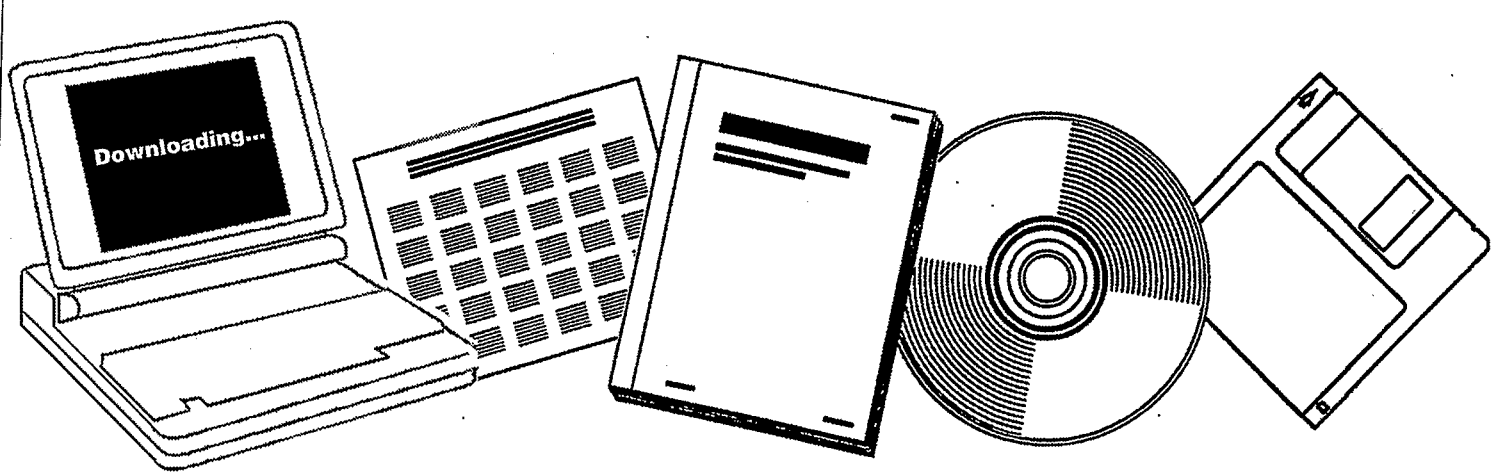
LIQUID-HYDROCARBON FUELS FROM SYNGAS. QUARTERLY REPORT, MARCH 1982-MAY 1982

UNION CARBIDE CORP., TARRYTOWN, NY.
TARRYTOWN TECHNICAL CENTER

1982



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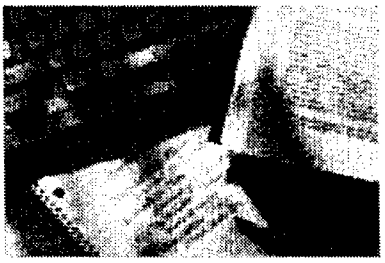

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TECHNICAL PROGRESS REPORT

Contract DE-AC22-81PC40077

Quarterly Report,

March 1982 - May 1982

LIQUID-HYDROCARBON FUELS FROM SYNGAS

Molecular Sieve Department - Engineering Products Division

Union Carbide Corporation

Tarrytown Technical Center

Tarrytown, New York

951 0520

Table of Contents

I. CONTRACT OBJECTIVE

The objective of the contract is to develop a catalyst and to select operating conditions for the direct conversion of syngas to liquid-hydrocarbon fuels, using microporous crystals- "molecular sieves" - in combination with transition metals.

II. SCHEDULE

The contract work is planned for a thirty-six month period, which started March 6, 1981. The work on the program is divided into four tasks. In Task 1, shape-selective catalysts (SSC's) are being evaluated for converting low molecular weight liquids such as methanol and propylene to desired products like gasoline, turbine and diesel fuel. In Task 2, the feed is syngas ($CO + H_2$), and the catalyst is a combination of transition metal component (MC) and SSC. Task 3 is a study of surface effects and reaction intermediates during the hydrogenation of carbon monoxide, carried out as a subcontract under the direction of Dr. Gabor A. Somorjai, of U.C. Berkeley. Task 4 is a series of management and technical reports.

III. ORGANIZATION

"Liquid Hydrocarbon Fuels from Syngas" is the goal of a research and development program on catalysts carried out by the Molecular Sieve Technology Department of the Engineering Products Division, Union Carbide Corporation at their Tarrytown Laboratories. Principal investigator is Dr. Jule A. Rabo. Program manager is Dr. Richard C. Eschenbach.

IV. PROGRESS SUMMARY

Task 1

Switching from methanol feed to propylene (plus hydrogen) resulted in a much more desirable product (more liquid, no solid). Work on catalyst synthesis is reported in Appendix A. Progress on the test setup is described in Appendix B. The Carle on-line gas chromatograph has been received and is being debugged. Mass balances have not been as good using sample bombs and off-line analysis as will be obtainable with the on-line G.C. Analytical technique development is reported in Appendix C. Test data with several catalysts are reported in Appendix D, for 10 tests with methanol feed and seven with propylene.

Task 2

Catalysts have been prepared with iron impregnation for testing in Bay 2. Instrumentation for activating catalysts according to preset schedules is almost complete.

Task 3

The high pressure apparatus is not yet complete. Calibration studies are under way, hydrogenating CO on surfaces of MC elements (see Appendix E).

V. CHANGES

Mod 006 increased the funding obligation to $1,467,200.

VI. FUTURE WORK

A variety of catalyst types will be run with propylene feed.

Syngas runs will be made with SSC catalyst types identified as interesting by Task 1 runs, adding iron or other MC component. Exploratory work on methods of incorporating the MC component will continue.

R. C. Eschenbach
Program Manager

RCE/eh
Encls.

Appendix A:

P. K. Coughlin
F. P. Gortsema

Catalyst Synthesis and Characterization

Synthesis of materials for testing under task 1 of the contract is proceeding on schedule. UCC 101, a large pore molecular sieve of moderate acidity, has been prepared as 1/8 inch extrudates using 20% alumina binder and 80% molecular sieve. Modifications of UCC 101 with acidity reduced even more have also been prepared. They are UCC 102, which is UCC 101 which has been ion exchanged with potassium, and UCC 103, which is UCC 101 which has been acid extracted.

Lewis acid sites, created by ion exchange of a zeolite with polyvalent cations, are a potential source of catalytic activity, and such sites will be investigated under task 1. For this purpose, a number of calcium exchanged Y materials have been prepared. Y-82, the most acidic Y catalyst, normally only has an ion exchange capacity of 32%, $NH_4^+/Al = 0.34$. This material was ion exchanged three times with excess sodium chloride to give a NaY-82 material with Na/Al = 0.32. Another preparation of NaY-82 was made by ion exchange first with sodium hydroxide then twice with excess sodium chloride. This material had a Na/Al = 0.59. The sodium hydroxide treatment had increased the ion exchange capacity of the zeolite. The CaY-82 made from this NaY-82 showed that calcium accounted for 95% of the exchange capacity of these materials. A NaY-62 which has a Na/Al ratio of about 1, was

also ion exchanged to give another CaY material.

Another property of the molecular sieve which could affect its catalytic properties is its hydrophobicity. Y zeolites are generally hydrophilic while ZSM-5 and silicalite are hydrophobic. A catalyst has been prepared from a hydrophobic form of Y zeolite. The activity of this material will be compared to the hydrophilic Y materials.

Extrudates were also prepared from molecular sieves with other shape selective properties. Three silicalites with different levels of aluminum and sodium impurities were extruded, as was LZ-105. A ZSM-5 type material, with Si/Al_2 = 35, was synthesized, ammonium ion exchanged and extruded. A ZSM-5 of Si/Al_2 of 80 was also ammonium ion exchanged. S-130, a medium pore TEA silicate molecular sieve, was also prepared as a catalyst. Samples of several new aluminum phosphate molecular sieves discovered by Union Carbide (U.S. Patent 4,310,440) have been scaled up to the several hundred gram size to test them under task 1 of this contract. Of the materials listed in the patent, the following have been selected because their shape selective properties should be appropriate to produce liquid hydrocarbon fuels in the correct boiling range:

AlPO-5	An O_{12}-ring unidirectional pore system having ∿8Å pore size
AlPO-11	An O_{10}-ring or possibly puckered O_{12}-ring pore system having ∿6Å pore size

Appendix A June 8, 1982

AlPO-17 Erionite structure

AlPO-31 New large pore material

The estimates of pore size were made from McBain adsorption data. These materials have now been scaled-up to yield approximate 200gm batches by hydrothermal synthesis techniques in 2 liter Parr stainless steel autoclaves with digestion carried out in the temperature range of 150-200°C. After the materials had been thoroughly washed to rid them of excess organic template, they were calcined and characterized with respect to x-ray diffraction, chemical analysis, and single point BET surface area determination. If the material was not single phase as determined by x-ray diffraction, the other analyses were not carried out.

AlPO-11 and -17 have been prepared phase pure. However, in the case of AlPO-5 and -31 some of the scaled-up batches have shown only one phase while others have proved to be mixtures of phases. Additional batches of AlPO-5 and -31 are now being made to build up inventories of approximately 300-400 gm of each material for full characterization before testing of these samples begins.

Synthesis and characterization work has also begun on metal loaded molecular sieve catalysts. A catalyst made by coprecipitation of a 4:1 mixture of iron and manganese on UCC 101 is currently being characterized by ESCA. The preliminary results of this surface study of the oxidized catalyst show, as expected, a surface enhancement of the metals over the molecular sieve. The precipitation occurred on the outside of the molecular sieve and not in

the crystal pores. The surface studies also showed that there was no surface enhancement of the manganese over the iron. A surface enhancement could have occurred since the Fe^{3+} should be precipitated at a lower pH than the Mn^{2+}. The precipitation was probably done so fast that this effect did not occur. Preliminary investigation of other metal loading techniques has begun but no characterization results are available yet.

Appendix B: Catalyst Testing Facility L. F. Elek

Task 1

After one more methanol run was completed, in addition to the nine reported for last quarter, the reactor feed system was modified to switch from methanol to propylene feed. A special pressurized liquid propylene system was designed, fabricated, pressure tested and put in operation in reactor Bay #1.

Catalyst testing Bay #2 was also completed and was equipped with the same liquid propylene feed system. It was put in operation at the beginning of May.

The damaged Berty reactor has been repaired under warranty and has been shipped back to us.

We are working together with our analytical department on the installation and debugging of the on-line gas chromatograph for analyzing the gaseous product.

Task 2

All major equipment with the exception of four mass-flow controllers has been received. The programmable temperature controller has been assembled and tested; we are ready to carry out syngas runs using either Bay 1 or Bay 2 for catalyst activation.

The construction and assembly of Bay 3 (activation bay) is proceeding on schedule and will be completed by July 1, 1982. The temperature programmer can then be used with any one of the three reactor bays.

Appendix C: Analytical Techniques

J. M. Basile
D. J. Cadden

The Carle Model 530 gas chromatograph, to be used for on-line gas phase analysis, has arrived. The G.C. has been set up next to the Berty reactors and is currently being checked out.

Samples of LHF products, sent to Perkin-Elmer for physical separation of the hydrocarbon group-types by liquid chromatography, have been separated. We are now awaiting efforts by Envirochem to quantitate these group-type fractions via their Unacon Model 810B, concentrating purge and trap, G.C.

Appendix D: Catalyst Testing Operations

C-L Yang
G. N. Long
L. F. Elek

The new DOE Berty Reactor system in Bay 1, room 33L was ready for operation at the beginning of the year. Through the end of May, we made a total of 17 runs with the system, ten runs with methanol feed and seven with propylene. Another Berty reactor system in Bay 2 also became ready recently and we made one propylene run in that system. A brief description of the catalysts used, feed composition, feed rate, operating pressure and temperatures are listed in Table 1.

TABLE 1 OPERATING STATUS

METHANOL OPERATION (CH3OH-N2 FEED AT 0.63/0.37 RATIO)

RUN NO.	CATALYST	CH3OH WHSV	PSIG	T C	CONDENSED PRODUCT
9710-1	LZ-105-6	1	322	372	MILKY CRYSTAL & OIL
9710-2	LZ-105-6	1	307	365	MILKY CRYSTAL & OIL
9710-3	ZSM-5	1	303	369	LIGHT YELLOW CRYSTAL
9710-4	UCC-101	1	322	377	
9710-5	UCC-101	1	298	372	
9710-6	Y-82	1	294	373	
9710-7	Y-82	1	300	400	
9710-8	UCC-101	1	105-51	372, 402	
9710-9	UCC-101	1	25	370, 408	
9710-10	ZSM-5	1	25	370, 409	
		3	25	369, 410, 450	

PROPYLENE OPERATION (C3H6-H2 FEED AT MOSTLY 1:1 RATIO)

RUN NO.	CATALYST	C3H6 WHSV	PSIG	T C	CONDENSED PRODUCT & REMARKS
9710-11	LZ-105-6	1	25	410	OIL
9710-12	LZ-105-6	1	27	450	OIL
9710-13	LZ-105-6	1	150	410	OIL, DARK BROWN TO YELLOW
9710-14	UCC-101	1	150	410	OIL,YELLOW. CATALYST DEACTIVATES.
9710-15	UCC-101	0.27*	25	410	VERY LITTLE PRODT. *C3H6/H2 @ 1/4
9710-16	UCC-101	1	150	280	LITTLE PRODUCT.
9710-17	UCC-101	1	150	340	MORE PRODT,CLEAR & TURNING YELLOW

RUN NO	CATALYST	C3H6 WHSV	PSIG	T C	CONDENSED PRODUCT
9972-1	LZ-105-6	1	150	280, 310, 340, 370, 280	OIL
		1	150,75,300	280	OIL
		1	300,150,50	370	OIL

Material Balance

A. Methanol Operation

When methanol is the feed material, the product consists of an effluent gas stream downstream of a condenser, an aqueous condensate and a hydrocarbon condensate. The total effluent gas volume is measured for the test duration and its composition is analyzed by GC. For the aqueous condensate, we determine weight and its chemical analysis in wt.% H_2O, CH_3OH and dimethylether. For the hydrocarbon condensate, we measure the weight. A molecular formula of $C_{10}H_{14}$, tetramethyl benzene, is assumed for the hydrocarbon. The volume of feed methanol consumed over the duration is noted and then converted to weight. The material balance is reported in terms of the ratios of carbon atoms, hydrogen atoms and oxygen atoms between the products and the feed. A consistency ratio is also computed, which for methanol operation is defined as follows:

$$\text{Consistency Ratio} = \frac{\text{g.atoms C in HC prod. + g.moles DME}}{\text{g. moles } H_2O \text{ produced}}$$

B. Propylene Operation

With propylene feed, there is no aqueous product, thus the computations are simpler. The material balance is a weight ratio of hydrocarbon products from the reactor effluent gas and the hydrocarbon condensate to that of propylene feed. The hydrogen gas, which was co-fed along with propylene, was not included in the material balance.

Other Measurements

The hydrocarbon products are characterized by Simulated Distillation (ASTM-D-2887) and FIA analysis for weight percent aromatics, olefins and saturates. Other physical properties such as density and refractive index are also determined.

Methanol Operation

The catalyst weight used in each run is generally 20 gm. Methanol was fed at 1.0 WHSV (weight hourly space velocity: gm/hr methanol per gm. catalyst) in a methanol/nitrogen mixture of approximately 0.63/0.37 mole ratio. Nitrogen was introduced to help in controlling the reactor pressure. Methanol was fed during daytime hours only for about 7 hours, with nitrogen flowing continuously overnight. Liquid product and effluent gas samples were collected each day. The liquid product samples contained an aqueous layer, an oil layer and a solid hydrocarbon phase. These three layers were separated by centrifugation and submitted for various analyses. The gas samples were analyzed by gas chromatography.

Data for runs 9710-1 through 10 (methanol feed) are given in Tables 2 to 7. For the first three runs (Run 9710-1,-2,-3), active catalysts with good life expectancy, medium pore types LZ-105-6 and ZSM-5, were used. At the operating conditions chosen, (1.0 WHSV, 300 psig 370°C) the hydrocarbon products were mostly solid crystals (with some oil). The solid crystals were found to be highly methylated aromatic products, primarily durene (m.p. 79°C), with other tetramethylbenzenes, toluene, xylenes, and trimethylbenzenes as reported earlier. The solid products caused plugging in the pressure control valve and product lines, resulting in shutdown for high reactor pressure.

The next six runs (Run 9710-4,-5,-6,-7,-8,-9) were made using UCC-101 and Y-82 catalysts. The UCC-101 has lower activity than LZ-105-6 or ZSM-5 while the Y-82 deactivates rapidly; hence the hydrocarbon yield is low. Most of the runs were carried out at 1.0 WHSV, 300 psig and 370°C. In the later runs, lower pressures (50 and 25 psig) and higher temperatures (400-410°C) were tried. The C_5^+ hydrocarbon yields are low and mostly solid. There is no FIA data on the products from Runs 9710-1 to 9710-9, because the hydrocarbon products are mostly solid and also too small in quantity in most of the cases.

In the last run, Run 9710-10, the catalyst was ZSM-5, known to have good catalyst life. The methanol feed rate varied from 1 to 3 WHSV, the ratio of CH_3OH to N_2 feed rate remained constant at 0.63 to 0.37 mole ratio, the pressure was 25 psig and temperature set at 370, 410 and 448°C. At the higher temperatures of 410 and 448°C, the hydrocarbon products were all oily liquid with no solid; at 370°C, mixtures of crystalline solid and oily liquid hydrocarbons were made. Even at the highest temperature of 448°C (sample 9710-10-38) the oily liquid product is still highly aromatic (72.8%), but enough lower molecular weight hydrocarbons were made to render the tetramethylbenzenes soluble.

The conversion of methanol and product selectivity of the ten runs are plotted in Figure 1. The four catalysts, LZ-105-6, ZSM-5, UCC-101 and Y-82, all exhibit fairly good conversion of methanol. However, their catalyst stability and product selectivity differed a great deal. For LZ-105-6 and ZSM-5, the catalyst

stability is high and both were active throughout the test. The methanol conversion is high, between 90-100% with almost all of it converted to hydrocarbons, with about 50-67% of the hydrocarbon in the C_5^+ range.

Both UCC-101 and Y-82 deactivated faster than the medium pore zeolite, with the Y-82 being the worst. Because of this, we plotted the conversion and selectivity as a function of time-on-stream, otherwise the data points would appear rather scattered (as in the middle plot of Figure 1.) Although the methanol conversion remained at 71-78% level with time on stream, the reaction went mainly to dimethylether after a few hours, and further conversion to hydrocarbons dropped precipitously with time. The relative product selectivity for C_4's and C_3's decreased even further, with the result that only the activity for methane formation held up. Experimental data showing these observations are plotted in Figures 2, 3 and 4.

The distillation ranges of the condensed hydrocarbon products are characterized by simulated distillation data, plotted in Figures 5 to 22. With methanol feed, in an internal recirculation reactor and zeolite catalyst, the products are mostly multiply methylated aromatics. On the simulated distillation plots, these appear as distinct peaks. One can identify the peaks of toluene, xylenes, tri-methylbenzenes and tetra-methylbenzenes in products from intermediate pore zeolites LZ-105-6 and ZSM-5, and peaks of penta-methylbenzene (b.p. 232°C, 450°F), hexa-methyl benzene

(b.p. 265°C, 509°F) and deca-methyl biphenyl ($C_{22}H_{30}$, probably the peak between 690-710°F) in products from the larger pore catalysts Y-82 and UCC-101. For the LZ-105-6 and ZSM-5, the distillation plot terminates at around 410°F. For the Y-82 and UCC-101 catalysts, the distillation plot starts at about 380°F and terminates at about 710°F, the desirable range for turbine and diesel fuel.

The relative weight percent of various distinct peaks can be estimated from the distillation plots and are tabulated in Table 8 together with the catalyst and the process conditions. The following observations can be made on the influence of process variables:

1. Higher pressure makes heavier products.
2. Higher temperature makes lighter products.
3. Higher space velocity makes lighter products.

Because of the multiply methylated benzenes made in the product, it was decided that methanol is not a good model compound as a feed to simulate reaction intermediates for Fischer-Tropsch synthesis. Propylene was tested and found to be an improvement in later Task 1 tests.

TABLE 2 RESULT OF METHANOL OPERATION

RUN & SAMPLE NO.	9710-1-1	9710-2-1	9710-3-1	9710-4-1	9710-5-1
CATALYST	LZ-105-6	LZ-105-6	ZSM-5	UCC-101	UCC-101
CH3OH WHSV	1.0	1.0	1.0	1.0	1.0
HRS ON STREAM	20.0	18.7	7.8	6.7	5.0
PRESSURE,PSIG	322	307	303	322	298
TEMP. C	370	365	369	377	372
FEED ALCOHOL CC	[443.0	[460.0	[69.0	[61.0	[78.5
HOURS FEEDING	[20.083	[18.733	[3.167	[2.467	[3.0
EFFLNT GAS LITER	[166.6	[186.52	[32.4	[33.93	[41.0
GM AQUEOUS LAYER	[169.51	[156.69	[26.29	[17.38	[27.03
GM HYDROCARBON	[44.67	[42.30	[5.93	[0.71	[2.27
APPEARANCE OF HC	CRYSTL & SOME OIL	CRYSTL & SOME OIL	CRYSTL	CRYSTL	
MATERIAL BALANCE					
ON C	.737		.784		.828
H	.816		.833		.892
O	.897		.861		.930
CONSISTENCY RATIO	.823		.913		.846
CH3OH CONVERSION	99.87		99.92		84.61
PRODT DISTRIBTN,%C-ATOM					
DIMETHYL ETHER	0.00		0.00		63.96
HYDROCARBONS	98.93		98.86		35.64
OTHERS(CO,CO2)	1.07		1.14		0.40
HC SELECTVTY,% C-ATOM					
CH4	0.74		1.30		15.31
C2 HC'S	2.26		2.45		9.34
C3	18.12		13.97		3.18
C3=	0.55		0.59		8.65
C4	18.99		24.72		5.00
C4= &C4==	0.34		0.37		5.40
C5	9.33		13.63		4.08
C5=	0.11		0.16		0.71
C6H14	3.80		6.03		4.33
C6H12	0.09		0.01		0.12
C7+	3.05		3.29		8.94
OIL & SOLIDS	42.62		33.47		34.94
SUBSUM C5+	59.00		56.59		53.12
FRACTN CONVTD C AS C5+	0.584		.559		.189
SIMULATED DISTILLATION					
10 WT % @ DEG F	331	331	380	428	424
16	334	334	383	457	431
50	390	391	390	504	505
84	397	398	394	691	653
90	398	400	397	701	697
RANGE(16-84%)	63	64	11	234	222

TABLE 3 RESULT OF METHANOL OPERATION

RUN & SAMPLE NO.	9710-5-2	9710-6-2	9710-7-A	9710-7-1	9710-7-2
CATALYST	UCC-101	Y-82	Y-82	Y-82	Y-82
CH3OH WHSV	1.0	1.0	1.0	1.0	1.0
HRS ON STREAM	9.0	6.5	1.5	6.5	12.5
PRESSURE,PSIG	299	294	300	300	302
TEMP. C	400	373	401	401	400
FEED ALCOHOL CC	[79.0	[92.0	[40.0	[130.0	[132.0
HOURS FEEDING	[3.00	[3.50	[1.5	[5.0	[5.0
EFFLNT GAS LITER	[46.5	[51.6	[19.8	[74.1	[74.9
GM AQUEOUS LAYER	[25.00	[30.18	[6.24	[44.38	[43.87
GM HYDROCARBON	[0.32	[0.30	[.0014	[0.29	[0.02
APPEARANCE OF HC					
MATERIAL BALANCE					
ON C		.856	.531	.842	.793
H		.895	.552	.909	.839
O		.922	.423	.962	.877
CONSISTENCY RATIO		.874	1.276	.788	.830
CH3OH CONVERSION		77.43	96.48	76.48	71.25
PRODT DISTRIBTN,%C-ATOM					
DIMETHYL ETHER		92.06	10.02	94.09	96.80
HYDROCARBONS		7.86	89.64	5.48	2.85
OTHERS(CO,CO2)		0.08	0.34	0.43	0.35
HC SELECTVTY,% C-ATOM					
CH4		22.63	11.96	48.08	56.68
C2 HC'S		13.59	11.14	8.38	6.19
C3		2.53	21.38	1.02	0.81
C3=		13.57	4.16	5.07	3.39
C4		3.40	28.51	0.50	0.00
C4= &C4==		7.86	2.46	2.25	1.62
C5		2.61	12.32	0.26	0.00
C5=		2.74	0.82	0.71	0.56
C6H14		0.00	4.07	0.31	0.28
C6H12		0.00	0.07	0.00	0.00
C7+		12.15	3.08	14.37	27.48
OIL & SOLIDS		18.90	0.03	19.07	3.0
SUBSUM C5+		36.40	20.39	34.72	31.32
FRACTN CONVTD C AS C5+		.0286	.1828	.019	.0089
SIMULATED DISTILLATION					
10 WT % @ DEG F	429	412	449	426	
16	458	428	474	437	
50	506	493	497	499	
84	653	591	698	644	
90	692	643	766	682	
RANGE(16-84%)	195	163	224	207	

TABLE 4 RESULT OF METHANOL OPERATION

RUN & SAMPLE NO.	9710-8-A	9710-8-1	9710-8-2	9710-9-1	9710-9-2
CATALYST	UCC-101	UCC-101	UCC-101	UCC-101	UCC-101
CH3OH WHSV	1.0	1.0	1.0	1.0	1.0
HRS ON STREAM	2.0	7.0	12.0	6.0	11.0
PRESSURE,PSIG	105	60	51	25	28
TEMP. C	372	371	402	370	408
FEED ALCOHOL CC	[53.0	[79.0	[132.0	[79.0	[77.5
HOURS FEEDING	[2.0	[3.0	[5.0	[3.0	[3.0
EFFLNT GAS LITER	[22.0	[43.7	[79.0	[41.8	[45.4
GM AQUEOUS LAYER	[14.21	[23.85	[42.88	[24.80	[24.50
GM HYDROCARBON	[0.06	[0.40	[0.20	[0.20	[0.47
APPEARANCE OF HC					
MATERIAL BALANCE					
ON C	.498	.666	.914	.783	.855
H	.606	.730	.969	.831	.910
O	.644	.777	1.001	.854	.942
CONSISTENCY RATIO	.738	.772	.849	.865	.845
CH3OH CONVERSION	89.94	78.95	77.57	78.83	79.75
PRODT DISTRIBTN,%C-ATOM					
DIMETHYL ETHER	34.68	86.77	91.02	83.38	85.63
HYDROCARBONS	64.99	12.78	7.68	16.40	12.56
OTHERS(CO,CO2)	0.33	0.45	1.30	0.22	1.81
HC SELECTVTY,% C-ATOM					
CH4	9.90	30.02	63.42	19.97	53.39
C2 HC'S	14.36	11.38	10.00	14.57	9.45
C3	5.86	1.86	1.08	1.58	0.93
C3=	10.02	10.94	5.51	18.20	5.04
C4	18.17	1.91	0.40	4.12	0.37
C4= &C4==	6.53	6.18	2.66	11.64	2.40
C5	14.45	1.43	0.18	3.16	0.20
C5=	2.23	2.34	0.74	4.20	0.74
C6H14	6.14	1.43	0.36	2.74	0.39
C6H12	0.15	0.05	0.00	0.19	0.00
C7+	10.93	9.72	7.26	12.07	5.72
OIL & SOLIDS	1.25	22.73	8.39	7.54	21.37
SUBSUM C5+	35.15	37.70	16.93	29.90	28.42
FRACTN CONVTD C AS C5+	.228	.048	.013	.049	.0357
SIMULATED DISTILLATION					
10 WT % @ DEG F	408	475	479	384	479
16	425	482	482	403	482
50	486	490	497	479	490
84	502	693	696	507	694
90	508	698	729	512	705
RANGE(16-84%)	77	211	214	24	212

TABLE 5 RESULT OF METHANOL OPERATION

RUN NO. 9710-10
CATALYST: ZSM-5 #9530-89 40 CC 20 GM
FEED: CH3OH/N2 @ .63/.37 MOLE RATIO

RUN & SAMPLE NO.	R-10-1	R-10-2	R-10-3	R-10-4	R-10-5
CH3OH WHSV	1.0	1.0	1.0	1.0	1.0
HRS ON STREAM	1.0	2.0	4.0	7.0	9.0
PRESSURE,PSIG	25	25	25	25	26
TEMP. C	369	370	370	370	409
FEED ALCOHOL CC	[26.0	[26.0	[52.0	[78.0	[51.0
HOURS FEEDING	[1.0	[1.0	[2.0	[3.0	[2.0
EFFLNT GAS LITER	[10.9	[10.7	[22.1	[33.6	[23.6
GM AQUEOUS LAYER	[5.82	[9.36	[19.34	[30.52	[18.9
GM HYDROCARBON	[1.88	[2.39	[5.77	[8.29	[5.17
APPEARANCE OF HC	[OIL WITH CRYSTAL		[OIL WITH CRYSTAL		[OIL ONLY
MATERIAL BALANCE					
ON C	.697	.743	.859	.834	.861
H	.637	.806	.854	.875	.876
O	.531	.847	.828	.900	.860
CONSISTENCY RATIO	1.321	.878	1.040	.928	1.004
CH3OH CONVERSION	97.14	97.39	96.41	94.09	94.31
PRODT DISTRIBTN,%C-ATOM					
DIMETHYL ETHER	0.00	0.00	0.00	0.00	0.00
HYDROCARBONS	99.02	99.14	99.26	99.36	99.10
OTHERS(CO,CO2)	0.98	0.86	0.74	0.64	0.90
HC SELECTVTY,% C-ATOM					
CH4	1.27	1.12	1.00	1.03	1.68
C2 HC'S	2.62	2.28	2.06	2.28	2.98
C3	27.67	24.42	21.54	20.12	22.73
C3=	0.57	0.54	0.57	0.78	1.54
C4	23.52	21.54	22.26	23.15	21.22
C4= &C4==	0.30	0.30	0.52	0.42	0.86
C5	7.09	6.62	7.10	8.08	6.33
C5=	0.04	0.03	0.24	0.05	0.16
C6H14	1.58	1.47	1.82	0.82	1.43
C6H12	0.03	0.04	0.15	0.03	0.03
C7+	1.45	1.42	2.01	1.60	2.34
OIL & SOLIDS	33.68	40.22	40.72	41.65	38.71
SUBSUM C5+	43.87	49.80	52.04	52.23	49.00
FRACTN CONVTD C AS C5+	.4344	.4937	.5165	.5190	.4856
SIMULATED DISTILLATION ON OIL & SOLIDS					
10 WT % @ DEG F	338	335	335	330	287
16	382	361	341	337	326
50	398	398	400	395	386
84	408	408	411	405	402
90	438	435	415	408	407
RANGE(16-84%)	26	47	70	68	76
FIA ANALYSIS ON OIL, WT %					
AROMATICS					99.3
OLEFINS					0.2
SATURATES					0.5

TABLE 6 RESULT OF METHANOL OPERATION

RUN NO. 9710-10
CATALYST: ZSM-5 #9530-89 40 CC 20 GM
FEED: CH3OH/N2 @ .63/.37 MOLE RATIO

RUN & SAMPLE NO.	R-10-6	R-10-7	R-10-8	R-10-9	R-10-10
CH3OH WHSV	1.0	3.0	3.0	3.0	3.0
HRS ON STREAM	14.0	21.0	26.5	31.5	32.5
PRESSURE,PSIG	26	25	25	26	25
TEMP. C	410	410	412	370	368
FEED ALCOHOL CC	[129.0	[440.0	[406.0	[152.0	[149.0
HOURS FEEDING	[5.0	[6.0	[5.5	[2.07	[2.0
EFFLNT GAS LITER	[57.9	[238.4	[218.1	[77.813	[59.1
GM AQUEOUS LAYER	[49.6	[168.18	[175.50	[68.03	[61.04
GM HYDROCARBON	[14.23	[30.65	[31.66	[25.34	[11.39
APPEARANCE OF HC	OIL ONLY	OIL ONLY	OIL ONLY	CRSTL+OIL	OIL+CRSTL
MATERIAL BALANCE					
ON C	.772	.740	.838	.789	.658
H	.815	.828	.925	.888	.777
O	.876	.884	.976	.990	.898
CONSISTENCY RATIO	.882	.838	.858	.797	.732
CH3OH CONVERSION	96.58	92.04	88.82	90.78	90.94
PRODT DISTRIBTN,%C-ATOM					
DIMETHYL ETHER	0.00	0.00	0.00	0.00	0.00
HYDROCARBONS	99.62	99.49	99.70	99.79	99.82
OTHERS(CO,CO2)	0.38	0.51	0.30	0.21	0.18
HC SELECTVTY,% C-ATOM					
CH4	0.96	1.25	1.13	0.72	0.67
C2 HC'S	3.01	4.01	3.66	4.31	4.62
C3	10.21	12.26	10.97	6.66	6.45
C3=	3.34	4.04	4.34	2.50	3.27
C4	17.79	23.32	21.67	18.04	18.19
C4= &C4==	1.97	2.51	2.66	1.61	2.42
C5	8.12	7.71	10.56	8.74	8.77
C5=	0.27	1.08	0.48	0.32	1.06
C6H14	4.01	4.66	5.78	9.40	9.04
C6H12	0.15	0.85	0.37	0.07	0.10
C7+	5.38	7.23	6.59	7.80	6.52
OIL & SOLIDS	44.80	31.07	31.77	39.83	38.88
SUBSUM C5+	62.73	52.60	55.55	66.16	64.37
FRACTN CONVTD C AS C5+	.6249	.5233	.5538	.6602	.6425
SIMULATED DISTILLATION ON OIL & SOLIDS					
10 WT % @ DEG F	285	289	285	282	280
16	323	324	300	310	290
50	383	357	352	386	384
84	401	399	398	399	397
90	404	402	401	401	399
RANGE(16-84%)	78	75	98	89	107
FIA ANALYSIS ON OIL, WT %					
AROMATICS	97.6	99.2	97.4	90.4	
OLEFINS	0.2	0.8	0.6	1.3	
SATURATES	0.2	0.0	2.0	8.3	

TABLE 7 RESULT OF METHANOL OPERATION

RUN NO. 9710-10
CATALYST: ZSM-5 #9530-89 40 CC 20 GM
FEED: CH3OH/N2 @ .63/.37 MOLE RATIO

RUN & SAMPLE NO.	R-10-11	R-10-38
CH3OH WHSV	3.0	3.0
HRS ON STREAM	36.5	42.5
PRESSURE,PSIG	25	25
TEMP. C	368	448
FEED ALCOHOL CC	222.5	515.0			
HOURS FEEDING	3.0	7.0			
EFFLNT GAS LITER	113.8	270.4			
GM AQUEOUS LAYER	95.37	222.01			
GM HYDROCARBON	18.31	36.09			
APPEARANCE OF HC	OIL+CRSTL	OIL ONLY			
MATERIAL BALANCE		
ON C	.769	.717
H	.858	.856
O	.943	.724
CONSISTENCY RATIO	.816	.738
CH3OH CONVERSION	91.08	91.19
PRODT DISTRIBTN,%C-ATOM		
DIMETHYL ETHER	0.00	0.00
HYDROCARBONS	99.81	99.61
OTHERS(CO,CO2)	0.19	0.39
HC SELECTVTY,% C-ATOM		
CH4	0.74	2.33
C2 HC'S	5.19	5.76
C3	6.38	10.30
C3=	3.04	7.74
C4	17.95	18.26
C4= &C4==	5.72	4.12
C5	8.41	5.59
C5=	0.71	0.96
C6H14	8.47	4.44
C6H12	0.74	0.59
C7+	7.00	7.42
OIL & SOLIDS	35.65	32.49
SUBSUM C5+	60.98	51.49
FRACTN CONVTD C AS C5+	.6086	.5129
SIMULATED DISTILLATION ON OIL & SOLIDS		
10 WT % @ DEG F	282	285
16	300	290
50	385	347
84	396	395
90	398	399
RANGE916-84%)	96	105
FIA ANALYSIS ON OIL, WT %		
AROMATICS	.	72.8
OLEFINS	.	9.4
SATURATES	.	17.4

TABLE 8 SIMULATED DISTILLATION FIGURES FROM METHANOL RUNS

FIG	SAMPLE	CATALYST	CH3OH WHSV	PSIG	TEMP	WT % OF VARIOUS METHYL BENZENE DI-	TRI-	TETRA	BOILING FRACTIONS 420-435	470-510	680-710
5	9710-1-1	LZ-105-6	1	322	370	3	17	73			
6	9710-3-1	ZSM-5	1	303	369		3	88			
18	9710-10-3	ZSM-5	1	25	370	3	11	70			
19	9710-10-6	ZSM-5	1	26	410	10	30	44			
20	9710-10-9	ZSM-5	3	26	370	7	22	53			
21	9710-10-8	ZSM-5	3	25	412	12	36	38			
22	9710-10-38	ZSM-5	3	25	448	20	43	25			

FIG	SAMPLE	CATALYST	CH3OH WHSV	PSIG	TEMP	WT % OF VARIOUS METHYL BENZENE DI-	TRI-	TETRA	BOILING FRACTIONS 420-435	470-510	680-710
7	9710-4-1	UCC-101	1	322	377					38	10
8	9710-5-1	UCC-101	1	298	372				8	48	8
9	9710-5-2	UCC-101	1	299	400				7	34	5
10	9710-6-2	Y-82	1	294	373				9	38	3
11	9710-7-A	Y-82	1	300	401					39	9
12	9710-7-1	Y-82	1	300	401				9	38	5
13	9710-8-A	UCC-101	1	105	372				19	48	
14	9710-8-1	UCC-101	1	60	371				4	53	13
15	9710-8-2	UCC-101	1	51	402					46	15
16	9710-9-1	UCC-101	1	25	370				19	41	
17	9710-9-2	UCC-101	1	28	408					53	12

NOTE ON TENTATIVE IDENTIFICATION OF THE FRACTIONS:
420-435 DEG F:
470-510 DEG F: HEXA-METHYL BENZENE
680-710 DEG F: DECA-METHYL BIPHENYL C22H30

FIGURE 1

CONVERSION OF CH_3OH to HYDROCARBONS

BERTY REACTOR

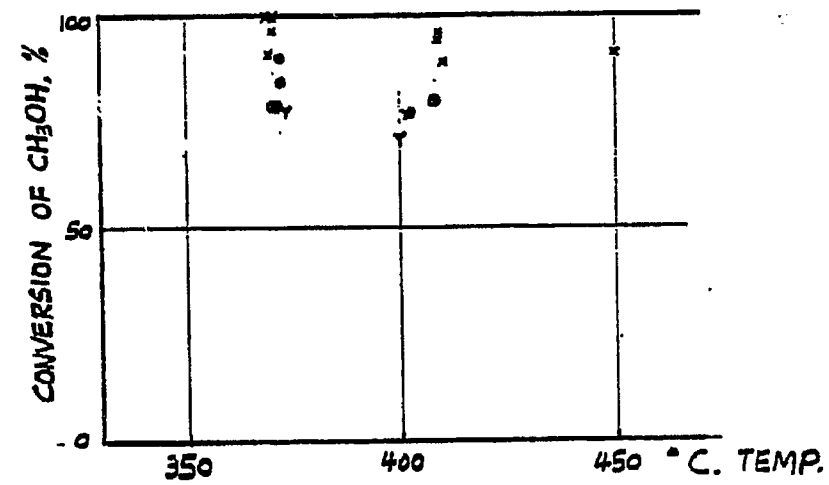
FEED: CH_3OH - N_2

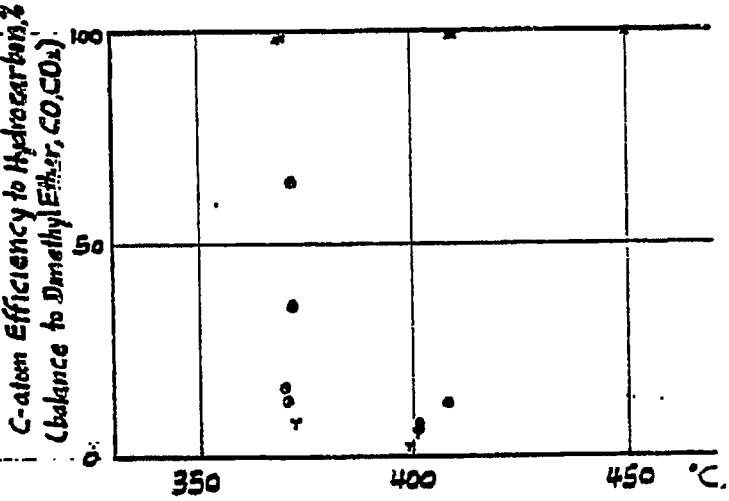
RUNS: 9710-1, -2, -3, -4
-5, -6, -7, -8, -9
-10

CATALYSTS:
× LZ-105-6
× ZSM-5
◎ UCC-101
Y Y-82

PRESSURES:
300, 105, 50, 25 PSIG

TEMP.:
370, 400, 410, 450°C.





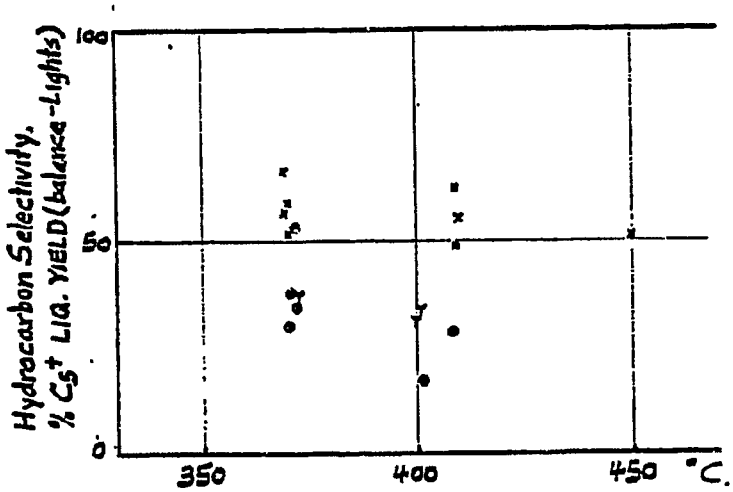


FIG. 2

STABILITY OF Y-82 with CH_3OH
RUN 9710-7, 300 PSIG, 400°C

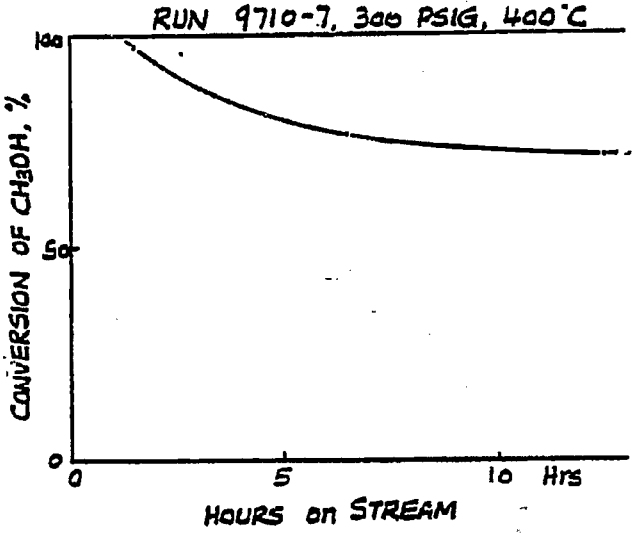
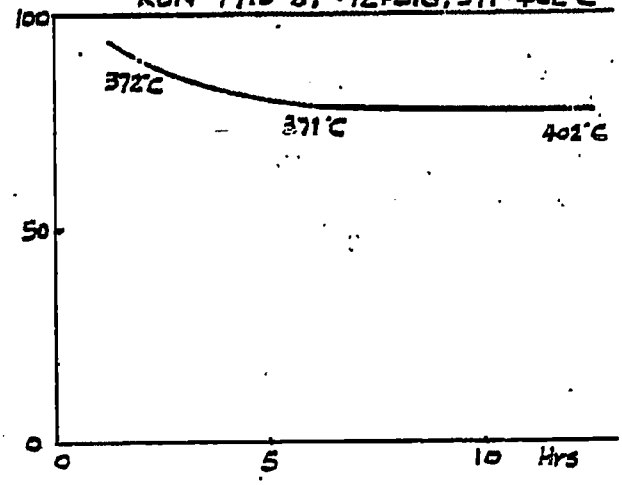
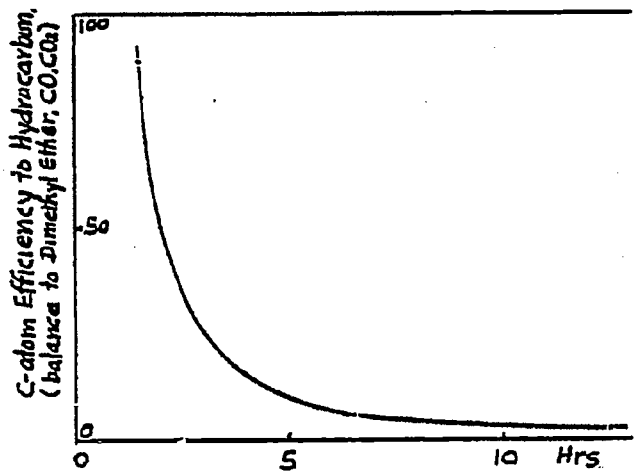
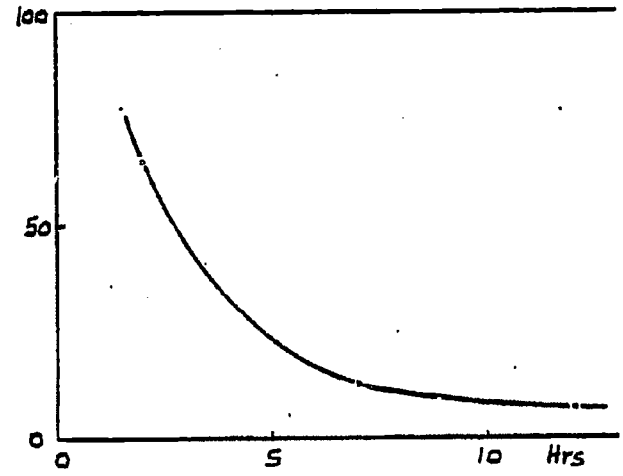


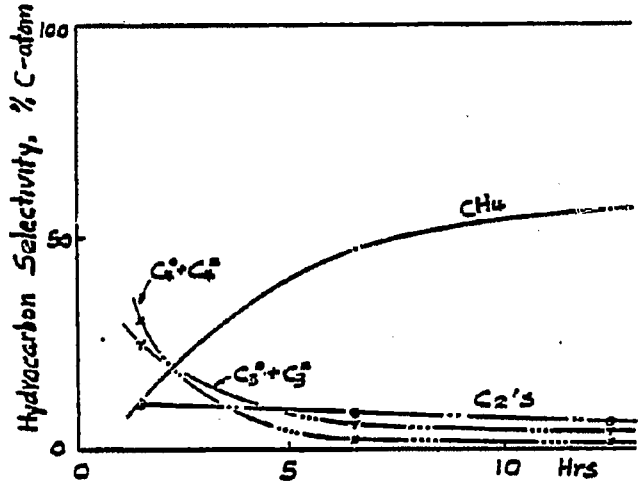
FIG. 3

STABILITY OF UCC-101
RUN 9710-8, ~72 PSIG, 371-402°C









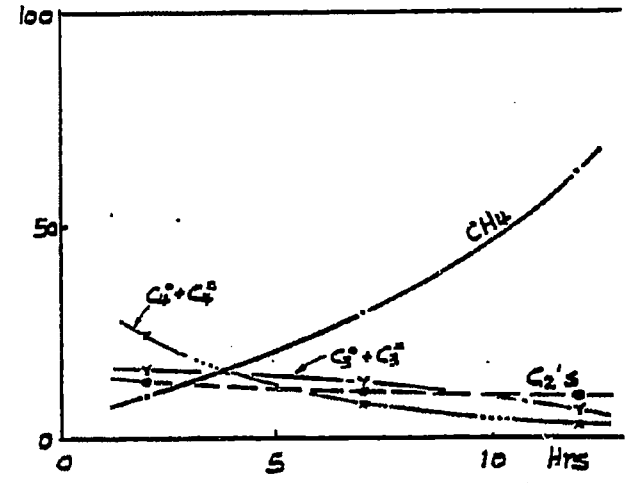
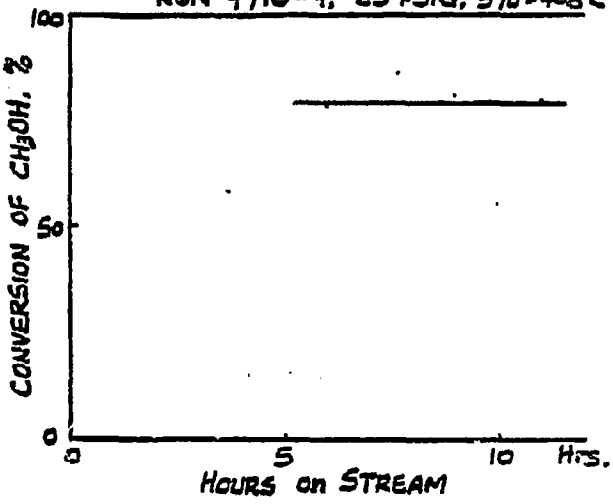
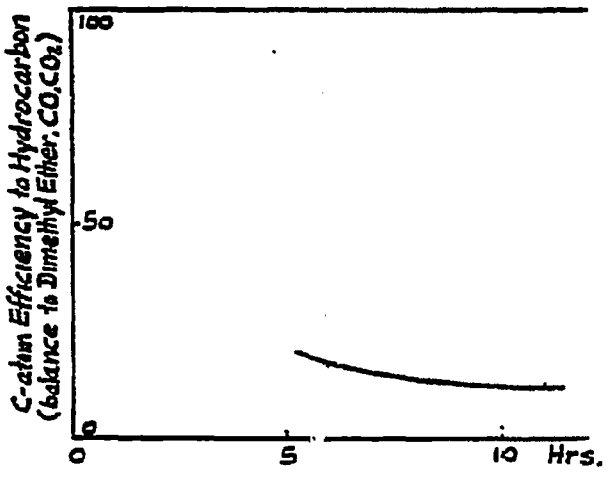
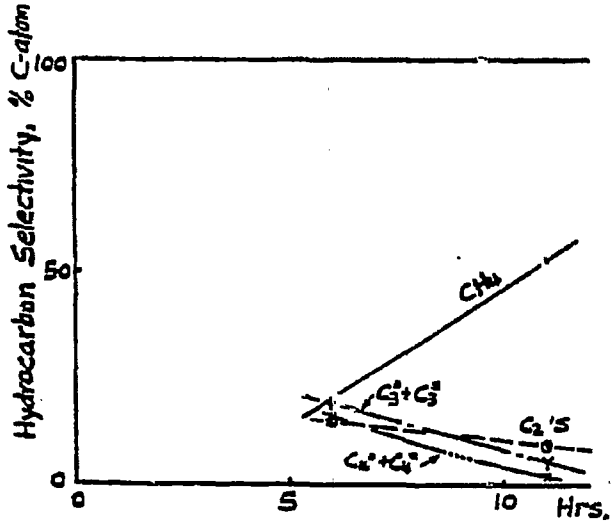


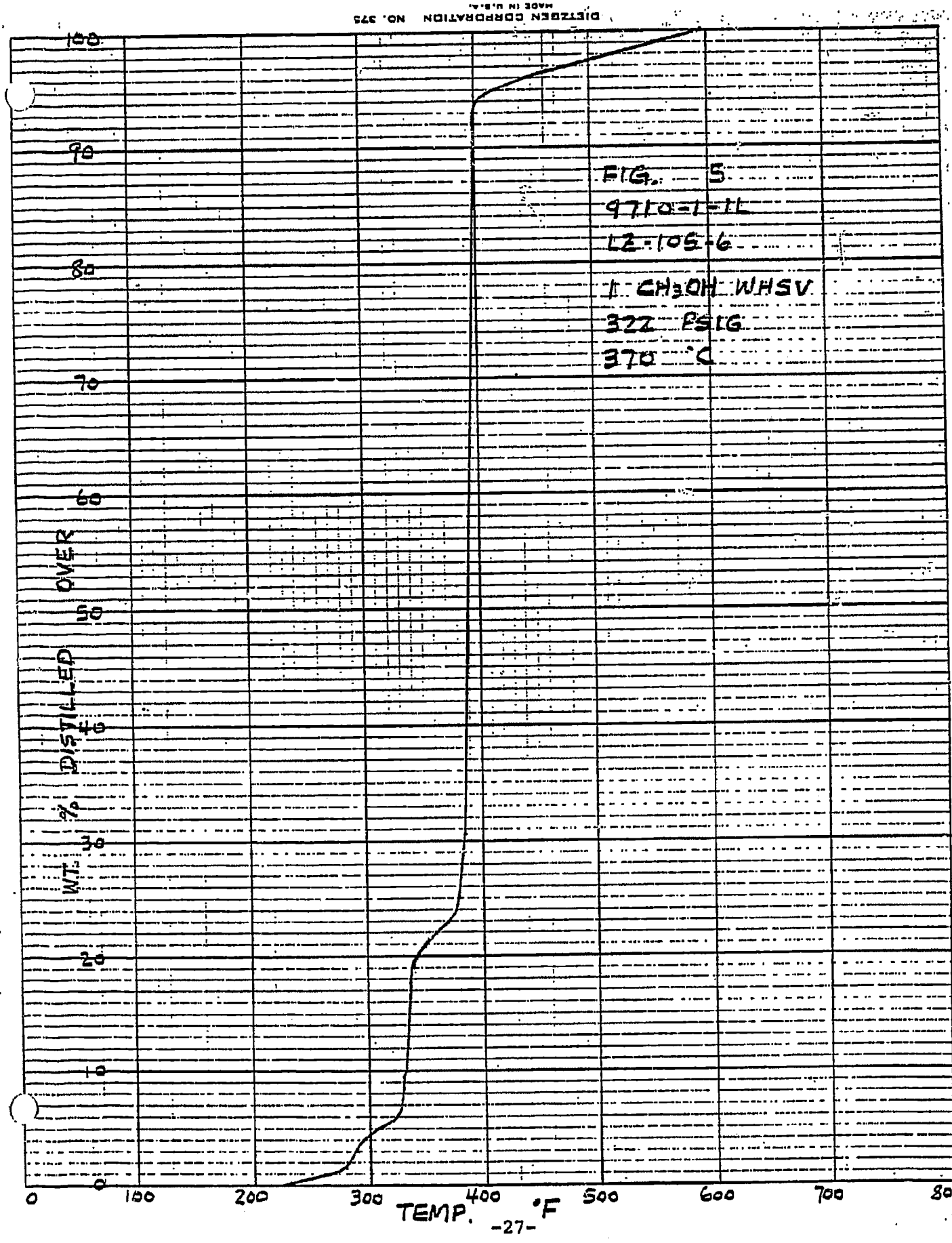
FIG. 4

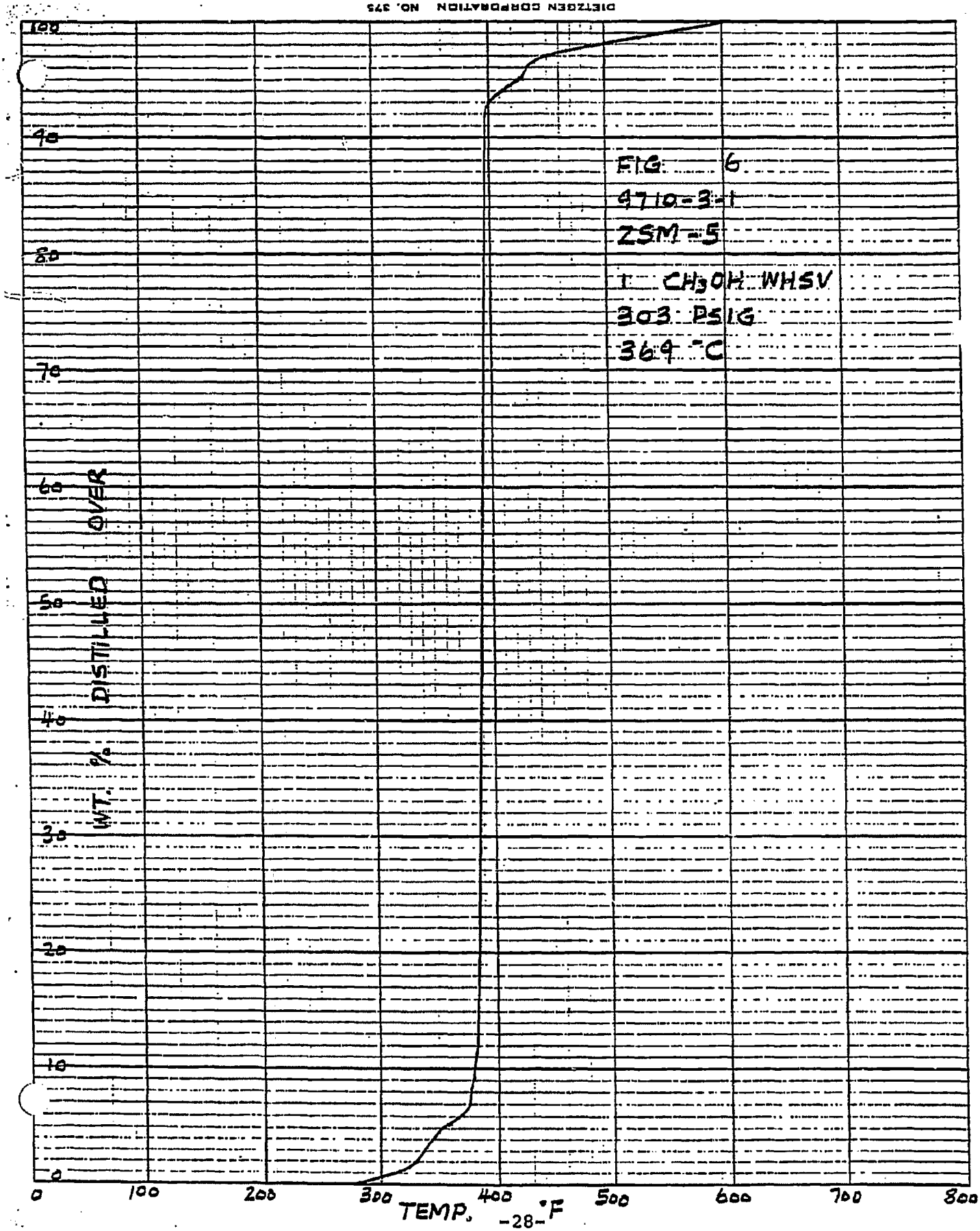
STABILITY OF UCC-101
RUN 9710-9, 25 PSIG, 370-408°C

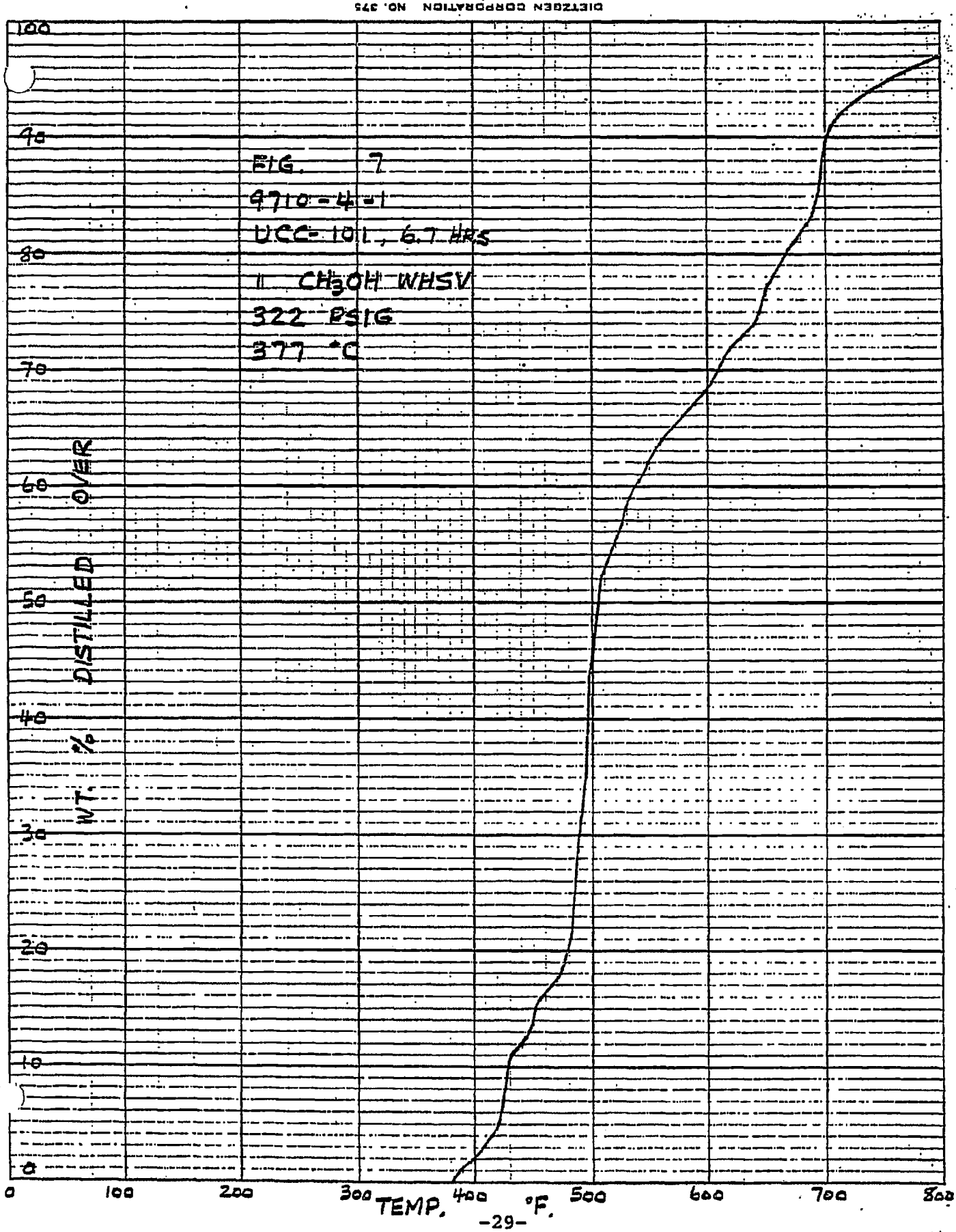


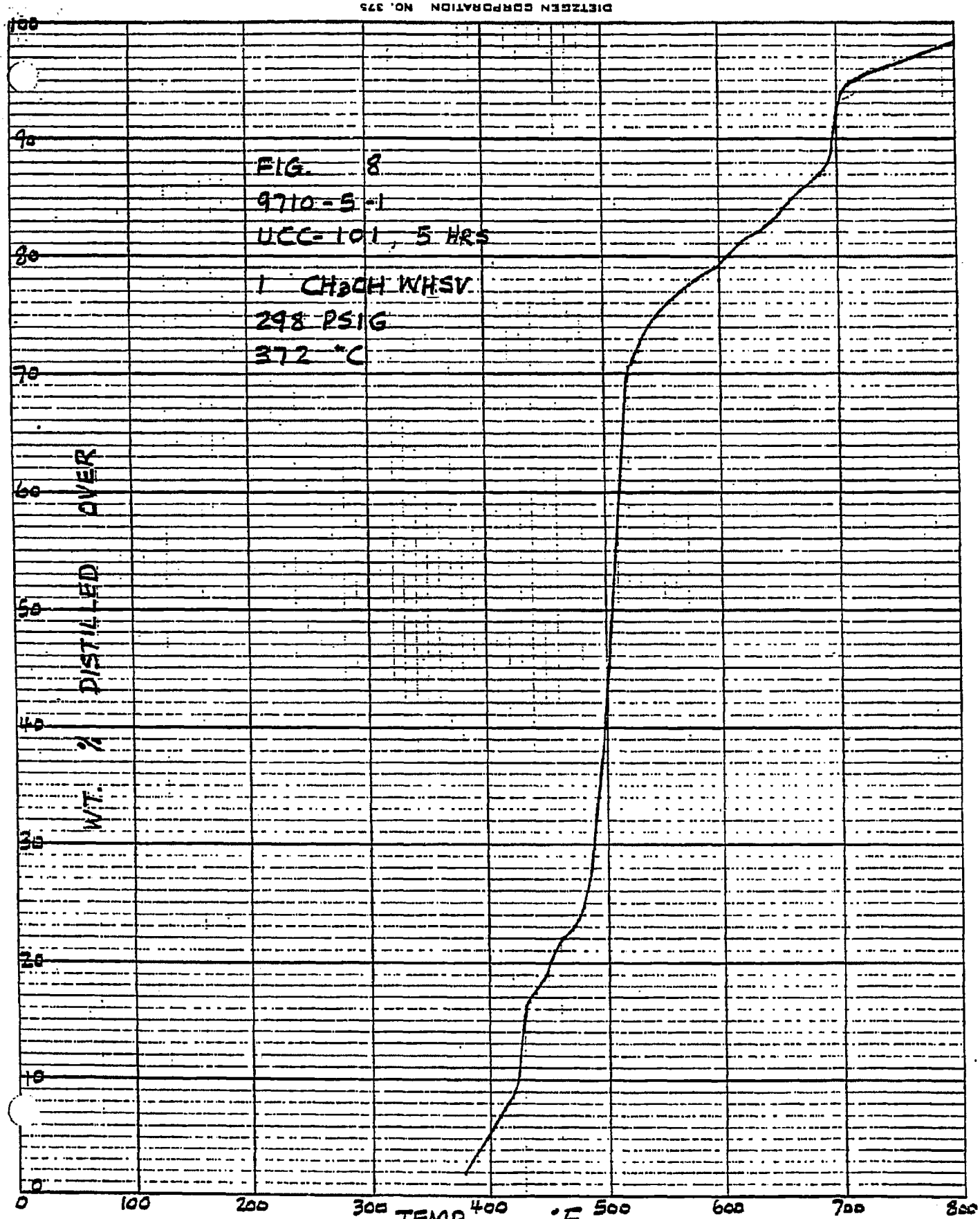


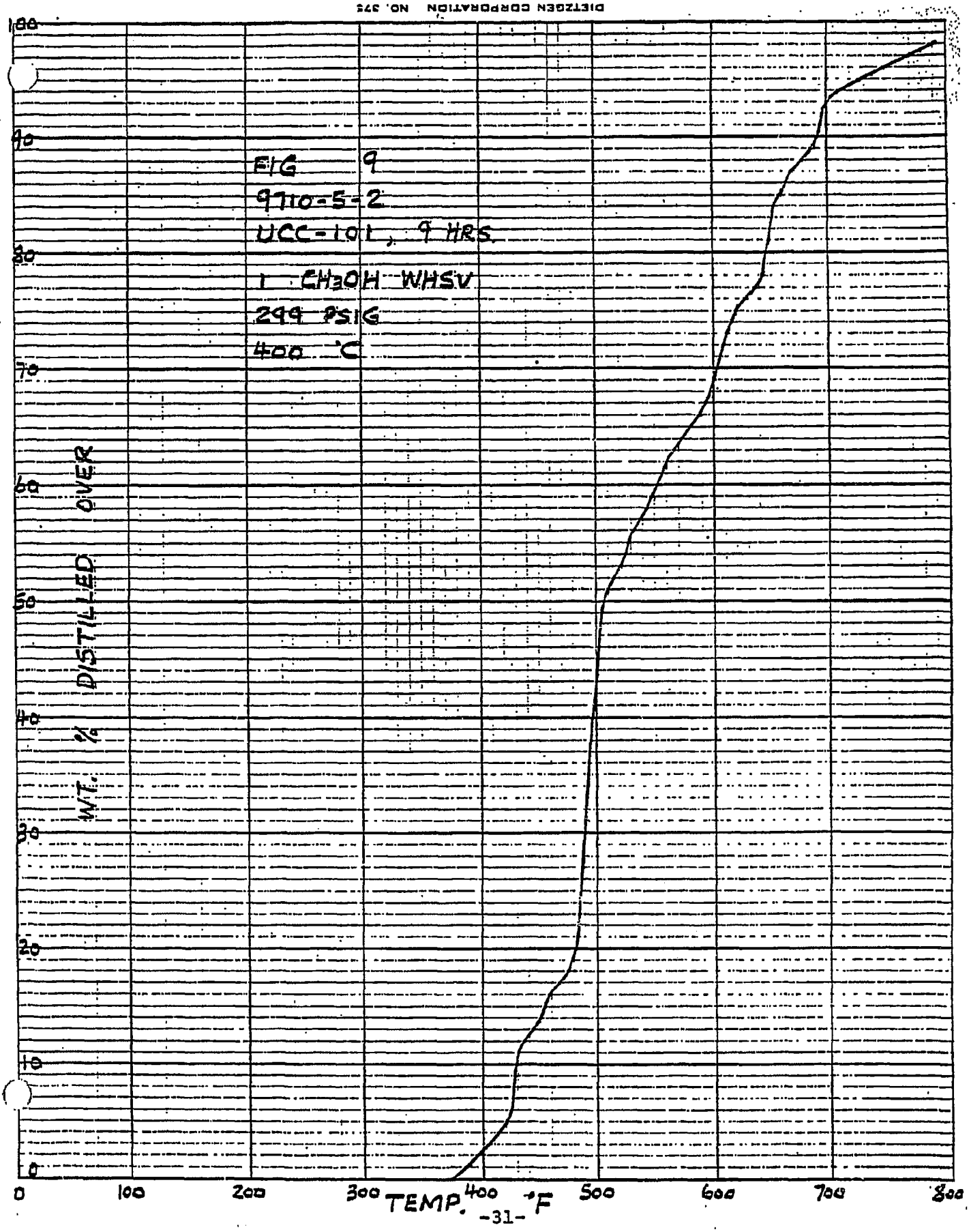


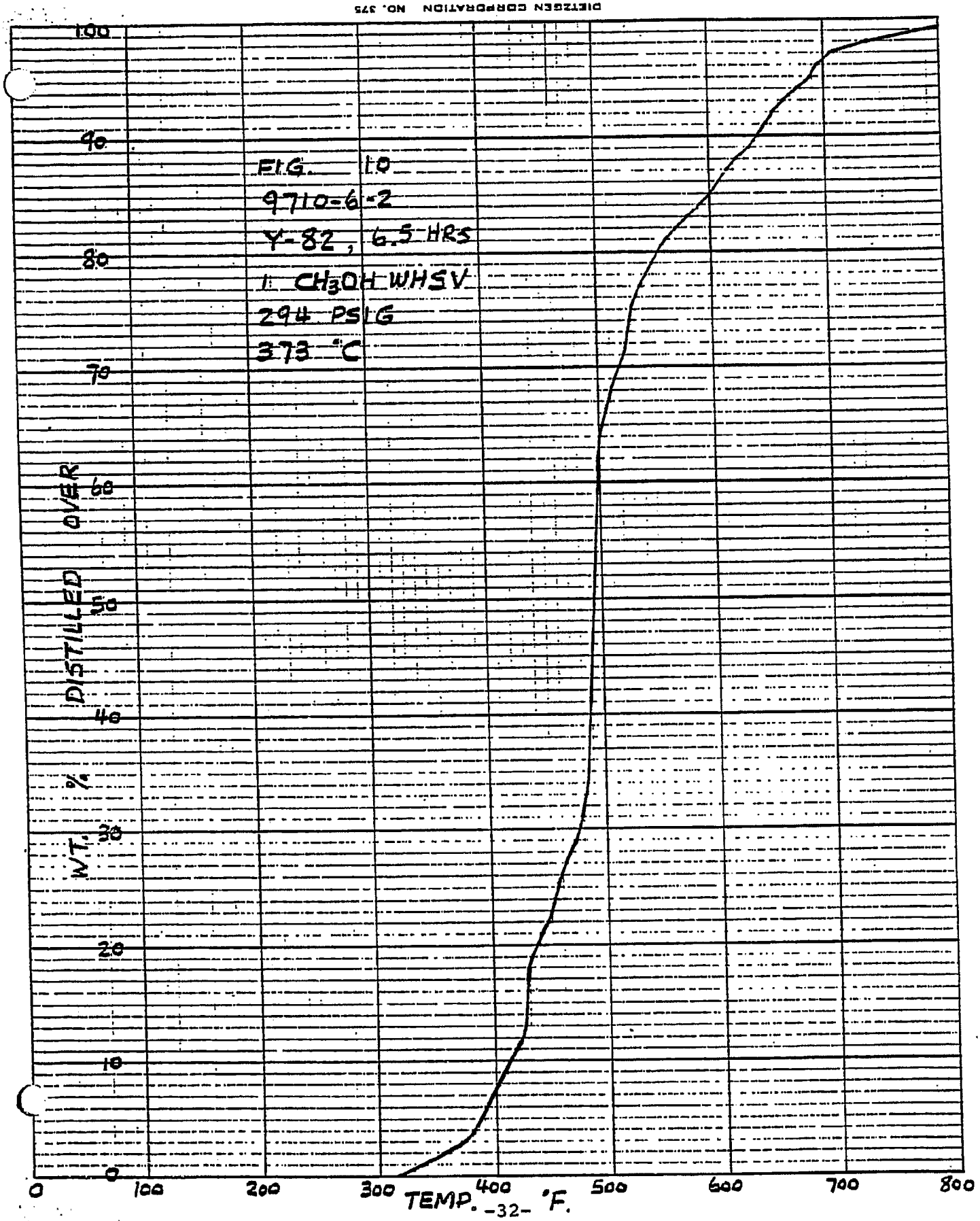

DIETZGEN CORPORATION NO. 375
MADE IN U.S.A.
100
90
80
70
60
50
40
30
20
10
0
% DISTILLED OVER
WT.
0
100
200
300
400
500
600
700
800
TEMP. °F
FIG. 5
9710-1-11
LZ-105-6
1 CH3OH WHSV
322 PSIG
370 °C

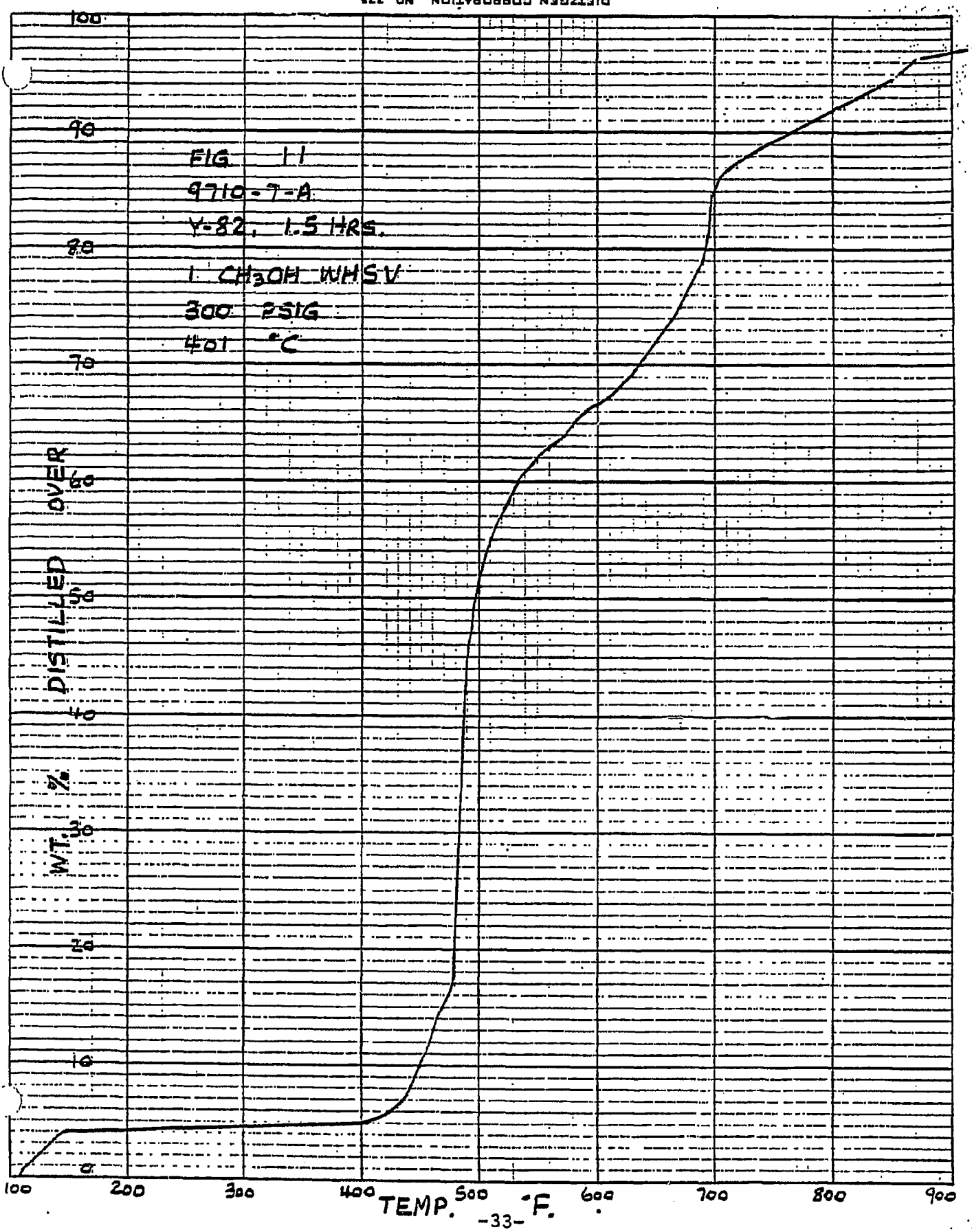


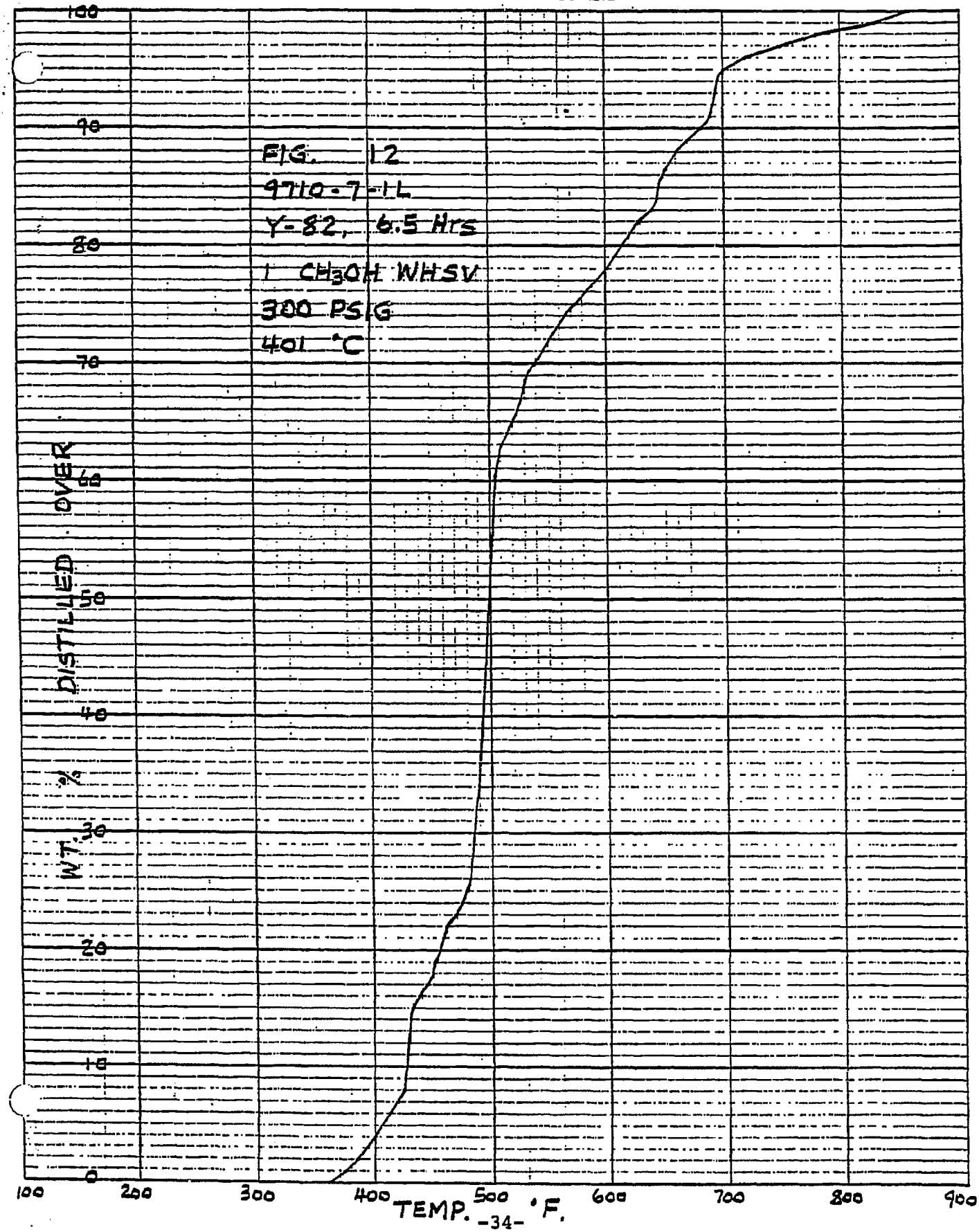


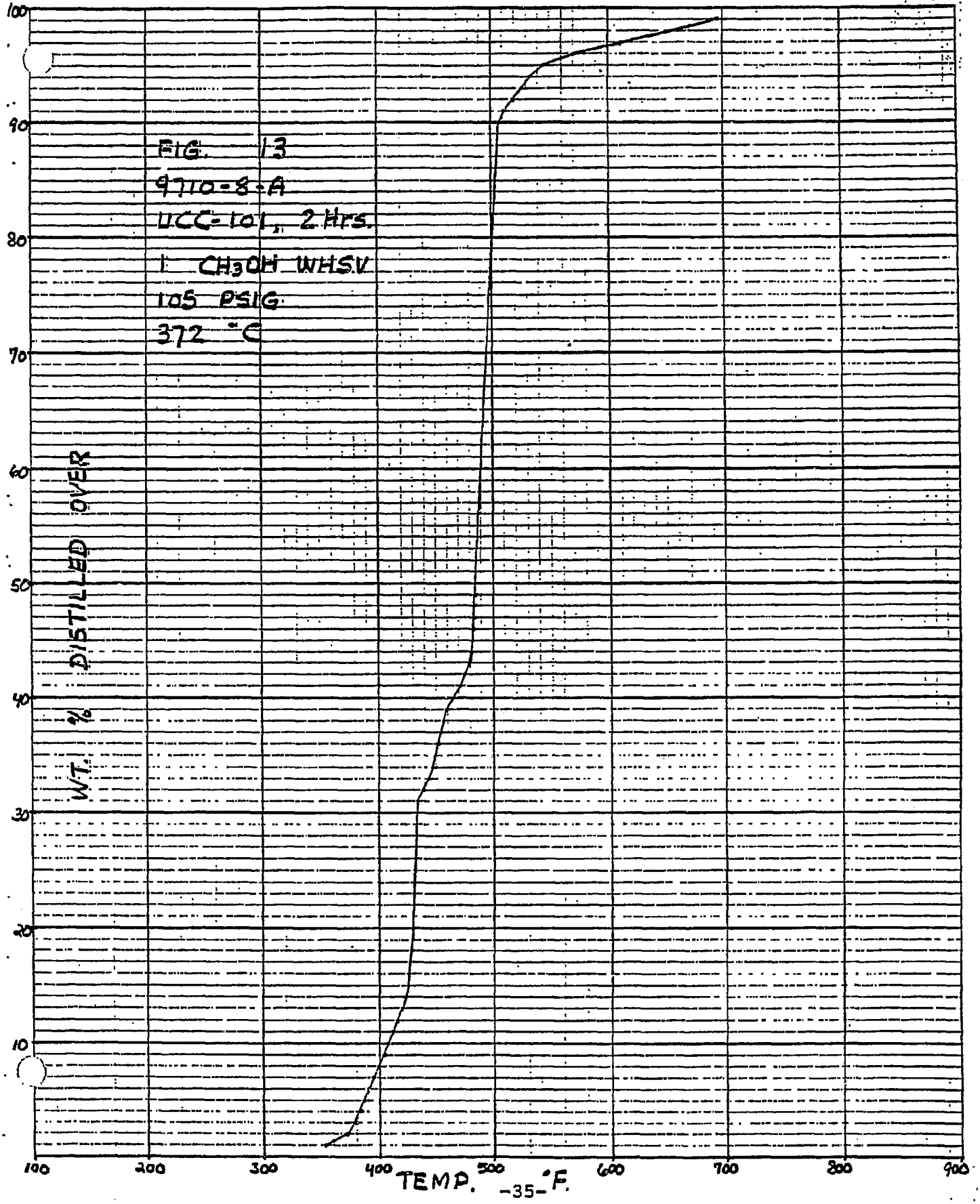


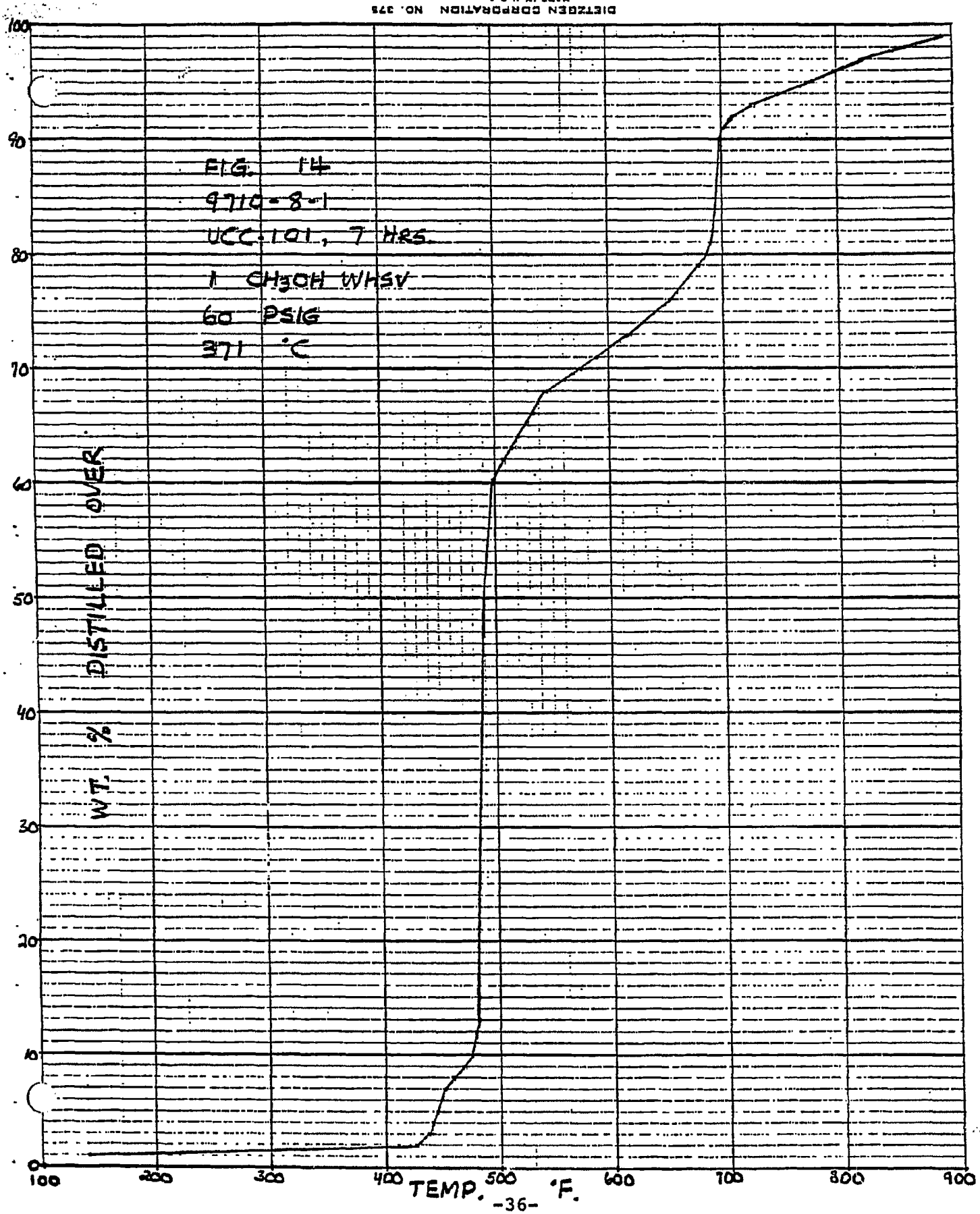


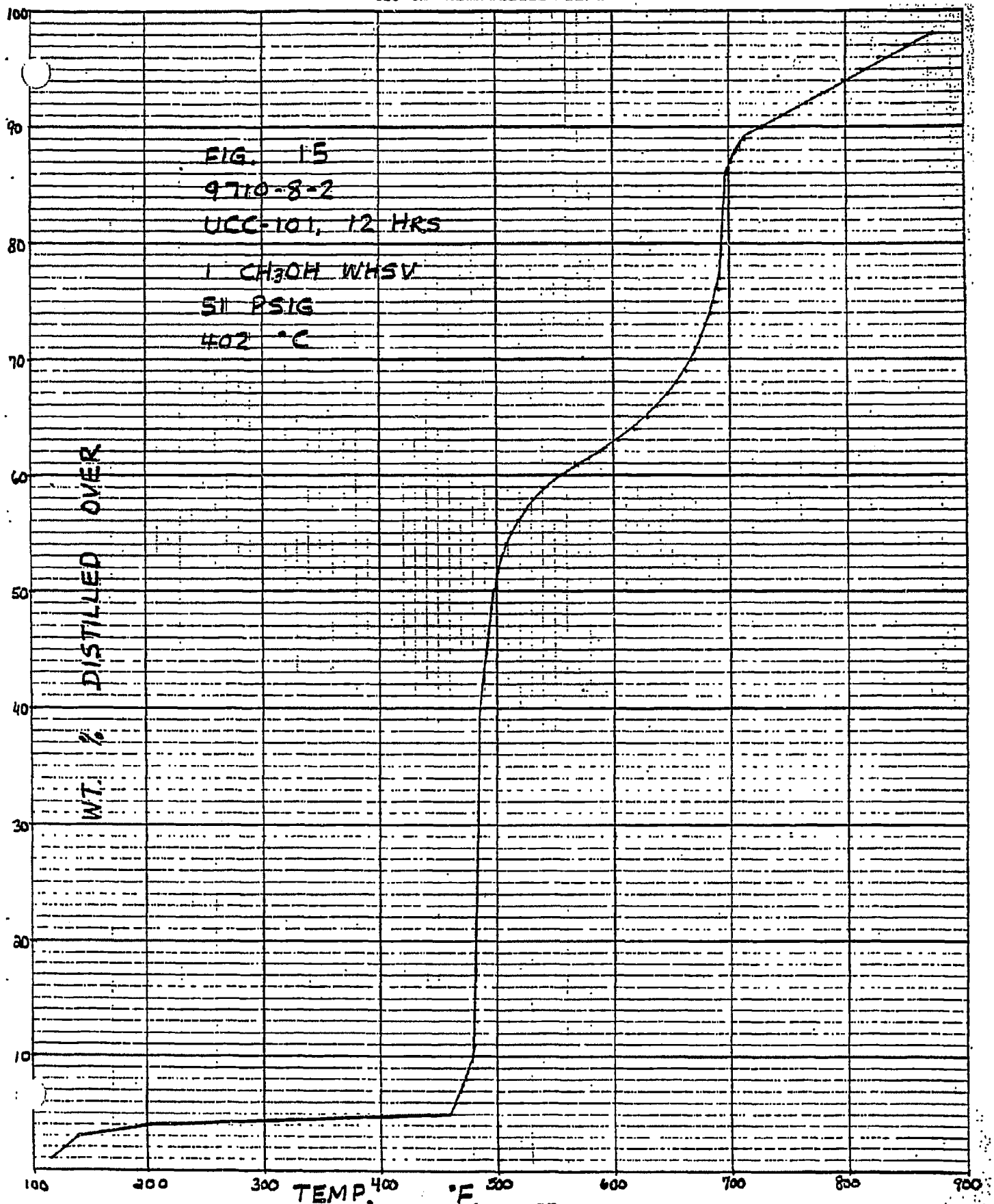


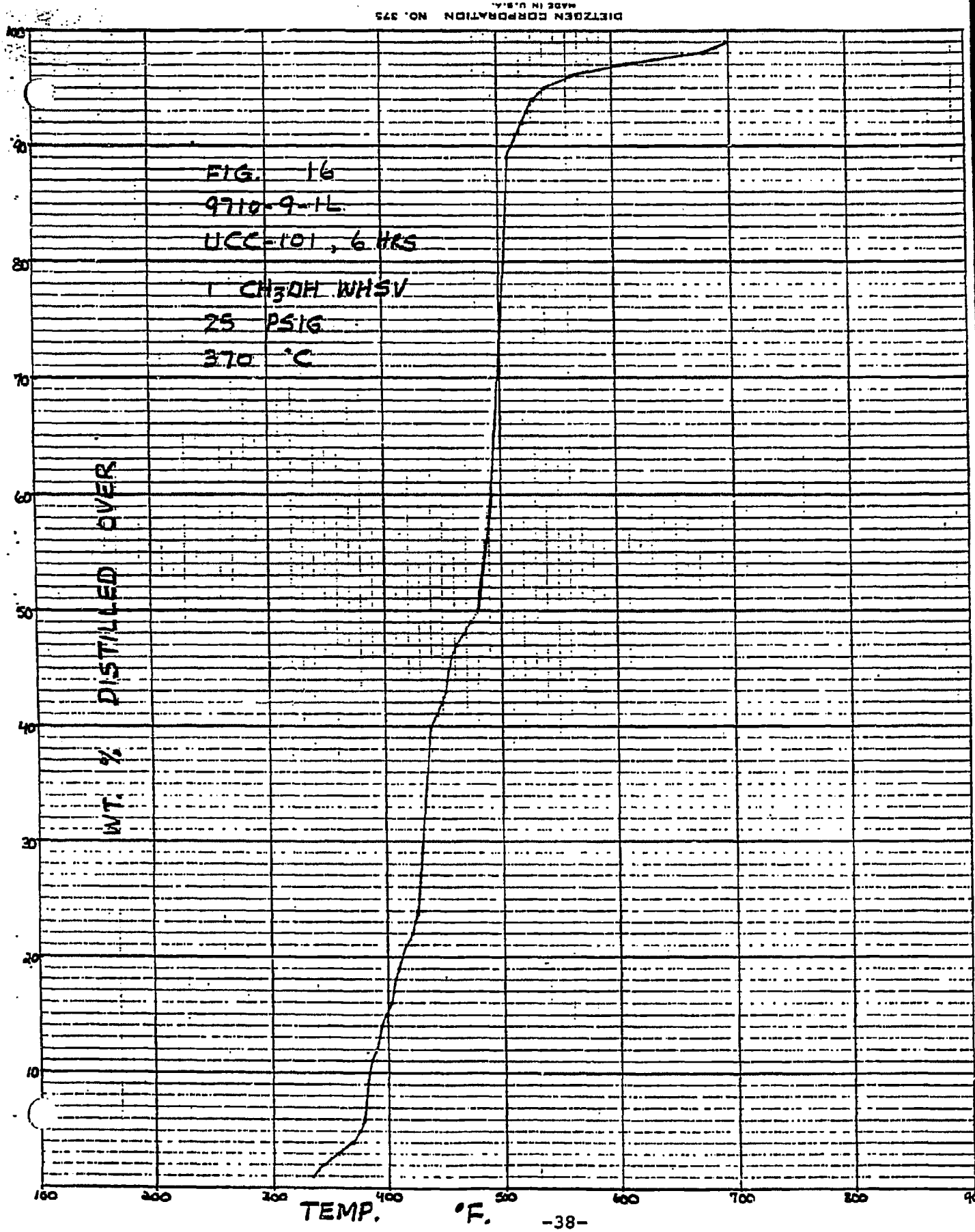


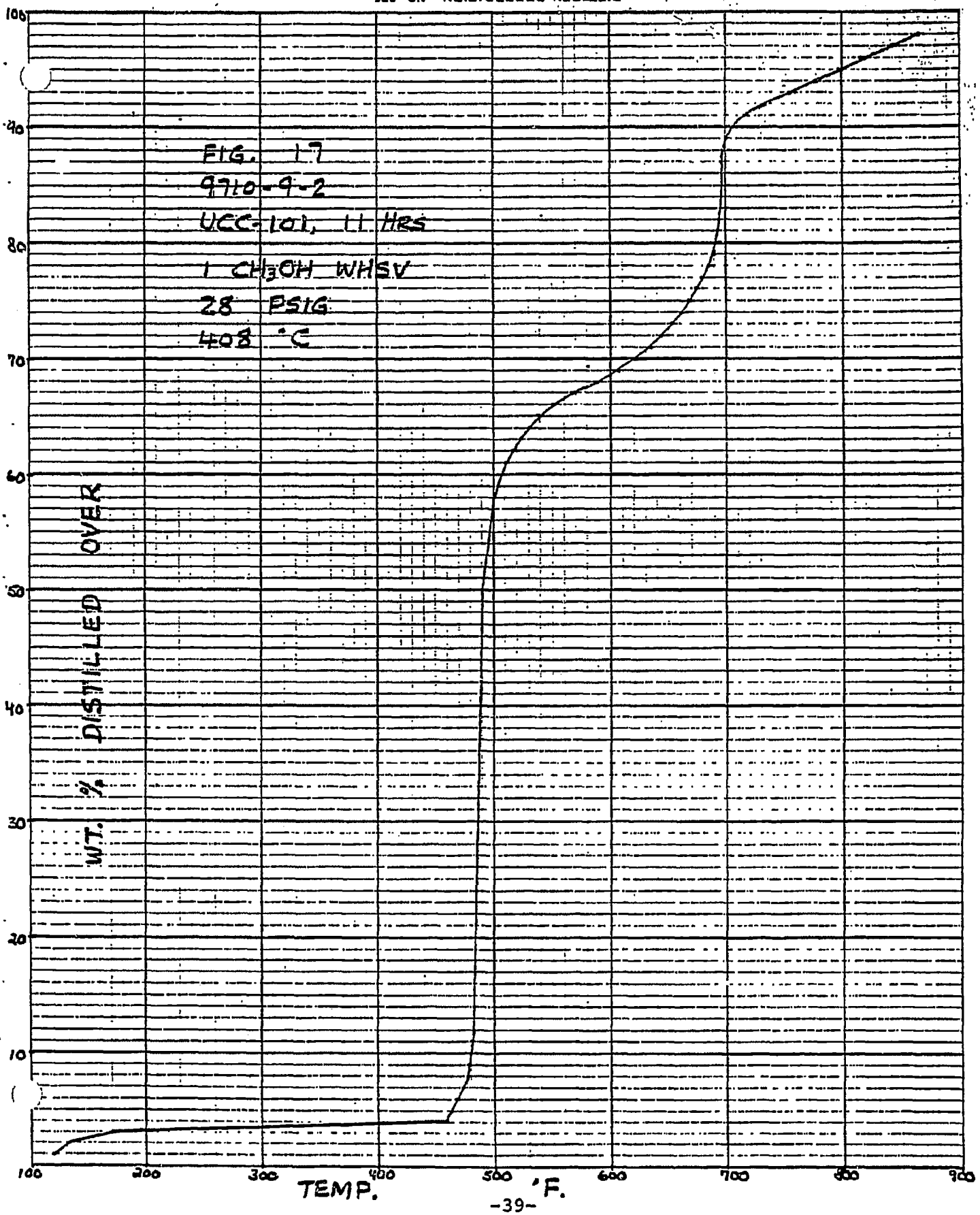


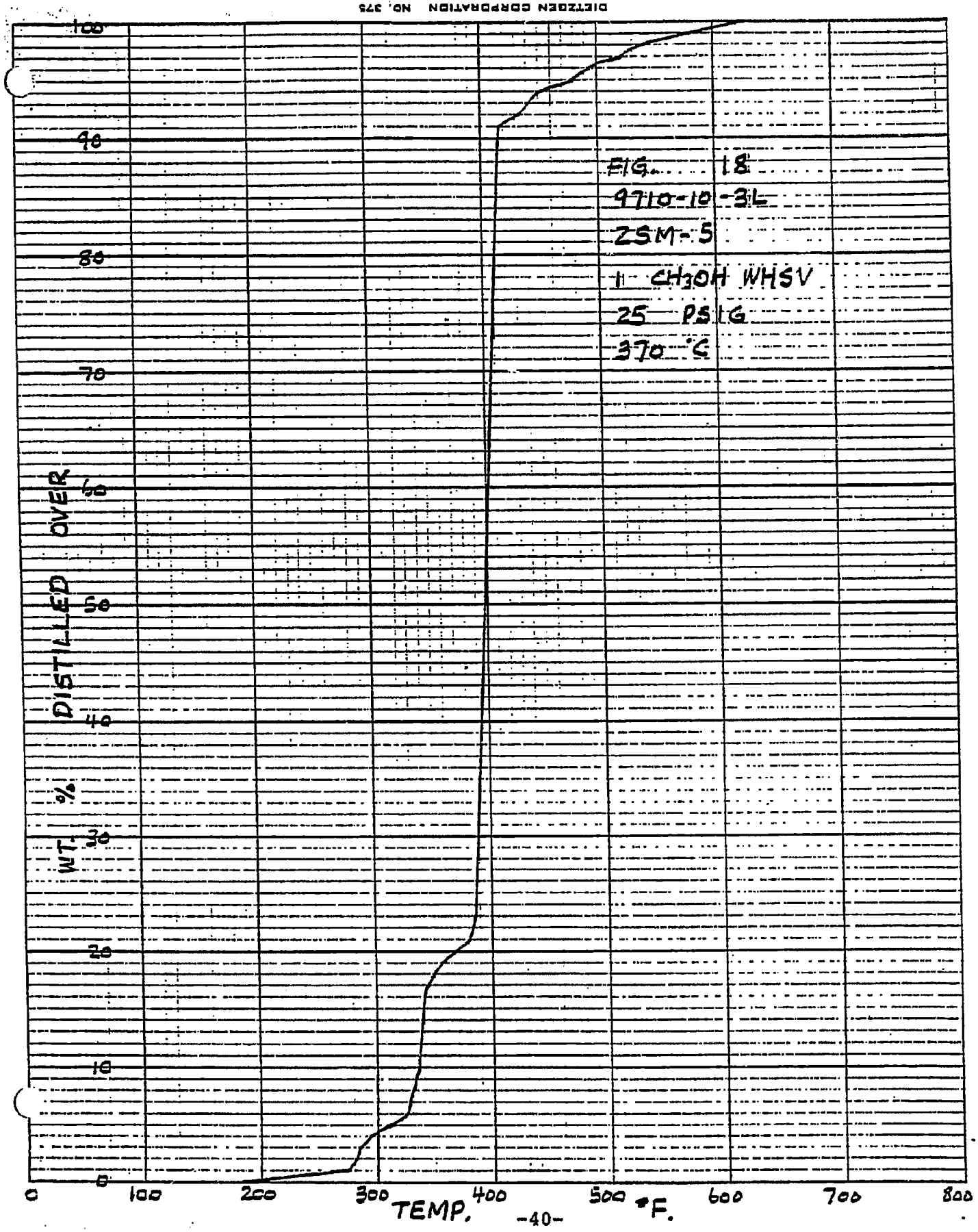


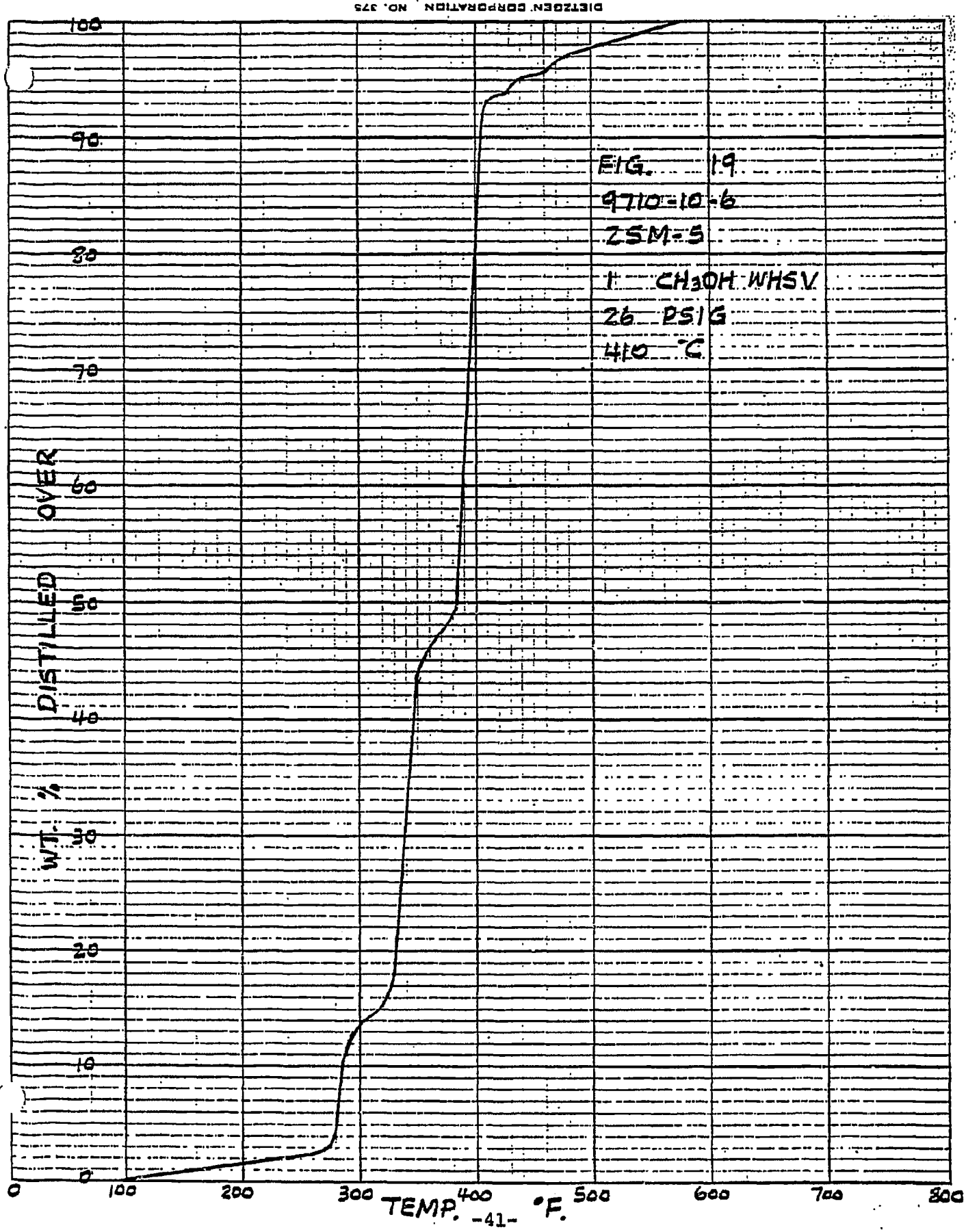


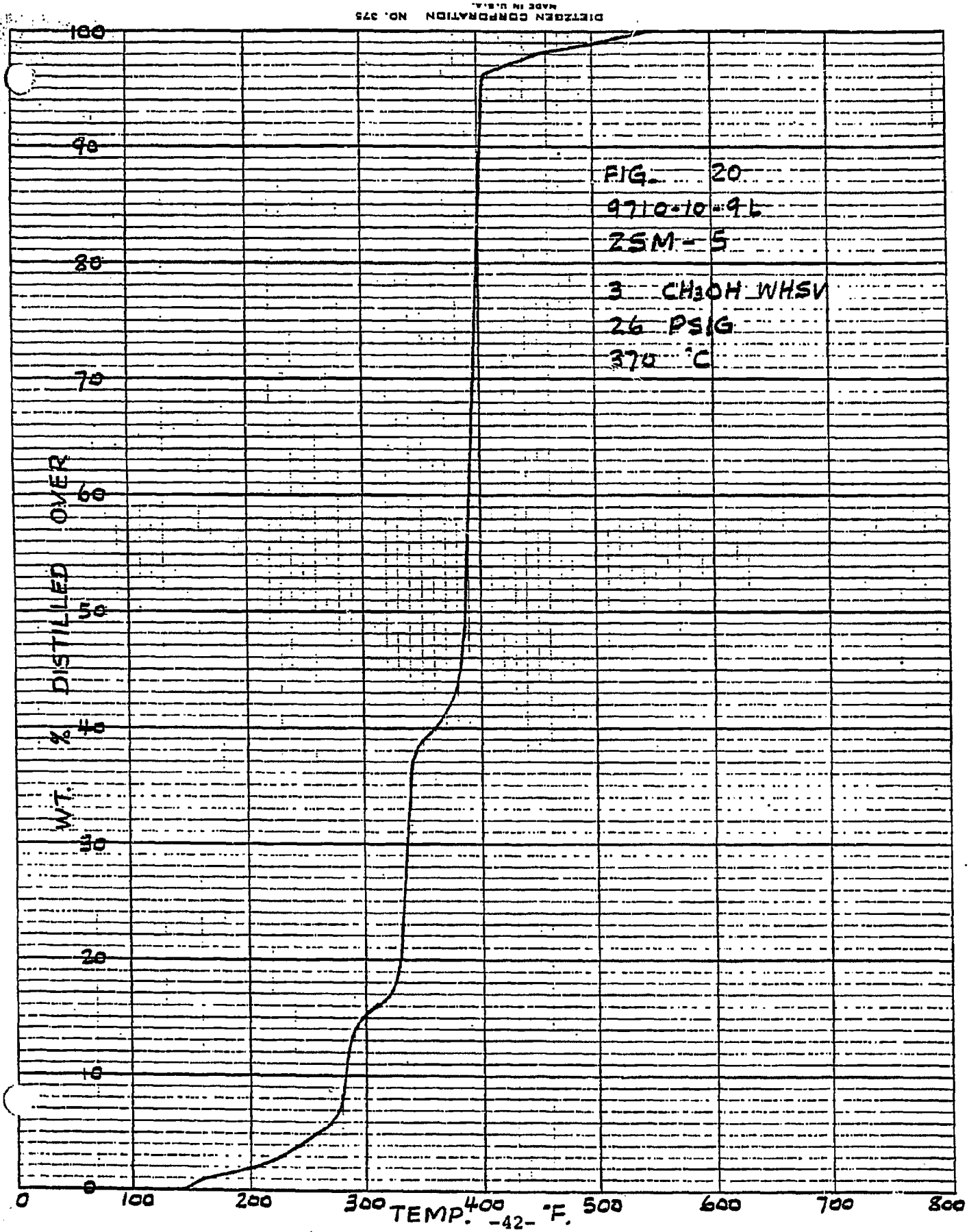


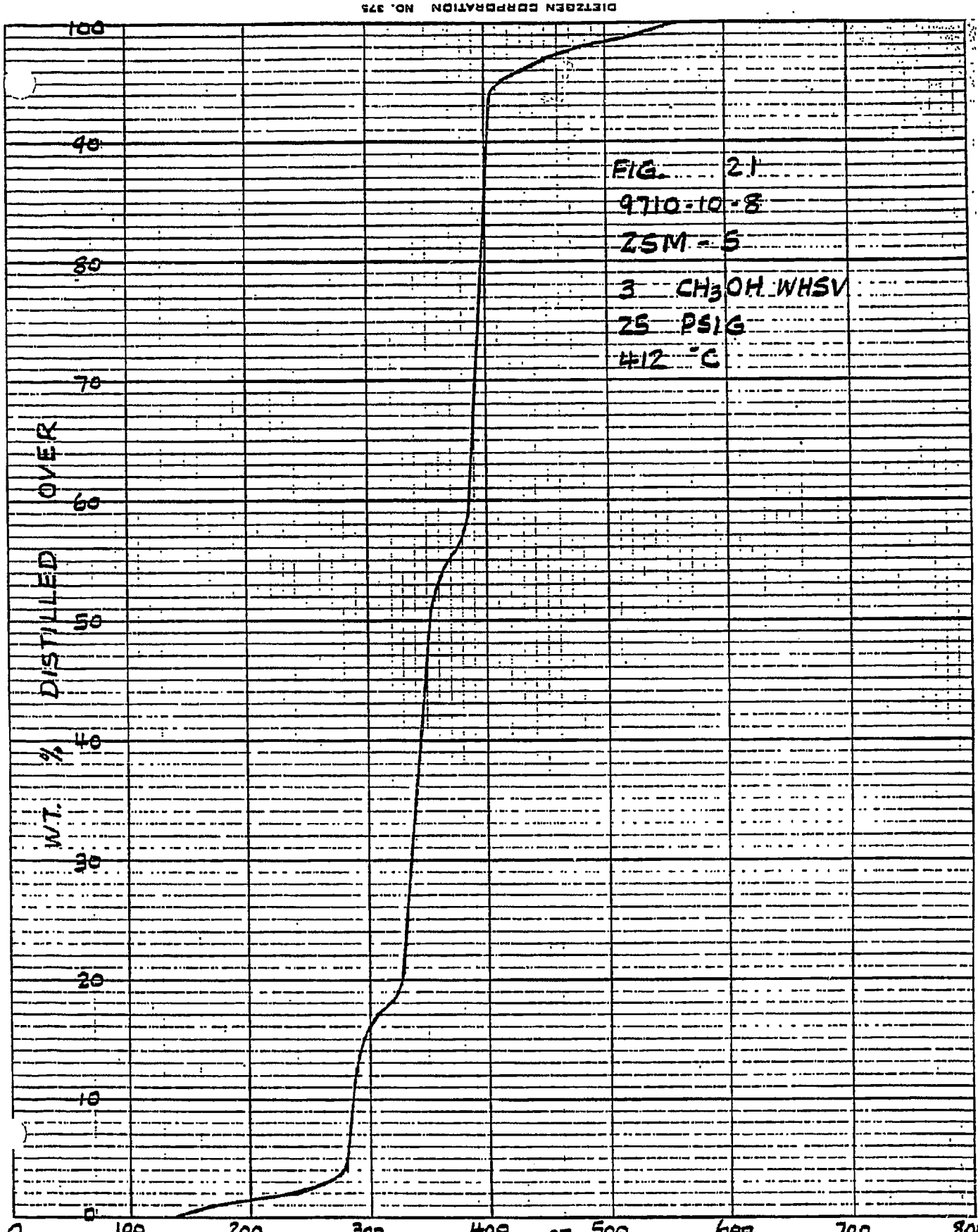

DIETZGEN CORPORATION NO. 375
MADE IN U.S.A.
FIG. 16
9710-9-1L
UCC-101, 6 HRS
1 CH3OH WHSV
25 PSIG
370 °C
WT. % DISTILLED OVER
100
90
80
70
60
50
40
30
20
10
160
200
300
400
500
600
700
800
TEMP. °F.

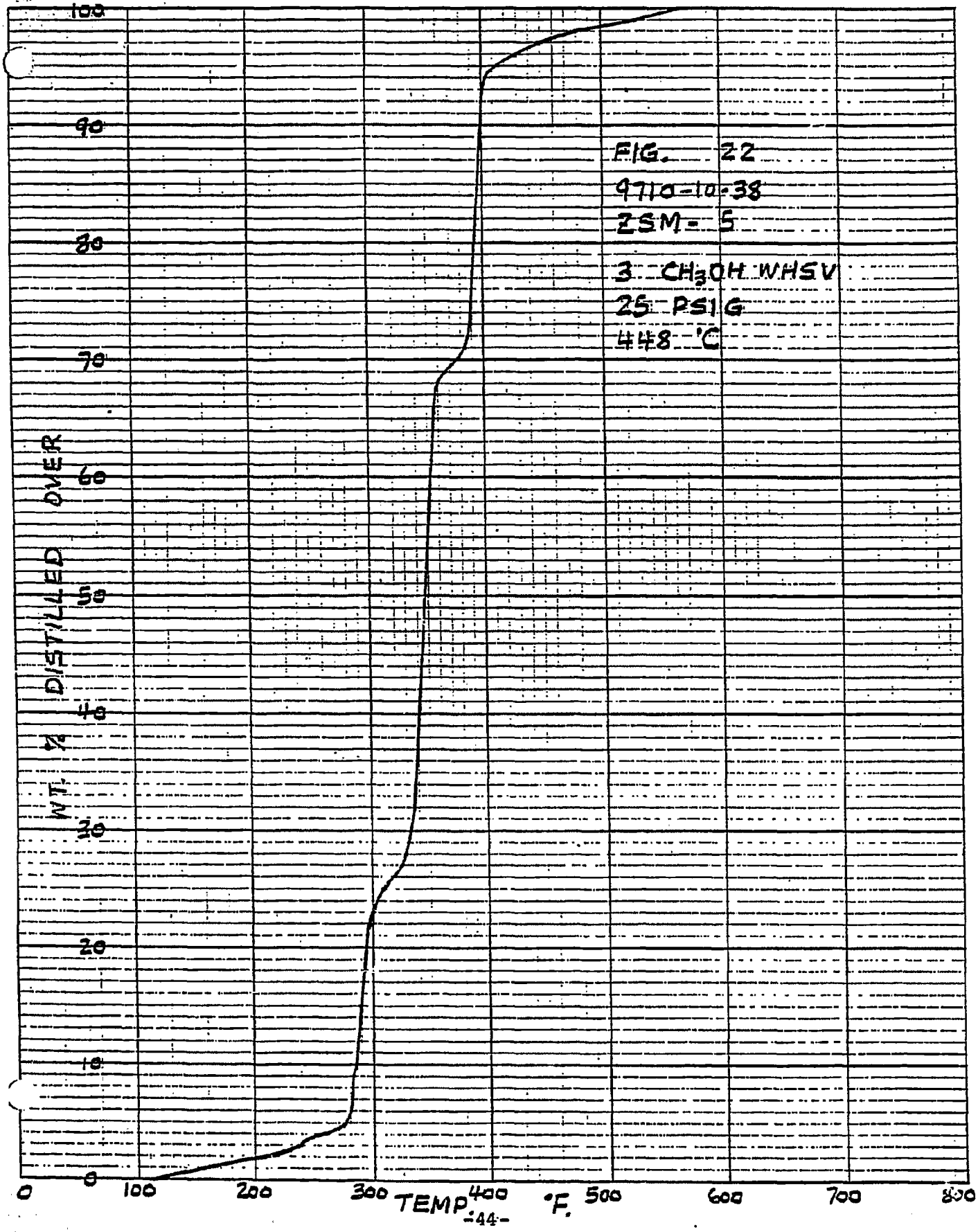

DIETZGEN CORPORATION NO. 375
MADE IN U.S.A.
FIG. 17
9710-9-2
UCC-101, 11 HRS
1 CH3OH WHSV
28 PSIG
408 °C
WT. % DISTILLED OVER
TEMP. °F.
100
200
300
400
500
600
700
800
900
10
20
30
40
50
60
70
80
90
100


DIETZGEN CORPORATION NO. 375
MADE IN U.S.A.
FIG. 18
9710-10-3L
ZSM-5
1 CH3OH WHSV
25 PSIG
370 °C
WT. % DISTILLED OVER
100
90
80
70
60
50
40
30
20
10
0
0
100
200
300
400
500
600
700
800
TEMP. °F.


DIETZGEN CORPORATION NO. 375
MADE IN U.S.A.
100
90
80
70
60
50
40
30
20
10
0
WT. % DISTILLED OVER
0
100
200
300
400
500
600
700
800
TEMP. °F.
FIG. 19
9710-10-6
ZSM-5
1 CH3OH WHSV
26 PSIG
410 °C


DIETZGEN CORPORATION NO. 375
MADE IN U.S.A.
100
90
80
70
60
50
40
30
20
10
0
% DISTILLED OVER
WT.
0
100
200
300
400
500
600
700
800
TEMP. °F.
FIG. 20
9710-10-9L
ZSM-5
3 CH3OH WHSV
26 PSIG
370 °C





Propylene Operation

Seven runs (Run 9710-11 to 9710-17) with propylene feed are reported in this section. The two catalysts used were LZ-105-6 and UCC-101. LZ-105-6 is an intermediate pore zeolite, UCC-101 is a larger pore zeolite. The general operating conditions appeared earlier in Table 1. The feed consisted of a mixture of propylene and hydrogen. The pressure ranged from 25 to 150 psig, and the temperatures tried were 280, 340, 410, and 450°C. For most of the runs the propylene was fed at 1 WHSV with C_3H_6 with H_2 added at 1 to 1 mole ratio C_3H_6:H_2. In one run, Run 9710-15 with UCC-101 catalyst, the propylene feed rate was slowed down to 0.27 WHSV with C_3H_6 to H_2 ratio of 1 to 4 at a pressure of 25 psig in an effort to extend the catalyst life.

Data from these runs appear in Tables 9 to 28. The propylene conversion, product selectivity for light hydrocarbons, gasoline range and diesel range hydrocarbons, and the product characterization in terms of aromatics, olefins and saturates are plotted in Figures 23 to 26.

Let us look first at the results of Run 9710-12 and Run 9710-13 using LZ-105-6 catalyst as plotted in Figures 23 and 24. The propylene feed rate was 1 WHSV and C_3H_6/H_2 ratio was 1/1. Although the pressure and temperature for the two runs are slightly different, there is a definite pattern of gradual deactivation as shown by the plot for propylene conversion. The plots show a steady decrease of conversion with time, and at 43-60 hours of operation, the C_3H_6 conversion dipped below

50% from an initial value of almost 100%. But even before the conversion level slipped below 50%, there was a dramatic and clear-cut pattern of decreasing conversion to aromatics and increasing production of olefins. In the early stages of operation when the catalyst is active, the high aromatic-make is accompanied by high propane and butane make. This seems to confirm one of the characteristic phenomena of catalysis with strong acid zeolites, namely the facility to promote hydrogen redistribution among the hydrocarbons:

Olefins → Aromatics + Paraffins

When the catalyst deactivates, and presumably the strong sites are eliminated by coking, this is also the first activity to diminish. Skeletal isomerization activity as shown by the iso/normal ratio in the product underwent some reduction as well.

Now let us look at the result of Run 9710-11 as plotted in Figure 25. The conversion of propylene started to drop quite significantly from 77%, to 58% between 46 hours and 53 hours of operation (sample no. 4 and 5). At this point, the continuous feeding of propylene to the catalyst was interrupted, but the hydrogen flow to the reactor continued overnight. Next day, the propylene was fed during daytime hours only with the hydrogen purge continued overnight. This mode of operation was repeated for the next three days for product samples 6,7, and 8. We see from the plot (Figure 25) that the propylene conversion level recovered from 58% back to a 72% level (sample 8).

The aromatic formation did not enjoy a similar recovery; the hydrocarbon product remained highly olefinic. The activities which recover after a hydrogen purge are the polymerization and the isomerization activities. This is encouraging since in the Fischer-Tropsch synthesis with syngas feed, there will be an excess of hydrogen over the catalyst with a metallic hydrogenating component present. Consequently, the deactivation phenomenon observed here is not expected to be as severe a problem in syngas runs as it was with propylene feed in these Task 1 tests.

Figure 26 shows the result of the propylene runs with UCC-101. This molecular sieve is a larger pore zeolite than LZ-105-6, and it also deactivates faster. These runs lasted from 7 to 14.5 hours on stream. For the sake of ease in comparison, all four runs are plotted side by side on the same page. For three of the runs (Run 9710-16, 9710-17 and 9710-14), the operating conditions are similar, with a C_3H_6/H_2 ratio of 1/1 feed, 1 WHSV C_3H_6 feed rate, and 150 psig pressure. The only difference was the temperature. The plots are arranged in order of increasing temperature: Runs 9710-16, 17 and 14 at temperatures of 277°C, 340°C and 408°C respectively. The propylene conversions for the three runs are all low, ranging from 15% to 31% with higher temperature giving higher conversion, but the catalysts all show signs of deactivation early in time, between 4 to 11 hours. As the temperature increased from 277° to 408°C, the product selectivity for C_1-C_4 light hydrocarbons increased and that for C_5^+ higher boiling hydrocarbons decreased.

Also, as the temperature increased, the aromatics in the product also increased.

The result of Run 9710-15 is also plotted on the same sheet at right. The operating conditions are quite different. A more dilute propylene feed is used, with a propylene/hydrogen mole ratio of 0.2/0.8. The propylene feed rate is slower, at 0.27 C_3H_6 WHSV. The temperature is 408°C and the pressure is lower, at 25 psig. The catalyst life is extended to about 15 hours due to lower olefin loading to the catalyst. The initial activity as shown by C_3H_6 conversion is higher, 41% at 3.5 hours. The product selectivity for C_1-C_4 light hydrocarbon fraction is also higher, probably due to the low operating pressure, the lower propylene feed concentration and the higher volumetric feed rate. The aromatics make is also lower than in Run 9710-14 at the same temperature.

For a comparison of the relative boiling range of the condensed product hydrocarbon molecules made from the intermediate pore size LZ-105-6, and the large pore size UCC-101 we can look at the simulated distillation data of the liquid collected from Runs 9710-13 and 9710-14, where the operating conditions are the same: 1 WHSV C_3H_6 feed rate, 1/1 C_3H_6/H_2 ratio, 150 psig and 410°C. Figures 27, 28, 29 and 30, 31 show respectively the simulated distillation plots of the samples from Runs 9710-13 and 9710-14. It should be pointed out here that the condensed liquid hydrocarbon sample used in simulated distillation constituted only a portion of the C_5^+ hydrocarbon

product, and its relative amount varies according to the activity of the catalyst as reflected by its conversion level. The relative amounts of the condensed hydrocarbons collected are tabulated below:

TABLE RELATIVE AMOUNT OF CONDENSED HYDROCARBONS

CATALYST	LZ-105-6			UCC-101	
RUN & SAMPLE	9710-13-1	9710-13-4	9710-13-6	9710-14-1	9710-14-2
C_3H_6 CONVERSION	97.2	72.8	33.2	31.0	15.3
PRODT SELECTVTY C_5^+ Wt.%	33.19	71.99	74.77	46.01	56.80
LIQ COLLECTED	20.0	41.2	18.9	14.1	2.89
RATIO LIQ/C_5^+	0.60	0.57	0.25	0.306	0.051

Among the first three figures 27, 28 and 29 for samples 13-1, 13-4 and 13-6, the plots for samples 13-4 and 13-6 are very similar, while the first plot for sample 13-1 is different. The first sample is a product made from a fresh LZ-105-6 catalyst; the catalyst is active with 97.2% conversion and makes a lot of aromatics. The distillation plot certainly reflects large quantities of aromatics present in the sample. One can see distinct peaks for toluene, xylenes, and other aromatics. The plot from the other two figures for samples 13-4 and 13-6 are similar and close to each other, smoother in appearance; the samples are olefinic in nature. Of the two plots for product samples from UCC-101 catalyst, the second plot, figure 31 for sample 14-2 is heavier in boiling range; however, this sample is not

representative of the C_5+ fraction, as the condensate was so small that it constituted only a very small fraction (5%) of the C_5^+ fraction (i.e. 95% of the C_5^+ stayed in the gas phase). It is reasonable to compare the plots of samples 13-6 and 14-1, or figures 29 and 30 because these two product samples are obtained at similar levels of conversion (33% and 31%) and represent similar proportions of the respective total C_5^+ fraction (0.25 and 0.306). The simulated distillation data are repeated below:

Catalyst Sample No. Simulated Distillation	LZ-105-6 13-6 @ Deg.F	UCC-101 14-1 @ Deg. F	Diff. (UCC-101-LZ-105-6) Deg. F.
10 wt.% @ Deg.F	165	249	+84
16	203	279	+76
50	286	383	+97
84	357	505	+148
90	384	560	+176
Range (16-84%)	154	226	+72

At all levels of the boiling point distribution, the liquid product collected from UCC-101 catalyst boils higher than that from LZ-105-6, on the average about 116°F higher. Not only that, the boiling range is also wider, 72°F wider for UCC-101. This demonstrates the potential of UCC-101 catalyst to produce higher boiling product. To do this properly, the process conditions would have to be optimized under syngas feed conditions. Higher pressure and lower temperature than the conditions for propylene feed runs 9710-13 and 9710-14 would probably lead to more desirable turbine and diesel range product yields.

It is envisioned that the rapid deactivation associated with the large pore UCC-101 on propylene feed may be significantly reduced by the introduction of water co-feed, and such experiments are planned for the near future. Furthermore, water co-feed more closely simulates the environment the catalyst will experience under Task 2 syngas feed operation. We therefore do not expect severe deactivation problems when UCC-101 is incorporated with a Fischer-Tropsh metal component and tested with syngas feed.

TABLE 9 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-11
CATALYST LZ-105-6 #9939-01 50 CC 34.36 GM (38.18 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 330 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-11-1	9710-11-2	9710-11-3	9710-11-4	9710-11-5
C3H6 WHSV	1.0	1.0	1.0	1.0	1.0
HRS ON STREAM5	5.7	22.3	29.3	46.3	53.3
PRESSURE,PSIG	24	24.3	26	40.6	26.4
TEMP. C	411	408	412	411	411
FEED C3H6 CC	[359.73	[1266.59	[524.16	[1200.15	[500.75
HOURS FEEDING	[5.75	[16.5	[7.00	[17.00	[7.00
EFFLNT GAS LITER	[194.9	[559.48	[232.57	[578.70	[254.5
GM LIQ HYDROCARBON	[55.8	[188.67	[66.43	[126.93	[25.61
WT FR. LIQ HC/FEED	.3025	.2905	.2472	.2063	.0997
MATERIAL BALANCE WT %	99.09	84.81	76.13	114.08	82.39
C3H6 CONVERSION %	94.37	85.75	81.08	77.18	58.27
PRDT SELECTIVITY WT %					
CH4	0.7233	0.1362	0.1342	0.0435	0.0454
C2 HC'S	2.3510	1.2298	1.2889	0.4009	0.4306
C3H8	30.1422	6.6663	6.0960	8.0471	4.6857
C4H10	17.9181	9.7681	7.6749	1.6753	0.9575
C4H8=	2.5276	13.4157	17.3353	21.1027	19.6511
C5H12	4.6290	5.1768	3.5549	1.6791	0.4909
C5H10=	0.7209	7.9965	5.1526	15.3231	12.2498
C6H14	1.1932	3.5439	3.3998	4.0980	3.4182
C6H12=	0.1787	2.0548	4.2998	12.8985	13.6338
C7+ IN GAS	7.0046	9.8013	10.7088	11.1796	23.5097
LIQ/SATURATES	0.3913	2.8147	2.7845	0.0000	0.0628
LIQ/OLEFINS	0.3587	9.7310	21.1862	20.3255	16.1558
LIQ/AROMATICS	31.8613	27.6649	16.3840	3.2266	4.7086
TOTAL	100.00	100.00	100.00	100.00	100.00
SUBGROUPING					
C1 -C4	53.66	31.22	32.53	31.27	25.77
C5 -420 F	35.41	63.90	63.52	67.25	73.31
420-700 F	10.92	4.88	3.95	1.48	0.92
C5 -END PT	46.34	68.78	67.47	68.73	74.23
FOR C5+ FRACTION					
SATURATES, WT %	13.59	17.77	15.53	8.41	5.45
OLEFINS	2.88	32.21	53.74	84.67	81.08
AROMATICS	83.53	50.02	30.73	6.92	13.47
ISO/NORMAL MOLE RATIO					
C4	1.375	2.030	1.932	0.098	1.278
C5	2.930	2.547	2.420	1.899	2.000
C6	4.850	2.644	1.910	1.158	0.650
C4=	0.451	0.423	0.415	0.371	0.346

TABLE 10 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-11 (CONTINUED)
CATALYST LZ-105-6 #9939-01 50 CC 34.36 GM (38.18 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 330 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-11-1	9710-11-2	9710-11-3	9710-11-4	9710-11-5
C3H6 WHSV	1.0	1.0	1.0	1.0	1.0
HRS ON STREAM5	5.7	22.3	29.3	46.3	53.3
PRESSURE,PSIG	24	24.3	26	40.6	26.4
TEMP. C	411	408	412	411	411
PRDT SELECTIVITY					
PARAFFIN/OLEFIN M RATIO					
C3	4.846	0.380	0.249	0.261	0.063
C4	6.843	0.703	0.427	0.077	0.047
C5	6.242	0.629	0.671	0.107	0.039
C6	6.521	1.684?	0.772	0.310	0.245
LIQ HC COLLECTION					
PHYSICAL APPEARANCE	OIL	OIL	OIL	OIL	OIL
DENSITY	0.913	0.822	0.771	0.739	0.688
N,REFRACTIVE INDEX	1.5340	1.4853	1.4573	1.4395	1.4305
FIA ANALYSIS, WT %					
AROMATICS	97.70	68.80	40.60	13.70	22.50
OLEFINS	1.10	24.20	52.50	86.30	77.20
SATURATES	1.20	7.00	6.90	0.00	0.30
SIMULATED DISTILLATION					
10 WT % @ DEG F.	234	189	158	156	161
16	239	219	186	169	174
50	332	297	282	260	259
84	479	399	385	359	343
90	492	434	418	392	375
RANGE(16-84%)	240	180	199	190	169
WT % @420 F	66.5	87.86	90.20	93.70	95.62
WT % @700 F	100.0	100.00	100.00	100.00	100.00

TABLE 11 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-11
CATALYST LZ-105-6 #9939-01 50 CC 34.36 GM (38.18 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 330 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-11-6	9710-11-7	9710-11-8		
C3H6 WHSV	1.0	1.0	1.0		
HRS ON STREAM5	60.0	65.5	71.083		
PRESSURE,PSIG	26	28.1	34.6		
TEMP. C	411	411	411		
FEED C3H6 CC	[478.80	[405.7	[406.35	[	[
HOURS FEEDING	[6.75	[5.5	[5.583	[	[
EFFLNT GAS LITER	[235.7	[192.9	[190.1	[	[
GM LIQ HYDROCARBON	[39.9	[36.92	[44.05	[	[
WT FR. LIQ HC/FEED	.1625	.1775	.2153		
MATERIAL BALANCE WT %	80.96	91.16	88.55		
C3H6 CONVERSION %	65.00	71.05	71.70		
PRDT SELECTIVITY WT %					
CH4	0.0490	0.0418	0.0463		
C2 HC'S	0.6845	0.5880	0.5056		
C3H8	3.8572	4.2219	3.2256		
C4H10	1.8031	1.9891	1.7410		
C4H8=	21.8982	19.8768	18.4689		
C5H12	0.8658	1.1184	1.0614		
C5H10=	11.7968	13.0022	12.6539		
C6H14	2.7372	3.5169	3.4618		
C6H12=	7.5585	7.5733	10.8295		
C7+ IN GAS	17.6239	20.4379	14.3994		
LIQ/SATURATES	0.1868	0.0000	0.2354		
LIQ/OLEFINS	24.2782	21.5267	27.4902		
LIQ/AROMATICS	6.6609	6.1071	5.8812		
TOTAL	100.00	100.00	100.00		
SUB-GROUPING					
C1 -C4	28.29	26.72	23.99		
C5 -420 F	69.84	71.72	74.07		
420-700 F	1.87	1.56	1.95		
C5 -END PT	71.71	73.28	76.01		
FOR C5+ FRACTION					
SATURATES, WT %	5.43	6.33	6.39		
OLEFINS	80.02	79.18	82.56		
AROMATICS	14.55	14.50	11.05		
ISO/NORMAL MOLE RATIO					
C4	1.746	1.521	1.640		
C5	2.291	2.052	2.120		
C6	0.957	1.060	1.024		
C4=	0.368	0.363	0.351		

TABLE 12 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-11 (CONTINUED)
CATALYST LZ-105-6 #9939-01 50 CC 34.36 GM (38.18 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 330 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-11-6	9710-11-7	9710-11-8		
C3H6 WHSV	1.0	1.0	1.0		
HRS ON STREAM5	60.0	65.5	71.083		
PRESSURE,PSIG	26	28.1	34.6		
TEMP. C	411	411	411		
PRDT SELECTIVITY WT %					
PARAFFIN/OLEFIN M RATIO					
C3	0.068	0.099	0.078		
C4	0.079	0.097	0.091		
C5	0.071	0.084	0.082		
C6	0.354	0.454	0.312		
LIQ HC COLLECTION					
PHYSICAL APPEARANCE	OIL	OIL	OIL		
DENSITY	0.744	0.742	0.718		
N,REFRACTIVE INDEX	1.4438	1.4382	1.4417		
FIA ANALYSIS, WT %					
AROMATICS	21.4	22.1	17.5		
OLEFINS	78.0	77.9	81.8		
SATURATES	0.60	0.00	0.7		
SIMULATED DISTILLATION					
10 WT % @ DEG F.	160	159	158		
16	182	176	172		
50	263	261	259		
84	358	355	354		
90	390	387	387		
RANGE(16-84%)	176	179	182		
WT % @420 F	94.0	94.36	94.21		
WT % @700 F	100.0	100.00	100.00		

TABLE 13 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-12
CATALYST LZ-105-6 #9939-01 50 CC 30.05 GM (35.29 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 290 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-12-1	9710-12-2	9710-12-3	9710-12-4	9710-12-5
C3H6 WHSV	1.0	1.0	1.0	1.0	1.0
HRS ON STREAM5	8.0	16.0	23.5	40.0	46.67
PRESSURE,PSIG	27	27	27	27	27
TEMP. C	450	450	450	450	450
FEED C3H6 CC	[509.70	[522.3	[478.2	[1087.	[427.9
HOURS FEEDING	[8.00	[8.0	[7.5	[16.5	[6.667
EFFLNT GAS LITER	[255.0	[206.1	[237.2	[545.8	[236.5
GM LIQ HYDROCARBON	[70.56	[69.14	[56.1	[58.2	[6.83
WT FR. LIQ HC/FEED	.2712	.2594	.2298	.1049	.0313
MATERIAL BALANCE WT %	86.87	75.60	91.85	75.58	76.01
C3H6 CONVERSION %	99.63	84.65	81.63	57.63	39.64
PRDT SELECTIVITY WT %					
CH4	1.3808	0.7249	0.5919	0.2477	0.2387
C2 HC'S	3.9354	2.8986	2.6976	1.1966	1.0108
C3H8	31.7184	12.3318	11.2230	5.5043	7.7904
C4H10	14.2628	11.7988	8.3879	1.2356	0.7373
C4H8=	3.2689	11.6079	15.0182	18.2750	20.2059
C5H12	3.5691	4.2221	3.3189	0.6389	0.3054
C5H10=	1.5454	4.5636	7.6056	10.6555	11.1623
C6H14	1.3018	2.5049	7.2215	4.8501	5.6256
C6H12=	0.6119	1.9458	4.4625	9.8439	18.5025
C7+ IN GAS	6.9863	6.7275	8.7270	23.4225	24.0324
LIQ/SATURATES	0.4713	2.1964	1.5373	0.0000	0.0000
LIQ/OLEFINS	0.4713	2.9285	5.3806	13.3921	7.3759
LIQ/AROMATICS	30.4768	35.5491	23.8282	10.7378	3.0127
TOTAL	100.00	100.00	100.00	100.00	100.00
SUB-GROUPING					
C1-C4	54.57	39.36	37.92	26.46	29.98
C5 -420 F	36.76	53.64	58.08	71.88	69.38
420-700 F	8.67	7.00	4.00	1.67	0.63
C5 -END PT	45.43	60.64	62.08	73.54	70.02
FOR C5+ FRACTION					
SATURATES,WT %	11.99	15.32	20.15	7.46	8.47
OLEFINS	6.02	16.36	30.57	63.76	77.27
AROMATICS	82.00	68.32	49.28	28.77	14.26
ISO/NORMAL MOLE RATIO					
C4	1.085	1.549	1.364	1.193	0.970
C5	2.160	2.148	2.170	1.917	1.648
C6	2.982	3.447	6.517	1.275	0.869
C4=	0.535	0.428	0.433	0.387	0.368

TABLE 14 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-12 (CONTINUED)
CATALYST LZ-105-6 #9939-01 50 CC 30.05 GM (35.29 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 290 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-12-1	9710-12-2	9710-12-3	9710-12-4	9710-12-5
C3H6 WHSV	1.0	1.0	1.0	1.0	1.0
HRS ON STREAM5	8.0	16.0	23.5	40.0	46.67
PRESSURE,PSIG	27	27	27	27	27
TEMP. C	450	450	450	450	450
PRDT SELECTIVITY WT %					
PARAFFIN/OLEFIN M RATIO					
C3	82.060	0.645	0.476	0.071	0.049
C4	4.212	0.981	0.539	0.065	0.035
C5	2.245	0.899	0.424	0.058	0.027
C6	2.078	1.257	1.580	0.481	0.297
LIQ HC COLLECTION					
PHYSICAL APPEARANCE	OIL	OIL	OIL	OIL	OIL
DENSITY	0.913	0.856	0.822	0.769	0.770
N,REFRACTIVE INDEX	1.5285	1.5030	1.4910	1.4540	1.4514
FIA ANALYSIS, WT %					
AROMATICS	97.0	87.4	77.5	44.5	29.0
OLEFINS	1.5	7.2	17.5	55.5	71.0
SATURATES	1.5	5.4	5.4	0.0	0.0
SIMULATED DISTILLATION					
10 WT % @ DEG F.	233	196	168	159	162
16	236	234	209	171	181
50	306	293	289	277	284
84	453	433	401	366	365
90	485	470	441	397	394
RANGE(16-84%)	217	199	192	195	184
WT % @420 F	72.4	82.8	87.0	93.1	93.9
WT % @700 F	100.0	100.0	100.0	100.0	100.0

TABLE 15 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-12
CATALYST LZ-105-6 #9939-01 50 CC 30.05 GM (35.29 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 290 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-12-6	9710-12-7			
C3H6 WHSV	1.0	1.0			
HRS ON STREAM5	63.33	69.33			
PRESSURE,PSIG	27	27			
TEMP. C	450	450			
FEED C3H6 CC	[978.8	[276.87	[	[	[
HOURS FEEDING	[16.667	[6.0	[	[	[
EFFLNT GAS LITER	[619.2	[230.6	[	[	[
GM LIQ HYDROCARBON	[1.56	[0.0	[	[	[
WT FR. LIQ HC/FEED	.0031	.0000			
MATERIAL BALANCE WT %	102.11	107.49			
C3H6 CONVERSION %	16.06	12.24			
PRDT SELECTIVITY WT %					
CH4	0.1539	0.2768			
C2 HC'S	0.6124	0.7257			
C3H8	29.2246	26.1884			
C4H10	0.4127	0.2912			
C4H8=	8.0065	7.4673			
C5H12	0.2418	0.2300			
C5H10=	5.9678	5.6253			
C6H14	7.9793	9.1143			
C6H12=	20.2008	29.1777			
C7+ IN GAS	25.3182	20.9034			
LIQ/SATURATES	0.0000	0.0000			
LIQ/OLEFINS	1.4718	0.0000			
LIQ/AROMATICS	0.4103	0.0000			
TOTAL	100.00	100.00			
SUBGROUPING					
C1 -C4	38.41	34.95			
C5 -420 F	61.32	65.05			
420-700 F	0.27	0.00			
C5 -END PT	61.59	65.05			
FOR C5+ FRACTION					
SATURATES, WT %	13.35	14.36			
OLEFINS	77.02	78.63			
AROMATICS	9.63	7.01			
ISO/NORMAL MOLE RATIO					
C4	0.3832	0.1786			
C5	0.6029	0.6154			
C6	0.7451	0.8829			
C4=	0.3262	0.3167			

TABLE 16 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-12 (CONTINUED)
CATALYST LZ-105-6 #9939-01 50 CC 30.05 GM (35.29 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 290 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-12-6	9710-12-7			
C3H6 WHSV	1.0	1.0			
HRS ON STREAM5	63.33	69.33			
PRESSURE,PSIG	27	27			
TEMP. C	450	450			
PRDT SELECTIVITY WT %					
PARAFFIN/OLEFIN M RATIO					
C3	0.0542	0.0354			
C4	0.0498	0.0376			
C5	0.0394	0.0397			
C6	0.3858	0.3051			
LIQ HC COLLECTION					
PHYSICAL APPEARANCE OIL		---			
DENSITY	0.744	---			
N,REFRACTIVE INDEX	1.4438	---			
FIA ANALYSIS, WT %					
AROMATICS	21.8	---			
OLEFINS	78.2	---			
SATURATES	0.0	---			
SIMULATED DISTILLATION					
10 WT % @ DEG F.	246	---			
16	272	---			
50	330	---			
84	413	---			
90	442	---			
RANGE(16-84%)	141	---			
WT % @420 F	85.6	---			
WT % @700 F	100.0	---			

TABLE 17 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-13
CATALYST LZ-105-6 #9939-01 43 CC 30.00 GM (34.05 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 285 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-13-1	9710-13-2	9710-13-3	9710-13-4	9710-13-5
C3H6 WHSV	1.0	1.0	1.0	1.0	1.0
HRS ON STREAM5	6.5	23.5	30.5	49.3	55.5
PRESSURE,PSIG	149	149	149	149	149
TEMP. C	410	410	410	410	410
FEED C3H6 CC	[393.3	[1076.0	[440.8	[1071.6	[394.46
HOURS FEEDING	[6.5	[16.833	[7.167	[16.833	[6.50
EFFLNT GAS LITER	[174.9	[456.1	[197.2	[488.89	[202.60
GM LIQ HYDROCARBON	[33.42	[129.66	[70.38	[146.32	[33.20
WT FR. LIQ HC/FEED	.1665	.2361	.3128	.2675	.1649
MATERIAL BALANCE WT %	86.78	79.47	91.58	89.54	94.07
C3H6 CONVERSION %	97.23	90.51	86.69	72.82	55.63
PRDT SELECTIVITY WT %					
CH4	2.9546	1.6485	1.5167	1.6234	1.5844
C2 HC'S	6.7002	3.3402	2.9545	2.6541	3.4606
C3H8	39.2707	16.2012	10.9699	6.3160	6.6522
C4H10	16.6900	15.4444	10.4359	2.8838	1.9024
C4H8=	1.1912	7.1262	10.2218	14.5296	16.3015
C5H12	4.2091	6.8590	5.2173	1.6728	1.0093
C5H10=	0.4215	3.8409	5.8190	8.8444	9.6614
C6H14	1.1600	3.4388	3.2288	2.6794	3.6413
C6H12=	0.0624	1.7218	1.9208	5.2912	9.5745
C7+ IN GAS	7.3186	7.4208	7.8250	12.2993	14.3439
LIQ/SATURATES	0.7608	3.9590	3.4307	1.9779	0.0000
LIQ/OLEFINS	0.3804	3.4641	17.2331	29.9981	27.9168
LIQ/AROMATICS	18.8804	25.5352	19.2277	9.2302	3.9517
TOTAL	100.00	100.00	100.00	100.00	100.00
SUBGROUPING					
C1 -C4	66.81	43.76	36.10	28.01	29.90
C5 -420 F	26.37	49.81	59.59	69.11	68.51
420-700 F	6.83	6.43	4.31	2.88	1.59
C5 -END PT	33.19	56.24	63.90	71.99	70.10
FOR C5+ FRACTION					
SATURATES, WT %	19.31	26.94	19.64	9.61	6.63
OLEFINS	3.02	17.44	44.37	73.74	85.19
AROMATICS	77.67	55.62	35.99	16.65	8.17
ISO/NORMAL MOLE RATIO					
C4	1.1081	1.5723	1.6006	1.3520	1.1954
C5	3.0558	2.5625	2.3316	1.9811	1.7615
C6	6.5961	3.5364	2.6188	1.2322	1.2927
C4=	0.4641	0.4116	0.4069	0.3560	0.3379

TABLE 18 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-13 (CONTINUED)
CATALYST LZ-105-6 #9939-01 43 CC 30.00 GM (34.05 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 285 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-13-1	9710-13-2	9710-13-3	9710-13-4	9710-13-5
C3H6 WHSV	1.0	1.0	1.0	1.0	1.0
HRS ON STREAM5	6.5	23.5	30.5	49.3	55.5
PRESSURE,PSIG	149	149	149	149	149
TEMP. C	410	410	410	410	410
PRDT SELECTIVITY WT %					
PARAFFIN/OLEFIN M RATIO					
C3	13.4417	1.4833	0.6843	0.1621	0.0801
C4	13.5250	2.0921	0.9855	0.1916	0.1127
C5	9.7059	1.7359	0.8716	0.1838	0.1015
C6	18.1512	1.9505	1.6417	0.4945	0.3714
LIQ HC COLLECTION					
PHYSICAL APPEARANCE	OIL	OIL	OIL	CIL	OIL
DENSITY	0.904	0.843	0.789	0.763	0.735
N,REFRACTIVE INDEX	1.5358	1.4972	1.4646	1.4485	1.4340
FIA ANALYSIS, WT %					
AROMATICS	94.3	77.4	48.2	22.4	12.4
OLEFINS	1.9	10.5	43.2	72.8	87.6
SATURATES	3.8	12.0	8.6	4.8	0.0
SIMULATED DISTILLATION					
10 WT % @ DEG F.	235	191	160	158	160
16	238	231	192	178	181
50	335	317	286	266	261
84	481	441	391	365	350
90	499	480	427	397	381
RANGE(16-84%)	243	210	199	187	169
WT % @420 F	65.9	80.5	89.2	93.0	95.0
WT % @700 F	100.0	100.0	100.0	100.0	100.0

TABLE 19 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-13
CATALYST LZ-105-6 #9939-01 43 CC 30.00 GM (34.05 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 285 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-13-6	9710-13-7	9710-13-8		
C3H6 WHSV	1.0	1.0	1.0	.	.
HRS ON STREAM5	73.8	79.8	97.5	.	.
PRESSURE,PSIG	150	149	149		
TEMP. C	409	409	408		
FEED C3H6 CC	[1155.9	[382.5	[1104.35	[.	[.
HOURS FEEDING	[18.25	[6.00	[17.75	[.	[.
EFFLNT GAS LITER	[615.9	[215.1	[650.8	[.	[.
GM LIQ HYDROCARBON	[32.2	[2.2	[0.0	[.	[.
WT FR. LIQ HC/FEED	.0546	.0113	.0000	.	.
MATERIAL BALANCE WT %	86.95	95.43	84.18	.	.
C3H6 CONVERSION %	33.19	24.26	10.70	.	.
PRDT SELECTIVITY WT %					
CH4	2.4156	2.7954	5.9907		
C2 HC'S	4.6085	5.4013	11.3046		
C3H8	7.8623	10.2299	16.2949		
C4H10	0.4586	0.6076	0.5006		
C4H8=	9.8880	11.2921	7.5778		
C5H12	0.2744	0.5327	0.3931		
C5H10=	6.9475	9.4303	5.3602		
C6H14	4.9028	6.5843	7.7578		
C6H12=	10.8054	17.2413	20.6765		
C7+ IN GAS	32.9593	30.9919	23.1751		
LIQ/SATURATES	0.0000	0.0000	0.0000		
LIQ/OLEFINS	17.7071	4.2228	0.7265		
LIQ/AROMATICS	1.1704	0.6704	0.2422		
TOTAL	100.00	100.00	100.00		
SUBGROUPING					
C1 -C4	25.23	30.33	41.67		
C5 -420 F	73.92	69.32	58.28		
420-700 F	0.85	0.35	0.034		
C5 -END PT	74.77	69.67	58.33		
FOR C5+ FRACTION					
SATURATES, WT %	6.92	10.21	13.97		
OLEFINS	88.78	82.73	75.68		
AROMATICS	4.30	7.06	10.35		
ISO/NORMAL MOLE RATIO					
C4	0.7019	0.6911	0.5810		
C5	0.8286	1.0270	0.4384		
C6	0.8418	0.8876	0.7298		
C4=	0.2883	0.2909	0.2947		

TABLE 20 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-13 (CONTINUED)
CATALYST LZ-105-6 #9939-01 43 CC 30.00 GM (34.05 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 285 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-13-6	9710-13-7	9710-13-8		
C3H6 WHSV	1.0	1.0	1.0		
HRS ON STREAM5	73.8	79.8	97.5		
PRESSURE,PSIG	150	149	149		
TEMP. C	409	409	408		
PRDT SELECTIVITY WT %					
PARAFFIN/OLEFIN M RATIO					
C3	0.0377	0.0317	0.0191		
C4	0.0448	0.0519	0.0638		
C5	0.0384	0.0549	0.0713		
C6	0.4431	0.3730	0.3664		
LIQ HC COLLECTION					
PHYSICAL APPEARANCE	OIL	OIL	OIL		
DENSITY	0.728	0.752	-.--		
N,REFRACTIVE INDEX	1.4284	1.4324	-.--		
FIA ANALYSIS, WT %					
AROMATICS	6.2	13.7	25.0		
OLEFINS	93.8	86.3	75.0		
SATURATES	0.0	0.0	0.0		
SIMULATED DISTILLATION					
10 WT % @ DEG F.	165	207	287		
16	203	240	299		
50	286	303	391		
84	357	388	443		
90	384	406	478		
RANGE(16-84%)	154	148	144		
WT % @420 F	95.5	92.8	94.2		
WT % @700 F	100.0	100.0	97.7		

TABLE 21 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-14
CATALYST UCC-101 #9530-90 54 CC 30.00 GM (34.24 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 290 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-14-1	9710-14-2			
C3H6 WHSV	1.0	1.0			
HRS ON STREAM5	3.75	8.0			
PRESSURE,PSIG	150	149			
TEMP. C	408	408			
FEED C3H6 CC	[191.3	[251.1	[	[	[
HOURS FEEDING	[3.257	[4.25	[	[	[
EFFLNT GAS LITER	[111.1	[154.9	[	[	[
GM LIQ HYDROCARBON	[4.16	[0.55	[	[	[
WT FR. LIQ HC/FEED	.0426	.0043			
MATERIAL BALANCE WT %	99.29	97.72			
C3H6 CONVERSION %	30.98	15.27			
PRDT SELECTIVITY WT %					
CH4	0.4737	0.5698			
C2 HC'S	1.1525	1.4976			
C3H8	46.0853	36.2637			
C4H10	1.3242	0.7388			
C4H8=	4.9526	4.1269			
C5H12	0.7812	0.6171			
C5H10=	3.1740	3.6390			
C6H14	6.6898	7.6566			
C6H12=	8.4768	14.5966			
C7+ IN GAS	12.8162	27.3997			
LIQ/SATURATES	0.7037	0.0000			
LIQ/OLEFINS	2.7726	0.0984			
LIQ/AROMATICS	10.5977	2.7957			
TOTAL	100.00	100.00			
SUBGROUPING					
C1 -C4	53.99	43.20			
C5 -420 F	41.37	56.02			
420-700 F	4.57	0.71			
C5 -END PT	46.01	56.80			
FOR C5+ FRACTION					
SATURATES, WT %	19.16	14.57			
OLEFINS	36.83	33.92			
AROMATICS	44.01	51.52			
ISO/NORMAL MOLE RATIO					
C4	1.1043	0.8488			
C5	1.2801	0.7114			
C6	1.6005	1.3779			
C4=	0.4742	0.4382			

TABLE 22 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-14 (CONTINUED)
CATALYST UCC-101 #9530-90 54 CC 30.00 GM (34.24 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 290 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-14-1	9710-14-2			
C3H6 WHSV	1.0	1.0			
HRS ON STREAM5	3.75	8.0			
PRESSURE,PSIG	150	149			
TEMP. C	408	408			
PRDT SELECTIVITY WT %					
PARAFFIN/OLEFIN M RATIO					
C3	0.2012	0.0635			
C4	0.2581	0.1728			
C5	0.2392	0.1648			
C6	0.7707	0.5123			
LIQ HC COLLECTION					
PHYSICAL APPEARANCE	OIL	OIL			
DENSITY	0.831	---			
N,REFRACTIVE INDEX	1.4894	---			
FIA ANALYSIS, WT %					
AROMATICS	75.3	96.6			
OLEFINS	19.7	3.4			
SATURATES	5.0	0.0			
SIMULATED DISTILLATION					
10 WT % @ DEG F.	249	321			
16	279	335			
50	383	434			
84	505	581			
90	560	614			
RANGE(16-84%)	226	246			
WT % @420 F	67.0	73.0			
WT % @700 F	99.5	97.7			

TABLE 23 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-15
CATALYST UCC-101 #9530-90 92 CC 50.00 GM (56.67 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/4 MOLE RATIO, 481 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-15-1	9710-15-2	9710-15-3		
C3H6 WHSV	0.27	0.27	0.27		
HRS ON STREAM5	3.5	7.0	14.5		
PRESSURE,PSIG	25	25	25		
TEMP. C	408	408	408		
FEED C3H6 CC	[77.40	[171.79	[186.3	[	[
HOURS FEEDING	[3.0	[6.5	[7.0	[	[
EFFLNT GAS LITER	[115.0	[252.7	[279.4	[	[
GM LIQ HYDROCARBON	[0.27	[0.59	[0.0	[	[
WT FR. LIQ HC/FEED	.0068	.0067	.0000		
MATERIAL BALANCE WT %	85.05	82.70	85.95		
C3H6 CONVERSION %	41.13	23.41	13.84		
PRDT SELECTIVITY WT %					
CH4	1.4463	1.4299	1.5548		
C2 HC'S	2.2528	2.2272	2.6465		
C3H8	47.2089	44.9272	53.2126		
C4H10	4.2708	1.4997	0.9080		
C4H8=	8.6915	7.1067	6.2749		
C5H12	2.1488	0.6552	0.4307		
C5H10=	4.8486	3.9651	2.9797		
C6H14	8.2165	6.5099	6.3195		
C6H12=	6.3173	12.0976	13.1388		
C7+ IN GAS	12.6762	16.1690	12.5345		
LIQ/SATURATES	0.1826	0.3242	0.0000		
LIQ/OLEFINS	0.0000	0.0000	0.0000		
LIQ/AROMATICS	1.7396	3.0883	0.0000		
TOTAL	100.0	100.00	100.0		
SUBGROUPING					
C1 -C4	63.87	57.19	64.60		
C5 -420 F	35.13	41.03	35.40		
420-700 F	0.97	1.72	0.00		
C5 -END PT	36.13	42.81	35.40		
FOR C5+ FRACTION					
SATURATES, WT %	32.53	21.09	22.43		
OLEFINS	30.91	37.52	45.53		
AROMATICS	36.57	41.40	32.04		
ISO/NORMAL MOLE RATIO					
C4	1.9354	1.3966	0.9873		
C5	3.4200	1.9608	1.1429		
C6	2.6993	1.7849	1.3031		
C4=	0.4076	0.4302	0.4253		

TABLE 24 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-15 (CONTINUED)
CATALYST UCC-101 #9530-90 92 CC 50.00 GM (56.67 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/4 MOLE RATIO, 481 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-15-1	9710-15-2	9710-15-3		
C3H6 WHSV	0.27	0.27	0.27		
HRS ON STREAM5	3.5	7.0	14.5		
PRESSURE,PSIG	25	25	25		
TEMP. C	408	408	408		
PRDT SELECTIVITY WT %					
PARAFFIN/OLEFIN M RATIO					
C3	0.3236	0.1342	0.0840		
C4	0.4743	0.2037	0.1397		
C5	0.4308	0.1606	0.1405		
C6	1.2702	0.5255	0.4697		
LIQ HC COLLECTION					
PHYSICAL APPEARANCE	OIL	OIL	OIL		
DENSITY	.	---	---		
N,REFRACTIVE INDEX	.	---	---		
FIA ANALYSIS, WT %					
AROMATICS	--.-	90.5	--.-		
OLEFINS	--.-	0.0	--.-		
SATURATES	-.-	9.5	-.-		
SIMULATED DISTILLATION					
10 WT % @ DEG F.	---	332	---		
16	---	341	---		
50	---	429	---		
84	---	566	---		
90	---	598	---		
RANGE(16-84%)	---	225	---		
WT % @420 F	--.-	48.0	--.-		
WT % @700 F	--.-	98.5	--.-		

TABLE 25 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-16
CATALYST UCC-101 #9530-90 55 CC 30.00 GM (31.10 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 290 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-16-1	9710-16-2			
C3H6 WHSV	1.0	1.0			
HRS ON STREAM5	3.0	7.0			
PRESSURE,PSIG	150	150			
TEMP. C	277	277			
FEED C3H6 CC	[186.9	[435.4	[	[	[
HOURS FEEDING	[3.0	[7.0	[	[	[
EFFLNT GAS LITER	[150.6	[253.6	[	[	[
GM LIQ HYDROCARBON	[0.51	[1.2	[	[	[
WT FR. LIQ HC/FEED	.0053	.0054			
MATERIAL BALANCE WT %	--.--	96.46			
C3H6 CONVERSION %	--.--	15.00			
PRDT SELECTIVITY WT %					
CH4		0.1079			
C2 HC'S		0.0403			
C3H8		15.6862			
C4H10		0.5482			
C4H8=		3.5706			
C5H12		0.4144			
C5H10=		3.1403			
C6H14		21.1521			
C6H12=		30.6467			
C7+ IN GAS		20.9406			
LIQ/SATURATES		0.3978			
LIQ/OLEFINS		3.0998			
LIQ/AROMATICS		0.2552			
TOTAL		100.00			
SUBGROUPING					
C1 -C4		19.95			
C5 -420 F		78.55			
420-700 F		1.46			
C5 -END PT		80.05			
FOR C5+ FRACTION					
SATURATES, WT %		30.21			
OLEFINS		67.69			
AROMATICS		2.10			
ISO/NORMAL MOLE RATIO					
C4	8.3000	8.9655			
C5	8.9512	5.0694			
C6	2.2362	7.4601			
C4=	0.1456	0.6385			

TABLE 26 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-16 (CONTINUED)
CATALYST UCC-101 #9530-90 55 CC 30.00 GM (31.10 GM AFTER THE RUN)
FEED C3H6/H2 @ 1/1 MOLE RATIO, 290 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-16-1	9710-16-2
C3H6 WHSV	1.0	1.0
HRS ON STREAM	3.0	7.0
PRESSURE,PSIG	150	150
TEMP. C	277	277
PRDT SELECTIVITY WT %		
PARAFFIN/OLEFIN M RATIO		
C3	-.----	0.0267
C4	0.5769	0.1482
C5	0.2042	0.1283
C6	0.6844	0.6740
LIQ HC COLLECTION		
PHYSICAL APPEARANCE		OIL
DENSITY		---
N,REFRACTIVE INDEX		---
FIA ANALYSIS, WT %		
AROMATICS		6.8
OLEFINS		82.6
SATURATES		10.6
SIMULATED DISTILLATION		
10 WT % @ DEG F.	---	277
16	---	291
50	---	394
84	---	501
90	---	539
RANGE(16-84%)	---	210
WT % @420 F		60.0
WT % @700 F		98.8

TABLE 27 RESULT OF PROPYLENE(WITH H2) OPERATION

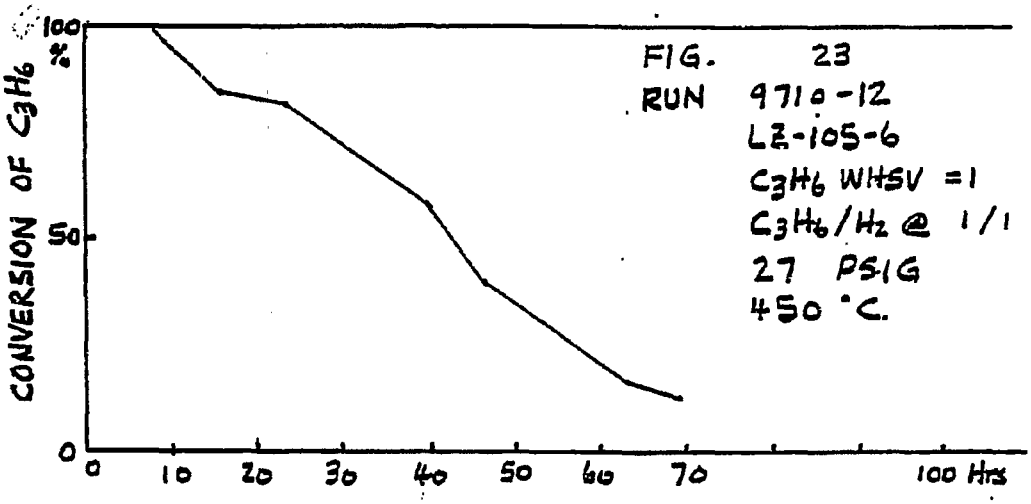
RUN NO. 9710-17
CATALYST UCC-101 #9939-27 51 CC 30.00 GM
FEED C3H6/H2 @ 1/1 MOLE RATIO, 290 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

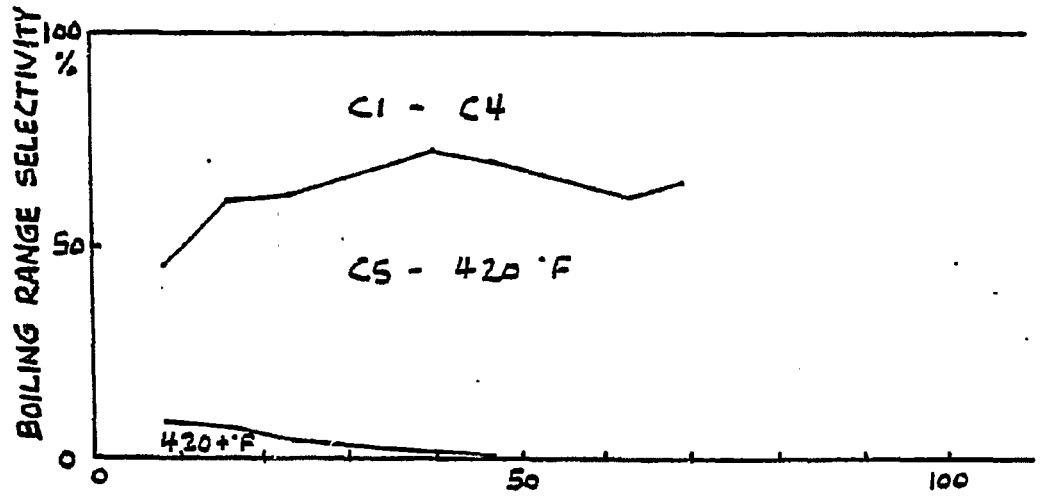
RUN & SAMPLE NO.	9710-17-1	9710-17-2	9710-17-3		
C3H6 WHSV	1.0	1.0	1.0		
HRS ON STREAM5	4.0	7.0	11.0		
PRESSURE,PSIG	150	150	150		
TEMP. C	340	340	343		
FEED C3H6 CC	[211.4	[185.0	[216.5	[	[
HOURS FEEDING	[3.5	[3.0	[3.5	[	[
EFFLNT GAS LITER	[118.9	[109.6	[127.9	[	[
GM LIQ HYDROCARBON	[5.19	[2.2	[1.64	[	[
WT FR. LIQ HC/FEED	.0481	.0233	.0148		
MATERIAL BALANCE WT %	96.43	95.92	96.58		
C3H6 CONVERSION %	24.15	17.08	14.32		
PRDT SELECTIVITY WT %					
CH4	0.3473	0.3484	0.1211		
C2 HC'S	0.0000	0.0000	0.0000		
C3H8	23.7735	22.3668	19.7841		
C4H10	1.5635	1.1107	1.0314		
C4H8=	7.1992	7.9631	8.6575		
C5H12	1.0453	0.7143	0.6312		
C5H10=	5.7367	6.2151	6.7000		
C6H14	7.8142	8.3348	8.5913		
C6H12=	12.6294	17.9358	20.2246		
C7+ IN GAS	18.7235	20.3773	23.2663		
LIQ/SATURATES	0.6774	0.0000	0.6376		
LIQ/OLEFINS	7.9590	3.5853	4.8477		
LIQ/AROMATICS	12.5312	11.0484	5.5073		
TOTAL	100.0	100.00	100.0		
SUBGROUPING					
C1 -C4	32.88	31.79	29.59		
C5 -420 F	61.53	62.18	65.99		
420-700 F	5.59	5.90	4.00		
C5 -END PT	67.12	68.21	70.41		
FOR C5+ FRACTION					
SATURATES, WT %	15.10	13.27	15.92		
OLEFINS	49.71	47.98	59.70		
AROMATICS	35.19	38.75	24.38		
ISO/NORMAL MOLE RATIO					
C4	4.5020	3.9380	4.9176		
C5	6.3333	4.5932	4.9048		
C6	2.0395	1.4443	1.3051		
C4=	0.5288	0.5610	0.5793		

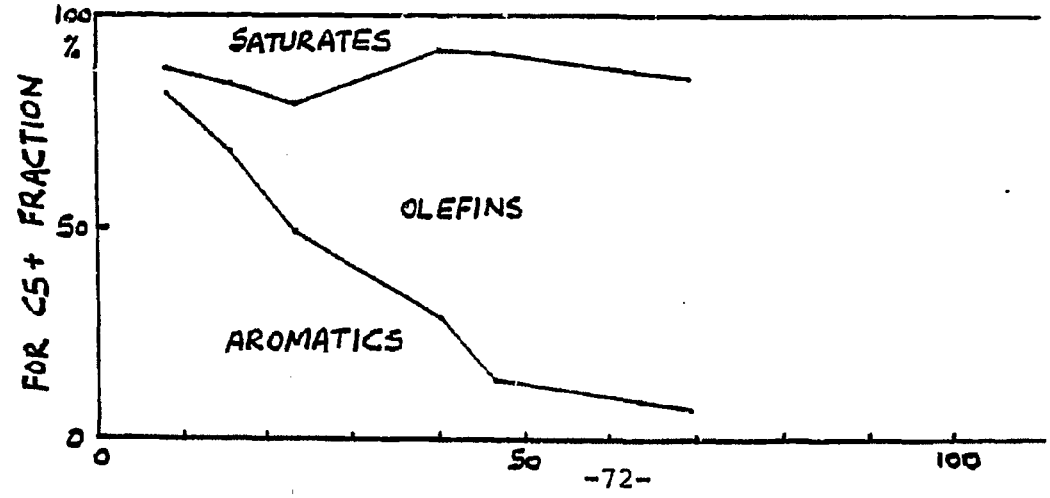
TABLE 28 RESULT OF PROPYLENE(WITH H2) OPERATION

RUN NO. 9710-17 (CONTINUED)
CATALYST UCC-101 #9939-27 51 CC 30.00 GM
FEED C3H6/H2 @ 1/1 MOLE RATIO, 290 CC/MIN H2 FLOW
C3H6 MW= 42.0813 DENSITY= 0.51041 GM/CC (@ 73 F)

RUN & SAMPLE NO.	9710-17-1	9710-17-2	9710-17-3		
C3H6 WHSV	1.0	1.0	1.0		
HRS ON STREAM5	4.0	7.0	11.0		
PRESSURE,PSIG	150	150	150		
TEMP. C	340	340	343		
PRDT SELECTIVITY WT %					
PARAFFIN/OLEFIN M RATIO					
C3	0.0727	0.0443	0.0318		
C4	0.2096	0.1346	0.1150		
C5	0.1771	0.1117	0.0916		
C6	0.6043	0.4538	0.4149		
LIQ HC COLLECTION					
PHYSICAL APPEARANCE	OIL	OIL	OIL		
DENSITY	0.790	---	---		
N,REFRACTIVE INDEX	1.4498	---	---		
FIA ANALYSIS, WT %					
AROMATICS	59.2	75.5	50.1		
OLEFINS	37.6	24.5	44.1		
SATURATES	3.2	0.0	5.8		
SIMULATED DISTILLATION					
10 WT % @ DEG F.	235	277	260		
16	265	289	278		
50	346	397	390		
84	459	520	548		
90	495	569	615		
RANGE(16-84%)	194	231	270		
WT % @420 F	73.6	58.8	59.8		
WT % @700 F	100.0	99.1	96.4		


CONVERSION OF C_3H_6
100
%
50
0
0
10
20
30
40
50
60
70
100 Hrs
FIG. 23
RUN 9710-12
LZ-105-6
C_3H_6 WHSV = 1
C_3H_6/H_2 @ 1/1
27 PSIG
450 °C.


BOILING RANGE SELECTIVITY
100
%
50
0
C1 - C4
C5 - 420 °F
420+°F
0
50
100


FOR C5+ FRACTION
100
%
50
0
SATURATES
OLEFINS
AROMATICS
0
50
100

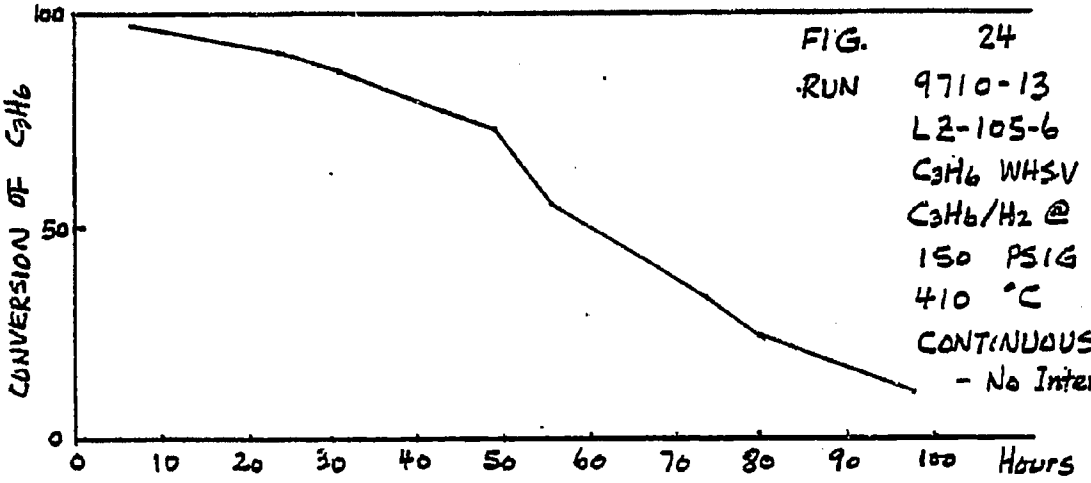
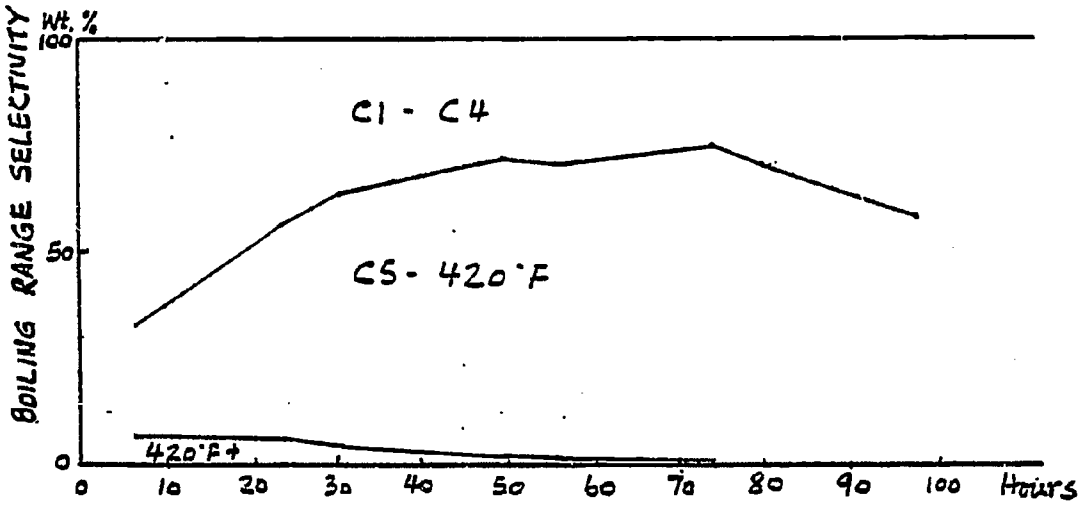
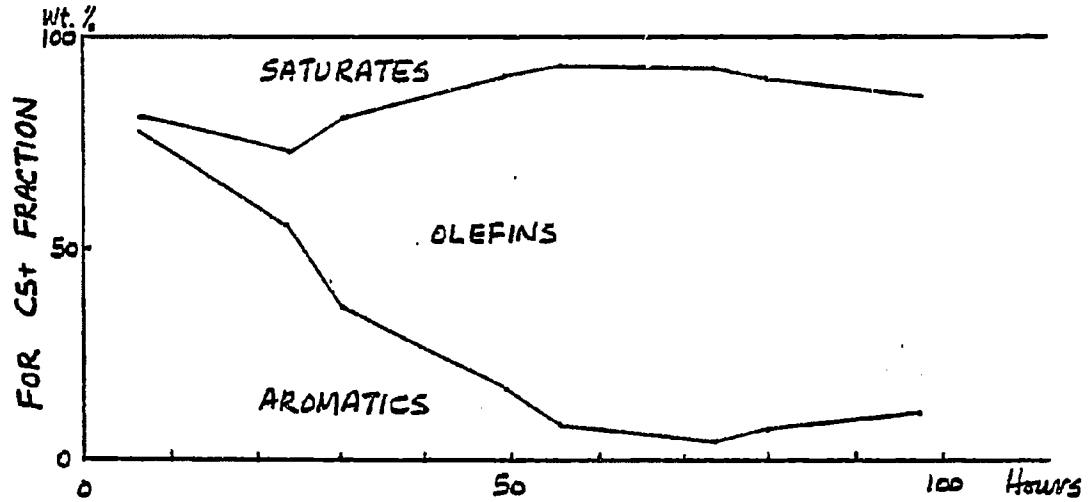


FIG. 24
RUN 9710-13
L2-105-6
C_3H_6 WHSV = 1
C_3H_6/H_2 @ 1:1
150 PSIG
410 °C
CONTINUOUS FEEDING
- No Interruption





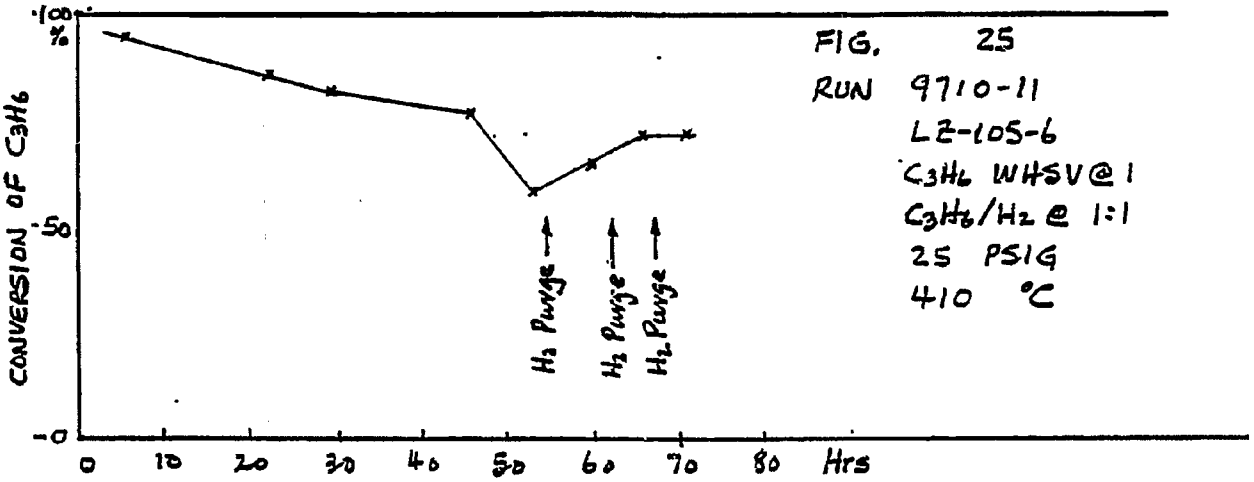
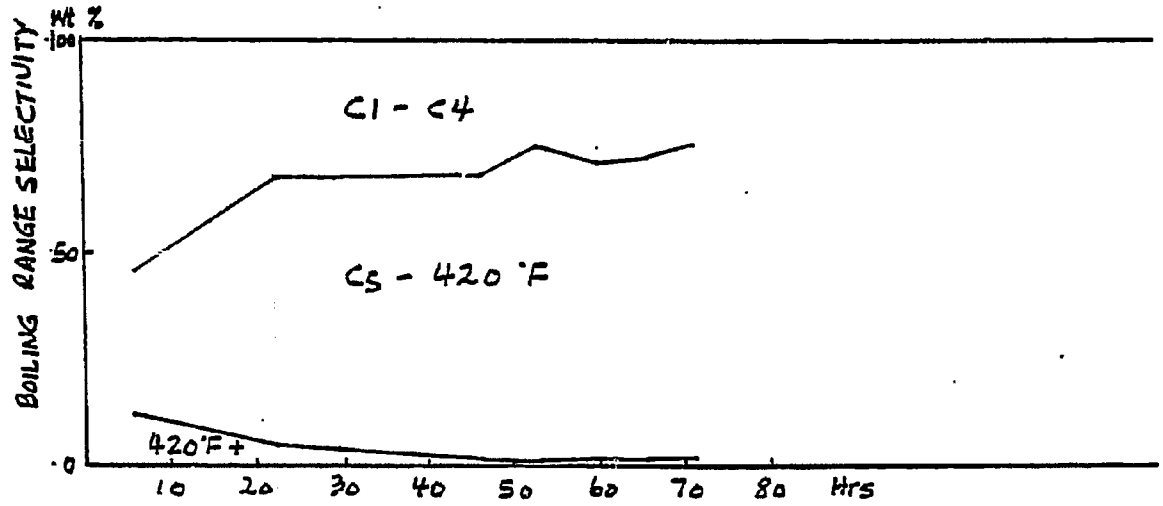


FIG. 25
RUN 9710-11
LZ-105-6
C_3H_6 WHSV @ 1
C_3H_6/H_2 @ 1:1
25 PSIG
410 °C



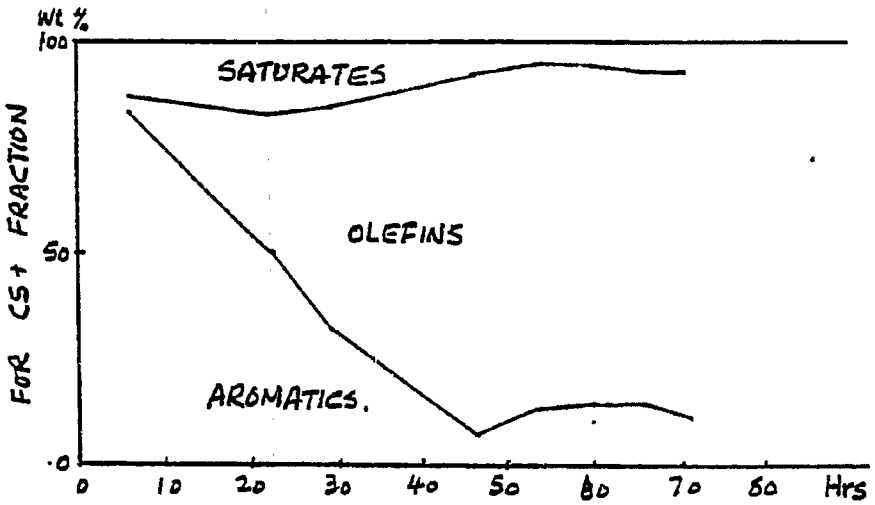
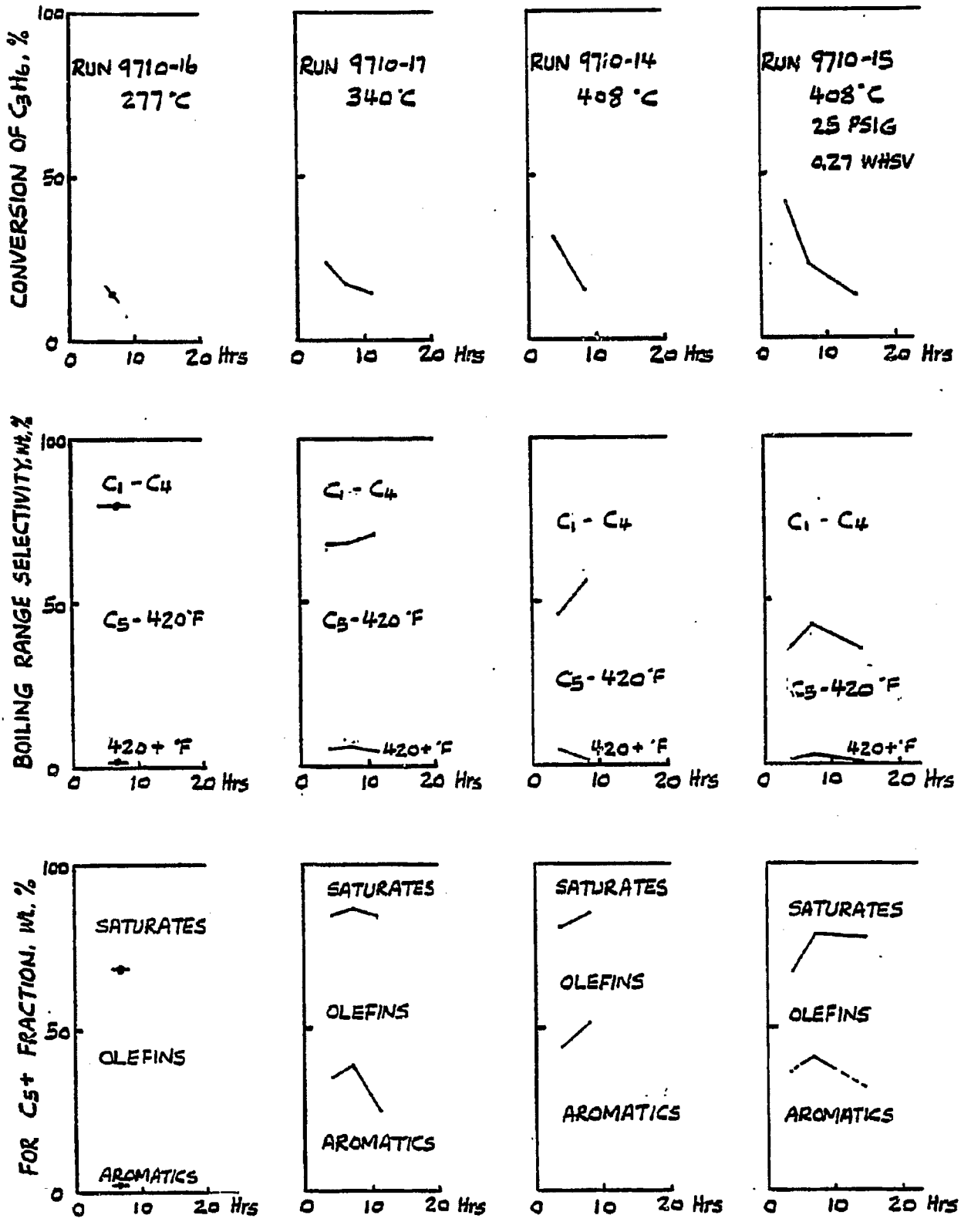


FIGURE 26
CATALYST UCC-101



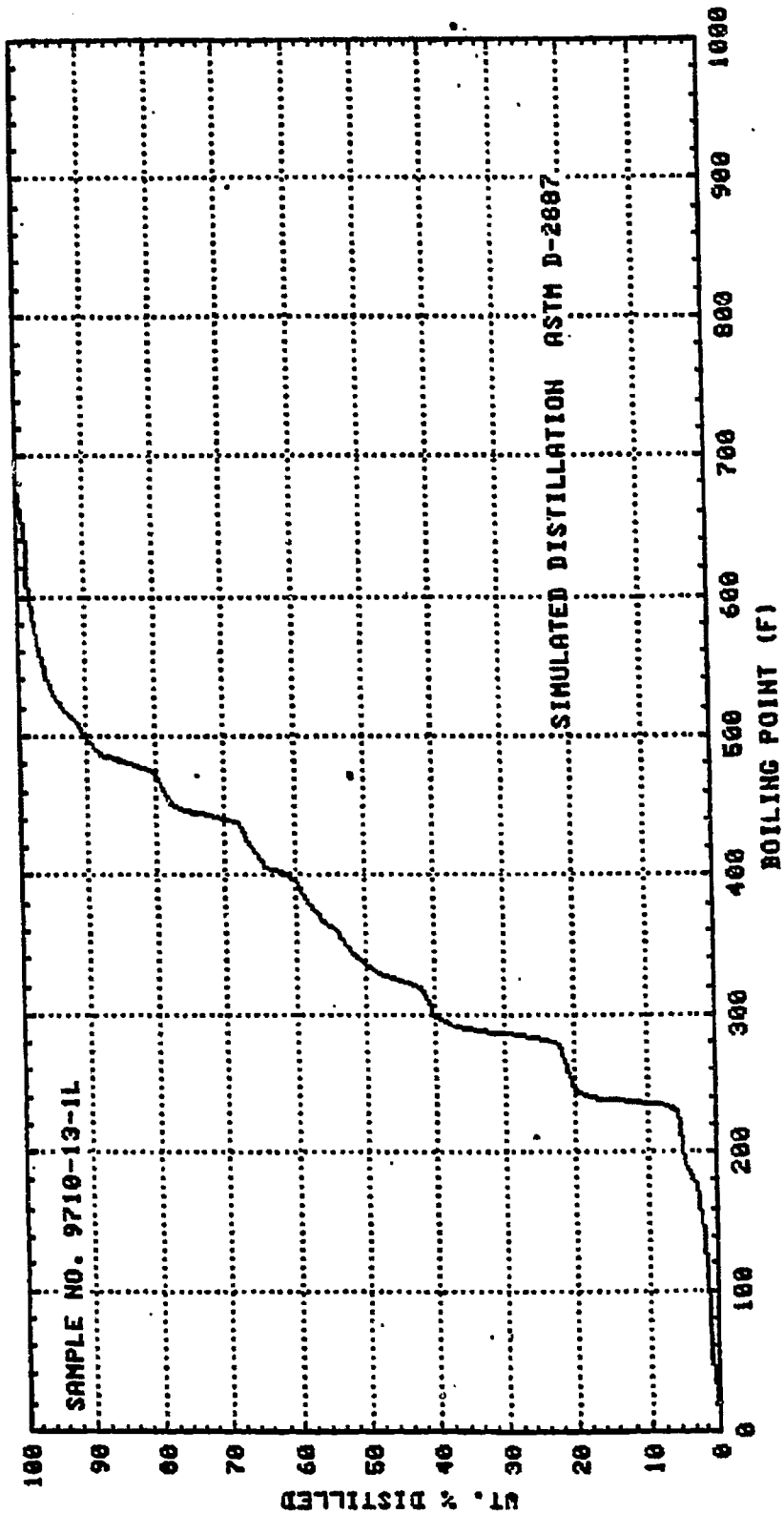

SAMPLE NO. 9710-13-1L
SIMULATED DISTILLATION ASTM D-2887
WT. % DISTILLED
BOILING POINT (F)
0
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500
600
700
800
900
1000

FIG. 27

FIG. 28

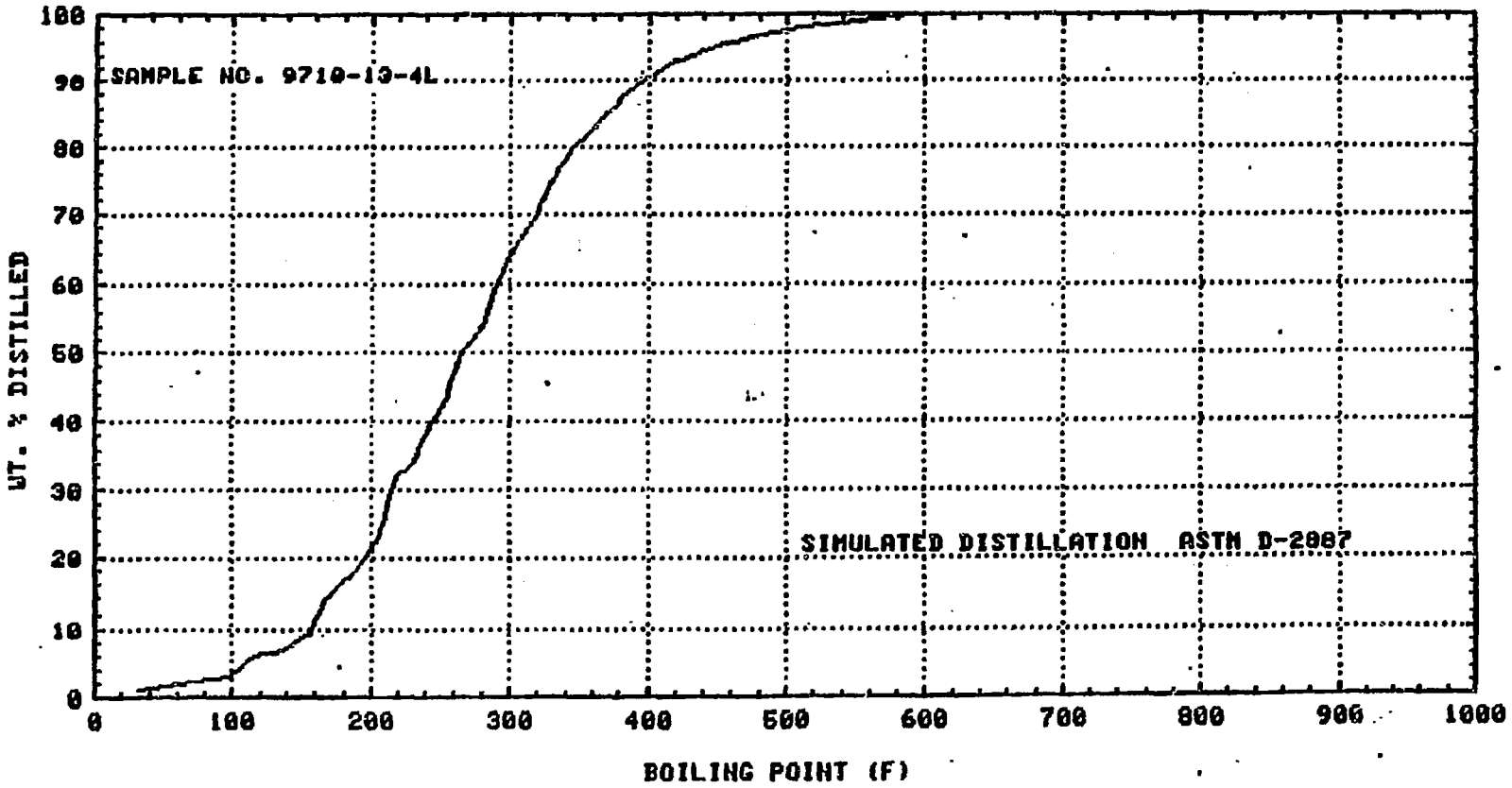
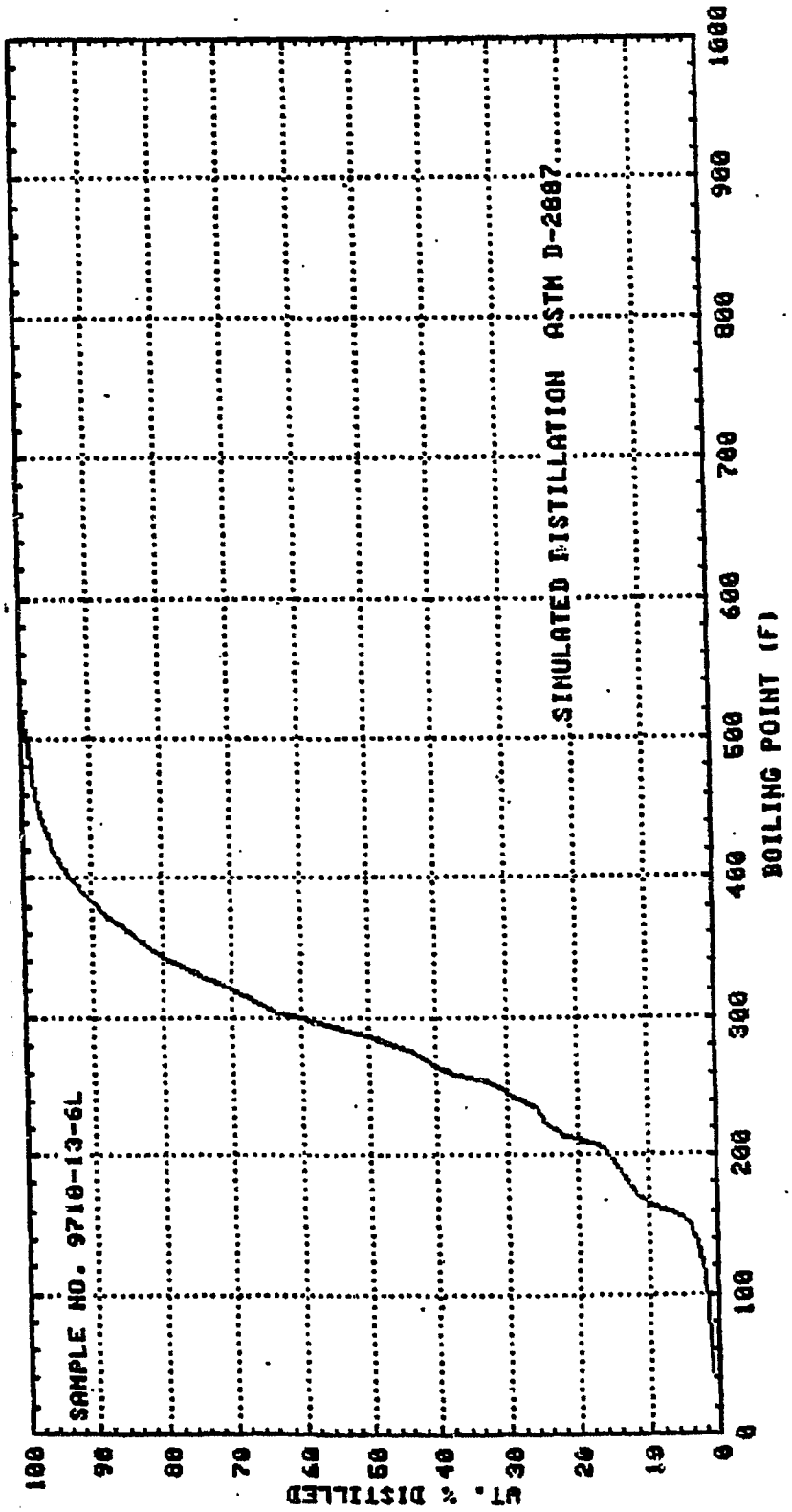

SAMPLE NO. 9710-13-4L
SIMULATED DISTILLATION ASTM D-2887
WT. % DISTILLED
BOILING POINT (F)
0
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500
600
700
800
900
1000

FIG. 29


SAMPLE NO. 9710-13-6L
SIMULATED DISTILLATION ASTM D-2887
WT. % DISTILLED
BOILING POINT (F)
0
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500
600
700
800
900
1000

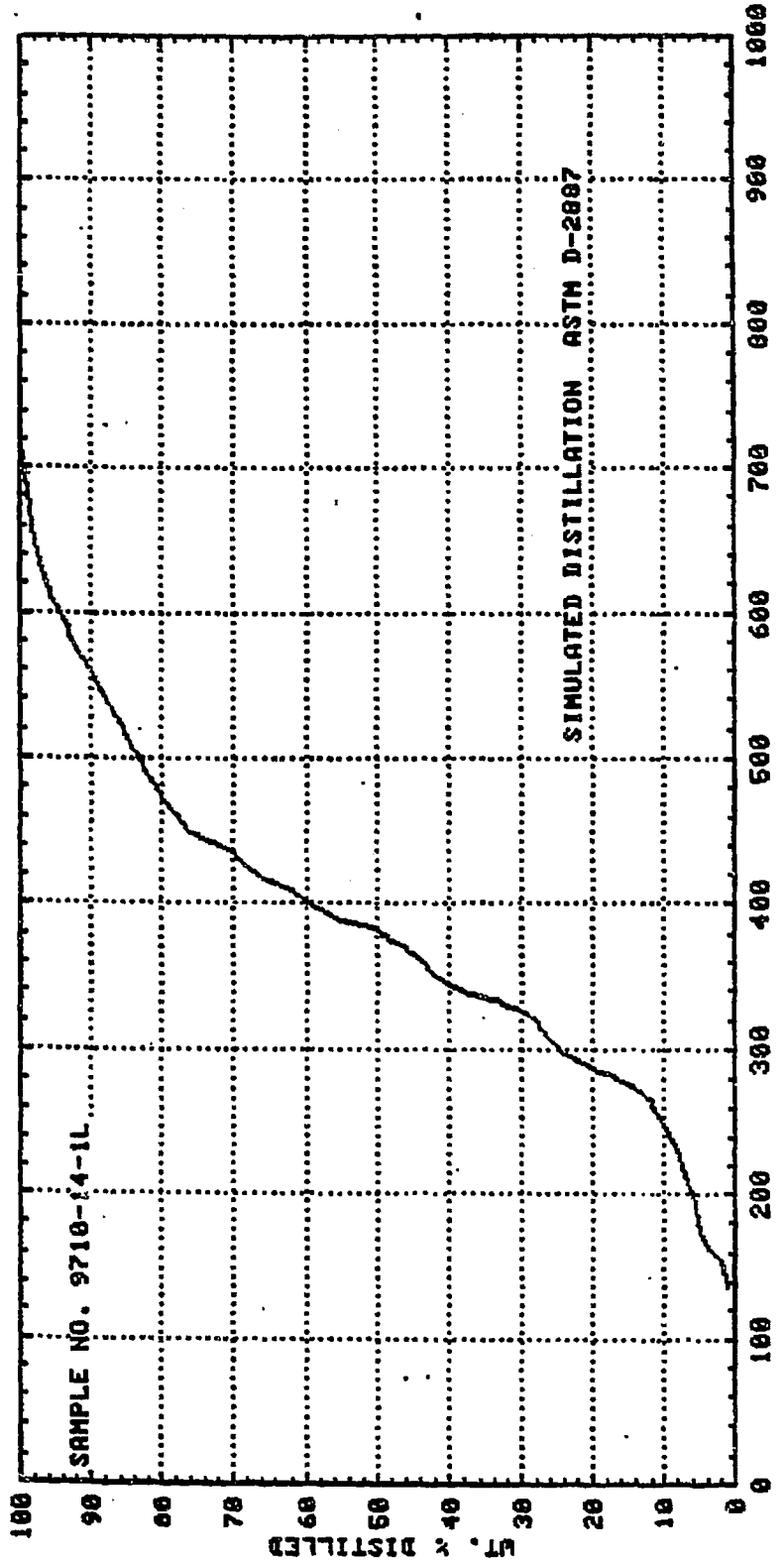

SAMPLE NO. 9710-14-1L
SIMULATED DISTILLATION ASTM D-2887
WT. % DISTILLED
BOILING POINT (F)
0
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500
600
700
800
900
1000

FIG. 30

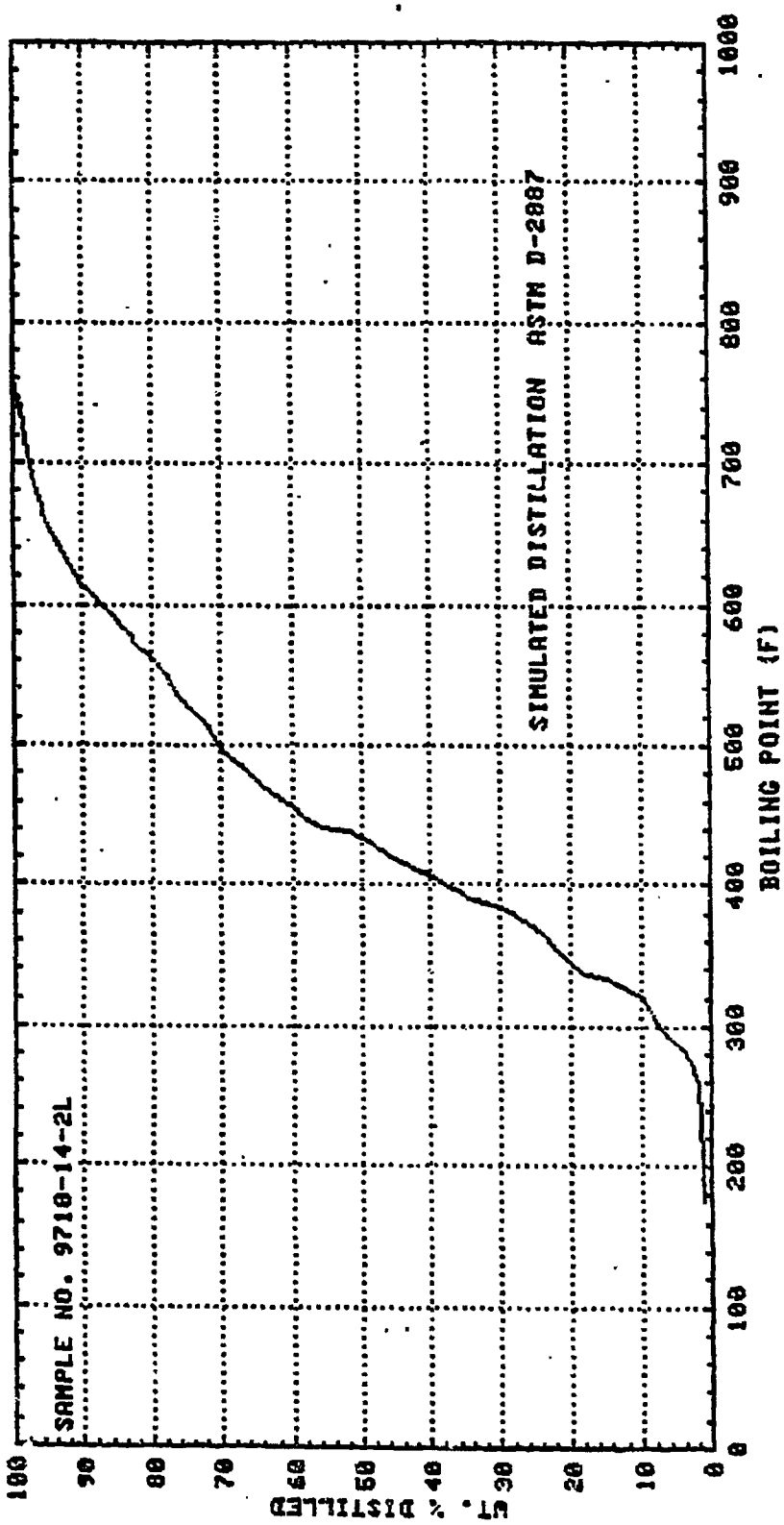

SAMPLE NO. 9710-14-2L
SIMULATED DISTILLATION ASTM D-2887
WT. % DISTILLED
BOILING POINT (F)
0
10
20
30
40
50
60
70
80
90
100
0
100
200
300
400
500
600
700
800
900
1000

FIG. 31

Appendix E: Study of Surface Structure & Chemistry

G. A. Somorjai

The new high pressure apparatus is in the last stage of preparation. Changes were made in the pumping system and catalysis chamber loop. We added a double pass cylindrical mirror analyzer that permits us to carry out both auger and x-ray photoelectron spectroscopy on catalyst surfaces. A potassium gun has been added to examine the effect of alkali metal promoters.

Calibration studies using Fe, Re and Pt crystal surfaces produced results that are consistent with data found in the literature. During the CO/H_2 reactions Re and Pt produced mostly methane, while Fe was most active, producing a wide range of straight chain saturated hydrocarbons.

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