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HERMANN GÖRING STEEL WORKS
PAUL PLEIGER HUTTE
STAHLWERKE BRAUNSCHWEIG

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COMBINED INTELLIGENCE OBJECTIVES
SUB-COMMITTEE

LONDON - H.M. STATIONERY OFFICE

HERMANN GORING STEEL WORKS
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STAHLWERK BRAUNSCHWEIG

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Reported by

Mr. J. D. DICKERSON, U. S. Ord.

CIOS Target No. 21/399
Metallurgy

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

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The investigations of the two men above are incorporated herein. Date of Investigation: 21 May 1945

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I. SUMMARY

Satisfactory steel was produced in sizable quantity from low grade ores mined locally without the assistance of imported high grade ores.

Armor plate, gun tubes and shells were produced in considerable quantities. Beneficiation by means of extensive dressing and sintering, followed by mixing of burdens was practiced with judgment and care. Close cooperation between the blast furnaces and steel melting departments resulted in the solution of difficult metallurgical problems. Vanadium was recovered from a special acid converter slag. The demand for coke oven gas, electricity produced from blast furnace gas, by-products and slag is an advantage of the location of this plant at the mines. The region is not as heavily industrialized as the Ruhr, from which most of the coking coal was obtained. The entire works are well designed and properly integrated. A plant layout diagram is appended.

II. INTRODUCTION

The extensive properties of the Hermann Goring works consisted of mines, blast furnaces, steel plants, and factories. This report covers investigations of the iron ore mines, blast furnaces, steel melting units, rolling mills, foundry, forging plants, and shell machining shops located in the vicinity of Watenstedt-Salzgitter.

It was said that the present investment involved 1,000,000,000 R.M. The plant was designed by H. A. Brassert & Co., Ltd., and was originally planned as four separate units, only one of which was completed.

The mines, steel works and shops in this vicinity employed over 35,000 persons, of whom approximately 80% were foreign.

The plant was considered to be of such importance that all installations were surrounded by artificial fog pots for screening against air raids. Flak installations were also noted.

III. SIGNIFICANCE OF INSTALLATION

The Paul Pleiger Works of the Hermann Goring Corporation showed Germany their possible independence of foreign ores. It is desired to emphasize the tremendous implication of potential steel production from the Salzgitter ore bodies by the means employed at this plant.

The condensed statement of Dr. Strickrodt follows:

During 1936-1937 the shortage of iron and steel in Germany became acute. Many of the smaller individually owned plants were forced to close, due to their inability to obtain material with which to work. The iron and steel which was produced was diverted to the fabricating companies associated with the larger steel producers. During this period many of these smaller concerns were forced to become associated with the larger producers in order to exist. This accounts for the rapid expansion of the Vereinigte Stahlwerke during these years.

This shortage of iron and steel was due to the lack of sufficient iron ore to satisfy the demand. Imports could not be increased to meet this demand, as the exporting countries, particularly Sweden, preferred to conserve their natural resources and refused to export more than a limited quantity each year.

The shortage finally became so serious that home building was curtailed, due to the lack of steel beams (wood being unavailable) and hardware. At this time the smaller concerns banded together and demanded that some use be made of the low grade ores available in Germany. Mr. Paul Pleiger became the spokesman for this group. He demanded not only the expansion of the pig iron production in Germany, but also the erection of a steel plant which would be independent of the Western German Iron and Steel Industry.

The steel industry of western Germany at first opposed the plan entirely. Later they insisted that the steel plant should be placed in western Germany. Mr. Pleiger, as the representative of the smaller concerns, demanded that the plant be located near the iron mines in the Salzgitter district. The government agreed with the latter demand, as the quantity of coal which had to be shipped was considerably less than the amount of iron ore required. Direct water transport routes from the coal pits to the plant were constructed to carry this traffic. The government also favored the location of the plant in Middle Germany, as this section of the country had no large industries.

A careful study of the problem of using the ores of the Salzgitter district indicated that a more economical operation could be achieved by the construction of a new plant, which would utilize all of the by-products, than by adding new facilities to existing plants. In addition, freight rates on finished products from the Salzgitter district to large steel consuming centers would be much lower than from the Ruhr.

The project is a government-owned corporation, with only a few preferred shares owned by individuals or private concerns. The opposition to the project was so great that it was believed to be necessary to protect it by a well-known name. Therefore, the name of Hermann Goring was selected. Goring at this time was at the head of the government department which sponsored the project.

The present management of the company is of the opinion that this plant will be required for the rebuilding of Germany and that it can compete economically with other German plants under the conditions which will prevail after the war. This belief is based upon the facts that this plant is close to the towns of Magdeburg, Brunswick and Hannover, all of which will required steel for rebuilding purposes, and that all of German will be more dependent upon German ores than they were before the war.

Another factor which will aid in economical operation is the sale of by-products. This plant is, in fact, the primary supplier of gas and electrical energy to all of the central and northern parts of Germany.

Most of the blast furnace slag produced is an excellent source of building material for roads and buildings. Procedures have already been developed for using this material in building bricks. Material of this type, plus constructional steel products, will be all that Germany will have for the reconstruction program, as it is estimated that during the war, enough wood was cut to put the nation 50 years behind in its reforestation program.

Interrogation of Reich officials will confirm or deny the above statement and may further resolve other reasons for this installation.

IV. PERSONNEL INTERVIEWED

- Dr. Georg Strickrodt, Acting General Manager and formerly Legal Advisor and Manager of Utilities
- Mr. Josef Wurm, Acting Asst. General Manager, formerly Chief Maintenance Engineer and Supt. of Shell Production
- Dr. Eduard Schiegries, Supt. of Blast Furnaces and Ore Preparation
- Dr. Konrad Hofmann, Supt. of Steel Melting
- Mr. Heinrich Schmieding, Acting Supt. of Rolling Mills
- Mr. Erich Schulte, Asst. Acting Supt. of Rolling Mills

Dr. Konrad Riedel, Acting Research Director
Mr. Brodac, General Foreman of Foundry
Dr. Heinrich Meyer, Acting Mining Engineer

V. PERSONNEL NOT AVAILABLE

Mr. Paul Pleiger, President of Hermann Goring
Dr. Rheinlander, Works Manager
Dr. Paul Schiegries, Supt. of Foundry
Dr. Wesseling, Supt. of Rolling Mills
Mr. Ackert, Supt. of Ore Preparation
Dr. Peetz, Head of Research Department
Dr. Franz Beckenhauer, Mine Manager

VI. MINING

Iron ores for use in the Reichwerke Hermann Goring were obtained from the mines of a subsidiary company - "Erzbergbau Salzgitter, G.m.b.H."

During the war the mine manager was Dr. Franz Beckenhauer, assisted by Dr. Heinrich Meyer. Dr. Beckenhauer was under military arrest and the mines were in the charge of Dr. Meyer. The mine administration offices were in Ringelheim Castle.

Eight mines operated during 1944 are listed below. Several others were being developed.

Salzgitter Area:

1. Pinkenkuhle at Salzgitter
2. Georg/Gitter at Gitter
3. Haverlahwiese No. 1 at Gebhardshagen
4. Haverlahwiese No. 2 at Gebhardshagen-Lichtenberg
5. Haverlahwiese open cut at Gebhardshagen
6. Hannoversche Treue at Engerode-Calbecht
7. Worthlah/Ohlendorf at Flachstockheim

Peine Area:

Peine I/II at Vohrum near Peine

Before the war these mines produced about 20,000 metric tons a day, of which about 6,000 tons were shipped out of the district. Maximum production was obtained in June 1940, when 30,000 metric tons per day were mined. The mines were equipped to produce 40,000 tons per day.

During the war, ore containing 30% Fe and 25% SiO_2 was sold for 6 R.M. per ton. The company was allowed 30 pf. for each additional one per cent of iron and was penalized 30 pf. for each percent below 30. For each percent of SiO_2 above 25 the company was penalized 15 pf., and similarly for each percent less than 25 it was granted an additional 15 pf.

Two different types of ore were mined, the high silicon ores of Salzgitter and the high lime ores of Peine. The Peine ores though low in iron, were desired because of their self-fluxing properties and their manganese content, which ranges from 2 to 4%. Quantitatively, the Peine ore is very minor compared to the siliceous ores. Average analyses are given below:

1. A composite sample dried at 100°C (from Hannoversche Treue, Haverlahwiese, Pinkenkuhle, Worthlah, and Georg):
2. Ore from Bulten (Peine):

	Fe	Mn	P	SiO_2	Al_2O_3	CaO	MgO	V	S	As
1.	30.5	0.15	0.5	25.2	9.4	4.5	2.0	0.10	0.30	0.06
2.	22.7	3.70	0.8	7.6	1.7	24.0	2.5	0.03	0.20	Trace

In March 1945, 6750 persons were employed at the mines, of whom 790 were prisoners of war, and 2230 were foreign laborers.

Ore reserves are estimated by the company engineers to be about 2 billion tons. This seems to be a reasonably conservative figure from the properties visited and the records examined. In the western part of the area near Haverlahwiese a drill hole 1100 meters deep is reported to have cut about 40 meters of ore averaging 45% Fe. This is the best ore found in the district, although it has not yet been opened. The Salzgitter ores contain an average of about 0.1% Vanadium. These ores have higher Vanadium content than any other domestic ores.

The ores consist of oolitic limonite (brown hematite) of Cretaceous age, which are found in a bed unconformably overlying high alumina Jurassic shales. The hanging wall is generally calcareous shale. The maximum thickness of the ore bed is 120 meters at Haverlahwiese, but this width is exceptional and widths of 30 to 50 meters are considered to be good.

Much of the ore is on the steeply dipping flanks of salt domes, and in places salt water is a serious problem. In general, though, water is not excessive.

Mining methods vary according to the types and physical conditions of the ores. Block caving is used at Pinkenkuhle, sub-level slicing at Haverlahwiese, and, where salt water is encountered, the stopes may be back-filled.

Near-surface ores are softer and are more easily mined than those in depth, but the average grades are about the same. During the first few years surface ores were the ones principally mined, and they still furnish a large proportion of the total. They are gradually being superceded by underground ores.

Mining machinery is modern and adequate. Part of it was brought in from the United States just before the war.

VII. RAW MATERIALS

A. Ore Preparation

Salzgitter ores of low iron and high silica content require beneficiation for the successful smelting of pig iron. When loosely agglomerated, the iron rich oolitic portion was separated by washing. The harder ores were crushed, screened, reduced to Fe_3O_4 in Lurgi kilns, magnetically separated, and sintered. The most intimately combined ores were reduced in Renn furnaces. A flow sheet of the ore dressing plant is appended.

1. Washing Plant: A washing plant was operated at Hannoversche Treue No. 3 mine, where the ore is amenable to this process and sufficient water is available. The fine grained siliceous particles were washed away from the oolites. Because of a stated artificially high freight rate differential on washed ore, washing was used less extensively than its technological value seemed to justify.

2. Crushing, screening and sampling: Ore was brought from the mines in special dump cars, mostly of 50-tons, with the newer models of 75 tons, capacity. The cars were bodily tilted by locomotive control. The contents were dumped into ore bins. Ore was fed from six chutes to six heavy roll type crushers, which crushed to a maximum size of approximately 6 inches, and had a capacity of 500 tons per hour each. The ore was further crushed to 2 inch maximum size in 12 similar roll crushers and was then screened. The crushed ore was delivered by conveyor belt through an automatic sampling building to the ore bed. Frequent analyses of these samples maintained excellent control.

3. Ore beds and storage: The ore beds consisted of eight large bays for storage of crushed ore and pyrite residues purchased from a nearby chemical plant. Handling facilities provided for movement of material in any desired direction by mechanical means. Self-loading and distributing machines, similar to those used in the Lake Superior area, were installed.

4. Lurgi Process and Magnetic Separation: The Lurgi process was designed to convert ore from Fe_2O_3 to Fe_3O_4 by a roasting process, after which the magnetic Fe_3O_4 could be separated from some of the gangue. A sketch of the Lurgi rotating tube furnace is appended.

Ore from the beds was transported to the Lurgi ovens by rubber belt conveyor. Crushed ore, not less than 1/8 inch in size, was charged into 8 rotary kilns, each approximately 165 ft. longby 12 ft. in diameter and tilted at an angle of 5°. Blast furnace gas was mixed with air and blown in the oven at 200 mm. pressure through sixteen mixer ports, regularly spaced around the oven periphery. The upper end of the kiln was reduced in diameter by an inner collar, which permitted the inlet of the ore. The speed of the gases discharging at this point was thus increased from 2 to 3 meters per second to 12 to 13 meters per second. Consequently, the fines, to the extent of 25% of the charge, were carried through the gas discharge. Gravity dust catchers collected and returned to the furnace 17% of fines. The remaining 8% passed through electrolytic separators (75,000 v.). Half of this product found sale as a pigment. The balance of the fines of low iron content was waste. It was believed by Dr. Schiegries that the design of these furnaces should be modified. A conical rather than cylindrical furnace could be built in such a manner that gases would leave the larger end of the furnace and would have little or no acceleration. Consequently, they would carry less fines.

These furnaces operated 700° to 800°C. Excellent control was maintained and recorded by means of 11 thermocouples, the leads of which operated on contact slip bands to potentiometers, and automatic carbon dioxide determinations. Temperature was adjusted and said to be held within 5°C. of that desired by adjustments which were based upon exhaust gas analyses.

The lining of these furnaces was made of pressed 8" x 8" x 1" chamotte brick. These furnaces, which had been in use for five years, were still operating with the original linings. A particle passed through these furnaces in 3 hours. The furnaces revolved twice per minute. Each handled 800 tons of ore a day.

The product was delivered by conveyor belts to primary and secondary crushers, one of each for each kiln, and then magnetically separated.

5. Mixing, sintering and experimental calcining: Ores crushed finer than 1/8", Lurgi concentrate, wet concentrate, lime, and coke were mixed and then sintered on 8 Dwight-Lloyd bands. The sintering machines had a sucking surface of 2.5 meters x 45 meters with a bed 250 mm thick. There were 2 buildings each housing 4 machines, and each machine had a capacity of 1500 tons daily. The resulting fines were returned to the pre-mixing bins. Groups of two machines operated with one stack. It was said that mixtures containing more than 30% Lurgi concentrate, because of the residual magnetism of this material, made too compact a mass for satisfactory sintering.

An interesting development was the experimental bonding of the Lurgi concentrate with lime water through which was passed carbon dioxide in the form of exhaust gas. This development provided lime and iron concentrate in a usable state at a cost of 0.4 R.M. per ton. The cost of sintering was said to be 2.5 R.M. per ton.

B. Limestone Kilns

There were 4 vertical limestone kilns, 3 of which had been operated. During part of 1944 only 2 were required. Each kiln produced 150 tons per day of burned lime, 125 tons of which were suitable for use in the converters. The balance of fine lime was sold.

The stone contained only 2% magnesium carbonate and less than 1.5% silica. Dr. Hofmann paid close attention to the quality of his burned lime, insisting that it be thoroughly burned and of high purity. The fuel used was desulphurized blast furnace gas preheated in recuperators to 230°C. A cross-sectional drawing of the kiln is appended.

C. Renn Process

Iron ore in which the iron existed as iron silicate (Glauconite, etc.) was crushed and recrushed in roll crushers, and screened. The fines, of 3 mm. maximum, were conveyed by belts to Renn kilns of which three had been constructed, but only two operated. These cylindrical furnaces had an inside diameter of approximately 10 ft. and were about 220 ft. long. They were inclined less than 5° from the horizontal and rotated 4 times every minute, passing a particle through the furnace in 8 hours. Each furnace produced 150 tons per day.

The kilns were lined with Silesian schist, which lasted only 3 to 4 months. Dr. Schiegries believed that it would be advantageous to line the exit end with hematite and water cool this portion of the furnace wall. Chrome brick had not been tried in the Renn furnaces because of its unsatisfactory performance in the Lurgi operations. The exit end of the furnace was restricted to a diameter of approximately 5 ft. Most serious wear was said to be on the walls of the furnace in the last 50 ft. and not on the shoulder.

Sufficient heat for reducing and melting the iron was obtained by firing powdered coal through the luppen discharge end of the furnace. This process did not melt the gangue, but by melting the iron achieved a viscous flowing mass. It was believed that 1100° to 1200°C. was required, depending upon the ore. Higher temperatures would have shortened the life of the lining.

A modification over the Krupp-Borbeck process was the arrangement of discharging on to a steel plate conveyor before spraying with water.

The resulting luppen was crushed and magnetically separated.

This process recovered 98% of the charged iron when using Salzgitter ores, and the luppen contained 92% Fe.

Frankenstein ores were used for the recovery of nickel iron.

Analyses of this luppen showed:		Element	Percent
Sample a.	Coarse material	Ni	7.09
		P	0.31
		Mn	Trace
	Fine material	Ni	3.48
		P	0.63
		Mn	0.14
Sample b.	Coarse material	Ni	6.6
		P	0.20
		Mn	Trace
	Fine material	Ni	4.64
		P	0.29
		Mn	0.23

The cost of this operation was said to be 90 to 100 R.M. per ton of iron. Dr. Schiegries stated that this process was an excellent means of beneficiating finely conglomerated high silicate ores, but because of its high cost, could be applied only when sufficient alloy content was recovered. The substance of this statement is evident when it is considered that mild steel billets with no alloy content sold for 121 R.M. per ton. Dr. Schiegries stated that Krupp had advertised this process as beneficial in the recovery of titanium and molybdenum.

Dr. Schiegries believed that he could develop much cheaper reduction in a short, wide diameter, vertical stack, fired with blast furnace gas.

VIII. COKE OVENS AND BY-PRODUCTS

The coke oven plant consisted of 6 batteries, each containing 55 ovens. Practically all of the coke oven gas was saleable, and it was planned to increase the equipment to 8 batteries.

Contracts were let to four different builders of coke ovens because of the speed with which it was desired to complete the plant. There were, therefore, four slightly different systems in operation, all of which were said to be performing satisfactorily.

The plant consumed approximately 10,000 metric tons of coal per day, of which 8,000 tons were used in the coke plant and 2,000 tons in the power house. Prior to the war, it was planned to use coal only from the Ruhr district brought in by water transport. Special canals were constructed for this purpose. The unloading facilities and coal storage yard were exceptionally good. During the war, it was necessary to obtain up to 40% of their coal from Silesia. As this was inferior for coking it was mixed with coal from the Ruhr. In addition, local brown coal was used in the power-house to conserve the better grades for coking purposes.

The coal was carried from the yard to the pulverizers and thence to other storage hoppers by electrically operated conveyors. Another set of electrically controlled and operated conveyors carried pulverized coal to the mixing units and coke ovens. Any desired mixture of the various pulverized grades could be obtained by changing a few levers on the central control panel.

The by-products recovered, and the methods of recovery, were comparable to those in use in other large coke producing plants. The by-products obtained were creosote, phenol, carbolic acid, ammonia (used for munitions and fertilizer , sulphur (also used to prepare carbon disulphide , and residual tar products, one known as "Cumaron Harz", which was sold as a substitute for tin for lining cans. The tar product residue was used in the plant as an ingot mold wash. Methane was also collected and converted to methyl alcohol. Aircraft gasoline was refined from crude benzol.

The personnel interviewed stated that the only manner in which the by-products processes differed from those in use in other countries was that this plant operated the fractionating towers at higher pressures (20 atmospheres) and endeavored to obtain more fractions than other plants.

IX. BURDEN MIXING

Adequate provision was said to have been made for the thorough mixing of the materials comprising the blast furnace burden. Dr. Schlegries believed that this pre-mixing succeeded in maintaining uniform operation of his blast furnaces.

X. BLAST FURNACES

It was planned to build 32 blast furnaces in 4 groups of eight. The first group and two furnaces of the second group had been completed. These furnaces were of latest design. Each was capable of producing 450 to 550 tons of pig iron per day when heavily burdened with the high gangue Salzgitter ores beneficiated up to 42% iron.

It was believed by Dr. Schiegries that a maximum production of 650 tons could be reached on the larger furnaces when operating on ideal burdens of completely prepared Salzgitter ores. The temperature of the blast was 650°C. and the pressure one atmosphere. Volume of air blown was 80,000 to 100,000 cubic meters per hour in the larger furnaces and 70,000 cubic meters in the smaller. The diameter of the furnaces was 6.5 meters and 6.0 meters at the bosh, and the height was 27 meters. Two Dorr thickeners were employed for four furnaces. There were electrolytic dust catchers.

A diagram of a new turbo-blower driven by blast furnace gas is appended. This unit was in the final stage of completion.

The large slag volume found sale as a building material, some of it having been made into blocks and bricks, and much of it having been used in road construction.

Two types of iron were made:

Ratio of CaO to SiO_2	Percentage							
	C	Mn	Si	S	P	V*	As*	Cr*
.7 TO .9	3.0	.30	1.00	.250	1.7	.32	.13	.12
1.0 to 1.1	3.2	1.80	.80	.050	1.9	.26	.11	.13

* Residual for December 1943.

The majority of the iron produced was of the lower manganese type. One production plan consisted of a combination of six furnaces operating on the lower manganese, one on the more basic higher manganese burden, and one making vanadium rich iron. Peine (Bultener) ores and open-hearth slag yielded most of the manganese of the more basic type. This higher manganese iron did not require desulphurization with soda ash, thus avoiding loss of manganese.

It was said that coke consumption in the blast furnaces, not including coke for sintering, was as follows:

Condition of ferrous portion of burden	Percentage Fe	Coke consumption in blast furnace. Kg. per metric ton of iron
High % of raw Salzgitter ores	29	1300/1350
Salzgitter ores beneficiated and sintered	42	1090/1150

It was said that earlier operations, with less basic burdens of entirely undressed Salzgitter ores, consumed 1800 to 2000 Kg. of coke per ton of iron. Iron produced under such low basicity was too high in sulphur (.50 to 1.00%) content and too low in manganese (under .20%). Dr. Schiegries recognized the necessity of beneficiation by classification, sintering and complete mixing of his burden.

Average burden data for December 1943 production is appended.

One furnace was burdened with Thomas slag and dust for the production of vanadium rich iron.

XI. DESULPHURIZATION AND HOT METAL MIXERS

The high manganese iron was not desulphurized before adding it to the mixers. The lower manganese iron of .250% sulphur was treated with sodium carbonate and the slag removed before addition to the mixer. The combined iron in the mixer was said to average:

C - 3.00%
Mn - 0.80%
Si - 0.80%
S - 0.14%
P - 1.70%

This mixed iron was again treated before charging in the converters. After this further treatment the average analysis was reported to be:

C - 3.00%
Mn - 0.65%
Si - 0.70%
S - 0.04%
P - 1.70%

This double process was not entirely satisfactory as there was not enough agitation in the ladle during casting. The desulphurization at this point was very inefficient as the sulphur was reduced from 0.25% to 0.14%. Soda ash in powdered form was used exclusively for this treatment.

The desulphurization treatment just prior to placing the iron in the converter was carried out with a mixture of 2 parts soda ash and 1 part lime. The mixture produced a more viscous slag than soda ash alone. This more viscous slag rises slowly in the ladle and thus was considered to be more efficient than plain soda ash. In this second treatment the sulphur was reduced from 0.14% to 0.04%.

The results obtained on some experimental treatments with soda ash - lime briquettes were so satisfactory that a briquetting plant was being installed. For this practice soda ash-lime briquettes were prepared in two roll-briquetting machines. These briquettes were approximately ½" x 1" x 2".

It was said by Dr. Hofmann that when these briquettes are used only one desulphurizing treatment would be required. The less basic iron was collected at the blast furnace in a large ladle and then poured into another ladle containing the soda ash-lime briquettes. This treatment was very efficient. The sulphur was reduced from 0.25% to 0.04%, maximum. Only 6 Kg. of briquettes per ton or iron were required in this process.

Iron with a sulphur content of 0.05% was considered to be satisfactory as approximately 0.012% was removed in the converter.

There were three mixers each with a capacity of 1200 tons.

XII. STEEL MAKING

A. Thomas

There were six basic converters, said to be the largest in the world, with an average capacity of 50 tons each and maximum capacity of 63 tons. The lower part of the converter was hemispherical. The addition of burned lime averaged 13.0%. Blowing required 12 to 16 minutes according to the age of the converter lining and the consequent size of the charge.

Several grades of steel were produced. Additions of basic iron remelted in the three cupolas were used for the medium and hard grades. Most of the recent production was killed steel for bombs and shells. There was also some production of low nitrogen, low phosphorus and low sulphur steel for welding rods. Low metalloid steel for charging electric and acid open-hearths was also produced (P-.015 max., and S - .015 max.). All steels were fully blown to .02 to .03% carbon content. Converter steel was all top poured in the moulds.

Shell steels were produced in the converters to the following analyses: The old analysis for all calibers up to 15 cm. were produced to Krieglist Number Th 65.

C	Mn	P	S	Si
.55/.70	.50/.80	.120	.060	.20/.50

New analysis specifications were issued early in 1943 as follows:

Krieglist No.	Caliber	C	Mn	P	S	Si
Th 35	8.8 cm.	.30/.43	.35/.50	.090	.060	.15
Th 40	10.5 cm.	.35/.50	.35/.50	.120	.060	.15
Th 40	15 cm.	.38/.52	.35/.50	.120	.060	.15/.40
Th 40	12.8 cm (Flak)	.45/.50	.50/.60	.120	.060	.15/.40
Th 65	8.8 "	.55/.65	.45/.65	.120	.060	.15/.40
St C 25.61	Bombs	.09/.15	.30/.50	.060/.070	.050	.35
St C 35.61	"	.22/.32	.30/.50	.070	.060	.50

Steel to all specifications was poured in both open top and hot top molds. Top discards on open top and hot top material were the same. On material over .40 carbon, the top 5% was scrapped and the next 10% was cropped as a safety cut. The 10% cut was usually scrapped unless orders were available for low grade rails, the chemistry being too high to pass a bend test on concrete bar. With a carbon content of under .40, the top 5% was scrapped and the safety cut of 10% was rolled into concrete bar. Material was poured cold to minimize pipe and excess segregation.

When hot topped steel was used, two types of molds and hot tops were employed. The big-end down mold had a cast metal hot top with a brick lining. The big end up mold had an integral hot top which was also brick lined.

Phosphorus was said to average .060% and tail-end ingots occasionally were diverted to mine rails because of a phosphorus reversion.

It is estimated that 15,000 tons of ingots would be required to supply their own shell forging plants. Accurate figures were produced proving that an average steel ingot production of 28,000 tons was maintained during 1944. This represented about 4% of the total Bessemer ingot production.

The quality of the Thomas steel was said to be good, as observed in rolling, despite lower than normal manganese in both iron and steel and a high arsenic content of .14% in the finished product. Dr. Hofmann attributed this success to the skill of his blowers and his excellent lime, which was thoroughly burned in vertical kilns with desulphurized blast furnace gas preheated in recuperators to 230°C. Residual vanadium was said to be .05%.

The production of Thomas steel of low nitrogen content (.008%), by a double blowing process, was claimed to be invented and developed in this plant. It was also claimed that the production of alloy steels by mixing electric furnace steel and Thomas steel in the ratio of 1 to 3 in the ladle was started by this company. The steel produced by mixing was said to be surprisingly clean. This process was considered by the man interviewed to be an excellent source of cheap alloy steel, although requiring a great deal of care, especially in the blowing operation.

Dr. Hofmann believed that much of the current trend towards nitrogen control in Germany was the result of a 'style' established by Dr. Eicholz of August Thyssen, at Hamborn. Dr. Hofmann was familiar with the nitrogen content of his incoming iron (.010 to .017%). Dr. Hofmann did not follow the Thyssen trends. He did not enrich his blast with oxygen and did not use sodium carbonate in his blows. He did add 3 to 4% of steel scrap, and considered as much as 10% to control the temperature, which was relatively low. The early slag was decanted and a relatively low height of metal was used. The methods employed by their chemists for the rapid determination of nitrogen in iron and steel are attached.

Extensions were built to the nearly spherical converters, making them somewhat pear-shaped. When questioned regarding the design, Dr. Hofmann stated his definite preference for converters of 35 to 40 tons capacity of the conventional square bottom shape.

B. Open Hearth

Three tilting basic open-hearths were installed adjacent to and in line with the 6 converters. These open-hearths were designed for 120 tons, but because of the bath area of 55 square meters they were regularly charged with 160 tons.

It was the usual practice to charge only 10% iron, except occasionally up to 20% iron was charged. Carbon was obtained regularly through the charging of coal and sometimes charcoal.

Chromium was recovered from scrap. In 1943 one of the open-hearths was converted to acid practice. By this change, 80% of the .90% chromium charged was recovered. By the end of 1943 the shortage of manganese had become so critical that this furnace was again made basic. Charges high in silicon were then melted, using high silicon scrap when available. No lime was charged. Burned lime was added sparingly maintaining a slag just slightly basic. It was said that with this practice 80% of the chromium was recovered with much less loss of manganese. This slag, being highly reflective, caused extremely short roof life.

The open-hearth shop produced 4,000 tons per month of armor plate ingots. The latest practice, consisting of mixing basic open-hearth steel with alloy rich electric steel, gave good results as judged by this relatively heavy production of armor plate ingots. For the last 6 months of operation, ingots, and before that slabs and ingots, were shipped to the Hermann Goring plant at Linz, Austria, for rolling and fabrication. This tonnage, together with approximately 6,000 tons, stated to be produced at Linz, was probably Germany's largest source of rolled armor plate. Specifications follow:

	C	Mn	P	S	P+S	Si	Cr	V	Mo	Ni
Early Types	.37 .47	.60 .90	.03-	.03-	.05-	.20 .50	1.2 1.6	.15	-	1.3 1.7
" "	.32 .43	.30 .65	"	"	"	.15 .50	2.0 2.4	-	.20 .30	-
" "	.44 .54	.80 1.10	"	"	"	.50 .80	.80 1.10	.25	.15 .25	-
Recent Types										
16/30 mm.	.41 .49	.40 .80	"	"	"	*.75 1.05	.45 .75	-	-	-
35/50 mm.	.41 .49	.60 1.00	"	"	"	* "	.75 1.05	-	-	-
55/80 mm.	.41 .49	.80 1.20	.030	.030	.050	.75* 1.05	.90 1.20	-	-	-
---	.40 .47	.70 1.0	"	"	"	.70 1.00	1.10 1.40	.10 .15	"	-

* Silicon later reduced to .50 - .80%.

Approximately 1,000 tons of armor plate ingots were in stock. The surface appearance of these ingots was excellent. There were two sizes, 3 tons and 4½ tons. A drawing of the mold for the 4½ ton ingot is appended. Molds for armor plate were hand sprayed with the tar remaining from the distillation of 'Cumaron Harz'. This tar was said to be fluid from 200° to 800°C. and was said to be effective in preventing surface defects.

C. Electric furnaces

Two electric furnaces, each with a capacity of 60 tons, were installed in place of the originally planned fourth open-hearth. The 12,000 KVA transformers were too far from the furnaces for best operation, and the location of these furnaces was inconvenient, as they were at the end of the open-hearth shop away from the converters. A list of important steel specifications with end uses is appended.

D. Duplexing

Formerly, when heavy production of electric furnace or open-hearth steel was required, it was the practice to duplex fully blown converter steel. The disadvantages of delays and the inability to recover alloying elements from scrap caused duplexing to be discontinued.

E. Mixing

Recently the practice was to make alloy steels by mixing in ladles low phosphorus and low sulphur basic open-hearth and basic converter steel with alloy rich electric furnace melts.

Four practices were on record:

Process Symbol	Ratio			Tons per hour
	Electric	Open-hearth	Thomas	
M 1	1	1	0	13.3
M 2	1	2	0	25.0
M 3	1	3	0	30.0
M 4	1	0	2	18.7

Mixing permitted maximum recovery of alloys from scrap and the use of relatively low alloy-high carbon ferro alloys. The electric furnace could be charged with chromium bearing scrap. Additions of alloy pig iron were used. Sufficient manganese was obtained for the entire mixed heat through early additions of spiegeleisen to the electric furnace. Alloy recovery was excellent, but the phosphorus in the electric furnace melt was high. This high phosphorus was diluted by the balance of the mixed heat which was carbon steel melted under extreme basicity (several slags when necessary) to obtain minimum phosphorus and sulphur. For instance, the open-hearth portion of the heat, at .25 to .45 carbon, was:

P- .005 to .009
S- .010 to .015

It was said to be difficult to meet chemical specifications when using the M3 process, and the need of skilled help and excellent control was necessary throughout this entire procedure.

The M4 process was used only in the last 6 months of operation. Steel for armor piercing shot produced by this method was said to be good. Dr. Hofmann believed that this practice has an excellent future in the production of stainless and austenitic manganese steels.

It was claimed that these mixed heats generally met current chemical specifications but it was recognized that a scale on the ladle crane would permit greater accuracy than measuring by volume. It was also claimed that these steels were clean and had excellent mechanical properties. The fact that they produced 4,000 tons per month of armor plate ingots may be significant. Attention is called to the high production rates for alloy steels in the mixing processes.

Consumption of Ferro-alloys is appended.

XIII. VANADIUM RECOVERY

The production of vanadium as an alloying element in Germany during the war was urgent. Not only was vanadium used in high-speed tool steels, but also as a substitute for chromium, nickel, and molybdenum in other alloy steels. During the last half of the war, the production of special vanadium-rich converter slags at the Hermann Goring works amounted to 50 to 100 tons of contained vanadium per month, representing a substantial part of the vanadium-rich slags produced in Germany. On the average, the Hermann Goring slags contained a higher percentage of vanadium than most of the other slags produced in Germany. This was due to the facts that the blast furnace burdens treated at the Hermann Goring plant were relatively rich in vanadium, that a relatively large percentage of converter steels was produced, and that the final vanadium bearing slag was produced in an acid converter.

The Salzgitter iron ores contain approximately 0.1 percent vanadium (V). The acid and basic iron produced in the blast furnace contains 0.3 percent V. After experimental work, large-scale production of vanadium-rich slag, was started in the middle of 1942. The Thomas slag resulting from blowing the iron averaged about 1.5 percent V. This slag, "dust" or spittings from the converter, and some acid Salzgitter ore, were charged into one blast furnace and remelted, yielding a pig iron rich in vanadium and phosphorous, (about 1.5 percent V, 9.0 percent P, 1.0 percent Mn, 0.1 percent S, and 1.5 percent C). This iron was blown down in a converter with a fire clay lining on a dolomite bottom, without any additions, yielding a slag of a dry consistency which was said to average about 14.5 percent V, and 9.5 percent P, and less than 2 percent CaO, 0.01 percent Si, 0.03 percent Mn, and 0.1 percent S. The vanadium-rich slag was sent to chemical plants for production of vanadic acid and conversion to ferrovanadium; the residual iron was sent to blast furnace works in Westphalia producing Thomas iron without vanadium; and the resulting Thomas slag, containing no appreciable amount of vanadium, was sold as fertilizer slag.

Vanadium was recovered at special chemical plants by roasting the vanadium-rich slag with NaCl or Na_2CO_3. This process converted the vanadium to a water-soluble sodium vanadate, which was leached with water, and precipitated as sodium vanadate (vanadic acid) with acid.

Production of Vanadium slag is appended.

XIV. SOAKING PITS AND ROLLING MILLS

The rolling mills at the Watenstedt Works were suitable for rolling slabs, blooms, billets, bars, structural shapes, rails, wire and hot rolled strip. The mills are listed below:

1 - 42" Blooming Mill (changed to 44" without change of bearings)
1 - 32" Reversing 2-high roughing mill
1 - 26" Continuous billet train of 2 stands
1 - 23" Cross Country Mill
1 - 20" Continuous billet train of 6 stands (intended to roll billets for drop forgings but not operated)
1 - 16" Continuous light structural and intermediate bar mill (not operated recently)
1 - 12" Light structural and bar mill
2 - 8 " wire and rod mills
1 - 20" Continuous hot strip mill

The rolling mills came into operation at various intervals between 1939 and 1943, inclusive.

Blast furnace gas, coke oven gas, electricity and water supply were adequate. Water was reclaimed through cooling towers and settling basins.

Soaking Pits

Stripping and soaking pit bays were arranged perpendicularly to the flow of rolling. Ingots were received in the stripping bay from the melting units, stripped and placed on cars which were located on two individual sets of circular tracks. This arrangement made it more convenient to transport ingots from the stripping bay to the soaking pit bay. Three cranes were provided in each bay for stripping and charging.

Nine pits of the Salem type were installed and four more were partially completed. The 20 foot diameter pits, holding 18 five-ton ingots radially spaced, were heated by means of tangential burners and down draft flow of combustion. The mixture of blast furnace and coke oven gas was preheated to 400°C. and the air to 600°C. The heat losses were said to be 1.5%.

42" Blooming Mill

The blooming mill was originally designed to roll 1,000,000 tons of ingots per year. However, the maximum produced in any one month was waid to be 80,000 tons.

Mill data are listed below:

Diameter of rolls (formerly 42")	44"
Ingots rolled per hour for shell steel	*30
Ingots rolled per hour for merchant products	*35
Ingots rolled per hour for maximum	*42

* Blooms over 8" x 8" were finished on 42" blooming mill. Blooms under 8" x 8" down to 4" x 4" were finished on 32" roughing mill.

A 900-ton hot cropping shear, having a capacity of 350 mm. square, was provided adjacent to the 42" blooming mill and 32" roughing mill.

32"-Reversing 2-High Roughing Mill

The 32" roughing mill rolled slabs for the 22" continuous hot strip mill, and billets for the 23" cross country mill in the usual range of sizes of 7¼" x 6", 6" x 6" and 4¾" x 4¾"; also billets 6" x 6", 5⅜" x 5⅜" and 4¾" x 4¾" for the 20" continuous billet train. It was said this mill was of sufficient capacity to take care of the full output of the 42" bloomer.

*The rolling rates given for the 42" mill could only be met by taking all finishing passes on the smaller sections on the 32" mill.

Instead of the conventional type of manipulator, a new type was installed. It was built by the Krupp-Grusonwerk of Magdeburg. The action of turning the bloom was accomplished by means of coordinated levers and linkages, having 2 rollers on the ends of 2 levers, which contacted the bloom, while still in motion, and turned it 90° for the next pass.

The tilting mechanism was limited to blooms up to 8" wide.

26" - Continuous Billet Mill

This train was installed for the rolling of material for drop forged shells, but was never operated. Since only a small tonnage would have passed through this train, it apparently did not belong in the line with the 32" mill.

23" - Cross Country Mill

Products rolled were:

Rounds	2⅜" to 5"
"I" Beams	4" to 8"
Angles	2¼" to 4¾"
Channels	4" to 8"
Light Rails	15 to 24 kg/meter

The maximum output on these various sections was rated at 30,000 tons per month. Production actually obtained was 60 to 70 tons per hour, and the monthly tonnage did not exceed 15,000 tons. Among the products of this mill were 81 mm. rounds and 75 mm. squares, used for 8.8 cm. shells.

The mill was composed of 2-3 high roughing stands with 25" diameter rolls and a staggered train of 6-stands. When rolling light sections, it was difficult to maintain sufficiently high finishing temperature.

The bars were fed alternately to 2 roller alleys, having 3 hot saws each, positioned to cut the product to length.

20" - Continuous Billet Mill

The 20" billet mill was scheduled to roll 50,000 tons of products per month, which was 60% of the tonnage produced on the 32" roughing mill. Through difficulties of roll speed regulation and with flying shear, the production never reached over 20,000 tons per month.

The mill consisted of 6 stands with alternating horizontal and vertical rolls. The first two stands were open passes, then diamonds and squares alternating in the last four.

For the rolling of 2½" billets on this mill, entering billets of 6" x 6" or 5⅛" x 5⅛" were used, and for 2" billets, 4¼" x 4¼". This mill also rolled 3⅝" and 4⅛" billets for 8.8 cm. and 10.5 cm. shells.

16" - Continuous Light Structural and Intermediate Bar Mill

Products rolled were:

Rounds	2" to 3"
"I" Beams	2⅛" to 4"
Angles	2" to 3½"
Channels	2⅜" to 4"
Special light sections for building purposes.	

12" - Light Structural and Bar Mill

Products rolled were:

Rounds	5/16" to 2"
Angles	1" to 3"
Flats	1" to 3"

This mill was rated at 15,000 tons per month. The highest output reached was 300 tons of ½" rounds per 10-hour day.

8" - Wire and Rod Mill

2-8" Demag mills were installed, each consisting of 3 trains in line of 5, 4 and 2 stands. The two strands leaving the continuous train passed through three sets of Seimag finishers, which had horizontal and vertical rolls. Rods were coiled in the usual manner and conveyed to the shipping bay.

20" - Continuous Hot Strip Mill

The 20" hot strip mill consisted of 9 stands, 6 of which were used for roughing and 3 for finishing. The mill was limited to 20" width.

Billet Yard and Distribution to Reheating Furnaces

There were two roller conveyors for transporting material from the 32" mill and the 20" continuous mill to the appropriate bays (J, K, L and M).

From the extensive cooling beds in Bay "L", billets were charged directly into reheating furnaces, for the 23" and 12" mills. Billets for the 16" continuous and 8" wire mills were roller conveyed back to Bay "K" for charging into reheating furnaces. There were 8 furnaces located in Bay "M", 2 each for the 23" and 16" mills of 50 tons per hour each and 2 each for the 12" and 8" mills of 40 tons per hour each. These furnaces were fired with a mixture of blast furnace and coke oven gas.

Bays V, W, X, Y and Z were used for finishing operations on the various products, and for storage and shipping.

These mills were fairly universal in character, being capable of rolling a complete line of products. 1200 men were required for their operation.

The mill buildings were badly damaged by bombing on January 14, 1945.

The following data are appended:

1. Mill Layout
2. Rated Production per hour of various Mills
3. Output Semi-finished Material 1943, 1944 and 1945
4. Output of the 42" Blooming Mill
5. Production Data 23" Cross Country Mill
6. Production Data 12" Light Structural and Bar Mill

XV. GREY IRON AND STEEL FOUNDRY

The steel foundry, which was only partially completed, was about one mile from the main steel plant. It was designed primarily as a producer of castings for use in the plant. The greatest tonnage to date was ingot molds for the steel plant.

The plant consisted of three long bays, two of which were used by the iron foundry. This foundry had three cupolas with a capacity of 10-12 tons per hour each and one small cupola with a capacity of 3-4 tons per hour. One bay of the foundry was used exclusively for the production of ingot molds. This bay was mechanized, in that all molding was done on jolting machines.

The second bay of the iron foundry was used for the production of miscellaneous castings. All of these castings were molded by hand.

Most of the steel castings were made from steel produced in the main steel plant. One 8-ton, top-charged, electric furnace was installed and the foundation for a 3-ton furnace of a similar type had been completed. Castings up to six tons pouring weight were completed in the steel foundry. All castings larger than this were molded in the steel foundry and then assembled and cast in the main melting shop. Castings up to 25 tons in weight were produced in this manner.

All steel castings were molded in chamotte. The iron castings were molded in a naturally bonded sand. The usual mold drying ovens were available. No heat treating equipment was installed in this building. all heat treating being carried out in the main plant.

The maximum production which had been attained was 3,000 tons of iron castings per month, and 200 tons of steel castings per month. The personnel interviewed estimated that when the plant was completed and working at capacity, it would be possible to produce a total of 10,000 tons per month, 9,000 tons of iron castings and 1,000 tons of steel castings.

Small, modern, well equipped pattern and machine shops were adjacent to the foundry building.

This portion of the plant was undamaged.

XVI. AMMUNITION PLANTS

A. Underground Installation in Hannoversche Treue Mine

The personnel and machinery for this plant were transferred from the Netherlands to the Hannoversche Treue mine near Salzgitter. There were 65 persons employed per shift, working 3 shifts of 8 hours each. Here it was planned to finish machine 8.8 mm. anti-aircraft shells.

For protection against bombing, a mine drift 240 meters below ground level was selected. In this drift, 1500 meters long, 85 machine tools were installed. The cross-section of the drift was half oval, having a width of approximately 5 meters at floor level and a height of 4 meters. The machines were arranged along one side of the drift. Directly against the wall, on the same side of the drift, was a bogey conveyor. This arrangement allowed just sufficient working space for the operator between the machine and the conveyor.

Shells were delivered from the Watenstedt plant rough machined, were lowered through the mine shaft, transferred to mine cars at drift level and delivered to the starting point of the machining operations. The shells were then advanced through the various operations, each lathe performing one or more of the necessary steps of finishing the bore, turning the outside diameter and facing to length, and finally finishing the thread in the noze. Machines were generally single tooled in each operation. The banding was performed automatically, after which the shell was finish-machined and tested hydraulically, three at one time, under a load of 1,000 kg. The usual inspection for dimensions was then made, after which the shells were returned to their source, rust proofed and prepared for shipment.

This plant was capable of producing 8.8 cm. anti-aircraft shells at the rate of 75,000 per month. Construction and installation of machine tools were under way to increase production to 150,000 shells per month.

Sintered carbide tools performed the machining operations without cutting lubricant. To maintain maximum life of threading tools, the point and sharp corners on the top face were stoned to approximately 3,000 of the 8.8 cm. shells to destroy one plane. Through recent re-design of the internal parts of shell they had been able to reduce this number to 350. As nearly as could be determined, the effectiveness was improved by the placing of small dumb bell shaped parts in the shell body. These parts were so constructed that, on penetration of the plane gas tanks, the gasoline entered the drilled ends of part and reacted with inflammable material contained in them, thus setting the plane afire.

This equipment was observed after at least two months idleness, and although the machine tools had not been rust-proofed, no corrosion was evident. The free circulation of air through the drift and constant temperature prevented moisture from condensing on the equipment.

B. Watenstedt Plant - 8.8 cm. Shells

The Watenstedt shell plant where the majority of the 8.8 cm. anti-aircraft shells were made was above ground. Maximum production was reached in November 1944, at which time they produced 540,000 rough machined shells. Of this number, 200,000 were finish-machined at this plant and the balance were shipped to other points for finishing.

The arrangement of this highly productive plant is shown on the appended plan.

Broken billets, 9 cm. square, 20 cm. long, weighing 12 kgs. were fed into continuous heating furnaces, adjacent to the 90-ton vertical shell presses. These 90-ton shell presses were built by Eumuco Koln (Sclebusch). The shell was completely formed in the same press with the exception of the nozing operation. There were 2 sets of 4-ring dies arranged vertically on one side of the press. This arrangement permitted one set to cool without interruption of production, thus promoting longer die life. There were 9 furnaces and 9 presses used in the hot forming of the shells. The average production of each press was 100 to 120 shells per hour. The square blank was reduced in length and centered in the first die, and then pierced to depth in the second die by means of a standard tool steel piercing head. The pierced bottle was pushed through a set of 4 vertical rings integral with the press side-frame. These blanks dropped on a suitable conveyor under the machine, where they were conveyed up to the sand cooling beds adjacent to the inspection stand, where they were checked for concentricity and size. The forged blanks were then transported to the six noze-heating furnaces, and subsequently to three nozing presses each of 150 tons capacity. They were able to maintain a production of 375 blanks per hour each nozing press.

Part of this production was distributed to the 26 production lathes in this department. The balance was delivered to the production tools buildings 1, 2 and 3, as shown in the appended plan.

Lathe finished shells were then automatically banded, finish machined and tested hydraulically under a load of 1,000 kg., after which they were cleaned, painted and boxed for shipment. An elaborate overhead conveyor system was used to carry shells through these operations.

In building No. 1, the production equipment was placed transversely to the flow of materials. This arrangement proved to be inefficient. Production in buildings 2 and 3 was improved 10% over that in building No. 1 by the longitudinal arrangement of the machine tools.

Production lathes in all shops were arranged with open bases permitting the chips to drop into chip breaker, which was integral with the machine. The broken chips were then conveyed directly to an intersecting conveyor running below floor level and thence to railroad cars.

Carbide tipped tools, tooling and dry cutting were similar to the practices in the underground plant.

It was stated that they were able to maintain cutting speeds of 80 to 120 meters per minute when threading, 70 to 75 meters when rough machining, and an average speed of 90 meters on finishing operations. The average tool life was said to be 350 shells when threading and 800 shels when turning.

A chart which shows increase in the production of 8.8 cm. shells from August 1943 to December 1944 is appended. Bomb damage, to other parts of the plant, deterred this increase in production by causing material and power shortages.

C. Watenstedt Plant - 10.5 and 12.8 cm. Shells

Shells of 10.5 and 12.8 cm. were produced in Department H.K. III. The area of this department was 3500 sq. meters.

The major producing equipment included 3 pusher-type furnaces, one Schloemann vertical forging press, two horizontal hot push benches and two nozing presses. A layout of equipment is appended.

The forging operations were similar to those employed for the production of 8.8 cm. shells, except that a separate push-bench was arranged horizontally.

A chart showing increase in the production of 10.5 and 12.8 cm. shells is appended. These curves show that an order was issued by the Government, during August 1943, stopping production of the 10.5 cm. shells. This line was converted to the production of 8.8. cm. shells. The curve also shows a decided loss of production after October 1944 due to the lack of power and material caused by bombing.

All shells made at this plant used sintered iron bands.

Sintered iron bands were used on all shells made in these plants. The sintered iron plant was destroyed by bombing. Bands were obtained from plants located in Helmstedt and Salzgitter.

D. Underground Plant at Haverlahwiese Mine

The fourth level of the Haverlahwiese No. 1 mine was being converted to a shop for finishing gun barrels and making hand grenades when the war ended. The level, which extends about 1.5 km. north from Haverlahwiese No. 1 shaft to the Haverlahwiese No. 2 shaft had been widened and heavy concrete floors had been laid through part of its length. The depth of this level at No. 2 shaft was 580 meters. Much heavy machinery, said to have been brought from a plant near Breslau, was scattered along the side of the drift, but had not been installed for operation.

No pumping was done in the mine for about three weeks after the war ended and the result was that the fourth level was flooded. The machinery was badly rusted and if not soon reconditioned will be useless. Also, as a result of the flooding, the concrete floor had buckled and broken along the walls.

XVII. FORGING PLANT

The Watenstedt forging plant was originally planned to produce 15 cm. gun barrel forgings. A production average of 150 barrels per month was reached within six months after starting operations in August 1942. No facilities were provided for machining, and the barrels were shipped to Stahlwerke Braunschwieg G.m.b.H. for further finishing operations.

The usual practice of forging gun barrels was in evidence.

Dr. Eduard Schiegries conducted an interesting experiment. By twisting a small gun barrel four times in one meter the bursting strength was doubled. The operation was performed hot. Only two such barrels were made and tested. In Dr. Schiegries' opinion the results justified the consideration of designing heavier twisting equipment for larger guns.

The Forging Plant covered approximately 21,000 sq. meters in the three completed bays. The fourth bay (NO. 1) was not completed. The distance from floor to top of crane rail was 16 meters.

There were 4 cranes in Bay No. 2, one scrap crane of 5-tons capacity, and 3 bridge cranes with capacities of 10, 50 and 150 tons.

Bay No. 3 contained:

1 Hydraulic forging press (Schloemann Type), 5,100 tons capacity, with 3 stages of working pressure - 1700, 3400 and 5100 tons. Reported working pressure was 350 atmospheres.
2 Bridge Cranes having 80 and 120 tons capacity.
2 Forging Cranes having 120 tons capacity.
4 Holding Pits
5 Heating Furnaces.
5 Fired Annealing Pits

Bay No. 4 contained:

1 Hydraulic forging press (Schloemann Type) 1,800 tons capacity, with 3 stages of working pressure - 600, 1200 and 1800 tons. Reported working pressure 350 atmospheres.

5 Holding Pits
5 Heating Furnaces
5 Fired Annealing Pits
1 Slow Cooling Pit (Sand)

The 1,800 ton press could forge ingots up to 15 tons and the 5,100 ton press, ingots up to 100 tons.

Cranes, crane devices and furnaces were suitably designed to handle the work of the 1,800 and 5,100 ton presses.

All furnaces used a mixture of blast furnace and coke oven gas.

Originally it was planned to install a 15,000 ton forging press and furnaces in Bay No. 2.

Foundations had been installed in this bay for one 25-ton and one 5-ton electric melting furnaces.

Accessory installations included three manipulators ranging in capacity from 5 to 100 tons.

The working pressure of the water of 350 atmospheres was produced in a separate building. This plant was equipped with a 6,000 liter accumulator with six pumps driven by high voltage motors, rated at 570 kw at 6,000 volts.

XVIII. RESEARCH LABORATORIES

A large laboratory was built to care for the problems and control arising in a steel plant planned to have 32 blast furnaces and to make 400,000 tons of pig iron per month. It appears from the large biochemical department of the laboratory (which controlled the purity of the local water supply) that this research department was also to aid in the development of the surrounding communities. The building had been damaged by bombing and fire. The equipment and records were said to have been destroyed by foreign laborers. It was evident that considerable studies were made of refractories, water and steel, as well as the development of applications for blast furnace slag as a structural material.

Of the 200 technical employees forty were women. There were four metallurgists, eight chemists, one physicist, one mineralogist, thirteen analytical chemists, and the necessary assistants and clerks.

Samples from the melting units were delivered to the routine analytical laboratory through a pneumatic tube system.

XIX. TRANSPORTATION FACILITIES

Coking coal from the Ruhr was transported in 600 to 1000 ton barges through the Midland Canal to the slip on the northwest side of the plant. At this slip there were five unloading bridges, each rated at fifty tons capacity, and capable of handling the daily plant consumption of 10,000 tons of coal. Coal storage capacity was 480,000 tons. Brown coal was brought in by rail from local mines near Helmstedt.

Ore from the Salzgitter district was delivered in cars, normally of 50-ton capacity, and dumped at ore bins adjacent to the crushing plant.

Limestone from the nearby districts was transported by means of 45-ton cars known as "satchel wagons". Cars were fitted with three removable containers, having a capacity of fifteen tons each. These containers could be unloaded directly into the limestone kilns or the storage bins.

Track facilities were about 190 miles in length of which 150 miles were used for transportation of materials within the plant. The remaining 40 miles were used temporarily for building construction. There were 1200 switches for plant service and 300 for the temporary track. Twenty-five switching stations were required, the majority of which were electrically operated. All tracks were standard gauge, using normal standard German rail, equivalent to 90 lb. per yard.

Materials were moved throughout the plant by means of 27 coal fired locomotives with 6 axles, 2 with 5 axles, 3 with 4 axles and 43 with 3 axles. Ten fireless and 13 Diesel locomotives with 2 axles each were used for the same purposes. Approximately 2500 plant-owned cars were used to serve the various departments.

For the loading and unloading of scrap, 10 magnet cranes were used.

A 50-ton locomotive crane was provided for maintenance of rolling stock.

Plans were well under way for a new coal handling method. A system of containers was to be made of such construction that they could be loaded readily at loading dock, then lashed together in barge form and towed and pushed to the slip. Here the containers could be lifted and dumped as units. It was said that this method of transport was under trial in the Ruhr at the conclusion of hostilities.

An excellent system of roadways and elevated highways permitted safe transport to all parts of the plant with minimum congestion.

XX. PUBLIC UTILITIES

The public utilities operated by the Hermann Goring plant were almost as important as the iron and steel produced. The low grade ores of the Salzgitter district required a greater coke consumption per ton of iron produced than higher grade ores, and therefore produced more blast furnace gas. The amount of blast furnace gas produced was sufficient to provide fuel for burning the lime and heating the coke ovens as well as an excess for use in the power house, and other furnaces.

As blast furnace gas was available for plant operation, much of the coke-oven gas could be sold. This gas used not only by the surrounding communities, but was also delivered to Magdeburg, Berlin, Hannover, Kassel and the northern Harz district in the pipe lines owned and operated by the Hermann Goring works. Over one million cubic meters per day were produced and delivered through this system. In addition, there were emergency connecting links to the network of the Ruhrgas A.G. and the large gun works at Magdeburg-Ashalt. The plant was considered to be one of the principal sources of gas for the industry of northern and middle Germany.

The power plant, which was designed to operate on blast furnace gas, black coal from the Ruhr or Silesia and brown coal from Helmstedt, had a maximum capacity of 250,000 kw. The electrical energy was delivered to the North German high tension network at Lehrte at 220,000 volts. Then it was distributed through the northern part of Germany.

The water plant up to the present has served only the plant and the adjacent communities (approx. 150,000 persons). This plant was capable of delivering the full water supply of Brunswick, Wolfenbuttel and Fallersleben, through connecting pipelines which had been installed. A complete laboratory for water testing and water purification control was maintained to assure the delivery of pure water at all times.

XXI. PRODUCTION STATISTICS

Steel Production Statistics follow:

INGOT PRODUCTION (in Metric Tons)

Year	Thomas	Open-Hearth	Electric
1940	82195	---	---
1941	430342	75310	8012
1942	548246	199619	51608
1943	596838	147218	95078
1944	591681	162065	94066

The above Thomas Steel Ingot Tonnages are lower than figures obtained in interrogation, as is shown:

YEARLY PRODUCTION OF THOMAS STEEL (in Metric Tons)

Year	Hot Metal	Total Metallic Charge	Total Steel Blown	Ingots
1940	98509	100119	84309	82195
1941	590855	601949	516550	430342
1942	759303	788184	694732	548246
1943	866161	919507	763336	596838
1944	834270	894339	765992	591681
1945				39014

It appears that the differences between the amounts of steel blown and the ingot tonnages are in large part the amounts of vanadium rich iron treated for recovery of vanadium slag. The yearly total ingot tonnages are believed to have been:

1940	82195 metric tons	1943	839134 metric tons
1941	513664 " "	1944	847812 " "
1942	793473 " "		

Iron was produced in excess of the plant requirements. Vanadium rich blown iron may be included in the amount sold.

Pig Iron Production in Metric Tons

Year	Total Production	Amount Sold
1939	35890	- - - -
1940	277106	203336
1941	669676	1511
1942	900813	134672
1943	1091000	262910
1944	1082160	270325

Their figures of the production of blast furnace gas, coke oven gas, by-products and power are appended.

It was stated that the normal daily consumption of coal was approximately 10,000 metric tons. The production sheet shows little more than half of this amount.

Coal Consumption (Metric Tons)

Year	Coke Ovens	Power, etc.	Total
1940	432767	- - -	432767
1941	1461715	- - -	1461715
1942	1723335	421138	2144473
1943	1857132	727027	2584159
1944	1908986	950167	2589153
1945	130992	101262	232254

Their figures for the production of coke compare well with coal consumption.

Year	Coke Production (Metric Tons)
1940	298546
1941	1121014
1942	1222865
1943	1297760
1944	1315264
1945	90577

The yield of coke per ton of coal was 71.5% in 1943 and 68.9% in 1944. It was said that up to 40% of the total coal consumed in 1944 came from Silesia and was inferior in quality.

Considerable quantities of coke were consumed in sintering. The average burden statistics for December of 1943 compare well with statements made during interrogation. Burden sheets show a wet coke consumption of 1097 kg. per ton of low Mn iron when burdened with a metallic charge of 42% Fe. Coke consumption per ton of high Mn iron with a more basic burden (33% Fe) was 1279 kg.

XXII. ECONOMICS

The total investment in the Hermann Goring Works at Watenstedt, and the mines adjacent to them, was stated to be approximately 1,000,000,000 RM.

The present management stated that, under peace-time conditions which they assumed would prevail after the war, this plant would be able to compete economically with the other large plants in Germany. The production costs during the war had been high due to the use of unskilled foreign workers, interruptions by air raids and bonuses granted by the government to German workers who were away from home. Representative production costs of coke, pig iron, vanadium pig iron, Thomas steel, open-hearth steel, and electric steel for the years 1942, 1943 and 1944 are appended. It will be noted that in each instance the cost increased as the war went on.

Dr. Schiegries estimated that the cost of pig iron could be reduced considerably by modifying the blast furnace burden omitting the high priced concentrate of the Renn process and the washed ore. The use of the latter materials was required by the government during the war. Dr. Schiegries' estimate, which was based on present prices of raw materials and present freight rates, is appended.

Dr. Hofmann stated that steel could be produced at a competitive figure with slightly lower costs for pig iron and peace-time production. Dr. Hofmann's estimate is appended.

Both of these men pointed out that the only credits used in their estimates were those for blast furnace gas and converter slag. No credits have been used for the profits obtained from the sale of coke oven gas, blast furnace slag, by-products, electric energy or water, all of which would tend to reduce the total cost of all products produced.

XXIII. APPENDIX LISTING

1. Plant Layout Diagram
2. Flow Sheet of Ore Preparation Plant
3. Sketch of Lurgi Rotating Tube Furnace
4. Plan of Limestone Burning Kiln
5. Blast Furnace Blowing Turbine
6. Blast Furnace Burden Statistics for December 1943
7. Methods of Analysis for Nitrogen in Iron and Steel
8. Drawing of Ingot Mold for Armor Plate
9. List of Important Steel Specifications for Open Hearth and Electric Furnace Manufacture with end uses
10. Production of Vanadium Slag, and Consumption of Ferro-Alloys 1941-1945
11. Plan of Rolling Mills
12. Rated Production per hour of various Rolling Mills
13. Production of Semi-finished Material in 1943, 1944 and 1945
14. Production of 42" Blooming Mill in 1944 and 1945
15. Production of 23" Cross Country Mill in 1942, 1943 and 1944
16. Production of 12" Light Structural Mill in 1944 and 1945
17. Plan of 8.8 cm. Shell Forging and Machining Plant
18. Plan of 12.8 cm. Shell Forging and Machining Plant
19. Production Chart of 8.8 cm. Shell Plant
20. Production Chart of 12.8 cm. Shell Plant
21. Production Chart of Blast Furnace Gas, Coke Oven Gas, By-Products and Power
22. Actual Cost Sheets for Unit Production of Coke, Thomas Pig Iron, Vanadium Pig Iron, Thomas Steel, Open-Hearth Steel and Electric Steel Ingots
23. Estimated Cost per ton of Thomas Iron using present Cost of Raw Materials and Freight
24. Estimated Cost per ton of Thomas Steel
25. Factory Cost per ton of Sintered Steel