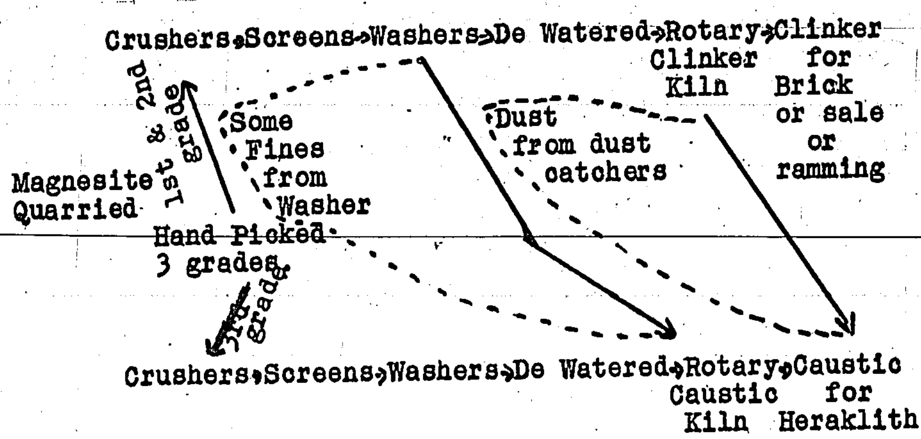
Exports to the U.S.A.

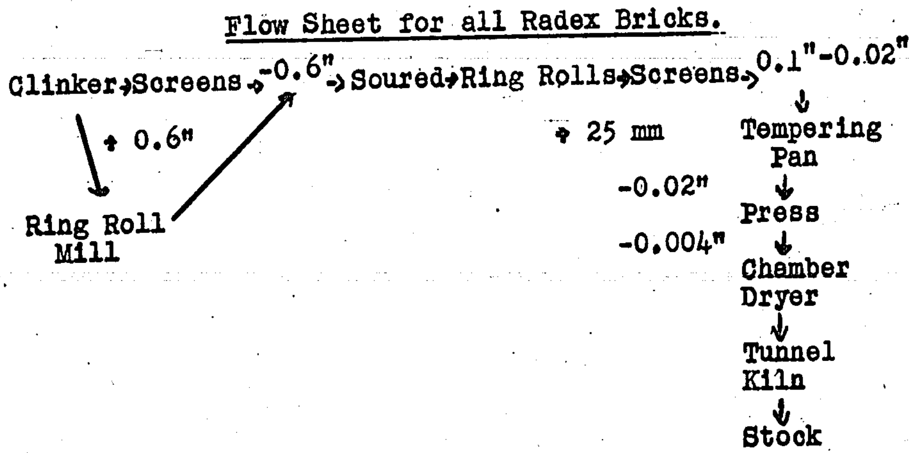
1928-1929 50,000 tons of magnesite clinker was exported.
1935 12,000 " " " " " "

III. Flow Sheets for Each Product.

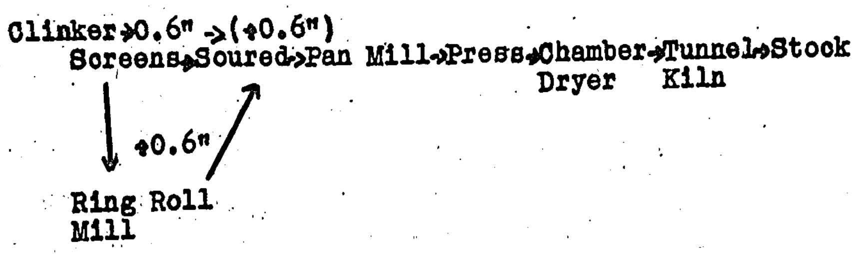
Flow Sheet for Caustic and Clinker.



Flow Sheet for all Radex Bricks.



Flow Sheet for Magnesite Bricks



IV. General Description of Process.

A. Raw Materials.

1. The Magnesite Quarry.

The proportion of overburden and reject stone varied in different parts of the quarry. In one position the reject stone was small but in another area was so high that provision was being made to mine the magnesite. It was stated that 300 men could mine 500 tons of magnesite a day. The magnesite is sorted into 3 grades according to the following table.

Analysis of Three Grades after Dead Burning

Percentage	Grade I for Radex A,E & EK	Grade II for Magnesite M.D	Grade III for Heraklith
Silica	2.5 - 3.0%	3.0 - 3.5%	4 - 6%
Ferric Oxide	4	4	4
Alumina	1	1	1
Calcium Oxide	2.5 - 3.0	3 - 4	4 - 8
Loss on Ignition	0.0	0.0	0.0
Magnesia	Obtained by difference	Obtained by difference	Difference

The reserves estimated by Radenthein at a consumption of 500 tons of raw stone per day is at least 20 years. The sorted rock is loaded into cars which are taken to a cable railway and the overburden and rejects are thrown over the hill. There are 4 shovels, 2 are 26.4 cubic feet capacity and 2 are 17.6 cubic feet capacity, these are only used for removal of reject. In the future it is hoped to instal a picking belt or table in the quarry and to crush at the top level. A tunnel has been run beneath the south quarry and analyses of the boring cores are given in the following table No. I (attached). These boring cores have been made at three stations along the tunnel as shown in Plate I.

Three separate bins are installed, one for each quality of material. There are three mills, each mill has a gyratory crusher, a screen and a washer. No. 1 washer is a helical screw washer, No. 2 and 3 washers are the inverted cone type. The function of the washers is to remove the material -¼ inch in size.

The screens are in closed circuit with the gyratory crushers and yield a product -3/4 inch. These mills yield 500 tons per day of good rock and 70 tons per day of refuse containing 25% silica.

The coarse washed product is transported to a silo and thence by bottom discharge on to an automatic weigh conveyor to the rotary kiln feeder. There are two rotary kilns, one for producing clinker and caustic and a smaller one for caustic only. The clinker kiln is 330 feet long and 9 feet 4 inches in diameter and is heated with pulverised coal. The smaller kiln is 164 feet long and 6 feet in diameter and produces caustic magnesite. Both kilns are attached to Cotrell dust extractors, the dust collected being caustic magnesite. The clinker kiln is lined with Radex A 9 inches thick in the burning zone and firebrick in the remainder. The lining life of the Radex A section varies from 6-12 months. No trouble has been experienced with clinker rings. The feed end of the kiln is equipped with lifters and the speed of rotation is 1 revolution in 4 minutes. The kiln is normally fired with pulverised coal though a producer gas plant is available whenever it is deemed necessary to keep the coal ash out of the finished product. Coal consumption is 30%. Silesian coal is used with a volatiles content of 20% and prewar ash content was below 6% but during the war rose to 15%. The calorific value of the coal prewar was 11000-12000 B.T.U. With low ash coal the silica pick up amounted to 0.2%, but with high ash coal this reached 1.0 to 1.5%. The burning temperature is 1750°C (3180°F) and the back end temperature 350-400°C (660-750°F). There is no carbon dioxide waste heat recovery. The clinker is cooled in a rotary cooler in which 75% of the air for combustion is pre-heated. The shell of the cooler is water spray cooled and the temperature of the product leaving the cooler is 200°C (390°F).

The bulk density of the clinker is 1700-1750 gr. per litre on the 1 - 2 m.m. fraction. An instrument room attached to the kiln had the following :

1. Producer gas volume metre
2. Coal consumption metre
3. Draught recorder on the fire head
4. Draught recorder on the cold end
5. Hydrogen and CO recorders on the waste gases
6. Temperature recorder on feed end
7. Temperature recorder for waste gases
8. Kiln revolution recorder.

B. (1) Preparation of Batch for Radex Products.

The clinker is sized in a ring roll crusher so that it all passes a 15 m.m. sieve. It is then treated with 2% of water and allowed to stand 4 days. During this period it reaches a temperature of 80-90°C (176-194°F) and any discreet particles of lime are hydrated. At the end of 4 days the material is cool and dry and has a loss on ignition of 0.1 - 0.2%.

Secondary grinding consists of a ring roll and screen in closed circuit yielding two products, a coarse material varying between 0.1" and 0.2" and a fine material -0.2" which is ground to fines in an air swept cylindrical ball mill using steel balls. The ball mill is 10 feet in diameter by 13 feet long and the product from this ball mill is less than 0.004" in size.

The ratio of coarse to fine is 7 : 3, if there is not sufficient fines in the primary grinding a proportion of 0.6" clinker is fed in the ball mill to meet requirements.

The grain sizings of all the Radex products is similar to the above.

Type of Brick	Radex A	E.	EK.	B.
Coarse material	70% magnesia	70% chromite	70% magnesia	70% fused magnesia (0.16" - 0.31")
Fine material	25% magnesia 5% alumina	30% magnesia	20% chromite 10% magnesia	30% fused magnesia

The batch is now tempered in Eirick mixers with no rollers but paddles. 4-5% sulphite lye solution (25° Baume) i.e., 1% of sulphite pitch dry basis is added to the mix. The tempered batch is transported by grab bucket to the press bins.

(2) Preparation of Batch for Magnesite M.D. Bricks.

The weighed batch of 0.6" soured magnesite clinker is tempered in an edge-runner mill with solid bottom and rotating heavy mullers. 5% of 25° Baume sulphite lye is added and tempering continued until the operator judges by feel that the batch is ready for pressing.

C. Moulding and Pressing.

There are 8 hydraulic presses and 1 mechanical press, all of which yield equally good bricks. The pressure on all presses is 7½ tons per square inch. The hydraulics each producing 250 bricks per hour and the mechanical 750 brocks per hour; 4 men operating each press. The material for each brick is measured by volume. Liner plates are 12 - 15% chrome steel and 45,000 bricks are made from each liner before repairing. The bottom and top plates are ordinary carbon steel. No de-airing is used on the presses. Wooden strip pallets are used for drying.

D. Drying.

The pallets are set in a chamber batch dryer. The dryer is operated at a temperature of 80°C-120°C (176-250°F) and dries the brick in 8 hours. Air for drying is taken from beneath the cars in a tunnel kiln, and 300 cubic feet of air are used per minute in each chamber. The dryer has no humidity control and no attempt is made to control circulation. The dryer loss of a properly soured batch is nil.

E. Firing.

The tunnel kiln is 550 feet long, 8 feet wide and the setting is 42 inches high. Each car holds 1000 9 inch equivalents (see brochure). The setting is 43 inches x 73 inches and the bricks are set 9 courses high on the 3 in. x 9 in. face. There are 75 cars in the kiln and the push can be varied between 6 and 30 cars in 24 hours or from 48 minutes to 240 minutes a push.

The bricks are burned at 1550°C-1600°C (2820-2910°F) and are held at the highest temperature from 6 to 30 minutes inversely in accordance with the time of push. At a push of 30 cars per day the cars leaving the kiln are at a temperature of 200°C (390°F). No air is blown into the kiln, the kiln is divided into ducts through which air passes. The lower passage wag is underneath the cars and is used for two purposes; first it cools the metal understructure of the car, and second it is used for drying the wet brick. Air for combustion is drawn into the air passage way about the cars by an exhaust fan at the entrance of the kiln. The gases passing through the kiln have three functions; as the air enters the kiln it is pre-heated as it cools the fired bricks, it is mixed with the gas in the firing zone and is used for combustion, the products of combustion pre-heating the green brick as they approach the firing zone. A portion of the air enters the walls of the kiln from the chamber underneath the cars at points adjacent to the gas ports. As high as 25% of undercar air is induced into the kiln. The diminished pressures in the two passage ways are so controlled to give minimum leakage round the cars.

There were two longitudinal water pipes running along each side of the kiln level with the deck of the cars.

The fuel for the kiln is producer gas and tar, the requirements are 15 to 20% of the weight of the brick in terms of coal. The gas is cleaned and separated from the tar, the tar being then fed through 9 ports in the kiln roof. 40% excess air is used for combustion. The kiln is fitted with a total of 60 burners, 30 on each side of the kiln. The B.T.U. requirement per long ton of bricks is 4,000,000 to 5,300,000. With magnesite bricks the kiln loss is 10-20%, with chrome-magnesite bricks it is 1-3%, and with the magnesite M.D. brick the loss is still higher.

The extra firing zone and a portion of the pre-heat and cooling zones above the car deck was constructed of chrome-magnesite bricks. Below the car deck the construction was all fire-clay brick. At the time of the inspection the kiln was down and it was possible to inspect the kiln lining. The chrome-magnesite in the hottest zones showed an appreciable thickness of loose sandy material which could be rubbed away by the fingers. Although the kiln had not been repaired for 5 years it was in excellent condition.

The kiln cars showed the extreme effect of heat particularly on the sand seals and sand seal plates. There were no curtains suspended from the roof arch to prevent the free passage of gas over the cars.

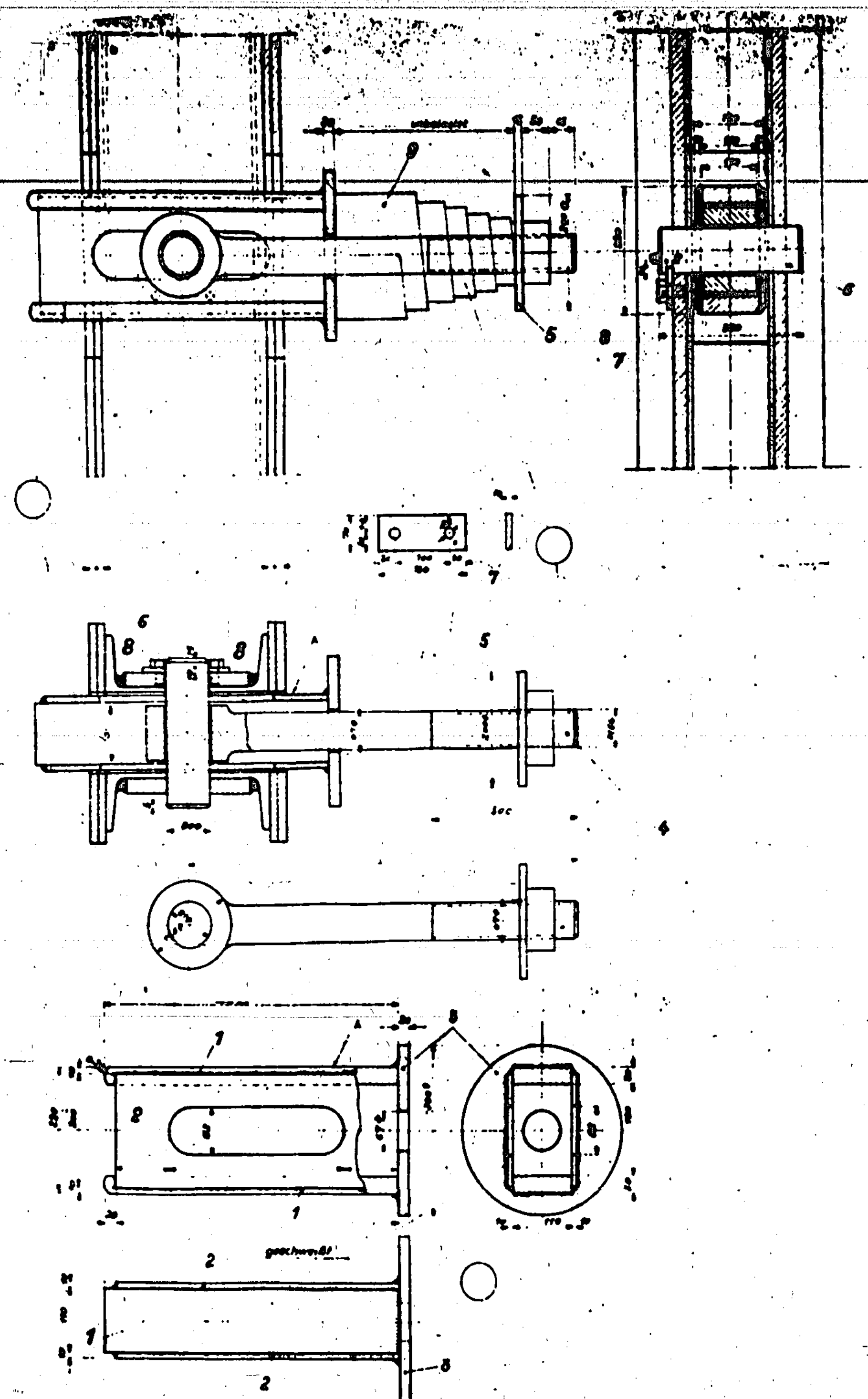
V. <u>Composition, Properties and Characteristics.</u>

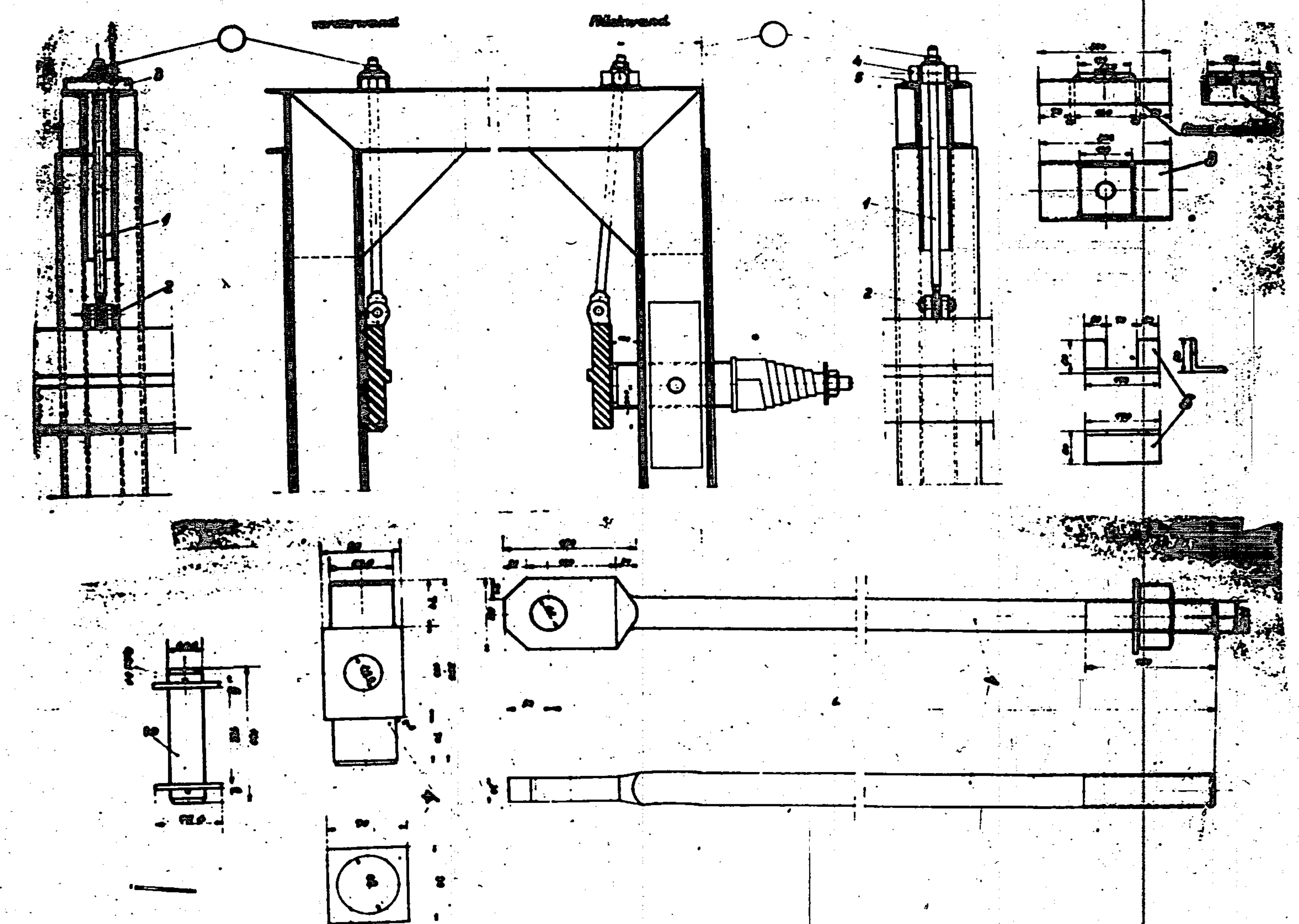
The firm manufactures three types of clinker and caustic and five kinds of brick. The highest grade clinker is used for the manufacture of Radex A, E and EK. The second grade clinker is used for magnesite M.D. and the third grade is used for ramming material and Heraklith. They have also experimented with fused magnesia as a possible substitute for chrome ore in the Radex E. It is interesting to note that when the highest grade material is used for electric fusion, the silica drops to 1.5%, the ferric oxide to 3% and the lime may drop to 2.0%. In the chrome-magnesite Radex E all the chromite (70% of brick) is coarse while on the Radex EK. the added chromite (20% of brick) is all fine. Except in the magnesite M.D. care is taken to eliminate from the batch all material having a particle size between 0.02 to 0.004 inches. The quality of the Radex E varies with the chrome ore used in its manufacture. The management prefers Turkish chrome ore Silica below 5%, Chromic Oxide 40-45%, lime below 1%. The rock should be hard. The Greek ore is high in Silica being 8-10% and is too friable. Serbian concentrates have also been used Silica 6-7%, Chromic Oxide below 42%, but this ore lacked uniformity. The management consider the spalling resistance to be the most important characteristic of Radex E, but it is of interest to note that no iron-oxide bursting tests have been made by them. Other properties considered important are the cold crushing strength (3000 lb.sq.in. minimum), refractoriness under load (28 lb.sq.in.) over 1600°C fail point and bulk density. In addition the firm have developed an after-contraction test (4 hrs. at 1750°C or 3180°F). A good brick should only show 1.0 to 1.5% shrinkage. More recently thermal shock tests have been carried out on bricks used in the shrinkage test. Each brick shows 70 reversals using Turkish Chrome but only 5 - 10 reversals using Balkan chrome due to intrification during the pre-heat. All tests are carried out by D.I.N. methods. The management are satisfied with their Radex E product as made by them before the war. The fused magnesia product which was a substitute owing to the shortage of chrome proved not so good and was more expensive. A complete roof trial on an open-hearth furnace with Radex B has given a life up to date of 850 charges and is still on.

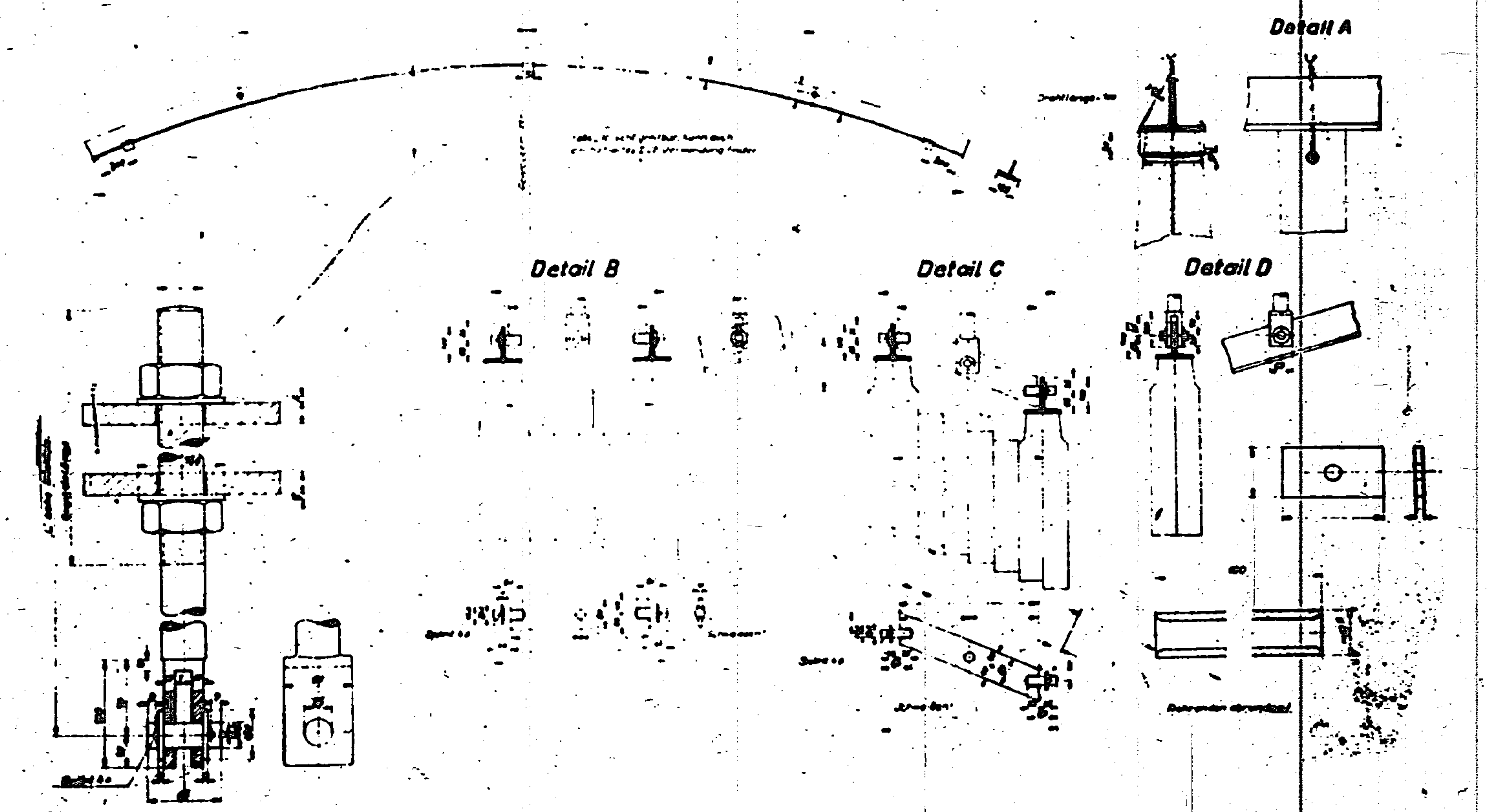
VI. Summary.

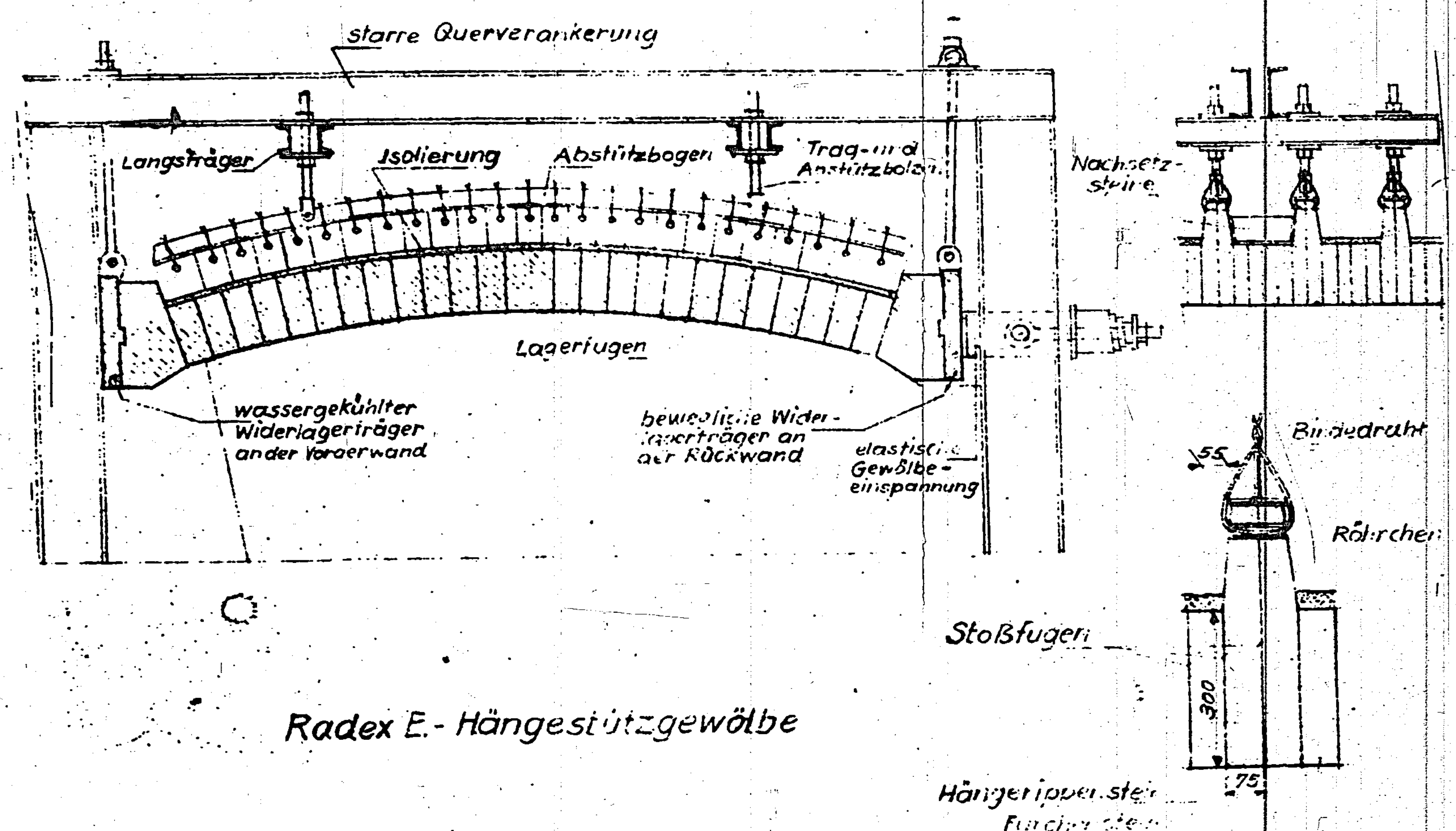
The quarry is in poor condition and underground mining is soon to be attempted. The clinker and brick plant is in excellent condition and the machinery is comparatively modern. Both in the quarry and in the brick plant the output per man hour is exceedingly low. The products made by this company are high grade and are recognised as such throughout the world. The plant has not suffered from bomb damage and as soon as materials (coal and chrome ore) are available the plant can start production.

The drawings shown in Plates 2, 3, 4 and 5 were obtained to show details of basis open-hearth furnace roof construction as recommended by this concern.






Detail A
Detail B
Detail C
Detail D



Radex E.- Hängestützgewölbe

VII. Personnel of Investigating Team.

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

PLANT NO. 16.

The Austro-American Magnesite Company,
The Heraklith Plant,
Ferndorf,
Nr. Villach, Austria.

I. Personnel Interviewed.

Mr. R. Nechwatal
Mr. K.F. von Kahler
Mr. G. Jack (Provisional Manager).

II. Products and Capacity.

A light weight building slab, capacity 500 tons per day (wt. 25 lb. per cubic foot.)

III. Flow Sheet.

```
10-ft aged → 15" → excelsior → coating → pressing → standard
   1 yr lengths  shavings   chamber     bands     lengths
                            agitated    in oven
                    ↑            ↑
               Magnesium      Caustic
               sulphate       Magnesite
                              Powder.
```

IV. General Description of the Process.

A. Raw Materials.

1. Prepared Excelsior from wood.
2. Caustic Magnesite.
3. 15° Baume Magnesium sulphate solution.

B. Preparation of Batch.

The wood shavings are prepared by cutting 15 inch logs longitudinally 3/16 inch in width and 1/32 inch in thickness. The shavings are conveyed through a bath of 15° Baume magnesium sulphate solution and are picked up with a fork drag angle conveyor so that excess liquid drains through and back into the tank. The wetted shavings are delivered into the top of a special shaking tower where powdered caustic magnesia is sprinkled over the wet shavings coating them uniformly. The coated shavings are delivered from the bottom of the tower to forming belts so arranged to yield a board either

1, 2 or 3 inches thick, 19 inches wide and 80 inches long. The belts carry the pressed continuous board through a heating tunnel at 300° - 400°C (570-750°F), though the material does not attain this temperature. The heating period lasts 15 minutes. After the board leaves the belts it is automatically cut into 79 inch lengths by a circular saw. Any defective pieces are reclaimed by cementing two together with an oxy-sulphate cement. The charge consists of the following 100 lb. wood, 30 lb. magnesium sulphate (anhydrous) 200 lbs of caustic magnesite. The magnesium sulphate is dissolved to give a 15° Baume solution.

A sheet is attached describing the properties of the product.

V. Summary.

The plant is in excellent condition and is operating and is producing a product which satisfies the owner. The design of the plant is modern and the product would appear to have a considerable future.

VI. Personnel of Investigating Team.

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

HERAKLITH

Light Weight Building Slab.

Weight per unit volume - 25 lbs. per cu. ft.

Thermal Conductivity.

1" Thick,	0.458 B.T.U. per hour	per square foot	
2" "	0.229 " " "		
3" "	0.153 " " "		

Sound Absorption

Coefficient has a value of -.50 to -.70 in middle range of frequencies.

Noise reduction coefficient -.55 to -.80 according to thickness.

Sound Insulation

4" Heraklith (Plastered both sides) = 49 Decibel
2" + 2" " (With roof felt interlining) = 58"

Standard Dimensions.

Standard Size 79 x 19 3/4" = Approx. 10 3/4 sq.ft.

Thickness	3/8"	5/8"	1"	1 3/8"	2"	3"	4"
Weight per square meter in lbs.	12.2	16.5	25.5	33	41	58	93 lbs

PLANT NO. 17.

Veitsche Magnesitwerke A.G.,
Veitsch, near Mitterdorf, Austria.

Visited August 22nd, 1945.

I. Personnel Interviewed.

Mr. F. Hoschkara (Managing Director since 1921)
Dr. F. Czedih-Eysenberg (Chief Chemist)
Mr. V. Richter (Assistant Quarry Manager)
Mr. K. Biowski (Technical Assistant).

II. Products and Capacity.

1. Deadburnt Clinker.
2. Magnesite Brick.
3. Special Magnesite Brick (Alumina addition)
4. Chrome-magnesite Brick.

Production.	1937.
Clinker	3,050 tons per month.
Bricks	1,300 " " "

III. Flow Sheets for Each Product.

Flow Sheet for Clinker.

Quarry
↓
4-8 inch Magnesite
↓
Stock Feed for Shaft Kilns
↓
Shaft Kilns
↓
Crusher
↓
Screens
↓
7 Disc Magnetic Separators
4 Drum " "

Discard (10-12%)	Sized Clinker (88-90%)
6-8% Silica	1.5-2.2%
3% Ferric Oxide	8.4-8.9%
16% Calcium Oxide	2.0-2.7%
60-65% Magnesite	86.0-86.7%
0.5-0.8% Alumina	0.5-0.8%

Flow Sheet for Brick.

Sized magnetically concentrated Clinker
↓
Pan mills - Screens in closed circuit
↓
Eirich Mixer Magesium sulphate - soln
↓
Presses
↓
Driers
↓
Chamber Kilns
↓
Brick Stores.

IV. General Description of Process.

A. Raw Materials.

(1) The Magnesite Quarry.

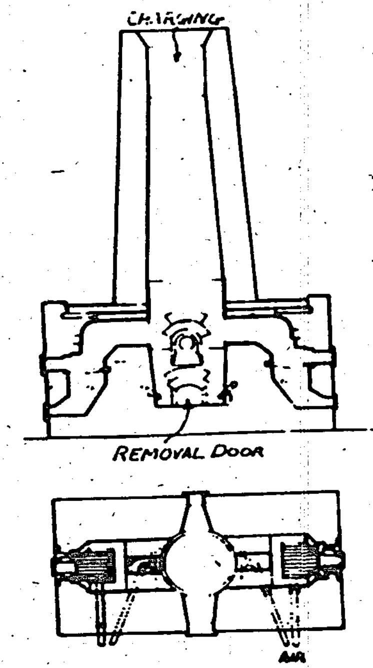
The rock is very coarse grained magnesite forming the entire top of the mountain to a depth of 1000 feet. The impurities consist of veins of white quartz, veins of white coarse grained dolomite and small inclusions of grey schist (graphitic). The yield of usable magnesite (4-8 inches) amounts to 25% of the total material quarried. Conventional quarrying and transportation is practised. Only one grade of stone is quarried for brick. All the stone is tipped into stock and has to be hand loaded into skips for charging into the Shaft Kilns. Before the war they quarried a second quality magnesite with up to 10% lime for furnace fettling. Estimated reserves at present rate 50 years. There are two batteries of Shaft Kilns, four on the old side and five on the new side. All these kilns were originally fired with coal using external fireboxes. Three of the battery of four have been converted to gas firing and are ready to go into production, the fourth being ready for conversion. The capacity of the coal fired Shaft Kilns is 16 tons per 24 hours and the capacity of the gas fired kilns is estimated at 30 tons per 24 hours.

Sketches of both types are shown in Plate I. Ultimately it is proposed to convert seven kilns to gas firing, six to be in operation at one time.

(2) Coal Fired Kilns.

These are 40 feet high and 6 feet 6 inches in

COAL FIRED
SHAFT K[illegible]
AT
[illegible]



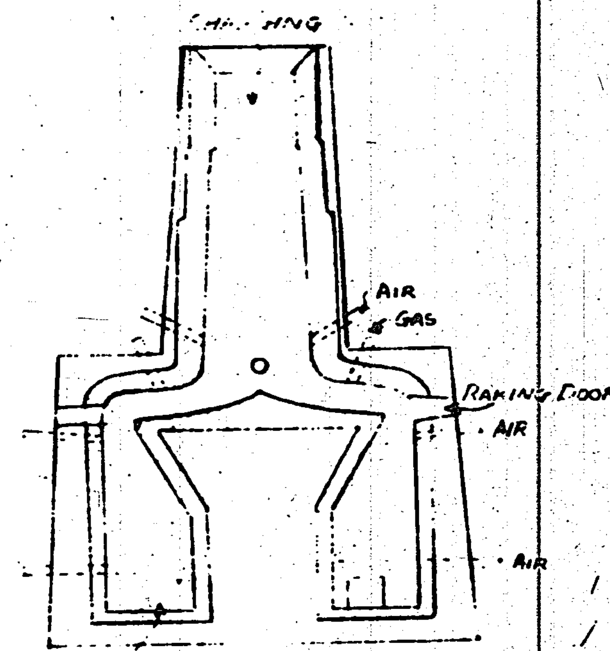


Plate No I
- 94a -

in diameter. They use two fireboxes only. The clinker is withdrawn by hand every four hours. The estimated burning temperature is 1500°C (2730°F) and the coal consumption 35% on the clinker basis. A blast pressure of 1 lb. per sq. inch is employed in two streams, one below the fireboxes and the other above the grate and below the stack. The exit gas temperature is 200-300°C (390-570°F). A magnesite brick lining is used in the burning zone and the remainder fire-brick. No steel shell is used. The lining life is 3 years.

(3) Gas Fired Kilns.

These are 52 feet high and 8 feet in diameter. They use two burners only, the producer being blown in at a pressure of 1 lb. per sq. inch and a temperature of 100°C (212°F).

(4) Rotary Kiln.

In 1922 a rotary kiln 200 feet long was installed but much trouble was experienced with balling up and ringing. Further, the product was considered inferior to shaft kiln material and rotary practice was discontinued.

(5) Magnetic Separation.

The product from the shaft kilns is screened and the oversize is ground in closed circuit. The graded products are put over magnetic separators, grading being essential for efficient separation. 88-90% of the clinker is magnetic and 10-12% of non-magnetic material is rejected. Magnetic separation is not applicable to low iron material or a rotary kiln product. The rock in this quarry lends itself particularly to this method of treatment.

B. Preparation of Batch.

For brick production the material is ground to suitable grain sizes using four edge runner mills and a Mexicon roll mill to produce the fines. Material from the pan mills is screened to pass 0.08 inches the oversize being returned to the mill. It is then screened and stored in bunkers. The various sizes are weighed on scale cars and mixed in an Eirich mixer with 1% of dry Magnesium Sulphate and enough 30° Baume solution of Magnesium Sulphate to yield 3% of water in the tempered batch. This adds approximately an additional 2%

of Magnesium Sulphate. The management claim that the Magnesium Sulphate combines with free lime to give gypsum and with magnesia to give green strength.

C. Moulding and Pressing.

There are seven hydraulic presses of various sizes but all exerting a pressure of 15,000 lbs per sq. inch. The output is 300 bricks per hour per press employing 4 men and 2 women. The mix is weighed into the moulds. Chilled white iron is used for liner plates and ordinary carbon steel for top and bottom plates.

D. Drying.

The bricks are set on rack pallettes in a room above the kilns. A temperature of 30°C (86°F) is employed. Drying time is calculated at 1 day for each 2 pounds (per brick).

E. Firing.

They use conventional Mendheim kilns burning to a maximum temperature of 1600°-1700°C (2910-3090°F). The coal consumption is 32-35%, a mixture of 80% black coal and 20% lignite being used. The soaking period at top temperature is 10-12 hours and the firing time is 50 hours. The bricks are set 14-15 high and rejects are 8% of which 6% are used internally. Magnesite bricks are used to kine the floor and walls of the kiln, the roof being of Ankrom.

V. Composition, Properties and Characteristics.

The gradings used for the special bricks are as follows :-

Chrome Ore (50%) Ma--

Ankrom 0.16-0.08 inches

0.08 -

TABLE NO. I   Magnesite and Special Magnesite Refractories

Properties	Veitsch Magnesite	Trieben Magnesite	Ankrom ∠50	V165	Ankral	Ankral*	Ankral I	Ankrit P.F.	Ankrit H.F.
Chemical Composition in %									
Silica	1.5-2.2	1.6-2.4	4.0	2.7	1.7	1.7	1.6	1.5	1.5
Alumina	0.5-0.8	0.4-0.8	13.5	7.0	8.0	4.76	7.0	0.5	0.5
Ferric Oxide	8.4-8.9	4.5-4.8	13.0	11.0	9.3	10.42	8.0	8.0	8.0
Calcium Oxide	2.0-2.7	2.2-3.0	1.0	11.7	2.32	2.78	2.4	2.5	2.5
Magnesium Oxide	86.0-86.7	89.6-90.8	48.0	65.5	75.2	76.19	81.0	87.4	87.4
Chromic Oxide	-	-	20.5	12.0	3.17	4.56	-	-	-
Ignition	0.1-0.2	0.1-0.2	0.13	0.1	0.04	0.08	0.1	0.1	0.1
Cold crushing strength in lbs. per sq.in.	9250-12900	9250-12900	2850	4280	4700	5700	2850	5000	-
Thermal shock resistance at 950°C (1740°F) Shocks.	0-2	0-1	>30	>40	>30	>40	20	10	10
Refractoriness under load of 28.4 lbs. per sq.in.									
Initial failure °F	3090	2985	3000	2840	2840	2785	2805	3090	3165
Failure temp. °F	3270	3130	3090	2910	2950	2820	2820	3270	3220
Bulk Density	2.90-3.05	2.80-2.96	3.90-3.00	2.86-3.04	2.80-2.96	2.81-2.94	2.70	2.85-2.95	-
Porosity %	17-21	19-22	22-25	18-21	19-24	20-23	26	18-20	-
Thermal Expansion 1000°C (1832°F)	1.2	-	0.88	-	1.1	-	-	1.2	-
Thermal Conductivity	3.3	-	1.74	2.35-2.40	2.35-2.65	2.35			-

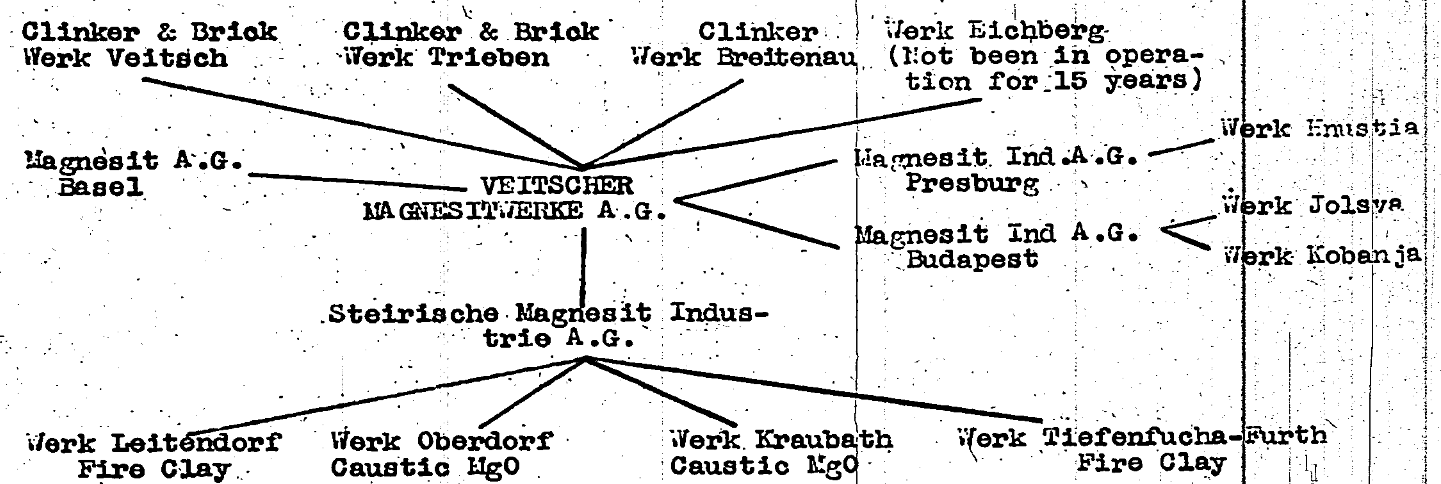
nature of the rock and the burning method make magnetic separation practicable, particularly with the good plant available. The shaft kilns are not modern in design. Although they are being re-designed for gas firing the new design does not approach modern practice. The brick plant does not contain modern equipment, the number of man hours per unit being exceptionally high. An analysis of the total labour employed is worthy of record and is as follows :-

	Men	Women	Production.
Quarry	245	-	7,500 tons per month
Shaft Kilns	89	-	3,500 " " "
Magnetic Separators	10	18	3,050 " " "
Brickworks.	113	45	1,300 " " "
Maintenance and General Labour	339	36	
Total ...	796	99	

VII. Personnel of Investigating Team.

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

ASSOCIATED PLANTS.



APPENDIX NO. I.

Translation of an abstract of

Standardization of Magnesite Brick and Special Magnesite Brick for Open-Hearth Furnaces.

Report No. 408 of the Steelworks Committee of the German Iron and Steel Institute.

This work is a continuation of the standardization of refractories for use in the open hearth furnace and supplements that of the silica brick. It has been carried out by the collaboration of experts from the steel industry and refractories manufacturers. One objective has been to increase the output of the refractories industry by reducing the number of shapes and sizes which are to be made in the future.

Because both silica and basic brick are used in these furnaces the standardization of brick made of both materials should be the same as far as is possible. Attention was directed to differences in methods of manufacture, of laying the brick and the special shapes that are required for different parts of the furnace.

The result of this work is presented in Blatt 1 to 3. These standards have as their basis experience gained from operations in many furnaces of various sizes and over a period of years. Furthermore the shapes are designed so that they can be made by the hydraulic press and no hand made pieces are to be made.

The standard bricks are 9.8" x 4.9" x 2.56" of DIN 1081 code No. 2. During the transition period only are the bricks of code No. 1 (9.0" x 4.5" x 2.56") to be used and only when it can be proved that the latter can be made at lower cost.

The number of standard brick may appear to be large but on the other hand only one basic dimension for each shape has been used. This reduces the total number of basic dimensions to twenty. A mold box made for one basic series can be used for arch brick having different angles by changing the press plates to obtain the desired angle.

The code numbers were based on the DIN 1082 standards or those for silica brick and new code numbers have been assigned only to new shapes. The first letter of the code indicates the radius (meters) of the arch and the second the order of the thickness of the arch.

I. Arch of the Furnace.

Experience has shown that for magnesite arches it is better to use keys rather than wedges. The wedges shown in Blatt 1 may be used for the end of the arch and only in exceptional circumstances for other portions of the roof.

A survey of a large number of open hearth furnaces shows that even from the smallest to the 120 ton furnaces can be built with arches of 13.1, 16.4 and 19.7 feet in diameter.

Inclined air shafts and highly inclined hearth arches will require chipping of keys Q21, 22, 41, 42 and 43 (Blatt No.1).

The arches for the port ring of cold gas furnaces are to be built with a radius of 6.5 feet using brick Q21 and 22.

The various keys can be used for the usual arch construction or as brick between ribs. The 11.8" (300mm) keys have proved adequate for the horizontal arch whereas for the inclined arch the 14.7" or 17.7" may be required.

Because the density of magnesite brick is higher than that of silica the effects of the increased weight and pressures must be taken into account by building reinforcement ribs to increase the stability. A good method of construction is to suspend or hang two rib bricks and then four courses of regular brick. The ribs are 7.9" longer than the other brick. When the arch becomes thin, insert brick (Blatt 3) may be placed between the slightly wedge shaped rib brick to extend the life of the arch. The L dimension of these insert bricks has not been standardized.

II. Skew Brick.

One skew has (Blatt 2) been standardized for use in the whole upper structure of the furnace. Skews 11.8" (rather than 10.2") may be made if no difficulties are encountered.

Skews for the back wall and the inclined air flue are made without tongue and groove but it is permissible to use them for the front wall construction. A notch of 1.2" x 2.4" is provided in the back of these skews for the purpose of fitting over plates attached to the skew back of the furnace.

Even when using the chrome-magnesite which are sensitive to temperature changes it is not necessary to use a complicated door arch. A plate suspended from the furnace steel work should be provided for the skew to rest against and the lower portion of the skew should be provided with a water cooling device. If a protecting arch is to be used it should also be given water cooling at the skews.

III. Front Wall Brick.

The door columns and side walls of basic brick should be well constructed with broken joints and little or no chipping of the brick should be necessary. Consequently the shapes V2B and V2L in Blatt 2 have been provided. The walls and columns should be inclined 15^{o} to 20^{o} and for this purpose the shapes 2G and 2BS of Blatt 1 are to be used in starting their construction.

IV. Vertical Flues.

The flues for producer and mixed gas furnaces can be built mainly with standard brick but cold gas furnaces require keys. Construction requiring a double tapered key brick should be avoided and no standards have been set up for these.

V. Gas Flues, Slag Pockets and Checker Chambers.

The arches used in these areas of the furnace can be built with DIN 1082 standards. In order to provide shapes for circles of smaller diameter the basic shapes (Blatt 1) were changed to conform to an average taper of $\frac{a - b}{2} = 65$

The arches of the checker chamber are to be built with the 9.9" x 9.9" wedges of Blatt 3 (4G series). The various chambers may be built with whole, half or double brick or a combination of these. The special bricks 2S (Blatt 1) are for the bottom of the flue construction. A special tap hole shape 2H50 (Blatt 3) for a radius of 40" is provided and by combining various arch brick all the desired diameters of circles can be obtained.

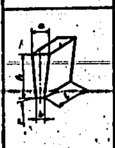
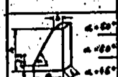
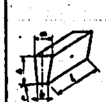
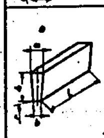
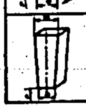
Bricks smaller than the basic shape 2 were used in recent years with great success for constructing flues in producer gas fired open hearth furnaces. Only the width of these varies whereas the taper remains constant and consequently no additional shapes are needed.

Special wedges are provided in Blatt 1 for the burner opening of the "Maerz" furnace.

Two skews, Wk1 and Wk2 of Blatt 3 for chamber arches, were chosen from the multitude available. When wedges 2G and 4G are used in combination with these, arches of any desired rise can be built.

The end skew WL was designed for use in the air flues in contrast with the Wk1 and Wk2 skews as standardized for silica linings.

Feuerfeste Baustoffe — Blatt 3
Formate der Magnesit- und Magnesitsondersteine für Siemens-Martin-Öfen

Format	Bezeichnung	Kurzzeichen	Maße in mm a	b	h	l	Gewölbe-Radius	Rauminhalt dm³	Bemerkungen
	Doppel-ganz-wölber	4G52	81	30	250	250	196	4,06*	Maß nach DIN 1082; Kammer-, Schlacken-kammer- u. Gaszugge-wölbe
		4G26	78	62	250	250	520	4,06	
		4G16	73	67	250	250	880	4,06	
		4G10	70	60	250	250	1550	4,06	
		4G6	68	62	250	250	2570	4,06	
		4G4	67	63	250	250	4065	4,06	
	Widerlager-steine	WL	250	67	250	65		3,80	Luftzuggewölbe
		WK1	250	135	233	65		3,04	Kammer-widerlager
		WK2	250	62	233	65		3,50	
	Halb-wölber	2H50	90	40	123	250	103	2,00	Gaszug-, Einsetzloch- und Abstichlochge-wölbe
		2H26	78	62	123	250	255	2,00	
		2H16	73	67	123	250	454	2,00	
		2H10	70	60	123	250	763	2,00	
		2H6	68	62	123	250	1312	2,00	
	Halb-wölber	2A26	56	30	123	250	152	1,33	Sonderhalb-wölber für Gaszugge-wölbe
		2L26	56	30	123	375	152	1,98	
		2A16	46	30	123	250	248	1,17	
		2L16	46	30	123	375	248	1,75	
		2A10	40	30	123	250	394	1,08	
		2L10	40	30	123	375	394	1,61	
	Hänge-Rippen-steine		119	110	500	-	6000		Herdgewölbe. Maß, Kurzzeichen und Ausführung der Aufhängung noch nicht endgültig festgelegt
			173	165	500	-	5000		
			121	110	500	-	6000		
			120	110	450	-	6000		
			180	165	450	-	5000		
			123	110	450	-	6000		
		Als Furchensteine zwischen den Hängerippen sind die auf Blatt 1 angeführten Querwölber zu verwenden oder können Sonderabmessungen angewandt werden, wobei grundsätzlich das Maß b = 110 und für den Verbandstein = 165 zu wählen ist.							

Blatt 3.

3. Vorderwandsteine:

Bei der Zustellung von Türpfeilern kann bei basischen Baustoffen auf die Verwendung von gutpassenden Formsteinen und entsprechend abgerundeten Steinen wegen der schwierigen und zeitraubenden Behauarbeit dieser Steine nicht verzichtet werden, weshalb gegenüber den Silikasteinformen neue Abmessungen vorgesehen wurden. Zur Erreichung guter Haltbarkeiten ist beim Einbau dieser Steine auf einen möglichst guten Verband aller Steinscharen untereinander größte Aufmerksamkeit erforderlich. Bei der Anordnung von Türbogen sind ebenfalls zur Ausschaltung der Behauarbeit die Widerlagersteine notwendig, die auf Blatt 2 dargestellt sind. Es empfiehlt sich, die Türpfeiler gleich den übrigen Seitenwänden des Herdraumes nicht waagerecht, sondern mit einer Neigung von 15 bis 20° auszuführen. Für den Uebergang der waagerechten Scharen des Magnesitherdes zu den geneigt verlegten Steinscharen der Vorder- und Rückwand sollen zweckmäßig die Spitzkeile 1 S, 2 S oder 2 BS angewendet werden.

4. Senkrechte Luftzüge und Tragkränze der Kammern bei Kaltgasöfen:

Während bei den Generatorgas- und Mischgasöfen die Luftzüge zum größten Teil aus Normalsteinen hergestellt werden, findet für die Luftzugwand und die Trompete bei den Kaltgasöfen der Querwölber, der für die Hauptgewölbe vorgesehen ist, Verwendung; falls die Luftzüge oder die Trompeten mit Halbmessern hergestellt werden, werden zum Teil doppelkeilige Wölber als Tragkränze benötigt. Für diese doppelkeiligen Wölber sind keine Normungen vorgesehen, da sie nach den Erfordernissen der Ofenbauweise verschieden hergestellt werden müssen. Zweckmäßig erscheint jedoch, auf die Vermauerung in Radien zu verzichten. Anzustreben ist, die Luftzugtrompeten-Seitenwände ~~von unten her gerade aufzumauern; soweit möglich, sind die Wände auf die Kammerseitenwände aufzusetzen.~~

5. Gaszug-, Schlackenkammer- und Kammergewölbe:

Für diese verschiedenen Gewölbe können folgende Gewölbearten Anwendung finden:

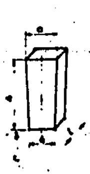
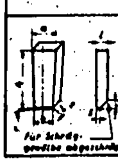
1. Halbkreisgewölbe,
2. Stichgewölbe,
3. Korbbogengewölbe.

Um zu den bestehenden DIN-Normen 1082 nicht noch neue Wölber hinzuzunehmen, wurden die genormten Wölber auch für die Siemens-Martin-Oefen gewählt. Soweit bei den Ganz- und Halbwölbern die Keiligkeit zum Mauern von kleinen Halbmessern nicht ausreicht, wurde unter Berücksichtigung eines mittleren Keilmaßes von $\frac{a+b}{2} = 65$ die Grundform 2 um die entsprechenden Keiligkeiten erweitert. Für die Kammergewölbe wurde die Grundform 4, d. h. der 250 × 250er Stein geschaffen. Gaszug-, Schlackenkammer- und Kammergewölbe können in Halb-, Ganz-, Ganz- + Halb- und als Doppelgewölbe hergestellt werden. Für die Gaszugsohlen wurde der Spitzkeil 2 S mit einer Neigung von 15° geschaffen. Die Wölber für die Zustellung von schrägen Gaszügen wurden gleich den Silikasteinformaten gewählt. Lediglich für die zweckmäßige Ausführung der Abstichöffnung ist noch eine weitere Form „2 H 50" entsprechend einem Halbmesser von 103 mm erforderlich. Durch die Kombination dieser Halbwölber kann somit jede Abstichöffnung mit mehreren übereinandergelegten Halbwölberscharen ausgeführt werden. Für die Zustellung von schrägen Gaszügen von generatorgasgefeuerten Siemens-Martin-Oefen wurden in den letzten Jahren mit bestem Erfolg Halbwölber der Grundform 2, jedoch mit kleineren Steinstärken angewendet, weshalb auch für diese Zustellungsweise einheitliche Abmessungen festgelegt wurden. Da alle diese angeführten Halbwölber in der Grundform 2 hergestellt werden können, wobei bei gleichbleibender Keiligkeit lediglich die Steinstärken verschieden sind, ergeben diese Steinformen keine zusätzliche Erhöhung der Steinformenzahl. Für Brennerköpfe von Oefen nach Bauart Maerz sind schließlich noch Sonder-Ganzwölber G 6 und G 9 vorgesehen worden (Blatt 1).

Aus der Vielzahl der bisher angewendeten Widerlagersteine für Kammergewölbe wurden nach eingehender Prüfung zwei Widerlagersteine für Kammergewölbe ausgewählt; Widerlagerstein WK 1 für Stichgewölbe für 13 % Stich und 60° Zentriwinkel, WK 2 für Widerlager mit 20 % Stich und 87° Zentriwinkel, wobei es möglich ist, durch Verwendung entsprechender 4 G- oder 2 G-Wölber auch Gewölbe mit entsprechend anderen Stichen und Zentriwinkel herzustellen. Außer diesen Widerlagersteinen wurde noch der Widerlagerstein WL geschaffen, der für Luftzugsgewölbe verwendet werden soll. Die Notwendigkeit dieses Widerlagers ist dadurch gegeben, daß die Widerlagerformate WK 1 und WK 2 fast ausschließlich für Kammergewölbe in Silika und nicht für basische Luftzugsgewölbe gewählt worden sind.

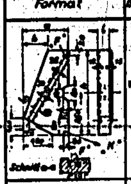
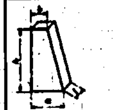
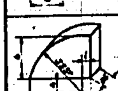
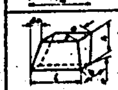
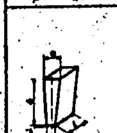
Druck von A. Bagel in Düsseldorf.

Feuerfeste Baustoffe — Blatt 1
Formate der Magnesit- und Magnesitsondersteine für Siemens-Martin-Öfen

Format	Bezeichng.	Kurz-zeichen	Maße in mm a	b	h	l	Gewölbe-Radius	Rauminhalt dm³	Bemerkungen
	Normalstein	2	250	123	65			2,00	
	Verbandstein	2B	250	187	65			3,04	
	Plättchen	2-32	250	123	32			0,98	
	Zirstein	2L	375	123	65			3,00	Vorderwandpfeiler, Rückwand, Luft u. Gaszug
	Spitzkeil	2S	132	65	250	123		2,03	Luft u. Gaszugsohlen,
		2BS	132	65	187	250		4,60	Übergang vom Herd zur geneigten Vorder- bzw. Rückwand
	Ganzwölber	G6	80	50	375	150	850	3,46	Sondergewölbe über Ge...
		G9	71	50	375	150	800	3,40	
		G51	69	65	300	150	6000	3,01	
		G52	70	65	375	150		3,75	
		G53	71	65	450	150		4,60	
		GB52	70	65	375	225		5,70	Gewölbeabschluß für Kippöfen
	Querwölber	Q61	115	110	300	65	6000	2,79	
		Q62	117	110	375	65		2,76	
		Q63	118	110	450	65		3,88	
		Q51	116	110	300	65		2,20	Querwölber mit Anfänger- oder Schlußsteine für Herdgewölbe und Luftzugwände
		QB1	175	165	300	65		3,31	
		Q52	118	110	375	65	6000	2,78	Spannweite 4-7m
		QB2	177	168	375	65		4,18	
		Q53	120	110	450	65		3,87	
		QB3	180	165	450	65		5,08	
 Für Schräggewölbe abgeschrägt	Querwölber	Q41	118	110	300	65		2,23	Querwölber für Herde besonders für Luftzuggewölbe
		Q42	120	110	375	65	4000	2,80	
		Q43	123	110	450	65		3,58	
		Q21	126	110	300	65	7000	2,40	
		Q22	130	110	375	65		2,93	

Blatt 1.

Feuerfeste Baustoffe — Blatt 2
Formate der Magnesit- und Magnesitsondersteine für Siemens-Martin-Öfen

Format	Bezeichng.	Kurz-zeichen	Maße in mm a	b	h	l	Gewölbe-Radius	Rauminhalt dm³	Bemerkungen
 Schnitt a-a	Widerlagsteine	WH3	280	143	450	65		5,32	
			mit Nut und Feder „F"						
		WH4	260	143	460	65		5,32	Herd-, Schräg- u. Luftzuggewölbe
			ohne Nut und Feder „F"						
			mit oder ohne Abschrägung „K" je nach Wahl des Widerlagerträgers						* Maß „a" auch mit 300 zulässig
	Pfeiler-Ecksteine	V2B	187	120	250	65		2,50	Vorderwandpfeiler
		V2L	260	150	375	65		4,88	
		V2R	375	250	85	51		4,70	
	Halbwölber	T	70	60	200	600	1250	6,11	Türbogen und andere Ofenteile
	Widerlagsteine	2WN	250	123	65			1,87	
		2WB	187	250	65			2,78	
		2WL	123	375	65			2,61	
	Ganzwölber	2G6	91	52	250	123	190	2,00	Kammer-, Schlackenkammer- und Gaszuggewölbe
		2G26	72	62	250	123	520	2,00	
		2G16	73	57	250	123	910	2,00	
		2G10	70	60	250	123	1650	2,00	
		2G8	68	62	250	123	2870	2,00	
		2G4	67	63	250	123	[illegible]	2,00	

Blatt 2.

Rechnung getragen werden muß. Als eine zweckmäßige Ausführung hat sich z. B. die Hängegewölbe-Bauweise ergeben, bei der je vier Scharen Furchensteine und je zwei Scharen Versteifungsrippen abwechselnd verlegt werden und alle Versteifungsrippen zur Beibehaltung der Gewölbeform als Hängesteine ausgebildet sind. Da die Hängerippensteine 200 mm höher sind als die dazwischenliegenden 300 mm hohen Furchensteine und die Hängerippensteine im vorschauenden Teil eine schwache Keiligkeit aufweisen, so können bei entsprechendem Verschleiß des Herdgewölbes, und zwar während des Betriebes, zwischen diesen **Hängerippensteinen** sogenannte **Nachsetzsteine** eingesetzt werden, die eine einfache Verstärkung des Gewölbes und somit eine Weiterführung des Ofens gewährleisten (Blatt 3). Zur Bemessung der Hängerippensteine sei noch erwähnt, daß die Stärke l und die Ausbildung zur Aufhängung dieser Steine den Erzeugerfirmen überlassen bleibt.

2. **Widerlagersteine:**

Für den ganzen Oberofen, d. h. Haupt-, Schräg- und Luftzugsgewölbe, ist nur ein Widerlagerstein vorgesehen. Wenn die Herstellung dieser Steine mit der Abmessung a = 300 mm keine Schwierigkeit bereitet, so können auch diese Steine verwendet werden. Während die Widerlagersteine für die Rückwand, das Schräg- und Luftzugsgewölbe ohne Feder und Nut hergestellt werden, können die Widerlagersteine für die Vorderwand Nut und Feder erhalten. Sowohl für die Vorderwand als auch für die Rückwand können die Widerlager mit einer Aussparung von 30 × 60 mm versehen sein.

Die Herstellung des Widerlagers als scheitrechten Bogen über den Türen machte in der bisherigen Form in der Herstellung wegen der komplizierten Formarbeit und der großen Stückgewichte erhebliche Schwierigkeiten. Aus diesem Grunde sind Türbogensteine in der Form von scheitrechten Gewölben nicht mehr vorgesehen, da es sich bisher besonders bei den Chrommagnesitsteinen erwiesen hat, daß man selbst bei diesen empfindlichen Steinen ohne diese komplizierten Türbogensteine gut auskommt, in dem man das Gewölbe gegen die normalen Widerlager wölbt. Bei dieser Ausführung sind bei dem auftretenden Gewölbedruck entsprechend stark bemessene Stahlgußwiderlagerplatten, und zwar sowohl an der Vorder- als auch an der Rückwand, erforderlich, die zweckmäßig an der Ofenarmatur aufgehängt und so geformt sind, daß sie den Widerlagersteinen und somit dem Gewölbe eine sichere Einspannung und ein sicheres Aufliegen ermöglichen. Durch Feder und Nut ist Gewähr gegeben, daß der Widerlagerstein — auch wenn er springt — nicht herabfallen kann. Als zweckmäßig hat es sich erwiesen, über den Türen die Unterkante der Widerlagersteine durch Kühlvorrichtung zu schützen. Neben der Ausführung, die Wasserkühlung in dem Formgußstück der Widerlagerplatten einzuformen, hat sich als besonders zweckmäßig erwiesen, den Kühlrahmen mit einer entsprechend ausgebildeten Nase zu versehen. Werden zum Schutze des Gewölbes nahe der Vorderwand Türbogen vorgesehen, so sind die Türbogensteine „T" einzubauen und zur wesentlichen Erhöhung der Haltbarkeit mit ihrer Unterfläche auf zwei wassergekühlte Tragrohre aufzulegen.

APPENDIX NO. II.

Translation of

STANDARDIZATION OF THE SIZE AND SHAPE OF SILICA REFRACTORIES FOR USE IN THE OPEN-HEARTH FURNACE.

Report No. 396 of the Steel-works Committee of the German Iron and Steel Institute. Published August, 1943 (2nd edition).

The standardization of the size and shape of silica refractories for use in open-hearth furnaces was carried out by a panel of experts selected from the steelworks committee of this organization, the refractories industry and furnace builders. Dr. Ing. C. Krentser served as chairman.

This work became necessary because of demands on the refractories industry for greater output brought about by the higher war time production of steel and because of the inferior quality of the silica brick. An insufficient supply of high grade quartzite has caused the lowered quality of the brick.

Chrome-Magnesite brick are not available and experiments have been started to learn whether Magnesite brick will withstand the conditions encountered in open-hearth roofs.

The standards which have been developed by this group are suitable for the smallest and largest furnaces of fixed or tilting design and when using coke oven, producer or mixed gases.

It is realized that the use of these standards will require changes in practice in many plants but proof of their suitability haw been demonstrated.

When working out these standards an attempt was made to eliminate very large hand molded shapes as well as very small brick, for example quarter brick, small angle wedges and such. Insofar as possible the DIN 1082 was used as a basis for the work. Although the 230 MM (9.05") has been discarded it may be necessary to use it for sometime. Nevertheless it has been ordered that new furnaces are to be built only with the new 250 MM (9.84") brick.

Tables I and II present the standards for the stationary furnaces and No. III those for the tilting furnaces.

I. Main Arches.

The standardized wedge and key brick provide for an arch having a radius of 5.5 M (18') and in widths from 4 to 7 M (13' to 23'). The thickness may be 300, 375 or 450 MM (11.8, 14.8 or 17.7"). The thin dimension of the smaller size Wedges is 75 MM (2.95") and of the Keys 120 MM (4.7"). An end brick, one and a half times the normal width, is included for use in building arches with broken joints. The shapes EI to 9 of Table No. III are for tilting furnaces.

Only one key is recommended for constructing air flues, slag pockets and uptakes having a radius of 1.5 to 2 M (4.9 to 6.6).

The 300 MM (11.8") brick should be used fof plain arches and between the ribs in ribbed arches. The ribs can be either the 375 or 450 MM (14.8 or 17.7") brick. Ribbed arches can be expected to give 20% increased life over the regular arch construction and hot repairs can be made without shutdown. No special brick for use between the ribs are to be manufactured. Mortar is to be used in laying the brick.

Plants using arches with a thickness of less than 300 MM (11.8") may use the wedges of DIN No. 1082.

II. Flues and Inclined Arches.

The main arches may be built of wedges and keys but only keys are suitable for inclined arches and air flues. The ends of the keys are not to be cut off but are allowed to melt off with a saving of labor. In the case of large tilting furnaces the inclined shapes with an angle of 35o as shown in Table No. III can be used.

Arches laid with these standard wedges and keys have a rise of 12%. Keys of the patented Johann design may be used.

III. Special Skews.

Only one skew has been designed for use in the complete upper part of the furnace. This has a tongue and groove for use in the front wall but is not so made for use in the back wall. The tongue and groove is of semi-circular cross sections. (See shapes WH1 and 2 of Table II). These skews have a rectangular notch of 30 x 60 MM (1.18 x 2.36") so as to fit over strips which can be welded or bolted to the skew back member.

Normal arches are to be used over door openings using skews placed against a plate suspended from the upper steel work of the furnace and against the cooling frame of the door. The skews may also be protected by water cooling where they rest on the door opening piers. Special protection of the door arches is permitted but is not advised.

IV. Front Wall Brick.

The silica brick for the front walls are Nos. 1, 2 or 2L of Table No. I and champhered by the use of shapes V1 or V2 of Table No. II. Rounded corners may be had with a little chipping.

Inclined front walls are recommended to obtain stability and wedges or skews may be used at the bottom of the wall to obtain slope of 12° to 15°.

V. Vertical Flues.

The flues in furnaces heated with producer and mixed gases are to be built with standard brick but for coke oven gas heated furnaces Keys are used. Air flues and uptakes if built with curves will require double tapered wedges and these have not been standardized. Such curved construction should be avoided.

VI. Arches for Gas Flues, Slag Pockets and Checker Chambers.

The various arches used in these portions of the furnace can be built with the DIN 1082 standards. The taper for whole or half arches is not sufficient for small diameters, consequently the basic shape 2 (Table II) was changed making use of an average taper of

$$\frac{a - b}{2} = 65$$

Arches in the chambers are to be built with our newly designed standard wedge brick of series 2_G, 4_G or 2_H in Table No. II.

The arch for the gas flue can be started with the special taper or skew brick 1S or 2S of Table No. I and these have an angle of 15°.

Two end skews for chambers were chosen from the large number available. These are WK1 and 2 (Table No. II) and are to be used with arches of 13% and 20% rise.

respectively. Also by using wedges 2_G and 4_G against the skews, arches of other degrees of rise can be built.

VII. Checker Brick.

Important considerations for the checker work are:

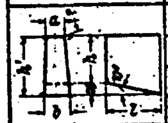
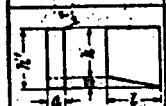
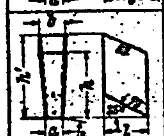
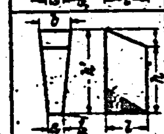
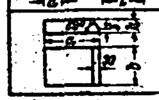
Free passage in the vertical flues
Prevention of slagging
Equalized conditions over the whole area
Top brick of larger size than the lower so that material may fall through the channels without blocking the passage.

It is recommended that the standard brick be used as much as possible although special shapes and honeycomb (LUNGEN) checkers are permissible.

The standard checker brick are Kl, 2 and 3 of Table No. II and brick Nos. 1 and 2 of Table No. I.

Blatt 3.

Zugelassene Silikasteine für Kippöfen

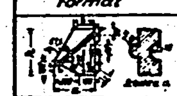
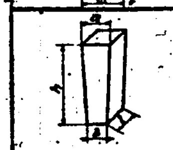
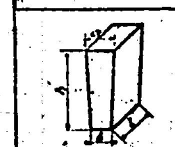
Format	Kurzzeichen	Bezeichnung	a	b	h	h'	l	r	Bemerkungen
	E1	Ringwölber	75	127	250	280	230	420	Herd- und Kopfring Obere Ecken
	E2	Ringwölber	75	87	250	280	230	820	Herdring Unten seitlich
	E3	Ringwölber	75	87	250	280	230	3500	Herd- und Kopfring Oben und unten
	E4	Ringstein	75		250	230	230		Herd- und Kopfring Seiten u. Ausgleich
	E5	Schrägwölber Binder	75	83	300	430	187	3500	Kopfring u. Stein und Luftzuggewölbe
	E6	Schrägwölber	75	83	300	387	125	3500	Kopf Luftzuggewölbe
	E7	Schrägwölber	75	132	300	430	187	420	Kopfring u. Stein Oben seitlich (Steine auf der Baustelle wie —·— behauen)
	E8	Schrägwölber	75		300	430	187		Kopfring u. Stein Ausgleich oben seitl. (Steine auf der Baustelle wie —·— behauen)
	E9	Widerlager	250	127	65				Kopf Gaszuggewölbe

A. Bagel, Düsseldorf

Blatt 2.

Feuerfeste Baustoffe — Blatt 2

Formate der Silikasteine für Siemens-Martin-Öfen

Format	Bezeichng.	Kurzzeichen	a	b	h	l	Rauminhalt	Bemerkungen
	Widerlagsteine	WH1	300	137	450	75	7,17	Herd-Schräg- und Luftzuggewölbe mit Feder und Nut
		WH2	300	157	450	75	7,17	Herd-Schräg- und Luftzuggewölbe ohne Feder und Nut
	Pfeiler-Eck-steine	V1	300	163	375	65	9,65	Vorderwandpfeiler
		V2	190	100	250	55	2,36	
	Ganzwölber	2G52	91	39	250	123	2,50	r = 196
		2G26	78	52	250	123	2,30	r = 520
		2G16	73	57	250	123	2,30	[illegible]
		2G10	70	60	250	123	2,00	[illegible]
		2G6	68	62	250	123	2,00	[illegible]
		2G4	67	63	250	123	2,00	[illegible]
	Doppel-Ganzwölber	4G52	91	39	250	250	4,05	r = 196
		4G26	78	52	250	250	4,05	r = 520
		4G16	73	57	250	250	4,05	[illegible]
		4G10	70	60	250	250	4,05	[illegible]
		4G6	68	62	250	250	4,05	[illegible]
		4G4	67	63	250	250	4,05	[illegible]
	Halbwölber	2H26	78	52	123	250	2,00	r = 520
		2H16	73	57	123	250	2,00	[illegible]
		2H10	70	60	123	250	2,00	[illegible]
		2H6	68	62	123	250	2,00	[illegible]
	Widerlagsteine	WK1	250	133	233	65	3,04	13% Stich — Kammerwiderlager
		WK2	250	82	233	65	2,50	20% Stich — Kammerwiderlager
	Gittersteine	H1	123	100	250		3,94	Gitter- und Kammersteine
		H2	100	100	250		3,20	
		H3	80	100	250		2,56	

Kammer- Schlackenkammer- Gaszug- Kanalgewölbe (for Ganzwölber, Doppel-Ganzwölber, Halbwölber)

13 % Stich und 60° Zentriwinkel, WK 2 für Widerlager mit 20 % Stich und 87° Zentriwinkel, wobei es möglich ist, durch Verwendung entsprechender 4- oder 2-G-Wölber auch Gewölbe mit entsprechend anderen Stichen und Zentriwinkeln herzustellen.

VII. Gittersteine.

Die Erfahrungen haben gezeigt, daß für die Ausbildung der Gitterwerke meist folgende Faktoren ausschlaggebend sind:

a) **Freier Durchgang** der senkrechten Kanäle.

b) Verhinderung der **Verschlackung.**

c) Gleichmäßige **Beaufschlagung** des gesamten Gitterwerkes.

d) Die oberen Steine müssen so viel **stärker** sein, daß Staub und abgeschmolzene Steinmassen durch sie hindurchfallen, ohne sich auf den unteren Stein festzusetzen.

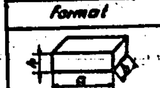
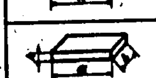
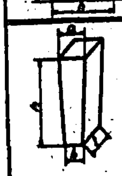
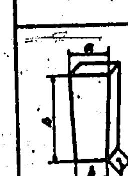
Spezialsteine sowie die Längen-Wabensteine bleiben erhalten, um Oefen mit zu niedrigen Kammern entsprechend ausgittern zu können. Es wird aber allen Stahlwerken dringend empfohlen, den Verbrauch an diesen Sondersteinen tunlichst einzustellen und sich mit den nachfolgenden festgelegten Knüppeln oder Normalsteinen zu behelfen, da die Leistungen der feuerfesten Industrie in diesen Steinen rd. 20mal so groß sind wie bei den schwierig herstellbaren Sondersteinen.

Für die normale Ausgitterung sind die in der Liste aufgeführten K 1-, K 2- und K 3-Steine und der Normalstein 1 oder 2 vorgesehen. Die Länge der Knüppel wurde mit 320 mm angesetzt. Es wird empfohlen, die **Kammertragsteine** dreifach zu teilen und mit Widerlagern auszurüsten. Von einer Vereinheitlichung dieser Steine ist wegen der unterschiedlichen Ofenabmessungen abgesehen. Die dreigeteilte Form ermöglicht aber das Auswechseln der Trägersteine ohne wesentlichen Bruch.

Blatt 1.

Feuerfeste Baustoffe — Blatt 1

Formate der Silikasteine für Siemens-Martin-Öfen

Format	Bezeichg.	Kurzzeichen	Maße in mm a	b	h	l	Rauminhalt dm³	Bemerkungen
	Normalsteine	1	230	115	65	—	1,72	
		2	250	123	65	—	2,00	
	Verbandsteine	1 B	230	175	65	—	2,62	
		2 B	250	187	65	—	3,04	
	Plättchen	1-32	230	115	32	—	0,85	
		2-32	250	123	32	—	0,98	
	Strecker	2 L	375	123	65	—	3,00	[illegible] Luft u. Gaszug
	Spitzkeil	1 S	102	65	230	115	2,61	[illegible]
		2 S	123	65	250	123	3,03	
	Gewölber	G 1	59	75	300	150	2,47	
		GA 1	115	112	300	150	5,14	Gewölber mit
		G 2	60	75	375	150	4,36	Anfänger- oder Abschl.-
		GA 2	117	112	375	150	6,06	stein für Herdgewölbe
		G 3	81	75	450	150	5,27	Radius = 8,5 m
		GA 3	119	112	450	150	7,77	Spannweite = 6-7 m
		GB 2	80	75	375	225	6,55	[illegible] für [illegible]
	Quergewölber	Q 1	137	100	300	75	2,78	
		QA 1	190	150	300	75	4,16	Quergewölber mit
		Q 2	123	100	375	75	3,19	Anfänger- oder
		QA 2	173	150	375	75	5,23	Abschlußstein für
		Q 3	140	100	450	75	4,22	Herdgewölbe und
		QA 3	195	150	450	75	6,33	Luftzugwände R = 8,5 m - Spw. = 6-7 m
		QA 2	143	120	375	75	3,70	Luftzuggewölbe R = [illegible] m - Spw. [illegible]

APPENDIX NO. III

Translation of an Abstract of the Paper

STANDARDIZATION OF POURING PIT REFRACTORY MATERIALS.

Report No. 397 of the Steelworks Committee of the German Iron and Steel Institute.

Published August 1943.

The purpose of this work in standardizing pouring pit refractories was essentially to provide a higher output of their manufacture by reducing the number of sizes and shapes and to shift as far as possible to machine versus hand molding.

The user may find it necessary to make changes in his practice which may not necessarily be advantageous. A period of transition is to be allowed in changing over to these standards.

I. Ladle Brick.

The lining is to be laid with the standard P40 brick of Blatt 12 which measures 9.4" x 4.9" x 1.6" and if thicker bricks are to be used the standard size of 9.4" x4.9" x 2.6" is recommended. The bottom is to be laid with the split No. 40 or Standard brick No. 65. The bottom bricks for the lining are to be B1 (7.3" x 6.1" x 4.9".) or B2 (8.3" x 7.3" x 6.1") and these may be laid flat or on edge. The wall of the ladle may be built with any one of the bricks in the range of thickness as follows: 3.5", 4.9", 6.1", 7.4", 8.7" or 9.4". The length of these bricks is 9.4". The diameter required may be obtained by selecting the required shapes according to the tabulation given in Blatt 13 and the diameters provided are between 51" and 122.". No radial bricks are to be manufactured even though these may have been used in the past. The linings for basic converter steel ladles should be rammed whenever possible.

II. Ladle Stoppers and Sleeves.

The stopper rods are to be limited to two diameters, 1.6" and 1.97" and with a screw pitch of 3.15" cut so as to have 6-1/2 threads. These are shown in detail in Blatt 5.

The sleeves are to have holes of 1.8" and 2.4" respectively for the two sizes of rolls. The outside diameters are 4.1", 4.7", 5.5", 6.1" and 6.7". All of the sleeves are to be 13" in length. These are shown in Blatt 3 and details of their joint design in Blatt 4.

The stoppers are of the same outside diameter as the sleeves shown above. They are to be made with grooves only (female) so as not to be damaged in shipment. Their design is such as to provide ample material below the end of the thread. Details of the stoppers are shown in Blatt 6 - 11 inclusive.

The nozzel insert bricks have been designed for five thicknesses of ladle bottoms, that is 4.8", 6.5", 7.5" 8.7" and 10". The inserts which are for installing from below are shown in Blatt 4 and those to be inserted from above in Blatt 16.

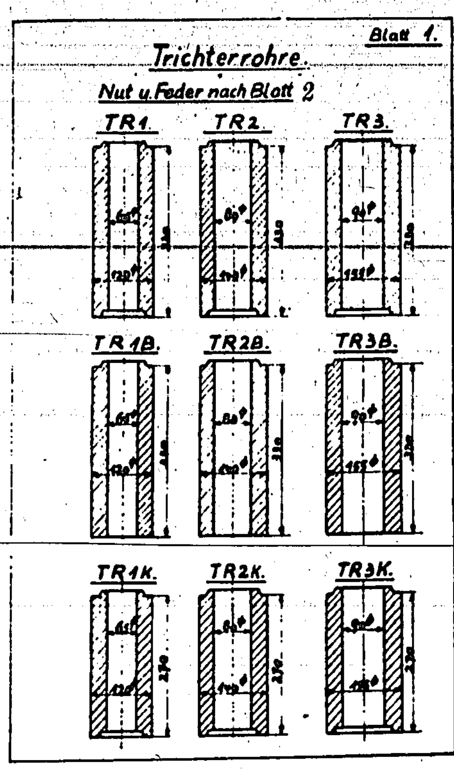
The nozzel brick design and their dimensions are given in Blatt 15, 17 - 21 inclusive. Their identification numbers are the same as those of the insert brick, for example insert L1 is to accommodate nozzel 1A. For the purpose of limiting the number of nozzels their hole or bore has been limited to the following:

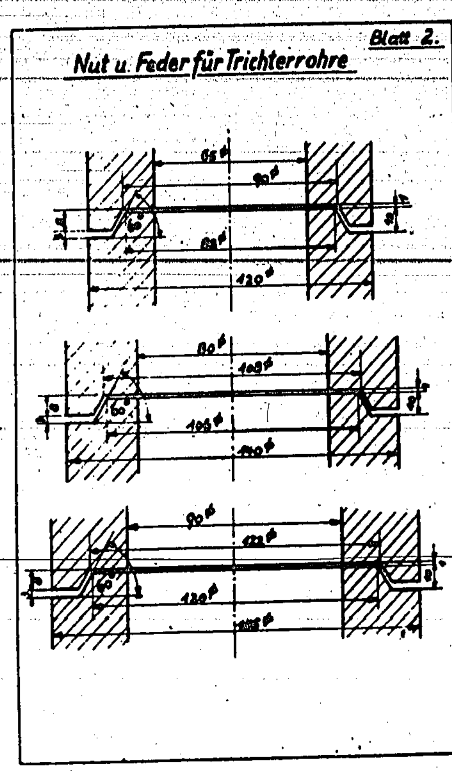
For diameters of 0.63" to 0.86" in steps of 0.08"
" " " 0.99" to 2.36" in steps of 0.2"
" " " 2.36" and up in steps of 0.4"

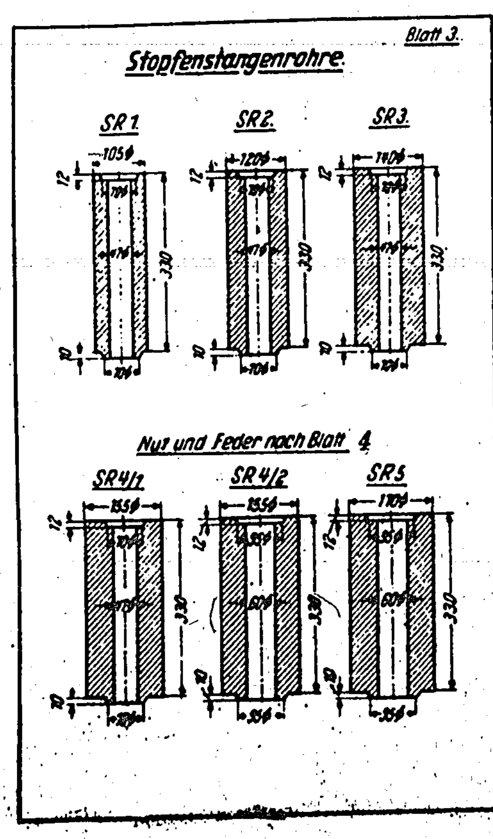
The nozzels 1, 2 6 and 7A are made with a core of 2.36" maximum. The head of the nozzel is inclined 10°. Blatt 18 - 21 show also the fit or seating of the stoppers. As requested by the manufacturers the top of the nozzel has been made flat.

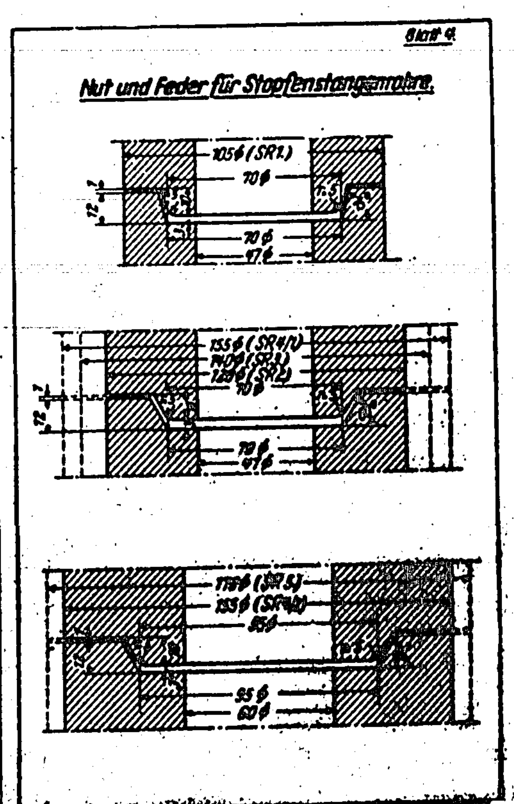
III. Runner Brick.

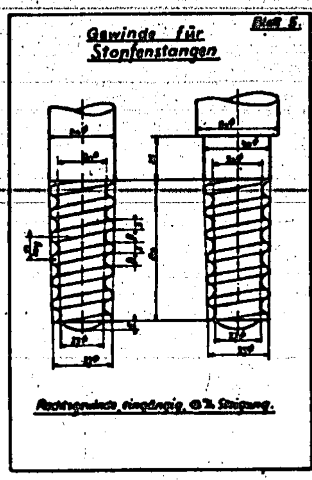
The standardized runner bricks have outside dimensions of 4.7", 5.7" and 6.1" with a bore of 2.6", 3.2" and 3.5" respectively. Their length is either 10.6" or 13". These are shown in Blatt 1 and details of their joint in Blatt 2. The TRB series may be used as the bottom piece. By various combinations of these bricks, heights between 51" and 122" can be obtained. Standards for center brick, outlets and other shapes for bottom casting are in preparation.

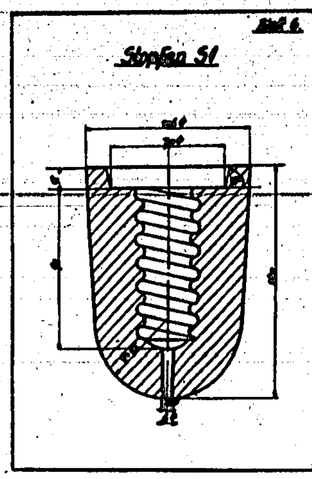

Blatt 1.
Trichterrohre.
Nut u. Feder nach Blatt 2
TR1.
TR2.
TR3.
TR1B.
TR2B.
TR3B.
TR1K.
TR2K.
TR3K.

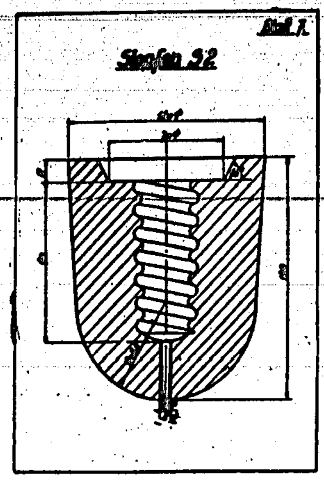

Blatt 2.
Nut u. Feder für Trichterrohre

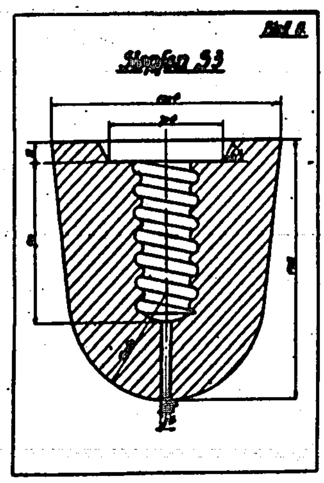

Blatt 3.
Stopfenstangenrohre.
SR1
SR2
SR3
Nut und Feder nach Blatt 4
SR4/1
SR4/2
SR5

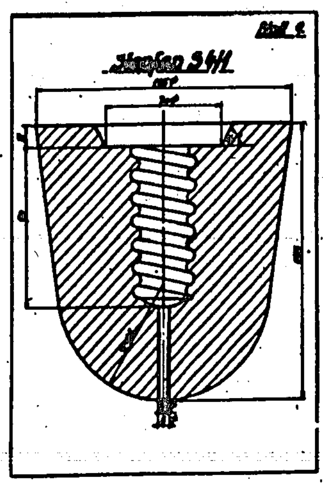

Blatt 4.
Nut und Feder für Stopfenstangenrohre.

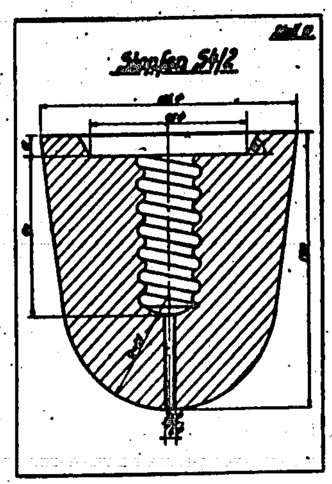

Blatt 5.
Gewinde für
Stopfenstangen

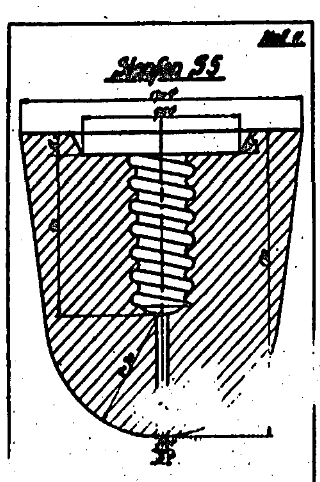

Blatt 6.
Stopfen S1


Blatt 7.
Stopfen S2


Blatt 8.
Stopfen S3

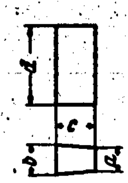

Blatt 9.
Stopfen S4/1


Blatt 10.
Stopfen S4/2

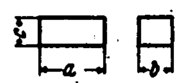

Blatt 11.
Stopfen S5

Blatt 12.

Normensteine für Pfannenausmauerung.



Pos	a	b	c	d	Gew
1P18	116	130	90	250	5,9
1P8	121	129	90	250	5,9
2P24	113	137	123	250	7,3
2P10	128	138	123	250	7,3
3P30	98	118	155	250	7,9
3P18	95	106	155	250	7,9
4P32	89	111	187	250	8,9
4P12	99	106	187	250	8,9
5P32	89	111	220	250	10,5
5P16	92	108	220	250	10,5
6P26	87	113	250	250	11,9
6P18	91	109	250	250	11,9

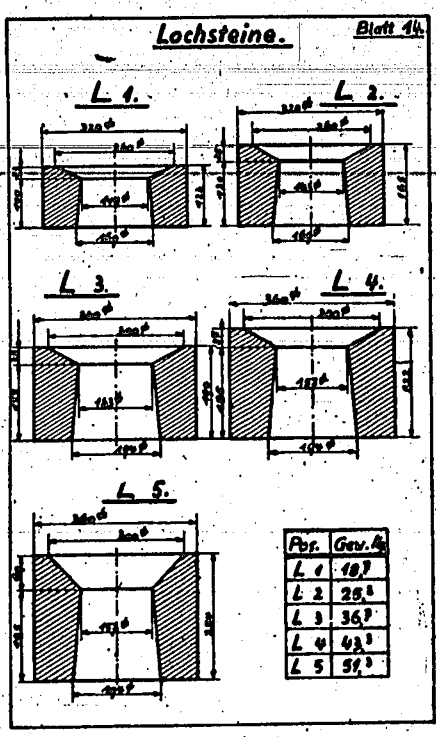


Pos	a	b	c	Gew
B1	187	155	123	6,8
B2	219	187	155	11,5
P40	250	123	40	2,3

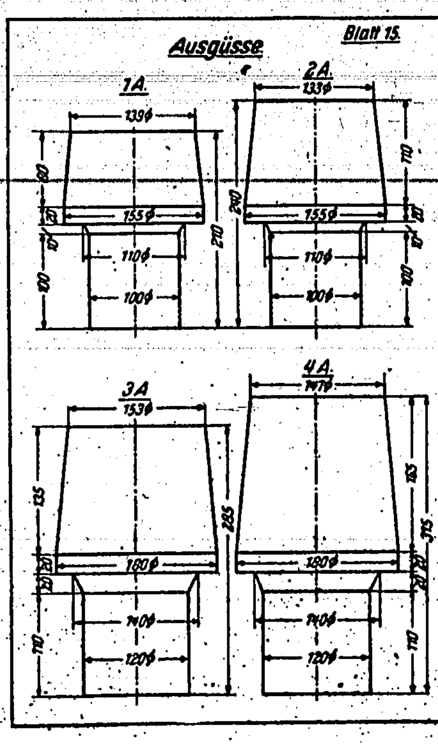
Blatt 13.

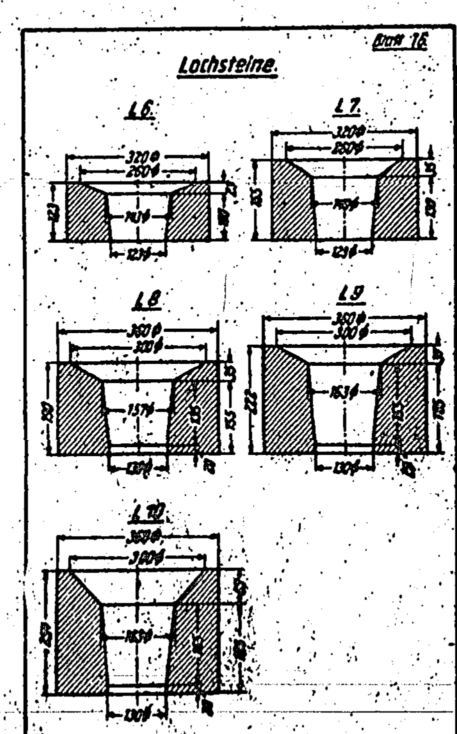
Pfannensteine.

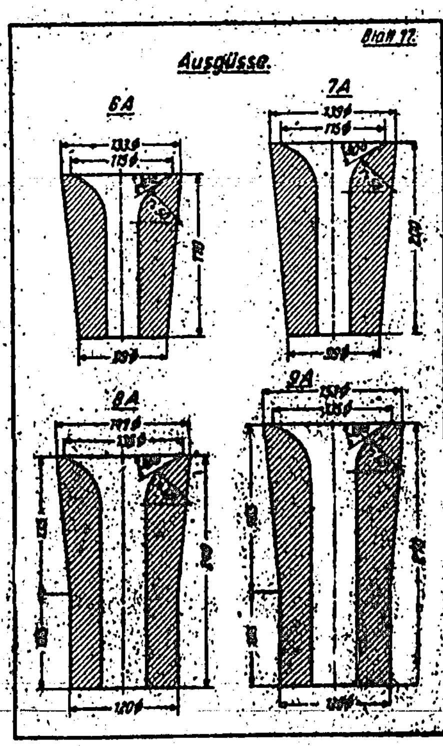
Äußerer Durchm. der Ausmauerung	Erforderliche Stückzahl im Ring											
	1P18	1P8	2P24	2P10	3P20	3P10	4P22	4P12	5P28	5P16	6P25	6P18
1300	30	–	30	–	–	–	–	–	–	–	–	–
1400	32	–	32	–	–	–	–	–	–	–	–	–
1500	28	7	28	6	–	–	–	–	–	–	–	–
1600	28	8	27	10	45	–	–	–	–	–	–	–
1700	24	16	26	13	48	–	–	–	–	–	–	–
1800	25	17	24	17	51	–	50	–	–	–	–	–
1900	22	23	21	23	43	11	53	–	–	–	–	–
2000	17	30	19	27	39	17	56	–	–	–	–	–
2100	19	31	17	32	35	24	47	12	59	–	57	–
2200	19	33	17	34	31	32	43	19	61	–	60	–
2300	13	41	13	41	27	39	39	26	64	–	48	15
2400	14	43	13	43	27	42	34	34	45	22	40	26
2500	–	60	10	45	22	50	28	43	35	35	34	35
2600	–	62	10	51	22	53	23	51	25	48	28	44
2700	–	64	10	54	15	62	23	54	15	51	20	55
2800	–	67	–	68	16	65	16	64		80	20	58
2900	–	69	–	69	–	65	15	67	–	83	–	62
3000	–	70	–	71	–	80	–	87	–	85	–	65
3100	–	74	–	74	–	91	–	80	–	88	–	68

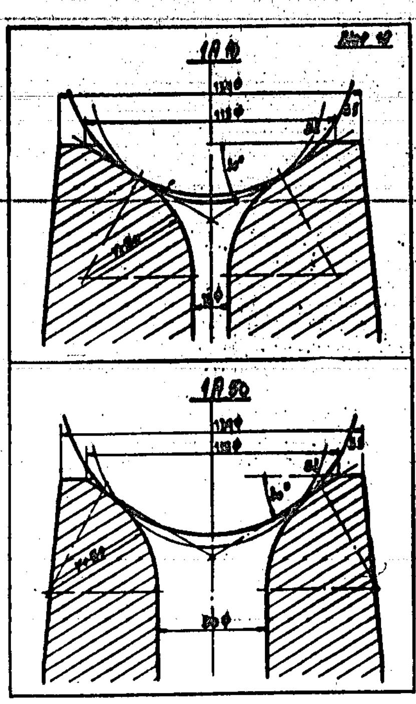


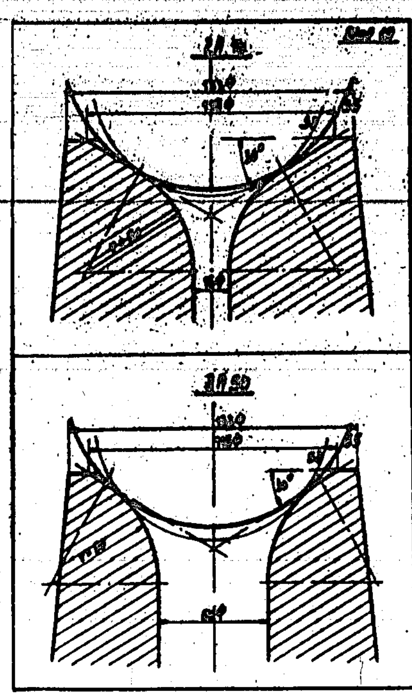
Pos.	Gew. kg
L 1	18,7
L 2	25,8
L 3	36,7
L 4	43,3
L 5	51,3

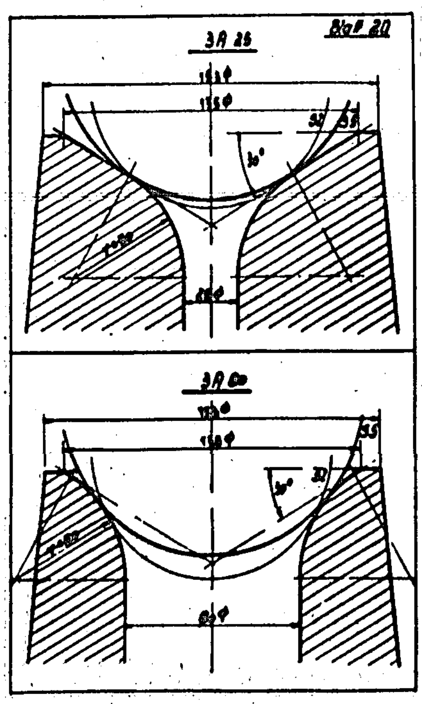


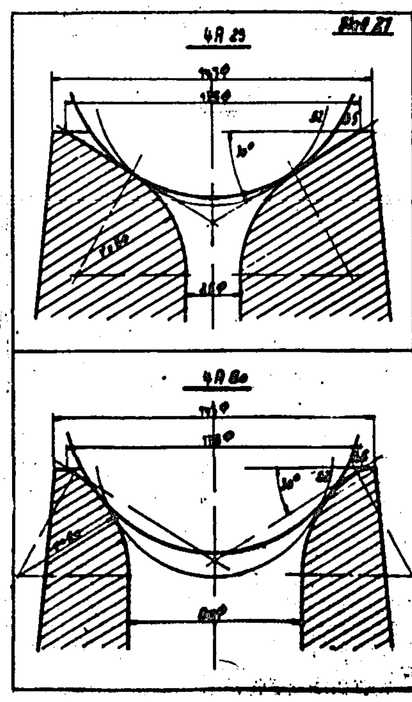


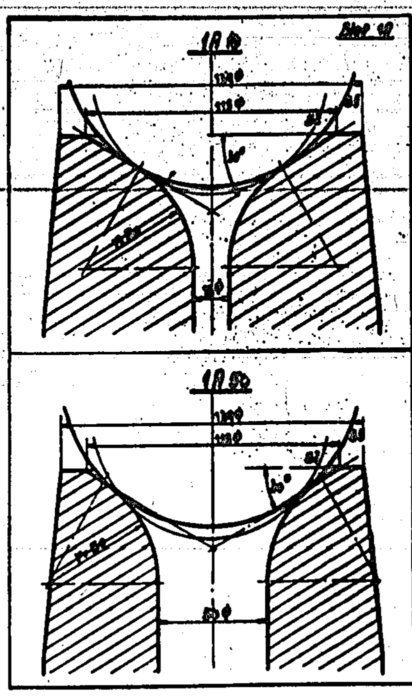


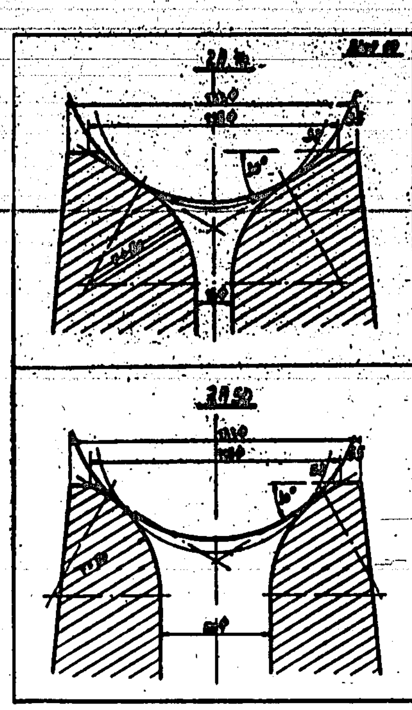

1A 50

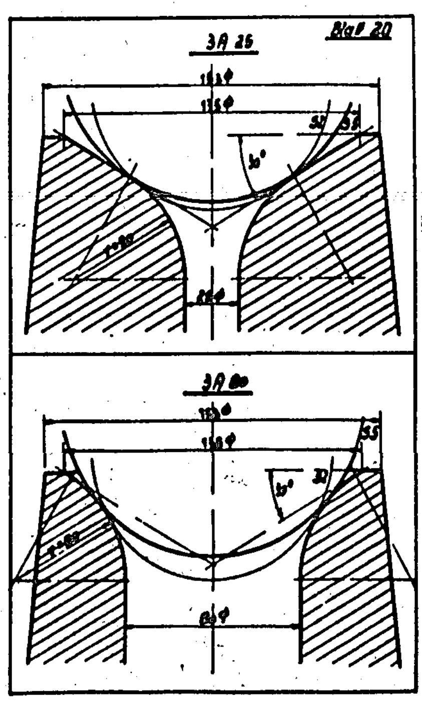


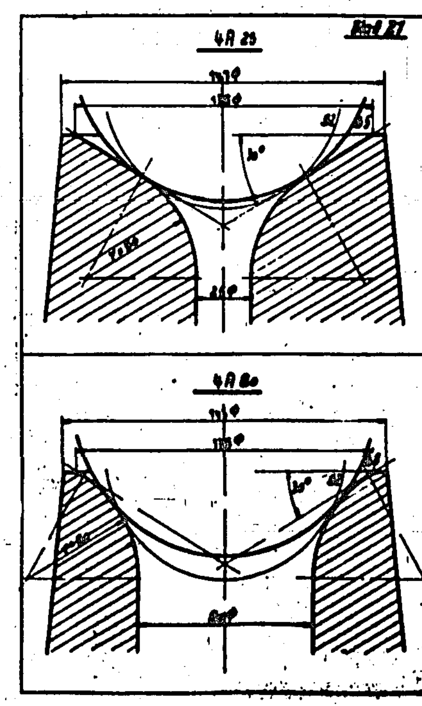

3A 25


4A 29


1A 50


2A 50


3A 25
Blatt 20
3A 80


4A 25
Blatt 21
4A 80

APPENDIX No. IV.

Translation of

STANDARDIZATION OF THE SIZE AND SHAPE OF REFRACTORIES FOR USE IN BLAST FURNACES AND HOT-BLAST STOVES.

Report No. 211 of the Blast furnace Committee of the German Iron and Steel Institute. Published September 1943.

Standardization of the size and shape of refractories has been carried out so as to increase production and decrease the labor required. The consumer will benefit from the standardization and reduction in the number of shapes by being able to stock a smaller variety of shapes. In order to achieve this the following must be kept in mind.

A. Advise the consumer and furnace designer to avoid using shapes which are difficult to make and those that are unnecessary.

B. Eliminate shapes which are too heavy.

C. Recommend the use of combinations of shapes for circles of different diameters so that fewer shapes will suffice.

D. Make use of rammed material in place of shapes that have to be made as special.

Experts from the Blast Furnace Committee of the V.d.E. and the refractories industry formed a panel under E. Rein, Bochum to standardize brick for the blast furnace and stoves. In carrying out this work the committee kept in mind the requirements of the furnace builder by including in the series of standards the shapes required for various size and contours of these furnaces.

The developement of blast furnaces during recent years in Germany shows that the welded steel shell design will become prevalent. The lining of this furnace can best be carried out with brick having an average weight of 22 lbs. Brick of this size may be used also for the strapped conventional design because the type and quality of the refractory material governs the life rather than the size of the units.

Brick of the smaller dimensions will be beneficial for the consumer and also for the maker because machine molding by dry or wet pressing is desirable and will save labor and particularly of the skilled hand molding variety.

Because an immediate change over to the smaller machine made shapes is not possible there is included in the list of standards the larger shapes which may be used during the transition period.

The exactness of the size and shape of the brick is to be such that joints of 0.078" to 0.118" (5/64" - 1/7") can be maintained. It is expected that the manufacturers who are best able to make brick to meet these requirements will instruct their competitors in this respect and special or patented methods of production may be made public.

I. Material for the Lower Portion of the Blast Furnace.

The coke-tar ramming mix for lining the lower portion (below the lintel)of the furnace has increased in use in Germany and in 1943 its use was made compulsory. This reduced the burden on the several manufacturers of carbon blocks and now permits are required for the use of these blocks or those made of clay.

The ramming process provides a jointless lining and one which prevents a break out. The mix consists of low ash cole and a dehydrated tar.

Below the rammed or block lining the foundation is laid up with semi-acid or normal clay brick for a thickness of 3 to 6 feet, and this foundation should be such as to withstand the formation of a salamander. A protective layer of clay brick of 9.8" thick is built against the carbon material so as to avoid burning out of the carbon before the furnace is blown in for production. Standard brick, A, C, E or G of Table 2 may be used for this.

The brick work for the bottom should be laid with shapes which will form an inverted keyed flat arch so as to prevent loosening or rising of the bottom.

Bottom brick of large size are used for reasons of safety and because the carbon blocks can be made in larger sizes than the clay, they are shown in Table No.I in larger dimensions and weigh about 330 lbs.as compared with 220 lbs. for clay shapes.

Furnaces up to 23 feet in diameter can be built with the eight shapes adopted. A space of 4" is left between the lining and the shell and is filled by ramming in carbon material. The height of each course of clay brick is 19.7" and the carbon block 23.6". The top surface of these being 19.7" x 7.9" and 25.6" x 11.8" respectively.

II. Material for the Hearth, Bosh and Finwall.

Im the future only 10 types of brick as shown in Table No. 2 will be permitted, that is 4 square and 4 radial shapes as well as the two smaller shapes J and K. This means a very large reduction in the present large number of shapes now in use. The thickness of these shapes is 3.86" or a total thickness of 3.94" including 0.08" for the joint.

The cooling boxes are to be of the standard height of 7.7", the cooling plate 3.9". Allowing for a joint thickness of 0.2" this portion can be built without any special brick.

In the conventional type of blast furnace the cooling boxes have flanges and the length of the brick behind the flanges is then 1.38" shorter and 1.2" is allowed for the thickness of the flange.

III. Large Shapes for the Hearth Bosh and Finwall.

During the transition period the large shapes of Table No. 3 will be permitted. These constitute three groups of six lots each and provide for a lining with a radius of 5.2, 7.9 or 15.7 feet. These shapes vary in weight between 6.6 and 15.4 lbs. The brick for use between the cooling boxes must be individually designed.

The large carbon blocks for the bottom are not standardized.

IV. Stove Brick for Division Wall and the Lining.

The standard diameter for the stove lining is 22.9 feet but the brick of Table No. 4 however can be used for diameters of 21.3, 21.9, 24.6 and 26.2 feet.

Two sizes of insulating refractory brick are listed and these may vary from 28 to 45 lbs. per cubic ft.

Formerly various designs were used for the shape of the stove but in the future a circular design only will be permitted. During the transition period however, the eliptical design may be used.

Brick used in making connections to flues, bustle pipes and such are not standardized. If possible use should be made of the wedges and skews of DIN 1082. Supporting brick for the checkers are not standard except when cast iron columns are used. The brick for the floor are A to G of Table No. 1.

V. Dome of the Stove.

Six shapes are provided for constructing the dome, these being shown in Table No. 5 along with the two designs of insulating brick. In addition four sizes of arch brick are given and these are for the construction of the checker supporting arches.

VI. Stove Checker Brick.

Standardization of the checkers is difficult because of the dust content that may be present in the gas. The thermal efficiency of 85 - 95% is quite common however.

Of the fifty shapes in general use only six groups have been selected for the standards as are shown in Table No. 6. A proper balance must be maintained between heat storage and heat transfer of the checkers. The following four types of checker work are listed:

1. The use of retangular brick and of a thicker section (smaller openings) at the top of the checker work than at the bottom.
2. Multi-hole shapes with and without horizontal cross channels.
3. Tubular shapes.
4. Checker work with inserts or core busters.

When partially cleaned gases are used the checkers of group one should be used and with cleaned gases those of the remaining groups are suitable.

VII. Pig Iron Ladles.

The standard brick used for steel works ladles are to be used unless it is of the rammed type.

VIII. Miscellaneous.

It is recommended that the space between the shell and lining of the armored blast furnace should not be filled with loose material but with a mixture of 1 part tar and 2 parts of fire clay grog ground to have a particle size not larger than 0.12" which is rammed into place. This ramming material may be used also around the tuyeres.

The space between the shell and insulation in the stoves may be filled with "TERRSTERCHAMOL" as recommended in Stahl & Eisen, Volumn 62 (1942) p. 210-211. This mass remains plastic for some time and does not skrink.

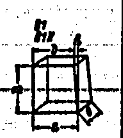
No agreement could be reached on the standardization of shapes for the tuyeres and particularly how much of the lining should be rammed.

Bastle pipes should be lined as per DIN 340 as shown in Table No. 7. The fire clay brick are to be surrounded with insulating brick.

B.F-Bottom Bricks — 4 — upper sections of B.F. hearth bosh ... T

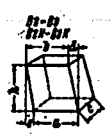
Zahlentafel 1. Hochofensteine für den Boden.

Maße in mm.



Werkstoff: Schamotte

Zeichen	a	b	c	d	e	h	Gewicht kg
B 1	525	500	200	25	—	500	102
B 2	525	500	200	50	25	500	102
B 3	525	500	200	75	50	500	102
B 4	525	500	200	100	75	500	102
~~B 5~~	~~525~~	~~500~~	~~200~~	~~125~~	~~100~~	~~500~~	~~102~~
B 6	525	500	200	150	125	500	102
B 7	525	500	200	175	150	500	102
B 8	500	500	200	175	175	500	100



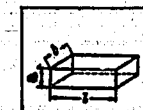
Werkstoff: Kohlenstoff

Zeichen	a	b	c	d	e	h	Gewicht kg
B 1 K	680	650	300	30	—	600	156
B 2 K	680	650	300	60	30	600	156
B 3 K	680	650	300	90	60	600	156
B 4 K	680	650	300	120	90	600	156
B 5 K	680	650	300	150	120	600	156
B 6 K	680	650	300	180	150	600	156
B 7 K	680	650	300	210	180	600	156
B 8 K	650	650	300	210	210	600	152

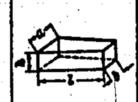
Zahlentafel 2. Feuerfeste Steine für Gestell, Rast und Schacht.

(Werkstoff: Schamotte.)

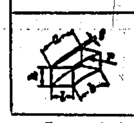
Maße in mm.



Zeichen	Länge l	Breite b	Höhe h	Gewicht kg
A	375	175	98	12,9
C	250	175	98	8,6
E	375	150	98	11,0
G	250	150	98	7,4



Zeichen	a	b	h	l	Keiligkeit	r	Gewicht kg
B	175	150	98	375	25	2250	11,9
D	175	150	98	250	25	1500	8,0
F	150	125	98	375	25	1875	10,1
H	150	125	98	250	25	1250	6,7

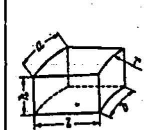


Zeichen	a	b	h	l	Keiligkeit	r	Gewicht kg
J	265	250	98	125	15	2080	6,3
K	254	250	98	125	4	7810	6,2

Bemerkung: Bei bandagierten Hochöfen, die Kühlkästen mit Flanschen haben, müssen die hinter den Flanschen liegenden Steine in der Länge „L" um 35 mm kleiner ausgeführt werden, und zwar unter Beibehaltung des Maßes b. Die Steine J und K sind mit einem einheitlichen Bogenradius von 4000 mm auszuführen; die eingeschriebenen Radien r entsprechen den angegebenen Keiligkeiten.

Zahlentafel 3. Großformatige Steine für Gestell, Rast und Schacht.

(Werkstoff: Schamotte.)



Bezeichnung	a (Maße in mm)	b	l	h	r	Gewicht kg
K 312	299	250	312,5	198	1600	34
K 375	308,5	250	375	198	1600	41,8
K 437	318,5	250	437,5	198	1600	49,5
K 500	328	250	500	198	1600	57,3
K 562	338	250	562,5	198	1600	65,7
K 625	347,5	250	625	198	1600	74
M 312	282,5	250	312,5	198	2400	33
M 375	289	250	375	198	2400	40
M 437	295,5	250	437,5	198	2400	47,5
M 500	302	250	500	198	2400	54,5
M 562	308,5	250	562,5	198	2400	62,2
M 625	315	250	625	198	2400	70
G 312	266,5	250	312,5	198	4800	32
G 375	269,5	250	375	198	4800	38,5
G 437	272,5	250	437,5	198	4800	45,5
G 500	276	250	500	198	4800	52
G 562	279,5	250	562,5	198	4800	59
G 625	282,5	250	625	198	4800	66

Zahlentafel 4. Winderhitzersteine für Mantel und Brennschacht.

Maße in mm.

Mantelsteine (Werkstoff: Schamotte)

Zeichen	a	b	l	h	Keiligkeit	r	Gewicht kg
M 1	135	125	250	98	10	3125	6,1
M 3	140	130	250	98	10	3250	6,3
M 2	260	250	125	98	10	3125	5,9
M 4	280	270	125	98	10	3375	6,4

Mantelsteine (Werkstoff: Isoliersteine)

Zeichen	a	b	l	h	Keiligkeit	r	Gewicht kg
J	218	210	125	98	8	3280	1,2 bis 2,0
J 1	218	210	125	65	8	3280	1,2 bis 2,3

Die Isoliersteine J haben ein Raumgewicht von 0,45 bis 0,7 kg/dm^3 und die Steine J 1 ein Raumgewicht von 0,7 bis 1,3 kg/dm^3.

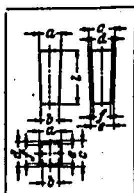
Brennschachtsteine (Werkstoff: Schamotte)

Zeichen	a	b	l	h	Keiligkeit	r	Gewicht kg
B 1	143	109	250	98	34	800	5,9
B 2	177	143	250	98	34	1050	7,5
B 3	144	113	250	98	31	900	6,0
B 4	175	144	250	98	31	1150	7,5
B 5	145	116	250	98	29	1000	6,1
B 6	174	145	250	98	29	1250	7,5

Uebergangssteine zwischen Brennschacht und Mantel sind von Fall zu Fall zu vereinbaren.

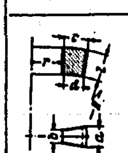
Zahlentafel 5. Winderhitzersteine für die Kuppel.

Maße in mm.



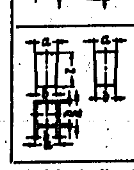
Kuppelsteine (Werkstoff: Schamotte)

Zeichen	a	b	c	d	e	f	l	Gewicht kg
K 1	105	98	119	117	110	108	230	5,0
K 2	105	98	119	115	110	106	230	5,0
K 3	105	98	118	112	110	104	230	4,9
K 4	105	98	119	110	110	101	230	4,9
K 5	105	98	119	105	110	96	230	4,7
K 6	105	98	117	99	110	92	230	4,7



Oeffnungssteine (Werkstoff: Schamotte)

Zeichen	a	b	c	d	l	R	r	Gewicht kg
K 7	195	117	200	162	230	2830	300	13,6
K 8	215	137	200	162	230	3060	350	15,4
K 9	216	157	150	118	200	3290	400	10,6
K 10	214	157	145	121	150	3290	400	7,7



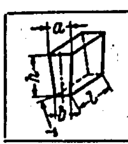
Kuppelsteine (Werkstoff: Isoliersteine)

Zeichen	a	b	l	Gewicht kg
J 2	104	100	150	0,7 bis 2,0
J 3	106	100	200	1,0 bis 2,8

Die Isoliersteine J 2 und J 3 haben ein Raumgewicht von 0,45 bis 0,7 bzw. von 0,7 bis 1,3 kg/dm^3.

Zahlentafel 7. Steine für die Ausmauerung von Heißwindleitungen.

Maße in mm.



Zeichen	a	b	h	l	Gewicht kg
2 H 38	84	46	123	250	3,7
2 H 26	78	52	123	250	3,7
2 H 16	73	57	123	250	3,7
2 H 10	70	60	123	250	3,7
2 H 6	68	62	123	250	3,7

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FIAT FINAL REPORT 741

CATALYSTS FOR COAL HYDROGENATION

Sherwood, Peter W.

OFFICE OF MILITARY GOVERNMENT

FOR GERMANY (US)

FIELD INFORMATION AGENCY TECHNICAL

OFFICE OF MILITARY GOVERNMENT FOR GERMANY (US)
Field Information Agency, Technical

FIAT FINAL REPORT NO. 741

15 March 1946

CATALYSTS FOR COAL HYDROGENATION

BY

Peter W. SHERWOOD

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 APPLICATIONS, THIS PUBLICATION CANNOT BE HELD TO GIVE ANY PROTECTION AGAINST ACTION FOR INFRINGEMENT.

FIELD INFORMATION AGENCY, TECHNICAL

ABSTRACT

Report on methods of preparation of ten coal hydrogenation catalysts developed by I. G. Farben at Ludwigshafen in addition to those used commercially as described in FIAT Final Report 422.

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Subject		Page

INTRODUCTION

A study was made of the reports of the Hochdruckversuche Laboratories of I. G. Farbenindustrie in Ludwigshafen/Oppau. It showed certain catalysts for coal hydrogenation which had been developed other than Nos. 5058, 7935, 7360, 8376 and 6434 which were the ones used commercially as described in Farragher and Horne, FIAT Final Report No. 422.

Information on the preparation of these catalysts was obtained from Drs. Simon, V. Funer, and Donath at Ludwigshafen.

1. PREHYDROGENATION CATALYST 7846

Composition:

Al_2O_3 87%

MoO_3 10%

Ni_2O_3 3%

The carrier is alumina which is prepared from commercial clay (Tonerde) with 60% Al_2O_3 and 40% moisture. This is dissolved in NaOH. It is then precipitated by adding nitric acid at a pH of 5.5-6.5 until a temperature of 50° is reached. The slurry is filtered and the filter cake is washed with a small quantity of water. The hydroxide is worked into a paste with water, filtered and washed with water until free of alkali. The cake is dried at 200°, ground, and peptised with approximately 2% nitric acid. The paste is deposited in layers on metal pans, dried somewhat, and cut into cubes of 1-2 cm length. The cubes are dried slowly and calcined at 400-500°. The cubes are washed with 5% NH_3 and recalcined. They are then saturated with an ammoniacal solution of MoO_3, dried and finally saturated with a solution of $NiCO_3$ in aqueous acetic acid. The catalyst is then calcined at 500-600°.

2. BENZINATION CATALYST 6109

100 g of bleaching earth, Terrana A extra, are treated with 100 g of a 10% solution of HF with good stirring; dry and pill while still slightly moist, dry and heat to 450°.

3. BENZINATION CATALYST 6108

Commercial bleaching earth Terrana A extra (from Deggerndorf, Bavaria) is moistened with 30% water, mixed thoroughly, passed through a 2 mm sieve, pilled to 5 or 10 mm pills, dried, and heated at 400-450°.

4. BENZINATION CATALYST 8754

Same as 8668 (vid. inf.) instead of zinc acetate, the equivalent amount of zinc sulfate is used.

5. AROMATIZATION CATALYST 8668

Composition:

10 parts by wt. of bleaching earth Terrana A extra activated with HF and dried.
90 parts by wt. activated alumina from $Al_2(SO_4)_3$ and NH_3.
1 part by wt. ZnO.
10 parts by wt. Cr_2O_3.
2 parts by wt. molybdenum oxide.

100 g bleaching earth, Terrana A extra, are etched with 100 g 10% HF and dried. The dried bleaching earth is mixed with 900 g activated alumina (app. 85% Al_2O_3) which has been prepared from aluminum sulfate by precipitation with NH_3 at approximately 95°C. The mixture is saturated with approximately 1400 cc of an aqueous zinc acetate (22g zinc acetate), dried at 110°. It is then saturated with app. 1000 cc chromic acid solution containing 132g chromic acid. Dry and treat with a solution of 20g molybdic acid in 1200 cc 1% ammonia. Dry at 110°, pill and heat at 350° for app. 14 hrs.

6. AROMATIZATION CATALYST 7495

This is Leuna catalyst K 157 of Terrana A and zinc sulfide. Its method of preparation was not known to the Ludwigshaefen staff.

7. AROMATIZATION CATALYST 7019

Composition:

A-carbon 80%

Cr_2O_3 15%

V_2O_5 5%

Anthracite, peat, and coal tar pitch are ground finely in the ratio 100:10:40. The product is stirred for two hours at 110°, ground again, and pilled. The pills are lightly sintered at 100-120°, carbonized at 500° and activated with steam at 800-900°. The activated pills are saturated first in a solution of ammonium vanadate saturated at 60-70° and then with a 40-50% aqueous solution of chromic acid. The product is dried. The proportions of solutions are so chosen as to give the above composition of catalyst.

8. DEHYDROGENATION CATALYST 7374

Composition:

100 parts activated alumina

12 parts MoO_3

2 parts MgO

100 g of pilled and heated activated alumina, produced from aluminum sulfate is saturated with a solution of 12 g MoO_3 in 18 cc 25% ammonia and 100 c water. This is dried at 110°. Then it is saturated with a solution of 2g MgO in 6 cc formic acid and 125 cc water. Heat for four hours at approximately 550°.

9. DEHYDROGENATION CATALYST 8074

Composition:

100 parts activated alumina

15 parts MoO_3

10 parts CrF_3

200 g activated alumina (dried at 110°), prepared by precipitation of aluminum sulfate with ammonia at app. 95°, is mixed with 20 g CrF_3 and pilled. The pills are activated at 300-450°, saturated with a solution of 34 g MoO_3 in 30 cc ammonia (25%) and 170 cc water. Dry and heat to 550° for 12 hours.

10. <u>CRACKING CATALYST 6752</u>

Composition:

Al_2O_3	33%
SiO_2	67%

Commercial water glass solution is treated with excess concentrated HCl until no more gel forms. Aluminum nitrate is added to the silica sol in the desired proportion. Precipitation takes place at 80° by adding ammonia solution at a controlled pH of 5.5-6.0 (antimony electrode). The precipitate is washed free of alkali and chloride. The filter cake is dried at 110°. The resulting powder is pilled and activated at 450°.