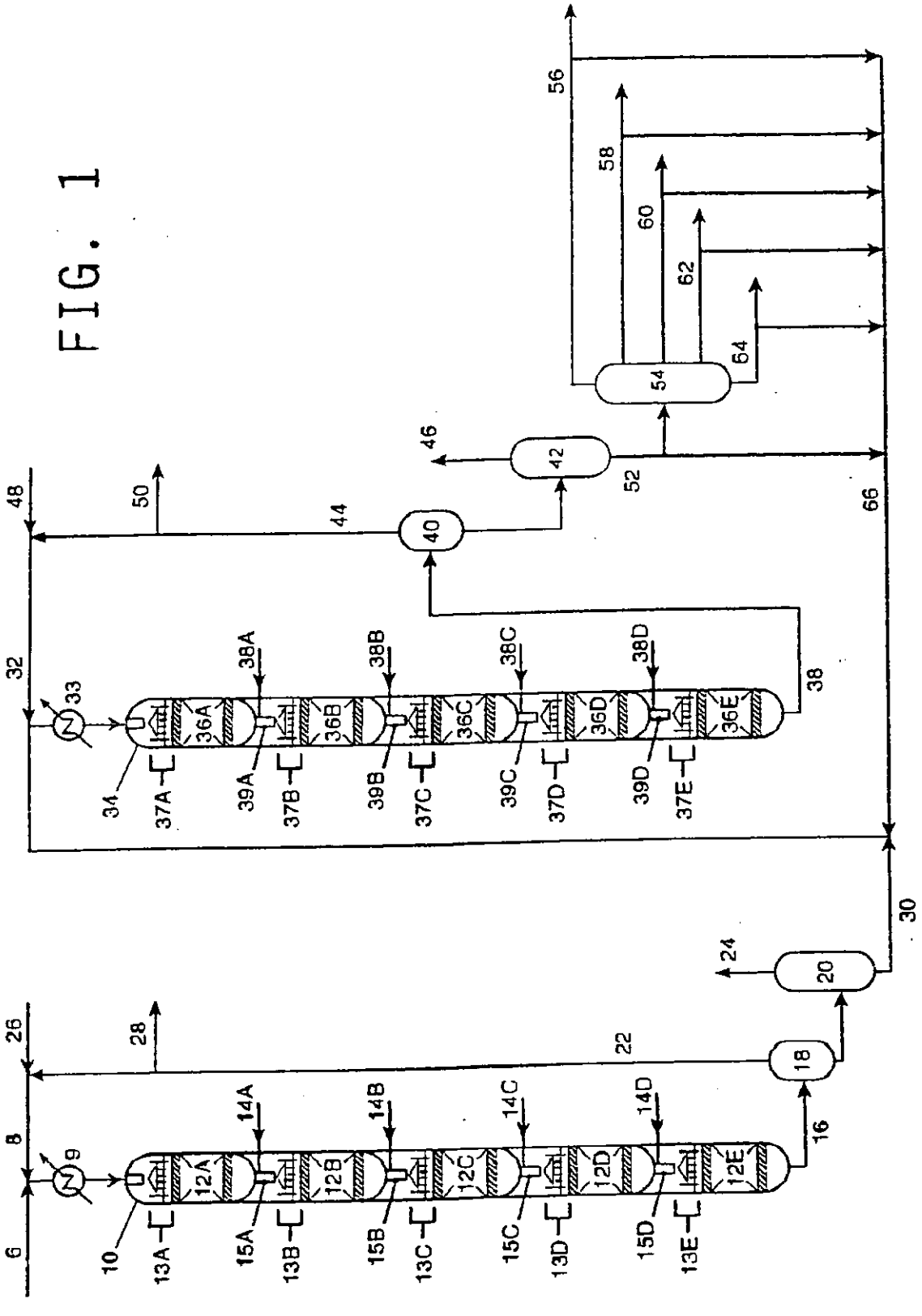
FIG. 1


56
58
60
62
64
54
46
42
52
66
48
50
44
40
32
33
38
38A
38B
38C
38D
36A
36B
36C
36D
36E
34
37A
39A
37B
39B
37C
39C
37D
39D
37E
30
24
20
26
28
22
18
8
9
14A
14B
14C
14D
16
12A
12B
12C
12D
12E
6
10
13A
15A
13B
15B
13C
15C
13D
15D
13E

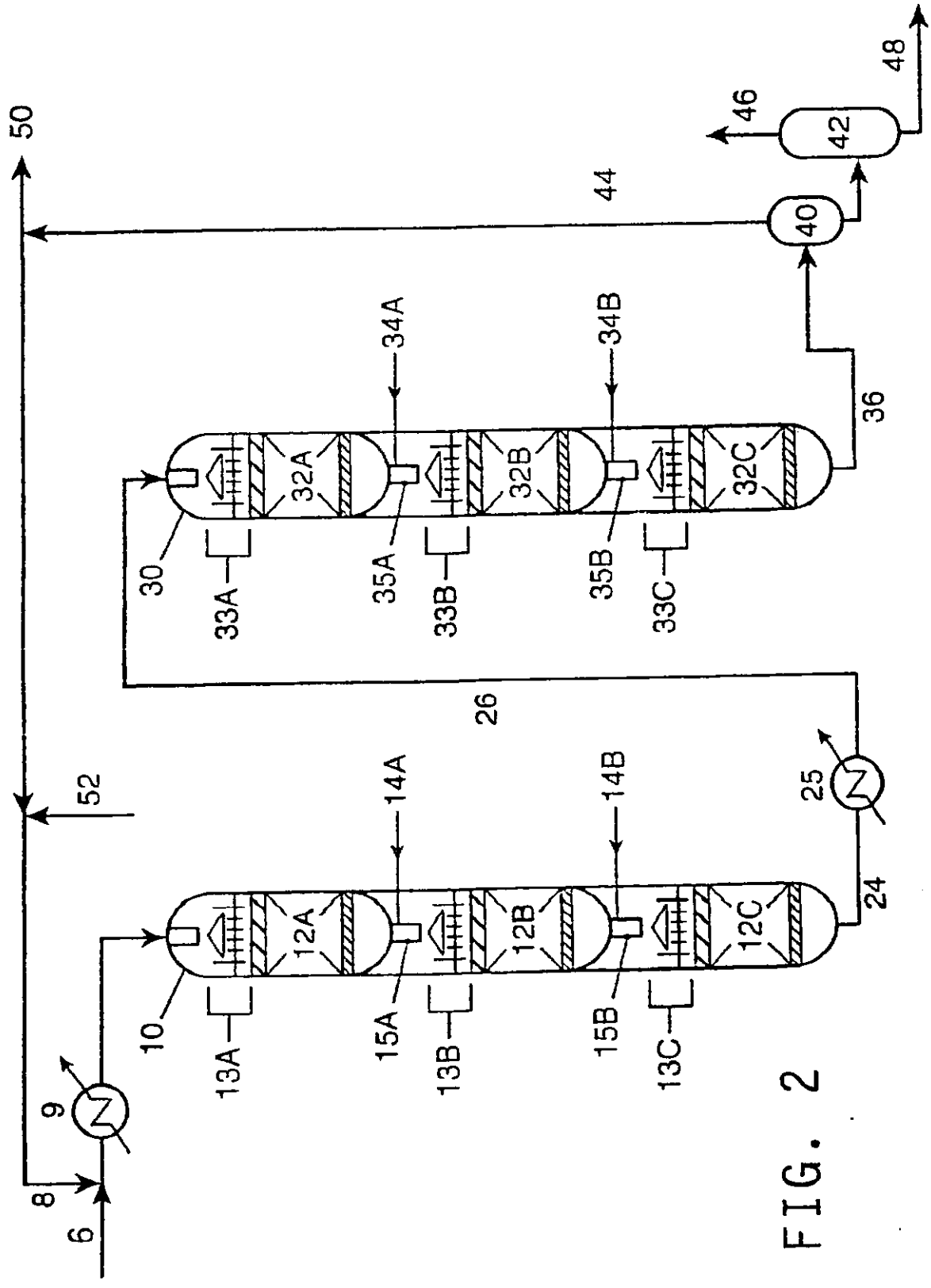

50
48
46
42
44
40
34A
34B
36
32A
32B
32C
30
33A
35A
33B
35B
33C
26
52
14A
14B
25
12A
12B
12C
24
10
13A
15A
13B
15B
13C
9
8
6

FIG. 2

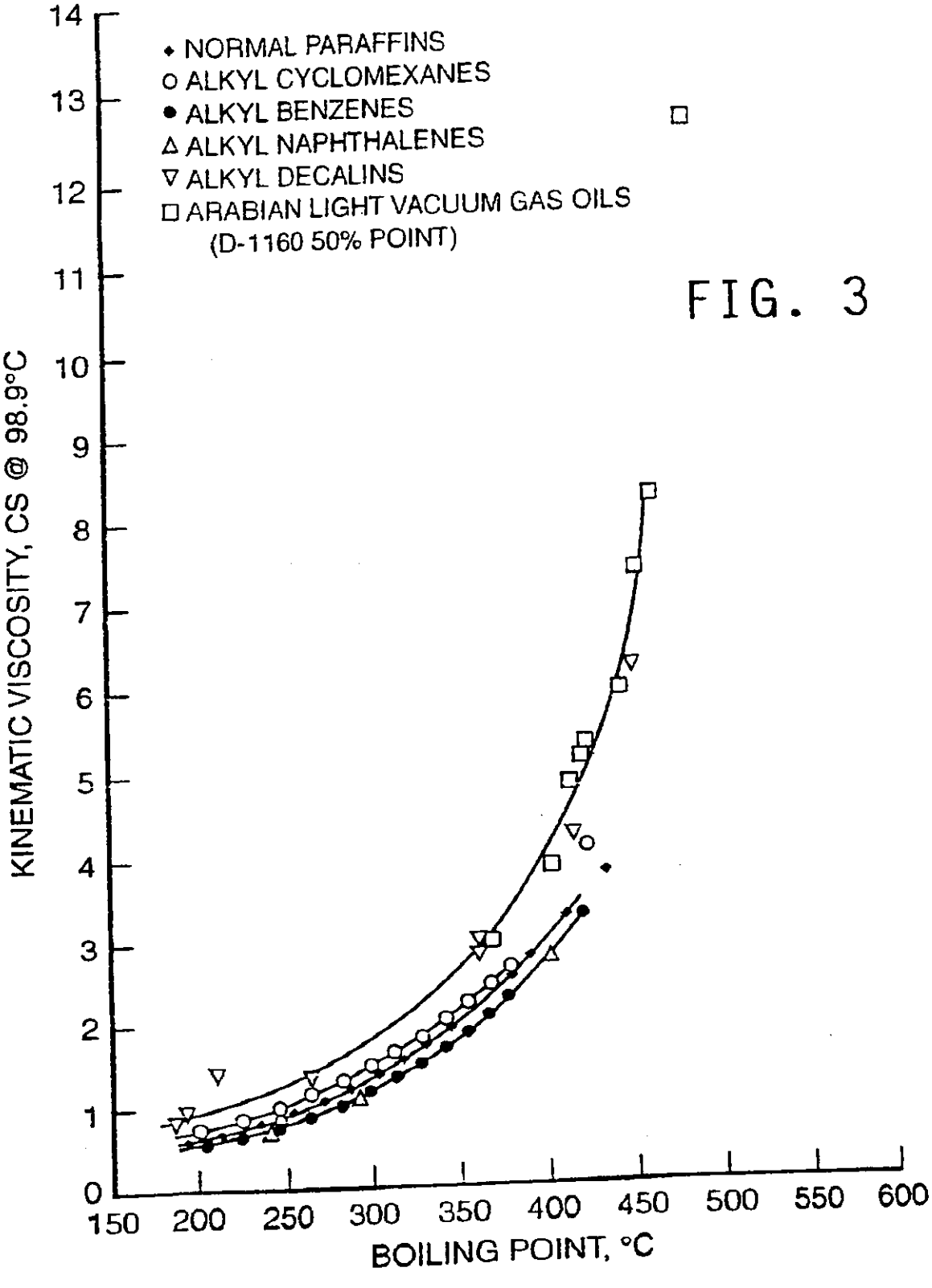
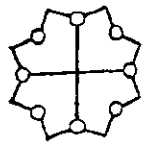
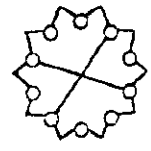
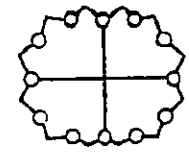
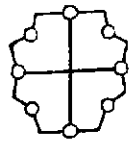
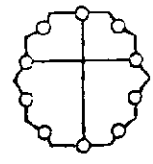
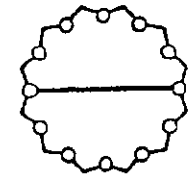
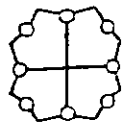
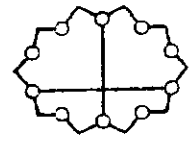
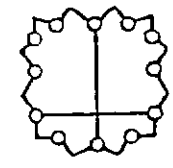
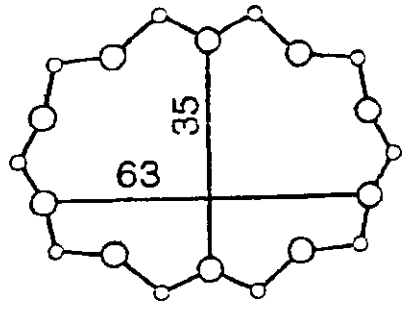

NORMAL PARAFFINS
ALKYL CYCLOMEXANES
ALKYL BENZENES
ALKYL NAPHTHALENES
ALKYL DECALINS
ARABIAN LIGHT VACUUM GAS OILS
(D-1160 50% POINT)
KINEMATIC VISCOSITY, CS @ 98.9°C
BOILING POINT, °C
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
150
200
250
300
350
400
450
500
550
600

FIG. 3

SMALL PORE 8-RING ZEOLITES	MEDIUM PORE 10-RING ZEOLITES	LARGE PORE 12-RING ZEOLITES
 ZEOLITE A	 ZSM-5	 MORDENITE
 ERONITE	 FEMENTE	 FAUASITE
 CHABAZITE	 AIP04-11	 ZEOLITE B



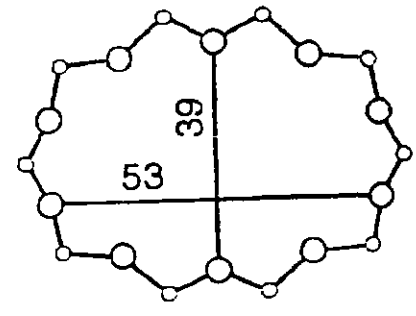


FIG. 4

FIG. 5

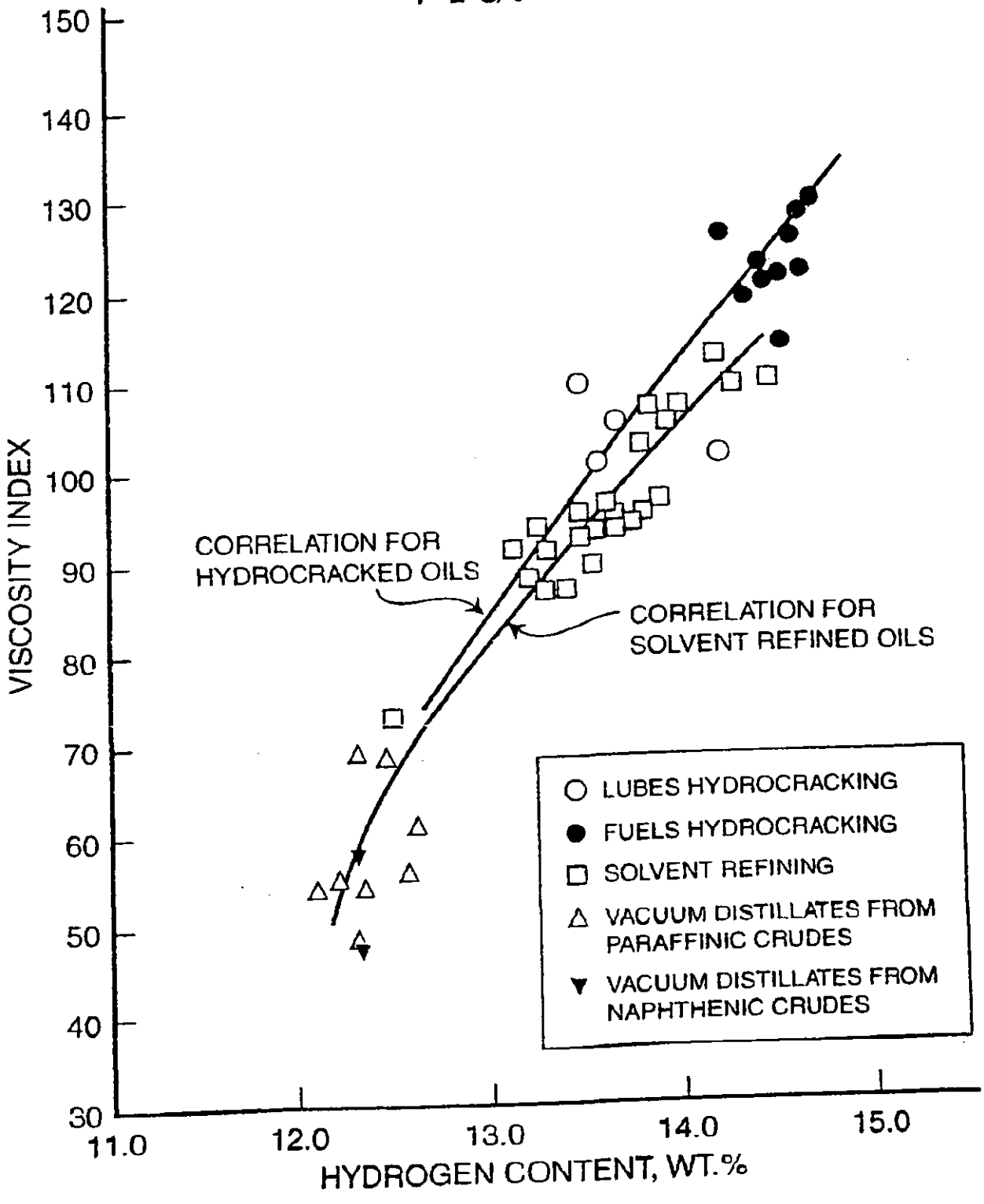

VISCOSITY INDEX
150
140
130
120
110
100
90
80
70
60
50
40
30
11.0
12.0
13.0
14.0
15.0
HYDROGEN CONTENT, WT.%
CORRELATION FOR HYDROCRACKED OILS
CORRELATION FOR SOLVENT REFINED OILS
LUBES HYDROCRACKING
FUELS HYDROCRACKING
SOLVENT REFINING
VACUUM DISTILLATES FROM PARAFFINIC CRUDES
VACUUM DISTILLATES FROM NAPHTHENIC CRUDES

FIG. 6A

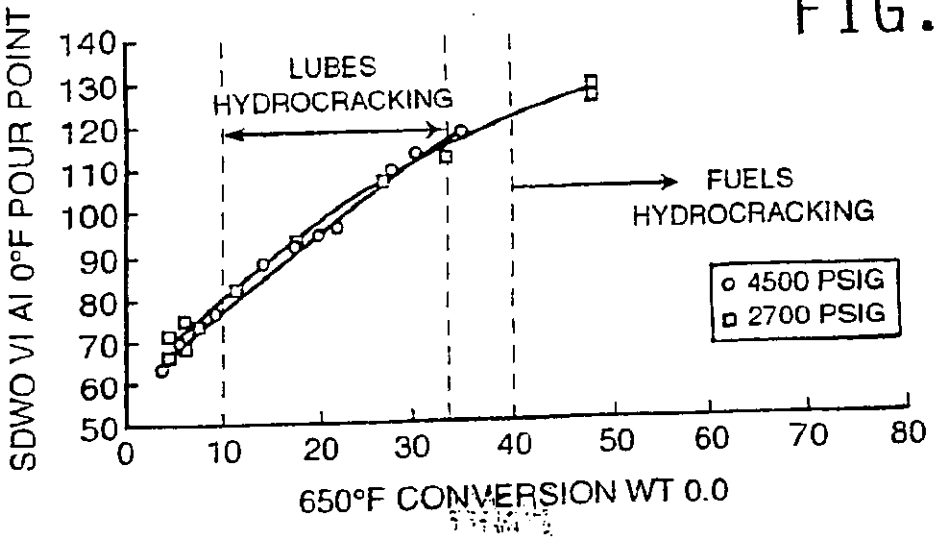


FIG. 6B

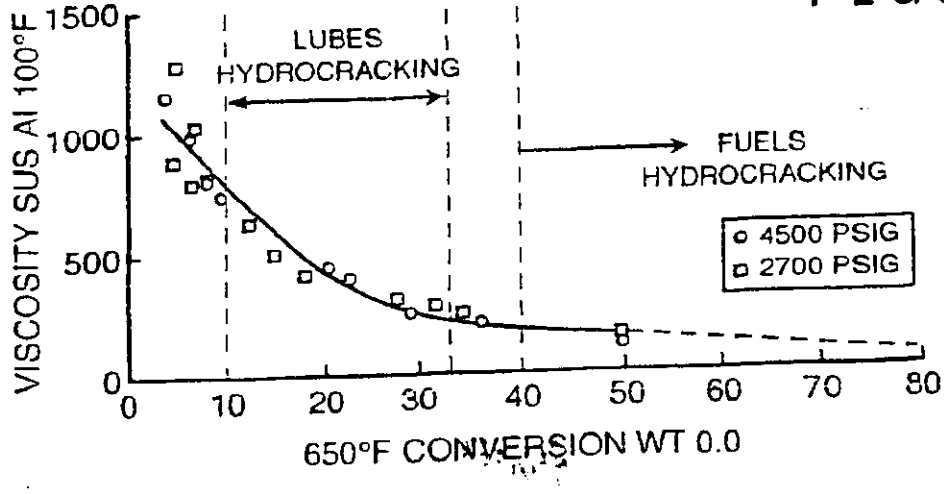
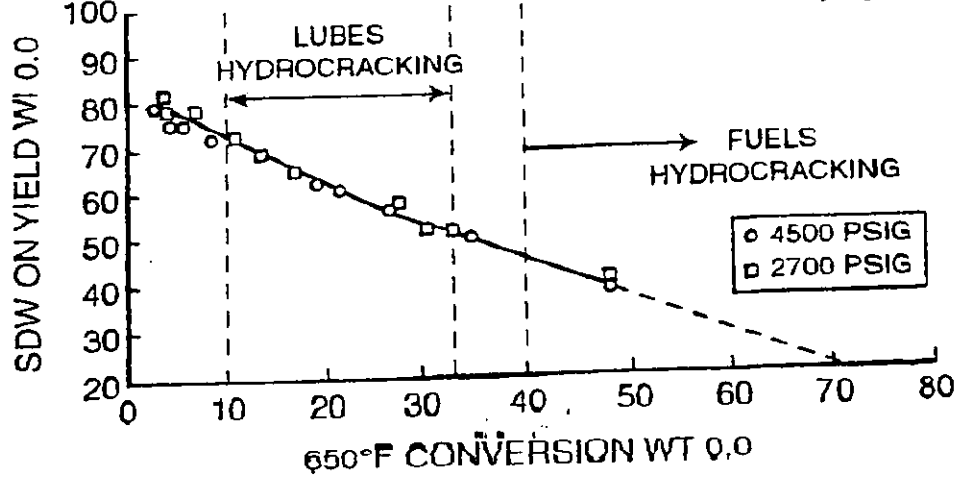


FIG. 6C



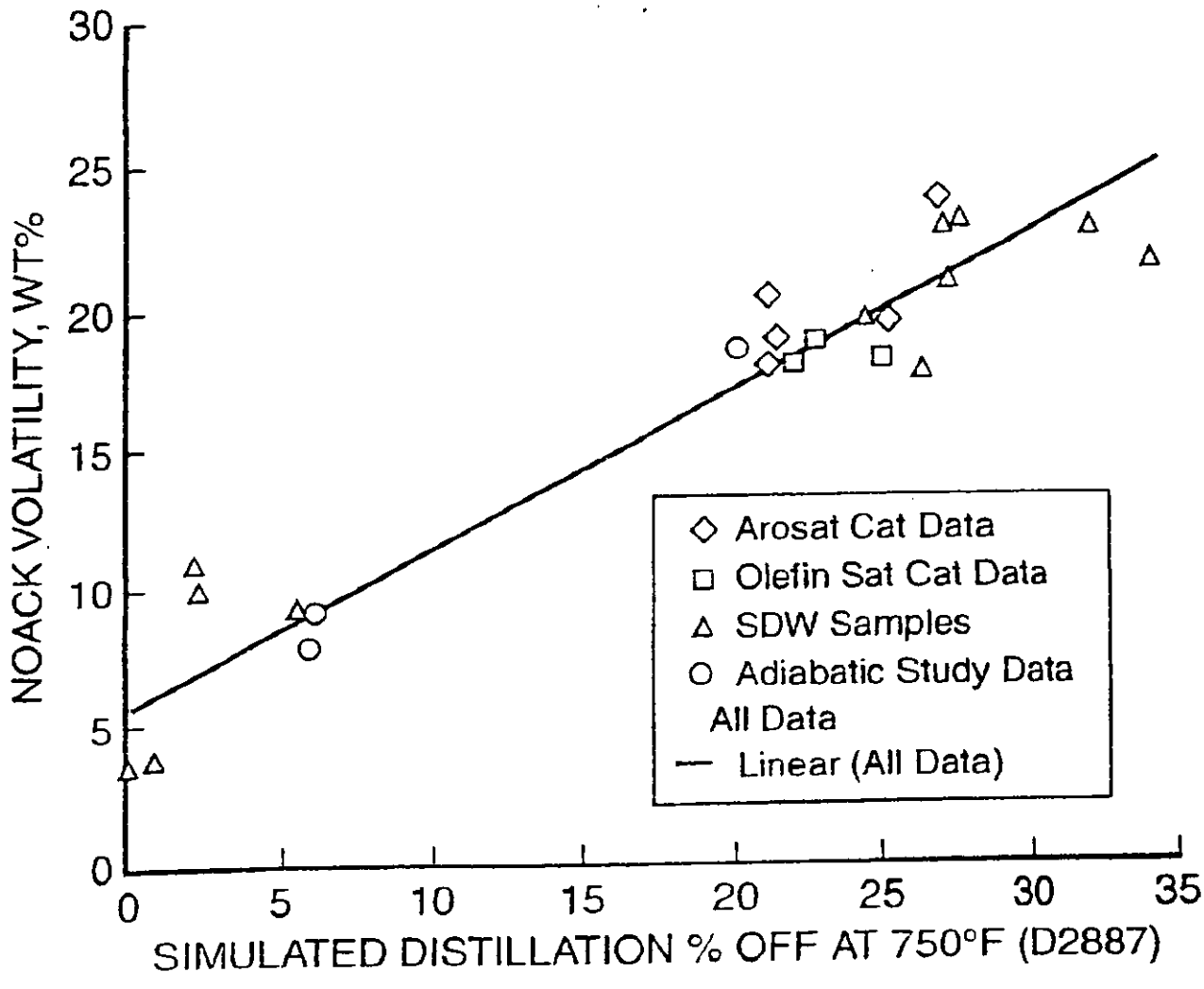

NOACK VOLATILITY, WT%
SIMULATED DISTILLATION % OFF AT 750°F (D2887)
0
5
10
15
20
25
30
35
Arosat Cat Data
Olefin Sat Cat Data
SDW Samples
Adiabatic Study Data
All Data
Linear (All Data)

FIG. 7

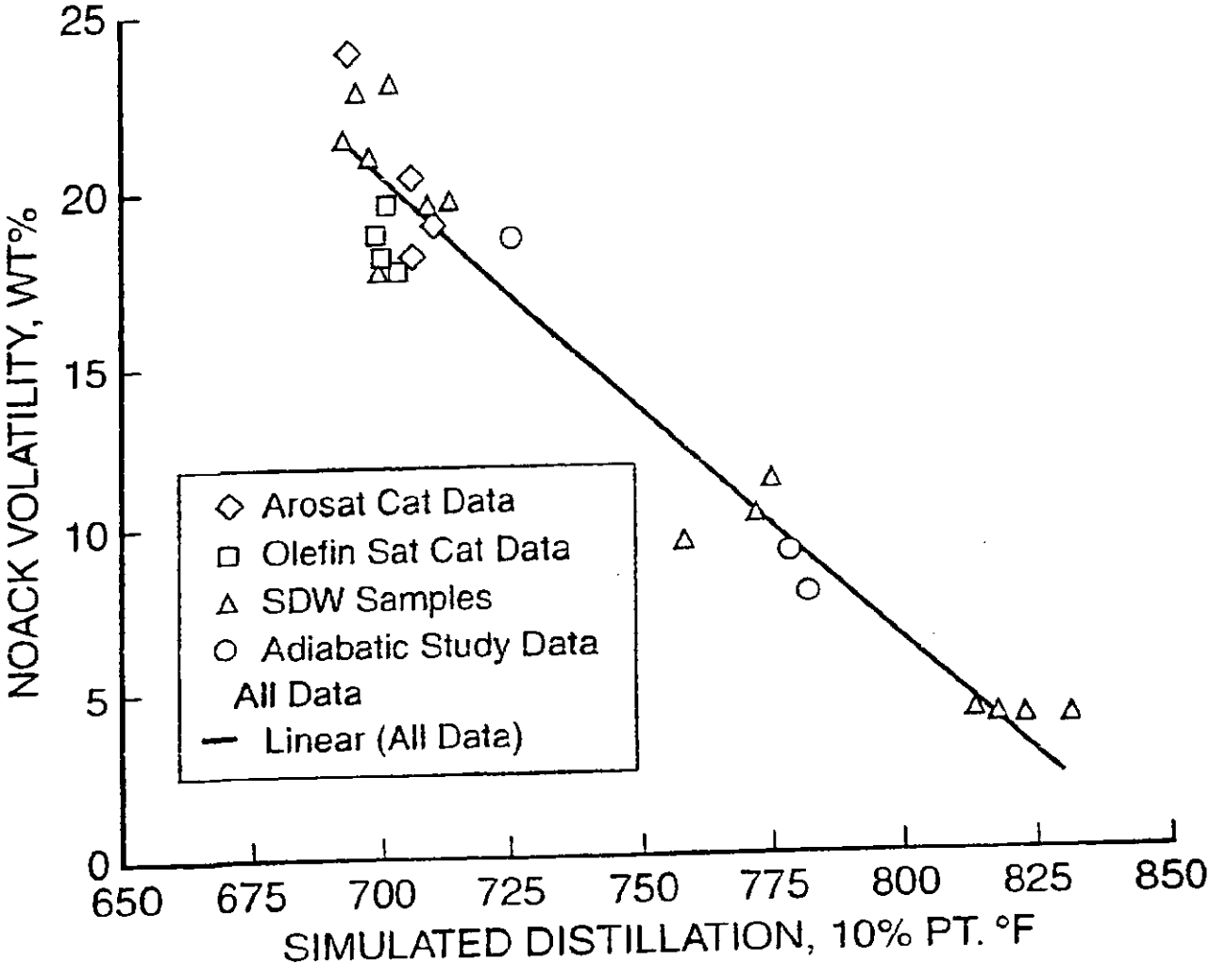

25
20
15
10
5
0
NOACK VOLATILITY, WT%
650
675
700
725
750
775
800
825
850
SIMULATED DISTILLATION, 10% PT. °F
Arosat Cat Data
Olefin Sat Cat Data
SDW Samples
Adiabatic Study Data
All Data
Linear (All Data)

FIG. 8

FIG. 9

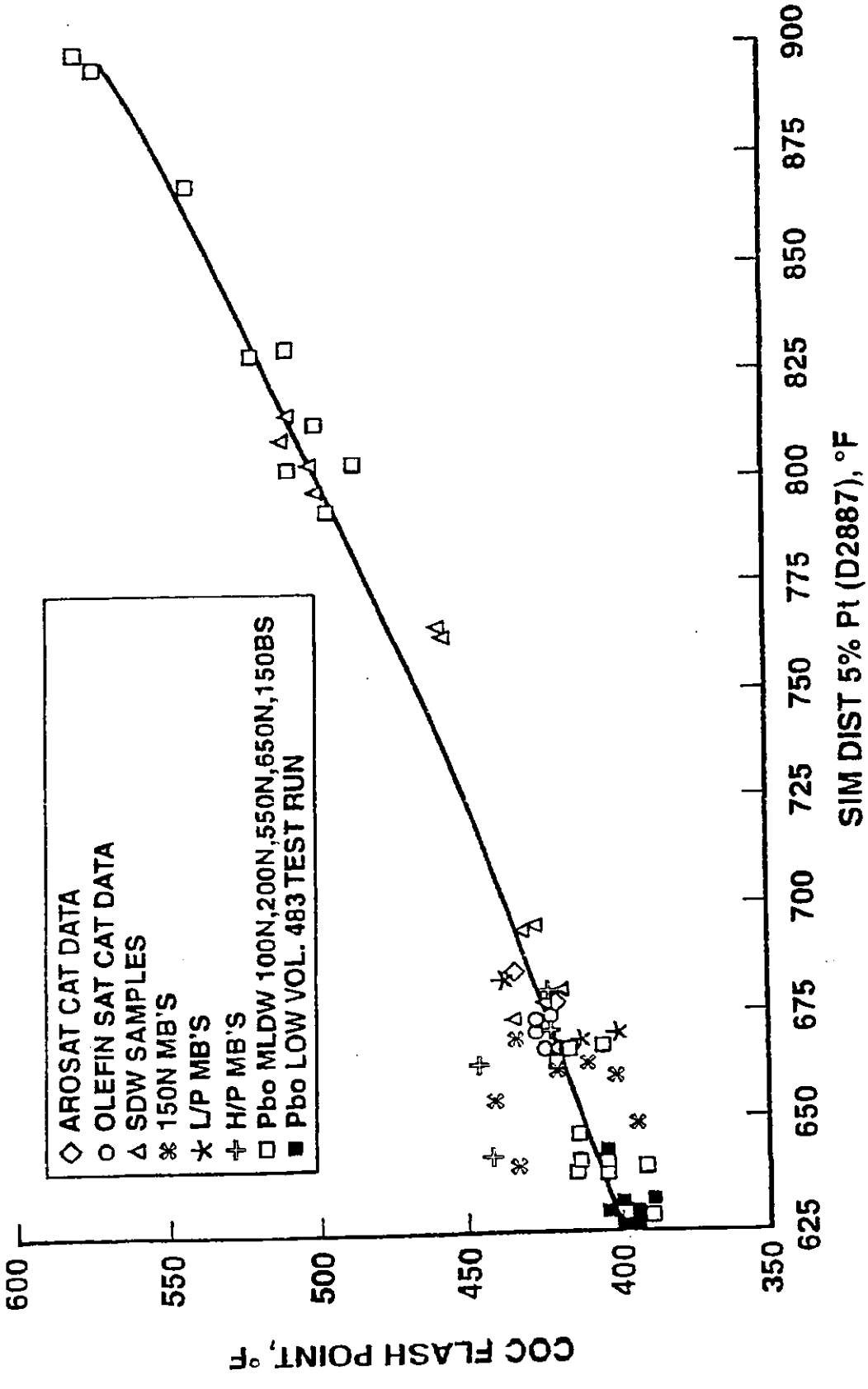

◇ AROSAT CAT DATA
○ OLEFIN SAT CAT DATA
△ SDW SAMPLES
✱ 150N MB'S
✕ L/P MB'S
+ H/P MB'S
□ Pbo MLDW 100N,200N,550N,650N,150BS
■ Pbo LOW VOL. 483 TEST RUN
COC FLASH POINT, °F
600
550
500
450
400
350
SIM DIST 5% Pt (D2887), °F
625
650
675
700
725
750
775
800
825
850
875
900

FIG. 10

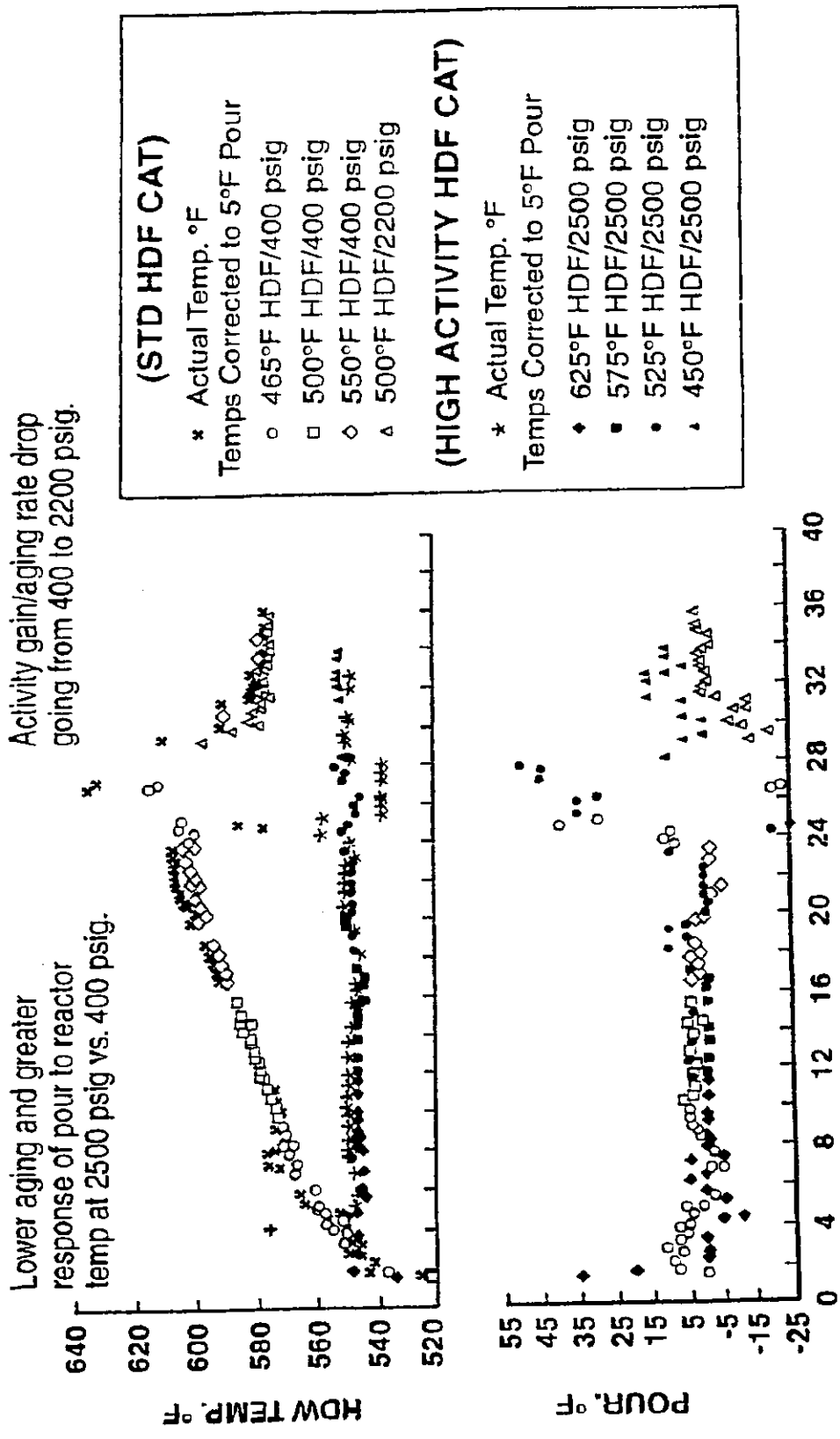
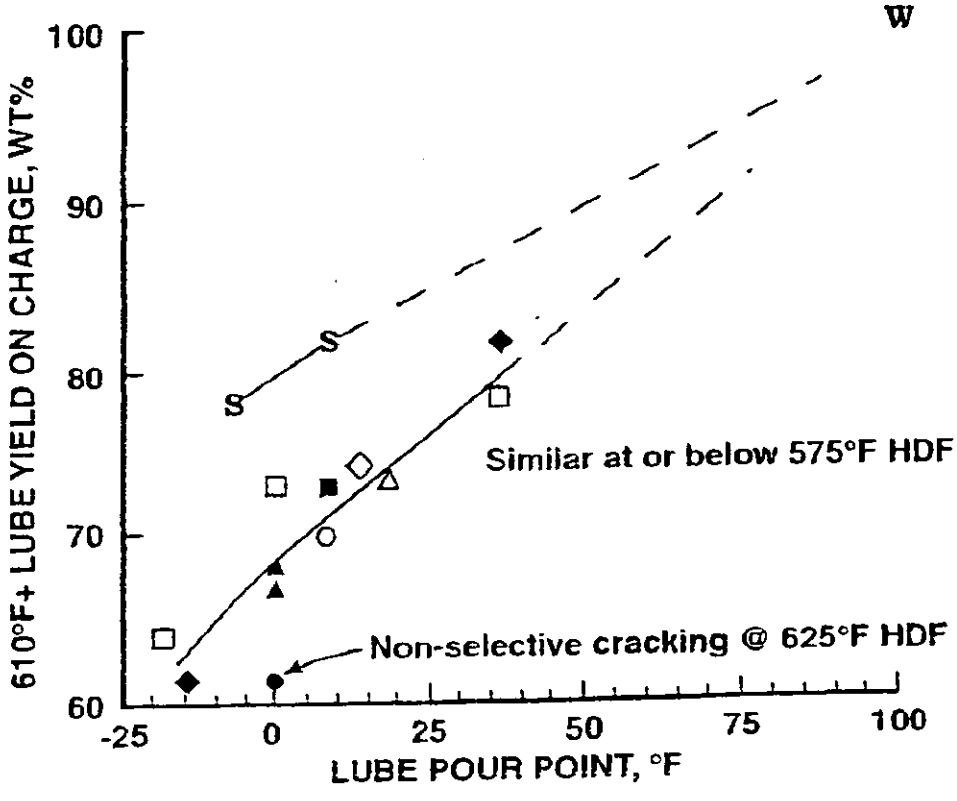
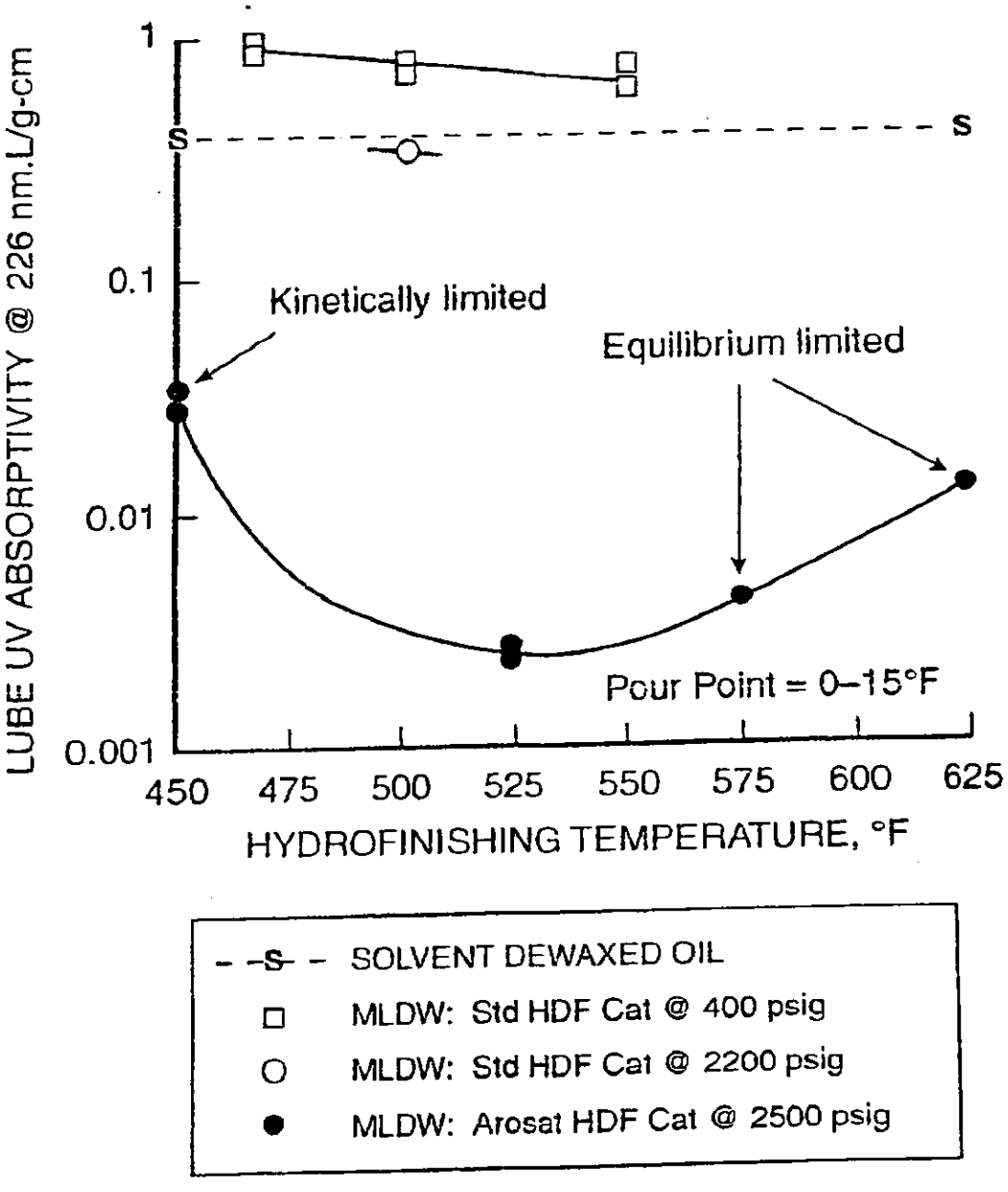

(STD HDF CAT)
* Actual Temp. °F
Temps Corrected to 5°F Pour
○ 465°F HDF/400 psig
□ 500°F HDF/400 psig
◇ 550°F HDF/400 psig
△ 500°F HDF/2200 psig
(HIGH ACTIVITY HDF CAT)
* Actual Temp. °F
Temps Corrected to 5°F Pour
◆ 625°F HDF/2500 psig
■ 575°F HDF/2500 psig
● 525°F HDF/2500 psig
▲ 450°F HDF/2500 psig
Activity gain/aging rate drop going from 400 to 2200 psig.
Lower aging and greater response of pour to reactor temp at 2500 psig vs. 400 psig.
HDW TEMP. °F
640
620
600
580
560
540
520
POUR, °F
55
45
35
25
15
5
-5
-15
-25
0
4
8
12
16
20
24
28
32
36
40
DAYS ON STREAM

FIG. 11



W	WAXY CHARGE
S	SOLVENT DEWAXING (dry wax basis)
	MLDW: Std HDF Cat @ 400 psig
□	465°F HDF
◇	500°F HDF
△	550°F HDF
	MLDW: Std HDF Cat @ 2200 psig
○	500°F HDF
	MLDW: Arosat HDF Cat @ 2500 psig
■	450°F HDF
◆	525°F HDF
▲	575°F HDF
●	625°F HDF

FIG. 12


LUBE UV ABSORPTIVITY @ 226 nm.L/g-cm
1
0.1
0.01
0.001
S
S
Kinetically limited
Equilibrium limited
Pour Point = 0–15°F
450
475
500
525
550
575
600
625
HYDROFINISHING TEMPERATURE, °F
SOLVENT DEWAXED OIL
MLDW: Std HDF Cat @ 400 psig
MLDW: Std HDF Cat @ 2200 psig
MLDW: Arosat HDF Cat @ 2500 psig

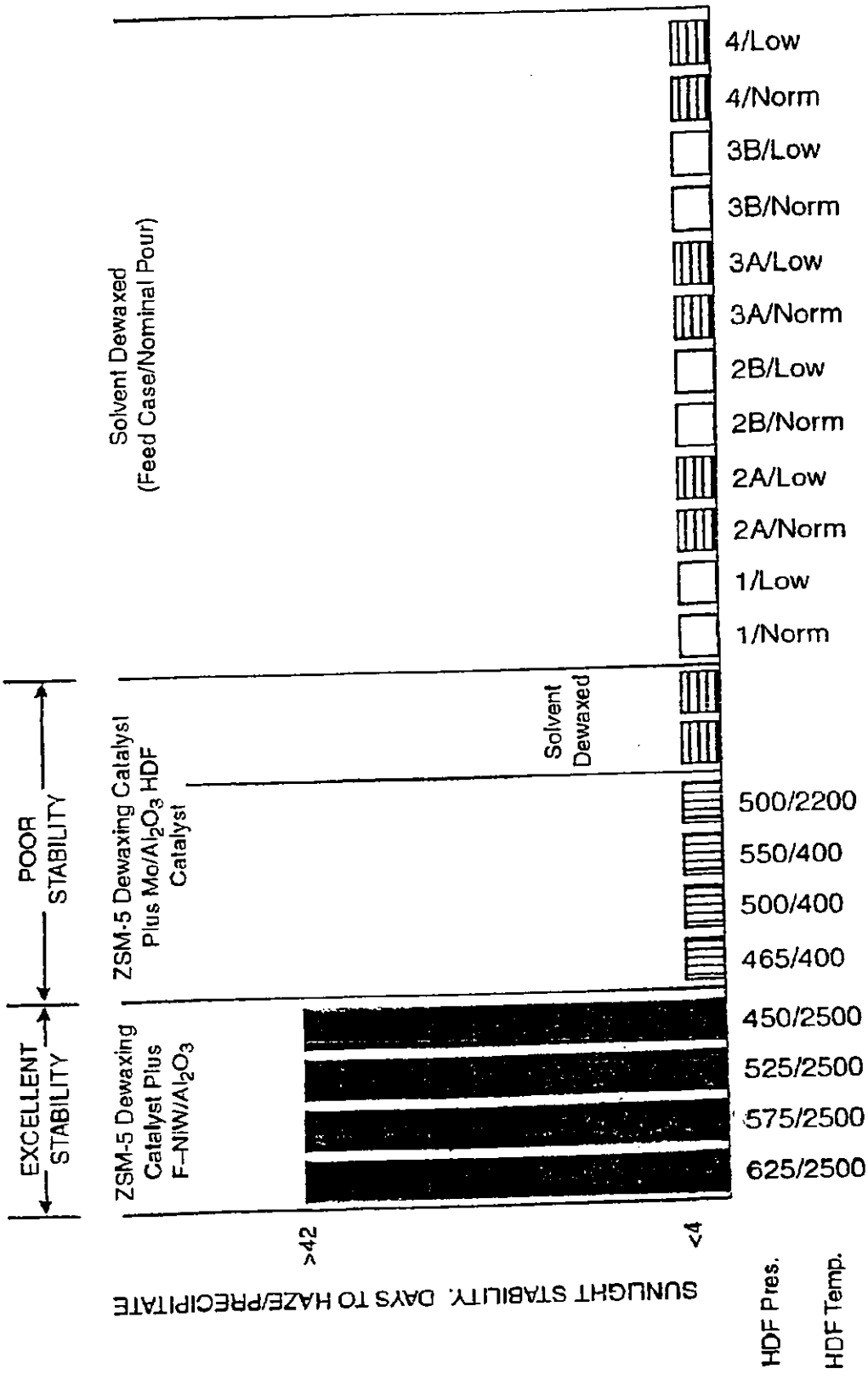

SUNLIGHT STABILITY, DAYS TO HAZE/PRECIPITATE
>42
<4
HDF Pres.
HDF Temp.
EXCELLENT STABILITY
POOR STABILITY
ZSM-5 Dewaxing Catalyst Plus F–NiW/Al2O3
ZSM-5 Dewaxing Catalyst Plus Mo/Al2O3 HDF Catalyst
Solvent Dewaxed
Solvent Dewaxed (Feed Case/Nominal Pour)
450/2500
525/2500
575/2500
625/2500
500/2200
550/400
500/400
465/400
4/Low
4/Norm
3B/Low
3B/Norm
3A/Low
3A/Norm
2B/Low
2B/Norm
2A/Low
2A/Norm
1/Low
1/Norm

FIG. 13

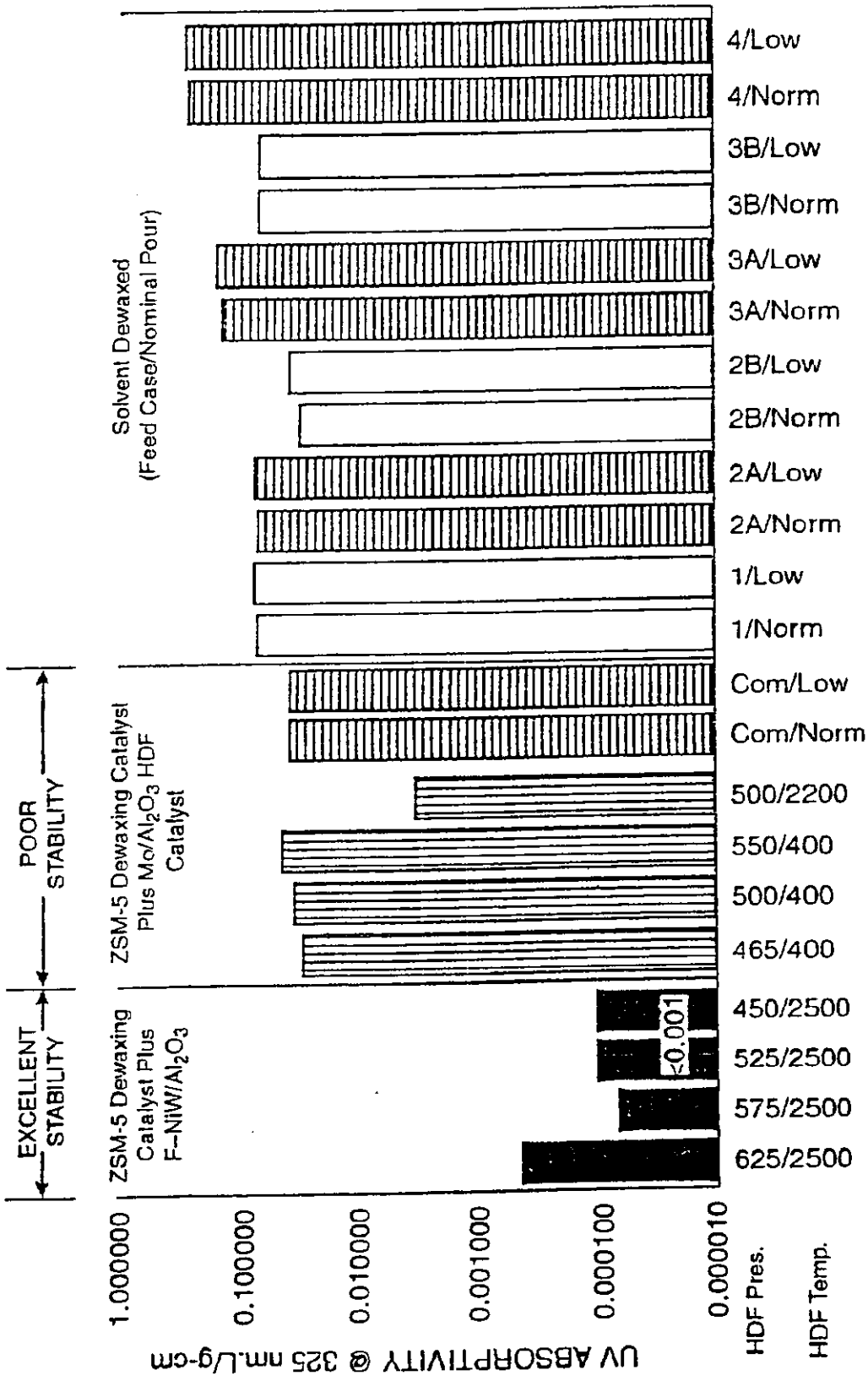

UV ABSORPTIVITY @ 325 nm.L/g-cm
1.000000
0.100000
0.010000
0.001000
0.000100
0.000010
HDF Pres.
HDF Temp.
EXCELLENT STABILITY
POOR STABILITY
ZSM-5 Dewaxing Catalyst Plus F-NiW/Al2O3
ZSM-5 Dewaxing Catalyst Plus Mo/Al2O3 HDF Catalyst
Solvent Dewaxed (Feed Case/Nominal Pour)
<0.001
450/2500
525/2500
575/2500
625/2500
500/400
465/400
550/400
500/2200
Com/Low
Com/Norm
1/Low
1/Norm
2A/Low
2A/Norm
2B/Low
2B/Norm
3A/Low
3A/Norm
3B/Low
3B/Norm
4/Low
4/Norm

FIG. 14

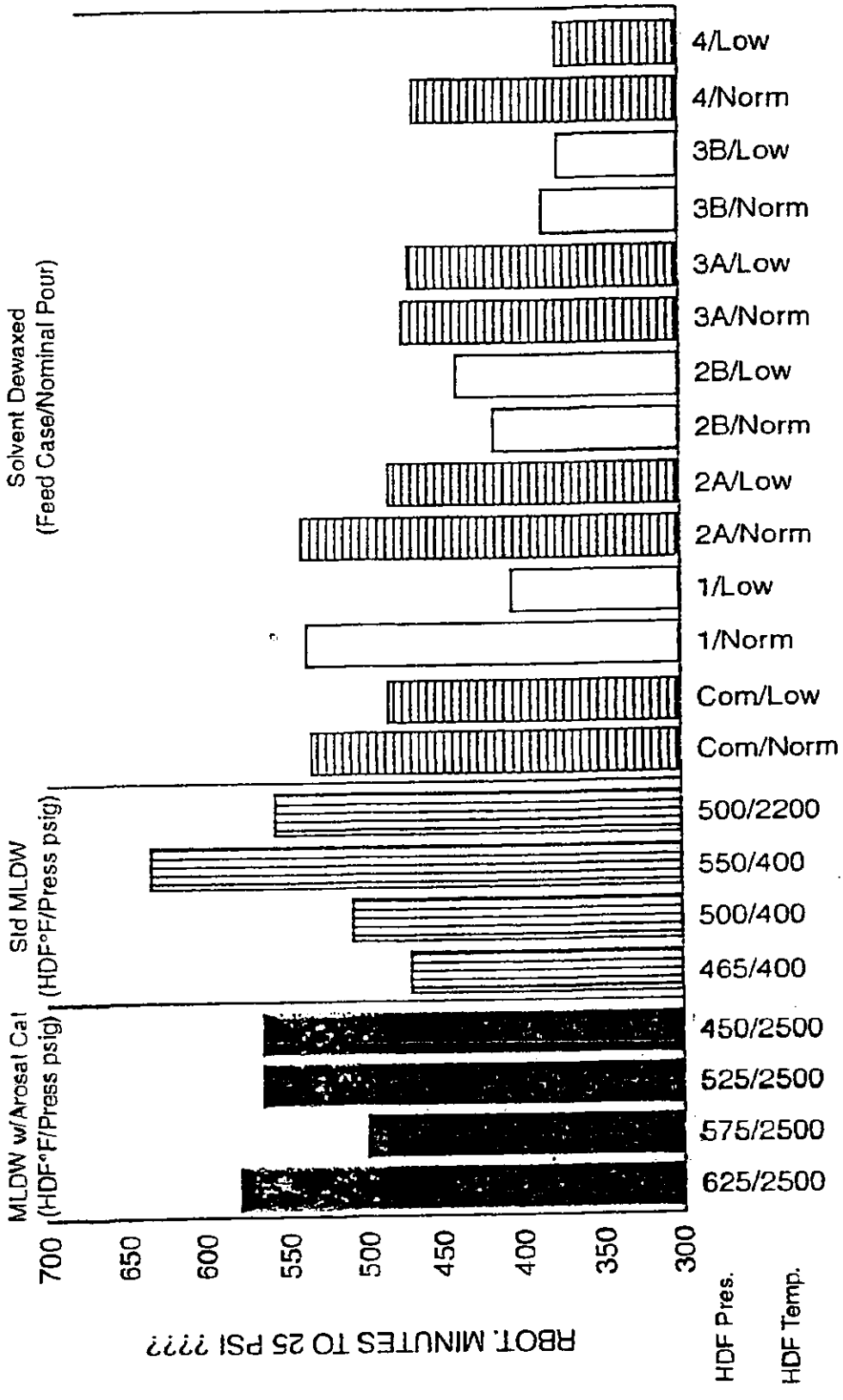

Solvent Dewaxed
(Feed Case/Nominal Pour)
Sld MLDW
(HDF°F/Press psig)
MLDW w/Arosal Cat
(HDF°F/Press psig)
4/Low
4/Norm
3B/Low
3B/Norm
3A/Low
3A/Norm
2B/Low
2B/Norm
2A/Low
2A/Norm
1/Low
1/Norm
Com/Low
Com/Norm
500/2200
550/400
500/400
465/400
450/2500
525/2500
575/2500
625/2500
700
650
600
550
500
450
400
350
300
RBOT MINUTES TO 25 PSI ????
HDF Pres.
HDF Temp.

FIG. 15

FIG. 16

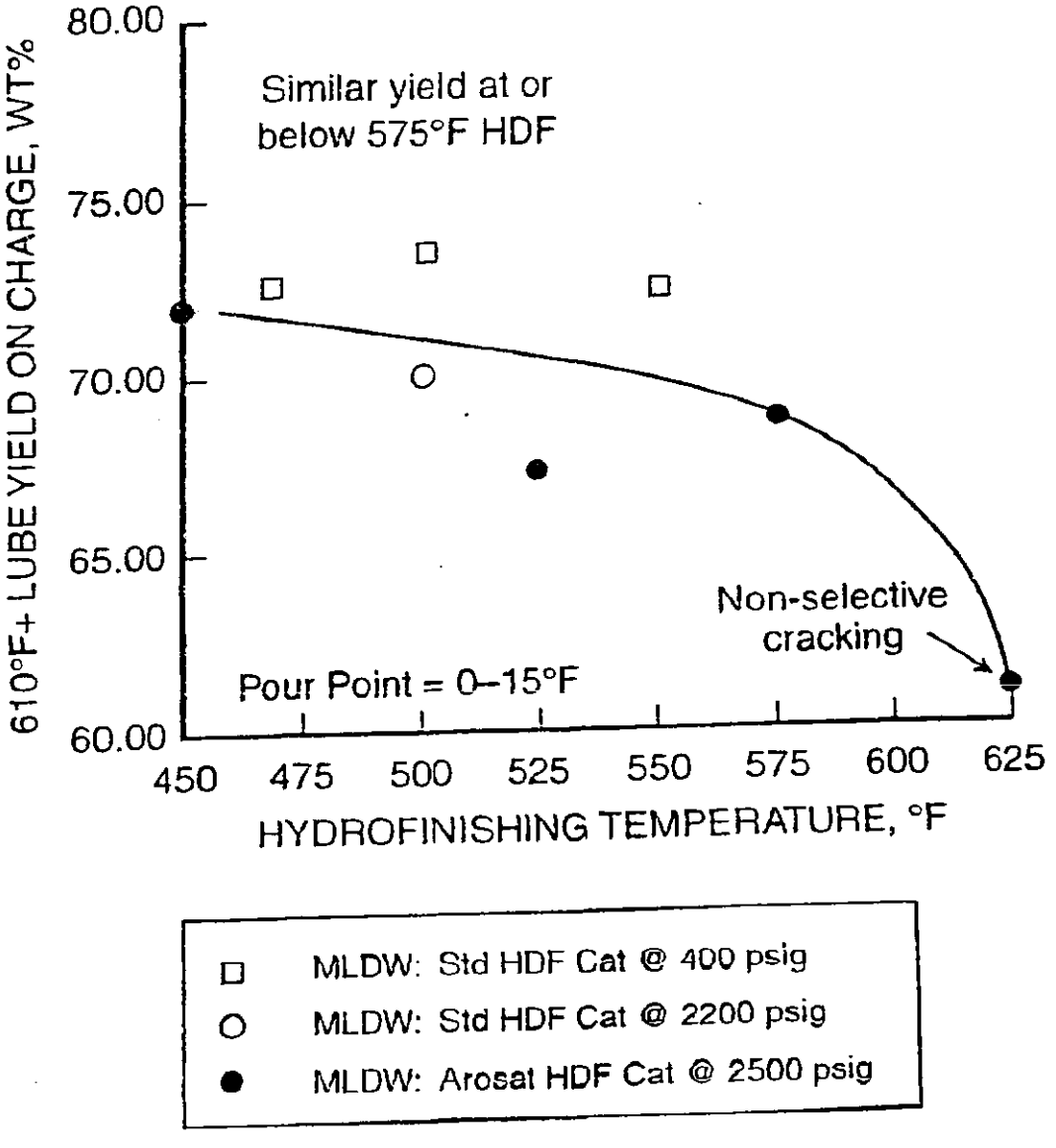

80.00
75.00
70.00
65.00
60.00
610°F+ LUBE YIELD ON CHARGE, WT%
Similar yield at or below 575°F HDF
Non-selective cracking
Pour Point = 0–15°F
450
475
500
525
550
575
600
625
HYDROFINISHING TEMPERATURE, °F
MLDW: Std HDF Cat @ 400 psig
MLDW: Std HDF Cat @ 2200 psig
MLDW: Arosat HDF Cat @ 2500 psig

FIG. 17

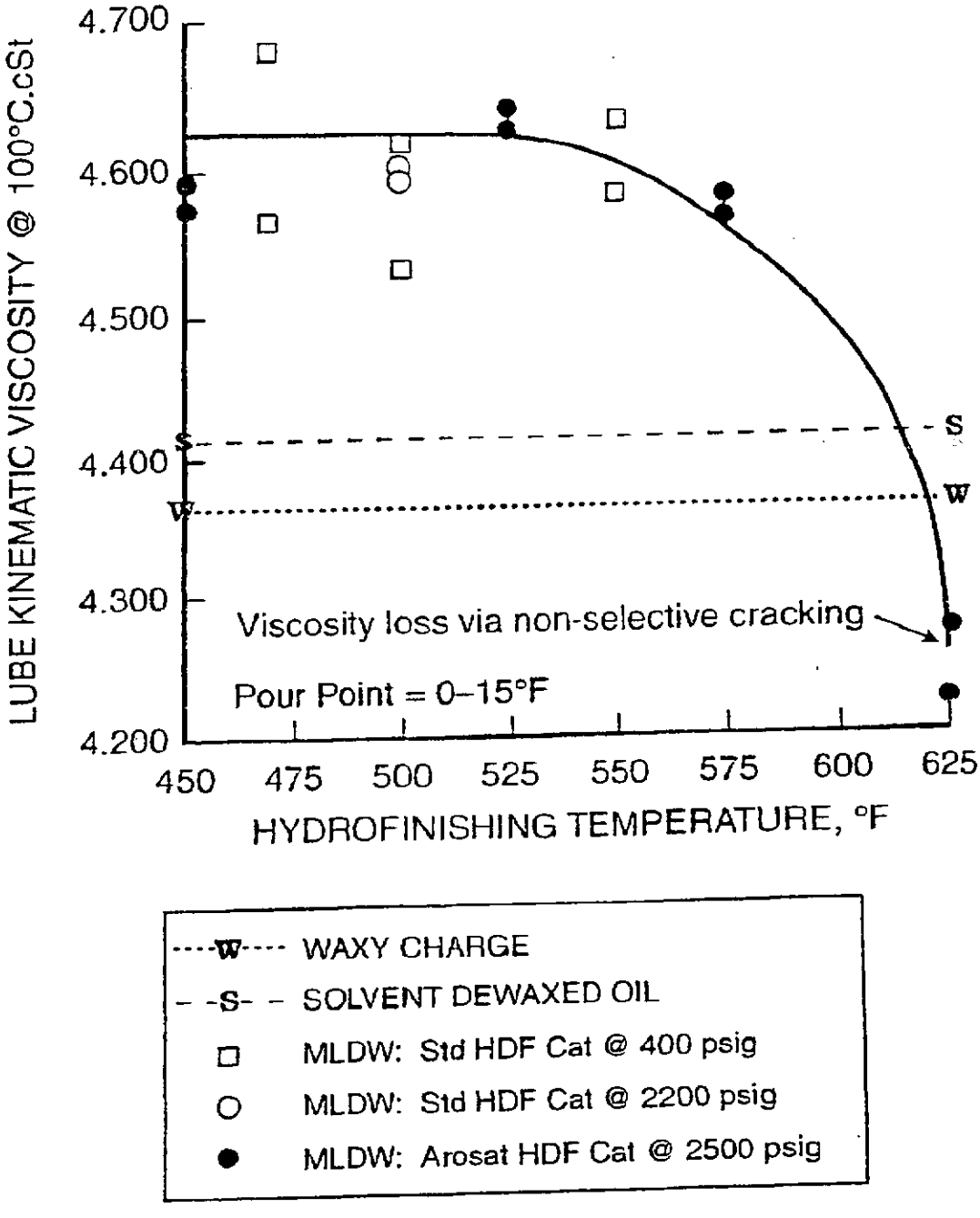
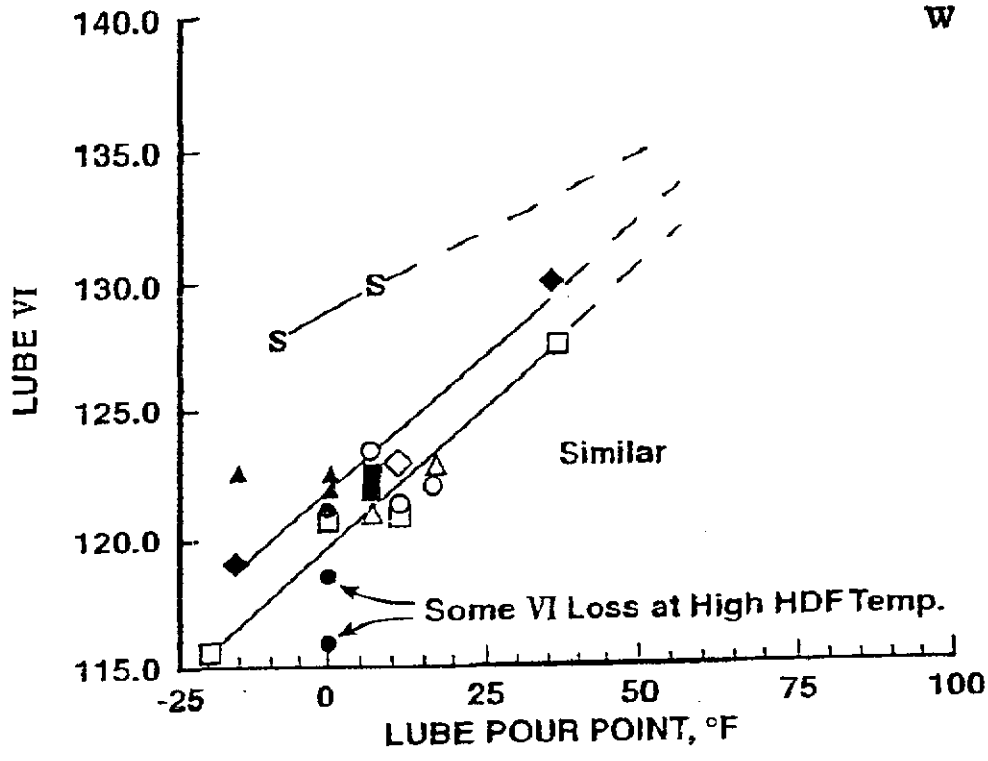
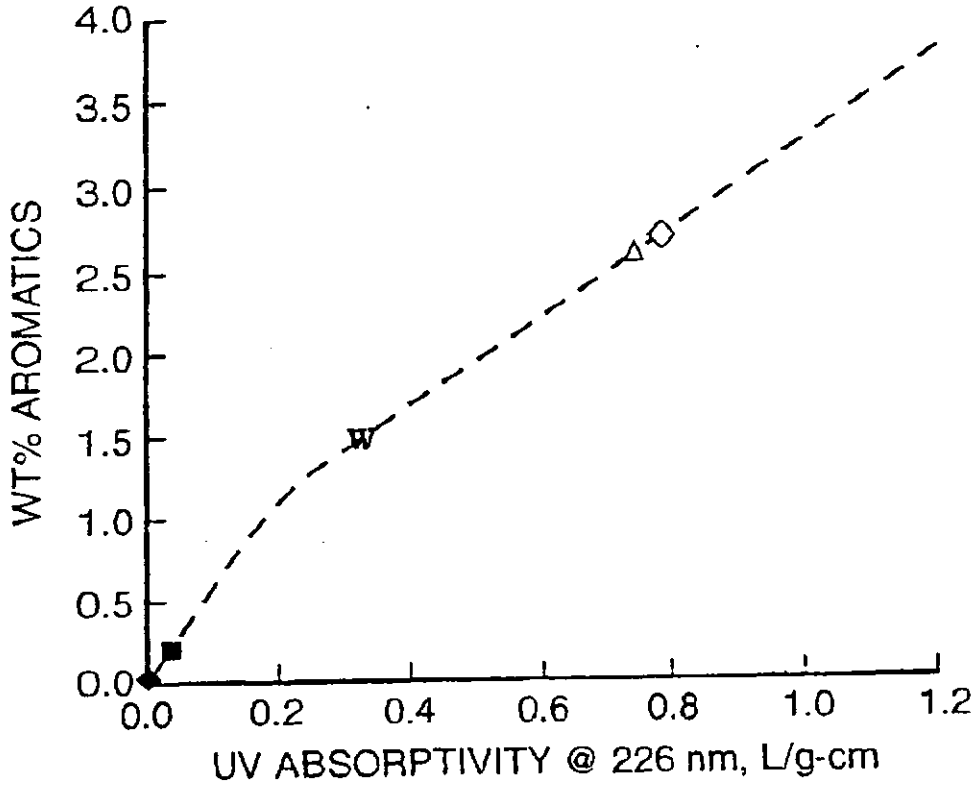

LUBE KINEMATIC VISCOSITY @ 100°C.cSt
4.700
4.600
4.500
4.400
4.300
4.200
S
W
Viscosity loss via non-selective cracking
Pour Point = 0–15°F
450
475
500
525
550
575
600
625
HYDROFINISHING TEMPERATURE, °F
W WAXY CHARGE
S SOLVENT DEWAXED OIL
MLDW: Std HDF Cat @ 400 psig
MLDW: Std HDF Cat @ 2200 psig
MLDW: Arosat HDF Cat @ 2500 psig

FIG. 18



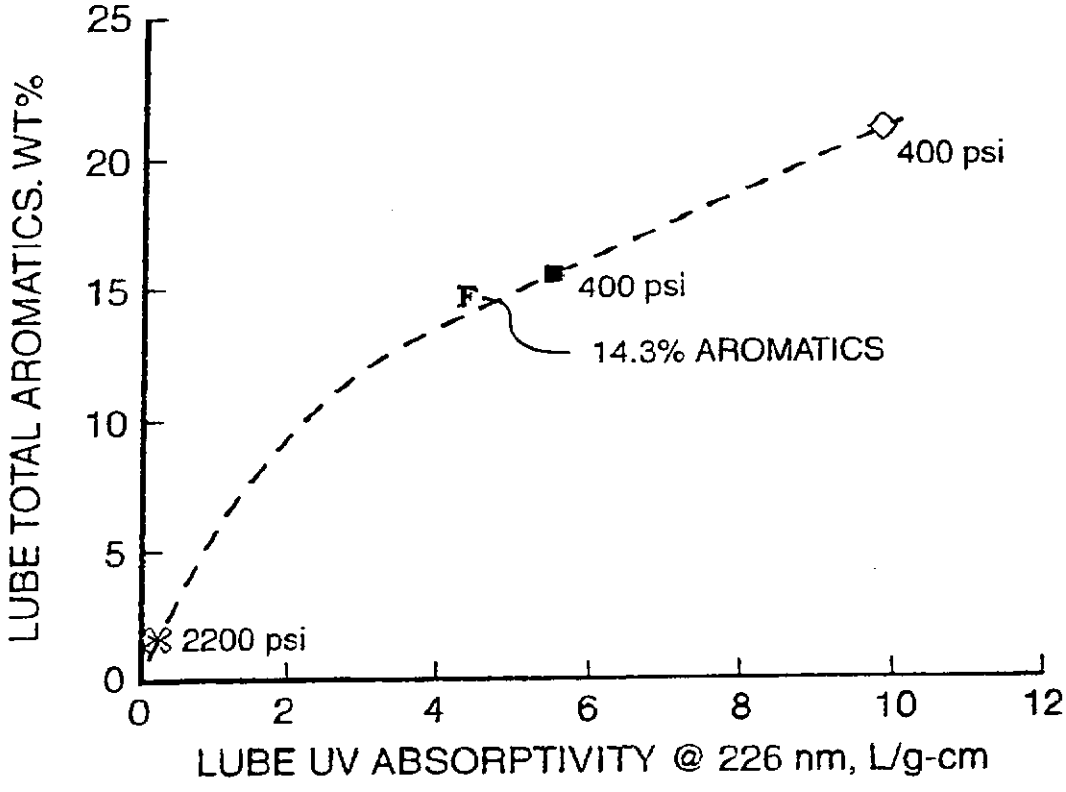
W	WAXY CHARGE
S	SOLVENT DEWAXED OIL
	MLDW: Std HDF Cat @ 400 psig
□	465°F HDF
◇	500°F HDF
△	550°F HDF
	MLDW: Std HDF Cat @ 2200 psig
○	500°F HDF
	MLDW: Arosat HDF Cat @ 2500 psig
■	450°F HDF
◆	525°F HDF
▲	575°F HDF
●	625°F HDF

FIG. 19



Total aromatics determined using
HPLC separation with high sensitivity
light scattering mass detector

FIG. 20



	LHSV	0.2% Pt/ ZSM-23°C	0.2% Pt/ ZSM-23°C	0.2% Pt/ ZSM-23°C
■	1	317	218	28.1
※	1	328	218	154.7
◇	1	334	218	28.1

F Waxy Feed

– – – Correlation

UV Absorptivity @ 226 nm can be correlated with Total Aromatics Content for a given family of hydrofinished lub stocks. It is especially useful at very low aromatics where the repeatability of aromatics analysis becomes poor.

FIG. 21

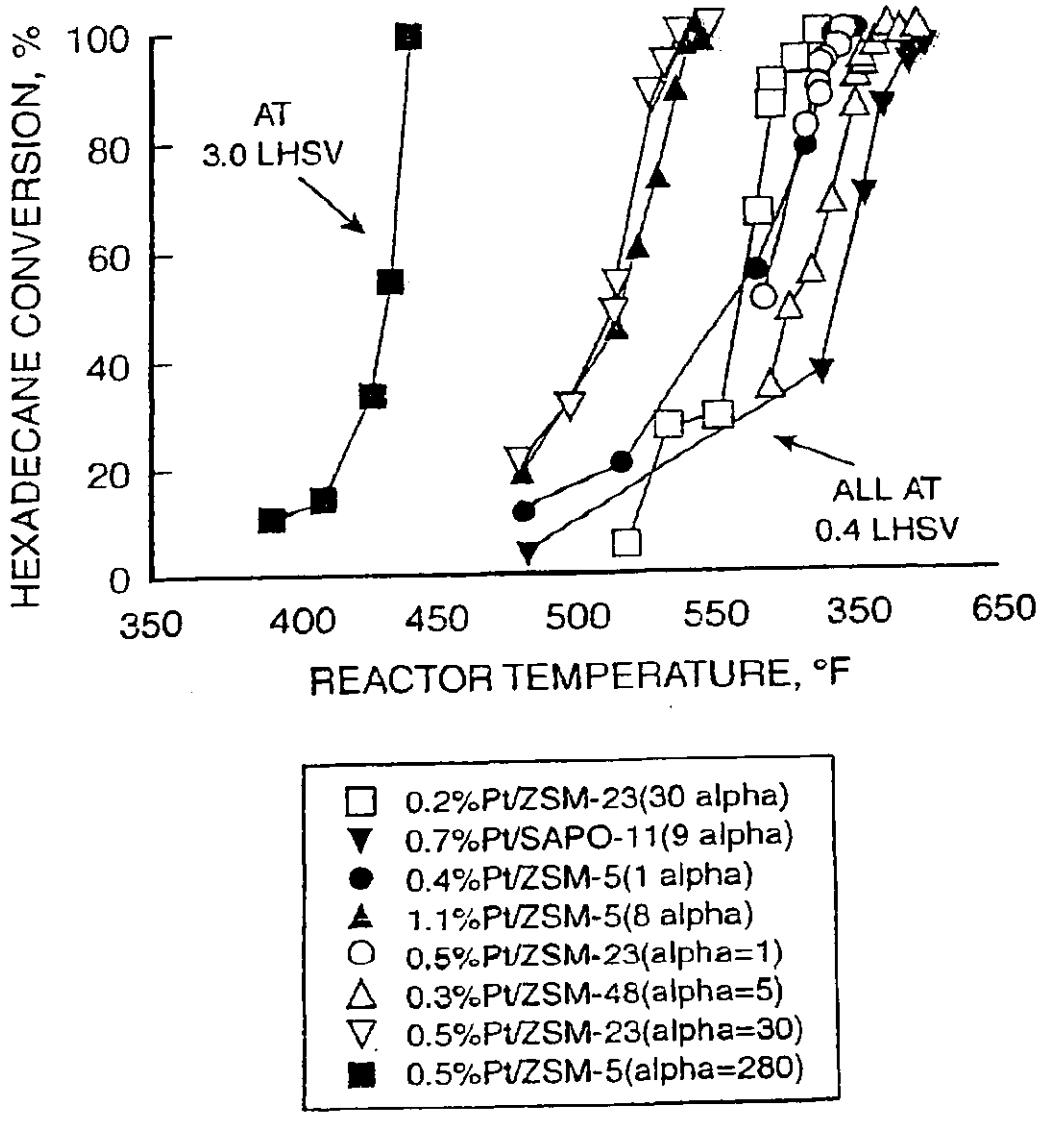

HEXADECANE CONVERSION, %
100
80
60
40
20
0
AT
3.0 LHSV
ALL AT
0.4 LHSV
350
400
450
500
550
350
650
REACTOR TEMPERATURE, °F
0.2%Pt/ZSM-23(30 alpha)
0.7%Pt/SAPO-11(9 alpha)
0.4%Pt/ZSM-5(1 alpha)
1.1%Pt/ZSM-5(8 alpha)
0.5%Pt/ZSM-23(alpha=1)
0.3%Pt/ZSM-48(alpha=5)
0.5%Pt/ZSM-23(alpha=30)
0.5%Pt/ZSM-5(alpha=280)

FIG. 22

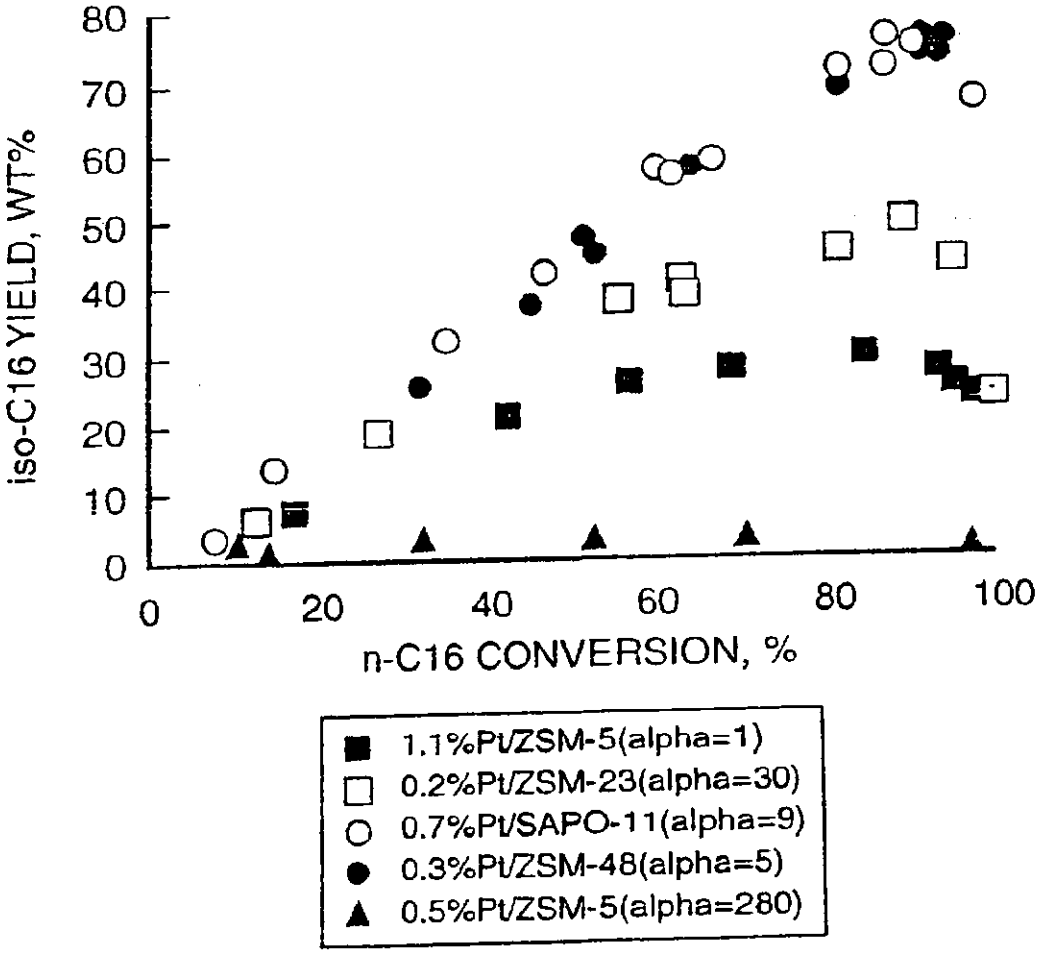

iso-C16 YIELD, WT%
0
10
20
30
40
50
60
70
80
0
20
40
60
80
100
n-C16 CONVERSION, %
1.1%Pt/ZSM-5(alpha=1)
0.2%Pt/ZSM-23(alpha=30)
0.7%Pt/SAPO-11(alpha=9)
0.3%Pt/ZSM-48(alpha=5)
0.5%Pt/ZSM-5(alpha=280)

FIG. 23

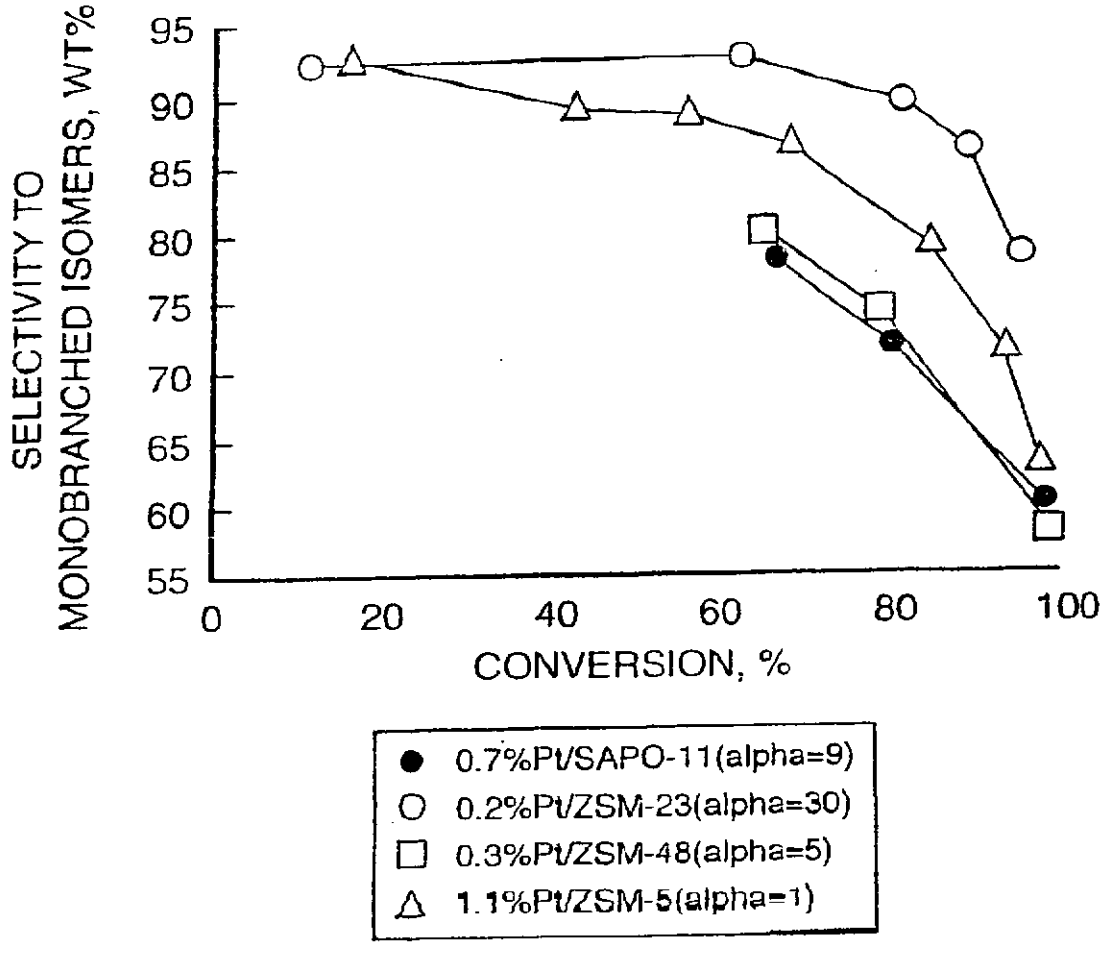
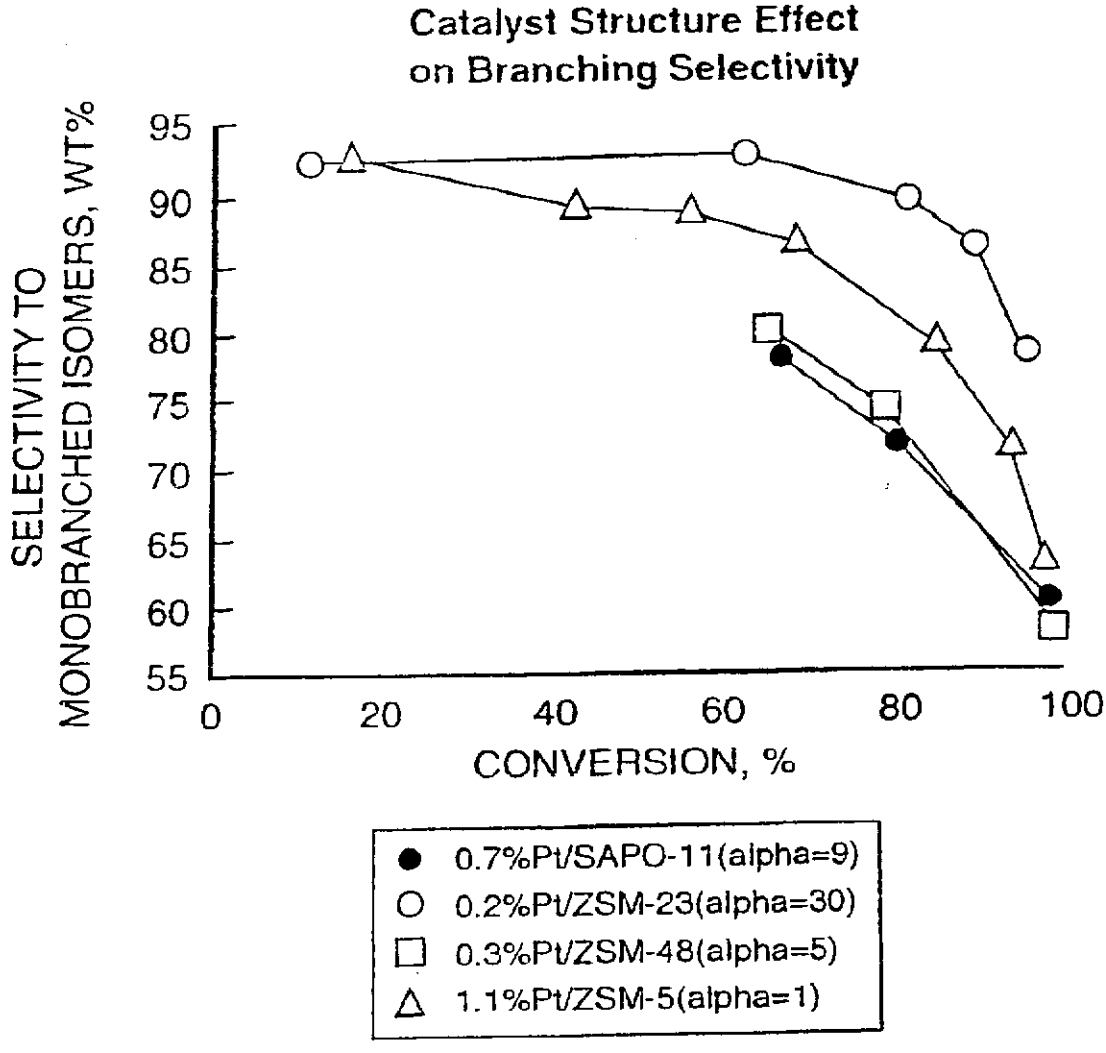

SELECTIVITY TO MONOBRANCHED ISOMERS, WT%
95
90
85
80
75
70
65
60
55
0
20
40
60
80
100
CONVERSION, %
0.7%Pt/SAPO-11(alpha=9)
0.2%Pt/ZSM-23(alpha=30)
0.3%Pt/ZSM-48(alpha=5)
1.1%Pt/ZSM-5(alpha=1)

FIG. 24


Catalyst Structure Effect
on Branching Selectivity
SELECTIVITY TO
MONOBRANCHED ISOMERS, WT%
95
90
85
80
75
70
65
60
55
0
20
40
60
80
100
CONVERSION, %
0.7%Pt/SAPO-11(alpha=9)
0.2%Pt/ZSM-23(alpha=30)
0.3%Pt/ZSM-48(alpha=5)
1.1%Pt/ZSM-5(alpha=1)