

FIG. 1

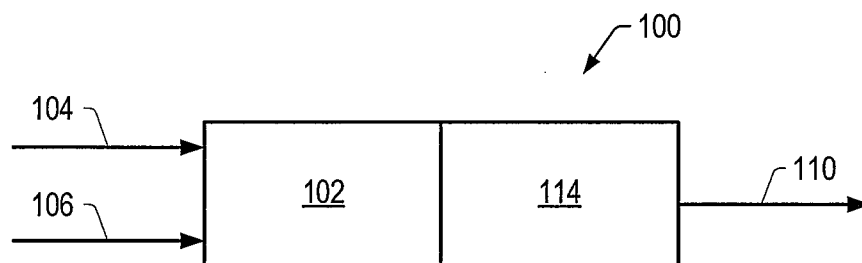


FIG. 2A

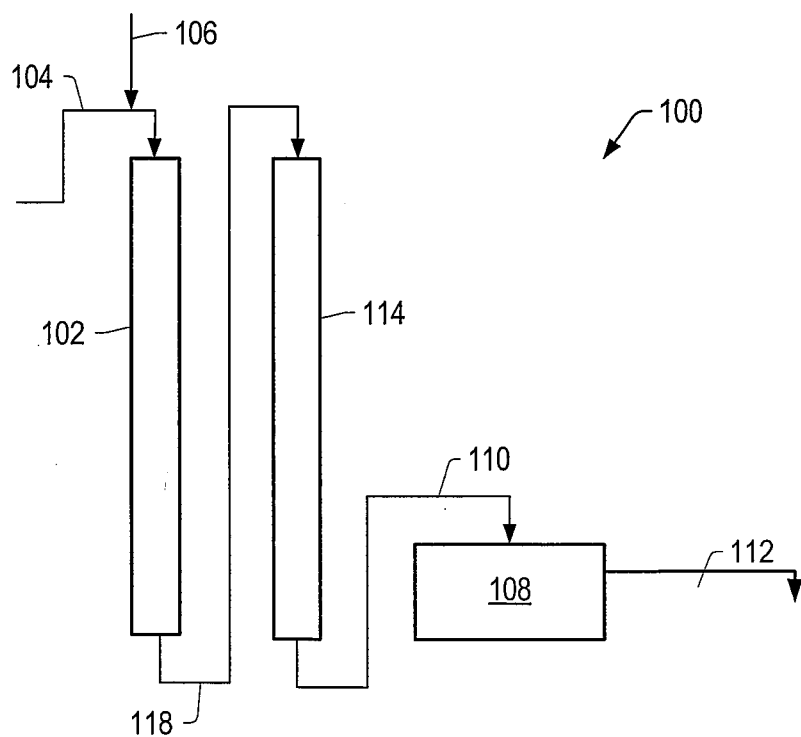


FIG. 2B

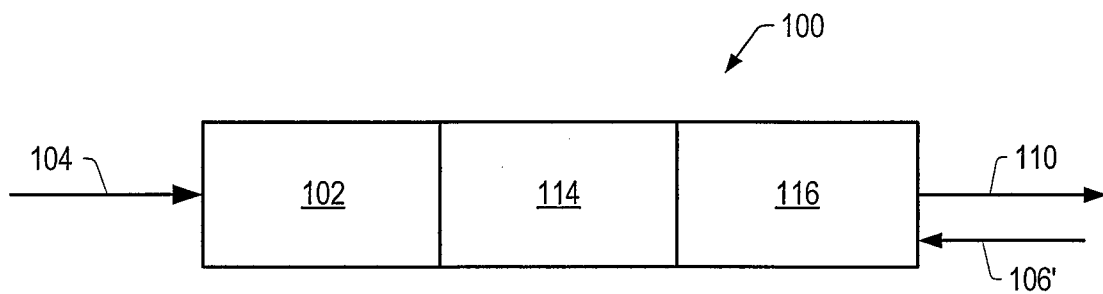


FIG. 3A

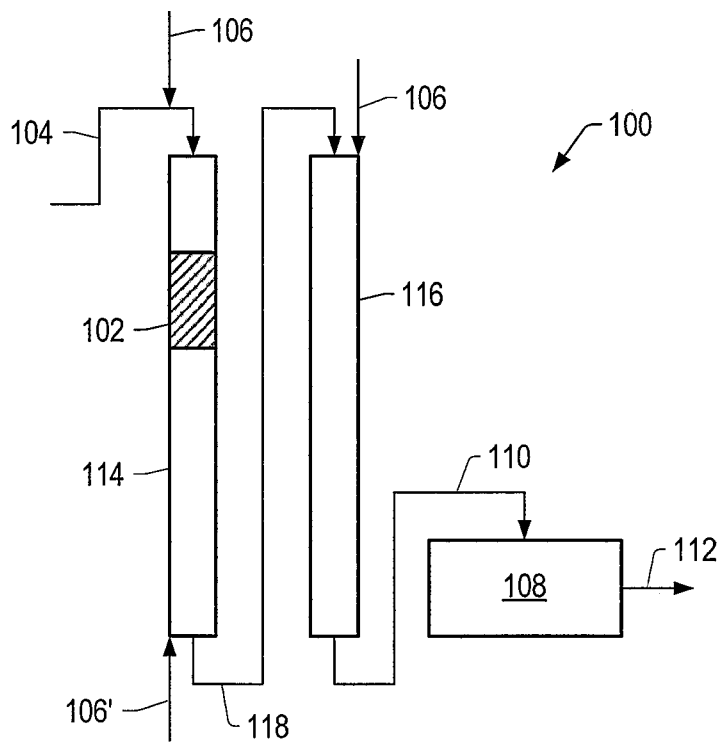


FIG. 3B

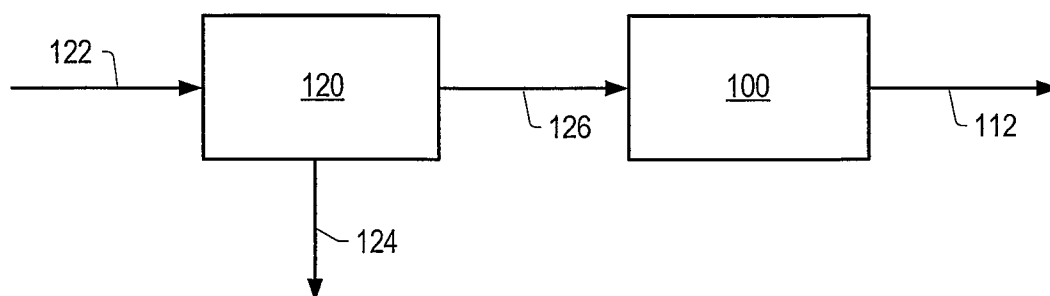


FIG. 4

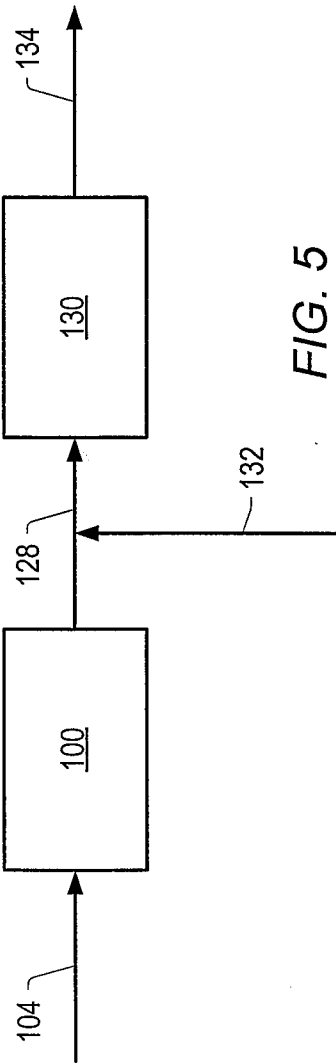


FIG. 5

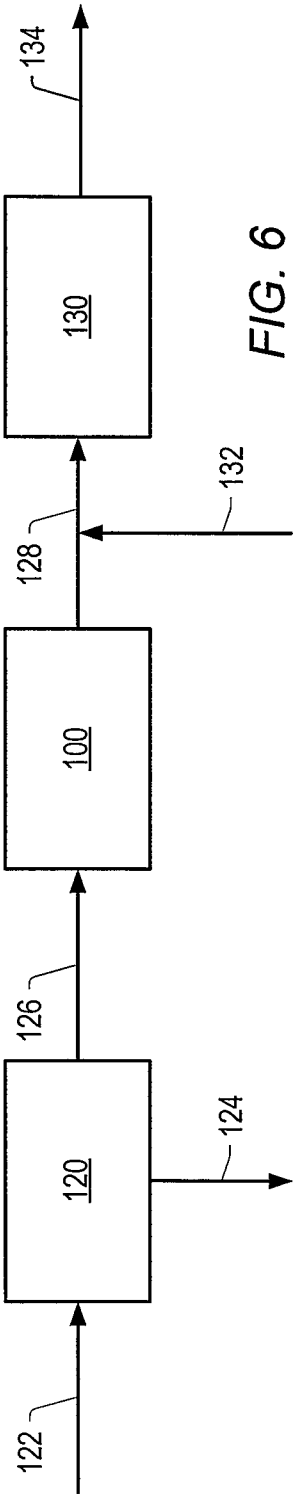


FIG. 6

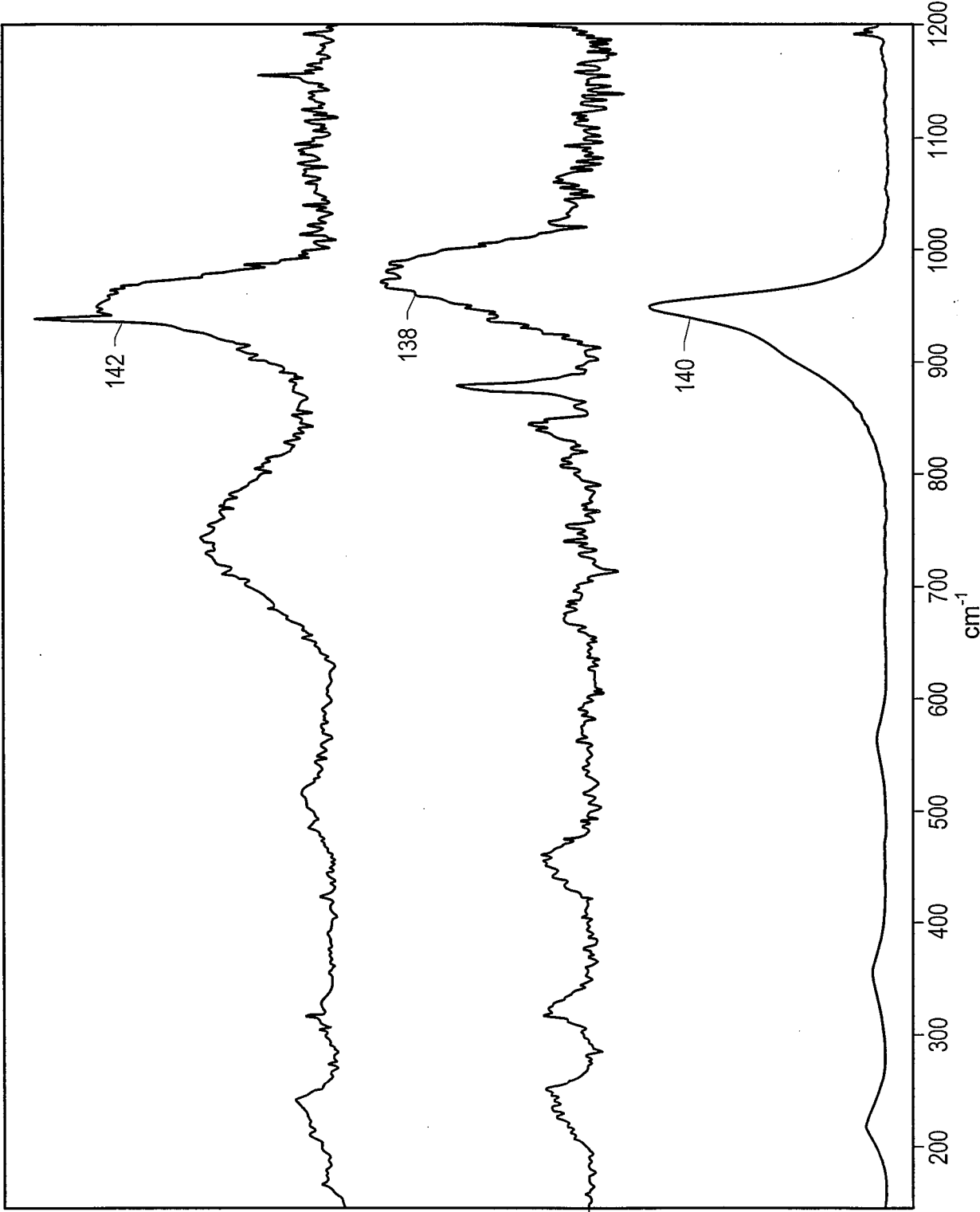


FIG. 7

Table 1

Property	Crude Feed	Crude Product
Example	5	5
TAN	0.8	0.09
API Gravity	24.9	28.6
Density at 15.56 °C (60 °F), g/cm ³	0.9046	0.8838
Hydrogen, wt%	11.68	12.54
Carbon, wt%	85.24	86.43
Sulfur, wt%	2.24	0.75
Oxygen, wt%	0.29	0.07
Nitrogen, wt%	0.19	0.16
Total Basic Nitrogen, wt%	0.05	0.05
Nickel, wtppm	27	7.6
Vanadium, wtppm	59	14.8
Micro -Carbon Residue, wt%	6.6	4.4
C ₅ Asphaltenes, wt%	5.21	2.3
Distillate, wt%	20.5	22.1
VGO, wt%	31.3	31.8
Residue, wt%	28.3	25.5
P-Value	4.5	4.5
Viscosity at 37.8 °C (100 °F), cSt	17.4	14.8

FIG. 8

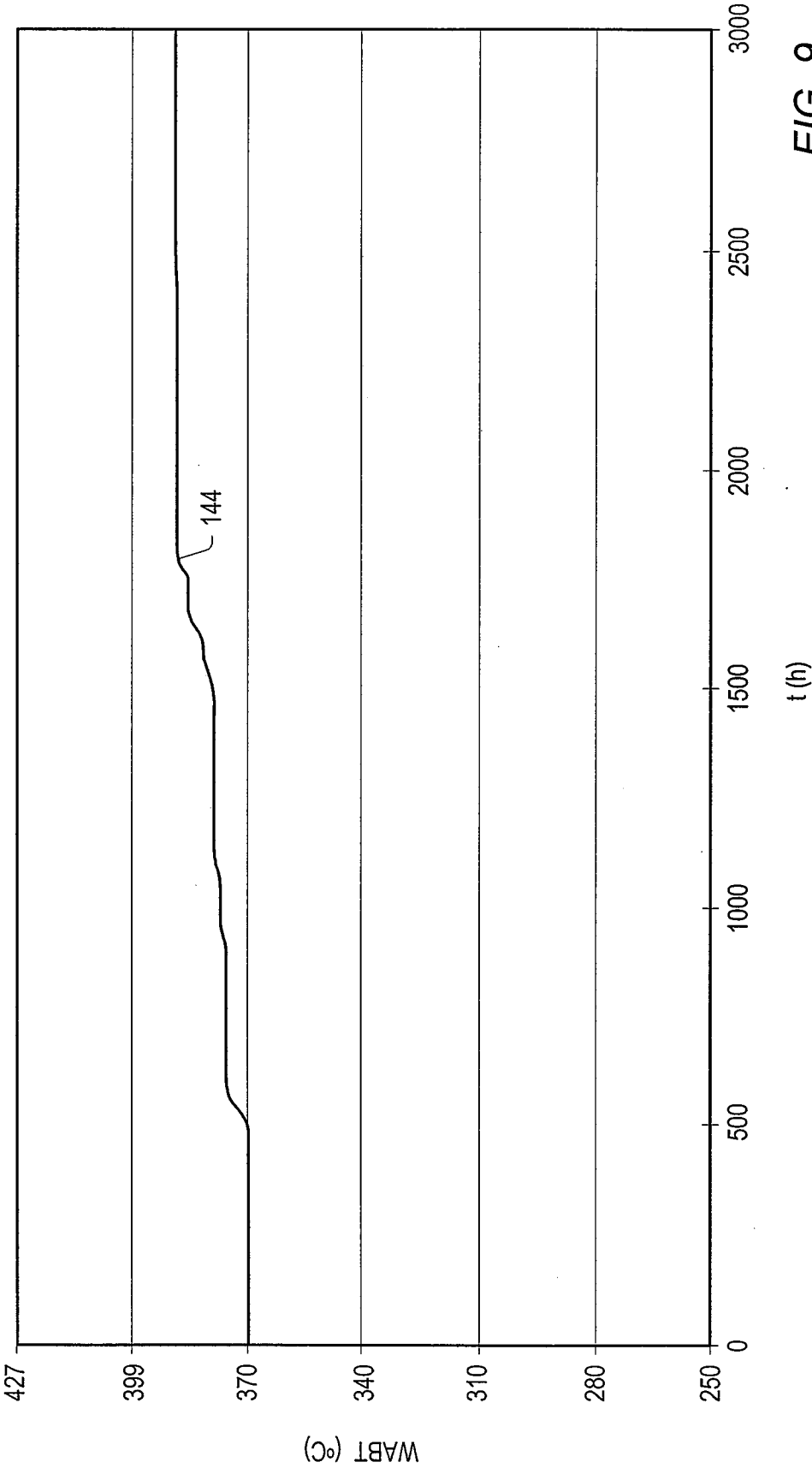


FIG. 9

Table 2

Property	Crude Feed	Crude Product
Example Number	6	6
TAN	10.3	0.42
API Gravity	13.2	12.5
Density at 15.56 °C (60 °F), g/cm ³	0.9776	0.9824
Hydrogen, wt%	11.54	11.71
Carbon, wt%	86.89	87.28
Sulfur, wt%	0.31	0.23
Oxygen, wt%	0.90	0.34
Nitro gen, wt%	0.38	0.39
Total Basic Nitrogen, wt%	0.14	0.15
Nickel, wtppm	13.7	10.7
Vanadium, wtppm	3.4	2.9
Iron, wtppm	19	2.5
Sodium, wtppm	37	24
Micro -Carbon Residue, wt%	7.2	6.7
C ₅ Asphaltenes, wt%	4.8	4.8
Distillate wt%	17.6	17.8
VGO wt%	44.6	44.1
Residue, wt%	37.8	37.8
P-Value	5	5
Viscosity at 37.8 °C (100 °F), cSt	6880	3893

FIG. 10

Table 3

Property	Crude Feed	Crude Product
Example Number	7	7
TAN	3.7	0.16
API Gravity	15.0	16.2
Density at 15.56 °C (60 °F), g/cm ³	0.9659	0.9582
Hydrogen, wt%	11.4	11.6
Carbon, wt%	87.1	87.4
Sulfur, wt%	0.43	0.33
Oxygen, wt%	0.42	0.20
Nitrogen, wt%	0.52	0.50
Total Basic Nitrogen, wt%	0.16	0.18
Nickel, wtppm	12.4	11.0
Vanadium, wtppm	19.2	15
Iron, wtppm	10.4	0.8
Calcium, wtppm	5.4	1.9
Sodium, wtppm	117	6
Zinc, wtppm	2.5	0.6
Potassium, wtppm	46	3
Micro -Carbon Residue, wt%	8.3	7.9
C ₅ Aspha ltenes, wt%		6.3
Distillate wt%	15.6	19.4
VGO wt%	39.6	37.6
Residue, wt%	38.8	40.1
Viscosity at 37.8 °C (100 °F), cSt	1224	862

FIG. 11

Table 4

Property	Crude Feed	Crude Product	Crude Product	Crude Product	Crude Product
Example Number		8	9	10	11
TAN	0.8	0.04	0.04	0.04	0.05
API Gravity	19.6	22.3	22.95	21.7	22.9
Density at 15.56 °C (60 °F), g/cm ³	0.9363	0.9198	0.9162	0.9236	0.9165
Hydrogen, wt%	11.68	12.0	12.10	11.91	12.08
Carbon, wt%	85.24	86.10	86.2	85.90	86.25
Sulfur, wt%	1.91	1.6	1.3	1.8	1.3
Oxygen, wt%	0.9	0.15	0.14	0.15	0.14
Nitrogen, wt%	0.22	0.20	0.19	0.22	0.20
Total Basic Nitrogen, wt%	0.06	NA	NA	NA	NA
Nickel, wtppm	27	18	15	14	14
Vanadium, wtppm	69	41	35	29	33
Micro -Carbon Residue, wt%	7.5	5.8	5.9	6.5	6.0
C ₅ Asphaltenes, wt%	6.0	4.0	4.0	3.4	3.9
VGO, wt%	30.0	34.6	34.6	35.1	34.8
Residue, wt%	34.9	31.5	31.2	31.2	31.0
P-Value	---	3.1	3.2	4.5	3.2
Hydrogen Uptake, Nm ³ /m ³	---	29.3	40.3	18.9	35.3
Viscosity at 100 °F, cSt	177	62.6	59.7	72.7	58.3

FIG. 12

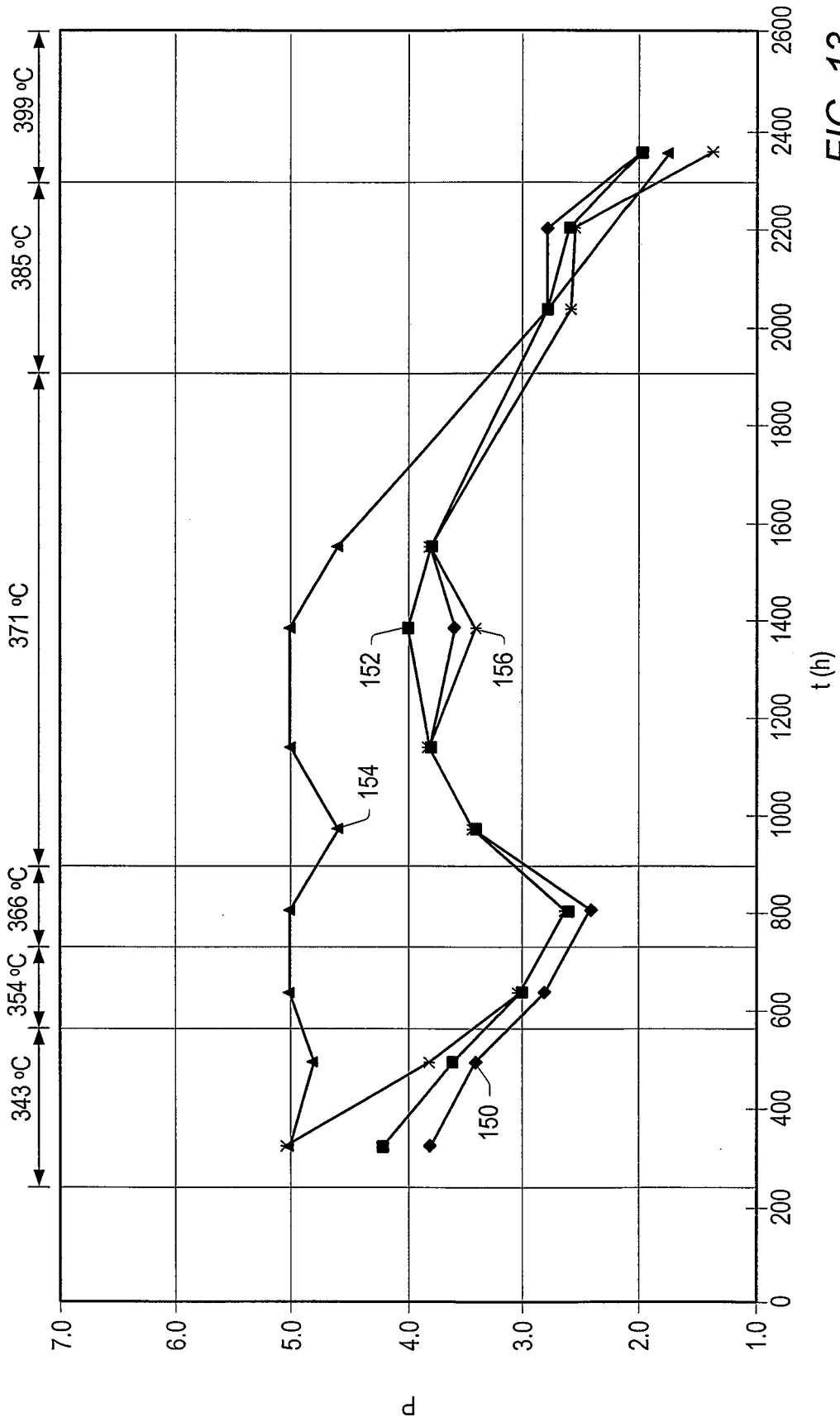


FIG. 13

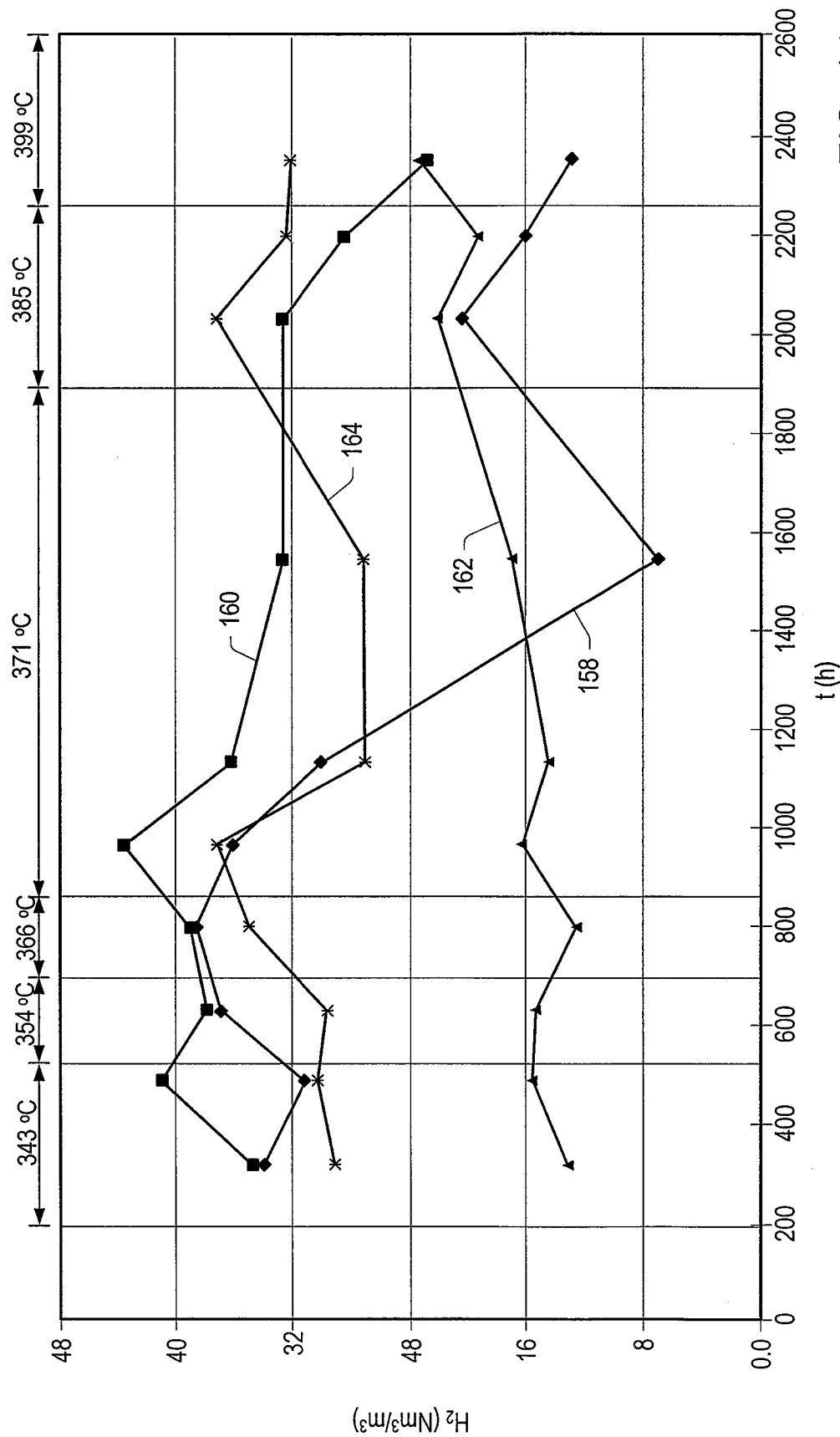


FIG. 14

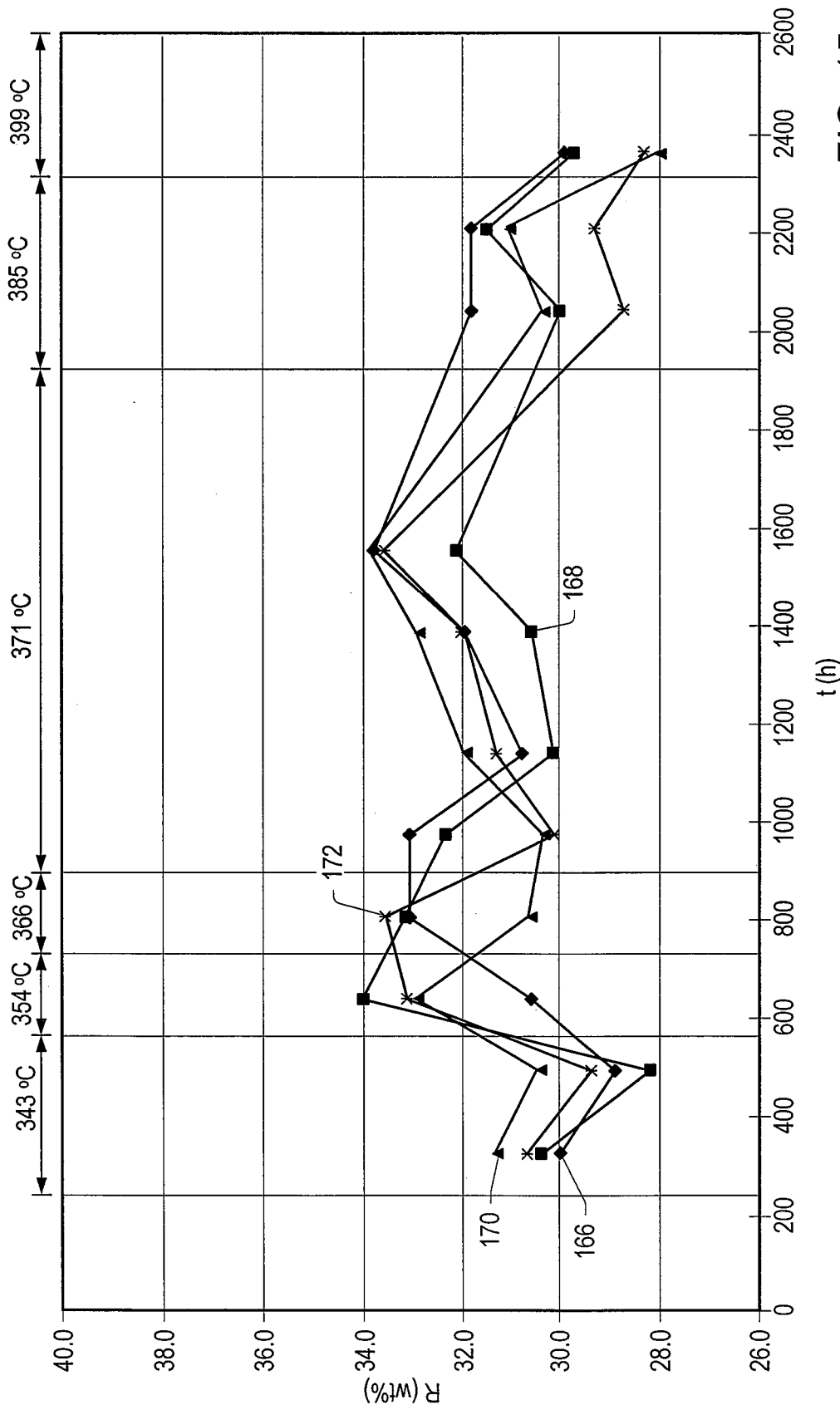


FIG. 15

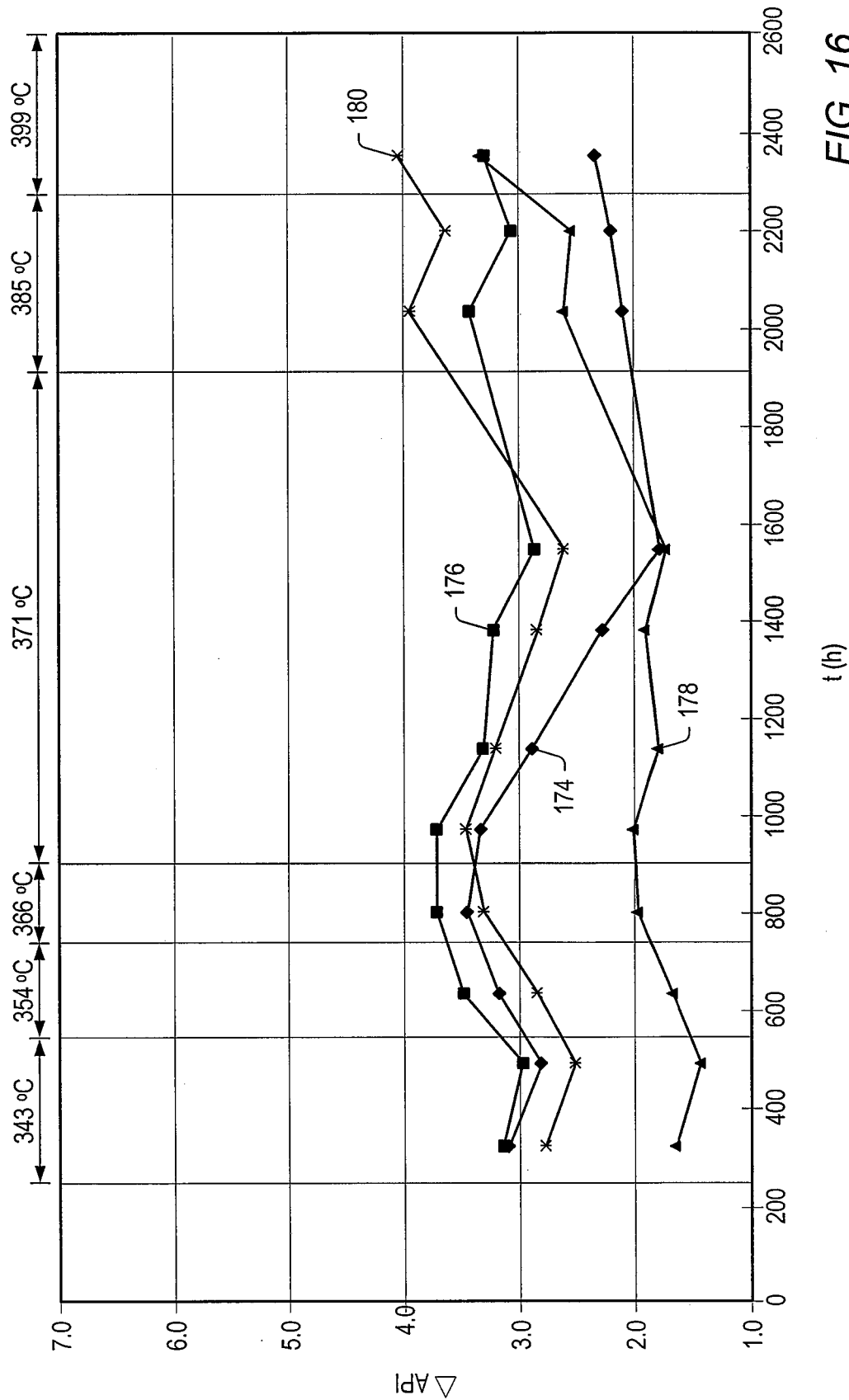


FIG. 16

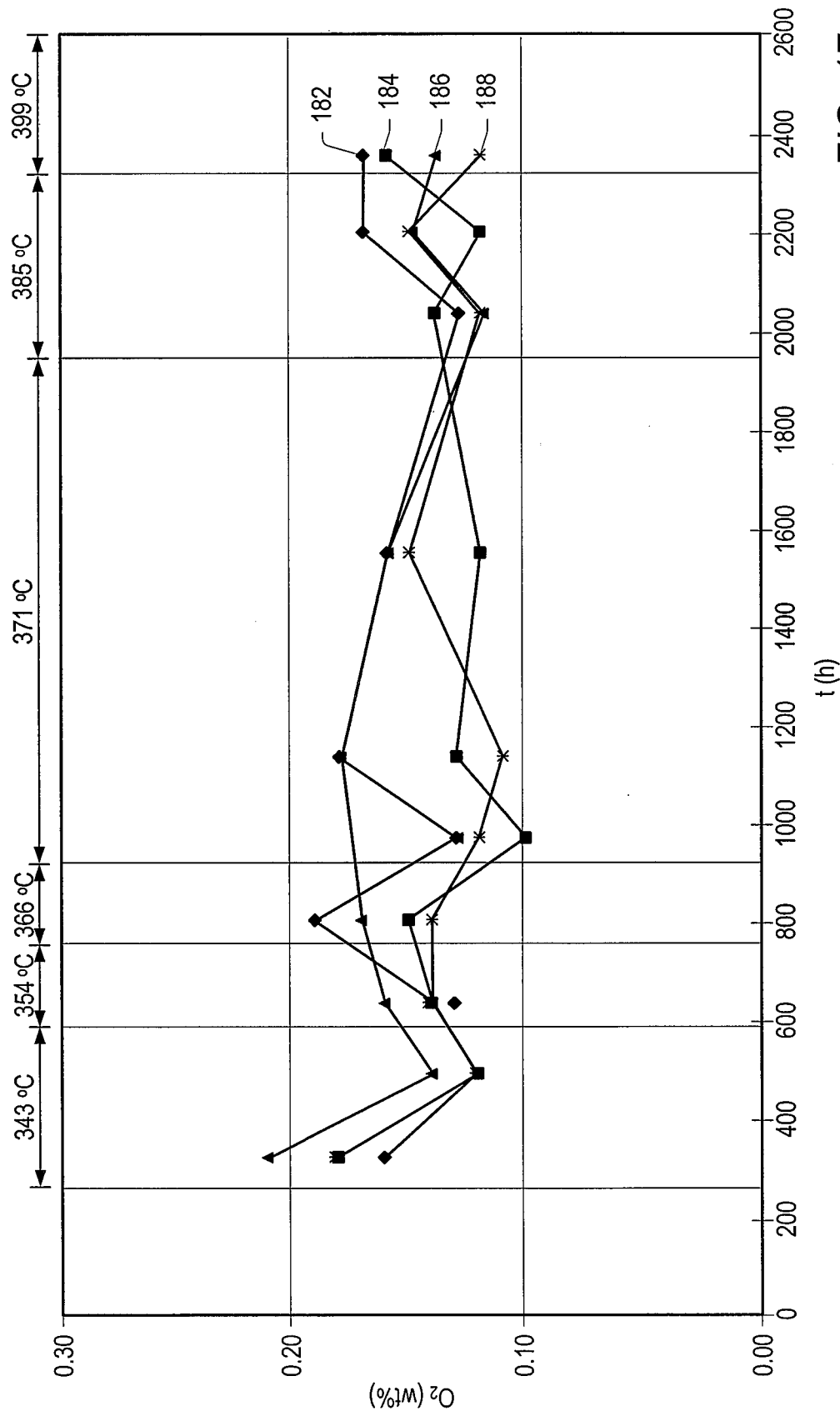


FIG. 17

Table 5

Property	Crude Feed	Crude Product	Crude Product	Crude Product	Crude Product
Example No.		15	16	17	18
Catalyst (% of total amount of catalyst in all contacting zones)	---	V(25%); Mo(75%)	V(50%); Mo(50%)	V(50%); Mo/V(50%)	Pyrex Beads
TAN	9.3	0.9	1.4	1.4	8
API Gravity	13.8	14.2	14.1	13.8	13.5
Density at 15.56 °C (60 °F), g/cm ³	0.9740	0.9712	0.9711	0.9716	0.9758
Hydrogen, wt%	11.50	11.59	11.62	11.58	11.48
Carbon, wt%	86.83	87.23	87.26	87.28	86.80
Sulfur, wt%	0.34	0.29	0.31	0.32	0.34
Oxygen, wt%	0.90	0.43	0.30	0.41	0.72
Nitrogen, wt%	0.42	0.42	0.41	0.41	0.42
Total Basic Nitrogen, wt%	0.14	0.14	0.14	0.14	0.14
Nickel, wtppm	14	14	14	14	14
Vanadium, wtppm	4	4	4	4	4
Iron, wtppm	32	3	4	4	18
Sodium, wtppm	---	9	10	7	
Potassium, wtppm	---	84	60	90	147
Calcium, wtppm	---	26	31	30	29
Zinc, wtppm	---	9	4	3	5
Micro -Carbon Residue, wt%	7.4	7.2	7.2	7.3	7.9
C ₅ Asphaltenes, wt%	5.5	4.1	4.0	4.1	5.0
VGO, wt%		41.7	41.3	41.3	40.8
Residue, wt%	37.8	41.9	41.7	42.4	43.2
P-Value	5	5	5	5	5
Hydrogen Uptake, Nm ³ /M ³	---	-1.0	1.9	-2.4	-8.9
Viscosity at 37.8 °C (100 °F), cSt	6830	4600	4240	5156	7576

FIG. 18

Table 6

Property	Crude Feed	Crude Product	Crude Feed	Crude Product	Crude Product
Example Number	6	6	19	19	19
LHSV, h ⁻¹	----	1	----	12.3	20.7
TAN	10.3	0.42	9.3	4	5.4
API Gravity	13.2	12.5	13.8	14.5	14.3
Density at 15.56 °C (60 °F), g/cm ³	0.9776	0.9824	0.9740	0.9695	0.9709
Hydrogen, wt%	11.54	11.71	11.50	44.68	11.58
Carbon, wt%	86.89	87.28	86.83	87.28	86.99
Sulfur, wt%	0.31	0.23	0.34	0.28	0.30
Oxygen, wt%	0.90	0.34	---	0.42	0.72
Nitrogen, wt%	0.38	0.39	0.42	0.41	0.41
Nickel, ppm	13.7	10.7	13.5	12.8	13.2
Vanadium, ppm	3.4	2.9	3.7	3.3	3.5
Sodium, wtppm	37	24	37	20	34
Calcium, wtppm	72	---	72	52	50
Zinc, wtppm	46	---	46	<0.4	<0.4
Potassium, wtppm	320	---	310	183	203
Micro - Carbon Residue, wt%	7.2	6.7	7.4	7.1	7.2
C ₅ Asphaltenes, wt%	4.8	4.8	5.5	4.6	4.6
Distillate, wt%	17.6	17.8	----	18.33	17.97
VGO, wt%	44.6	44.1	----	41.8	41.8
Residue, wt%	37.8	37.8	37.8	38.6	39.4
Viscosity at 37.8 °C (100 °F), cSt	6880	3893	6830	3774	4276

FIG. 19

Table 7

Property	Crude Feed	Crude Product	Crude Feed	Crude Product
Example Number	6	6	20	20
TAN	10.3	0.42	9.3	0.7
API Gravity	13.2	12.5	13.8	14.7
Density at 15.56 °C (60 °F), g/cm ³	0.9776	0.9824	0.9740	0.9678
Hydrogen, wt%	11.54	11.71	11.50	11.68
Carbon, wt%	86.89	87.28	86.8	87.42
Sulfur, wt%	0.31	0.23	0.34	0.24
Oxygen, wt%	0.90	0.34	---	0.20
Nitrogen, wt%	0.38	0.39	0.42	0.40
Nickel, ppm	13.7	10.7	13.5	10.9
Vanadium, ppm	3.4	2.9	3.7	3.3
Iron, ppm	19	2.5	32	13
Sodium, wtppm	37	24	37	9.8
Potassium, wtppm	320	---	310	175
Micro -Carbon Residue, wt%	7.2	6.7	7.4	6.8
C ₅ Asphaltenes, wt%	4.8	4.8	5.5	3.9
Distillate, wt%	17.6	17.8	---	17.8
VGO, wt%	44.6	44.1	---	42.8
Residue, wt%	37.8	37.8	37.8	40.1
P-Value	5	5	5	5
Viscosity at 37.8 °C (100 °F), cSt	6880	3893	6830	3781

FIG. 20

Table 8

Property	Crude Feed	Crude Product 1175 hours	Crude Product 5207 hours
Example Number	21	21	21
TAN	3.7	0.44	0.27
API Gravity	15.0	15.9	15.7
Density at 15.56 °C (60 °F), g/cm ³	0.9659	0.9600	0.9616
Hydrogen, wt%	11.4	11.5	11.49
Carbon, wt%	87.1	87.4	87.34
Sulfur, wt%	0.43	0.43	0.396
Oxygen, wt%	0.42	0.3	0.31
Nitrogen, wt%	0.52	0.52	0.51
Total Basic Nitrogen, wt%	0.16	0.17	0.16
Nickel, wtppm	12.4	12.7	13
Vanadium, wtppm	19.2	20.6	21
Iron, wtppm	10.4	1.1	1.4
Calcium , wtppm	5.4	0.6	0.4
Sodium, wtppm	117	0.8	1.1
Zinc, wtppm	2.5	0.9	0.9
Potassium, wtppm	46	1.5	1.7
Copper, wtppm	1.0	0.8	2.9
Chromium, wtppm	0.2	0.4	0.2
Silicon, wtppm	2.6	0.8	0.3
Magnesium, wtppm	0.2	0.2	0.2
Micro -Carbon Residue, wt%	8.3	8.1	8.0
C ₅ Asphaltenes, wt%	7.4	6.5	6.6
Distillate wt%	15.6	20.9	19.7
VGO wt%	39.6	40.7	40.7
Residue, wt%	38.8	37.1	38
Viscosity at 37.8 °C (100 °F), cSt	1224	1014	1066

FIG. 21

Table 9

Property	Crude Feed	Crude Product 286 Hours	Comparative Example 213 Hours
Example Number	21 and 22	21	22
TAN	9.7	0.26	0.8
API Gravity	13.2	21.2	23.97
Density at 15.56 °C (60 °F), g/cm ³	0.9776	0.9265	0.9101
Hydrogen, wt%	11.54	11.8	12.05
Carbon, wt%	86.89	87.38	87.2
Sulfur, wt%	0.31	0.18	0.101
Oxygen, wt%	0.90	0.24	0.35
Nitrogen, wt%	0.38	0.24	0.27
Total Basic Nitrogen, wt%	0.14	0.15	0.07
Nickel, wtppm	13.7	2.9	4.1
Vanadium, wtppm	3.4	0.6	0.9
Iron, wtppm	19	2.3	2.1
Sodium, wtppm	37	0.2	1.1
Silicon	41	0.7	2.2
Magnesium	1.5	0.1	0.2
Potassium	24	0.2	1.2
Zinc	53	6.4	0.7
Calcium	29	2.2	1.6
Chromium	0.2	0.1	0.2
Copper	0.9	0.5	0.5
Sediment, wt%	----	0.0013	0.19
Micro -Carbon Residue, wt%	7.2	3.8	3.2
C ₅ Asphaltenes, wt%	4.8	2.2	2.4
C ₇ Asphaltenes, wt%	5.3	1.1	1.5
Distillate wt%	17.6	38.6	50.8
VGO wt%	44.6	41.0	36
Residue, wt%	37.8	20.4	13.2
Viscosity at 37.8 °C (100 °F), cSt	6880	30.5	14.3

FIG. 22

Table 10

Property	Crude Feed	Crude Product			
Example No.		25	25	25	27
Contact Time, hours		603	1803	2952	671
Temperature, °C		385	400	410	400
Pressure, MPa		13.8	6.9	3.8	3.8
API Gravity	7.9	19.6	17.3	14.44	16.1
Density at 15.56 °C (60 °F), g/cm ³	1.0149	0.9363	0.9508	0.9696	0.9588
Hydrogen, wt%	10.109	11.68	11.13	Not Determined (ND)	ND
Carbon, wt%	81.987	86.57	85.78	ND	ND
Sulfur, wt%	6.687	1.28	2.59	4.3	3.25
Oxygen, wt%	0.62	0.464	0.19	0.38	----
Nitrogen, wt%	0.366	0.256	0.36	0.376	0.365
Nickel, wtppm	70	10.1	25	62	49
Iron, ppm	2.4	0.1	0.2	0.2	0.2
Vanadium, wtppm	205	17.5	56	189	115
Calcium, wtppm	6.7	2.3	2.3	4.1	0.2
Molybdenum, wtppm	6.6	0.4	0.3	0.4	0.5
Micro-Carbon Residue, wt%	12.5	5.6	7.9	10.7	8.3
C ₅ Asphaltenes, wt%	16.2	3.4	6	8.6	6.0
C ₇ Asphaltenes, wt%	10.9	2.3	4	6.8	4.4
Distillate, wt%		28.37	28.37	30.7	34.4
VGO, wt%		29.32	39.32	41.8	44.2
Residue, wt%	60	29	22.56	27.5	20.2
P-Value		2.2	1.2	1.2	---
Viscosity at 37.8 °C (100 °F), cSt	8357	129	71.2	74.4	53.1
Sediment	---	0.004	0.007	4.3	4.3
Hydrogen Consumption, Nm ³ /m ³		144	90	35	----

FIG. 23

Table 11

Property	Crude Feed	Crude Product		
Example No.	BC-10	29	31	33
API Gravity	15.1	23	22.8	23.1
Density at 15.56 °C (60 °F), g/cm ³	0.9651	0.9156	0.9168	0.9153
Hydrogen, wt%	11.47	12.354	12.261	12.291
Carbon, wt%	87.085	87.346	87.238	87.567
Sulfur, wt%	0.433	0.0293	0.0915	0.03660
Oxygen, wt%	0.42	0.058	0.136	0.031
Nitrogen, wt%	0.522	0.266	0.278	0.266
Total Basic Nitrogen, wt%	0.1611	0.0665	0.0915	0.0754
Nickel, wtppm	12.4	6.1	8.2	6
Vanadium, wtppm	19.2	4.7	7.6	4.4
Iron, wtppm	10.4	0.3		
Sodium, wtppm	117			
Micro-Carbon Residue, wt%	8.5	3.7	5.1	3.7
C ₅ Asphaltenes, wt%	7.4	3.7	5.1	3.6
C ₇ Asphaltenes, wt%	3.4	2.6	3.6	2.6
Distillate, wt%		31.2	32	31.5
VGO, wt%		40.2	37	40.1
Residue, wt%	43.3	24.1	25.5	23.5
P-Value		1.4	1.8	1.4
Viscosity at 37.8 °C (100 °F), cSt	1705	45	48.7	41.8
Hydrogen Consumption, Nm ³ /m ³		100	80	92

FIG. 24

Table 12

Property	Crude Feed	Crude Product
Example No.	Kuwait Long Residue	35
API Gravity	12.9	
Density at 15.56 °C (60 °F), g/cm ³	0.9797	0.9055
Hydrogen, wt%	10.987	
Carbon, wt%	84.146	
Sulfur, wt%	3.88	.2716
Nitrogen, wt%	0.252	.0941
Total Basic Nitrogen, wt%	0.0566	0.0210
Nickel, wtppm	16.9	3.9
Vanadium, wtppm	58	7.1
Iron, wtppm	2.1	----
Micro-Carbon Residue, wt%	12.8	3.2
C ₅ Asphaltenes, wt%	9.2	2.4
C ₇ Asphaltenes, wt%	5.4	1.5
Distillate, wt%		20.0
VGO, wt%		53.4
Residue, wt%	49.7	24.3
P-Value		1.2
Viscosity at 37.8 °C (100 °F), cSt	669.4	63.5

FIG. 25