RESEARCH ON THE BEHAVIOR OF IRON CATALYSTS WHEN OPERATED WITH H2-RICH SYNTHESIS GAS

I. Introduction

Why are operating temperatures below 200°C, desirable in the middle-pressure synthesis? How can those temperatures be obtained?

II. Tests with Fe Catalysts + 1/4 Percent K2CO3

A. Influence of Multi-Stage Operation

More recent experiments in which iron catalysts were used in benzine synchesis have shown that those catalysts will give yields which are very nearly equal to those obtained when using cobalt catalysts. Hydrocarbons obtained with iron catalysts compare favorably also to those obtained by cobalt when one compares their anti-knock properties. The catalysts must be used at temperatures of around 235-260°C., that is, approximately 45-70° higher than cobalt catalysts. When carrying out the middle-pressure synthesis with cobalt catalysts, we have made use of an apparatus which was cooled by steam. It was our desire to use the same set-up for experiments with iron catalysts, without having to make any experimental changes. It would have been advantageous therefore to be able to work at a lower operating temperature. This succeeds when one uses a gas which is richer in hydrogen than a normal gas used along with the iron catalyst.

A time test with mixed gas showed that it is possible to start the synthesis at 210°C. After 15 days of operation and working at 213°C., a yield of 100 g./ Nm³ of ideal gas was still obtained, and the increase in temperature to assure an economical yield was only small. After operating for 180 days, the necessary operating temperature to assure a feasible yield was 235°C.

On the tenth day of the synthesis, 97% of the CO gas was used up, whereas 50% of the initial H2 constituent remained unconverted. In order to keep the yields up, it was necessary to operate in two stages, and the gas leaving the first stage and entering the second stage had to be replemished with sufficient CO to bring its final composition up to its original value. Before replemishing the gas however for other reasons, it was desired to see what would happen if the gas issuing from stage one was conducted into stage two.

It may be seen that thus it was possible after 70 days of operation to obtain a yield of 157 g./Nm3 of ideal gas when operating in two stages.

In order to lower the temperatures still more, experiments were carried out in several (4) stages. A gas of composition $CO:H_2 = 1:4$ was used.

In Table II, the results of such a run may be observed. For the first 44 tays, the second stage was operated with an initial gas having the composition of the end gas from stage #1, including the gasol hydrocarbons. After the 44th day, the second stage was operated with a gas having been replenished with CO; however, the gasol had been removed. The third and fourth stages were operated with a gas as was obtained from the previous stages and the gasol was left in.

We were able to demonstrate that iron catalysts may be used at temperatures below 200°C., giving economical yields and producing only little CO₂. Generally, it was observed that at the lower temperatures, more water formed than CO₂. The CO consumption is satisfactory, and after the third stage, approximately 90% has been used up. The fourth stage was operated at 170°C., and after 20 days of operation, it was still not necessary to raise the temperature. The CO conversion amounted to 54%,

The yields of stages one and two, were tabulated and referred to $1\,\rm M_{H}^{-3}$ of initial gas as fed to the first stage (FFE). It was found that after the second stage, 106 g. of hydrocarbons/ $\rm M_{H}^{-3}$ of ideal gas were obtained. It was furthermore discovered that the gasol in the gas passing over the catalyst in stages 3 and 4 was converted into higher hydrocarbons and no longer could be quantitatively determined as gasol.

Average analysis of exit gas from Stage 1,

CO₂ 4.3% skw 1.1 co 7.4 H₂ 76.4 kw 3.8 N₂ 7.0

On adding 11.7% CO to this gas, one obtains the following gas:

CO₂ 3.9% sKV: 1.0 CO 17.1 H₂ 68.4 KW 3.4 N₂ 6.2

If the second gas has to be compressed into a 40-liter bomb up to a pressure of 160 atmospheres, one requires:

CO₂ 6.3% sKW 1.6 CO 27.3 H₂ 109.3 KW 5.5 N₂ 10.0

Rheinpreussen-Gasol was available with 32% skw and 58% kw; therefore only 1.6 atm. skw had to be added. At the same time, 3.4 atm. kw were compressed into the bomb; however, since 5.5 atm. kw were required, it was necessary to add an additional 2-1 atm. of CH₁. The mixing of the gases was easily accomplished therefore in this manner,

In order to refer the individual yields of the h stages to one cubic meter of the original starting gas, it is permissible to work in the individual stages with gases containing gasol. During those experiments, however, the conditions mera kept as nearly as possible to actual conditions because it appeared undesirable from the point of view of experience that the gasol of the end-gas should be removed after each stage. The yield determinations of the third and fourth stages low, however, that it is possible to obtain economic quantities of benzine when using iron catalysts (IV).

8. Recycling Experiment

Recycling in ; eneral gives similar results to those obtained when working in various stages. Therefore, a recycling experiment was undertaken with a furnace containing 18 reaction tubes and filled with 180 g. of catalyst.

The activity of the catalyst was checked with a CO-rich gas at 180°C, and then operation was started with a gas containing 1CO + 4H2. The operating temperature was 180°C. The conversion of CO was checked for both recycling as well as one single passage through the tubes. The work was carried out with 24 to 30 liters of end-gas, and approximately 100 liters were circulated. Consequently, during the recirculation, a 3 to 4 times higher flow velocity was obtained in the reaction furnace.

	183°			1880	203°		
	Circulated	Not circulated		Not circulated		lot	
Contraction	26ª	27%	33.5%	28%	31,5%	21.4	
C-balance CO conversion	42.5 g./Na3	32.5 g./fim ³	31.2 g√Nm ³ 61g	30.6 g./Nm3	31.2 g./Nm3	24.7 g/hm3	
			<u> </u>	00/3	61,5%	52%	

The preceding table shows contractions, carbon balance, and CO conversion at three different temperatures. From this experiment, the A.K. benzine was removed at 193°C. (without recirculation), and a distillation was carried through of the constituents boiling at 200°C. The boiling point indicated approximately normal pentane, normal hexane, normal heptane, and normal octane. A yield determination for the experiments of the 18-tube furnace at 193°C, and 30 liters of end-gas per hour showed 41.5 g./Nm3 of ideal gas. This yield was obtained without recycling of the end-gas. No comparative yield was obtained in the recycling experiment because the recycling pump failed to operate after some time.

C. Flow Experiment

The influence of the flow velocity was studied for the same catalyst at different temperatures (10 g. of iron or 15 g. of iron catalyst were charged into the furnace). The following table shows the end-gas quantities, the total gas quantity converted, and the converted CO per hour at various temperatures.

 -	Temperature ·	Liters end-gas per hr.	Percent con= traction	Liters A.G. per hr.	Converted gas quantity per hr,	con- verted per hr.	Percent CO con-
٨	1809	2 4 8	37 20 17	3,20 5,00 9,65	1,200 1 1,000 1 1,650 1	0,455 1 0,390 1 0,660 1	۲۲۲ 80
	1900	2 L 8.	711 511 58	2,78 5,26 9,30	0,780 1 1,260 1 1,300 1	0,680 1 0,680 1 0,564 1 0,600 1	69 56
	200°	2 4 8	35 2 7 20	3.08 5.48 10.00	1,080 1 1,480 1 2,000 1	0,531 1 0,535 1 0,330 1	33 90 51 山

From the tabulation, it is observed how for every temperature the contraction and the CO conversion reduced (about 50%) as the end-gas quantity increases from 2 to 8 liters per hour. Nevertheless, the total quantity of gas and the total quantity of CO converted increases steadily, so, for instance, at 200°C., approximately twice as much gas is converted for 8 liters of end-gas than for 2 liters of end-gas. The yield at 190°C. for 8 liters of end-gas was 34.4 g. of hydrocarbons per normal cubic meter of ideal gas.

D. The Influence of Different Modes of Catalyst Induction Upon the Operation of Hydrogen-Rich Starting Gas

The catalysts have been pretreated in the already well-known manner. ...e either worked with h liters of pure CO (per 10 g. of iron) for 25 hours (100 liters altogether) at 325°C. and 1/10 atm.; or we operated for 2-1/2 hours with hO liters of CO per hour per 10 grams of iron (100 liters altogether) at 325°C, and 1/10 atm.

In order to investigate the influence of different pretreatments of the catalyst upon operation with hydrogen-rich gas, the first thing we did was that we treated a catalyst according to the earlier methods long enough with mixed gas at 220°C.—255°C. and atmospheric pressure until it gave a contraction of 30% under the same conditions (h liters per 10 g. of iron per hour). Then we increased the pressure to 15 atm. and a gas of 100 + hh2 was used at 180°C. and 2 liters per hour of endegas. It was found that the yield even after a temperature of 200°C, was reached after 6 days of operation, was not as high as the yield when the catalyst was prestreated under reduced pressure.

after pretreatment	Temperature	Percent Contraction	CO conversion, percent	· Days of operation
with the deal ment	1815	12	20	1
with mixed gas	189	12	25	ੌਂ:
	196	22	37	7
	200	20	ែ រំ	3
•	199	30	16	77
	200	20	32	1
	199	20	34	. /
<u></u>	199	17	31	20
After pretreatment	180	30	<u> </u>	21
in vacuum with pure (0 181	24	60	1
	130	24		5 8
	180	21	6 6	
	179	1ú ₂ 5	28-2	10
	187		38.5	18
	190	23	48.5	26
	190	34	52	30
	170	23	50	43

Then the two methods of pretreatment are compared with each other, it may be now ticed that the vacuum treatment has the advantage. With the catalyst having been subjected to the vacuum treatment, the temperature had to be raised to 19000 only after operating for as long as 30 days. Also, the time of operation, the amount of carbon monoxide converted was higher than in the case of the catalyst pretreated under ordinary pressures. Since in both cases, the same catalyst was

used (78), it is out of the question that the differences in yields could be explained with a loss of activity of the catalyst. An experiment was carried out with a catalyst pretreated in vacuum and operated under normal pressure with a hydropen-rich gas (1:h). The results are tabulated in the next table and compared to those of the normal pretreated catalyst of the same constituents.

	Pretra	ated	<u>1</u> :	1:4		Not pretreated		
Tempera- ture	Con- trac- tion	CO con- version	No. of days	Temper- ature	Con- trac- tion	CO con- version	Mo. of days	
181 185 195 219 240 240	10 10 12.5 15	18 21 47 51 45	1 2 3 5 10 11 15	180 180 187 200 210 210 209 230	65557 766	12 23 20 h0	1 2 7 8 9 13 15	

It was not possible to obtain any appreciable amounts of hydrocarbons below 200°C. Then working at 200°C, or above, the conversions became normal. Approximately the same results were obtained in both cases when a hydrogen-rich gas was used under normal pressure and low temperatures.

Another experiment was carried out with the same catalyst. However, it was pretreated. The operation was carried through at 15 atm. with hydro, en-rich starting gas (1:h). The operating temperature was kept at 190°C. at first; however, the CO conversion under those conditions was only 10%. When the temperature was raised to 235°C., the contraction increased to 15%, and the CO conversion went up to 38%.

E. Influence of Operating Pressure Series

The influence of operating pressure upon the middle-pressure synthesis using iron catalysts was investigated at 0, 1.5, 3.5, 7.5, 15, and 30 atms. The following table shows the effect of the various pressures. In all cases, the catalyst used was the same as described before, and was pretreated prior to all experiments in a vacuum by using pure CO.

0 at	O atm. (see above table)				1.5 atm.				3.5 atm.			
***************************************	Con. trac- . tion	CC con- version	No. of days			CO con- version	Mow of days	Temp.	Con- trac-	Co con-	Non of	
181 185 195 219 240 240 240	4 7 6 10 12,5 15 19	18 21 47.5 51	1 2 3 5 10 11 15	180 180 180 189 190 190	9 17 15 26 22 8 6	29 43 27 58 52 23 31	2 7 10 34 27 37 39	181 130 131 130 130 130 139	33 37 20 20 14 23 31 26	60 91 60 57 48 42 59 58	2 7 10 16 23 32 37 47	

		3 na.				- <u> </u>					
Temp.	Jone trace tion	JU don≠ version	l.o of days	ie.,p.	Con trac-		To 25	Terro	1057 irse tipa	.47 <u> </u>	
181 180 180 180 181 182 130 180	34 38 25 30 26 32 27 21	52 70 71 68 55 52	2 7 10 15 22 32 36 49	180 131 130 180 179 179 137 170	30 24 24 21 17 19 23 34 23	71 60 68 53 33 48 62 50	10 18 24 25 30 43	130 135 135 130 130 130 130 130 150 150 150			

The experiments at 0 atm. 3x1 1.5 atm. are unsatisfactory at low temperature of run at 3.5 atm. showed a 40% conversion of CO after a month of operation at 12000. The experiment at 7.5 atm. showed the best results. After 50 days of openation at 180°C, the conversion had not decreased below 50%, and up to this since or in a slow decrease in activity of the catalyst was observed. The yield determination between the 34th and 33th day of operation still showed 40.5 g. of total hydrogenicus per 34 of ideal gas. Then working under 1) atm., it was necessary to raise the emperature from 180 to 19000, after 25 days of operation. A gield determination between the 16th and 80th days of operation showed 34.5 g. of total hydrocarbons per line of ideal as The 30 atm run showed an initial activity corresponding to 100/00 conversion. In order to avoid over-heating of the patalyst, the temperature and to be dropped to 17570. However, it could be mised again to 13670. on the Sta day. However, on the 20th day of operation, the conversion had dropped to 62%, and a temperature increase to 100%, was unavoidable. Fowever, this increase discrete help indefinisely. The yield determination detween the 9th and 13th law of approxition showed 4500 of metal hydrodarbons per find of ideal ras. From all rid ince experiments, it may se observed black bha most lavorable proserve is ? / aum / hon using a hydroxemerich gas of composition 200 a http:// It is a could be been an each 00 conversion occurs some where a bund 10 cum (soe tabulation s)

In order to lower the working temperature some more, when working with iron obtains, an experiment was carried out with an initial gas of composition $100 \pm 6H_2$ (same catalyst and same pretreatment as before). The experiment was started at 15 atm. and 160%.

Samperature	Contraction	GO conversion	Morro di di gra
1.50 °		70"	Commence of the Commence of th
153	26	ΰ 2	3
728	29	£ 2	
160	22	<u>م.</u> زرز	3
150	24	35	27
150	22	ćÇ	. j
140	20	5 ,1	20
150	20	45	21

The carbon balance on the 13th to 21st days of operation showed 23 g/ of confoneable hydrocarbons per $1m^2$ of pas. It was remarkable how little 30_2 was formed.

B. Normal Pressure Experiments

Another series of experiments was run with Fe and Cu catalysts and normal pressures and various starting gases containing different proportions of hydrogen and carbon monoxide. Both

Ferri- and Ferro-copper catalysts were used at normal temperature, and were tested for their activity by using mixed gas; at correspondingly lower temperatures.

Ferri - Cu Catalyst

	1 : 2			1 : 2 (Parallel Test)						
Temperature	Percent Contraction	Percent CO con- version	Days	Temperature	Percent Contraction	Percent CO con- version	Days			
235°	21		2	235°	22		2			
236	32		3	235	25		_			
229	26	80	4	233	27		7			
229	28	70	8	231	25		7			
230	22		9	245	30		,			
231	18		13		30		8			
245	33		14							
	1:4		-		1 : 6					
201	13	24	2	200	6	- - -	2			
201	18	(%0)	3	200	5		2			
200	14	24	4	205	5		4			
205	10	27	6	207	3		5			
210	9	<u>-</u> -	8	407	3		8			

Ferro - Cu Catalyst

1	: 2		1	: 2 (Para	allel Test	:)
34	90	2	231	31		2
30		3	228	30	90	2
32	90	4	227			7
28	90	8	229			8
31	90	10	230			10
25		19	230			11
1	: 4				6	
4		2	205			
12	30	3		10		2
11	59	7				3
13		10				4
			215	13 17	43 70	8 10
	34 30 32 28 31 25 1 4 12 11	30 32 90 28 90 31 90 25 1:4 4 12 30 11 59	34 90 2 30 3 32 90 4 28 90 8 31 90 10 25 19 1:4 4 2 12 30 3 11 59 7	34 90 2 231 30 3 228 32 90 4 227 28 90 8 229 31 90 10 230 25 19 230 1:4 4 2 205 12 30 3 209 11 59 7 210 13 10 210	34 90 2 231 31 30 3 228 30 32 90 4 227 34 28 90 8 229 30 31 90 10 230 33 25 19 230 34 1:4 1	34 90 2 231 31 30 3 228 30 90 32 90 4 227 34 28 90 8 229 30 90 31 90 10 230 33 90 25 19 230 34 1:4 1:6 4 2 205 3 12 30 3 209 10 28 11 59 7 210 13 40 13 10 210 13 43

The higher activity of the Ferro-Copper catalysts is especially apparent when operating with gas at temperatures of above 230°C. But when working with the hydrogen rich gases at around 215°C., this higher activity is scarcely noticeable.

When the experiments are compared with those employing a copper-free not pretreated catalyst, no important improvement can be noticed over a copper containing catalyst for the temperature range of 200-210°C.

Only approximately xunreadablex of the end gas consisted of ${\rm CO}_2$.

This experiment a___ proves that benzine may be produced at lower temperatures when using iron catalysts than the temperatures of the middle-pressure synthesis using cobalt.

Concerning the products of this reaction, it may be said that the paraffins obtained were of remarkably light color when using a hydrogen-rich gas. When a CO-rich gas was used, the products of the iron and middle-pressure synthesis were brown. The results have been given already on the distillation analyses of the fractions boiling below 200°C. (page 3).

One Percent Alkali Experiment

An experiment was carried out at 15 atm. And 180°C. , with the catalyst containing one percent potassium carbonate. The gas used consisted of $1\text{CO} = 4\text{H}_2$. It was found that the activity of this catalyst was considerable lower. Fe obtained yellow oil without solid paraffin.

III. Tests with Iron-Copper Catalysts.

Earlier experiments show that small additions of copper improved the activity of iron catalysts. In order to investigate this effect with a hydrogen-rich gas, Fe-Cu Catalysts were compounded. The catalysts used contained 5 parts of Fe and one part of Cu. The copper was co-precipitated with the iron. After the precipitation, the precipitate was made alkaline with 1/8 of potassium carbonate.

A. Influence of Pressure.

The Ferri-Cu Catalyst (5:1) was pretreated in a vacuum and was used for three experiments. One experiment was run at 0 atm., another at 1.5 atm., and a third at 15 atm. Pressure, using a hydrogen-rich starting gas. The following tabulation shows the results of the experiments.

	0	atm.			1.	5 atm.			15	atm.	
Temp	Con- trac- tion	No. of days	CO con- version	Temp	Con- trac- tion	No. of days	CO con-	Temp	Con- trac- tion	No. of	CO con-
189°	6%	1		180°		2				days	version
185	5	5	6	180		_		176°	24%	1	59%
215	25	16			14	8	20	182	23	6	46
			24	180	13	10	24	181	25	10	48
216	16	19	23	190	24	13	45	180	26	19	56
225	22	31	20	190	27	16	52	185	40	22	50 64
				193	13	29	42	185	32	25	59
								188	22	33	48

A comparison with the corresponding experiments carried out with a copper-free catalyst shows that for 0 and 1.5 atm., no improvements were observed. At 15 atm., it appears that a small increase in catalyst activity was noticed (see also tabulation 6).

APPENDIX

TOM Reel 101 Doc	91 ∟1	O SEO. WTD	Original Manuscript Page No.
The Foduction	•••••	••••••••••••••	1
I. The	Cataly	st	6
A. 1	Precip	itation of Catalyst	6
:	1. St	arting Vaterial	6
2	2. Pr	ecipitation With Sodium Carbonate	7
3	3. Pr	scipitation With Ammonia	10
1	to The	Addition of Kieselguhr	10
В. В	retre	atment of the Catalyst	10
נ	. Ind	fuction with CO-H ₂ Mixtures During the Synthesis	11
	8.	Mixed gas and atmospheric pressure	11
	b.	CO-rich gas and atmospheric pressure	12
	c.	CO-rich gas and elevated pressure	13
2	F	nuction with CO and H2 Nixtures in a rocess Separate from that of the Syn-hesis	15
	8.	Induction at various pressures and synthesis at ordinary pressure	15
	b .	Induction at ordinary pressure and synthesis at elevated pressure	16
	c.	Induction at reduced pressure and various temperatures, synthesis at elevated pressure	18
	d.	Influence of the induction pressure upon the synthesis at elevated pressure (induction temperature, 325°C.)	20
3.	Indi	ection with CO	21
	a.	Influence of the induction temperature at 1/10 atmosphere	

			Page Ik
		b. Influence of induction pressure	25
		e. Induction time	26
		d. Mixture of CO with other gases	29
		4. Theory of Induction Process	30
n	. I	he Synthesis	36
	A.	. The Synthesis Gas	36
	B.	The Synthesis Pressure	40
	C.	The Reaction Temperature	45
		1. Influence of Induction	46
		2. Influence of Gas Composition	49
		3. Effect of Too Low Starting Temperature	50
		4. Temperature and Reaction Products	รเ
	D.		52
	E.	Treatment with Hydrogen Before and After the Synthesis	<i>5</i> 5
		1. Pretreatment with Hydrogen	55
		2. Hydrogen Treatment Between Induction and Synthesis	56
		3. Hydrogen Treatment During the Synthesis	57
	P.	Catalysts Based on Ferrous Salts	<i>5</i> 9
	G.	The Influence of the Addition of Copper	60
	Я.	The Effect of the Addition of Kieselguhr	62
III.	The	Reaction Products	67
	A.	Liquid Hydrocarbons	69
	B.	Paraffin	72
	C.	General	73
	D.	OrmanuContaining Decision	76

_ ·	Page No.
E. City Gas	
IV. General Problems	81
A. Synthesis Gas Production	81.
B. Space-Time Fields and Apparatus Details	84
C. Pelleting of the Catalyst	89
D. Some Details on the Further Processing of the Primary Products	~
	91
Conclusion	98
Literature	102
TOM Reel 101 Doc. PG-21574-NID	
Introduction by Franz Fischer	1
I. Introduction	4
II. The Catalyst	8
A. Precipitation of the Catalyst	10
B. Pretreatment of the Catalyst	10
1. Induction with Mixtures of CO and H2 During the Synthesis	10
a. Experiments at atmospheric pressure	10
b. CO-rich gas and elevated pressure	n
2. Induction of the Catalyst By a Separate Process Preceding the Actual Synthesis	13
a. Induction at ordinary pressure and syn- thesis at higher pressure	13
b. Induction at different pressures and synthesis at ordinary pressure	14
c. Influence of the induction temperature upon the progress of the synthesis	15
3. The Influence of the Induction Upon the Syn- thesis Temperature	16
a. Time of induction	17
III. The Synthesis	19

		THE NO
	A. The Synthesis Gas	19
	B. The Synthesis Pressure	22
	C. The Reaction Temperature	23
	A. The Inclusions of the Alkali Contents on the	
	Iron Catalysts	25
	E. President of the Catalyst with Hydrogen	27
	7. The Effect of Addition of Mossigner	29
	G. The Construction of the Apparetus	29
	IV. The Products of Reaction	30
	A. Liquid Hydrocarbons	30
	B. Paraffin	32
	C. Gasol	33
	D. Oxygen-Containing Products	34
	E. City Gas	35
	V. Conclusion.	
Litera	ture	36
	el 101 Dec. PG-21581-NTD	39
I.	Introduction	1
n.	Iron-Copper Catalysts from Ferrous Compounds	4
III.	- an achier >_acmicators opertiage tradition is the kelidic	
TU	Compounds	22
	Needle-Iron Ore Catalysts	43
₹.	Influence of Pretreatment of Iron Catalysts	52
VI.	Influence of Carriers	61
AII.	Course of the Reaction with the Iron Catalyst	77
AIII.	Experiments on Water Formation	84
n.	Best Catalyst Developed	121
	Pagenematics of Coton -	100

-	_		Page No
II,	, He	generation of the Erit Gases	126
III.	T	n-Stage Experiments with Water-Gas and Mixed Gas on Iron-Copper Catalysts	130
IIII.		portance of the Iron Catalysts for the Simultaneous Production of CO-Deficient City Gas and Bensine in Gas Works	120
IIV.			
		dustion of the CO2 On Iron Catalysta	
XV.	Co	pper-Free Iron Catalyste	((?)
IVI.		action Products from Iron Catalysts	
WII,	Ad	rentages and Disadvantages of Iron Catalysts	176
		D. Doc. PG-21577-MID	
I.	Test	Tadmahd	
		roduction	(?)
II.	Tes	its with Iron Catalysts Containing 1/4 Percent K2CO3	2
	A.	Multi-Stage Operation	2
	B.	Gas Recycle Experiments	3
	C.	Flow Experiment	4
	D.	Influence of Catalyst Induction	5
	E.	Influence of Operating Pressure	6
	P.	Tests with 100+6H2 Gas Mixture,	7
	G.	Experiment with Catalyst Containing One Percent Al- kali	8
III.	Tes	ts with Iron-Copper Catalysts	8
	A.	Influence of Pressure	8
	B.	Normal Pressure Experiments	É