FINAL REPORT No. 335

ITEM No. 21

Copy 1

METALLGESELLSCHAFT A.G.

AND THE LURGI GROUP OF CHEMICAL ENGINEERING COMPANIES

Beswick, W. R., and Fraser, Norman L.

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BRITISH INTELLIGENCE OBJECTIVES

SUB-COMMITTEE

LONDON—H.M. STATIONERY OFFICE

Sheet No. 1.

Target: Metallgesellschaft A.G. and The Lurgi group of Chemical Engineering Companies.

Head Office. Metallgesellschaft Haus, Lurgihaus, Frankfurt-am-Main.

1945

Date of Visit. June 29th 1945 to August 16th 1945.

Team. W.R. Beswick

Norman C. Fraser.

(On behalf of British Ministry of Supply)

BIOS Target Nos. 21/3c, 30/6.06, C22/1361, C22/464, 21/12(ee) 21/12(c), 2eii/76, C21/721, C29/157.

BRITISH INTELLIGENCE OBJECTIVES SUB-COMMITTEE
32 Bryanston Square, London, W.1.

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Sheet No. 2

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OBJECT OF VISIT.

The object of the visit was to assess the trend of Chemical Engineering in Germany during the war by selecting one of the best-known firms for detailed examination. It was considered important to find out the lines on which their Research Departments had been working in order to foresee the possible future war potential of a concern of this nature.

It was known from previous investigating teams that Lurgi had particular connections with plant for the Fischer-Tropsch process, particularly on the development of the Re-cycling System and it was known that they had completed arrangements with Ruhr Chemie which would enable Lurgi to undertake the installation of complete Fischer-Tropsch Plants. As very full reports were being made on this section of their activity the present team did not spend any time on this.

It was known that Lurgi was 100% owned by Metallgesellschaft and it was suspected that all fundamental research was carried out by Metallgesellschaft. It was therefore considered desirable to survey the activities of this firm with a view to ensuring that the team were fully armed with some knowledge when interrogating Lurgi personnel, and also preventing any covering up of one company by the other.

It was not intended, therefore, to make a comprehensive technical investigation of the many other subsidiary companies of Metallgesellschaft.

GENERAL.

Conditions in Germany during July and August, 1945 when the inspection was carried out, are now too well known to bear repeating. The investigators would like to pay tribute to the co-operation received from members of the U.S.A.Forces attached to FIAT and various other organisations, since the investigators were in the American Zone almost the whole time.

What seemed at the time to be a real tragedy occurred the day after the team arrived in Frankfurt when they established that Lurgi had been given two day's notice to quit Lurgi House.

This meant a frantic scramble to find accommodation for hundreds of drawing cabinets, huddreds of files of information and equipment. These were scattered in complete disorder in the different buildings over a very wide area, none of which could accommodate the personnel of those departments and hence at no time was it possible to carry through a logical and consecutive investigation of any one departments, since these were still being moved from temporary accommodation during the period of investigation.

In addition to this, both Metallgesellschaft and Lurgi had dispersed a number of their departments prior to the occupation in order to diminish the risk of total loss due to air raid damage.

There is little doubt that this company had been working in the most disorganised condition for many months before the end of the war. Certain drawings had been lost together with their duplicates, although copies or photographs of any drawings the investigators particularly requested were made available, except in the few cases where previous investigators had taken the only copies. No original document or drawing of which a copy was not available was removed by our team. Reasonable accommodation and assistance was given by all senior personnel of both Metallgesellschaft and Lurgi.

The team arrived at Frankfurt on 29th June, 1945 and one member left on the 7th August, the other the 16th August.

It should be noted that whenever the term ton is used, this refers to the metric ton of 1,000 Kg. unless otherwise stated.

ACTIVITIES OF METALLGESELLSCHAFT

The Company is the most important German firm engaged in the buying and selling of ores, particularly of a non-ferrous type and, as during the last war, has been the key German firm dealing in Sulphur bearing ores such as Pyrites, in which particular business it has international associations. During the war it has acted as buyers on behalf of the Government in the purchasing of ores from Norway, Yugoslavia and Spain, taking the whole outputs of certain Mines. Similarly in regard to metals, the Company bought largely as Agents for the Government, including lead from Yugoslavia, and Nickel and Copper from Finland.

Via its subsidiaries the Company is one of the largest producers in Germany of non-ferrous metals, including the winning of metals from Ore, the production of Aluminium, Copper, Lead, Zinc and Tin, and non-ferrous scrap recovery.

It has an important ownership of further subsidiaries producing finished and semi-finished non-ferrous metal productions including Pistons, non-ferrous castings, sheets, tubes, stampings, powdered metallurgical products, insulated wires and cables.

The Company owns a fleet of ocean going cargo boats, a large fleet of tugs and salvage vessels, and a large inland fleet of barges.

Metallgesellschaft has played a large part in German research on ore reduction, particularly those ores which are Sulphur bearing. Also of equal, if not greater importance, is the work which has been carried out on th production and treatment of light metals. The organisation maintained for this work is extensive, as also for research on:-

Chemical work related to Sulphuric Acid.
Synthetic Oil.
Treatment and working of Synthetic Rubber.
Chemical engineering.
Fuel technology.

The Company has important engineering subsidiaries engaged in the design and contracting for:-

Chemical plant.
Ore treatment plant.
Mineral and Synthetic Oil plant.
Fuel carbonisation and gasification plant.
Electrical cleaning of gases.
Electrical separation of minerals and coal cleaning.

The Company controls or has substantial interest in 54 separately named firms, apart from overseas connections of a purely agency type.

STRUCTURE OF METALLGESELLSCHAFT.

Capital - 70,000,000 RM.

Principal Holders:-

British Metal Corp.Ltd. (3,060,000 are held by MG in Frankfurt)	9,180,000.
Schweizerische Ges. fur Metallwerte.	8,315,000.
DEGUSA (Deutsche Gold & Silber-Schiedeanstalt)	9,494,800.
Henkel & Cie. (who are owners of DEGUSA)	8,201,300.
I.G. Farben.	6,907,000.
	42,098,100.

Above are the chief shareholders, the balance being spread over many small holders.

There is a Board of Governors (Aufsichstrat) which is widely representative of the more important interests held by the Company and which is re-elected by the shareholders in the Annual General Meeting and members of which retire in rotation. The Board of Governors in turn nominate the Board of Management, or Vorstand, who are the executives actively engaged in running the Company. Details of these bodies are as follows:-

BOARD OF GOVERNORS (AUFSICHSTRAT).

No Chairman as at August, 1945.

FELIX WARLIMENT:

Vice Chairman. Chairman of the Management Board of Norddeutsche, Affinerie, Hamburg.

RUDOLF EULER:

Age 70. Fifty years with Company - 40 years as a Director on the Management Board. Only on Aufsichstrat since German collapse.

Son-in-law of Hochschild who, with the original William Merton, founded the Company.

Because of his non-aryan wife, Euler was removed from the Company about 1942.

Though maintaining retirement from active management, Euler is at present (August 1945) giving everyday advisory assistance, and by common consent at present takes the Chair at Meetings of the Management Board.

Speaks perfect English. Has travelled widely. Keen, capable and shrewd personality, and is active for his age.

Was on Board of Rotopulsor, A.G., Switzerland. On Board of Schweitzeischer Gesellschaft fur Metallwerke.

HERMANN J. ABS:

Director of the Deutsche Bank, Berlin.

HERMANN SCHLOSSER:

Chairman of Deutsche Gold & Silber Schiedenanstalt.

HERMANN SCHMITZ:

Chairman of Management Board of I.G. Farben Industrie A.G., Heidelberg.

BERNARD UNHOLTZ:

Chairman of Deutsche Metallwerke A.G. Frankfurt.

HANS WELTZIEN:

Proprietor of the Berliner Handels-Gesellschaft, Berlin.

LUDGER WESTRICK:

Chairman of Vereinigte Aluminiumwerke A.G., Berlin.

DR. RUDOLF KISSEL:

Eight years with Company.

Son-in-law of the late Carl Bosch of I.G. Farben. No longer on Management Board to which he was elected to favour contact with Nazi Government Supply Departments.

BOARD OF MANAGEMENT (VORSTAND).

DR. ALFRED PETERSON:

Is now Senior Director - age about 60.

Joined the firm 1913. In 1916 established the firm's first laboratories. Founded the Lurgi Group of Engineering Companies.

Member of a well-known pre-Nazi Hamburg family. His brother is now Burgomaster of Hamburg, and Alfred Peterson himself is now President of the Frankfurt Chamber of Commerce.

For his opposition to Nazi enroachment into the business Peterson was imprisoned in 1938 for one year at Frankfurt, and from 1939 until the German collapse was under house arrest. Is now reinstated on the Management Board of Metall.

A straightforward active personality with a technical and research background. As set out above, until the German collapse Peterson has had no contact with the business since 1938.

Speaks fair English.

FRANZ TRAUDES:

Second Director under Peterson - age about 57.

Has been with the Company for 30 years and a Director for 12 years.

Head of Legal Department and a key man forknowledge of linkage with subsidiary and associated firms.

Has travelled widely but speaks only moderate English.

Apparently an honest type but careful in his disclosures and, perhaps under instructions from the Board, answers only direct questions but does so fully. During July 1945 was taken into short term arrest in the course of financial

investigations by the military government. After release Traudes showed evidence of embitterment.

HENRY W. LUMME:

Age about 55.

Has been with the Company for 28 years and 5 years as a Director.

In charge of the shipping, transport, and insurance departments.

Speaks very good English, has travelled widely.

Has close knowledge of Company and its associates. Endeavours throughout to demonstrate efforts of Company to discard Nazi elements and influence and carry favour with Military Government and control.

Has not the character of Euler, Peterson or Traudes.

Before the war Lumme gave much assistance personally to the firm of Henkel & Cie. in the establishment of the latter's Whaling Fleet - the first possessed by Germany.

DR. JOSEF EITEL:

35 years with the Company, 4 years Director.

Metal Trading Department at Hamburg where he is located.

FRITZ HEDINA:

40 years with the Company, 12 years a Director.

Is now retiring but continues for the present. Was in charge of the Commercial and Personnel Department, now mainly engaged in an attempt to trace a vast number of invoices for ores and metals issued by the Company during the closing months of the Nazi Regime and render accounts for same.

DR. OTTO REULEAUX:

20 years with the Company, 4 years a Director.

Technical chief of V.D.M., Karl Schmidt, Silumin & Lurgi Thermie, thus dealing essentially with light metals.

DR-ING J. GEORG MULLER:

24 years with the Company, 8 as a Director.

Is responsible for laying down research policy and co-ordinating activity of the laboratories.

Speaks very good English.

A careful reliable type.

DR. FRIEDRICH AUGUST OETKEN:

24 years with the Company, 8 as a Director.

Is now head of the Lurgi Engineering Group with particular interest in Synthetic Oil and Gas.

Speaks good English.

Is a first class technical business man and gave the investigators all the help and assistance called for.

DR. HEINRICH MERK:

20 years with the Company, 5 years a Director.

Was Manager of the Metall. Bank, which still exists in name and, in fact, was used during the war not for banking business but for purchasing of mercury ores from Spain as agents for the Government.

Dr. Merk was removed from his Banking Managership by the Military Government because he joined the Nazi Party in 1941 but remains as a Director of Metallgesellschaft.

He is younger than the other Directors and was fully co-operative in regard to financial matters and shareholdings of other companies, etc.

Mention should also be made of other leading personnell:-

DR. HEINE:

Has taken place of Von Eichorn, who has just retired. Heine is a technical man, acts as House Comptroller at Frankfurt. Is in charge of Patents and Licence Agreements. He is also in charge of the Bonder business, as mentioned later.

WILHELM BROHMER:

Secretary at Frankfurt. In charge of the Book-keeping and Finance Department, with most of his

Department evacuated to Budesheim. A key man in regard to location of documents concerned with finance.

DR. ERICH THIELER:

In charge of the library at Bad Homberg.

DR. GERHARDT ROESNER: At Erbstadt.

Head of the four Inorganic Laboratories:-

(1) Langelsheim - Surface treatment of metals and other inorganic work.
(2) Erbstadt - Chemical and metallurgical development and processes.
(3) Erbstadt - Analytical work on inorganic materials and also fuels.
(4) Frankfurt - when available for rationalising the analytical methods for scrap non-ferrous metals.

ERNST BOTTCHER:

In charge of the Pyrites Department for inside Germany.

PROF. DR. ERICH SCHMID:

Important person. Was in charge of the Metal Laboratories at Niederhausen.

Apparently faithful to the Nazi Regime, since he attempted to report to Berlin according to Government instructions when the Allied Forces moved across the Rhine. Last heard of together with his principal assistant, Dr. Karl Lohberg, at Zell Am See, Austria.

HANS STEUERNAGEL:

In charge of the foreign Pyrites Department - Norway, Rio Tinto, European Pyrites and Cyprus Pyrites. Had much to do with the Norwegian Okla Company.

EMIL IWANOWSKY:

Metals Department.

CARL BORCHERT:

Metals Department. Temporarily evacuated to Escherscheim.

All above are Department Manager.

Also should be mentioned the following Prokuristen:-

HEINRICH BASSENGE:

Berlin Technical Manager.

DR. ALFRED DEDERER:

Economist. Now off duty due to illhealth.

EDUARD GOEBEL:

Berlin Metla Department.

WILHELM HESS:

Phosphates Department, Frankfurt.

GEORG OSWALD:

Ore Department at Braubach.

DR. WILHELM OVERATH:

Bonder Department at Langelsheim. Speaks good English.

It should be noted that the Company was subjected to interference from the Nazi Regime in 1938, the local Gauleiter being active in this direction, bringing on to the Management Board a local Metal Broker and financier called Wilhelm Avieny. Dr. Ludolf Plass, who was Directorin charge of the Lurgi Engineering Group, who was already on the Metall. Management Board, also proved to be a strong adherent of the Nazi Party. This was the time that Peterson, Schmidfelder and Richard Merton, who was the President of the Governing Board, was removed from the Company, and a year or two later Rudolf Euler. Kissel was brought on to the Governing Board more at the request of Metall than at Nazi behest.

Once Avieny got into the Company he used his influence to become Chairman of the management Board. From the list of current Directors given above it will be seen that Nazi elements no longer remain.

Mention must also be made of two Metall technical people who are abroad as representatives of their

Company.

SPAIN

Dr. H. E. Voisin,
Apartado 607,
Bilbao.

Alternatively,
Calle Miguel,
Moya 6,
Madrid.

Took up his duties in 1942.

JAPAN.

Dr. C. Krayer,

Tokyo.

A complete reorganisation of Foreign Agents was made from 1940 onwards and a full list of these is given on pages 25 - 29.

METHOD BY WHICH METALLGESELLSCHAFT INTERESTS ARE CONTROLLED.

Except for metal and ore trading, the activities of Metallgesellschaft are carried out through the medium of subsidiary companies. In many cases they are owned one hundred per cent and in other cases through substantial shareholding in associated companies.

In all one hundred per cent owned subsidiary companies, Metallgesellschaft nominated the Directors and generally it will be found that a member of the Metall. Management Board is the leading Director.

No separate balance sheet is published for one hundred per cent owned subsidiaries, the profits being turned in completely to Metall. For all those companies which have other shareholders than Metall. but of which the latter hold majority interests, separate balance sheets are made and dividends declared but Metall would be largely represented on the Board of Governors. In companies where Metall. have not a majority holding their influence on the Board naturally varies but it was their policy to maintain directive influence as far as possible.

The following is a statement of Metallgesellschaft's subsidiaries and holdings in associated companies grouped into the type of Industry:-

MINING INDUSTRY.

Company.	Percentage Holding.	Location	Local Personality
Sachtleben A.G. Capital 22,500,000. Pyrites.	50 % I.G. holds 25% via Duisburger Copper Company.	Koln	Dr. Schutz.
Schlesische Bergwerks & Hutten A.G. Capital 1,091,000. Coal and Zinc.	Sold in 1942 to the Deutsche Bank	Beuthen.	
Kupferbergbau Stadberge. Copper.	100 % via V.D.M.	Neidermaasberg.	

INTEREST OF METALLGESELLSCHAFT IN ORE TRADING.

In addition to Metall's own activity in Pyrites, the following subsidiaries are concerned with Ores:-

Company.	Percentage Holding.	Location.	Local Personality.
Eisenerz-GMBH 1,500,000 RM.	100 %	Berlin	P. Winckelmann.
Dealers in:- Iron Ore Pyrites Cinders Chrome Ore Bauxite			
Verkaufskontor der Sachtleben A.G. GMBH	50 % 50 % Sachtleben	Meggen.	E. Bottcher

Company.	Percentage Holding.	Location.	Local Personality.
Rawack & Grunfeld Ertshandels Mij. 400,000 Flr.	25 %	Rotterdam	
European Pyrites Corp. Limited. £5,000.	50 % 50 % Rio Tinto.	London	
Now in liquidation.			
Schwefelkies Gesellschaft MBH.	100 %	Frankfurt.	E. Bottcher.
	METAL TRADING.		
Hamburger Metallhandels Gesellschaft MBH 50,000 RM.	100 %	Hamburg.	J. Eitel (at Frankfurt)
Metall & Lurgi GMBH VIEN. 50,000 RM.	100 %	Vienna.	O. Kurz.
Metall-Verkaufs Gesellschaft MBH 300,000 RM.	100 %	Frankfurt.	W. Backrass.
Aluminium-Verkaufs Ges. MBH 50,000 RM.	20 % 80 % V.A.W.	Berlin.	-. Bayer.
Silumin Ges MBH 50,000 RM.	50 % 50 % V.A.W.	Frankfurt.	P½ Schmitz.
Aluminium Zentral GMBH 21,000 RM.	15 %	Berlin.	Prof.Haas.
NV Montaan Metallhandel 500,000 Flr.	100 %	Amsterdam.	See Eitel at Frankfurt.

METAL MANUFACTURE.

Company.	Percentage Holding.	Location.	Local Personality.
Aluminiumwerk GMBH 50,000 RM.	50 % 50 % I.G.	Bitterfeld.	H. Beuleax. (at Frankfurt)
Aluminium.			
Berzelius Metallhutten GMBH	100 %	Duisburg. Bensburg. Braubach.	See R.Seiffert at Koln.
Zinc and Tin.			
Metallhutte Call GMBH. 500,000 RM.	100 % via Berzelius	Call/Eifel.	G. Gloger.
Non-ferrous scrap.			
Ertel Bieber Company GMBH 1,000,000 RM.	50 % 25 % I.G. 25 % WASAG	Hamburg	B.Boettger.
Copper.			
Lurgi Thermie GMBH.	100 %	Horrem/Koln Steeg am Hallstadtersee Saarau.	O.Schober.
Silicon Aluminium (Silumin).			
Norddeutsche Affinerie 22,500,000 RM	38 % DEGUSA 38 % DEGUSA 25 % Brit. Metal Corp.	Hamburg	K. Heide.
Copper, Lead.			
Karl Schmidt GMBH. 4,000,000 RM.	100 %	Neckarsulm	O.Schleiner
Aluminium scrap recovery.		See also under Finished Products.	

Company.	Percentage Holding.	Location.	Local Personality.
Blei und Silberhutte Braubach GMBH 5,000 RM.	100 % via Berzelius	Braubach	see R.Sieffert
Lead.			
Deutsche Pulvermetallurgishce GMBH 100,000 RM.	50 % 50 % DEGUSA	Frankfurt	J.Dornauf.
Powdered Metals.			
Hans Heinrich Hutte GMBH 500,000 RM.	100 %	Langelsheim	H. Kuhr
Lead, zinc, bearing metal.			
RUBBER MANUFACTURE.			
Kautschuk GMBH 250,000 RM	100 %	Frankfurt	C.Berchert
Softeners, etc. for the Synthetic Rubber Industry.			
Metallochemische Werke A.G. 550,000 RM	100 %	Frankfurt	C.Borchert
Up to 1943 operated under original name of DARTEX A.G. Rubber cements, Brake linings, proofing compounds, Revertex products.			
Revertex Limited. £275,000.	31 %	London.	
Concentrated Latex.			

FINISHED METAL PRODUCTS, ALSO SEMI-FINISHED PRODUCTS.

Company	Percentage Holding.	Location.	Local Personality.
Norddeutsche Leichmetal und Kolbenwerke GMBH 500,000 RM.	100 % via Karl Sehmidt.	Hamburg Altona	Hofer
Light alloy pistons.			
Karl Schmidt GMBH 4,000,000 RM.	100 %	Neckarsulm. Heilbronn.	
Light alloys pistons, alloys.			
Vereinigte Deutsche Metallwerke A.G.	80 % direct. 10 % via Sachtleben.	Heddernheim.	
70,000,000 RM.			
VDM Halbzeugwerke GMBH.	100 % subsidiary of V.D.M. A.G.		
Semi-finished and non-ferrous metals.		Heddernheim.	
Copper cables and aluminium wire.		Gustavsburg.	
Light metal sheets.		Aschaffenburg.	
Alloy bearings.		Rodelheim.	
Plated steel tubes.		Offenbach.	
Railway equipment.		Karlstadt.	
Alloy bearings.		Amstetten/Vien.	
" "		Weipert/Sudeten.	
Tubes, profiles etc:		Altena.	
Copper and Nickel sheets, special wires.		Duisburg.	
Duralumin sheets and strips.		Eveking/Westf.	
Zinc and lead sheets and tubes.		Koln.	
Aluminium tubes, rivets, brass products.		Nurnburg.	

Aluminium alloy and Elektron castings. Brass sheets, rods and tubes.		Hildersheim. Werdohl/Westf.
VDM Sudkabel GMBH. Insulated wires and cables.	100 % subsidiary of V.D.M. A.G.	Mannheim. Neckarau. Industriehafen/ Mannheim.
VDM Sinter-metallwerke GMBH	100 % subsidiary of VDM A.G.	Ettlingen.
Sintered metal products in copper, aluminium, bronze.		Heurod. Busenbach.
Schles. Bergwek & Hutten A.G.	Metall. disposed of their interest during the war.	
Aero Union A.G. 150,000 RM.	25 %	Berlin.
War time concern for aluminium products.		
Hans HeinrichmHutte GMBH. 500,000 RM.	100 %	Langelsheim.
Lead base bearing metal. See also chemicals.		
Ges. fur Oberflachen-technik MBH 20,000 RM.	100 %	Frankfurt. Wiesbaden.
Operating company for the Bonder process.		See Dr. Schuster at Langelsheim

Chemical Manufacture.

Company	Percentage Holding	Location	Local Personality
Sachtleben A.G. 22,000,000 RM	50 % 25 % I.G.	Koln Homberg	Schutz.
Lithophone zinc oxide, Barytes, sulphur.		Meggen Wolfach.	

Company	Percentage Holding.	Location	Local Personality
Norddeutsche Affinerie 22,000,000 RM.	38 % 38 % DEGUSA 25 % Brit. Metal. Corp.	Hamburg	K. Heide.
Cuprous products, Sulphuric Acid, Arsenic, Bismuth.			
Chemischen Produkten-fabriken Pommerensdord-Milch A.G. 4,440,000 RM.	15 %	Stetten Berlin/Oranienburg.	Lang.
Superphosphate, fertilizers.			
Hans Heinrich Hutte GMBH 500,000 RM.	100 %	Langelsheim	H. Kuhr.
Bonder anti rust compound, zinc oxide, lead base bearing-metal, litharge.			
Deutsche Aktivkohle GMBH 1,800,000 RM.	33 % 30 % I.G.	Frankfurt.	J.G.Muller
Active carbon.			
Aktivkohle Union Verwaltungs GMBH 20,000 RM.	25 %	Frankfurt.	A. Heinzeler
Active carbon development.			
Carbo-Norit-Union GMBH	12½% 12½% I.G.	Frankfurt	
Active carbon			

CHEMICAL ENGINEERING.

Company	Percentage Holding.	Location	Local Personality.
Lurgi Ges. fur Chemie und Huttenwesen MBH 50,000 RM.	100%	Frankfurt.	F.A.Oetken.

Complete installations for ore reduction.
Sulphuric acid manufacture.
Treatment and processing of sulphur and sulphurous products.
Zinc manufacture.
Artificial fertilizers, cellulose, etc. etc.

Lurgi Ges. fur Warmetechnik MBH 25,000 RM	100%	Frankfurt.	F.A.Oetken.

Complete installations for fuel carbonisation and gasification, briquitte manufacture.
Vegetable oil plant, fatty acids, etc.
Benzole and mineral oil plant.
Synthetic oil plant.
Food drying.
Sale of active carbon.

Lurgi Apparatebau GMBH 100,000 RM.	100%	Frankfurt.	Geiss.

Electric precipitation.
Lead chemical plant.
Electric separation of ores, coal cleaning.

Lurgi Werkstatten GMBH 20,000 RM.	100%	Frankfurt.	A.Nattcher.

Constructural workshops for Lurgi Bau.
Also houses the Lurgi technical labs.

Company	Percentage Holding.	Location	Local Personality
Siemens-Lurgi-Cottrell Elektrofilter GMBH. 1,000,000 RM.	50 %	Berlin	Dr. Buff.

Patent holding and research company for Electrostatic Filters.

MINING ENGINEERING.

Bergbau und Metallurgische GMBH. 50,000 RM.	100 %	Frankfurt.	Kolschein.

Consultants to the Metall. group on mining and ore treatment.

SHIPPING.

Lehnkering & Cie A.G. 2,100,000 RM.	50 %	Duisburg.	O.Wagner.

Shipping agents, forwarders, trading company. Ship ownders. Rhine barges.

Unterweser Reederei A.G. 3,500,000 RM.	100 %	Bremen.	H. Meinecke

Ship owners.

Montan Transport GMBH 100,000 RM.	100 %	Hamburg.	C. Glogner.

Shipping agents and forwarders.

INTEREST IN NON-GERMAN FIRMS, UNCLASSIFIED.

American Lurgi Corp.	100 %	New York
La Calcinadora	30 %	Mexico

Company.	Percentage Holding.	Location.
The Fuel Industries Limited.	60 %	London.
Schweizerische Ges. Metallwerte.	9 %	Basel.
Carbonit Prima S.A.	25 %	Bukarest.
"SEDEM" Bergbau Ges.	25 %	Bukarest.
Rotopulsor A.G. 200,000 Sfr.	100 % via NV Montaan Metallhandel.	Shaffhausen, Swiss.

Metallgesellschaft also owns a property holding Company in Frankfurt called :-

Gervinusstrasse Grundstucks Ges. M.B.H.
Office in Frankfurt.

See J. Umhey of Metall.

BANKING:

Delbruck Schickler & Company,
Berlin.

Metall. have substantial holding but are sleeping partners also in :-

Delbruck von der Heydt,
Koln.

FOREIGN AGENTS OF THE METALLGESELLSCHAFT A.G.

	Date when appointed:
BELGIUM:	
Lehnkering & Cie A.G. Antwerp. 7, Place van Rijswijk.	(?)
Metall & Lurgi S.A. Brussels. 34, Rue de la Loi.	26.3.42.
Dr. Jules Mersch Brussels.	(?)
BULGARIA:	
Dr. Herbert Rauscher Sofia. Gurko 64.	17./26.6.41.
DENMARK:	
Aage Christensen Kopenhagen-K. Norregade 15	29.3.38.
C. J. Holm Kopenhagen. Kronprinzensgade 14.	(?)
FINLAND:	
A. B. Algol O/Y. Helsingfors. Unionsgatan 22.	19./31.7.28.

	Date when appointed:
FRANCE:	
R. Aumas Paris (8). 23, Avenue de Messine	(?)
Metall & Lurgi S.A. Paris. 17, Place des Etats Unis.	1940.
Dr. C. Miesen Lille. 4, Rue Pierre Dupont.	1941.
GREECE:	
Bureau Techn. Dimitri Scalistiri Athens. Rue Philhellenes & Xenophon, 8.	(?)
ITALY:	
La Metallochimica Mailand. Via Solferino 7.	1938.
Unione Maritima Industriale S.A. Genua. Sottoripa 57, R5.	1942.
CROATIA:	
Dragutin Barolin Zagreb. Meduliceva ul.16.	1941.
Metall & Lurgi, B.m.b.H. (fruhr Metallhandelsgesellschaft) Wein IX. Hermann Goringplatz 6.	(?)

	Date when appointed:
NETHERLANDS:	
Laran-N.H. Ter Kuile Rotterdam. Vredelaan 42.	8.10.42.
Lehnkering & Co.'s Scheepvaartbedrijf N.V. Rotterdam.	(?)
Montan Transport G.m.b.H. Rotterdam-W. Westzeedijk 104	(?)
N.V. Montaan Metaalhandel Amsterdam C. Keizersgracht 564.	21. 7.23.
NORWAY:	
Egeberg & Mohn Oslo. Raadhusgatan 5 b	29. 5.25.
Th. Halvorsen A/S. Bergen.	(?)
Metal & Lurgi Oslo. Kongensgate 7	16.12.41.
ESTHONIA:	
Eickert, Rijs & Co. Riga. Aldara Iela 1/3	(?)
Metall & Lurgi Ostland Riga. Domplatz 5	24. 2.43.
PORTUGAL:	
Zickermann Sociedade Lisbon Avenida da Liberdade 11	(?)

	Date when appointed:
PROTECTORATE:	
Friedrich Ohmann Prague. Sokolstr. 68.	ca 1939
RUMANIA:	
Gerometall Rober Fischer Bukarest III. St. Pia Bratianu 5.	27. 3.43.
SWEDEN:	
Dr. Ing. Herbert Lickfett Stockholm. Sveavagen 21	(?)
SWITZERLAND:	
M. F. Christen Zurich-Kusnacht Hornweg 11	5. 9.40.
A. Schubarth Basel. Mauenstr. 9	(?)
SLOVAKIA:	
Zoltan Balogh Pressburg. Lorenzertorgasse 15.	31. 1.41.
SPAIN	
Dr. H. E. Woisin Bilbao. Apartado 607	19. 2.43.
Dr. H. E. Woisin Madrid. Calle Miguel Moya 6.	1942

	Date when appointed:
TURKEY:	
W. Ertel c/o Hugo Hermann Istanbul. Galata 1120	1942
HUNGARY:	
Ferro-Cyan Chemikalien- u. Metallhandelsgesellschaft m.b.H. Budapest. Kossuth Lajos Ter 4.	26.6.42.

METALLGESELLSCHAFT RESEARCH ACTIVITIES.

Dr. Muller was in charge of all research activity and stated that his main work was to co-ordinate research by all departments and subsidiaries and prevent overlapping.

A fairly free hand was given to individual companies in regard to their research and particularly the Lurgi Engineering subsidiaries operated with a very large measure of freedom in regard to technical and pilot plant research and development, since it was of commercial value to the Lurgi group to arrange trials of plant with their clients, many of whom were quite outside the Metallgesellschaft combine. Reference to the research and development activities of the Lurgi group are dealt with separately in that section.

The Metallgesellschaft laboratories in operation at the time of the visit were as follows:-

1. Metal Laboratory at Niederhausen under the temporary control of Dr. Weber.

2. Chemical Laboratory. Dr. Roesner, located at Erbstadt, is head of four inorganic laboratories in all. These are:-

Langelsheim in the Harz under Dr. Schuster, dealing with "Bonder" development.

Erbstadt under Dr. Ley, dealing with chemical and metallurgical work, development and processes, etc., including acid, gases (e.g. sulfadine process) phosphoric acid, wet H_2SO_4 catalytic process.

Erbstadt under Dr. Becker. Analytical Laboratory for inorganic materials and also fuels; there are thus two laboratories at Erbstadt in the same building, employing about 20 workers in all.

Frankfurt under Dr. Fischer. Permission was sought to re-open one of the less badly damaged laboratories at M.G. house to employ six research workers on rationalisation of methods of analysis of non-ferrous scrap metals, particularly aluminium and Al-alloys

by micro, optical and electrical methods. The target here being to reduce the quantity of chemicals and the time employed in scrap recovery.

The pre-war Research Laboratories of M.G. at Frankfurt are generally well known and were the subject of an article published in the M.G. periodical review for 1930. These were very badly damaged by fire during an incendiary raid and despite the fact that dispersal of some of the work had already been carried out some valuable equipment was destroyed.

Such pre-war activities were spread over the following departments:-

Analytical Laboratory.

Chemical Laboratory.

Colloid-Chemical Laboratory.

Synthetic Material Department.

Metal Laboratory.

Heat Exchange Department.

Literary Department.

Detailed year to year statements are available in the research documents brought back entitled "Annual Reports", those available being from 1928 to 1941 and will be found to contain information relating to personnel, new equipment and brief reference to the work carried out by various departments.

CHEMICAL LABORATORY ERBSTADT:

This is housed on two floors of a former diamond polishing factory. The top floor being used for laboratory-scale work and particularly dealing with the analytical section.

The more interesting work was being carried out in the basement where the following three pieces of

equipment were particularly noted:-

1. An apparatus for testing the rate of reduction or oxidation of gases evolved from any ores. This comprises a small rotating furnace and a complicated well made glass apparatus with high vacuum mercury pump to evacuate the apparatus initially to a vacuum better than 1/10 mm. Hg: and a glass gas circulating pump: an arrangement is made for drawing off the gases from time to time for analysis.

The saturation pressures of sulphates by decomposition at temperatures of 500°C./800°C. has been determined.

2. A small stationary furnace for determining the working conditions required for reducing iron oxides in ceramic furnaces. The rate of reduction is determined from the diffusion rate. Pellets of iron oxide and coke are mixed either intimately or in layers.

3. A rotary tube about 40/50 mm. dia. x 1 m. long in a fixed electric furnace of the resistance type. Devices for ore charging and discharging without the admission of air are incorporated.

Data for the Lurgi Chemie ore preparation plant at Watenstadt was obtained in this apparatus.

PHOSPHATE PRODUCTION:

New development work undertaken by the Laboratories which was emphasized as being of considerable value for post-war Germany (the emphasis on non-war potential was very noticeable) is that for the production of technical phosphates as set out below (as distinct from fertilisers) and vanadium from basis slag.

Under a Reich Planning scheme all firms who previously made technical phosphates were to adapt their plants to the M.G. process. Such firms were inter alia

Chemische Fabrik at Budenheim near Mainz.

" " at Albert near Weisbaden.

Huttenchemie at Manheim.

Julien at Ludwigshafen.

Benkiesar at Ludwigshafen.

The basic slag was to have been provided by RRochling in the Saar and Nord Deutsche Hutte near Bremen, and sent to Kalischemie, Brunsbuttelkoog, a Krupp subsidiary near Hamburg who had surplus rotary kiln capacity which had been previously used for phosphate production. Here the basic slag was to be converted to iron phosphide (Eisenphosphor)

A pilot plant for the whole purpose had been operated at Sachtleben where up to 20 tons of sodium phosphate had been produced.

The crude basic slag contains 0.3% vanadium and 8% phosphorous = 16% P_2O_5. When converted to the crude Fe_2P, there is 15% phosphorous and 1% vanadium.

The iron phosphide produced in coke fired blast furnaces is ground and mixed with sodium carbonate and heated in Rotary Kilns to 800°/900°C. It is then bleached with water where the vanadium and phosphate contents are dissolved. By crystallisation the sodium phosphate is separated from the vanadium content.

The mother liquor is recycled until the vanadium content is enriched to 10/12 gms/1. The small amount of sodium phosphate remaining in the mother liquor is precipitated by adding magnesium salts to form magnesiumphosphate. The mother liquor, now free from phosphates, is treated with ammonium chloride or sulphate to precipitate $NH_4 VO_4$, or is treated with HCL to produce V_2O_5. This process of obtaining vanadium is claimed as much cheaper and simpler than the normal process.

M.G.'s interest is to produce phosphate for their "Bonder" process, but trisodium phosphate and others are manufactured for the following:-

Yeast culture: Kraft type cheese: Baking Powder: Water purification, etc:

Kalichemie had produced about 1000 tons of iron phosphide but it was understood that most of it had been destroyed in air attacks.

Each of the chemical firms had successfully produced a few tons of phosphates.

Henkel is claimed to have considerable interest in this process but the problem is how to get the iron phosphide - it is thought that H.G. Watenstadt, who manufactured vanadium by other methods, might take the matter up from the Va angle. Previously they had wasted all the phosphate content of the basic slag.

The chemical firms mentioned had all previously made phosphoric acid received from the I.G. electrothermic process, all plants of which are now in the Russian Zone.

See Roesner Report (Abschrift 27/3/45) and technical reports 1962 and 1995 dates 5/4/43 and 21/2/44 respectively.

Dr. Roesner stated that work was now proceeding on a new process for production of vanadium and phosphoric acid in standard modified electric ovens. See Report R.2004.

Also on the recovery of elemental sulphur from Industrial and Water Gases.

Both persons seemed very co-operative and spoke English, Dr. Fischer fluently. The latter impressed us as being straight and honest. The former seemed to be trying to impress both the non-war potential of M.G. present activities and their desire to co-operate and to be allowed to get going.

Old publications available in documents:-

"Der Drehrohrofen als Rostrofen"

"The Research Laboratories of M. G."

"Der Drehrostofen fur die Rifritrostung".

METAL LABORATORY:

This was located at the Taunus Lederwerke at Niedenhausen, near Weisbaden. In temporary charge is Dr. Weber assisted by Dr. Wolbank and a staff of twelve to

fifteen. The chief work is specialised X-Ray examination of metals. The technical brains behind M.G. work on metals had been Dr.Erich Schmid who fled just before the collapse of Germany and in August was stated to be at ZellamSee together with his assistant, Dr.Karl Lohberg. No research work had been carried out after the occupation and the building was expected to be taken over for other purposes.

COLLOID-CHEMICAL LABORATORY:

When inspected by the writers this Laboratory was accommodated in the basement of Peters Pneu Werkstatten, Dornoholzhausen, Near Bad Homberg. Dr.Miedel, who has been fifteen years with the Company, was in charge but there was also a commercial man named Edye who had been with M.G. for only two year prior to which he had been in South East Europe for a Berlin trade development company known as Sud Ostropa A.G. Edye proved to be a suave and unsatisfactory type of young man. The secretary, Fraulein Nagel, was also interviewed.

Their main task of importance was research on developing and improving Napthalene base softeners for Buna. Until recently about twenty were working in the Department - now 7/8. In order to be allowed to work at all they are temporarily doing some research on foodstuffs. Most of the equipment belonged to Peters since all the Colloid equipment was destroyed at Frankfurt, although most records had been salved.

They have an interesting semi-commercial Vulcaniser with quick closing door and internal rectangular boxes containing steam heaters for air blown in at the back by a motor driven fan. Dimensions about 2'0" by 3'6" long. Used for work on reclaiming rubber and for Buna development.

A powerful double drive roller mill by Berstof, Hanover, and a special mixing mill by Krupp Grusenwerk.

The research on Napthalene systems has been centred on raw materials from German Oil refineries (unsaturated Hydrocarbons) and accelerators supplied by I.G., the final product evolved is called Z.D. Napthalene.

The Oil Companies manufacture Z.D. to the specification evolved by M.G.

There are now only three fully qualified research workers at the laboratory. Two investigators, Major Perry and Dr. Garvey, visited the laboratory on the 15th April 1945 and took away samples and some files of research records.

37.

METALLGESELLSCHAFT LITERARY DEPARTMENT, INCLUDING TECHNICAL AND RESEARCH RECORDS, TECHNICAL CORRESPONDENCE AND LIBRARY.

The writers visited this on the 11th July, 1945 at its evacuation address of Proworoffstrasse, Bad Homberg, where Dr Erich Theiler is the Technical Librarian.

The following documents were found to be housed:-

1. All reports on research, amounting to many hundreds, covering the activities of the whole group of companies. A set of these from 1930 onwards was collected and sent back to C.I.O.S. Headquarters after checking that no originals were taken so that the continuity of reports at Bad Homberg, as at that time, was preserved for any subsequent investigating teams.

As will be seen from the extensive list of reports in the Appendix these cover light metals, chemical and rubber industries and are indicative of the widespread technical activities of this firm.

2. There was also a technical correspondence carefully filed with registry including correspondence with consultants and foreign agents.

3. Technical abstracts are prepared by Dr. Theiler for the Company and its subsidiaries. These are taken from over two hundred technical journals and again cover many industries. An example of these is contained in the documents.

Dr Theiler operated his own system of indexing and a description of this system is also contained in the documents.

4. There also exists here a very extensive up-to-date technical reference library including bound volumes of many technical Institution and Society publications.

Altogether this literary department is of considerable interest, particularly to the Light Metal and Chemical Industries.

SUNDRY METALLGESELLSCHAFT PROCESSES.

During the investigation the Team took the following brief notes of certain M.G. processes, not, however, connected with the Lurgi Group.

BONDER PROCESS:

A well known system for protective surface coating of metals. Handled in Germany by Ges fur Oberflachen Technik M.B.H., a 100% M.G. subsidiary located at Frankfurt and Wiesbaden.

Certain technical reports relating to the process are listed in the appendix and it would appear that development had taken place in regard to surface coating preparatory to deep drawing of metals particularly for shell casings and tube drawing. Practical results were also claimed for application of Bonder by spraying as apposed to the usual bath method.

The Bonder fluid, which is a composition of zinc phosphate, zinc nitrate and freephosphoric acid, is manufactured by Hans Heinrich Hutte at Langelsheim in the Harze. The Bonder laboratories are also located here.

Dr. Overath and Dr. Schuster are the M.G. personalities primarily connected with Bonder activities.

POWERED METALLURGY:

M.G. were associated with Degusa in the Deutsche Pulvermetallurgische G.M.B.H. which, at present, is located as offices only at 32 Meyleus Strasse, Frankfurt.

Dr.Josef Dornauf, who was in charge, is a metallurgist who joined M.G. twenty-one years ago and up to 1939 had been in technical charge of Silumin G.M.B.H.

This company is a holding and development company for the powdered metal process and full scale production piston rings, small compounds, etc., was dealt with by sections of V.D.M., in particular the V.D.M. Sinter Metallwerke G.M.B.H., with Works at Ettlingen, Henrod and Busenbach.

Of interest was a Degusa development which was now being pursued by P.M. for the production of powdered iron by centrifugal action in combustion with water. Two hundred tons of powdered iron had been produced on the pilot plant, having a 70% conversion to the requisite fineness of 576 mesh.

Molten iron is poured on to a disc fitted with knives and revolving at 6,000 R.P.M.

A cone of water surrounds the stream of molten iron, adjusted in such a manner that just before hitting the knives the metal has to pass through a fine film of water.

A full description of the process and detail drawings of the centrifugal machine are contained in the documents.

Technical reports listed in the appendix and relating to Powdered Metallurgy are as follows:-

1710, 1782, 1830, 2005, 2008.

RUBBER PROCESSES:

Metallgesellschaft had apparently intended to widen out into the Rubber Industry prior to the war and of interest are the technical reports as listed in the appendix and which originate from the Colloid Chemical Laboratory.

Wartime work appeared to centre around the M.G. subsidiary, Metallochemische Werke A.G. of Frankfurt, formally known as Dartex A.G., and comprised rubber bonded brake linings, waterproofing of cloth and bonding of cloth into double texture. A special adhesive was developed for bonding unvulcanised rubber to metal and an adhesive for unvulcanised synthetic rubber.

The bonding material for rubber to metal was stated to contain:-

30% Igetex S.
20% Igetex M
5% Sulphur

1% Zinc Oxide.
0.5% Sublimate of Mercury.
40% Water.
7% Haemoglobin.

Best results were stated to have been obtained with metal previously coated with tin or copper.

LURGI GROUP OF COMPANIES.

The Group started because the other Non-Ferrous Metal Companies claimed access to some of the processes acquired by Metallgesellschaft from home and abroad. It was more convenient to develop and sell these processes, with or without tonnage licences, through a separate operating company. In addition, it was found advisable to have separate companies in view of the propensity of technical men to be individualists and to work better on their own.

There is one common Aufsichstrat to all the Lurgi Companies and at the time of investigation that comprised Dr. Peterson, (Chairman), Herr Traudes, Herr Merk and Dr. Reuleax.

All financing of the activities of the Companies is carried out by Metallgesellschaft and the nominal capital of each company is of the order of 50,000 Reichmarks.

In order to obtain continuity of policy there was one Accountancy Department covering the requirements of all four operating companies. Dr. Behlaert was in charge of this, but he would have a separate section in each company which would work as part of its individual organisation under the Commercial Director of that company. The Commercial Director would be responsible also for the organisation of sales, personnel, wages, etc.

An annual budget is set for each company to spend on research and development.

It was only during the war that a Progress and Planning Department became necessary in order to keep pace with the major changes in control position which were frequently taking place in Berlin. Lurgi claimed that the Central Government Production Controlwas most inefficient due to the calibre of the senior Government Officials, many of whom had to be long-standing Nazis regardless of their capabilities.

Lurgi seldom quote for buildings, but they would employ Civil Engineers and Architects and frequently acted as consultants for buildings, layout, ancilliary plant etc. It was only in such cases as the Bohlen Gas Works that they undertook the supply of complete factories as opposed to complete plants.

During the war most of the contracts received were, in effect, open orders although certain orders placed by the

Government were costed. It was understood en passant that the German equivalent of E.P.T. was based on the 1939 profit and whilst the percentage was high it was so calculated that the profit incentive to expand business definitely existed.

Man hours in the Drawing Office required for a contract were not taken as a basis for overheads, although it would influence the overhead but in the same way as degree of risk, novelty of plant, etc., would influence it. In the cases where the clients requested research or development work to be carried out and no order followed, then a charge of material plus laboratory personnel time plus 200% plus 20 to 25% overall overhead for office charges would be made.

In those cases where they had complete drawings for the plant for the client to arrange manufacture, they expected to make a charge equivalent to the estimated cost of the plant if they were selling it as such, less the sum they would have to pay to sub-contractors for manufacture.

When giving a guarantee of performance, this was always of a limited kind, they would not lose more than 10% on maximum cost of the plant. It was gathered that where they had any doubt this percentage was previously added on.

It was stated that during the war considerable losses had been occasioned through installing plants before they had had sufficient manufacturing experience for that particular process.

On the question of foreign subsidies before the war it was stated that a system of Ausfuhrabgabe was in operation. This was a subsidy arranged through a Central Control Office in Berlin for the Export Department. On claiming assistance against foreign competition a German firm was given a bottom limit below which it could not go. This was stated to be a maximum of 20% below the normal quoted price, but emphasis was laid on the fact that the Germans expected to obtain their orders through offering superior guarantees. The following is an actual statement given by Lurgi as to the operation of this subsidy:

"Subject: Supplementary Export-method.

In order to understand the business-transaction in question it will be explained simply by an example.

"A German firm gets an inquiry of a foreigner. The German offers at RMs 110,000,--, and the firm abroad answers that they have got an offer at the price of RMs 100,000,-- from another firm abroad. They intend, however, to place the order with the German firm provided that they will be agreed with the price mentioned. Now the German firm applies to its competent Commercial Group and encloses a statement of the costs arisen which don't grant them under normal conditions to accept the order because in this case the business-transaction would be finished with a considerable loss. After examination the Commercial Group accepts the compensation of the amount to the German exporter which has to cover the whole loss or in another case only a part.

Under these circumstances the German exporter is in a position to accept the order.

When the customer abroad pays the amount of the invoice the exporter fills up an acknowledgement of receipt of the export-proceeds and encloses the corresponding evidences (forms).

This offer is to be directed to the Deutschen Reichsbank. In conformity with the payments arrived the Golddiskontbank compensates the promised amount of the loss either in one or in several sums to the exporter.

On this way the account will be balanced.

This method was in use with certain countries especially those whose rate of exchange was considerably devaluated."

Francfort on-the-Main,
July, 24th 1945.

Kg -"

Foreign Agents were appointed on Government request throughout Europe, particularly in about 1938 onwards. These were remunerated mainly through commission and it was stated that expenses were only paid when well substantiated.

It was stated that over a considerable period I.G. were not important clients since they tended to design for themselves and purchase only specialities. Lurgi believed that Bamag got a considerable amount of work from I.G., partly because they had a factory and partly because of a personal connection since one of their

directors, Dr. Siebert, was a former senior executive at I.G.

Of the four companies Lurgi Gesellschaft fur Warmetechnik m.b.h. has appreciably the largest turn-over. The total value of contracts including the sales of Activated Carbon, received between 1926 and 1941 was 236 million Reichmarks. The total personnel employed in 1929 was 130 and in 1941 was 457.

During the same period Lurgi Gesellschaft fur Chemie und Huttenwesen m.b.h. received contracts to the value of 142 million Reichmarks and had a staff of 80 in 1929 and 240 in 1941.

From the profit-making angle, the total profit for seventeen years ending September, 1942 in millions of Reichmarks were approximately as follows:-

Lurgi Spuelgas	4.75
Sales of Activated Carbon	4.7
Oils and Fats	0.95
Krause Spray Driers	0.68
Refuse Disposal	0.57
Crystallisation	0.5

Comparable figures for Lurgi Chemie are:

Sinter Plant	6.05
Multiple Hearth Furnaces	3.25
Sulphuric Acid "Intensive" Processes	0.50
Rotary Kilns	0.4

Lurgi Apparatebau G.m.b.h. was almost entirely devoted to the supply of Electrical Precipitation Plant of the Cottrell type. About 5 to 10% of the turn-over was accounted for by plant for mechanical separation.

Lurgi Werkstatten was largely formed to produce the Multiple Precipitation Chambers for Lurgi Apparatebau. During the war they had manufactured a considerable number of small single tube Electric Precipitators for producer gas driven vehicles. These works had been considerably damaged by air action.

The general organisation of each company would comprise the Vorstand, Dr. Plass being the Chairman of each Vorstand until he was removed after the end of the war when Dr. Oetken the previous

technical chief of Lurgi Warme, took over Dr. Plass' position.

Dr. Oetken's deputy in each Company would be the Senior Technical Division Director. Each Division would have a number of Departments; the head of each of these departments would have his deputy and assistant.

When an enquiry was received it would go to the Departmental Manager concerned who would arrange for an engineer to calculate the size, take out weights, prices of components and bought out material, specify in detail, pass to the Commercial Department for checking, adding overheads, profit and contingency and then the Divisional Head and Commercial Department Head would together sign the tender. In certain cases the Departmental Head could sign a tender if it was straightforward repetition work. In certain others when, for instance a Sulphuric Acid Spaltenlage was being quoted, which would comprise sections from the three companies, then the Chairman of the Group would sign the final tender.

In such latter case the contract when received would be handled by the company which had the major plant responsibility; this would be Lurgi Chemie in the case mentioned, and they would purchase the Gas Producer Plant from Lurgi Wärme and the Cottrell Precipitators from Lurgi Apparatebau.

In the case of Lurgi Chemie there was one central Drawing Office, or "Construction Office", which was under Ober. Ing. Jacob Schwalb. This comprised approximately 70 employees of whom roughly 20 were engineers, mainly mechanical and metallurgical and 20 were "Constructeur" i.e. Design Draughtsmen and the remainder "Zweiter Constructeur" i.e. detail Draughtsmen.

Whilst certain personnel specialised in one or other of the branches of Lurgi Chemie and were, as far as possible: kept on their own specialities, there was a good deal of elasticity.

In the case of Lurgi Wärme each job had its own Technical and Drawing Office staff.

There did not seem to be a universal rule as to the method of engineering any one contract. In certain cases an engineer would follow right through from design to installation and operation, but in the case of a larger plant different individuals would engineer, instal and operate. Broadly speaking this did depend on the size and number of contracts handled by

each department.

For pressure vessels, Germany would appear to be fortunate in that the code is a state controlled code and is operated by the Dampfkesselueberwachungsverein.

The important sub-contractors for fabricated work for the Lurgi Group included:

Concordius, Coblenz.
Keurer & Loerch, Krefeld.
K.K.K., Frankenthal.
Siller & Jamart, Wuppertal.
Paukerwerken, Wein.
Dortmunder Union.
M.A.N., Gustavsberg b.Mainz.
Orangewerke, Gelsenkirchen.

Although no written evidence could be found that a grant was given which could be expended before a new process was expected to pay for itself, it is a fact that for a number of processes they had lost several hundred thousand Reichmarks over a period of 3 to 5 years before the processes started paying for themselves. Apart from this they had specifically reserved from profits money to be spent on developing new processes and this was used particularly during bad years when their technical staff was not otherwise employed.

Staff salaries are not being quoted since they are misleading without a considerable knowledge of the economic cost of living in Germany, but broadly speaking it was stated that they had increased basically by about 10 to 15% during the war. In addition, approximately 10% was being paid at Christmas to most staff members and they were earning 20 to 25% overtime.

Departmental Heads who had a percentage of profits were, in the year ended September, 1943, earning as much as 100% over and above their total salary.

Pensions became payable (on retiring) after 15 years service at the rate of 40% of the retiring salary plus 1% for each additional year served with the company. Approximately 4% of the individuals salary is deducted for this and other National insurances.

It was understood that Lurgi did not advertise extensively in Germany since they claimed their products were so well-known.

Lurgi Chemie had no Agency or branch offices in Germany. Lurgi Waerme had an engineer resident in Leipzig by the name of Ruckers, who was mainly responsible for erection. It was understood that he had remained in the Russian area at the request of Lurgi, with the hope of re-starting Lurgi Business in the Russian area.

Lurgi Apparatebau had several Agents in Germany, Dr. Antrup in Berlin, Herr Rathart in Essen, Herr Achebbach in Cologne and Herr Fritsche in Leipzig.

It is generally known, and will, of course, be realised that, with the exception of Lurgi Apparatebau, the Lurgi Group has no factories of its own.

The following is the list of foreign representatives of the Lurgi Company as given to the investigators in writing on the 26th July, 1945.

Name	Address	District assigned to.	Company
~~O.Y.Algol, A.G.~~	~~Helsingfors,~~ Unionsgatan 22	~~Finnland~~	~~Lurgibau~~ Lurgichemie Lurgiwaerme
American Lurgi Corporation.	New York City, 80, Broad Street.	U.S.A.	Lurgichemie Lurgiwaerme
Birger & Carlson & Co. A.B.	Stockholm C Malmskillnadsgatan 33	Schweden	Lurgibau Lurgichemie
Albert H. Bruecke	Englewood - New Jersey	U.S.A.	Lurgiwaerme
F.M.Christen	Kuessnacht-Zuerich Hornweg 11	Schweiz	Lurgibau Lurgichemie Lurgiwaerme
Aage Christensen	Kopenhagen-K. Norrevoldgade 34	Denmark	Lurgibau Lurgichemie Lurgiwaerme
Egeberg & Mohn	Oslo Radhusgatan 5 b	Norwegen	Lurgibau Lurgichemie
Fritze J.Ernst	Sofia Boul.Ferdinand 64	Bulgarien	Lurgiwaerme

Name	Address	District assigned to:	Company
Hugh Griffiths, Esq.	London 16, Queen Anne's Gate	England	Lurgiwaerme
Huntingdon Heberlein & Co.	London	England	Lurgichemie
Dr. Carl Krayer	Tokyo Central P.O. Box 366	Japan und Mandschukuo	Lurgibau Lurgichemie Lurgiwaerme.
Metall & Lurgi	Wien VI Hermann-Goering-Platz 6	Oesterreich Tschechoslowakei Ungarn Jugoslawien	Lurgibau Lurgichemie
La Metallochimica	Milano Solferino 7	Italien einschl. seiner Kolonien	Lurgibau Lurgichemie Lurgiwaerme
J.Rolland & Co.Ltd.	London, S.W.1.	England	Lurgiwaerme
A.S.Rolland	Paris 8, Rue de Richelieu	Frankreich	Lurgiwaerme
Sarotec, Soc. An. Romana Technica Pentru Reprezenta si Antreprise	Bukarest I Strada C.A. Rosetti 14	Rumaenien	Lurgibau Lurgichemie Lurgiwaerme
D.Scalistiri	Athen Rue Philhellenes & Xenophon 8	Griechenland	Lurgibau
W.C.Stignis (Technisch-Bureaux) Techno-Chema")	Utrecht Prinz Hendrik-laan 31	Holland	Lurgiwaerme
Technisch Bureaux "Techno-Chema"	Amsterdam C Keizersgracht 788	Holland	Lurgibau Lurgichemie
Dipl.Ing.W.Troeller	Luxemburg Danziger Platz 6	Belgien Luxemburg	Lurgibau Lurgichemie Lurgiwaerme
Dr. H.J.Woisin	Bilbao Apartado 80	Spanien und Portugal einschl. Kolonien	Lurgibau Lurgichemie Lurgiwaerme

Sheet No. 49.

Several recent copies of the Annual Reports of the three Lurgi Companies are available under the term "Bilanz und statisischer Bericht". Each of these comprise some 40 to 60 pages of interesting statistical information relating to costs etc.

LURGI RESEARCH AND TECHNICAL DEVELOPMENT

It was found that although the approach to new developments varied slightly as between one Lurgi company and another, the general principle was the establishment of commercially saleable plant built up to serve a process or to utilise some reagent or catalyst such as had already been made available as a result of fundemental research or by the acquisition of some foreign patent or process, in either case by Metallgesellschaft.

Undoubtedly during the war period - which for such concerns as this extended from 1937-1945 - there had been a pursuit of developments inspired as much by the needs of the State in its preparedness for total war, as for any purely commercial aims of the company itself.

Thus it was found that contact between Lurgi Warme and I.G. on the subject of synthetic fatty acid distillation went back to 1938. Combination of I.G. and Lurgi will be readily seen in the section of this report dealing with the Phenosolvan system of Phenol recovery utilising the I.G. solvent. Both these represent new processes but there was also found the type of arrangement where improvements of importance were made by Lurgi to existing processes, such a case was the recycling system for the Fischer Tropsch plants. Dr. Oetken of Lurgi claimed that this development arose out of the association that Lurgi had with these plants when they installed activated Carbon equipment on the first F.T. programme.

Again there was a noticeable readiness to adapt existing plant designs to new applications, this will be seen in the agreement between Lurgi Warme and the M.A.N., concern for the use of the Lurgi high pressure Gasification system but without Oxygen blast. for use with Gas turbines. Such developments confined primarily to plant, were carried through by Lurgi with little help from M.G.

On the metallurgical side outstanding examples of the breaking into new ground are seen in the use of the long known ore sintering plant for the successful production of cement clinker and almost conversely, the adaption of rotary kilns of large size for the reduction of ore preparatory to magnetic separation.

It was seen that Lurgi went quickly from the pilot plant right up to the largest industrial scale in one step. Undoubtedly, the war status of the country forced the pace in these matters and, as in the Spalt-Anlage Sulphuric Acid Plants, were not free from trouble and reference to the report on Nordhausen will also show that in the case of SO_2 recovery, were not always overcome. On the whole the picture that was found showed a group of highly competent and well organised engineering firms who formed no small part of the technical achievement of the Reich in its effort to be self-supporting in the important industrial branches of fuel, metals and chemicals.

The foregoing indicates, in a general manner, the entry of the Lurgi group into new developments which normally followed in a natural sequence to research of a fundemental character which had already been carried out by Metallgesellschaft or its associates. As an example should be noted the Sulfadin process for SO_2 and sulphur recovery. Here the laboratory work of M.G. was followed by a pilot plant installed at the M.G. subsidiary, Norddeutsch Affinerie at Hamburg. The next stage was the full scale plants installed by Lurgi at Nordhausen, etc.

The work on Rotary Ore Reduction Kilns were based on pilot plant installed at the Cologn Works of Sachtleben A.G., another M.G. subsidiary, and concurrent laboratory work by M.G. on special equipment at Erbstadt, established the data required by Lurgi, who were thereby able to go ahead with the design of the large and important installation costing millions of marks at the Hermann Goering Reichwerke at Watenstadt.

Lurgi had little or no part in those M.G. developments which centred around the ultimate production of some special product or material, e.g. powdered iron, Bonder, Revertex, etc., these, and the like, were separated off into individual companies responsible for the development, improvement and commercialisation, of the particular product. This distinction was found to be inherent throughout the whole of the Metallgesellschaft structure and thus the whole of the strength of the Engineering group of Lurgi was applied to the development of chemical, metallurgical and fuel plant and equipment, capable of commercial exploitation.

This must not be taken to imply that the Lurgi group had no research staff or laboratory facilities. Each of the Lurgi companies had, in fact, very ample resources in this direction but they were used to the end of plant design and operation rather than to the development of new processes or chemical products, as such. The nearest approach found by the writers, of Lurgi undertaking work which might normally have been expected to be the responsibility of M.G. was that laboratory research being undertaken by Lurgi Warme at their Mouson Strasse Laboratory on the recycling of Fischer Tropsch gases. This covered gas composition at varying velocities and temperatures and with different catalysts.

LURGI RESEARCH & TEST STATION:

Lurgi Bau, Warme and Chemie, each had a separate research and test station in one group of buildings at Lurgi Werkstatten, Mouson Strasse, East Frankfurt. In addition Lurgi Warme had certain pilot plant at Heddernheim, and Lurgi Bau activities in the Harze Mountains have been described elsewhere in this report.

LURGI WARME:

At Mouson Strasse there was a glass laboratory for routine work which was intact but closed at the time of inspection.

Laboratory research on Fisher Tropsch synthesis was being continued in a battery of electrically heated reaction vessels.

The test house, as distinct from the laboratory buildings, housed the spray dryer as described under that section.

At Heddernheim, Lurgi Warme had maintained a permanent test station at the V.D.M. Works but slight damage had been sustained and no work was proceeding. The equipment comprised:-

1 Full-scale Spul Gas Unit, in rather delapidated condition but available for work with adjacent gas condensers.

Autoclaves, pumps and equipment for vegetable oil treatment.

Shale distillation shaft of very crude type which had been used for tests in connection with the Schweitzer Kiln.

LURGI CHEMIE:

The principal equipment at Mouson Strasse was a small but complete unit of D.L. sintering plant on which various ores were tested and which had latterly been used for research on the burning of cement clinker. It was stated that the chief work during the war had been directed towards the roasting of sulphurous ores with the recovery of maximum SO_2.

Work had also been started on the treatment of zinc ores in shaft type kilns but had not yet reached any practical stage, although Pilot Plant was available.

LURGI BAU:

Dealt with under that section.

RESEARCH EXPENDITURE:

Typical annual allocations for research granted to the companies are as follows:- excluding 7½% Profits to M.G. Research.

L. Chemie	L. Warme.	L. Bau.
30,000 RM.	80,000 RM.	100,000 RM.

SUMMARY:

As engineering companies, Lurgi had the unique advantage of being completely associated with the very large industrial concern of Metallgesellschaft and all its subsidiaries, and thereby able to draw upon an infinitely larger fund of research and development experience than could every be supported by their own activities had they been purely and simply an engineering and contracting group existing on the revenue of their own commercial activities.

There is no doubt that it was of considerable benefit to Metallgesellschaft to maintain the Lurgi group, particularly Lurgi Chemie as leading world specialists in the treatment of ores, sulphur, etc., since thereby they secured contact of a very useful kind with industrial developments throughout the world which impinged on their own business.

LURGI GESELLSCHAFT fur WAERMETECHNIK m.b.H.

Lurgi Waerme is not split up in quite the same way as Lurgi Chemie, but on the other hand its individual divisions are more self-contained and even the departments within the divisions will have their own Designers, Draughtsmen, Commissioning Engineers, etc.

The executive people or Vorstand of the Company consist of Dr. Oetken, Dr. Georg Mueller and Karl Behlaert.

Activated Carbon Division:

is under Dr. Georg Mueller, is directly responsible to the Vorstand and is run quite separately. This division contributes substantially to the profits of the Company, particularly so far as sales of activated carbon is concerned.

It is understood there has been little technical development during the war and as the Lurgi process is well-known and has been described in literature in this country, it was not investigated in any detail at all.

Dr. Heintzeler is in charge of the sale of Activated Carbon and Dr. Ruping in charge of the sale of the plant. When interviewing Ober.Ing. Vollman he stated that in the Solvent Recovery of Benzine in the Fischer Tropsch process, as the gases were clean the carbon beds could be considerably deeper than the normal three to four inches. When steaming out ultimate drying was not regarded of importance, but it was essential that the gases should be cooled, and in the Fischer Tropsch process the gases are recycled to obtain greater cooling, particularly for Butane and Propane.

It was mentioned that a pilot plant for the recovery of Ethylene had been installed, but the full scale plant was lost to a firm putting forward a Pressure Oil System, it being stated that in this case as high pressure was available, the advantages of the activated carbon system disappeared as the absorption capacity of activated carbon does not increase rapidly with high pressure.

Fuel Plant Division:

This second division was under the supervision of Director Dr. Hubmann who was also assistant to Dr. Oetken in the technical supervision of this and the Steam Plant Division. Dr. Danulat was Dr. Hubmann's assistant.

The main departments in this division were as follows:

Lurgi Spuelgas under Voerkel. This department also incorporates the Lurgi Schweitzer Kiln.

Krupps Lurgi Low Temperature Process for bituminous coal under Meyer

Pressure Gasification Department under Dr. Danulat.

Gas Producers under Kolb. This department also includes Tunnel Kiln for shale distillation.

Lurgi Krupps hard coke process under Heiner.

Fischer Tropsch Recycling Process under Dr. Danulat. This process is not described at all in this report since it had been investigated in detail by previous teams and a comprehensive report on the whole synthesis is in the course of preparation, which includes that section of it which Lurgi have developed. It will be noted elsewhere in this report that Lurgi have recently concluded an arrangement with Ruhr Chemie so that Lurgi would be in the position to offer the complete plant.

Steam Division

This was under Dr. Kurt Mueller. Dr. Mueller had been in the army from 1939 until the end of 1943. He stated generally that the Steam Division had lost its position during the war since it was less vitally concerned with immediate war potential. The Evaporator Section was mainly only of value to Lurgi in so far as it had supplied concentrators for liquids which would ultimately be dried in the Krause Spray Drier.

As a number of the Veg. Oil Refineries in the Hamburg and Harburg Districts had been damaged they were hopeful that the Fatty Acid Department would come into its own for rehabilitation. It was not felt that the future for the various processes treating by-products of mineral oils was likely to hold great development.

Oils and Fats Department under Morlock included Fat Splitting and plant for the production of Synthetic Fatty Acids. The Chemist, Milbars had considerable knowledge of this department.

Krause Spray Drier Department under Roepstorff (not a very progressive individual). His assistant was Fischer who had considerable knowledge of the plant and Kretzdorn had been in charge

of the demonstration Spray Drier as Moussonstrasse, although he was temporarily employed in the Military Government.

The Vapour Recompression Evaporator Dept. was also under Roepstorff.

The Crystallisation Dept. which included such specialities as the production of Magnesium Oxide was under the direction of Ebner.

The Department concerned with various processes including synthesis of High Alcohols and Lubricating Oils and also the production of Phenol by the Pheno-solvan Process was under the direction of Dr. Kohrt.

The Distillation of Mineral Oil by various processes had originally been under Siebert, but he left the Company at the time of the investigation and Dr. Kohrt had taken over although Meyer knew more of the details of this department.

It should be noted as a matter of interest to subsequent teams that a number of reports on commissioning of plants were available in Dr. Kohrt's office at the Polytechnikum at Friedberg. As these were the originals they were not taken away but are listed below:

G T 11/13	Gew. Elwerath Haengensen.
G T 29	Liquigas S.A. Mailand
G T 30	Ruhrbenzin Halton
G T 31	Romano Amerie
G T 32	Ruhrbenzin Halton
G T 34 and G T 35	
G T 36/38	Hoesch Benzin
G T 37	Chemischewerke
G T 40	Rheinpreussen
G T 42 & 45	G.B.A.G. II also I
G T 46	Politz
G T 47	Rheinpreussen
G T 48/52	U.K. Wesseling
G T 50	Preussag Hanover
G T 57/72	D.E.A. Heide
G T 59/60	S.T.W. Brux
G T 62/64/63	G.B.A.G.
G T 78/89	Brabag
G T	Current Plant Commissioning and Experiments.

The Chemical Department which carried out fundamental research for the Company was under the guidance of Dr. Herbert who was responsible

direct to the Technical Directors and not to the two divisions. As is described elsewhere there is an Active Carbon Research Laboratory at Bad Homberg.

The Commercial and other departments being common to all divisions of Lurgi-Waerme, are similar to that described in the general Lurgi Section.

At the time of investigation there was considerable dispersion; the Activated Carbon Section was in the Silumen Building adjacent to Mg. Offices. The Fuel Section was in some outbuildings of V.D.M. at Heddernheim and certain pilot plant for the Steam Division was also situated in the V.D.M. Works at Heddernheim although considerable damage had been done to both the Works and the Pilot Plant.

The Steam Division was divided between some outbuildings of the Polytechnikum at Friedberg and the old castle at Bad Homberg, which latter was closing down as the investigators were leaving.

A list of the major contracts received by the Company from January, 1937 onwards is amongst the documents available, as is also a list of the technical staff employed at the end of July, 1945.

The following personnel were interrogated, the date of the first interrogation being given in brackets. The position held in the Company is also given.

Ober.Ing. Emil Morlock	(19.7.45.)	Fatty Acids: Veg. Oils etc.
Arthur Milbars	(19.7.45.)	Fatty Acids: Veg. Oils Chemist.
Richard Bayer	(19.7.45.)	Chemist.
~~Dr. Hubman~~	~~(19.7.45.)~~	~~Spulgas: Gas Producers.~~
Dr. Danulat	(19.7.45.)	Pressure Gasification
Ober.Ing. Kolb	(19.7.45.)	Gas Processer
Dr. Kohrt	(20.7.45.)	Phenosulfan, Distillation etc.
Ober.Ing.Paul Roepstorff	(31.7.45.)	Krause Driers & Evaporators
Ing. Franz Fischer	(31.7.45.)	
Dr. Ruping	(1.8.45.)	Active Carbon
Professor Gesencke	(8.8.45.)	Evaporation, Steam Jets.
Curt. Mueller	(13.8.45.)	Procurist in charge all "Steam" Plants.
Hans Heck	(14.8.45.)	Commercial

W. Vallmer (14.8.45) Project & Client Contact.
W. Bonnes (14.8.45) Erection and Design.

The Annual Statistical Reports give a great deal of interesting information on the costs and developments of the various departments, and the following two tables are extracted from these.

The first table calls for little comment.

From the second table it will be noted that the profit is small in relation to the output; this is to some extent explained by a considerable carry over, because the output for the year ending 1942, although only increased to 32,000,000 Reichmarks shews a profit of 3,300,000 Reichmarks after making allowance for loss of fee from the Japanese Licencees for the Lurgi Spuelgas Plant of 640,000 Reichmarks.

So far as value of orders received is concerned, the outstanding item is Lurgi Spuelgas representing 106,000,000 Reichmarks for the years 1926 to 1942. (The following figures refer to the same period.)

	Reichmarks.
Lurgi Krupps	14,000,000
Distillation of Mineral Oils	12,000,000
Deodorisation, including Fatty Acid	12,000,000
Shale Oil Distillation	8,000,000
Krause Spray Driers	7,000,000
Crystallisation	7,000,000
Synthetic Fatty Acid	7,000,000
Producer Gas	7,000,000
Sale of Activated Carbon	42,000,000
Sale of Activated Carbon Plants	17,000,000

The list of orders received, however, does not necessarily fall in line with the profit made from the various lines of business.

Without referring in too great detail to the various processes, it should be noted that the total profit to the end of 1941 for Spuelgas was 1,640,000 Reichmarks which included losses of 500,000 in 1938 and 370,000 Reichmarks in 1941. Krupps Lurgi which had a total loss of 640,000 Reichmarks up to the end of 1940 shewed a profit of 110,000 Reichmarks in 1941 (a further profit of 40,000 Reichmarks was made in 1942). On the other hand the High Pressure Gasification had shewn a total loss, without any profit to date of 890,000 Reichmarks at the end of 1941 (a further 300,000 Reichmarks was lost in 1942).

It will be seen that Lurgi did not throw up a process in the face of considerable loss if they had reason to believe ultimate profit would be obtained.

When interrogating Herr Heck who was the Commercial representative of Behlaert's department attached to Lurgi Waerme, he stated that the technical heads of departments were expected to evaluate the risk of developing a new process and estimate the date when it should be a paying proposition and the directors were not alarmed if this was stated to be 5 or 6 years. Money was continually reserved from profits for the development of new processes and in particular this was spent during bad years by devoting the time of technical staff to such development work.

Sheet No. 61

LURGI-WAERME.

Items of interest from Annual Statistical Report for the year ending September, 1941.

		Reichmarks.
Work in hand		6,375,000
Tax Certificates held		1,310,000
Credit with Mg.		21,500,000
Profit		1,050,000
Written off: Plant, Machinery, Furniture, etc.		180,000
Salaries		1,720,000
Wages (erectors etc.)		500,000
Compulsory Social & Health Insurance		117,000
Voluntary Social & Health Insurance & Contributions		293,000
Various taxation		500,000
Experimental Costs - Clients works etc.	110,000	
less charges made to Clients	30,000	80,000
Patents		57,000
Contribution to Mg. Patent Office		38,000
Contribution to Mg. Legal Office		10,000
Output (Sales)		27,200,000
To Reserve Fund		130,000
Mg. Technical Research		85,000

EXTRACTS FROM LURGI-WAERME ANNUAL STATISTICS.

	1929	1933	1936	1937	1938	1940	1941	1926-41
Value of Contracts received (including Act.Carbon) in million R.M.	6	4	11	29	15	46	44	236
Value of output (including Act.Carbon) in million R.M.	6	4	19	11	17	26	27	157
Staff employed	130	128	211	282	314	387	457	-
Travelling Expenses Abroad in 1000 R.M.	164	124	220	225	253	267	323	2858
				1938	1939	1940	1941	1928-41
Contribution to M.g.Technical Dept. ($7\frac{1}{2}$% Profit) in 1000 R.M.				?	42	64	85	
To Reserve Fund				?	65	95	130	
Contracts received (excluding Act.Carbon) Home in 1000 R.M.				10500	31540	41308	38077	166892
Contracts received (excluding Act.Carbon) Europe in 1000 R.M.				766	700	645	1490	16745
Contracts received (excluding Act.Carbon) Overseas in 1000 R.M.				1211	470	52	8	8741

LURGI WARME FUEL SECTION.

STAFF:

Dr. Hubmann - Carbonisation and Oil Shale.

Dr. Danulat - High Pressure Gasification.

Dr. Kolb - Gas Producers.

6 Chief Engineers.

6 Experimental-Operating Engineers.

28/30 Draughtsmen.

LOCATION:

At August 1945:-

V. D. M. Copper Works,

Heddernheim,

Nr. Frankfurt.

Lurgi Warme maintain their Experimental Station at these Works; they are fairly intact and comprise a Spul-Gas Unit, some Edible Oil Plant, Autoclaves, etc., and a Shaft Kiln for shale distillation of a very crude type.

GAS PRODUCERS:

Kolb joined Lurgi in 1917 from Erhardt & Sehmer, now over sixty.

Mechanical Producers are made in two sizes:-

2·6 M. and 2·0 M. inside diameter.

A static plant of 1·6 M. is made.

The fuel is in all cases hand fed by hopper and bell and an internal chute is fitted or not according to the fuel. With large grade fuel the chute is omitted so as to allow the fuel to build up at the sides. Low pressure boiler jackets of rivetted constructions are provided as described for visit to Allendorf (Lurgi Chemie) but it was admitted that when operating with fuels having a fine ash there was a tendency for this ash to build up on the sides and prevent heat transfer to the extent that independent steam supply was necessary.

Two types of mechanical grate are fitted:-

1. The original Lurgie large diameter shallow dome type, little altered since 1920.

2. The narrow fir cone type with one ash plough and the usual ash extraction shovel. The grate runs on a ball track and is friction driven by worm and track. The seal between blast pipe and rotating grate is by adjustable gland.

Gasification rates for the 2·6 M. Plant were given as follows:-

Rhineland Briquettes	18/20 tons.
Mittle Deutsche Briquettes	24 tons.
Coke	20/22 tons.

For highly bituminous coal a simple pre-distillation zone is superimposed above the generator.

Where clean gas is required this is achieved by means of a ring-packed condenser-cooler in which the temperature of the gas is reduced to 80-90°C. which was stated to be the best for the electrostatic precipitator, which is invariably used.

Centrifugal blowers and gas exhausters are used usually supplied by Kuhnle, Kopp & Kausch.

Before distribution, the gas is passed through a simple type of ring filled drop catcher.

Lurgi stated that the demand for Gas Producers had fallen off considerably and during the war they had supplied only about fifty Units.

Incidentally, it was stated that during air raid conditions the Fern gas supply had been very reliable and Producers had not been adopted for emergency use.

See description of Allendorf Plant [M_2SO_4]

DRY BASE GENERATOR:

See Drawing O.14356 - 1.12.44 - contained in documents.

This Drawing is self-explanatory. Of minor interest is the steel skid ring which is fixed by screws to grate bottom. This slides on 4 column supported C.I. riding blocks.

The gland blast pipe joint is standard Lurgi construction.

Installed at Nordhausen, Russian Zone, for Elemental Sulphur Recovery.

LURGI SCHWEITZER KILN:

Installed at Frommern, near Wurtenberg.

This Plant is complete but has not run. It's purpose is to recover the oil in the shale by internal

downwards gasification of the carbon and a 4 % recovery of oil is achieved.

The Kilns have vertical steel shafts mounted in a building with overhead crane and when the slow downward progression of the gasification zone - 0·1-0·3 metres per hour - is complete the whole Kiln is lifted out of the building and tipped, refilled and set in position again.

Dr. Hubmann considers that the combination of oil recovery and residual agregate suitable for making self-binding building blocks to be well suited to German post-war conditions, particularly in the Wurtenberg area where there is no coal supply. The German "Desert" programme of Miellers gave only 2 % oil and depended entirely on slave labour, and further completely disfigured large areas of good land.

Dr. Oetken, however, expressed the opinion that the downward gasification allowed too much sulphur to build up in the oil.

An experimental Shaft is installed at the Lurgi Research Station at Heddernheim. This is a very simple piece of equipment about 1 metre dia. x 5 metres high with a flat Cast Iron grate.

TUNNEL-SCHWELANLAGEN:

This is a tunnel kiln used for shale distillation. Two Units of 400 tons per day throughput each were installed in 1944 at Heide, a small village north of Hamburg near the Danish border, for The Deutsche Erdol A.G.

The principle is one of recycling the distillation gases which are themselves maintained at a suitable temperature by means of a producer gas fired tubular heat exchanger. Reference should be made to drawing number 16544 showing the layout of the whole plant and drawing number 16103B. which provides the cross section of the Oven and the heat exchanger. These drawings are contained in the documents.

A series of tubs are charged with raw shale by means of table feeders from an overhead conveying system, after which the tubs continue on a telpher track to the entrance of the oven.

The oven is 2 m. diameter of mild steel construction with plates 8 mm. thick.

The trucks themselves engage on rail tracks inside the oven and have a perforated metal base below which is a suction box.

The trucks are shunted through the oven by a hydraulic pusher and as one enters so also a truck of spent shale is discharged at the other end.

There is a drop in the rails coinciding with the location of a suction box in the oven and as the wheels of the truck pass into this drop so a seal is effected between a suction box on the truck and the suction box of the Kiln; each suction box is coupled up to a gas recycling fan of which there are twelve in number.

Orders were taken for similar sized units to be installed at Kivioli & Kohlta-Jarve and Jewe, all in Esthonia, but were uncompleted.

LURGI COAL CARBONISATION PLANT:

Although Carbonisation Plants form a large part of the Lurgi Warme activity they are not dealt with in this report having been fully examined by earlier investigators.

PRESSURE GASIFICATION FOR GAS TURBINES:

Investigations of documents at Metallgesellschaft offices at Frankfurt indicated a provisional understanding between the firm of M.A.N. and Lurgi Warme regarding the installation of Pressure Gas Plant and Gas Turbine Equipment for land Power Stations.

Messrs. Oetken, Hubmann and Danulat were interrogated and disclosed the following - from the work carried out by Lurgi in Pressure Gasification with oxygen blast they were satisfied that similar plant, but operating without oxygen blast, could make an important contribution to gas turbine development and, following a conference between Lurgi, M.A.N. and the Kraftswerk-Ausscheiss des Generalinspektor fur Gas, Wasser und Energie (Regierungsrat Foerster) it was agreed that a joint scheme would be prepared for a 10,000 Kw. Unit to be installed at the Trattendorf (Berlin) Power Station of the Elektrowerke A.G. See copy of tender dated 16/5/44 entitled - SGA.13112 - Kraftswerk Trattendorf, Gasturbinenanlage.

Owing to the deteriorating war situation the final instructions to proceed with the Gas Plant were never given but from reports of other investigators to the M.A.N. Works at Ausburg, it is understood that a 10,000 Kw. Gas Turbine was in course of construction.

The Trattendorf Plant was to consist of three Gas Generators, each of 5·0 m.^{2} cross sectional area to give a total gas production of 20,000 cu.metres of gas at a pressure of 20 atm. on the basis of the following figures:-

ANALYSIS OF RAW BROWN COAL:

Ash	3 %
Fixed Carbon	20·6 %
Moisture	52·0 %
Volatiles	24·4 %

This Coal, dried to a moisture content of 30 % as required for gasification, would then have the following composition:-

Combustibles	65.5 %
Water	30 %
Ash	4.4 %
Tar	8.1 %

Gross C.V.	4250 cals.
Nett	3880 cals.

COMPOSITION OF GAS PRODUCED:

CO_2	21.8 %
H_2S	0.4 %
CnHm	0.2 %
CO	11.7 %
H_2	26.9 %
CH_4	9.0 %
N_2	30.0 %
Ho	2090
Hu	1870

Air consumption for gasification	0.38 cu.m. per cu.m. gas
Steam consumption for gasification, including Benzine recovery.	0.395 Kg. per cu.m.
Gas production per ton of dried coal.	1600 cu.m.

PRODUCTION FIGURES:

Normal gas production	20,000 cu.m. per hour.
Fuel consumption	12.5 tons per hour. (30 % moisture).
Steam consumption	7.9 tons per hour.
Air	7,600 cu.m. per hour.
Power	1,085 Kwh, per hour.
Fresh Water	20 cu.m. per hour.
Feed Water	0.5 cu.m. per hour.
Circulating water	340 cu.m. per hour.
Tar and oil	0.610 tons per hour.
Benzine	0.150 tons per hour.

USE OF PRESSURE GAS WITH TURBINE:

The major advantage claimed for pressure gasification lies in the fact that gas compression costs are eliminated since the gas feeds straight into the Turbine at the desired pressure. For a 10,000 Kw. Set the comparison of power absorbed by compression, as between atmospheric and pressure gasification was stated to be:-

Atmospheric: compression power - 3,460 Kw.

Pressure type: " - 1,015 Kw.

Or a saving of over 2,000 Kw.

The second favourable factor lies in the fact that since the gas is already at the requisite Turbine entry pressure fine cooling and cleaning such as would be required for a compressor is avoided. In fact, satisfactory cleaning of the gas and condensation of tars and moisture to a high degree, can be carried out at as much as 145°C., and the retention of this sensible heat assists the thermal efficiency of the Turbine.

TAR RECOVERY:

With fuels having a tar content of 3% and over it is anticipated by Lurgi that it would pay to cool the gas sufficiently to recover tar and benzine, but with less than 3% it was proposed to send the gas straight to the Turbine at its outlet temperature of 300/350°C.

BLAST PREHEAT:

Operating without oxygen enrichment it was proposed to preheat the blast steam to 500°C. and also to experiment with preheated air. In each case this blast preheat would be provided by the Turbine pass-out gases.

GAS COOLER:

The standard washer cooler is 2,000 mm. high by 800 mm. diameter and is fixed adjacent to the generator outlet. Water or tar is circulated in a closed circuit with reducing valve type of overflow. There is a waste liquor circulation pump and a cooler of the heat exchange type which, for this gas turbine work, would

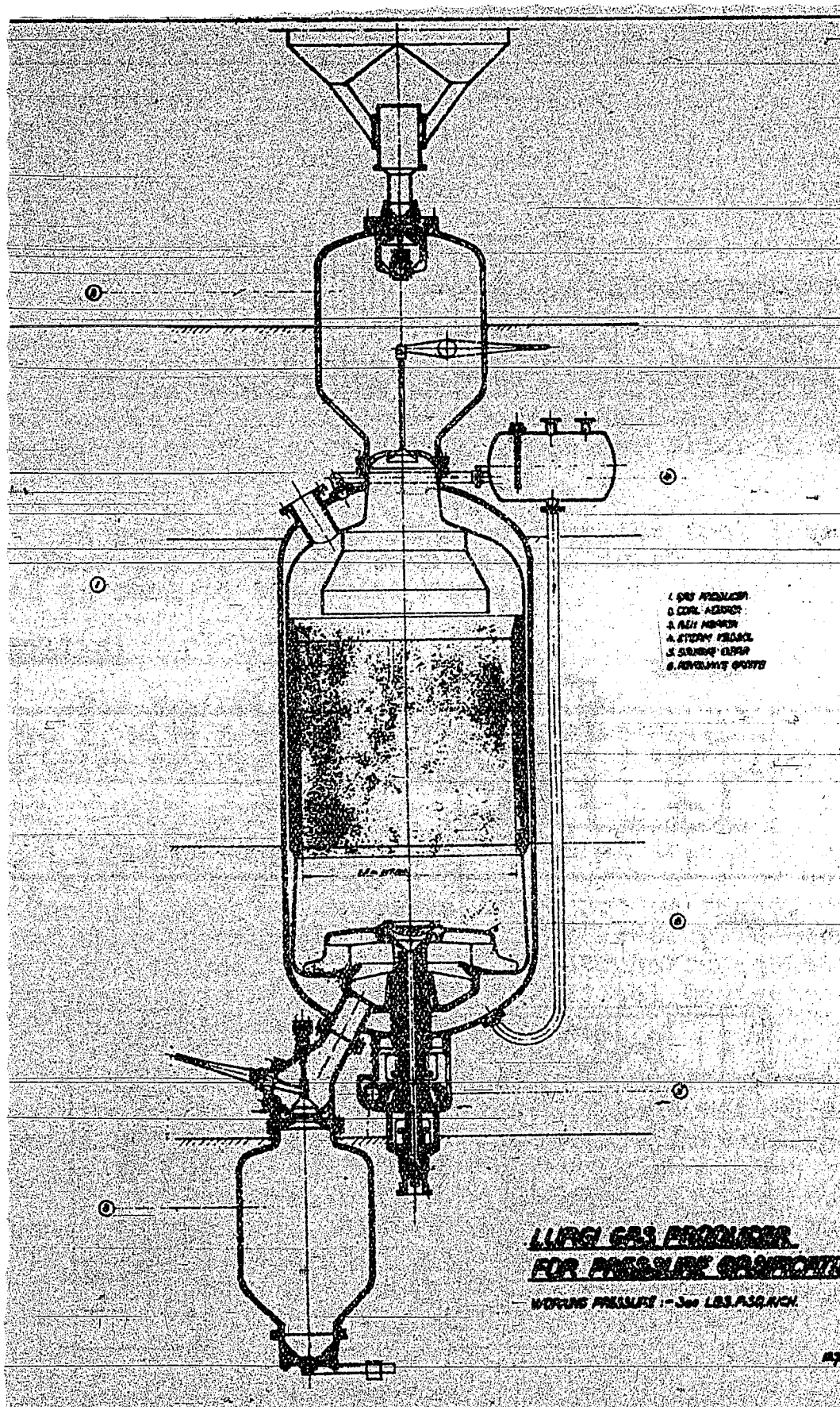

LURGI GAS PRODUCER
FOR PRESSURE GASIFICATION.
WORKING PRESSURE :- 300 LBS. P.S.I.G. APPROX.

FIG 1

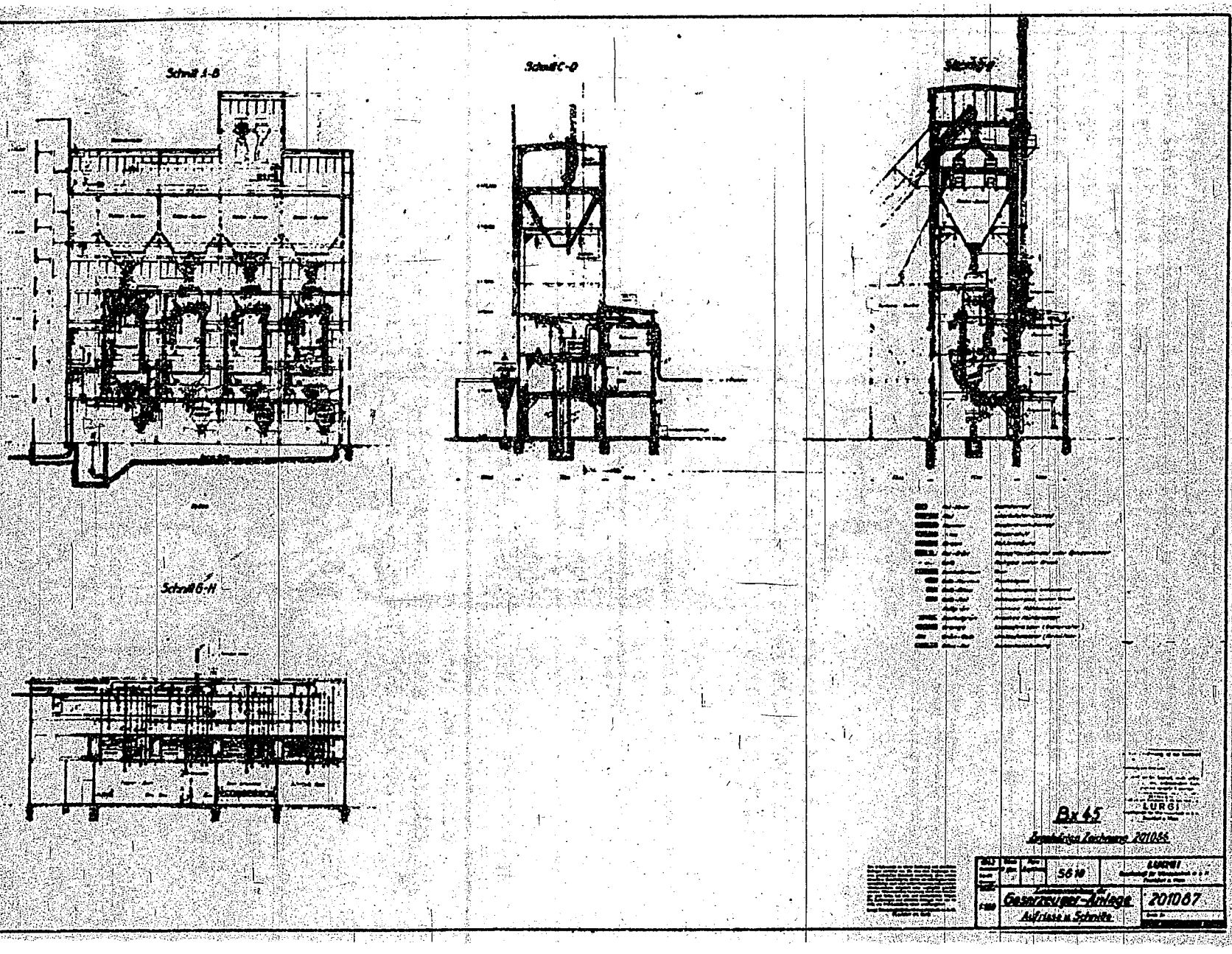

Schnitt A-B
Schnitt C-D
Schnitt E-F
Schnitt G-H
Bx 45
LURGI
5610
Gaserzeuger-Anlage
Aufrisse u. Schnitte
201067

Fig. 2

cool the circulated liquor only sufficient to reduce the gas temperature to 145°C. The washing and cooling liquor is admitted as a spray and on this account, as also on account of the temperature, CO_2 is not removed from the gas despite the pressure of 20 ats. at which the washing is carried out. In fact, for turbine work the presence of CO_2 was stated to be not a disadvantage.

FUEL HANDLING:

At Trattendorf the wet brown coal, having 50-55% moisture, was to be elevated to an overhead bunker from which it passed over a screen into a Buttner Drier in which the moisture is reduced to 30%.

A second screen further cleans the fuel from "fines" after the Drier and both wet and dried screenings were used as fuel in the drier furnace.

PLANT DETAILS:

For typical cross section of standard 2.5 m.Unit see rigure 1, also for layout of Multi-Unit Plants see figure 2 which relates to an Oxygen Gasification Plant at Brux.

Detailed engineering drawings of this standard Unit were said by Lurgi to have been brought away by an earlier Team. Further detailed drawings could not be found. It was stated that the manufacture of Lurgi Pressure Generators, so far built, had been carried out by Gutenhoffnungshutte at their Sterkrade Works near Holten and by the Mittel Deutsche Stahl-werk at Riesa near Dresden.

Lurgi were apparently still dissatisfied with fuel admission details and hydraulic equipment was to have been adopted had the Trattendorf scheme gone forward.

Reference should also be made to a tender to I.G.Farbenindustrie A.G., Bitterfeld, dated 20/6/44, which relates to a single generator unit having an hourly capacity of 7650 cu.m. pressure gas operating on poorer quality fuel.

FUEL:

Although it is claimed that the Pressure Gas Plant successfully gasifies "fines" it will be noticed that quite extensive coal screening plant was to have been installed. The normal fuel grading for brown coal was 2 mm. - 25 mm.

PLANT FOR TREATING OILS AND FATS.

This department was at the time of investigation situated in an outbuilding of the Polytechnickum at Friedburg, about 20 miles north of Frankfurt. The head of the department was Ober-Engineer Emil Morlock, age 63 years, served with Lurgi since 1927, last known address - Saarstrasse 21, Friedberg. He has no knowledge of English, his chief assistant is Arthur Milbars, a chemist who is about 45 years old. He understands English but speaks very little.

Vegetable Oil Deodorisation.

A typical Lurgi Plant is shown on the attached Flow-sheet Drawing No. DO.8062 dated 6.10.38. (See Figure 3).

The unrefined oil is pumped from storage to an overhead charge tank. In the case of very impure oils it then runs to a preliminary Refining Tank (No.32) of 5 tons capacity, to which a small quantity of weak H_2SO_4 (5%) is added. L.P.Steam on the jacket raises the temperature to 60 to 70°C and a propeller in a draught tube circulates the oil. This process takes just under an hour.

More normally the oil goes straight to the first Neutralizing Vessel (1). This is the same design as above. About 200 to 300 Litres of Soda lye of 20°Be is added from an overhead Charge Tank through a Measuring Vessel. A small quantity (about 400 to 600 Litres) of stock is drawn off from the bottom. The balance of the charge is pulled up by vacuum to the Bleaching Vessel (3). This Vessel is under a vacuum and fitted with simple stirring gear: the temperature varies from 90 to 100°C. Bleaching Earth is sucked in by vacuum. The reaction takes at 1/4 hour. The water jet of the Barometric Leg (6) also washes out any Bleaching Earth dust. The oil is now pumped (9a) to the Filter Presses (10a and b). The first small quantity is run back into the Bleaching Vessel. As soon as the liquid is clear it is run direct to an intermediate Storage Tank whence it is pumped (16) to the Hydrogenation Plant supplied by Bamag or other firm.

From the Hydrogenation Plant the oil returns to an overhead storage tank, thence to a further Soda Treatment Tank (2) where it is heated up to about 60°C in about 1/4 hour. A small amount of soda lye is usually added and the soap stock taken off from the bottom to the Storage Tank (jacketed). The charge is pulled by vacuum to the Bleaching Vessel (4). (This Vessel is

smaller than Vessel No.3 since only a part of the oil goes to the hardening process. From here the liquid is pumped (9b) to the Filter Presses 11a and b. The liquid then passes to an intermediate holding tank prior to being pulled into the Deodoriser.

Drawing No. V.1725 which is available but not attached to this report, shews a typical Lurgi Deodoriser. This particular Vessel is the secondary Deodoriser (20) but is similar to the first Deodoriser (19). The difference is that for the first Deodoriser the arrangement for collecting the ketone is not supplied, but a distributing bell in the liquid vapour zone, the base of which is about 30 to 40 cm. above the liquid level, is added and into this exhaust steam from the secondary Deodoriser Booster Pump is injected. The lower liquid level applies, therefore, to the first Deodoriser.

About 40 to 50 Kg. live steam per hour is injected into the central vertical circulating tube and the bottom perforated coil. About 1 Kg. of h.p. steam per Kg. of oil treated is consumed per hour for both Deodorisers. The holes in the top portion of the vertical tube are not really necessary. The normal charge is 5 tons and a vacuum of about 30 to 40 mm.Hg. is applied. A temperature of 150/160°C is achieved and treatment time is about 3 to 4 hours.

The secondary Deodoriser (20) Drawing No.V.1725, has a higher vacuum produced by a Booster, the exhaust steam from which acts as supplementary steam for the primary Deodoriser and is injected into a distributing bell in the liq-vapour zone beneath the deflector plate, but 30 to 40 cm. above the liquid level. A feature of this Vessel is the dished device in the top for removing the condensed ketones. The double plate acts as an "air" insulator to prevent re-evaporation. The oil seal is necessary on account of bolted construction to enable the cover and top to be removed.

The ketones go through a syphon (to balance pressure difference) to a container (29) which is connected direct to the lower vacuum line; vacuum in the secondary Deodoriser is 8 to 10 mm. Hg. and the temperature 170/180°C. Time 3 to 4 hours.

The secondary Deodoriser discharges to a water cooled Cooling Vessel (21) where the oil is cooled to about 50°C, sometimes lower. It then drains toa Finished Product Tank and provision is made for a final filtration if desired. The cooler is maintained under the same high vacuum and is also connected to the rough vacuum pump for preliminary evacuation.

There is also available but not attached to this report a list of firms to whom this type of Vegetable Oil Deodorising Plant has been supplied. In certain of these cases the Deodorising Vessel and Vacuum Equipment only have been supplied by Lurgi. Also available but not attached is Drawing No. DO.5789 dated 30.3.35., shewing a 20 ton per 24 hour Vegetable Oil Refinery Plant. It will be noted, therefore, that four charges are treated per 24 hours. The only plant visited was the Fritz Hollman A.G.Plant at Bad Rothenfelde. This was described by Herr Niermeir, the Process Plant Manager.

Vegetable Oil Refinery -
Fritz Hollman A.G. Dissen-Bad Rothenfelde.

Interrogated: Fritz Hollman - nephew of the Main Proprietor.
Herr Niermeir - Process Plant Manager.

The Plant as a whole was installed by Harburger Eisen-und Bronzewerke A.G.; Lurgi supplying some of the Deodorisers and Vacuum Equipment. It was understood that the Preheaters and Lurgi Booster had been discarded and the method of steam injection radically altered.

The output of the whole Plant was 100 tons of oil per 24 hours. Rape Oil was the most frequently used raw material.

Of the five Deodorisers four are in use; each takes a charge of 4500 Kg. oil, which is fed in with heating coils in action, time for charging and heating up to 120/130°C is about half an hour. Steam at 8 to 10 atm. pressure is used in the coils and is superheated to 300°C. for the open steam which is added at the rate of approximately 200 Kg, per hour for 4 hours, the coils being turned off towards the end of this process. During the period of discharge, lasting about half hour, cold water is passed through the coils. The high pressure condensate from the coils goes to a tank for heating water for the Bleaching Tanks. The open steam coils rotate by the action of the steam itself. Numerous small perforations in two alternating types of Disperser are used.

The Vacuum in the Deodorisers is only 25 mm. Hg. This is supplied by a large two-stage vacuum pump - cooling water is constant from wells at 11°C. A smaller single stage pump evacuates the Bleachers.

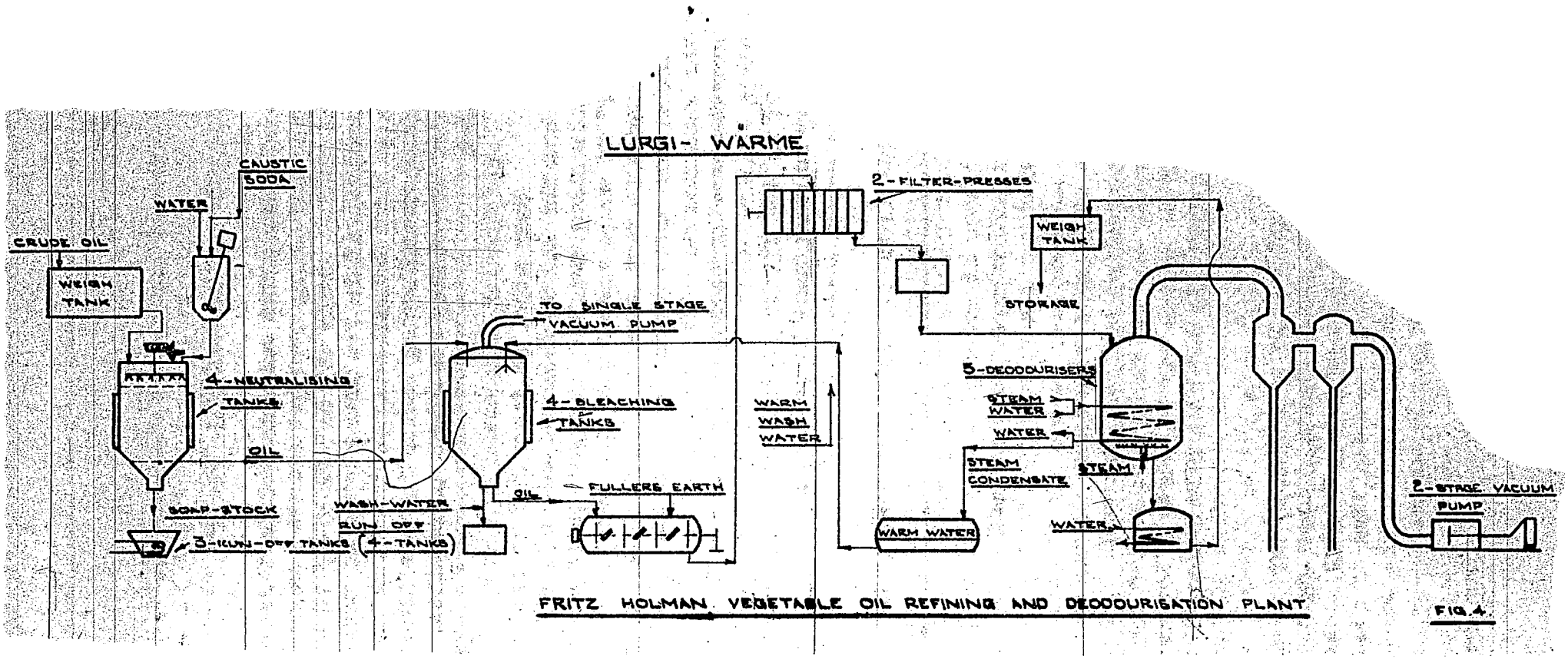
No hydrolysis is carried out as Fatty Acids are available from the soap stock. They had planned to instal a Hydrogenation Plant, also a Fatty Acid Distillation Plant just

before the war (not necessarily Lurgi).

See Flowsheet Fig. No. 4

The plant was arranged on three floors, the bulk of the equipment being arranged around a mezzanine floor with a central well. Crude oil is pumped up to a daily charge tank and from that it is fed into the weigh tank where it is passed to one of four neutralising tanks, which is not agitated but has a rotating distributing device for the incoming oil. Soda and water for mixing are added as required. The tank is steam jacketed.

Soap stock is drawn off to one of three run-off tanks and the oil is decanted and pulled by vacuum to one of four bleaching tanks. Although these are termed "bleaching Tanks" it would appear that the only operation carried out is washing with warm water pulled up from the ground floor by vacuum, the water having been heated by steam condensate from the deodorisers. The wash water is run off and the oil drops gravitationally to one horizontal mixer on the ground floor where Fullers Earth is added. From this mixer the oil is pumped to the filter presses whence it passes through an intermediary holding tank before being delivered to the deodorisers.



FRITZ HOLMAN VEGETABLE OIL REFINING AND DEODORISATION PLANT

FIG. 4.

Fat Splitting.

The Lurgi Fat Splitting Process is shewn on the attached Flow Sheet D.O.8495 dated 23.8.40. see Fig. 5.

Water which is heated in Preheater No. 3 to about 90°C and retained in the Feed Tank, No.10, is charged into Measuring Vessels No. 7 together with the appropriate quantity of crude fat from the Charge Tank No.9. As a typical example, for a neutral oil which is to be split 90%, the total quantity of water, which includes the direct steam injected in the Autoclave, is of the order 55 water to 45 fat.

A high pressure Reciprocating Pump No.6 charges the Autoclave No.1, which is shewn on drawing No. D.O.E.2255 dated 4.9.41. which is available but no reproduced in the report.

Steam at a pressure of 26 atmospheres is introduced through a small open coil at the bottom of the vessel and agitation is carried out by means of a simple paddle stirrer of small diameter rotating at 90 to 100 R.P.M.

The horse power consumed by the Agitator is 2/3, but normally a 5 H.P. motor is installed.

Stainless clad steel is normally used by Lurgi and Krupps guaranteed to them that it is as completely satisfactory in service as if made from solid stainless steel. Krupps themselves fabricate the Autoclaves. It was stated that Kelloggs in U.S.A. had made such a vessel to Lurgi design and when last heard of this was giving complete satisfaction.

For vegetable and similar fats where the temperature required for splitting is below 230°C. V2A steel contact is satisfactory, but for higher temperatures or more corrosive fats V4A is required. Bushes are made from a zinc free phosphor bronze; the stub shaft can be made of a chrome nickel steel in order to give a lower co-efficient of friction. A deep type of drip catcher is welded on to the shaft close to the bearing. 2,000 Kg. of crude fat is a normal charge; the hot liquid level is about 750 Mm. from the top of the domed cover. Normally charging takes about half an hour; heating approximately 3/4 hours and an average reaction time of about 2 hours; half an hour is required for discharging. A total process time of four hours for the most difficult fats should be adequate. This means, therefore, that about 6 charges can be treated per 24 hours.

The Autoclave is discharged under pressure to an expansion

Vessel No. 2 when steam is flashed off and the split fat cooled by evaporation. A pressure of 17 atmospheres is retained in the Autoclave so as to save heating time with the subsequent charge.

The fatty acid passes from the Expansion Vessel to one of two Settling Vessels No.8, and Glycerine water is drawn off from the bottom of the cone to Tank No.11, the fatty acid being withdrawn from a level half-way up the cone to storage.

Lurgi have reason to believe that one of their Autoclaves in U.S.A. and one in England are being used for Hydrogenation purposes. They state that probably hydrogen is introduced at 25 atmospheres in the presence of a nicket catalyst, prepared from formate by the wet process, and depending on fine suspension of the catalyst.

A list of plant supplied is available.

When visiting the Merische Seifen Werke at Witton a typical Fat Splitting Plant was seen. Although this was worked in conjunction with Lurgi Fatty Acid Distillation Plants it was stated not to have been supplied by Lurgi, on the other hand the principle of the plant was so similar to that described above that it could be taken as typical of the Lurgi Plant.

It will be noted that the proportion of fat to water is somewhat less than that given by Lurgi and that the cycle is slightly shorter.

A description of the plant is as follows:-

About 3 tons of fat and 1 ton of water are fed into a Coil Heated Pre-heater and warmed to about 80°C. This passes through a balance type of Measuring Vessel and is fed by a Brown Bouverie 3-Plunger Type of Reciprocating Pump into the Autoclave, charging time being 10/15 minutes.

The Autoclave which was made by Krupps was stated to be of V2A Extra Streel and was about 5'-6" dia.

In addition to the 4 ton charge approximately 1 ton of steam at 30 atmospheres is injected.

The speed of the stirrer was stated to be 200 R.P.M. There are two bottom draw-off cocks one of which has a short stand pipe so that normally a few inches of split fatty acid remains in the bottom of the Autoclave in order to lubricate the bottom foot-step bearing of the stirrer.

Normally a 90% split is obtained and the 10% neutral fat which is not split is separated during the subsequent distillation process when it is accumulated and resplit. About 250 kg. of Glycerine is formed during the splitting process.

The temperature in the Autoclave is reached about 1/4 hour after charging has been completed and the whole cycle, including discharging, takes about 2 hours.

The fatty acid is passed to overhead Expansion Tank where the bulk of the steam is blown off and a simple deflector plate and perforated disc arrangement seems the only means of separation. In practice some fatty acid is carried over so that a trap had to be introduced in the waste steam main.

The Glycerine in the fatty acid, which is normally about 20% of the quantity of acid is washed out with warm water in three Aluminium Settling Tanks, the Glycerine water and fatty acid being separated as on the Lurgi Plant.

Continuous Fatty Acid Distillation.

Unfortunately owing to dispersal of targets it was not possible to obtain complete set of working drawings for any one plant. Drawings, however, are available (but not attached to the report) shewing the principles of construction of the Still Body, the Still internal equipment and the Condensers. German Patent No. 675345 should be read in conjunction with this description. A copy of this patent is available. Of the fifty-odd plants supplied by Lurgi the last 19 are of the continuous type. None of these has been installed in Gt. Britain. The list of plants supplied is available but not attached to the report.

The attached Flow Sheet Drawing No. DO.8488 dated 6.8.40. shews the plant, see Fig. No.6.

A 90% split Fatty Acid is regarded as the most economic material for distillation. The sales value of the Foots decides how far the distillation should be carried. Normally to obtain a water-white fatty acid double distillation is necessary.

The throughput of this Plant, which corresponds to a Still 1.6 meters diameter, is 12 tons of crude fatty acid per 24 hours. The crude fatty acid is fed into a pre-heater No.1, which also acts as a preliminary Degasifier. This is connected to the low vacuum line and by means of a steam heated coil the temperature is raised to about 90°C. The crude fatty acid is drawn into the still by vacuum through an inlet in the base of the dished bottom and not in the well; the surface vacuum in the Still is 3-4 mm. of mercury absolete.

In order to obtain circulation, about 2 - 3 Kgs. of steam per hour is injected into the central tube of the well and about 50% of the charge is distilled immediately the emulsion of steam and fatty acid reaches the top of the central tube. Half the quantity, therefore, of emulsion passing up the central tube is deflected downwards in the form of a spray, and a small proportion of this is drawn off through a funnel into a circumferential annulus. The fatty acid has to flow the complete length of this annulus over heating tubes, and a small open steam coil lies in the bottom of the annular space. At the end of its path only Foots remain and this is continually drawn off to the Foots Receiver No.12.

Control is effected by analysing the Foots and subsequently varying the pressure of the steam in the closed coil in the Foots annulus, or alternatively by varying the rate of feed.

The normal liquid temperature in the Still is between 200-210°C. depending on the type of fatty acid being treated. The vapour velocity of the distillate at the top outlet of the Still was stated to be between 30 and 40 metres per second.

A typical Still Body is shewn on Drawing No.Z1/1859 dated 29.6.38. (Lurgi Drawing No.D.0.E.7935). They normally prefer a Cast Silicon Iron construction but they have had the Still fabricated in V2A Steel. The internal arrangement of the heating coil, steam spray coil and the annular arrangement for drawing off the Foots continuously, together with an elementary type of vapour separator enclosed in the Still itself, is shewn on Drawing No. D/1327 dated 25.6.38. (Lurgi Drawing No. D.0.E.8099). Both these drawings are available but not attached to this report.

The distillate passes through the Swan neck (3) to a Primary Condenser No.4 and a secondary Condenser No.5. These are of the baffle type and are shewn in a drawing No. D.0.8328 dated 29.7.39., which is available but not attached to this report.

It has been found by experience that if the cooling of the condensate is too rapid a harmful effect resulted. A higher temperature, therefore, is obtained in the Primary Condenser by using glycerine as a cooling medium. An incidental advantage is that corrosion problems on the aluminium body of the condenser were avoided.

The Glycerine Circulation Pump No.16 delivers about 5-6 cubic metres of glycerine per hour. Approximately 80% of the total condensate is brought down in the Primary Condenser at a temperature of about 100°C. Glycerine from the water cooled Glycerine Cooler No.13 enters the Condensers at about 50-60°C. This leaves the first Condenser at 90-100°C. and leaves the second Condenser at about 80°C.

The Vessel No. 18 is a Glycerine Expansion Tank attached to the Glycerine Cooling circuit.

The non-condensable residual vapours passing from the secondary Condenser enter an air cooled Expansion Vessel No.6. The drop in vapour velocity brings down about 1% condensate as a minimum and a maximum of 5% light fraction. These are normally returned to the Preheater for re-distillation.

The Receiver No. 9 situated subsequent to the Booster No. 8 collects about 1/4% of the distillate. Should the fatty acid be of a strongly foaming type then a slightly larger quantity of distillate will be collected in this Vessel. This also acts as a final catch-all in the event of the plant getting out of balance. No. 17 is a small final condensate Receiver for this small proportion of condensate which passes through the plant.

The vacuum jet and booster steam consumption is about 5 - 8 times the quantity of steam used in the plant, but this depends upon the leakage which occurs. Ideally five times the quantity of steam used in the plant should be sufficient, but in practice it was understood that leakage usually raised the figure to 8.

An overall loss of less than 1/2% fatty acid input was claimed for this plant.

Free fatty acid taken away in the Foots is normally between 5% and 7% when based on oleic acid of molecular weight 282.

A plant layout drawing No.DO.8682 dated 30.7.42. is available but not attached to this report. It will be noticed that as there is an existing Distillation Plant, the Fat Splitting Plant is for double the output. The distillation plant, therefore, shewn on the drawing is the 12 ton per 24 hour plant.

A Fatty Acid Distillation Plant was inspected at the Maerkische Seifen Industrie factory at Witten. This plant has an actual throughput of 15 tons of fatty acid per 24 hours, being, therefore, slightly in excess of the guaranteed throughput of 12 tons per 24 hours. The Official interviewed claimed to be perfectly satisfied with the plant.

Although this plant has been installed for a number of years, its general appearance and layout is very similar to the more modern plant, with the exception that the well is not fitted.

Generally speaking, the performance figures given by Lurgi were confirmed and the following additional data was obtained.

About 1/2 ton of steam was used per ton of fatty acid treated. This figure covers both the coil heating and steam injection, and unfortunately no separate figures could be obtained. About 3/4 ton of steam per ton of fatty acid treated was required for the jet. If Lurgi's figure of 5 - 8 times the quantity of steam injected is taken as fact, the amount of steam injected can be approximately worked out.

Slightly different figures for quantities condensed were obtained. These were: -

About 66% of the distillate condensed in the Primary Condenser and cooled to about 80°C. and about 25% of the distillate condensed in the secondary Condenser and cooled to about 60°C. The remaining percentage was collected in the air cooled Condenser.

The pitch was stated to contain 1% of the charge in the case of good natural fatty acid, but on occasions this was 2 - 3%. This will be noticed to be a lower figure than Lurgi itself claims. The pitch was re-split after sufficient build-up had been accumulated.

About 100 Kilogrammes of fatty acid was collected daily in the after condenser. The overall loss of fatty acid from the plant was about 1/2% of the input.

The vacuum varies from 2-4 mm. mercury absolute and depends on the vapour tension of the fatty acid being distilled, this decreasing with the higher molecular weight when higher vacuum is required. They could not measure the drop in vacuum over the condensers. The vapour pipe on the Stills to the Primary Condenser was about 80 cm. diameter.

The plant was stated to have been in continuous operation on more than one occasion for a period of six months. When they required to change from one stock to another it usually took about two hours to clear the contaminated material from the Still. However, since they were themselves utilising the distilled fatty acid, they could use the intermediate tainted distillate for laundry soap.

A small quantity of steam is injected into the Preheater in order to break down surface tension so as to assist de-aerating and drying.

There was a modern high temperature Fatty Acid Distillation Plant supplied by Lurgi in the same building. This was really supplied as a trial plant for the much larger plant supplied in connection with the Synthetic Fatty Acid Distillation and Production Plant. It was normally used for balancing production or for second distillation of synthetic fatty acid for special purposes.

The main feature of this plant was that it was heated by a high temperature, high pressure hot water circulating system.

Hot water at about 150 atmospheres pressure at a temperature of approximately 360°C. was circulated. An interesting feature is that only about 50 litres of water were in circulation at once. The water was heated by a Town's Gas heated tubular type of heater. The sustem was supplied complete by Sangerhausen and Lurgi claim to know little of its operation. However, a customer's general arrangement drawing was seen and this indicated that the feed pipe from the pipe still type of heater was 63 mm. internal diameter by 85 mm. external diameter. The coils were stated to be of the same size, and the heating surface was believed to be similar to that which they normally used for a steam Still of the same output. It is interesting to note that they insist on an overall co-efficient of heat transfer of between 300 and 500. It is clear, therefore, that steam must be mixed with water so as to give turbulent flow. The return pipes are 38 mm. inside diameter by 54 mm. external diameter. No circulating pump is used. The heat user (Still) must be at sufficient height above the heat producer to permit balanced gravity return. In point of fact this was from 3 - 5 metres. A hand pump is used to obtain and maintain pressure appropriate to these conditions.

The only other feature distinguishing this Distillation Plant from that described above is that this being the more modern type it is fitted with a well.

A subsidiary company, the Deutsche Fettsaeurewerke had a large Fatty Acid Distillation Plant as part of the Synthetic Fatty Acid Production Plant from Gatsch described elsewhere in this report.

There were two parallel batteries of four Stills, each of which was heated by high pressure hot water circulating system as previously described above. Each of these Stills had its own pair of Condensers of the conventional type.

The approximate output of each Still was 12 - 15 tons per day.

The most interesting feature of the plant was the attempt to produce continuous fractionation. The four Stills in each battery were stated to run in series. In the first Still, C.9. were drawn off, in the second C.10 - C.18, in the third C.19 - 22 and in the fourth fractions higher than C.22.

This had obviously not proved completely successful

since the Deutsche Fettsaeurewerke had added a Fractionating Column to the first Still in the case of one battery and to the second and third Stills in the case of the second battery. These were packed with corrugated sheets down which the reflux flowed. Roughly these Columns were 3'-0" - 3'-6" internal diameter by 15'-0" - 18'-0" high.

Attached to each was a Reflux Condenser having a reflux ratio of 4 : 1. Different Stills in the two batteries had these Fractionating Columns since different fractions were required for various purposes. The split of the fractions is claimed under these circumstances to be accurate up to 3% of exactness. Patents have been applied for this plant by M.F.I.

The throughput of the plant was 50 tons per day and about 15% of this was obtained from the first Still in each battery, about 50% from the second Still in each battery, about 20% from the third Still in each battery and about 15% from the fourth Still of each battery including Foots.

No operational charts or log sheets were obtainable for the Fatty Acid Distillation Plant at these two united works. It will be understood, therefore, that the individual interviewed was not necessarily reliable on all details. This applies particularly to the large Fatty Acid Distillation Plant described.

The condition of the plants at these allied works was first class and they were immediately ready to go into production as soon as any raw materials were available. In point of fact, the plant first described was operating during part of the day on which the visit was made.

Glycerine Distillation.

A detailed flow sheet drawn to scale No. DO.6968 and drawings of the Still itself, No. D.O.E.7083 dated 18.2.37. are available, but not attached to this report. The normal feed to this plant is 700/800 Kg. per hour of Crude Saponification Glycerine containing approximately 85% of recoverable glycerine, the balance being water and pitch.

The crude glycerine is fed into the bottom of a Pre-heater and preliminary Drier about 1.96 metres diameter by approx. 3.1 metres overall height. This contains a long internal coil heated by low pressure steam with a standard centre tube up which the glycerine passes with the aid of steam injected in the bottom. The vacuum in this Pre-heater is of the order of 40 m.m. If the moisture in the feed is 8-10% then it is reduced to 3-5% in the Pre-heater, the temperature being raised to about 95°C. A reflux condenser containing raschig rings is placed above the Pre-heater and there is a cooling coil above the ring level.

The pre-heated glycerine is drawn off from the Pre-heater at a level just above the top of the heating coil and passes to the Still. This is 2.2 metres diameter by 3.1 metres deep and contains two banks of double heating coils 1.8 metres diameter and 1.4 metres diameter respectively. These are heated by steam at 12 atmospheres pressure. In the bottom of the Still is a small low pressure ring main from which 8 radial spray tubes 32 mm. internal diameter, each containing 25 holes 4 mm. diameter on each side of the tube in the horizontal plane protrude. Low pressure steam is used in these.

Low pressure steam is also introduced into an annular space around the base of the tube, the top of the annulus is welded to the tube itself and the bottom of the annulus is welded to an inverted cone 241 mm. internal diameter at the base by 172 mm. internal diameter at the top. The gap between the top of the cone and the base of the central tube is 10 mm; the centre tube is 203 mm. internal diameter.

The total quantity of injected steam is about 12% of the hourly charge, i.e. approximately 100 Kg. per hour.

Above the Still there is a small raschig ring entrainment separator containing 1.3 cubic metres of aluminium rings 25 x 25 x 1 mm.

The Still is operated under a vacuum of 12 mm. Hg. absolute.

For normal soap lye glycerine the plant will operate for 3/4 days before the accumulation of Foots necessitates closing down: If saponification glycerines are used the plant can run for 5/6 days. Due to the war time shortage of soap lye glycerines they were using glycerine from an unstated source where the Foots accumulation forces the plant to be shut down after about 12 hours.

Lurgi are not convinced of the necessity of having the raschig ring Reflux Condenser and the raschig ring entrainment Separator, but some clients preferred to have these. In the plant described an additional final Separator was fitted by the client just before the steam booster.

The vapour pipe from the entrainment separator is 600 mm. diameter and leads to a series of 4 baffle type Condensers. These four Condensers were stated to operate under vacua of 10 mm.; 7 mm.; 4 mm.; and 2/3 mm. of mercury absolute respectively. The first two Condensers are glycerine cooled and the second two are cooled by warm water. In both cases the cooling medium is circulated by a centrifugal pump.

The overall loss of glycerine is claimed, in the case of saponification glycerine, to be 1.5% and in the case of soap lye glycerine to be 2/3%. In the case of saponification glycerine the glycerine contained in the Foots which is sent to waste is included in this figure. If the Foots from soap lye glycerine is sent to waste, then the overall loss rises to 6%. If the plant economics require a lower loss then the Foots can be washed, cooled, centrifuged and after purification by $Al_2(SO_4)3$ returned to the crude feed, thus reducing the overall loss to the 2/3% mentioned above. (Another staff member gave figures if soap lye glycerine is 3/4% minimum loss with 8% if glycerine was left in the Foots).

With saponification glycerine it is claimed that with perfect operation of the plant, pure glycerine could be obtained by single distillation, but more generally a second distillation was required.

The German equivalent to B.P.Glycerine is Deutsches Arznei Buch No.6 (D.A.B.6.). It is customary to treat the glycerines distilled on Lurgi plants with activated carbon before this specification could be reached. The analysis of glycerine is based on esterification by Acetic Anhydride.

Normally the Pre-heater and Still are fabricated in Mild Steel and the Condensers made in Aluminium.

The steam consumption of the vacuum jets is 5/8 times the quantity of water in the crude plus the steam injected. The vacuum system is designed to produce a vacuum of 2 mm. under closed suction.

Summary of Oils and Fats Department.

Broadly speaking, there appears to have been little technical development of the Vegetable Oil Deodorising Plant during the last few years. It would not appear that Lurgi in any way held the monopoly of this particular process and their main selling point appears to be the utilisation of their steam jet vacuum equipment.

On the Fat Splitting Plant again there did not seem to have been any radical change in design during recent years. Although no definite connection between Lurgi and Krupps could be established, it seems not unreasonable to assume that as Krupps made all the Autoclaves for Lurgi, in such cases when Krupps supplied the Autoclaves direct, based on the Lurgi system, there may have been some form of reciprocal arrangement. Lurgi stated that they were not seriously considering development of Continuous Fat Splitting Plant due to the wide variety of stocks used in the industry.

On the Fatty Acid Distillation side again, for normal products the only radical development during recent years is the arrangement for continuous draw-off of the Foots. The main technical development on Fatty Acid Distillation Plant arises from its adaptation to the production of synthetic fatty acid. The attempt in this process to obtain fractional distillation by using four Stills in series under increasing vacua would not appear to have met with complete success. On the other hand, the addition of the Sangerhausen high temperature, high pressure water heating system seems to operate successfully. Lurgi did not seem to consider they would normally use this system for conventional Fatty Acid Distillation.

No evidence could be found that their Glycerine Distillation Plant had been improved at all during the war, and on the whole it seems that they had paid little attention to technical development here and had concentrated on synthetic fatty acid distillation.

The table given below shews the value of orders received for the various sections of this department during the past few years and also gives the amount of money expended on research and development more recently. It should be noted that a certain amount of this money spent on research was recovered from the client. The departmental profit and loss for the last three or four years is shewn on the table.

OILS AND FATS DEPARTMENT.

Figures in thousand Reichmarks for years ending on 30th September.

		1929-1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942
Contracts Received	Deodorisation F.A. Dist. Glycerine Dist.	675	654	1079	877	1215	361	848	756	1152	1099	428	684	718	648
	Fat Splitting						96	385	115	565	231	120	95	295	3
	Synthetic Fats												4370	731	1544
Research Expenditure.	General												16	6	8
	Synthetic Fats												13	24	25

PROFIT AND LOSS FOR WHOLE DEPARTMENT.

1939		1940		Gross Profit 1925 - 1940.	1941		1942.	
Profit	Loss	Profit	Loss		Profit	Loss	Profit	Loss.
67	-	63	-	1,014	-	19	-	41 *

* Probably due to the large Synthetic Fats Contracts of 1940 being as yet uncommissioned or causing operational difficulties.

W I T T E N

When visiting the Fat Splitting and Fatty Acid Distillation Plants at Witten an interesting installation was seen. This is only described briefly here since its only connection with the Target Firm was that it provided the Synthetic Fatty Acid for a large Lurgi Distillation Plant, described above.

Dr. Imhausen, Director and Dr. Prosch the Technical Superintendent, were interviewed.

The Marksiche Seifen Industrie is the owner of the Deutsche Fettsaeurewerke but the large plant installed in the works of the latter for the production of Fatty Acids from Gatsch produced by the Fischer-Tropsch Synthesis is owned 50% by M.S.I. and 50% by Henckel & Cie. The cost of this plant was R.M.12,000,000.

The two firms had suffered air raid damage (mostly March 19th) and their laboratories, office containing all records and drawings, and the electrolytic cells and Fat Hydrogenation Plants were amongst those destroyed. Their Glycerine Distillation Plant - a van Rymbeck, was scheduled to be replaced by a new Lurgi Plant in about 1940, but was prevented by the war.

Their Oxidation Plant is only briefly examined since it is only a forerunner to produce materials for a plant supplied by our target firm. It is interesting to note, however, that the pilot plant was scaled for 100 Kg. charge so that the step up was courageous. The scale of increase on the Oil Deodorisation Plant was similar and it was vehemently asserted in the latter case that there had been practically no teething problems.

Lack of gas is the immediate cause of non-operation of the plant since they have in stock a limited quantity of crude material.

See attached Fig. No. 7 shewing a general rough flow sheet.

Oxidation Plant.

Gatsch is brought from the Fischer-Tropsch Plants in rail wagons and pumped into storage tanks. The analysis of the Gatsch deliveries varies slightly.

The oxidation of Gatsch is carried out catalytically in 48 vertical aluminium (100% Al) vessels. 40 of these are of

10 tons capacity each and 8 are of 20 tons, made by Schmidding Werke, Coln-Hannover. They have cooling coils and an air diffusion plate.

Process: 0.2% by weight of permanganate of Potash as a solution in distilled water of 10% strength is added to the batch of Gatch. Air at the rate of 50 cubic metres per hour per ton of Gatch is blown in through the bottom diffuser plate. The air is supplied by a battery of 4 Guttehofnungshuette motor driven Turbo Blowers.

The batch is warmed up by steam in the coils to 110°C after which the exothermic temperature is controlled by water in the coils to 100°C.

The oxidation continues for 25 hours by which time 30/33% of Fatty Acids have formed.

Also during the 25 hours, 4% of Light Fatty Acids, alcohol and light boiling paraffins come off, and for this reason the spent air leaving the top of the tower passes through a Condenser and drip catcher which catch these light fractions before the air blows to atmosphere.

The whole of the batch is transferred to a Settling and Saponification Vessel. Here the batch is first neutralized with Sodium Carbonate. This allows one-third of the unoxidized Paraffins to separate out. These are turned to the raw stock. Caustic lye is then added and the batch agitated by agitator gear of the propeller type.

This provides an emulsion of soap and Paraffins which is passed through a pipe still, Towns gas fired, the temperature being 360°C., a small amount of steam sometimes (? always) being added to assist in the operation of the pipe still.

The pipe still is followed by an inbuilt Flash Evaporator where, because of the temperature and the pressure, the soap is thrown down and the Paraffins, being the remaining two-thirds of the unoxidized batch, are condensed and returned to raw stock, being centrifuged en route to remove water. The hot soap is immediately discharged by screw feeders into water since the temperature of 360°C would cause it to spoil if given access to air.

The soap-water mixture is then fed into an open acid-proof brick lined tank with propeller agitator where it is split

into Fatty Acids by treatment with H_2SO_4. These raw Fatty Acids are distilled as described under Fatty Acid Distillation.

The plant has a capacity of 40,000 tons input per annum of 300 working days and gives a conversion of 80%. The raw Fatty Acids have the following range of carbon content:

4% light fractions.
15% C9-C10
50% C10 - C18
20% C18 - C22
The rest Pitch.

From the C10 - C18 fraction is distilled the C10-C12 which is used for manufacture of edible fats. The 4% initial fractions are processed to make softeners for the artificial rubber industry and are remarkable for their fluidity at low temperatures.

Synthetic Edible Fats.

200 tons per month of Synthetic Edible Fats are made from Synthetic Fatty Acids, which in turn are synthetic hydrocarbon as their base.

The plant is simple, being much the same in layout as a natural edible oil plant.

Conversion:

A 3 ton charge is made up of C10-C12 Fatty Acids carefully distilled and glycerine, the proportion of glycerine being 13.8% but which varies slightly according to the exact nature of the acid.

At 10 mm. Hg. vacuum and 220°C. the charge is esterified, a very fast stirrer with a 4-bladed propeller being used. The Vessel was made by Bamag.

A 98% conversion is effected.

Refining:

In the Refining Vessel the batch is first neutralised with NaOH, washed with water and then dried out completely under high vacuum. A mixture of Fullers Earth and activated carbon is added and the whole thoroughly agitated.

Filtering:

The Fullers Earth and active carbon is extracted in two Filter Presses of normal type.

Deodorising:

At 4mm Hg. vacuum and heated to 200-220°C. by 40 atm. steam, the oil is deodorised. Live steam is admitted to the charge to assist in driving off the odorous volatiles. The Deodoriser has a superimposed Reflux Condenser and Cooler.

All vessels are made by Bamag.

The finished fat has a melting point of 34°C and does not require hardening. After two years a sample was found to be sweet to taste and granular in composition.

Margarine:

In normal type churns the fat is mixed with 20% distilled water, carotene, salt and flavouring. After churning the Margarine is chilled on an Ammonia cooled drum and finally kneaded in a vacuum machine made by Schroder of Lubeck.

Krause Spray Driers.

This department operated with the Evaporator Department under Paul Roepstorff who is 52 years of age and has been with Lurgi since 1920. During this time he spent about six years in Italy installing and commissioning Spray Driers and Evaporating Plant, and also paid one or two visits to England. He can speak moderate English. He was not more co-operative than he had to be.

From a list of orders which is available but not attached to this report, it will be seen that they have received 263 orders. Of these about 25 have been cancelled during the war, many of them for Russia, or were not delivered before the occupation.

In addition, a further 70 are of small size, some of which may have been used on the commercial scale, but most of them were for development or very special products.

This leaves, therefore, approximately 170 Spray Driers of type 100 and upwards. Of these more than half were supplied for milk products and soap products, the latter predominating.

Normally the chamber of the Spray Drier is made in concrete although stainless steel and, on other occasions, acid resisting lining has been employed.

Up to 1936 they used an underdrive for the larger size Driers, but they found that with an overhung drive they were able to get a lower temperature since this gave complete co-flow of air and powder, as opposed to part co-flow and part counter-flow. It was found that the temperature of the powder was lowered about 8 - 10°C. In practice, therefore, with a normal air temperature of 150°C. for a standard plant the powder temperature does not exceed 60°C. and more usually with the modern overhung drive a temperature of 50°C. is normal.

All Lurgi Spray Driers have the bag type of filter which is supplied by a firm called Beth of Lubeck. In the case of the smaller driers, these filters are contained in a space around the Drier itself, but in the case of the larger Driers there is a separate filter chamber.

They guarantee an overall recovery of 98 - 99%. In the case of dried milk about 70% of the powder is collected in the chamber and about 30% in the filter.

There are 13 standard models of Spray Driers. These

are types 10, 25, 50, 100, 150, 250, 350, 500, 750, 1000, 1250, 1500 and 2000.

These sizes were originally fixed to correspond numerically with the throughput of milk in litres per hour.

The following typical diameters in relation to size of plant are given:

Type	100	-	4 metres dia.
Type	250	-	5 metres dia.
Type	500	-	5.5 metres dia.
Type	1000	-	6.5 metres dia.

There are three types of discs. Firstly a two nozzle disc 170 mm. diameter for Types 10 - 50, as shewn on Drawing K.III/2204.

The discs for types 50 - 750 are 355 mm. diameter and are shewn on Drawing No. K.IV/2441. There are four nozzles to each disc up to type 250, each nozzle being 40 mm. long by 8 mm. bore and made of Stainless Steel. For types between 250 and 750 there are eight nozzles 50 mm. long by 5 mm. bore.

The disc for types 1000 - 2000 is 385 mm. diameter and is shewn on Drawing No. K.IV/2436.

These drawings are available but not attached to this report.

For materials other than soap there are four nozzles, these may vary from 52 to 45 mm. in length and are all 15 mm. bore. For soap there will be eight nozzles, but particulars of the size and bore were not taken.

Lurgi make their own discs and have a special small workshop for this purpose at Oberuersel, Nr. Frankfurt, Epsteinstrasse 2b.

The standard periphial speed of the disc is 150 m/sec. In order to give flexibility to the plant the variable speed drive is normally arranged so that it has a range of speed of 5000 - 7500 R.P.M.

In fixing the inlet and outlet sizes for the suction fan and delivery fan for air, they normally take a 25% diameter

in excess of the theoretical for the inlet and a 30% diameter excess of the theoretical for the outlet.

The equipment for discharging the powder normally rotates at about 1 R.P.M.

The feed is controlled by adjusting the by-pass quantity by means of a hand operated cock. The speed from the gearwheel type of pump (this is also made at the small workshop at Oberuersel, mentioned above) is constant at a pressure of 10 - 15 metres of water.

So far as possible standard plants are used and a certain amount of judgment is exercised in the selection of size by knowledge of the difficulties of drying the particular products concerned. Control is reasonably flexible so that throughput or air temperature adjustments will cater for most unknown variations.

They have a demonstration plant which will be described later, so that they are able to try out working conditions for the control of products for which they have little previous experience.

Two typical modern plants for the production of albumen from yeast milk were examined, and the principal drawings together with data sheets are available but not attached to this report. For purposes of reference see list of drawings which are given below.

Contract No.K.V.230 for Type 500 Spray Drier, ordered December, 1941 by Feldmuehle Papier & Zellstoffwerke A.G., Berlin.

Raw Material	Hefemilch (Yeast milk to produce Albumen).
Throughput	750 Kg. per hour raw material.
Percentage of solid in feed.	35%
Quantity of moisture to be removed.	450 Kg. per hour.
Liquid temperature	45°C.
Quantity of powder produced	285 Kg. per hour.
Residual moisture	10%
Steam consumption	788 Kg. per hour at 2.5 atmospheres. 410 Kg. per hour at 8 atmospheres.
Total filter surface	305 Cu.M comprising 8 Filter Chambers each containing 17 Bags 20 cm. dia. by 325 cm. long.

Sheet No. 97

List of drawings available:

K.VI/1788	Layout drawing or Spray Drier and Concentrator.
K.VI/1619	Drying Chamber and Filter Structure.
K.VI/1678	Hot Air Distribution Channels.
K.V.E.1060	Air Heater.
K.V.E.1213	~~Structure for Beth Filter.~~
K.VI/1448	Discharge Gear.
K.IV/2684	Discharge Gear Drive.
K.IV/2688	Discharge Chute.
K.V.E.1126	Discharge Conveyor.
K.VI/1633	Exhaust Air Equipment.

Contract No. K.V.209/208 for two type 101[illegible] Spray Driers.

List of drawings available:

	~~Calculation Sheet.~~
K.VI/1549	Plant Layout.
K.IV/2573	Drive for Emptying.
K.VI/1548	Drying Chamber.
K.VI/1547	Filter Casing.
K.VI/1553	Suction and Blowing Apparatus.
K.VI/1554	"Schlauchböden"
K.VI/1558	Discharge Mechanism.
K.VI.1563	Air Inlet Channels.
2.4525a	"Zentral-Aggregat"
K.IV/2436	Spray Disc.
K.IV/2343	Drive for Spray Disc.
K.IV/2569	Dividing Walls for Filter.
	Temperature-Moisture Chart.

Demonstration Spray Drier.

The original experimental spray drier at Houssonstrasse was 1.3 - 1.5 metres diameter. Lurgi stated that this was sufficiently large to enable them to obtain results for their own purposes. It would appear that during the war a contract for a small commercial sized plant, Type 50, was cancelled after the plant was nearly at the complete stage and Lurgi, therefore, decided to instal this in their experimental station. Possibly the taxation position was such that they were able to do this with very little expense to themselves.

The present plant is, therefore, more in the nature of a demonstration rather than a trial plant. The standard output is of the order of 150 litres of water evaporated per hour.

The Drying Chamber is about 9 feet diameter by about 8 feet high, having a flat, slightly inverted conical roof. The walls and floor are lined with acid resisting brick and the top is made of dull polished Stainless Steel. There is a door 6'-6" high by 2'-4" wide (also brick lined) with Stainless Steel Flanges and soft rubber joints. There is a sight glass in the door and a light glass in the wall immediately above the door.

There are four evenly spaced filter bags through which the exhaust air passed from four outlets in the bottom of the chamber. These outlets are approximately 21" wide by 24" deep in the vertical, the base sloping upwards at between 30 and 45°, the minimum section being 1'-2" across.

The air after passing through the four filter bags is collected in an annular space at the top of the drier and is pulled through a fan to a steam heated heater, or alternatively an electric heater. (There are three banks of heater, each having a capacity of 17 Kw.) The air then passes to an inlet in the top of the Drier and it was noted that fresh air could be added to this or taken in entirely at the same place. The air was introduced to the Drier through an annular space 16" external diameter by approximately 11"" internal diameter. This was placed immediately above the spray disc, the driving shaft of which passed through the centre of the 11" tube.

A steam injection line was also available and this has been used on occasions to clear the feed pipe, but it was understood that it was put in experimentally and no conclusive results had yet been obtained from it.

The spray disc was neither assembled nor available, but it would appear to hang about 12 - 14 inches from the top of the Drier.

Two thermostats are situated in the chamber adjacent to the door and are 16" from the top and bottom of the Drier respectively and approximately $10\frac{1}{2}$" long.

The raw material feed is contained in two conical steam jacketed feed tanks of about 7 - 10 gallons capacity each. A rubber connection to a funnel controlled by a hand operated cock leads to the actual feed pipe.

The motor to the geared spray disc drive is a standard type of 1420 R.P.M.motor.

A second geared motor drives a shaft which operates through equal bevels and drives four shafts along the four sides of the rectangular top of the Drier. By means of two eccentric cans at each corner, operating one after the other, it operates a shaking device on each dust filter and also opens a small damper to cause fluctuation in draught on the filter bags. The speed of rotation is approximately 1 cycle per minute.

The underdriven discharge scraper and discharge system comprises a horizontal bar about 4" from the floor of the Drier, having two paddles on each arm, each paddle is about 18" wide and can be adjusted both laterally and vertically. The outside scraper on one bar only can also be adjusted so as to operate vertically and sweep the bottom of the side walls about 18" down to ground level.

As an addition to this standard arrangement, and obviously after the plant was installed, an arm which is wire stayed goes to the top of the side of the Drier so that two scrapers respectively 12" and 16" long by 5" wide can be attached to scrape the top of the side of the Drier. The top of these scrapers was 1.3/4" from the top of the side. It was understood that this was only used occasionally when circumstances were such that the spray would adhere to the side of the Drier.

The scraper paddles are made of a fiberite type of substance backed with Stainless Steel.

A motor driven worm reduction gear drives the scraping and discharge apparatus through a bevel and crown wheel drive. An extension of this drives large and small pulleys to operate a simple flap type discharge valve, the speed of which is approximately 15 - 20 R.P.M.

The bottom outlet of the Drier is 16" x 6.1/2" reducing to about three quarters of that size for the flap discharge valve.

The bottom outlet opening is recessed so that a grid and covering plate can be placed there if and when only a small quantity of raw material is available, i.e. insufficient to fill the discharge system and conveyor and have sufficient surplus for results to be obtained.

There are two manometers connected to the inlet and outlet of the air fan, but no records could be obtained stating what normal pressures were used.

The plant was normally run by Ober-Engineer Kretzdorn who is at present working for the Military Government.

It was understood that in principle this Drier was used for determining the working conditions and sizes of the Driers being offered to clients, rather than for research purposes to improve their existing type of Drier.

They seemed reasonably satisfied that they had sufficient market for the Drier as at present designed, and that there was, therefore, little serious improvement to be carried out.

Evaporators.

Dispersal of offices and personnel, coupled with transport difficulties made the investigation of this section less detailed than was desirable. However, the drawings and quantities were obtained for several typical plants; these are available but not attached to the report.

In principle, Lurgi are only interested in the Vapour Recompression type of Evaporator, but they have supplied triple effect Evaporators with forced circulation for sulphite liquor and they have also made salting type Glycerine Evaporators.

Although they list 363 plants as having been supplied by them (this list is available), in point of fact, a considerable proportion of these are only for the Vapour Recompressors or certain units such as the heater. In addition approximately 40 of these were either cancelled during the war or unfulfilled at the time of the collapse.

Of the 62 Evaporation Plants supplied since 1937, 12 were for Kartoffelfruchtwasser, 12 for milk and whey, 7 for albumen, 5 Glycerine, 4 tomato juice, 4 sulphite liquor and 18 sundry plants.

An analysis of the 50 previous contracts shews that 15 were for milk and whey, 11 for tomato juice, 3 glycerine, 3 sulphite liquor and 18 for sundry products.

These plants are briefly described hereunder, giving in each case the list of drawings which are available.

Contract CV 268. This was one of the Kartoffelfruchtwasser Plants ordered in 1938. It was understood that the ultimate purpose of the plant was to obtain albumen and that the potato waste liquor was from starch plant.

Product	Potato waste liquor.
Throughput	4300 Kg. per hour.
Percentage solids concentrated to	5.5% 45%
Temperature	40-45°C.
Quantity of water evaporated	3800 Kg. per hour.
Steam pressure	7 atmospheres.
Steam consumption	2150 Kg. per hour.
Quantity of cooling water	60 m^3/h
with temperature rise	15 t 32°C

This plant is arranged for continuous operation, and the Calandria of the Evaporator is 2.4 metres diameter by 105 cm. deep, contains 2173 copper tubes 30 mm. inside diameter by 33 mm. outside diameter, laid out in hexagonal form so that an arrangement of weirs and baffles makes it in effect a multi-pass heater.

The vapour separation chamber, 2.7 metres diameter, contain elaborate baffle arrangements necessitated by the foaming nature of the product. Calculation sheets for the Pre-heater and Evaporator Calandria suraces and quantities of cooling water in the Vapour Recompressor and also sheet shewing the calculations for the Vapour Recompressor itself, are available.

Drawing No. C.III/4124 gives diagrammatic layout of the plant with all pipe connections; drawing No. C.VI/4095 shews the general arrangement of the plant; drawing No. C.VI/4142A shews the copper Evaporator Body and Vapour Separator; drawings Nos. C.IV/4132 and C.VI/4076 shew the Vapour Recompressor arrangements.

Contract CV 307/8. This is a twin plant for potato waste liquor similar to CV 268, supplied in 1941.

The quantity of cooling water would be 40 times the quantity of steam evaporated if the cooling water is raised from 15° C. to 30°C. and 60 times the quantity of steam evaporated if the cooling water is raised from 15°C. to 25°C.

Drawing No. C.III/4254 shews an undimensioned layout of the 2 plants and drawing No. C.IV/4269A details the Evaporator with 2.6 M. diameter Calandria being 1.2 M. between tube plates. The hexagonal form of construction with the weirs is shewn somewhat more clearly than in the drawing for CV268.

Contract CV 272. This is a large quadruple effect forced circulation wood pulp sulphite liquor Evaporator ordered in 1939 and has the following characteristics:

Product	Sulphite waste liquor.
Throughput	38,000Kg. per hour
Percentage solids	9.5%
Concentrated to	50%
Temperature at each stage	110/95/78/55°C.
Quantity of water evaporated	31,000 Kg. per hour (8,000 Kg. 1st stage 5 - 7,000 each subsequent stage).

Steam pressure	2.5 atmospheres.
Steam consumption	10,500 Kg. per hour
Quantity of cooling water	190 m^3 /h
with temperature rise	15 to 40° C.

Drawing No. C.VI/4094 shews the schematic layout of the plant with coloured lines for the various services.

The heaters are of an entirely different type, being 1.3 metres diameter and each having 340 copper tubes 40 mm. inside diameter by 45 mm. outside diameter and 604 cm. long.

Heaters are of the floating head type. The vapour Separators are 2.8. metres diameter made of special Cast Iron and have a simple type of separator incorporated in the top. The following drawings are available:

C.II/4132 - Flow diagram.
C.III/4127 - Arrangement of Evaporating Plant.
C.IV/4141 - Layout for steelwork.
C.VI/4090 - General layout of plant.
C.II/4123 - Heater.
C.III/4149 - Evaporator.
C.VI/4130b - Distributor for Evaporator.
C.II/4128 - Liquid Expansion Vessel.
55347 - Superheater.
1599 - Evaporator top.
C.III/4128- Position of fittings on Evaporator.
C.II/4128 - Heater Tube Plate layout.
C.IV/4226 - Drip Catcher.
C.III/4250- Heater Injector.
C.IV/4156 - Arrangement of "Leitwerks" in Heater.

Contract CV 288. This is a saponification glycerine water non-salting type Evaporator having single effect on account of the small size of the plant.

Product	Glycerine water.
Throughput	376 Kg. per hour.
Percentage glycerine in feed	5%
concentrated to	88%
Temperature	55°C.
Quantity of water evaporated	355 Kg. per hour.
Steam pressure	16 atmospheres.
Steam consumption	210 Kg. per hour.

This is a Vapour Recompression type of Evaporator with the heating Calandria and Vapour Separating Chamber incorporated in a single unit.

The plant layout is shewn on Drawing C.VI/4101A and the pipework and services layout on Drawing C.III/4184. Drawing No. C.IV/4178 shews the Evaporator incorporating a heater 950 cm. inside diameter by 910 cm. between tube plates, having 242 solid drawn tubes 38 mm. inside diameter by 43 mm. outside diameter. There is an Entrainment Separator incorporated in the upper section of the Evaporator. Drawing No. C.II/4168 shews the Mild Steel Receiver.

Contract CV.327.

This is a Vapour Recompression type of Evaporator for the concentration of lemon and orange juice. Drawing No. C.III/4319 shews the schematic layout of the pipework and Drawing No. C.IV/4340 shews the general arrangement of the plant.

The Calandria Body, which is made in Stainless Steel, is 1.5 M. diameter by about .65 M. between the tube plates, having 759 tubes 30 mm. inside diameter by 33 mm. outside diameter. The Separator, also made of Stainless Steel, is 1.25 M. diameter by 1.3 M. on the straight with a conical bottom and simple separating cylinder in the top.

Product	Lemon and Orange Juice.
Throughput	1,250 Kg. per hour.
Percentage solid in feed	12½%
concentrated to	60% (believed 70%)
Temperature	35 - 38°C.
Quantity of water evaporated	1,000 Kg. per hour.
Steam Pressure	6 - 8 atmospheres
Steam consumption	700 Kg. per hour.
Cooling water with temperature rise	75 cu.M. per hour.
	25°C to 31°C.

The following drawings are available:

C.IV/4340 - General layout.
C.III/4319 - Pipeline layout.
C. 10462 - Heater and Evaporator
C.II/4258 - Preheater
C.IV/4305 - Condenser

C.IV/4323 - Contents of Condenser.
C.III/4325 - Calandria Tube Plate.
C.III/4313 - Flange Connection Heater.
C.II/4243 - Sight Glass Pipe.
C.I/4141 - Rohrbodenberieselung.
C. 3932 - Sampling Cock
C. 3895 - Spray Nozzle
C.III/4202 - Special Cock.
C.II/4195a - Arrangement Draw-off Cock.
C.II/4268 - 3-stage Vacuum Pump.
C.VI/4155 - Diffuser & Nozzle.

Contract CV 289.

This is a double effect salting type Glycerine Evaporator with vapour recompression on the first stage and also forced circulation on the first stage. The Evaporator was built during 1940.

The crude 8% lye is concentrated to about 25 to 30% in the forced circulation Evaporator which has only one salt box. The concentrate is bled off and the circulating pump forces it to the second effect. Here it is concentrated to 45 to 50%. There are two salt boxes attached to this Evaporator. The semi-finished crude Glycerine is held in a Receiver until sufficient accumulation has been obtained. It is then finally concentrated in the second effect to 80%. This arrangement is shewn on General Arrangement Drawing No. C.VI/4109 and on Flow Drawing No. C.IV/4196b.

An analysis of the problem indicates that this is a reasonable arrangement since the recompressor would not be required for this final concentration. On the other hand a definite statement was made and confirmed in writing that the final concentration took place in the forced circulation effect. This statement is, however, suspect, since at the same time a figure of only 16% concentration in the first effect for the preliminary concentration was given, and this would be very low indeed from the entrainment performance angle. The drawing figures are therefore preferred.

The heater for the first stage is 0.9 M. diameter and is of the floating head type. It is arranged for four passes, the inlet and outlet both are in the bottom. There is a total of 248 tubes 30 to 33 mm. diameter by 3.25 M. long. Tubes and tube plates are copper.

The first effect Evaporator has elaborate internal separating arrangements and entrainment baffles which can be

seen in Drawing No. C.VI/4102a.

The se ond effect Evaporator has the calandria incorporated in the body of the Evaporator. The calandria is 1.26 M. diameter containing 562 copper tubes 30 to 33 mm. diameter and 0.85 M. between copper tubes plates. The rest of the Evaporator is steel. The down-comer is 280 mm. diameter. Further details including the entrainment device similar to that in the first effect, and the heating coil in the bottom of the cone can be seen in Drawing No. C.IV/4186a.

Product	Crude Glycerine.
Percentage solid in feed	8%
concentrated to	80%
Temperature	70°C 1st stage; 35°C 2nd.
Quantity of water evaporated	1,500 Kg. per hour.
Steam Pressure	12 atmospheres
Steam consumption	780 Kg. per hour.
Quantity of cooling water	30 to 45 Cu. M. per hour
with temperature rise	15 to 20°C.

Alternatively:

Water consumption	45 cu. M. per hour.
with temperature rise	20 - 30°C.

Circulating Pump	190 cu. M. per hour against a head of 7 M. of water.
	1st stage 25 - 30%
	2nd stage 50%
	3rd stage 80%.

The following drawings are available:

C.VI/4109 -	General Arrangement Drawing
C.IV/4185 -	Building layout.
C.IV/4196b -	Pipework layout.
C.VI/4102a -	Evaporator 1st stage.
C.IV/4186a -	Evaporator 2nd stage.
C.IV/4190a -	Heater.
C.III/4198a-	Heater de-aerating pipe.
C.IV/4198 -	Container for lye
C.III/4193a-	M.S. Container
C.II/4194 -	Condensate Container.
C.IV/4192a -	Mixture Condenser.
C.III/4192a-	M.S. Salt Box.
C.3509 -	Compressor Housing.

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C.IV/4198 - Jet Nozzle
C.II/4206 - Sampling Device.
C. 3597 - Sampling Device arrangement.
C.VI/4107 - Pipework details.
C.III/4209a - Valve Spindle for Evaporator.
C.I/4114 - "Stauscheiben"
~~C.II/4197 - Light & Sight Glass for Evaporator.~~
C.II/4188 - Heater dehydrating device.
C.II/4193 - Water Separator.

Plant for the Manufacture of MgO by Reduction of $MgSO_4$

The visit to this Factory was interesting because it was one of the few instances when Lurgi had tackled a process outside their normal range. However, it was not illogical since they had already installed large Crystalisation Plants here (see below) and it also enabled them to sell a Sulphuric Acid Concentration Plant, also the first section of the Plant involved Evaporators. As would appear to be their custom, a pilot plant had been installed at another works belonging to the client. The step up from this was courageous and in point of fact not entirely successful since the small scale results were not borne out in practice.

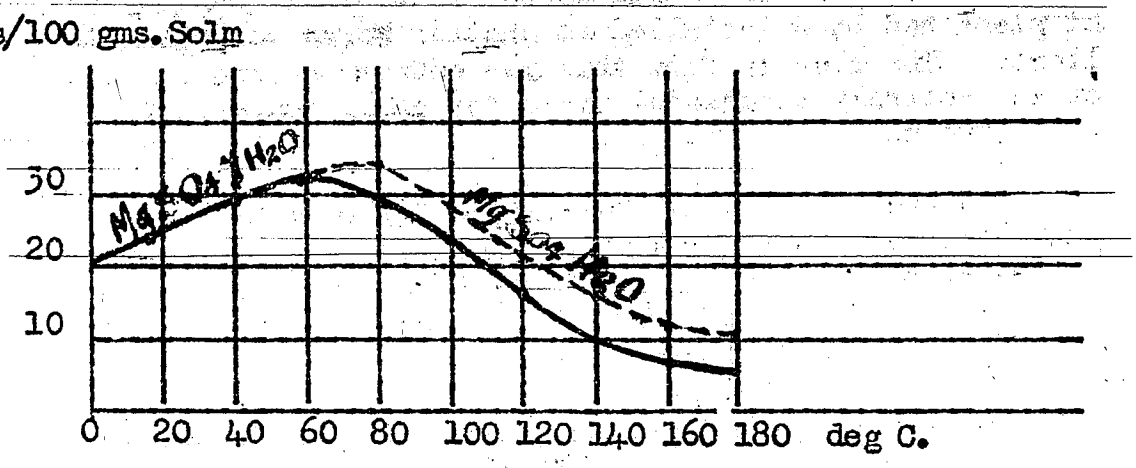
The factory was the "Vereinigte Kaliwerk Salzdetfurth A.G.", Werk Hattorf, near Hersfeld. The Director interrogated was Herr Fritzemeyer (the Chief Engineer, Ober. Ing. Arnemann was away). Additional information was subsequently obtained from Ing. Karl Ebner of Lurgi-Waerme. C22/464

The plant was designed to reduce 2820 Kg. of $MgSO_4$ per hour to give a daily output of 22,500 Kg. of MgO and 55,000 Kg. of Sukphuric Monohydrate per day. The plant was based on a pilot plant operated in Hamburg. It has never worked satisfactorily since, apart from normal difficulties which could have been overcome, the gas generators were required to produce gas at a temperature of 500/600°C. from Steinkohle, having a calorific value of 1500 Cal./Cu.M., but they could only obtain coke giving gas with a value of 1200 Cal./Cu.M. (and dusty coke at that), thus the temperature was only 250/300°C.

The Salts obtained from the mine contain approximately 12% KCl; 70% NaCl; 26% $MgSO_4$; 2% $MgCl_2$ (110%!!) This is treated in large vats with mother liquor from the Potash Process which contains 100 gms/L KCl at 112°C. and leaves the vats with 180 gms/L This plant is termed a "Planfilter". The undissolved salts are washed with water to remove the NaCl and the remaining solid material is "Jieserit" containing 80/85% $MgSO_4$ (with 1 H_2O of crystalisation), about 2% of Calcium Chloride, Sodium Chloride and Calcium Sulphate, 5% water as moisture, the balance being represented as water of crystallisation.

The Kieserit is dissolved in water at 60°C. to give a solution containing 450 gms. $MgSO_4$ per L. and is then taken to a triple effect Evaporator as shewn on Schematic Drawing No. W2/2066 (available but not attached to this report). The essence of

this plant is rapid circulation of the "Kieserit" at a rate of 1000 Cu.M. per hour to prevent crystallisation and also to get supersaturation. At 60°C. "Kieserit" when cooled produces $MgSO_4 7H_2O$ (Epsom Salt) and when heated above 60°C produces $MgSO_4$, H_2O, but supersaturation is possible. It is concentrated to 600/650 gms./l at 100/110°C. and delivered through a steam jacketed pipe at 120°C. to the calcining tower: If the temperature is higher or lower crystallisation takes place in the pipe.



The Reduction Plant, as originally designed, is shewn on Drawing No.W1/2104, available but not attached. Temperatures and quantities are design figures. Generator Gas is burnt with preheated air so as to enter the Calcining Tower at 1000/110°C. The concentrated "Kieserit" solution is sprayed into the tower through six 1" bore nozzles, having 1/2" steam pipe injecting steam at 3-4 atmospheres at the rate of 40-60 Kg. per hour per nozzle: the solution pressure is 1.1/2 - 2 atmospheres and the solution rate 400/600 litres per hour. The Tower is 7 metres diameter by 12 metres deep approximately. The type of Injector Nozzle is shewn on Drawing No. W2-2175. Temperature of exit gases is 350/380°C. The $MgSO_4$ with sp.weight of 0.1 Kg/L. 98% pure is at a temperature of 200/250°C. This was conveyed to a roller type Crusher which, however, was not a success and was replaced by a Crushing Mill made by Bauermuster of Hamburg: crushed to 0.1 to 0.3 mm. crystals: the problem us not yet completely solved.

Air preheated to 500°C. blows the crystals to the Reduction Tower under a pressure of 200/300 mm. Water. Temperature and pressure are essential and lack of temperature has caused difficulty.

In the Experimental Plant M_gO built up round the top and a design was evolved with a pendant double pipe for water circulation, to rotate at about 1.1/2 R.P.H. In practice this was found unnecessary and, anyway, the sand seal and top gland were far from gas tight: the seals were, therefore, welded up.

The combustion temperature which should be 1500°C. was 1200/1300°C. For revised Burner Head see Drawing No.W1-2193a. The temperature at the base must be 950°/1000° otherwise too much $MgSO_4$ remains unreduced and the product is too impure. In practice only 900°C. was achieved, hence the plant failure.

The original special "Abscheider" (in effect a simple cyclone), was made from "Sicromal" which failed under the temperature and is being replaced by a brick lined Separator.

The temperature of the SO_2 leaving the heat exchange system is 200/220°C and must not be higher otherwise trouble is caused in the Cotterell Precipitator.

Scheme Drawing No.TK1 5039 shews the modified layout with the non-rotating Burner Head and the changed system of heat exchange to enable Braun Coal to be used. The production of Furnace Gases at 350°C. but with a value of 1500/1600 calories is shewn on Scheme TK1 5038. These modifications are only partly made but the Firm is anxious to complete due to the great accumulation of $MgSO_4$.

M_gO for making Furnace linings and, by the addition of $MgCl_2$ for flooring, are the principle products. For these purposes the M_gO must be clean and at least 95/98% pure.

The SO_2 goes to a cleaning plant as shewn on Drawing No.W2/2092. The hot gas Cottrell collects the remaining M_gO. The SO_2 passes through a lead Washing Tower having acid resisting stone lining; the gases are cooled to about 40°C. and passes to two more Cottrells and then washed again in a similar Tower and cooled to 30/35°C, then through another Cottrell and thence to the Acid Plant. The Cottrell Plants are 3.7. by 6.7. by 17.5 Metres. The M_gO dust follows a path 8 Metres long through the Filters, but the hot gas filter has a path of 4 Metres.

In the Acid Plant it was not found practical to make Oleum but some Monohydrate was produced for the Artificial Silk Industry. This Plant is quite standard and is shewn on Scheme

Drawing No. WIII/819.

The clean gas which contains about 6.3 Vol.% SO_2 is mixed with air to give 4.7%. The Drying Tower uses 96% H_2SO_4. Although not shewn on the Drawing it would seem that this acid, which has picked up some water, is mixed with the Absorption Tower Acid where the water is used for water of reaction.

Conversion of SO_2 to SO_3 in Contact Chamber reaches 98%. In the Absorption Towers an absorption of 99.7 to 98% acid takes place or else Oleum can be produced. There are 781 tubes in the Contact Chamber.

The following drawings are available but not attached to this report:

W2/2066	TKE.1109
W2/2175	TKI.5039
W1/2193a	TKL.5038
W1/2104	W2. 2092.

WIII/819.

CRYSTALLISATION.

This department is under the charge of Ober.Ing. Ebner, age 43, who speaks good English and is quite forthcoming. At the time of the investigation it was situated at the Old Schloss, Bad Homberg, but was shortly to be moved to Friedburg. Many of the drawings had been burned but certain photographs were obtained and prints of these are available. The department was not completely reorganised and in no case could a complete set of drawings be obtained for any one plant.

Since two of the Plants described are at the Hattorf Plant, the section preceding this describing the $MgSO_4$ Reduction Plant should be read in conjunction with this.

The type of Crystallisation Plant designed by Lurgi operates continuously and in essence consists of a series of two or three compartment Vessels having mechanical, or most recently air, agitation. The liquor flows from compartment to compartment, each of which is subjected to increasing vacuum. A feature of the plant is the overflow device contained in each compartment. The overflow pipe which may be 20 cm. dia. has the top 20 cm. hot water jacketed to prevent the formation of crystals in this section.

Sheet No. 112

Epsom Salt Plant $MgSO_4 . 7H_2O$.

See $MgSO_4$ Reduction Plant for particulars of salts mined at Hattorf where this plant is situated.

Scheme Drawing No. W.IV/370 (available but not attached) has added to it the sizes of apparatus, different vacua, vapour pressures and temperatures of the different stages.

Rough vacuum is obtained on two preliminary dehydrating Vessels VI and VII by using the mother liquor from the Centrifuges as the cooling medium, thus also heating it up for use in the "Kieserit" Dissolving Tanks. Water is added to the mother luquor in order to dilute it.

The solution enters Vessel VI at 60/75°C. From VII the solution can either go to VIII for production of large Epsom Salt Crystals at the rate of 30 Cu.M. per hour, or to the higher vacuum vessel VIV for crystallisation at a rate if 100 Cu.M. per hour to produce small crystals. Both units can run concurrently. The degree of vacuum is controlled by the dampers. Recycling of the mother liquor does not cause a build up of the impurities beyond 5% on account of loss at Centrifuge, loss when clearing the Crystallisers etc.

For quantities crystallised see cooling curve in W.Gensecke report - see Chem.App. 1940; 10; 145. - "Anwendung der Wasserdampf Kaltemaschine bei der Kystallisation" page 1. Roughly when cooling from 45°C. to 27°C 130 gms./L is obtained by direct cooling and 65 gms./L from evaporation = 200 gms./Lfeed: $MgSO_4 7H_2O$; about 90 gms./L feed of water is evaporated: Specific gravity of feed is 1320 and the outgoing M.L. 1350. There is, therefore, approximately 1030 gms./L of M.L. That is 1320 gms./L feed solution contains 900 gms. water plus 420 gms. $MgSO_4$: 200 gms. Epsom Salt and 90 gms. water evaporated = 290 ∴ M.L. = 1320 - 290 = 1030.

After the Centrifuge of the continuous vertical type, made by Haubold of Chemnitz, the crystals are dried in a Schilde Trommel Drier with 70% Air co-flow.

Potash Crystallisation.

In the Plant originally operating at Hattorf in 1930, there were three simple Vessels operating under vacuum. The crystals build up on the sides and in the connecting pipes.

It will be seen from the Table Fig. 8 Item 1 that the bulk of the crystals are 0.10. to 0.20 mm. dia. It is desired to get maximum quantity of 0.30 to 0.50 mm. and 0.20 to 0.30 mm. in that order.

The first improvement made by Lurgi was to improve the Vacuum and also to enter the feed through a conical device with warm water jacket, as Fig. No. 8. This avoided the build up of crystals on the sides of the Vessel and in the pipes connecting the three Crystallisers, but the crystal size deteriorated. See item 2 of Fig. No. 8

Lurgi then installed a four stage Vacuum Crystallisation Plant as described and illustrated in Gewencke Description, p. 12. See Fig. No. 8. This improved the crystal size, but still not sufficiently in the right direction. See item 3 in Fig. No. 8 Items 4 to 8 represent results with different solutions and improvement in crystal size will be noted.

It would appear that items 9 to 13 in Fig. No. were made on an intermediate plant, the ultimate end of which is shewn on Drawing No. WIV/563a (available but not attached) which is essentially the same as WIV/556 but with slightly more heat exchange. (Mother liquor to 85°C. in summer).

Although the dates do not agree, the plant shewn on Scheme Drawing No. WIV/556 can be taken as producing approximately the sizes of crystals shewn in Fig. 8. items 21 to 24 where the crystal size is as required.

On Scheme Drawing No. WIV/556 the liquid temperatures are shewn (red for summer and green for winter - river cooling water was used for the jets and the steam temperatures and vacua can be interpolated from the table printed on the drawing. The mother liquor is heated to 81°C.

The mother liquor contains 100 gms. K Cl per L. and after heat exchange to 81°C. is heated in an exhaust steam heater to 112°C. and used to dissolve the K Cl in the mined salts to increase its content to 180 gms./L

Composition Cold liquor (out)		Composition Hot liquor (in).
100	K Cl	180
40	$MgSO_4$	40
80	$MgCl_2$	80
110	NaCl	150
900	H_2O	80

FIG. 8

Kaliwerke Aschersleben
Schachtanlage Hattorf
Philippsthal/Werra

Korngrössenzusammensetzung von Hartsalzschlerkalium aus Vakuumkühlanlagen

	gekühlt auf °C	Ueber 3 mm %	Zwischen 2 und 3 mm %	Zwischen 1 und 2 mm %	Zwischen 0,75 und 1 mm %	Zwischen 0,50 und 0,75 mm %	Zwischen 0,30 und 0,50 mm %	Summe über 0,30 mm %	Zwischen 0,20 und 0,30 mm %	Zwischen 0,10 und 0,20 mm %	Summe zwischen 0,10 und 0,30 mm %	Zwischen 0,08 und 0,1 mm %	unter 0,08 mm %	Summe unter 0,10 mm %
dreistufige Vakuumkühlanlage														
1) 3 Körper, alte Vakuumanlage vom 29.11.1930		0,02	0,02	0,05	0,15	0,38	7,69	8,31	21,52	61,49	83,01	4,07	4,61	8,68 *)
2) 3 Körper, Lurgi Vakuumanlage vom 27.10.1933		-	-	-	-	0,08	0,45	0,53	1,96	25,43	27,39	7,48	64,60	72,08
vierstufige Vakuumkühlanlage														
3) 4 Körper, Lurgi Vakuumanlage Probe vom 13.12.1930		-	0,01	0,05	0,05	0,19	0,45	0,75	3,07	55,48	58,55	10,12	30,58	40,70
4) 4 Körper, Lurgi Vakuumanlage Probe vom 19.3.1931		-	-	-	-	0,07	1,83	1,90	6,80	30,86	37,66	20,33	40,11	60,44
5) 4 Körper, Lurgi Vakuumanlage vom 21.9.1933		-	-	-	-	0,34	1,40	1,74	7,21	44,59	51,80	13,61	32,85	46,46
6) 4 Körper, Lurgi Vakuumanlage vom 22.9.1933		-	-	-	-	0,93	4,57	5,50	9,53	42,97	52,30	10,22	31,98	42,20
7) 4 Körper, Lurgi Vakuumanlage vom 27.9.1933		-	-	-	-	3,16	8,37	11,53	19,07	48,69	67,76	7,66	13,05	20,71
8) 4 Körper, Lurgi Vakuumanlage vom 28.9.1933		-	-	-	-	2,78	6,161	8,94	10,69	43,04	53,73	11,99	25,34	37,33
neunstufige Vakuumkühlanlage														
9) Lurgi Vakuumanlage, 9stufig 8.12.33		-	-	-	-	0,98	9,04	10,02	21,72	39,53	61,25	9,51	19,22	28,73
		-	-	-	-	1,05	9,08	10,13	20,56	36,81	57,37	9,27	23,23	32,50
10) dito 12.12.33		-	-	-	-	1,44	14,08	15,52	22,22	28,94	51,16	9,39	23,93	33,32
11) dito 18.12.33		-	-	-	-	1,65	12,14	13,79	23,71	33,56	57,27	7,19	21,75	28,94
12) dito 19.12.33		-	-	-	-	2,88	14,89	17,77	22,09	31,03	53,12	8,36	20,75	29,11
13) dito 22.12.33		-	-	-	-	4,13	14,23	18,35	19,83	29,05	48,88	7,16	25,60	32,76
Kristallisationsversuche														
14) Probe vom Versuch mit Bivak vom 18.10.1932		-	-	11,00	9,50	23,00	29,30	72,80	11,50	12,60	24,10	-	-	3,10
15) Ungünstigste Probe der Versuche in Hamburg 10.-14.10.33 *)		-	-	1,64	0,06	11,91	35,86	47,47	34,03	16,56	50,59	0,58	1,36	1,94
16) Beste Probe der Versuche in Hamburg 10.-14.10.33 *)		-	-	4,99	19,41	39,29	18,05	81,74	9,97	6,83	16,80	0,38	1,08	1,46
neunzehnstufige Vakuumkühlanlage														
17) Lurgi Vakuumkühlanlage, 19stuf. 7.8.34	47	-	-	-	0,17	2,06	30,59	37,15	36,70	25,28	59,98	1,95	0,94	2,89
18) dito 7.8.34	50	-	-	-	0,29	4,63	28,79	33,71	38,42	26,51	61,93	3,14	1,22	4,36
19) dito 15.8.34	36	-	-	-	-	2,51	27,44	29,95	44,81	24,65	69,46	3,55	1,04	4,59
20) dito 16.8.34	35	-	-	-	0,07	4,05	24,70	28,82	35,03	30,36	65,39	3,91	1,88	5,79
zweiundzwanzigstufige Vakuumanlage														
21) Lurgi Vakuumanlage, 22stufig 3.9.34	35	-	-	-	0,20	6,26	39,56	46,02	37,23	15,74	52,97	0,61	0,40	1,01
22) dito 3.9.34	37	-	-	-	0,18	10,38	43,05	53,61	32,85	12,82	45,67	0,54	0,18	0,72
23) dito 4.9.34	29	-	-	-	1,13	14,43	41,93	57,49	28,43	13,50	41,93	0,28	0,30	0,58
24) dito 4.9.34	29	-	-	-	0,64	10,50	39,23	50,37	33,54	15,01	48,55	0,43	0,65	1,08

*) Bei den Versuchen in Hamburg wurde die Lauge von 60 - 70° gekühlt auf 35°C in achtstufiger Anlage.

*) Die Kühlung erfolgte nur bis 43°C, die weitere Kühlung anschliessend durch Vatnerkühlturm, welcher Feingut zusätzlich erzeugte.

Input of hot solution is 200 cu.M. per hour and output cold solution is 180 Cu.M. per hour. During Crystallisation 15,000 Kg/hr. of water is evaporated; 24,000 Kg/hr. KCl and NaCl in approximate proportions of 60 to 65 and 40/35 respectively is obtained. The mother liquor is 180 cu.M. (230,000 Kg)/hr. and passes out to the Centrifuges. The Salts are washed if necessary.

Certain detail drawings under Types TK60 and TK74 (relating to Scheme Drawings Nos. WIV 556 and WIV/563a) are available as list below.

T K	74	Condenser	A1 - 2355/1
T K	74	"Wasserkammer"	A 1070/2a
T K	74	"Oberflachen Kond."	A2 - 2234/4b/3
T K	74	Outlet	A3 - 2344
T K	74	Tubes and Tube Plate	A3 - 2240/7
T K	74	Outlet	A3 - 2345
T K	74	"Spuelkopf"	A 2313
T K	74	Condenser	SK - 1227
T K	74	Inlet and Outlet	A 2314
T K	74	Dividing Walls	A 2262a
T K	74	Expansion Springs	A2 - 2233a
T K	74	Tubes and Tube Plate	A3 - 2238a/1
T K	74	Condenser Stuffing Box	A 2226/1a
T K	74	Stirring Gear Arrangement	A1 - 2342
T K	74	"Bruedenstutzen"	W1 - 2095
T K	74	Tubes and Tube Plate	A3 - 2241b/1
T K	74	Sight Glass	A 1141c
T K	74	Schematic Layout for KCl Crystallisation Plant.	

T K	60	Stirring Gear	A 110 c
T K	60	Surface Condenser	A 1344
T K	60	Surface Condenser	A 1712/1
T K	60	Tube Plate	A 1349
T K	60	Stirring Gear	A 1319a
T K	60	"Wasserkammer"	A1 - 1070/2a
T K	60	Dividing Walls	A 1726b
T K	60	Stirring Gear	A 1719/?
T K	60	Stirring Gear	A 1804
T K	60	Schematic Layout	W IV - 556.

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T K	85	Melting Vessel	A1 - 2377c
T K	85	Rubber Lined Flash Crystalliser	A1 - 2563a
T K	85	Spray Evaporator	A2 - 2553a
T K	85	Overflow and Drawoff Pipes	A2 - 2566a
T K	85	"Misch Kondensator"	A1 - 2561

T K	75	Receiver	A 2187
T K	75	Stirring Gear	A ? 1726/2
T K	75	"Spuelkopf"	A 2175a
T K	75	Condenser	A 2191/1
T K	75	Schematic layout for Glauber Salt Crystals Plant	W V 197
T K	75	Calculation Sheets.	

T K	10	Surface Condenser	A 745b
T K	21	Tube Plates	A 1024a

One drawing with number and description missed by photographer.

PHENOL RECOVERY:

The Lurgi - I.G. Phenosolvan System.

In May 1941 Lurgi Warme and I.G. extended an earlier agreement relating to phenol recovery system to cover a new development termed the Phenosolvan System which was the subject of German and world patents of each of the Companies.

The basis of this agreement assured to Lurgi the sale of the requisite plant and to I.G. the sale of the special solvent which was required. In addition, I.G. were to have, as far as possible, the right to purchase from plant operators the raw phenols which were thus recovered.

Lurgi-I.G. Agreement and Patent List. See document 172 IV.

Typical Plant Contract. See document 87 IV. - This comprises tender and acceptance of order relating to Blechhammer.

The Inventor of the process is stated to be Dr. Herbert, head of the Metallgesellschaft Chemical Laboratories.

Essentially the system is a recycling one in which the solvent absorbs the phenol from the liquor or water in one part of the system and gives it up in another as raw phenol, after which the solvent returns to the system for further absorbtion. The system is used for recovering phenols resulting from the washing of hydrogenation oils.

In Germany the solvent was manufactured and sold only by I.G. under the trade name PHENOSOLVAN. It is an ester of iso butyl - formula CH_3, COO, C_4, H_9. This ester is made with iso butanol and acetic acid and is non-toxic and has a flash point similar to light gasolene. The boiling point is about 120°C and it's viscosity is low. Cost was 1.10 M. per kilo.

Phenosolvan was claimed to be the best solvent for phenol so far developed, the advantages being:-

Exceptionally high capacity for absorbing phenol.

Only 10% volume solvent required in relation to the volume of effluent treated.

Very low loss of solvent - 0.1-0.2 grammes solvent per litre of effluent treated.

Absence of emulsification between the solvent and effluent.

Since the recovery of the phenol from the solvent is carried out by distillation the solvent is returned to the system in a clear and pure condition. Due to the solvent having a lower boiling point than phenol and tar oils, prolonged operation can be carried out without tarry contaminations.

PLANTS INSTALLED:

The first plant had a treatment capacity of 25 cubic metres per hour of waste water and was erected at Politz near Stettin in 1941.

The second, and much larger plant, was installed at Blechhammer for the Oberschlesischen Hydrogenation Works. Here there are three identical units working in parallel, each capable of dealing with 45 cu.metres of effluent per hour.

One unit deals with the effluent from a carbonising plant and another the effluent from the coal hydrogenation plant. The third unit is a spare to either.

The first unit of this plant, which was ordered in January 1942, was put to work in December 1943.

A third plant is installed complete at Brux in Czechoslovakia but was never started up.

A fourth order was in course of execution for coke ovens at Saarbrucken.

OPERATING RESULTS:

Although the system will remove a phenol content of 10 kilogrammes per cubic metre down to between 200 and 300 grammes, the latter is not sufficient to allow of the treated water to be discharged into fresh water rivers, etc., for final elimination of oxygen absorbing elements, biological treatment is usually adopted.

The following are figures relating to Blechhammer:-

Quantity of water per hour	45 cbm.
Phenol contents, untreated	5 g/l.

Phenol contents, treated.	250	g/cbm.
Steam Consumption, 18ats.	75	kg/cbm water
" " 2.5 ats.	95	kg/cbm "
Consumption of solvent.	230	g/cbm "
Production of phenol.	9	kg/cbm "

ANALYSIS OF PHENOLS AS RECOVERED:

Carbolic acid	25 %
m-cresol	7 %
o+p - cresol	17 %
xylol	4 %
Neutral oil	0.5 %
Pyrocatechin	12 %
Higher phenols	34.5 %

CAPITAL COST:

Plant, foundations, electrical equipment, etc.,
For three units of 45 cbm .. .. 1,869,500 Mks.

OPERATING LABOUR:

For three units:-

Per shift.	3 trained operators.
	3 assistants.
Day shift only.	1 assistant.

POWER CONSUMPTION:

Average consumption - three units - 170 kw/hr.

COOLING WATER:

5 kg/cbm. water treated.

Derailed operating data from Blechhammer is contained in the documents:-

87 IV C.
87 IV D.

PRE-TREATMENT OF EFFLUENT:

Since oil and tarry matter go automatically into the raw phenol and do not come off, provided that the latter has a boiling point of over 230°, mechanical oil separation is the only pre-treatment usually adopted for carbonising effluent.

The water usually contains hydrogen sulphide, ammonia and carbon dioxide - the latter in combination. Where, however, there is free ammonia present, as in hydrogenation effluent, it is necessary to degas with carbon dioxide.

LAYOUT OF PLANT:

See Flow Diagram EP.1006. Fig 9.
Document No. 87 IV C

The water to be treated is pumped to the degassing tower (2). In this the waste gas from the subsequent section of the plant is washed to recover from it any solvent vapour which it may contain.

Next the water is brought into contact with the solvent in counter current, multi stage extraction vessels (3). Here the solvent takes up the phenol from the water and, as enriched solvent, separates from the water.

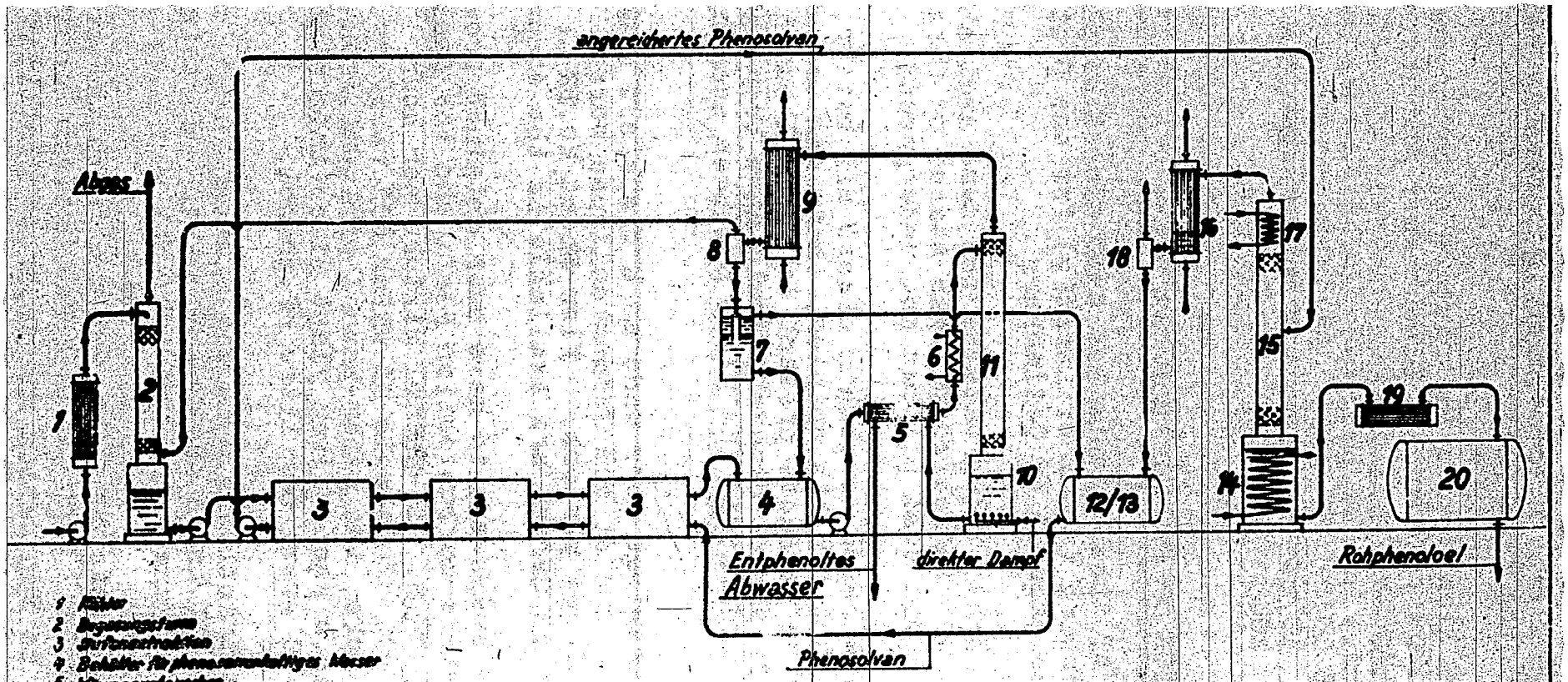
The water, now free of phenol but carrying a small amount of phenol rich solvent, runs into the balancer tank (4) and from there over the heat exchanger (5), the preheater (6) to the column marked (II). This is a column in which direct steam is admitted at the base sufficient to drive off the phenolsolvan which, together with water, is condensed in the condenser (9).

The water and phenosolvan pass over a gas separator (8) into a decanting vessel (7) in which they separate. The upper layer of solvent is led to the solvent collecting tanks (12/13) and the lower watery layer is returned to the balances tank (4).

The waste gas from the separator (8) is washed with the incoming raw water in the wash tower (2).

From the base of the column (II) the water flows over a heat exchanger (5) to the waste water main.

The solvent which was enriched with phenol in the multi stage extraction vessels (3), is distilled out in the still (14) and vacuum column (15), which latter is fitted with a reflux condenser (17). via a condenser (16) and a gas separator (18), the solvent is recovered in the collecting tanks (12/13) for subsequent re-use in the system



1 Kühler
2 Regenerierofen
3 Zentrifugalextraktion
4 Behälter für phenosolvanhaltiges Wasser
5 Wärmeaustauscher
6 Vorwärmer
7 Phenosolvan-Abscheider
8 Gasabscheider
9 Kondensator
10 Destillierblase
11 Abtreib-Kolonne
12 Phenosolvan-Sammelbehälter
13 " -Vorratsbehälter
14 Destillierblase
15 " -kolonne
16 Kondensator
17 Rückflusskondensator
18 Gasabscheider
19 Kühler
20 Rohphenoloel-Behälter

Fig 9.

LURGI
Gesellschaft für Wärmetechnik m.b.H.
Frankfurt a. Main

Schema einer Phenosolvananlage

EP 1006

The raw phenol is drawn off from the bottom of the still to be cooled in the cooler (19), finally being collected in holding tank (20).

The following are the numbers of arrangement and detail drawings relating to Blechhammer and which are included in the documents:-

EPE 1062	EP 1103	EP 1125b	EP 1061c
EP 1076c	EP 1024	- C 8458	EP 1044
EP 1045	EP 1047	EP 1048	

SOLVENT EXTRACTION OF PHENOL FROM TAR OIL:

One of these Plants has been almost completed by Lurgi at Altenburg (south of Leipzig) for the Deutsche Erdol A.G. at the request of Geilenberg.

The Plant, being outside the zone available to the writers, was not inspected but was stated by Lurgi to be erected in a brown coal pit but not underground.

It was hoped to obtain diesel oil but Dr. Kohrt of Lurgi stated that, in his opinion, there was too much sulphur and gumming products present in the oil but he was confident that the phenol recovery would have been satisfactory. It is understood the Plant has been seen by U.S.A. engineers.

All drawings were made at a dispersed drawing office on the site and at the German collapse were destroyed by displaced persons. Flow Sheet No.TR III 1011 and a description in German are available in the documents.

Crude stock was to have been obtained from a Lurgi Low Temperature Carbonisation Plant and the designed throughput was 15 cu.m. oil-phenol mixture per hour containing about 30% of phenols of which 80% recovery was expected. With more, the water-phenol effluent from the Plant was taken to a Phenosolvan Plant since this mixture would contain 20/30 grms. per litre of phenol.

The extraction system was similar in principle to the well known Duo-Sol Process. In this case methanol and hexane being the solvents.

The solvents come into contact with the stock in extraction vessels, much as in a Phenosolvan Plant, after which there is separation and separate distillation of each solvent, phenol free oil leaving the Plant as one

product and water free phenols as another with hexane and dehydrated methanol returning to the extraction vessels for further recycling.

LURGI PLANT FOR SYNTHETIC LUBRICATING OIL:

This Plant, which is installed at Rheinpreussen, has been covered by previous investigators. The Plant was not visited by the writers. A flow sheet No.AS1263 was obtained from Dr. Kohrt and this, together with a typewritten description of the Plant in German, is contained in the documents. This description gives details as to the sizes of the various vessels, etc., and should prove useful to any-one contemplating such equipment.

The process generally comprises:-

Chlorination.

Synthesis, using aluminium chloride as catalyser.

Distillation.

Refrigeration and centrifuging.

Final treatment of oils.

Alterations were stated, by Kohrt, to have been carried out at Rheinpreussen of which Lurgi were not informed.

POLYMERISATION PLANT FOR THE RECOVERY OF HIGHER ALCOHOLS:

This process is well known in U.S.A. where a number of plants have been installed. Lurgi work in the liquid phase.

Plant has been installed at the Rheinpreussen Factory at Moers (Near Duisberg) in 1939 to work 14 tons of liquified gasol containing approximately 40% by weight of Olefines.

The recovery of Olefines is about 70-80% but Dr. Kohrt considers that the cost of reconcentrating the sulphuric acid (14 tons) for this plant makes the plant uneconomic.

The Plant has been seen by earlier investigators.

Contained in documents is German description and flow sheet AS.1216 and M.A.N. Drawing BM.151853. giving details of 20 atm. autoclave.

PLANT FOR EXTRACTION OF PROPANE, BUTANE, ETC.:

These Plants were put in by Lurgi for the recovery of bottled gases and several such stabilising plants were installed including installations at mineral oil works. The Plants were not visited but consist of stabilising and compressing the gas, in some cases with the application of activated carbon. See Sheets 37365, GT.365A, 36967, and layout print GT.569.

ACTIV-KOHLEN UNION A G. 21/12(ee)

This is the development Company maintained jointly by I.G. Metallgeselschaft, Degussa, & Verein Prague.

In August 1945 it was operating in the basement of the Metall Library dispersal premises ar Proworoffstrasse, Bad Homberg.

The name of the Company was changed from Carbo Norit Union A.G., in 1939, when Nordit Co (Dutch) and Picci (French) relinquished their interest.

Dr Engelhard, in charge, speaks fair English and was reasonably communicative. There is normally a staff of 20, comprising one legal man for Patents, one Secretary, three Senior Chemical Engineers, named Dr Achnelt, Dr Bratzler, and Miss Muller; the rest of the staff are Assistant Technical Chemists.

The main function of the concern is to develop new applications for Activated Carbon and to take out Patents; also to advise the Metall Engineering subsidiary Lurgi Warme on technical applications and development possibilities. The concern does not design plant; this would be done by Lurgi Warme, but in special cases would nevertheless be responsible for stating the guarantee in terms of output, quality, degree of gas purification etc; furthermore it would provide operating staff to supervise the starting up of large installations.

All costs are borne by the holding companies, together with establishment and patent charges. Where assistance is given to Lurgi Warne the latter only pay out of pocket expenses incurred on their behalf.

WAR-TIME WORK.

Work of importance carried out during the war was stated to be recovery of CS_2 from Zellwolle and artificial silk processes. The gasses were first washed for removal of H_2S with Na_2CO_3 solution containing a small quantity of Activated Carbon as catalyst generally according to the

the reaction $Na_2Co_3 + H_2S + O_2 = Na_2S_2O_3$. Following this the gases were passed through a battery of Activated Carbon vessels for removal of CS_2.

During the war Zellwolle was used for the production of Tyre fabric.

FISCHER TROPSCH SYNTHESIS.

The use of activated carbon for this industry has been covered by other teams. Apparently improvements in efficiency had been achieved after modifying the earlier plants on the lines of using more air for drying and vapourising under a pressure of up to 8 Ats.

ETHYLENE RECOVERY.

A small but successful plant was stated to have been installed at Leverkusen with full automatic control for recovery of Ethylene. The special Activated Carbon used on this plant had been developed by I.G. and was similar to that used for the removal of toxic gases.

Following results at Leverkusen, two large plants were designed on similar lines, one for Hermann Goering Werkstatten, and the other for Gelsenkirchner Bergbau A.G. It was hoped to recover 90% of the C_2H_4 in the Coke Oven Gas.

These were not proceeded with because a system of pressure oil washing put forward by Still & Co. of Recklinghausen, though giving a recovery of only 60%, nevertheless called for a considerably less quantity of steel, and on this count was the more acceptable plant.

SEPARATION OF METHANE FROM TOWNS GAS.

Dr. Ruping stated that Lurgi Warme have given some consideration to the extraction of Methane from towns gas by means of active carbon with gas refrigeration.

A trial plant had been almost completed at Nuremnerg Gas Works, using an old Ammonia refrigerating unit sufficient to cool the gas down to - 40/50°C.

After passing through active carbon Benzol extraction plant, a third of the total gas, is cooled further for drying, and then after passing through regenerative exchangers enters the main Ammonia Cooler, after which two active carbon chambers are used alternatively, on the line for absorption, and off for extraction. A Vacuum Pump extracts the Methane, which is expected to be of 80% purity.

The residual gas, after passing back through the regenerative exchangers rejoins the outgoing stream of normal towns gas.

Reference should be made to flow sheet figure 10 - which was drawn out by Dr Ruping.

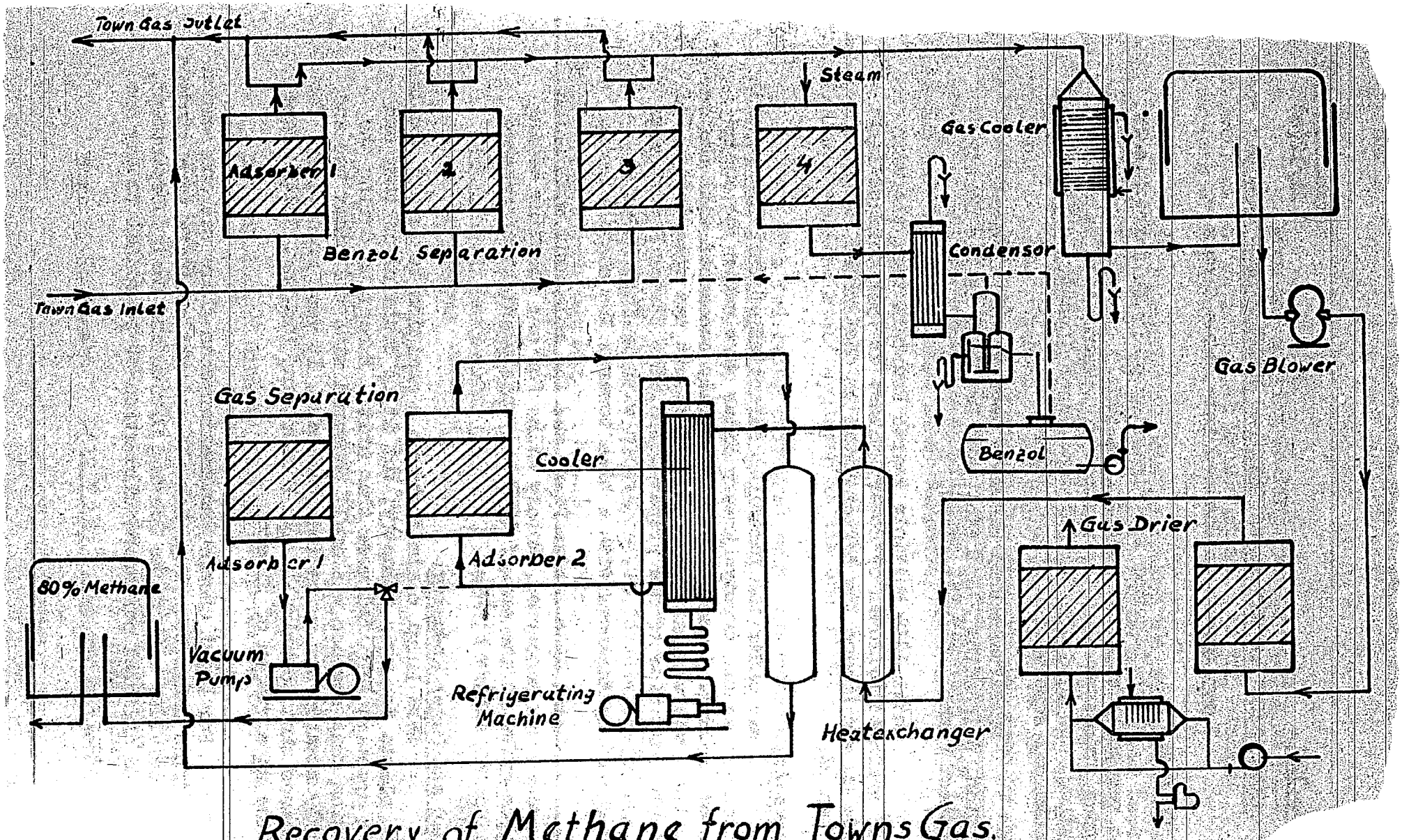
GENERAL.

Activated Carbon was of course used extensively throughout the war for Gas Masks.

There had been no recent developments in decolourising. There had been a small usage for "Anoden" battery cells where Activated Carbon was substituted for MnO_2. Although extensive research had been expended on this, difficulties under Winter conditions had not been overcome.

PRESENT WORK.

When the writers visited Bad Homberg, the laboratory was being allowed to continue research only on problems connected with water purification.



Recovery of Methane from Towns Gas.

Fig. 10

LURGI GESELLSCHAFT fur CHEMIE und HUETTENWESEN m.b.H.

Lurgi Chemie is divided into three Groups:-

Lurgi Chemie:

which is under the direction of Dr.Wolfhart Siecke, who is responsible for the design and supply of Acid Plants and analogous processes. For the purpose of organisation as opposed to costing, the Division for Pulp and Paper Industry comes under the technical supervision of Dr.Siecke.

Dr.Barwasser is Siecke's deputy for Sulphur Production, Sulphadine Plant etc., and Dr.Stahl is his deputy for Contact Plant and Spalt nlage.

Until 1935 Multiple Hearth Roasters were the main line of business followed by Rotary Kilns. In 1935 Contact Plant equalled up and became the largest item in the Annual Budget from then on.

Huettenwesen:

was under the technical direction of Herr Klenke with Dr.Wittenberg as his deputy. Rotary Kilns were under the supervision of Dip.Eng. Jordan who was primarily concerned with the ore preparation, whereas his deputy Herr Markwort was more interested in the chemical side of ore preparations. The Sinter Plants were under the supervision of Dr.Wenderborn with Dr.Kurt Meyer as Senior Operating Engineer with a bias towards the chemical side.

Until 1936 Sinter Plant was the sole unit with which Huettenwesen was concerned, Rotary Kilns for ore roasting coming into production at the end of 1937 but this plant never reached the value of Sinter Plant.

The Pulp and Paper Industry:

Here Lurgi claim to be in a position to supply complete process plants for this industry, but it is doubtful if they had ever in practice supplied more than units. Excepting during the depression this section was small compared with the other two and from 1939 onwards was quite insignificant. It was, presumably, for this reason that technically its senior man, Dip.Eng. Zoltau came under the supervision of Siecke.

.....

For Lurgi Chemie and Huettenwesen there was one common Drawing Office under Ober.Ing. Schwalb and whilst there were tendencies to specialise within the Drawing Office and Design Department, there was no official permanent allocation of personnel to any one Group.

From the section dealing with Research, it will be seen that there was a well equipped demonstration plant for ore preparation and enriching at Moussonstrasse in the eastern district of Frankfurt.

It is worthy of note here that the main function of this Group was to develop process plant for metallurgical factories, although Mg. and its subsidiary companies had been comparatively small customers during the past ten to 15 years as they had been largely re-equipped just previously. The reduction of currency available for the purchase of foreign ores since the 1914-18 war had tended to reduce the manufacturing capacity required by Mg.

Dr. Oetken was chairman of the Vorstand with Klenke, Siecke and Behlaert as the other members.

A list of the major contracts received by the Group from January, 1937 is amongst the documents available, also a list of technical staff employed at the end of July, 1945.

The following personnel were interrogated, the date of the first interrogation being given in brackets. Also the position they held in the Company is given.

Herr Klenke	(7.7.45.)	Vorstand
Dr.Wolfhart Siecke	(6.7.45.)	Vorstand. Acid Plant.
Dip.Eng.Paul Jordan	(7.7.45)	Sen. Prokurist for Ore Preparation.
Herr Ernst Markwort	(7.7.45)	Chemico (Metallurgist)
Dr.Joseph Barwasser	(9.7.45.)	Prokurist - Chem.& Met. SO_2 and Sulphidine.
Dr.Herbert Wittenberg	(9.7.45.)	Dwight-Lloyd Sinter Plants
Dr.Helmuth Wenderborn	(9.7.45.)	Asst. to Wittenberg.
Dr. Kurt Meyer	(9.7.45.)	Operating Engineer for Sinter Plant.
Dip.Eng.Otto Kreisler	(10.7.45)	Sulphite Mills - mainly engineering.
Dip.Eng. Zoltau	(10.7.45)	Sulphite Mills - mainly technical & chemical.
Dr. Wilhelm Thumm	(10.7.45)	Sulphur & SO_2 - Sinter Plant.
Dip.Eng.Joseph Sinigoy	(10.7.45)	Operative Engineer H_2SO_4 Plant.
Herr Giess	(10.7.45)	
Ober.Ing.Jacob Schwalb	(12.7.45)	Head of Design D.O.
Herr Karl Behlaert	(12.7.45)	Chief Executive Commercial also other Lurgi Cos.
Herr P. Speickart	(12.7.45)	Asst. to Wittenberg

Ober Ing. E. Krause	(12.7.45)	Section Design Leader. Rotary Roasting Kilns.
Wilhelm Marten	(12.7.45)	Progress & Inspection.
Paul Mohr	(12.7.45)	Section Leader. Part H_2SO_4 Plants.
Dr. Stahl	(14.7.45)	H_2SO_4 Plants.

The following table gives certain extracts from the Annual Statistical Report for certain selected typical years. From this it will be noted that Chemie made a loss of nearly a quarter of a million Reichmarks in the year 1941. This, however, was very largely due to considerable carry forward of work in hand on Contact Plants, there being a nominal loss of 93,000 Reichmarks for these Plants in the year ending 1941 as against a profit of 440,000 Reichmarks during 1942. In the year ending 1942 Chemie made a total profit of 908,000 Reichmarks, Huettenwesen more than doubled their profit during the year ending 1942 and the Pulp and Paper Division also recorded a small profit of 12,000 Reichmarks.

The next table shewing some extracts for the year ending September, 1941, is self explanatory.

Unless otherwise stated, the term " urgi Chemie" or Chemie" when used in this report, covers the three sections mentioned above and is therefore an abbreviation of Lurgi Chemie & Huettenwesen.

EXTRACTS FROM LURGI-CHEMIE ANNUAL STATISTICS

	1929	1933	1936	1937	1938	1940	1941	1925-41
Value of Contracts received in million R.M	11	1	8	16	26	25	8	142
Value of output in million R.M.	6	1.5	4	8	11	13	17	110
Staff employed	80	65	99	130	163	204	240	0
Travelling expenses abroad in 1000 R.M.	174	72	122	192	220	236	282	2610
Profit from Chemie in 1000 R.M.						681	-231	2468
Profit from Huettenwesen in 1000 R.M.						289	1071	3209
Profit from Zellstoff in 1000 R.M.						-11	-49	-105
to Reserve Fund in 1000 R.M.						100	140	420
Contribution to M.g. Technical D in 1000R.M.						65	94	490
								1928-41
Contracts received from Europe and Overseas in 1000 R.M.						2398	969	30,646
Home Contracts in 1000 R.M.						22619	7338	99,619

Sheet No. 131

LURGI CHEMIE

Items of interest from Annual Statistical Report for year ending September, 1941.

		Reichmarks
Work in hand		3,000,000
Tax Certificates held		750,000
Credit with Mg.		10,000,000
Profit		1,160,000
Written off; Plant, Machinery, Furniture, etc.		430,000
Salaries		1,113,000
Wages (erectors etc.)		430,000
Compulsory Social & Health Insurance		74,000
Voluntary Social & Health Insurance & Contributions		186,000
Various taxation		305,000
Experimental Costs - Clients Works etc.	38,000	
less charges with respect to work at Houssonstr.	10,000	28,000
Patents		82,000
Contribution to Mg. Patent Office		28,000
Contribution to Mg. Legal Office		5,000
Agents: Russia 12,000: Japan 23,000		35,000
Output (Sales)		8,250,000
To Reserve Fund		140,000
Mg. Technical Research		94,000

LURGI CHEMIE RANGE OF ACTIVITIES.

Taking them in the order shewn on their leaflet entitled "Range of Activities of Lurgi Chemie":-

Chemical Industry

(A) Construction of Sulphuric Acid Factories
This will be dealt with in detail in this section.

(B) Sulphidine Process
This will be dealt with in detail in this section.

(c) Sulphuric Acid Concentration Plants.
In point of fact Lurgi have not made any Sulphuric Acid Concentration Plants, but they have developed a process with the Klepp-Lurgi process which involves adapting a process of wet sulphuric acid concentration from gases. Project drawings of this have been got out and they are quite confident that they can concentrate up to 93%. The more optimistic members of the staff think they could get up to 97%, but others expressed 95% as the probable maximum.

The amount of SO_2 available in sludge acid from the Petroleum Industry is insufficient to justify the process and in point of fact they have installed plant for burning the sludge acid to raise steam.

(d) Nitric Acid Plants.
They have not, in point of fact, proceeded with this.

(e) Phosphoric Acid Plants.
The Nordengren Phosphor Plant was not successful due to its low output and the heavy cost of repairs. Lurgi lost a lot of money over this process. There is one pilot plant in Sweden and also one full-scale plant, but the latter has not been in really satisfactory operation. The essence of the process is to use an acid with 66°Be instead of the normal 54°Be.

(f) Landskrona Band Filter.
They had supplied about 10 of these Filters but they are up against sever competition from Rotary Filters.

There has been no development by Lurgi since the war as it was understood that the inventor really had all the know-

how and that Lurgi had not assimilated all this. Dr. Aulisch of Ertzgebilder was mentioned as having been connected with this. It was understood that the Filters had never been free from trouble, although one installed by U.C.B. at Reims in Belgium in 1936 for Phosphoric Acid and Phosphate Salt was presumed to be working satisfactorily after certain improvements had been made by the user.

The rubber band tends to wear out quickly and Buna proved to be most unsatisfactory. The copper present in the solution when Gypsum, for example, is being treated attacks the rubber.

It was stated that Lurgi have a semi-technical plant on loan, but nobody seemed to know where it was, and it was thought to be in Czecho-Slovakia.

(c) Superphosphate Mills.

Their superphosphate business had always been small and they claimed this to be due to the German tendency to use mixed phosphates. The Keller Plant developed by the Anglo-Continental Guano Company was mentioned as being satisfactory for large scale production and a Swedish Plant (VISCO) was thought to be suitable for small scale production.

They do not consider that the manufacture of Superphosphate by a direct contact with sulphuric acid is the most satisfactory process on account of impurities produced and they did think that a more satisfactory system would follow if the phosphate rock was reduced in an electric furnace and then burned to phosphoric acid.

Dr. Siecke claimed to have in his mind a process on these lines, and to have seen the technical data of an I.G. Plant, together with costs, throughput, etc. He said that if Lurgi became interested again in Superphosphate they would endeavour to operate this plant under licence rather than develop one of their own, since they did not consider the market to be sufficiently large.

In any case they feel that for a considerable time to come reconditioning of existing plants will be the vogue in Germany rather than developing competitive processes where satisfactory systems already exist.

(h) Spiral Kilns.
This clearly calls for no comment.

(i) Mechanical Multiple Hearth Roasters and Rotary Kilns.
This will be dealt with in some detail.

(j) Sinter Machines.
This will be dealt with in some detail, including their use for cement production.

(k) Sulphur Combustion Furnaces.
Described briefly below.

(l) Rotating Sulphur Burners.
No longer in production.

(m) Mechanical Saltcake Furnaces.
Not proceeded with.

3) Pulp & Paper Industry.

(a) Lurgi Cellulose Cooking Process.
This is reported briefly below.

(b) Digester Filling Apparatus.
This is reported briefly below.

(c) Elimination of SO_2 gases from Waste Liquor
This is reported briefly below.

(d) Waldhof Process for Elimination of Resin contained in pulp.
This process has not proved a success.

(e) "Mannheim-Waldhof" Liquor Preheating Process.
This process had not proved economic.

(f) Scrubbers.
This is described below under the heading "Preparation of Sulphurous Acid"

(g) Sulphur Combustion Furnaces.
Described briefly below.

(h) Mechanical Multiple Hearth Roasters and Rotary Kilns.
This will be dealt with in some detail.

(i) Lurgi Coolers of Special Design.
No information was obtained.

(j) Lurgi Expansion Coolers.
These are now not used as they are very expensive and occupy too much floor space.

(k) Complete Liquor Preparation Plants.
There was no information available on this.

(l) Design & Engineering of Complete Sulphite Pulp Mills.
A rather schematic layout drawing No. Z.1642 dated 2.4.35. is available but not attached to this report.

Sulphur Burners.

This is fairly well described in their German leaflet available but not attached.

The Melting Tanks uses about 1/2 Kg. low pressure steam per 100 Kg. of Sulphur melted. This is then pumped to an overhead Charge Tank from which it falls by gravity through a steam jacketed pipe to the Injection Nozzle where about 1/2 Kg. of steam per 100 Kg of Sulphur is injected to assist in the diffusion. This is shewn on Drawing No.2260 dated 10.12.33., which is available but not attached. (Compressed air injection is no longer used since this over cools the Sulphur).

The temperature in the Chamber is about 1200°C. and this temperature must be maintained otherwise SO_3 is formed. Approximately 526 cm. of air is used per Kg. of Sulphur burned, and control is effected by observation of the shape of the flame cone, together with a periodic analysis of the exit gases, which is taken by hand.

They know of only one automatic gas analysis control system which is in operation in a Swedish plant, but they do not consider it a very attractive proposition.

Approximately 5 to 6 cm. of SO_2 is produced per Kg. of Sulphur burned.

The correct relation of diameter to length in the Sulphur Furnace is important to prevent sublimation or the formation of excess SO_3. Good lagging is essential. A typical Furnace is shewn in Drawing No.2214e which is available but not attached.

Subsequent to the Furnace there is a somewhat primitive type of water cooled condenser.

The average concentration of the gas contains about 15 to 16% of SO_2 which is definitely less than "Bis zu 19%" claimed in their leaflet.

They only make six sizes, namely 100, 200, 300, 400, 500 and 600 Kg. Sulphur burned per hour. It was stated that the nozzles of the smaller sizes tend to choke.

Plant for the Pulp and Paper Industry.

Preparation of Sulphurous Acid (Scrubbers)

The Towers are of conventional design, but Lurgi claimed to have improved the process by alternating the sequence of the two Towers once a day so as to prevent excessive deterioration of the lime in either tower at the base where the temperature always tends to be highest.

The Towers are about 3 M. diameter at the base, tapering to 2 M. at the top. The depth of the lime filled section is 30 to 35 M. The Towers can be made of either pinewood or cement. The lumps of lime stone should be on the large size, say 20 cm. across so that the fall of liquid down the Tower does not take more than 3 to 4 minutes on the average.

15% SO_2 gas from the Sulphur Burner passes up the first Tower and is then piped down to the base of the second Tower, and in each case flows counter-flow to the water being fed into the first Tower, which is fed to weak acid with about 2 to 3" SO_2 liquid and approximately 1% lime.

About 1200 cm. of weak acid is produced from the Plant per day.

The weak acid is then narrowed by bubbling SO_2 gas of 30 to 40% concentration, which is drawn off from the Digestor during the latter part of the process. A rough sketch Fig.No.11a shews the flow sheet for this process.

Digestor Charging Systems.

Huntermueller: This is simply a small electrically driven propeller type of spreader located in the charging neck of the Digestor. It is a simple job but not very effective.

Fresk: This system relies on obtaining a rotary motion of the chips by injecting air tangentially into the throat of the Digestor. This results in an even spread of chips and a more compact mass. The system is claimed to be successful in practice and the quantity of the charge is increased by about 25% over a normal gravity charging system. This has the incidental advantage that it decreases the quantity of Acid in the Digestor which has to be heated up. Se Fig. 12 a.

Swenson: This is operated under Swedish licence

and claims the same advantages as are achieved with the Fresk system. In addition, however, as the charging process takes about one hour and steam is being injected during this time, a certain amount of heat is put into the chips, also a more intimate contact of the chips with steam is obtained before the chips become part of a mass. It is claimed to be less costly in operation than the Fresk system.

The chips are stated to be heated up to nearly 90°C with less time for charging and more than a hour saved on the normal 4 to 5 hour heating up period.

About 4 tons of steam per hour are required to heat up a 200 cu.M. charge, which corresponds to approximately 20 tons of pulp. Drawings Nos. S.C.321 and 322 dated 1944 are available but not attached.

Improvement on Digesting Process.

In the normal process live steam is injected at the bottom of the Digestor and the acid moves slowly by convection against the resistance of the mass of wet chip or pulp. Treatment is therefore slow and the mass in the centre of the Digestor tends to be overtreated and the mass on the outside of the Digestor to receive insufficient treatment. This normally takes 16 to 17 hours. The sulphurous acid which has been enriched after leaving the Towers by the addition of SO_2 from the Digestor itself is introduced to the Digestor at a concentration of 6%. Lurgi pre-heat this to 60 to 70°C., the pressure in the Digestor is about 5 atmospheres.

Steam is taken from the Vessel itself and a Compressor driven by a 100 H.P. motor pulls the acid from the top coil and forces it through the injector into a smaller perforated coil at the bottom of the Digestor.

Approximately 10 to 12 m^3 of acid is circulated per minute. The diameter of the perforated coil is about 10 cm. at its narrowest and 300 cm. at its widest. The perforated area is constant per unit of length.

In some cases the Injector is situated inside the Vessel itself, in which case expansion "bellows" must be fitted.

When the digestion process is complete, the draw-off coil must be not less than 20 cm. below the liquid level. All parts coming into contact with the acid are made of V_2A Stainless

Steel and it was stated that neither corrosion nor erosion takes place.

About two to three hours of the Digesting time is saved, but what is more important is that a better pulp is claimed since no acid burning takes place. See Fig. 11b Drawing No. Z.2377 is available but not attached to this report.

Recovery of SO_2 Gases from Waste Liquor.

About 0.8% of the waste liquor from the Digestor is SO_2. The volume of waste liquor per charge is about 50 to 55% of the full capacity of the Digestor. The pressure of the liquor entering the Recovery Vessel varies from 2 atmospheres at the commencement of the cycle to atmospheric pressure at the end. During this time the temperature decreases from 105°C. to 97°C. In the Vessel there are a number of trays which are ring packed and by the liquid fall over the rings flash evaporation takes place.

The SO_2 content of the residual liquor is 0.1%, the total saving is approximately 10% of the sulphur burned per ton of pulp. One ton of pulp required approximately 100 Kg. of Sulphur which is equivalent to 200 Kg. of SO_2. This recovery process therefore saves approximately 24Kg. of SO_2 per ton of pulp treated. See Fig. 12b.

Most of the pulp liquor units installed by Lurgi are in Finland, Iceland and Latvia, but there are two plants in Germany, Aschaffenburg at Redenfelden, near Rosenheim and Feldmueller at Konigsberg.

Drawing No. Z.1642 dated 2.4.35. is available but not attached and shews a schematic plant layout.

SULPHURIC ACID

In 1940 and 1941 Sulphuric Acid Plants assumed an important position in Lurgi-Chemie order book, representing approximately 50% of the contracts received in each year, to a total value in the two years of nearly 20 million Reichmarks.

Dr.Siecke and Dr.Stahl, together with Dr.Thumm were the principle persons concerned.

As it was understood that subsequent teams would be investigating the Sulphuric Acid Plants, and in point of fact they have done so before the completion of this report, it is not proposed to go into very great detail over the Lurgi plants.

An important war time type of plant was that for the production of Sulphuric Acid (Mono Hydrate) and Oleum from spend acid in explosives works. Four of these have been installed at Allendorf, Schlebusch, Herrlichtenau and Elsnitz Bromberg.

These were responsible for approximately 500,000 tons per annum which was a quarter of the total German production of Sulphuric Acid.

One of these was visited and is described below:

Sulphuric Acid Plant at Dynamit A.G., Allendorf, Nr.Marburg. 2eii/76

This plant comprises a self-contained section of a large explosives factory built in forest land during the war. The function of the plant was to utilise spend acid from the T.N.T. process and by combustion with producer gas and the purification of the resultant gases, conversion to SO_3 in Contact Chambers and finally absorbed into weak acid to produce both Monohydrate and Fuming Acid.

The plant was in perfect condition and operated right up to within a few hours of the zone being occupied. Two interesting entries on the last log sheet, dated 12.3.45., read:

"12.00 - 16.00 Stillstand wegen Fliegeralarm.
16.00 Betrieb abgefahren."

All the buildings were made of reinforced concrete. A second unit had been planned and the Producer Gas plant largely installed.

Flow Sheet No. KT.4678, together with the legend on a separate sheet, are available but not attached to this report.

Producer Gas Plant.

There was a battery of four Lurgi hand-fed mechanical grate type Producers with steam jacket suitable for 0.5 Kg. per sq. cm. pressure. A second identical battery had recently been installed adjacent to this for an Acid Plant extension but was not, however, proceeded with.

Fuel: Brown coal briquettes which were brought in by rail are stacked in a covered stock yard by an overhead travelling crane and three ton grab. The coal stockage under cover was 5,000 tons. Below the stockyard level, hoppers feed briquettes into a steel plate feeder to a wire rod S spring screen and from this screen into a tumbler or drum feeder, the gap in which coincided with the bucket of a bucket and link elevator.

The travel of the bucket train passes horizontally over the four reinforced concrete storage bunkers into which fuel is tipped by an adjustable tip so that any bunker may be filled. From the bunker a hand operated gate valve allows fuel to pass into the bell sealed charging hopper which has a hand operated lid.

The low pressure boiler jacket, of riveted construction, raises only half the steam required and the balance required for saturation is from highpressure works supply.

The jacketed boiler had an annular steam offtake ring main which fed into a steam drum, the whole being heavily lagged.

A cast iron grate is carried on a ball track and the drive is by means of friction drive from motor and gear mounted on an operating platform (worm and worm track of usual type).

Steam blown poke holes are fitted.

In the adjacent machinery house, two centrifugal air blowers, each of 5,400 cu.M. per hour are housed (one being standby). The pressure is 445 mm., 13.5 H.P. all at 15°C and 1.2 Bar.

There are also two centrifugal gas exhausters each of 13,200 cu.M. per hour at 80°C. and 0.8 Kg/cm. density; 305 mm. pressure, 23 H.P. (one standby).

The hot gases leave the Producer (top pressure about

200 mm.) and enter a common hydraulic main and washing tower. At 80°C. a Lurgi Cottrell Precipitator takes out tar and dust and the gas booster or exhauster passes the gas forward for distribution via a small spray catcher.

In general the Producer Plant and all auxilliaries were of robust design and first class workmanship, but instruments were few and hand control applied throughout. Originally the tar was sent to Hydrogenation Works, but latterly rail disorganisation made this impossible and the Precipitator was not used and the tarry gases were sent to the Acid Plant.

Starting up instructions for the Producer Plant and Cottrell Precipitator were among the documents collected - Ref.70 Geb.054. Log sheets of Gas Producer Plant are available - Spaltanlage Allendorf Geb.053 (Machines) and (Generator).

Spaltanlage.

The producer gases passed through a bricklined overhead pipe to the building housing the Acid Burning Plant (Spaltanlage). There are four Combustion Furnaces (Spaltoefen) with separate secondary combustion chambers; in the same building the Air-Gas Heat Exchangers and Air Fans are housed. See layout drawing No.A.W.252 dated 13.7.40.

An external spend acid stock tank fed the overhead charge tank through two (one spare) centrifugal glandless acid pumps. The acid is passed through a rotameter to the acid injectors having a cast iron body with renewable alloy nozzle with side air inlet into which primary air was fed at 1 atmosphere pressure. The body was made in two sections for cleaning purposes and was removed about every six months. The air is supplied by three Demag Rotary Compressors (one spare) Type 076, 721 cu.M. per hour at 980 R.P.M. The acid consumption is 30/35 tons of acid per furnace per day at 85% to 86% concentration.

The combustion furnaces were fed by two burners, mixed gas and air at the burner offset to give tangential flow (each is fitted with centre sight glass). These furnaces are shewn on drawing No. A.W.200 dated 24.3.41. The main modification to this drawing is elimination of the arrangement for removing the furnace hearth on rollers and the hearth has subsequently been welded to the body. This is cleaned out every three months by hand.

The consumption of producer gas was 1,000 cu.M. per ton of acid feed and a similar quantity of air. The Plant was designed to use air heated by means of tubular heat exchangers.

The air from the two centrifugal fans passes outside the tubes taking heat from the combustion gases. Owing largely to the failure of the method of introducing the combustion gases into the secondary combustion chambers (see below), so little dust was extracted therein that it blocked the tubes of the heat exchangers so quickly that they were a failure. The dust was mainly iron oxide. Other means of preheating the air resulted in burning out the tubes; preheating was then discontinued.

The secondary combustion chambers, see drawing No. A.W.212 dated 25.3.41., were altered by changing the gas inlet from a rectangular section towards the top of the chamber, to a circular section of 10'-9" outside circumference, the top of which was 21" below the lower edge of the original inlet (now blanked off).

A number of log sheets for this plant are available but not attached - Spaltanlage Allendorf Geb.054. Ref.70.

Repairs to the refractory lining were frequent and one of the set was always off the line; coatings of iron oxide built up on the walls of both vessels.

SO_2 Cooling and Cleaning.

From the cracking building (Spaltanlage) the gases at 700°C. are taken via brick lined Mild Steel main to the cooling and cleaning plant.

The first cooling tower is of lead and the connecting branch coupling up to the Mild Steel hot gas main is also of lead but externally water sprayed by twin circumferential spray pipes to prevent distortions.

This first tower is an empty vessel into which spent cold acid of 78% strength is sprayed from the top. Three pumps (one spare) feed the cold acid, each pump giving 75 Cu.M. per hour = 150 cu. M. wash acid per tower per hour.

The gas entering the base of this tower at about 600°C leaves the top at 60°C and the acid at 65/70° flows into eight lead acid coolers. These are circular lead trenches with six water coils inside. From the eight coolers the acid flows into a receiver from which it is pumped by three pumps (1 spare) to the top of the tower. In all for three towers there are 24 coolers, 3 receiving tanks and 9 pumps. On the top of the towers are three circumferential manifolds feeding quick removable sprays, lead cased with bronze auger shaped removable centres.

The second tower is of mild steel and ring filled. The gas enters at 60°C and leaves at 40°C.

The strength of acid used for cooling is 92%.

From tower No. 2, the gases at 40°C. pass to the third or intermediate tower of lead, which it leaves at 30°C. to enter six dry precipitators in series with universal changeover connections. The precipitators are of lead construction by Lurgi Bau, who were responsible for the supply of all the lead work on the plant.

The whole of this section is under suction and at the entry to No.3 tower is a simple air slide which is adjusted to allow 10%of oxygen to enter the gas stream, this being required for the contact conversion process.

Log sheets of this are available but not attached to this report; ref; 70 Geb.055.

Contact House.

Saturated with H_2O at 20/25°C., say 3% water, the gas, cold and clean enters the Contact House where it enters the base of a lead drying tower, ring packed, and sprayed from the top by 60 Be 78% acid. The gas leaves there with 0.7 Grms. H_2O/Cu.M. and enters the second drying tower of mild steel where it is sprayed with acid of 92% strength, which reduces the H_2O to 0.3 to 0.5 grms. Cu.M.

The cooling of the acid wash at this section is effected by C.I. atmospheric coolers mounted on the roof of the annex which houses the receiving tanks and pumps.

As H_2O is absorbed by the washing acid, the excess is led off into the stream going to the cracking furnace (Spaltanlage). It should be noted that this washing acid is the spent acid of 95% strength which comes in whole or part first to the contact house. The dry gas passes finally through in parallel twin disc filters before entering the exhauster-boosters. There are two machines, one in operation, built by K.K.K. as follows:

25,800 cu.M. per hour at 50°C with 1.16 Kg/Cu.M. density,
2,950 R.P.M. against 720 mm. water pressure, motors
214 H.P.

The gas is now in a condition for the conversion to SO_3 and splits into two equal streams, each through two large vertical tubular heat exchangers to enter the contact chamber or convertor.

A by-pass allows cold gas to go direct into the top of the convertor for temperature control.

Convertor (see drawing No. KT.4381)

The dry preheated gas enters the Convertor by a circumferential inlet manifold with a master baffle or damper disc to deflect the stream to an equal pressure all round. Multi inlets from the manifold, each with an adjusting damper, allow the gas to pass into the body of the Convertor at about mid-height. (When starting up the Convertor is heated by hot air to bring it up to working temperature).

First passing upwards around the outside of a mass of vertical tubes which are filled with catalyst, the gas is further preheated. A layer of catalyst is traversed before entering the tubes for downward travel. The entry temperature is about 300°C.

After leaving the catalyst filled tubes a baffle is passed for gas mixing and then a bottom layer of catalyst completes the conversion and the gas, now SO_3, goes to the above mentioned heat exchangers to give up generated heat to the incoming SO_2.

Lowered in temperature to 180°C. the SO_3 is further cooled on a tubular indirect cooler (water) and at 50/60°C. enters the base of the absorption tower. At this point the divided gas stream again unites.

The absorbing liquid is spent acid recyled over coolers (atmospheric) to give a balance of required strength and the fuming acid goes out to the factory. A second absorption tower similarly fed by recycled acid is operated to give the monohydrate.

The waste gases are washed by alkali solution before going to atmosphere but this had not proved entirely satisfactory as the gases had even so killed many of the surrounding pine trees and a tall brick chimney had been added later.

A full complement of hourly log sheets for the sections of the plant are available and should be examined for actual temperatures, pressures and quantities in preference to the few figures quoted herein.

Sheet No. 146

The following drawings are available but not attached to this report:

A.W. 200	Combustion Furnace.
A.W. 212	Secondary Combustion Chamber.
A.W.252	Layout of Combustion Section.
K.T. 4381	Contact Vessel.
K.T. 4678	Flow Sheet.

Standard Lurgi Plant supplied to the Sefanitro Concern.

The most modern contact plant was being supplied by Lurgi to a Spanish concern at Sefanitro. It was stated that a considerable proportion of the equipment had been delivered to site but it was not complete. It was a complete factory including large modern ore roasting kilns. The Cooling, Contact and Conversion Plant is substantially as described above.

The plant layout is shewn on drawing No. K.T.6012 and the following drawings are available:

A.W. 2783	K.T.3097	K.T.3992	K.T. 4383
K.T. 2257	K.T.3317	K.T. 3997	K.T. 4384
K.T. 2282	K.T.3558	K.T.4352	K.T. 4751
K.T. 2807	K.T.3598	K.T.4382	K.T. 6577

Dr. Siecke stated that Lurgi had actually installed 6 or 7 Sulphuric Acid Plants during the war, each having an output of 150 to 175 tons per day. Processes had been developed by Aussiger Verein of Prague together with I.G.Farbenindustrie and that the latest example actually operation was at Nord Deutche Affinerie at Hamburg. It was not considered that the plant was superior to the I.C.I. or Kuhlman Plants.

Sheet No. 148

Klepp-Lurgi Concentration Plant.

This was an experimental process installed at an explosives factory and used in conjunction with a Standard Spaltanlage. Drawing No. C.K.L.132 shews the layout, but as existing equipment was used the sizes are not necessarily correct; generally speaking the vessels were too large.

Spent acid at 70% was the raw material and it was hoped to concentrate this to between 90% and 95%, but Dr. Stahl was doubtful if they would attain a higher concentration than 85% to 90% maximum.

It would seem that the plant was to be used as a preliminary to the Spaltofen system to decrease the quantity of water vapour. Lurgi evidently doubted the enthusiasm of Klepp the Dynamit A.G. inventor.

The Furnace, item 1, is a typical Spaltofen in to which the acid at about 120°C. is sprayed in the normal manner. An excess of secondary air is supplied together with a normal quantity of generator gas, providing an ultimate ratio of 10 air to 1 gas, giving a temperature of 250°C. to 300°C. This effects evaporation of water only.

Some Acid falls to the bottom of the furnace and is drawn off to Tank 4 at 90% strength (not the 96% optimistically shewn on the drawing). The smaller acid particles are carried forward in the gas stream to Cyclone 2. The balance of the Acid is vapourised and entrained in the gas stream passes to Wash Tower, 3, where it is washed with 70% acid to produce 80% acid. This is drawn off to Tank 5, which acts as the feed tank for the furnace. The circulating acid is cooled to about 100°C. with continual draw off as required for the Furnace.

Amongst suggestions for improvement in design made by Dr. Stahl, were increase in the height of the furnace and decrease in the diameter of the Cyclone from 4M to 3M, having a height of about 7M.

Fundamentally this plant was stated to be only a Gaillard Tower with an electric precipitator.

It should be noted that Siecke, who is senior to Stahl, but of somewhat optimistic outlook, was enthusiastic about the prospects of this plant.

WET CONTACT PLANT

This is a process for obtaining 75% Sulphuric Acid from H_2S.

The gaseous products comprising approximately 3% H_2S and about 20% of CO_2 are burned with Generator Gas at about 600°C. in a Claus Kiln. The combustion gases now contain approximately 1.5 to 2% SO_2, 6% O_2, 10 to 12% H_2O and the balance CO_2 and N_2. It is essential that the gases be clean and in practice it is found to be the case. The temperature of the combustion gases entering the converter should be about 450°C.

The contact vessel (which has also been called the convertor) has four layers, each about 20 to 30 cm. deep of vanadium catalyst. It is air jacketed for cooling and approximately a quantity of air equal to the throughput of gases, i.e. 6,000 cu.M. per hour is required for cooling.

In the normal process as shewn on drawing No. K.N.4880, the gases, now containing SO_3, pass to an absorption tower where slow cooling takes place and 2/3 to 3/4 of the SO_3 is condensed in this tower. The remaining 1/3 or 1/4 then passes to a Cottrell.

The exit gases contain approximately 8 to 8.5% H_2O and it has been stated that at Bohlen, which uses this process, 78% acid was obtained with a 95 to 97% total acid conversion.

At the latter plant, corrosion troubles were experienced in the pipelines and absorption towers on account of the high temperature which was used to eliminate excess water vapour.

An alternative method of condensing the acid is by the use of a procelain tube type of condenser as shewn on drawing No. K.N.3240. In practice, however, considerable trouble has been experienced with this type of condenser at the joint of the tube and the tube plates, particularly the top tube plate. The advantage of using this type of condenser is that more rapid cooling can be effected and the formation of mist avoided. It is doubtful if Lurgi have actually installed a satisfactory condenser of this construction.

This process is not considered economic compared with obtaining SO_2 from Pyrites Burners, but in plants where it is necessary to eliminate H_2S and an output of the order of 10 to 15 tons of acid per day is required, it is considered by Lurgi that this plant has a commercial future.

As mentioned above it is essential that the gases be clean, therefore, if a Pyrites burner is used, the gases have to be cooled before the appropriate cleaning can take place and the heat exchanger design for subsequent re-heating causes difficulties.

A source of H_2S is from Ammonia Saturators. Another source is the H_2S produced during the hydrogenation of fuels where the H_2S is removed and enriched by washing with an organic compound called Alkazid. This was said to be described in I.G. Patent literature.

A typical gas cooler is shewn in drawing No. Z.1813.

SULPHIDINE PROCESS.

This process for the enrichment of SO_2 from Smelter Gases by the use of Toluene or Xylidine is well known and a number of plants have been installed by Lurgi. Normally the enriched SO_2 gas is reduced to produce elemental sulphur.

Typical plants installed by Lurgi include:

Sulphur from zinc blend at Kattowitze, a trial plant being installed in 1940 and a commercial plant in 1943.
Sulphur from FeS_2 at the rate of 10 to 12 tons per day at the Saur Fabrik Schweizer, Schweizer Halle, Basle, in 1945.
Sulphur from rotary kiln anhydrite at the rate of 70 tons per day for I.G.Farbenindustrie, Wolfen, Nr. Bitterfelde in 1940.

As a matter of interest the sulphur and SO_2 produced on this latter plant was used in the sulphonation and chlorination of hydro-carbon for the production of a synthetic fatty acid known under the trade name of "Mersol" which is used as a raw material for soap manufacture.

Sulphur and cement from anhydrite at Nordhausen. This plant is described hereunder.

Nordhausen Plant.

This plant was designed to produce 180 tons of cement and 50 tons elemental sulphur per 24 hours from 250 to 300 tons of ore. The raw materials were Buntsandstein containing Al_2O_3, SiO_2, CaO, Kiesabbrand (Fe_2O_3) and anhydrite ($CaSO_4$).

In normal circumstances a rotary furnace would have been installed, but on account of metal and manpower shortage a sintering plant was provided on this occasion. The concentration of SO_2 from the sintering plant is of the order of 4 to 6% whereas a rotary furnace will give 8 to 10%.

The plant was ~~commissioned~~ ordered in 1941 and finally installed in 1943. By this time the emphasis on the production of elemental sulphur had considerably decreased and no priority was therefore obtained for modifications which were required to over-

come certain difficulties which had arisen, due to the fact that an unanticipated quantity of H_2S was obtained in the sintering plant which upset the balance in the Sulphidine Plant.

It would also appear that excess sulphur gave considerable trouble in the cement process and Lurgi excused themselved by stating they did not have time to carry out the appropriate trials on the raw materials which would have shewn up these two faults.

All drawings mentioned in this section are available but not attached to this report. Certain quantities have been added by the writers to these drawings and it is only the intention here to give a brief outline of the process to make the perusal of these drawings more intelligible.

Fig 13 Drawing No. Z.238 shews schematic layout of the whole plant. A typical sintering plant for the production of cement is shewn on drawing No. 6647, but it is not for the Nordhausen Plant.

About one million cubic metres of gas containing 4% SO_2 is passed to a water spray tower, which is only necessary when it is required to aid the electric precipitation in the dry cottrell by increasing the dust conductivity.

In addition, on this particular plant, approximately 70 to 80,000 cubic metres of gas containing SO_2, O_2 and N_2 from the sulphur reduction plant is added at this stage, although more normally it would be returned to the sinter plant. In this case the layout was such that long pipelines would have been required, in which case the sulphur dust would tend to settle in the pipelines.

As will be seen from drawing No. SCH.145, a sulphur compound burning chamber is shewn in dotted lines, which represents the more normal process but which was not supplied in this case.

After the dry cottrell the gases enter a water wash tower at 150°C where they are cooled to 50 to 60°C. before passing through to the wet Cottrell precipitators. There is a subsequent cooling tower where the gases are cooled to 20 to 25°C. At this temperature they pass to the sulphonation plant. This is shewn on drawing No. X.680. The pipeline schematic drawing No. X.550 should be examined in conjunction with this.

The first section of this plant comprises 3 Absorption Towers with Xylidine passing counter current against the gases. In spite of inter-coolers between each Absorption Tower, the exo-thermic reaction increases the final temperature of the enriched Xylidine to 35°C. which has to be cooled before it is

passed to the Distillation Section.

Final traces of SO_2 are washed from the gases in a tower by 3 to 4% sulphuric acid, the gases then passing to atmosphere.

In the plant described, approximately 200 grammes of SO_2 is absorbed per litre of Xylidine solution, but when rotary furnaces are used, approximately 400 to 500 grammes of SO_2 is absorbed per litre of solution. The limiting factor is, in each case, a tendency for crystallisation to take place.

The enriched Xylidine is distilled and fractionated to produce 100% SO_2 which passes to the Reduction Plant. The Xylidine passes back after cooling to 25°C to the third Absorption Tower, but because some sulphenation occurs, due to the presence of SO_3 liquor, regeneration is necessary. A proportion of the Xylidine, therefore, from the Distillation Plant, passes to another plant where a portion of the acid from the wash tower is also treated.

In the first stage of this, $Na_2 SO_4$ is produced and this, together with the Xylidine which has been by-passed to the plant, passes to a small steam heated Evaporator where Xylidine and water passes over to a Condenser and the $Na_2 SO_4$ goes to waste.

After the Condenser where the water is separated out from the Xylidine, the Xylidine passes to a steam coil heated, agitated Vessel to which is added $Na_2 CO_3$ for the purposes of regeneration, and the Na_2 is run off to waste, the purified Xylidine being returned to the Absorption Plant.

The Reduction Plant is shewn on drawing No.SCH.145. About 680 to 720 Kg. of coke of 20 to 40 mm. size is required per ton of sulphur which has to be dried if there is more than 8% moisture present. This is fed into a specially designed dry base generator into which the bulk of the 100% SO_2 is passed for mixing with an equal quantity of air. The subsequent gases go through a gas drier and dust separator, as shewn on drawing No.1369a and thence to a Catalyst Chamber, one third of 100% SO_2 being added at this stage to reduce the gas temperature from 800 to 600°C.

The gases entering the Catalyst Chamber are CO_2, COS, CO and S_2 and the catalyst is ferrous alumina made from a bauxite base. The ground Fe_2O_3 is made into a paste into which 1" diameter stone or brick has been dipped.

It is then crushed and filled into Raschig Rings 150 mm. deep x 120 mm. bore x 15 mm. thick. The Collection Chamber is shewn on Drawing No. SCH.80.

The resultant gases, CO_2, N_2 and S_2 are cooled to 450°C. when they pass to the Sulphur Condenser.

It should be noted that the relationship of temperature to percentage of sulphur in the gases is important since sulphur tends to condense at 300°C. having a 50/50 percent mixture.

The Sulphur Condenser and After Cooler are shewn on drawings Nos. SK.2632 and C.1541.

The Condenser has hot water heated tubes (under pressure of 2 to 3 atmosphere), the hot water being pumped from a pre-heater through the After Cooler at an entrance temperature of 70 to 90°C. It is important that this temperature is maintained in the After Cooler otherwise the sulphur will block the After Cooler, and trouble has been experienced in this connection. About 85% of the sulphur is condensed in this and drawn off at a temperature of 130°C; about 15% of sulphur is recovered in the After Cooler and the balance goes to an electric cottrell precipitator at about 135°C. (Importance is attached to maintaining this temperature below 140°C. which is not always easy in practice).

After the Cottrell the sulphur burning chamber, which has been mentioned previously, is sometimes installed, but in any case after a final washing the residual SO_2 passes back to the gas cleaning plant for re-circulation.

It is claimed that about 90 to 92% of the sulphur contained in the ore is recovered, but it would appear from a statement made, that at the Schweizer Plant, where an output of 10 to 12 tons per day was achieved, this figure was not normally reached.

In the last plant supplied the loss of Xylidine was stated to be 0.5 Kg. per metric ton of SO_2 produced.

The Sulphur Reduction Plant is based on the I.C.I.-Boliden-Sieper process. For dry base Reduction Generator see Drg. No. 13619a.

As a matter of interest a photostat of the I.G., Wolfen contract with Lurgi is available.

Sheet No. 155

The following Metallgesellschaft reports which are available, might be worth while considering in conjunction with the Sulphidine Process:

1364
1376
~~1425~~
1541
~~1666~~
1676
1677
1744
1760
1761
1826

DWIGHT-LLOYD SINTER PLANTS:

Interrogation of Dr. Wittenberg and Dr. Helmuth Wenderborn indicated that the Dwight-Lloyd Sinter Machines formed a major part of the Lurgi Chemie business. From the records of orders it would appear that between 1937 and 1943 forty-five Sinter Machines were ordered, five remaining uncompleted.

Of these orders thirty-six Plants were for the Iron Industry, five for non-ferrous ores and four for cement manufacture.

The following sizes of plant were supplied by Lurgi:-

Circular Machines - 10 sq.m. and 20 sq.m. grate area.

Normal straight type - 26, 34, 42, 50, 62·5 and 75 sq.m. grate area, the last of these having a width of 2½ m. and a length of 35 m. including the drive. The plant is not radically different from the basic D-L design save for the fitting of a roll feeder with gate adjustment for the depth of bed.

Cyclone dust catchers are used as being adequately efficient and not too costly. Sinter fans of rivetted construction are used. Hemeatite iron grate bars give a life of 3-6 months or, with easily melted ores, one year.

APPLICATION OF PLANT:

Recent Plants installed in order of importance:-

Iron Ore.

Cement.

Zinc Blend.

Anhydrite.

IRON ORE:

During the war the most important installations have been:-

Reischwerk, Watenstadt. - 8 Plants of the largest size operating in conjunction with the Magnetic Separation Plant.

Reischwerk, Linz, Austria. - 4 Plants of the largest size.

Outputs of up to 35 tons per day per sq. metre of grate area are claimed with good sintering ores dropping to 13 tons per day per sq. metre with ores of poor sintering characteristics. Under ideal conditions outputs of over 2,000 tons per day have been achieved on the largest Plant.

Dr. Wittenberg stressed that for maximum results they aim at a grain size of 5-7 mm. and never exceeding 8-10 mm.

CEMENT:

In conjunction with the Magdeburg Krupp Grusonwerke, Lurgi have installed the D-L Plant for the burning of cement clinker. Krupp, who are established cement machinery contractors, invariably took the main contract and Lurgi dealt with the clinker burning only.

The following plants were said to have been installed:-

1938 - Koenigsofen, Near Prague, - 150 tons per day.

1939 - Oppeln Silesia - 300 tons per day.

1941 - Dotternhausen, Near, Wurtenburg - 200-300 tons per day.
(This plant uses spent oil shale).

1943 - Nordhausen - 150 tons per day.
This plant was to use anhydrite as part of the complete sulphur extraction plant and never made cement owing to process difficulties.

So far the D-L Plant has only been used for dry process but Pilot Plant work was stated to have been satisfactorily carried out on the wet process.

For the dry process a normal type of grate is used and the raw meal after normal preparation, during which 20% of the total fuel used is intermixed, is granulated in a Trommel Mixer and fed on to the grate containing moisture of 11-13%. The remaining 80% of the fuel is mixed with the granulated meal in the Trommel.

An under layer of burnt clinker is maintained and the bed of granulated raw meal and coke is about 20 Cms.. The clinker is burnt under observation and at the discharge end passes over a vibrating screen made by Shenck of Darmstadt, specially suitable for hot clinker and sinter.

There is a substantial amount of rejected fines and partially burnt clinker but this is necessary since an essential part of the secondary preparation of the granulated raw meal is an admixture of dry rejected fines. The proportion of returned fines admixed to the raw meal just prior to entry into the granulating trommel is 60-100% of the raw meal (dry weight).

With the dry process a fuel consumption of 1200 calories per kilo is claimed and in practice the fuel consumption was stated to vary between 17% and 20%.

Pilot results on the wet process show that this can be operated but the percentage of returned fines must be far higher, 200 to 400% of the dry weight of the raw meal being necessary. With the wet process a fuel consumption of 23% was expected.

A great advantage claimed with the process was the continuous operation under open observation, the ability to stop the machine at will without harmful results and, of course, the suitability of coke breeze as a fuel.

A complete layout drawing of a Cement plant is included in the documents - this is No.73-4.

Lurgi Machines were practically all built by Concordia Hutte near Koblenze.

Sinter fans were supplied by K.K.K. of Frankentahl also by Schiel of Eschborn, near Frankfurt.

Reference should be made to Stahl und Eisen 63/1943, Volume 45 and 46, in which was published a paper by Dr. Wittenberg giving the result of extensive experiments towards increasing the output of Sinter Machines.

For the Rotary Machine reference should be made to drawing 2675 contained in the documents.

MECHANICAL MULTIPLE HEARTH ROASTERS:

Lurgi were found to have installed many of their Multiple Hearth Furnaces for pyrites, zinc, etc. The furnaces were built in sizes having 7, 9 and 11 hearths, giving a throughput of from 6 to 35 tons of pyrites per day.

Lurgi stated they had definitely abandoned water cooling in favour of air cooling otherwise there was no departure from generally known details.

ZINC PLANT:

Complete Zinc Works was built by Lurgi for the Preussag Unter Hartzer Berg und Hutte Werke at Goslar. Three Sinter Plants, each of 200 tons per day capacity, are used for roasting the blend, the SO_2 gas being treated by contact process to give 180 tons per day of sulphuric acid.

The Zinc Retorting Plant was installed by Lurgi to the designs of the New Jersey Zinc Company.

THEDA FURNACE:

The Theda Muffle Furnace is built by Lurgi, ten having been installed during the war for dealing with the residue of Zinc Retorting Plants. The Plant is usually gas fired.

Installations can be seen at Berzelius Works, Duisberg, and at Berge Borbeck, Essen.

LEAD:

Lurgi built the Harris Plant under license from Great Britain. One Plant was installed during the war being erected for the Czech Government in 1941, this Plant was located at Pribrau.

Reference should be made to the following Research Reports brought by the Team to this country:-

1871 dated 23/7/41.

1926 dated 15/6/42.

ORE REDUCTION KILNS AT REICHWERK HERMANN GOERING, WATENSTADT:

C21/474

The Hermann Goering Works treat the local Salzgitter acid iron ore deposits. These are mainly brown hemeatite which varies considerably in its analysis. On a totally dried sample the total Fe content was stated to be 27%, total Si O_2 30·3%, AL_2O_3 10%, CaO 7·7%, but apparently varied from 20% up to 33% total Fe.

The Lurgi Kilns serve to reduce the Fe_2O_3 to Fe_3O_4 for subsequent magnetic separation of the silicious matter, after which the concentrated ore is agglomerated in a Dwight-Lloyd sinter plant, and thereafter forms the principal burden for the blast furnace.

Eight kilns are installed capable of treating 1,000 tons of ore per day each. They are gas fired with blast furnace gas containing approximately 30% CO, 3% H_2, 8-10% CO_2, the balance nitrogen. This gas has a calorific value of 900-1000 KCal/m^3.

The kilns are 50 m. long by 3·1 m. diameter and have 10" thick firebrick lining. The diameter given is the inside diameter across the face of the brick lining.

There are four distinct zones in the kiln - preheating, calcination, reduction and cooling, each zone taking about equal space. The highest temperature (800°C) is reached in the centre of the kiln.

A feature of the design is the provision of twelve gas burners in staggered location around the calcination zone. These have mixed gas and air at the burner and are fed by mains of rectangular section which rotate with the kiln. At each end of the kiln is a manifold with a fixed and a moving half with a labyrinth seal between the two halves. Via these manifolds the gas is fed from the exit end of the kiln and the air from the entry end. Individual control is provided at the burners by coke oven type valves.

A separate supply of reducing gas, but without

air, is fed into the discharge end by a single large diameter main. The respective volumes of the gas are as follows:-

At the central rotating burners 2-3000 cu.m. per hour, split up as required between the 12 burners.

At the single main at the exit end 8-9000 cu.m. per hour.

The blast furnace gas pressure is 250 mm. water gauge and the air, which is all fed in at the central burners, is 10-12000 cu. m. per hour at 180 mm. water gauge.

The temperature range in the kiln is as follows:-

Preheating	200°C.
Calcination	740-800°C.
Reduction	700 falling to 350°C.
Cooling	350-100°C.

In addition to cooling effected by the cold reducing gas there is also a final spray of 15-40 litres per minute of water, according to throughput which is sprayed on to the reduced ore before it falls into the cooling bunkers.

The cooling bunkers serve principally as stock bins from which the ore, at 60°C., is taken by rubber conveyor bands to the grinding plant.

Before entering the Kiln the ore, which is graded 0-20 mm. and with a moisture content of about 8%, comes from an overhead feed bunker via oscillating plate feeder into a continuous weighing device.

The waste gases contain 22-24% CO_2, 2-4% O_2 and 0-0·3% CO, moreover there is 0·5 grms. SO_2 per cu.m. of waste gas and this caused a certain amount of corrosion.

These gases pass first into a static dust settling chamber with fine water sprays, giving a very limited addition of moisture, and thereafter into an electrical precipitator. The dust carried out of the kiln represents 10% of the total charged or 7/9% of the total iron content and utilisation of dust is important. The screw dust conveyor from the bottom of the precipitator and dust catcher leads to a Fuller Kenyon Pump which sends 60% to the kiln as returned dust and 40% to the sinter plant for admixture in the sinter charge.

Other features of the kiln are the Jaeger rollers, of which there are two sets, support the kiln tyres of 30" width. The kiln drive is by spur ring and pinion from enclosed reduction gear and nine "V" belts on to a motor of 50 h.p. The top, or feed end, tyre has locating runners on each side.

Nine pyrometers are fitted along the length of the kiln, each being coupled up to a set of circumferential contact rings which allow continuous connection between pyrometer and recorder.

The post-reduction plant was not examined but the following notes were collected by the writers.

After leaving the cooling bins the ore is crushed by roll crushers from 0-20 mm. down to 0.3 mm. grading, after which it passes to the magnetic separation plant supplied by WEDAG of Bochum. The first roll discards the silica and passes the ore on to the second roll, this discards further silica and a little iron, the ore itself being discharged into storage. The final concentrate is 40% Fe with a loss of 11-12% in the discarded gangue.

SINTERING:

Sintering is carried out on eight Dwight Lloyd Plants each of 75 m^2 grate area. The concentrates are mixed with better class ores, blast furnace dust, wet concentrated ore, etc. A typical mixture was given as 30% ex Lurgi Kilns, 30% wet concentrates, 30% good ore and 10% blast furnace dust.

The Lurgi kilns were in excellent condition and were a most impressive installation and although nominally or 1000 tons per day each throughput this varied according to the demand from the blast furnace plant from 500 tons per day up to 1200 tons per day.

The following drawings are available among the documents:-

HCIII 10205.

HCIII 9917.

HCIII 10030.

HCIII 10027.

HCIII 10001.

HCIII 10000.

Z 2202

There are also two Metallgesellschaft research reports on this Plant and are available through B.I.O.S. Headquarters. These are:-

Lurgi-Groppel-Aufbereitungsverfuhren
Number 1903 - Dated 19/2/42.

and

Part II - Number 1932 - Dated 24/8/42.

A single kiln, 3·6 m. diameter by 44 m. long, is installed at Sollhause, Blomberg south of Baden-Baden.

This kiln is fired with producer gas and has a throughput of 900-1000 tons per day. The fuel consumption is stated to be 5-6 % of the raw ore in terms of coke fed to the Producer Gas Plant.

Lurgi Rotary Kilns were mainly built by Orangewerke, Gelsenkirchen and by Korerverinder Lerch Krefeld.

LURGI APPARATEBAU G.M.B.H.

PERSONNEL:

Dr. Oe tken - Vorstand.
Dr. Jak Giess - "
Dr. Dietrich - Mechanical Dust Separation.
Herr Seitz - Due to retire.
Herr Natchcker - Commercial Manager.
Richard Boehme - Technical development.
Dr. Schnitzler - Research Engineer.
Dr. Stieler- " "

This section was not covered in full details as it was anticipated that Electrical Precipitation would form the subject of a specialised team, it further appeared that during the war - except for matters mentioned below, Lurgi Bau had concentrated on a large volume of standardised business.

GENERAL:

The company is similar to the other Lurgi concerns in its relation to Metallgesellschaft but has its own manufacturing organisation known as Lurgi Werkstatten situated at Mouson Strasse, East Frankfurt.

There was also a link with the Siemen concern both in regard to patent holding and for the supply of electrical equipment.

Within the Lurgi group this section ran its own drawing office and a separate tendering department and its commercial department was more highly organised with branch offices for the sale of the main product which was the well known Cottrel Electrical Precipitator referred to as the Lurgi Elektrofilter.

PRODUCTIONS:

Elektrofilters - These were built on standardised lines and were of the single and double chamber type and also of multi tube construction. From the list of 1937/44 orders

which is available in the documents it will be seen that the majority of orders were for the following applications:

Central electricity stations for flue gas cleaning.

Blast furnace gas cleaning.

Iron ore preparation plants.

Brown coal drying and preparation plants.

Tar removal from coke oven gas, etc.

The Chemical Industry.

A small single tube precipitator was in production for motor vehicle Producer gas cleaning. This was known as the Sagill Tintze cleaner and was provided with its own current generator to be driven from the car engine. A considerable number of these outfits were made by Werkstatten but were expensive to install.

The Soderberg Electrode.

Lurgi Bau handled this electrode for electric furnaces mainly by licence agreements.

Electrostatic cleaning of coal and minerals.

This was a new development the subject of many patents and had reached full scale development by the early war years. Research was being pursued actively and some detail of this work is given later in this section.

Lead work for the Chemical Industry.

Lurgi Bau had carried out some large contracts for chemical leadwork during the war, particularly on behalf of their sister concern Lurgi Chemie.

Works.

These were seriously damaged three times during the war and had been rebuilt twice. Located at Mouson Strasse, East Frankfurt, they were essentially suited for the multiple

production of the relatively light steel casings for precipitator units. The works normally employed about three hundred and fifty workers. From 1942 onwards scarcely a single order was completed.

Research Activity.

Lurgi Bau's research expenditure was as follows:-

1940/41	-	79,000 M.
1941/42	-	104,000 M.
1924/42	-	837,000 M.

At Mouson Strasse Research Station, Lurgi Bau had their own section in which was found electrical equipment suitable for precipitation experiments. Some plant had obviously been removed and subsequently this was stated to be at the Berg Akadamie in the Harza Mountains.

As the team was routed to visit this area a search was made, at the request of another specialist team, for both equipment and personnel connected with the electrostatic separation system.

VISIT TO CLAUSTHAL ZELLERFELD.

ELECTROSTATIC SEPARATION:

INTERROGATED:

Dr. Otto Rellensman	of	Berg Akadamie.
Ing Richard Boehme	of	Lurgi Bau.
Ing Schnitzler	of	Lurgi Bau at Lantenthal.

NOT INTERROGATED:

Dr. Ing Stieler	of	Lurgi Bau at Riefensbeck.

On arrival the Berg Akadamie was found to be intact but closed. Dr. Rellensman was located in offices at the rear and with him was Richard Boehme of Lurgi Bau.

Dr. Pashke is no longer in charge of Berg Akademie, he was variously stated to have been taken into detention and later to have been in the Ruhr at the time of the German collapse and

and not heard of since. Professor Alfred Grumbrecht is now in charge but was not available at the time of the visit. Professor Valentiner was also mentioned as a B.A. man who, with Rellensman and Grumbrecht, had taken part in reasearch which B.A. were themselves, independently of Lurgi, doing on electroflatation.

Incidentally, Grumbrecht received annual payments of 1500/2000 R.M. direct from Lurgi Bau.

Briefly the B.A. work is on the lines of a fast magnetic roll which holds one material and throws the other forward, Rellenman claimed that excellent promise was being shown in the system they were developing, particularly with brown coal. Materials must be dry and finely ground. Their work was attacking the same problem as the Lurgi Bau research but was complimentary rather than conflicting and they had made facilities for Lurgi at B.A. to continue work from 1943 onwards.

B.A. return to their building in early August.

LURGI BAU SYSTEM:

The single roll pilot plant on which Lurgi carried out trials preparatory to the large scale installation at Oberhausen Ostefeld, built in 1942, and the large plant complete in February, 1945, at Konigen Elizabeth Mine of the Mannesman Comapny is regarded more as a routine testing unit than as research equipment. It is now located in the Kaiser Schact Mine at Clausthal Zellerfeld where it was taken for safety in 1945 from the near by B.A. It is being packed up for return during August to Frankfurt where it will be set up at Mouson Strasse test laboratories. The Unit has an 8" roll and overall is about 3'0" x 2'0" x 2'0".

The real research laboratory of Lurgi Bau for electrostatic separation was found at the end of an addit of a lead glanze mine known as the Erzbergwerk Lautenthal owned by the Preussag Unterhartzberg. The mine is exactly opposite to Lautenthal Station. The laboratory, which is small, was fitted up within the last 12 months and Schnitzler, who is in charge lives in a small office beside the Lautenthal Road.

Both Stieler and Schnitzler have been active on this reasearch but Boehme knew little of the matter. Dr. Richard

Heinrich of Metallgesellschaft, Frankfurt, was several times referred to as being connected with the development, as will be seen, his name is attached to certain of the numerous patents held by M/G.

The principal equipment comprises:-

1 small 4½ dia. roll separator - this is virtually a working model operating on 14/15000 volts.

1 equipment also bench size for determining the electro inductive capacity of materials at varying degrees of atmospheric humidity.

Work had been done on the following samples:-

Anhydrite ex Heilbrown.
Chromite.
Felspar.
Titanit.
Zinc Blend.
Salt Crystals.
Limestone.
Brown Coal.
Hematite Ore.
Fluarite.

Documents available:-

Reports of work on the big plant at Osterfeld. Folder marked C.I.O.S. 581.

Tests at Osterfeld by Lurgi Bau on electro separation.

Folder of Patents, 33 in number, from 1936 as follows:-

633095/096	644637/638	645950	682759	687595
688129	689186	691165	698593	699025
700975/976/977		705007	707209	717289
718165	718561/562	718918	720635	722888/889
723571	725209	726169/170		729007
702027	700653	720636.		

Schnitzler believed that one or two further Patents were being applied for.

The documents were taken on the assurance that all originals were available at Clausthal, Lautenthal or Frankfurt.

This report is intended only as an indication of the present location of personnel, equipment, etc., the scientific investigation of the research and process being outside the scope of Team 581. Clausthal and Lautenthal are both about 12 Km. from Goslar.

OTHER DEVELOPMENTS:

A search was made among Lurgi Bau files to ascertain any other developments which might have been attempted during the war but the only references which could be found for such work were the following:-

1. In 1941 the Company were considering a new Patent for ultraschallsender and British Patent 413762 was mentioned, this relates to high frequency sounding for Naval work but as far as could be gathered from interrogation Lurgi Bau did not proceed with the matter. Dr. E. Hammerschmid of Dusseldorf was referred to in this connection in the brief correspondence which was found.

2. An Elektrozyklon had been offered to the Company by K. G. Knecht of Stuttgart, Bad-Cannstatt, but here again interrogation failed to illicit any detailed information.

Both these matters had apparently been handled by a Herr Gohrer who, like certain other Lurgi officials, had left the Company at the time of the German collapse.

ENGINEERING SUB-CONTRACTORS. C21/721

DEUTSCHE EISEN KONSTRUKTION A.G.

This firm is owned by, or closely allied to V.D.S.W. They have another factory at Dusseldorf besides the two described hereunder.

Dortmund Factory: It is situated in Teichstrasse which is a continuation of Unionstrasse running from Rheinstrasse.

The Managing Director, Herr Mauterer and the Head of the Technical Department were interrogated.

This is a large factory equipped and laid out for structural steel fabrication. The main building is about 300 M. long x 60 M. wide and has the two side wings normal to German Engineering factories. There is an adequate supply of heavy lifting facilities, drilling machines, plate planing machines etc.

Normally they only carry out a comparatively small amount of fabricated plate work, although at the time of the inspection they were producing the Blister Section of Submarines to pass on to Orange Werke. The machine shop is only of moderate size.

The most interesting feature from the Chemical Engineering aspect is the stress relieving furnace which is 16 M. long x 5 M. wide x 3.5 M. high from the trolley. This was installed during the war as many of their prefabricated bridge sections had to be stress relieved.

Orange Werke, Gelsenkirchen: The following were interrogated:

Herr Preimark who is the Technical Chief, speaks good English but was not unduly co-operative.

Herr Neufeld who is Commercial Manager, speaks good English.

Herr Scholts New Works manager just brought in from Dortmund Factory to reorganise for post war production. He speaks no English but was quite forthcoming.

This factory is a moderate sized Plating Shop with some additional heavy equipment which had been added for war time requirements.

The main shop is 125 M. long x 32 M. wide x 11 M. high to the crane hook. One gable is open for a travelling crane to pass out for plate collection from either rail, barge or their own stock.

There is one crane of 20 metric tons and two or three of 15 metric tons capacity each in this bay. There are the usual large drilling, gas cutting and gauging machines, numerous standard welding machines and an automatic welding machine which was dismantled since it had been designed for a special purpose.

There is one side wing of the same length but of lesser height which is used for marking off and light plating. The other wing contains a light machine shop, a heavy rivetting bay approximately 20 to 25 M. high and stores..

In the open on each side of the factory are the section and bar stores, the plate store, large cold saw and cropping machine, and in the plate store section is housed a small Smith s. Shop including punching machines and also a modern Wagner Plate Edge Planer having a 16 M. gap with mechanical clamps, and a minimum speed of 0.42 mm. per second; maximum speed 5.55 mm. per second. Adjacent to this was a heavy plate bending machine of the horizontal four roller type with hinged end frame, the top roller being removed on each occasion. It has only been used for bending 1" plate approx. 12 to 15 ft. wide to a 9 ft. radius.

The main output of the firm was prefabricated Submarine Sections. The special layout of this section has considerable engineering interest, but its special nature puts it outside the scope of this report. As a matter of interest, each section weighs 100 tons is 18 ft. diameter with the blister mentioned previously welded on, and about 30 ft. long. This is number 6 of 12 sections in the Submarine. They are all welded and spot check X-ray photographs are taken of the circular seams. It was stated that the final tolerance on diameter and circularity was ± 3 mm. The maximum output was one every two days and about 30 were in various stages of production, each on its own trolley.

The firm has comparatively little experience of Chemical Plant other than units made to drawing. The machine shop would be inadequate for normal chemical plant of the size the factory could undertake. They have little experience of stainless steel fabrications, but have acquired a good knowledge of heavy welding during the war.

FELLNER & SIEGLER G.m.b.H., FRANKFURT A.M. WEST.

This firm had been considerably damaged, more than half of it seriously.

It is a somewhat old fashioned concern normally manufacturing Rotary Kilns and Furnaces for Chemical Ore Roasting and Cement processes. They have manufactured plate work to Lurgi's drawings.

They have one or two heavy wheel lathes, the largest having a $3\frac{1}{2}$ M. diameter face plate. There is a moderate sized slow drive planing machine with average sized horizontal boring machines, drills etc.

They appear to manufacture a good quality of article of non pressure type. They manufacture what appeared to be a sound design of small Disintegrating Mill and similar equipment.

The Plating Shop is about 60 M. long x 15 M. wide x 8 M. High, containing three electrified cranes of 15 tons metric capacity. There is also a horizontal 3 roller plate bending machine 6 M. wide but not of very heavy construction. It can roll a plate 4 M. diameter x 20 mm. thick x 5 M. wide. There is no roof to this building and the drills and other machines are damaged.

They have no foundry, gear cutting machine or accurate centre lathes.

It was stated they have another factory at Wielbach bei Meilenberg A.M. of about the same size but undamaged. This factory has a cast iron foundry and more modern and precise machine tools. It was stated that prior to the war about half their output was exported.

One of their directors is claimed to be a Norwegian national.

A catalogue of their products is available but not attached to this report.

KUHNE KOPP & KAUSCH, FRANKENTHAL, PFALZ: C29/157

Dr. Kurt Winkler (Member of the Vorstand) and Dr. Eng. Heine, the Head of the Fan and Exhauster Department were

interrogated.

It is a moderate sized factory which has been acustomed to the manufacture of Chemical Plant. They had five main types of work but now almost the whole of it had been removed from the shops and dumped on to the side walks. These are:

1) Large Centrifugal Exhaust Fans in fabricated steel cases in the larger sizes up to say 12 ft. diameter. The smaller Fans were made from iron castings. A number of these Fans were on order for Lurgi.

2) A very interesting small Steam Turbine of the vertical type for use as a prime mover.

3) Evaporators both brick lined and lead lined of the Vogel-busch type.

4) Pressure Vessels up to 10 ft. diameter but not for high internal pressure.

5) General homogeneous lead lined vessels etc.

The machine shop was 60 M. square but not very modern layout or equipment. They could turn flanged sections 12 ft. diameter by about 2 ft. deep. They have moderately large planing and drilling machines and smaller horizontal borers, vertical boring and turning mills etc. There were some moderate sized centre lathes and slotting machines, but most of them were fairly old.

The main fabrication shop is about 250 ft. long x 70 ft. wide x 20 ft. high having a 20 metric ton travelling crane and equipped with one or two large drills, gas burning machines and a special purpose automatic electric welding machine. There is a secondary fabrication shop about 2/3 of this size with a 15 metric ton travelling crane and contains large bending rolls about 16 ft. wide and a large radial arm drill.

The lead shop was completely dismantled and was just under 3,000 sq. M. in size. The plant for external lead covering of tubes was dismantled. No plate planer was seen and they have no hydraulic press (their heavy ends appeared to be press spun).

There was a firm five to six miles away on the railway which did their stress relieving.

Their X-ray plant had been completely smashed during the occupation.

They had another large new erection shop which was at the time under military occupation and not visited. They have a disused foundry which was mainly used for storage and is about 2,500 sq. M. floor space.

The present staff and works personnel is about 180 but had been nearly up to 2,000 during the war.

They have discontinued rubber lining.

Catalogues of their Fans and Exhausters are available but not attached.

K.K.K. had devised a system for external coating of steel tubes which essentially comprised mild steel tower 15 m. high by 1.1/2 m. square with stairways and suitable placed platforms in which the tube was mounted.

The device for coating the tube consisted of an upper and lower portion. The upper portion being a gas heated bowl and the lower portion a water cooled neck with a gland below. The upper portion was filled with molten lead which was maintained at a correct temperature by adjustment of the gas burners and in the lower portion water circulated for chilling. The gas and water were coupled up to the device by flexible pipes and the whole outfit was drawn upwards by means of chain blocks.

The equipment was essentially simple in its design and obviously depended upon knowledge of the operators for successful results.

For sketch of Coating Device see fig. 14

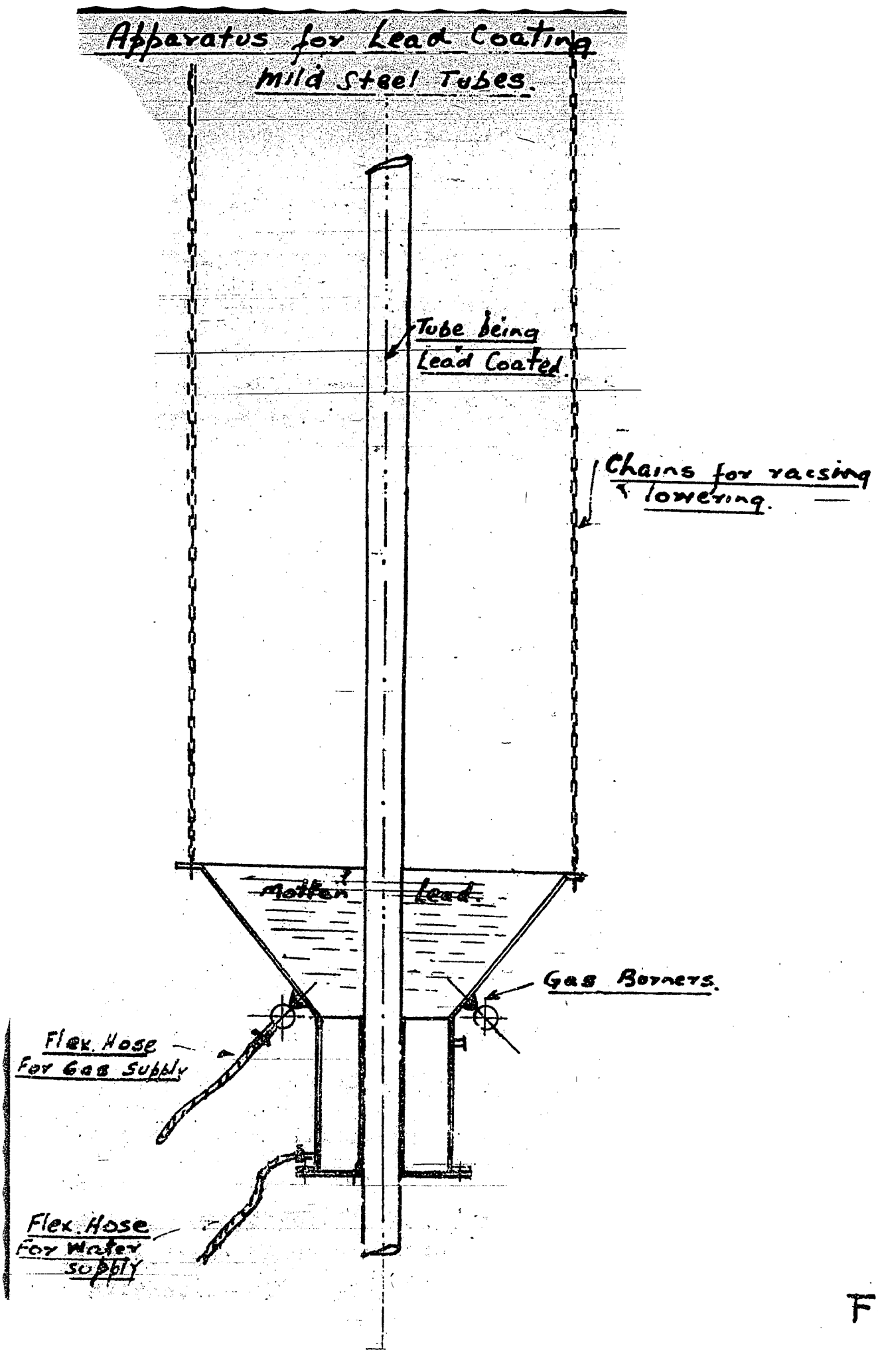

Apparatus for Lead Coating Mild Steel Tubes.
Tube being Lead Coated.
Chains for raising & lowering.
Molten Lead
Gas Burners.
Flex. Hose For Gas Supply
Flex. Hose For Water Supply

FIG 14

SUMMARY:

This summary is written by the investigators in the light of seven weeks of intensive investigation involving contact with the majority of the senior and a few junior executives of Metallgesellschaft and Lurgi such as were available. During this time many impressions were gained and much evidence examined which could not be fitted into the factual and technical matter of the preceding report but it is hoped that any fundamental opinions expressed in this summary will be found to have support from the main body of the report.

Although it would not be germane to this report to make recommendations as to the future of Lurgi in relation to the parent company it would not, however, be unreasonable to assume that if the state of the German Chemical and it's allied Industries in any way encourage the German Governments and people of the future to be satisfied that it could again go to war and defy a blockade, then the Chemical Engineering firms such as Lurgi are undoubtedly one of the leading factors making that step possible; synthetic oil, synthetic fats, synthetic rubber and the reasonably efficient use of Ersatz material of construction were largely made available by the practical efforts of Lurgi and a few similar firms.

It was not easy to trace how far results were impaired by political interference of the Nazis with a firm such as this, disturbed as it was on several occasions, both in respect of non-Aryans and Anti-Nazi personnel together with the subsequent installation of "good party members" but it was certainly stated that the imposition of Party careerists on Government Control Departments had been a cause of interruption and inefficiency.

CONNECTION BETWEEN METALLGESELLSCHAFT & LURGI:

There is no doubt that Lurgi benefitted in many ways from this association.

The Aufsichtsrat of Metallgesellschaft contained a number of prominent industrial figures who could negotiate at high level for manufacturing licenses. etc. The extensive

Laboratories of Metallgesellschaft were of great assistance to Lurgi. Comparatively limitless finance meant that a long term view could always be taken, and losses on processes in the course of development could be allowed to make considerable inroads on the profits of Lurgi for several years in a manner which would cripple a normally financed business.

The bulk of Lurgi contracts was for firms who in no way competed with Metallgesellschaft or its subsidiaries. Thus no suspicion was engendered in the mind of the purchaser that the holding company would obtain an unfair advantage.

The not inconsiderable financial connections between Metallgesellschaft (together with its subsidiaries) and the two great concerns, I.G. Farbenindustrie and Henckel & Cie, were of definite advantage to Lurgi.

Officials of Lurgi tried to minimise the connections with I.G. At the time of the investigation it seemed probable that I.G. would shortly be taken over by the Military Government and possibly broken down. (The Investigators, incidentally, formed the opinion that a Top Line Conference took place immediately after their arrival for policy consideration of the attitude to be taken towards their investigation).

A reasonable conclusion would seem that for average contracts with individual I.G. Factories, Lurgi only obtained contracts on the merits of performance and/or price, but that there were back doors open through Metallgesellschaft for contracts or agreements of really first class importance.

WAR-TIME DEVELOPMENT:

This really started in 1935 and 1936 when the Mineral Ore and Acid programmes were getting well into their stride. The very rapid increase in the size of staff and receipt of orders could not be accounted for by the most optimistic normal industrial expansion. It is true that the foreign trade increased very slightly at this stage but the gap between foreign and home trade increased exceedingly

fast during this period.

There were comparatively few direct Government orders at either this or later dates.

During such an expansion an accumulation of experience inevitably accrues to a firm which employs so many first class technicians, but the improvement of existing processes, or the development of new plants between the years 1939 (or, for that matter 1937) and 1943 was much less than had been expected.

Lurgi's contributions to the development of the Fischer-Tropsch Synthesis is reported elsewhere and the present investigators are not in a position to comment on its importance authoritatively.

High pressure gasification and development in Lurgi Bau methods of separation (still in the development stage are significant.

With their Spuel Gas and Lurgi Krupp carbonising systems well established, Lurgi had in the Warme section an open field for many large contracts of a profitable nature. The National policy had been established for the fuel industry in a manner which allowed full scope for expansion on set lines. There was a demand for hydrocarbon and tar products suitable for the many Hydrogenation plants, on the one hand, and for a supply of carbonised fuel and briquettes on the other, which was met by the above type of Plants. The supply of long distance or "Fern" gas was already an established part of the German fuel industry and this again enabled Lurgi to push ahead, at great cost, with the development of their high pressure gasification plant in the certain knowledge that success would be followed by an adequate volume of ultimate business, this particular plant not only provided a supply of good calorific value gas at a high pressure but, unlike other systems, ensured a full recovery of the much needed bye-products. Established for the Gas Industry, the plant was then being adapted, both for gas turbine work and for the production of ammonia synthesis gas, though the elimination of Methane for the latter had not so far been solved.

In the case of Lurgi Bau, the established policy of making the optimum use of home raw materials gave insurance to the large expense on research and development of the novem system they had brought up to full scale operation for electrostatic cleaning of coal and which was being pursued further in regard to other German raw matenials in the mineral and chemical field.

It will also be noted how the need to cover the interal demand for phenols on a large scale led to co-operation between Lurgi Warme and I.G. resulting in the large scale installations which are described under that section.

The plant for the distillation of Synthetic Fatty Acids did not, in the opinion of the investigators, show great imagination and the problems of fractionation were either overlooked or left unsolved so far as Lurgi were concerned.

The "Spaltanlage" for Sulphuric Acid were undoubtedly important and, except as detailed in the next sentence, successful. Some important modification had to be made by the clients to the after-combustion chambers, and the failure of the subsequent heat exchangers with the loss of pre-heat to the air entering the "Spaltofen" caused decrease in efficiency. The system was directly aimed to serve the German methods of explosive production.

The jump in scale from small Pilot Plants to large commercial size units was on many occasions very courageous, particularly as several plants would frequently be completed before the first installation was proved to be successful. In amny cases this jump caused heartbreaking teething troubles and proved that even a concern with Lurgi's experience could not, with impunity, eliminate the usually accepted steps.

There was reason to suppose that these jumps were either made under Government pressure or by reason of the fact that high taxation and enlarged turnover made the rectification losses of little commercial significance.

TYPICAL EXAMPLES ARE:-

(1) Nordhausen Cement & Sulphur Production Plant - Lurgi claim that there was insufficient time to assay the ores properly or process them on the Mousonstrasse Pilot Plant.

(2) Metallgesellschaft $MgSO_4$ Reduction Plant at Hattof.
Many troubles were experienced on the large full scale plant which had not been apparent on the small scale pilot plant, involving the client in great cost and loss of production.

(3) H_2SO_4 Spaltanlage - see above.

EXPORT:

The arrangement made by the Government for assisting exporting firms faced with strong foreign competition is given on Pages 42 and 43, where a typed statement is reproduced. This statement was given to the authors after interrogation of 2/3 senior commercial members of Metallgesellschaft and Lurgi, and supports the opinion held in many quarters before the war.

Since Lurgi were never manufacturers they had no objection to their Plants being built in the purchasers county but where possible they parcelled out the drawings to different firms and had one of their own Engineers supervise manufacture and, later on, erection.

It might have been expected that the 1937 Achema held on the "home ground" would materially have increased their exports. There is a very small increase in the value of orders received in 1937 and 1938 but only a normal continuation of the slight upward rise in the curve. What effect the Munich crisis had on this can only be a matter of conjecture.

CONSUMER INDUSTRY RELATIONSHIP:

It was made abundantly clear, on many occasions, that process information and plant performance data were almost invariably available to Lurgi for any Plant which they had installed. Lurgi almost always commissioned the Plant and usually managed to visit it for "servicing" purposes some months later.

Lurgi seemed well informed on modifications and improvements made by their client. In fact, on only one occasion did the investigators find them ignorant of a substantial modification made by the client, and in that

case there was no "consumer interest" motive for concealing it. It was an equal chance as to whether it was a case of (a) ignorance, (b) genuine forgetfulness, or (c) No names no pack-drill!

This latter possibility was a common experience of Technical Teams. An honest and straight forward answer was almost always given to a direct question, volunteered information was the exception rather than the rule.

PILOT PLANT:

Except for standard plant units, pilot plant work was usually carried out in a client's works, or in the works of a firm having some connection with the parent company.

On no occasion was any evidence found that the client restricted the use of the process plants developed from the pilot plants. Sometimes these were Royalty agreements, and an impression was gained that Lurgi would keep their co-originators informed of any improvements they subsequently made.

Certain standard pilot or demonstration plant units were available at Mousonstrasse, Frankfurt, or at V. D. M., Heddernheim (Nr. Frankfurt). In the case of the Colloid Section of Metallgesellschaft, this was housed in the Peterswerk Rubber Factory at Dornholzhausen (Nr. Bad Homberg)

Certain movable units were often loaned to clients and many became mislaid during the confusion towards the end of the war. It was often stated that "the pilot plant was loaned to Firm 'X'", now in the "Russian" (or "British" Zone).

OPERATING DATA:

Although the investigators always acted under the cloak of their Team number and thus concealed any industrial connections their names might evoke, the answer to many questions on performance and process data was often initially "This is well known, why ask us?". The inference drawn was that the German Consumer Industry gave full operating information to the contractors and it was not appreciated that the same co-operation was not the rule in British Industry.

It was common occurrence to be told that the design

performance was "x" but after some months of operation it was"x + 10%", for example.

RESEARCH:

As will be seen from the appropriate sections covering this, most fundemental chemical metallurgical research was carried out by Metallgesellschaft (Lurgi Apparatebau was partly an exception to this). Lurgi companies had full access to this and some of it was carried out at the instigation of Lurgi. Each company contributed 7½% of its profits to Metallgesellschaft's Central Research Department. The Team secured many hundreds of interesting research reports covering the Metallurgical, Chemical, Rubber (Colloid Laboratory) and, in one case, Synthetic Resin, Pulverised Metal (Pulvereisen), Protective Coating (Bonder) Industries, etc. These are available in the documents and are fully listed in the appendix. (None of these have been translated at this date)

During the war expediency and the utilisation of substitute materials of construction would seem to have been important preoccupations of the Research Departments; the tendency, of course, was to research along the lines of metal utilisation and plant development connection with war industries.

Two interesting reports, not listed elsewhere, were prepared by Von Eichhorn on the eve of his retirement. "Development of the Thermo-electric Production of 'Silumin-Vorlegierung and the Future of this Process" 2nd. October, 1942; and "Development of Aluminium, Aluminia, Silumin and 'Silumin-Vorlegierung'" of 20th March, 1943. These are available in the documents.

There is little doubt from this and other evidence that Metallgesellschaft had, as a prime aim, the attainment of a predominant position in the German Light Metal Industry.

DISPERSAL:

There is no doubt that when large-scale night air-raids commenced, an almost panic dispersal took place. This caused very considerable inefficiency and delay in execution of contracts.

As the offices and main laboratories of both Metallgesellschaft and Lurgi were in the "non-industrial" areas of Frankfurt the investigators can testify that the disruption of these centres, both by threat and actuality, caused immense disturbance and had a not inconsiderable effect on the output of several vital industries. The subsequent dislocation of transport completed this.

INCOMPLETED CONTRACTS:

Reference to the lists of contracts in the documents will show the magnitude of this. It ran into many millions of Reichmarks for Lurgi and an equivalent amount for Metallgesellschaft. Many plants were 80%-90% finished, but for many months the remaining few percent had held up completion. Towards the end such a state of chaos had existed that much material was just lost.

The investigators are grateful that they do not have the responsibility of unscrambling this egg!

WORKMANSHIP & MATERIALS:

On the whole it was found that the war-time execution of equipment was up to a good standard. On some of the older and standard designs, e.g. producer gas plants, no attempt had been made to redesign up to modern standards and as an exampled drawings involving rivetted construction had obviously been passed straight into the shops rather than redesigning for all welded construction.

On the other hand the enforced need to use concrete buildings and other structure, such as gas main supports, provided scope for fresh designs of the flat roof and portal type. These were well carried out and there had been little shortage of labour for such work as opposed to the shortage of steel which had rendered the adoption of concrete imperative.

It was noticed that materials had not been spared on work of high priority but in several cases controls were simple and instrumentation was limited, though not lacking to any serious degree.

TECHNICAL STAFF:

By the time the team had arrived on the target certain of the staff had "left".

It must not be overlooked that the whole of the Metallgesellschaft combine ties back to a central organisation and such voluntary dispersal of technically important men, such as Plass, may not be intended as a permanency and there may be an attempt to fit them into some other part of the whole network at a later date. Some of the commercial staff and some junior technicians were on armed service and had not returned or been heard of at the time of the investigation.

METALLGESELLSCHAFT A. G.

Technical and Research Reports.

M.9 Laboratory Annual Reports up to 1939 containing reports on general progress. Analytical Laboratory, Chemical Laboratory, Colloid-Chemical Laboratory, Synthetic Material Department, Metal Laboratory, Heat Exchange Department, Literary Department.

Annual Report	1.10.28 to 30.9.29	16.12.29-1003
-do-	1.10.29 to 30.9.30	31.1.31 - 1294
-do-	1.10.30 to 30.9.31	15.2.32 - 1381
-do-	1.10.31 to 30.9.32	10.1.33 - 1422
-do-	1.10.32 to 30.9.33	20.1.34 - 1470
-do-	1.10.33 to 30.9.34	1.2.35 - 1524
-do-	1.10.34 to 30.9.35	25.1.35 - 1556
-do-	1.10.36 to 30.9.37	15.3.38 - 1653
-do-	1.10.37 to 30.9.38	10.2.39 - 1724
-do-	1.10.38 to 30.9.39	5.2.40 - 1779
-do-	1.10.39 to 30.9.40	1.2.41 - 1838
-do-	1.10.40 to 30.9.41	20.7.42 - 1928

Number	Date	Description
14	8-1939	Metallgesellschaft Periodical Review.
1000	5.12.29	Calculation - Electrolysis II.
1005	28.12.29	Chlorination of Bauxat.

Number	Date	Description
1009	11.1.30	Metal Lab - Aeron Propeller material quality statistics 1929.
1011	11.1.30	METAL LAB - Special bronz for railway bearings.
1014	18.1.30	METAL LAB - The shearing strength of compacted alloys.
1015	15.1.30	PHYSIC-CHEMICAL LAB - Remelting of zinc in an electrically heated salt bath oven
1018	1-1930	TECHNICAL CHEMICAL LAB - Iron phosphate experiments Rolandshutte.
1020	22.1.30	METAL LAB - Permanent stability of compacted alloys.
1025	24.1.30	ANALYTICAL LAB - Determination of phosphoric acid.
1028	28.1.30	METAL LAB - Hyblum.
1046	26.2.30	TECHNICAL CHEMICAL LAB - Absorption of roast gases with lyes containing copper chloride.
1064	14.3.30	TECHNICAL CHEMICAL LAB - Drying of gases from roasting by means of SO_3.
1073	1.4.30	TECHNICAL CHEMICAL LAB - Burning of phosphorous vapour mixed with blast furnace gas to phosphoric acid.
1077	1.4.30	TECHNICAL CHEMICAL LAB - Elimination of residue phosphors in blast furnace gas.
1087	16.4.30	TECHNICAL CHEMICAL LAB - Ammonium Sulphate II.
1134	27.6.30	CHEMICAL LAB - Ammonium Sulphate III.
1201	29.8.30	Crystallisation experiments at pressure of 1200-1300 atmospheres.

Number	Date	Description
1243	25.9.30	Crystallisation experiments at high pressures (Supplement to Report 1201)
1289	7.1.31	Ammonium Sulphate IV.
1321	7.1.31	Ammonium Sulphate works experiments at Visp - 16th January - 18th April 1931.
1336	29.8.31	Ammonium Sulphate V.
1353	30.10.31	Decomposition of waste gases containing sulphur dioxide.
1356	16.11.31	Catalytic oxydation of SO_2.
1357	12.11.31	Catalytic oxydation of SO_2.
1363	9.12.31	Ammonium sulphate. Works experiments at Visp; 13th October - 27th November. 1931 VI.
1364	6.1.32	CHEMICAL LAB - The enrichment of sulphur dioxide by means of absorption under pressure.
1376	10.2.32	Enrichment of gases containing SO_2 by means of absorption without pressure.
1389	12.8.32	Wet Catalytic oxidation of SO_2 III .
1400	5.7.32	III - Catalysis of wet gases in iron oxide dust.
1403	15.9.32	Heating of fatty acid distilling retorts with superheated steam.
1425	13.1.33	The washing out of SO_2 with Xylidin.
1455	6.9.33	CHEMICAL LAB - Sxombathy Process. Parts I and II.
1457	11.10.33	Catalytic oxydation of SO_2.
1471	12.1.34	Ammonium sulphate works experiments in Visp 3rd August - 28th November, 1933.

Number	Date	Description
1473	17.1.34	Catalytic oxydation of SO_2. V. - Work on the production and forming of contact masses.
1493	18.6.34	Wet catalysis at the experimental gas works East.
1509	26.10.34	Reduction of roast blends with carbon oxide.
1510	1.11.34	Condensation of Sulphuric Acid from gases containing SO_3 and H_2O.
1513	3.12.34	Method for the examination of the contact material I.G. Mass.
1514	3.12.34	Method for the examination of contact material Aussiger mass.
1522	14.1.35	Comparison from the examination of Aussiger and I.G. contact material.
1534	25.4.35	Hydrogen sulphide from carbonisation gases. Works experiments in the Gas Works East 7th January - 18th April 1935.
1541	20.7.35	CHEMICAL LAB - Elementary sulphur from sulphur dioxide - experimental plant, Hamburg.
1542	29.7.35	Initial production of sulphuric acid at the mine "Emil" of the Hoesch-Koeln-Neussen A.G. - 24th June - 17th July, 1935.
1573	31.3.36	Hydrogen Sulphide combustion furnace.
1581	8.6.36	Sulfidine research at Baelen.
1582	11.6.36	Sulfidine research at Sturzelberg Works of Sachtleben.
1589	7.8.36	Sulfidine research and recovery with 100% SO_2 Toluidine and water mixture.

Number	Date	Description
1591	15.8.36	Experimental works in Gaswork O. 2nd July 1936 to 29th July 1936.
1592	13.8.36	Sulfidine use of Chemikalien.
1614	19.5.37	Utilisation of Hydrogen Sulphide and carbon monoxide sulphide as elementary sulphur in the final gases of a sulphur extraction plant.
1618R	5-1937	Laboratory experiments for the decolourisation of black contact sulphuric acid.
R1620	about 6-1937	Decomposition of waste sulphuric acid with generator gas.
1640	8.12.37	Wet catalysis and semi-direct ammonia sulphate process.
1646	24.1.38	Treatment of Keciburlu sulphur-ore.
1649	1.2.38	Laboratory experiments for the colourisation of black contact sulphuric acid with oxon.
1651	24.1.38	Treatment of sulphate lyes - Howard Process.
1659	21.2.38	COLLOID CHEMICAL LAB - Experiments about the behaviour of naptholes in caoutchouc.
1660	16.3.38	CHEMICAL LAB - Elementary sulphur from sulphur dioxide - experiment plant, Hamburg.
1662	17.3.38	Reaction during the decolourisation of black contact sulphuric acid with ozon.
1666	27.4.38	SO_2 absorption in dimethylanlin.
1674	25.4.38	Suitability of arsenical sinter for the production of cellulose - lyes.
1676	13.6.38	The absorption of SO_2 mixtures of Xylidin.

Number	Date	Description
1677	14.6.38	SO_2 absorption in dimethlanlin.
1678	15.6.38	Comparative data on the absorption of sulphur dioxide in organic basis.
1680	18.6.38	Production of elemental sulphur from gases containing hydrogen sulphide.
1682	6.7.38	Decolourisation of black contact sulphuric acid with ozon.
1683	9.7.38	COLLOID CHEMICAL LAB - Analytical investigations in the field of Latex Plant. Part II.
1684	30.7.38	METAL LAB - Cadmium bearing metals.
1685	15.7.38	METAL LAB - About the spectium analysis of silumin.
1686	10.12.36	COLLOID CHEMICAL LAB - Report on the centrifugal affect of Latex in the plate separator. Part I.
R1687	16.7.38	METAL LAB - On the physical meaning of technological material indexes.
R1688	14.7.38	Method of determining the zinc contents in iron, chrome and phosphoric acid.
1689	20.7.38	COLLOID CHEMICAL LAB - Report on brake and clutch linings.
1690	8.7.38	CHEMICAL LAB - Process for the production of technically pure copper and zinc sulphate.
1691	22.7.38	COLLOID CHEMICAL LAB - Thin walled diving articles from high viscous T-Vertex.
1692	1.8.38	COLLOID CHEMICAL LAB - On centrifugal concentrates. Parts I and II.

Number	Date	Description
R1693	8.8.38	Expenses for the working up of ball mill dusts.
1695	25.8.38	Production of calcium bisulphite from 100% pure SO_2.
1696	23.8.38	Elimination of Flurine compounds from roaster gases.
1697	7.9.38	COLLOID CHEMICAL LAB - Self-adherent coatings of caoutchouc milk.
1698	9.9.38	Strengthening of leather by Revertex.
1699	20.9.38	METAL LAB - On the blowing process for pressing cable coverings.
1700	28.9.38	COLLOID CHEMICAL LAB - On rubber sponge and rubber moss.
1702	28.9.38	COLLOID CHEMICAL LAB - Protection from discolouration of Latex concentrates.
1703	20.9.38	COLLOID CHEMICAL LAB - The fastening of synthetic rubber on to metals.
1705	30.9.38	COLLOID CHEMICAL LAB 9 Influence of heat treatment on the alternating tenacity of silumin.
1706	30.9.38	METAL LAB - Investigation on Pyrotenax cables up to the 1st October, 1938.
1707	27.10.38	Ammonia regneration.
1708	1.7.38	COLLOID CHEMICAL LAB - About Cyclohexylamin compounds as caogulant for Revertex.
1709	13.10.38	COLLOID CHEMICAL LAB - The water absorption of Vultex.
1710	30.9.38	METAL LAB - Investigation into the production of permanent magnets from powdered metal.

Number	Date	Description
1711	1.10.38	COLLOID CHEMICAL LAB - The use of Revertex in the textile industry.
1712	15.10.38	COLLOID CHEMICAL LAB - Rubber to metal adhesion.
1713	1.11.38	The disintegration of sulphuric acid in Coronet Pebble-Phosphates.
1714	20.10.38	COLLOID CHEMICAL LAB - Production and testing of Naptholenes for caoutchouc substitutes. Part II (continuation of Report No.1659).
R1715	7.11.38	COLLOID CHEMICAL LAB - Decomposition of nickel sulphate.
1717	12.11.38	COLLOID CHEMICAL LAB - Report on the brake and clutch linings position on the 1.11.38 Part II.
1718	23.11.38	Decomposition experiments of sulphuric acid at Schlebusch.
1719	9.12.38	METAL LAB - Sondersilumin with high working absorption.
1720	22.12.38	CHEMICAL LAB - Phosphatisation under current.
1721	4.1.38	Reduction of sulphuric acid at Schlebusch, behaviour of the nitric compounds.
1722	12.1.39	Recovery of SO_2 with Dimethylanlin.
R1723	30.12.38	METAL LAB - Hardened lead bearing metals.
1725	28.12.38	About the possibility to avoid incrustations at the vapourisation of sulphite lyes.
1726	15.2.39	CHEMICAL LAB - Comparative investigations on the corrosion of varnished fittings.

Number	Date	Description
1727	14.2.39	CHEMICAL LAB - Phosphatisation as pre-treatment for fire-enamelling.
R1728	17.2.39	Process of Rudolf Jahn: smelting of Antimony.
G1730	24.2.39	Behaviour of light metals at various temperatures.
1731	16.2.39	Sulfidine Process - Recovery absorption medium.
1732	16.2.39	COLLOID CHEMICAL LAB - Experiments in the drying of fibre-leather.
1733	10.3.39	Behaviour on roasting of sulphur bearing materials.
1734	21.3.39	Compacted zinc alloys.
1735	21.3.39	Pressed and rolled zinc alloys.
1736	21.3.39	Oxidation of Sigal Powder for the production of ceremic materials.
1737	9.3.39	Production of Rotschlamin from Tetanium.
1738	1.10.38	Silumin mixture control 1935/1937.
R1739	28.3.39	Research by Gelsen Chemie. Removal of sulphur from coke oven gas.
1740	22.4.39	CHEMICAL LAB - Post-treatment of phosphate layers.
1741	5.4.39	CHEMICAL LAB - Production of pure tertiary zinc phosphate, secondary and tertiary iron (II) and manganese (III) phosphate.
1742	3.5.39	Elimination of hydro-silicosfluoric acid from sulphuric acid.

Number	Date	Description
1743	3.6.39	Elimination of arsenic from ferrous materials.
1744	19.5.39	Elimination of sulphur dioxide from final gases.
1745 CONFIDENTIAL	7.6.39	METAL LAB - Heat-proofed Beryllium-aluminium - bronzes.
1748	13.4.39	Note dealing with the cultivation of caoutchouc producing plants in German colonies under Mandate.
1749	10.7.39	Report by the Chemical Laboratory. A check up on the British Patent No 501,739 Spray Phosphatisation by the addition of nitrate.
G1750	18.7.39	Investigation on the line of fracture in light metals.
1751	12.7.39	Treatment of residual acid.
1752	4.7.39	ANALYTICAL LAB - Reports about analytical quick determination of calcium in lead alloys.
R1753	5.7.39	About the present work with the Pulfrisch Photometer.
1754	24.7.39	Powdered iron - Ther separation of selenium from hydro-chloric acid with active carbon.
1755	31.7.39	COLLOID CHEMICAL LAB - Naptholene as auxiliary product in the working up of Buna. Continuation of Reports Nos. 1659 and 1714.
1757	22.8.39	METAL LAB - Extended experiments on an Al-Cu-Mg-Alloy.
G1758	4.9.39	METAL LAB - Crystallisation of Al-Si-Alloys.

Number	Date	Description
1760	21.9.39	Recovery of Dimethylinilin from the final gases of a plant for the production of sulphur-dioxide.
1761	30.9.39	Vapour pressure graphs of Xylidin and Toluidin.
R1762	15.9.39	Investigations into anti-corrosion processes, chromate basis.
1764	20.9.39	METAL LAB - Critical survey of the examination of bearings on machines with static loads.
1765	10.11.39	Magnetizing of ferrous materials by means of reduction by pyrites.
1766	15.11.39	Production of iron sulphate from corrosive liquor.
1767	10.11.39	CHEMICAL LAB - Short process on manganese basis.
1768	30.9.39	METAL LAB - Corrosion experiments at pated Lautal.
1769	1.12.39	Nitrate from Nitrate in phosphatisation baths, work of the Pyrene Company Limited, England.
1770	23.12.39	ANALYTICAL LAB - Quick determination of zinc in aluminium alloys by means of Dithison.
R1771	19.12.39	Bondered and varnished band steel.
1772	19.12.39	Laboratory experiments for the production of furfurol from sulphite lyes.
1773	18.11.39	German plastics and Kunststoff Plastic Producers.
R1774	3.1.40	Desulphurisation of pig iron with lime.
R1775	11.1.40	Elimination of hydrogen cyanide from gases containing H_2S

Number	Date	Description
1776	5.1.40	Measuring of the electric resistance in phosphate coatings.
1777	17.11.41	METAL LAB - Solder for zinc alloys.
1779b CONFIDENTIAL	5.2.40	Special extract from the Annual Report 1938/1939. Part: Metal lab.
R1780	8.2.40	Reduction speed of sinter scale with hydrogen at various temperatures.
1781	12.2.40	The production of Waldsassener magnetic pyrites.
R1782	20.2.40	Production of powdered iron, themodynamical considerations.
R1783	17.2.40	Coatings of speculum zinc.
1784	4.3.40	CHEMICAL LAB - Surface treatment of metals for corrosion protection and cold forming.
1785	19.4.40	COLLOID CHEMICAL LAB - The production of Latex concentrates by means of electrophorese acid electro-cose.
1786	8.340	COLLOID CHEMICAL LAB - P_H determination with the aid of the low ohm glasselectrode.
R1787	12.3.40	Reduction rate of sinter-scale.
1788	14.3.40	METAL LAB - Investigation into the utilisation of sulphur from calcium sulphate.
1789	9.3.40	METAL LAB - Purity and corrosion permanency of magnesium metal of different origin.
1790	16.3.40	Anti-corrosion method patent literature.
1792	27.3.40	The Ferrous Phosphate method.

Number	Date	Description
1793 CONFIDENTIAL.	21.3.40	CHEMICAL LAB - Chemical Technical States Institute: Corrosion protection of Bonder Castings.
1795	17.5.40	Absorption of sulphur dioxide from roaster gases with basicssolution of aluminium sulphate. I.C.I. system.
1796	27.9.40	Napthole and napthemic acid products as auxiliary products for the production of synthetic rubber and plastics.
1797	21.5.40	Rust proofing and on phosphatic plastics.
1798	29.9.39	The elimination of arsenic from concentrated sulphuric acid to fine limits.
1799	30.5.40	Granodine rust proofing.
1800	31.5.40	Hardness testing of zind alloys.
1801	6.5.40	ANALYTICAL LAB - Newer methods for the examination of Bonder-bath solution.
1802	19.6.40	Research into the silica contact of sintered iron.
1803	19.6.40	CHEMICAL LAB - Phosphatisation by the spraying method.
G1804	27.6.40	Anti-friction properties of bearing alloys.
1806	4.7.30	The training in the Paper Technical Institute of the States High School in Koethen (Hanhalt).
1807	9.8.40	METAL LAB - Natrium content in volatiles to the quality of alloys of the silumin group.
1809	12.8.40	METAL LAB - Beneficial addition of manganese to silumin.

Number	Date	Description
G1810	17.8.40	Blistering and corrosion of aluminium zinc and magnesium alloys.
G1811	20.8.40	Hardness - creep - experiments on zinc alloys.
R1812	17.8.40	See R.1795 - I.C.I. system.
1813	27.8.40	CHEMICAL LAB - The use of barren aluminate.
R1814	29.8.40	The production of S/9 zinc.
1815	29.8.40	METAL LAB - Lead base bearing metals.
R1816	19.9.40	Production of powdered iron V.
1821	26.9.40	METAL LAB - Creep properties of sinter-materials.
R1822	1.10.40	Corrosion protection processes. Patent literature II.
1823		Absorption temperature of SO_2, Sulfidine system.
1825	28.10.40	Electro-phosphatisation of refined steel.
1826	24.10.40	Absorption of sulphur dioxide.
1827	31.10.40	Elimination of hydrogen cyanide from gases containing H_2S II.
G1828	19.11.40	METAL LAB - Improvement of the spectrographic analysis of fine zinc alloys.
1829	19.11.40	Absorption temperature of SO_2. See No.R.1823.
1830	20.11.40	Powdered iron - Utilisation of iron sulphate from corrosive liquor.

Number	Date	Description
1831	20.11.40	Vapor pressure from a basic solution of aluminium sulphate.
1832	5.12.40	CHEMICAL LAB - The Atrament - C-Process.
1833	13.12.40	CHEMICAL LAB - Water softening with barium aluminate.
G1834	4.1.41	Hints for the grinding, polishing and surfacing of soft metals.
R1835	15.1.41	Method of measurement of stability according to Prof.J.W.Mueller.
G1836	24.1.41	METAL LAB - Metals as substitute materials.
1837	1.2.41	CHEMICAL LAB - Thermical aluminium production I. Vapour pressure of aluminium.
R1839	25.1.41	Pre-copper process for deposition of copper preparatory to phosphate coatings.
G1840	18.2.41	Creeping properties of technical zinc alloys.
G1841	18.2.41	METAL LAB - Intercrystaline corrosion of zinc alloys containing aluminium I.
1842	22.1.41	CHEMICAL LAB - Chromate protection method I.
1843	13.3.41	Filtration of phosphoric acid.
1844	4.3.41	CHEMICAL LAB - Thermical aluminium production II. Vapour pressure of silicium-monoxide.
1845	10.3.41	CHEMICAL LAB - Testing of varnished milk cans.
R1846	11.3.41	The Antox III method of pretreatment for the varnishing of steel strips.

Number	Date	Description
R1847	15.3.41	METAL LAB - Intercrystalline corrosion of zinc alloys II.
G1848	10.3.41	Spectral analysis silumin.
R1849	19.3.41	Production of powdered iron VI.
1850	28.3.41	Laboratory experiments for the evaporation of Ehinger sulphite liquor.
G1851	31.3.41	Zn-Al 1 Zinc Alloy.
1852	24.4.41	CHEMICAL LAB - The treatment of the final gases in sulphur extraction plants.
R1854	29.4.41	The precipitation of albumin with sulphite liquor.
1855	5.5.41	CHEMICAL LAB - A method for the quantative determination of corrosion resistance of phosphate coatings.
G1856	10.5.41	METAL LAB - Experience with the spectral analysis of fine zinc alloys.
R1857	23.5.41	The precipitation of albumin with sulphite lyes. Works experiments Kyritz, May 1941.
1858	26.5.41	METAL LAB - Manufacture of metal ceramic products by drawing.
1859	6.6.41	Decomposition of iron sulphate with iron sulphite in the experimental plant, Homberg.
1860	6.6.41	A short process of phosphatisation on a chlorate basis.
G1861	10.6.41	Development, properties and use of zinc spray-cast alloys.
1862	25.6.41	METAL LAB - Investigation about Zn-Al-Cu cast alloys.
G1863	24.6.41	METAL LAB - Hardening and texture of aluminium alloys.

Number	Date	Description
G1864	26.6.41	METAL LAB - Polishing by means of anodic composition of metal alloys.
1865	26.6.41	CHEMICAL LAB - Concentration of sulphuric acid.
1866	2.7.41	Powdered iron.
1867	27.5 41	METAL LAB - The further development of railway bearing metal.
1868	3.7.41	METAL LAB - Anti-friction values of lead base bearing alloys.
1869	8.7.41	Corrosion tests with various Al-Mg + Cast Bronze Metals.
R1870	8.7.41	CHEMICAL LAB - Corrosion protection of zinc and its alloys with solutions containing.titanate sulphuric acid.
1871	23.7.41	Analytical methods for the Harris process for the refining of raw lead.
G1872	29.8.41	METAL LAB - Corrosion tests on zinc sheet in solutions containing natrium chloride.
1873	28.8.41	METAL LAB - A time switch aparatus for the independent controlling of spectral photographs.
G1874	12.9.41	METAL LAB - Development work on silumin-gamma.
1875	5.9.41	The precipitation of inorganic and organic substances from beech wood sulphite lye.
1876	23.9.41	Kretschmar Process I.
1877	24.9.41	Kretschmar Process II.
1878	26.9.41	Roasting with pure oxygen.
1880	10.10.41	METAL LAB - Investigation of corrosion of zinc alloys with and without surface protection. I. Seawater.

Number	Date	Description
1881	10.10.41	METAL LAB Investigation of corrosion of zinc alloy with and without surface protectior.
		II. Steam.
1882	10.10.41	METAL LAB - Investigation of corrosion of zinc alloys with and without surface protection.
		III. Atmosphere.
1884	3.10.41	ANALYTICAL LAB - A new method for the determination of Fluorine.
1885	4.11.41	METAL LAB - The uniformity of methods of analysis for the determination of magnesium and iron.
1886	27.10.41	Cooling, washing and drying of 100% SO_2 - sulfidine.
1887	15.10.41	The elimination of iron from aluminium-sulphate-solutions by treatment with titanic anhydride.
R1888	29.10.40	The precipitation of Albumin with sulphite lye. Continuation of the laboratory experiments.
R1891	11.11.40	Potato albumin cost of production.
1892	17.11.41	METAL LAB - Development of a cadmium containing solder with a large range of solidification.
R1893	17.11.41	The Phosphatol Process.
1894	11.12.41	Investigation regarding stress corrosion.
G1895	11.12.41	METAL LAB - Further investigations on aluminium - zinc - magnesium alloys.
R1896	18.12.41	The accuracy of the geometric method of the aluminia silicate problems.

Number	Date	Description
G1897	22.12.41	METAL LAB - Intercrystalline corrosion of zinc alloys - III.
1898	1.1.42	Prevention of freezing by means of Lactat
G1899	1.12.42	Coatings and protective varnishes for metals.
1900	21.2.42	"Bondered" and varnished black plate canning tins.
1901 CONFIDENTIAL.	11.2.42	METAL LAB - Drawing tests on infantry shells I.
1902	7.2.42	METAL LAB - Solders - cadmium.
1903	19.2.42	CHEMICAL LAB - Lurgi Iron Ore preparation
1904	27.2.42	METAL LAB - Cadmium solders.
1905	12.3.42	METAL LAB - The behaviour of positive plates with gratings from lead calcium in the lead-collector.
1906	12.3.42	METAL LAB - Alloy Z.710 produced with U-Al-alloy.
G1907	1.4.42	Corrosion protection of zinc and zinc alloys with metallic bright surface.
1908 CONFIDENTIAL.	13.3.42	Corrosion protection of Infantry Shells.
1910	30.3.42	Note dealing with the calculations for the production of iron powder from iron sulphate.
1911	9.4.42	Heat resistance of aluminium cast alloys
R1912	11.4.42	Crystallisation of aluminium sulphate from aluminium sulphate solutions containing magnesium sulphate.
1913	20.4.42	Corrosion of aluminium alloys under tension compared with copper.

Number	Date	Description
1914	20.4.43	The Swiss Baunderite Process.
1918	1.5.42	Dehydration and decomposition of aluminium sulphate.
G1920	27.5.42	METAL LAB - Welding and soldering of zinc and zinc alloys.
1921	19.6.42	METAL LAB - Crystalline corrosion of zinc alloys.
1923	26.6.42	CHEMICAL LAB - Dehydration and decomposition of aluminium sulphate.
1924	8.7.42	METAL LAB - Spectral chemical analysis of lead alloys.
R1925	10.7.42	Investigations regarding the Nowathy Proeess.
~~1926~~	~~15.6.42~~	The wet method of the Harris Process IV.
1929	3.8.42	Production of Tertiary Zinc Phosphate from technical zinc liquor and super phosphate.
1932	24.8.42	CHEMICAL LAB - Lurgi ore preparation method II.
1934	3.9.42	Distillation of zinc, magnesium and lead from aluminium.
R1935	14.9.42	Retesting of the Kirsebern Process.
1936	24.9.42	The Nowathy Process and the suitability for the preparation of aluminium silicum pre-alloys.
1937	19.10.42	Treatment of natrium sulphate.
1938	28.10.42	METAL LAB - The effect of compression on aluminium, zinc and magnesium alloys and pure aluminium.

Number	Date	Description
1939	4.11.42	CHEMICAL LAB - Solubility of aluminium and aluminium silicum alloys in lead.
1940	21.11.42	METAL LAB - Spectral chemical analysis of natrium in silumin.
G1941	25.11.42	The zinc-alloy Zu-Cu 1 for sheet metal and bands.
G1942	25.11.42	METAL LAB - The examination of stress corrosion on aluminium alloys.
1943	19.11.42	Method of examining varnish films.
1944	18.1.43	The heat transfer of steam heated water tubes.
1944a	9.2.43	Heat transfer of steam during condensation.
1945	12.9.42	LITERARY DEPARTMENT - Memorandum about the activities of the Metallgessellschaft in the field of aluminium.
1945		T.S.Bericht -do-
R1946	18.12.42	Production of iron sulphate from iron and sulphuric acid.
R1947	21.12.42	The gas content of the Fe_3O_4
1948	22.12.42	Production of aluminia for the Rubber Industry.
1949 CONFIDENTIAL.	28.1.43	METAL LAB - The development of a mixed Zn-Mn 1-Ph.
1940	1.2.43	METAL LAB - Subsequent development of hardened lead bearing metal.
1951	9.2.43	Refinement of silumin.
1952	10.2.43	METAL LAB - The oxydation of cadmium alloys in a liquid phase.

Number	Date	Description
1953	10.2.43	METAL LAB - Drawing tests on infantry shells II. Simplification of the drawing process by means of post-treatment of the phosphate - layer with fatty acid soaps.
1954	23.2.43	The position of the Kretschmar Process on the 20th February 1943.
1955	2.3.43	METAL LAB - The enlarged volometric examination of metal structures by the use of X-rays.
1956 HIGHLY CONFIDENTIAL	23.2.43	METAL LAB - Practical experiments with plug valves from ZAMAK-alloys.
1957	16.3.43	ANALYTICAL LAB - Experiments for the determination of mica (glimmer) in sands containing lithia mica.
1958	22.3.43	METAL LAB - An optical method of examining phosphate during drawing.
1959	31:3.42	Research in the field of naptholene.
1959a	31.3.42	-do-
1960	27.3.43	New methods in phosphate production.
1961	84.43	Method of cold phosphatisation of Messrs. Langbein, Pfanhauser Works A.G. Leipsig.
1962	5.4.54	CHEMICAL LAB - Semi-technical experiments for the production of zinc phosphate at the Sachtleben A.G. Works Homberg.
1963	13.4.43	Preparatory treatment of alloys.
1965	20.4.43	METAL LAB - The action of phosphate coating in shavings.

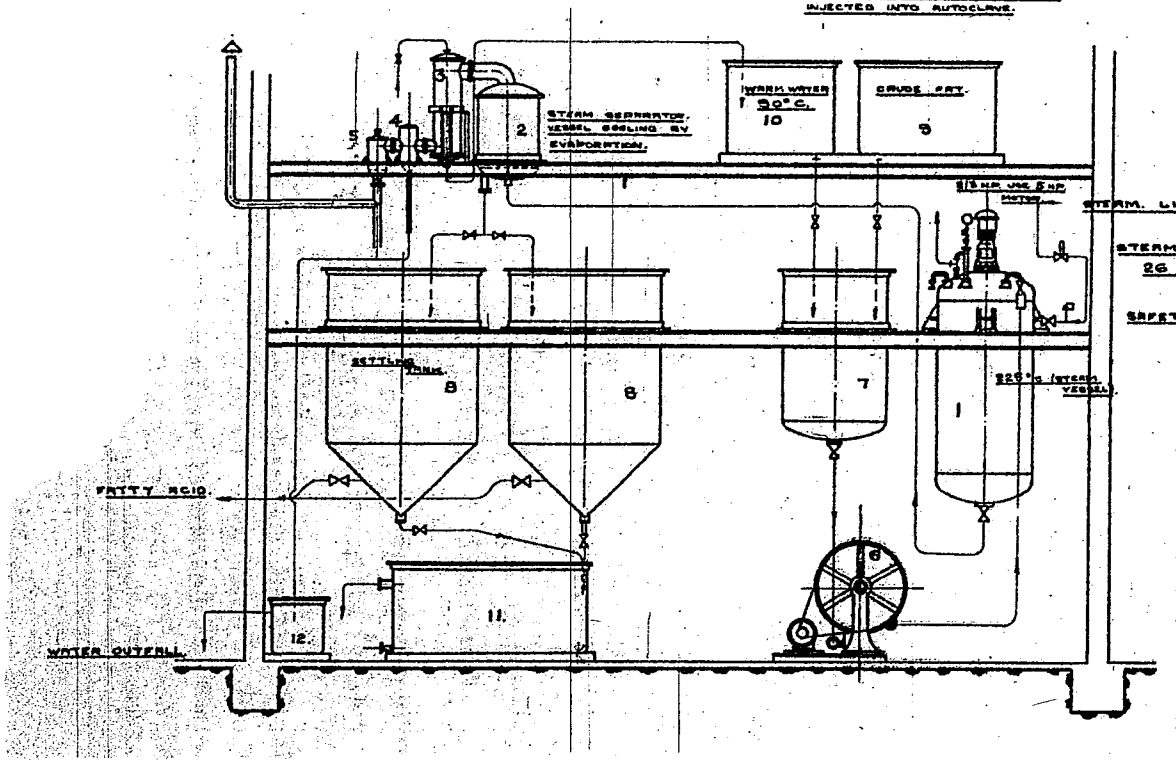
Number	Date	Description
1966	14.4.43	CHEMICAL LAB - ~~Prevention of metal rupture during drawing~~. Solubility of Pb. in Al-Si-Alloy. Investigation into the Kirseborn Process. Part II.
1969	28.4.43	METAL LAB - Properties of zinc alloys with a high content of aluminium.
1970	6.5.43	METAL LAB - Cast zinc alloys with low aluminium contact.
R1971	6.5.43	Process of the Societe Electro Metallurgique due Planet for the electro themrical production of magnesium.
1973 I. 1973 II.		Zinc alloys Zn-Mn 1-Pb.
G1976	27.3.43	Aritifical production of seawater.
1977	6.8.43	Testing for small quantities of H_2S in gas containing SO_2.
1978	1.9.43	METAL LAB - Re the hardening process of silumin-gamme.
R1979	11.8.43	Fundamentals in the production of aluminia.
R1980	14.8.43	Part II - Process of the Societe Electro Metallurgique de Planet for the production of thermical magnesium II.
G1981	30.9.43	Production and anti-friction qualities of sinter bearings, particularly on Al-u, Fe-Basis.
1982	2.10.43	Investigations into the use of the phosphate layers for drawing metals without rupture.
1983	18.10.43	A quick method for the determination of zinc phosphate and nitrate in Bonder-baths.

Number	Date	Description
1985	30.10.43	CHEMICAL LAB - Investigation regarding the use of Thomas meal for the production of Bonder-material.
1986	2.11.43	CHEMICAL LAB - Investigation regarding the use of salamoniac as zinc basis for the production of Bonder-Material
1990	8.12.43	Heat treatment silumin gamma.
1991	27.12.43	Shock resistance of zince alloys at low temperatures.
1992	15.12.43	Thecold ferrous phosphate method.
G1993	1.2.44	The substitution of roller bearings by plain bearings.
1995	21.2.44	Production of trinatrium phosphate from iron phosphate.
1998	11.4.44	Present day metallic anti friction bearings.
1999	23.5.44	The hot pressing of powdered metal bearings.
G2000	24.1.44	METAL LAB - The refining of silumin.
2003	20.7.44	Production of phosphate coatings at room temperatures from phosphate baths containing nitrate.
R2004	8.8.44	The production of Vanadium addition to phosphoric acid in the electric furnace.
R2005	25.9.44	Production of powdered iron in the tunnel oven (final report Bremen)
2006	27.11.44	METAL LAB - Operating properties of aluminium bearing metals.
2007	11.11.44	X-ray examination during hardening of aluminium alloys.
2008	16.12.44	Production of powdered iron in the tunnel oven (final report Bremen).

ADDENDUM.

Number	Date	Description
1021	21.1.30.	Further experiments on the problem of Gas Turbines.
1759	2.9.39.	Investigations on aluminium, zinc, magnesium alloys.
1763	30.9.39.	Corrosion experiments at the Meteorological Station.
1916	27.4.42.	Alumina from German raw materials.

55% WATER IN "7" FOR A NEUTRAL OIL TO BE SPLIT 90%, INCLUDING DIRECT STEAM INJECTED INTO AUTOCLAVE.



Nº	Nº Off	DESCRIPTION
12	1	WATER CONTAINER.
11	1	GLYCERINE WATER CONTAINER.
10	1	WARM WATER CONTAINER.
9	1	CRUDE OIL CONTAINER.
8	2.	SETTLING TANK.
7	1	MEASURING VESSEL.
6	1	HIGH PRESSURE FEED PUMP.
5	1	AFTER CONDENSER.
4	1	PRIMARY CONDENSER.
3	1	FEED WATER HEATER.
2	1	EXPANSION CHAMBER.
1	2.	FAT SPLITTING AUTOCLAVE.

FIG 5

LURGI.

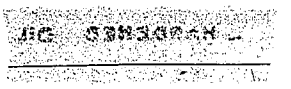
GESELLSCHAFT FUR WARMETECHNIK M.B.H.

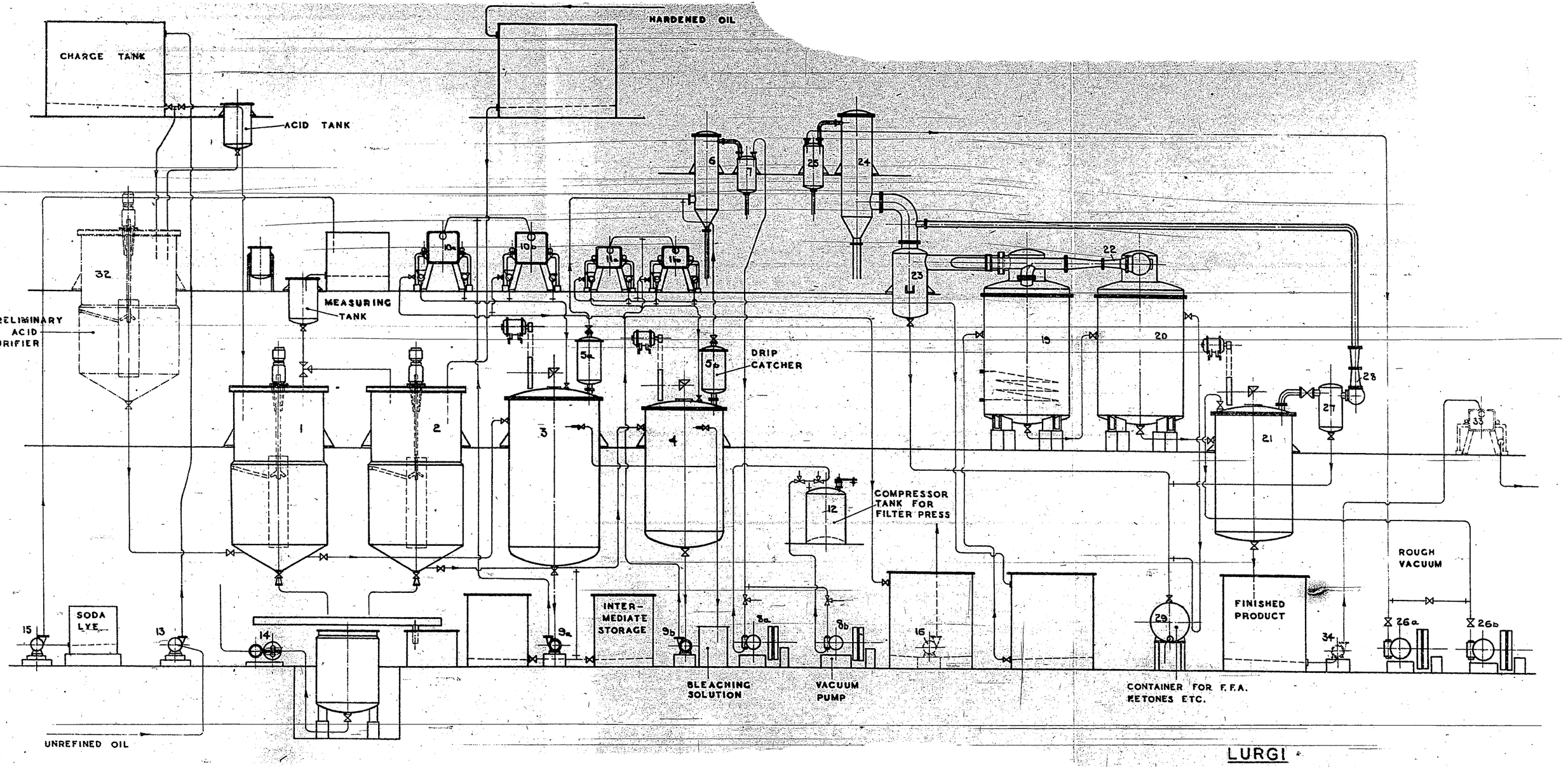
FRANKFURT ON MAIN.

SCHEME FOR FATTY ACID, HIGH PRESSURE SPLITTING TANK.

Nº D.O. 6945.

DATED 23-8-40.





LURGI

GESELLSCHAFT FUER WAERMETECHNIK M.B.H.

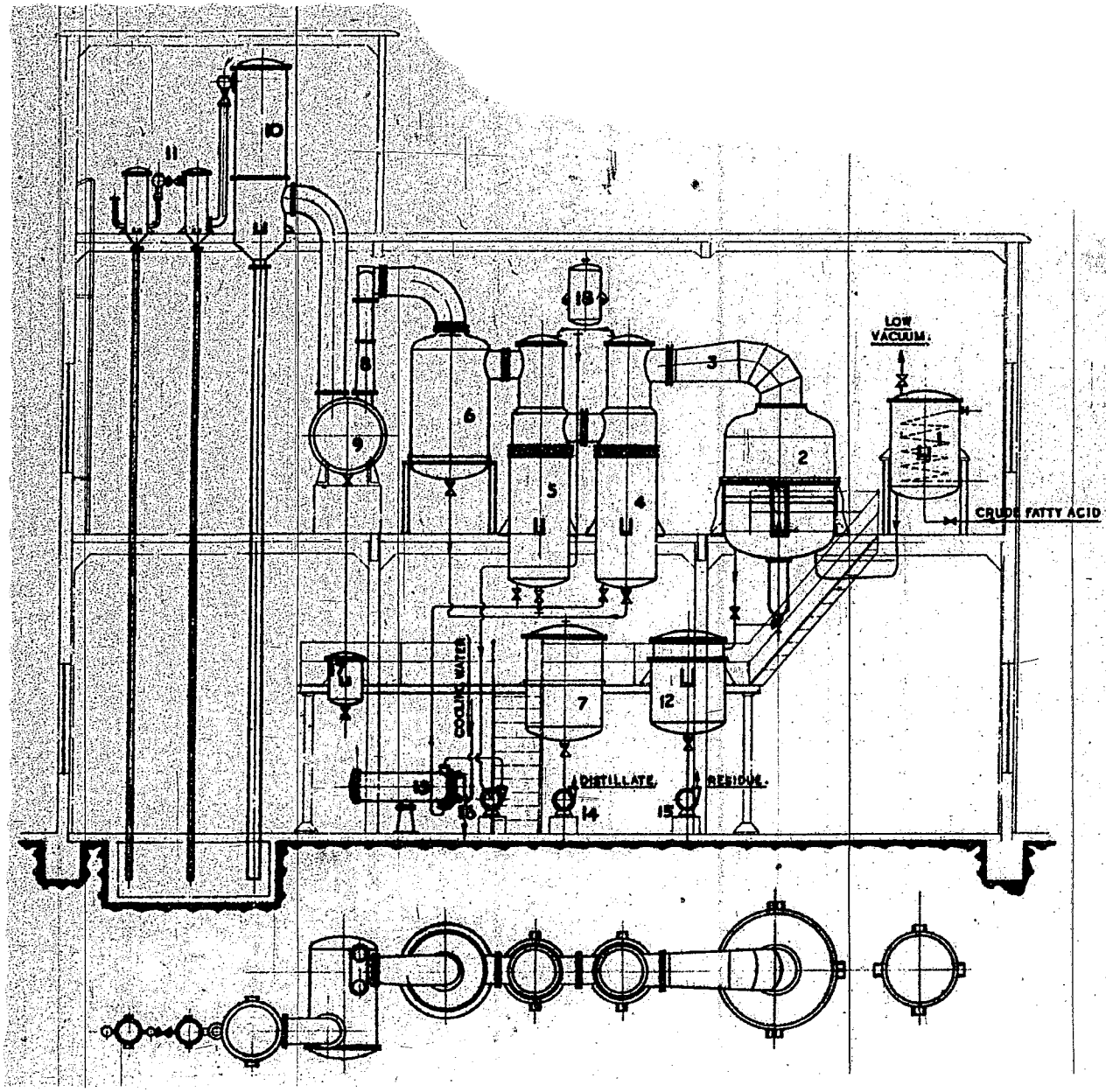
D.O.A. 41133. DRAWN 6.10.38.

SCALE 1/4 - 1-0" DRG Nº D.O. 8062.

FLOW SHEET FOR VEGETABLE OIL REFINING PLANT WITH AN OUTPUT OF 20 TONS/24 HOURS

[GARESH FLOUR MILLS, LYALLPUR]

FIG 3.



1.	PREHEATER.
2.	STILL.
3.	VAPOUR PIPE.
4.	PRIMARY CONDENSER.
5.	SECONDARY CONDENSER.
6.	AIR COOLER & SEPARATOR.
7.	INTERMEDIATE DISTILLATE STOR:
8.	STEAM JETS.
9.	SEPARATOR.
10.	SPRAY CONDENSER.
11.	VACUUM PLANT.
12.	RESIDUE CONTAINER.
13.	GLYCERYNE COOLER.
14.	DISTILLATE PUMP.
15.	RESIDUE PUMP.
16.	GLYCERINE CIRCULATION PUMP.
17.	ENTRAINMENT RECEIVER.
18.	GLYCERINE EXPANSION TANK.

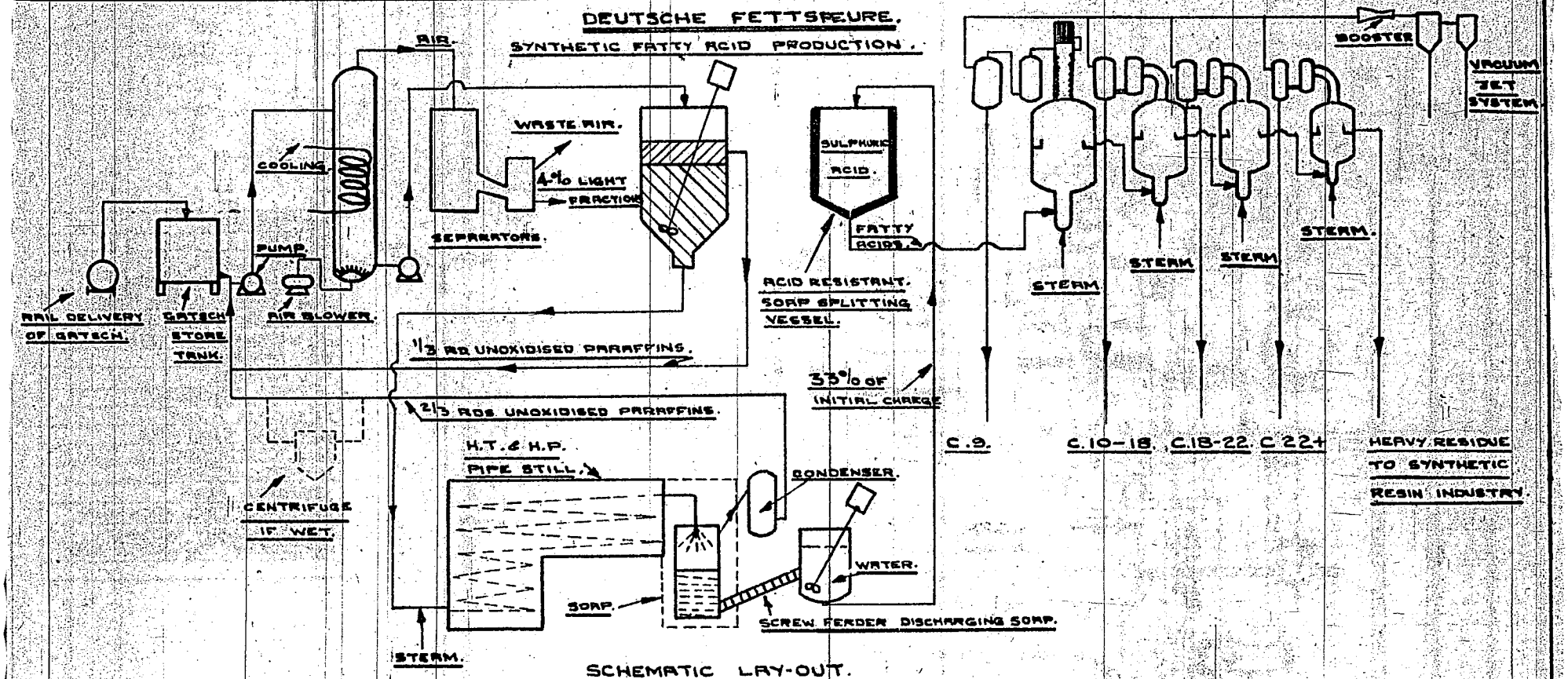
FIG 6

HIGH VACUUM FATTY ACID DISTILLATION FOR CONTINUOUS WORKING - DUTY 25 TONS PER 24 HOUR DAY.

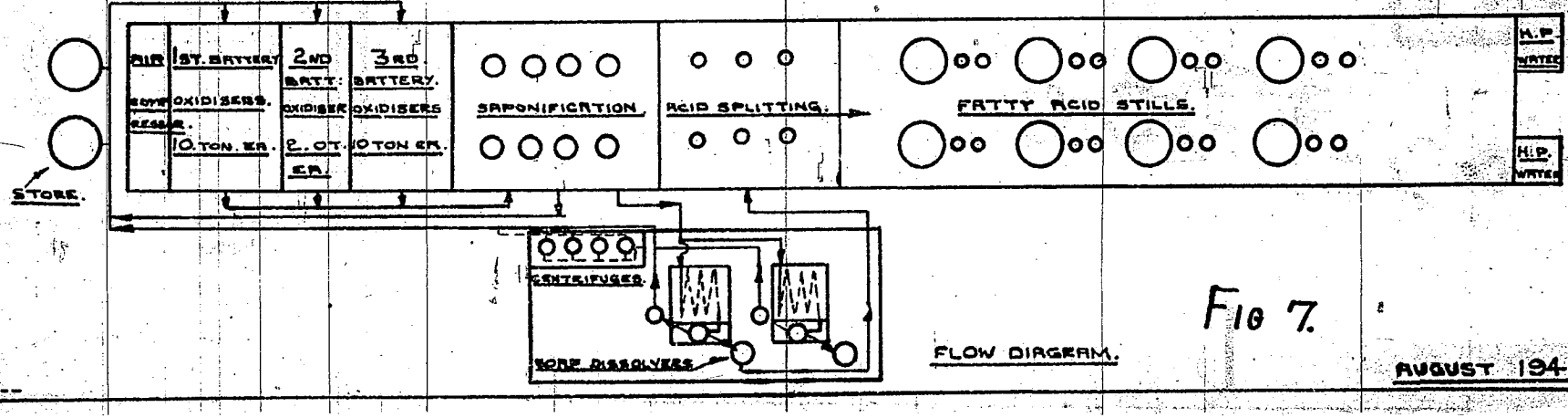
LURGI DRG. NO. D.O. 5488.

DEUTSCHE FETTSPEURE.

SYNTHETIC FATTY ACID PRODUCTION.



SCHEMATIC LAY-OUT.

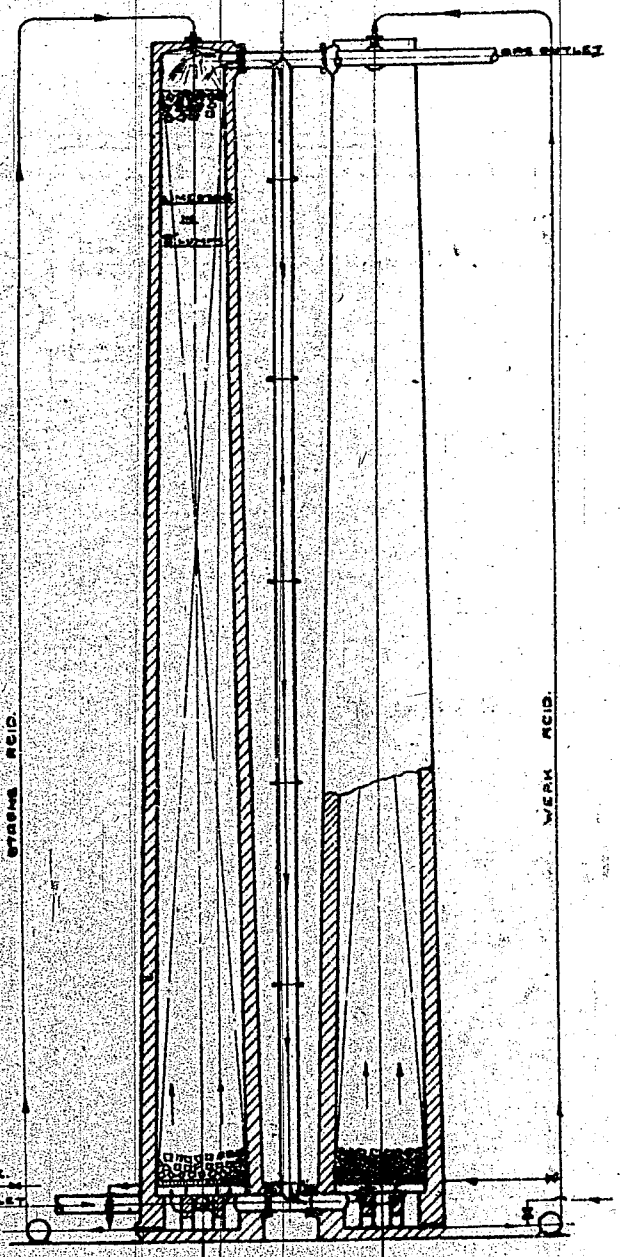


FLOW DIAGRAM.

FIG 7.

FIG. N°

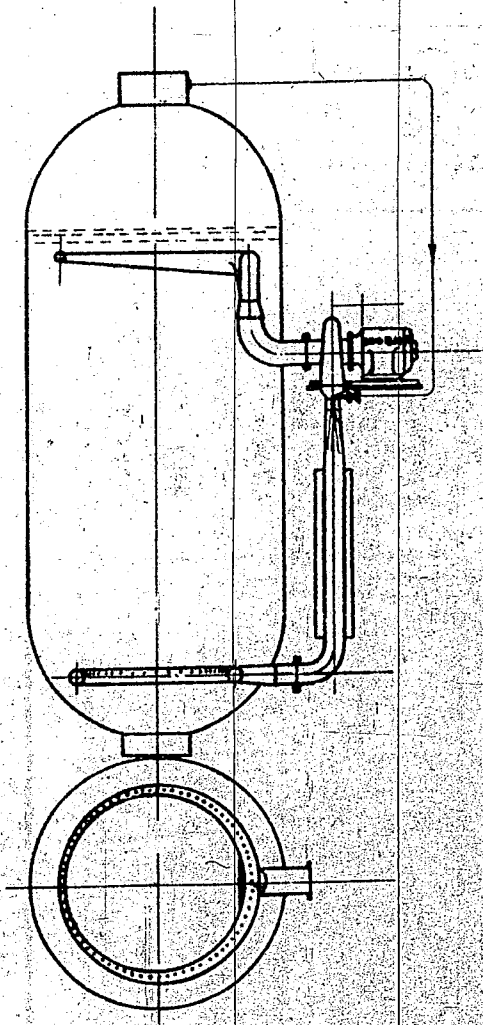
AUGUST 1945.



PREPARATION OF SULPHURIC ACID.

SCALE 10 FT = 1 INCH (APPROX).

Fig. 11a.



DIGESTING PROCESS.

Fig. 11b.

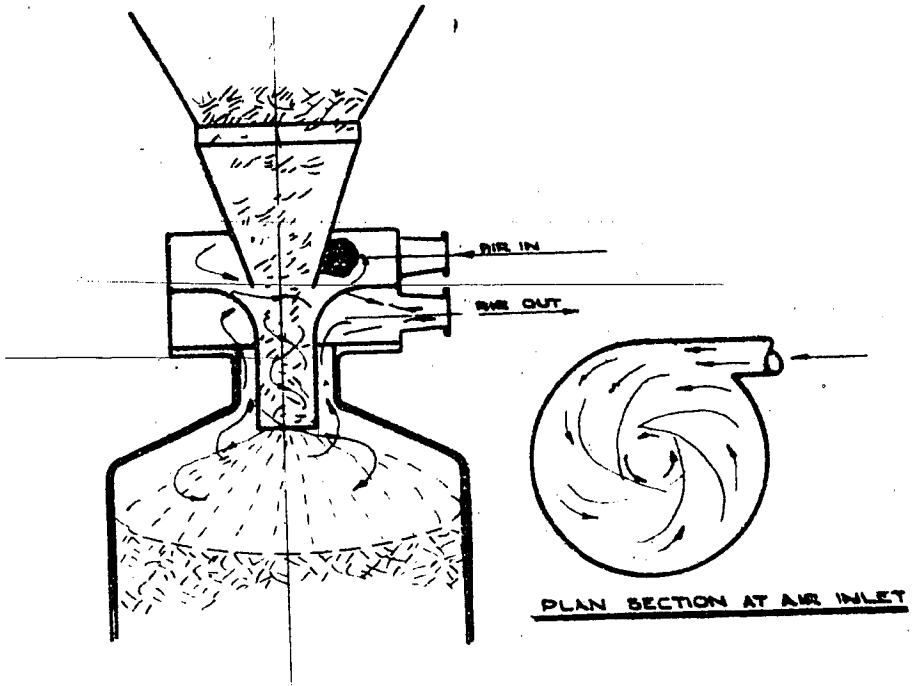


FIG 12a FRESK CHARGING SYSTEM

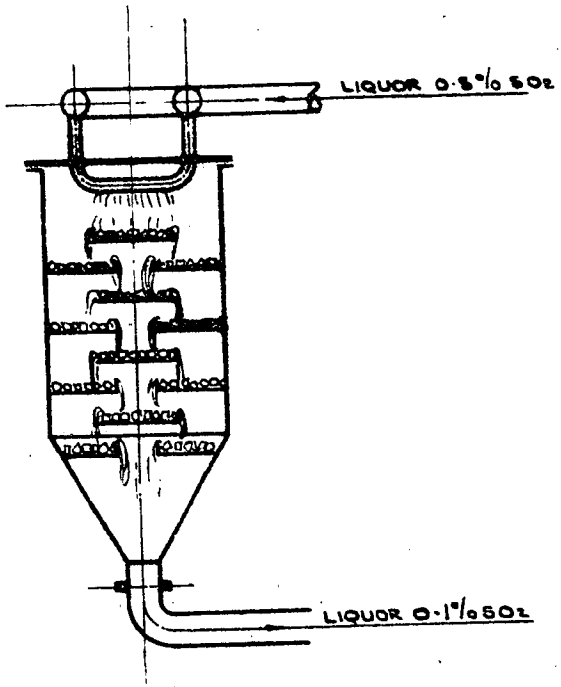


FIG 12b. S.O2 RECOVERY

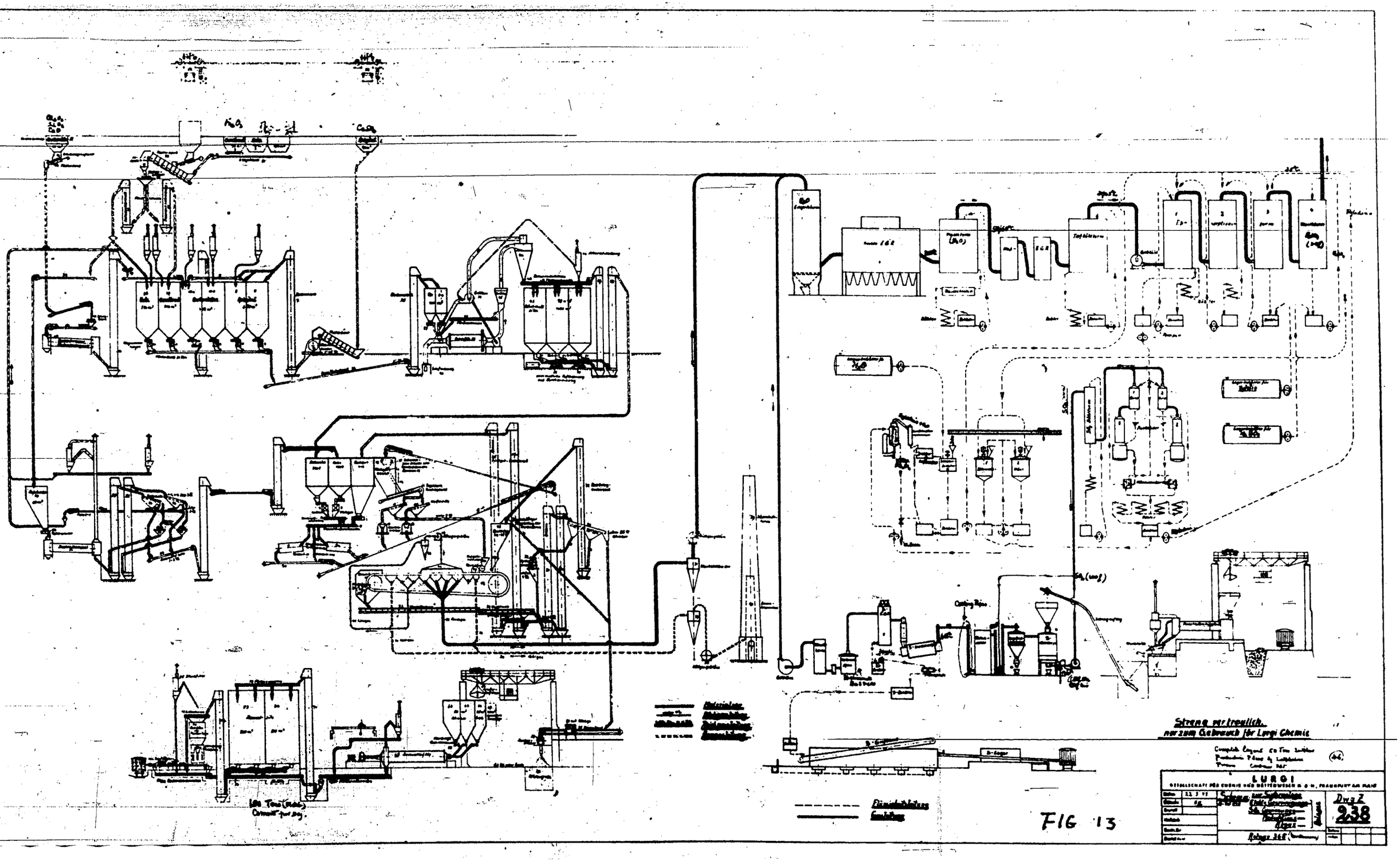


FIG 13