Sulzer - Item 9g (00804 to 00814)
"Heizkraftanlagen mit Gegendruck-Kolbendampfmaschinen; Production de chaleur et de force matrice dans des installations pourvries de machines à vapeur à piston fonctionnant avec contre-pression; Combined heating and power plants with back-pressure piston type steam engines" by H.Nyffenegger, Obering, Winterthur. German-language article, with half-page summaries, and titles to figures, in French and English. Pages 60-68, 80, 92. 11 pp.

Sulzer - Item 10 (000466 to 000512)
"Carried out High Pressure Steam Plants". An assembly of photographs and drawings, showing sectional views, plant arrangements, and details of the various features. 47 pp.

Sulzer - Item 11 (000513)
No.898129 - A large folded diagram of a high-pressure steam plant with reheater, similar to Fig.32 (p.52) of Item 9f above.

Sulzer - Item 12a (000514 to 000529)
"Sulzer Hochdruckanlagen mit Trommellosem Einrohrdampfkessel und Selbsttätiger Regelung" (For translation see Item 12b below) 16 pp. 5417-1.

Sulzer - Item 12b (000530 to 000538)
"Sulzer High-Pressure Plant with Drumless Monotube Steam Generator and Automatic Regulation". A typed translation of Item 12a above. 9 pp. 5417e-1.

Sulzer - Item 13 (000539 to 000542)
"Sulzer High-Pressure Steam Plant with Monotube Steam Generator". 4 pp. 5898e.

Sulzer - Item 14 (000543 to 000548)
"Measurement of the salt-content in the boiler feed-water of industrial monotube steam generator plants". 6 pp. 308e. Bch.1.

Sulzer - Item 15 (000549 to 000551)
"High pressure installations equipped with Sulzer Monotube Steam Boilers". Typed memo, 27th September,1945. 3 pp.

Sulzer - Item 16 (000552 to 000555)
"List of Sulzer Monotube Steam Generators in service or under construction". Mimeographed list of 51 installations, undated. Obtained September 27th,1945. 4 pp.

Sulzer - Item 17a (000556 to 000563)
Front and inside cover of "Technical Review Sulzer", No.2,1945 and "A New Method for the Treatment of Regulation Problems" by Dr.P.Profos, Pages 1 to 6. 8 pp.

Sulzer - Item 17b (000563 to 000567)
"The Oilfree Reciprocating Compressor as a Heat Pump" by O.Walti. Pages 6 to 10. 5 pp.

Sulzer - Item 17c (000567 to 000572)
"Centrifugal Pumps in Heat Pump Plants " by J.Sprecher. Pages 10 to 15. 6 pp.

Sulzer - Item 17d (000572 to 000596)
"The Economy of Concentrating Plants with and without Heat Pumps" by W.Wittwer. Pages 15 to 19. 5 pp.

Sulzer - Item 17e (000577 to 000582)
"The Past and Future of the Steam Engine" by O.Walti. Pages 20 to 25. 6 pp.

Sulzer - Item 18 (000588 to 000607)
"Sulzer Examples of Work Done by the 'Boiler, Apparatus and Plate Work Department'". 98 pictures or diagrams of types of equipment built, with brief explanatory statement about each. 20 pp. 5903e.

Sulzer - Item 19 (000608 to 000623)
"Sulzer Products". A summary, with illustrations. 16 pp. 5949e.

Sulzer - Item 20a (000624 to 000630)
"Sulzer Technical Review". No.1, 1945. "This number is devoted to the opening of Sulzer Bros.' Central Research Laboratory at Winterthur". Cover, frontispiece, contents and foreword by D.Sc.Tech.F.Oederlin, Managing Director. pp. 1-5. 7 pp.

Sulzer - Item 20b (000631 to 000667)
"Brittleness and Toughness of Metals at High Temperatures" by Dr.W.Siegfried. Pages 43-79. 37 pp.

Sulzer - Item 20c (000668 to 000676)
"The Oscillographic Equipment of the New Physical Laboratory" by Dr.W.Marti. Pages 80-88. 9 pp.

Sulzer - Item 20d (000677 to 000689)
"The New Sulzer Research Laboratory".
Pages 140 to 152. 13 pp.

Sulzer - Item 21 (000690 to 000741)
"Sulzer Strahlungs Heizung-System Crittall".
(Sulzer Radiation Heating, Crittall System)
34 + 2 pp. + 14 pages of loose copies of testimonial letters in German or French.
Z.No.6008 Add - 40.

Sulzer - Item 22 (000742 to 000754)
"Sulzer Einige Referenzen über wärmetechnische Anlagen" (A few references on Sulzer radiation-Heating installations). Names and locations of nearly 100 installations with length of heating coil. Z.No.5740-D.dc 30 - Z.No.6008.A.C.-dd-3.

Sulzer - Item 23 (000755 to 000760)
"Sulzer Zentral Heizungen" (Sulzer Central Heating). Collection of small pictures of buildings containing central heating plants, air conditioning, district heating and ventilating installations. 6 pp. Z.No.4644-V.34.

APPENDIX

For bibliographic references to the publications cited, see the three lists of "Documents and Publications" following parts I, II and III of this report. The originals have been deposited in Bag 1481 and microfilmed on Reel SF.6.

There are no tables or illustrations accompanying this report.

PERSONNEL OF TEAM

The information contained in this report was obtained by Dr.Harold J.Rose, (U.S.) Scientific Consultant for F.E.A. - T.I.I.C.

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FIAT FINAL REPORT NO. 432

UNCLASSIFIED

THE MANUFACTURE OF REFRACTORIES AND INFORMATION CONCERNING THEIR USE IN THE IRON AND STEEL INDUSTRY OF WESTERN GERMANY

Seil, G.E.

WARNING: Some products and processes described in this report may be the subject of U.S. patents. Accordingly, this publication cannot be held to give any protection against action for infringement.

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JOINT INTELLIGENCE OBJECTIVES AGENCY
WASHINGTON, D. C.

OFFICE OF MILITARY GOVERNMENT FOR GERMANY (US)
Office of the Chief of Staff

FIAT FINAL REPORT NO. 432 25 February 1946

THE MANUFACTURE OF REFRACTORIES AND INFORMATION CONCERNING THEIR USE IN THE IRON AND STEEL INDUSTRY OF WESTERN GERMANY

BY

G. E. SEIL A. T. GREEN
S. M. PHELPS J. H. CHESTERS
F. L. TOY M. DOUGLAS
J. W. WHITTEMORE M. F. GOUDGE
G. R. RIGBY

Joint Intelligence Objectives Agency

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

FIELD INFORMATION AGENCY, TECHNICAL

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I. INTRODUCTION

A. Purpose of Investigation

The object of this investigation was to learn of significant advance which may have been made in Germany during recent years in the field of the manufacture of refractories and their use in steel plants.

The manufacture of refractories was to be investigated to obtain developements in plant lay-out, processing equipment, dryers and kilns, as well as raw materials and the substitutes used and the composition of mixes. Properties of the finished products were to be ascertained and the methods used in their evaluation.

The use of basic refractories in the roof of basic open hearth furnaces has received considerable attention in Germany over a period of years. For this reason, study was to be devoted to the design of the furnaces and especially the roofs and the properties of basic refractories in the roof. In order to evaluate the behaviour and life of the furnace lining attention was to be directed to the operation and metallurgical work carried out in the furnace.

Extensive use has been made of carbon refractories in the lower portion of blast furnace linings in Germany, a practice which is not common in other countries, consequently the design of a type of carbon refractory and furnace operation was to be studied. Information was to be sought concerning the manufacture of this type of refractory.

B. Personnel of Investigating Team (No. 778)

Dr. J.H. Chesters, Refractories Technologist,
Central Research Department,
United Steel Co. Ltd.,
Stocksbridge, Nr. Sheffield, England.

Mark Douglas - Technical Director,
The Steetley Co. Ltd.,
Worksop, Notts, England.

Monson F. Goudge,
Canadian Bureau of Mines,
Industrial Minerals Division,
Ottawa, Canada.

A.T. Green,
Director of Research,
British Refractories Research Association,
Mellor Laboratories,
Stoke on Trent, Staffs. England.

S.M. Phelps,
Director of Research Refractories Fellowship,
Mellon Institute,
Pittsburgh, Pa., U.S.A.

Dr. G.R. Rigby,
Senior Research Worker,
British Refractories Research Laboratories,
Stoke on Trent, Staffs. England.

Dr. G.E.Seil,
Technical Consultant,
Day and Zimmerman Inc.
Philadelphia, Pa., U.S.A.

Francis L. Toy,
Assistant Manager of Research & Development,
Carnegie Illinois Steel Co.,
Pittsburgh, Pa., U.S.A.

J.W. Whittemore,
Head of Department of Ceramic Engineering,
Virginal Polytechnical Institute,
Blacksburg, Va., U.S.A.

C. General Outline of Itinerary.

The American members of the team arrived in London between the dates of June 25th and July 18th. Because of the delay in forming the English complement of the team and difficulties in obtaining transportation to Germany, the team did not arrive at Bad Oeynhausen, Germany, until July 29th. Transportation to a centrally located billet was obtained on July 31st and the first plant visit was made the following day. Five plants in the general district of Dusseldorf were investigated by the team after which it was divided into two groups because of specialized experience of the personnel and so as to facilitate the work.

On August 8th Messrs. Chesters, Douglas, Rigby, Seil and Toy left Ratingen to visit basic refractories plants in the Mannheim area of Germany and in Southern Austria. At this point the team was joined by Mr. M.F. Goudge for the purpose of visiting the Austrian plants.

These targets were completed on August 24th, and the team arrived at Frankfurt on August 26th and at London on August 27th.

The other members of the team, Messrs. Green, Phelps and Whittemore remained at Ratingen visiting plants other than for the manufacture of basic brick that were in the district, and left for Rhondorf on August 14th for a better located headquarters for the remaining targets. This portion of the team returned to Bad Oeynhausen, August 17th and to London August 19th.

In general a factual report was prepared by the team in the field within a day or two after each plant visited. On returning to London these reports were put into final form.

II. GENERAL SUMMARY.

A total of 14 refractory plants and 2 steel plants were visited. With the exception of 2 refractory plants the factories were not in production and it was therefore impossible to check by visual observation statements made by their personnel. It is believed, however, that a fairly accurate picture of refractories manufacture and refractories application in the iron and steel industry in Germany has been obtained.

The bomb damage in the plants visited is negligible and with one exception all are in a position to commence production in 2 to 12 weeks, given the necessary raw materials and fuel. During the present stoppage most plants are carrying out extensive repairs and renewals.

ACID REFRACTORIES.

In general the silica and alumino silicate refractories have been made by conventional methods and in plants which for the most part are old and not too well laid out. Labour has been cheap and as a result labour saving devices have not been used to any extent. The most modern plant visited was well planned and contained good equipment but even so no special effort had been made to incorporate labour saving devices. Apparently little has been done during the war period in developing new processes or products except where substitution had to be made. Effort had been directed toward production rather than on the quality of products.

Because of having to prepare calcine for use as grog in fire clay refractories the efficiency of firing operations has received attention. Various styles of ring or Hoffman kilns were the most common type in use although tunnel kilns have been used to some extent. The new chamber kiln of Plant No. 11 employing cars for the ware is noteworthy.

Detailed information has been obtained on the Scheidhauer and Giessing process for the manufacture of various types of refractories including a large production of tank blocks. Apparently this process has been undergoing changes as is evident in the practice described in Plants No. 7, No. 13 and the new Plant No. 11 where grinding and mulling of the batch is to be done in a wet pan to obtain the desired particle sizes. This is in contrast to the preparation of three particle sizes that were mixed without grinding.

It might be of interest to mention that Plant No.

10 had made use of air hammers for moulding but the batch was prepared by normal methods, probably to avoid payment of patent royalties for the S. & G. process.

The manufacture of silica refractories does not call for particular comment, although mention might be made of the high percentages of sand in products to be used in steel plants, the reason for this being that the sand contains a relatively low percentage of alumina in contrast to that of the quartzite.

During the war period the standardisation of the size and shape of many refractory products was effected through the co-operation of the manufacturers and consumers, with the object of reducing the number of sizes and shapes to be made and stocked. The adoption of this system has apparently proved worth while and they hope to continue its use in the future.

BASIC REFRACTORIES.

In the field of basic refractories the team is satisfied that no improvements in technique, either chemically or physically, have taken place in Germany and Austria since pre-war days when their products were available in America and Great Britain. Their plants are in many instances out of date and the more modern ones are in no way superior to modern American and British plants. The following features of their practice are worthy of note :-

1. They employ higher brick firing temperatures than all British and most American plants.

2. All German and Austrian brickmakers are convinced that Turkish chrome ore produces the best quality chrome-magnesite brick.

3. They have experimented with but have not marketed unfired brick. This practice is common in America but not in Great Britain.

The raw magnesite deposits in Southern Austria are most disquieting having regard to the maintenance of quality should the all basic open hearth furnace be generally adopted by the steel trade, and on the bore hole evidence available the life of the deposits now being worked in respect of good quality magnesite may prove very limited.

THE ALL BASIC FURNACE.

The all basic furnace employing a suspended roof has met with considerable success in Germany, but it is necessary to lay stress on the fact that metallurgical conditions in the open hearth furnace are not as severe as in American and British practice. In the plants visited a high percentage of hot blown metal or active mixer metal of low phosphorous and sulphur content is used and in consequence shorter melting and refining times are required. The time from tap to tap in furnaces of 35 to 75-ton capacity varied from 4 to 6 hours, and this should be borne in mind when discussing the life of the all basic furnace in terms of total heats made. This metallurgical practice also contributes largely toward the success of the all basic furnace as no severe temperature fluctuation is experienced such as occurs in the cold scrap and pig process.

BLAST FURNACE HEARTHS.

It is interesting to note that carbon hearths in the form of blocks or rammed monolith are common practice in Germany. In Great Britain they are now being adopted, whilst in America little more than theoretical interest has been shown. The process of manufacture of the carbon block is relatively simple, the only special equipment necessary being the carbonising oven.

PLANT NO. 1.

REPORT OF VISIT TO THE MANNESMANN WERKE AT HUCKINGEN (RUHR).

I Personnel Interviewed.

(1) Dr. Werner Knapp	Assistant Manager
(2) H. Kahlhofer	Blast Furnace Superintendent
(3) A. Gallmayer	Open Hearth Superintendent
(4) Dr. G. Speith	Assistant Open Hearth Superintendent
(5) Dr. P. Dickens	Chief Chemist.

II General Equipment.

3 - Blast Furnaces (700 tons per day each).

2 - 1000 ton Metal Mixers, supplying Bessemer Plant.

5 - 30 ton Basic Bessemer Converters. (Not investigated).

6 - 75 ton Hot Metal Fixed (Stationary) Open Hearth Furnaces.

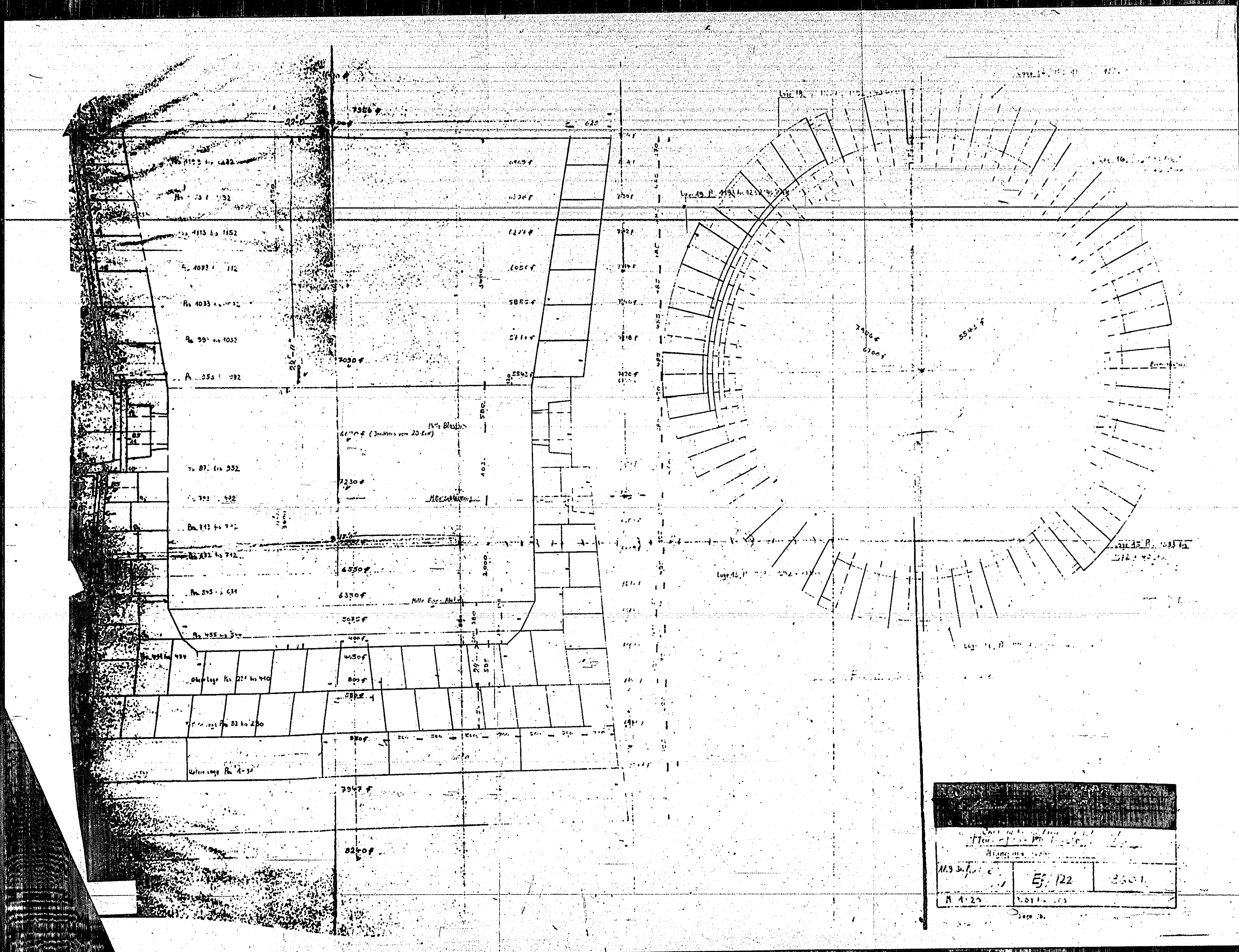
2 - Electric Furnaces (not investigated).

Fabricating Mills (not investigated).

III Blast Furnaces.

The blast furnaces had hearth diameters of 18 ft, the make was about 700 long tons of basic iron of approximate analysis 0.5% silicon, 0.05% sulphur, 1.8% phosphorous and 0.8% (max.) manganese. Interesting features were the carbon lining extending up to the lintel plate and the top armouring.

The carbon lining consisted of large machined carbon blocks, the largest blocks being about 2ft x 2½ft x 6½ft,. See Plate I. These blocks were manufactured by Siemens at the Ratibar Works. The tap-hole was lined with firebrick but the slag notch and tuyeres were inserted through the carbon lining. One carbon lining made 3,200,000 tons of iron between 1929 - 1945. One breakout near the tap-hole



Ej. 122
M. 1:20

occurred after three years operation. This firm preferred prefabricated blocks to a rammed hearth as the blocks were more consistent. The carbon blocks were laid dry, each block being numbered. Before blowing-in the furnace, oxidation of the carbon was prevented by covering with a temporary firebrick lining. Carbon lining up to the lintel is standard practice in this plant. Water cooling of the hearth consisted of a continuous spray on the outside of the steel hearth jacket.

The stack was lined with relatively large fireclay blocks with ground surfaces. No carbon disintegration of these blocks in use was reported. These blocks were laid in fireclay mortar the thickness of the lining being 3¼ feet, but in the opinion of the management half this thickness is adequate.

The throat armouring consisted of hollow cast iron boxes bolted together, filled with a mixture of clay and sand, but in the future the management are considering substituting these by water cooled replaceable cast iron boxes.

The stove cycle depends on the top temperature of the stove, the gas for heating the stoves being well cleaned.

An interesting adjunct to this plant was the manufacture of road blocks from the blast furnace slag, which did not exceed 42% CaO in composition, the CaO/SiO_2 ratio being 1.25 max. The method consisted of running the slag into a shallow bath divided by vertical steel plates into moulds of dimensions 6in x 6in x 6in. The bottom of the moulds was covered by ¼inch of 3.16in grain coke followed by a thin layer of 3/16in grain blast-furnace slag. 4inch strips of flat iron were next placed across the centre of each mould. The slag was poured into the pit, filling the moulds, and to ensure slow cooling the pit was filled to a total thickness of 12 inches, 6 inches of slag covering the tops of all moulds. This covering was discarded when cold, one week being allowed for annealing.

A. <u>Documents and Drawings.</u>

Drawing of Carbon Hearth of Blast Furnaces, Siemens.
Planiawerke 20483. (Plate No. 1)

B. <u>Samples Procured.</u>

Samples of Carbon Blocks.

C. Conclusions.

Carbon blocks in this plant are considered preferable for the hearth and lining up to the lintel plate. Spray cooling of the outside of the hearth jacket and bosh is used in conjunction with the carbon lining. The throat armouring is unusual. No carbon disintegration in the stack has been reported and this is significant because the iron content of the brick is round 2.0%.

IV. Bessemers.

Both the lining and bottom of the converters are made by ramming a tarred dolomite monolith. Magnesite tuperes have been considered but are not regarded as economical.

V. The Open Hearth.

Four furnaces were of the Maerz type, the other two were ordinary design. A novel feature of the Maerz furnaces was a replaceable section between the water-cooled part end and the uptake. This has the advantage that it can be kept accurate in dimensions thus giving consistent flame direction. All the furnaces were heavily stayed.

A. The All-Basic Furnace Roof.

Eight or nine basic brick roofs have been tested in two of the Maerz furnaces. These were as follows - 1 Radex E (Turkish Chromite), (25% Cr_2O_3), 1 Veitsch Ankrom (Grecian Chromite), 5 or 6 straight Ankrit mag. (Veitsche), and 1 Veitsch Ankrom V (10-12% Cr_2O_3) obtained by grinding old bricks. No trials have been made of unfired bricks. The management did not believe that any Dynamidon bricks had been used in roofs. The lives reported were as follows - Radex E over 2,900 heats, the Ankrit roofs varied between 600-800 heats and showed great sensitivity to temperature fluctuations. The ankrit roofs were only used to conserve chrome ore. The Ankrom V roof gave about 1,300 heats. During the war the roof life of silica averaged 250 heats, prewar this figure was about 350 heats. Ankrom bricks made with Grecian chromite gave 1,600 heats. The latest Radex E bricks are also made from Grecian chromite and are less durable than those made from Turkish chromite. The management have no knowledge of Radex E bricks being made from Yugo Slav chromite, Turkish ore appears to be preferred. Good furnace design, for example the Maerz, is considered essential to long life. A high percentage of hot metal (about 70% in this case) is regarded as of primary importance for the economic operation of a basic roof. Temperature variations should be minimized and normal shut down is one shift per week with the gas maintained as far as possible during the repairs. In connection with the above lives it must be noted that these furnaces do approximately 35 casts per week. With the roof lasting 2,900 heats virtually no repairs were made, the wear being remarkably even and the final thickness between the ribs only about 2 inches. The metallurgical load on these furnaces is extremely light due to the use of blown metal.

Detailed data on the Radex E roof (2,900 heats) now follows. This has been obtained as answers to a prepared questionnaire. Similar numbering of the replies is used in all open hearth reports made by this team.

1. The furnace commenced operation June 12th, 1941.

2. The furnace was a hot metal stationary type.

3. The capacity was 75 tons.

4. The hearth area was 432 sq.ft. (40 sq. meters).

5. The rate of working was 76.5 lb.sq.ft. of hearth area per hour.

6. With silica roofs the rate of working was 73.8 lb.sq.ft. of hearth area per hour.

7. The charge consisted of manganese ore (30% Fe. 12% Mn.), together with 70% hot blown metal, balance scrap. No mill scale was used in the feed. The percentage analysis of the hot blown metal was 0.06-0.08 P, 0.05 S, the carbon being adjusted with coke to 0.60.

8. The roof span was..(See Foot Note at end of Plant I.)

9. The length between the ports was.. (See Foot Note at end of Plant I).

10. The height from sill level to centre of arch was..(See Foot Note at end of Plant I).

11. The thickness of the roof was 19½ inches (rib), 15 inches (between ribs).

12. The roof rise was ..(See Foot Note at end of Plant I.)

13. The superstructure for both Radex E and Ankrit are the same, however the method of attaching the ribs differs in the two cases. In the Radex, the flat-iron to which two rib bricks are connected by a pin, is directly suspended from the superstructure. In the Ankrit construction a bowed T iron of the exact contour across the roof is suspended from the superstructure through flat irons. The rib bricks are wired firmly to the bowed T iron which is notched so that the wires are rigidly held. For particulars of brick dimensions and general layout - see Plate II.

14. Coil springs were used on the tie-rods between the nut on the tie rod and buckstays. The buckstays were not rigid but could bend with the adjustment. Practically no adjustment was required after a week when temperatures had been obtained. There was no spring adjustment on the skewback.

15. For brick dimensions and shapes see Plate I.

16. The roof had ribs every fourth course.

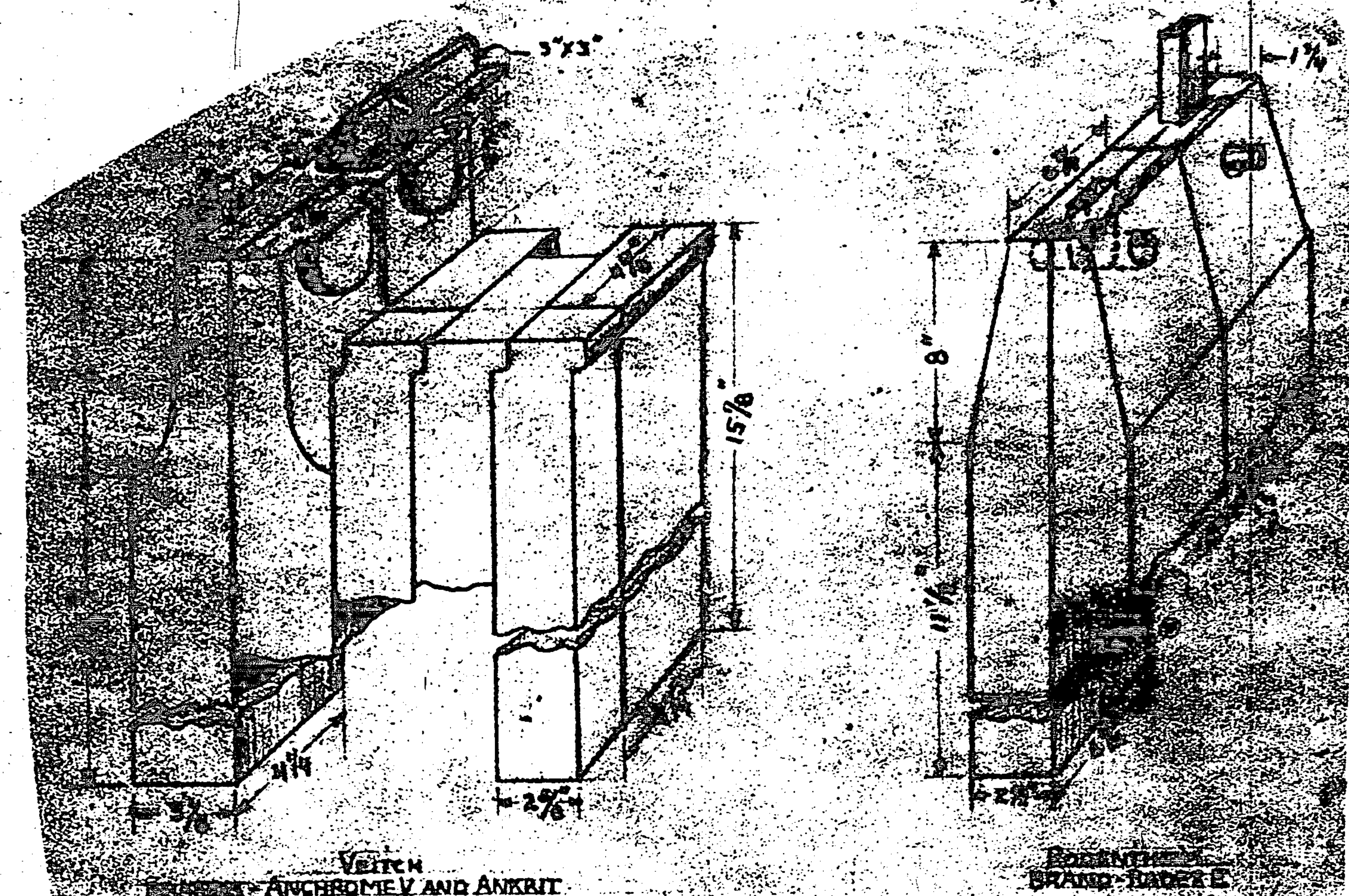
17. Steel sheets or mesh were used between certain joints.

18. No allowances for expansion were made other than those obtained through the metal sheets, on the contrary the bricks were pressed tightly together.

19. The Radex roofs were insulated with 1½ inches of insulation supplied by Radenthein. The nature of this is unknown. The Ankrit roofs were not insulated.

20. Test data on the bricks before use is given in appended documents 47/39. No iron oxide bursting tests were made.

21. Maerz ports were used in conjunction



DESIGN FOR SUSPE[illegible]ING BASIC REFRACTORY ROOFS [illegible] OPEN HEA[illegible]

PLATE I

with the Radex roof.

22. The port bricks were Radex E.

23. The ports were water cooled with 6 steel tubes 30 mm in diameter, all in parallel.

24. The fuel used was mixed coke oven and blast furnace gas. The ratio during melting was 2 coke oven to 1 B.F. gas, but this ratio was appreciably decreased during refining.

25. There are no data relating to roof temperature.

26. The more difficult types of steel were used in the Radex furnace, the carbons ranging from 0.12 to 0.35 and the manganese up to 1.5%. The steel was used for sheets, tube and plate. Steel made in the all basic furnace was more uniform and cleaner than steel made in other furnaces, this is attributed to the higher operating temperatures.

27. The charge consisted of 70% of hot metal based on the total metal charged.

28. The Radex furnace was shut down for 1 shift per week for repairs. During this period the gas was kept on wherever possible.

29. The water cooling on the furnace apart from the ports consisted of 1 horizontal tube in the air uptakes and 2 horizontal tubes from door to door. The door jambs were also water cooled but not the doors proper.

30. The life of the Radex roof was 2,923 heats or 83 weeks at 35 heats per week, involving a total make of 220,000 tons of steel. Virtually no repairs were made to the roof during its entire life, the roof wearing back very evenly over its surface.

31. The roof was only taken off when it was too thin for operation, the roof peeling away in layers of 0.4 to 0.8 inches.

32. The checkers were repaired three times during the life of the roof. A comparison of the failures in silica roof compared with a basic roof reveals that silica roofs fail directly above the tap hole. With the basic roof there was no noticeable increase in wear over the tap hole compared with other parts of the roof. It was the opinion of the management that the method of roof suspension was not as important as the quality of the basic refractories.

B. Hearth Construction.

The sub-hearth consists of 1 course of firebrick, 3 courses of magnesite bricks, 15 inches of rammed tarred dolomite graded 0.4 to 0.8 inches, any dust being accidental.

The average fettling time is 20 minutes and average fettling consumption 26 lb. per ton. All fettling is carried out by hand.

Experiments have recently been made with the Crespi type hearth eliminating the magnesite brick. There is no reduction in fettling consumption using the Crespi construction but less bad bottom time.

C. Sources of Further Information.

The management stated that in their other plants where an all cold metal charge was worked, basic roofs had not proved economical. While this firm claimed the record for basic roof life it was stated that the firm of Bochum Verein had installed more basic roofs.

D. Documents and Drawings.

Documents relating to the properties of unused brick number 47/39. A drawing of the carbon hearth of the blast furnace (Plate No.1) and a diagram of the Ankrit and Radex roof bricks has been prepared (Plate II.).

E. Samples Procured.

2 Radex E and 2 Ankrit roof rib blocks.

F. Conclusions.

The Mannesmann Stahlwerke believe they hold a world record for a basic furnace roof life measured in heats. This record is probably bound up with (a) the light metallurgical load since blown metal was used, (b) the quality of the chrome-magnesite brick, (c) the specially constructed suspended roof and (d) the absence of weekly shut downs which allow the roof to remain at a uniform temperature.

VI. Summary of Plant Visit.

Team 778 visited the Mannesmann Werke at Huckingen, and have prepared reports relating to the refractories and furnace design of the Blast Furnace and Basic Open Hearth Furnace plants. The outstanding features are the excellent results obtained (1) with carbon block hearths and bosh in blast furnaces, and (2) with suspended arched chrome magnesite roofs in open hearth furnaces.

VII. Personnel of Investigating Team.

J. H. Chesters.
M. Douglas.
A. T. Green.
S. M. Phelps.
A. R. Rigby.
A. E. Seil.
F. L. Toy.
J. W. Whittemore.

FOOTNOTE.

The answers to questions 8, 9, 10 & 12 were to be obtained from a drawing to be forwarded to the Team and did not come to hand before leaving for England.

VIII. SUMMARY OF RESULTS ON CHROME-MAGNESITE BRICKS.

MANNESMANN WERKE-HUCKINGEN

INVESTIGATION REPORT No. 47/39.

October 23, 1939.

RESEARCH WORKER - PANNEN.

The following results have been obtained on 184 bricks tested in these laboratories.

Manufacturer	Brand	No. of bricks tested
Veitscher Magnesitwerke (Carl Spater)	Ankrom	10
Koppers	CM - Chrommagnesit	15
Magnesital, Koln-Mulheim	Chromo-Dur	15
Osterr. Magnesit A.G. Radentheim	Dia - Chrom	6
" "	Radex E	40
Didier - Werke	Rubinit	38
Eisenerzgesellschaft - Dusseldorf - Brohltal	U - Rex	38
Weibenberg - Schweidnitz	Chrommagnesit	6
Dynamidon - Werke	Magnesidon 35	11
Teichaer Vertriebsges., Brauns & Bottcher	Techroma	5

Maximum, minimum and average values are given in the following tables.

"Dia-Chrom" bricks from Radentheim are a cheaper product used only for backing purposes.

The following are the conclusions reached for all chrome-magnesite bricks tested :-

Chemical Composition	Average Value	Spread in Values
Silica	4.44 %	2.34 - 8.02 %
Alumina	10.40 %	5.82 -15.10 %
Ferric Oxide	13.26 %	9.62 -21.83 %
Lime	1.26 %	---
Magnesia	40.55 %	---
Chromic Oxide	28.0 %	---

Physical Properties

Pefractoriness under load.

Beginning of Deformation 1550°C (2820°F) Load 28 p.s.i.

End of Deformation 1640°C (2980°F)

Radex E bricks with an average value of 1610-1670°C, (2930-3040°F) are the highest values.

Specific Gravity Average 3.87.

Bulk Density Average 2.92 gr.cc.

Porosity Average 25.1% Spread from 14.7 - 31.2%.

Crushing strength at room temperature - 160.6 p.s.i (average)

Average 126 Kg/sg.cm.

Thermal Expansion to 1000°C. (1832°F)

Expansions were linear varying from 0.75 - 0.94% with an average value of 0.86%.

POROSITY.

Brand	Min.	Max.	Average.
Ankrom	24.3	28.1	25.6
Koppers	24.1	29.0	26.2
Chromo - Dur	26.5	31.2	28.4
Dia-Chrom	20.9	28.4	25.2

Porosity..continued...

Brand	Min.	Max.	Average.
Radex E	20.6	27.8	23.8
Rubinit	17.7	30.2	25.6
U - Rex	14.7	26.3	22.3
Weibenberg	25.7	30.4	27.9
Magnesidon	23.0	27.0	24.8
Techroma	26.7	29.7	27.9

REFRACTORINESS UNDER LOAD.

Beginning of Deformation.

Brand	Min.°C.	Max.°C.	Average.
Ankrom	1490	1600	1560
Koppers	1380	1540	1470
Chromo-Dur	1450	1590	1520
Dia-Chrom	1490	1590	1530
Radex E	1500	1700	1610
Rubinit	1430	1700	1560
U - Rex	1380	1660	1510
Weibenberg	1360	1490	1430
Magnesidon	1370	1560	1500
Techroma	1480	1560	1520

END OF DEFORMATION

Ankrom	1580	1670	1620
Koppers	1540	1690	1620
Chromo-Dur	1530	1660	1610
Dia-Chrom	1620	1680	1650
Radex E	1610	1700	1670
Rubinit	1480	1700	1590
U - Rex	1500	1700	1610
Weibenberg	1470	1610	1540
Magnesidon	1570	1700	1610
Techroma	1600	1610	1605

FERRIC OXIDE

Brand	Min.	Max.	Average	Spread
Ankrom	14.25%	14.52%	14.38%	0.27%
Koppers	9.72	10.44	10.10	0.72
Chromo-Dur	11.01	13.11	11.95	2.10
Dia-Chrom	11.64	11.91	11.78	0.27
Radex E	11.65	15.20	12.60	3.55
Rubinit	9.69	19.73	12.55	10.04
U - Rex	15.37	21.83	17.17	6.46
Weibenberg	11.70	13.18	12.44	1.48
Magnesidon	9.65	10.15	9.83	0.50
Techroma	-	-	14.87	-

CALCIUM OXIDE

Brand	Min.	Max.	Average	Spread.
Ankrom	0.36%	1.70%	1.03%	1.34%
Koppers	1.18	1.41	1.28	0.23
Chromo-Dur	1.41	2.00	1.80	0.59
Dia-Chrom	1.65	1.70	1.68	0.05
Radex E	0.76	1.75	1.28	0.99
Rubinit	sp.	2.60	1.19	2.60
U - Rex	0.36	2.40	1.14	2.05
Weibenberg	0.74	1.60	1.17	0.86
Magnesidon	1.00	1.41	1.14	0.41
Techroma	-	-	1.12	

CRUSHING STRENGTH

Lowest Value

Brand	Min.	Max.	Average.
Ankrom	96	160	125
Koppers	25	75	50
Chromo-Dur	84	147	112
Dia-Chrom	47	92	70
Radex E	55	185	117
Rubinit	20	237	74
U - Rex	63	439	181
Weibenberg	43	138	97
Magnesidon	104	147	123
Techroma	63	117	94

Highest Value

Brand	Min.	Max.	Average.
Ankrom	117	190	143
Koppers	29	84	56
Chromo-Dur	92	147	123
Dia-Chrom	59	104	82
Radex E	59	219	134
Rubinit	27	378	96
U - Rex	75	466	219
Weibenberg	59	202	119
Magnesidon	104	160	130
Techroma	67	190	119

Average Value.

Brand.	Min.	Max.	Average
Ankrom	109	175	134
Koppers	27	80	62
Chromo-Dur	88	147	118
Dia-Chrom	53	98	76
Radex E	57	202	126
Rubinit	23	308	85
U - Rex	69	449	200
Weibenberg	51	190	112
Magnesidon	104	151	126
Techroma	65	154	107

SPECIFIC GRAVITY

Ankrom	3.84	3.87	3.85
Koppers	3.74	3.84	3.78
Chromo-Dur	3.80	3.90	3.84
Dia-Chrom	3.85	3.89	3.87
Radex E	3.78	3.94	3.89
Rubinit	3.74	3.89	3.80
U - Rex	3.66	3.95	3.81
Weibenberg	3.81	3.88	3.84
Magnesidon	3.80	3.87	3.84
Techroma	3.80	3.84	3.82

BULK DENSITY

Ankrom	2.79	2.91	2.87
Koppers	2.68	2.85	2.79
Chromo-Dur	2.64	2.83	2.75
Dia-Chrom	2.78	3.07	2.89
Radex E	2.81	3.09	2.97
Rubinit	2.68	3.07	2.84
U - Rex	2.83	3.12	2.97
Weibenberg	2.67	2.83	2.77
Magnesidon	2.81	2.94	2.89
Techroma	2.70	2.80	2.75

SILICA

Brand	Min.	Max.	Average	Spread
Ankrom	4.20%	4.36%	4.28%	0.16%
Koppers	4.26	5.32	4.81	1.06
Chromo-Dur	4.24	5.25	4.75	1.01
Dia-Chrom	4.20	4.34	4.27	0.14
Radex E	3.02	4.81	3.84	1.79
Rubinit	4.10	4.90	4.59	0.80
U-Rex	2.34	4.66	3.80	2.32
Weibenberg	6.76	6.82	6.79	0.06
Magnesidon	5.08	6.92	5.69	1.86
Techroma	-	-	8.02	

ALUMINA

Brand	Min.	Max.	Average	Spread
Ankrom	14.10%	15.10%	14.60%	1.0%
Koppers	8.73	8.97	8.85	0.24
Chromo-Dur	12.46	13.39	12.99	0.93
Dia-Chrom	9.19	9.84	9.52	0.65
Radex E	8.96	12.68	9.90	3.72
Rubinit	8.60	13.20	10.64	3.60
U - Rex	9.37	14.0	11.26	4.63
Weibenberg	6.63	10.80	8.72	4.17
Magnesidon	5.82	6.99	6.39	1.17
Techroma	-	-	7.81	

MAGNESIA

Brand	Min.	Max.	Average	Spread
Ankrom	39.86%	40.66%	40.26%	0.80%
Koppers	45.84	47.39	46.71	1.55
Chromo-Dur	39.10	41.64	40.47	2.54
Dia-Chrom	40.65	41.60	41.13	0.95
Radex E	37.45	43.19	40.50	5.74
Rubinit	36.41	44.28	39.61	7.87
U - Rex	32.59	41.67	38.21	9.08
Weibenberg	38.70	39.42	39.06	0.72
Magnesidon	44.32	49.13	46.71	4.81
Techroma	-	-	43.74	

CHROMIC OXIDE

Brand	Min.	Max.	Average	Spread
Ankrom	24.67%	25.09%	24.88%	0.42%
Koppers	23.46	26.38	25.06	2.92
Chromo-Dur	25.40	26.25	25.87	0.85
Dia-Chrom	30.77	31.0	30.89	0.23
Radex E	28.38	33.18	31.00	4.79
Rubinit	23.49	32.07	28.90	8.58
U - Rex	22.0	28.56	24.84	6.56
Weibenberg	27.66	30.82	29.24	3.16
Magnesidon	27.27	28.06	27.77	0.79
Techroma	-	-	22.17	

CHROME-MAGNESITE PRODUCTS

Summary of Mean Values

Brand	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Cr_2O_3	Refractoriness under load Beginning	End	Specific Gravity	Bulk Density	Porosity	Crushing Strength Min.	Max.	Average	No. of bricks
Ankrom	4.28	14.60	14.38	1.03	40.26	24.88	1560	1620	3.85	2.87	25.6	125	143	134	10
Koppers	4.81	8.85	10.10	1.28	46.71	25.06	1470	1620	3.78	2.79	26.2	50	56	52	15
Chromo-Dur	4.75	12.99	11.95	1.80	40.47	25.87	1520	1610	3.84	2.75	28.4	112	123	118	15
Dia-Chrom	4.27	9.52	11.78	1.68	41.13	30.89	1530	1650	3.87	2.89	25.2	70	82	76	6
Radex E	3.84	9.90	12.60	1.28	40.50	31.00	1610	1670	3.89	2.97	23.8	117	134	126	40
Rubinit	4.59	10.64	12.55	1.19	39.61	28.90	1560	1590	3.80	2.84	25.6	74	96	85	38
U - Rex	3.80	11.26	17.17	1.14	38.21	24.84	1510	1610	3.81	2.97	22.3	181	219	200	38
Weibenberg	6.79	8.72	12.44	1.17	39.06	29.24	1430	1540	3.84	2.77	27.9	97	119	112	6
Magnesidon	5.69	6.39	9.83	1.14	46.71	27.77	1500	1610	3.84	2.89	24.8	123	130	126	11
Techroma	8.02	7.81	14.87	1.12	43.74	22.17	1520	1605	3.82	2.75	27.9	94	119	107	5
															184
Average	4.44	10.40	15.86	1.26	40.55	28.0	1550	1640	3.87	2.92	25.1	117	137	127	
Min:-	2.34	5.82	9.65	Sp.	32.59	22.0	1360	1470	3.66	2.64	14.7	20	27	23	Spread
Max:-	8.02	15.10	21.83	2.60	49.13	33.18	1700	1700	3.95	3.12	31.2	439	466	449	Spread

Huckingen, 25th November 1945.

INVESTIGATION REPORT NO. 54/40.

Test Results on Chrome-Magnesite Bricks used in works trials.

Shortly after the outbreak of war the production of chrome ore and chrome-magnesite bricks was controlled. In consequence works went over to the manufacture of chrome free or low chrome products. Works trials were made with these bricks in open-hearth furnaces at Heinrich Bierweshutte and Grillo Funke and the following observations made.

These substitute products could be grouped in three clases -

1. Pure maghesite with high shock resistance.
2. Bricks in which the chrome content was replaced by other materials.
3. Bricks, in which the chrome content was appreciably diminished.

To the first group belong the following -

Brand	Manufacturer	Standard Brick Reichmark/ton
Ankrit	Veitscher Magnesitwerke	244.80
V S T	Dynamidon - Werke	244.80
Emgeo	Didier - Werke	220. -
Urex A	Eisenerzges. Brohltal	240. -
Radex A	Radentheim	

To the second group belong -

Brand	Manufacturer	Standard Brick Reichmark/ton
Urex M N	Eisenerzgesellschaft Brohltal	230. -
Urex MNT	" "	240. -
Nosolit	Dr. Gerlach	225. -

To the third group belong -

Brand	Manufacturer	Standard Brick Reichmark-ton
Urex E	Eisenerzgesellschaft Brohtal	220. -
Radex E.K.	Radentheim.	

Test Data.

Mean Values obtained (Tables I-III) were as follows -

Table I.

The Dynamidon V.S.T. brick has a particularly low Fe_2O_3 content which affects the under-load properties.

The Ankrit brick has the highest refractoriness under load - over 1700°C.

Table II.

Urex M.N. and M.N.T. bricks have Mn_3O_4 or Al_2O_3 in place of chrome. These do not give as good results as the chrome-magnesite bricks, nor does the use of Zircon in Nosolit bricks.

Table III.

The chrome oxide content of these bricks varies considerably and the results are not as satisfactory as with the normal product.

Works Trials.

Ankrit

H.B.H. - Front wall, Furnace I, built 7.3.40 removed 25.5.40 after 392 heats. 180 m.m. of the original 250 m.m. remained, the furnace being taken off for other reasons.

Grillo Funke - 'Stirn' walls 248 melts.

VST

H.B.H. - Front walls Furnace II, 6.8.40-28.9.40, after 230 melts the bricks were worn out. After only 8 days spalling was evident.

Grillo Funke - Air uptake under the gas burner 248 melts.

Emgeo

H.B.H. - Right gas uptake Furnace I, 16.6-31.8 after 347 melts.

Grillo Funke - Air uptake under gas burner, 231 melts.

Urex M.N.

H.B.H. - Air uptake, Furnace IV, 6.9-27.10.40 after 251 melts.

Grillo Funke - Air uptake after 136 melts.

Nosolit

H.B.H. - Uptake, Furnace I. Life only 60 melts.

Urex M.N.T. and Urex A. A trial of these bricks is in hand in an uptake.

Radex E.K. and Radex A. No works trials completed but the following results obtained at other plants.

H.B.H. - Silica Front wall 220-250 heats.
Uptake in silica 150-180 heats.

Grillo Funke - Urex E in uptake, 220 heats.

Conclusions.

Works trials confirm the laboratory results. Best service was given by Ankrit, next came V.S.T. followed by Emgeo. Urex M.N. was rejected by Grillo Funke whilst Radex E.K. and Radex A still await test. The Nosolit bricks were no use at all.

TABLE I.

25.11.40.

No.	Manufacturer	Brand.
719	Veitsch	Ankrit
740	Dynamidonwerke	V.S.T.
734	Didier	Emgeo-Di
798	Eisenerzges	Urex A
	Radenthein	Radex A

Chemical Composition

No.	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Cr_2O_3	Mn_3O_4
719	7.36	0.00		8.58	3.4	85.60	▼	0.50
740	2.90	0.48		3.86	3.49	89.00	▼	0.38
734	0.92	0.46		7.76	3.60	86.60	▼	0.64
798	1.40	2.21		8.04	2.85	85.67	▼	

Physical Properties

				Cold Crushing Strength			Refractoriness under load		
No.	Spec. Grav- ity	Bulk Den- sity	Poro- sity	Min.	Max.	Aver- age	Begin to Fail	20% Coll- apse	Range
719	3.57	2.82	21.0	414	515	444	u1700		
740	3.51	2.60	25.6	180	277	243	1620	1650	30
734	3.61	3.01	16.8	414	685	529	1630		u70
798	3.61	2.81	22.3	274	302	288	1460	1500	40

TABLE II.

25.11.40.

No.	Manufacturer	Brand.
735	Eisenerzges	Urex Mn
736	"	Urex MnT
799	Radenthein	Radex EK
690	Gerlach	Nosolit.

Chemical Composition

No.	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Cr_2O_3	Mn_3O_4	ZrO_2
735	1.59	22.39	0.15	6.79	3.00	56.00	1.75	8.19	
736	3.50	46.72	0.20	3.10	3.20	28.30	0.49	14.18	
799	3.58	3.64		5.35	2.87	78.16	6.26		
690	69.6	0.98	1.82	1.50	1.65	51.00			24.0

Physical Properties

No.	Spec. Grav-ity	Bulk Den-sity	Poro-sity	Cold Crushing strength Min.	Max.	Aver-age	Refractoriness under load. Begin to fail	20% Coll-apse	Range	Spall-ing	Slag Resistance. Solution Penetration.
735	3.64	2.63	28.0	91	129	106	1450	1460	10	25	No attack.
736	3.61	2.57	28.9	172	232	191	1505	1540	35	18	Small attack .
799	3.57	2.81	21.2	96	147	121	1500	1500	0		
690	2.79	1.91	31.5	75	96	82	1530	1530			

TABLE III.

25.11.40.

No.	Manufacturer	Brand.
717		Urex E
737	Eisenerzges	Urex E 10
741		
779	Brohlbal	Urex E
780		"
781		

Chemical Composition.

No.	SiO_2	Al_2O_3	TiO_2	Fe_2O_3	CaO	MgO	Cr_2O_3	Mn_3O_4
717	3.80	10.80		11.44	1.75	59.40	11.03	
737	1.86	10.26	0.30	8.12	3.10	68.06	3.22	5.56
741	2.70	10.70		11.34	2.40	46.00	16.27	
749	3.25	15.58		10.00	2.86	58.52	9.54	
780	4.05	14.73		10.90	2.30	53.80	14.24	
781	3.40	17.72		10.20	2.62	57.35	8.52	

Physical Properties.

				Cold Crushing Strength			Refractoriness under load.			
No.	Spec. Grav-ity	Bulk Den-sity	Poro-sity	Min.	Max.	Aver-age	Begin to Fail	20% Coll-apse	Range	Spall-ing.
717	3.75	2.84	24	75	147	109	1520	1550	30	90
737	3.61	2.76	24	75	146	101	1430	1440	10	50
741	3.79	2.84	25	67	108	97	1520	1560	40	35
749	3.67	2.62	22	117	282	173	1540	1540	±	
780	3.72	2.56	31	55	104	78	1490	1500	10	
781	3.66	2.71	26	181	374	245	1530	1570	40	

PLANT NO. 2.

REPORT OF VISIT TO THE HOCHUMER VEREIN GUSSTAHLFABRIKAHON A.G.

Visited August 3rd, 1945.

I. Personnel Interviewed.

Dr. W. Feldmann, Blast Furnace Manager
Mr. H. Poech, Works Director
Mr. F. Clever, Sales Manager
Mr. P. Bremer, Open-Hearth Superintendent.

II. General Equipment.

5 - Blast Furnaces, diameters of hearths between 14.7 and 20.3 feet.

3 - Metal Mixers each 300 tons capacity (Tilting active O.H. furnaces) heated with mixed blast furnace and coke oven gas. These are located in No. II plant.

4 - Open Hearth Plants.

Plant 1: 4 - 35 ton fixed furnaces, cold coke oven gas fired carburetted with pitch. The charge is cold pig, hot metal from metal mixers, manganese ores and scrap.

Plant 2: 6 - 60 ton fixed furnaces, producer gas fired. The charge is 100% hot metal.

Plant 3: Located at Hortrop, has 5 tilting furnaces of the following capacity - 1 at 250 tons, 2 at 180 tons and 2 at 120 tons. These are fired with mixed coke oven and blast furnace gas. The charge consists of 30% hot metal from the blast furnaces and scrap.

Plant 4: Located at Weitmar, has 6 - 60 ton fixed furnaces. Three are heated with producer gas and 3 with cold coke oven gas carburetted with a mixture of 70% pitch and 30% gas oil. The charge is cold pig iron and scrap.

4 - Electric Furnaces of Demag (Herault) design.

These are basic furnaces with silica roofs. The capacities are 2 at 40 tons, 1 at 12 tons, 1 at 6 tons. The two 40 ton furnaces have rotating hearths and sand seals.

III. Blast Furnaces.

	Hearth Diameter	Daily Capacity
Blast Furnace I	16.4 ft.	400 tons
Blast Furnace II	18.0 ft.	550 "
Blast Furnace III	14.7 ft.	400 "
Blast Furnace IV	16.4 ft.	400 "
Blast Furnace V	20.3 ft.	600 "

Blast Furnace V is a utility furnace without pillars, all welded case approaching a cylinder in contour. The stack lining thickness is 1.6 ft. and the stack coolers are flush with the inside wall and are of the open type. This construction is approved by the management.

The analysis of the pig iron in percent is as follows: - C 4.5, Si).5 - 0.8, Mn 1.5 - 2.0, P. 0.15, S 0.03. The iron content of the ore burden is 50-56% the coke consumption is 1650 - 1980 lbs. per ton and the slag analysis is SiO_2 35%, CaO 45%, Al_2O_3 8-9%, MgO 7-85. Before the war Spanish and Swedish ores were used, during the war German and Swedish ores. Table I presents the analysis of iron ores, on the as received basis, as used at various times by this concern. The blast pressure was 12 p.s.i. and the top gas temperature was 400-500°C (750-930°F) the stock line being maintained 21 feet down the furnace. When pyrites sinter was used in the burden metallic zinc was carried away in the outgoing gases and clogged up the downcomers and bas of the Halberg Beth cleaners.

The following table gives the material of construction and total tonnages of iron have been made with the last lining in the furnaces.

No.1 furnace 2.7 million tons - still in blast.
No.2 furnace 1.1 million tons - and burst due to hydration.
No.3 furnace 1.5 million tons - and was bombed.
No.4 furnace 3.0 million tons - now ready for relining.
No.5 furnace 0.15million tons - and still in blast.

TABLE I

BOCHUMER VEREIN-GUSSTAHL FABRIK

Analyses of Iron Ores on the As Received Basis

Type of Ore	Fe	Mn	P	SiO_2	CaO	Al_2O_3	MgO
Kiruna-D-Stck.	59,50%	0,20%	1,80%	2,70%	6,00%	1,00%	1,00%
Grangesberg-Stck	59,50	0,20	0,90	5,00	2,00	1,80	1,00
Grangesberg-Mulm	61,00	0,20	0,70	4,50	3,70	2,00	1,00
Gellivare	59,50	0,20	0,95	6,00	2,00	1,07	1,00
Gellivare-Mulm	62,00	0,20	0,80	4,50	1,50	1,50	0,80
Gellivare-B-Conc.	62,50	0,10	0,29	3,30	2,50	1,50	1,00
Stripa II	40,00	0,15	0,65	30,00	2,00	2,50	2,00
Guldmesbytte-Nyberg	30,00	3,50	0,05	10,40	10,00	9,50	9,88
Karlgrube	48,50	0,18	0,75	17,40	3,50	3,80	1,70
Lekomberg	47,00	0,18	1,10	20,00	6,30	-	-
Dunderland-Conc.	64,00	0,10	0,04	5,00	2,00	-	-
Appatit Conc.	4,30	0,11	14,00	4,20	44,00	1,50	3,20
Orkla	39,00	0,45	0,03	36,00	5,30	-	- (1)
Minette-Luxenburg	24,00	0,30	0,50	15,00	22,00	3,50	-
Minette-Kalkwacken	18,00	0,20	0,50	13,00	27,00	3,50	-
Franzoesische-Minette	30,00	0,30	0,60	5,00	16,00	3,50	-
Fricktal	27,50	0,10	0,46	12,50	15,80	4,80	2,00
St.Remy	43,70	0,48	0,70	12,00	2,00	5,00	-
Mozay	43,00	0,18	0,60	16,00	0,80	10,00	-
May sur Orne	42,50	0,50	0,35	14,50	2,00	5,00	1,00
Rouge	44,50	0,16	0,50	15,80	Trace	6,50	Trace
Mortain-Spat	40,00	0,30	0,80	20,00	3,00	7,00	-
Qued-Zem	46,50	0,40	0,70	13,50	2,00	-	-
Abadonada	50,00	0,39	0,80	12,50	0,75	2,40	0,10
Afrau	42,00	1,20	0,05	6,00	5,00	0,50	3,50
Marampa	30,00	0,12	0,10	8,38	0,40	7,00	Trace
Quenza	52,00	1,70	0,06	4,00	4,00	0,30	-
San Miguel	42,00	0,90	0,04	8,50	6,50	1,20	0,70
Malacspera	52,50	1,15	0,02	10,00	3,50	1,50	0,80
Wabana	51,00	0,18	0,88	12,00	3,50	4,35	0,70
Seriphos	44,38	1,80	0,06	11,00	4,50	0,80	0,70
Kavra	42,50	1,10	0,02	17,00	2,50	0,60	0,90
Benisaf-Feinerz	51,00	1,20	0,06	3,60	2,50	0,20	0,70
Kiesabbrände	51,50	0,15	0,03	6,20	0,90	0,70	Trace (2)
Gichtstaub (fremder Bezug)	35,50	0,45	0,67	12,60	10,00	4,50	1,50
Gichtstaub eigener	35,50	0,60	0,70	14,80	12,20	3,50	2,00
Bauxit-Rückstände	30,00	0,25	0,04	7,58	2,50	15,50	-
Salzgitter-Roherz	27,40	0,30	0,40	20,00	4,60	6,50	2,50
Salzgitter-Mischerz	36,50	0,22	0,45	22,30	4,90	8,79	2,17
Salzgitter-Nassconc.	31,70	0,27	0,45	13,20	4,40	8,50	2,50
Bültener	22,00	2,75	0,62	6,00	20,00	1,00	1,00
Sedelingen	24,50	0,40	0,87	8,00	26,00	6,70	1,10
Kahlenberg	19,70	0,21	0,33	15,20	20,00	4,00	0,90
Fortuna-Conc.	31,75	0,20	0,47	17,50	2,64	6,37	1,64
Ida-Conc.	30,03	0,18	0,46	15,47	6,37	7,28	2,09
Fluesseisensteine							
" Gruben	32,50	0,20	0,28	14,00	14,30	4,20	1,20
" Rauchenberg	25,00	0,25	0,32	12,00	22,00	4,60	0,50
Brauneisensteine Oberhessen	30,50	0,35	0,38	6,60	9,60	7,20	0,18
" Rohte	19,25	0,19	0,43	14,40	18,00	9,10	0,65
" Neiderstein	38,00	0,65	0,25	12,00	0,50	15,10	Trace
" Marie-Caroline	25,00	0,52	0,59	15,00	4,56	7,80	1,60
" Markoldend	18,50	0,38	0,40	17,50	16,00	9,82	1,67
Porta	22,23	0,26	0,49	16,11	11,06	8,80	2,29
Klippenflöz	13,67	0,09	0,18	10,83	34,07	3,19	1,21
Pegnitzer-Conc.	34,11	0,37	0,30	16,53	0,44	9,13	0,70
Barbecke	25,50	0,32	1,69	13,27	18,30	2,70	1,00
Agglomerat (1939)	42,50	0,55	0,65	20,00	9,50	6,50	2,00
Agglomerat (1944)	37,00	0,52	0,70	18,50	12,00	7,00	1,80
Agglomerat-Vanadin	33,00	1,53	2,70	14,50	23,00		

(1) Sulphur = 2.40% (2) Sulphur = 1.72%

The linings in the furnaces are given in the table below :

	Hearth and Bosh	Stack
No. 1 furnace	Carbon Block	Firebrick 3.2 ft.
No. 2 furnace	Rammed coke-tar	Firebrick 3.2 ft.
No. 3 furnace	Carbon Block	Firebrick 3.2 ft.
No. 4 furnace	Carbon Block	Firebrick 3.2 ft.
No. 5 furnace	Rammed coke-tar Carbon Block -	Firebrick 1.6 ft thick.

The firebricks for the stack were 'Alu-Dur' from Martin and Pagenstecher, consisting of large blocks (except in the case of the utility No. V furnace) with a 42% Al_2O_3 content. The iron content could not be obtained. The advantage of using small bricks as in No. V furnace was that vertical expansion is accommodated in the joints avoiding damage to the coolers. These blocks were not surface ground. The throat armouring consisted of cast iron blocks which were water cooled and no inner steel sheeting was used.

It was reported that the general opinion in Germany was equally divided in favour of carbon blocks and rammed coke-tar hearths. Feldmann stated that he would never use anything but a carbon hearth and he preferred the carbon blocks. The best German blocks were said to be made by Siemens Planiawerke, but that Martin and Pagenstecher's blocks were used in this plant. The only specifications given to the brick makers for carbon blocks was that the ash content of the coke should be below 9 - 10% and the bulk density of the blocks should be 1.8 (it must be noted that this figure is obviously misquoted as the true specific gravity of carbon is 1.9).

Where hearths are rammed a well supported high grade firebrick is used as a form. This not only prevents oxidation but affords a protective support until the working face of the ramming is carbonised. The jacket of all these hearths are spray cooled. Feldmann had never heard of anyone spraying the carbon blocks themselves. When burning in a rammed lining no water is passed through the bosh coolers otherwise the rammed material adjacent to the coolers is not coked and is liable to flow. At this plant ramming is carried out with pneumatic rammers.

Considerably less breakouts occur using carbon than using firebrick and less on carbon blocks than rammed hearths. When breakouts occur they were in the tap-hole area at the same level as the tapholes. At this works the tap hole is made by ramming the coke-tar round a steel tube which is left in and filled with clay. When burning out the tap hole the oxygen lance is introduced obliquely alternately to the left and then to the right. This is supposed to maintaim the lining thickness for a considerable area round the tap hole.

Carbon disintegration in the stack was a problem with linings 3 feet thick causing rapid wearing back to the noses of the cooler blocks. In the utility furnace it should be noted there is no lining in front of the cooler noses and the lining thickness has been reduced. Feldmann is of the opinion that zinc is deleterious to the lining life and that zinc spinel has been detected in the brickwork.

With carbon hearths the bear or salamander is greatly reduced being only 3 - 6 ft. thick.

Feldmann has made considerable use of a water-cooled multiple sampling probe to determine the CO/CO_2 ratios from the wall to the centre of the stack. From these gas analyses they control the burdening of the furnace. The concensus of the team is that the gas analysis is affected by the action of the steel tube.

The hot blast stoves are cycled in temperature and not on time a top temperature of 900°C is not exceeded.

A. Conclusions.

The experience in this plant is that the carbon hearth is preferable to the firebrick hearth and the carbon blocks hearth to the coke-tar rammed hearth. Carbon disintegration has been found at this plant and is considered to reduce relatively quickly the thickness of linings 3 ft. thick. For this reason the lining of more recent furnaces has been decreased in thickness to 1.6 ft. The exceptional makes of these furnaces should be considered in relation to the rich burden used.

IV. The Metal Mixers.

These are similar in construction to open-hearth tilting furnaces of 300 tons capacity. They reduce the pig iron metal to the following percentage analysis: C 2.5, Si 0.0, Mn 0.20, P 0.02, S 0.03.

V. The Open-Hearth Furnaces.

A Radex E roof was first installed in 1933 and gave life of 1200 charges with producer gas, no not metal being used in the charge. In 1936 a second Radex E roof heated with coke-oven gas gave a life of 1000 charges using 25% hot metal in the charge. In all 8 - 10 basic roofs have been tried. The construction of these roofs varied considerably, a suspended roof was stated to have been tried in 1944, but those examined were spring roofs with the ribs wired to a bowed T iron, the ends of which were not supported above the skewback. The T iron support is not sufficient to carry the whole weight of the span but would support any local weak area.

A direct comparison between the spring and suspended roof could not be given as the air raids in 1944 necessitated many shut down with the furnace having the suspended roof.

In order to obtain a long life with a basic roof it is essential to avoid fluctuations in temperature. The weakest point in the basic roofs at this plant is the knuckle which only lasts 500 charges and takes 24 hours to charge. Both Radex and Ankrom bricks have been used and were considerably better than Ankrit or Magnesidon as these latter bricks were deficient in chrome. Radex E roofs are considered the best, 1463 charges being obtained from such a roof in 1938 with two knuckle repairs.

(a) Details of the All Basic Roof giving 1463 charges.

(1) This roof was used prewar either 1938 or 1939.

(2) The hot metal content of the charge consisted of a maximum of 45% of mixer iron or 25% of pig iron or any other combination which gives the same carbon content. If the mixer metal is as high as 50% the cast is reduced to 3.5 hours, with 35% mixer metal the length of cast is 5.75 hours. Using all hot pig iron the management estimated that the roof would have lasted only 1100 charges. In No. 2 shop they could make 6 heats a day using mixer metal.

(3) The capacity of the furnace was 35 tons.

(4) The hearth area at the metal line was 290 sq.ft. The depth was 16 ins.

(5) The rate of working was 56 lbs. sq. ft. hearth area per hour. The rated capacity is 30 casts per week or 4000 tons per month.

(6) The rate of working with silica roofs was 43 lbs. sq. ft. hearth area per hour or 22.23 heats per week with

many more repairs.

(7) The feed ore is Swedish iron ore.

(8) The span from skewback to skewback is 14.5 ft.

(9) The distance between the ports is 29.5 ft.

(10) The height from the sill plate to the top of arch is 5.9 ft.

(11) The thickness of roof is 9.8" with ribs of 14.75".

(12) The rise per foot of chord was 1.5 ins.

(13) The roof was a sprung roof.

(14) Coil springs were used outside the back buckstays.

(15) The bricks are set dry.

(16) The roof is ribbed with 5 course between the rib bricks. Present basic Ankrom roofs were double rib with 3 courses between.

(17) Steel plates were inserted between the bricks, later this has been changed to screens.

(18) No extra expansion allowances were allowed other than the steel sheets.

(19) The Radex E roof was insulated with a proprietory material supplied by Radenthein.

(20) No testing was carried out on the roof bricks but they relied on the manufacturers guarantee of 1000 heats. A bonus of 8 - 12% was paid to the melters for every heat over the 1000.

(21) The furnace had Hoesch double ports burning coke over gas.

(22) The ports on the furnace were made of Radex E bricks.

(23) The burner nose of the furnace was water cooled.

(24) The fuel used was stripped cold coke oven gas carburetted with 8.3% of pitch on a B.T.U. basis. The pitch

has a calorific value of 14,400 B.T.U. per lb. and the coke oven gas 450 B.T.U.

(25) No continuous temperature measurements have been taken on the roof. The highest stop temperature taken with an optical pyrometer was 1780°C (3240°F), but generally the readings were 1700°C (3090°F). The hottest part of the roof was immediately over the tap-hole.

(26) Almost all types of steel were made in the Radex furnace, carbon steels ranged from Armco to 1.5 carbon, structural steels and low alloy steels up to 4% nickel and 2% Cr. The steel made in the Radex furnace was hotter than usual and sometimes a heat had to stand 20 minutes before pouring.

The steel from the Radex furnace was not improved in cleanliness but less slag was used on the Radex heats as there was no silica solution, in fact silica had to be added for slag volume. The Radex steel was more uniform than steel made in a silica roof furnace. Segration in each individual ingot did not differ with the type of furnace.

(27) The proportion of hot metal used varied from 25 - 45%.

(28) The furnace was laid off for one shift per week for repairs with the gas on if possible.

(29) The doors and door jambs of the furnace were water cooled. The knuckle was also water cooled but this was given up as it greatly increased the amount of gas required.

(30) The roof life in time was about one year. The weight of steel made was 51,000 tons. During the life of the roof the knuckles were renewed twice but less than 10% of the roof proper was renewed. No comparable data were available for silica roofs as an acid roof had never been used on a basic furnace, but the management were of the opinion that a silica roof on a basic furnace would give 350 - 400 charges. This is based on the fact that in their acid furnaces on 6½ hour melting time they had 500 charges. The front walls were parged to give the same life as the roof.

(31) The furnace was taken off because part of the roof fell in. It was then 0.8" thick at the tap hole and the thickest part of the furnace was 4" thick over

the front wall. If the top temperatures of the furnace is maintained, the flakes from the roof are much thinner than when the temperature is allowed to drop. If the roof temperature drops below 800°C (1470°F), the flakes may be 2 in. or 2¼ in. thick.

(32) With Radex furnaces the material in the slag pockets is cinder like. The management could not understand the statement that at Mannersmann the slag pocket material in the Radex furnace was vitrified.

b. Hearth Contruction - The hearth construction was - 1 course of firebrick on the pan, 1 course of magnesite on the flat and 10 ins. of rammed tarred dolomite. The dolomite warmed on a plate and pneumatically rammed. The dolomite was 0.4" to 0.8", all dust being removed. The fettling consumption was 55 lbs. per ton of steel, and the fettling time was 15 minutes. They considered Crespi furnaces to be good but they had not got much experience.

c. Conclusions.

The management must consider the basic roof successful as they have never used a silica roof on a basic furnace.

VI. Electric Furnaces.

The hearth and side walls of the electric furnaces are made of rammed tarred dolomit similar to that used on the open hearth. The taphole and door jambs are bricked with magnesite. The roof on the 40 ton furnaces were of silica, the life being 60 - 70 charges. The roof consisted of a central band arch, the segments adjacent to the band were arched at right angles. The lives of the hearths of electric furnaces were 40 ton furnaces 500 charges, 12 ton furnaces 800 charges, 6 ton furnaces 1000 charges. The tarred dolomite side walls lasted 80 - 90 charges.

Conclusions.

The practice with the electric furnaces is normal and calls for no comment.

VII. Summary of Plant Visit.

Team 778 visited the Werks of Bochumer Verein on August 3rd, 1945 and have prepared reports relating to the refractories and furnace design of the blast furnaces, open-hearth and electric furnaces. The outstanding features are a comparison between rammed carbon linings and carbon blocks in the blast furnaces; the justification for basic roofs on all basic open-hearth furnaces, and the fact that this organisation found it unnecessary to suspend the bowed T irons from a superstructure. The management confirmed the superiority of the Radex E bricks.

VIII. Personnel of Investigating Team.

J.H. Chesters.
M. Douglas.
A.T. Green.
S.M. Phelps.
A.R. Rigby.
A.E. Seil.
F.L. Toy.
J.W. Whittemore.

PLANT NO. 3.

Heinrich Koppers, G.M.B.H.
Wiesenstrasse 61,
Dusseldorf-Heerdt, Germany.
Visited August 4, 1945.

I. Personnel Interviewed.

Mr. R. Huer, Works Director
Dr. H. Frank, Works Manager.

II. Products and Capacity.

Silica Refractories - 4,500 tons per month, of which 1,000 tons were used in steel plants and 3,500 for coke ovens.
Sillimante (Mullite) and Fire Clay Glass Tank Blocks.
Refractory Insulation.
Special products, e.g. fused alumina, silicon carbide crucibles and tubes.

III. Silica Refractories.

A. MANUFACTURING FLOW SHEET.

Quartzite	Sand.
1. Washing and Hand Sorting	1. Stored as received
2. Storage	2. Dryer
3. Primary Jaw Crusher	3. Cylindrical Ball Mill
4. Secondary Jaw Crusher	4. Storage of Fine Material (65% thru 230 mesh Tyler screen).
5. Dry Pan	
6. Screens	
7. Rolls	
8. Storage of coarse grind.	

Wet Pan
(Milk of Lime and Sulphite liquor added).

Ageing Bin

Forming

Drying

Firing

B. **DESCRIPTION OF MANUFACTURING PROCESS.**

The raw materials used were as follows :-

1. Findlings Quartzite from Westwald (0.6-0.8% Alumina)
2. Findlings Quartzite from Saxony (0.8% Alumina)
3. Fels Quartzite from Assmannshausen (1.8-2.0% Alumina)
4. Kassel Quartzite
5. Carboniferous sandstone from Langerwoche Duren (1.6-2.0% Alumina)
6. Sand from Gassdorf (0.2-0.4% Alumina).

The preparation of the raw materials and the batch are shown in the flow sheet above and require no comment.

Mixes for coke oven shapes and steel plant brick are :-

Coke Oven Shapes.	Steel Plant Brick.
60% Fels Quartzite 0-0.32"	40% Findlings (Westwald)
20% Sand as received	20% Findlings (Saxony)
20% Sand, ball milled	20% Sand as received
	20% Sand, ball milled.

Batches of 880 lbs. were mixed and tempered in a wet pan after the addition of milk of lime and sulphite liquor. Mixes for coke oven shapes were mulled for 20 min. and contained 3% lime. Open hearth roof brick mixes were tempered for 35 min. and had a lime content of 2%. In general the mulling reduced the grain size from 0.35" to 0.236" (largest particles).

After tempering the batch was aged for 24 hours to allow the moisture to become more uniformly distributed (and possibly for better workability). For hand molding a moist content of 6% was used and for pressure forming 4%.

Two rotating table presses were used, one with the pressure applied mechanically and the other hydraulically operated, each with an output of 1,000 to 1,200 pieces per hour per man. These presses were designed so as to provide a gradual increase in pressure during the stroke but with a holding period or dwell at the finish. Brick and shapes were made on three other presses which were of the more conventional hydraulic type. One of these was of a larger size which applied a pressure of 4,300 to 5,700 lbs per sq. inch. This had a capacity of 220 bricks per hour. All of these presses have an automatic maximum pressure control value. Two men were required for the operation of these presses and off-bearing necessitated additional men.

Small flat steel pallets of about 1/8" in thickness were used for each shape. These were cleaned periodically by dipping in dilute sulphuric acid, washing in water, drying and neutralising in lime. A former practice had been to dip the pallets in hot tar.

Drying was carried out in a chamber dryer having 24 compartments each fifty feet in length. The dryer was maintained at 70° to 80° C. and heated by means of the gases of combustion from the tunnel kiln. Humidity was not measured or controlled.

The plant had two tunnel kilns designed primarily for firing silica refractories. These were 455 ft. in length and contained cars 8 ft. in width and 9 ft. 9 in. in length. The height of setting on the cars was approximately 108 ins. The hot zone was 39 ft. in length and the total firing zone 152 ft. The cars were pushed at 4 hour intervals and remained in the kiln 9 days. No facilities were provided for keeping the cars aligned. The tracts were welded at the joints and the car wheels for one track were flanged on both sides while the opposite had a flat face. The steel construction work on the outside of the kiln was exceedingly light.

These kilns were fired with coke producer gas which was washed and preheated, in the kiln regenerators, operating on 20 min. cycles. The hot zone temperature of firing was 1460°C. (2642°F). The fuel consumption was approximately 10% of the finished ware, but calculations based on other evidence indicated that this figure should have been nearer 25%.

In an adjoining part of the plant silica brick and shapes were made by the conventional hand mold process. At this location there are 14 round down draft kilns measuring 32 ft. in diameter. Each of these was of 100 ton capacity and had a turnover of 20 days. An interesting feature of this kiln layout is the communicating flue system which allowed the waste heat from the kiln under fire to preheat the successive kilns. This enabled the ware in the forward kiln to be heated to 600°C. (1112°F) before actual firing in that kiln began. The firing efficiency was reported to be 26% of the weight of the ware.

C. PROPERTIES OF THE SILICA REFRACTORIES.

Properties of the silica refractories were reported to be :-

Bulk Density	1.76 - 1.85
True Sp. Gravity	2.32 - 2.35 (coke oven shapes)
True Sp. Gravity	2.40 (steel plant brick)
Porosity	20.00 - 22.00% (coke oven shapes)
Porosity	18.00% (steel plant brick)

In the opinion of the investigators the actual porosity was higher than the above figures.

IV. Sillimanite (Mullite)

During normal times, Indian Kyanite was used as a raw material, but as a war time necessity, synthetic mullite was made. The latter was made by combining the proper proportions of Kaolin and Bauxite, which had been finely ground and made into a slip which was filter pressed so that dobies could be formed. These were calcined in a special kiln at 1560°C. (2840°F). After grinding, the grog was bonded with a mix of the same composition as that used in making the grog. Some of the mullite products were fired in small chamber kilns in which a single car was used to hold the ware.

V. Glass Tank Block (Fire Clay).

Schamotte glass tank block were made of a calcine which had been fired to 1400°C. (2552°F) in a tunnel kiln. Ten per cent of bonding clay was used in the preparation of the batch and this bond was of the same composition as the clay used for the schamotte. Humic acid and an electrolyte were used in the bond which allowed the use of 4½% of water.

A special machine had been designed and constructed by the company for the purpose of forming the tank block. This operates on the principle of rapidly vibrating the mass while being formed. The sides and ends of the mold as a unit are slowly raised and lowered over a short distance by mechanical means while the bottom platten was vibrated by means of a heavily constructed pneumatic vibrator. During this operation a heavy static load was applied to the top platten resting on the mix. The purpose of the movement of the sides of the mold was to help eliminate occlude air and develop a denser mass.

After drying, the blocks were fired in small gas fired periodic kilns which were lined with high grade, light weight refractories manufactured in the plant.

Three standard types of block were made, these containing 26, 33 and 40-41% alumina.

VI. Chrome and Chrome Magnesite Products.

These products were manufactured in the normal manner using magnesite from Veitsch and chrome ore from Yugoslavia. The bricks were fired in the tunnel kiln and boxed with silica. The temperature during this firing was raised to 1500°C. (2732°F.)

VII. Dolomite Products.

1. Fully Stabilised Dolomite Brick.

Dolomite was stabilised by the addition of serpentine and 1% of chrome ore. In earlier work 6% of chrome ore was used. This mixture was clinkered as dobies at 1500°C. (2732°F.). Brick made from the product contained 40% magnesia, 38% lime and 13% silica. Work on this product had only been experimental and none of the material had been sold during the war.

2. Unstabilised Dolomite Brick.

This material was made in accordance with the process used at Vireaux in France. Dead burnt dolomite was graded in particle sizes from 0 to 0.236 inches and was pressed dry with no further additions under a pressure of 17,000lbs. per sq.in. The brick are fired at 1,500°C. (2732°F.) and are later dipped in heated tar. It was stated that they could be stored for 3 or 4 months without deterioration and that they had received favourable reports on their service in steel plants.

VIII. Summary.

It appears that emphasis had been made on production during the war period rather than toward quality. The tunnel kilns and battery of interconnected periodic kilns used in the firing of silica refractories are of interest. Because of the unavailability of Indian Kyanite, a synthetic product was made. A unique machine has been developed for the molding of glass tank block. Lack of raw materials prevented much work being done on the manufacture of chrome and chrome magnesite products and no progress was reported to have been made on the developement of basic brick or open hearth roofs. Experimental work had been conducted on both stable and unstable dolomite brick but no quantity production has been made.

IX. Personnel of Investigating Team.

J.H. Chesters.
M. Douglas.
A.T. Green.
S.M. Phelps.
A.R. Rigby.
A.E. Seil.
F.L. Toy.
J.W. Whittemore.

PLANT NO. 4.

MARTIN AND PAGENSTECKER
KREFELD-LINN, GERMANY.

Visited August 6th, 1945.

I. Personnel Interviewed.

Mr. R. Seibes - Technical Director.

II. Products and Capacity.

Silica Refractories - 4,000 tons per month
Magnesite Refractories - 1,000 tons per month.

III. Silica Refractories.

This product is made in accordance with normal practice and as is common in Germany, a substantial amount of sand is used in the batch. The bricks were fired in chamber kilns using producer gas as fuel.

IV. Magnesite Refractories.

The raw material was previously made by the Alterra process, calcium ferrite being synthesised at 1,100°C (2012°F) in a rotary kiln and was then mixed with Grecian magnesite. This mix was fed in a wet condition to a 150 ft. rotary kiln, the high temperature zone of which was at 1,500°C (2732°F). This process was abandoned during the war in favour of Austrian magnesite. The bricks were made in accordance with the usual procedure with the exception that the drying temperature was reported to be over 100°C (212°F). Chrome magnesite bricks were not produced during the war because chrome ore was not available.

V. Summary.

Silica bricks at this plant were manufactured by the usual methods. The layout and equipment for the manufacture of magnesite according to the Alterra process was relatively good.

VI. Personnel of Investigating Team.

J.H. Chesters.	G.R. Rigby.
M. Douglas.	G.E. Seil.
A.T. Green	F.L. Toy.
S.M. Phelps.	J.W. Whittemore.

PLANT NO. 5.

MARTIN AND PAGENSTECKER
ERKRATH, GERMANY.

Visited August 6th, 1945.

I. Personnel Interviewed.

Mr. W. Girsch - Works Manager.

II. Products and Capacity.

Fire clay casting pit refractories (except stoppers) - 1,800 tons per month.
Carbon block and coke tar ramming material for blast furnaces.

III. Fire Clay Casting Pit Refractories (other than stoppers).

Rod covers, trumpets, guide tubes, centre brick and runner brick were made of grog and bonding clay and had an alumina content of 34-39%. Normal practice was followed in their manufacture but mention might be made of a semi-mechanical device for cutting the holes in centre brick. The essential idea of this equipment is shown in Plate I.

Drying of the ware carried out in rooms above the kiln, the floor boards being spaced so as to allow the circulation of heated air. The ware was placed on long boards laid up as a rack with brick supports serving as spacers. A second method of drying was to stack the ware in a similar manner in the moulding room and heated air was admitted during the night.

IV. Carbon Block and Coke Tar Ramming Mix.

The raw material used for both products were foundry coke received in pieces of maximum size of 1.5 in. and coke oven tar which has been dehydrated.

The coke was screened to eliminate the fines before passing through a rotary dryer so that the coke dust would not be lost up the stack. The finely divided material was added to the batch later. The coke is ground in 550 lb. batches in a large dry pan with mullers weighing 5 tons each, 66 in. in diameter and a 21 in. face. The bottom of the pan is steam heated to avoid chilling of the batch. The

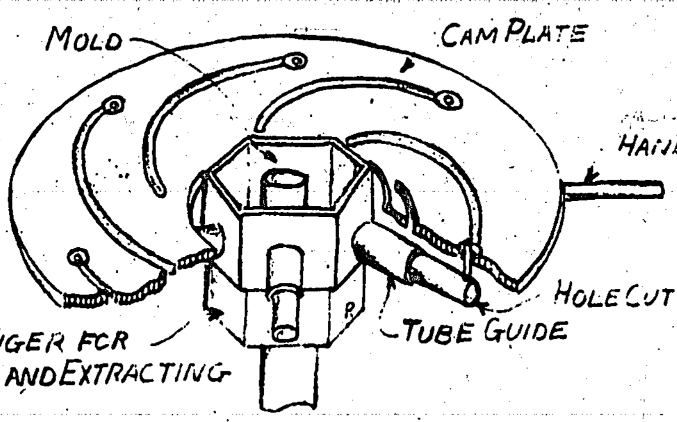


PLATE I DIAGRAM SHOWING PRINCIPLE OF DEVICE FOR PRESSING AND CUTTING HOLES IN CENTER BLOCKS grinding operation proceeds for eight minutes after which the tar which has been previously heated to 80°C (176°F) is introduced and the mulling operating continued for three minutes.

When visiting the Martin & Pagenstecker plant at Mulheim (Report No. 10) Dr. Eric Martin provided additional information regarding the mix used for carbon blocks and ramming material. The approximate ash content of the hard foundry coke used is 12%. The following table presents information regarding the tar content of the mix and typical particle size distribution of the coke -

	Ramming Material % in batch		Block % in batch	
Per cent of Tar used	15	18	15	18
Particle size of Coke in inches.				
0.0-0.004	19	19	24	21
0.004-0.02	25	24	26	24
0.02 -0.04	10	10	11	10
0.04 -0.08	8	6	7	7
0.08 -0.12	6	5	5	6
0.12 -0.16	3	1	1	3
0.16 -0.20	3	4	2	2
0.20 -0.24	10	12	7	8

Additional information was given on the distillation characteristics of the tar and the pitch content. The statement was made that the material other than pitch in the tar was anthrazenol. Typical characteristics of the tar were as follows -

Temperature Range of Distillation.	Per cent of Distillate and Pitch content of four typical samples.			
170°-235°C	8.8	0.6	6.0	4.8
235°-270°	6.0	4.1	8.6	8.3
270°-360°	28.7	33.6	29.4	29.2
Pitch content	56.5	61.7	56.0	57.7

Mention should be made of the use of 10% of anthracite replacing part of the coke in the mix when acid resisting carbon products were being made.

Blocks of various sizes are formed in wooden moulds, some of the larger sizes being about 54 in. in length. Sufficient material is placed in the mould to fill it and this is rammed into place with pneumatic hammers. The remaining half of the mould was filled with successive layers and rammed. The moulded piece was allowed to cool before placing in the kiln.

The ramming material batch is taken from the mixing pan and placed in paper bags of convenient size for shipping.

The blocks are carbonized in a special oven which consists of adjacent rectangular chambers. On the bottom of the chamber a mixture of coke breeze with 10% sand is spread and the blocks placed upon this. The addition of sand was to prevent sticking of the coke to the block. The remainder of the chamber is filled with the mixture of coke and sand to prevent oxidation of the war during the heat treatment. The chambers were about 6 ft. wide and 5 ft. high and 25 ft. in length. Dividing walls between the chambers contained a system of flues. The coal fired furnaces were below the floor of the chamber at the front of the oven. The heated gases passed through flues under the floor of the chamber and upward through the back wall and then forward over the setting in removable flues. At this point the gases were divided so as to pass to the back of the kiln through the flues in the sidewalls and then to the stack. The total heating period was four days and at the end of that time, the ware was at 1000°C (1832°F) according to the Manager. Ten days were allowed as a cooling period before the sand which had been placed over the removable flues as a seal was removed. Two days later the ware could be removed from the ovens. If occasion demanded the finished blocks were machined to final size by means of a travelling bed grinding machine.

The porosity of the blocks was given as 28-30%.

V. Summary.

The feature of principal interest at this plant was the manufacture of carbon refractory materials which was carried out without unusual equipment with the exception of the carbonizing ovens. This form has been manufacturing carbon blocks for thirty years and claims that their produce is equal to that made by Siemens

Planiawerke. The Didier plant at Duisburg is a third manufacturer of this product.

VI. Personnel of Investigating Team.

J.H. Chesters.
M. Douglas.
A.T. Green.
S.M. Phelps.
G.R. Rigby.
G.E. Seil.
F.L. Toy.
J.W. Whittemore.

PLANT NO. 6.

DR. OTTO & CO., G.M.B.H.
DAHLHAUSEN, BOCHUM, GERMANY.

~~Visited August 8th, 1945.~~

I. Personnel Interviewed.

Otto Saffran - Ceramic Engineer
Earnest Daeler - Secretary to Managing Director.

II. Products and Capacity.

Silica Refractories - 2,000 tons per month for carbonizing plants, 500 tons for other uses.
Fire Clay Refractories - 3,500 tons per month.
Sillimanite Refractories (Mullite)
Silicon Carbide Products.

III. Silica Refractories.

A. Manufacturing Flow Sheet.

Quartzite	Sand	Lime and Sulphite Liquor
1. Jaw Crusher.	1. Storage	
2. Cone Mill.		
3. Symonds Mill.		
4. Vibrating Screens.		
5. Storage.		

Wet pan

Machine Moulding (70%)	Hand Moulding (30%)
Keller Dryer	Hot Floor

Gas Fired Chamber Kiln

B. Description of Manufacturing Process.

The raw materials used were as follows :-

1. Fels quartzite (2.0 to 3.0% alumina).
2. Findlings quartzite (1.0 to 2.0% alumina).
3. Sand (max. 1.0% alumina).

The quartzites were sorted at the mine and the sand was obtained in the ground state from the Quartz Mahlwerke, Frechen, near Cologne. A second kind of sand used was Silber sand.

In the preparation of the ground quartzite the management were of the opinion that the cone and Symonds Mills produce angular grains which account for the density of their finished product. When making certain types of open hearth brick the quartzite is given additional grinding during tempering in the wet pan and this operation is for a duration of 30 to 40 minutes or about twice that of the time used for regular products.

The composition of two batches for coke oven brick were :-

	Mix 1 for Upper Structure	Mix 2 for Under Structure
Findlings quartzite	50%	30%
Fels quartzite	30	20
Sand	20	50

The sand used in Mix 1 was both Silber Sand finely ground sand. In Mix 2, 30% of the total amount of sand was in the "as received" condition and the remainder a finely ground material. Frequently silica brick bats become a portion of this mix.

The steel plant grade of brick contained as much as 40% sand for the purpose of having a lower alumina content in the product.

Pressure forming of brick was carried out in hydraulic presses, one with 120 tons capacity, one of 100 tons and two with 80 tons.

The moulded ware was dried either on hot floors or in a 60 chamber dryer similar to the Keller dryer.

Firing of the ware was carried out principally in a chamber kiln fired with coke producer gas. The kiln consisted of 36 chambers each of 25 tons capacity. Two chambers were under fire at the same time, each at different positions in the kiln. The chamber turnover was 21 days and fuel consumption 25% of the weight of the finished ware.

Additional firing capacity consisted of 14 round down draft kilns of good design. They also had a turn-over of 21 days, including a 30 hr. soaking period, and required 40 to 45 % of fuel based on the weight of the ware.

C. Properties of the Silica Brick.

The Properties of coke-oven silica brick are -

Specific Gravity	2.36
Porosity	25%
Load Test D.I.N. 28 p.s.i.	1650°C (3002°F) Collapse Temperature

The interview bright out the statement that before the war steel plant silica bricks were fired to produce a Specific Gravity of less than 2.36 but during the war the practice has been to use brick with a gravity of about 2.40-2.42. The final transformation in the brick taking place in the furnace and while in a confined space.

The steel plant product shows a load test temperature of failure 28 p.s.i. of 1680°C (3056°F).

IV. Sillimanite (Mullite) Products.

During the war period a substitute grog was made to replace natural Kyanite. This was comprised of a mixture of clay and alumina (Feldsmuhle). The percentage of bonding clay varied from 10 to 20% and no electrolytes were used. At one time de-airing of the batch was practised but has been discontinued.

V. Silicon Carbide Products.

Vertical retorts and other products for the zinc industry were made from silicon carbide using customary methods of manufacture. Scrap silicon carbide ware from zinc plants was used for making a second grade ware which found use in operations ancillary to the zinc retorts.

VI. Light Weight Refractories.

Insulating refractories were made by using combustibles in the mix although napthaline had been tried but was not found to be entirely suitable. The lightest weight product was made with peat coke as the combustible. The standard product, however, was made using brown coal containing 10-11% of ash and ground to a particle size of 0-0.02 inches. 40% of this provides a porosity of 60% and the maximum percentage ever used was 60.

VII. Fire Clay Refractories.

A considerable area of the part of this plant devoted to the manufacture of fireclay products had been destroyed by bombing. The manufacturing practice appears to follow conventional lines. The principal feature of interest lay in the tunnel kiln for firing. This was about 500 feet in length with a firing zone of 160 feet heated by 10 burners on each side. The cars were approximately 10 feet square and the setting was about 7½ feet in height. The cars were in the kiln for 6½ days and were pushed at the rate of 7 or 8 cars per day. The cars were unusually high, measuring about 5 feet from the track to the top and the sand seal appeared to be very effective in keeping the understructure of the cars cool. The maximum capacity of the kiln was 3,800 tons per month.

In addition to the tunnel kiln a chamber kiln similar to that described under silica brick was used for firing clay refractories.

IX. Summary.

Silica refractories are made in the conventional manner but it is of interest to note that in order to obtain a low alumina content a large amount of the low alumina sand had to be used.

The tunnel kiln for clay refractories is of large capacity but no other feature is of particular interest in the fire clay plant.

Light weight fire clay refractories are manufactured in considerable quantity by the burn-out process using brown coal.

No comment is warranted concerning other products which are made or regarding processes used.

X. Personnel of Investigating Team.

A.T. Green.
S.M. Phelps.
J.W. Whittemore.

PLANT NO. 7.

DIDIER WERKE, G.M.B.H. (SCHEIDHAUER AND GIESSING), DUISBURG, GERMANY.

~~Visited August 9th and 10th, 1945.~~

This plant is part of the Didier Werke, A.G. It was learned in conversation that the number of plants and their locations are shown in the following diagram-:

Didier Werke Organization
Head Office
Berlin Wilmersdorf
Westfalische - Str 90.

Western Plants

Duisburg/Rhein	(600 employees)
Niederdallendorf	(550 ")
Niederlahnstein	(225 ")
Biebrick	(300 ")
Mainslar	(500 ")

Northern Plants

Stettin Werke

Eastern Plants

Hermaunsbad/Th.
Thonberg/Sachen
Sarran/Schlesien
Gleiwitz/Schlesien
Grenau/Schlesien
Ratibar/Schlesien
Weidenau/Bohmen

Southern Plants

Marktredwitz/Bayern
Eisenberg/Th.
Kulmiz

I. Personnel Interviewed.

Johannes Kathariner - Technical Manager.

II. Products and Capacity.

Fire Clay, Sillimanite, Silica, Silicon Carbide and Carbon Refractories and Graphite Stoppers.

The total output per month averaged 3,400 tons. This output was divided according to the method of manufacture as follows -

Pneumatic hammer (S. and G.)	25%
Hydraulic pressing	10%
Extrusion and repressing	25%
Hand Moulding	10%
Rotating table press	1.4%

In addition to the above the plant has a capacity to make 50 tons of carbon blocks or 250 tons of coke tar ramming materials per month.

Note: The pneumatic hammer method of pressing involves a process developed by this company and is commonly known as the Scheidhauer and Giessing process and will be referred to as the S. and G. process throughout the report.

III. Fire Clay Refractories.

A. Manufacturing Flow Sheet for S. and G. process and Hydraulic Pressed Brick.

Fire clay Grog (Schamotte)
1. Jaw Crusher
2. Rolls
3. Screen
4. Storage bin for 3 sizes.

Plastic Clay
1. Ball Mill
2. Screen
3. Blunger-clay and electrolyte

Double Arm Mixer or Eirich (Lancaster type)

Metal moulds and Air hammer (S. and G. process) — Hydraulic presses

Drying

Firing

B. Description of Batch Preparation for S. and G. Process and Hydraulic Press Forming.

The grog is purchased as lump, calcined Westwald clay. During the war, however, calcined Silesian Clay was used and this had an alumina content of 46% in contrast with the Westvald which had 39-42%. Clays from Czechoslovakia and the Palatinate have also been used. In general three grades of fire clay refractories have been made and these contain 36, 40 and 42% alumina.

The grog as received was passed through a jaw crusher, rolls and screens so as to obtain three definite sizes of grog. These are stored separately in bins.

The bond clay was dry ground in ball mills. One of the mills was a very short type which has slots in the cylinder with a surrounding screen. This mill gives a preliminary reduction after which it passes through a conventional ball mill of large size with a capacity of 12 tons in 8 hours. The clay was screened so as to have a maximum particle size of 0.002 inches.

Before adding the clay to the batch it was prepared as a slip with additions of an electrolyte, Casseler Braun, and dextrine. Batches of the slip were prepared in the following manner -

560 lbs of cold water was introduced into a mixing chamber and the following solutions A, B and C were added in order -

A. 6.6 lbs of hot water.
10.56 lbs soda ash.

B. 6.6 lbs of hot water.
4.4 lbs Casseler Braun.

C. 12.1 lbs of hot water.
13.2 lbs of dextrine.

To this mixture was added 880 lbs of the ground clay and blunging was carried out for 2 to 3 hours. This provides a slip with a specific gravity of not less than 1.53 and averaged 1.55. Viscosity determinations were used for control work making use of a tube with a capacity of 100 c.c. and having an orifice tube at the bottom with an inside diameter of 3 m.m. The test is made by filling the tube and recording the emptying time which should be 250 seconds. On the basis of the dry clay content of the slip it contained 1.2% soda ash, 0.5% Casseler Braun and 1.5% dextrine. The total weight of each batch of slip was 1,493 lbs or a volume of 115.5 gallons. Five batches of the above slip were introduced into a ribbon type mixer where it was slowly agitated for two or three days and even a longer time was claimed to be beneficial. It is likely that the Sp. Gr. and viscosity of the slip were made at this stage of the processing.

The grog batch to which the prepared clip was added consists of the following -

3 parts grog - 0.0-0.04 inches.
1 part " - 0.04-0.098 "
2 parts " - 0.098-0.236 "

Twenty per cent by weight of slip is added which is equivalent of 12% clay on the dry basis. Apparently the lowest per cent of dry clay which has been used is ten.

The grog and slip were mixed either in the double arm or Eirich mixer for a period of 30 to 45 minutes, after which it is transferred to the moulding department.

NOTE : Casseler Braun is a powdered material prepared from Braun Coal and it was reported to contain humic acid.

C. Forming Shapes by the S. and G. Process.

Special heavily constructed and ribbed iron moulds were used and these have a number of features which enable the size of the mould to be changed. In addition spacers were inserted to change the mould size. Two workmen were used at each mould, one introduced the batch so as to provide a layer of uniform thickness while the second man rammed the material into a dense mass by means of an air hammer. The batch was continuously introduced into the mould so that laminations would not develop. When the mould was nearly full an extension piece was placed on the opening so that overfilling could be carried out and later the excess material above the mould proper was cut off and the surface slicked.

A rather heavy air hammer with a stroke of about ten inches was used. The nose piece on the hammer measured about 1½ by 3 inches in area and the face of this was V grooved with spaces of about 5/16 of an inch. Even though these depressions filled with the batch they were found to be effective.

The formed shapes were placed on pallets made of heavy channel iron and these were slid into the desired position on the drying floor over metal faced rails.

D. Hydraulic Presses Brick.

The batch prepared for the S. and G. process was also formed in hydraulic presses making standard or special shapes. Two sizes of hydraulic presses were used, the larger having a total capacity of 250 tons pressure, and operated with 125 strokes per hour. Three nine inch brick were made with each pressing and received a pressure of 4,100 lbs per sq. in. The largest area for rectangular shapes which could be pressed was 16 by 20 inches. When making shapes of this order and with a thickness of about five inches the mould was filled in two operations and for a seven inch thickness three fillings were required. The top surface of the mix was scratched between each filling.

Two operators attend each press, one weighed out the batch and the other operated the press. Off bearing being done by other workmen. Rams applied pressure against the batch from top and bottom, the upper ram moving a longer distance than the bottom. De-airing is accomplished by making preliminary pressing from the top after which the plunger is backed off to allow the air to excape. The final pressing operation is at a uniform rate with a dwell at the maximum pressure.

The mould liners were made of carbon steel, surface hardened in carbon and when both sides of the plates were used a total of about twenty thousand pieces were made. Apparently special steels have not been used.

An exceptionally large hydraulic press had been installed during the war period. Apparently this had not been put into successful operation and it was claimed that it was intended for forming locomotive arch block, blast furnace shapes and large pieces thicker than 6 inches. It was stated that the area of the largest pieces to be formed was the same as that made on the smaller presses (16 by 20 inches) and that the increased pressure was required for shapes ranging in thickness from 6 inches to 9 inches. The press was claimed to have a capacity of 750 tons but calculations show that this was closer to 1000 tons. The diameter of the ram was 22.8 inches and apparently the maximum pressure as indicated by the gauge was 400 atmospheres. The maximum operating pressure during moulding was to be 5,300 lbs per.sq.in. on the shape being moulded.

E. Drying.

The drying of shapes moulded by either process was carried out on floors located above the kilns. The floor boards in these rooms were spaced about ½ inch apart to allow the hot air to circulate. Even large shapes were dried in periods up to 3 days whereas material made in the usual manner required from 6 days to 3 weeks under the same drying conditions.

The drying shrinkage was from 0.0 to o.3% in contrast with 6-8% for ware made in the conventional manner.

F. Firing.

The firing of ware made by either process was carried out in continuous chamber kilns. Four kilns were available for the firing and these varied from 14 to 40 chambers. Each chamber had a capacity of 15 tons and had a turnover of approximately ten days. The chambers were heated with coal introduced through the top of the kiln and fuel was added to the chambers under fire for a period of 12 to 14 hours. The coal consumption was 12 to 14% of the weight of the ware. Sagger cone 10-11 was brought down (1310°C-2390°F). The firing shrinkage was 0.0 to 0.1% as against 2-3% for the ware made in the conventional manner. The kiln loss was stated to be 3½%.

G. Properties.

The properties of products made by the S. and G. process are presented in Table 1.

IV. Repressed Brick.

Fire clay products made by extrusion and repressing followed the usual method of manufacture. The crushed grog (Schamotte) was screened in a rotary screen and was mixed with bonding clay in a short pug mill. Lumps of this material were elevated to the moulding floor where it was passed through an auger machine. Wire cuts were transferred to a location where they were repressed. The repress was well designed and was operated by means of a cam driven by an electric motor. The press was mounted on wheels so that it could be moved along one side of the dryer floor so that its output could be delivered directly to the desired aisle of the drying racks. The drying and firing was carried out in the manner described for the S. and G. process.

The properties of brick made by this method are presented in Table 1.

V. Rotating Table Pressed Brick.

A small quantity of standard size brick were made on the rotating table type mechanical press. Preparation of the batch and the drying and firing of shapes followed the normal practice.

TABLE NO. 1.

Properties of some fireclay products made by Scheidhauser and Giessing plant of Didier Werke, A.G.

	Repress Brick			Air Hammer Molded (Sand G. Process)						
	A.1	A.2	A.3	I	II	III	B 1	B 2	C 1	C 2
Bulk Density	1.90	1.90	1.90	2.05	2.05	2.00	2.05	2.15	2.4	2.65
Seger Cone	33	32/33	31/32	33	32/33	32	32	32	-	-
Porosity	28	27	27	23	22	21	18/20	16/18	20/22	12/16
Hot Load (ta °C Test (1) (te °C	1380 1600	1370 1600	1350 1580	1420 1630	1400 1610	1350 1600	1380 1580	1380 1580	1550 1650	1700 1700
Crushing Strength (2)	150	180	180	350	400	500	500	700	500	1000
Spalling (3)	15	12	10	30	20	15	10	5	50	50
Alumina	42	40	36	42	40	37	38	38		
Silicon Carbide									48	85

(1) Load test according to German D.I.N. specification
(2) In KG/CM^2 = 28 p.s.i.
(3) Spalling by Arbitrary test dipping ends of heated brick into water, number of cycles for 25% loss shown.

VI. Carbon, Block and Ramming Material.

A. Preparation and Forming.

These products were manufactured from high quality foundry coke, with a maximum ash content of 10% and tar.

The coke was dried prior to being passed through a jaw crusher after which it passed through rolls and screens to obtain particles ranging from 0.0 to 0.2 inches. The ground coke was mixed with tar in a double armed, steam heated mixer maintained at approximately 50°C (122°F) After introducing the heated pitch the mixing proceeded for 30 to 45 minutes. The batch used in making blocks and the ramming material are as follows -

		Block	Ramming Material
Ground Coke		1430 lbs	1430 lbs
Tar		275 lbs	286 lbs
Tar	(Pitch content	70%	62%
	(Anthrazenol	30%	38%

After mixing the batch is dumped on a steam heated metal floor maintained at 40°C (104°F). The ramming mix is placed in paper bags for shipment and the blocks are moulded in wooden moulds which are metal lined when making standard size shapes. Air hammers such as described in the S. and G. process are used to ram the material in place Blocks as large as 5 ft. square in section and 13 ft. in length were claimed to have been made. Because of the softness of the moulded shapes care was required in transporting them to the position where they were allowed to harden by cooling.

B. Carbonizing the Blocks.

The tar content of the block was carbonized to form a bond and to increase the density of the product. This was carried out in an oven of special design, a section of which is shown diagrammatically in Plate I. It consists essentially of a battery of four paralled chambers the side walls of which contain the heating chamber. The formed carbon block are placed on a bed of finely ground coke and sand after which the same material is used to fill the remainder of the chamber. This prevents the oxidation of the blocks during the heating operation. Coal is used as

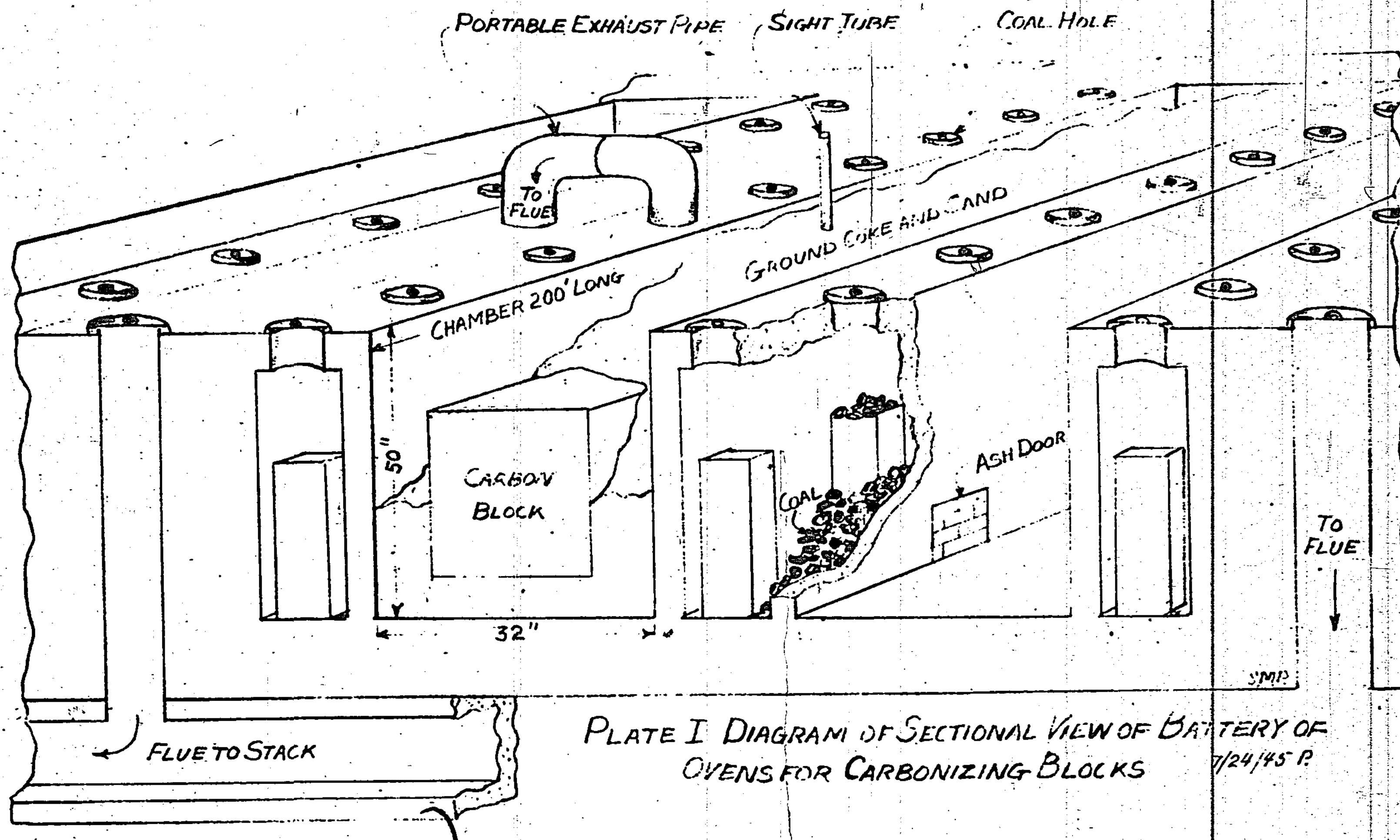


PLATE I DIAGRAM OF SECTIONAL VIEW OF BATTERY OF OVENS FOR CARBONIZING BLOCKS 7/24/45 P.

fuel and this is introduced into the compartment of the dividing wall between chambers. Plate I shows the series of coal holes and a cutaway portion of the dividing wall showing the coal. Assuming that the firing was begun at the far end of the chamber the coal was introduced on the coal holes of the wall on either side of the chamber. A portable exhaust pipe is then connected between a flue opening and a coal hole some distance forward from the fire. A coal hole lid on the far side of the fire is removed to permit air for combustion to enter the firing compartment. Firing in this general manner progresses to the opposite end of the ovens and the total period of time required to reach maximum temperature is approximately three weeks and three weeks is allowed for cooling. The temperature in the vicinity of the blocks is judged by sighting into the open end of a 2 inch pipe sealed at the other end which had been inserted into the ground coke surrounding the blocks. The maximum temperature attained was 700-800°C (1290° - 1470°F). Removal of the ash after a firing is carried out through the ash doors spaced at intervals in the side wall of the chamber and which are bricked up before loading the kiln.

Because of the necessity of the heat to pass through the ground coke to reach the block and the long period of time required to complete the carbonizing the "firing" efficiency was low and in the order of 100% of the weight of the ware.

C. Properties of the Block.

Data pertaining to the block were obtained and is as follows -

Crushing strength - 3,270 lbs. per sq. in.
Bulk density - 1.38
Specific Gravity - 1.82
Porosity - 26%
Water Absorption - 18%

VII. Summary.

Detailed information has been obtained on the manufacture of fire clay products by the process developed by Scheidhauer and Giessing which consists essentially of the preparation of grain sized grog bonded with a clay that has been carefully prepared in the form of a slip. The batch produced was initially moulded in the S. and G. process by means of air hammers and heavily constructed metal moulds. The same batch, however, has been successfully used also in hydraulic pressed products. The S. and G. process allowed a minimum amount of bonding clay to be used with obvious advantages. Large shapes can be made with finished surfaces that are plain and because of the low drying and firing shrinkage accuracy of size can be maintained.

Carbon block and coke-tar ramming material for use primarily in lining the lower portion of blast furnaces were made with a comparatively simple layout of equipment although the carbonizing oven was of a special design.

Properties of fireclay refractories made by the S. and G. and repressed methods are presented as well as those of the carbon block.

VIII. Personnel of Investigating Team.

A.T. Green.
S.M. Phelps.
J.W. Whittemore.

PLANT NO. 8.

Alphons Custodis, G.M.B.H.
Dusseldorf, Germany.

Visited 11th August 1945.

I. Personnel Interviewed.

Georg Fritsche - Erection Engineer.

II. Products and Capacity.

Two types of plastic, fire clay refractories
Castable refractory concrete.

III. Discussion of Plant.

The production of the plant followed normal practice for the manufacture of these products. One interesting feature was the dry mixer used in the production of castable concrete which was over 30 ft. in length. It was evident that most of the production was used for the firms activity in lining and repairing boiler settings. The plant was not in operation and all of the records were stated to be in Bavaria with Alphons Custodis.

IV. Personnel of Investigating Team.

A.T. Green
S.M. Phelps
J.W. Whittemore.

PLANT NO. 9.

Deutsche Carborandum Werke
Dusseldorf, Reizholz, Germany.

Visited 11th August 1945.

I. Personnel Interviewed.

Works Manager.

II. Discussion of Plant.

This firm has not manufactured refractories since before the war. They specialise entirely on the manufacture of abrasives. Both the silicon carbide and corundum were purchased from other firms.

III. Personnel of Investigating Team.

A.T. Green.
S.M. Phelps.
J.W. Whittemore.

PLANT No. 10.

Martin and Pagenstecher, G.M.B.H.
Mulheim-Koln.

~~Visited 13th August, 1945.~~

I. Personnel Interviewed.

Dr. Eric H. Martin - Managing Director
Mr. Carl Wehrman - Works Manager.

As a matter of record the subject of an interview with Dr. Eric H. Martin is here reported.

(a) Constitution of the firm of Martin and Pagenstecher.

The firm was formed in 1873 and part of the works inspected at Mulheim was erected at that time. In 1922 the firm became a subsidiary of the Steinnes-Steel Combine. In 1926 owing to a reorganisation of the Steel Combine, Martin and Pagenstecher became a subsidiary of the Vereingte Stahlewerke.

(b) In the course of the conversation with Dr. Martin information was obtained regarding the standardisation of sizes and shapes of refractories for use in various industries. This work was carried out through the intensive co-operation of the producers of refractories and the consumers. The object was to reduce the number of refractory products and shapes so as to alleviate the burden on the manufacturer and to reduce the variety of sizes and shapes stocked by the user. The resulting standards were adopted and use was made of them by virtually all parties concerned even though this subject was not adopted by D.I.N. Dr. Martin expressed the view that the use of these standards would be continued in the future.

Translation of abstracts of the printed matter bearing the following titles append the report.

(i) Standardisation of Magnesite and Special Bricks for Open Hearth Furnaces.

(ii) Standardisation of Silica Brick for Open Hearth Furnaces.

(iii) Standardisation of Pouring Pit Refractories for Steel Works.

(iv) Standardization of the Size and Shape of Refractories for use in the Blast Furnace and Hot-Blast Stove.

(c) Additional information was obtained from Dr. Martin relative to the manufacture of carbon refractories in this company's plant at Erkrath and this information has been incorporated in the report for Plant No. 5.

II. Products and Capacity.

Fire clay refractories, including those for the casting pit and glass tank blocks - Normal production was 5,000 tons per month, and with an employment of 350 men.

III. General Description of Manufacturing Processes.

The principal clay used during normal times was obtained from Westwald. During the war a Pfalz clay was used and this originally contained 39-40% alumina but this figure has since dropped to 36%. A special blue Westwald clay was used at one time because of its plasticity but the supply has diminished during the war.

The crushing, grinding and grading of grog (schamotte) followed normal practice.

An appreciable amount of their products were made by air hammer ramming of the batch in metal molds similar to the Scheidhauer and Gilssing process (See Report No.6) with the exception that a special preparation of the bond as a slip is not employed. The batch for this type of molding was prepared by conventional methods as a semi-dry pressed mix. No electrolyte or other adjuvants were used. Long stroke air hammers operating under 90 lbs. pressure were used with a nose piece measuring 2 by 3 inches with a serrated face of V grooves spaced about 5/16 inch. The ribbed molds seemed well designed from the standpoint of lightness, the ribbing being heavier in the center area than near the edges. General purpose fire clay refractories and glass tank blocks were made by this process.

Extruded repressed brick were made in the usual fashion , the repressing being carried out on an electrically operated press of the same type seen at a number of German plants. These are manufactured by Berger and Co. G.M.B.H., Bergisch Gladbach Bei Koln and by Weserhutte

9 KT - Ges. Bad Oeynhausen in Westfaleu. These presses allow the repressing of a 1000 standard brick per hour with two workers.

The method for making hand made products followed normal practice.

The drying of the products was carried out in open rooms making use principally of waste heat from the cooling kilns.

Two types kilns were used, one being a continuous kiln without chambers and rectangular periodics. One of the continuous kilns was gas fired and the other was coal fired from the top. Brown coal was used in the gas producer and with this fuel the efficiency was reported to be 18-20% for the Chamber Continuous kiln.

The statement was made that the size of standard brick is now 9.85 by 4.85 by 2.56 inches.

In addition to the above products casting pit refractories were made at this plant although nothing of unusual interest was observed. Stoppers both clay and graphite were made at a rapid rate on a motor driven screw press with automatic controls for the movement of the spindle. It was learned that Stoecker and Junz, Koln Mulheim produced two thirds of the stoppers made in Germany and that only six concerns produce stoppers and nozzles. Nozzles had been made entirely of magnesite and these proved very satisfactory for hot steel. Their high thermal conductivity resulted in a coating of the metal being formed on the surface thereby protecting the nozzle. Magnesite inserts in clay were not used.

Ladle brick were fired to produce a dense body in special small kilns making use of a reducing atmosphere.

IV. Summary.

An interview with Dr. Martin resulted in obtaining valuable literature on the subject of standardisation of size and shapes of a variety of refractory products which had been effective during the war. Translations of these append the report.

The air hammer method of forming in a manner similar to the S. and G. process is of interest and may have been used to avoid royalties in connection with that method.

V. Personnel of Investigating Team.

A.T. Green, S.M. Phelps, J.W. Whittemore.

PLANT NO. 11.

Didier Werke, G.M.B.H.
Niederdallendorf, A.Rh.

Visited 15th August 1945.

I. Personnel Interviewed.

Dr. Herman Knuth - Director of Works.
Mr. Frederich Stegg - Director of Works in Niederdallendorf.
Mr. Eric Schroth - Technical Director of the West Works Group.

II. Products and Capacity.

Silica Refractories - 2,000 tons per month maximum.
Fire Clay Refractories - 3,000 tons per month maximum, but only 1,000 tons per month when 2,000 tons per month of silica refractories are made.

III. Plant Under Construction.

This plant is the second largest of the Didier Werke and because of extensive bomb damage work was begun in 1942 to build a modern plant for fire clay and silica refractories manufacture. To date only foundation work has been started on the silica plant but the fire clay department almost completed. The following description applies to this portion of the plant. It is probably the most modern and best planned refractories works in Germany.

A. General Description of Plant Layout.

Storage space is provided outside of the building for raw materials and this measures about 75 by 150 feet. The main building which is well designed of reinforced concrete houses all operations. It measures approximately 230 by 270 feet with a cut out area in one corner for the gas producer plant and this is about 75 feet square. The grinding room adjacent to the raw materials storage measures about 35 by 150 feet and was five stories high so as to accommodate the grinding equipment, elevators, screens bins and batch weighing equipment. Adjacent to this area is located the mixing machinery from which the batch is taken to a large room measuring 150 by 260 feet. A portion of this area measuring 80 feet wide was to be used for molding and the remaining width of the room for drying. Alongside the dryers was located the kiln room measuring 85 by 260 feet. This affords space for two kilns, one of which has been constructed.

B. Flow Sheet for Fire Clay Refractories.

1. Large, 3 stage, dust mill	1. Large Gyratory Crusher	1. Gyratory Crusher
2. Vibrating screen	2. Large Dry Pan	2. Symonds Mill
3. Bins	3. Vibrating Screens	3. Vibrating Screens

Fine Grog
Ring Roll Mill
(Mexicon)

Bins Bins Bins Bins

Batch Weighing Car

Wet Pan Eirich Mixer

Hydraulic Presses
or
Scheidhauer and Giessing Process
(Pneumatic Hammer)

Keller Dryer

New Type Hoffmann Kiln with cars.

C. General Description of Process.

Grog (Schamotte) and bonding clay were to be obtained from the Westwald and they were to be taken from the storage area to the grinding equipment by hand operated push carts. The bonding clay was to be reduced to 0.0 - 0.02 inches at the rate of 3 to 3½ tons per hour in the dust mill screened and stored in bins. The grog was to be crushed to one inch pieces or smaller in either of two gyratory crushers. In one instance it was then transferred to the large dry pan for further reduction in size after which it was screened in order to separate the desired particle sizes and then stored in bins. Additional grinding for very fine sizes (maximum 0.02 inches) was performed in the ring roll mill (Mexicon). In the second instance the grog from the crusher passed through the Symonds Mill and was screened and stored. The statement was made that the three principal sizes of grog to be used were 0.0 - 0.04 inches, 0.04 - 0.098 inches and

0.098 - 0.24 inches. Twenty six storage bins were available, each with a capacity of twenty tons.

A car mounted, batch weighing equipment delivers the mix from the silos to the mixing equipment.

When making of the Scheidhauer and Giessing Process the batch will be delivered to the Eirich Mixer and the process carried out similar to that reported for the Duisburg plant. Some question arises, however, as to whether an electroyte will be used. Emphasis seems to have been placed on the preparation of the batch in the large wet pan which would be a departure from the process already in use at other didier plants. Mixing and tempering in the Eirich Mixer does not reduce the particle size of the grog but this would not be the case in the wet pan. Conversation brought out the fact that experimental work has shown that wet pan grinding of particles of two sizes, namely, 0.0 - 0.08 inches and 0.08 - 0.24 inches will proceed so as to ultimately produce a gradation of sizes required for maximum density or minimum amount of bonding clay. It would seem that this plant has been designed to make use of that principle in the preparation of the batch. The proposed percentage of bond clay is expected to be from six to ten and there is a possibility that an electrolyte will be used.

Although no pressing equipment has been installed the plans were to make use of hydraulic presses for the more or less standard sizes or shapes using a pressure in the order of 5,00 lbs per sq. in. although it is likely that this equipment will follow the pattern of that used at Duisburg. Forming by means of the air hammer will also be used (S. and G. Process).

Drying will be carried out by means of the Kelier type dryers.

The Didier company claimed high firing efficiency in their kilns and this appears to be born out in the investigation of various plants in Germany. Data obtained from the Didier Werke are as follows:

Fire Clay Refractories (Cone 12-13) - 9 to 11% coal
Silica Refractories (Cone 15-16) - 12% coal
Magnesite Refractories (Cone 16-17) - 14% to 16% coal
Note: Seger cones are referred to.
The general type of kiln used in the various Didier plants visited were the Ring Kiln of either chamber or open variety fired either by producer gas or coal. At this plant, however, a new kiln has been designed and constructed.

This is of interest because of the effort to combine the efficiency of the ring kiln with the advantages of cars as used in a tunnel kiln.

The general principle of the new kiln is to load the ware on cars, three of which are used to fill each chamber of the kiln. The third car will have built on its structure framework and refractories which will constitute the door of the chamber. Eighteen adjacent chambers are provided along each side of the kiln which measures 46 by 115 feet. A track system extends around the kiln and is used for transfer cars which take the kiln to the stock platform. The three cars of ware in each chamber hold a total of 15 tons. The contemplated output of the kiln will be 1,000 tons per month, with an efficiency of 14% for fire clay refractories and 16% for silica.

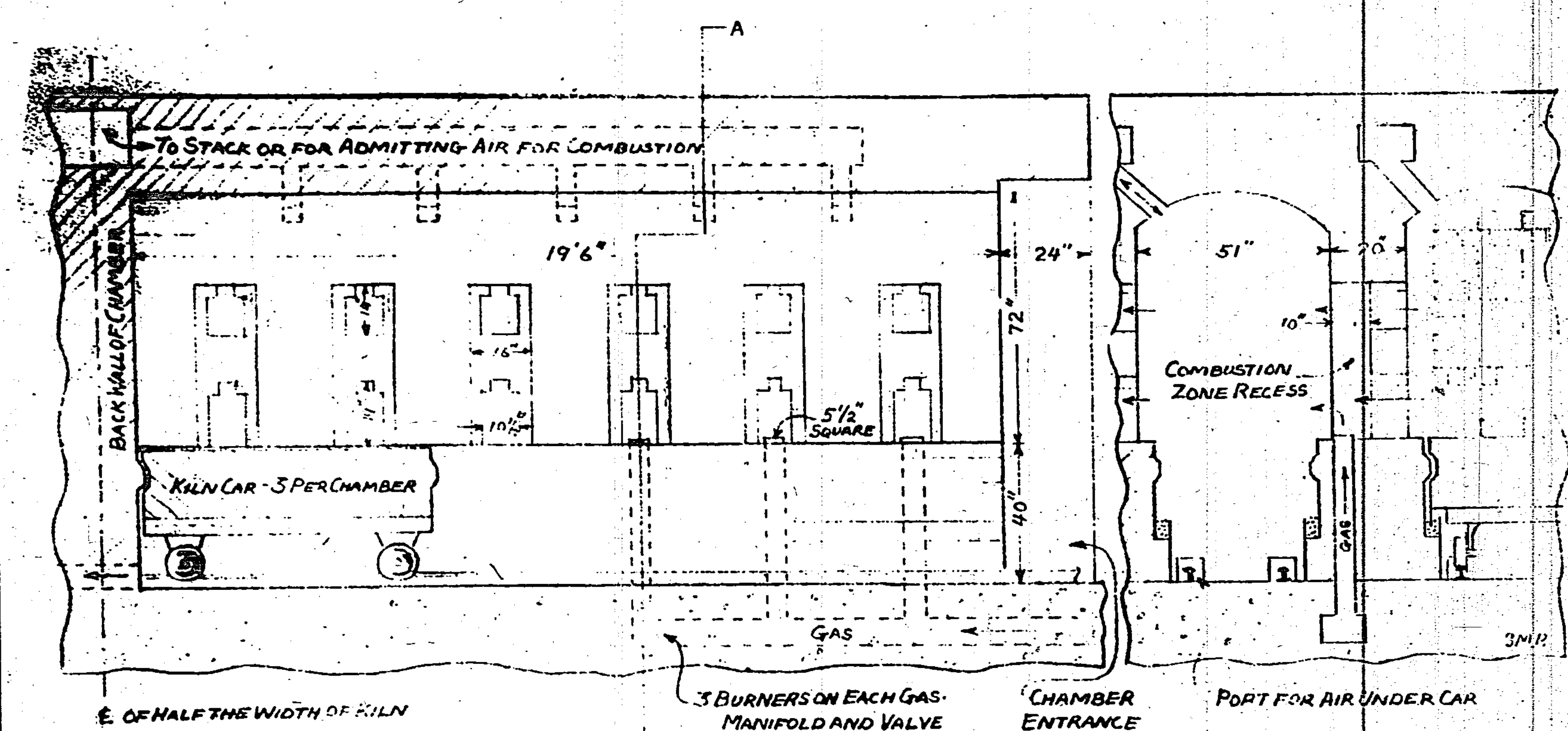
Plate I presents a diagram of the sectional views of a chamber in the kiln. The heating is carried out by means of producer gas and the success of firing of adjacent chambers, together with making use of preheated air from "fired" chambers follows the principle used in ring kilns. The dividing wall between chambers is constructed of silica brick and the remainder was built of high grade fire clay brick. The division wall has built into it six burners with air ports to admit heated air for combustion. Openings in the arch of each chamber allow the exhaust gases to be taken out of a chamber located the desired distance from firing zone. Each car is provided with sand seals and an arrangement is made for circulating air under the cars.

IV. Silica Refractories.

Although construction had been started on the bombed silica plant this had not progressed beyond foundation work for crushing machinery. The remaining portion of the plant showed that silica refractories had been manufactured in a conventional manner including Keller dryers and a Hoffman Ring Kiln. A rather heavy mechanical toggle press had been used for pressing brick and shapes but this machine which was of Swiss manufacture was reported to have given trouble because of abrasion occurring in some of the bearing. A novel feature of this press was a device to indicate and control hydraulically the pressure applied.

V. Summary.

The new fire clay plant under construction embodies



To Stack or for Admitting Air for Combustion
Back Wall of Chamber
19'6"
24"
72"
40"
16"
10½"
5½" Square
Kiln Car - 3 Per Chamber
Gas
51"
20"
10"
Combustion Zone Recess
Gas
3MR
℄ of Half the Width of Kiln
3 Burners on Each Gas Manifold and Valve
Chamber Entrance
Port for Air Under Car
A
A

Section A-A

straight line flow of materials although more manual labour will be required than should be necessary in a modern plant. The plant machinery appeared to be of good design and large capacity. The grinding of a batch consisting of grog of two particle sizes in the wet pan to obtain the desirable gradation of sizes is an interesting feature. The departure in kiln design is noteworthy and its performance should be of interest in the future.

VI. Personnel of Investigating Team.

A.T. Green.
S.M. Phelps.
J.W. Whittemore.

PLANT NO. 12.

Rheinischer Vulkan Chamotte U. Dinaswerke, M.B.H., Oberdollendorf, A.Rh.

Visited 16th August, 1945.

I. Personnel Interviewed.

Mr. Felix Kuehne, Director of Works.

II. Products and Capacity.

Fire Clay Refractories - 1,400 tons per month
Silica Refractories 300 to 400 tons per month
Graphite stoppers and nozzles
The plant employs 200 men.

III. Discussion of Plant.

The firm owns deposits of fire clay and silica in the Westwald from which they have obtained most of the clay and silica that they had used. Small amounts of local clay had been used for the manufacture of Schamotte. There was nothing unusual in the preparation of the clay, Schamotte or silica for the manufacture of ware. Hand forming and mechanical pressing were used. In drying the ware, Keller dryers and hot floor dryers were used.

Silica refractories were fired in periodic kilns and the fire clay refractories were fired in a typical modern tunnel kiln. This kiln, which was only two years old, was 370 ft. in length and had a hot zone of 40 ft. It held 60 cars, each with a capacity of four tons. The kiln was well insulated with kieselguhr up to 11 inches in thickness. An underpass was provided under the cars. The capacity of the kiln was 60 tons per day. The efficiency when firing fire clay refractories to cone 12 (Seger cone) was 13%. When firing silica brick in their periodic kilns to cone 15 the efficiency was 35%.

Graphite stoppers were fired in a round periodic and a rectangular periodic kiln with built in saggars.

IV. Summary.

The plant and equipment were very old, the only modern feature was a tunnel kiln. The processes used and products made were not worthy of any comments.

V. <u>Personnel of Investigating Team.</u>

A.T. Green.
S.M. Phelps.
J.W. Whittemore.

PLANT NO. 13.

Didier Werke,
Niederlahnstein, Germany.

Visited 16th August 1945.

I. Personnel Interviewed.

Dr. Rohde - Director of Works.

The team was accompanied by Dr. Gerhard of the Niederdallendorf Works who served as interpreter.

II. Products and Capacity.

Fire Clay Refractories - 1,200 tons per month. This included 400 tons of glass tank block of which 250-300 tons were made by the S. and G. process.

III. Discussion of Plant.

The Schamotte and bonding clay are obtained from the Westwald and both are the same mixture of selected clays. The crushing and grinding is accomplished with the usual type of machinery.

The mixing of the batch is carried out by two methods, one for the S. and G. process and the other for hand made tank blocks. In the case of the former the slip is prepared in large blunger after which it is placed in one of four mixers of 26 tons capacity where they obtain prolonged mixing for one week. The batch for this process contained the following :-

Clay	1,320 lbs
Soda	17.6 lbs
Casseler Braun	8.8 lbs
Water	35 to 40%.

Fifteen per cent of clay on the dry basis is used for bonding the sized grog. The particle size of the grog is 0.0 - 0.2 inches and 0.2 - 0.98 inches. The slip is mixed with the graded grog in an arm mixer, after which it is ready for moulding.

The hand made tank block mix was placed in a large wet pan with only enough moisture to prevent dusting. It was then transferred to a feeder which fed into a pug mill where the required water was added. The batch was then aged for four weeks after which it was passed successfully through two successive pug mills. This mix contained 33% clay for the bond. The mix is very plastic so that smaller shapes can be made by mold bumping or in the case of large blocks by hand pressing and slicking to fill the mold.

The drying of the S. and G. block required one day to a week depending on the size. The hand made shapes required up to four weeks of drying time.

The firing is carried out in ring chamber kilns. The fuel used was producer gas from brown coal and the fuel consumption was 22% of the tonnage of ware fired. This is considered as good efficiency because of the large size of the blocks fired. The ware was fired to cone 14 (Seger cone).

The porosity of the S. and G. block was 16-18% and of the hand made blocks 20-22%.

The faces of the tank block were frequently ground to shape and size. Certain surface defects such as slightly penetrating surface cracks are removed by reducing the size of the block.

IV. <u>Summary.</u>

A good product is made at this plant and it is probably the largest manufacturer of tank block in Germany. The layout of the plant is on good lines making use of modern equipment. The kiln efficiency is good considering the type of product fired.

V. <u>Personnel of Investigating Team.</u>

A.T. Green.
S.M. Phelps.
J.W. Whittemore.

PLANT NO. 14.

Dynamidon Werke Engelhorn & Co.,
Waldhof, Mannhein,
Sandhofer Strasse 116.

Visited (1) 11th August 1945.
(2) 14th August 1945.

This firm is contained within the premises of a large chemical works all the property of Engelhorn & Co. The chemical works makes a variety of products and was stated to be the largest unit making quinine in Germany. Waldhof is a suburb lying two or three miles North East of Mannheim.

I. Personnel Interviewed.

When visited 11th August Mr. Holzer was interviewed. Mr. Holzer was engineer to the chemical works and knew nothing of the brick plant. When visited 14th August Mr. R. Engelhorn (Director) and Mr. F. Baumhauer interviewed. Dr. Schaefer, chief chemist, was ill.

II. Products and Capacity.

High Alumina
Magnesia
Chrome Magnesite
Sintered Magnesia products.

Capacity of Plant :-

	1939	1942
High Alumina Dynamidon	2,400 tons	1,900 tons
Magnesite	1,100	1,400
Chrome Magnesite	2,200	100
Spinel Bricks	-	700

III. Flow Sheets for Each Product.

High Alumina (Dynamidon)
Magnesia
Chrome Magnesite
} Same flow sheet

1. Purchase sized materials
2. Temper in mixer with 6-7% water
3. Formed in vibrating moulds
4. Dried in warm room 8 days
5. Fired in periodic kilns

IV. General Description of Process.

A. Dynamidon 65 per cent Alumina Product.

Raw Materials 80 per cent sintered bauxite (0.24 inch grains)
20 per cent clay.

ometimes fused corrundum replaced part of bauxite.

Vibrated in a mould with 6-7 per cent water, fired in 35 hours to 1400°C (2550°F) when fuel is discontinued. (no soaking period).

With muffle blocks a wooden mould is used but blocks are dried on a plaster plate.

The bricks are used in rotary cement kilns and in the lead industry.

B. Magnesia Brick.

Raw Materials.

Electrically fused Grecian magnesite first used in the original magnesidon brick, this was later replaced by electrically sintered Grecian magnesite.

The management next began to turn to dead burnt Grecian magnesite since the sintered product was costly, and was not homogeneous due to migration of impurities in the fusion process. The Grecian magnesite was dead burnt in shaft kilns and produced by the Anglo Greek Magnesite Co. This also proved variable due to non uniformity in burning. The next change was to substitute specially selected Veitsch magnesite from Breitenau for the Grecian magnesite. The Veitsch product was more consistent in quality. By 1935 substantial quantities of the Veitsch material was being used. No Grecian magnesite has been used since the war began. With Veitsch magnesite the slag resistance increased but thermal shock resistance was lowered. The analyses of these materials are as follows :-

	Silica	Ferric Oxide	Lime
Greek Dead Burnt	2-3%	1.0%	2-3%
Veitsch " "	1-2%	8.0%	1-2%

Crushing and Grinding.

Graded materials are purchased and blended as follows :-

45% 0.04-0.12 inches, 25% 0.008-0.04 inches and 30% 0.004 inches. The grains between 0.004-0.008 inches are not used in the mix.

Mixing and Tempering.

An Eirich mixer is used, the time for tempering is 5 minutes with 6 - 7 per cent water. No sulphite lye is used in the magnesite batch.

Forming.

The bricks are formed in vibrating moulds. This is considered preferable to machine pressing although it is slower in production.

Drying.

Bricks are dried in a warm room on wooden pallets at 80 - 95°F for 8 days.

Firing.

The magnesia bricks are fired in periodic kilns the setting being 6 feet high. The firing cycle is 1500°C (2730°F) in 30 hours, held for 3 hours and cooled, the kilns being turned over in 8 days. The fuel consumption is 40 - 50 per cent, brown coal briquettes being used. The kilns require repair after about 2 years service. They are built with a siliceous firebrick backed with 1/8 inch of chrome magnesite paste.

Manchurian magnesite has also been used. The management said it was very uniform and well burnt.

C. Chrome Magnesite Bricks.

Raw Materials.

Veitsch Magnesite
Turkish, Greek or Bulgarian Chrome Ore of very varied analyses.

The best results are obtained with Turkish Chrome Ore.

Crushing and Grinding.

All materials were bought graded. The batch consisted of :-

5 per cent magnesite dust.
30 per cent magnesite dust 0.04-0.12 inches grading
25 per cent of chrome ore dust
40 per cent of 0.08-0.12 inches chrome ore

Mixing, Forming and Drying.

The same as for magnesite.

Firing.

The firing cycle is 1520° - 1540°C (2720-2800°F) soaking period being four hours.

Service Results and Uses.

Roof life obtained at Bochumer Verein No. 4 shop on a 60 ton furnace using cold pig and scrap was 500 heats.

D. Spinel Bricks (V 33 bricks)

Raw Materials.

75 per cent magnesia
25 per cent ferro-chrome slag largely magnesia aluminate.

The magnesite is used in the medium and coarse fractions, the spinel in the fines.

The production follows that of chrome magnesite bricks.

Uses.

Hearths of pre-heating furnaces and copper refining furnaces. The spalling resistance was good the expansion coefficient being about 8×10^{-6} (20°-1000°C. 68-1832°F).

V. Additional Notes.

(i) The management said that Radenthein did not use fine chrome ore in their bricks, but sold it to the chemical industry.

(ii) Radenthein were alleged to have used many varieties of chrome ore but obtained their best results with Turkish chrome.

(iii) The management consider Veitsch Ankrom bricks to be quite as good if not better than Radex E.

(iv) Experiments have been made on the manufacture of stabilised dolomite bricks aiming at a tricalcium silicate composition using additions of fine sand as the source of silica. The stabilisers used in their order of preference are (1) B_2O_3 (2) P_2O_5 (3) Cr_2O_3. Chrome was not regarded as satisfactory in this respect. The clinker was burnt as dobies at 1500°C (2730°F) in periodic kilns, crushed, size similarly to the magnesia brick grading and fired at 1450°C (2550°F).

(v) Table I shows the analyses, properties and characteristics of the four type of brick manufactured. This tabulation was submitted to Mr. Engelhorn and Mr. Braumhauer who confirmed the data which was obtained by a previous metallurgical commission.

(vi) During the war this firm was rationed to 2,000 tons of magnesite products.

(vii) The analyses book was examined and in the opinion of the team the analyses are doubtful.

VI. Summary.

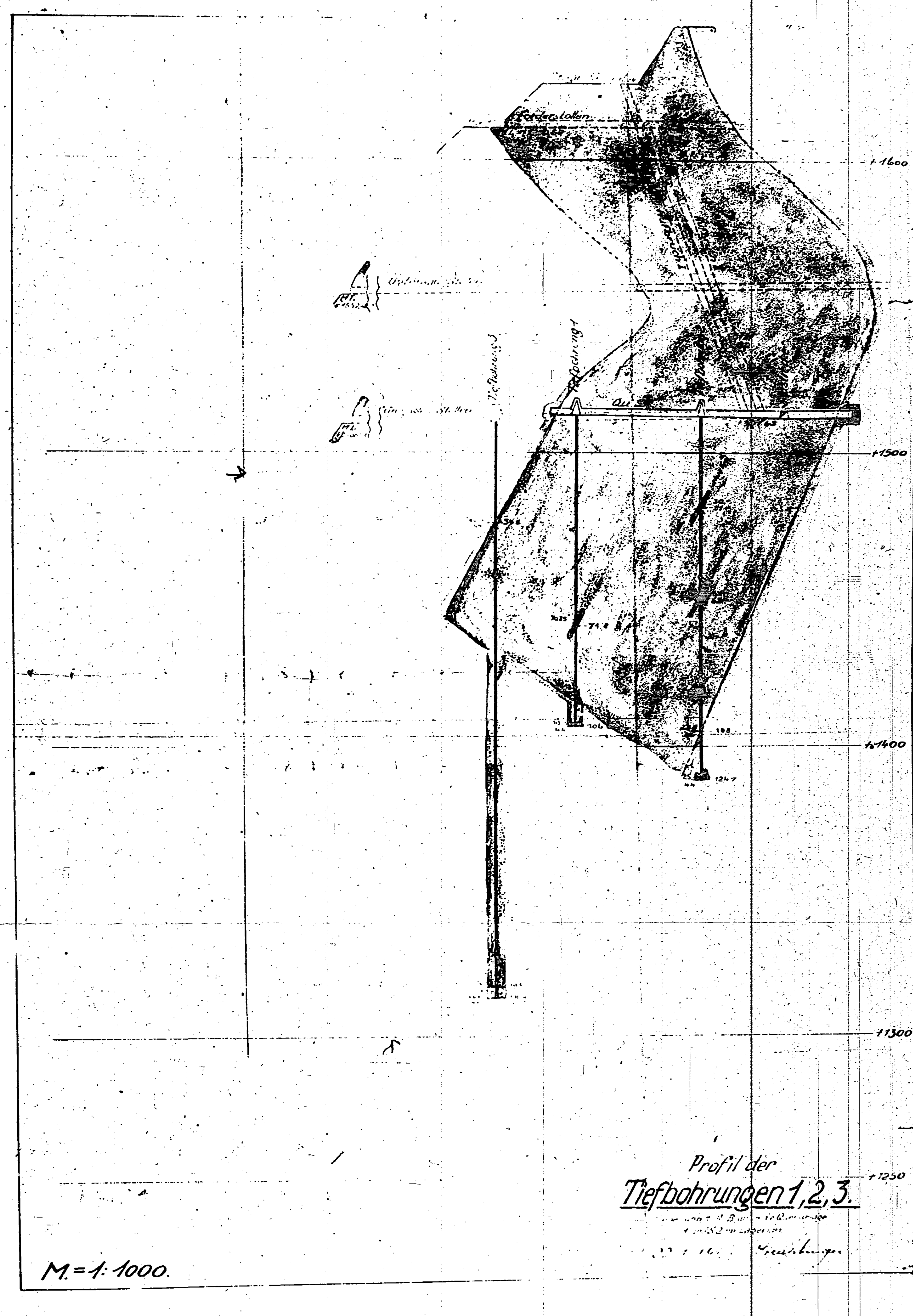
At this works production was unusual in that the bricks were formed from a wet vibrating mass. The drying was a very slow cycle at a low temperature. The bricks were fired in very small kilns, the firing cycle being exceedingly rapid resulting in a quick turnover of kilns. The stacking height (6 feet) was unusually high considering the final firing temperature was 1400° - 1500°C (2550-2730°F).

VII. Personnel of Investigating Team.

J.H. Chesters.
M. Douglas.
G.R. Rigby.
G.E. Seil.
F.L. Toy.

TABLE NO.I. **Approximate Properties of Special Refractories made by Dynamidon G.m.b.H. Mannheim-Waldorf.**

Properties	Dynamidon Brick	Magnesidon "V36" Brick	Magnesidon "V33" Brick	Magnesidon "35" Brick
Chemical Composition				
Silica	20-25%	2.5%	3.0%	5.0%
Alumina	65-70%	1.2%	23.0%	9.0%
Ferric Oxide	5.0%	4.5%	4.0%	10.0%
Titania	3.0%	-	-	-
Calcium Oxide	0.5%	3.8	2.0%	1.0%
Magnesium Oxide	-	-	68.0%	45.0%
Chromic Oxide	-	-	-	30.0%
Ignition	-	-	-	-
Bulk Density (g/c.c.)	2.35	2.7	2.65	2.9
Water Absorption	-	9-10%	9-10%	6-8%
Porosity	25%	24-25%	24-25%	21-24%
Refractoriness	Seger cone 38	2000°C(3630°F)	2000 C(3630°F)	-
Refractoriness under load (28.4 lbs per sq. inch)				
Initial failure	1400°C(2550°F)	1600°C(2910°F)	1550-1560°C (2822-2840°F)	1560-1650°C ([illegible]°F)
Fail temp.	1600°C(2910°F)	1700-1750°C (3090-3180°F)	1700-1750°C (3090-3180°F)	1760°C ([illegible]200°F)
Thermal Expansion	at 1300°C(2370°F) 0.6%	at 1000°C (1832°F) 1.2%	at 1000°C (1832°F) 0.8%	-
Spalling resistance	-	Good	Very Good	Slight
Cold crushing strength, in lbs per sq. in.	-	5,000	3,[illegible]	-
		- Sla.-		


+1600
+1500
+1400
+1300
+1250
Profil der
Tiefbohrungen 1,2,3.
M.=1:1000.

PLANT NO. 15

Austro-American Magnesite Company (up to the war).
Deutsche Magnesit A.G. (during the war).
Osterreichische Magnesit A.G. (since the war).
Radenthein, Austria.

Visited 19th and 20th August 1945.

I. Personnel Interviewed.

Dr. O. Hauschka (Administrator)
Mr. R. Nechwatal (Commercial Director)
Mr. P. von Lanser
Mr. J. Bersek (Consulting Engineer)
Mr. W. Blaschinz (Production Manager)
Mr. A. Fehmes
Mr. F. Bartu
Mr. K.F. von Kahler (Physical Chemist)
Mr. H.L.M. Steyrleithner (Head Engineer of Maerz Offenbau a subsidiary plant)
Mr. A. Awerzger (Mines Manager).

NOTE: The firm has recently engaged Mr. Konopicky as a research worker.

II. Products and Capacity.

1. Magnesite M.D. brick.
2. Magnesite Radex A brick.
3. Chrome-Magnesite Radex E brick.
4. Radex E.K. brick.
5. Radex B brick.
6. Magnesite Clinker.
7. Caustic Magnesite.
8. Heraklith Board.

Production per month in 1944 -

3000 ton of bricks.
2000 ton of ramming mix (Clinker)
5000 ton of caustic magnesite (see Heraklith report)

Analysis of Brick production is as follows:-

	Magnesite M.D.	Radex A	Radex E.
Percent of tonnages in 1938	10-15	30-40	50-60
Percent of tonnages in 1944	50-60	30-40	0-20

(For capacity of Heraklith Board see separate report on this plant.)