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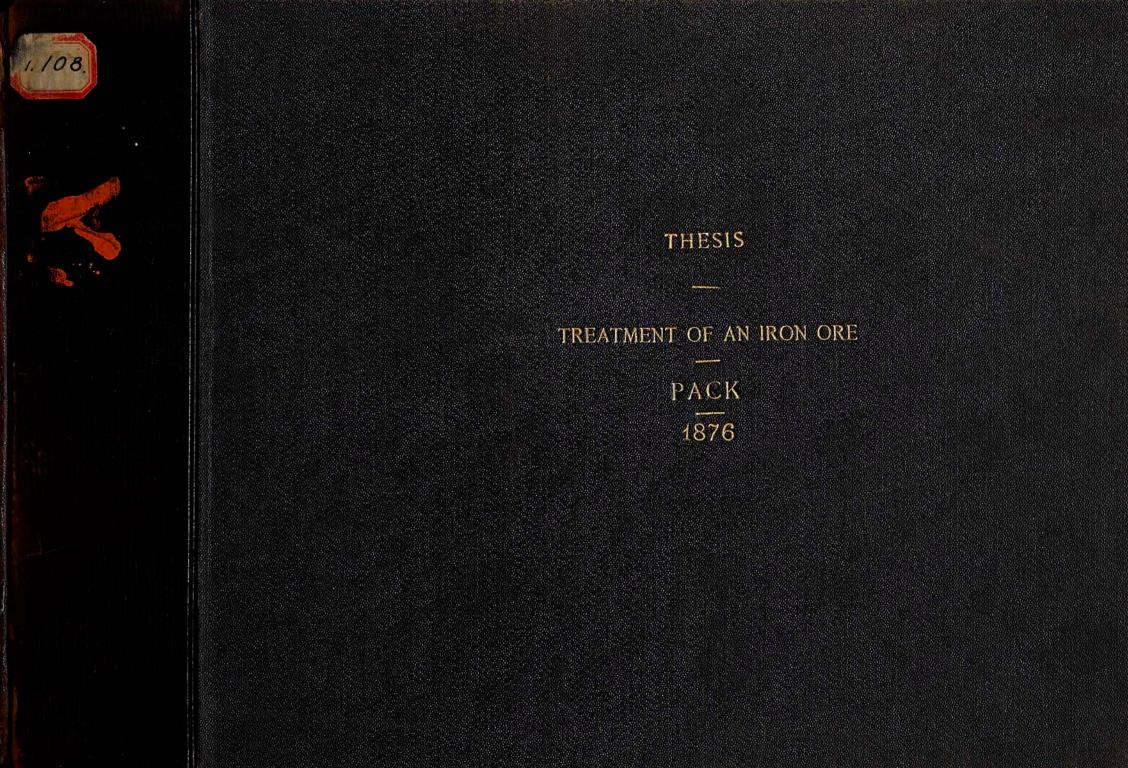
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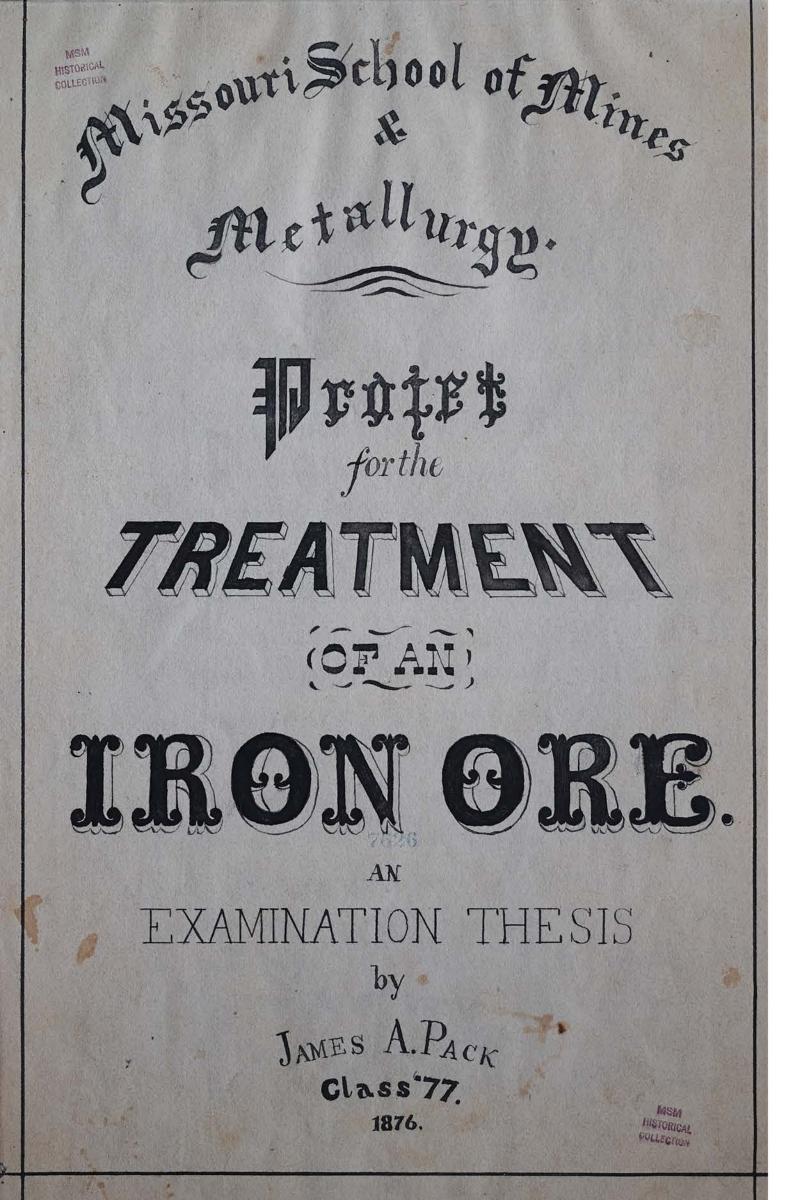
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Missouri School of Mines & Metallurgy.

> Project for the TREATMENT OF AN **IRON ORE.**

AN **EXAMINATION THESIS**

> by James A. Pack Class '77.

> > 1876.

To great is the degree of perfection that marks the various processes of von production that it seems almost useless to essay to furthere study a subject which has received the lest thought and lifetime labors of the greatest metallurgists of all ages. Myer as we believe that there are still isolated cases whose various conditions have not received that consideration necessary to the most economical production of the pig; and believing that a most perfect knowledge of these einditions is essential to the final perfection of the metallurgy of won; and knowing further that a wide extended interchange of experience & discoveries alone can perfect. any serence we have undertaken the study of an individual case, the conditions of which

So great is the degree of perfection that marks the various processes of iron production that it seems almost useless to essay to further study a subject which has received the best thoughts and lifetime labors of the greatest metallurgists of all ages. Yet as we believe that there are still isolated cases whose various conditions have not received that consideration necessary to the most economical production of the pig; and believing that a most perfect knowledge of these conditions is essential to the final perfection of the metallurgy of iron; and knowing further that a wide extended interchange of experience & discoveries alone can perfect any science we have undertaken the study of an individual case, the conditions of which

will be developed in the course of this proper. It is required here that there shall be produced in one day twenty tons of gray pig iron containing 3% carbon.

The lurnace is situated in the midst of a rich iron producing segion conveniently supplied with an abundance of water. The exterior of the furnal is build of magnesian linestone while the interior is constructed of an extremely reproctory sand stone, the intervening space between the walls being well filled with rubble. The dimensions of this frincal are computed by means of a formand are as ula given by follows; Diameter at boshes - 18.8 ft. " " throat ----9.4 H. .. . crueible - --

will be developed into the course of this paper.

It is required here that there shall be produced in one day twenty tons of gray pig iron containing 3% carbon.

The furnace is situated in the midst of a rich iron producing region with fuel of easy access and also conveniently supplied with an abundance of water.

The exterior of the furnace is built of magnesian limestone while the interior is constructed of an extremely refractory sandstone, the intervening space between the walls being well filled with rubble. The dimensions of this furnace are computed by means of a formula given by and are as follows:

> Diameter of boshes - - - - - 18.8 ft. throat - - - - - - - 9. 4 ft. crucible - - - - - 4.7 ft.

treights. Belly from top of crucible - -15.83 44.70 Furnace 75.20 Angle of boshes -65°. She various sections of the furnace are shown on plates I + II. Ones. The ore used is a mixture of equal parts of three ores having the composition fiere anniexed; 111 d'errie bride ----- 91.612 -- 73.604 ---79.437 Aumina -3.800 - - 2.608 5.228 Lime 0.384 - - - 12.402 0.174 Magnesia -0-221 4.290 4.843 Thosphoireacid - --0.156 0.230 0.074 Inlphur 9. 151 05 214 3 0.073 Arlica 3.853 6.491 1.941 Mater Manganese-0.081 77.298 100.352 100. 177

Nince the mean composition is as follows;

Heights	
Belly from top of crucible 15.83	3 ft
Shaft 44.70	ft
Furnace 75.20) ft
Angle of boshes 65°.	

The various sections of the furnace are shown on plates I and II.

Ores.

The ore used is a mixture of equal parts of three ores having the composition here annexed:

	1	Ш	111
Ferric Oxide	91.612	73.604	79.437
Alumina	3.800	2.608	5.228
Lime	0.384	12.402	0.174
Magnesia	0.221	4.803	0.290
Phosphoric Acid	0.156	0.230	0.074
Sulphur	0.151	0.214	0.073
Silica	3.853	6.491	11.941
Water		÷	1
Manganese	0.000	0.000	0.081
	100.352	100.177	97.298

Hence the mean composition is as follows

Ferrie Dxide - - -81.551 Alumina - ---3.878 Manganeze -6.027 Dime -4.320 Magnesia -1.771 Phosphorie acid -0.153 Sulphier -0.146 Arliea -7.428 Water 0.724 99.999 Containing 57.08670 of non. It will be seen by colculation that there is needed for the production of twenty tous of fing containing 3 % o corbon 33.98 tons of ore: or for the production of each ton of pag there is required 1.70 lows ore. The fuel resed for the reduction of the one is coke and has the composition, Carbon ---Ash 13 Water ele - -

Ferric Oxide 81.551
Alumina3.878
Manganese 0.027
Lime 4.320
Magnesia 1.771
Phosphoric acid 0.153
Sulphur 0.146
Silica 7.428
Water <u>0.724</u>
~~ ~~ ~

Containing 57.086% of iron.

It will be seen by calculation that there is needed for the production of twenty tons of pig containing 3% carbon 33.98 tons of ore; or for the production of each ton of pig there is required 1.70 tons of ore.

Fuel.

The fuel used for the reduction of the ore is coke and has the composition.

> Carbon - - - - 78 Ash - - - - - - - 13 Water etc- - - 9

100

4.320 - 1.771 0.153 0.146 - 7.428 -<u>0.72</u>4 99.999

For every ton of fing produced there is consumed one ton fuel; hence, for each ton of one there is required .58 tons of firel of the given composition. Flux. It would seen on taking the oxygen ratios of the slag forming constituents of the one that these matters were alroady present in the proper proportions for the removal of all imprintees from the non, but it is found by experience that with a repractory one such a small preentage of flux is not sufficient to bring about the most gerfect fusion. Hence there is required an addtronal amount of flux which has the composition given under; Daleie carbonate ---- 35.45 Magnesie- - 28.67 Alimina - - - - - ----0.41 36.06 Anea ---99.99

For every ton of pig produced there is consumed one ton fuel; hence, for each ton of ore there is required .58 tons of fuel of the given composition.

<u>Flux.</u>

It would seem on taking the oxygen ratios of the slag forming constituents of the ore that these matters were already present in the proper proportions for the removal of all impurities from the iron, but it is found by experience that with a refractory ore such a small percentage of flux is not sufficient to bring about the most perfect fusion. Hence there is require an additional amount of flux which has the composition given under: Calcic carbonate - - - - 35.45 Magnesic "----28.87

Alumina - - - - - - - - - 0.41

Silica - - - - - - - - - - - 36.06 99.99

On inspecting the foregoing it will be observed that for each ton of pig produced there is required .247 tous of flux of the given composition. Charge. On considering the amount of one reduced in therety four hours and also the proportions of the ore, fuel & this are see that the charge introduced into the furnace in twenty four hours is as given under; Ore ---- 33.98 tous loke - - - - 20.00 hours Flux ---- 4.94 lons Fotal charge in 24 hrs 58.92 .. from which there is produced twenty toos group peg containing 370 carbon. The iron also contains other A pilicon, but these being

On inspecting the foregoing it will be observed that for each ton of pig produced there is required .247 tons of flux of the given composition.

Charge. On considering the amount of ore reduced in twenty four hours and also the proportions of the ore, fuel & flux we see that the charge introduced into the furnace in twenty four hours is as given under:

Ore - - - - - - - - - - - - - - - - 33.98 tons Coke - - - - - - - - - - - - - - - 20.00 tons Flux - - - - - - 4.94 tons Total charge in 24 hrs 58.92 " from which there is produced twenty tons gray pig containing 3% carbon.

The iron also contains other Impurities, as sulphur, phosphorus & silicon, but these being

small have not been considered. The manner of charging varies according to circumstances; but in regard to time it is performed with sufficient rapidity to keep the furnace full to the throat. The charge is elevated to the threat of the furnall by a variety of means, but in general in first countries the apparatus represented on Plate III Jig 2 is resorted to, this being simply an melined plane on which runs a car elevated by means of Steam. Blast. The blast is not and is healed be passing through a series of pipes. Sections of which are given on Plate III Figs 192. The blast is heated by waste gases from the turnel head which are conducted by

small have not been considered. The manner of charging varies according to circumstances; but in regard to time it is performed with sufficient rapidity to keep the furnace full to the throat.

The charge is elevated to the throat of the furnace by a variety of means, but in general in level countries the apparatus represented on Plate III Fig 2 is resorted to, this being simply an inclined plane on which runs a car elevated by means of steam.

<u>Blast</u>.

The blast is hot and is heated by passing through a series of pipes, sections of which are given on Plate III Fig 1 & 2. The blast is heated by waste gases from the tunnel head which are conducted by suitable pipes to the heating apparatus. The amount of an thrown into the furnace by the blower is determined by means of a rule given by Junner and is found in the given case to be 2800 Abs. per minule. At this point in order that the minimum amount of fuel shall be consumed it is necessary that we know that the amount of moisture with which the blast is charged that we may this compute the amount of heat absorbed in the conversion of this water into steam und also the amount of heat returned in the burning of the hydrogen of the decomposed steam. It appears evident here that if all The gases from the tunnel head could be utilized in both heating the blast and generating the steam the amount of fuel consumed in producing one ton of non would be exactly one ton, to already

suitable pipes to the healing apparatus.

The amount of air thrown into the furnace by the blower is determined by means of a rule given by Tunner and is found in the given case to be 2800 lbs. per minute. At this point in order that the minimum amount of fuel shall be consumed it is necessary that we know that the amount of moisture with which the blast is charged that we may thus compute the amount of heat absorbed in the conversion of this water into steam and also the amount of heat returned in the burning of the hydrogen of the decomposed steam. It appears evident here that if all the gases from the tunnel head could be utilized in both heating the blast and generating the steam the amount of fuel consumed in producing one ton of iron would be exactly one ton, as already

stated; but since in this case the steam is generated by means of direct fuel the amoust issed is somewhat in adnance of that given. The pressure of the blast is equal two inches mercury.

The stag is a combination of sub silicate, misilicate and bisilicate, the bisilicate portion being augmented by the ash of the fuel which is nearly a true bisilicate. Without considering the small percentages of sulphin, phosphorie acid and manganese, portions of which enter the grig iron, the day has the composition, Silien --- 45.45 Magnesia ---- 20.20 Dine ~-- 26.26 Alumina --- 8.08 99.99 Istal

stated; but since in this case the steam is generated by means of direct fuel the amount used is somewhat in advance of that given. The pressure of the blast is equal two inches of mercury.

<u>Slag</u>.

The slag is a combination of sub-silicate, unisilicate and bisilicate, the bisilicate portion being augmented by the ash of the fuel which is nearly a true bisilicate. Without considering the small per centages of sulphur, phosphoric acid and manganese, portions of which enter the pig iron, the slag has the composition,

> Silica - - - - - 45.45 Magnesia - - - 20.20 Lime - - - - 26.26 Alumina - - - - <u>8.08</u> Total 99.99

The furnal used is the common open hearth blast farnale of the dimensions given. The blast is supplied by three tuyeres The various sections are shown on Plates I ATT.

Gigs. 142 Plate III show the opparatus for heating the blast, Fig. being the section through the pipes (p, p, p). The furnace for hooting is at f.f., the flomes circulating freely among all the gipes. Gig & shows the cross section of this apparatus.

The works should be constructed with a view towards the most economical handling of both the row materials and the prodnets. These objects were considared in the construction of the plan of works on Plate II, the works being in the most condensed and conversient form possible. Rolla Sho your 17th 1876. gos. a. Boela The furnace used is the common open hearth blast furnace of the dimensions given. The blast is supplied by three tuyeres. The various sections are shown on Plates I and II.

Figs. 1 & 2 Plate III show the apparatus for heating the blast, Fig 1 being the section through the pipes (p,p,p,). The furnace for heating is at f.f., the flames circulating freely among all the pipes. Fig 2 shows the cross section of this apparatus.

The works should be constructed with a view towards the most economical handling of both the raw materials and the products. These objects were considered in the construction of the plan of works on Plate IV, the works being in the most condensed and convenient form possible.

Rolla, Mo June 17th 1876.

[Plates]

Jas. A. Pack

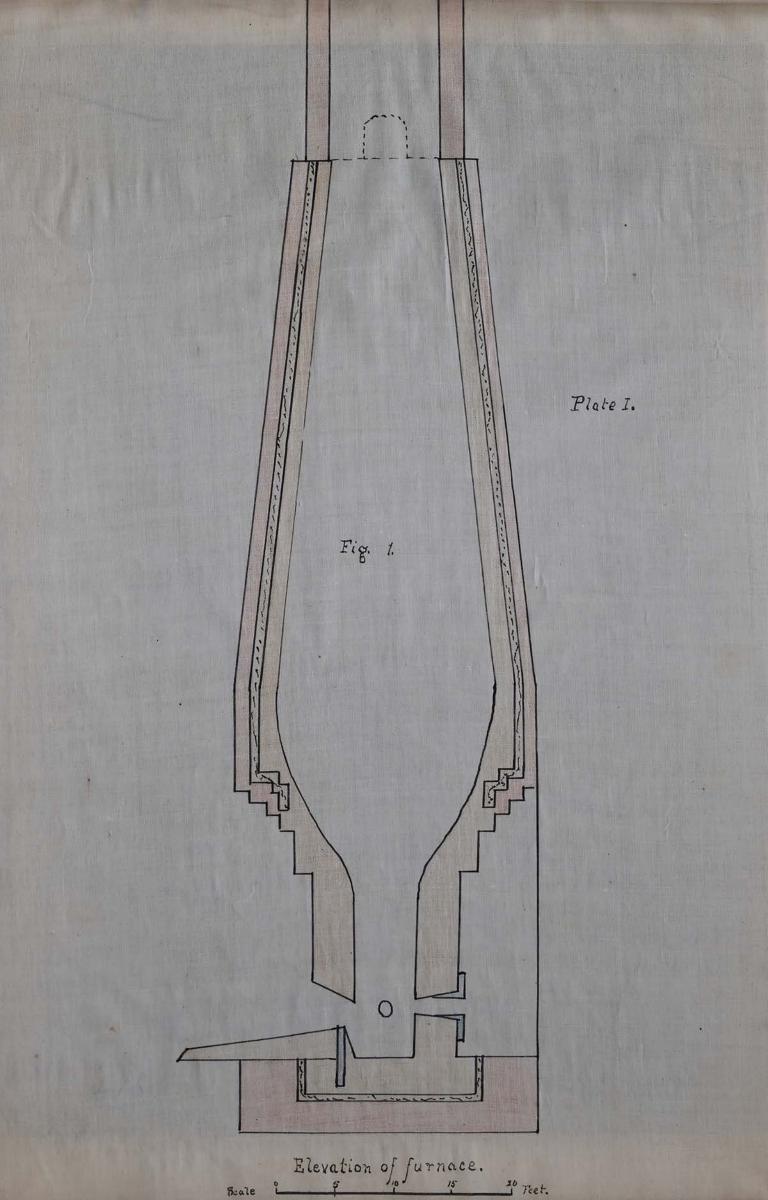
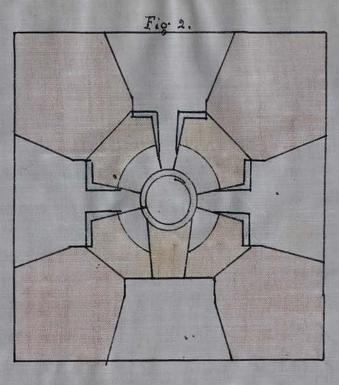
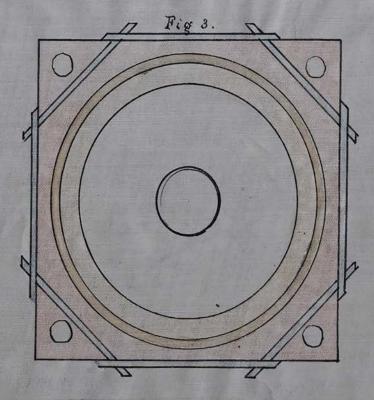


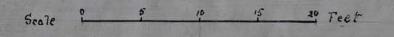
Plate II.



Ground Plan.



Section through boshes.



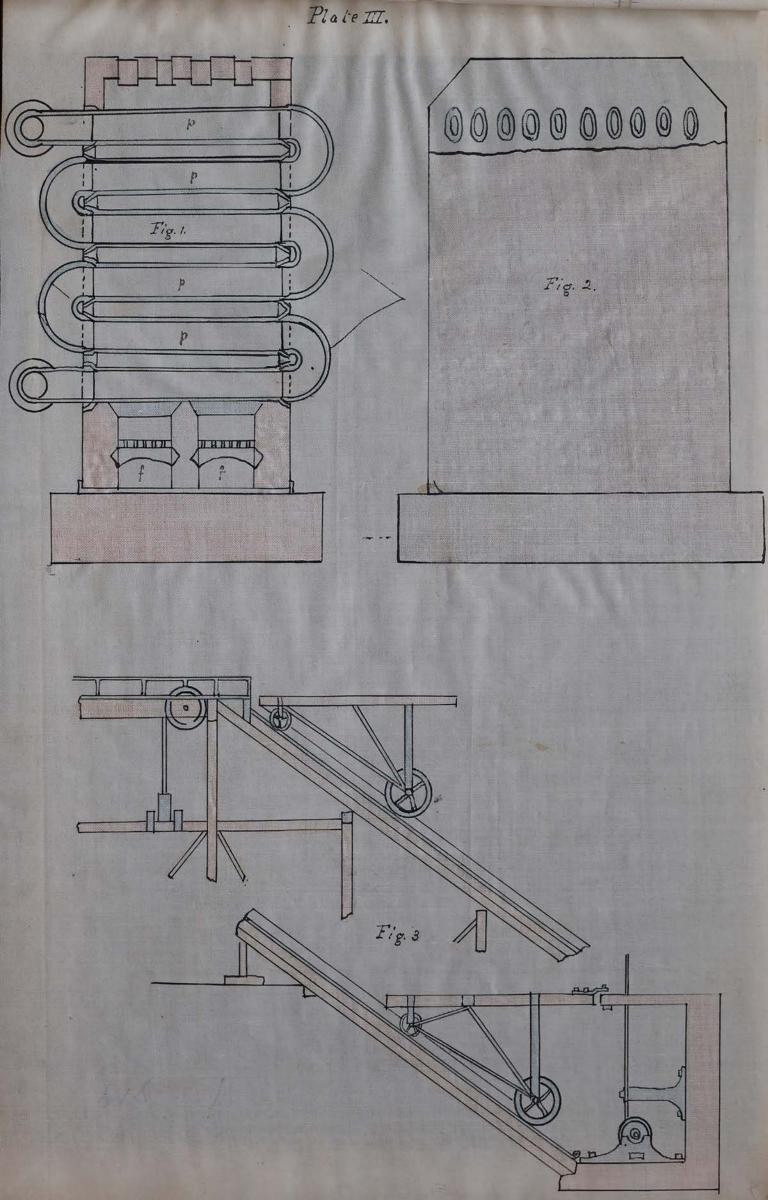


Plate IX.

