

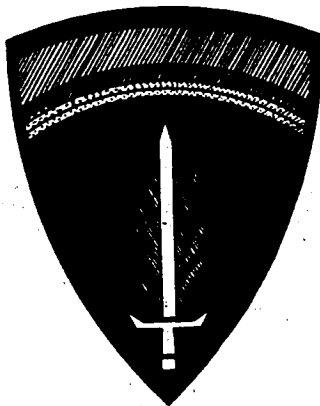
Cafey 1

FIAT FINAL REPORT 888

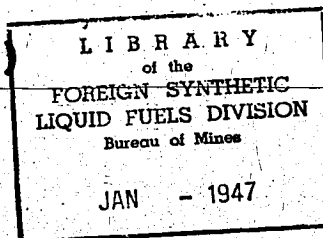
METHANOL SYNTHESIS AT

I.G. FARBENINDUSTRIE PLANT AT OPPAU.

Robert John Ed Dewling, M.W. L.E.



OFFICE OF MILITARY GOVERNMENT
FOR GERMANY (US)



FIELD INFORMATION AGENCY TECHNICAL

OFFICE OF MILITARY GOVERNMENT FOR GERMANY (US)

FIAT FINAL REPORT NO. 888

1 August 1946

**METHANOL SYNTHESIS AT
I.G. FARBEWINDUSTRIE PLANT AT OPPAU**

BY

**JOHN ROBEILL
WILLIAM L.E. DEWLING**

TECHNICAL INDUSTRIAL INTELLIGENCE DIVISION

**THIS REPORT IS ISSUED WITH THE WARNING THAT IF THE SUBJECT MATTER SHOULD
BE PROTECTED BY U.S. PATENTS OR PATENT APPLICATION, THIS PUBLICATION
CANNOT BE HELD TO GIVE ANY PROTECTION AGAINST ACTION FOR INFRINGEMENT.**

FIELD INFORMATION AGENCY, TECHNICAL

ABSTRACT

Presents information on process and equipment design of the methanol synthesis plant at Oppau, and reviews the latest developments achieved by I.G. Farbenindustrie in the art of methanol synthesis,

TABLE OF CONTENTS

<u>Subject</u>	<u>Page</u>
Introduction	1
<u>PART I - Methanol Synthesis System</u>	
General	2
Process Description	3
Description of Equipment	4
Operating Data, Yields and Utilities	6
Catalysts	7
<u>PART II - Methanol Distillation System</u>	
Process Description	8
Description of Equipment	10
Operating Data, Yields and Utilities	11
Analytical Methods	12
Appendix 1 List of German Personnel Interviewed	13
" 2 Bibliography	14
" 3 Figure 1 Flow Diagram of the Synthesis System	15
Figure 2 Interchanger	16
Figure 3 Synthetic Converter	17
Figure 4 Converter Details	18
Figure 5 Flow Diagram of the Distillation System	19

INTRODUCTION

Objective:

The I.G. Farbenindustrie plant at Oppau was visited on several occasions between July 15 and July 27, 1946, to study the methanol plant and obtain all necessary information.

Evaluation:

In general, the process employed at Oppau for the synthesis of methanol is similar to that used in the United States. However, certain process and design features incorporated in this plant, and improvements made in newer plants built elsewhere in Germany by I.G. Farbenindustrie, are considered to be of particular interest.

Guide to the Reader:

Synthetic methanol production has been investigated at Oppau only. Information on other, more recently built methanol plants, was obtained from interrogated personnel who have been connected with other installations. The reader is referred to Appendix 2 for a list of previous reports on this subject.

PART I - METHANOL SYNTHESIS SYSTEM

General.

The methanol production technique at Oppau is based on experience gained in the manufacture of ammonia and isobutyl alcohol. The first isobutyl unit at Oppau was attached to the ammonia plant, use being made of certain ammonia plant equipment and building facilities.

Methanol, which is used at Oppau for the production of formaldehyde, was formerly received from the I.G. Plant at Leuna. Later, as the demand for formaldehyde increased, a new isobutyl plant was constructed at Oppau and the isobutyl plant, connected with the ammonia plant, was converted to methanol production.

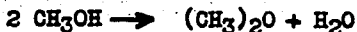
At present there are two complete methanol synthesis loops in operation at the ammonia plant, each having a capacity of 90 to 100 tons per day, and the new isobutyl plant is shut down because of an insufficient supply of gas.

According to the interrogated personnel the modern methanol plants built elsewhere in Germany by I.G. Farbenindustrie are very similar in construction and layout to the new isobutyl plant at Oppau. However, a different catalyst is used and the space velocity for methanol synthesis is about 3 times that for isobutyl synthesis.

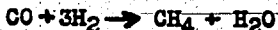
Methanol is produced from hydrogen and carbon monoxide, in the presence of a suitable catalyst according to the following reaction:



The following undesirable side reaction, giving small amounts of dimethyl ether also takes place:



If the temperature of the catalyst is allowed to rise above about 400°C. the following highly exothermic reaction takes place with further increase in temperature:



The raw material used for methanol synthesis at Oppau is a water gas of approximately the following composition:

52.5% H_2 , 41% CO , 5% CO_2 , and 1.5% N_2

Sulfur is removed from this gas by passing it through activated carbon at low pressure. A portion of the gas is sent through a low pressure CO conversion system to adjust the ratio of H_2 to CO to the proper proportion and the combined gas is then compressed to 25 to 27 atm., and scrubbed with water for the removal of CO_2 . This is followed by a final compression to about 260 atm. after which it is sent to the synthesis system as fresh make-up gas.

Process Description

Fig. 1 gives the flow diagram of a methanol synthesis loop. Although the equipment is generally designed for a maximum pressure of 325 atm., the usual operating pressure at Oppau is 250 to 260 atm.

The fresh make up gas has the following approximate composition:

68.0% H_2	
29.0% CO	Ratio $\frac{H_2}{CO} = 2.2$ to 2.4
0.5% CO_2	
2.1% N_2	Maximum sulfur content, 1 to 2 mg/cu.m. of gas
0.2% CH_4	

This gas is passed through a vessel containing activated carbon which removes catalyst poisons such as carbon oxysulfide and iron carbonyl. The removal of these impurities takes place at room temperature, and it is necessary to inject into the gas stream about 0.5 gm. of ammonia per 1 cu.m. of gas, as well as oxygen in slightly over the stoichiometric amount for oxidizing the sulfur contained in the gas. The purified gas is introduced into the synthesis loop at the suction side of the circulator.

Starting at this point the flow of gas is as follows: The gas leaving the circulator passes through an oil trap, where lubricating oil is removed, and is then conducted to the interchanger. In this vessel the gas is heated by the gas leaving the converter and, after passing through the starting heater, enters the converter. A portion of the cold gas by-passes the interchanger and is injected between the catalyst beds in the converter for temperature control. The gas leaving the converter passes through the interchanger where it is cooled by the incoming gas and then goes to a double pipe water cooler in which the product is condensed. The product is removed from the gas stream in the product separator following the water cooler and the non-condensed gases are returned to the suction of the circulator. A constant bleed is maintained after the product separator to control inert gas concentration in the loop.

Condensate removed from the product separator containing methanol, water, dimethylether, higher alcohols and impurities is known as "raw methanol" and is sent to the distillation system.

Description of Equipment.

One complete synthesis loop consists of the following equipment:

- 2 Activated carbon vessels - suitable for either 2 or 3 synthesis loops. One is operated and one is spare. These vessels are vertical towers 800 mm. I.D. x 8 m. high and each contains 4 meters of activated carbon (M Khole) packing. The packing is 7 to 10 mm. in size. See section on catalyst for preparation of activated carbon.
- 1 Circulator - At Oppau several of the old vertical-type steam driven circulators, originally installed for ammonia production, are used. The new plants are equipped with more modern machines. For instance, at the Waldenburg plant where 3 methanol loops were erected for a total production of 300 tons per day, 3 electrically driven circulators each having a capacity of 100,000 to 110,000 cu. m. per hr. NTP, were installed. They are constant speed units and operate at 122 R.P.M.
- 1 Oil Trap - Oppau uses standard vertical cylindrical vessels. The newer methanol plants are using cylindrical vessels 600 mm. I.D. x 6 m. long, installed at a small angle from the horizontal in order to provide a large disengaging surface.
- 1 Product separator - Oppau uses standard vertical cylindrical vessels. Newer plants have inclined vessels, similar to the oil traps, and are 800 mm. I.D. x 6 m. long.
- 1 Water cooler - Horizontal double-pipe unit consisting of 4 rows in parallel, 10 pipes high. The inside pipes, 45 mm. I.D. x 8 m. long, carry the high pressure gas while water is circulated counter-currently in the outside pipes which have an I.D. of 120 mm. The total surface of 1 unit is approximately 260 sq. m. The inside pipes are made of N5 steel (3% Cr, 0.25% Mo, 0.1% C). It was found that severe corrosion took place at the inlets to the cooler and pieces approximately 1 ft. long of N8 steel (3% Cr, 0.5% Mo, 0.5% W) were welded to the N5 pipes at the inlet ends.
- 1 Interchanger - (Fig.2) This unit is of the shell and tube type. The shell is a steel forging made of S2 carbon steel (Siemens Martin steel with 0.2% C, having 40 to 45 Kg/sq. mm. tensile strength and 26% elongation), 800 mm. I.D. x 12 m. long. It has a 10 mm. thick liner of N5 (3% Cr, 0.25% Mo, 0.1% C) or N8 (3% Cr, 0.5% Mo, 0.5% W) special steel protected by a 2 mm. thick brass (63% Cu, 37% Zn) liner. The two heads are also protected with 2 mm. thick brass plates. The tube bundle consists of 757 copper manganese alloy (Cu + 1.5% Mn) tubes, 8 mm. I.D. x 14 mm. O.D. x 10.34 m. long, rolled and silver soldered into copper manganese tube sheets. The total surface is 265 sq. m. There are 57 baffles each with circular holes 51 mm. dia. giving a total gas passage area of 285 sq. cm. The tube bundle is surrounded by a 2 mm thick copper manganese plate on the outside of which a 125 mm. thick

kieselguhr brick lining is installed, held in place by a 2 mm. thick brass shell. The tube bundle has funnel-shaped heads at each end made of copper manganese, the lower funnel being bolted to the bottom head of the vessel while the upper funnel is provided with a stuffing box which permits the tube bundle to expand. To prevent gas from by-passing the tube bundle, 5 asbestos packing rings are provided along its length as well as stuffing boxes at each end.

- 1 Converter - (Fig. 3). The shell is a steel forging 800 mm. I.D. x 12 m. long. The inside linings of the converter, similar to those of the interchanger, are indicated on Fig. 4. For installing the 10 mm. thick special steel liner the forging is heated with steam to a temperature of 250°C. and then the liner is inserted. The method used for inserting the 2 mm. thick brass liner is indicated on Fig. 4. The bulged portion of the liner is pressed against the shell with a jack and the whole liner is then hammered.

The present methanol converters in use at Oppau have old type catalyst baskets. Gas is introduced into the bottom of the converter and rises through a central tube in which a heating element is inserted. The gas then flows downward through the basket, which is completely filled with catalyst. Inserted into the catalyst mass are five equally spaced perforated pipe rings, made of N8 or copper manganese alloy, through which cooling gas is introduced. This converter is charged with approximately 2.6 to 2.7 cu. m. of catalyst, having a specific gravity of 1.4 to 1.5, and is said to have a capacity of 90 to 100 tons per day at 260 atm. pressure.

The newer type converters, such as were installed in the Hydebreck plant, have 6 catalyst beds. The cooling gas is introduced under each of the five top beds, the general arrangement being indicated on Fig. 4. The catalyst grate is made of N8 steel and is covered with a copper manganese screen, having 3 mm. openings, on which the catalyst rests. Four 3 point thermocouple leads are installed for measuring the temperatures in the converter. This type converter is charged with approximately 3 cu. m. of catalyst having a specific gravity of 1.4 to 1.5 and is said to have a normal capacity of 110 tons of raw methanol per day with a possible maximum of 150 tons per day at 300 atm. pressure.

Miscellaneous: In the more recent installations the starting heater is in a separate vessel as indicated on Fig. 1. The heating element consists of 40 mm. wide x 7 mm. thick copper bands wound around porcelain insulated pipes. Transformers for the starting heaters can be regulated to furnish from 80 to 400 KVA at 16 to 20 volts.

In recently built plants the shells of the high pressure vessels are of the wrapped or wound construction as described by Norman W. Krase in FIAT Final Report No. 611 dated December 12, 1945, entitled:

"Design and construction of high pressure compressors and reaction equipment". When built in this manner the special steel liner is 25 mm. thick and serves as a mandrel for the windings.

Piping in the synthesis loop, carrying hot gases, is made of M8 steel

Another interesting feature in the newer plants is the provision made for the expansion of the interconnecting hot piping. Both the interchanger and the starting heater are supported by 10 cm. diameter rolls and can move as the hot piping interconnecting them expands. This arrangement obviates the necessity of long expansion bends.

Operating Data, Yields and Utilities.

a. Operating Conditions

A typical analysis of gas at the inlet of the converter is as follows: 18.4% CO, 67.2% H₂, 0.7% CO₂, 0.6% CH₄ and 13.1% inert gases. Plant experience has indicated that the percent CO in the gas entering the converters must be less than 20% in order to prevent the formation of appreciable quantities of higher alcohols.

The maximum operating temperature in the catalyst bed is between 360 and 390°C. The normal pressure drop across the converter with a new catalyst charge is 12 to 14 atm. After about 6 months of operation this pressure drop increases to about 20 atm. It was pointed out by the operating personnel that it is very important to maintain a constant pressure drop across the converter, as a sudden variation of even a few atmospheres increases the amount of undesirable components in the raw methanol. As the catalyst gets older in order to maintain a desired production rate, the pressure drop is increased very gradually by regulating the by-pass valve across the circulator.

The raw methanol leaving the synthesis loop has the following approximate composition: 1 to 2% (CH₃)₂O, 6 to 8% H₂O, 90% CH₃OH and 0.8 to 1.0% higher alcohols and ketones. The following information on the composition and properties of raw methanol was obtained from operating data for the Waldenburg plant:

Appearance	clear and colorless
Specific weight at 20°C	0.821
Water per cent	10 to 13
Dimethylether	10 to 12 c.c./500 c.c.
Free acid	2 to 5
Saponification number	5 to 8
Bromine number	2 to 3

According to the operators the bromine number of the raw methanol should be as low as possible. A high number indicates the presence

of unsaturated alcohols and ketones. The upper limit is from 5 to 7. Good quality product should have 3 and excellent product 1.

b. Material quantities.

Approximately 3000 cu. m. of fresh feed are required per ton of raw methanol. The circulation rate is about 8 times the make-up or approximately 100,000 cu. m. per hour. The average bleed from a loop is about 15% of the fresh feed or 450 cu. m. per ton of raw methanol.

c. Production capacity and yields.

A synthesis loop as described above, with the new type converter, is said to have a normal capacity of 110 tons of raw methanol per day. The conversion per pass is between 12 and 16% of the amount of CO fed to the converter. The yield of methanol contained in the raw product based on the CO fed into the system is approximately 72%. This yield based on the H₂ fed into the system is approximately 62%.

d. Utilities.

It is estimated that, under normal operating conditions one methanol synthesis loop as installed at Oppan, producing 100 tons of raw methanol per day, requires the following utilities per ton of raw methanol:

Electricity	25 kwh.
Steam	0.3 tons
Cooling water	130 cu. m.
Operating labor	1.54 man hours.

Catalysts.

The activated carbon (M Kohle) used for the removal of sulfur compounds and iron carbonyl from the fresh feed is prepared in the following manner: Ruhr anthracite 1 to 10 mm. in size is used as raw material. 400 liters of this material are charged into a special brick-lined furnace and the charge is ignited. Air, water gas and enough steam for temperature control are introduced into the bottom of the furnace. A temperature of 920°C, (not to exceed 950°C) is maintained for 3 hours. During this time the bulk density of the raw material, which at the start is 700 gm/liter, increases to 900 gm/liter and then decreases to 550 gm/liter which should be the density of the final product. The resulting product is screened and the 7 to 10 mm. material is used for the activated carbon vessels.

The catalyst used for methanol synthesis is a zinc chromate having the following composition before reduction: 26 to 30% Cr₂O₃, 59 to 64% ZnO, 1 to 1.5% graphite and 9 to 10% H₂O.

This catalyst is prepared at the I.O. plant at Leuna as follows: 100 kg. of zinc oxide in fine powdered form are mixed with 240 liters of water to form a suspension. Then 50 kg. of chromic oxide are added. According to Leuna this addition should be very rapid as the zinc chromate mixture has thixotropic properties and a non-homogeneous product may result, giving a poor quality catalyst. Approximately 150 liters of the water is then removed in a press. The material is dried in a shelf dryer with air at 110°C, pulverised in a mill, mixed with graphite, and then tabletted. The finished product is in the form of small cylinders 10 mm. diameter x 10 mm. high.

At present a new and simpler method is employed at Oppau for the preparation of this material: 100 kg. of pure powdered zinc oxide and 40 kg. of pure crystalline chromic oxide are mixed in a stainless steel (18-8) mixer and 40 liters of water are added, as well as 2 kg. of graphite. The temperature must not exceed 30°C. when graphite is added, otherwise lumps are formed. From the mixer the material is sent to the pelleting machine. The specific gravity of the pellets is 1.7 to 1.75. The catalyst made according to this method has not yet been employed on a large scale.

The normal catalyst life was said to be from 6 months to 1 year. On removal of a spent charge about 60 to 70% is found to be pulverized. A change of catalyst is made when the pressure drop across the converter reaches approximately 20 atm. and the spent catalyst is pneumatically removed from the converter. New catalyst should be carefully charged to avoid breakage.

A new catalyst charge is reduced in the following manner: The synthesis loop is purged with nitrogen and a pressure of 2 to 3 atm. of nitrogen is applied. The circulator is started at about 1/3 of the normal rate (30,000 cu. m. per hour), and fresh gas is slowly fed to the system. The temperature is slowly raised by means of the starting heater to 100 to 110°C, and the pressure to 260 atm. These conditions are maintained for 30 to 48 hours, during which time water separated in the product drum is measured. In the next 24 to 36 hours the temperature in the converter is raised until the entire catalyst bed is at a temperature of 250°C. At this stage the temperature can be raised to the normal operating temperature in 2 to 3 hours.

PART II - METHANOL DISTILLATION.

Process description.

Fig. 5 gives a flow diagram of the methanol distillation system. Raw methanol from the synthesis system is expanded into the raw product storage tank which operates at 12 - 15 atm. Dissolved gases are thereby released and are vented. The liquid flows through a second expansion valve which reduces the pressure to 6 - 8 atm., is preheated and introduced into the 1st rectification column. In this column the dimethylether is distilled

off, condensed, and sent to a storage tank, 95% pure dimethylether is obtained and is used for making dimethyl sulfate and dimethyl aniline.

The bottoms, free of methylether, are sent to a 2nd rectification unit. In this unit "V" methanol (Vorlauf methanol), consisting of 95% methanol and 5% methyl isobutyl ether, methylal, methyl formate, etc., is separated and goes to a "V" methanol storage tank. The bottoms are cooled and introduced into settling and intermediate storage tanks. In the line going to these tanks a 1% solution of potassium permanganate in water is added to the stream in the amount of 0.3% of the product flow. The purpose of this addition is to oxidize any organic compounds and decompose the iron carbonyl contained in the product. The temperature at the mixing point should not exceed 30°C, otherwise oxidation of methanol takes place.

The liquid is allowed to stand in the intermediate storage tanks for at least 8 hours and preferably 24 hours for settling to take place. The clear liquor is decanted and conducted to the 3rd rectification unit. The sludge settled on the bottom of the intermediate storage tanks goes to a filter press. The filtrate is also sent to the 3rd rectification unit and the filter cake is discarded. The side stream of the 3rd rectification column is the pure product and goes to the product measuring tank where it is analyzed for purity. If it meets the specifications it is sent to the final product storage. A portion of the reflux is sent to the "V" methanol storage tank. The total production of "V" methanol from the 2nd and 3rd rectification units amounts to 3 - 10% of the crude methanol. This product is injected into the isobutyl alcohol synthesis system or used as fuel.

The bottoms from the 3rd rectification column are sent to a residue storage tank and from there are fed into the reboiler of the 4th rectification column which operates in a batchwise manner. The first overhead from the 4th rectification column is pure methanol and is sent to the product measuring tank. After a certain time the purity of the overhead is such that it must be sent to the raw methanol storage tank. Finally, when ethyl methyl ketones, di-isobutyl ketones, diisopropyl alcohol and mostly isobutyl alcohol begin to boil off, the overhead is sent to the higher alcohols storage tank. This product is used in the isobutyl plant. The residue in the reboiler, which is mainly water, is discarded.

The elaborate methanol distillation system described above is considered necessary at Oppau in order to obtain a product pure enough for formaldehyde manufacture.

Description of equipment

The following tabulation presents the principle information on the various rectification columns:

Rectification Column No:	1	2	3	4
Diameter	Top Sect. 0.6m. Bot. Sect. 1.0m.	1.5m.	2.9m.	1.5m.
Height	8.5m.	22.5m.	23.6m.	22.5m.
Material of construction: column Bubble caps	steel -	steel cast iron	steel cast iron	steel cast iron
Type of plates:	Bamag sieve type	Bubble caps	Bubble caps	Bubble caps
Number of plates:	Top Sect. 23 Bot. Sect. 21	70	70	70
Distance between plates	-	30 cm.	-	-
Feed injection point from bottom:	8th, 12th and 18th plates	16th, 20th and 28th plates normally 20th	17th, 21st and 27th plates normally 21st	16th, 20th and 28th
Side stream take off point from bottom:	-	-	52nd, 56th and 60th plates normally 60th	31st, 37th and 41st plates

The above information was given from memory by Dr. E. Haarer and since the detailed drawings for this equipment could not be located, the accuracy of this information cannot be vouched for.

Operating data. Yields and Utilities

The distillation system as described is said to be suitable to handle normally 160 to 190 tons of crude methanol per day, with a maximum of 240 tons per day.

The following tabulation presents the principal operating data for the various distillation columns:

Rectification column No.:	1	2	3	4
Operating pressure (absolute):	6 to 8 atm.	1 atm.	1 atm.	1 atm.
Temp. at the bottom of the column:	110° C.	68 to 70° C.	89 to 90° C.	72 to 100° C.
Temp. at the top of the column:	30 to 35° C.	62° C.	64° C.	46 to 98° C.
Ratio of reflux to distillate:	10:1	6:1	-	3:1 to 1:1
Ratio of reflux to side stream:	-	-	2.5:1	-

As the operation of the 4th rectification column is batchwise, operating conditions at the beginning and end of the cycle are given.

The above information was also given from memory by Dr. E. Haarer and its accuracy cannot be vouched for.

One ton of raw methanol furnishes the following products:

Pure methanol	780 to 830 kg.
"V" methanol	30 to 100 kg.
Dimethylether	20 kg.
Higher alcohols	0.2 to 0.3 kg.

The yield of pure methanol, based on the methanol content of raw methanol fed to the system, is approximately 89%.

In the methanol distillation system the following utilities are required per ton of pure methanol produced:

Electricity	17.0 kWh.
Steam	2.7 tons
Cooling water	163.6 cu.m.
Operating labor	0.7 man hours

Analytical methods

The distilled methanol is subjected to the following chemical tests:

1. Sulfuric acid test - To 5 c.c. of methanol cooled to under 5°C. is added 5 c.c. of pure concentrated H_2SO_4 . The resulting mixture is shaken and its temperature should not exceed 5°C. A dark coloration of the mixture indicates the presence of traces of olefines, which are very poisonous to formaldehyde catalyst. A slight coloration is acceptable. If the solution remains white, the product is of excellent quality.

2. Boiling point test - An entire sample of methanol must distill off without a temperature increase of more than 0.3 to 0.4°C.

3. Potassium permanganate test - 1.3 c.c. of 0.1% $KMnO_4$ solution in water are added to 100 c.c. of the product. The mixture must be placed in a water bath and maintained at 17 to 18°C. The color should change from violet to brown in not less than 20 minutes. A longer period indicates a better product, while a shorter period indicates that an insufficient amount of $KMnO_4$ has been added in the process.

4. Test for iron - 10 c.c. of 25% NH_4OH and 10 c.c. of 30% H_2O_2 are added to 100 c.c. of methanol. The mixture is boiled with a reflux cooler for 30 minutes. The flocculent iron compound is filtered out, dissolved in hydrochloric acid, and a standard colorimetric test for iron is applied. Traces of iron in the product indicate that an insufficient amount of $KMnO_4$ has been added in the process for breaking up the iron carbonyl.

5. Bromine number - This test is applied to the raw methanol. To 100 c.c. of product, the bromine solution is slowly added until a yellow coloration identical to the standard solution is obtained. The number of c.c. of bromine solution added is the bromine number.

The bromine solution is prepared by adding 4.2 c.c. of concentrated bromine to 1000 c.c. of 50% acetic acid and the resulting mixture well shaken.

The standard solution is prepared by adding 0.05 gr. of potassium dichromate to 1 liter of water.

APPENDIX 1

LIST OF GERMAN PERSONNEL INTERVIEWED

AT THE I.G. FARBE INDUSTRIE PLANTS AT LUDWIGSHAFEN AND OPPAU:

<u>Name</u>	<u>Position</u>	<u>Location</u>
Dr. K. Goeggel	Chief of High Pressure Department	Ludwigshafen
Dr. D. Timm	Assistant to Dr. Goeggel	Ludwigshafen
Dr. H. Soenksen	Head of Organic Department	Oppau
Dr. H. Rabe	Head of Catalyst Preparation Plant	Oppau
Dr. E. Haarer	Superintendent of Methanol Distillation Plant	Oppau
Dr. F. Duerr	Chemist	Oppau
Dr. F. Winkler	Head of CO and H ₂ synthesis experiments	Oppau
Mr. G. Schulze	Engineer	Ludwigshafen
Mr. K. Bossert	Superintendent of isobutyl synthesis plant	Oppau

A P P E N D I X 2

BIBLIOGRAPHY

Copies of the reports listed below were transmitted to Washington D.C.
Inquiries should be addressed to:

Office of Publications Board
U.S. Department of Commerce
Washington 25, D.C.

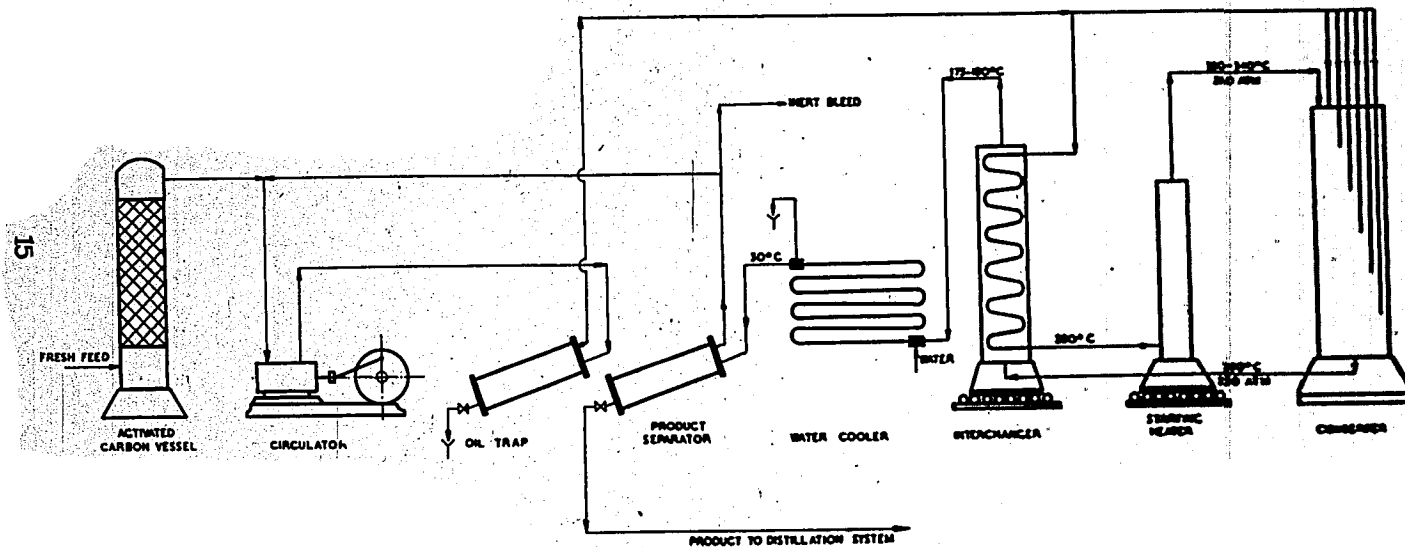
1. Related Reports Published by Allied Intelligence Agencies:

CIOS Report, File No. XXVIII-27
FIAT Records Branch File No.
17361/TP200/P964
Leuna Works near Merseburg.

CIOS Report, File No. XXX-103
FIAT Records Branch File No.
14088/TP200/P705
I.G. Farbenindustrie A.G. Works,
Ludwigshafen and Oppau.

CIOS Report, File No. XXVII-85
FIAT Records Branch File No.
13400/TP200/P683
I.G. Farbenindustrie A.G. Works,
Ludwigshafen and Oppau.

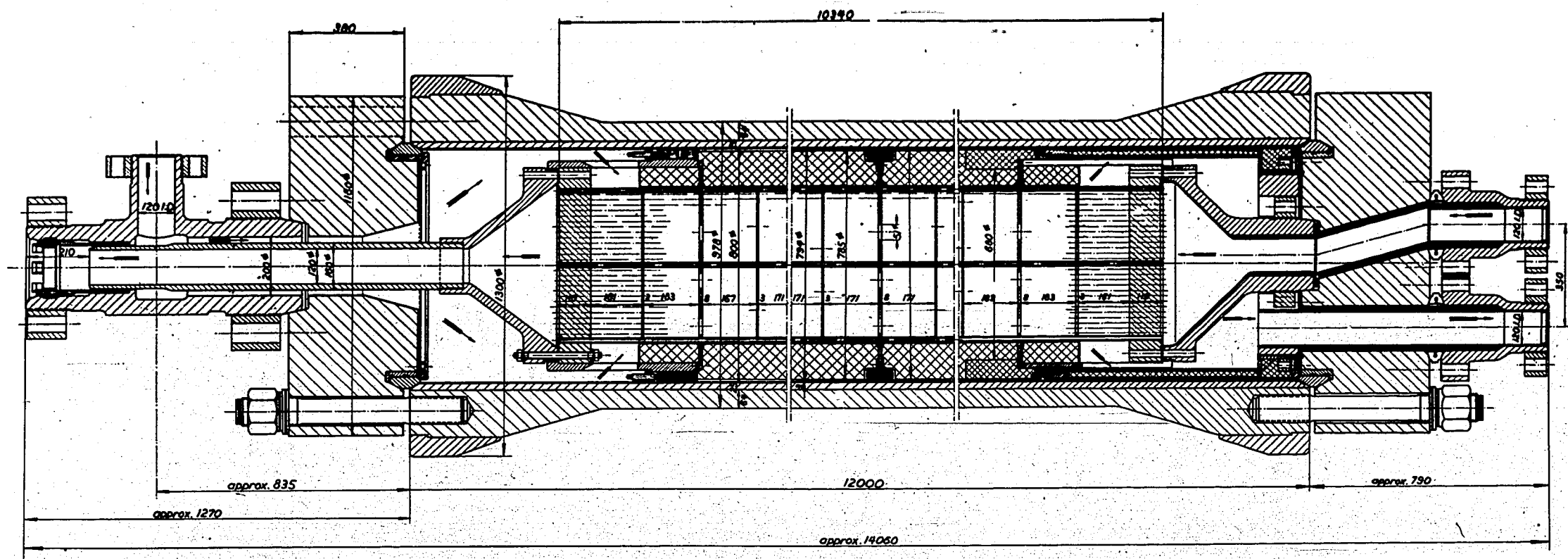
CIOS Report, File No. XXXII-107
FIAT Records Branch File No.
9351/TP200/P435
I.G. Farbenindustrie A.G. Works,
Leuna.



SYNTHETIC METHANOL
THE FINAL REPORT NO. 600
FLOW DIAGRAM OF THE SYNTHESIS SYSTEM

DATE: APRIL 1, 1944

FIG. 1



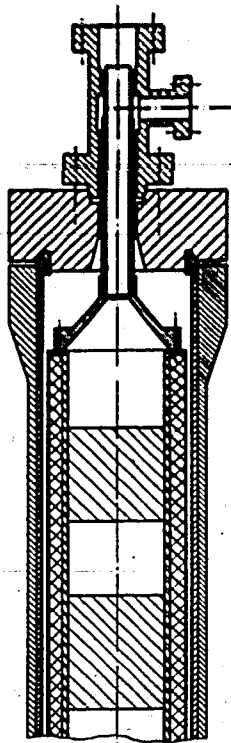
SYNTHETIC METHANOL

FIAT FINAL REPORT No. 888

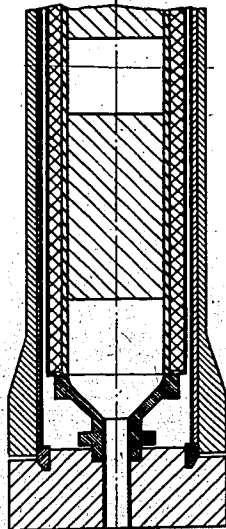
INTERCHANGER

DATE: AUG. 1, 1946

FIG. 2



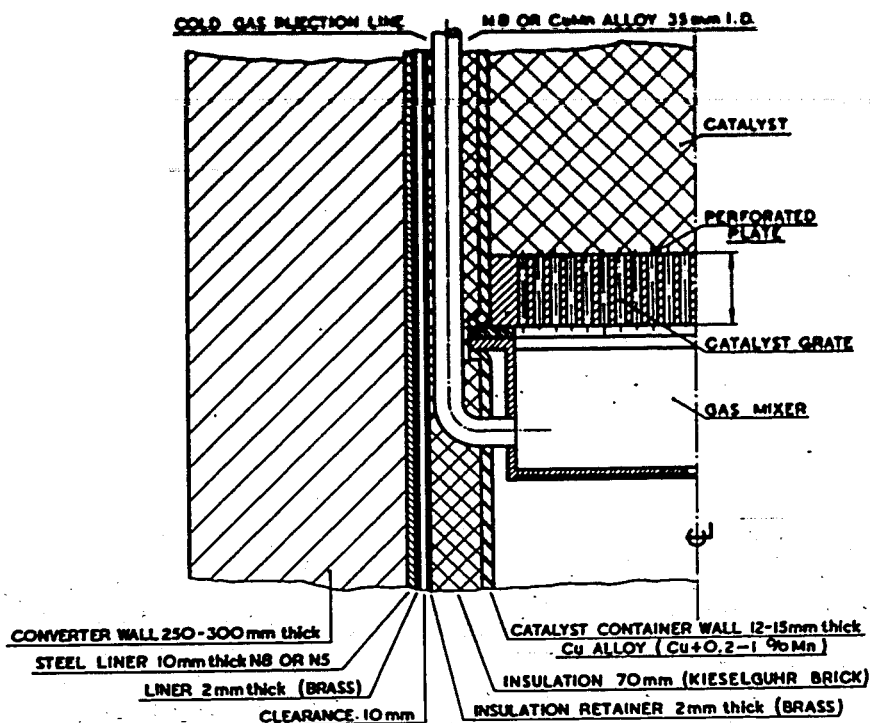
NOTE:
QUENCH LINES,
CATALYST GRATES
& MINOR DETAILS
NOT SHOWN.



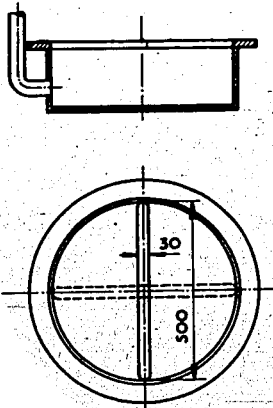
SYNTHETIC METHANOL
FIAT FINAL REPORT No. 888
CONVERTER

DATE: AUG. 1, 1946 FIG. 3

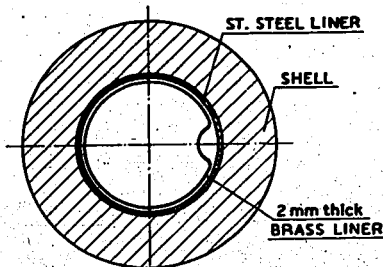
SECTION THROUGH CONVERTER



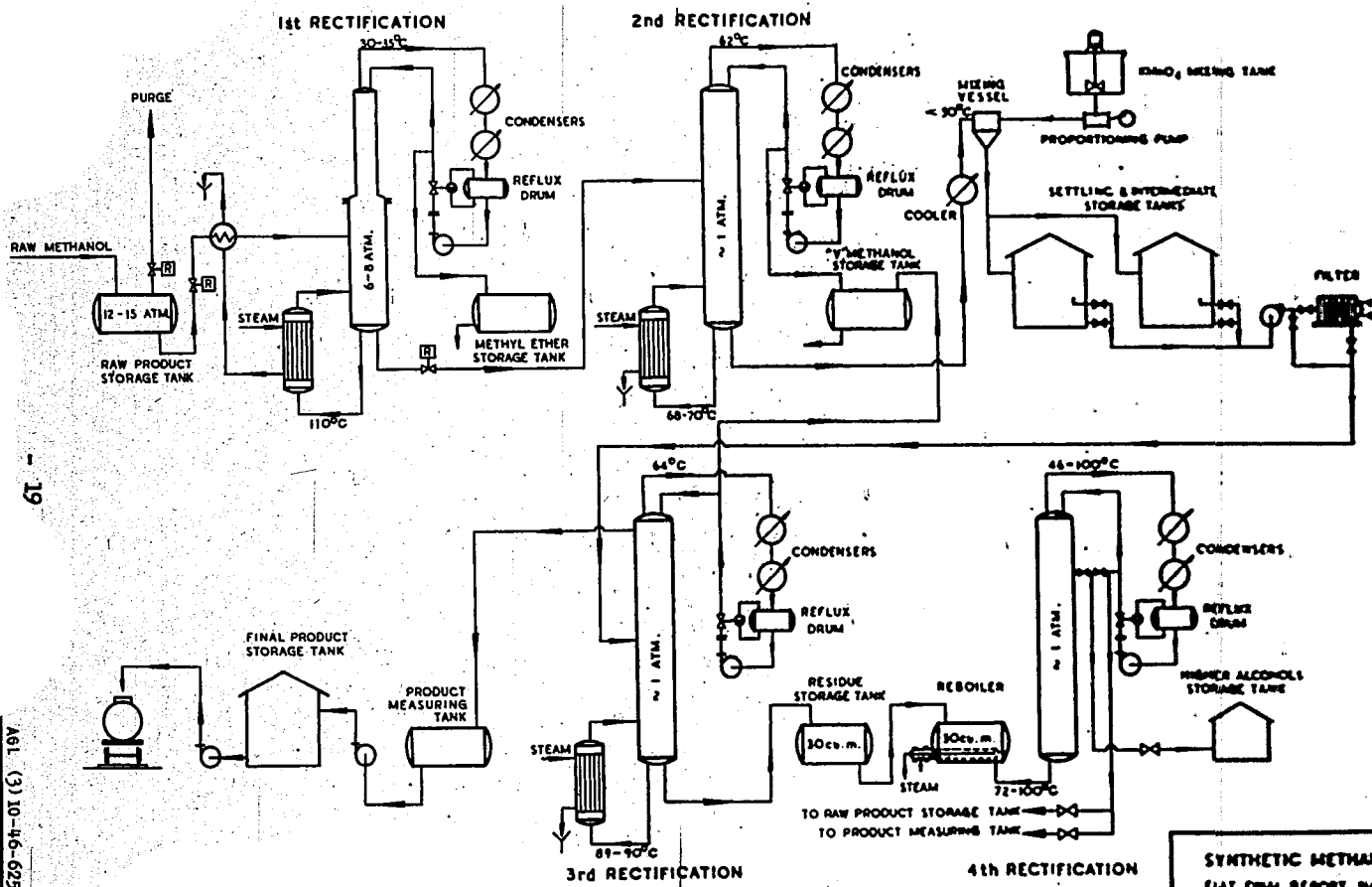
GAS MIXER



METHOD OF INSTALLING
COPPER ALLOY LINER



SYNTHETIC METHANOL
FIAT FINAL REPORT No. 888
CONVERTER DETAILS
DATE: AUG. 1, 1946 **FIG. 4**



SYNTHETIC METHANOL
 FIAT FINAL REPORT No 888
 FLOW DIAGRAM
 OF THE DISTILLATION SYSTEM
 DATE: AUG. 1, 1946 **FIG 5**