II. HIGH PRESSURE HYDROGENATION. (Cont'd.)

(t) Circulating Pumps - Seven Hundred Atmospheres.

The circulating pumps were plunger type machines of one hundred seventy (170) millimeters diameters. They were converted piston type machines. The diameter of the piston was two hundred (200) millimeters, and the piston rod was one hundred (100) millimeters in diameter. The capacity varied from fifty-two thousand (52,000) to sixty-two thousand (62,000) cubic meters/hour. The working life of a set of packing was from sixty (60) to two hundred (200) days. The oil consumption per machine was from eighty (80) to about thirty (30) liters per hours. In starting, entrainment of frothy effluent caused difficulties, but these stopped after raising the effluent temperature to one hundred twenty (120) degrees centigrade and starting the recycle gas washer (Fig. 17).

(u) Circulating Pumps - Three Hundred Twenty-five Atmospheres.

These are in contrast to the seven hundred (700) atmosphere pumps arranged two (2) ways and are also of lighter construction. They required frequent maintenance of the heads and crank shafts. The average working period of the packing was one hundred sixty (160) days.

(v) Oil Feed Pumps.

The middle oil feed pumps (325 atmospheres) are packed with Götz metal. The packing metal contained ten (10) to twelve (12) percent tin. Numerous difficulties of the packing glands could be reduced by careful installation and regular maintainance. Lubrication of the center of the plunger with coal effluent residue mixed with middle oil prevented rust formation by water sprayed for cooling. Diesel oil was fed to the packing. The seven hundred (700) atmosphere auxiliary press pumps of the recycle gas oil washer worked opposite, because of the fear of initial operating difficulties.

(w) Expansion Machines.

They are adversely affected by the solid matter carried with frothy effluent into the wash oil. The removal of the freth delayed getting the plant into normal operation and made frequent changes and filtrations of the wash oils necessary. Safety precautions in operation proved wise. The reversing valve for reversing the piston from working stroke to discharge stroke caused considerable difficulty. The valve was replaced by a bored hole to the operating cylinder. The engine then operated without difficulty.

(x) Installation, Maintenance, and methods of Operation to Avoid Difficulties.

(1) The starting of the seven hundred (700) atmosphere sump phase was without incident. Later difficulties arose sporadically.

(2) The technical maintenace was placed in the most competent hands; however, the actual installation was done by unskilled people, and yet the apparatus was fully tight when starting up. Those charged with maintenance of the high pressure apparatus used utmost care. Repairs were made quickly and competently carried out. The operational supervision was good in spite of the cosmopolitan set of workmen. Noteworthy is the fact that no tube ruptures occurred through overheating in the coal stalls. Only once did a lens joint between the first and second reactor fail. It caused a fire, but was not serious. In the construction of other hydrogenation works, where chamber fires occurred with powerful fine pointed flames, brick work of the chamber walls were built higher than the reactors, and the windows opposite the paste press houses were walled up. Likewise, for fire protection the windows on the chamber operating walkways and those over the recycle pumps were walled up. Here one mistake was made, an intermediate expansion was not sealed off. The escaping gases ignited and damaged the buildings. For further operating protection the expansion piping, which was especially dangerous, was carried outside overhead.

(3) In the installation of the plant the emergency blow down lines of all of the chambers were led out of the operating chambers into a common line for economy sake. This line meant a serious hazard to the operating crew and apparatus as it was exposed to fluctuations of temperature.

II. HIGH PRESSURE HYDROGENATION. (x)(Cont'd.)

A serious fire developed once at a remote place on the line during a chamber blow down. On this account a second alarm system was installed by the first.

(4) Special attention was paid to the quick opening valves of the high pressure, and the control switches of all driving pumps were connected to one master switch. By this means the high pressure apparatus can be stopped within a few seconds. The arrangement is for airraid protection, but it is useful in normal operation.

(5) The production rate may be estimated by the H_2 generation except in sporadic cases. After elimination of the caviar difficulties (October 1942) the only things that could stop operations were gas production and very heavy demands on the technical section, The average chamber operating time was usually forty-two (42) days. It rose in 1943 to sixty-six (66) and in 1944 to eighty-four (84) days.

(6) The relatively short operation time is largely dependent on the war. A total stoppage or flow caused coking in the chambers. When air raid warning sounded, diluent oil was pumped into the chambers and caused the temperature to drop and often the de-sanding failed to work. The apparatus would then become plugged up from salt crusts.

(7) In normal operation the average chamber operation time was over one hundred (100) days. The simultaneous use of more chambers reduced the hydrogen capacity, especially the high chamber charges, to fifty (50) m^3/hour. These peak loads was later abondoned on account of erosion in the preheater tubes and the asphalt decomposition became too difficult. Later they succeeded in avoiding erosion through bypassing part of the chamber inlet gas that used to be added to the coal paste and passed through the preheater tubes. It was shown by experience with both de-sanding reactors to be possible to use charges about fifty (50) m^3/hour. By use of both chambers the asphalt decomposition was practically complete after the first two reactors. The cold gas charging to the reactors as previously described was used. It is worth noting that in the lower part of the first reactor

II. HIGH PRESSURE HYDROGENATION. (x)(Cont'd.)

the gas and paste were in counter-current flow. The result is that it should be used in conjunction with the counter-current hot separator to obtain similar throughputs at a wide change of reactor volumes.

(8) In Example I (Fig. 18) is shown a chamber with three (3) pieces. In the first reactor the main flow of the paste is down. A small paste flow is allowed to be carried out to the top to keep the reactor full. In the second reactor both gas and past flow upwards. The third apparatus is a counter-current hot separator which must work well, because fresh gas is injected into it. Example II (Fig. 18) shows a straight counter-current apparatus.

IMPORTANT OPERATING RESULTS - 1943

Stream efficiency (Actual operating hours) (Possible operating hours)	sump chambers	84.4 %
	paste presses	75.5 %
	circulating pumps	81.9 %
Avg. Reaction volume (sum of all chambers)		98.1 cu.meters
Avg. No. of chambers used		3.00
Avg. Paste injected/chamber		37.5 cu.met/hr.
Coal Paste fed		1.43 t m^3 reaction volume/hr
Middle Oil made		0.265 t m^3 reaction volume/hr
Coal converted		99.2 %

FRESH GAS USED

Fed to middle oil reforming	2038.5 cu.meter/ton
Fed to paste	373.6 cu.meter/ton
Circulating gas (Chamber entrance)	575. cu.meter/ton
H_2 in Circulating gas (Chamber entrance)	71.9 %
Pressure	625 atm
Solids in coal paste	41.0 %
Ash content of solid	13.3 %
Pure carbon in coal paste	35.6 %

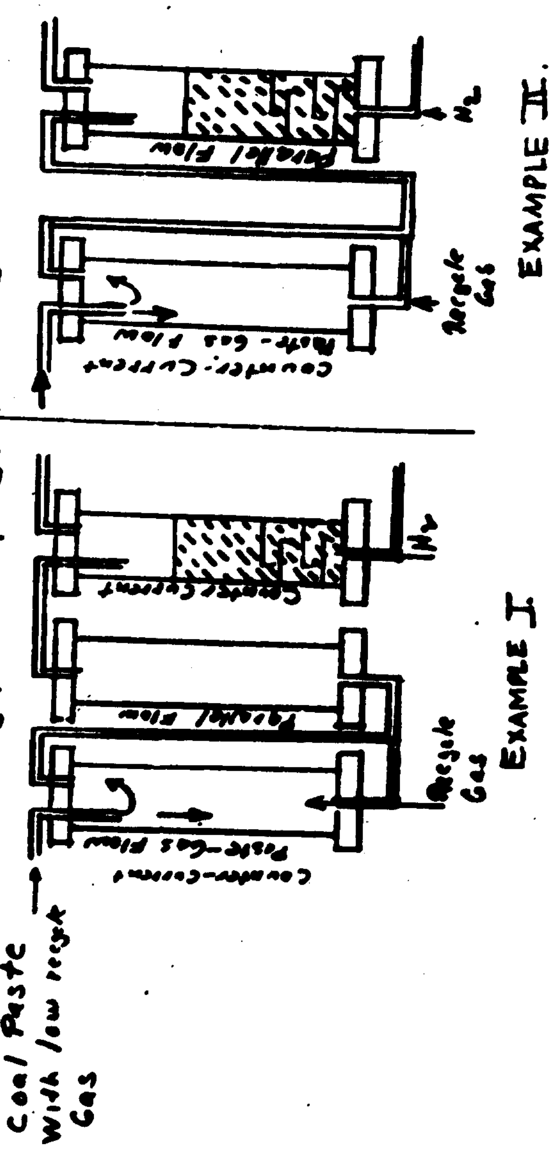

FIG. 18 — Two Types of Chambers

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II. HIGH PRESSURE HYDROGENATION. (Cont'd.)

FRESH GAS USED (Cont'd.)

Red earth based on dry lignite/water free	5.76 %
Sulfur - dry lignite/water free	0.129%
Screen reject over 400 mesh	10.6 %
Screen reject over vibrating screen	0.6 kg/ton

COMPOSITION OF DILUENT OIL

Sump phase residue	34.2 %
Centrifuged oil	56.7 %
Outside oil	9.1 %
Boiling range-up to 340°C	10.6 %
Solids	4.0 %
Asphalt	8.85 %
Effluent (based on paste and seal oil)	51.0 %
Mud " " " " " "	33.8 %
Middle oil - up to 340°C in effluent	38.8 %
Middle oil - up to 340°C in mud	11.2 %
Solids in mud	18.5 %
Asphalts in mud oil	15.6 %

DISSOLVED GAS

In effluent	lean	74.9 cu.met/cu.
	rich	14.2
In mud		122.5
In wash oil	lean	151.3
	rich	46.9

INTERMEDIATE EXPANSION PRESSURE

Effluent	38. atm.
Wash oil	35. atm.

HOURLY QUANTITIES

Coal paste	112.6 cu.met/hr
Cold oil and seal oil	8.8 cu.met/hr
Water injection	6.4 cu.met/hr
Effluent	65.5

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II. HIGH PRESSURE HYDROGENATION. (Cont'd.)

HOURLY QUANTITIES (Cont'd.)

Mud		41.0	
Middle oil reformed		25.4	tons/hr
Fresh gas required		51,583.	cu.met/hr
Gas in effluent	lean	4,902.	" " "
	rich	929.	" " "
Wash gas	lean	7,851.	" " "
	rich	2,274.	" " "
Gas in mud		5,027.	
Wash oil		50.1	cu.met/hr