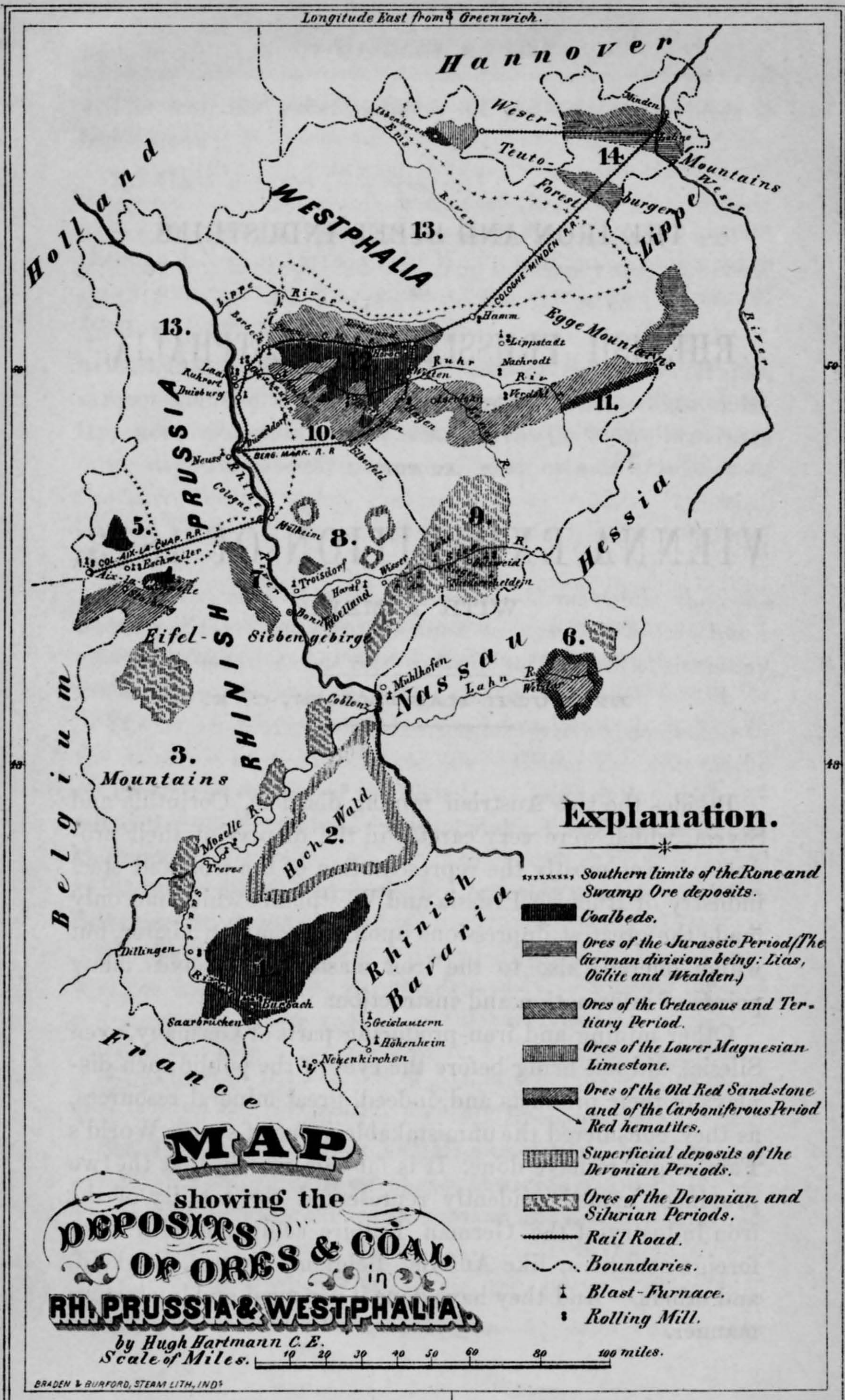

Longitude East from Greenwich.
Hannover
Holland
WESTPHALIA
PRUSSIA
RHINISH
Belgium
France
Nassau
Hessia
Lippe
Rhinish Bavaria
Weser
Teuto-Forest
Mountains
Egge Mountains
Eifel-
Siebengebirge
Mountains
Hoch Wald
Lippe River
Ruhr River
Rhine
Moselle R.
Lahn R.
Weser River
COLOGNE-MINDEN R.R.
BERG. MARK. R.R.
COL. AIX-LA-CHAP. R.R.
Minden
Hamm
Lippstadt
Ruhrort
Duisburg
Neuss
Cologne
Mülheim
Troisdorf
Bonn
Coblenz
Mühlhofen
Treves
Dillingen
Saarbrücken
Geislautern
Höhenheim
Neuenkirchen
Elberfeld
Eschweiler
Aix-la-Chapelle
Explanation.
Southern limits of the Rone and Swamp Ore deposits.
Coalbeds.
Ores of the Jurassic Period (The German divisions being: Lias, Oölite and Wealden.)
Ores of the Cretaceous and Tertiary Period.
Ores of the Lower Magnesian Limestone.
Ores of the Old Red Sandstone and of the Carboniferous Period Red hematites.
Superficial deposits of the Devonian Periods.
Ores of the Devonian and Silurian Periods.
Rail Road.
Boundaries.
Blast-Furnace.
Rolling Mill.
MAP
showing the
DEPOSITS
OF ORES & COAL
in
RH. PRUSSIA & WESTPHALIA.
by Hugh Hartmann C. E.
Scale of Miles. 10 20 30 40 50 60 80 100 miles.
BRADEN & BURFORD, STEAM LITH, IND.

THE IRON AND STEEL INDUSTRIES

OF

RHENISH PRUSSIA AND WESTPHALIA,

GERMANY,

AT THE

VIENNA EXHIBITION OF 1873.

WITH A MAP.

BY HUGH HARTMANN, C. E.

Besides the two Austrian mining districts, Corinthia and Styria, which were very careful in the display of their products, it was mostly the representation of the iron and steel industry of Rhenish Prussia and Westphalia which not only made the greatest impressions upon the common visitor, but which offered, also to the iron masters themselves many points of information and instruction.

Other mining and iron-producing parts of Germany, even Silesia, did not bring before the eyes of the public such displays of their products and, indeed, great mineral resources, as they, considered the unmistakable value of such a World's Fair, ought to have done. It is for this reason, that the two provinces named evidently represented the totality of the iron industry of the German Empire compared with other foreign countries, like Austria, Belgiam, France, England, and others. And they have done it in a good and interesting manner.

The iron and steel industry of these two provinces is based upon:

1. Good-natured iron-ores, and

2. Bituminous coal beds which reach from Belgium through Rhenish Prussia into Westphalia, and from France into the district of Saarbrucken, the south-west corner of Rhenish Prussia.

The iron masters, especially those of the Lower Rhine, are not confined to the use of ores of their immediate vicinity, notwithstanding that there are in both provinces large deposits of ores; they work, also, ores of provinces of the surrounding states, and even from remote countries, such as Spain, and the northern coast of Africa, Sweden and Norway.

It is evident, that with such manifold materials, the conducting of the blast furnaces must be very interesting, but I may add that it is also very difficult on account of the many different properties of the ores to be treated.

The iron manufacturing districts are grouped according to the existence of the raw materials. Either the ores or the coal form the centers of the district, corresponding with the respective money value, contents and general properties of the same.

There are in all four decidedly bounded groups which can be enumerated, viz:

1. The iron works of the Saar coal beds, including the furnaces and rolling mills on the Moselle within the boundaries of Rhenish Prussia.

2. Those of the District of Aix la Chappelle, within the coal beds on the rivers Inde and Worm.

3. Those of the Lower Rhine and Westphalia, which extend in a long line from Heuss, Dusseldorf, Duisburg, via Doitmund, as far as the upper parts of the rivers Lenne and Ruhr.

The county "Mark," the oldest seat of Westphalia iron industry, forms still the geographical center of this widely

extended line (the cities Doitmund, Witten and Hagen being also the principal market places for the iron trade), while it is flanked easterly by the territory of Arnsburg, and westward by those of Essen and Duisburg.

In connection with this third group, which is the most important one regarding quantity of production and business performed, there is to be enumerated also an outpost ot Westphalia, as I may call it, situated more to the northwest, and nearer to the coast of the Northern Sea, the district of Osnabruck. This somewhat remote district, belonging geographically to the province Hannover, is strictly connected with Westphalia by its commercial and other interests.

4. Those in the neighborhood of the ore beds of the territory of Siegen, Wetzlar and including the furnaces on the river Lahr and near Neuwied on the Rhine.

There are only a few remarkable differences in the physiognomy of these four groups, appearing in the peculiarities of those materials, which are the most accessible ones. While on the one hand the blast furnaces of the territory of Siegen are mostly working sparry ores, and those on the borders of the Lahr red hematite, the furnaces around the city of Saarbrucken on the other hand smelt frequently the oolitic ores of Luxembourg and Lorraine, the furnaces of Westphalia, the black band of the coal formation and those around Osnabruck the ores of the magnesian limestone. But these distinctions will be compensated more and more, because good and rich ores can be worked upon at any locality of the provinces in which they are found, provided that the second principal material—coke or coal—is at hand in close vicinity. The moveableness of the iron industry, i. e. the free choice of the raw material would be, even at present, a far greater one, if the means for transportation were shaped in a manner more corresponding with the interest, prosperity, and the increase of the industry itself. There is without any doubt a great progress made in this regard of late years; but the vivacity, the spirit of enterprise,

which so highly characterizes the American people, are still needed to a great extent.

The manufacturing of wrought iron and steel is mostly confined to the presence of coal alone. Exceptions are the environs of Siegen, Osnabruck and Neuwied, but the fabrication of the articles named there, has not yet reached the extent of business of the other districts.

The use of charcoal for fuel is nearly abandoned. Only to certain qualities it is in some cases still applied, but the art of iron manufacturing is progressing in such a manner, that even such sharp distinctions between iron made with charcoal and such with coke, will soon become of historical interest only.

At Vienna the four different groups were represented by about seventy firms, while upper and Lower Silesia, both very well known for their iron products and situated almost in close proximity to the Austrian Capital, were represented only, the former by eight, the latter by two companies.

THE FIRST GROUP

occupies the most southwestern part of Rhenish Prussia. Like at other places of Germany and elsewhere the most important mines are worked in the most ancient strata of the coal measures. The country in question and the adjacent parts of France represent several groups of small mountains which are of primitive formation on the ridges and of transit state on the flanks. In the sinuosities between occur the deposits of coal, which have become the great centers of manufacturing.

The coal basin ot the Saar, a tributary of the Moselle, near the frontiers of France, affords a very important and extensive field of bituminous coal. Of this field, represented on the accompanying map in Fig. 1*, not less than 103 beds are described, the thickness varying from 18 inches to 15

*For the better or easier understanding the different coal and ore beds, related to in the text, are numbered on the map.

feet. Alongside the coal, nature itself has deposited iron ores, the intrinsic value of which alone is very small, indeed, but whose abundance in the neighborhood of the fuel becomes extremely precious. The coal beds bear many gangues of clay iron stones, of which more than one hundred are known; there occurs, also, some black band and some red hematite in the vicinity of the city of Saarbrucken, but the mining of all these ores together, is not sufficient to supply the requirements of the blast furnaces of this group. To a great extent ores from Lorraine, Belgium and Luxembourg are imported. The ores, mined on the Maas, the Moselle and in the Ardennes and Vosges, are partly brown hematites, which are found either in veins or in large masses, embodied in the Lias (one of the foreign divisions of the Jurassic period, which is divided in Lias, Oolitic and Wealden) or in clay formations overlaying the former, partly granular ores of the same formation (Lias) or of the chalks.

The latter (granular) ore, occurring in pieces of nut size or lens shape, is accumulated by means of a clayey, or an iron containing calcareous paste to very extensive beds. The mines near Metz and Nancy, which are worked upon this ore, are on a very large scale.

The principle ores of the Vosges (Lorraine) are red oxide of iron and brown hematite, which form veins of great thickness in districts composed of greenstone, limestone and graywacke. Near the sources of the Moselle, in the Vosges, there are also beds of iron ores which traverse formations of graywacke, clay, slate and porphyry. On the banks of this mountain range are veins worked upon powerful deposits of brown hematite and compact bog ore, accompanied with a great deal of debris.

The Luxembourg ores, of the northern part of the state, belong to the formation on the banks of the river Ourthe, as it will be described under the second group. Those of the Southern part belong to the Lias formation, which extends into Lorraine, as described above. The ores are found partly in veins, partly as superficial deposits, as granular

ores or in compact masses, embodied in an iron bearing clay of yellowish brown color.

On the southern and northern banks of the Moselle, after the river enters Rhenish Prussia and cuts its way through the Eifel Mountains, there are lastly superficial beds of brown iron ores and oolites (Fig. 2 and 3), the latter showing, when broken, concentric coals, the outside ones being very hard, but the interior becoming progressively softer towards the center, which is usually earthy and of light yellow color. The mountains in which these ores occur are secondary.

Some analyses of the new ores mentioned are the following: *

BROWN IRON ORES FROM THE BANKS OF THE MOSELLE.

The ore is porous, with yellowish brown and light brown stripes.

Peroxide of iron	85.10	81.30	69.50
Alumina	2.70	5.00	12.00
Lime	12.20	1.20	3.50
Phosphoric acid	——	0.60	0.00
Water	——	11.80	14.00
	100.00	99.90	99.20
Metallic iron	59.50	56.91	48.65

BROWN IRON ORE, COMPACT.

Protoxide of iron	65.18=Fe 50.69	
Alumina	3.78	
Magnesia	0.09	
Water	9.81	
Silica	21.10	and insoluble silicates.
Phosphate of lime	0.44	
Sulphate of lime	0.15	
	100.55	

*I shall give not only of this, but also of the following groups, some characteristic analyses which are mostly from private communications or from authorities like Rammelsberg, Karl, etc.

CLAY IRON STONE, COMPACT, DARK.

Protoxide of iron - -	35.00	
Protoxide of manganese -	trace	
Lime - - - - -	1.50	
Alumina - - -	2.75	
Silica - - - -	4.55	
Phosphoric acid - -	0.10	
Clay and quartz - -	30.60	10.60 clay, 20.00 quartz
Water and carbonic acid -	23.00	
Organic matter - - -	2.45	
	99.95	

GRANULAR IRON ORE, BLACK BROWN; THE CONTENTS OF MANGANESE ARE VARIABLE.

Peroxide of iron - -	31.50	62.15
Peroxide of manganese - -	2.90	0.75
Alumina - - - - -	2.00	0.80
Silica - - - - -	0.25	3.75
Clay and quartz or sand - -	53.60	14.66
Water and Carbonic acid - -	9·30	17.72
Phosphoric acid - - -	——	0.12
	99.55	99.95
Metallic iron - - -	22.05	43.50

The total production of the mining districts of the Maas, Moselle and Ardennes was in 1872,.....669,205 tons of ores.
Of the Vosges..... 24 920 tons of ores.
Of the Saarbrucken..... 42,200 tons of ores.

To enumerate all the iron establishments, etc., which were represented at Vienna, would be of no use to the reader in this country. Only such of this group, as well as

of the following, which are in fact prominent, shall find a place in this description. With this point in view, I cite:

1. THE LUXEMBOURG MINING AND SAARBRUCKEN IRON WORKS COMPANY AT BURBACK.

The Company has four blast furnaces, built in 1856, which are from 48 to 50 feet high. The square contents of the boshes and those of the mouth of the furnaces are of a proportion=1: 0.25 to 0.286. They are blown with three or four tuyeres which have a diameter of $1\frac{1}{2}$ to $2\frac{1}{2}$ inches. The pressure of the blast air varies from 2.85 to 4.4 lbs. per square inch and has a temperature from 250-300° C. (480-570°F). The coke used for fuel is made in 131 coking furnaces, of coal of the Saarbrucken beds, which is very good, containing very little ashes and giving a hard, but porous coke, weighing about 26.5 lbs. per cubic foot. The amount of coke required per one ton of pig iron is:

For white pig.....3000 to 3300 lbs.
For gray pig.....4000 to 4800 lbs.

The ores worked by this Company are mostly from mines near Nancy and from Luxembourg, the mines being the property of the Company. Of the brown iron ores, the two different classes are melted, one being of the compact quality, the other being a soft, clayey ore. With the intention of cleaning the ores from the merely mechanical admixtures which are in several respects of an unfavorable influence to the smelting process, they are washed. The washed ores contain from 35 to 40 per cent. of metallic iron, and bear often bands of an excellent calcareous matter. Red hematite from the borders of the Lahn is also used.

The production of the four blast furnaces amounted to 50,000 tons in 1872, or per day and each furnace to about 70,000 pounds.

The rolling mills of the company, comprising 56 puddling and 21 balling furnaces, with 10 pairs of puddle and finishing rolls, converted the above amount into 42,000 tons

of wrought iron. Half the quantity of this latter product were beams, girders and other materials for building purposes, while the rest consisted of rails.

The company displayed at Vienna a collection of girders of the most different profiles. Well known are the rolling mills for the manufacture of single and double ⊤ supporters, which are produced to a length of 70-72 feet. Those exhibited at Vienna were of a length of 54, 59 and 70 feet.

2. MESSRS. STUMM BROS., OF NEUENKIRSHEN.

The iron establishments of these gentlemen were, in past times, a domain of the Duke of Nassau, but went into the possession of the French Republic in 1792, and in 1806 into the hands of the present proprietors. The total technical apparatus of this establishment was, in 1872, 6 blast furnaces, 192 coking furnaces, 2 cupola furnaces, 52 puddling, 18 balling furnaces, 11 sets of roughing and finishing rolls, which are worked by means of 71 steam engines of a nominal power of 7,466 horses, 14 steam hammers, 7 water wheels and 90 steam boilers.

The total production amounted to 39,644 tons of rails, 910 tons of merchant iron, and 2,616 tons of cast iron. Two more blast furnaces and 96 coking furnaces are in progress of construction. The display of the firm consisted of a collection of ores illustrated by chemical analyses, pig iron, cast work, profiles of wrought iron, etc.

3. MR. KRAEMER'S IRON WORKS AT QUINT,

Near the old and well known city of Treves, (the Roman "Castra Trevirorum" in Cæsar's "De Bello Galluo,") or Frier, as the Germans call it. This establishment is a very old one, erected about one hundred years ago, containing at present 5 blast, 45 puddling and 12 balling furnaces. The production of 1872, with a force of 1,200 workmen, was 18,000 tons pig iron

and 22,500 tons of wrought iron (the latter including a great amount of pig, bought in open market). The market for the products of the establishment is the next neighborhood and the S. E. of the province. The coal is from Saarbrucken, and also the additional pig iron. The building of the Moselle Valley R. R. will give a new impetus to the establishment.

The display of iron ores, chiefly representing such of the vicinity of Frier, was extraordinarily complete, and of great local interest. Specimens of pig, profiles of wrought iron, cast iron pieces, water tubes, gas pipes, bells and machinery, were remarkably exhibited. Of special notice was a peculiar method of suspending large bells, by means of pinion nd rack, combining, t o a certain extent, security and moveableness.

4. GERMANIA IRON WORKS, S. F. BUDERUS, PROPRIETOR.

Established in 1844 by I. Glayer. This rolling mill is well famed for the manufacturing of sheet iron and galvanized iron for roofing purposes. The establishment contains 14 puddling, 6 balling and 9 re-heating furnaces, with 6 sets of rolls. The production in 1872 was 2,750 tons common, and 840 tons galvanized sheet iron; 500 workmen were employed in this fabrication.

5. DILLINGER IRON WORKS COMPANY,

at Dillinger on the Saar. The company was formed as far back as 1763, and owns now iron mines near Saarbrucken, in Nassau, Luxembourg, Lorraine and France, blast furnances and rolling mills at Dillenburg, Geislautern and Hohenheim. While the manufacture of pig iron chiefly takes place at the two latter named places, the rolling mills are concentrated at Dillengen. The specialty of the company is fine charcoal sheet iron, but besides this any kind of wrought iron, beams, girders, trusses for bridges, boiler plates and plates for water cisterns, etc., are manufactured. The total production of 1872 amounted to 24,000 tons of

wrought iron; the working force numbers about 2000 men. The best proof of the extension of the labors of the company, were the collections exhibited at Vienna. Among others there were iron plates for bridge building, 3.28 feet wide, 13.45 feet long, weighing 2,300 lbs.; a boiler plate 6.24 feet wide, 21.13 feet long, weighing 2,130 lbs. The good quality of the iron was directly proved by some objects of cutler's work; excellent sheet iron was displayed for the purpose of button manufacturing.

Concluding with this short description of the larger companies of the Saarbrucken district, this first group, I do not omit to state that there was still a remarkable number of exhibitors at Vienna which I do not enumerate for want of universal interest, but which have surely great local importance. Some well managed foundries, machine shops for agricultural implements, and others are well famed for their products among customers at home and at a distance.

THE SECOND GROUP.

The iron works of this group ore founded upon the coal and ore beds marked upon the map, Figs. 3, 4 and 5, and also upon the use of Belgian ores.

The coal beds on the rivers Worm and Inde, have a certain connection with those of Belgium, of which that of Hainault is the most important one, covering an area of 200,000 acres, and of which the beds of this group are the north-eastern continuation. The number of coal seams is very considerable, but the layers are thin, and often very much disturbed, so as to require special modes of working. The quality of the coal is also very variable; it is a bituminous one, burning rapidly, with much flame, thus giving an intense heat. Sixty different seams of coal are known.

The Belgian ores, extensively used in the furnaces of this group, in general belong to the limestone of the coal measures; they are partly brown, soft hematite, partly hard, red hematite. North of the banks of chalk, which outline the coal beds on the river Sambre, there is a belt of slate

which separates the former from following formations of chalk and dolomite, while the latter more northwards are followed by another belt of slates. It is in the zone of chalk where the brown hematites chiefly are found, while the red ores are contained in veins of the slate. The red ores are coarse grained and composed very regularly of reddish blue and blue gray, lense shaped pieces agglutinated by red paste. The brown ores are not of so good a quality as the red ones.

Argillaceous iron ores of the coal beds on the Worm are mined to a limited extent, while those of the Inde coal beds are not worth mining. Near the line of these beds there are also ores of hydrate of iron, occasionally zinciferous, in the transition rocks, where they form sometimes veins, sometimes irregular deposits. This ore is partly explored by open quarrying, partly by under-ground working.

The ores of the Sifel Mountains (Fig. 5), southward of the Worm and Inde, and thence to the Moselle, are very numerous; it is brown iron ore, superficially deposited, but very often going down to a great depth in veins. Some spathic ores are also found in this region.

Analyses of some of the ores mentioned are the following:

RED HEMATITE.			BROWN IRON ORES.			
Peroxide of iron.....	83.5	82.5	Peroxide of iron.....	31.5	59.0	72.8	44.5
" manganese	0.5		Water & carb. acid	8.0	18.0	4.8	8.0
Silica.....	10.0		Gangue matter....	59.5	22.0	21.0	44.5
Alumina.....	1.4			99.0	99.0	98.6	97.0
Carbonate of lime.....	4.6						
Earthy matter.....		17.5					
	100.00	100.0					
Metallic iron	58.45	57.75	Metallic iron	24.05	41.05	50.96	31.15

I cannot omit to mention here two peculiar methods of preparing those ores which are agglutinated by that red, clayey paste, before they are brought into the furnaces.

The first method is successfully carried on at the Cornelia

mine, near Stolberg. The ore of this mine occurs partly in small pieces of nut size, partly entirely pulverized and mixed with clayey matter. The greater parts are firstly separated by hand work, and the rest intimately stirred up with water in a cylinder, in which a vertical shaft, upon which are mounted horizontal arms, constantly revolves. The thus produced slime is then conducted, by means of more water, to large cisterns. The coarse pieces remaining at the bottom of the cylinder are taken out and brought directly into the furnace, while the slime is allowed to settle down in the cisterns. From these it is taken out from time to time, formed in bricks and roasted. The roasted ore bricks contain from 40 to 43 per cent of metallic iron. The lighter clayey matter is allowed to flow off from the cisterns, while the heavier ore settles down. At Cornelia, seven workmen produce from two cisterns 50,000 lbs. of such bricks per 12 hours, at a cost of $4.25.

The second method, which is merely a washing process, is followed at such mines where the ores, occurring in the shape of grains, nuts, or small pieces, are merely agglutinated by clay, which is of no use in the furnace. The ore is brought into wooden flues, water admitted, and the mass frequently stirred up. The flues are generally two feet wide, one foot deep, and from eight to twelve feet long, and have an inclination of two inches to one foot, i. e. about ten degrees. After being worked for some time with a rake, the slime is allowed to run off, while the remaining ore is taken out with shovels full of small holes. It is possible to wash in this way ten tons of ore, with eight to ten cubic feet of water in one hour.

A far better effect is insured in a washing by means of machinery, which is oftentimes used. The wash machine consists of a large cylinder, placed horizontally, with series of small pockets inside, which are arranged in the shape of spirals. The whole apparatus is revolved by a steam engine. With such a cylinder of twelve feet length, five feet diameter, and a direct acting engine, which has a steam cylinder of 10.35 inches diameter, and 16.07 inches stroke,

2,500 pounds of ore can be washed in one hour, the total expense per 100 lbs. of washed ore being less than two cents.

The dimensions of the furnaces of this group are the same—unimportant differences omitted—as generally used throughout Belgium, and the description of one may serve as a guidance more or less to all the furnaces related to below.

Height, total	50	feet.	
" of the center of the tuyeres from the bottom	2	feet,	6 inches
" of the hearth	7	"	
" of the boshes above the bottom	19	"	3 "
Diameter of the mouth	8	"	
" of the boshes	15	"	
" of the hearth, above	3	"	6 inches
" of hearth below	3	"	

Each furnace is generally blown with three tuyeres, and there are attached to each stack two or three hot-air stoves, for there is at present a great inclination to have the temperature as high as possible. The system of the stoves is different, as described under the third group.

The coking furnaces are mostly of Dubochet's system, which was invented by Mr. Pouwels, engineer of the gas works of the city of Paris, and which are built on a grand scale at the coking establishment of Madame de Wendell, near Saarbrucken. This system, by which the furnaces are charged, without interruption, from above, and discharged from below, comprises fifty furnaces in one set; each coking room is charged with about five tons of coal, requiring about sixty hours for coking. Each furnace, when being in full operation, gives about 3,000 lbs. of coke per twenty-four hours, with a yielding of sixty per cent. of the coal. A few establishments make use of furnaces of Fabry's system. These furnaces are small, only of a capacity of about 4,000 lbs. of coal, which are ready coked in twenty-four hours, and it is said that they yield from seventy to seventy-five

per cent. The charging and discharging can be done by three men in ½–¾ hour. These results are very good ones, but the erecting and maintaining of the furnaces is very expensive, and they are very fragile.

I give next a few figures to show the composition of the charges of the blast furnaces of this group, with a view of presenting a general idea of the manner in which they are conducted. Omitting the names of the establishments, (by special request,) in one case, each charge is usually composed as follows, viz:

1,390	lbs.	of coke.
675	"	spathic ore and brown hematite from Nassau.
675	"	brown iron ore.
150	"	granular ore.
350	"	lime (23.35 per cent of the ores).

For the production of one ton of gray pig were required:

3,850	lbs.	of coke.
3,700	"	ore.
860	"	lime.

The number of charges given in twenty-four hours is 55–60; the furnace is blown with three tuyeres, each of 2.64 inches in diameter, the nose pipes having a diameter of 2.4 inches, the temperature of the blast being from 400–450° F.; its pressure 1.5–2 lbs. per square inch.

In another instance, the charge is usually composed as follows:

1,300	lbs.	of ores, of a mixture similar to the one above, containing in the average, 42 per cent met. iron.
1,300	lbs.	of slags of the rolling mill.
900	"	lime.
1,600	"	coke.

For the production of one ton of white pig, are required 3,000 lbs. of coke.

For the production of one ton of gray pig, are required 3,600–4,000 lbs. of coke.

The furnace is blown with three tuyeres, allowing 4,310 cubic feet of blast air per one minute, which has a temperate of 250–300° C.

The display of the iron works of this group was rich, and very well organized. I mention that of the larger establishments.

1. THE ROLLING MILLS OF E. HOESCH & SONS, AT DUREN.

The firm owns the oldest rolling mills of Rhenish Prussia, which are situated at Lendersdorf, on the Cologne and Aix la Chapelle R. R., and also mills at Eschveiler, situated on the same line, and at Doitmund, Westphalia. The annual production amounts to 20,000 tons of wrought iron, of which about three quarters are rails.

The display comprised sets of wheels for railroad cars, made of steel, and polished steel plates. Very interesting, and showing clearly its construction, was a wheel of which all the different parts were loosely joined together, so as to give a clear idea of the mode of manufacturing.

2. THE MINING AND SMELTING COMPANY, "CONCORDIA."

The blast furnaces of this company were built in 1855; they are three in number, working ores from the vicinity, sparry ores from Siegen (fourth group), and red hematite from Nassau. There are eighty-five coking furnaces. The production of 1872 was 25,000 tons, or about twenty-five tons per twenty-four hours per stack. The product is, in the average, a white crystalline, seldom a gray or mottled pig. Of special interest in the display were pieces of pig, showing a considerable quantity of a glistening carburet of iron.

3. AASHENER IRON WORKS COMPANY,

At Rothe Erde, near Aix la Chapelle. This establishment, which is one of the most important and renowned, technic-

ally as well as commercially, throughout Middle Germany, has an old fame. It was founded in 1845, but since that time its accomplishments are enlarged by many new amplifications and modifications. It comprises at present rolling mills, wire drawings and Bessemer steel works. The production of 1872 was 39,500 tons of wrought iron and 1,000 tons of wire, both species of every possible description. The company employs about 1,000 workmen. Of excellent quality are especially such materials which are required in mining business, rails, crossings, girders, pillars, supports, etc., and wire used in woolen manufactories, for combs, etc.

There were displayed

10–12 different Nos. of bar iron.
20–24 " " nail rods.
5–6 " " for sieves.
4–6 " " of bundles of wire for needle manu-
5–6 " " for combs. [facturing

Besides telegraph wire, spiral springs, etc.

4. THE ROLLING MILLS OF ENGBERTH & CUNGER,

Near Aachen, with an apparatus of sixteen puddling, eleven balling furnaces and five pairs of rolls, the firm produced in 1872, 8,500 tons of wrought iron. A foundry and machine shop is connected with the mills, which produced 9,450 tons of wares. The product of the rolling mills is merchant iron, such for bridge building, also flat iron of the most different dimensions, axle trees, etc., samples of which were displayed at Vienna.

The enumeration of these few establishments of the second group may be sufficient.

THE THIRD GROUP.

Each of the numerous works of this group is supplied with coal for fuel which comes from the Ruhr coal bed. The Ruhr is a small tributary of the Lower Rhine, entering

this river at Ruhrort, not many miles above the boundaries between Prussia and the Netherlands. This coal field is marked on the map Fig. 12, and is a great deposit of bituminous coal, which is mined at hundreds of places. *

The ores used are of the most different character. To a great extent red and brown hematite from the Lahn, sparry ores from the territory of Siegen (of which I shall speak especially under the fourth group) and also Spanish ores, etc., are worked upon.

The Ruhr coal bed itself is very rich with veins of iron ores, but many of them are impure, and not suitable for the blast furnaces. This ore is mostly black band, besides which compact spathic ore and some argillaceous iron ore occur.

Of the three principal basins into which the Ruhr bed is subdivided, the southern and middle one contain some rich black band, which generally forms the upper layer of the coal, sometimes the lower; seldom it is intermitting the coal. There are about nine large mines worked upon this ore in the southern, numerous points of mining in the middle, but only two or three mines in the northern basin. Of the seven or eight veins of the blackband the thickness varies from ten to one hundred and forty inches, which are often interrupted by gangue masses.

Brown iron ore is found in the lower chalk, which forms the northern and eastern boundaries of the coal bed; it is mined at about four or five places.

South of the coal bed the different groups of the Devonian age form a mountainous country, termed the Sauerland, or Egge Mountains, Fig. 11 of the map. The upper Devonian formations, forming the northern edge of this mountain range, bear to a great extent red hematite, in large veins, very rich in metallic iron. The ores are very different in character, sometimes compact, hard and quartz bearing, sometimes soft, without quartz, but being calcareous. The

*A collection of specimens of coals from this and other beds of the provinces in question, made with the intention of testing their relative fitness for the iron industry, will be analyzed by Prof. Cox and brought into comparison with Indiana Block Coal, when they are received from Europe.

compact ores are prevalent; calc-spar, quartz and hornstone are often, iron pyrites and manganiferous ores sometimes its companions. Six or seven mines are worked upon it.

Of merely scattered occurrence are the other ores of the upper Devonian and the coal measures of the Carboniferous period (Fig. 10), which form the northern lining of the graywacke mountains. There are brown, red and argillaceous ores, partly in large veins, partly merely in pockets, forming in some way a transition to the ores of Fig. 12 of the map.

To the north and northwest of the coal bed there are very extensive beds of bog and swamp iron ores (granular brown oxides), Fig. 13. These ores always contain some phosphorus and often manganese; they are found in layers from a few to 12-18 inches thickness on the banks of all the tributaries of the Rhine and the river Ems, where they cover areas of square miles in continuous beds.

Lastly, the Weser Mountains and the Teutoberger Forest, Fig. 14, are ore bearing. These two mountain ranges, which have a parallel northwesterly stretching, are of the most variable geological formation. There are large deposits of ætites argillaceous iron nodules on the Weser, where this river forces its way through rocks of the Jurrassic formations (forming the "Porta Westphalica" of Roman remembrance). Granular iron ore, sometimes quite loose, sometimes agglutinated by calcareous or clayey paste, are found upon the formations of the Cretaceous period of these mountains. Ores are also found in the Lias, especially at the Southern outskirts of the Teutoberger Forest, forming veins of red iron ore, several feet in thickness. Finally the most northwestern foot hills of both ranges contain upon some coal beds of anthracite, of the magnesian limestone around the city of Osnabruck, brown iron ores in veins of from 6 to 24 feet extension, and more. Noteworthy is a mine, located about five miles from the city mentioned, which is worked upon a vein of 47 feet thickness.

I can not omit referring, that at the northern bank of the Weser Mountains, between the Porta Westphalica and the

city of Minden, about 3 miles distant from the former place, coal is mined; Wealden, the third division of the Jurassic formations, being the geological feature. The coal is very gaseous and mining extremely dangerous. Coke made of this coal is used in the blast furnaces which stand in the Porta Westphalica.

Analyses of ores of Fig. 10 of the map, I was unable to procure.

Analysis of ores of the deposits marked

FIG. 11.

The following analysis gives an average of the most important mines; the ores are worked upon to a great extent in the blast furnaces near Doitmund. (See below):

Peroxide of iron - -	47.71	=Fe 33.39
Silica - - - -	14.80	
Alumina - - -	4.00	
Lime - - - -	27.72	Carbonate of
Water - - - -	5.60	
	99.83	

Analyses of ores of the deposit marked

FIG. 12.

Compact spathic ore of the coal beds near Hattingen on the Ruhr:

Protoxide of iron - -	52.00	=Fe 40.43
Magnesia - - -	2.29	
Carbonic acid - - -	35.92	
Peroxide of iron - -	2.75	
Water - - - -	6.13	
	99.09	

The roasted ore contains 50 to 60 per cent. of metallic iron.

BLACKBAND.

Protoxide of iron - -	.....	0.67	7.71
Carbonate of protoxide of iron	60.15	.....	.....
Magnesia - - -	.....	1.21	2.22
Carbonate of Magnesia -	2.40	.....	.....
Lime - - - - -	.....	6.06	4.64
Carbonate of lime - -	1.53	.....	.....
Carbonic acid - -	.....	trace	0.76
Peroxide of iron - -	0.94	43.57	54.72
Peroxide of manganese -	.....	1.88	0.94
Alumina - - -	6.64	11.91	4.04
Silica - - - - -	1.03	32.34	20.53
Water and organic matter -	4.96	0.44	1.42
Sulphuric acid - -	0.29	0.73	0.64
Phosphoric acid - -	.....	0.61	0.72
Carbon - - -	21.27	1.20	2.94
	99.21	100.62	101.28
Metallic iron - -	46.77	31.20	44.17

The first of these analyses is of ore from a mine near Bochum; the ore is smelted in the furnaces of the Iron Works Company "New Scotland." The second and third analyses are of roasted ores, in which state they are used as an admixture in the blast furnaces at Horde. The samples represent the best ores of this kind found in Westphalia. *

Analyses of ores of the deposits marked

FIG. 13.

GRANULAR IRON ORES, FROM THE BANKS OF THE EMSHER, A TRIBUTARY OF THE RHINE.

Peroxide of iron - -	76.80	52.73
Silica, soluble - - -	1.00	6.33

*All the plates related to here and elsewhere can be found on the map.

Silica, insoluble - - -	6.52	27.39
Water, chemically combined -	13.78	11.26
Phosphoric acid - - -	1.42	1.90
Sulphuric acid - - -	0.30	0.19
	99.82	99.71
Metallic iron - - -	53.76	36.91

Analyses of ores which represent fair samples of the deposits described as

FIG. 14—RED IRON ORE FROM PORTA.

Peroxide of iron -	47.64	=Fe 33.34
Silica - - -	16.66	
Alumina - -	8.19	
Lime - - -	3.42	
Magnesia - -	2.76	
Water - -	17.83	inclusive Carbonic acid
Phosphoric acid -	1.17	
Sulphuric acid - -	2.01	
	99.68	

The ore is partly transferred into brown iron ore.

BROWN IRON ORE, FROM THE MAG. LIMESTONE NEAR OSNABRUCK.

Peroxide of iron - -	63.04	=Fe 44.12
Peroxide of manganese -	3.75	
Magnesia - - -	2.04	
Silica - - -	18.79	soluble and insoluble
Water - - -	11.20	chemic. and hygrosp.
	98.82	

ARGILLACEOUS IRON ORES (ÆTITES) FROM PORTA.

Peroxide of iron	48.79	=Fe 34.15
Carbonic acid	20.13	evaporated in calcining
Alumina	9.43	
Silica	14.56	
Magnesia	2.76	
Lime	3.05	
Sulphuric Acid	1.03	
	99.75	

The ore is analysed after having been calcined, from which reason the iron appears as peroxide.

SPATHIC ORE, FROM THE "OLDENDORF MINE," NEAR MINDEN.

Carbonate of protoxide of iron	71.45	=Fe 44.35
Carbonate of protoxide of manganese	1.15	
Carbonate of protoxide of magnesia	9.09	
Peroxide of iron	11.95	=Fe 8.36
Gangue matter	3.75	
	97.39	

The ore bears a crystalline appearance, but is very much impregnated and inpured by particles of slate.

I may add a few figures relative to the production of the ores mentioned above.

The total amount of ore mined in 1872 of the deposits shown in

Fig. 10 were	25,600 tons	
Fig. 11 were	18,450 tons	(which is by no means in compliance with the extent of the beds.)
Fig. 12 were	307,750 tons	(blackband, spathic, etc., ores.)
Fig. 13 were	70,700 tons	
Fig. 14 were	55,150 tons	
	477,650 tons	

In relation to the Spanish ores used by the iron masters of this group, I have to state that the mountain ranges of the Kingdom of Muria and Estremadura include some iron veins in the crystalline or elder sedimentary rocks, of from 3 to 10 feet thickness. Also the Pyrenees and the mountains of Biscay, Asturia and the north of Galicia, which are their prolongations, contain important mines of iron ores. They consist of deposits of red oxide of iron and sparry ores, as continuations of the more northern French sparry ores, which traverse the old red sandstone. There are also mines upon beds of hydrate of iron, subordinate to transition limestone.

Average analyses of the ores are the following:

RED HEMATITE.

Peroxide of iron - -	88.20=Fe 61.74
Silica - - - -	10.00
Alumina - - - -	0.55
Carbonate of lime - -	1.80
Loss - - - -	0.43
	100.98

BROWN HEMATITE.

Peroxide of iron -	75.05=Fe 52. 53	70.10=Fe 49.07
Peroxide of manganese	1.45	3.65
Lime - - -	.....	0.22
Magnesia - -	.....	0.23
Alumina - -	.....	6.33
Silica - - -	.....	13.66
Clay - - -	12.50	.....
Water - - -	11.00	.....
Loss - - -	.....	5.71
	100.00	99.90

SPARRY ORES.

Protoxide of iron - -	57.72=Fe 44.77	53.17=Fe 41.35
Protoxide of manganese	3.40	3.70
Lime - - -	1.90	2.30
Magnesia - - -	1.80	3.80
Silica - - -	0.08	7.60
Water and carbonic acid	35.78	29.71
	100.68	100.28

Of the Swedish and Norwegian ores also of course, only the best ones are imported for admixture.

The best iron mines of Norway are situated on the coasts of the gulf Christiana and on the side facing Jutland. The ores consist almost solely of black oxide of iron, forming beds of from 4 to 60 feet thick in the gneiss.

The best Swedish mines, of Wormeland, are also worked upon veins or beds of black oxide of iron, several yards thick, in rocks composed of hornblende, talcose and granite. The mines of Dannemora stand in the first rank of those of Sweden and even of Europe; there are also the immense, well known beds of brown iron ore, north of Stockholm, the Swedish capital, which are excellent for the contents of manganese. Some anlyses of the latter ores are shown in the following:

Peroxide of iron - -	65.57	70.38	61.84
Peroxide of manganese -	3.87	4.01	3.43
Lime - - - -	0.82	0.88	0.50
Magnesia - - -	0.15	0.21	0.06
Alumina - - -	5.08	1.23	5.19
Silica - - - -	7.15	9.18	11.33
Phosphoric acid - -	1.13	0.31	0.67
Sulphuric acid - -	trace	trace	0.43
Water, etc - - -	16.22	13.79	16.54
	99.99	99.99	99.99
Metallic iron - -	45.89	49.26	43.28

Of the African ore, such as calcareous brown hematites, from the northern coast, are imported which are reported to contain:

Peroxide of iron - -	57.25=Fe 40.07
Peroxide of manganese - -	3.50
Lime - - - -	10.00
Magnesia - - - -	2.00
Alumina - - - -	1.60
Clay - - - -	4.00
Water - - - -	21.00
	99.35

Before entering upon the discussion of the iron establishments having exhibited at Vienna, I give next a short general view of the blast furnaces, coking furnaces, hot air stoves, etc., as they are built at present, more or less, at all the iron works of this group. The first

BLAST FURNACES

in Rhenish Prussia and Westphalia, were built by Belgian engineers and workmen, years ago, but mostly during the period from 1852–1858, when the development of the iron industry had a great rise throughout the European Continent. The Belgian engineers built, of course, upon Belgian patterns, and following their steps, the German iron masters found it practicable to give their furnaces such measures as are contained in the table below. This table gives the dimensions of furnaces well known for the quality of their products and enumerated in the list of exhibitors at Vienna:

	Phœnix Iron Works.	Henrichshutte on the Ruhr	Horder Iron Works	Muhlhofen Iron Works.
HEIGHT.				
Total	53ft.	54ft.	52ft. 5in.	48ft. 6in.
Of the center of the tyeres above the bottom	2ft. 6in.	2ft. 5in.	2ft. 6in.	2ft. 6in.
Of the hearth	7ft. 6in.	7ft. 9½in.	5ft. 5in.	7ft.
Of the boshes above bott.	21ft. 6in.	17ft. 9½in.	16ft. 11in.	22ft.
DIAMETER.				
Of the mouth	7ft.	9f. 6in.	9ft.	10ft 6in.
Of the boshes	15ft 6in.	15ft. 3in.	15ft. 4in.	15ft.
Of the hearth, above	4ft. 6in.	4ft.	2ft. 1in.	4ft.
Of the hearth, below	3ft.	2ft. 10in.	2ft. 1in.	3ft. 6in.

During a period following the time named, some engineers entered the manner of English iron masters, and this in such cases where the blackband is smelted. As an example I give the dimensions of a blast furnace, which is in blast a great many years for the production of gray pig:

Height, total	48 ft.
Height of the boshes above the bottom	10 ft. 8 in.
Height of the hearth	4 ft.
Diameter of the mouth	9 ft. 10 in.
Diameter of the boshes	15 ft. 9 in.
Diameter of the hearth	5 ft. 10 in.
Total cubical capacity.	5,650 cubic feet.

The upper outside casing of the furnaces is either of mason work (Belgian model) or of heavy sheet iron (English model); in the first case, octagonal, conical or pyramidal; in the latter, conical, but always corresponding with the inner lining of the stack, from which it is separated by intermediate shells.

The lower part of the outer casing is either a square of mason work, leaving the usual four openings on opposite sides, or the hearth itself stands entirely free and is cooled by water, the upper part being supported by pillars.

Of late, furnaces of Mr. F. Buttgenbach's patent, a well known iron master of the lower Rhine, are introduced. The first model of this gentleman's furnace was exhibited at the Paris Exhibition, 1867. The principle idea in constructing this furnace is, to have the hearth easily accessible from all sides; also the inner lining of the upper part, and to have the mason work entirely independent from the inner shell. Each part of the furnace is accessible while the same is in operation and constantly cooled by the free access of the atmosphere. This idea is executed in building up the hearth and boshes by themselves, as far as about 3½–4 feet below the greatest diameter, where a circular outer casing of mason's work, built around the hearth in a suitable distance, sets in so as to support the upper inner shaft. The latter is also exposed to the atmosphere and has no other coating but rings which sustain the shaft. A further peculiarity of the Buttgenbach furnace is a series of tuyeres, which are placed in two rows above the usual blowing tuyeres. Cold water is freely circulating through the same, so as to keep safe the hearth from burning out. These tuyeres are at the same time a ready means in case of necessity to supply the hearth at such places with blast air where obstructions should appear. The latest peculiarity of the Buttgenbach system is, that the platform is supported by pillars which serve as flues for the waste gases. These pillars are supported by a sheet iron vessel, of a form of which I shall speak below, and which is placed on the top of the mason work, which is put around the lower part of the furnace. Several years experience has proved, that there is no fear to be entertained in cooling the furnace too much and thus producing irregularities in its behavior.

In either of the foregoing cases, the hearth, bottom, breast and dam of the blast furnaces in Rhenish Prussia and Westphalia are made of mill stone grit from Marchin on Huy, in Belgium. This valuable material is a coarse conglomerate, composed of white quartz pieces, conglomerated by a whitish quartz mass. Sometimes there are gray or brown spots in it, created by the presence of iron; small spots or

thin veins are not considered noxious; large ones are. These rocks occur in layers of from two and a half to three feet thickness. In cutting the stones for use in the furnaces, it is found necessary that the sides of the hearth stand vertically to the layers. The mass is extremely hard and very difficult to be worked; it bursts into pieces easily when suddenly brought into fire. For this reason a new hearth is always fitted out with a coat of fire bricks, so as not to allow the fire to operate directly upon it when the furnace is blowing in. One cubic foot (English) of this mass weighs about 155 pounds, and the ready made stones for one furnace (bottom, breast, dam and hearth) cost about $1,500.

The ring wall is generally made either of Garnkirk (near Glasgow, Scotland) or Belgian fire bricks. There are some deposits of fire clay on the banks of the Rhine, near Bonn and Coblentz, and in Hessia, but its qualities are not considered good for the purpose in question. For the building up of these bricks, which are bought in the average at seventy cents per one hundred pounds, at the establishment, clay from Dudley, Stafford county, England, is often used, which sells at three to eight dollars per ton, according to the quality. Clay from Andenne, near Namur, Belgium, where it is found in small beds in the transition rocks, is also often used. As to the

TUYERES AND BLOWING ENGINES,

The furnaces are blown with three, five and six tuyeres. Those of Belgian construction generally have one tuyere on opposite sides, and one in the posterior wall; sometimes there are two at each side, the direction being somewhat declined from the center of the furnace, so as to force the blast in a kind of revolving way into the hearth. Where the hearth stands free, the tuyeres are placed around in equal intermediate distances. The diameter of the nose pipes varies, according to the working of the furnace, from one and a half to two and a half and three inches; the pressure also from one and a half to three lbs. per square inch. The

quantity of blast air blown into the furnace is variable from 2,700 to 4,500 cubic feet per one minute, the temperature from 250 to 400° C. Two furnaces mostly have one blowing engine of 100–150 horse power, or two of seventy-five to eighty horse power each. The engines are either beam blowing engines, or horizontal ones, some of them with slide valves, others with flap valves. At all the different establishments one receiver or regulator of the blast supplies all the furnaces, whatever may be their number. For with the increase of its cubical capacity the uniformity of the stream of the blast is facilitated.

The furnace of English pattern which I mentioned on page 39 is blown with seven tuyeres of from 2.5 to 3.25 inches diameter; the pressure of the blast air is 2.2–3 lbs. per square inch, its temperature 300° C. The daily production being twenty-five to thirty tons, and the amount of fuel (coke) required per one ton of pig being 1.65 tons, the quantity of blast air necessary for the production of one ton pigs is calculated to 204,762 cubic feet, or 3,530–4,300 cubic feet per one minute.

Each blast furnace has generally now three sets of

HOT AIR STOVES,

Which communicate with one line of conducting pipes leading to the blast furnaces. Thus in case of repairs required in one set the other two may be kept in full activity, capable of supplying an abundance of heat to the blast. Of course they are of different construction, but the following are such as are mostly used:

1. Apparatus with syphon pipes, flattened laterally or round, as in some cases. A system of such pipes is set in a kind of oven, from which the flame is taken out at the top of it; but it then again descends before it reaches the chimney, entering it nearly at the height of the fire grate. By this manner the pipes are kept in a bath of ignited air, and not exposed to the corroding influence of a current flame. There are usually 36 pipes in two sets, arranged alongside, which

(the pipes) are six by two and a half inches wide (inside), and have a length of four feet. Under each set of pipes is a grate eighteen inches wide. The distance between the pipes of one set is, from center to center, eight inches, and of the center of one set to the center of the other three feet six inches. The flues, nine in number, are six inches wide, and terminate in a chimney twenty feet high and sixteen inches wide.

2. To prevent the alteration of form to which the arched pipes are subject, at a high temperature, this system is somewhat changed in the manner that the arch is cut in two, the upper end of the pipes enlarged, (so as to represent the form of the butt end of a pistol,) and the pipes separated by means of an interior wall. The blast goes up and down in each pipe, there being an opening in the interior wall at its upper end. Generally there are fifty-six pipes, or 28 on opposite sides, in each oven of from twelve to fourteen feet length. The surface exposed to the flame is about 2,500 square feet.

3. Another apparatus has horizontal pipes, their section being a parallelogram, to give more heating surface and also more depth of pipe, so as to make it stronger and less liable to bend by its own weight when softened by the red heat. From twelve to thirty of such pipes are placed in three to five rows, one above the other. Each pipe has a length from five to ten feet; the greatest diameter is ten to fourteen inches, the smaller about three inches, inside. The pipes are placed vertically in distances from five to ten inches between the rows.

4. Of late there are apparatuses built in which the pipes are free hanging, supported from above. This system involves two advantages: first, it is very easy to exchange defective pipes; and secondly, all the heat is entirely utilized, and in the most effective manner. The pipes are eighteen to twenty inches wide and divided by an interior wall in two rooms, so as to force the blast, which comes from the main pipe placed on the top of the oven, to go first

down and then up. The length of the pipes is about twelve to thirteen feet. Thirty-six pipes are placed in two sets, eighteen in each row, in one oven.

The next apparatus in order to mention are the

COKING FURNACES.

1. Francois' or Renroth's system. The furnaces of this system are built in a shape that their bottom forms a parallelogram, the dimensions being about the following: the floor is of as many square feet as cwt. of coal are intended to charge the furnace once. The proportion of the width to the length is, 1:6 or 1:7, the length not averaging twenty-five feet. The vertical side walls are closed by an arch, the height from the floor to the center of it being about twice the width. The width is generally from thirty-eight to forty inches. The side walls are five inches thick, the flues between the walls also five inches wide; the bottom and walls are hollow, for the purpose of allowing the gases to heat the whole apparatus; thirty and more of such furnaces are often combined in one set. The arches closing the furnaces are seven to eight inches thick. The central flue, into which the gases flow after having circulated around the furnaces, and which terminates in a chimney stack, is of a width of about one-twentieth of the square contents of the furnaces. The latter are filled from above with five to six tons each, which are ready coked in forty-eight to sixty hours; the yielding is about sixty to sixty-two per cent.; the cost of coking is ten to twelve cents per 100 pounds. This system is generally now followed by all the iron establishments in Westphalia, while in Rhenish Prussia, also,

2. Appolt's system is followed. In this system the coal is coked in smaller quantities than in any other furnace. They are apt to produce a superior quality of coke, which has a compact, glistening appearance. Coal

From Saarbrucken yields in such furnace.....68 per cent.
From Liege yields in such furnace.....80–82 per cent.
From Ruhr beds yields in such furnace.....75–78 per cent.

Nearly all the iron masters are now using the

WASTE GASES

For heating the boilers of the steam engines, or the hot air stoves. Some years ago there existed a great waste of fuel in heating the cold blast, and while one sought the advantages of hot blast, the expenses for providing it greatly outbalanced the benefits or economy which it was intended to create. Why not apply for this purpose the gases already created in the furnace and generally wasted? This question met for a long time with great opposition, and this because the method of gaining the gases had always been conducted in a decidedly wrong manner. All those methods which withdraw the gases from below the mouth of the furnace, are always injuring the smelting process because they hurry the same. In defining the dimensions of a blast furnace (heights and widths) it was found necessary—first by experience, and afterwards by theoretical confirmation—that the masses intended to be subdued to the smelting process must remain a certain time in the furnace. The gases, created by combustion, decomposition and composition, must remain long enough in contact with the metalliferous ingredients, in order to execute that portion of the process which is termed the preparation and reduction. Arrangements extracting the gases before they have fulfilled this effect are wrong, as they damage the whole operation considerably. Only after having had the necessary effect they can be collected without doing any injury. This principle is fulfilled in a prompt manner in the apparatus of Mr. Langen, general superintendent of the Lieg-Rhine Mining and Smelting Co. whose apparatus can be found at present affixed to a great number of the blast furnaces of Rhenish Prussia and Westphalia. The apparatus itself is very simple, but this is one of its prerogatives,

because all other more complicated arrangements cannot endure very well the change of temperature which often takes place at the mouth of the furnace. Mr. Langen's arrangements are the following: Upon the mouth of the furnace there is placed a truncated cone of cast iron; the smaller diameter (which corresponds with the one of the mouth) is placed below, and the height of the cone is to be calculated from the amount of materials i. e. coal, or ores and flux, intended to charge the furnace once.

Next to this cone, and fitting into its smaller diameter, comes a cylinder which has about twice the height of the cone, and has a two-fold design:

Firstly, to charge the furnace with the materials; and

Secondly, to receive the gases after they escape off the surface of the masses, and conduct the same, by way of connecting tubes, to the places where they may be required for economical use.

To fulfill the first object, the cylinder is covered at its top, leaving only the center to about three feet wide open. The edge of this opening is mounted with an angle iron pointing downwards, so as to go in the upward curved lower end of a suspended tube. The thus made little room is filled with water, to prevent the gases from escaping at this place. Suspended in chains, the cylinder can easily be moved up and down by means of levers mounted on pillars and a windlass affixed to the outer end of the levers. After filling the cone, or, properly speaking, the open room between the cone and cylinder, the latter one is wound up, and the coke, or ores and lime, slope down into the furnace without any obstacle. And this is done in a way very advantageous to the whole process: the heavier ore will fall nearer to the circumference of the furnace, while the lighter coke goes more to the center, and it is known that the greater amount of the gases takes its way along the sides of the furnace. Thus this method of charging has the great advantage of bringing the ores in more intimate contact with the gases.

To fulfill the second object, the gases take their way out of the mouth through the cylinder into a tube suspended by the same arrangement of pillars which support the levers mentioned, and thence, by means of following flues, next to a cleaning apparatus. Of course, the first receiving tube is mounted with valves for the regulating of the flowing off of the gases, as well as for the cause of safety; for explosions, created by the mixture of the gases with air, are inevitable. The cleaning apparatus is a vessel or tube, open on one side to a certain height and provided there with an addition which prevents water, filling the bottom of the vessel so as to close the opening, from flowing off. Here the gases deposit all the dust, or fine ore and coke particles carried off from the furnace, while a great part of the water, which is always suspended in the gases as vapor, is condensed. At the same time, this apparatus acts as a great valve, because the column of water can easily be thrown out by any event of an explosion, thus paralyzing its injurious effects. From this cleaning place, the gases, in a merely cleaned state, are conducted to the steam boilers, or hot air stoves.

The pressure of the gases of a furnace which is in good behavior, is not more than 0.2–0.33 lbs. per square inch; the temperature about 75–80° Celsius.

The gases of one furnace are considered to be sufficient for two steam boilers of an engine of 70–75 horse power, and one hot air stove.

In all instances, the gases should first be used under steam boilers, and only in the second place for the heating of the blast air. Considered that the effect produced by the gases in either case is a benefit to the management in general, it should be theoretically the same, whether used for the producing of steam or hot air. But, practically, there is a difference. The quantity of blast air required in a furnace, is proportioned to the amount of gases given off by the furnace but there is no such relation between this amount and the temperature of the blast. If there occurs any misbehavior of the furnace a higher temperature is mostly

always a remedy against it. Exactly in such cases the amount of gases diminishes on account of the growing coolness of the furnace, and for this reason it is safe not to depend upon the gases for the heating of the blast, but to have fire places for direct firing attached to each hot air stove.

Finally, I must add a few remarks to the

ROASTING OF THE ORES.

To enumerate all the different kinds of roast-kilns would go beyond the limits of this paper. Most all of the roasting process is executed in furnaces, sometimes between little walls, (rost-stadeln, in German,) or in heaps in the open air. In the two latter cases the fuel is always in immediate contact with the ore which is intended to be roasted, while in the former, this contact may or may not, as in furnaces with gas firing, take place.

The roasting of the blackband is always done in heaps. Alternate beds of fuel and ore, which is used in medium sized lumps, are formed, the fire kindled at the lower part and the combustion so conducted as to be slow and to let the whole mass be equally penetrated by heat. The heat itself is to be regulated so as not to melt or vitrify the ores, which is done by covering with earth where too much activity is displayed, or in piercing holes to give air where it is imperfectly developed.

Such ores which are very fine are often roasted in stadeln. Three walls surround the roasting place, with openings around to allow the successive admittance of air to the fire. There are also little chimneys inside of the walls, corresponding with openings and flues in the bottom, in order to create draughts of air in the surrounding parts.

Little can be said as to the consumption of fuel in these two cases, because it varies with the variety of the ore, some blackband burning even by itself, without any admixture of fuel.

The furnaces employed to roast the spathic ores differ

much. The requirement in this case is the disengaging of combined water and carbonic acid, and the decomposition of sulphuret. No ores in the form of small, little pieces, or powder, are roasted in kilns; they can only be used in the shape of lumps. To extract the decomposited sulphurets, roasted spathic ores are always kept for months exposed to the influence of the atmosphere.

In enumerating the iron works based upon the use of the materials and apparatus described above, and which were represented at Vienna, I shall follow a geographical line, commencing on the banks of the lower Rhine, going eastward along the line of Cologne-Minden R. R. as far as Hamm, Westphalia, and departing north or southwards from this road, as far as necessity requires.

1. SUMMER, BLOSER & CO.,

Proprietors of the Neusser Iron Works, at Neuss, on the Rhine, displaying collections of ores and pig iron, also a model of Mr. F. Buttgenbach's blast furnace. This gentleman is general superintendent of the company. The establishment, situated in close vicinity to the river and two important railroads, is enabled to smelt the choicest ores, which can be conducted thither at very low rates The collection of ores exhibited was therefore remarkable for its foreign constituents, especially of Spanish ores, which are melted by the company for several years. The production is about thirty tons per twenty-four hours per furnace. The quality of the iron is regulated by the commissions ordered.

2. PRUSSIAN MINING AND SMELTING CO.,

At Dusseldorf. The company owns three extensive coal mines and the iron works, "Vulcan," situated near Duisberg on the Rhine. At "Vulcan" there are four blast furnaces which are blown upon foundry pig, white, glistening iron and spiegeleisen, just as demands for any of these qualities require. Situated on the right bank of the Rhine, and being the terminus of several important railroads, this

establishment, like others of the vicinity, is enabled to smelt the most different ores, from near by or from remote countries. At Vienna was displayed a collection of twenty different ores, of the most different origin, and a very interesting illustration of five different methods of working was given, which are followed in smelting the ores, and producing a quality of iron satisfactorily to the demands of the customers.

3. Mining and smelting company,

"FREDERICK WILHELM IRON WORKS,"

At Mulheim on the Ruhr, which not only owns mines and blast furnaces, but also a very large foundry and machine shops. The production of the company was, in 1872, 8,150 tons of cast iron, ready made machines of any description, water tubes and gas pipes. The four blast furnaces produce about twenty-five tons of gray pig each per twenty-four hours.

4. Mining and smelting company,

PHENIX,

At Saar, near Ruhrort on the Rhine. The company owns a very extensive stock of apparatus for the fabrication of pig and wrought iron, ore and coal mines.

The company produced, in 1872, from two mines near Berge Borbeck, on the C. M. R. R.,* with seven hundred workmen, 150,000 tons of coal; from twenty-eight mines were produced, by 1,000 miners, also 150,000 tons of ores. Besides these, the company smelts, to a great extent, foreign ores, such as Spanish, and others, for which reason the display of ores was divided in two classes, i. e., ores from their own country and foreign ores.

The ores are smelted at three different places, viz:

At Saar, near Ruhrort, in six blast furnaces.

At Borbeck, on the C. & M. R. R., in four blast furnaces.

* Cologne-Minden R. R. ** Bergisch Markisch R. R. (See Map.)

At Kupferdreh, on the B. & M. R. R., in two blast furnaces.

With such a variety of ores and furnaces, the company is, of course, enabled to produce any quality of iron wanted, from gray pig No. I, to spiegeleisen. While the blast furnaces at Saar and Borbeck mostly work for the requirements of their own rolling mills, those at Kupferdreh work for dealing with other firms. The product of the latter furnaces is especially well famed for its excellent qualities as foundry pig.

The rolling mills at Saar mostly produce rails. In rolling mills at Eschweiler, near Aix la Chapelle, (strictly belonging to the second group of this paper,) owned also by the company, rails, T and ⎓ double T irons for building purposes, axle trees, angle iron, etc., are produced.

Of late, there is also a Bessemer Steel works in operation at Saar. The total production of the company amounted, in 1872, to:

At Saar -	38,450 tons of pig iron;	31,150 tons of rails
At Borbeck	17,850 tons of pig iron.	
At Eschweiler		10,200 tons of rails. 7,800 tons merch't iron.
At Kupferdreh (not given).		
Total - -	56,300 tons.	49,150 tons.

5. Mining and Smelting Company

"GUTE HOFFNUNG IRON WORKS"

at Herkerade, near Oberhausen, on the C. M. R. R. This Company was formed during the present year (1873) of the old firm, Jacobi, Haniel & Huyssen, established in 1808, and owns:

First. The iron works at Oberhausen, comprising ten blast furnaces and very extensive rolling mills, producing rails, merchant and sheet iron.

Second. A Bessemer Steel Work and rolling mills, for the manufacturing of steel rails, at New Oberhausen.

Third. Machine shops on a grand scale at Herkerade, and an extensive foundry at the same place.

Fourth. A ship yard for the construction of iron vessels, steamers, gunboats, etc., for navigation on the Rhine and seacoast navigation.

These four establishments are worked with a force of about 8,000 men, producing, in the average, 75,000 tons annually of ready made iron of any quality or form.

The display of the firm consisted of a large collection of raw materials and products, and some monster pieces; a U iron, 46 feet long, and a piece of flat iron 55.75 feet long and twisted, cold, to a spiral.

6. Iron Works Company

"STYRUM,"

near Oberhausen. The rolling mills of this Company, established in 1857, and containing at present 40 puddling and 20 balling furnaces and 11 sets of rolls, produced, in 1872, 15,000 tons of bar, flat and facing iron, with 650 workmen.

Specimens of every kind of products were displayed; flat iron of 3.25 ft. width and boiler plates 8.25 ft. wide, were noteworthy.

7. I mention here the

"HEINRICH'S IRON WORKS"

at Hattingen on the Ruhr, which were not represented at Vienna, but which may find a place in this report because the blast furnaces of this establishment are especially worked upon blackband and spathic ores of the Ruhr coal beds. These ores are melted here to a greater extent than at any other iron work to be mentioned. The establishment is owned by the Berlin Discount Company, who also owns

extensive works and mines in Upper Silesia. It contains four blast furnaces which are situated on the banks of the Ruhr, in the closest vicinity of the ore and coal mines, thus affording a very cheap transportation of the raw materials. The blast furnaces are constructed on a large scale, after such dimensions which are found to be the best for the melting of blackband. The belly is nearly cylindrical and a wide hearth is provided, both on account of the easy fusibleness of the ores and for the quicker slope of the charges. The accurate dimensions were given above in the table of heights and widths of blast furnaces.

The blackband used is always roasted, either in heaps or stadeln; some mines contain so much of organic matter that they do not require any admixture of fuel. Heaps of 50 ft. length, 12-15 ft. wide and about 8-10 feet high require from two to three months time for roasting. The roasted ores contain up to 55 per cent. of metallic iron, the richest ores bearing a dark blue color, the poorer ones a light red one. These latter ores would give a small yielding in the furnaces, but they are excellent for admixing to the spathic ores because they always contain some clayey matter.

The compact spathic ores, or carbonate of iron, which are used here, has no relations externally with the sparry variety. (See 4th group).

It comprehends most ot the clay iron stones, and particularly that which occurs in flattened masses of various size among the coal beds. The color is dark gray, its fracture coarse grained. The coal used is very bituminous and yields a porous, but strong coke. The coal is brought direct from the mine to the coking furnaces, for it is found that its qualities are deteriorated by exposing it for a longer time to the influence of the atmosphere, giving an easy crumbling coke. The coking furnaces are of Francois' system, 6 ft. wide, 22 ft. long, each charged with 120 Scheffel (220 bushel) of coal, which are ready coked in 28-30 hours. The gases of these furnaces are used for heating the steam boilers, which are placed on their top. The yielding of coke is about 55.62 per cent. by weight.

For flux, limestone is used, containing about 98 per cent. of carbonate of lime. The daily production per furnace is about 30 tons; the yielding of the ores in the average 38 per per cent., of the mixture (inclus. lime) 28.5-30 per cent.

The charges are usually composed as follows:

3,100 lbs. of spathic ore,
1,390 lbs. of blackband,
1,570 lbs. of lime,
2,400 lbs. of coke,

while for the production of one ton of pig iron are afforded:

3,606 lbs. of spathic ore,
1,606 lbs. of blackband,
1,814 lbs. of lime,
2,792 lbs. of coke.

The temperature of the blast air is about 300° C., its pressure 2.5 lbs. per square inch. There are three tuyeres, those on opposite sides of 4.5 inches, the one in the posterior wall of 3.25 inches diameter, thus giving an amount of 3,710 cubic feet blast air per one minute.

The slag is strong, light gray and white, only the edges are glassy and always showing a superamount of bases (lime). In cases where its stoney quality turns over into a glassy one, the iron changes from gray into white, but the addition of a few per cent. of lime will always restore the proper behavior of the furnace. The quantity of slag per 100 lbs. of iron is found to be 120 pounds.

The iron produced in the furnaces is worked in a rolling mill, and a foundry and machine shop also belonging to the Company. The latter three establishments work for the demands of the numerous coal mines in the neighborhood.

8. The

"BOCHUMER STEEL WORKS"

at Bochum, on the C. & M. R. R. This establishment is,

besides the one of Mr. Kruppe, the largest steel work of Westphalia, and perhaps of Germany; it had a beginning upon a very small scale, in the year 1843. From that time until 1854 it was the property of Messrs. Meyers and Kuhne, when it came into the possession of its present owners, a stock company. The firm has now coal mines near the city named, likewise iron mines in the territories of Siegen and Nassau, blast furnaces at Mulheim on the Rhine, and the well famed "Cast Steel Works" at Bochum.

It is a principal peculiarity of this latter establishment to produce any article required for the market of cast steel, like others do of cast iron. The mode of working is a secret, which was first introduced by the previous owner, Mr. Meyer, now the general superintendent of the company. The accuracy of the different articles now produced is really astonishing, and of such an accomplishment that no further working upon the cast pieces, by hammer or file, is required.

There were a great many useful things of this kind displayed at Vienna. Bells, springs, ship propellers—one of six tons weight—wheels for railroad cars, and other numerous products, manifesting the well deserved fame of the company.

The production of 1872 amounted to 48,000 tons ready made cast steel articles, including 7,200 tons of car wheels. 5,000 workmen were employed for the fabrication.

The steel works contain sixteen puddling, nine balling and ninety-two re-heating furnaces, twenty-seven melting furnaces, seven Bessemer converters and steam hammers, and numerous forges.

9. The "New Steel Works Co.," (Daelen, Schreiber & Co.,) at Bochum, established in 1869, own a first class Bessemer steel work, which produced, with three hundred workmen, four cupola furnaces, 2 converters and seven regenerative furnaces, in 1872, 9,000 tons of tires for railroad cars, axle trees and parts of machinery.

10. Rolling mills of

SCHULZ, KNAUDT & CO.,

At Essen, established in 1856, produced, in 1872, with four hundred workmen, fourteen puddling, six balling and four re-heating furnaces, rolls, etc., 7,000 tons of sheet iron, boiler plates, such for locomotives and others of heavy weight.

11. Rolling Mills of

GRILLO, FUNCKE & CO.,

At Gelsenkirchen, near Essen, established in 1866, produced in 1872, with four hundred workmen, in seventeen puddling, 8 balling furnaces, and the corresponding sets of rolls, 9,500 tons, nearly all boiler plates, and others.

12. FREDERICK KRUPPS'

Steel work, at Essen, is of wide-world fame and often described already. Established in 1810, the very extensive establishment comprises at present four coal mines, four hundred and fourteen ore mines, five iron works with twenty blast furnaces, nine hundred and twenty furnaces of every description for the producing of cast steel, and steam engines of a total of 10,000 horse power, not including seventy one steam hammers.

The display at Vienna was brilliant, comprising some thirteen different light and heavy cannons, machines, wheels, axles, rails, tires, and a cast steel block of 52.5 tons weight, which was founded with the contents of 1,800 crucibles, containing each sixty pounds of steel, and afterwards forged under a giant steam hammer to an octagonal of the weight stated. Series of fine fractures of steel, collections of ores, coal and pig iron gave also an idea of the wealth and accomplishment of the firm.

13. The iron works of the mining and smelting company,

"HORDE,"

Near Doitmund. The origin of these works must be traced back to the year 1839, when they first were erected by Mr. Piepenstock. The company own at present coal and iron ore mines upon blackband, at Horde and Hasslinghausen, upon sparry ores and brown hematite in the Hartz mountains. The mining business of the company alone gives employment to about 1,500 miners, who produced, in 1872, 185,000 tons of coal, and 36,500 tons of ore.

Not having spoken yet of the ores of the Hartz mountains, I give here the following short remarks:

The Hartz, a hilly country situated W. S. W. from the old city of Magdeburg, on the Elbe, covers an area of about 43 miles in length, from S. E. to N. W., and 18 miles in breadth. The common rock of this range is graywacke, which is covered with a transition limestone. The granite supports all this system of rocks, while at certain points trap and hornstone appear. Silver and copper are the principle metals found in the mountainous country, but besides this there are a great many mines of iron in different parts of the Hartz, the principal ores being spathic ore and red and brown hematite, which occur in veins, beds or masses.

At Horde there are 8 blast furnaces, rolling mills with 82 puddling, 56 balling and 16 re-heating furnaces, 4 cupola furnaces, 164 coking furnaces and two Bessemer steel works with 8 converters, besides the other necessary apparatus.

The blast furnaces produce about 75,000 tons of pigs annually, and it is said that they consume per ton of iron:

4,640 lbs. of ores.
1,250 lbs. of lime.
2,500 lbs. of coke.

The production of the rolling mills and the steel works is given as 60,000 tons per annum.

The display at Vienna did show that the Company does not cultivate a special branch of manufacturing, for mostly every kind of wrought iron was exhibited. Rails for railroads and mines, merchant iron of any description, heavy blocks of steel, stringers, tires, girders, bar, flat and square iron, nail rods, etc., etc., were displayed, and the collections completed by full descriptions and drawings of the apparatus employed, and tabular statements of the consumption of raw materials used and the products gained. There was a tire, unadjusted, horizontally suspended with a center needle revolving, showing the accuracy of the work, etc.

14. The Iron Works of the

"WESTPHALIAN UNION,"

comprising four different establishments:

A. Department Hanem, formerly Cosack & Co., comprising large rolling mills, which were established in 1853, and producing annually 14,000 tons of wrought iron. The work consists of 30 puddling and 9 balling furnaces, 4 steam hammers, 5 sets of rolls, a foundry, a machine shop, a manufactory for galvanized iron, another for the fabrication of refractory bricks, etc.

B. Department Wachrodt, comprising rolling mills with 21 puddling and 7 balling furnaces, and 7 sets of rolls, producing annually 12,000 tons.

C. Department Lippstadt, comprising a rolling mill with 10 puddling and 2 balling furnaces, and 3 sets of rolls; also, several charcoal blast furnaces and a wire drawing plant; the mills produce about 6,500 tons per annum.

D. Department Verdohl, comprising a rolling mill with 16 puddling, 3 balling furnces, and three sets of rolls; also, 2 blast furnaces and a wire drawing plant. The annual production amounts to 9,500 tons.

The products of the Company have a well founded fame, and the display of the different articles, especially that of wire, was an attractive one.

15. HOBRUKER, HERBES & WITTE,

at Hamm, established in 1856, produced in 1872 with 950 workmen in 30 puddling, 6 balling furnaces, 6 sets of rolls and 424 draw-benches and 60 nail-making machines, 13,500 tons of wire and 3,750 tons of wire nails. The telegraph wire produced by this firm is excellent. As a proof of the good quality of the wire produced see the products of Mr. Newfeld, of Doitmund, who is the manufacturer of both iron and steel ropes.

16. "STEEL WORKS" AT WITTEN

on the Ruhr, established 1854, comprising a cast-steel work, forges, etc., and producing especially gun barrels, sabres, cannons, pistons for steam engines, and weapons of any kind, displayed in a neat collection.

17. Mining and Smelting Company

"NEW OEGE,"

near Limburg on the Lenne, a tributary of the Ruhr, established in 1830, producing in two blast furnaces excellent spiegeleisen for the Bessemer process, and in a rolling mill with 24 puddling and 10 re-heating furnaces annually about 13,850 tons pig-metal, 600 tons cast iron and 8,900 tons of wrought iron. Number of workingmen employed, 560. A specialty of the Company are rolls, switches, pulleys, etc., of hard cast.

18. Rolling Mills

"STEINHAUSER HULTE,"

at Witten on the Ruhr, established in 1857, produced in 1872 with 27 puddling, 12 balling, 2 re-heating furnaces and the corresponding number of rolls, 22,550 tons of rails and angle iron. There is also of late a Bessemer Steel Work established by this Company.

19. Steel Works of

ASBECK, OSTHAUS & CO.,

at Hagen, especially manufacturing springs, established in 1853, produced in 1872 with 400 workmen in 26 puddling, 3 re-heating furnaces and several sets of furnaces for cementation, 8,850 tons of bar steel.

20. Steel Works of

SODING & HALBACH,

established 1783, produced in 1872, in 38 furnaces, 5,750 tons of steel in bars, and especially anvils. The establishment is located at Hagen.

There still remains a large number of exhibitors of this group to be enumerated, but it would be tiresome and uninteresting to the readers in this country to name them all, because it would be only a recapitulation of their products, etc. Be it sufficient to say, that the different displays were fine and well adapted to give an impressive idea of the skill and industry of Westphalia's numerous iron masters.

I must give, however, the short description of the two great iron works which are situated on Wesphalia's outpost, near Osnabruck, in the province Hannover, on the western foot hills of the Teutoburger Forest.

1. IRON AND STEEL WORKS, NEAR OSNABRUCK.

They were established in 1869, and produced with 900 workmen, in 1872, 21,750 tons of steel, mostly from pig iron of the iron works of the vicinity. There was a complete display of the finest steel, of fractures showing the quality of the raw materials and half ready made products, of rails, axle trees, tires, angle iron, etc., and with others a rail wound into a spiral which could be easily set into oscillation, showing the perfectness of the product.

2. Mining and Smelting Company

"GEORGE AND MARIE,"

at Oesede, near Osnabruck. This Company, which is to be accounted for as a producer of first class pig iron, as well as for the many inventions and improvements realized by their worthy engineers, was established in 1856. The Company own at present three great coal mines upon anthracite and partly bituminous coal, and iron mines upon ores of the magnesian limestone, from which in 1872 not less than 225,000 tons were produced. These very good natured ores are melted in six large furnaces, of which five are always in full working condition. Extensive machine shops and a large foundry are branches of the iron work, and the total establishment represents one of the greatest, best arranged and best managed iron works of Germany. The production of pigs amounted to 75,500 tons, of which about 70 per cent. are used for Bessemer steel producing, while the remaining part of the production is sold to rolling mills at high prices, on account of the excellent quality of the iron. It is an invention of Mr. Lurmann, the manager of the blast furnaces, to transform the slag resulting from the blast furnaces into a fine, hairy, woolen-like mass, which is most usefully employed in enveloping steam pipes, etc., for preservation against cooling.

Messrs. N. H. Meyers & Co., at Osnabruck, produce also of the slag artificial stones for sidewalks, floors, steps, imposing stones, etc., etc., using metallic oxides for coloring, which gives the work finish and durability.

The limits of this paper will not permit a full description of this very interesting establishment, but I must state, that it is unwillingly in fact, I omit further particulars, because they really deserve attention.

THE FOURTH GROUP.

The transition lands which form in the Northwest of Germany a pretty extensive range of hills, include several famous deposits of iron ores (besides zinc, lead and copper.)

The principal mining points are on the right bank of the Rhine and on its tributary the river Lahn, in the territories of Nassau and Berg. Veins of hydrate of iron or brown hematite are explored at a great many points along with veins, or properly speaking masses of sparry ores and beds of red oxide of iron. The Old Red Sandstone of the territory of Siegen bears a great number of powerful veins of these ores which accumulate sometimes to incredible masses. The center of the ore bearing formation has an extent of at least 45 miles length from N. to S. W., while the field covers an area of not less than 24 miles width.

There are three principal lodes which can be distinctly traced, having in the average a power of from 7 to 28 feet, but culminating at Stahlberg, near Musen, to a grandious mass of the finest sparry ore of 80 feet thickness. These three lodes are in the average sparry ore, but besides this, excellent brown iron ore, formed by decomposition of the former, is found—both species being manganiferous. These lodes are marked on the map Fig. 9.

Superficial deposits of granular brown oxide, in pieces nearly round, much varying in size and agglutinated by a calcareous and argillaceous paste, occur in extended masses northwestward of the sparry iron region; they are marked Fig. 8.

The tertiary formations which cover the country north of the Siebengebirge and the adjacent hills, contain rich deposits of clay iron stones (Fig. 7), partly of excellent quality. They are mined on the northern flanks of the "Hardt" tableland, which outlines the Siebengebirge (a range with seven prominent peaks) northwards.

Noteworthy above all the latter deposits—the sparry ores excepted—are the abundant and beautiful veins of hydrate of iron, and red hematite of the territory of Wetzlar and those on the banks of the Sayn and Lahn, Fig. 6. As to their geological formation I may add, that they are entirely of the same position as those ores described under Fig. 11, and are in fact their continued lodes. These ores mostly occur in moulds, near to the surface. Red iron ores are

predominant, hard and compact ones—containing some quartz—as well as some soft ones, which are free from quartz, but calcareous.

ANALYSES OF ORES FROM THE TERRITORY OF SIEGEN.

FIG. 9.

A. Sparry Ores.

	1.	*2.*	*3.*	*4.*	*5.*
Protoxide of iron	44.9	46.3	46.97	47.10	48.83
Protoxide of manganese	10.3	9.1	7.56	8.19	10.80
Magnesia	1.6	4.5	2.22	2.45	1.41
Lime	1.0	.....	0.46	0.34	0.41
Carbonic acid	37.0	38.4	36.15	36.45	38.38
Gangue mass	4.2	1.4	5.74	4.60	0.17
	99.0	99.7	99.10	99.13	100.00

B. Decomposed Sparry Ores.

	*a.**	*b.**	*c.**	
Protoxide of iron	45.85	.....	.....	*a** has a
Carbonate of prot. of iron	———	31.19	.....	brownish red color.
Protoxide of manganese	8.00	.....	.....	
Carbonate of Protoxide of manganese	.....	8.48	.....	*b**is a brownish black,
Magnesia	2.00	.....	0.44	still crystal-
Carbonate of magnesia	.....	9.45	.....	ized.
Lime	0.46	.....	0.60	
Carbonate of lime	.....	1.68	.....	*c** has a
Carbonic acid	36.06	.....	.....	black color.
Peroxide of iron	6.60	38.83	76.76	
Peroxide of manganese	.....	.....	16.56	
Silica	.....	3.24	.....	
Gangue mass	0.66	.....	.....	
Water	.....	5.71	5.64	
	99.63	98.58	100.00	

C. Brown Hematite.

Peroxide of iron	86.35	89.27	75.70	82.27	86.12
Peroxide of manganese	0.51	0.65	.....	.....	0.75
Silica	0.85	.....	7.61	4.50	1.70
Water, chem.–hygro.	11.38	10.08	13.32	13.26	11.43
Phosphoric acid	.....	.....	2.67	.....	.....
	99.09	100.00	99.30	100.03	100.00

ANALYSES OF RED HEMATITES FROM THE TERRITORY OF WETZLAR.

Peroxide of iron	80.95	73.77	92.45	92.68
Silica	16.74	23.16	5.03	4.52
Alumina, lime and magnesia	0.97	1.41	0.65	2.80 (Alumina
Water	0.83	1.21	1.08	.....
Phosphoric acid	0.51	0.45	0.19	.....
	100.00	100.00	99.40	100.00

ANALYSES OF ORES FROM THE TERRITORY OF NASSAU.

A. Red Hematite.

Iron, metallic	43.80	38.73	39.73	35.96
Manganese	trace	1.64	trace	0.73
Oxygen	18.77	16.59	17.02	15.71
Lime	0.42	2.02	16.80	26.49
Magnesia	0.04	1.41	.....	1.43
Alumina	11.15	11.09	3.46	3.46
Silica	17.79	17.41	19.99	14.69
Phosphoric acid	1.10	1.64	0.33	0.60
Water	1.17	3.70	0.95	0.61
Loss (in calcining)	5.85	3.63	0.50	0.25
Sulphur	trace	.....	0.02	trace
	100.09	97.86	98.80	99.93

B. Brown Hematite.

Iron, metallic	21.76	32.48	36.84	32.50
Manganese	7.07	trace	trace	6.97
Oxygen	11.86	13.93	15.78	16.99
Water	3.51	3.11	.....	.....
Alumina	15.31	13.82	6.36	1.61
Lime	5.47	.....	0.65	3.09
Magnesia	2.23	0.08	trace	trace
Silica	26.11	28.42	30.26	26.41
Phosphoric acid	0.94	1.86	0.66	1.35
Loss (in calcining)	6.22	6.74	5.23	10.82
Sulphur	.....	0.18	0.10	0.10
	100.78	100.62	95.88	99.74

The total production of the deposits marked

Fig 6 was in 1872: 88,000 tons { 19,550 tons brown hermatite / 68,450 tons red hermatite } in Wetzlar territory.

267,647 tons red hematite in Nassau territory.

Fig. 7 was, in 1872, 27,700 tons brown and clay-iron stone.

Fig. 8 was, in 1872, 9,650 tons brown hematite.

Fig. 9 was in 1872: 320,150 tons { 236,100 tons sparry ore. / 69,000 tons brown hermatite. / 1,550 tons red hermatite and clay ore. }

Total 713,147 tons.

Before I undertake the enumerating, etc., of the exhibitors at Vienna, I shall also give a short description of the manner in which the furnaces of this group are conducted.

In a letter incorporated with the last geological report of Indiana, it is stated that the oldest furnaces of the Siegen territory are worked with charcoal for fuel, but somewhere above I mentioned that this fuel will be set aside entirely in a short time. For coke is recognized now as the true fuel even for producing the finest quality, spiegeleisen. Several establishments are already renowned for the excellent conducting of their furnaces with coke for fuel. Of these, I mention the iron works at

MUHLHOFEN,

Near Sayn, on the Sayn, a small tributary of the Rhine. The furnaces there are blown with three tuyeres of $2\frac{1}{2}$–$2\frac{3}{4}$ inches diameter each, $2\frac{1}{2}$ lbs. pressure of the blast, and a temperature of the latter of 270–300° C.

There are in the average required per ton of iron,

4,720 lbs. of ore,
1,834 lbs. of lime,
3,152 lbs. of coke.

The yielding of the ores being about 42.25 per cent. all the year round.

The mixture for gray pig iron is:

70 per cent. of brown hematite,
20 per cent. of red hematite,
10 per cent. of clay iron-stone.

With 40 per cent of lime as admixture for flux.

For the production of spiegeleisen the mixture of ores is composed as follows:

38 per cent. of sparry ore,
20 per cent. of brown hematite,
30 per cent. of red hematite,
12 per cent. of clay iron-stone.

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With 38 to 40 per cent. of lime for flux. The cost of production is about $25 per ton. The waste-gases of the furnaces (two) are nearly sufficient to create the necessary steam for the blowing engine and to produce the above stated heat of the blast air. Each furnace produces about 25 tons per 24 hours.

Generally, the iron masters conducting furnaces of this group use for the fabrication of

Spiegeleisen, $\begin{cases} \frac{2}{3} \text{ parts of sparry ores,} \\ \frac{1}{3} \text{ parts of brown hematite, etc.} \end{cases}$

Gray pig, $\begin{cases} \frac{2}{3} \text{ parts of brown hematite, etc.,} \\ \frac{1}{3} \text{ parts of sparry ores.} \end{cases}$

Red hematite and iron glance, which contains up to 70 per cent. of metallic iron, are admixed in very different proportions; it is the best means for enlarging the production.

On account of the excellent qualities of the ores in past times, when charcoal was used for fuel, and the lime too far away from the establishments by missing railroads, no flux whatever was admixed; but of late, since such roads are built and the charcoal is replaced by coke, lime, of course, had to be introduced to the mixture.

The display of the iron works of this group did in no way fulfill the expectations which were entertained, on account of the mineral wealth and superiority of the ores of the different territories belonging to it. This group, with its grand richness of precious metals, presents the same in relation to Germany, what Styria and Corinthia do to Austria, Taberg and Dannemora to Sweden, the Ural to Russia, Cumberland and Lancashire to England. It is for this reason that a display was expected that would show how the marvellous ores of this group form the real foundation of the great iron and steel industry of Rhenish Prussia, as well as of Westphalia. But there are to be mentioned only:

1. I. H. DRESLER, SEN.,

Of Siegen. This firm, established in 1790, own about sixty mines, producing annually, with 760 miners, about 50,000 tons of ores of every description. The ores are partly melted in the furnaces of the "Heinrich Iron Works," near Au, on the Sieg, partly sold. The latter named establishment produced in 1872, 20,500 tons of first-class spiegeleisen in two blast furnaces, using coke for fuel, and it is far

famed for its many innovations in the manufacturing of this species of iron, and for its many skillful arrangements and its management in general. The firm owns also rolling mills at Geisweid, near Siegen, containing 11 puddling, 3 balling and 13 re-heating furnaces, for the fabrication of sheet iron and wire. The production of 1872 was 8,000 tons with 280 workmen.

2. GABRIEL BERGENTHAL & CO.,

Owners of the Germania Iron Works, near Grevenbrouh, Siegen, which has a production of 3,000 tons of ores and 2,500 tons of pig iron per annum.

3. "CHARLATTEN IRON WORKS,"

At Niederschelden, near Siegen. This work, established in 1864, has the greatest production of spiegeleisen in the territory of Siegen, using coke for fuel. The production of two blast furnaces was, in 1872, 25,520 tons, or about 70,000 lbs. per 24 hours, of which the greater part was exported to England.

4. JACOB KREUTZ, SIEGEN.

By the work of 1,200 miners, 75,000 tons of ore are mined annually, and partly smelted in furnaces at Niederschelden, owned by Mr. Kreutz, partly in the Charlatten Iron Works.

5. ROLAND IRON WORKS,

Established in 1866, produced in a blast furnace at Hardt, on the Sieg, 15,000 tons of white iron for conversion into bar iron.

6. WISSENER MINING AND SMELTING CO.,

Produced in 1872, with 600 to 700 workmen, 23,500 tons of ore, and 24,000 tons of pig iron, including 14,800 tons of first-class spiegeleisen.

7. COLOGNE-MUSEN MINING AND SMELTING CO., AT LOHE, NEAR SIEGEN.

This firm own the very oldest mines of the territory of Siegen, mining, besides iron ores, also such of lead and copper. The production of iron ores amounts to about 66,000 tons per annum; the smelting work comprises two coke and two charcoal blast furnaces, in which spiegeleisen is exclusively produced. The total production of iron amounted to 30,000 tons in 1872, of which about 1,000 tons were converted into steel, in a newly erected Bessemer work.

I may add that the charcoal furnaces are about 35 feet high, 12 feet across the boshes, that they have a hearth 32 inches wide above, 23 inches below; the tuyeres are 2 feet 10 inches above the bottom, the height of the boshes is $4\frac{1}{2}$ feet, with a declination of fifty-five degrees. They produce about 10,000 pounds each per 24 hours.

8. FREDERICK WILHELM IRON WORKS,

At Troisdorf, on the Sieg, owned by the Sieg-Rhine Mining and Smelting Co., known with the iron masters by the many inventions of its general superintendent, Mr. Langen, whose apparatus for collecting the waste-gases I described above.

The establishment comprises, blast furnaces, foundry, machine shops and rolling mills. In the furnaces, ores of Siegen are melted above all others, and such of the Lahn. The production in 1872 was 19,000 tons pig metal, mostly white and spiegeleisen, 10,000 tons of bar iron and 2,050 tons of cast iron work. There are two blast furnaces, eight re-heating furnaces with a corresponding number of rolls, and seventy-three coking furnaces.

Having thus laid down, to a limited extent, the mode and results of the operative iron industry of Rhenish Prussia and Westphalia, I still have to express the regret which I feel in not having been able to make the

report as full as I wished to do. This, on account of failing to prepare such exact drawings as would have been valuable in better explaining the text. In investigating any single branch of art or industry, we should examine it in its origin, its progress, improved state and subsequent perfection, and illustrate it by figures and drawings. The true product of chemical mixtures and operations which it involves, should also, in every case, be calculated and compared with the actual results. For such a maxim, steadily kept in view, will seldom fail to disclose whatever is erroneous, and thereby lead to improvement. Conducting blast furnaces upon the most rational and economical principles is a great problem which every iron master should make as an exemplar of his own, but very often, indeed, is most carelessly neglected. And there can be even some greater questions involved in the producing of "such common material as iron," as one may say:

"The iron industry of a country, like any transformation of primary materials, by chemical or mechanical processes, into general objects of market value, is well apt for the purpose of illustrating the standard of knoweledge to which a people has risen, and the extent of business life and general wealth prevailing. Iron, the use of which is universal, is a symbol of civilization; it is no minister of luxury and refinement, but represents the honest industry of labor."