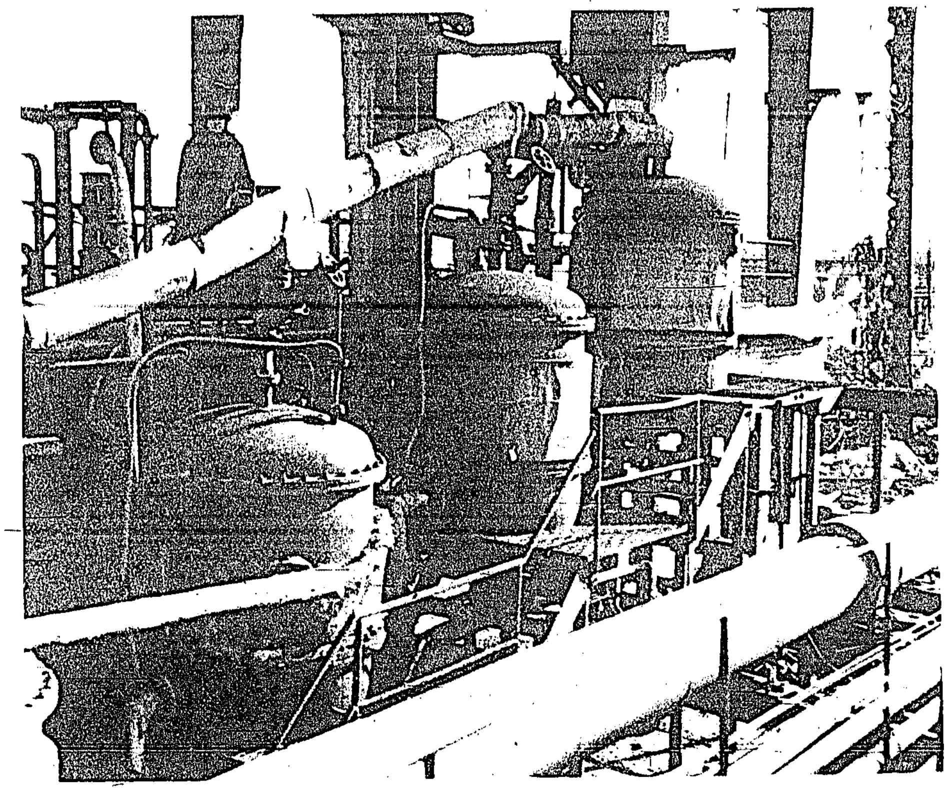

Figure [illegible]

[illegible]
Building [illegible]

used for removing a small amount of polymer as an overhead product. The temperature at the top is 90°C., and at the bottom 120°C. The pressure is 0.6-0.8 atms. The bottoms from the first column enter the second column containing 36 plates on the 11th plate. Open steam is used to take overhead a water alcohol mixture containing about 75% alcohol. Water is withdrawn from the bottom of the column Pressure in the column is 1.2-1.3 atms. and the temperature at the top of the column is 110-115°C.

The overhead from the second column enters the third column containing 70 plates, which is the benzol azeotrope column, on the 55th plate. 90% benzol is refluxed to the top of the column and impure isopropyl alcohol is taken off the 10th plate as a vapor, and the impure butyl alcohol is taken off the bottom of this column. This column operates under 2.2-2.4 atms. with a top temperature of 60°C and a bottom temperature of 104°C. The impure isopropyl alcohol passes to a 30-plate column entering on the 6th or 8th plate. Pure isopropyl alcohol is taken overhead and the bottoms returned to the azeotrope column on the 10th plate. The impure butyl alcohol is fed to a 20-plate column on the third plate. Pure isobutyl alcohol is taken overhead and a heavy residue is the bottom product. The overhead from the azeotrope column is a mixture of alcohol, benzol and water, The mixture passes to a separator where a water layer is taken off and returned to the column on the 56th plate. The upper layer is then charged to a 60-plate column entering on the 20th plate. Direct steam is used for distilling overhead an alcohol-benzol mixture which is returned to the azeotrope column as reflux. Water is withdrawn as the bottom product from this column. 600 liters per month of 90% alcohol is added make-up.

Various seized records show that the alcohol plant also produced fusel oil, and "Dilenol". The latter is unidentified but may be crude higher alcohols. As derivatives of these primary products crude acetone, propyl ether and "Syrup Rheal" were also made.

"Syrup Rheal" appears to be a by product of the acetone manufacture but is not further identified. Research notes indicate that aluminium alcoholate was also being made at Moers but no information was obtained as to method or scale of manufacture or of commercial use of this product.

By a license agreement dated 15 July 1938 Rheinpreussen obtained rights to dehydrate alcohols by an unspecified process covered by German patents (Listed) of the firm E. Merck, Darmstadt. Semi-annual accountings of the royalty payments due Merck, in accordance with this licence reveal the figures quoted below for alcohol production. For recent years monthly production figures are also given.

|  | Butyl Alcohol Kilograms | Propyl alcohol including that converted to acetone Kilograms |
|---|---|---|
| First half 1940 | 143600 | 48560 |
| Last half 1940 | 387770 | 106840 |
| First half 1941 | 376346 | 134216 |
| Last half 1941 | 496203 | 252794 |
| First half 1942 | 524178 | 278543 |
| Last half 1942 | 276940 | 187511 |
| First half 1943 | 617188 | 505359 |
| Last half 1943 | 630282 | 566225 |
| First half 1944 | 556654 | 638970 |

The distribution of the bulk of the alcohol shipments in 1944 is shown by Table XX page 79. The identity of "Sektoll" is not established. Another unidentified product, "Dilenol", was shipped almost exclusively to Geb Overlack, Meunchen-Gladbach. One or both of these products may be amyl alcohols which are known to have been made and are not otherwise accounted for in the shipping records. Mixed butyl-propyl ether was shipped in about the same quantities entirely to Overlack at M. Gladbach. From January through June isopropyl ether was shipped exclusively to Wiegand Svehne, Oberhausen, but in quantities of only about one ton per month. In July the shipments of this ether were as follows:-

|  |  |
|---|---|
| I.A.Farben. Frankfurt/M | 14 Tons |
| Pankower Transp. Berlin/Pankow | 13 Tons |
| Chemische Fab. Gruenau, Berlin/Gruenau | 14 Tons |

| | |
|---|---|
| Below 300°C | 11.0% |
| 300-330°C | 0.3 |
| 330-350 | 0.7 |
| 350-375 | 1.2 |
| 375-400 | 2.1 |
| 400-425 | 1.9 |
| 425-450 | 4.9 |
| above 450 | 76.9 |
| loss | 1.0 |
| | 100.0 |

The total wax boiling above 300°C had a molecular weight of 430 and the fraction boiling above 450°C had a molecular weight of 530. The congealing points (Method IP 76-44T) were as follows:

| | |
|---|---|
| Total wax | 80-81°C |
| Above 300 C | 87-88°C |
| Above 450 C | 91°C |

## IX ALCOHOL PLANT

The alcohol plant (Building 106) was erected in 1940. Here the olefins from the stabilizer over-head are absorbed in sulfuric acid and hydrolyzed to alcohols and some incidental polymer which is blended in motor fuel.

The $C_3$ and $C_4$ feed containing approximately 30% olefins is contacted for one hour with 58°Be. sulfuric acid by stirring in a water jacketed reaction vessel (Made by Lurgi) under 10-15 atms. pressure. Cooling water is used in the jacket during the summer months, but not during the winter. The temperature is not allowed to rise above a maximum of 45°C. Following the mixing period, the reactor contents are allowed to settle for 30 minutes.

The bottom layer from the reactor, that is the ester and acid layer, is drawn off to storage. This material is then charged to a second mixer where it is contacted with water at atmospheric pressure and temperature. This mixer operates continuously. The material flows into a separator where a polymer is taken off as the upper layer and sent to motor gasoline blending. The lower layer is then passed to a four-stage hydrolyzer of which the first three stills are shown by Fig. 26, page 78. Ester is hydrolized to alcohol by heating with open steam in the 4 stages, all maintained under a pressure of 0.2 atm absolute. The temperatures in successive stages are as follows:

| | | | |
|---|---|---|---|
| 1) | 75-80°C | 2) | 80-88°C |
| 3) | 88-95°C | 4) | 95-104°C |

The liquid from the 4th stage is 25% sulfuric acid; it is sent to the acid concentrator for concentration to 58°Be. and returned to the esterfication reactor.

The vapors from the 4 hydrolyzers consisting of a mixture of alcohol and water of 50% concentration pass through a caustic washer to storage.

The upper layer from the primary contactors is the unreacted $C_3$ and $C_4$ hydrocarbon and polymer. It is drawn into a storage vessel containing steam coils and is vaporized from the storage vessel through a caustic washer into a gas holder. The material is then compressed and charged to a re-run column where $C_3$ and $C_4$ product is made overhead for use as bottled gas (treibgas). The small amount of polymer bottoms is blended into motor gasoline. The production of alcohols from 26-28 tons per day of Fischer-Tropsch $C_3$-$C_4$ fraction is 2.0-2.1 tons per day of isopropyl alcohol, and 3.2-3.5 tons per day of a mixture of secondary and tertiary butyl alcohols.

The alcohol purification system consists of 6 bubble plate towers. The 50-50 water alcohol mixture from the hydrolysers enters the first column containing 30 plates on the 16th plate. A small amount of caustic is introduced on the 18th plate. Open steam is

|  |  |
|---|---|
| 140 | 83.5 % |
| 150 | 88.5 |
| 160 | 93.0 |
| 170 | 95.5 |
| 178 | 97.0 |
| End point | 178°C |
| Residue | 1.7% |
| Loss | 1.3% |
| Bromine No. | 66 |
| Olefin content | 42% |

## E. Hard Paraffin and Gatsch

In 1944 "Hart Paraffin", recovered by washing of the synthesis catalyst with benzin, was shipped mainly to Norddeutsche Mineralolwerke, Stettin-Politz, but small shipments were made to other scattered plants. Monthly reports to Arsyn for 1943 characterize the Hart Paraffin as having a melting point above 65°C. Gatsch, recovered as bottoms from distillation of the synthetic crude oil, was shipped entirely to the Fettsaüre-Werke, Witten. The use made of these waxes is unknown but it seems probable that they were in part oxidized to fatty acids for the production of soaps and other derivatives. Some of the work along this line conducted at Moers is discussed later under the subject of Research Activities.

A considerable stock (12 tons) of hard paraffin was left in the Moers plant and a sample was obtained. This wax is yellow in color, has a destinctive odor and was stated to have a melting point of 80-100°C. A sample was examined by the Petroleum Board with the following results:-

|  |  |
|---|---|
| Melting point (ASTM Pet.Method) | 90°C |
| Iodine No. | 3½ |
| Saponification value | 1 |
| Ash | 0.13% |
| Water | 3.0% |

Examination of another portion of the same sample by the Fuel Research Station yielded the following information.

The sample was distilled under a pressure of approximately 1mm abs. and the observed boiling points were corrected to 760mm giving the following distillation record:-

|  | CIOS No.1<br>P.B.No.45/989<br>Mech 573 | CIOS No.5 |
|---|---|---|
| Specific Gravity /60°F | 0.7609 | 0.757 |
| Color | 15 Saybolt |  |
| Odor | Typical of F.T. |  |
| Initial BP | 192°C | 195 |
| 200° | 3.5% | 3.0 |
| 210 | 17 % | 17.5 |
| 220 | 35 % | 37.0 |
| 230 | 53 % | 55.0 |
| 240 | 69 % | 71.5 |
| 250 | 82 % | 84.5 |
| 260 | 91 % | 92.0 |
| 270 | 95 % | 95.5 |
| End point | 276°C | 279 |
| Recovery | 97% | 98.5 |
| Residue | 2% | 1.5 |
| Unsaturates | 8.0% | 10-11% |
| Aromatics | Nil |  |
| Unsulphonatable | 92% |  |
| Bromine No | 13.8 | 10 |
| An.Pt. before Sulphonation | 83.0°C |  |
| An.Pt. after Sulphonation | 86.6% |  |
| Cetane No. | 86 |  |

A sample taken from one of several drums marked "Leuchtol" in a box car awaiting shipment to Plant IV was identified as CIOS No. 4. This was tested by the Petroleum Board under their number 45/988 Mech 574 and was found to be identical with CIOS Sample No.1.

A sample was taken from tank car FS Italia No 551033 which was reported in captured documents to contain intermediate product. This was identified as CIOS No. 7 and was analyzed by the Fuel Research Station with the following results:-

|  |  |
|---|---|
| Sp.g at 20°C | 0.685 |
| Initial boiling pt. | 42°C |
| 50°C | 3.0% |
| 60 | 12.5 |
| 70 | 25.0 |
| 80 | 35.0 |
| 90 | 44.0 |
| 100 | 54.0 |
| 110 | 63.0 |
| 120 | 71.0 |
| 130 | 78.5 |

## TABLE XIX .

### Principal Recipients of Kogasin Shipments from Rheinpreussen 1944 - Metric Tons

| 1944 | Light Kogasin Chemische Werke, Huls. | Light Kogasin Rubrehemie Holton | Light Kogasin I. G. Farben Ludwigshaven | Heavy Kogasin Rheinpreussen Anlage IV | Heavy Kogasin Rubrehemie Holton | Heavy Kogasin I. G. Farben Ludwigshaven |
|---|---|---|---|---|---|---|
| January | 105.036 | 385.550 | - | 345.520 | 53.600 | 11.950 |
| February | 198.130 | 213.860 | - | 268.110 | 131.250 | 17.130 |
| March | 263.840 | 64.970 | 36.760 | 355.860 | - | 8.500 |
| April | 236.840 | 300.660 | - | 340.940 | - | 17.250 |
| May | 251.900 | 212.490 | - | 366.370 | - | - |
| June | 155.560 | 316.540 | 35.070 | 507.050 | 64.030 | 16.880 |
| July | 79.940 | 13.800 | - | 86.040 | - | - |
|  | No additional stock or shipments |  |  | None | - | - |
| August |  |  |  | 22.500 | - | - |
| September |  |  |  | No additional stock or shipments |  |  |

| | | |
|---|---|---|
| Sp.Gr. at 20 | Not below | 0.740 |
| Solid Print | Not over | -38°C |
| Flame Point | Not below | +37°C |
| Viscosity | Not below | 1.05 E at 20°C |
| Neut. No. | Not over | 0.4 |
| Cetane No. (HWA) | Not below | 70 |
| Initial boiling pt. | About | 160°C |
| End boiling pt. | Not over | 360°C |

Rheinpreussen replied that they could meet this requirement by blending Mittelol with heavy benzin as follows:-

| | Mittelol | Schwerbenzin | 1:1 Mixture |
|---|---|---|---|
| Sp.Gr. | 0.752 | 0.742 | 0.7465 |
| B.P.A. | -26.5°C | -36.0(-42.)°C | -25.0(-32.0)°C |
| Solid Point | -29.0°C | -44.0°C | -45.0°C |
| Flame Point | | | 45.0°C |
| Vis /20°C | | | 1.07°E |
| Cetane No. | | | 78 |

It will be noted that the "SDK" Diesel fuel shipped from Moers during the last year of operations also met these specifications. Unfortunately the designations of these shipments are not indicative of the extent to which such fuel was used by the Luftwaffe.

### D. Kogasin

The distribution of shipments of light and heavy kogasin from Moers during 1944 is shown by Table XIX page 71. The heavy kogasin shipped to Rheinpreussen "Anlage IV", Homberg was used for the manufacture of synthetic lubricating oils and was stated to have a boiling range of about 250-350°C. The specifications and uses of the other shipments are unknown.

Two samples of oil were taken from tank car Essen 5-8394, which was reported in captured documents to contain light kogasin. These samples were identified as C105 No.1 and C105 No.5. Sample No.1 was analysed by the Petroleum Board and No.5 by the Fuel Research Station, with results as given below:-

## TABLE XVII

### PRINCIPAL RECEIPIENTS OF SYNTHETIC DIESEL FUEL SHIPMENTS FROM RHEINPREUSSEN, 1944

| Main Consignees: | OLES Regensburg | Kuno Ebert Regensburg | WIFO Ebrach | Rh.Ossag Torgau | Kriegs-marine | Benzol V. Magdeburg |
|---|---|---|---|---|---|---|
| Tons: | | | | | | |
| January | 151.500 | 154.000 | - | - | - | - |
| February | 99.850 | - | 102.850 | - | 125.170 | 98.000 |
| March | 150.800 | - | - | 146.500 | - | - |
| April | 205.500 | - | - | 357.500 | - | - |
| May | - | - | 83.000 | 141.600 | - | - |
| June | 201.400 | - | - | 174.400 | - | - |
| July | - | - | - | 66.700 | - | - |

## TABLE XVIII

### Principal recipients of Mixed Diesel Fuel Shipments from Rheinpreussen, 1944

2

| Tons<br>Main Consignees | Rheinpr. Cologne | Rheinpr. Duisburg | Rheinpr. Moers | DAPG Wesel | DAPG Maggen | Bezol.V. Dortmund |
|---|---|---|---|---|---|---|
| January: | 34.200 | 100.500 | - | - | - | - |
| February: | - | - | 55.700 | 47.550 | - | 59.160 |
| March: | - | 67.320 | 77.700 | - | - | 51.260 |
| April: | - | 33.500 | 58.000 | - | - | - |
| May: | - | 122.250 | 71.500 | - | 48.400 | - |
| June: | 100.000 | 61.650 | - | 84.760 | - | - |
| July: | - | 97.500 | -- | - | 10.000 | - |

Table XV

## Synthetic Diesel Fuel (SDK)
## Monthly Shipment Reports to "Arsyn"
## 1943 - 1944

| Month: | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quantity: Tonnes | 506 | 346 | 396 | 420 | 510 | 429 | 601 | 439 | 487 | 510 | 836 | 679 | 533 | 563 | 538 | 745 | 529 | 684 | 67 |
| Tests: Density | 0.746 | 0.744 | 0.743 | 0.745 | 0.747 | 0.748 | 0.748 | 0.747 | 0.749 | 0.748 | 0.750 | 0.749 | 0.748 | 0.747 | 0.747 | 0.747 | 0.747 | 0.748 | 0.748 |
| Filterability | <60<br>-35 | 60<br>-35 | <60<br>-40 | <60<br>-35 | <60<br>-20 | <60<br>-35 | <60<br>-25 | <60<br>-35 | <60<br>-35 | <60<br>-35 | <60<br>-35 | <60<br>-35 | <60<br>-35 | <60<br>-35 | <60<br>-35 | <60<br>-35 | <60<br>-35 | <60<br>-35 | <60<br>-35 |
| Solid Point°C | -41 | -44 | -49 | -45 | -43 | -39 | -38 | -41 | -41 | -40 | -40 | -41.5 | -41 | -41 | -41 | -41 | -41 | -40 | -38 |
| Flame Point°C | 27 | 30 | 26 | 29 | 32 | 40 | 37 | 30 | 43 | 40 | 44 | 49 | 42 | 46 | 47 | 46 | 48 | 48 | 50 |
| Cetane No. | 77 | 77 | 77 | 76 | 78 | 76 | 76 | 76 | 76 | 78 | 73 | 73 | 75 | 75 | 75 | 75 | 78 | 78 | 78 |
| Boiling Range°C | 156<br>-252 | 159<br>-244 | 158<br>-225 | 162<br>-246 | 155<br>-236 | 169<br>-240 | 167<br>-243 | 160<br>-234 | 164<br>-252 | 160<br>-250 | 165<br>-245 | 164<br>-247 | 165<br>-240 | 165<br>-238 | 165<br>-250 | 165<br>-245 | 165<br>-247 | 165<br>-250 | 168<br>-255 |

TABLE XVI

## Mixed Diesel Fuel (MDK)*
## Monthly Shipment Reports to "Arsyn"
## 1943 - 1944

| Month: | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quantity: Tonnes | 934 | 908 | 962 | 955 | 875 | 550 | 479 | 763 | 679 | 403 | 297 | 480 | 299 | 319 | 454 | 397 | 593 | 440 | 104 |
| Tests: Density | 0.847 | 0.848 | 0.846 | 0.847 | 0.848 | 0.849 | 0.848 | 0.848 | .0848 | 0.899 | 0.899 | 0.887 | 0.881 | 0.881 | 0.879 | 0.880 | 0.879 | 0.881 | 0.881 |
| Filterability | <60 | 60 | <60 | <60 | <60 | <60 | <60 | <60 | <60 | <60 | <60 | <60 | <60 | <60 | <60 | <60 | <60 | <60 | <60 |
| Solid Point | -32 | -34 | -35 | -34 | -32 | -32 | -33 | -33 | -30 | -26 | -28 | -25 | -27 | -29 | -26 | -26 | -30 | -29 | -25 |
| Flame Point | 57 | 58 | 61 | 61 | 62 | 61 | 63 | 62 | 61 | 65 | 65 | 61 | 62 | 62 | 63 | 59 | 62 | 63 | 68 |
| Cetane No. | 55 | 53 | 55 | 54 | 54 | 54 | 54 | 55 | 57 | 45 | 45 | 45 | 48 | 48 | 48 | 48 | 50 | 50 | 50 |
| Boiling Range | 170<br>-285 | 171<br>-280 | 170<br>-280 | 171<br>-285 | 171<br>-288 | 171<br>-286 | 171<br>-283 | 171<br>-284 | 170<br>-284 | 170<br>-295 | 170<br>-300 | 170<br>-302 | 170<br>-295 | 170<br>-309 | 170<br>-300 | 170<br>-305 | 170<br>-300 | 171<br>-320 | 170<br>-320 |

* Designation changed to "NDK" Oct. 1943 and subsequent months

Table XIV Principal Recipients of Grundbenzin Shipments from Rheinpreussen - 1944 -

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Jan: | WIFO Ebrach<br>102.150 | WIFO Berlin<br>205.700 | WIFO Derben<br>258.200 | WIFO Farge<br>358.100 | Z.Holl. Gelsenk.<br>101.500 | R.Mueser Bochum<br>184.100 | NITAG Dortmund<br>157.450 | Thyssen Duisbrg<br>105.300 | Ruhroel Bottrop<br>350.300 |
| Feb: | WIFO Ebrach<br>143.800 | Benz.V. Stuttg.<br>125.000 | WIFO Derben<br>456.100 | Konstantin Bochum<br>110.000 | Z.Holl. Gelsenk.<br>197.100 | R.Mueser Bochum<br>132.500 | Muller Gladb.<br>117.400 | OLEX Regnsb.<br>347.400 | Ruhroel Bottrop<br>209.700 |
| March: | Rheinpr. Heilbr.<br>175.850 | RAAB Karlsruhe<br>147.900 | Gasolin Stuttg.<br>108.550 | Konstantin Bochum<br>145.800 | Rhenania Cologne<br>163.650 | R.Mueser Bochum<br>111.500 | Ebert Regensb.<br>801.400 | -- | Ruhroel Bottrop<br>113.300 |
| April: | NITAG Magdeb.<br>583.150 | NITAG Neuss<br>144.900 | Dr.Marks Cologne<br>107.600 | Benzol V. Eickel<br>365.000 | Betriebsgess. Dresden<br>397.000 | -- | — | — | Ruhroel Bottrop<br>201.550 |
| May: | WIFO Amstetten<br>407.500 | RAAB Duessel.<br>104.100 | Strohmeyer Freib'rg<br>122.75 | Rhenania Magdeburg<br>199.000 | | | | OLEX Regensb.<br>368.100 | |
| June: | NITAG Dortmund<br>166.350 | Gasolin Frankfrt<br>108.800 | Zentralbuero Vienna<br>356.600 | D.Erdoel Pechelbronn.<br>697.000 | WIFO Heiligenstadt<br>268.000 | OLEX Danzig<br>145.000 | | | |
| July: | WIFO, Derben<br>660.700 | -- | — | -- | — | OLEX, Danzig<br>100.350 | | | |

Apparently engine tests were conducted by Bosch at Stuttgart, and by the Rheinpreussen and Ruhrchemie laboratories to prove that Fischer-Tropsch oil boiling from 150° to 320°C could be used satisfactorily with current Diesel engines and injectors. However no exhaustive or recent engine test data pertinent to this problem have been found.

In the discussions of increased Diesel fuel production there were occasional references to the need for considerable quantities of propylene to be used in some undisclosed manner for the production of a pour point depressant. Chlorine was also needed for this project but it was stated that the chlorine supply problem had been solved. No evidence has been found as to the extent to which such a pour depressant was made or used.

The basis for the final decision as to diesel fuel specifications does not appear in available records. The quality, as well as the quantity, of the two grades of fuel finally shipped by Rheinpreussen is shown in Table XV and Table XVI. The SDK is believed to be entirely Kogasin but the combination of about 76 cetane number with a solid point of about -42°C (-44°F) indicates the use of a pour depressant. The mixed diesel fuel MOK contains a coal tar oil (Waschol) the specifications of which are unknown. Shipments in 1944 averaged 45% "Waschol" and 55% Kogasin.

A flow diagram (Doc 78) indicates that the Rheinpreussen diesel oil refining process involves mixing suitable fractions and proportions of Kogasin and tar oil and treating the mixture with weak acid followed by weak alkali after which the oil is centrifuged, contacted with bleaching earth and passed through a filter press. No verbal confirmation of the details of this process was obtained.

The principal recipients of Diesel fuel shipments from Moers in 1944 are shown by Tables XVII and XVIII, pages 69 and 70.

On 13 March 1942 Arsyn notified Fischer-Tropsch plants that the Luftwaffe would require unspecified quantities of Diesel fuel meeting the following specifications.

Table XII

## PRINCIPAL RECIPIENTS OF RHEINPREUSSEN TREIBGAS SHIPMENTS, 1944
Metric Tons

| Principal Consignees | Matzerath Erkelenz | Hinkel Essen | Hilleke Essen | Benzol Verband Koblenz | Benzol Verband Frankfurt | Benzol Verband Stuttgart | Hugo Stinnes Mannheim |
|---|---|---|---|---|---|---|---|
| January: | 58.250 | 115.400 | 11.500 | 42.060 | -- | -- | 21.150 |
| February: | 119.900 | 192.600 | 12.800 | -- | 41.450 | 20.500 | 19.650 |
| March: | 271.700 | 106.000 | 11.200 | 38.800 | -- | -- | -- |
| April: | 197.400 | 171.200 | 6.600 | 22.500 | 21.000 | -- | 83.090 |
| May: | 94.400 | 114.900 | 14.600 | 46.800 | 20.800 | -- | 87.600 |
| June: | 30.900 | 37.000 | -- | -- | -- | -- | 42.500 |

---

Table XIII

## "Grundbenzin"
## Monthly Shipments Reported to "Arsyn", 1943-1944

| Month | Jan. | Feb. | Mar. | Apr. | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan. | Feb. | Mar. | Apr. | May | June | July |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Quantity Tonnes: | 2710 | 2451 | 2709 | 2647 | 2745 | 2558 | 2737 | 2715 | 2545 | 2794 | 2645 | 2607 | 2653 | 2537 | 2705 | 2661 | 2805 | 2218 | 720 |
| Tests: | | | | | | | | | | | | | | | | | | | |
| Sp.Gr. | 0.679 | 0.679 | 0.682 | 0.683 | 0.685 | 0.682 | 0.683 | 0.683 | 0.682 | 0.680 | 0.680 | 0.679 | 0.679 | 0.679 | 0.682 | 0.681 | 0.680 | 0.681 | 0.682 |
| % off at 75°C | 41 | 41 | 40 | 37 | 39 | 39 | 37 | 40 | 40 | 42 | 42 | 42 | 42 | 43 | 40 | 38 | 40 | 39 | 39 |
| V.P.(Atm) | 0.73 | 0.68 | 0.58 | 0.57 | 0.59 | 0.59 | 0.58 | 0.59 | 0.64 | 0.72 | 0.77 | 0.79 | 0.81 | 0.78 | W0.78<br>S0.60 | 0.58 | 0.70** | 0.62 | 0.63 |
| End B.P.°C | 160 | 158 | 157 | 160 | 163 | 165 | 166 | 165 | 163 | 161 | 166 | 162 | 160 | 157 | 160 | 161 | 161 | 162 | 170 |
| Octane No. (R.M) | 60 | 61.5 | 59 | 55 | 56* | 54.3* | 53.0 | 52.4* | 55* | 57 | 58 | 57.2* | 57.4* | 56.7* | 54.7* | 53.5* | 55.2* | 54.4* | 55** |

* M.M. instead of R.M.

** Winter grade on orders from Arsyn

## TABLE XI

## RHEINPREUSSEN PRODUCTION AND DISTRIBUTION OF TREIBGAS
### 1944 - Metric Tons

| 1944 Month | Production | Distribution * | |
|---|---|---|---|
| | | Zentralburo** | Alcohol Plant |
| Jan. | 638,300 | 390,780 | 243,800 |
| Feb. | 680,400 | 440,132 | 189,000 |
| Mar. | 794,800 | 643,153 | 183,200 |
| Apr. | 801,300 | 591,556 | 187,300 |
| May | 722,700 | 518,029 | 230,900 |
| June | 689,800 | 462,848 | 216,900 |
| July | 227,700 | 135,438 | 68,300*** |

* Excluding small amounts used by Rheinpreussen plants

** Includes small amounts "fur Rechnung Benzol-Verband, Bochum"

*** The total stock on hand (46,122 Tons) was destroyed by the bombing of 19 July, 1944.

The principal recipients of Rheinpreussen shipments in 1944, excluding companies getting relatively small quantities in cylinders, are shown by Table XII, page 63.

### B. Grund Benzin

In recent years the great demand for Diesel fuel has apparently resulted in the lowering of its initial boiling point to the extent that only one benzin was made and shipped. This is sometimes referred to as stabilized benzin and presumably takes the alternative name of "grund-benzin" from its use as a base stock for blending in motor fuels. Data on the total shipments and principal properties of this benzin as made at Moers are given in Table XIII, page 64. The principal recipients of benzin shipments from Moers in 1944 are shown in Table XIV, page 65.

Although the Moers plant had facilities for adding lead tetra-ethyl to gasoline it was stated that no lead had been available there for the last two years. Seized correspondence indicates that this may have been in accordance with agovernment ruling that lead blending should not be done with any facilities which could not be made absolutely safe against bombing.

The necessity of reducing the benzin endpoint to around 160°C to make the required quantity of Diesel fuel introduced a serious problem of avoiding excess front-end volatility which was a subject of prolonged discussion and repeated compromise.

### C. Diesel Fuel

Seized documents 74 and 82 reveal that means for increasing Diesel fuel production began to be discussed seriously late in 1939 with particular consideration being given to lowering the initial boiling point to about 150°C and blending with aromatic stocks of similar boiling range from high temperature coking. It was foreseen that less gas oil would be available for cracking and the gasoline quality would be impaired accordingly. The reduction of benzin endpoint would necessitate some shifting of butanes from benzin to Treibgas which might require changes in pressure regulators etc. for use of the latter as motor fuel. The aromatic stock desired for blending was tar wash oil which would have to be replaced by heavy synthetic gas oil for benzol recovery and this introduced a number of operating problems.

## VIII QUALITY AND DISTRIBUTION OF PRODUCTS

Interrogation at the Moers plant yielded very little information regarding product quality or distribution, but seized documents were somewhat more helpful. Product quality standards for synthetic fuel plants in West Germany were apparently worked out to meet Government requirements by the Arbeitsgemeinschaft fur Hydrierung, Synthese, and Schwelung, abreviated "Arsyn", having headquarters in Berlin (NW 7 den Dorotheenstrasse 35111) and a branch office in Essen at the Krupp A.G. (Dr. - Ing Fritz Müller). Correspondence with, and reports to, this organization have yielded considerable information on product specifications and how they were met by Rheinpreussen.

The destinations of practically all shipments of stabilized benzin, Diesel fuel and Liquefied gas were apparently dictated by the "Zentralburo fur Mineralol GMBH". The address of this bureau was originally Berlin 1 Charlottenberg 9, Adolph Hitler-Platz 7/9, but on 26 August, 1943, "as a precautionary measure against catastrophe" it was changed to Dresden-Altstadt, Beustrasse 7. Although other records indicated shipments merely to "Zeutralburo", one book was found (Doc 15) showing the exact destination of each carload or cylinder of such products shipped during 1944.

From the above sources most of the following information about specific products has been derived.

### A. Liquefied Gas (Flussiggas; Treibgas)

Figures for prospective production of liquefied gas by all Fischer-Tropsch plants in West Germany were assembled at conferences held in August and October, 1939 (Doc 88) and are summarized in Table X page 60. Plants showing zero percent olefins presumably had polymerization units or were converting olefins to alcohols as at Rheinpreussen. The estimates contemplated setting aside 15000 tons of Treibgas per year in 1940 and 1941 for aviation engine factories but how this would be used is not stated.

The division of Rheinpreussen's primary production between alcohol manufacture and shipment for fuel in 1944 is shown by Table XI page 61.

## TABLE X

### ESTIMATED PRODUCTION OF LIQUEFIED GAS FOR MOTOR FUEL BY SYNTHETIC FUEL PLANTS

(Metric Tons)

| | Last three Mos. 1939 | Total 1940 Tons | % olefins | Total 1941 |
|---|---|---|---|---|
| Scholven | 13,500 | 54,000 | 0 | 54,000 |
| Gelsenberg | 700 | 20,800 | 0 | 50,000 |
| Victor Rauxel | 350 | 2,800 | 50 | 2,800 |
| Rheinpreussen | 1,800 | 5,400 | 50 | 5,400 |
| Ruhrbenzin | 1,200 | 6,000 | 50 | 6,000 |
| Krupp | 900 | 4,300 | 50 | 4,500 |
| Essener Steinkohle | 1,350 | 5,400 | 50 | 5,400 |
| Hoesch | 1,500 | 4,800 | 40 | 5,000 |
| Rheinbraun | | 20,000 | 0 | 40,000 |
| Total | | 123,500 | | 170,000 |

## TABLE VIII

### MONTHLY PRODUCTION TOTAL *
### ALL LIQUID PRODUCTS - METRIC TONS

| | 1942 | 1943 | 1944 |
|---|---|---|---|
| Jan. | 5,754,466 | 5,713,123 | 5,593,659 |
| Feb. | 5,460,766 | 5,403,285 | 5,296,845 |
| Mar. | 6,109,418 | 5,910,451 | 5,747,675 |
| Apr. | 6,010,346 | 5,800,730 | 5,729,077 |
| May. | 6,357,390 | 5,925,868 | 6,020,837 |
| June. | 6,171,988 | 5,386,936 | 4,956,244 |
| July | 5,117,943 | 5,728,477 | 1,520,445 |
| Aug. | 3,825,625 | 5,551,051 | 29,100** |
| Sept | 5,473,729 | 5,260,693 | 20,410 |
| Oct. | 5,535,115 | 5,740,129 | 127,400 |
| Nov. | 5,826,542 | 5,455,951 | 13,000** |
| Dec. | 5,884,066 | 5,635,008 | 0,000** |
| Totals | 67,527,394 | 66,692,702 | 35,054,692 |

** Monthly statement missing; total estimated from other records.

* From CIOS documents 17 and 20.

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Table IX

### Monthly Production of Primary Products*
### 1944.
### Metric Tons.

| Month | Treibgas | Benzin | Light Diesel Fuel | Mixed Diesel Fuel** | Light Kogasin | Heavy Kogasin | Hart Paraffin | Gatsch |
|---|---|---|---|---|---|---|---|---|
| January | 638.300 | 2653.312 | 533.470 | 170.000 | 491.650 | 411.247 | 230.200 | 404.200 |
| February | 680.400 | 2537.045 | 563.180 | 172.500 | 413.108 | 416.522 | 137.260 | 330.300 |
| March | 794.800 | 2705.295 | 537.470 | 244.000 | 365.722 | 364.368 | 143.970 | 353.800 |
| April | 801.300 | 2661.307 | 744.920 | 197.000 | 537.500 | 358.190 | 165.440 | 375.500 |
| May | 722.700 | 2805.479 | 528.600 | 329.500 | 464.390 | 366.598 | 220.000 | 411.300 |
| June | 689.800 | 2228.242 | 684.370 | 273.000 | 507.322 | 388.060 | 157.300 | 403.209 |
| July | 227.700 | 719.903 | 67.300 | 72.000 | 93.740 | 86.040 | 18.890 | 105.060 |
| August | -- | -- | -- | -- | -- | -- | 20.000 | 8.500 |
| September | -- | -- | -- | -- | -- | -- | 17.000 | 3.410 |
| October | -- | -- | -- | -- | -- | -- | -- | -- |
| November | -- | -- | -- | -- | -- | -- | 10.000 | -- |
| Total | 4555.000 | 16310.583 | 3659.310 | 1458.000 | 2873.432 | 2391.025 | 1620.060 | 2395.090 |
| % of Grand Total | 12.9 | 46.3 | 10.4 | 4.1 | 8.1 | 6.8 | 4.6 | 6.8 |

* From CIOS Documents 17 & 20.

** Kogasin Component only.

## VII PLANT CAPACITY

The normal output of primary liquid products was stated to be 180-200 tons per day of which about half was benzin and liquefied gas. Diesel oil and wax were indicated to be the other major products but no satisfactory information on product distribution was obtained until seized records were studied.

Table VII, page 56 has been prepared from statements submitted in connection with quarterly royalty payments to Ruhrchemie (Docs. 1 and 2) and shows annual output ~~of~~ principal products from 1939 through 1944. Even for the best years 1940 and 1941 the output of this plant was only a little over one third of the generally assumed capacity figure of 180,000 tonnes per year. Monthly production totals for 1942, 1943 and 1944 are shown by Table VIII, page 57. It will be seen that production fell off suddenly as a result of the severe air raid on the night of July 19-20, 1944. It is believed that all production reported subsequent to July, 1944, resulted from the working up of accumulated stocks of crude oil and perhaps recovering wax and oil from the catalyst in the remaining reactors.

The production of principal products by months for the year 1944 is shown in Table IX page 58.

Table VII

### ANNUAL PRODUCTION OF PRIMARY PRODUCTS
(according to Ruhrchemie License Accounts)*

| | 1939** | | 1940 | | 1941 | | 1942 | | 1943 | | 1944 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tons | Wt % | Tons | Wt % | Tons | Wt % | Tons | Wt % | Tons | Wt % | Tons | Wt % |
| Stabilized benzin | 32291.181 | 61.5 | 33277.875 | 48.8 | 33942.628 | 47.7 | 30025.489 | 46.3 | 31970.060 | 51.4 | 16362.656 | 51.7 |
| Heavy benzin | 2481.230 | 4.7 | 280.900 | 0.4 | 249.975 | 0.3 | 262.950 | 0.4 | 32.340 | 0.0+ | 137.950 | 0.5 |
| Kogasin for mixed diesel fuel | 7999.247 | 15.2 | 8740.339 | 12.8 | 8180.851 | 11.5 | 7025.886 | 10.8 | 5219.855 | 8.4 | 1764.947 | 5.6 |
| Light Diesel fuel | | | 11991.164 | 17.6 | 8213.429 | 11.6 | 8178.594 | 12.7 | 6445.310 | 10.4 | 3219.023 | 10.2 |
| Liquefied gas | 5420.988 | 10.3 | 6112.429 | 8.9 | 7379.136 | 10.4 | 6762.280 | 10.4 | 6094.340 | 9.8 | 3154.857 | 10.0 |
| "Hart" Paraffin | 736.087 | 1.4 | 1397.733 | 2.1 | 1407.568 | 2.0 | 1712.555 | 2.6 | 1679.670 | 2.7 | 1165.070 | 3.7 |
| Kogasin | 132.958 | 0.3 | 1800.634 | 2.6 | 6655.620 | 9.3 | 5765.480 | 8.9 | 5932.570 | 9.5 | 3381.810 | 10.7 |
| Gatsch | 3481.191 | 6.6 | 4660.601 | 6.8 | 5092.674 | 7.2 | 5147.670 | 7.9 | 4832.310 | 7.8 | 2414.800 | 7.6 |
| | 52542.882 | | 68261.675 | | 71121.881 | | 64880.904 | | 62206.455 | | 31601.113 | |

* CIOS Documents Nos. 1 and 2.

** Earlier figures from this source not complete since Royalty payments did not begin until 1939. Total 1937-38 production stated elsewhere to be 35,600 tons.

goes to the alcohol plant for utilization of its olefin content. This overhead is normally handled as a liquid under pressure and identified as "gasol". Except for the part used for alcohol manufacture it was apparently sold mostly as motor fuel under the less confusing name of "Treibgas". A diagram was obtained showing the arrangement of the original stabilizing unit (Doc.31). A second stabilizing unit was built in [illegible] when the capacity of the original unit proved inadequate.

The combined oil from the water scrubbers is fractionated to yield light and heavy benzin, light kogasin, middle oil, heavy kogasin, and a waxy bottoms known as "gatsch". Practically no information could be obtained about the properties or uses of these products except by subsequent study of seized documents. The opinion was expressed that the gasoline had [illegible] but this was subsequently proved wrong.

An oil cracking unit had been erected in the Moers plant but was never used for the intended purpose. This was described as a Wilke unit, but subsequent study of documents indicated that it was a Carburol unit built by the Wilke Co. A complete set of drawings, including engineering calculations, for this unit was obtained (Doc.26). The fractionating equipment on this unit had been used to supplement inadequate capacity of the primary fractionating plant, but the whole unit was dismantled and moved after suffering some bomb damage. Probably the desirability of using Kogasin as Diesel fuel instead of cracking stock was a factor in this move.

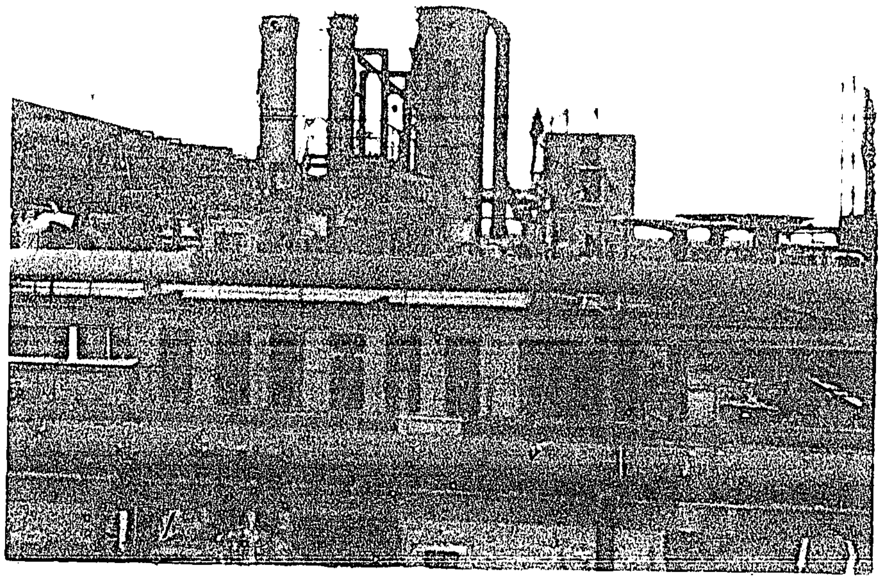


Figure [illegible].

[illegible] 56 [illegible]
[illegible] Alcohol plant 118 to right of the [illegible]
water scrubbing towers.

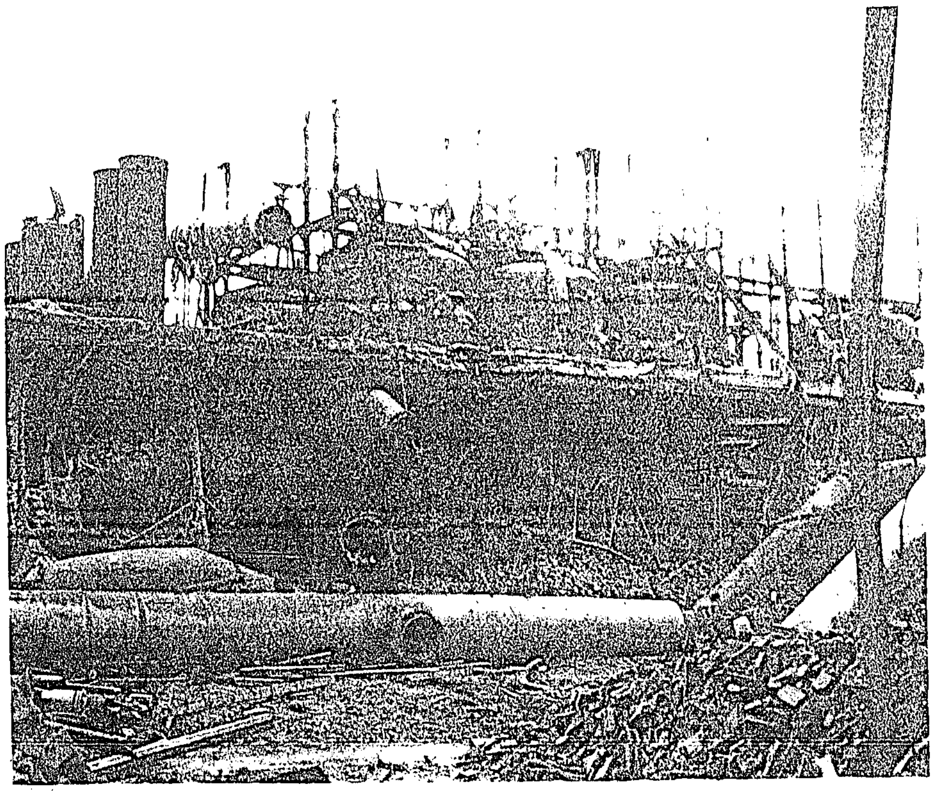


Figure [illegible]

[illegible]

of the catalyst bed had a different effect from increasing throughput to a bed of standard depth. A lower olefin content is observed with the deeper bed indicating the primary products to be olefinic, and normally undergoing more or less secondary hydrogenation, depending on the depth of bed.

As a part of the exchange of technical information between Ruhrchemie licensees it was apparent~~ly the practice to exchange copies of patent applica~~tions relating to the Fischer-Tropsch process. A number of these applications dating from 1936 to 1939 were captured (Doc 81) and brief abstracts thereof are attached as Appendix D. Probably the U.S. equivalents of some of these applications are among those seized and made public by the Alien Property Custodian.

Washing wax from the catalyst with a solvent at its boiling (or condensing) point, the subject of Brabag 182389, was apparently being practiced at Rheinpreussen. With this exception there is no evidence as to what extent, if at all, the procedures in question have been used. No applications of this character filed later than June 1939 were found.

## H. Product Recovery

The condensible products from the first and second stages of synthesis were recovered in separate but essentially similar units comprising water scrubbing towers for cooling by direct contact with water and condensing the heavier oil, and batteries of charcoal absorption chambers for recovering the light benzin and $C_3$-$C_4$ hydrocarbons. Each charcoal unit consisted of seven towers, normally divided as follows:- 2 towers absorbing, 1 tower steaming, 2 towers drying and 2 towers cooling. The time cycle is as follows: absorption 40 minutes, steaming 20 minutes, drying 40 minutes, and cooling 40 minutes. The remains of some of the charcoal absorbers are shown in Fig.24 and a more general view of the absorption plant is shown by Fig.25. The charcoal was obtained from Lurgi at Frankfort. No significant data on the performance of the charcoal absorbers have yet been found.

Part of the dry gas (Rest gas) from the final charcoal absorbtion is returned to the gas cracking unit for conversion of its Methane and the balance is used as fuel. The distillate from the charcoal absorbers is stabilized to yield a light benzin bottom which is used as a blending stock for motor fuel, and a normally gaseous product overhead, consisting mainly of $C_3$ and $C_4$ hydrocarbons, which

A report from Brabag (Ruhland) transmitted to Rheinpreussen by letter dated 21 March 1938 discusses the efficiency of hydrogenation as a means for regenerating spent Fischer-Tropsch catalyst. The author concludes that a hydrogenation step for said catalyst having a reduced activity in consequence of desposition of paraffin therein is effective in increasing the life-period of the catalyst. The recommended conditions of hydrogenation are temperatures of 200 to 225°C and a flow of hydrogen equivalent to 1000 $m^3$ per hour per oven. Compared with the production of catalyst ovens that have operated without hydrogenation for over 2000 hours, hydrogenation [illegible] increase the production about 25%.

The following disadvantages however attend regeneration by hydrogenation:

1 The paraffin is not completely removed from the catalyst.

2 By reason of catalytic cracking a part of the paraffin in the catalyst is decomposed and

3. Paraffin (wax) of new and particularly high molecular weight are formed.

The comment in the second paragraph of page 6 is interesting. It states as follows:

> "The formation of methane during the hydrogenation of the catalyst is at present viewed as an index of progressive cracking of iso paraffins because methane is manifestly a reaction product of these iso paraffins."

Informal reports from Brabag dated 4 and 5 January, 1938 (Doc 92) discuss experimental work on the effect of impurities in synthesis gas. Laboratory experiments showed some advantage for final purification with active charcoal but plant tests did not confirm this advantage, probably because of other uncontrolled factors. Active carbon gave a sulfur content of only 0.1 - 0.2 gm/100 $m^3$ compared with 0.4 - 0.5 gm/100 $m^3$ from normal fine purification.

The hydrocarbon content of the synthesis gas is ordinarily 0.1 - 0.2 gm/$m^3$ before fine purification and 0.5 to 1.0 gm/$m^3$ after fine purification indicating some synthesis reaction which is suspected of involving resin-forming hydrocarbons. The effect of such hydrocarbons in synthesis is not definitely known.

An oxygen content greater than 0.12% by volume in the synthesis gas is known to be quite detrimental to the catalyst. The air introduced for fine purification leaves 0.02% of $O_2$ in the synthesis gas, but its effect on the synthesis catalyst is unknown. Fresh catalysts blanketed with $CO_2$ may become red hot due to reaction with oxygen in the air during transfer to the ovens but this does not seem to impair catalyst activity or life.

Carbon dioxide has not been found to enter into the synthesis reaction. Its chief effect seems to be as a diluent, causing lower conversions as the $CO_2$ content is increased and the CO + $H_2$ content is decreased. Increasing the ratio of $H_2$ to CO appears to promote the hydro-cracking of oil and wax on the catalyst.

Increasing the ratio of CO:$H_2$ in synthesis gas tends to make heavier as well as more saturated products. Initial operation of a catalyst with synthesis gas relatively rich in CO seems to cause some permanent damage since abnormally short life results from subsequent operation with normal gas. Commerical fine purification does not remove all of the impurities which harm the catalyst. A spent catalyst contains bound $CO_2$ equivalent to 7-8% of the cobalt when calculated as carbonate.

Thiophene and other cyclics seem to be the most detrimental type of sulfur compounds. A given amount of sulfur as thiophene is much more detrimental if benzol is also present. Pure benzol or naphthalene apparent does not harm the catalyst. Acetylene up to 1% in the synthesis gas does not appear harmful.

High space velocity, once through, gives reduced percent conversion but increased unit productivity. Recycling gives a lower boiling product and a recycle ratio of 2.5 to 1 gives practically no oil heavier than benzin. Decreasing the depth

1. Gas contraction calculated from nitrogen contents. Nitrogen was directly determined (Feinbest) and not by difference.

2. From this, carbon and hydrogen balances were calculated, and the quantities of both coming out in the liquid products + gasol thereby determined.

Liquid products + gasol production was calculated by dividing the carbon lost from the gas by 0.845, which is evidently considered the average carbon content of these products. Similarly liquid products + gasol production was calculated by dividing the hydrogen lost from the gas by 0.297, which is evidently a factor determined by experience, since much of the hydrogen goes to water.

In two tests of the first stage of synthesis gas contraction was 41.7% and 52.8%, respectively. On nine tests of the second stage gas contraction varied from 32.1% to 41.6% with an average of 36.1%. Three tests of both stages in series showed gas contraction of 71.0%, 72.8% and 73.2% respectively.

The following shows results of two tests, one for the first stage and one for the second chosen so that the outlet of the first stage and the inlet of the second nearly correspond.

| | First stage | | Second stage | |
|---|---|---|---|---|
| | Inlet | Outlet | Inlet | Outlet |
| $CO_2$ | 8.9 | 21.4 | 21.0 | 34.4 |
| $C_n H_{2n}$ | 0.0 | 1.6 | 0.3 | 1.1 |
| $O_2$ | 0.0 | 0.1 | 0.0 | 0.0 |
| CO | 26.2 | 14.4 | 15.7 | 3.3 |
| $H_2$ | 51.5 | 26.0 | 28.7 | 7.0 |
| $CH_4$ | 0.7 | 10.0 | 7.6 | 14.9 |
| $N_2$ (determined) | 12.43 | 26.36 | 26.59 | 39.19 |
| Gas contraction | 52.8% | | 32.1% | |
| * Liquid products + gasol $g/m^3$ inlet gas | 95.6 | | 52.4 | |
| * Same, based on $H_2$ + CO content | 123.0 | | 118.0 | |

* Calculated from carbon balance

Calculation shows a total yield of liquid products + gasol of about 155g/$m^3$ of pure synthesis gas ($H_2$ + CO). One of the tests made in series on both stages showed a calculated yield of 175.0 g/$m^3$.

The normal life of a charge of catalyst is about four months. Three or four times during this period the catalyst is dewaxed by washing for 12 to 15 hours at 160°C with synthetic benzin having a boiling range of about 140 to 180°C. Hydrogenation was originally used for this purpose, the hydrogen being made by the iron-steam reaction. It was stated that benzin washing has been used for the last two years because it is much more "effective", but it seems probable that the reason for the change was the desire to recover the high melting point wax instead of largely destroying it by hydro-cracking on the catalyst. The benzin is distilled from the extract and the residual wax, known as "Hart Paraffin" is cast in pans to make cakes for shipment.

An informal report from the Rheinpreussen laboratory dated 15 March 1938, entitled "The Removal of Paraffin from Used Catalyst" describes a series of experiments directed toward the removal of paraffin from used Fischer-Tropsch catalyst by its heating with water and solutions of NaOH, $Na_2 CO_3$ and $Na H CO_3$. The conclusions reached are as follows:-

1. By heating Fischer catalyst with a 4-5% soda solution at atmospheric pressure a satisfactory removal of paraffin can be achieved. The removal amounts to 65-75%.
2. For effecting a sufficient removal of paraffin the mixture of catalyst and solution of soda must be heated to above 100°C. The melting point of the paraffin in the catalyst is so high that a temperature of 96-98°C is inadequate.
3. Small grain sizes of the catalyst are more difficult to free of paraffin than the larger ones.
4. Silica converted to soluble form during the treatment is only slight.
5. For a clean paraffin separation 3 parts of soda solution to one part of catalyst is considered most favorable.

was stated to be 195 to 200°C and the pressure not over 3000 mm. of water (4.26 psi). The pressure on the cooling water is increased from 2.5 to 9.0 atm. during the life of the catalyst. This corresponds to a range of water temperature from 139°C. to 180°C. which does not seem reasonable for the stated 5°C. rise in catalyst temperature. It seems probable that the latter figure is in error, but nothing bearing on this point has yet been found in the seized records.

From a plant record book (Doc.19) and corresponding graphs, a rather detailed picture of the performance of the synthesis ovens during the last half of 1941 and the first half of 1942 can be obtained. During this period the synthesis gas charge rate averaged about 630 cu.m. per hour per oven. The charge rate was in general quite steady but on some days averaged as low as 520 M$^3$ per hour, and on others as high as 740 M$^3$ per hour. The product yield figures, for some unknown reason, showed much greater fluctuations from day to day with no apparent correlation with charge rate. The total liquid product, including "Gasol" ($C_3$ and $C_4$ hydrocarbons) averaged 150-155 grams per cubic meter, with a daily minimum of 135 gm/M$^3$ and a maximum of 175 gms/M$^3$. The yield of products heavier than the "Gasol" averaged about 135 gm/M$^3$ with a minimum of 112 gm/M$^3$ and a maximum of 155 gm/M$^3$.

The performance of the individual stages is also illustrated by reported date for 1941 and 1942 from which Table VI page 46 has been compiled. These data are derived from independent analyses of material to and from each stage and obvious inconsistencies suggest that analytical errors, in some cases, were considerable. For the period in question the CO-conversion in the first stage averaged about 70%, and in the second stage about 65%. The efficiency of CO utilization measured by the proportion converted to useful products ($C_3$ and heavier) is generally considerably lower for the second stage, probably in part because of the greater dilution of gas processed in this stage. There is no apparent explanation for certain exceptions to this relationship (18 September in particular). The original data also include hydrogen balances for these operations.

Further data on synthesis oven performance are provided by a collection of data sheets (Doc.73) for tests conducted in April, May and June 1943. The calculation procedure was as follows:

### TABLE VI

### Conversion in Individual Stag of Synthesis

|  | FIRST STAGE |  | SECOND STAGE |  | OVERALL |  |
|---|---|---|---|---|---|---|
| 1941 | % CO Conv. | CO Conv. Eff. Fac.* | %CO Conv. | CO Conv. Eff. Fac | % CO Conv. | CO Conv. Eff. Fa |
| 23 July | 74.7 | 3.33 | 77.9 | 1.49 | 94.5 | 2.76 |
| 8 Aug. | 76.8 | 5.63 | 61.0 | 1.99 | 90.5 | 3.70 |
| 19 Aug. | 70.6 | 4.00 | 64.0 | 2.35 | 89.3 | 3.76 |
| 28 Aug. | 72.8 | 4.51 | 64.3 | 0.89 | 90.3 | 3.08 |
| 18 Sept | 75.8 | 4.02 | 65.2 | 7.69 | 92.3 | 4.26 |
| 2 Oct. | 74.8 | 4.58 | 61.0 | 1.62 | 90.1 | 3.61 |
| 21 Oct. | 75.6 | 3.14 | 68.1 | 2.82 | 92.3 | 3.37 |
| 5 Nov. | 77.7 | 3.95 | 62.9 | 3.80 | 91.7 | 4.50 |
| 18 Nov. | 78.2 | 4.86 | 79.0 | 2.48 | 95.1 | 3.22 |
| 9 Dec. | 74.4 | 5.20 | 68.4 | 2.44 | 91.9 | 4.38 |
| 29 Dec. | 76.4 | 5.37 | 69.6 | 2.82 | 92.6 | 4.60 |
| 1942 |  |  |  |  |  |  |
| 6 Jan. | 77.1 | 4.35 | 66.7 | 1.70 | 92.4 | 3.74 |
| 31 Jan. | 74.0 | 4.65 | 57.8 | 4.38 | 89.1 | 4.10 |
| 10 Feb. | 75.4 | 6.26 | 60.8 | 1.88 | 90.4 | 4.80 |
| 25 Feb. | 78.3 | 3.80 | 69.4 | 1.87 | 93.4 | 3.40 |

* CO Conversion Efficiency Factor

$$= \frac{\text{Vol CO Converted to } C_3 \text{ and heavier}}{\text{Vol CO Converted to } CO_2,\ CH_4\ \&\ C_2H_2}$$

Not calculated or designated as such in the original data.

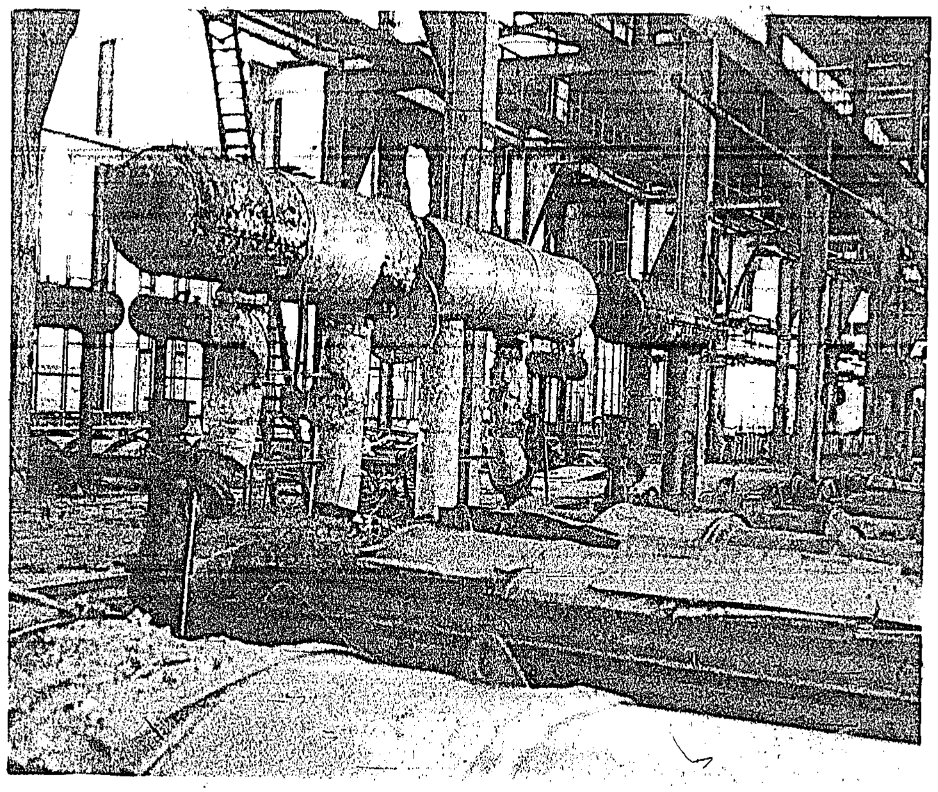


Figure 21.

[illegible] of oven.

Figure 22.

Steam drums of older ovens viewed from control floor.

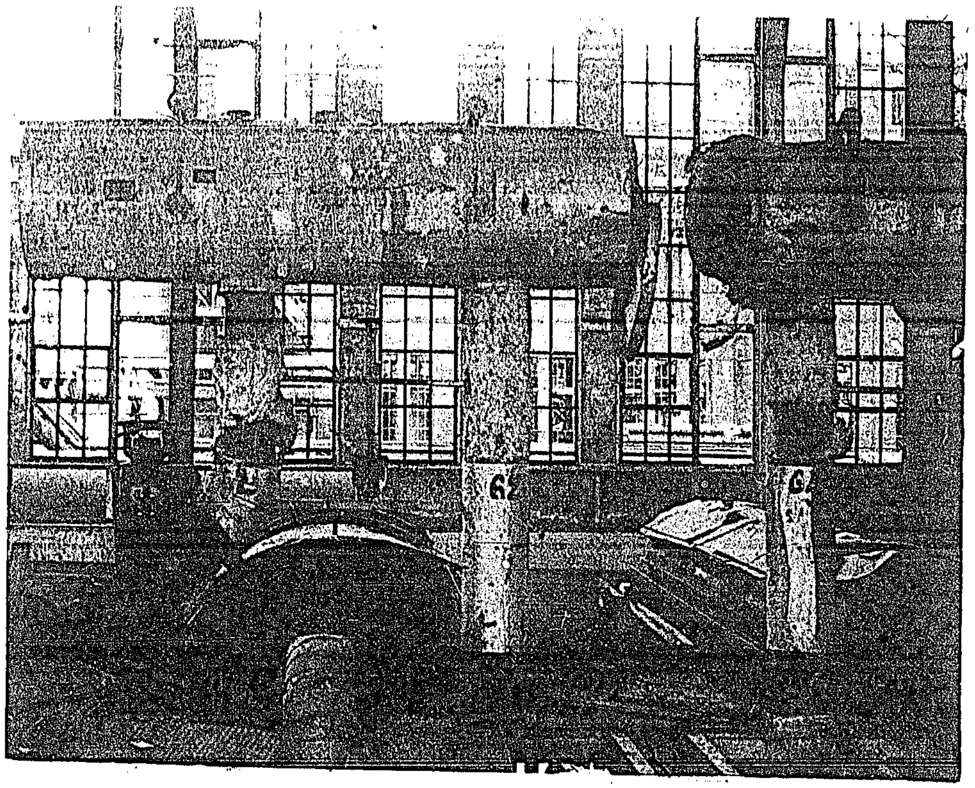


Figure 19.

Steam drum for one of newer ovens viewed from control floor.

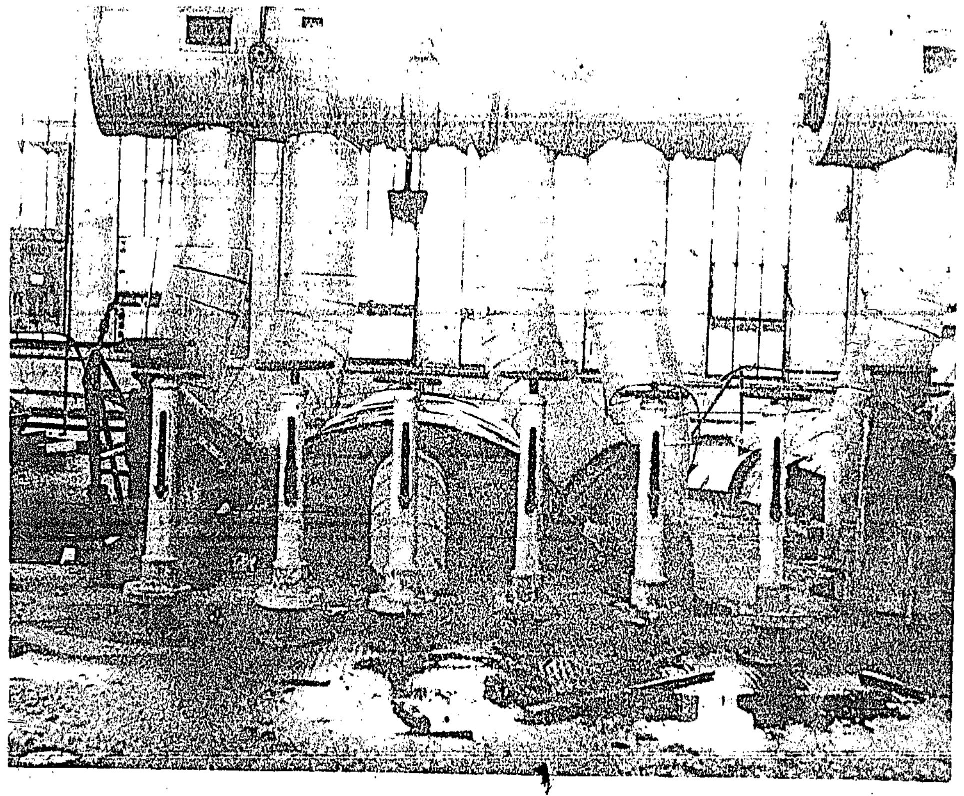


Figure 20.

Steam drum serving a part of [illegible] ovens, viewed from control floor.

Each reactor is approximately 1.5 meters wide 2.9 meters high and 5 meters long. The horizontal water cooling tubes extend lengthwise of the reactor. There are 11 tubes in each of the 29 horizontal rows, the tubes being approximately 2.5 cm outside diameter. Horizontal headers, spaced as indicated by the cut-off rows of tubes in Fig.18, are connected at both ends of the reactor and their ends join vertical headers at each corner of the reactor as can be seen partially on the reactor at the left in Fig.16. The vertical headers on the same side of each reactor have a connecting line at the bottom. The vertical headers at the inner end (nearest the center of the building) of each reactor are connected to a superimposed steam drum, wherein steam pressure, and thereby reactor temperature is controlled.

The more recent units were arranged with a steam drum for each reactor as shown in Fig.19 whereas earlier units had two reactors connected to each drum as shown by Fig.20. Several units of each type are shown by Figures 21 and 22.

The edges of the transverse cooling plates can be seen in Figs 17 and 18 although the spacing is so close that the individual plates can not be distinguished. These plates are approximately 1 cm face to face. The catalyst fills the space between the plates and around the tubes.

No detail drawings or descriptive matter relating to reactor construction were found among the seized documents. It is understood that the reactors were made by Mannesmannrohren Werke, Dusseldorf.

## G. Synthesis Procedure

It is customary to operate 60 ovens in the first stage and 30 in the second stage, with the remaining 6 emptying and filling or out of service for repairs or catalyst washing. Synthesis gas is supplied to the first stage of ovens direct from the fine purification step at a temperature of 150-160°C and at a rate of 1000-1200 cubic meters per hour per oven. (This stated rate is higher than indicated by captured documents.) The effluent is subjected to water scrubbing and charcoal absorption after each stage although in early operations only water scrubbing was used after the first stage. The catalyst temperature

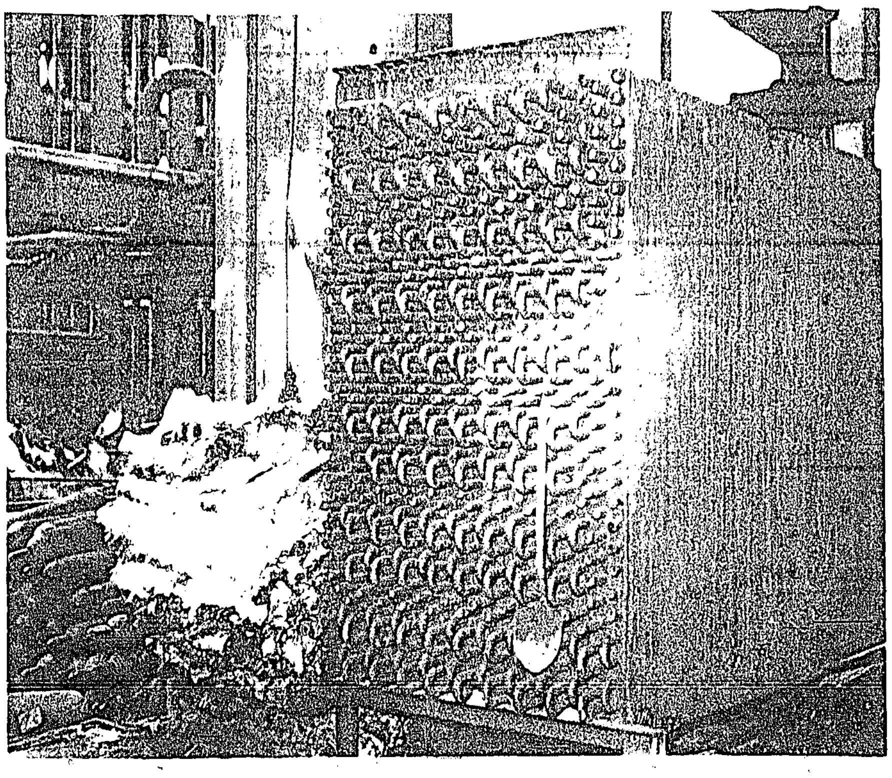


Figure 16

[illegible]

Figure 10

[illegible] wall [illegible]
to tubes.

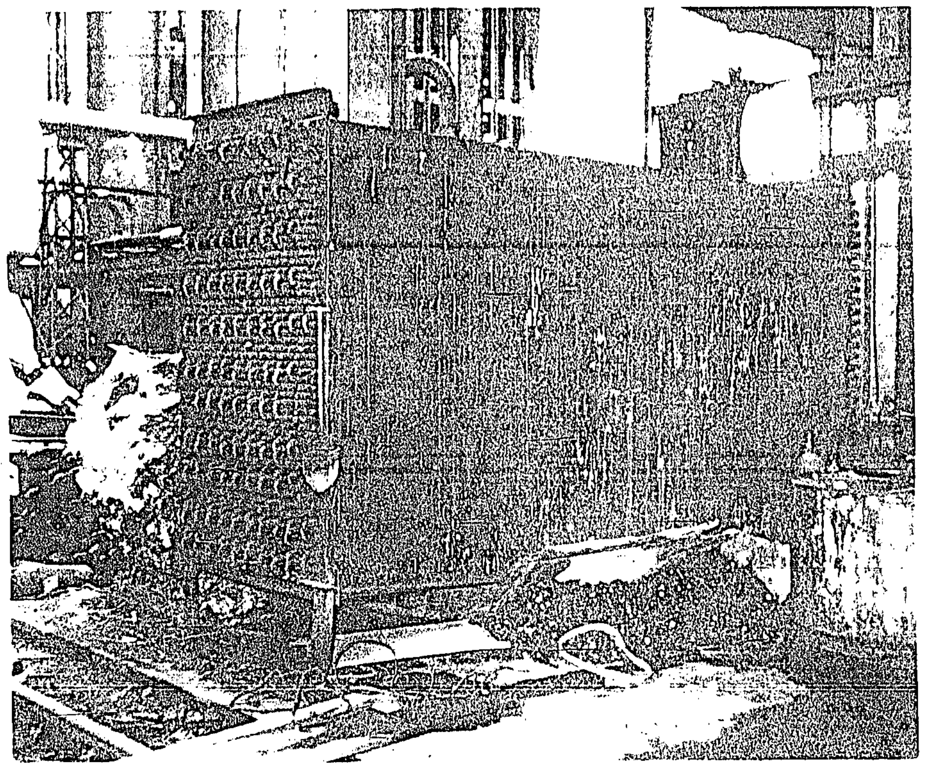
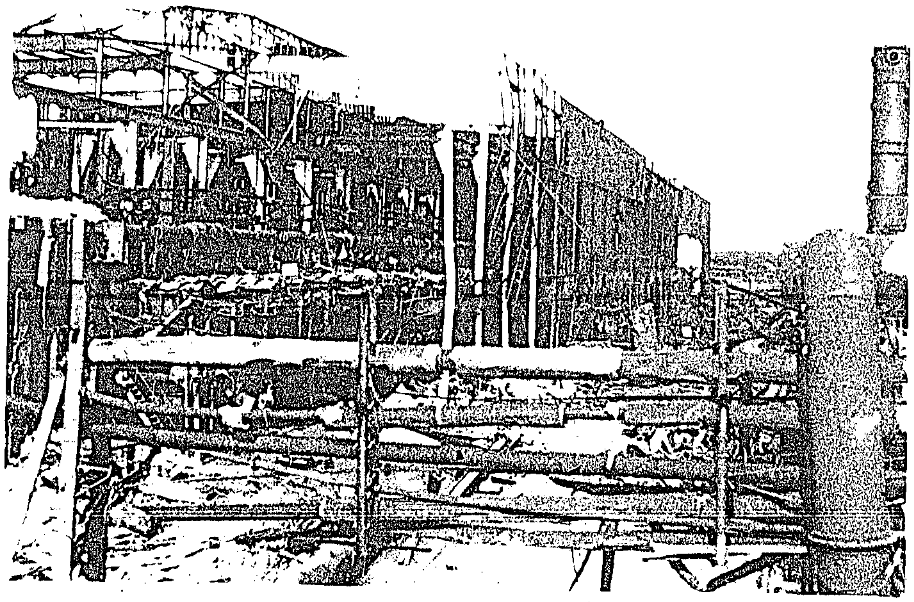


Figure [illegible]

[illegible]



[illegible]

F. Synthesis Ovens.

The contact oven house is shown by Fig. 15, which also shows the extensive damage done to the south end of this building by bombing. The ovens are arranged in two parallel rows along the length of this building. The first 36 ovens, in the south end of the building, were erected in 1936: the next 12 were erected in 1937, and the last 48 were erected in 1938.

Figure 16 shows the outer ends of three ovens viewed from the ground level. Below these ovens can be seen the catalyst discharge troughs, and in the [illegible] is a portable bucket elevator for dumping spent catalyst into kubels for return to Ruhrchemie.

The synthesis ovens themselves were of the rather well-known early Ruhrchemie type, designed for low pressure operation. One of these ovens which had been removed from the battery is shown in some detail by Figures 17 and 18. For some unknown reason, the water tube leaders had been cut off from this reactor, but this leaves the spacing of the tubes more apparent.

## TABLE IV
## Components of Synthesis Catalyst
## Shipments from Ruhrchemie to Rheinpreussen *

| Month 1942 | Kilograms shipped Cobalt | Thorium | Kieselguhr | MgO. | Component Ratios by weight. Th/Co | Kies./Co. | MgO/Co |
|---|---|---|---|---|---|---|---|
| Jan. | 19571 | 995 | 32045 | 1481 | 0.0508 | 1.637 | 0.0756 |
| Feb. | 20922 | 1061 | 36323 | 1538 | 0.0506 | 1.735 | 0.0734 |
| Mar. | 21278 | 1096 | 36418 | 1644 | 0.0513 | 1.710 | 0.0771 |
| Apr. | 21681 | 1129 | 36060 | 1732 | 0.0519 | 1.658 | 0.0796 |
| May | 21571 | 1125 | 37343 | 1573 | 0.0521 | 1.728 | 0.0728 |
| June | 24163 | 1241 | 40994 | 1715 | 0.0513 | 1.691 | 0.0708 |
| July | 19966 | 1018 | 33729 | 1381 | 0.0509 | 1.688 | 0.0692 |
| Aug. | 13692 | 711 | 24243 | 1010 | 0.0519 | 1.770 | 0.0736 |
| Sept. | 21655 | 1121 | 37126 | 1605 | 0.0517 | 1.713 | 0.0740 |
| Oct. | 21313 | 1067 | 37141 | 1650 | 0.0500 | 1.741 | 0.0773 |
| Nov. | 11769 | 586 | 20396 | 867 | 0.0497 | 1.730 | 0.0735 |
| Dec. | 17536 | 888 | 29634 | 1290 | 0.0505 | 1.688 | 0.0734 |
| 1942 Totals & Ave. | 235117 | 12038 | 401452 | 17486 | 0.0512 | 1.706 | 0.0744 |
| June 1943 | 9281 | 467 | 18947 | 713 | 0.0503 | 2.040 | 0.0768 |
| Dec. 1943 | 18231 | 928 | 39012 | 1352 | 0.0508 | 2.139 | 0.0740 |
| June 1944 | 10853 | 545 | 19529 | 806 | 0.0502 | 1.799 | 0.0742 |

* Data from CIOS Document No.7.

## TABLE V.
## Catalyst shipments from Ruhrchemie to Rheinpreussen
## Expressed as kilograms of Cobalt.

| | 1940 | 1941 | 1942 | 1943 | 1944 |
|---|---|---|---|---|---|
| Jan | | 22220 | 19571 | 17928 | 15240 |
| Feb | | 20360 | 20922 | 17452 | 14353 |
| Mar | | 22453 | 21278 | 19864 | 19008 |
| Apr | | 21010 | 21681 | 17653 | 20590 |
| May | | 22896 | 21571 | 24881* | 19340 |
| June | | 23323 | 24163 | 24356** | 10853 |
| July | 20904 | 22819 | 19966 | 13117 | 3603 |
| Aug | 21117 | 21367 | 13692 | 16727 | None reported |
| Sept | 16894 | 25310 | 21655 | 16988 | 24258 |
| Oct | 22843 | 21030 | 21313 | 20510 | No further Shipments |
| Nov | 15286 | 22992 | 17536 | 18065 | |
| Dec | 21129 | 22985 | 17928 | 18231 | |
| Total | 118173 | 268765 | 241276 | 225772 | 127245 |

*Includes 17335 kg. from Brabag

** Includes 13567 kg. from Brabag

Although it is known that catalyst was not made or reworked by Rheinpreussen, no specific information has been found on the technology of these operations as carried out by Ruhrchemie and occasionally by Brabag. Some discussion of the subject took place in connection with controversy over the cost of reworking, included in Document No. 2 which remains to be studied in detail. From Document No. 7 recording shipments of catalyst from Ruhrchemie to Rheinpreussen Table IV, page 32 has been prepared. There seemed to be no significant trend in compositiom during 1942. Comparable figures for June and December 1943 and June 1944 indicate no trend during these years unless possibly toward a slightly higher ratio of Kieselguhr to cobalt.

The total shipments of cobalt by month from July 1940 to September 1944 shown in Table V, page 33. The shipments were low in August 1942, in May, June and July 1943, January and February 1944, and June 1944 and later. There is no indication for the reason for these depressions, but it is possible that they were associated with bombings of Ruhrchemie plants or their sources of supply. The shipment to Rheinpreussen in September indicates some optimism even at that date about resuming synthesis operations at Moers.

The exact basis of calculation catalyst reworking costs is not clear from first reading of the seized account books, but it appears that Rheinpreussen's monthly payments to Ruhrchemie amounted to 3.7 to 4.2 marks per kilo of cobalt returned by Ruhrchemie.

A Rheinpreussen memorandum 27 August 1942 describes a method reported by Hoesch-Benzin for evaluating synthesis catalysts, involving measurement of hydrogen and carbon monoxide adsorption separately at normal pressure and temperatures of 50, 100, 150 and 200°C. It is stated that adsorption increases with temperature over this range and that much more hydrogen than CO is adsorbed per gram of cobalt. From these adsorption curves, it is implied that some

measure of activity can be derived although just how this is done is not explained.

From the minutes of conferences of Ruhrchemie licensees, extending over the period from November 1936 to July 1939 (Document 93), the following additional information about catalysts and operating conditions was derived.

### Effect of $ThO_2$ - Mg O ratios.

No final conclusions were reached at the meetings as to the exact effect of the Mg O content. In general, the trend of opinion indicated that a ratio of 1 Th $O_2$ to 1.6 Mg O gave satisfactory results and about as good a catalyst containing a higher proportion of Th $O_2$. Further increase in Mg O content was tried but the experiments had not run long enough to determine its effect.

### Sulfur Removal.

The major item of interest found in the discussion of sulfur removal concerned the effect of oxygen in the operation of the Feinreinigung. With 0.012 vol. percent $O_2$ the $H_2S$ removal was very poor. With 0.177 to 0.205 volume percent oxygen, good $H_2S$ removal was secured except at extremely high rates of gas throughput. When the $O_2$ content was increased to 0.802 to 0.903 volume percent, the efficiency of $H_2S$ removal was seriously decreased. Organic sulfur removal was not very effective with 0.012 volume percent oxygen but was effective with 0.177 to 0.443 volume percent. The best results were secured with 0.177 to 0.205 vol.percent oxygen.

### Miscellaneous Items.

Other matters discussed at the meetings concerned general matters of plant operation such as emptying and reloading the convertors with catalyst, removal of paraffin, removal of carbon deposits, and regeneration with hydrogen or by washing with Fischer-Tropsch product.

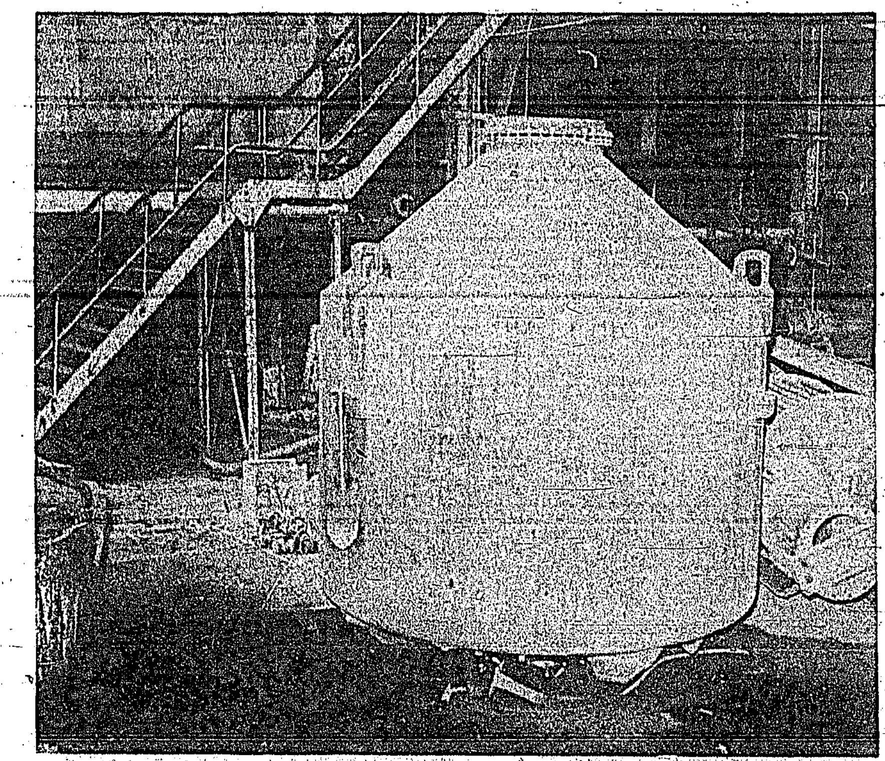


Figure 14.

"Kübel" used for shipping synthesis catalyst.

Before removing the can of catalyst from the Kubel, the cover of the can was put in place and it was sealed with adhesive tape within a few minutes thereafter. This was identified as CIOS sample Bo.2. The Fuel Research Station analyzed sample No. 2 and tested both samples for activity with the following results:

| | % | | | % | |
|---|---|---|---|---|---|
| Moisture | 1.0 | | Ca 0 | 0.9 | |
| Loss on ignition | 4.0 | | Mg 0 | 0.9 | (0.9) |
| $Si\ O_2$ | 47.9 | (47.5) | Ni | 0.1 | |
| $Fe_2O_3$ | 6.5 | | $-SO_3$ | nil | |
| $Th\ O_2$ | 1.8 | (1.8) | $-CO_2$ | 0.2 | |
| $Al_2O_3$ | 1.9 | | Unaccounted for | 5.6 | |
| $Co_2O_3$ | 29.2 | (28.7) | | 100.0 | |

The material "unaccounted for" may be undetermined elements or may be due to false assumptions as to the state in which the known elements are present in the sample.

The amount of material insuluble in acid/ 52.7% gives a minimum figure for the kieselguhr content, and 100 - ($CO_2O_3$+ $ThO_2$+ MgO) gives a maximum figure.

The composition of the catalyst expressed in the usual manner would therefore appear to lie between the limits shown:

| Co | $ThO_2$ | MgO | Kieselguhr |
|---|---|---|---|
| 100 | 8.8 | 4.4 | 260 to 330 |

This result is in complete disagreement with information obtained by the Ruhr Party, which was that the catalyst used in all Western-German Fischer-Tropsch plants had the composition:

100 Co, 5 $ThO_2$, 8 MgO, 180-220 Kieselguhr

The above analytical results should therefore be regarded as tentative.

Both samples 2 and 10, as obtained, were completely inactive for synthesis at 185°C. and 195°C. After reduction with hydrogen at 400°C. in the usual manner, both catalysts showed gas volume contractions of 10% and 20% respectively when evaluated at 185°C. and 195°C.

The fine purification (Feinreinigung) plant for removal of organic sulfur comprises a battery of five chambers filled with lump catalyst containing iron oxide plus sodium carbonate. The chambers were 4.7 meters inside diameter and about 6 meters high with brick insulated walls to facilitate operation at elevated temperature. The gas is preheated in a small pipe heater to reaction temperature which ranges from 180°C with a fresh catalyst to 280°C when the catalyst is nearly exhausted.

A sample said to be the fine purification catalyst was obtained and identified as CIOS Sample No.9 The result of the analysis of this sample as reported by the Fuel Research Station is as follows:

| | |
|---|---|
| Moisture | 8.0 |
| $Fe_2 O_3$ | 34.4 |
| $Na_2 CO_3$ | 23.8 |
| $SO_3$ | 3.5 |
| Unidentified | 30.3 |

Miscellaneous laboratory notes (Document 61) indicate that the fine purification catalyst contains about 29% of $Na_2 CO_3$. Apparently experiments on the regeneration of the fine purification catalyst with oxygen were conducted in 1941 from the records of which the following information was derived:

The fully spent mass showed as a typical analysis 33% $Na_2 SO_4$, 0.3% $Na_2 SO_3$, and 4% $Na_2 CO_3$. This indicates that the reaction in Feinreinigung is essentially a catalytic oxidation and that $O_2$ in the synthesis gas is essential, as other documents and data have indicated. Spent mass that had not been regenerated showed - 16 - 30% $Na_2 SO_4$, 0.4% $Na_2 SO_3$, and 7 - 15% $Na_2 CO_3$. The above analyses indicate that the original mass contained about 30% $Na_2 CO_3$, the remainder presumably being $Fe_2 O_3$.

The gas leaving the fine purification and going to the reactors was stated to have the following composition.

| | |
|---|---|
| $CH_4$ | 0.5% |
| Other hydrocarbons | 0.2 |
| $CO_2$ | 8.0 |
| $O_2$ | 0.1 |
| $N_2$ | 8.0 |
| CO | 28.0 |
| $H_2$ | 55.0 |

From other sources it was learned that the sulfur content is 0.4 to 0.5 gms S per 100 $M^3$ after normal fine purification.

### E. Synthesis Catalyst

The Moers plant used a cobalt Catalyst but the persons interrogated claimed to know nothing more about its composition except that it had not changed since the plant started operations. The catalyst is obtained from Ruhrchemie at Oberhausen-Holten and is returned to them for reworking. The catalyst is received in the reduced state in steel "Kubels" as illustrated by Fig 14. Each Kubel holds approximately 3 metric tons which is sometimes a little more and sometimes a little less than required to fill a single synthesis oven. An overhead travelling crane moves and dumps these containers. Return shipments of spent catalyst are made in the same Kubels which are carried on specially built rail cars holding two Kubels each.

One Kubel filled with what was stated to be fresh synthesis catalyst was found in the northeast corner of the synthesis building. The cover was not bolted tight and some deterioration of the catalyst might have occured due to infiltration of air during several months standing. On 7 March the cover was partly removed and a small sample of catalyst taken (CIOS No.10) without any special precautions to exclude air from the Kubel. The sample did not ignite spontaneously and the sample container was sealed promptly and the cover replaced on the Kubel. On the following day the cover was again partly removed to permit a large sample can to be lowered onto the top of the catalyst in the vessel. The can was previously purged with $CO_2$ and a blast of $CO_2$ was directed into the upper part of the Kubel while the sample was being taken. It was impossible to dig deeper than about one foot below the surface of the Catalyst and at this depth, where the sample was taken, the catalyst was observed to be at a dull red temperature.

## D. Synthesis Gas Purification.

The mixture of converted water gas and cracked coke oven gas is passed at atmospheric temperature to a battery of eight "Grobreinigung" towers for removal of $H_2S$. Each tower is approximately 11 meters in diameter and 10 meters high, containing 800 tons of catalyst in beds about 0.3 meters deep on 18 trays spaced 1 meter apart. The catalyst is stated to be iron oxide (luxmasse) and to have a life of about 12 weeks after which it is thrown away. The gas velocity through the catalyst was stated to be 1 meter per second. Air in the amount of 1.4% of the gas treated is added to the gas ahead of the coarse purification to function as an oxidizing agent in the subsequent fine purification step.

A sample of this catalyst was obtained. Results of its analysis as reported by the Fuel Research Station are as follows:

| | |
|---|---|
| Moisture | 49.5 |
| Loss on ignition at 475°C. | 5.4% |

The ignited and air dried catalyst showed the following analysis which is typical of Luxmasse:

| | |
|---|---|
| Moisture | 3.4% |
| $SiO_2$ | 0.8 |
| $Fe_2O_3$ | 56.0 |
| $Al_2O_3$ | 27.4 |
| CAO | 6.2 |
| $SO_3$ | 1.9 |
| $CO_2$ | 2.2 |
| Difference | 2.1 |
| | 100.0% |

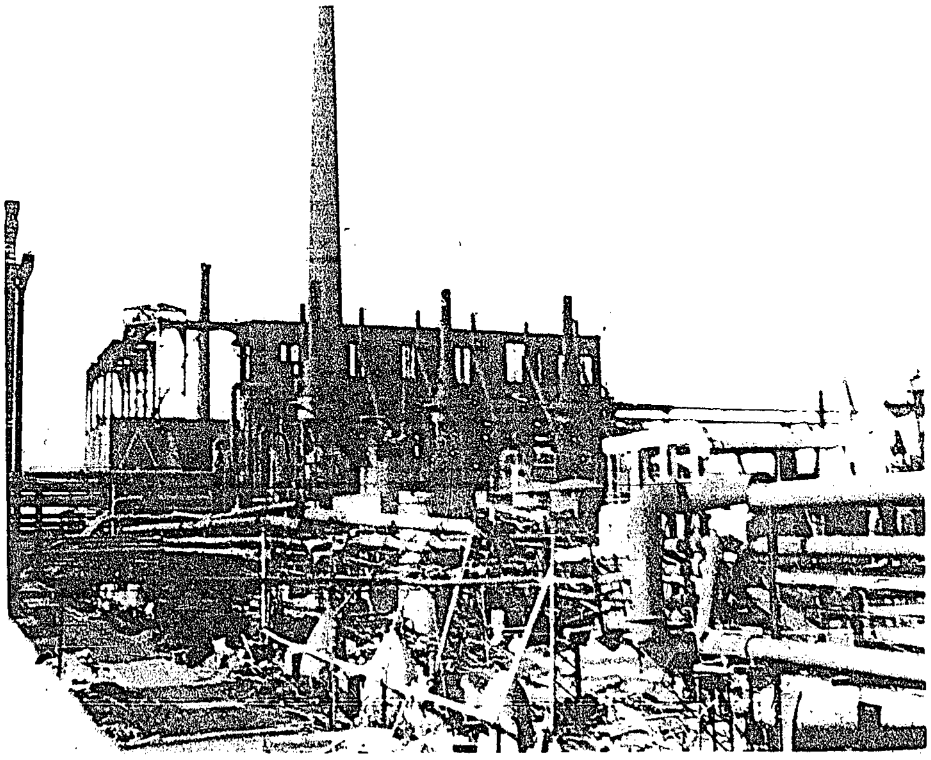


Figure 16.

[illegible]
purification plant (65) looking NW from south
of contact oven house 94.

### Water-gas Shift Catalyst, Sample No. 6.

This sample consisted of greyish-brown, irregular-shaped pieces, approximate size range, 1/2 to 3/4 in., of great hardness and mechanical strength. Bulk density: 1300 g./liter.

| Analysis: | % |
|---|---|
| Moisture (by distillation with xylene | 5.0 |
| Additional moisture given off at 800°C. | 13.0 |
| $SiO_2$ | 5.1 |
| $Fe_2O_3$ | 38.5 |
| $Cr_2O_3$ | 5.4 |
| $Al_2O_3$ | 2.5 |
| Ca O | 18.2 |
| Mg O | 5.2 |
| $-CO_2$ | 5.0 |
| $-SO_3$ | 1.9 |
| Difference (alkalies, etc.) | 0.2 |
| | 100.0 |

This analysis presents no unusual features. Chromium oxide is a normal promotor for the shift catalyst, and lime is a recommended addition, burnt dolomite being often used as the basis of the catalyst.

---

## TABLE III.

## OPERATION OF WATER GAS GENERATORS AND CONVERTORS.

### Average composition of coke.

| | |
|---|---|
| $H_2O$ | 8.2% |
| Volatile + C | 82.6% |
| Ash | 9.2% |

### Average Generator Operation.

| | |
|---|---|
| Coke charged to generators | 981,220 metric tons/day. |
| Water gas produced | 1,146,070 $M^3$/day. |
| Gross steam consumption | = 1870 metric tons/day.<br>= 95 pounds/Mcf. |
| Steam generated in waste heat boiler | = 1095 metric tons/day.<br>= 56 pounds/Mcf. |
| Net steam consumtion | 39 pounds/Mcf. |

### Average Convertor Operation.

| | |
|---|---|
| Water gas converted | 210,900 $M^3$/day. |
| % of total water gas | 18.4% |
| Converted gas volume | 260,400 $M^3$/day. |
| Steam consumption (30 atm) | 86 metric tons/day. |
| Water consumption | 1 004 $M^3$/day, |
| Coke oven gas cracked | 251,590 $M^3$/day |
| Steam to cracking stoves | 250.4 metric tons/day. |
| Cracked gas production | 389,370 $M^3$/day. |
| Coke oven gas used as fuel | 4,862 $M^3$/day. |
| Heating value | 4,455 Cal/$M^3$. |
| Other gas (Rest gas) used as fuel. | 122,200 $M^3$/day. |
| Heating value | 2,292 Cal/$M^3$. |

## VI. Synthesis Plant

The general procedure involved in the Moers Fischer-Tropsch operations will be reviewed prior to consideration of the individual steps in greater detail.

Water gas is made from coke in eleven Koppers generators and is passed in part through a catalytic convertor unit to increase the ratio of hydrogen to carbon monoxide. Coke oven gas is "cracked" with steam non-catalytically in a battery of six Cowper stoves and is mixed with converted water gas in the proportion required to give a 2:1 ratio of hydrogen to CO. The mixed gas subjected to coarse purification (Grobreinigung) for $H_2S$ removal by passage through iron oxide, and then is contacted with iron oxide plus sodium carbonate at elevated temperature for fine purification (Feinreinigung) to remove organic sulfur. The purified gas goes to the first stage of synthesis ovens, comprising two thirds of the total, and then to water scrubbers and charcoal absorbers for removal of condensible products ($C_3$ and heavier). The unabsorbed gases pass through the second stage of synthesis ovens and to a final water scrubbing and charcoal absorption. Oil condensate from the water scrubbers is fractionated to make several distillate cuts and waxy bottoms known as "gatsch". The light hydrocarbons recovered from the charcoal are stabilized to yield benzin bottoms and a $C_3$-$C_4$ fraction overhead which is liquefied under pressure and designated by the somewhat confusing term "gasol".

### A. Water Gas Generation

The water gas generators are arranged in two batteries. The older battery, containing six generators was built in 1936 and a second battery of four generators was built in 1938. A fifth generator was added to the latter battery in 1943. Fairly complete drawings and descriptions of these generators were picked up (Doc 25) which indicate that they were conventional in construction and operation except for somewhat more elaborate provisions for recovering waste heat than would be used in the United States. It was stated that normally nine of the eleven units were in service and that the total coke consumption was about 900 (metric) tons per day. The operating cycle of each generator was given as 80 seconds blast, 6 seconds purge, 60 seconds up run, 50 seconds down run, and 6 seconds purge.

From the data in a seized record book (Doc. 19), Table III, page 24, has been prepared summarizing the operation of these generators as carried out in 1941 and 1942

The remains of the old battery of water gas generators is shown by Figure 13, page 25.

### B. Water Gas Conversion.

Approximately 18% of the water gas produced was passed through a pair of catalytic convertors to increase the ratio of $H_2$ to CO. The average performance of these convertors is also shown in Table III. These convertors are approximately 3 meters in diameter and 6 meters high, and operated at 450-500°C. The converted gas is water washed and combined with the remainder of the water gas in holder (55).

From seized document No. 61, it appears that the convertor catalyst contained the following ingredients although its entire composition was not given:

| | |
|---|---|
| Cr | 3.7% |
| Mu | 0.1% |
| P | 0.1% |
| As | Trace |

A sample stated to be fresh convertor catalyst was obtained. The results of an analysis of this sample made by the Fuel Research Station are given on page 23a.

### C. Coke Oven Gas Cracking.

To further increase the synthesis gas supply and to complete the adjustment of the $H_2$:CO ratio to the desired 2:1, coke oven gas in the amount of about 10,000 cubic meters per hour is "cracked" with steam in a battery of three Cowper stoves. These are refractory lined chanbers approximately six meters in diameter and twenty meters high packed with refractory checker brick. No significant drawings or further details of construction were obtained. The stoves are used in rotation on a cycle comprising blast, steam purge, "crack", and steam purge. The cracking temperature was stated to be 1200°C. From seized document No. 19 the following figures were taken as representative of this cracking operation in 1941 and 1942.

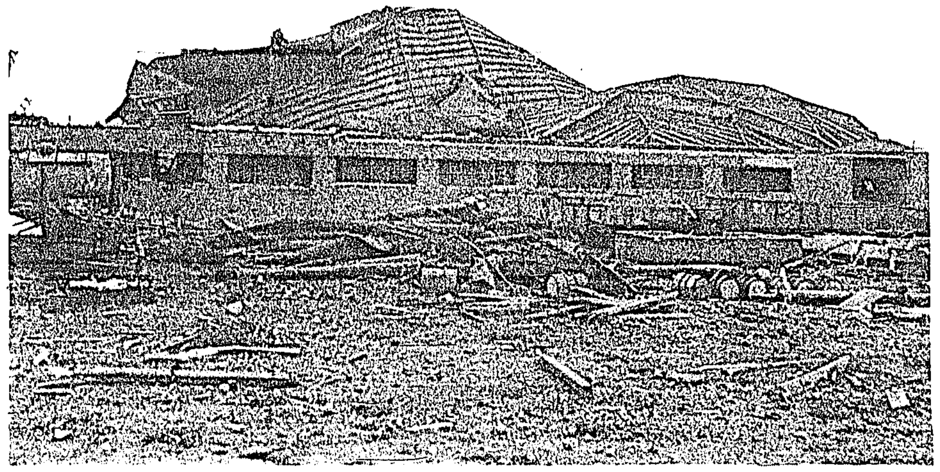


Figure 11.

[illegible] lant (.2) looking east.

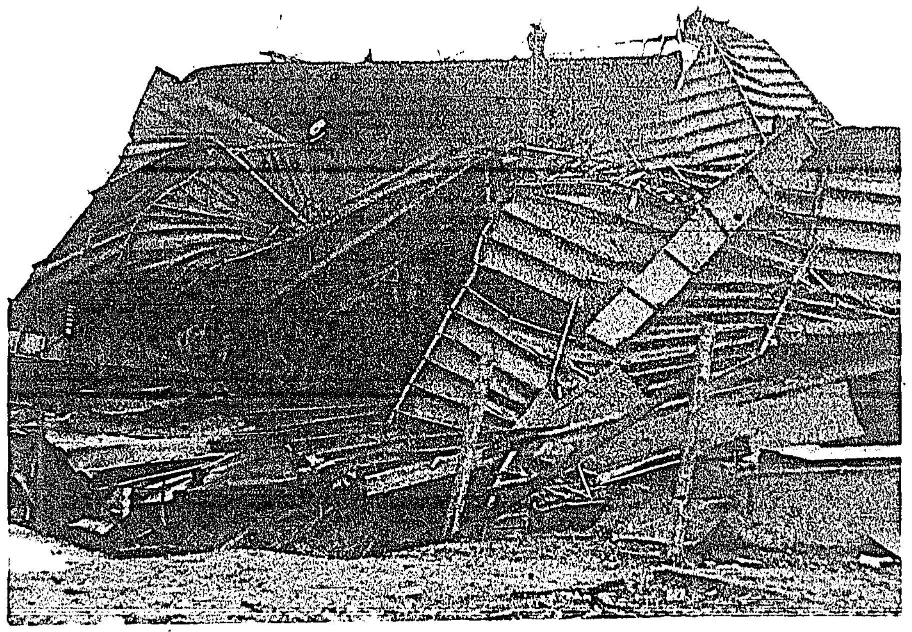


Figure 12.

[illegible] 56 looking [illegible]

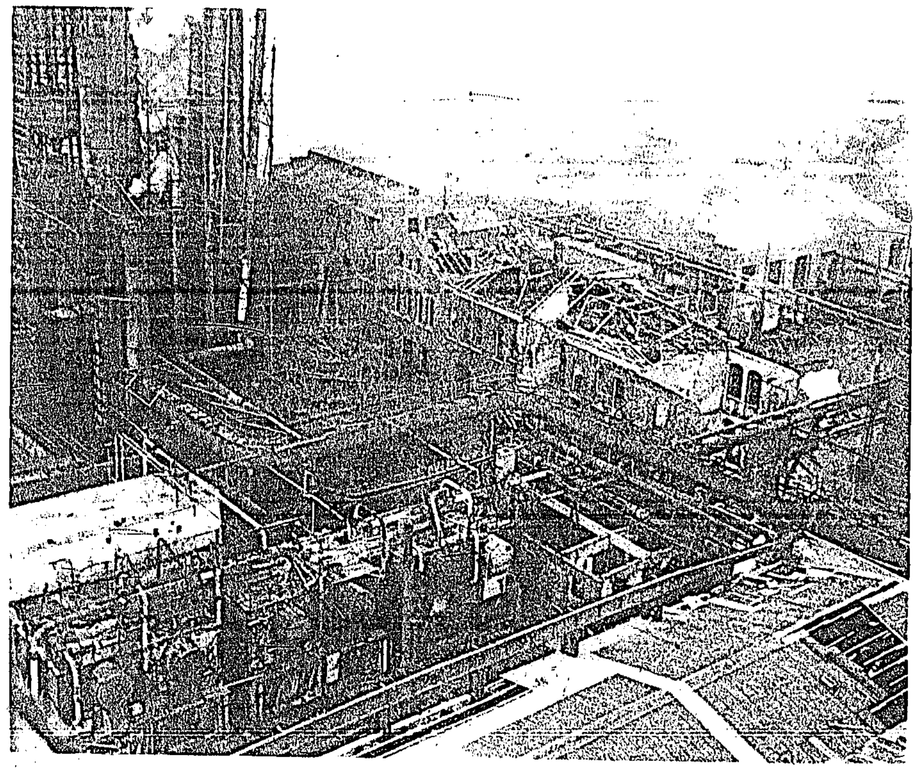


Figure 9.

[illegible] (67) lower left, [illegible] scrubbers, upper left; ammonium sulfate plant (65), center, looking NE from north end of new coke ovens (22), continued on 00011.

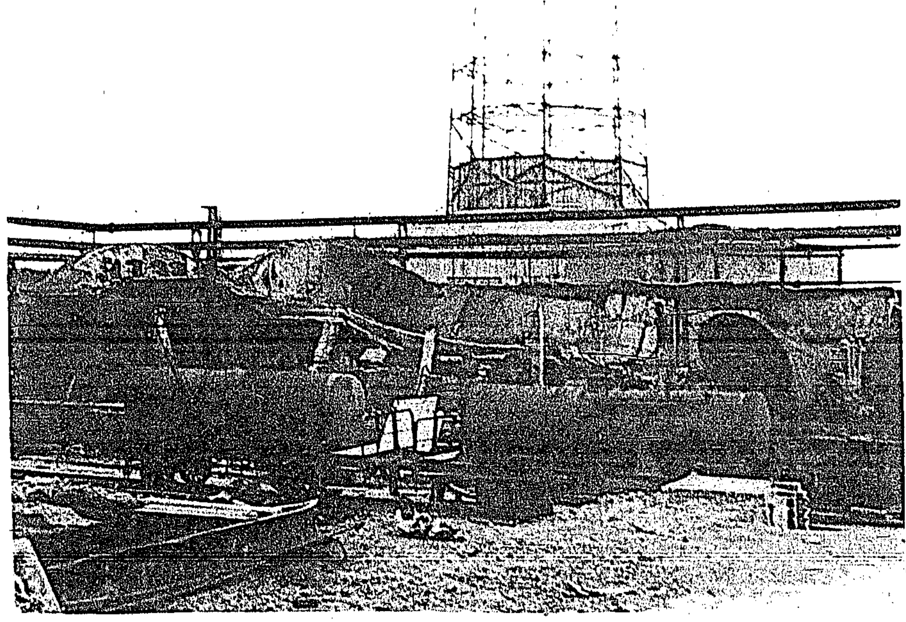


Figure 10.

Cooling tower (88) with remaining [illegible] pans (73) in foreground, looking east.

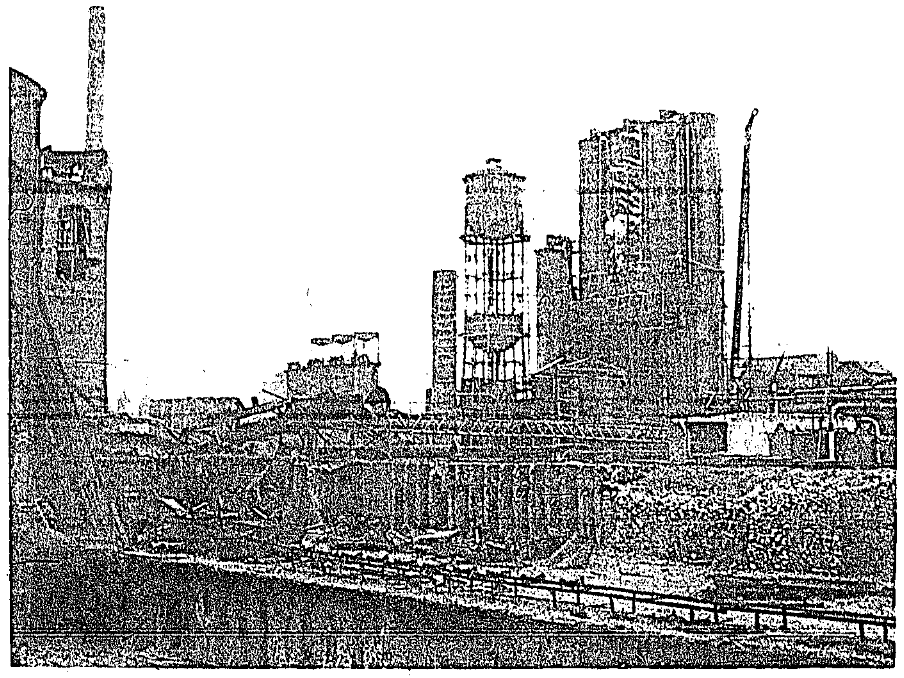


Figure 7

[illegible] with [illegible]
in background, looking NE from bridge between old
coke ovens (25) and new coke ovens (22).

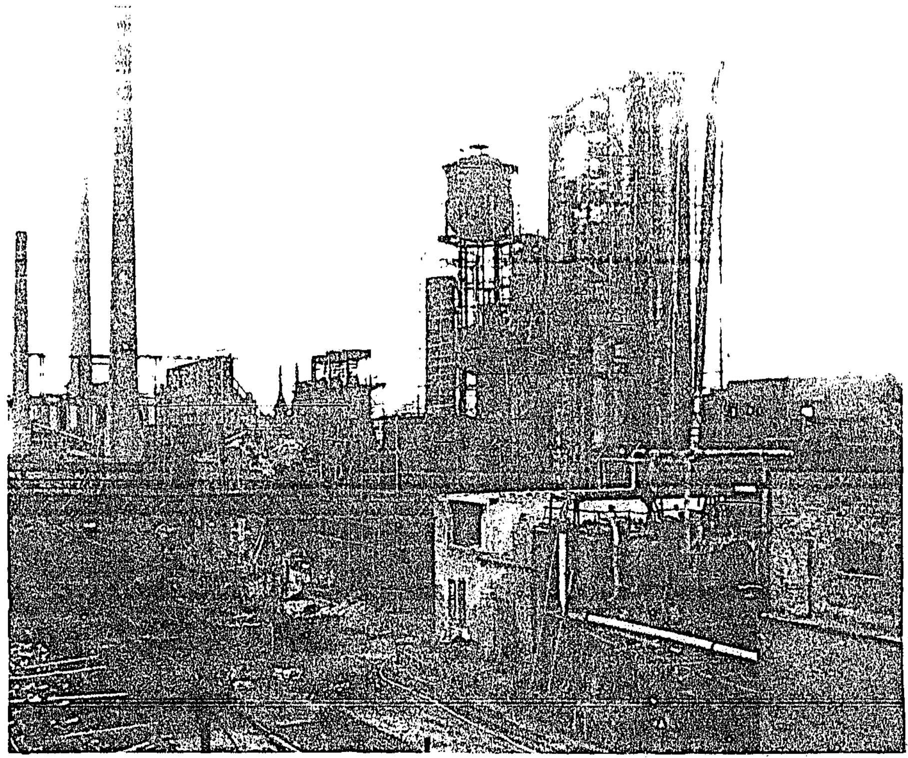


Figure 8

[illegible]
nearest stack, boiler house (48) [illegible]
stack; gas generators (78) to right of boiler house
looking NE from south end of old coke ovens (25).

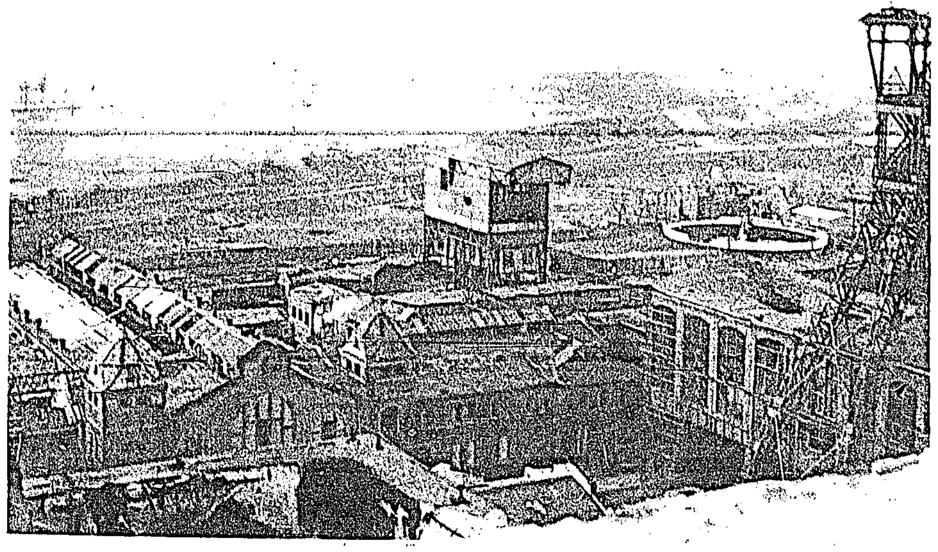


Figure 5.

Coal crusher and storehouse (6) lower left and mine headgear (1[illegible]) lower right, looking NW from top of coal bunker at new coke ovens (2[illegible]).

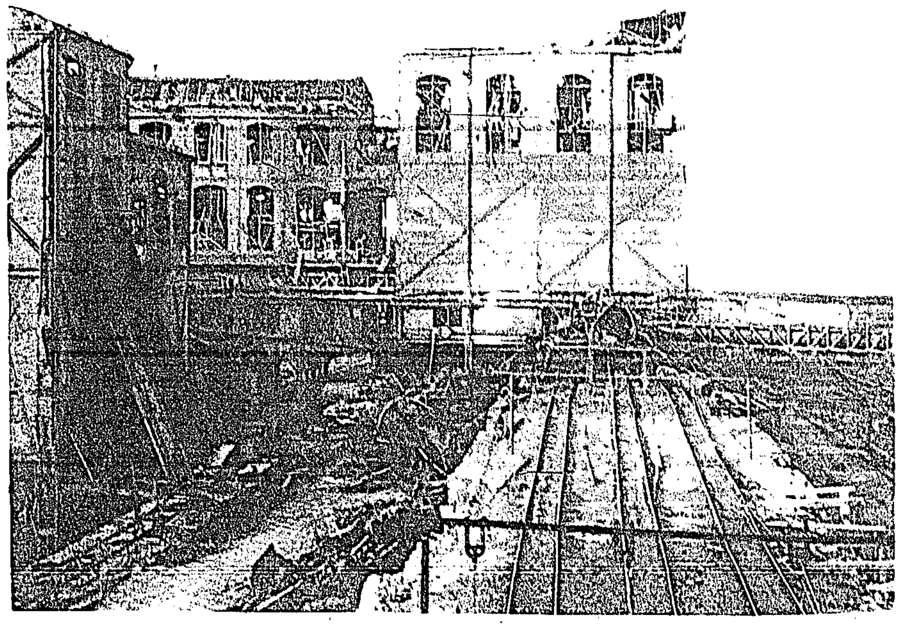


Figure 6

[illegible] tower (extreme left).
Looking north along top of old coke ovens ([illegible]5).

The organisation of the Moers-Meerbeck plant was outlined by our informants as follows:

| | |
|---|---|
| Synthetic Fuel Plant | |
| Managing director | Baumgartner |
| General plant | Breitenstein |
| Processing | Rumof |
| Alcohol plant | Dr. Haeuser |
| Boiler and machinery | Biermann |
| Power | Nute |
| Workshop and erection | Lohmann |
| Plant control | Ing.Juengling |
| Technical office | Herr Menger |
| " " | Herr Girke |
| Coking Plant | |
| Managing director | Hacklaender |
| Deputy | Ditzel |
| Plant engineer | Hold |
| Assistants | Witzke, Bilo, Schmalz, Koehn |
| Technical office | Westerlage |
| Laboratory | |
| Chief chemist | Dr.Grimme |
| Chemist | Dr.Schmitt |
| " | Dr.Wiedmann |
| " | Dr.Campen |
| " | Dr.Woellner |
| Engine testing Laboratory | Dr.Dahnefelser |

This list of laboratory personnel is believed to be incomplete and does not include the organization of the Research Laboratory about which very little information could be obtained.

## V Coking Plant

Various parts of the coking and by-product recovery plants are shown by Figures 5, 6, 7, 8 and 9. Figures 10, 11 and 12 are also from the same areas of the plant showing particularly the bomb damage.

The plant contains three batteries of coke ovens of which the two oldest were built in 1907-08 and the newest was built in 1928-29. There are 210 ovens in all. The newer ovens handle 20 tons of coal per charge, which is coked in 32 hours. The normal throughout of all ovens was 1800 tons of coal per day which yielded 1500 tons of coke per day. The coal was stated to have the following average composition.

| | |
|---|---|
| Water | 9-10% |
| Washed and dried coal | |
| Ash | 6-7% |
| Volatile | 24% |
| Carbon | 69% |
| Sulfur | 0.8% |

The coke oven gas produced at this plant is augmented by that from ovens at adjacent Shafts IV and VI. Of the combined total, 10000 cubic meters per hour is converted to synthesis gas, about 3000 cubic meters per hour goes to surrounding towns as fuel and the balance is used in Plant V as fuel.

No further details were obtained about the coking operations or the recovery of by-products since there appeared to be nothing new or unconventional in this part of the plant.

## IV Personnel and Organization

The general director of Rheipreussen plants was Heinrich Kost. His principal assistants are presumably those named on circular letters issued late in 1944 and early in 1945, from which Table II, page 11 has been prepared.

More detailed information regarding a number of employees of the synthetic fuel plant and laboratories were found on personnel cards which were seized for future use as desired (Document 101).

## TABLE II

## MANAGERIAL PERSONNEL OF RHEINPREUSSEN PLANTS

Gen. Direktor
  Kost

Herra Direktor
  Uterberg
  Küppers
  Fehlemann
  Strüven Schacht V
  Dr. Grimme "
  Dr. Kölbel "

Inspector
  Blöcher
  Bofenschen
  Wengeler

Betriebsführer
  Heuer Schacht VI
  Ley "
  Kühl "
  Schmidt "
  Schröder Neumühl
  Thielicke Schacht I/II
  Ziegler " V

Maschinenfahrsteiger
  Gelhausen
  Schaffranitz

Kokereichef
  Rohrwasser Schacht I/II

Betriebsführer
  Hackländer
  Dossman
  Richter, Neumühl
  Kirchhoff Schacht I/II
  Bergmann

Oberassistant
  Bamberger

Baumeister
  Arntzen, Neumühl
  Hilbert

Brandinspektor
  Vondran

Rechnungsführer
  Flottmann
  Schmitz

Markscheinder
  Schulte

Oberingeniews
  Dr. Kochs
  Scholler
  Körner

Dipl. Ingenieur
  Nennstiel
  Deckert
  Bruckhaus

## TABLE I

### Correction and Amplification of Building Identities

| Building Number | Identity | |
|---|---|---|
| | Assumed | Actual |
| 1 - 5 | | Not shown on plans. |
| 10 - 11 | Unknown | Locomotive shops. |
| 12 | " | Workshops. |
| 13 | " | Gatehouse. |
| 14 | " | Lunch room. |
| 15 | " | Conveyor machinery. |
| 17 | Crushing & loading | Washing. |
| 18 | Unknown | Compressors. |
| 23 | Cooling tower | Coke conveyor. |
| 24 | Unknown | Coke breaker. |
| 28 | " | Pitch casting plant. |
| 30 | " | Impregnating oil tank. |
| 32 | " | Diesel oil refining. |
| 33 | " | Decarbonating plant. |
| 34 | " | " " |
| 36 | Condensation & tar recovery | Power house. |
| 37 | Tar stills | Boiler house. |
| 39 | Distillation unit. | Pump house. |
| 40 | Unknown | Gas cooler. |
| 41 | " | " " |
| 49 | " | Distillation building. |
| 50, 51 | Ammonium Sulfate Preparation | Tank pits and Crystallizing building. |
| 53 | Pitch bays | Water settling basins. |
| 55 | Wet gas holder | Water gas holder. |
| 56 | Water purification | Water settling basins. |
| 57 | Pump house | Permutit plant. |
| 62 | Pump house | Store house. |
| 73 | Unknown | Cooling pans. |
| 74 | " | Pump house. |
| 76 | Gasholder | Holder for residue gas. |
| 77 | Wet gasholder | Holder for "cracked" gas. |
| 84 | Pump house | Central power house. |
| 88 | Nitrogen plant | Hydrogen plant. |
| 92 | Unknown | Paraffin distillation. |
| 93 | " | Machine shops. |
| 96 | Workshops | Laboratory. |
| 97 | Unknown | Engine test laboratory. |

## TABLE I ( continued)

| Building Number | Identity | |
|---|---|---|
| | Assumed | Actual |
| 98 | Unknown | Charcoal absorption towers. |
| 99 | " | Water scrubbers. |
| 106 | Condensation columns | Alcohol plant. |
| 107 | Storage cylinders | Oil cracking unit. |
| 108 - 111 | Distillation plant | " " " |
| 113 | Unknown | Stabilization unit. |
| 117 | Distillation plant | " " |
| 118 | Unknown | Alcohol plant. |
| 120 | " | Research laboratory. |
| 121 | Lab. or workshop | Storehouse. |
| 123 | Packed products shed | Liquefied gas. shipping. |
| 124 | Unknown | Liquefied gas storag |
| 125 | " | " " " |
| 126 | Distillation plant | Liquid fuel shipping |
| 127 | " " | Liquid fuel blending |
| 128 | " " | " " " |
| 130 | Unknwon | Lead tetraethyl blending |
| 131 | " | Gate house. |
| 132 | Covered loading bay. | Fire apparatus & garage. |

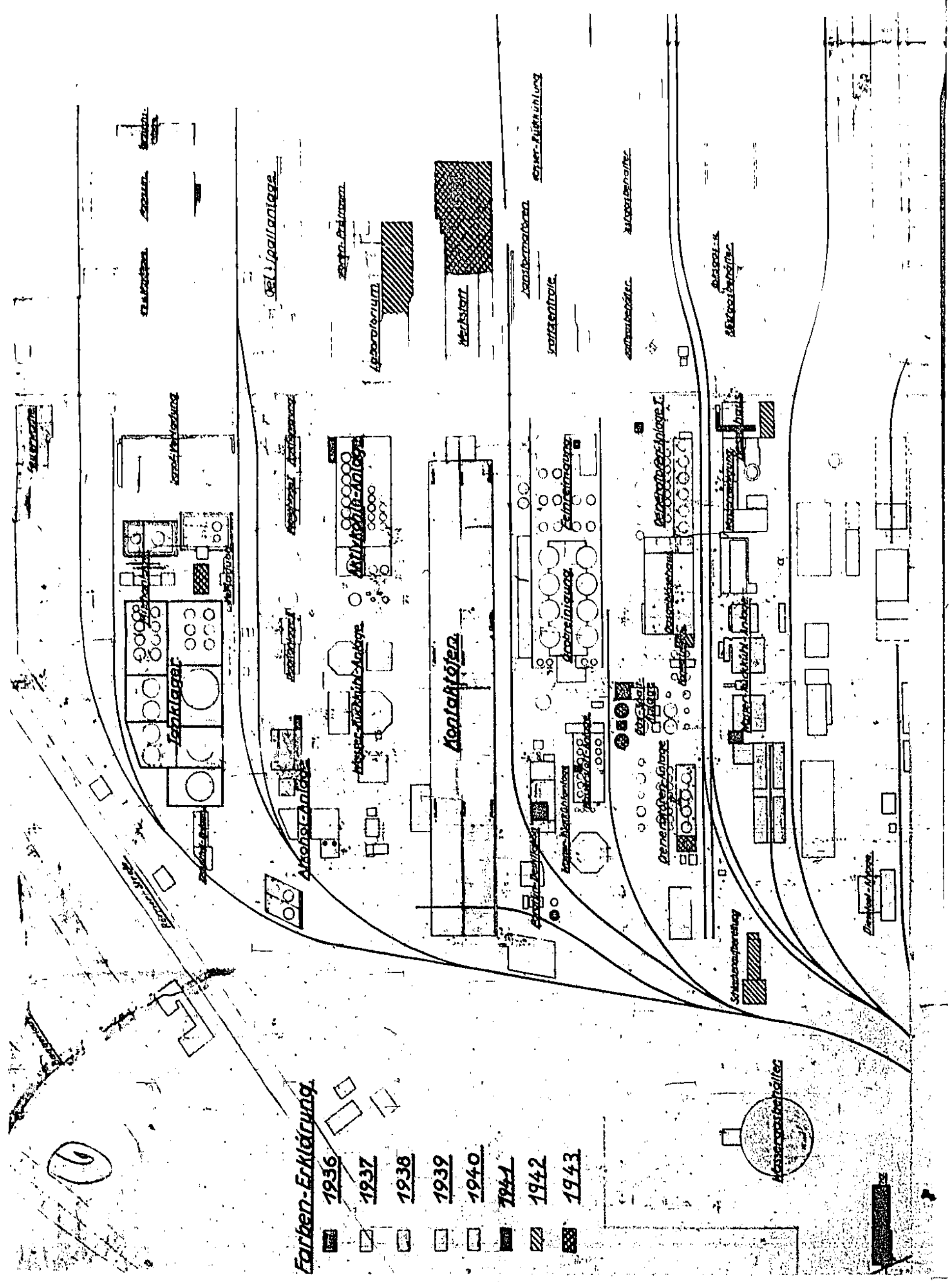
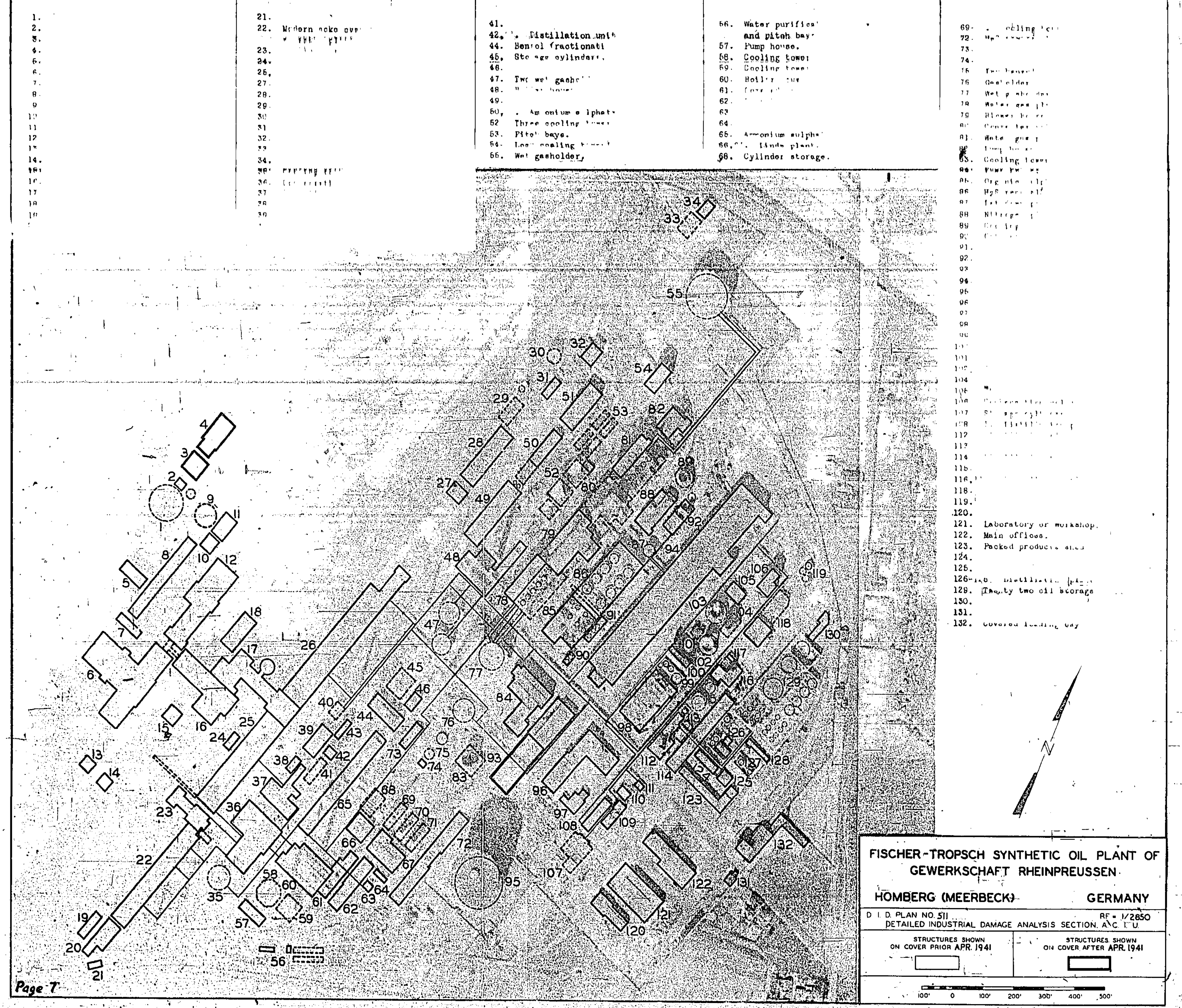


Figure 3

Plot Plan of Synthesis Plant
Rheinpreussen Moers



FISCHER-TROPSCH SYNTHETIC OIL PLANT OF
GEWERKSCHAFT RHEINPREUSSEN

HOMBERG (MEERBECK) GERMANY

D. I. D. PLAN NO. 511 RF = 1/2850
DETAILED INDUSTRIAL DAMAGE ANALYSIS SECTION. A. C. I. U.

STRUCTURES SHOWN ON COVER PRIOR APR. 1941 ▭

STRUCTURES SHOWN ON COVER AFTER APR. 1941 ▭

## III Plant Layout

Among the documents seized were large plot plans of the coking plant (Plan No.3) and of the synthetic fuel plant (Plan No. 6) The latter has been reproduced as Figure 3 page 6 and both have ~~been used to check the identity of the buildings~~ in the target area against the identities shown by Figure 4 which was the best previous information. In table I page 8 is a list of only those buildings for which more accurate or more informative identification could be obtained from the plantplans. In general the previous identification was sufficiently accurate for the purpose at hand. However it will be noted that the laboratory building, 96, was thought to be a workshop, while the engine testing laboratory, 97, the research laboratory, 120, were unidentified. Building 121 though to be a laboratory or workshop proved to be a storehouse. These mistakes are not surprising in view of the similarity in structures of the buildings in question. Just southwest of the research laboratory, 120, was a new building for pilot plant research not shown in the DID plan. In the area just north of gasholder 95, was a large bomb shelter or "bunker", also not indicated on Fig.4. This was reported to be capable of sheltering 600 to 1000 people and appeared to have suffered no real damage from bombing.

From one of the captured plot plans of the Treibstoffwerke it is possible to determine the years in which various additions to the plant were made. It is assumed that the pilot plant research building, southwest of building 120, and the bunker were built in 1944 since they are not shown on the plan which includes 1943 construction.

In normal times the synthetic fuel plant (Treibstoffwerke) employed about 1000 men and women in the operating departments and about 25 research workers.

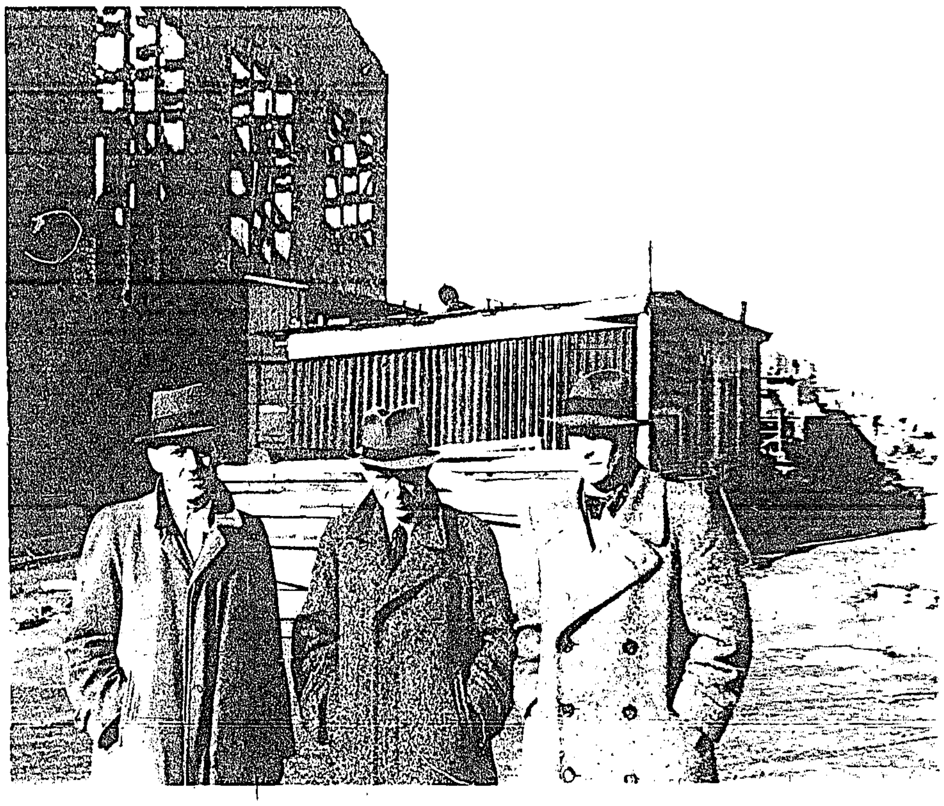


Figure [illegible]

[illegible] right, [illegible]
Wilhelm [illegible], Fritz [illegible].

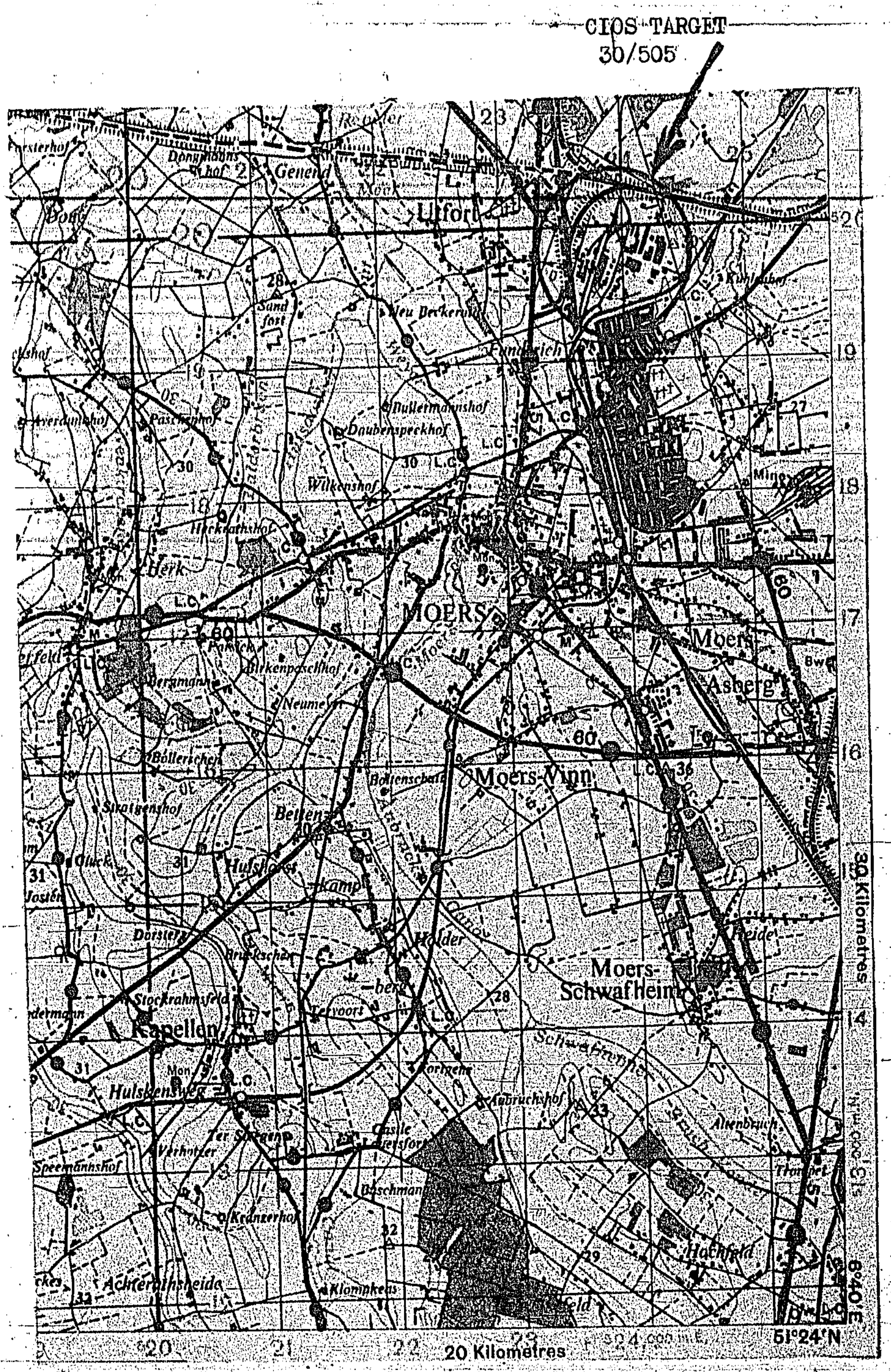


Figure 1
Map showing Target Area

## II Inspection Procedure

The Moers-Meerbeck plant of Rheinpreussen was occupied by American troops on the evening of 4 March, 1945 and the CIOS party arrived on the morning of 6 March. (Captain Eyles (21 Army Group Hdqtrs.) Military leader of the party had called at the plant on the evening of 5 March.) The inspection was concluded on the morning of 9 March. The only persons found in the plant who appeared to be competent to give information about operations there were Betriebsführers, Ziegler and Hackländer, and Betriebsleitern Breitenstein and Lohman. Ziegler was a power engineer but familiar with coking operations, and furnished only a small part of the total information. Hacklander was manager of the coking plant and Breitenstein and Lohman were assistant-manager and construction foreman respectively in the Synthetic fuel plant. These three shown in Fig. 2 furnished most of the information about Fischer Tropsch operations. All information in this report, for which other sources are not specified or obvious, was obtained from the four men named.

All technical and top administrative personnel had been moved to unknown locations east of the Rhine. Apparently the most valuable records, including research reports and notebooks, had also been moved. The documents which remained, chiefly in basement store rooms, were examined as carefully as time permitted and those which looked most informative were confiscated. In some places this examination was difficult because the documents had been scattered by combat troops who were billeted in practically all of the few habitable rooms in the plant. Some documents were found in boxes partly packed with indications that the shipping of documents to safety had been hasty and was not completed.

An effort has been made to abstract, and in some cases to translate, what appear to be the most important documents, on the basis of subject matter and dates, for inclusion with the present report. A large part of the seized material has been recorded on microfilm to facilitate future examination.

A list of the seized documents is attached as Appendix A.

## CIOS TARGET 30/5.05
## RHEINPREUSSEN FISCHER-TROPSCH PLANT

### I Target Identification

The location of the Fischer-Tropsch plant of the Steinkohlen-Bergwerk-Rheinpreussen is shown by Figure 1 page 2. It has been referred to variously as located in Homberg, Homberg-Meerbeck, Moers, and Moers-Meerbeck, of which the last is the most accurate designation. This plant is one of a chain of Rheinpreussen plants identified locally by the number of the mine shaft with which they are associated. South of Homberg, near the Rhine, is the original plant at Shafts I, II and III, and here also is the Main Office of the Company. West of this plant, about half way between Homberg and Moers is a coking plant at Shaft IV. A short distance northeast of Moers is the present target at Shaft V and considerably farther to the northwest is another coking plant at Shaft VI nearLintfort. There is an affiliated plant, Gewerkschaft Neu-Muhl, a short distance northeast of Duisberg. All Fischer Tropsch activities were confined to the Moers-Meerbeck plant.

## INDEX TO TABLES

CONFIDENTIAL

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## PERSONNEL OF INSPECTION TEAM

W.C. SCHROEDER U.S. Bureau of Mines
H.V. ATWELL Petroleum Administration
for War, USA.

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## INDEX TO FIGURES

(Same as XXVI-80) and TOM-8
except folded plan
lacking in XXVI-80

**CONFIDENTIAL**

# STEINKOHLEN-BERGWERK RHEINPREUSSEN
# MOERS-MEERBECK
# (HOMBERG)

Reported By

H.V. ATWELL, USA.
W.C. SCHROEDER, USA.

On behalf of the

British Ministry of Fuel and Power
and
U.S. Technical Industrial Intelligence Committee

CIOS Target No. 30/5.05
Fuels and Lubricants

T.O.M. No. 8 report was issued May 15, 1945

COMBINED INTELLIGENCE OBJECTIVES SUB-COMMITTEE
G-2 Division, SHAEF (Rear) APO 413

**CONFIDENTIAL**

Copy 1

2

ITEM No. 30
FILE No. XXV-6

COPY No. ~~158~~

T.O.M.- 8

Classification Cancelled,
by authority of
The Joint Chiefs of Staff,
by Col. E. W. Gruhn.

(Same as
XXVI-80)

CONFIDENTIAL

# STEINKOHLEN-BERGWERK RHEINPREUSSEN
# MOERS-MEERBECK

Atwell + Schroeder

CONFIDENTIAL

COMBINED INTELLIGENCE OBJECTIVES
SUB-COMMITTEE

## INSPECTION OF SYNTHETIC LUBE OILS

### KUHLMANN COMPANY

| | Lube F-2 | Lube S-3 | Lube 5/6 | Lube 25/30 |
|---|---|---|---|---|
| Uses | Refrigerating machines | High speed transmission | Motors & transformers | Compressors & motors |
| Density 0 15° C | 0.83/0.835 | 0.835/0.84 | 0.84/0.835 | 0.85/0.86 |
| Engler Viscosity @ | | | | |
| 20° C | 6 to 8 | 11 to 13 | - | - |
| 50° C | 2 to 2.5 | 3 to 3.5 | 5 to 6 | 25 to 30 |
| 100° C | 1.2-1.3 | 1.3-1.4 | 1.6-1.7 | 3 to 3.5 |
| Flash - Luchaire | 135° C | 145° C | 160° C | |
| Flash - Open cup | 145° C | 155° C | - | 230° C |
| Fire Point | 175° C | 180° C | 190° C | 270° C |
| Acidity | 0.2/0.4 | 0.1/0.3 | 0.1/0.2 | 0.1 |
| Pour Point | -30/-35 C | -25/-20°C | -15/-10°C | -5° C |
| Conradson Carbon | 0.01 | 0.01 | 0.02 | 0.05 |
| Ash Content | 0.02 | 0.02 | 0.05 | 0.05 |

---

## INSPECTION OF SYNTHETIC OILS - STANDARD KUHLMANN

| DESIGNATION | API GRAVITY | VISCOSITY 122°F | VISCOSITY 212°F | VISCOSITY 392° | V.I. | FLASH °F | HARD ASPHALT c/o METH. SNCF SPEC. 179 | POUR POINT °F |
|---|---|---|---|---|---|---|---|---|
| Spindle | 15.9 | 42 -73 | | | | 284 | | 27 |
| Transformer A | 17.4 | 84 max. | | | | 311 | | 23 |
| Transformer B | 17.4 | 84 max. | | | | 311 | | -4 |
| Turbine | 15.9 | 95 - 110 | | | | 356 | | -10 |
| Motor 1 | 15.9 | 281 max. | | | >70 | 419 | | 10 |
| Motor 2 | 14.4 | 563 max. | | | >70 | 446 | | 5 |
| **CYLINDER OILS** | | | | | | | | |
| Saturated Steam | 12.1 | | 96 - 121 | | | 392 | <0.6 | |
| Low Superheat | 12.1 | 1370-2300 | | | >60 | 518 | <0.4 | 27 |
| High Superheat | 12.1 | | 350 - 480 | | >80 | 572 | | 43 |
| Very High Superheat | 12.1 | | 350 - 480 | | >80 | 572 | | 43 |
| Heavy Machine Oil | — | 84 | | | | 271 | | |

NOTE: THESE SPECIFICATIONS ARE THE MINIMUM.

IN GENERAL THE STANDARD KUHLMANN CAN

PRODUCE BETTER THAN THE ABOVE

At present, this heavy cut is being hydrogenated for special use. This is being done at 100 atmospheres pressure and 200°C with standard Fischer Tropsch Catalyst (Cobald-Thorium-Magnesium-Kieselguhr). This produces a substance similar to vaseline which is being used in the cosmetic industry.

This plant is only producing 1000 litres/day but if needed becomes urgent it can process 2000 litres/day.

## Quality of Products

The quality of these lubricating oils is not exceptionally good. The "oiliness" is poor and the oils apparently oxidize readily.

A tabulation of these inspections is included at the end of the report.

24th March 1945

R.C. ALDRICH
Lieut. USNR (NavTecMisEu)

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Harnos

## ANALYSIS - SYNTHETIC LUBRICATING OILS

### KUHLMANN COMPANY

| | Lube F-2 | Lube S-3 | Lube 5/6 | Lube 25/30 |
|---|---|---|---|---|
| APL Grav. | 38.0-39.0 | 37.0-38.0 | 35.0-37.0 | 33.0-35.0 |
| Viscosity, SSU | | | | |
| at 68°F | 209-281 | - | - | - |
| at 122°F | 65-83 | 102-121 | 174-210 | 880-1050 |
| at 212°F | 35-39 | 39-43 | 50-54 | 103-121 |
| V.I. | -70 (approx) | -70 | 85 | 82 |
| Flash, °F (Luchaire) | 275 | 293 | 320 | - |
| Flash, °F (Open cup) | 293 | 311 | - | 446 |
| Fire, °F (Open cup) | 347 | 356 | 374 | 518 |
| *Neut.No. | 0.2-0.4 | 0.1-0.3 | 0.1-0.2 | 0.1 |
| *Pour Point, °F | -22 | -13 | -5 | 23 |
| Carbon Residue, % | .01 | .01 | .02 | .05 |
| Ash, % | .02 | .02 | .05 | .05 |
| Use | Refrigerating machines | High speed & transmission | Engines & transformers | Engines & Compressors |

*Methods possibly differ from A.S.T.M.

The gas oil is first chlorinated in 9 lead lined tanks arranged in series. The flow is countercurrent, that is the gas oil enters the first tank and is contacted by chlorine which has already passed through the other 8 tanks. Raw chlorine enters the last tank into which the gas oil flows. This reaction is slightly exotherinic and the heat of reaction is removed by water cooled coils. No mechanical agitation is needed, as the chlorine supplies sufficient agitation in bubbling through the gas oil. The temperature of the reaction is approximately 90-100°C. chlorine and hydrochloric acid leaving the last tank are passed through a conventional gas oil absorption unit to remove any valuable gas oil entrainment. The hydrochloric acid is used at this plant for other chemical processes.

The benzol and dichlorethane are mixed in the presence of Aluminum chloride in a special, mechanically agitated tank. The benzol enters at one end of the tank while the dichlorethane is injected through the sides. The temperature is maintained at 70°C. The tank is divided into three sections, each having an agitator and dichlorethane injection line.

In a similar tank, having 6 instead of 3 compartments, the chlorinated gas, oil and benzol-dichlorathane are mixed also in the presence of aluminum chloride, the benzol-dichlorethane enters the end of the drum, while the gas oil is injecte through the side. The temperature is held at 70°C.

The reaction is terminated in a third such tank. No side injection occurs but the temperature is raised to 110°C. Following this, no chemical changes or condensation are thought to take place. The total time in passing through the three tanks is 6 hours. The total quantity of aluminum chloride used is 10% by weight.

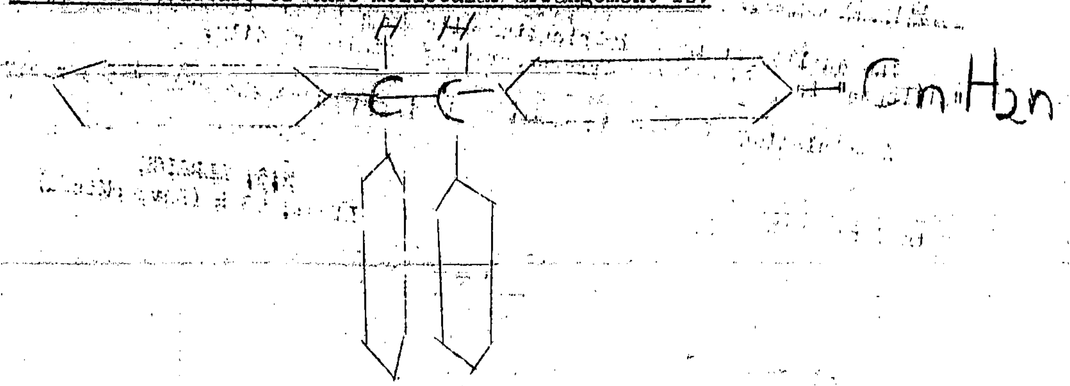
The liquid product is next put through a stripping tower with open steam where the uncombined benzol is removed. This is used over again. The stripped oil is now sent to a horizontal settling drum where the products settle into two layers. The upper is decanted as the high grade product, while the lower containing sludge, is of inferior quality. The aluminate is washed from the sludge by water. In order to lower its viscosity the washed polymer is blended with gas oil. No further treatment is required. This oil is used for general machine lubrication where a high grade quality is not needed.

The upper layer, after decantation, is given a conventional clay treatment. It is then sent to a pipe still with 2 side streams. The overhead product is gas oil which is sent back for reprocessing. The upper side stream is transformer oil. The bottoms product is very high grade steam cylinder oil which can be used with superheat temperatures up to 350°C. The present volumetric break down of these products is:- recycle gas oil 20%, transformer oil 30%, turbine oil 30%, and steam cylinder oil 20%.

Quality of Products

As already mentioned, the quality of the upper layer is extremely good. The viscosity index is approximately 100% for the lubricating oils. This is due to its unusual chemical makeup; as the oil consists of a polybenzene with a long saturated paraffine chain added on. The oil then is roughly half aromatic and half paraffinic giving it both a high viscosity index and a low pour point. A tabulation of these inspections is included at the end of the report.

A typical structure of this mollecular arrangement is:



Description of Process

(b) Kuhlmann Co. -Harnes.

This process starts with the gasoline product from the Fischer-Tropsch process. Under normal conditions, this product will contain 50% alphatic paraffines and 50% olefines. The olefine content on the gasoline can be increas in the Fischer-Tropsch reaction by lowering the normal $H_2/CO$ ration from 2/1 to 1/1 and also raising the temperature.

The gasoline is mixed with 3% aluminum chloride and placed in a revolving cylindrical drum with steel balls in the bottom to increase contact surface. This reaction takes place at room temperature and requires 5 hours.

At the end of the reaction two layers are formed, the lower a heavy polymer chemically bound with aluminum chloride and an upper layer, of paraffinic gasoline and free polymer. These are separated in a decanter. The heavy tar is treated with $N_aOH$ and washed with water, giving an aluminate, $N_aCL$ and a lube oil produced.

The free polymer and gasoline are allowed to stand for 4-5 days in order to completely separate. The light or upper cut is steam stripped to remove the gasoline which is used as motor fuel. The gas oil and lube remaining after steam stripping are clay treated and filtered. The resulting oils are a gas oil, a light lube suitable for cold service and a heavy lube for ordinary lubrication.

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PERSONNEL OF INSPECTION TEAM

Lieutenant R.C.ALDRICH, USNR, (NavTecMisEu)

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NAVTECMISEU
REPORT No. 80-45

U.S. NAVAL TECHNIC
IN EUROPE,
Fleet Post Office, N.Y., NY.

## Synthetic Lubricating Oil Production in France

### Introduction

The manufacture of synthetic lube oils is a subject of vital interest at this time to the U.S.Navy. Not only are the processes themselves important, but the quality and usefulness of the products obtained are subjects which call for careful study. It has been known for some time that the Germans have been using synthetic lubricants for all types of service since the outbreak of war. Some details of their work are now available here in France. In order to equip the Navy with a background on this subject, two field trips were made to study French plants producing synthetic lubricating oils; the first to the Kuhlmann Co. at Harnes (Lille) and the second to the Standard Kuhlmann Plant at Lestaque (Marseille). The former is only a pilot plant but operates on a process developed in Germany. The latter produces 25 tons of products per day and uses a process developed especially by the French which is probable now well known at this time outside of their country. Both processes are also interesting in that they use as a basic raw material the gas oil made by the Fischer-Tropsch process. Should a plant using this process be built in the U.S., the offtake could be used to make lubricants, if these products ever come into demand.

### Description of Process

(a) Standard Kuhlmann - Lestaque.

This process uses Fischer-Tropsch gas oil, benzol, and dichlorethane, as raw materials. To make one ton of finished lubes, 600 kg of gas oil are required, 600 kg of benzol and 160 kg of dichlorethane. The gas oil should be just as paraffinic as possible - i.e. the Fischer-Tropsch process should be carried out with a $H_2/CO$ ratio of 2/1 and the temperature of the reactors held down to 190°C. in order to produce a few olefines and as many paraffines as possible. The end point of its distillation should not be above 350°C. The benzol used is not a pure compound but contains some toluene and a little Xylens, its end point should not be over 150°C.

Item 30
file XVIII-5

Copy 1

Report No. 365

OFFICE OF THE PUBLICATION BOARD

DEPARTMENT OF COMMERCE

WASHINGTON, D. C.

# SYNTHETIC LUBRICATING OIL PRODUCTION IN FRANCE

Reported By

Lieut. R. C. Aldrich, Lt. USNR

[1945]

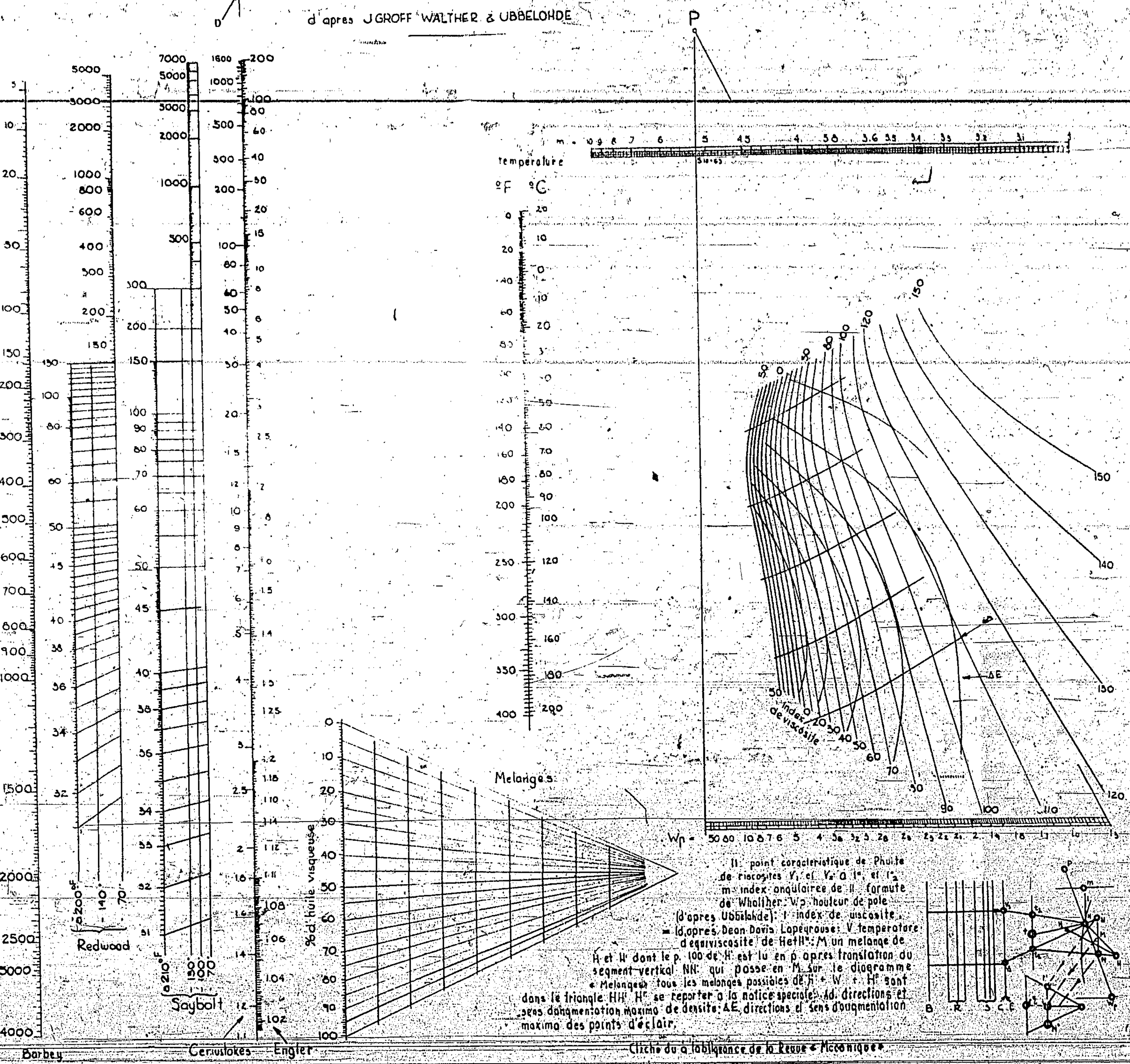
This report has been declassified and released to the Office of the Publication Board by the War and Navy Departments.

NOTE: The Publication Board, in approving and disseminating this report, hopes that it will be of direct benefit to U. S. science and industry. Interested parties should realize that some products and processes described may also be the subject of U. S. patents. Accordingly, it is recommended that the usual patent study be made before pursuing practical applications.

Price $ .25

# ABAQUE VISCOSITE TEMPERATURE DES HUILES DE GRAISSAGE

d'apres J. GROFF WALTHER & UBBELOHDE



H: point caracteristique de l'huile de viscosites $V_1$ et $V_2$ a $t_1$ et $t_2$; m: index angulaire de H formule de Walther; Wp: hauteur de pole (d'apres Ubbelohde); I: index de viscosite = (d'apres Dean Davis Lapeyrouse; V temperature d'equiviscosite de H et H'': M un melange de H et H' dont le p. 100 de H' est lu en p apres translation du segment vertical NN' qui passe en M sur le diagramme « Melanges » tous les melanges possibles de H + H' + H'' sont dans le triangle HH' H'' se reporter a la notice speciale; Ad. directions et sens d'augmentation maxima de densite; ΔE directions et sens d'augmentation maxima des points d'eclair.

Cliché dû à l'obligeance de la Revue « Mecanique »

60436

| **Viscosity Index** | **Polhöhe** |
|---|---|
| 120 | 1.5 |
| 100 | 1.8 - 1.9 |
| 80 | 2.1 - 2.25 |
| 60 | 2.4 - 2.6 |
| 40 | 2.8 - 3.0 |
| 20 | 3.2 - 3.4 |
| 0 | 3.6 - 3.8 |

Since the only physical parameters used in calculating Polhöhe are viscosities at different temperatures, it apparently has no greater technical significance than Viscosity Index or any of the various other similar expressions that have been developed in the petroleum industry.

24th February 1945

R. C. ALDRICH,
Lieut., USNR, (NavTecMisEu)

A4589 Fosh & Cross Ltd., London.

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60436

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NAVTECMISEU
REPORT NO. 73

U.S. NAVAL TECHNICAL MISSION
IN EUROPE
Fleet Post Office, N.Y., N.Y.

# "Polhöhe Measurement of Lubricating Oils"

## Introduction

Technical information that will be forthcoming from Germany relating to lubricating oils may include values for the "Polhöhe" and we have accordingly obtained some information on this test method.

There is a booklet in French entitled "Lubrifiants" which is a compilation of a number of technical articles on lubricating oils. In this booklet is a monograph opposite page 30 which allows the calculation of the Polhöhe of an oil from certain physical measurements. This monograph is reproduced on page 5 of this report. A copy of "Lubrifiants" may be borrowed from Military Intelligence Research Section, 40 Hyde Park Gate, London, S.W.1. When making request refer to File CIOS/MIRS/102.

## Method of Testing

The Polhohe value is similar to our Viscocity Index measurement in that it is an evaluation of the rate of change of viscosity with temperature. Two viscosity measurements at two different temperatures are necessary in order to obtain a Polhöhe value. Using the chart in the pamphlet, two lines are drawn, one each connecting a viscosity value (on the scales at the left of the chart) with its corresponding temperature, (on the temperature scale in the middle of the chart). These lines are extended to the right and their point of intersection is found. A line is then drawn from the point P (at upper right of chart) through the intersection of the above described two lines, and is extended downward until it intersects the horizontal line (at lower right of chart) labeled Wp. The value read at the intersection of the line on the Wp scale is the numerical value of the Polhöhe.

It will be noticed that oils of constant Viscosity Index (shown by lines labeled Index de Viscosite) but varying viscosity give roughly constant values of Polhöhe.

A low value of Polhohe corresponds to a high Viscosity Index, and hence to a high refinement of high native quality with respect to the viscosity-temperature relationship. As a very rough guide for oils of ordinary viscosity, the following table related Viscosity Index to Polhöhe.

60436

Report No. 280

OFFICE OF THE PUBLICATION BOARD

DEPARTMENT OF COMMERCE

WASHINGTON, D. C.

# POLHOEHE MEASUREMENT OF LUBRICATING OIL

Reported By:

R. C. Aldrich,
Lieut., U.S.N.R. (NavTecMisEu)

[1945]

This report has been declassified and released to the Office of the Publication Board by the War and Navy Departments.

**NOTE:** **The Publication Board, in approving and disseminating this report, hopes that it will be of direct benefit to U. S. science and industry. Interested parties should realize that some products and processes described may also be the subject of U. S. patents. Accordingly, it is recommended that the usual patent study be made before pursuing practical applications.**

| Author and Title | C.I.O.S. File No. | Item No. |
|---|---|---|
| CHAFFEE, C. C. Wirtschftliche Forschungsgesellschaft m.b.H. WIFO Fuel Blending Station. 1945. 7 p. | XXVI-68 | 30 |
| CHAFFEE, C. C., ATWELL, H. V. I. G. Farbenindustrie Mainkur-Hoechst. (1945) 33 p. | XXVI-79 | 30 |
| CHAFFEE, C. C., SCHINDLER, H., HOWES, D. A. Wirtschaftliche Forschungsgesellschaft m.b.H. (WIFO) Fuel Blending Station, Heiligenstadt, Germany. 1 July 1945. 8 p. | XXVII-93 | 30 |
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