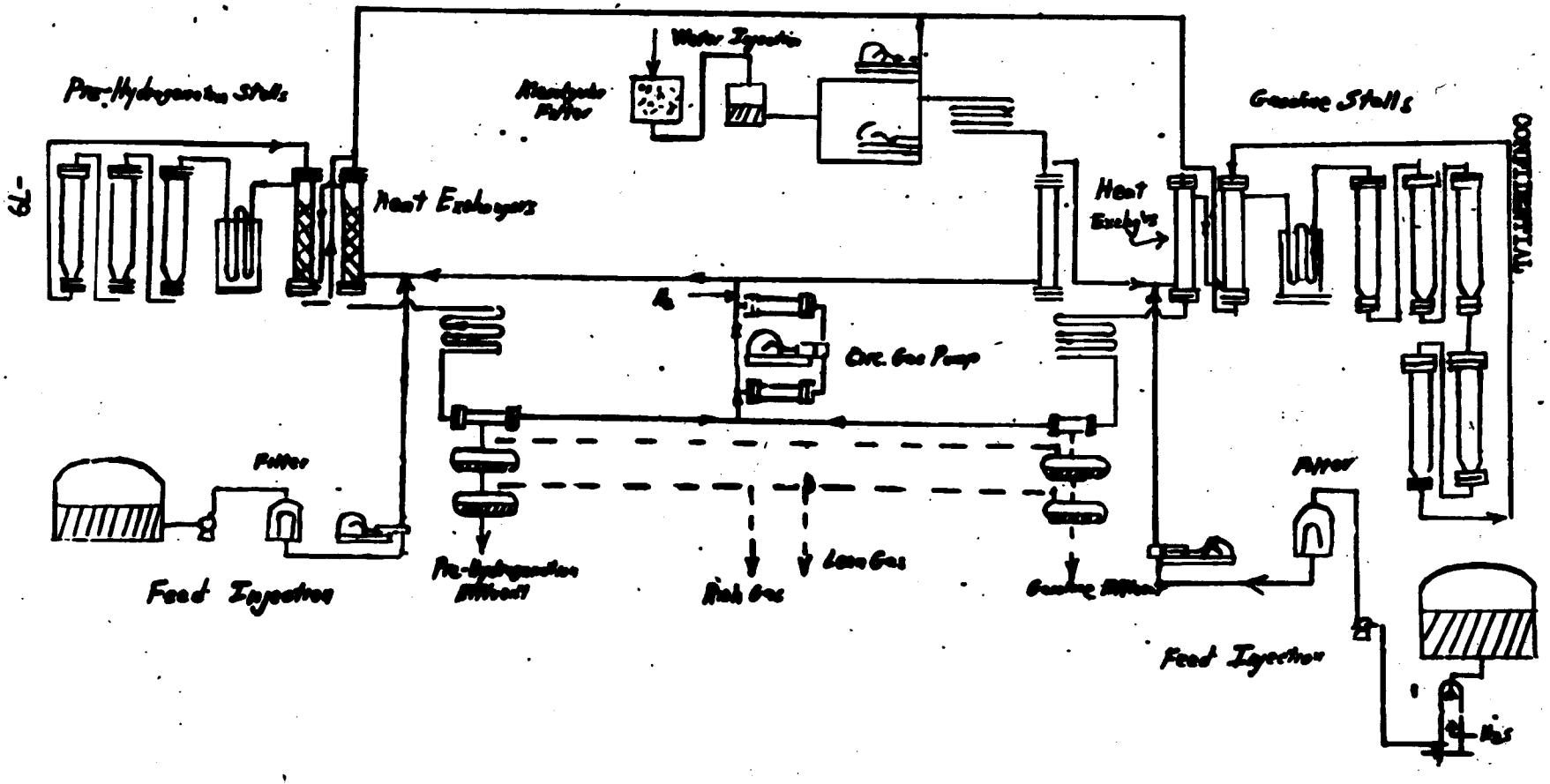
III. GAS PHASE HYDROGENATION.

(a) This unit runs at three hundred twenty-five atmospheres pressure. It consists of four (4) stalls, four (4) gas circulating pumps, six (6) feed pumps for middle oil, three (3) feed pumps for water injection, two (2) water wash towers and sulfurizing equipement for the prehydrogenation and gasoline stalls (Fig. 19).

(b) The stalls each have two (2) regenerators, six hundred (600) millimeters diameter, and catalyst chambers. The latter are one thousand (1,000) millimeters diameter, eighteen (18) meters long and have a catalyst volume of eight (8) cubic meters. Two of the stalls have electric preheaters and the other two gas-burning preheaters. The latter have one (1) oil burner and two (2) circulating blowers. At this time, two (2) stalls of three (3) chambers and one (1) stall of five (5) chambers are filled with the prehydrogenation catalyst 5058/7846 W. The fourth stall of five (5) chambers is filled with gasoline catalyst 6434. Each circulating pump handles seventy-five thousand (75,000) cubic meters/hour at a differential pressure of thirty-five (35) atmospheres. All middle oil injection pumps are enclosed in the stalls. In order to prevent the products of the prehydrogenation and gasoline stalls from mixing, all piping is equipped with double valves and intermediate expansion. The pump suction lines are fitted with porous filters. Three (3) of the six (6) feed pumps have variable speed motors. The feed pumps will handle twenty-five (25) cubic meters/hour and the condensate pumps six (6) cubic meters/hour. The condensate is filtered through kieselguhr.

Fig 10

High Pressure Gas Phase



III. GAS PHASE HYDROGENATION. (Cont'd.)

(c) The process, as mentioned, works in two (2) steps; the prehydrogenation of the sump-phase middle oil, and the gasoline production step. The former is accomplished by a simultaneous cracking and hydrogenating of the middle oil to a liquid suitable for the production of gasoline. The latter catalyst is more of a cracking catalyst, producing aromatics and iso-paraffins. The former catalysts are designated 5058 and 7846. Catalyst 5058 contains tungsten, an element difficult to obtain in Germany, so 7846 was developed as a substitute. The final catalyst is 6434. All chambers in one stall are connected in series. The operation and arrangement of the stalls is almost identical with the sump phase units.

(d) It must be emphasized that special precautions must be used with catalyst 6434, as it is extremely sensitive to alkaline nitrogen compounds as well as oxygen, both free and combined. Hence the prehydrogenation product must be well refined. Its phenol content can not exceed 0.03 percent and the alkaline nitrogen five (5) milligrams/liter. By water wash, the NH_3 content is reduced to from 0.02 to 0.03 grams/cubic meter. The catalyst must also have H_2S added, up to from 0.4 to 0.5 percent.

(e) The degree of refinement of this feed is measured by the difference in specific gravity between the feed and effluent streams of the stall. These should be from 0.10 to 0.11 entering the prehydrogenator, and 0.075 leaving.

(f) From these values, the catalyst temperatures are established. Using catalyst 5058 this should be 18.5 M.V. and 7846 one (1) M.V. higher. The 6434 catalyst chamber uses nineteen (19) to twenty-one (21) M.V. The increased value is due to slow loss of catalyst activity through refining requirements which the 6434 catalyst requires. The loss of activity in the prehydrogenation chamber took three (3) years to occur and in the 6434 chamber one and one-fourth (1¼) years. This may be considered a normal life.

(g) The A middle oil used in the gas phase consists of seventy-five (75) percent liquid from lignite and twenty-five (25) percent oil from the outside (tar, etc). The composition varies with the specifications of the oil from outside. It normally

III. GAS PHASE HYDROGENATION. (g)(Cont'd.)

contains fifteen (15) percent phenols but has gone up as high as twenty (20) percent. The high phenol content, attained during the early days of operation, caused high heating of the chambers with resulting loss in production. Later, when the phenol content dropped, the original catalyst activity was restored and full capacity regained.

(h) In the beginning of 1943, a 6434 stall was built to produce aviation gasoline. This required increased purity from the prehydrogenation unit which in turn lowered the capacity of the same. The average capacity was 0.6 kilograms/liter catalyst space (going up at times to one (1) kilogram/liter.). The capacity of the 6434 stall was higher, and averaged 0.75 to 0.8 kilograms/liter (maximum 1.1 kilograms/liter of space).

OPERATING RESULTS - 1943

Stream efficiency	(actual operating hours)/(possible " ")		
Gasoline stalls		75.2	
Middle oil stalls		51.8	
Circulating pumps		53.2	
	Catalyst		
No. of operating stalls (avg)	5058	2.08	
	6434	0.80	
Avg. reaction vol.	5058	37.4	cu.meters
	6434	12.4	" "
Avg. injection feed	5058	0.824	cu.met RV/H
	6434	1.120	" " " "
Avg. throughput	5058	0.764	tons/cu.met RV/H
	6434	1.070	" " " " "
Gasoline capacity (180°C end point)	5058	0.280	" " " " "
	6434	0.710	" " " " "

III. GAS PHASE HYDROGENATION. (Cont'd.)

OPERATING RESULTS - 1943 (Cont'd.)

	Catalyst		
Fresh gas/injection feed	5058	432.0	cu.met/ton
	6434	255.0	" " "
Cooling gas/injection feed	5058	700.0	" " "
	6434	262.5	" " "
Circulating gas (stall inlet)	5058	4325	" " "
	6434	1610	" " "
H_2 in circulating gas (stall inlet)		83.9 %	@ 306.5 atm
Gasoline (180 C end point) in A middle oil		22.8 %	
Phenols in A middle oil		15.4 %	
H_2S in injection feed	5058	38.2 %	
	6434	68.0 %	
Freed gas in effluent	5058 lean	24.9	cu.met/cu.met
	5058 rich	11.5	" " " "
	6434 lean	58.2	" " " "
	6434 rich	29.3	" " " "
Intermediate expansion pressure	5058	28.	atm.
	6434	28	"
Hourly rates - Middle oil injection	5058	29.9	cu.met/hr
	6434	12.1	" " "
Water injected (NH_3 wash water)	5058 + 6434	6.85	cu.met/hr
Fresh feed gas	5058	12,340	" " "
	6434	3,670	" " "
Effluent gas	5058 lean	818	" " "
	5058 rich	377	" " "
	6434 lean	1,660	" " "
	6434 rich	750	" " "

III. GAS PHASE HYDROGENATION. (Cont'd.)

AVERAGE PROPERTIES OF ENTERING AND EFFLUENT PRODUCTS - 1943

PREHYDROGENATION

A Middle Oil

Sp. gravity	0.927 @ 20°C		(Aromatics 62.5 %
API (Phenol free prod)	4.0	?	(Olefines 17.2 %
Phenol content	15.4		(Naphthenes 9.2 %
Mat'l boiling up to 180°C	20.5		(Paraffines 11.4 %

5058 Effluent

Sp. gravity	0.825 @ 20°C		(Aromatics 15.0 %
API	52.0		(Olefines 2.0 %
Phenol content	0.03		(Naphthenes 29.4 %
Alkaline nitrogen in B middle oil	5	mg/liter	(
Gasoline content up to 180°C	38	%	(

Properties of the Gasoline - 180°C End Point

Sp. gravity	0.765 @ 20°C		(Aromatics 8.4 %
API	43.4	?	(Olefines 1.9 %
Cut below 100°C	22.	%	(Naphthenes 30.4 %
Octane number (motor method)	60.5		(Paraffines 59.3 %

Samples taken after the 5058 stall had the following inspections:

Sp. gravity	0.825 @ 20°C	
API	20.0	?
Phenol content	6.0	%
Gasoline up to 180°C	25.0	%

GASOLINE MANUFACTURE

Feed to 6434 Stall

Prehydrogenation middle oil	56.0	%
6434 recycled middle oil	44.	
Sp. gravity	0.824 @ 20°C	

III. GAS PHASE HYDROGENATION. (Cont'd.)

Feed to 6434 Stall (Cont'd.)

API	54.0	
Alkaline nitrogen	5.0	mg/liter
End point	328.	°C.

6434 Effluent

Sp. gravity	0.768 @ 20°C		(Aromatics 7.2 %
API	54.		(Olefines 2.6 %
Gasoline - 150°C end point	49.0	%	(Naphthenes 58.0 %
Gasoline - 180°C end point	68.0	%	(Paraffines 32.2 %

Gasoline properties - 150°C End Point

Sp. gravity	0.724 @ 20°C	(Aromatics 6.1 %
API	53.5	(Olefines 1.9 %
Gasoline - 100°C end point	49.0	(Naphthenes 43.5 %
Octane number (motor method)	73.3	(Paraffines 48.5 %