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GAS UTILITIES IN GERMANY

Pfeiffer, Getz, Osborne

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COMBINED INTELLIGENCE OBJECTIVES
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Reported by
Mr. B.V. Pfeiffer, T.I.I.C
Dr. C.A. Getz, T.I.I.C
Mr. A. Osborne, T.I.I.C

CIOS Target No. 33/151
Utilities

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

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MANUFACTURE OF GAS AT LEIPZIG GAS WORKS, LEIPZIG

1. Introduction.

The Leipzig Gas Works located in Leipzig is a municipal operated and owned property. It purchased approximately 5% of its gas requirements from the Energie A.C. with headquarters at Markleeberg. The company manufactures the balance of its gas requirements. The director of the company is Earnst Homborg, and the plant engineer is Paul Thieroff. Both showed us through the plant.

2. Carbonizing Plant

This consists of:

a. Two batteries of Koppers Ovens, each battery containing 18 ovens. The ovens are heated by 6 detached Koppers Producers. These ovens can carbonize 300 tons of coal per day and can produce 100,000 m^3 (4800 Kg. Cals. per m^3) of gas per day.

b. Two batteries od Didier Inclined Ovens, each battery containing 18 ovens. The ovens are heated by gas produced by the ovens. The ovens can carbonize 200 tons of coal per day and can produce 140,000 m^3 (4800 Kg. Cals. per m^3) of gas per day. One battery is out of operation awaiting complete refilling.

3. Water Gas Plant

This consists of:

a. Two Bamag machines, equipped with automatic controls and self-cleaning generators. Each machine can produce 70,000 m^3 (2600 Kg. Cals. per m^3) of gas per day.

b. Two Pintisch Company machines are under construction and are 90% completed. They are equipped with automatic controls and self-cleaning generators. It is estimated that each machine will be able to

produce 100,000 m^3 (2600 Kg. Cals. per m^3) of gas per day.
Coke produced in the carbonizing plant is used in the water gas generators.

4. Fisher Tropsch Plant

In June 1944 the company started the erection of 12 Fisher Tropsch ovens for the production of synthetic oil. The plant was completed about 75% in April 1945, when heavy bombing of the gas works stopped all work on this installation. It is estimated that this plant will handle 220,000 m^3 of 4300 Kg. Cals. per m^3 of gas and 250,000 Kilos of synthetic oil per day. This oil when refined will produce 50% motor fuel, 30% Diesel oil and 20% lubricating oil. All synthetic oil will be shipped to a central refining plant at Zeitz in Central Germany. Other Fisher Tropsch Plants located at Nurenberg, Furth, Erfurt and other cities in Central Germany will ship their synthetic oils to Zeitz for refining. The Fisher Tropsch Plants use activated carbon for complete sulphur removal and a cobalt catalyst heated to 200°C for producing synthetic oil.

5. General Comments

Ammonia has not been recovered in the carbonizing plant since 1937 due to competitive conditions brought about by the numerous low price synthetic ammonia plants, and the high prices of sulphuric acid to produce sulphate.

A mixture of 70% Lux and 30% Bog Ora (Natural iron oxide) are used for H_2S removal. Spent purifying material is sold to chemical plants for sulphuric acid production.

Coal, known as hard coal, is received by rail from Zwickau. Due to the present coal shortage and plant damages, the use of gas is limited and consumers can only secure sufficient gas for their use during the

following hours:

3:00	to	5:30	o'clock (Bakeries only)
7:00	to	9:00	"
12:00	to	14:00	"
17:00	to	19:00	"

During all other hours of the day the gas pressures throughout the city are reduced to 1/2" water pressure. Consumers are notified through radio broadcasts as to the actual hours during which gas will be available. All automatic gas appliances such as gas refrigerators, water heaters, etc., are not permitted to be used.

The plant was heavily bombed with fire bombs in December 1943, and in May 1944, causing some damage to structures, buildings and holders, most of which have been repaired. About 15 high explosive bombs were dropped on the plant in February 1945, damaging holders and coal handling equipment which are now being repaired.

The gas main distribution system throughout the city was severly damaged by bombs. These breaks are gradually being repaired.

There is nothing of unusual interest to the gas industry at this plant.

MANUFACTURE OF GAS AT BOHLEN GAS WORKS BÖHLEN

1. Introduction

The Böhlen Gas Works located in Böhlen is a privately owned company. It sells all the gas produced to the Energie A.G. (located at Markleeberg). This latter company operates a gas grid system and resells the gas purchased to approximately 20 cities extending from Zwichau to the south of Böhlen and to Magdeburg to the north of Böhlen. The director of the company is A. Böhn with whom we discussed various plant operating features. Hans Otto, plant engineer showed us through the plant and explained operations.

2. Gas Generating Facilities

In 1940 five Luvgi gas generators were installed. In January 1945 five additional Luvgi gas generators were put into operation.

Eight generators are usually in operation and produce 480.000 m^3 of 4200 Kg. Cals. per m^3 per day. The generators have an internal diameter of 2.5 meters. Each generator can produce 60,000 m^3 per day.

3. Oxygen Plant

A Linde-Frankel air liquifaction plant is installed for the production of oxygen. It consists of two small machines each having a capacity of 1000 m^3 of O_2 per hour, and two larger machines each having a capacity of 2000 m^3 of O_2. The oxygen is 95% to 97% pure and contains from 3% to 5% N_2. One large and one small machine is usually in operation. Oxygen is produced at 20 to 22 atmospheres pressure.

4. Cost of Plant

The total cost of the plant was as follows:

Machinery and apparatus.....8,180,000 marks
Buildings and structures .....1,920,000 "
Miscellaneous ..... 629,000 "

Total cost 10,729,000 "

It is estimated that the Linde-Frankel oxygen plant cost 3,600,000 marks.

5. Operating Results

Brown coal shipped by railroad from Kulkwitz is used. The coal as received contains from 50% to 55% water. This moisture is reduced to 15% in steam driers after which the coal is crushed to 2 to 10 m.m. in size before it is charged to the generators.

Plant operating results are as follows:

Oxygen used.....0.15 m^3 per m^3 gas made
Coal " .....1.45 Kilos per m^3 gas made
Steam " .....1.46 " " " " "
Electric power used ..... .27 Kwh. " " " "
Tar made .....128 Grams " " " "
Light oil made ..... 52 " " " " "

The cost to produce oxygen is from 2.0 to 2.4 pfg per m^3 which includes the fixed charges on the plant. The capacity of the oxygen plant is 4000 m^3 per hour. It requires a total of 6 men per shift 3 shifts per day to operate the oxygen plant.

All gas is produced at a pressure of 20 atmospheres. It is washed, cooled, purified, metered through orifice meters and delivered to the gas grid system at this pressure.

6. Miscellaneous

The gas is purified in high pressure steel purifiers 8 meters high and contains 6 cu. meters of Lux purifying material. Each box has 6 layers 1/2 meter deep of Lux

and is divided flow and can be reversed in flow. Spent oxide is sold to a chemical plant for sulphur recovery used to manufacture sulphuric acid.

The tar and light oil produced is sold to the Bramag Company in Böhlen.

Because of the damage from extensive bombing and also because of coal shortage the plant was only producing 150,000 m^3 of gas per day. It was estimated that it will require from 3 to 4 months before full operation of the plant will be available.

TRANSMISSION OF GAS BY THE ENERGIE A.G. MARKLEEBERG

1. Introduction

The Energie A. G., with headquarters at Markleeberg purchase all the gas produced by the Böhlen Gas Works Company at Böhlen and distributes the gas to numerous cities and municipalities around Zwickau, Chemnitz, to the south of Böhlen; Erfurt, Jena, to the west of Böhlen; Halle, Leipzig, Dessau, to the north of Böhlen. Director Bernhart of the Company was interviewed.

2. Description of Grid System

The gas grid system consists of approximately 1100 Km. of steel welded mains varying in size from 4" to 12". Of this amount of mains the company owns 200 Km. on which system they retail gas direct to customers. On the balance of the system they wholesale gas for other companies. There are two 12" mains between Böhlen and Leipzig.

The grid was started in 1928 by extending a main from Magdeburg to Wiederitsch, a distance of 100 Km. Gas is distributed at 20 atmospheres.

All mains are steel welded and wrapped with a tar felt covering to protect them against corrosion. Shut off valves are placed about every 3 Km. In built up areas leakage control tubes are installed at every welded joint.

The grid system is tied in with the Reichswercke Grid System at Magdeberg.

3. Purchase Price and Selling Prices

The purchase price of gas is 2.78 pfg. per m^3. It is resold under contract to the various cities and municipalities from 7.5 pfg per m^3 to as low as 3.5 pfg per m^3 depending upon the quantity sold, etc.

GENERATION OF GAS AND HYDROGENATION BY THE BRAMAG COMPANY BÖHLEN

1. Introduction

Interviewed Director N. von Felbert and plant engineers Frederick Mott and Richard Lachner of the company. Mr. L. Ruckes (Central Germany) representative of the Lurgi accompanied us on our visit to this plant.

2. Generating Facilities

Three Winkler Gas Generators having a diameter of 4.5 feet and 120 feet high are installed. Each generator can produce 25,000 m^3 of 1200 Kg. Cals. per m^3 of gas per hour.

The Linde Frankel Oxygen Plant has a generating capacity of 15,000 m^3 per hour of 98% oxygen gas and 2% nitrogen. The process is air liquifaction and the cost to produce 1 m^3 of oxygen is 2.0 pfg. including fixed charges.

3. Operations

The Winkler Gas Generators are fed at the bottom with a screw conveyor with coke of an average size of 1.5 m.m. The coke is fed on the the grates to depth of 2 meters. Oxygen and steam enter below the grate at a pressure of .3 atmospheres which keeps the coke in a turbulent state. Eighty percent of the oxygen required is fed below the grates and the balance of the oxygen (20%) enters 8 meters above the grate. The pressure above the grates averages .1 atmospheres. The ash accumulating below the grate is removed by a screw conveyor. Twenty percent of the ash produced goes through the grate and balance (80%) flows along with the gas stream. Seventy-five percent of the carbon in the coke is consumed in making gas.

The gas leaving the generators at 9000C analysis as follows:

CO_2	25.0%
CO	30.0%
N_2	43.0%
N_2 & CH_4	2.0%

From the generators the gas passes through a Waste Heat Boiler where its temperature is reduced to 150°C. The gas is then passed through a centrifugal water cooler and a brush washer, cooling the gas to 30°C before it enters a relief holder. An exhaustor passes the gas through Lux purifiers where the H_2S content is reduced from 10 grams per m^3 to .028 grams per m^3. From the purifiers the gas passes through a hot water washer and saturated. Steam is also injected (1 Kg. per m^3) at this point and the temperature of the gas is raised to 100°C. The gas is next passed through two reactors which are filled with 1 c.m. long chromium $Fe(OH_3)$ catalysist. The following reaction takes place:

$$CO + H_2O = CO_2 + H_2$$

The temperature of the gas at the outlet of the first reactor is 450°C and by adding water in the second reactor the gas is cooled to 400°C. From here the gas goes to a washer cooler that cools the gas to 30°C before going to a small holder. The gas at this point analysis

CO_2	1.0
CO	.1
H_2	97.0
N_2&CH_4	1.9

The hydrogen so produced is used in a hydrogenation plant where tars, light oils and crude benzine (which are purchased) are treated to produce motor fuels.

It was stated that the cost of producing 1 m^3 of compressed hydrogen is 8 pfg.

Because of heavy bombing the plant was not in operation.

LOW TEMPERATUE CARBONIZATION PLANT
A. S. W. SAXONIA WORKS
ESPENHEIM

1. Introduction

Mr. L. Ruckes, Lurgi representative and Dr. E. Thamaraus, chief chemist, went through the plant with me. The plant produces coke, which is sold to the adjacent large electric company and to the Böhlen Gas Works, motor fuels, crude benzine and carbon electrodies.

2. Carbonizing Plant

There are 30 Lurgi Low Temperature Carbonizing Ovens installed capable of carbonizing 9000 tons of brown coal briquettes per day and producing 1,800,000 m^3 of 1800 Kg. Cals. per m^3 of gas per day.

3. Brown Coal Briquettes

The plant has the largest briquetting plant in Germany. Thrity-seven presses compress dried brown coal into 9000 tons of briquettes, under 1200 atmospheres of pressure. The brown coal is received from a large adjoining stripper mine.

4. Products Produced

(a) Coke

Two-thirds of the coke produced, 6,000 tons per day, is used in an adjoining electric station for the generation of steam. The balance of the coke is sold to the Böhlen Gas Works.

(b) Gas

The gas produced, 1,800,000 m^3 per day, is used to heat the ovens 700,000 m^3 and 1,100,000 m^3 in the synthetic oil plant.

(c) Tar Oils and Crude Benzine

The plant produces 765 tons of tar oils per day are refined into Diesel oil, fuel oils, paraffins and pitch. The pitch having no ash is reduced to petroleum coke which in turn is made into electrodes. 135 tons of crude benzine is produced which is shipped to a central refining plant for motor fuel production.

(d) Sulphur

A Koppers Liquid Sulphur plant purifies the gas and recovers the sulphur in cake form from this plant.

5. Miscellaneous

The plant was shut down because of extensive damage from bombing. It is estimated that large quantities of new equipment and materials will be required and that it would take 2000 men four months to put this plant back into operation.

GENERATION OF GAS
ERFURT GAS WORKS
ERFURT

1. Introduction

Interviewed Director Conrad Weiss and then went to the gas plant for inspection. Plant Engineer Willy Schaefer showed us through the plant.

2. Gas Generating Equipment

The gas plant has 9 Vertical Chamber Ovens built by the Deutsche Oven A. G. of Leipzig. The ovens can produce 80,000 m^3 of 4300 Kg. Cals. per m^3 of gas per day and can carbonize 150 tons of coal per day. Ovens are steamed and have attached producers.

3. Operations

The company sells all the coke, tar, light oils and 15% concentrated ammonia liquor. Spent oxide is sold to a chemical company for sulphur recovery.

4. Gas Distribution

Gas is distributed to the city under low pressure. Gas pumped to 6 atmospheres is sent West to Vacha through a 150 mm steel welded main 50 km long and sent South to Saalfeld through a 150 mm steel welded main 150 km. long. The high pressure gas system it connected with the Central Germany Grid System by a steel welded main extending to Miltitz.

5. Miscellaneous

The plant was not in operation. It was badly damaged from bombing. All three holders were severely damaged. The plant has a crude benzole reconvery plant which is protected from fire with an automatic carbon dioxide system. Coal shipped from the Ruhr District is used in the plant.

GENERATION OF GAS
KASSEL GAS WORKS
KASSEL

1. Introduction

Interviewed Herr Richards who is in charge of the municipal operation of Electric Plant, Gas Works and Water System. Director Fritz Graubmann is in charge of all gas operations. He showed us through the plant.

2. Gas Generating Equipment

The plant was 4 batteries of Didier Vertical Chamber ovens. The total ovens installed are 75. Two batteries are fired with attached producers while the other two are fired by 4 Pintsch producers. Each producer can produce 50,000 m^3 of 1800 Kg.Cals. per m^3 per day. Ovens are steamed.

The total coal carbonized per day is 400 tons which produce 220,000 m^3 of 4300 Kg. Cals. per m^3 of gas per day. Coal used comes from the Ruhr district.

Two Pintsch Water Gas Sets can produce 20,000 m^3 and 24,000 m^3 of 2700 Kg. Cals. per m^3 per day of blue gas. These sets are hand operated and are equipped with mechanical generators and Waste Heat Boilers.

The plant has a Benzole recovery plant. The benzole recovered is refined for motor fuel. They can produce 3000 kilos of motor fuel per day. Plant was built in 1940.

3. Operations

Part of the coke produced is used in the Producer Plant and in the Water Gas Generators. The balance is sold.

The tar, light oil, motor fuel and spent oxide produced are sold. Ammonia is not recovered because of its low value. The weak ammonia liquor is sent to waste.

Lux purifying material is used for H_2S removal.

4. Gas Distribution

Gas is distributed to the city through an intermediate transmission system and district gas regulators. Gas is also delivered to Henzchel (5 km. away) at 2 atmosphere pressure where it is recompressed to 20 atmospheres and sent to the Reichswerke Gas Grid System.

5. Miscellaneous

The plant was not in operation because of coal shortage and damage from bombing. All three holders at the plant were damaged by flak from bombs and "straffing" from planes. They were being repaired at the time of our visit.

GENERATION OF GAS
BREMEN GAS WORKS
BREMEN

1. Introduction

Interviewed Director George Meyer and discussed plant operations. Plant Engineer Frederich Armbricht showed us through the plant.

2. Gas Generating Equipment

The plant has 2 batteries od Didier Inclined Ovens having a total of 12 ovens and carbonizing 360 tons of coal per day. The ovens can produce 130,000 m^3 of 4800 Kg. Cals. per m^3 of gas per day. One half English and one half Ruhr district coal is used.

Two Pintsch Water Gas Machines which are hand operated and equipped with mechanical grates can produce 30,000 m^3 of 2000 Kg. Cals. per m^3 of blue gas per day. These generators use coke produced in the plant.

3. Operations

Ammonia Liquor is worked up to 20% strength and sold. Very little profit is made therefrom.

Coke is mainly sold for domestic use. Tar and light oils recovered are sold was well as spent oxide.

4. Miscellaneous

Gas is pumped at 5 atmospheres to Bremen Haven and also to North Deutche Heutte where it is sold at wholesale.

Gas is delivered to the city through an intermediate transmission system and district regulators at .3 atmosphere.

All three holders were severely damaged by bombs. The plant itself was also badly damaged from bombing. Because of shortage of coal and damage to plant it was not in operation.

REPORT ON RUHRGAS, A.G.
21 MAY 1945

Organization

Ruhrgas, A.G. was organized under the laws of Germany in October 1926 by a group of important coal and steel companies in the Ruhr district to effect a more profitable utilization of coke oven gas. The stockholder companies were members of the Rheinisch-Westphalian Coal Syndicate and controlled about 90% of the coal mining capacity and coke oven production of the Ruhr district. About 50 companies participated thru stock ownership. Among these were:

United Steel Works Corporation
Harpen Mining Corporation
Rhine-Westfalia Electric Power Corporation
Rhine Steel Works Corporation
Recklingshausen Mining Corporation †
Hibernia Mining Corporation †
Fried. Krupp Corporation
Essen Coal Mining Corporation
Good Hope Steel Corporation of Oberhausen
Mannesmann Tube Corporation
Mathias Stinnes Mining Company
Köln-Neuessen Mining Association

† Controlled thru stock ownership by Prussian Government

There has been little change in the stock ownership so far as known since incorporation with the exception of the addition of Klöckner-Werke, A.G. and Bergbau, A.G., Lothringen. No Stockholder holds more than 24% of the stock.

The corporation was organized with capital stock of 5,950,000 dollars at the then current rate of exchange. A 6½ sinking fund bond issue in the amount of 12,000,000 dollars was made in October 1928 with maturity date 1 October 1953. The bonds are a direct obligation of the corporation and are secured by the title to pipe lines and other property of the corporation. In addition, the

bonds were guaranteed by the stockholders. The shares of the stockholders aggregated 400,000,000 dollars market value at the then current rate of exchange, after adjustment for inter-company holdings. (One RM equals 23,8 cents).

The balance sheet as of 31 December 1943 (balance not yet arrived at for year ending 31 December 1944) shows the following approximate figures:

Capital Stock	RM	28 millions
Reserves		3,6 "
Original cost of plant		125 "
Depreciation		62 "
Quick assets (raw materials, stores, claims, securities)		36 "
Liabilities		37 "

An annual dividend of 5% after all costs and interest has been paid since 1935.

At the outset, the corporation acquired about 185 miles of pipe lines of various sizes from the Rhine-Westfalia Electric Power Corporation. These lines were laid about 1913. A large construction program was immediately started, most of which was completed by the end of 1929. The system now consists of about 900 miles of transmission pipe line of various sizes. Many of the lines are jointly owed with the Thyssen'sche Gas- und Wasserwerke G.m.b.H. The lines extend from Köln thru the Ruhr district to Hannover, and south along the Rhine to Koblenz. A line also extends thru southwest Westphalia to Frankfurt-am-Main. Essen is the heart of the system. Pipe as large as 800 mm. (31 inches) in diameter is used. More than half of the lines are 400 mm. or larger. Including lines jointly owned with Thyssen, but not including Vereinigten Elektrizitätswerke nor Westfälischen Ferngas lines, the system consists of the following quantities and sizes of pipe.

Diameter Millimeters	Length Meters
800	47 090
700	129 300
600	158 680
500	215 550
450	11 640

Diameter Millimeters	Length Meters
400	260 287
350	8 400
300	273 530
250	106 825
200	165 120
150	44 360
125	6 960
100	37 090
80	2 780
70	1 180
50	478
Total	1 469 270

General Description of System

The main western line is located on the east bank of the Rhine. It runs generally from Gelsenkirchen, thru Oberhausen, Duisburg, Düsseldorf, to nearly opposite Koblenz. Most of the line is from 500 to 800 mm. in diameter with a large portion 800 mm. The southern portion is 400 and 300 mm. The line is fed by coke plants in the Essen-Gelsenkirchen area (Prosper, Emil, Nord-Wolfsbank, Consolidation). This line also receives additional supplies from plants near Hamborn and Oberhausen. Numerous smaller lines stem from or intersect this line.

A branch of this line crosses the Rhine north of Köln and extends southward toward Bonn or the West side of the river.

Another line runs from Hamm thru Bielefeld to Hannover. This line was built in 1930 and is about 180 kilometers long. It is mostly of 500 and 400 mm. pipe. It is fed by coke plants near Hamm and by two plants east of the Weser River. An older medium pressure line supplies Münster from Hamm.

A third line runs from Dortmund thru Plettenberg, Siegen, Wissen to Frankfurt-am-Main. This line is from 700 to 300 mm. in diameter with a large portion of 600 mm.

There are other subsidiary or branch lines but the above are the more important. All lines are inter-connected so that it is possible to meet peak requirements in one area by drawing on production in another area.

There are pipe line connections with Thyssen'sche Gas- und Wasserwerke, G.m.b.H. so that gas from the Thyssen coke plant at Hamborn, from the Vereinigte Stahlwerke and from the Aachen district can be utilized. A pipe line inter-connection exists with Saar-Ferngas, A.G. in the Main district. Another inter-connection exists in Hannover with the Ferngasgesellschaft of the Hermann Göring Werke which in turn owns a transmission pipe line from Hannover to Berlin. There are also plants or gas plants which do not normally deliver gas to the grid. Among these are those located at Düsseldorf, Frankfurt-am-Main, Mainz, Dortmund, Bielefeld and with the Gewerkschaft Westfalen in Ahlen.

Method of Operation

Ruhrgas owns no coke oven production of its own. Its business is transporting gas. It buys gas produced by stockholder's coke plants, transports it and sells it to large industrial consumers, distribution companies and municipalities. This constitutes about 50% of the business. The aim always has been to negotiate direct sales contracts with the large industrial consumers even though the consumer actually was located on the lines of a distribution company or even another transmission company. This has resulted in transmission arrangements with such concerns as Westfälische Ferngas, A.G. and Vereinigte Elektrizitätswerke Westfalen. Gas for domestic consumption has without exception been supplied thru distribution companies who purchase the gas wholesale.

In order to obtain a larger volume of coke oven gas, Ruhr-gas installed producer gas equipment at the Robert Müser coke plant. The producer gas thus made is used to replace coke oven gas for heating the ovens. A similar arrangement was made with the Concordia coke plant but construction was never completed.

The remaining 50% of the business is transmission of gas which the company does not own. This is done chiefly for stockholder companies. As an example, the coke plant of the Vereinigte Stahlwerke delivers gas to Ruhrgas at Gelsenkirchen and the gas is transported thru Ruhrgas lines to plant of Vereinigte Stahlwerke near Siegen. Large users of this service are: Vereinigte Stahlwerke, Krupp, Mannesmann, Rheinstahl (for I.G.Farbenindustrie), Hoesch and Gutehoffnungshütte.

Sources of Supply

Four of the coke plants supplying the company are on the west aide of the Rhine, two outside of the Ruhr district near the Hannover pipe line in Obenkirchen and Barsinghausen and the remainder in the Ruhr district. Altogether there are about 50 coke plants which supplied the company during the

year ending 30 September 1944. In addition, coke oven gas was obtained from Saarferngas and from the municipal plant at Düsseldorf. Nature gas was obtained from one source. The Wolfsbank, Lothringen and Viktor 3/4 coke plants are connected to the system but did not supply any gas during that period. Details of the receipts of gas are shown in appendix B.

Volume of Gas

The volume of gas handled has shown a constant increase. In 1928, 137 million cubic meters were handled. Figures for the past several years are:

Year	Cubic meters	
1938	2 700 000 000	
1939	2 949 000 000	
1940	2 844 000 000	
1941	2 931 000 000	
1942	3 127 000 000	
1943	3 343 000 000	
1944	3 100 000 000	(estimated by the company)

For the year ending 30 September 1944, 3,666,713,350 cubic meters of gas was handled. Of this, 1,767,383,256 cubic meters were gas which the company did not own but merely transported. The allocation of the gas handled is as follows:

Transported only	1,767,383,256	Cu.meters
Purchased and sold	1,814,320,136	" "
	3,581,703,392	
Lost	85,009,958	
Total gas handled	3,666,713,350	

An analysis of the gas transported and purchased and sold shows for the same period:

Transported for or sold to industries	3,085,850,050	cu.meters
Sold to distribution companies or municipalities	495,853,342	" "
	3,581,703,392	" "

An analysis of the industrial gas shows:

Class of Industry	Cubic Meters
Iron and steel	1 053 233 199
Steel fabrication	1 275 699 990
Chemical	501 924 799
Glass and ceramic	70 080 645
Metal manufacturing	146 641 553
Other	38 269 864
Total	3 085 850 050

During the year ending 30 September 1944, the peak day was 25 September 1944, with 11,782,000 cu.meters. The lowest delivery was 8,575,000 cubic meters on 19 November 1943 On 20 September 1944, which is a typical day shows that the peak hour was 1900 when deliveries were at the rate of 480,000 cubic meters. The lowest delivery was at the rate of 391,000 cubic meters at 0300. This is only a proportion of 1 to 1.22 between minimum and maximum loads, which is very low compared with most systems. The 24 hour delivery for the day was 9,751,000 cubic meters.

Operation

The pipe lines taken over from Rheinisch-Westfälisches Elektrizitätswerk, A.G., situated for the most part in the Wuppertal - Solingen district, were chiefly cast iron with lead joints. Lines laid by Ruhrgas are steel with welded joints. Pressures up to 14 atmospheres are carried.

Earlier lines followed the streets and highways. During the past five to ten years lines have been laid thru the fields.

In the mining district, expansion joints are located every 100 meters. Beyond the Ruhr district, expansion joints are placed 150 meters apart in built-up areas and much farther apart elsewhere. Valves are installed usually from three to five kilometers apart depending on circumstances. In built-up areas leakage control tubes are installed at every welded joint.

Guards (pipe line walkers) are stationed along the transmission lines at various points. The intervals vary from 5 to 25 kilometers, depending upon whether the area is built up or rural. Telephone communication is maintained between each guard post. The guards check the leakage control tubes and blow drip pots. Daily inspections are made in some districts and weekly in others.

In case of leakage or line-breaks, the guards inform the motorized repair crews. Repair crews are stationed at greater intervals and are normally equipped to handle all emergency line repairs as well as routine maintenance. There were 12 repair crews subordinated to five engineer districts distributed throughout the system.

Pipe lines are carried across the canals and smaller river on special pipe bridges or on existing bridges. The Rhine is crossed at two points, at both of which there are double lines laid in the river bed. The Ruhr, Wupper and Weser are also crossed by river bed crossings.

Compressors are located at the coke plants. These are usually sufficient to maintain line pressure. With but two exceptions the compressors are owned and operated by the cokeries. The compression equipment at the Robert Müser and the Rheinpreussen coke plants is owned by Ruhrgas. There are intermediate compressor stations owned by Ruhrgas as follows:

Location	Capacity (cubic meters per hour)
Huckingen	36,000
Niederschelden	48,000
Wessen	20,000
Niederursel	10,000

The Huckingen station supplies the territory on the west bank of the Rhine. The Niederschelden station supplies the Main district. The other two stations are located at sites of holder.

Piston type compressors are usually used. Most of the compressors are steam driven. Steam driven piston type

compressors have proved more practicable for handling large quantities of gas at several atmospheres pressure. Gas driven equipment was found suitable only where there was a constant supply of gas in sufficient volume. Some of the smaller plants use electric drive positive-displacement compressors.

Practically all of the coke plants now have equipment for removal of sulphur from the gas. All gas entering the lines is purified except that in the line from Concordia to Teerverwertung. An offiliated company, Arbeitsgemeinschaft zum Entzug con Schwefel (Corporation for extracting sulphur from gas purifying mass) has sulphur recovery plants at Horst and Horten. Plants making synthetic oil also have an interest in these plants. Neither Horst nor Horten are operating at the present time. About 75% of the coke plants have equipment for refrigerating gas and removing napthalene. After compression, the gas is passed thru bath of special oil, heated to 180 C and then refrigerated. None of this equipment is now operating because of a shortage of oil.

Gas is measured at the point of receipt and disposal. In certain instances the output of more than one coke plant is measured at a single measuring station.

Three different types of meters are used; wet meters, crifice meters and rotary positive-displacement meters. Practically all of the gas is measured by one of the latter two types because of the size limitation of wet meters.

Because of a number of factors, including which are large number of suppliers, wide extent of system itself, thereby enabling a certain amount of storage in the lines, fairly constant load and interconnections, much less gas holder capacity is necessary than usually required. Most of the gas holders are in the Ruhr district. They are generally located at coke plants and are usually owned or controlled by the producers. Ruhrgas owns holders at Homberg, Wissen and Niederursel. Most of the holders are of the dry-disk type.

Some of the holders are very large. The largest holder in the world is located at the Nordstern coke plant. It is a dry type holder 149 meters high and with a diameter of 80 meters. It has a capacity of 600,000 cubic meters.

Practically all of the holders have been destroyed or damaged. Appendix A gives data regarding location, capacity, condition and ownership of the holders.

The company has private telephone lines and a telemetric system. Cables for both are laid in the pipe line trench. Telemetric stations are located at the coke plants and at various points on the lines and the readings are automatically transmitted to the gas-central at Essen. Direct telephone communication is maintained to compressor stations, certain heavy consumption points and other key installations.

Quality of Gas

The composition of the coke oven gas is about as follows:

CO_2	2.0%
CnHm	2.0%
O_2	0.5%
C_O	5.0%
H_2	55.0%
CH_2	25.0%
N_2	10.5%
	100.0%

The heating valve was 4600 calories per cubic meter but was reduced to 4500 calories. Of late it has been down to 4300 calories. It has been the effort of the company to execute as many contracts as possible on the basis of calorific content rather than volume using 4300 calories as the standard.

During normal times the company employed about 740 people in all categories. Of these, 260 were subject to military or similar service which left the company with 480. Of these 480, 62 were executives, engineers and other principal employees. The remaining 418 (480-62) comprised operating employees, clerical staff and laborers. These are made up as follows:

Employees

Operating employees	- male	230
" "	- female	17
Clerical staff	- male	88
" "	- female	83
		418

About 62% of operating employees and 75% of the clerical employees are present and available.

Damage

The grid system suffered bomb damage several times during the years 1940-1943 but repairs generally could be completed within a day or so. During the early part of 1944 bomb damage to the grid system, the cokeries and the systems of distribution companies increased. However, these difficulties generally could be overcome in a comparatively short time. In the latter part of 1944 bomb damage increased in intensity. The result was a sharp decrease in output as the following figures will show:

Month 1944	Delivery
September	300 million cubic meters
October	250 " " "
November	150 " " "
December	88 " " "

The figures for 1945 are even less.

Prior to the isolation of the Ruhr "pocket" by the U.S. Army the company knew of pipe line damage at about 300 points which had not been repaired. Between that time and the occupation, additional damage occurred. The company estimated that there are probably about 400 unrepaired breaks at the present time. Most heavily hit was the interior Ruhr district between Duisburg and Dortmund.

Many river crossings, especially those on bridges, and these comprise nearly all, are damaged. Certain of the river bed crossings will require extensive repair. For example,

replacement of the Weser River crossing on the Hannover line will require some time after it is started. In the meantime, Hannover can only receive such gas as can be produced by coke plants east of the Weser.

J. L. TURNER,
Major CE.

Appendix A

GAS HOLDERS

(a) AT COKE OVEN PLANTS

PLACE:	COKE OVEN PLANT:	CONTENTS X 1000 CBM:	CONDITION:	OWNERSHIP:
1 Gelsenkirchen-Horst	Nordstern	600	destroyed or damaged	GBAG
2 Thyssengas, Hamborn	-	300	same	Thyssen'sche Gas- u. Wasserwerke
3 Dortmund	Hansa	175	same	60% GBAG 40% Ruhrgas
4 Dortmund	Min.Stein	175	same	60% GBAG 40% Ruhrgas
5 Bottrop	Prosper	160	same	Rhein. Stahlwerk
6 Homberg	RheinpreuBen	125	same	Rhurgas
7 Dortmund	Rob.Müser	125	same	Harpen
8 Dortmund	Gneisenau	125	same	Harpen
9 Essen-Karnap	Mathias Stinnes 1/2 und 3/4	120	same	Gewerkschaft Mathias Stinnes
		1905		

(b) IN THE GRID OF RUHRGAS

1 Wissen	-	175	repair probably possible	Ruhrgas
2 Niederursel	-		probably in working state	Ruhrgas

Now all gasometers are badly damaged; in how far repair will be possible cannot yet be said in the most cases.

But for the holder in Niederursel where gas is stored on pipes, the holders are dry.

Appendix B

GAS RECEIVED - CUBIC METERS
YEAR ENDING 30 SEPTEMBER 1944.

NAME OF COKE PLANT:	DELIVERY:
Alma	9 913 729
Bruchstrasse	1 832 264
Erin	146 366 017
Erin an Teerverwtg	37 378 264
Hansa	392 292 702
Minister Stein	222 796 232
Nordstern	206 361 025
Zollverein an Olsberg	6 696 778
Thyssen-Hamborn	23 000 000
Consolidation 1/6	13 576 197
Consolidation 3/4	192 104 203
Königin Elisabeth	55 161 474
Emscher-Lippe	190 708 935
E.-Lippe für Datteln	1 085 269
Hannover	15 475 089
Mont Cenis	95 750 922
Osterfeld	129 116 017
Osterfeld f. Osterfeld u. Sterkrade	3 505 521
Emil	128 165 959
Radbod f.Westf.Union	14 970 279
Radbod f.Hannoverltg.	42 994 468
Gneisenau	247 994 517
Robert Müser	9 825 466
Bergmannsglück	32 541 587
Waltrop	17 687 225
Auguste Victoria	57 190 725
Barsinghausen	23 340 797
Georgschacht	8 980 292
Chem. Werke Hüls (Erdgas)	5 702 584
Consordia	47 338 751
Ernestine	11 018 114
Ewald	164 667 023
König Ludwig	157 087 956
Friedr.Heinrich	66 604 957

NAME OF COKE PLANT:	DELIVERY:
Graf Bismarck	36 357 843
Heinrich Robert	65 542 582
Königsborn	96 755 021
Mansfeld	14 406 639
Minister Achenbach	92 277 252
Monopol	6 490 107
Prosper	221 529 185
Neumühl	23 441 306
Rheinpreussen	1 705 437
Reichsw. Hermann Göring	1 641 400
Sachsen	67 769 624
Mathias Stinnes	26 166 554
Saarferngas	10 439 892
Stadtwerke Düsseldorf	1 901 904
	3 666 713 350

GENERATION OF GAS
HAMBURG GAS WORKS
HAMBURG

1. Introduction

Intreviewed Director Selberg and Plant Engineer Friederich Stief. Both went through the plants with us.

2. Gas Generating Capacity

There are five gas generating plants in Hamburg as follows:

(a) Grasbrook Plant

Five batteries of Didier-Stettine Inclined Ovens having a total of 33 ovens which can carbonize 1200 tons of coal per day and produce 500,000 m^3 of 4800 Kg. Cals. per m^3 per day. These ovens are fired with attached producers and have Waste Heat Boilers.

The plant also has 4-Bamag Water Gas Machines capable of producing 50,000 m^3 of 2600 Kg. Cals. per m^3 of blue gas per day. Coke produced in the carbonizing plant is used in the water gas generators. The machines are hand operated, equipped with mechanical grate generators and Waste Heat Boilers.

(b) Barmbeck Plant

Two batteries of Otto Ovens having a total of 40 ovens which can carbonize 480 tons of coal per day and produce 150,000 m^3 of 4800 Kg. Cals. per m^3 per day. The ovens are heated by 4 Otto detached producers using pea coke and can produce 50,000 m^3 of 1200 Kg.Cals. per m^3.

The plant also has 2 Pintsch Water Gas Machines hand operated and equipped with mechanical grate generators and Waste Heat Boilers. Coke produced in the plant

is used in the generators which can produce 5,000 m^3 of 2600 Kg. Cals. per m^3 of blue gas per day.

(c) Tiefstack Plant

Two batteries of Didier Inclined Ovens having a total of 14 ovens, which can carbonize 600 tons of coal per day and produce 200,000 m^3 of 4800 Kg. Cals. per m^3 of gas per day. Six Pintsch (detached) producers are used to heat the ovens. They use 20 tons of stein coal each per day and can produce 60,000 m^3 of 1200 Kg. Cals. per m^3 each per day. Batteries are equipped with Waste Heat Boilers. One-half English and one-half Ruhr coal is used in the ovens.

Two Pintsch Water Gas Machines hand-operated and equipped with Waste Heat Boilers and mechanical grate generators can produce 50,000 m^3 of 2700 Kg. Cals. per m^3 of gas each per day.

In 1932, one Pintsch-Hildebrand Gas Generator was installed. This is a complete gasification unit and uses brown coal briquettes. This unit can produce 100,000 m^3 of 3000 Kg. Cals. per m^3 of gas per day. The plant cost 50,000 marks. Its operation and results obtained are described in an article written in the January 6, 1940 and August 15, 1942 "Das Gas Und Wasser Fach", by engineer Fredrich Stief. The cost to produce gas on this unit is 2.0 to 2.5 pfg. per m^3. It requires 2 men per shift 3 shifts per day to operate this gas generator.

(d) Bahrenfeld Plant

Three batteries od Didier Inclined Chamber Ovens having a total of 18 ovens which can produce 100,000 m^3 of 4300 Kg. Cals. per m^3 per day. Ovens can carbonize 330 tons of coal per day. They are fired with attached producers. Ovens are steamed.

(e) Bergedorf Plant

One battery of Didier-Vertical Chamber Ovens having a total of 4 ovens can produce 25,000 m^3 of 4300 Kg.Cals. per m^3 per day. Ovens can carbonize 50 tons of coal per day. They are fired with attached producers. Ovens are steamed.

3. Operations

One half English and one half Ruhr coal is used in all carbonizing plants.

Purification of the gas is done with 75% Lux and 30% Iron Bog Ore. All spent oxide is sold for sulphur recovery.

All ammonical liquor is worked up to a strength of 15% to 20% and sold. Very little profit is made. Ammonia is not recovered at the Bahrenfeld and Bergedorf Plants.

All tar and light oils recovered are sold. There are Benzole Recovery Plants installed at Grasbrook and Barmbeck Plants. The crude Benzole is sold to a central refining plant.

4. Distribution of Gas

City has pressures are carried at 100 m.m. of water. Gas is also compressed by straight line compressors to 4 atmospheres for distant distribution and outlying holder stations. Rotary compressors deliver gas at .4 atmospheres to a belt line for distributing gas through district regulators.

The company operates 11 outlying holder stations having a total storage capacity of 121,800 m^3. The 5 plants have a total holder capacity of 739,000 m^3.

5. Miscellaneous

All plants were shut down because of severe damage from bombing and not having coal for operations.

All plant holders were completely destroyed by bombing and will require extensive repairs or complete rebuilding. The total gas storage capacity amounting to 850,800 m^3 had 3 M.A.N. dry type holders having a total capacity of 300,000 m^3. All M.A.N. holders were destroyed.

The gas main distribution system had 1400 breaks, because of bombing.

The Pintsch-Hildebrand complete gasification generator is of interest. It was stated that further development of this generator could be made to reduce construction costs and possibly increase efficiencies.