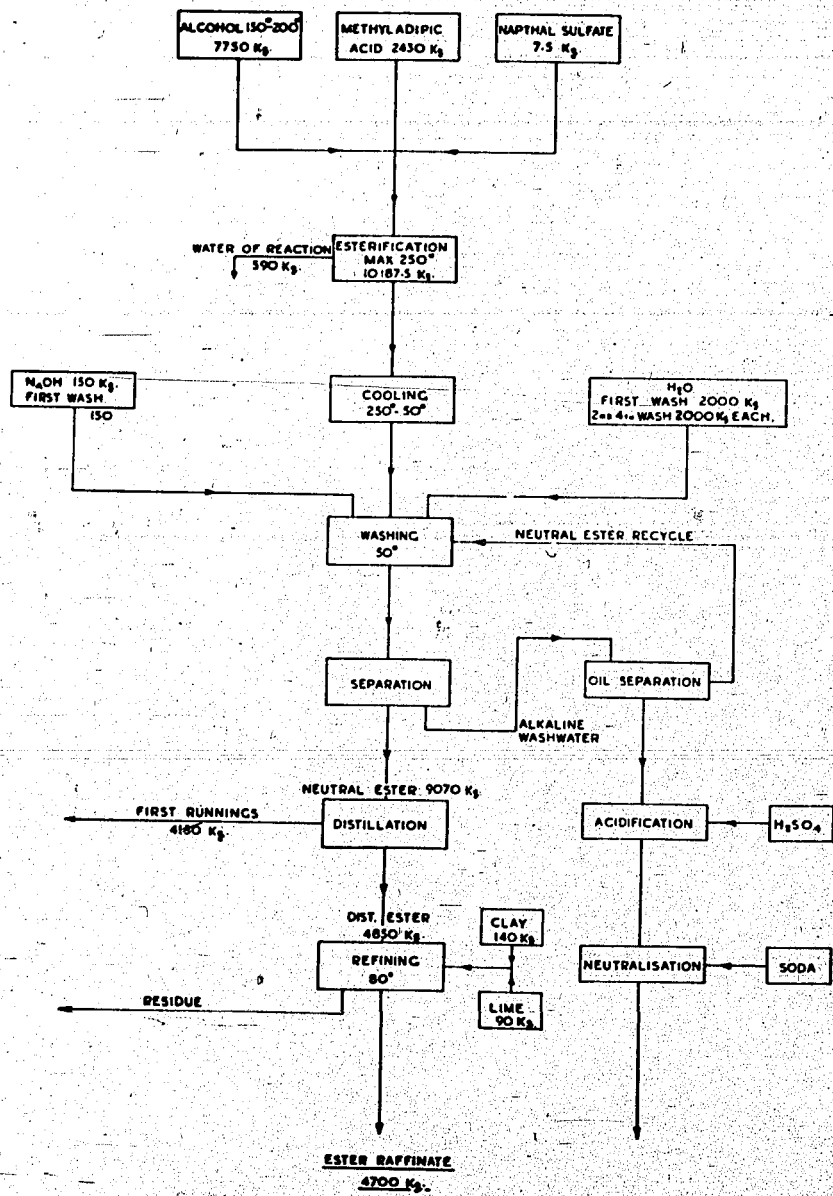
**ESTER 622 (300-22)**

1-BATCH = 4.1 T<sub>6</sub> PRODUCT IN 15 WORKING HOURS

1-BATCH = 4.7 T<sub>6</sub> PRODUCT IN 22 WORKING HOURS

QUANTITIES IN K<sub>g</sub> PER BATCH

QUANTITIES IN K<sub>g</sub> PER BATCH



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ATTACHMENT XI.

ESTERS AS LUBRICANTS.

Dr. Zorn.

It has been known for a long time that the lubricating quality of natural hydrocarbon lubricating oils is improved by adding natural fatty oils. In special cases automobile and aero-engines have even been lubricated with natural fatty oils alone, e.g. castor oil. Again and again, however, it has been shown that natural fatty oils cannot provide satisfactory lubrication for such engines in the long run because fatty oils have not sufficient thermal stability. This is due to the thermal sensitivity of the secondary hydroxyl group of the glycerol in an acid medium. On the other hand, the properties of the fatty oils with respect to lubricating quality, i.e. pressure resistance and wear diminution are considerably better than those of hydrocarbon oils. Therefore it appeared to be necessary to synthesise esters which combine good lubricating quality with a good thermal stability. There was the additional requirement of the automobile industry viz. good viscosity temperature characteristics, i.e. a V.I. above 120, and a good low temperature stability, i.e. a setting point below  $-50^{\circ}$ .

For the reasons mentioned above, Dr. Zorn at Oppau, in collaboration with Dr. Löwenberg at Leuna, started to synthesise esters and to carry out engine tests on them in the year 1938. This work was then continued at Leuna during 1939, 1940 and 1941. The esters which were produced during that period have proved themselves in numerous different fields of lubrication. They are listed in the tables below. A critical examination of the data from the point of view of the relation between chemical constitution and lubricating properties will follow in a second report. The main contributors in the preparation, development and testing of the ester lubricating oils have been Dr. Löwenberg and Dr. Hössig (Miss) also Dr. Metzger and Dr. Gericke.

ZORN (Signed).

Index Date of Manufacture	Ester from Ethylene Glycol and	Spec Wt	Viscosity in c.St. and E.			V.I.	Table 1. Flesh Set Point	Flesh Point.
			20°	28°	50°			
150 22.4.39	1st runnings fatty acid C <sub>5</sub> -C <sub>7</sub>	0.957	6.00	3.81	1.47	3.478	-50	146
			1.479	1.290	1.060			
281 11.10.39	1.Pt fatty acid C <sub>5</sub> -C <sub>7</sub> 2.Pt " " C <sub>5</sub> -C <sub>9</sub>	0.959	8.04	4.95	1.78	3.422	-31	172
			1.655	1.369	1.015			
149 22.4.39	1st runnings fatty acid C <sub>7</sub> -C <sub>11</sub>	0.945	8.325	5.08	1.79	3.470	-31	156
			1.630	1.400	1.097			
269 4.10.39	Leuna acid 140-2	0.946	7.35	4.29	1.54	3.224	-74	141
			1.595	1.332	1.063			
80 4.1.39	Leuna acid 200-250	0.938	10.4	5.95	1.87	3.713	-77	160
			1.868	1.474	1.105			
85 1.1.39	1 Pt Leuna acid 140-250 ) 1.5 Pts Leuna acid 200-250)	0.944	11.8	6.375	1.99	3.645	-76	148
			2.00	1.511	1.118			
92 1.4.1.39	Leuna acid 200-250+10% Soap fatty acid	0.937	22.6	11.7	2.90	3.673	-54	178
			3.17	1.991	1.207			

Table 11

Index Yr	Date of Manufacture	Ester from 1.4 Butylenglycol and	Spec Wt @ 20°C	Viscosity in c.St. and E°				Set Point	Flash Point.
				20	38	50	99		
146	19.4.39	1st running fatty acid C <sub>5</sub> -C <sub>7</sub>	0.950	7.64 1.620	4.58 1.387	-	1.78 1.095	3.348 -46	163
227	7.8.39	1 Pt 1st running fatty acid C <sub>5</sub> -C <sub>7</sub> 1 Pt " " " " " C <sub>7</sub> -C <sub>9</sub>	0.938	9.90 1.878	5.79 1.46	-	2.00 1.119	3.377 -80	169
437	25.7.40	nC <sub>8</sub> acids	0.947	7.24 1.585	4.54 1.354	-	1.67 1.085	3.443 -33 (-25)	180
266	22.9.39	Oil acids	0.936	96.7 12.74	41.66 5.56	-	6.85 1.551	3.412 129	277
275	15.3.39	Leuna acids C <sub>6</sub> -C <sub>7</sub>	0.935	8.34 1.681	4.98 1.391	-	1.79 1.097	3.415 -72 below	160
266	15.3.40	1 C <sub>8</sub> Acid	0.936	12.8 2.10	6.89 1.555	-	1.98 1.117	3.857 -72 below	200
236	15.8.39	Leuna acids 140-250	0.936	11.4 1.962	6.29 1.803	-	1.95 1.114	3.689 -72 below	168
101	2.2.39	1 Pt Leuna acid 140-250 1.3 Pts Leuna acid 200-250	0.931	15.3 2.55	8.19 1.668	-	2.46 1.165	3.460 192 -72 below	180
264	22.9.39	Leuna acid 140-250+5% Oil acid	0.935	11.66 1.987	7.02 1.566	-	2.28 1.148	3.370 -64	162

Index Date of Nr. Manufacture	Ester from 1.4 Butylene glycol and	Spec wt. 20°C	Viscosity in E and c.St.			V.I.	Table 11A. Set Point Flash Point.			
			20°	38°	50°			99°		
265	28.9.39	0.934	12.7	7.18	-	2.32	3.359	-	-71	184
			2.09	1.580	-	1.152				
171	13.5.39	0.932	20.0	10.4	-	2.80	3.541	170	-71	176
			2.87	1.868	-	1.188				
268	4.10.39	0.930	14.8	11.8	-	2.94	3.644	149	-70	203
			2.59	3.00	-	1.211				
371	3.4.40	1.020	14.8	7.81	-	2.30	3.594		-10 (12)	
			2.30	1.633	-	1.150				
645	7.4.41	1.003	233.3	74.1	40.9	8.21	3.765	81	-40	346
			50.7	9.77	5.45	1.670				

Index Nr	Date of Manufacture	Ester from 1 Mol Adipol or Methyladipol and 2 Mol.	Spec Wt	Viscosity in ° and c.St.				M. V.I.	Set Point	Flesh Point.
				20°	30°	50°	99°			
388	12.3.41	Adipol Leuna Acid C-C <sub>6</sub> 7	c.St. 0.923 E.	10.9 1.915	6.50 1.521	4.90 1.384	2.14 1.133	3.415	under -70 (-35) under	180
313	2.9.41	i-C <sub>8</sub> -Acid	c.St. 0.920 E.	16.6 2.49	8.675 1.711	6.18 1.494	2.37 1.157	3.726	-72 (-50)	202
312	3.9.41	Leuna Acid 260-250	c.St 0.926 E.	23.53 3.28	12.2 2.04	8.60 1.704	3.20 1.235	3.437	-70	202
749	7.3.41	Methyladipol n C <sub>8</sub> -Acid	c.St. 0.916 E	15.4 2.36	8.875 1.729	6.53 1.524	2.71 1.190	3.505	-29 (-16) under	210
839	12.8.41	Leuna Acid C C <sub>6</sub> 7	c.St. 0.923 E.	12.3 2.05	7.15 1.577	5.31 1.420	2.25 1.145	3.462	-70 (-35) under	187
692	24.6.41	i-C <sub>8</sub> -Acid	c.St. 0.915 E.	18.2 2.67	9.20 1.758	6.50 1.521	2.48 1.167	3.696	-70 (-20)	202

Table III.

Table IV

Index No.	Date of manuf.	Ester Dimethylolpropane anf	Spec. wt. 20°C	Viscosity in cSt and Po 200 300 50 990	M	V.I. point	Set point +10	Flash point 272
543	5.1.41	Sorp fatty acids cSt	-	110 49.5 - 8.14	3.245	137	+10	272
		EO		14.48 6.56 - 1.664				



Table V.

Index Nr	Date of Manufacture	Ester from Dimethylolpentane or Dimethylolhexane and	Spec Wt	Viscosity in E° and c.St.				m.	V.I.	Set Point	Flash Point
				20°	38°	50°	99°				
<u>Dimethylolpentane</u>											
253	12.4.39	Leuna Acid 140-250	c <sub>0</sub> St. E	0.923	17.6 2.60	8.83 1.725	-	2.31 1.151	3.860	-	-65 167
145	15.6.39	Leuna Acid 180-200	c <sub>0</sub> St. E	0.925	27.4 3.75	12.2 2.04	-	2.72 1.191	3.976	82	-65 163
127	25.3.39	Leuna Acid 200-250	c <sub>0</sub> St. E	0.921	44.4 5.89	19.9 2.86	-	3.78 1.287	3.845	103	-59 188
148	21.4.39	Leuna Acid 140-250+20% lat runnings fatty acid C <sub>5</sub> -C <sub>6</sub>	c <sub>0</sub> St. E	0.923	17.5 2.59	8.90 1.731	-	2.36 1.156	3.799	-	-69 151
128	25.3.39	Leuna Acid 200-250+5% Soap fatty acid	c <sub>0</sub> St. E	0.918	55.1 7.39	22.7 3.18	-	4.36 1.538	3.653	125	-17 198

Index Nr	Date of Manufacture	Ester from Dimethylolpentane or Dimethylolhexane and	Spec wt	Viscosity in E° and c.St.				V.I.	Set Point	Flesh Point.	
				20	38°	50°	69°				
142	15.3.39	Dimethylolhexane Leuma Acid 180-200	c.St 0.922 E	25.6	12.4	-	2.85	3.849	97	-66	163
147	21.4.39	Leuma acid 140-250+20% 1st running fatty acid C <sub>6</sub> -C <sub>6</sub>	c.St 0.928 E	16.5	8.57	-	2.30	3.808	-	-73	156
38	8.10.38	Leuma acid 200-250	c.St 0.919 E	36.06	15.9	-	3.47	3.699	125	-55	175
131	25.3.39	Leuma acid 200-250+15% Soap fatty acid	c.St 0.913 E	48.8	21.66	-	4.16	3.709	118	-15	176
161	3.5.39	Leuma Acid 200-250+20% Soap fatty acid	cst 0.917 E	6.47	3.06	-	1.321	3.628	129	-9	179
153	4.4.39	Leuma acid 200-250+25% Soap fatty acid	c.st 0.914 E	49.9	22.1	-	4.33	3.611	131	-4	196
				6.61	3.11	-	1.355				
				55.1	23.0	-	4.46				
				7.03	3.22	-	1.347				

Index Nr	Date of Manufacture	Ester from Dimethylolhexane or Dimethylol H.S. and	Spec Wt	Viscosity in c.St and E <sup>o</sup>			Table VII Set Point	Flesh Point	
				@ 20°C	38°	50°			
210	20.6.39	Dimethylol H.S. 2 Pts. 1st runnings fatty acid C <sub>5</sub> -C <sub>6</sub> 3 Pts. 1st runnings fatty acid C <sub>7</sub> -C <sub>8</sub>	c.St E <sup>o</sup>	15.8 2.38	8.41 1.688	2.40 1.160	3.610	-76	174
167	11.5.39	1st runnings fatty acid C <sub>5</sub> -C <sub>6</sub> +20% 1st runnings fatty acid C <sub>7</sub> -C <sub>11</sub>	c.St E <sup>o</sup>	14.5 2.27	7.92 1.645	2.23 1.145	3.741	-78	159
207	20.6.39	1st runnings fatty acid C <sub>5</sub> -C <sub>6</sub> *30 % 1st runnings fatty acid C <sub>7</sub> -C <sub>11</sub>	c.St E <sup>o</sup>	13.6 2.18	7.35 1.595	2.07 1.126	3.843	-76	120
179	25.5.39	Leuna Acid 165-250	c.St E <sup>o</sup>	27.5 3.76	13.4 2.16	8.91 1.208	3.937	-80	158
152	25.4.39	Leuna Acid 180-250	c.St E <sup>o</sup>	36.6 4.90	16.2 2.45	3.29 1.243	3.903	-57	159
158	28.7.39	Leuna Acid 140-250*5% 1st runnings fatty acid C <sub>5</sub> -C <sub>6</sub>	c.St E <sup>o</sup>	17.6 2.60	9.06 1.746	2.33 1.153	3.887	-70	159

Table VIIA.

Index Dte of Mr. Manufacture	Ester from Dimethylolhexane or Dimethylol E.S. and	Spec Rt.	Viscosity in c.St. and E°				Set Point	Flash Point.	
			20 C.	38°	50°	99°			m.
178 25.5.39	Leuna Acid 140-250*10% 1st runnings fatty acid 0, 6, 11	c.St. E° 0.925	17.6	8.90	-	2.31	3.878	-	149
164 8.5.39	Leuna Acid 165-250*15% Leuna acid	c.St. E° 0.922	32.8	14.9	-	3.14	3.764	98	164
157 24.4.39	Leuna Acid 190-250*15% 1st running fatty acid	c.St. E° 0.920	35.0	15.6	-	3.12	4.001	75	169
			4.70	2.38	-	1.228			

Table VIII.

Index No. Date of Manufacture	Ester from 1. Mol Trimethylolmethane and 5. Mol	Spec Viscosity in c.St and $\rho$				m. V.I.	Set Point	Flash Point.		
		@ 20°C	20°	38°	58° 99°					
163	8.5.39	1st runnings fatty acid $C_9-C_{11}$	c.St 0.917 $\rho$ 9.0	68.2	31.3 4.23	5.51 1.437	3.535	134	-23	205
453	17.7.40	Sheep fatty acids $C_{10}-C_{16}$	c.St 0.920	-	110.6 14.58	14.9 2.31	3.002	132	+6 (+10)	300
335	22.12.40	1 Mol Soap fatty acid $C_{10}-C_{16}$	c.St 0.948 $\rho$ 77	595	191.7 25.23	15.3 2.35	3.564	86	+11	225
454	12.8.40	50% Soap fatty acid 50% Oil acid	c.St 0.924 $\rho$ 27.0	205	84.2 11.09	12.2 2.04	3.066	135	-9 (+5)	290
216	30.6.39	Oil Acids	c.St 0.915 $\rho$ 14.91	113.3	52.4 6.94	9.30 1.822	2.896	154	-51 (-21)	309

Table VIIIA

Index Nr	Date of Manufacture	Ester from 1. Mol Trimethylolmethane and 3. Mol	Spec Wt.	Viscosity in c.St. and Eo			V.I.	Set Point	Flash Point		
				@ 20°C	38°	50°					
600	24.3.41	Formic Acid	c.St. Eo	1.224 3.14	22.3 10.0	6.62 1.532	2.52 1.171	4.609	114	-58	172
1.	13.10.37	Acetic Acid	c.St. Eo	1.112 4.36	32.3 12.4	7.63 1.619	2.26 1.146	5.081	-	-49	182
590	11.3.41	1st runnings fatty acid C <sub>9</sub>	c.St. Eo	0.990 2.90	20.5 10.8	-	2.72 1.191	3.722	139	under	205
584	7.3.41	1st runnings fatty acid C <sub>7</sub>	c.St. Eo	0.958 4.50	33.5 15.9	10.9 1.913	3.68 1.279	3.507	157	-70	241
202	20.6.39	1st runnings fatty acid C <sub>5-6</sub> " " C <sub>5-9</sub> " " C <sub>5-9</sub>	c.St. Eo	0.968 4.61	34.1 16.2	-	3.61 1.272	3.611	143	-67	184
272	11.10.39	1st runnings fatty acid C <sub>5-7</sub> " " C <sub>7-9</sub> " " C <sub>7-9</sub>	c.St. Eo	0.965 4.58	34.0 16.5	-	3.84 1.292	3.457	160	-62	227
62	18.11.38	1st runnings fatty acid C <sub>9</sub>	c.St. Eo	0.950 6.87	51.9 23.5	-	4.78 1.374	3.451	145	-46	206

Table VIII

Set Flash Point

Spec Viscosity in c.St. and P<sub>0</sub>

W.I.

Index Date of Manufacture Ester from:  
1. Mol Trimethylolbenzene  
3. Mol

24.8.33 Leuna Acid C<sub>6</sub>

29.10.40 2. Mol Leuna Acid C<sub>6</sub>

27.3.35 Leuna acid C<sub>6</sub>-C<sub>7</sub>

16.7.41 2 Mol Leuna Acid C<sub>6</sub>

21.12.40 1. Mol Leuna Acid C<sub>6</sub>-C<sub>7</sub>

21.3.40 2 C<sub>6</sub>-Acid 2 Ethyl-n-Hexyl Acid

28.3.40 1 Pt. 1 C<sub>8</sub> acid 2 Pts Oil Acid

25.9.41 Leuna Acid 140-180

5.12.38 Leuna Acid 140-250

8.5.39 Leuna Acid 165-250

Index No.	Date of Manufacture	Ester from:	Spec Viscosity in c.St. and P <sub>0</sub>				W.I.	Set Flash Point
			20°C	30°C	50°C	99°C		
10	24.8.33	Leuna Acid C <sub>6</sub>	c.St. 0.978 P <sub>0</sub> 4.09	14.8 2.30	-	3.21 1.536	114 -66 178	
1	29.10.40	2. Mol Leuna Acid C <sub>6</sub>	c.St. 0.991 P <sub>0</sub> 8.13	23.4 3.26	14.4 2.26	3.82 1.291	52 -57 198	
6	27.3.35	Leuna acid C <sub>6</sub> -C <sub>7</sub>	c.St. 0.960 P <sub>0</sub> 5.04	16.2 2.45	10.5 1.887	3.37 1.251	109 -59 205	
599	16.7.41	2 Mol Leuna Acid C <sub>6</sub>	c.St. 0.972 P <sub>0</sub> 9.43	29.1 3.95	17.9 2.63	4.52 1.352	73 -50 193	
568	21.12.40	1. Mol Leuna Acid C <sub>6</sub> -C <sub>7</sub>	c.St. 0.990 P <sub>0</sub> 15.14	37.8 5.05	-	4.44 1.345	-27 -44 194	
336	21.3.40	2 C <sub>6</sub> -Acid 2 Ethyl-n-Hexyl Acid	c.St. 0.948 P <sub>0</sub> 6.54	49.3 2.97	-	3.84 1.292	92 -63 210	
337	28.3.40	1 Pt. 1 C <sub>8</sub> acid 2 Pts Oil Acid	c.St. 0.924 P <sub>0</sub> 15.93	121 7.10	53.7 -	9.31 1.768	146 -59 300 (-10)	
846	25.9.41	Leuna Acid 140-180	c.St. 0.964 P <sub>0</sub> 5.33	40.0 2.63	17.9 1.991	3.53 1.265	99 -60 204	
70	5.12.38	Leuna Acid 140-250	c.St. 0.965 P <sub>0</sub> 8.08	61.2 3.80	27.8 -	4.38 1.340	71 -49 190	
165	8.5.39	Leuna Acid 165-250	c.St. 0.960 P <sub>0</sub> 11.83	89.80 4.45	33.1 -	4.90 1.384	73 -48 199	

Index Nr	Date of Manufacture	Ester from 1. Mol Trimethylethane and 3. Mol	Spec Viscosity in c.St. and E°					m.	V.I.	Set Flash Point Point.	
			@ 20°C	30	50	99	0				
141	15.4.39	Leuna Acid 180-200	c.St. E°	76.5 10.08	31.2 4.22	-	4.54 1.384	4.153	56	-54	199
155	27.4.39	Leuna Acid 180-250	c.St. E°	0.954 14.49	110.7 5.21	22.3 3.13	5.37 1.425	3.935	71	-49	215
140	13.4.39	Leuna Acid 200-250	c.St. E°	0.849 16.19	123 5.65	42.5 -	5.57 1.442	3.864	65	-48	209
572	14.2.41	2. Mol Leuna Acid 200-250	c.St. E°	0.962 25.40	193 7.86	59.5 4.37	6.57 1.528	4.014	49	-44	208
589	10.5.41	1 Mol Leuna Acid 200-250	c.St. E°	0.882 56.2	427 13.83	105 -	7.80 1.634	3.938	20	-33	198

Index Nr	Date of Manufacture	Ester from 1. Mol Trimethylethane and 3. Mol	Spec Viscosity in c.St. and E°					m.	V.I.	Set Flash Point Point	
			@ 20°C	30	50	99	0				
83	5.1.39	1 Pt Leuna Acid 140-250 1.3 Pts 200-250 +10% Soap fatty acid E°	c.St. E°	0.988 15.27	116 5.75	43.2 -	6.20 1.496	3.714	99	-27	195
102	2.2.39	1 Pt Leuna Acid 140-180 1.3 Pts Leuna Acid 200-250+15% Soap fatty acid	c.St. E°	0.958 17.77	135 6.16	46.4 -	6.32 1.611	3.746	94	-9	186



Table VIII B

Index No.	Date of Manuf.	Ester from 1 Mol Trimethylololthane and 3 Mols	Spec. wt. @ 20°C	Viscosity in cSt and Po			V.I. m	Set point	Flash point
				20	38	50			
108	1. 3. 39	1 Pt. DS 140 - 250 1.3 Pt. LS 200 - 250 + 20% fatty acids	0.982	135	46.4	6.37	3.747	94	196
109	24.12.39	1 Pt. LS 140 - 250 1.3 Pt. LS 200 - 250 + 10% stearic acid	0.956	103	37.5	5.72	3.703	102	205
180	23. 5.39	LS 165 - 250 + 5% fatty acids	0.968	91.9	35.0	5.15	3.811	79	190
415	23. 6.40	LS 165 - 250 + 7.5% fatty acids	0.952	75.5	30.4	4.12	3.712	110	235
181	23. 6.39	LS 165 - 250 + 10% fatty acids	0.953	101.0	37.0	5.41	3.840	86	195
201	19. 6.39	LS 165 - 250 + 25% Lauric acid	0.954	95.6	36.4	5.30	3.856	82	192
200	18. 6.39	LS 165 - 250 + 50% Lauric acid	0.946	90.8	35.2	5.47	3.723	101	192
426	12. 7.40	LS 200 - 250 + 5% fatty acids	0.947	144.7	60.4	6.54	3.809	82	249
413	26. 6.40	LS 200 - 250 + 7.5% fatty acids	0.946	128	47.0	6.56	3.692	99	250
292	6.11.59	LS 200 - 250 + 10% fatty acids	0.947	142	49.0	6.71	3.694	101	247

Table VIII.

Index Nr.	Date of Manufacture	Ester from 1 Mol Trimethylololthane and 3 Mol.	Spec Wt.	Viscosity in c.St. and $\text{E}^{\circ}$				m.	VI.	Set Flash Point Point.
				20°	38°	50°	99°			
124	20.3.79	Leuma Acid 200-250 +15% Soap fatty acid	0.946	168 22.11	56.7 7.5	-	6.84 1.550	3.821	75	-7 185
445	16.8.40	Leuma Acid 200-250+50% Soap fatty acid	0.940	175.1 23.05	67.1 8.85	-	9.06 1.746	3.413	117	-12 281 (-10)
894	20.10.41	1. Mol Is 200-250+1. Mol Soap fatty acid	0.965	585 76.9	200 26.3	105 13.83	20.2 2.89	3.097	88	-6 220 (*6)

Table VIII G

Index Date of No. manuf.	Ester from 1 Mol. Trimethylololthane , and 3 Mol. 5% fatty acids	Spoc. wt. @ 20°C.	Viscosity in 20 38 50 99	Set V.I. point	Flash point
602	24. 3.41. HC-acid + 5% fatty acids	cst 0.965 Po 6.50	20.9 2.97	4.213	48 -57 197
97	14. 1.39 LS 140 - 250 + 12.5% fatty acids	cst 0.954 Po 9.65	29.8 4.06	4.99	107 -28 197
117	14. 3.39 LS 140 - 250 + 15% fatty acids	cst 0.967 Po 9.81	30.2 4.09	4.94	101 -10 196
126	25. 3.39 LS 140 - 250 + 18% fatty acids	cst 0.949 Po 9.26	28.8 3.92	4.76	98 -7 188 (?)
111	6. 3.39 LS 140 - 250 + 25% fatty acids	cst 0.957 Po 10.5	33.4 4.50	5.36	106 +2 194
48	27.10.38 1 Pt. LS 140 - 250 1 Pt. LS 200 - 250	cst 0.968 Po 12.15	33.1 4.45	4.90	74 -52 206
47	24.10.38 1 Pt. LS 140 - 250 1.5 Pts. LS 200 - 250	cst 0.966 Po 15.01	59.27 3.24	5.42	72 -48 207
67	28.11.38 1 Pt. LS 140 - 250 2 Pts. LS 200 - 250	cst 0.958 Po 15.93	41.7 5.55	5.64	74 -47 200
90	14. 1.39 1 Pt. LS 140 - 250 1.3 Pts. LS 200 - 250 + 7.5% fatty acids	cst 0.953 Po 12.70	36.8 4.93	5.62	101 -41 192

Table VIII H

Index No.	Date of manu.	Ester from 1 Mol Trimethylololthane and 3 Mol:	Spec. wt. @ 20°C.	Viscosity in cSt and P <sub>c</sub>			m	V.I.	Set point	Flash point	
				20	38	50					59
424	5. 6.40	2 Pts. LS 200 - 250 8 Pts. soap fatty acids Eo	cSt 0.930 Eo	199 81.7 26.19	10.76	-	12.6 2.08	2.963	140	-4 (+10)	309
457	4. 9.40	1 Pt. LS 200 - 250 9 Pts. soap fatty acids Eo	cSt 0.932 Eo	257 33.8	89.6 11.8	-	12.5 2.07	3.095	132	+4 (+10)	294
466	24. 9.40	0.5 Pts. LS 200 - 250 9.5 Pts. soap fatty acids Eo	cSt 0.930 Eo	189.7 24.96	76.4 10.07	-	11.9 2.01	2.996	120	+4 (+10)	292
435	13. 8.40	8 Pts. LS 200 - 250 2 Pts. Stearic acid	cSt 0.942 Eo	113.7 17.60	49.5 6.56	-	6.75 1.543	3.694	97	-44	257
865	6.10.41	$\frac{1}{2}$ Mol Adipic acid 2 Mol C <sub>6</sub> -C <sub>7</sub> acid	cSt 1.033 Eo	865 113.8	245.4 32.8	127 16.72	20.8 2.96	3.257	108	-35	224

Table IX

Index No.	Date of manuf.	Ester from Trimethylolpropane and fatty acids	Spec. wt.	Viscosity in cSt and E°			V.I.	Set point	Flash point
				20	38	50			
158	11.4.59	IS 140 - 250 + 15% soap fatty acids	0.959	75.25 9.92	30.33 4.11	4.60 1.359	3.979	78	-9 197
172	15.6.59	IS 145 - 250 + 10% first run fatty acids C7-C11	0.958	85.2 10.96	32.45 4.38	4.98 1.391	3.865	93	-48 191

Index Date of Nr Manufacture	Ester from Glycerine and	Spec %t.	Viscosity in c.St. and E <sup>o</sup>			Table I. Set Point Flash Point		
			20	33	50			
153 15.4.39	1st runnings fatty acid C <sub>5-6</sub>	c.St. E <sup>o</sup> 0.985	16.7	8.90	2.44	3.600	-76	197
			2.50	1.731	1.164			
151 21.4.39	1.Pt 1st runnings fatty acid C <sub>5-7</sub> 1.Pt " " " C <sub>7-11</sub>	c.St. E <sup>o</sup> 0.979	22.2	11.5	2.84	3.708	-71	192
			3.12	1.972	1.202			
152 15.4.39	1st runnings fatty acid C <sub>9-11</sub>	c.St. E <sup>o</sup> 0.941	52.7	24.3	4.96	3.406	139	195
			6.97	3.37	1.590			
242 11.8.39	Stearic Acid	c.St. E <sup>o</sup>	--	--	7.225	--	--	222
					1.584			
217 6.7.39	Oil Acid	c.St. E <sup>o</sup> 0.923	90.0	42.7	8.90	2.855	162	290
			11.86	5.68	1.722			
2 8.5.37	Leuma Acid C <sub>6</sub>	c.St. E <sup>o</sup> 0.978	20.2	9.66	2.44	3.862	--	187
			2.89	1.30	1.164			
5 17.5.38	Leuma Acid C <sub>7</sub>	c.St. E <sup>o</sup> 0.962	22.4	10.8	2.65	3.811	113	202
			3.15	1.905	1.164			
4 30.5.38	Leuma Acid C <sub>8</sub>	c.St. E <sup>o</sup> 0.956	41.9	17.8	3.50	3.631	97	209
			5.58	2.62	1.262			
5 30.5.38	Leuma Acid C <sub>9</sub>	c.St. E <sup>o</sup> 0.954	48.6	20.8	3.62	4.056	96	215
			6.44	2.66	1.273			
270 4.10.39	Leuma Acid 140-250	c.St. E <sup>o</sup> 0.970	52.1	14.7	3.11	3.859	96	198
			4.33	2.29	1.227			
186 4.4.39	Leuma Acid 140-250+15% Soap fatty acid	c.St. E <sup>o</sup> 0.965	48.66	21.2	3.67	3.811	112	195
			6.45	3.01	1.304			
28.3.37	Leuma Acid 200-250	c.St. E <sup>o</sup> 0.954	54.4	34.0	4.93	3.962	71	207
			12.44	4.57	1.397			

Index Nr	Date of Manufacture	Ester from Glycerine and	Spec Wt.	Viscosity in cSt and P <sup>o</sup>			V.I.	Set Point Point	Flash Point	
				20 <sup>o</sup>	38 <sup>o</sup>	50 <sup>o</sup> 99 <sup>o</sup>				
214		Leuna Acid+10% Soap fatty acid	c.St. P <sup>o</sup>	104.5 13.75	38.5 5.14	5.31 1.420	3.948	69	-53	200
81	1.1.39	1. Pt Leuna Acid 140-250 1.3 Pts Leuna Acid 200-250	c.St. P <sup>o</sup>	59.8 7.51	24.3 3.37	4.22 1.526	3.863	93	-59	203
56	11.11.38	1. Pt Leuna Acid 140-250 1.5 Pts Leuna Acid 200-250	c.St. P <sup>o</sup>	62.53 8.27	24.86 3.44	4.62 1.36	3.642	85	-53	208

Table II

Index No	Date of manufacture	Ester from 1.Mol Pentaerythritol and 4.Mol	Spec Rt.	Viscosity in c.St and F°					V.I.	Set Flash Point Point
				20°	38°	50°	99°	m.		
488	1.10.40	Soap fatty acid	c.St. F°	-	182.2.	-	20.7	3.045	121	+12 250
			F°		26.08	-	2.95			
488	17.7.40	Leuna Acid C <sub>6</sub> -C <sub>7</sub>	c.St. F°	0.989	105.2	37.5	5.45	3.842	86	-52 235
			F°		13.86	5.02	1.432			
573	14.2.41	3 Mol Leuna Acid C <sub>6</sub> -C <sub>7</sub>	c.St. F°	1.000	137.5	61.1	6.61	4.633	46	-43 228
			F°		24.67	8.07	1.531			
597	14.3.41	2 Mol Leuna Acid C <sub>6</sub> -C <sub>7</sub>	c.St. F°	1.02	432.7	116.4	9.22	4.063	30	-35 220
			F°		56.9	15.32	1.760			
459	4.9.40	Leuna Acid C <sub>6</sub> -C <sub>7</sub> +10% Soap fatty acid	c.St. F°	0.986	137.2	51.3	1.541	3.754	89	-38 232
			F°		18.06	6.79	6.11			
427	17.7.40	Leuna Acid 200-250	c.St. F°	0.961	453	117.2	10.46	3.784	70	-31 231
			F°		58.6	15.43	1.874			
439	7.7.40	Leuna acid 200-250+7.5% Soap fatty acid	c.St. F°	0.958	349.3	111	10.7	3.674	85	-42 265
			F°		46.0	14.61	1.886			
453	4.9.40	Leuna Acid 200-250+15% Soap fatty acid	c.St. F°	0.971	376	113.2	10.4	3.761	73	-34 265
			F°		49.5	14.9	1.867			



Table XI.

Index Date of Nr. Manufacture	Ester and Adipic Acid and:	Spec Viscosity in c.St and E <sup>o</sup>				M.	V.I.	Set Flash Point Point.
		@.20	20°	38°	50° 59°			
421 1.7.40	Methanol	c.St. E <sup>o</sup> 1.062	3.08	2.14	1.55	0.851	-	+5 139
			1.224	1.133	1.070	-	-	-22 138
422 1.7.40	Ethanol	c.St. E <sup>o</sup> 1.009	3.41	2.31	1.888	0.990	-	(-18)
			1.254	1.151	1.104	-	-	-25 170
335 12.1.40	n-Butanol	c.St. E <sup>o</sup> 0.901	5.71	3.63	2.99	1.49	2.886	-
			1.454	1.273	1.216	1.063	-	233 +4 215
423 7.8.40	n-Octanol	c.St. E <sup>o</sup> 0.519	14.8	8.75	6.23	2.85	2.748	(+10)
			2.30	1.718	1.503	1.203	-	0 163
370 3.4.40	1-Butanol	c.St. E <sup>o</sup> 0.552	6.50	4.03	-	1.56	3.424	under
			1.521	1.514	-	1.071	-	-78 175
362 15.2.40	C <sub>6</sub> -Alcohol Synth.	c.St. E <sup>o</sup> 0.543	7.97	4.76	-	1.75	3.333	-
			1.649	1.372	-	1.092	-	-43 189
364 15.2.40	1 C <sub>6</sub> -Alcohol	c.St. E <sup>o</sup> 0.535	8.81	5.675	-	1.98	3.365	(-42)
			1.733	1.451	-	1.117	-	under
365 15.2.40	1 C <sub>8</sub> -Alcohol	c.St. E <sup>o</sup> 0.925	14.5	7.35	5.35	2.26	3.244	-78 215
			2.25	1.637	1.466	1.146	-	under
315 13.11.39	Leuma Acid 140-165	c.St. E <sup>o</sup> 0.937	12.0	6.90	-	2.11	3.617	-
			2.02	1.596	-	1.130	-	under
719 16.7.41	Leuma Acid 140-180	c.St. E <sup>o</sup> 0.934	14.5	7.86	5.76	2.24	3.704	-72 180
			2.27	1.639	1.483	1.144	-	-
455 4.9.40	Leuma Acid 140-200	c.St. E <sup>o</sup> 0.933	15.4	8.39	-	2.45	3.933	-76 186
			2.36	1.686	-	1.185	-	under
566 28.2.40	Leuma Acid 140-250	c.St. E <sup>o</sup> 0.933	17.6	8.92	-	2.59	3.613	137 -72 180
			2.60	1.733	-	1.178	-	-

Table XII.A.

Index No.	Date of Manufacture	Ester from Adipic Acid and:	Spec Viscosity in c.St. and E°				V.I.	Set p Flash Point			
			@ 20°C	20°	38°	50°					
457	24.3.40	Leuna Acid 165-200	c.St. 0.932	20.1	10.03	-	2.70	3.592	163	-70	200
			E	2.88	1.834	-	1.189				
290	11.1.39	Leuna Acid 165-250	c.St. 0.930	20.9	11.44	-	2.93	3.591	160	-69	187
			E	2.97	1.866	-	1.210				
325	13.11.39	Leuna Acid 180-250	c.St. 0.930	22.73	16.4	10.85	3.65	3.601	143	-69	178
			E	4.41	2.47	1.810	1.276				
414	25.6.40	Leuna Acid 180-250	c.St. 0.932	33.4	18.0	12.0	3.51	3.564	145	-63	190
			E	5.13	2.64	2.02	1.259				
493	23.10.40	Leuna Acid 200-250	c.St. 0.930	48.0	21.6	14.1	4.33	3.583	137	-64	200
			E	6.50	3.05	2.23	1.335				
		<u>HOC(CH<sub>2</sub>)<sub>4</sub>COOR</u> <u>Per-O<sub>2</sub>-Alcohol</u>									
567	10.2.40	1-C <sub>8</sub> -Alcohol	c.St. 0.922	15.1	8.50	6.20	2.52	3.460	161	-24	207
			E	2.38	1.696	1.496	1.171				
546	10.1.40	Leuna Acid 165-200	c.St. 0.919	17.3	9.39	-	2.66	3.451	175	-29	208
			E	2.57	1.775	-	1.185				

Table XII

Index No.	Date of manu.	Mixed Ester of the halfesters (HE) of the HOOC(CH <sub>2</sub> ) <sub>4</sub> COOR	Spec. wt. at 20°	Viscosity in cSt and E°				M	V.L.	Melt. point °C	Flash point °C
				20°	30°	50°	99°				
(?) 539	5.1.41	1.4 Butandiol + 2 Mol HE	1.005	90.0	39.67	-	7.18	3.224	145 (?)	-5	200
540	5.1.41	Pentaglycol + 2 MOL HE	1.002	138	54.4	-	8.48	3.284	132	-42	220
				18.16	7.19	-	1.694				
		R - IA 140 - 180									
721	21.7.41	Glycol + 2 Mol HE	0.992	43.53	20.1	15.3	4.30	3.482	150	-62	218
				5.79	2.88	2.15	1.333				
720	21.7.41	1.4 Butandiol + 2 Mol HE	0.993	57.7	26.8	17.2	5.375	3.350	150	-33	216
				7.63	3.67	2.56	1.425				
836	12.9.41	Adipol + 2 Mol HE	0.983	64.2	29.53	19.8	6.14	3.159	162	-19	205
				8.47	4.00	2.85	1.490				
637	12.9.41	Methyladipol + 2 Mol HE	0.995	87.3	40.2	25.3	7.225	3.230	144	-60	218
				11.5	5.36	3.49	1.384				
778	19.8.41	Dimethylolpropene + 2 Mol HE	0.982	64.0	27.9	17.8	5.30	3.455	139	-56	205
				8.45	3.81	2.62	1.419				
724	21.7.41	Dimethylolpentane + 2 Mol HE	0.989	93.4	40.33	25.52	6.94	3.354	137	-53	215
				12.5	5.38	3.52	1.559				

Table XIIIa

Index No.	Date of manuf.	Mixed Ester of Adipic acid HOOC-(C <sub>2</sub> H <sub>4</sub> ) <sub>n</sub> -CO-OR with	Spec. wt. 20°	Viscosity in cSt and Po				V.I.	Sett. point	Flash point
				38	50	99	m			
		R = IA 140 - 180								
722	21. 7.41	P3 + 3 Mol HE	cst 1.011 Po 226	81.25	47.07	10.75	3.295	125	-51	217
			29.7	10.71	6.24	1.900				
733	21. 7.41	P4 + 4 Mol HE	cst 1.021 Po 482	177.7	101.1	19.5	3.035	124	-45	208
			63.4	23.38	14.31	2.81				
		R = IA 165 - 200								
541	5. 1.41	1.4 Butandiol + 2 Mol HE	cst 0.999 Po 137.5	56.1	-	9.34	3.174	144	-6	237
			18.09	7.42	-	1.771				
542	5. 1.41	Pentaglycol + 2 Mol HE	cst 0.975 Po 104.75	38.95	-	6.375	3.515	125	-47	206
			13.80	5.20	-	1.511				
637	28. 6.41	P3 + 3 Mol HE	cst 0.987 Po 234.7	84.2	47.93	11.04	3.275	123	-49	215
			30.9	11.09	6.36	1.928				
605	25. 5.41	P3 + 2 Mol HE	cst 0.995 Po 77.5	135	99.2(?)	18.8	3.144	117	-33	217
			127.6	24.35	15.07	2.73				
657	23. 5.41	P3 + 1 Mol HE	cst 1.037 Po 970	259.3	122.2	15.9	3.802	54	-30	195
			127.6	34.1	16.08	2.42				
		R = IA 180 - 250								
860	2.10.41	Adipol + 2 Mol HE	cst 0.975 Po 177.5	70.8	40.73	9.50	3.368	121	-37	231
			23.36	9.26	5.43	1.785				
323	14. 4.41	Pentaglycol + 2 Mol HE	cst 0.980 Po 146.7	55.1	32.6	7.975	3.442	120	-51	184
			19.32	7.29	4.39	1.649				
662	10. 6.41	P3 + 3 Mol HE	cst 0.990 Po 333	108.8	62.5	13.1	3.233	121	-45	220
			43.8	14.32	8.25	2.13				
706	6. 7.41	P3 + 2 Mol HE	cst 0.985 Po 368.7	121.9	67.5	13.6	3.291	114	-43	200
			48.5	16.04	8.91	2.18				
707	8. 7.41	P3 + 1 Mol HE	cst 2.010 Po 1164	309.3	159.5	23.6	3.270	103	-36	186
			153.1	40.7	20.99	3.29				

Table XIV.

Index No.	Date of Manufacture	Ester from $\alpha$ or $\beta$ Methyladipic acid and	Spec Viscosity in c.St. and E°				Set Point	Flash Point				
			Wt	20°	35°	50°			99°			
<u><math>\alpha</math> Methyladipic Acids.</u>												
445	12.8.40	n <sub>D</sub> <sup>20</sup> -Alcohol	c.St. E°	0.927	16.8	9.33	6.66	2.66	3.432	183	-32	208
			E°		2.51	1.770	1.535	1.185			(-15)	
538	28.4.41	n <sub>D</sub> <sup>12</sup> -Alcohol	c.St. E°	0.913	36.1	17.3	12.1	4.23	3.226	179	+16	231
			E°		4.84	2.57	2.03	1.351	(?)		under	
516	13.8.41	Leuna Acid 140-180	c.St. E°	0.944	16.1	8.65	6.20	2.36	3.735	-	-72	131
			E°		2.44	1.709	1.496	1.166			under	
664	22.5.41	Leuna Acid 140-200	c.St. E°	0.940	16.5	8.65	6.14	2.36	3.735	-	-72	150
			E°		2.43	1.709	1.490	1.156			under	
755	29.7.41	Leuna Acid 130-250	c.St. E°	0.933	45.2	20.5	13.4	4.07	3.712	120	-60	166
			E°		6.52	2.97	2.16	1.313				

Table XV.

Index Nr	Date of Manufacture	Ester from $\beta$ -Methyladipic acid	Spec. Viscosity in c.St and E <sup>o</sup>				V.I.	Set Point	Flash Point		
			20 <sup>o</sup>	33 <sup>o</sup>	50 <sup>o</sup>	99 <sup>o</sup>					
622	1.4.41	n C <sub>8</sub> -Alcohol	c.St. E <sup>o</sup> 0.820 2.43	16.0 1.760	9.22 1.537	6.67 1.207	2.80 1.207	3.161	223	-36	227
640	23.4.41	n C <sub>12</sub> -Alcohol	c.St. E <sup>o</sup> 0.899 4.81	35.6 2.71	13.6 2.14	4.71 1.368	2.956	135	+10	?	
714	9.7.41	L.A. 140-200	c.St. E <sup>o</sup> 0.926 2.53	17.0 1.732	6.51 1.551	2.51 1.170	3.531	167	under	-72	185
713	8.7.41	L.A. 180-250	c.St. E <sup>o</sup> 0.913 6.57	45.6 3.01	21.2 2.13	13.6 1.321	4.16 1.321	3.672	125	-59	?

Table XVI.

Index Nr	Date of Manufacture	Mixed Ester from $C_8$ or Methyladipic Acid $HOOC(OH)_2(CH_2)_3CH_2COOR$	Spec nt	Viscosity in c.St. and $E^o$			Set Flash Point Point.
				20°	30°	50°	
576	25.2.41	R-3-Alcohol	0.824	7.84	2.86	3.446	under -70
576	25.2.41	HO-Alcohol		1.033	1.159		(-46)
649	9.5.41	R-3-Alcohol	0.807	15.0	3.76	3.340	178
			3.02	2.32	1.895		-20
							(-10)
819	8.8.41	R-13-Alcohol	0.806	21.2	5.00	3.151	175
				3.01	2.53		+19
718	15.7.41	HO-Alcohol	0.908	13.85	4.5	3.331	164
			5.33	2.85	1.360		(-10)
650	12.5.41	Penteglycol	0.840	23.4	5.75	3.307	154
			7.68	3.87	1.457		+8

Table XVII.

Index No.	Date of Manufacture	Miscellaneous Esters	Spec Viscosity in c.St. and P <sub>0</sub>			m. V.I.	Set Point	Flash Point.		
			wt %	20°	35°				50°	90°
591	12.3.41	E.S.-Alcohol-Nephthaleic Acid	c.St. 0.828 P <sub>0</sub>	20.3 2.90	9.76 1.809	7.00 1.564	2.56 1.175	3.714 139	-61 (-45)	176
333	10.11.37	L.A. 140-165-Phthalic Acid	c.St. 1.007 P <sub>0</sub>	60.4 7.98	27.6 3.77	-	3.92 1.300	4.293 6	-55	197
334	21.3.40	1.68-Alcohol-011 Acid	c.St. 0.887 P <sub>0</sub>	15.8 2.41	9.03 1.743	-	2.75 1.193	3.295 217	-67 (-18)	222
606	26.3.41	1.0-Alcohol-Septic Acid	c.St. 0.912 P <sub>0</sub>	23.2 3.24	12.2 2.04	8.70 1.713	3.30 1.244	3.466 189	-72 (-42)	235
931	16.1.39	1.0-Alcohol-Phthalic Acid	c.St. 0.990 P <sub>0</sub>	121 15.93	23.8 5.18	-	5.04 1.396	4.101 16	-48	178
429	17.7.40	L.A. 165-250-Phthalic Acid	c.St. 0.988 P <sub>0</sub>	334.7 44.0	77.7 10.25	-	7.075 1.571	4.180 123	-37	195
453	21.8.40	L.A. 190-250-Leuca Acid 200-250	c.St. 0.891 P <sub>0</sub>	27.0 3.70	12.0 2.02	-	2.86 1.204	3.771 3.945	-65	175
94 6	13.1.39	L.A. 200-250-Monochloroacetic Acid	c.St. 0.958 P <sub>0</sub>	17.2 2.56	8.40 1.687	-	2.19 1.189	3.945 4.265	-	163
334	10.11.39	L.A. 200-250-Phthalic Acid	c.St. 0.977 P <sub>0</sub>	351. 46.2	89.2 11.75	-	7.34 1.594	4.265 4.215	-3	under
861	26.9.41	Cyclohexanol-Leuca Acid 200-250	c.St. 0.917 P <sub>0</sub>	7.65 1.621	5.30 1.419	-	1.54 1.029	4.215 3.663	-	under
		2-2-4-Trimethyl(3) Oxypentol(1)+n <sub>8</sub> Acid	c.St. 0.910 P <sub>0</sub>	16.5 2.48	8.95 1.736	6.45 1.517	2.46 1.165	3.663	-	-72



Table XVIIa

Index No.	Date of manuf.	Miscellaneous Esters	Spec. wt. 20°	Viscosity in cSt and E°			Sett. point	Flash point
				20°	35°	50°		
274	9. 4. 40	n-Butanol + Monochlor-acetic acid	-	1.171	1.24	-	-	94
				1.088	1.032	-	-	
275	11.10.39	n-Butanol + n-C <sub>6</sub> -acid	-	1.68	1.88	-	0.720	under
				1.084	1.037	-	-	-72
274	11.10.39	n-Butanol + L.S. C <sub>5</sub>	-	1.58	1.18	-	0.657	under
				1.073	1.024	-	-	-72
331	18.11.39	n-Butanol + L.S. C <sub>6</sub>	-	1.64	1.25	-	-	under
				1.08	1.033	-	-	-72
		Isobutylphthalate	-	37.87	15.75	-	2.82	56
				5.06	2.40	-	1.20	163
230	4. 8. 39	C <sub>6</sub> -Alcohol + 1, 2, 3, 4-Butan-tetracarboxylic acid	1.044	-	57.9	-	8.57	31
				-	7.66	-	1.684	-
452	30. 8. 39	C <sub>6</sub> -Alcohol + 2 Mol Ethylene-oxide + 1 C <sub>6</sub> -acid	0.942	6.00	4.82	-	1.79	under
				1.651	1.578	-	1.097	78
450	23. 8. 39	C <sub>6</sub> -Alcohol + 5 Mol Ethylene-oxide + H.S. acid	0.989	20.7	11.6	-	3.31	45
				2.95	1.981	-	1.245	207
438	5. 8. 40	H.S.-Alcohol + 8 Mol Ethylene oxide + Adipic acid	1.053	130.8	63.1	-	12.2	8
				17.2	8.33	-	2.04	(45)
485	8.10.40	H.S.-Alcohol + 4 Mol Ethylene oxide + Methyladipic acid	1.025	74.3	34.0	-	6.188	44
				9.80	4.57	-	1.554	(38)
494	8.10.40	H.S.-Alcohol + 6 Mol Ethylene oxide + Methyladipic acid	-	82.4	38.5	-	7.76	44
				10.92	5.14	-	1.631	(34)
430	17. 7. 40	H.S.-Alcohol + H.S. acid	0.862	3.41	2.28	1.85	1.02	under
				1.254	1.148	1.103	1.003	72

Table XVII B.

Index No.	Date of Manufacture	Miscellaneous Esters	Spec Viscosity in c.St. and $E^0$					Set Point	Flash Point		
			@ 20° C	20°	38°	50°	99°				
285	6.11.35	$C_{14}$ Glycol-Lauric Acid C <sub>6</sub> -C <sub>7</sub>	c.St. $E^0$ 0.883	17.15	8.45	-	2.17	3.990	-	-65	167
				2.55	1.691	-	1.137				
447	17.8.40	Hexantriol-Lauric Acid C-C <sub>7</sub>	c.St. $E^0$ 0.660	40.8	17.0	-	3.23	4.051	62	-57	192
				5.44	2.53	-	1.238				
446	19.8.40	Hexantriol-Lauric Acid 200-250	c.St. $E^0$ 0.853	87.6	37.6	-	9.275	2.574	174	-42	230
				8.92	5.03	-	1.765				
140	13.1.39	Leucetriol-Lauric Acid 140-II	c.St. $E^0$ -	88.75	34.4	-	5.86	3.804	93	-50	203
				11.69	4.62	-	1.415				

END

TOM REEL 249

EM 34

THIS REEL INCLUDES  
TRANSLATIONS OF THE  
DOCUMENTS FROM F.D. 2874 TO THE END OF  
THE LIST OF TRANSLATIONS MICROFILMED AT  
THE BEGINNING OF THIS REEL.

THE END

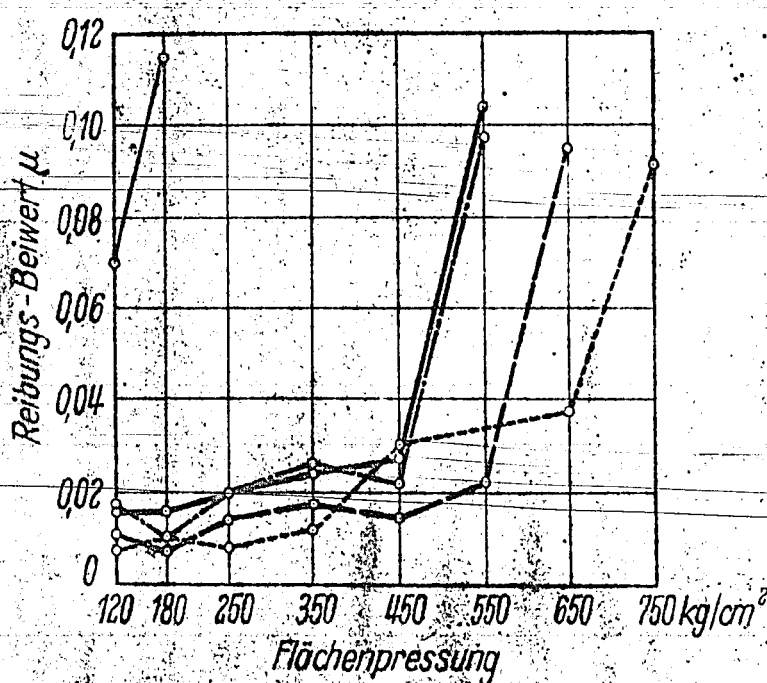
T.O.M. REEL

B.M. 34

249

Motor: NSU-201  
 $N_g = 8 \text{ PS}_g$  (Vollast)  
 $n = 3000 \text{ U/min}$   
 Schmieröltemp.  $60^\circ\text{C}$

Verschleiß-Prüfmaschine:  
 Siebel-Kehl  
 St 60.11 gegen EC 124  
 $t = 120^\circ\text{C}$  (V180)  
 $v = 10 \text{ m/s}$

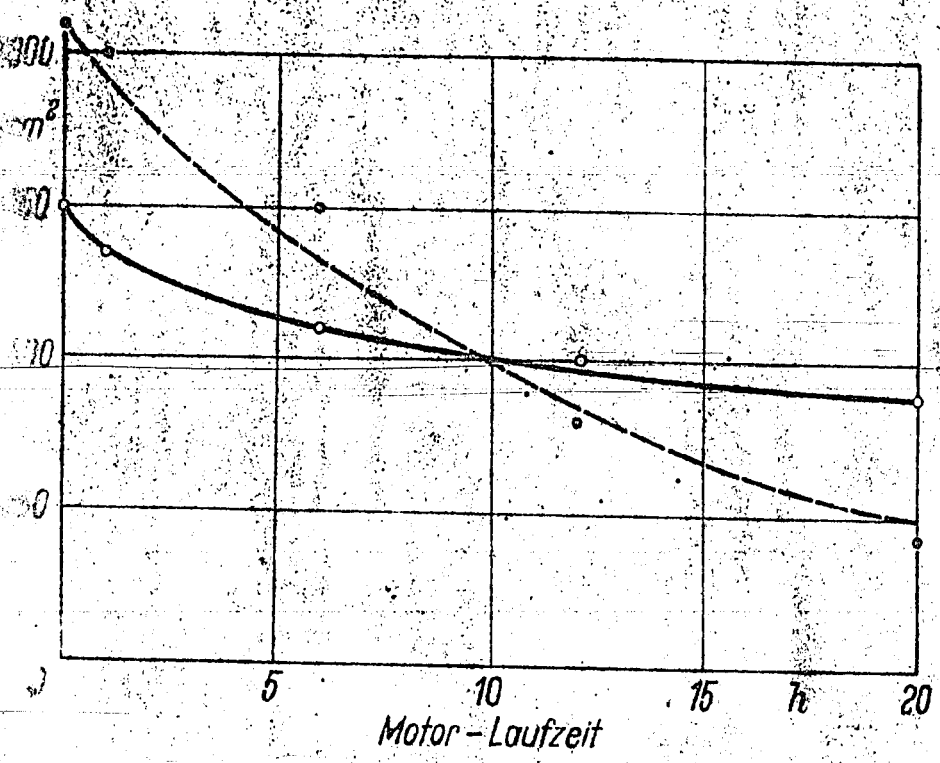


- Rotringöl rein
- - - Rotringöl mit Zusatz nach 20h Vollast
- · - Rotringöl mit Zusatz nach 12h Vollast
- - - Rotringöl mit Zusatz nach 6h Vollast
- · · Rotringöl mit Zusatz nach 1h Vollast

2 - Rotringöl (reines) 0,8% - 0,9% im motorischen Einzylinder-Versuch

Motor NSU-201  
 Ne = 8 PS<sub>e</sub> (Vollast)  
 n = 2000 U/min  
 Schmierötemp. 60°C

Verschleiß-Prüfmaschine  
 Siebel - Kehl  
 St 60.11 gegen EC 124  
 t = 120°C (V180)  
 v = 1,0 m/s



—○— Rotringöl + 0,8% Q91s  
 - - -○- - - Rotringöl + 1% Diphenylphosphat + 1% Laurylalkohol

3 - Abnahme der Wirkung von Ölzusätzen mit der Zeit

18. Description of the FKFS ignition delay measuring apparatus. K. Staiger and L. Huber. No date. 10 pages. - The purpose of this work was the construction of an apparatus which would permit a direct and continuous determination of the ignition delay. This was achieved by the use of an indicating device for the beginning of injection and combustion; these occurrences excited a current in an electric circuit which in turn caused a rotating coil galvanometer to indicate the measured value. The indicator precision's independence of the pressure variations in the engine (and therefore of the compression chosen and of the advance injection angle) is guaranteed by the use of a photocell for indicating the beginning of combustion. The necessity of changing frequently the window installed in the engine for observation purposes (soot formation) can be neglected in these tests, since a single measurement takes only 1 to 3 minutes.

The scattering of the measured values can be limited by careful operation to  $1/4$  of a crankshaft degree and, even under unfavorable conditions, is not greater than 1 degree. A large number of measurements has shown the possibility of determining the cetane number of a fuel to  $\pm 1.5$  units.

The possibility of combining a recording instrument with the indicator is now being tested.



Nur zum Dienstgebrauch im Geschäftsbereich des Empfängers

# Deutsche Kraftfahrtforschung

im Auftrage des

Reichs-Verkehrsministeriums

TECHNISCHER FORSCHUNGSBERICHT

Zwischenbericht Nr. 45

Beschreibung zum Zündverzugsmeßgerät

Bauweise FKFS

Bearbeiter: Dipl.-Ing. K. Staiger

Bericht aus dem

Forschungsinstitut für Kraftfahrwesen und Fahrzeugmotoren  
an der Technischen Hochschule Stuttgart

Prof. Dr.-Ing. W. Kamm

## Zur Beachtung!

Dieser Bericht ist bestimmt für die Arbeiten im Dienstgebrauch des Empfängers. Der Bericht darf innerhalb des Dienstgebrauchs nur an Persönlichkeiten ausgehändigt werden, die aus dem Inhalt Anregungen für ihre Arbeiten zu schöpfen vermögen. • Verwendung zu Veröffentlichungen (ganz oder teilweise) sowie Weiterleitung an Persönlichkeiten außerhalb des Dienstgebrauchs des Empfängers ist ausgeschlossen. • Der Bericht ist unter Verschluss zu halten.

Die Entwicklungsarbeiten wurden im Auftrag des Reichsverkehrsministeriums durchgeführt.

Das Forschungsinstitut für Kraftfahrwesen und Fahrzeugmotoren an der Technischen Hochschule Stuttgart dankt an dieser Stelle dem Herrn Reichsverkehrsminister für die zur Durchführung der Forschungsaufgabe gegebene Unterstützung.

## Übersicht

Es wird ein im Forschungsinstitut für Kraftfahrwesen und Fahrzeugmotoren an der Technischen Hochschule Stuttgart entwickeltes Verfahren beschrieben, das gestattet, den Zündverzug in Dieselmotoren zu messen. Der Zündverzug wird hierbei an einem in  $^{\circ}$  KW geeichten Zeigerinstrument abgelesen.

## Gliederung

### Beschreibung des Geräts

1. Meßverfahren
2. Arbeitsweise
  - a) Bestimmung des Einspritzzeitpunkts
  - b) Bestimmung des Zündzeitpunkts
  - c) Grundsätzliche Schaltung
  - d) Betriebsleistungen
3. Kurze Besprechung des vollständigen Schaltbilds
4. Zusammenfassung. Schrifttum.

## Anhang

### Handhabung des Geräts in Verbindung mit dem Kraftstoffprüfmotor des FKFS

- a) Anschließen der Leitungen am Netzgerät
- b) Einstellen der Geräte am Motor
- c) Einsetzen des Quarzfensters
- d) Eichen und Messen

Forschungsinstitut für Kraftfahrwesen und Fahrzeugmotoren  
an der Technischen Hochschule Stuttgart

Der Bericht umfaßt: 6 Seiten Beschreibung  
8 Abbildungen.

Abteilungsleiter:

gez. L. H u b e r

FKFS Nr. 270

Bearbeiter:

gez. K. S t a i g e r

## 1. Meßverfahren

Bei der Messung des Zündverzugs besteht die Aufgabe, die Zeit zwischen dem Beginn der Einspritzung des Kraftstoffs in den Dieselmotor und dem Beginn seiner Verbrennung festzustellen. Man kann hierbei zwei Teilaufgaben unterscheiden:

Einmal ist es notwendig, den Einspritz- und Verbrennungsbeginn erkennbar zu machen und zweitens ist ihr zeitlicher Abstand zu bestimmen.

Der Spritzbeginn ist durch das Anheben der Düsenadel gegeben. Man kann daher die Bewegung der Nadel zur Anzeige des Einspritzbeginns ausnützen, indem man beispielsweise durch die Nadel einen elektrischen Kontakt betätigt oder direkt die Nadelbewegung mittels geeigneter Gebersysteme elektrisch aufzeichnet.

Der Verbrennungsbeginn läßt sich aus dem Druckverlauf im Zylinder ermitteln als die Stelle im Druck-Zeit-Diagramm, an der sich die Arbeitskennlinie über die reine Kompressionslinie erhebt. Zeichnet man nun oszillographisch gleichzeitig Druckdiagramm, Düsenadelbewegung und Zeitmarke auf, so kann der Zündverzug durch Ausmessen der Strecke Einspritzbeginn-Druckbeginn ermittelt werden.

Infolge der Zwischenschaltung des photographischen Prozesses erhält man den Zündverzug nicht sofort und eine fortlaufende Bestimmung ist nicht möglich. Es sind daher eine Reihe Verfahren bekannt geworden, die eine direkte Bestimmung des Zündverzuges ermöglichen sollen. Ihnen allen ist gemeinsam die Vermeidung von Oszillographen und Anzeige des Zündverzugs durch Steuerung eines elektrischen Kreises vom Motor aus. Die Anzeige kann dabei durch auf dem Schwungrad umlaufende Glühlampen erfolgen.

Das im folgenden näher beschriebene Gerät gestattet die direkte Bestimmung des Zündverzugs durch Ablesung des Meßwerts an einem Zeigerinstrument. Die zur Steuerung verwendeten Organe wurden so ausgewählt, daß ein rasches und genaues Messen in einem weiten Verstellbereich der Maschine möglich ist.

## 2. Arbeitsweise

### a) Bestimmung des Einspritzzeitpunktes

Die Bestimmung des Einspritzzeitpunktes geschieht durch einen auf die Düsenadel aufgesetzten Kontaktgeber, der in Abb. 1 im Schnitt gezeigt ist.

Für die Wahl des Kontaktgebers war die außerordentliche Einfachheit bei ausreichender Genauigkeit ausschlaggebend. Der Kontaktabstand ist genau einstellbar und beträgt im Betrieb  $1/100$  bis  $1/50$  mm. Bei einem Nadelhub von etwa 0,5 mm und einer Zeit bis zur vollen Öffnung von  $1/1500$  s beträgt die Differenz zwischen dem wahren Beginn des Anhebens und dem Schließen des Kontakts etwa 0,025 ms, was einer Verschiebung der Anzeige um 0,3° KW bei  $n = 2000$  U/min entspricht. Da bei der Feststellung des Verbrennungsbeginns ebenfalls mit einer grundsätzlichen Ver-

zögerung von  $0,3^{\circ}\text{KW}$  und einer Toleranz von  $+0,3$  bis max.  $+0,5^{\circ}\text{KW}$  gerechnet werden muß, erscheint ein erheblicher Mehraufwand zur exakten Feststellung des Einspritzzeitpunkts nicht gerechtfertigt.

#### b) Bestimmung des Zündzeitpunkts

Da die Gewinnung eines Steuerimpulses aus dem Druckdiagramm nur für bestimmte Betriebseinstellung der Maschine mit Sicherheit möglich ist, wird der Verbrennungsbeginn durch das Aufflammen des Kraftstoffs bestimmt, wodurch es möglich wird, den Zündverzug laufend mit jeder Änderung an der Maschine anzuzeigen. Zu diesem Zweck ist im Zylinderkopf des Motors ein Quarzfenster einzusetzen, über welches das Licht auf eine Photozelle gelenkt wird, die das Aufflammen des Kraftstoffs in einen elektrischen Spannungsstoß umwandelt. Abb. 2 zeigt den Quarzfenstereinsatz, wie er am Kraftstoffprüfmotor des Forschungsinstituts verwendet wird.

Zur Auslösung der Steuerung ist eine bestimmte Mindesthelligkeit des auf die Zelle fallenden Lichtes nötig. Die Steuerung erfolgt daher um die zur Erreichung dieses Schwellwertes nötige Zeit später als der wahre Verbrennungsbeginn. Die Verzögerung ist für eine bestimmte Größe dieses Wertes nicht konstant, sondern hängt von der Intensität der Verbrennung und dem Zustand des Beobachtungsfensters ab. Je niedriger nun der Schwellwert absolut liegt, desto geringer wird auch die Verzögerung zwischen dem wahren Verbrennungsbeginn und der Steuerung. Damit werden auch die Schwankungen, die für die Meßunsicherheit verantwortlich sind, geringer. Durch genügend große Empfindlichkeit der Photozellensteuerung läßt sich so eine Anzeigetoleranz von  $1/4^{\circ}\text{KW}$  erreichen. Durch einfaches Umliegen eines Schalters am Gerät kann man dabei jederzeit prüfen, ob die Anzeigegenauigkeit gewährleistet ist.

#### c) Grundsätzliche Schaltung

Die grundsätzliche Schaltung zur Übertragung der Steuerimpulse auf das Anzeigeelement ist in Abb. 3 gezeigt.

Durch den Kontakt an der Düse wird die Gittervorspannung der zunächst gesperrten Röhre R so geändert, daß in ihrem Anodenkreis und also auch über das Anzeigeelement M ein Strom  $i_a$  fließt. Durch eine elektrische Speichereinrichtung, bestehend aus dem Kondensator  $C_2$  und dem Widerstand  $R_2$  wird der Strom  $i_a$  unabhängig von der weiteren Düsennadelbewegung solange aufrecht erhalten, bis die Röhre R bei Verbrennungsbeginn über die Photozelle Ph und den Verstärker V einen negativen Spannungsstoß erhält und damit wieder gesperrt wird.

Der Verlauf des Stromes in der Röhre R über der Zeit  $t$  oder dem Kurbelwinkel  $\varphi$  entspricht also einer Rechteckkurve nach Abb. 4. Während der Zeit des Zündverzugs fließt der Strom  $i_a$ ; dann folgt eine Pause bis zur nächsten Einspritzung. Führt man diese Stromstöße einem Drehspulinstrument genügender Trägheit zu, so zeigt es den mittleren Strom

$$i_m = i_a \cdot \frac{t_0}{T} = i_a \cdot \frac{\alpha}{7200} = 0 \cdot \alpha ;$$

d.h. sein Ausschlag ist dem Zündverzug, gemessen in  $^{\circ}$  KW, proportional. Das Instrument kann daher in  $^{\circ}$  KW geeicht werden und hat linearen Skalenverlauf.

Da Instrumente mit so großer Trägheit, wie sie hier benötigt wird, sehr umständlich zu handhaben wären, wird der Rechteckstrom einem normalen Drehspulinstrument über ein Glättungsglied, bestehend aus Widerstand und Kondensator, zugeführt.

#### d) Betriebsleistung

Der Meßbereich des Instruments reicht von 0 bis  $35^{\circ}$  KW und kann durch einen Nebenwiderstand auf  $70^{\circ}$  erweitert werden. Die Ablesemöglichkeit ist  $0,1^{\circ}$  KW, jedoch darf dieser Wert nicht mit der tatsächlichen Meßgenauigkeit gleichgesetzt werden, die in den oben angegebenen Grenzen liegt, also etwa  $\pm 2\%$  des angezeigten Wertes beträgt.

### 3. Kurze Besprechung des vollständigen Schaltbilds Abb. 6

Die Impulse der Photozelle werden in einem normalen zweistufigen Spannungsverstärker verstärkt, der mit zwei Röhren AF 7 bestückt ist. Am Ausgang dieses Verstärkers liegt eine Leistungsröhre (AC 2), die den Strom für die Aufladung des Speichergliedes  $C_1$ ,  $R_1$  liefert.  $C_1$  wird über die Diode AB 2 aufgeladen, das Ganze stellt also einen Spitzen-Gleichrichter dar. Die Entladung erfolgt über den Gitterableitwiderstand der Steuerröhre AL 4 mit einer Zeitkonstante  $T_1 = R_1 C_1 = 2 \cdot 10^{-9} \cdot 2 \cdot 10^6 = 4 \cdot 10^{-3}$  s. Solange die Impulse der Photozelle die doppelte Sperrspannung der AL 4, also etwa 20 Volt erreichen, wird über das Speicherglied eine zusätzliche Sperrung über etwa  $1/250$  s erreicht ( $n = 2000$  sind dies  $47^{\circ}$  KW).

Beim Schließen des Kontakts an der Düsenadel wird das Gitter der AL 4 direkt mit Masse verbunden. Am regelbaren Kathodenwiderstand kann der dann fließende Anodenstrom eingestellt werden (Eichung). Beim Schließen des Kontakts wird außerdem der Kondensator  $C_2$  über den 4000 Ohm-Widerstand auf Massepotential aufgeladen. Öffnet der Kontakt wieder, so bleibt das Potential am Gitter der AL 4 zunächst erhalten, da  $C_2$  sich erst über  $R_2$  entladen muß. Die Zeitkonstante dieses Kreises ist  $T_2 = C_2 \cdot R_2 = 0,03 \cdot 10^{-6} \cdot 2 \cdot 10^6 = 0,06$  s. Nach  $1/200$  s =  $60^{\circ}$  KW bei  $n = 2000$  ist der Kondensator  $C_2$  erst zu 10% entladen, so daß der Strom in der Röhre praktisch bis zum Verbrennungsbeginn gleichgehalten wird. Da die gesamte Entladung bei dieser Zeitkonstante länger als eine Umdrehung dauern würde, so daß die Röhre nach Abklingen des Sperrimpulses von der Photozelle wieder durchlässig würde, wird die Entladung von  $C_2$  und damit die Sperrung etwa  $35^{\circ}$  nach o. T. durch den Unterbrecher U zwangsläufig durchgeführt, indem das Gitter direkt an den Spannungsteiler 50 k Ohm / 200 k Ohm gelegt wird. Durch diese verhältnismäßig einfachen Mittel wird die Verwendung einer Hochvakuumröhre zur Steuerung des Instrumentstroms möglich.

Mit Hilfe des Umschalters  $S_2$  kann die Höhe des Impulses, der vom Photozellenverstärker kommt, geprüft werden. Beim Umschalten auf Prüfen wird dem Gleichrichter eine Vorspannung erteilt, so daß die Sperrung stark verzögert wird, wenn der Impuls die Höhe