14.

Richmond iron Furnace
by
Robinson 76

7 vol ½ Cloth & corners

The Richmond Charcoal Iron Furnace

By

Thos. W. Robinson.

The Richmond Charcoal Iron Furnace.

This furnace is in Berkshire County Massachusetts about a mile and a half from the station Richmond on the Boston and Albany rail road.

It is one of several furnaces in this county owned and worked by a company called the Richmond Iron Co. whose headquarters are at Richmond.

The first of the furnaces built by this company was one at Richmond in 1829-30 about fifty feet from the present furnace. It was about thirty feet high. The hearth was twenty seven inches, and the mouth two feet, in diameter. At first only one tuyere was used but soon afterwards another was inserted. This second one was however of but little use as it was almost always clogged up with chilled iron and slag.

The blowing engines for the cold blast were run by water power from a fall about ten feet from the furnace.

The method of charging was very rude, the ore and limestone being put in by basketfulls and box fulls regardless of the weight of the materials.

This was afterwards improved upon by weighing the charge on a scale, consisting of a bar, suspended from a movable crane by a chain, on one end of which was a large scoop balanced by weights placed on the other end. After weighing the charge in this scoop the crane was swung so as to bring it over the mouth and its contents dumped in.

The amount of iron produced was very small varying from one to three tons per day. A casting of three tons was considered an excellent days work.

The present furnace was built in 1864. of an oval shape and had four tuyeres, two on each side. In the rear arch an opening was left for drawing off a part of the slag. An additional tuyere on each side was afterwards inserted, making six in all, but it was found that only four of them could be kept open, the others continually clogging up with chilled slag and iron. The wind for the hot blast was produced by two blowing cylinders about six feet in diameter worked by a forty three inch stroke engine.

The disadvantage of having the furnace open both in the front and rear was that it was not under such perfect control, and the slag became cooled and did not flow easily. An extra man also was required to watch the rear fire.

The advantage was that more ore could be run down in a given time than with only one fire. From thirty five to forty charges were made in twenty four hours yielding from ninety five to one hundred tons of iron per week.

Five years ago the shape of the hearth and stack was changed from oval to circular with about its present dimensions. Three years later the rear fire was closed up and two tuyères inserted in its place. These two were found not to work as well as one and it was accordingly changed. Improvements have been continually made in the charging and working. The ore and limestone are now very accurately weighed and the charcoal measured.

The only use made of the slag is for repairing the roads for which it is admirably suited.

A side track from the rail road runs to within about eighty rods from the furnace for the use of the company.

For the study of the details of the furnace the following heads will be considered in order.

I. The Construction.

II. The Accessories and Machinery.

III. The Manner of Working.

IV. The Results of Chemical Analyses.

I. The Construction.

The site chosen for building the furnace was at the bottom of a steeply inclined bank whose vertical height is about thirty feet. A wooden building, one end of which rests on the top of the bank and the other on the furnace, its floor being on a level with the mouth of the furnace and the top of the bank, bridges over the intervening space.

This building or shed called the "top room", Fig. 1a, contains the piles of ores and flux from which the charges are taken and weighed on the scale E. The ore and limestone are carted directly into the "top room" the loads being previously weighed at the office. About forty five feet from the furnace and half way up the bank a vertical stone wall s was recently built to serve as a protection for the bank and a support for the top room. It also forms the east wall of the boiler room b. Extending north and south between the wall s and the furnace are, the boiler room b, the engine room c and the room d containing the piston regulator J and the receiving tank K.

The floor of the room b is about twelve feet below the floor a, d is about six feet below b and c about six feet below d.

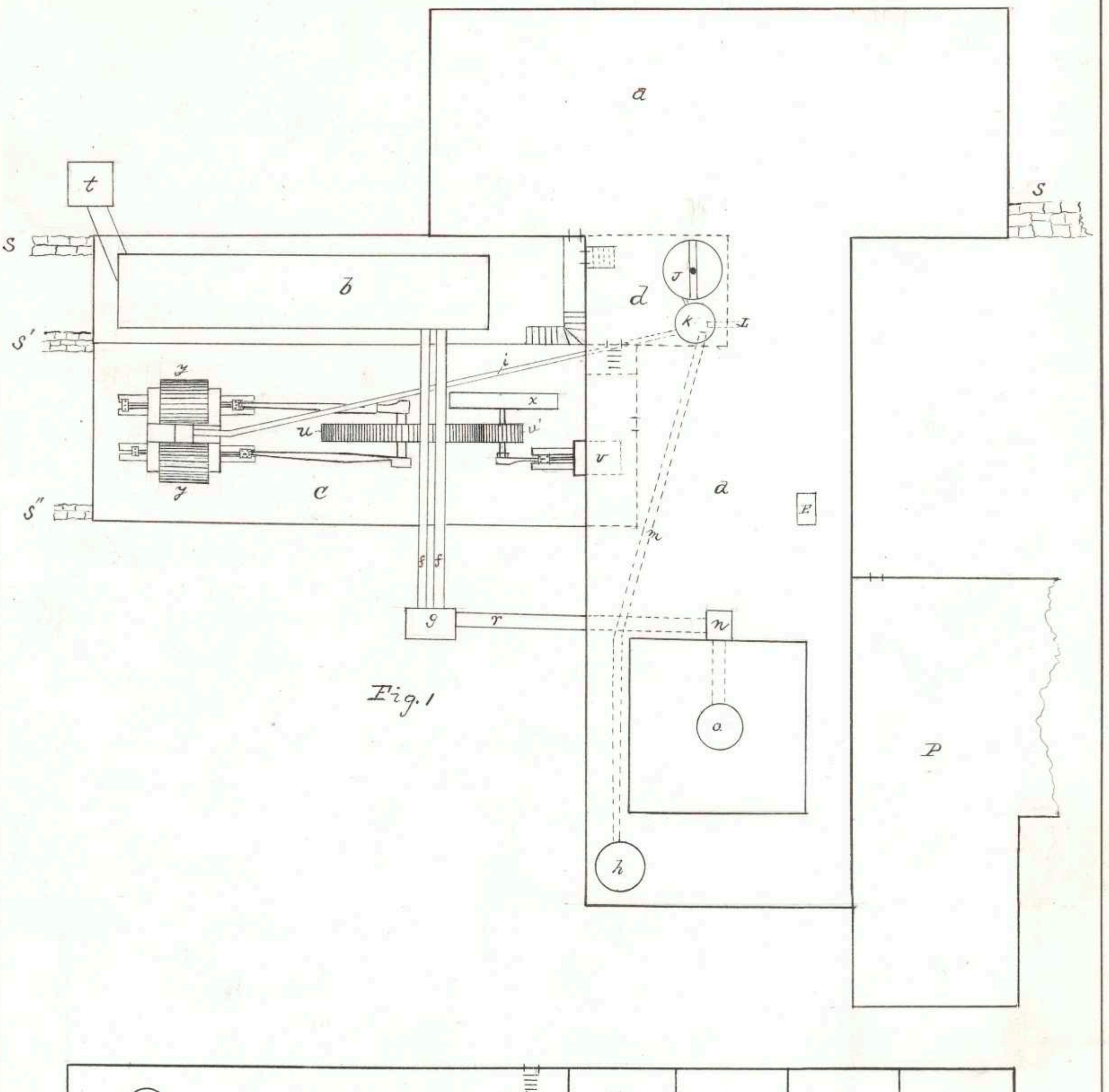


Fig. 1

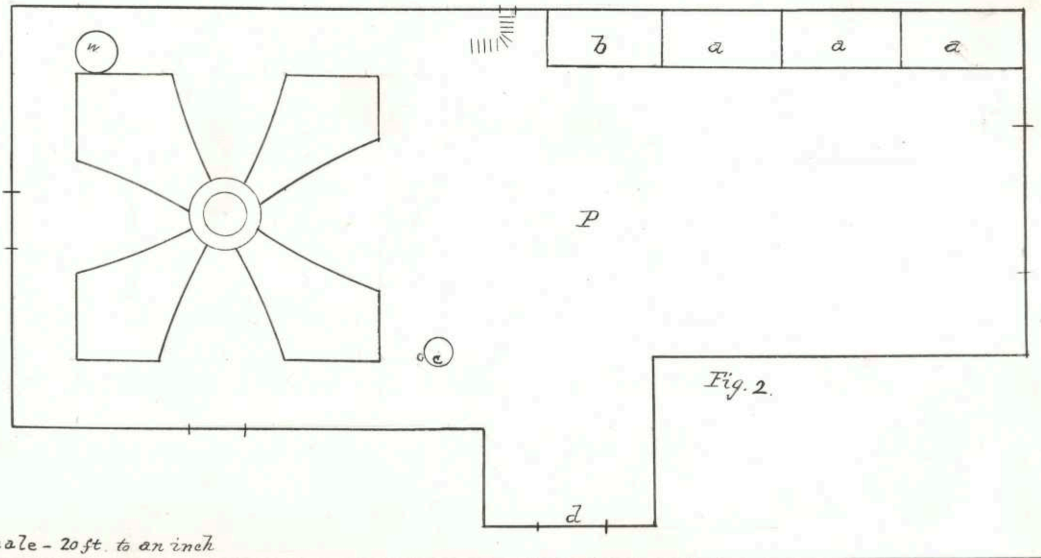


Fig. 2

Scale - 20 ft. to an inch

s' and s" are stone walls built as supports for the boiler and engine rooms. s' forms the east wall of the engine room.

The boilers b are fired by gases taken from the furnace by a flue about eight feet below its mouth. The gas from the flue first passes into the box n. and then through a twenty three inch pipe r to the box g from which it is carried through two sixteen inch pipes f.f. to the grates under the boilers. The necessary draft for drawing off the gas is obtained by the chimney t. The box g, is supported by trestle work about twenty four feet high. The pipes f.f. and r, and the boxes g, and n are made of riveted pieces of boiler plates.

The blowing cylinders y.y are worked by the engine v, the power being transmitted by the cog wheels u. The wind from these cylinders passes through a tin pipe i to the tank k. This tank is connected with the piston regulator J by which a uniform pressure is obtained. The tin pipe m carries the blast to the tank h from which it passes through the heating ovens to the tuyeres. I is a small tin pipe serving as an escape for the wind when it is shut off from the tuyeres as is the case while casting. On the south side is built the "casting

house' P enclosing the lower part of the furnace for a height of about twenty feet and extending out in front as shown in Fig. 2.
A wooden tank W about twelve feet high and four feet in diameter, kept constantly full of water from a neighboring spring, supplies the boilers, dam, tymp and tuyères. C is a half barrel into which a stream of water is kept running for cooling the tools of the workmen. a. a. a. are bins for holding the sand used in making the moulds for casting The bin b contains the clay used for daming up the space between the tymp and dam while casting.

For a foundation for the furnace a hole about six feet deep, Fig 3. a, was filled up with old pieces of brick and stone, rammed down very firmly and solid. On top of this bed was laid a layere of stone, Fig. 3 b and Fig. 4 b, containing channels, c. c. c, Figs. 3 + 4, about four inches square which are covered over with iron plates. On the two sides and rear of this course of stone is built up a "jam wall", d, of common brick in which openings are left, e Fig. 3 and e Fig. 11, about the diameter of a brick, which connect with the channels c, c, c, and serve as vents for the steam from the water which drains into them.
On rainy days the steam comes out of these vents

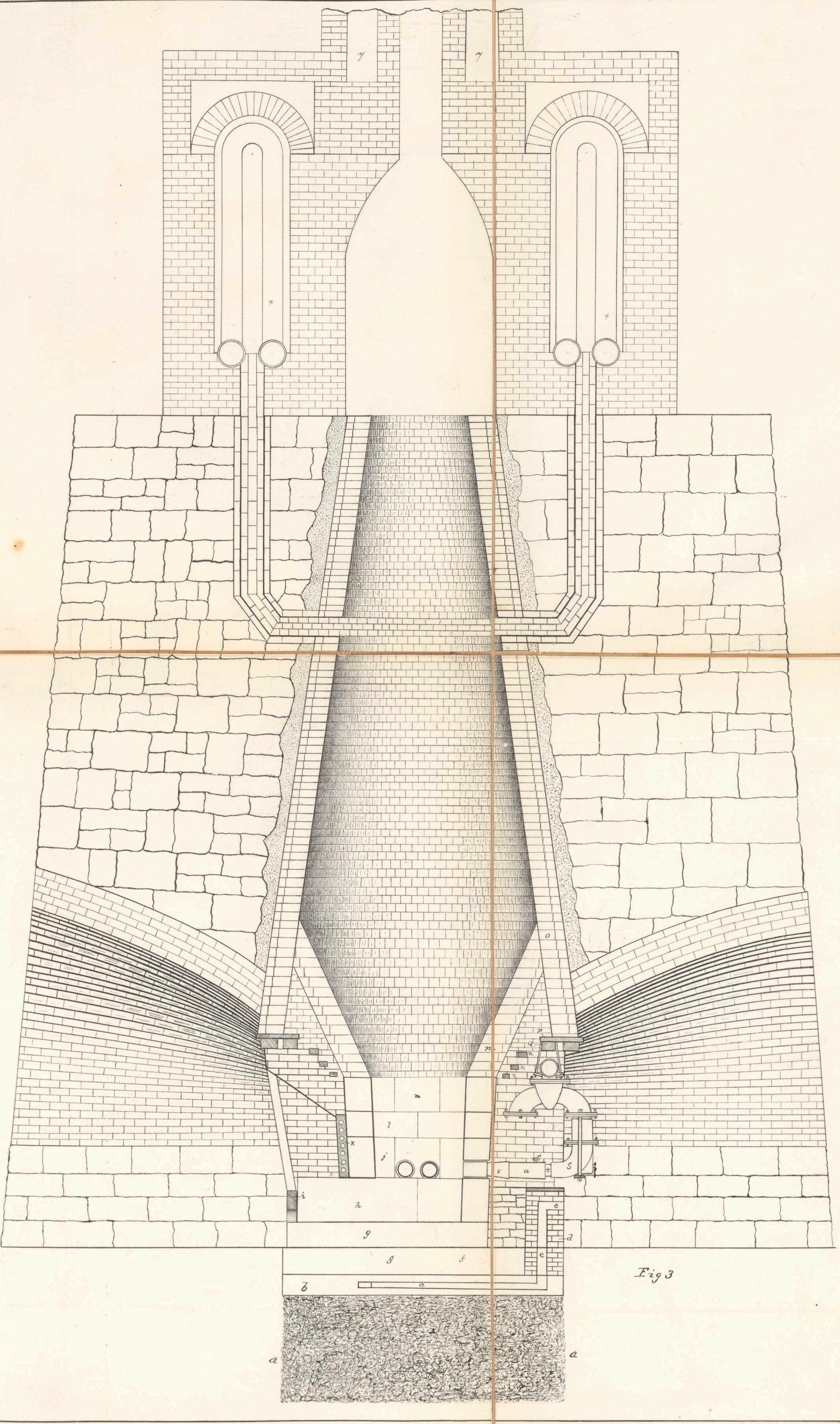


Fig 3

in considerable quantities.
On top of the layer of stone b, the channels being covered over with iron plates, a layer of clay, f Fig. 3, a foot thick, is very firmly hammered down and on this is laid the hearth stone g. This is a very fine fire stone which comes from Conn. It is very carefully selected so as to avoid all cracks and blemishes. It consists of one piece and is one foot thick.
Upon the hearth a course of this same stone, h, twenty inches high, is laid as shown in Fig. 5. h, the joints being very carefully smoothed and fitted. The inside diameter of this course is thirty eight inches.
Resting against the ends of this course is the dam, i Figs. 3 + 5. the top of which is six inches below the top of the layer of stone. The dam is shown in detail in Fig. 9. a is a projecting piece of iron about one and a half inches thick which serves to keep the trough, t Fig 10, in place. b. b are iron rings by which the dam is handled. The direction of the current of water is represented by the arrows. The upper part just above the tap hole is made three inches thick.
The next course of this stone j Figs 3 + 6 is eighteen inches high, the front part of it arching over the space A Fig 5 forms the tymp arch. The front of the tymp arch is kept cooled by an iron tymp, K Fig 3, cast around a coil of pipe through which a stream of

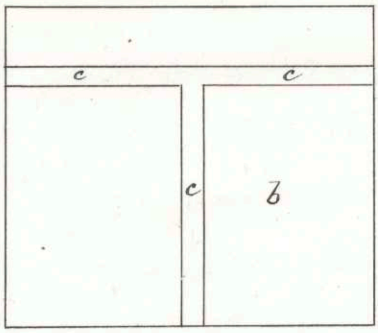


Fig. 4.

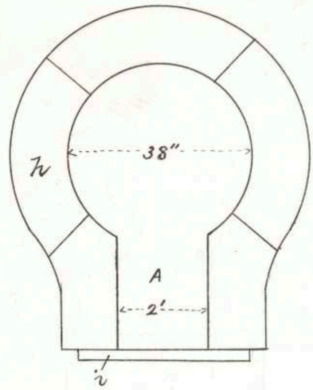


Fig. 5.

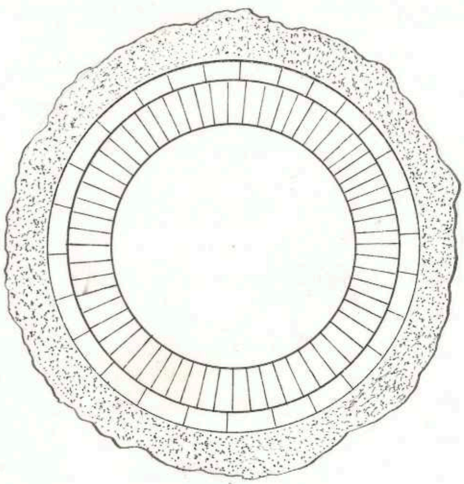


Fig. 7.

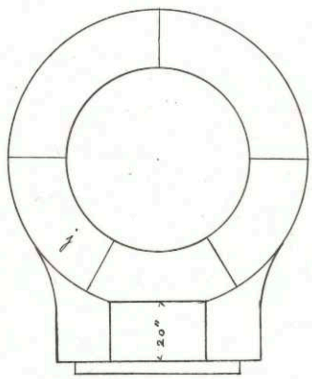


Fig. 6.

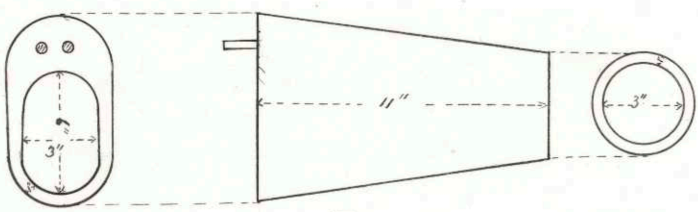


Fig. 8

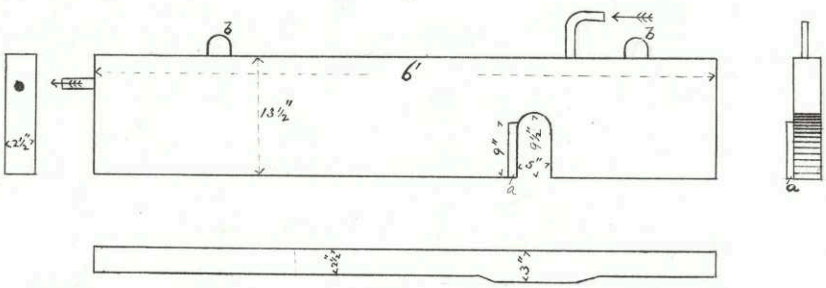


Fig. 9.

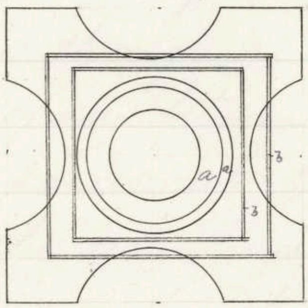
water is kept flowing. In this course are inserted the tuyères, two on each side and one in the rear. The tuyeres are made of wrought iron with the dimensions given in Fig 8. They consist of two wrought iron rings of the shape of the end views of Fig. 8 around the inside and outside of which two wrought iron plates are welded leaving an inch between them which is the thickness of the smaller ring and of the larger one except where the water pipes are welded in. The inside plate is first welded to both rings and then the outter one.

Tuyeres consisting of iron cast around a coil of pipe were used but it was found that the end of the tuyere melted off leaving the pipe exposed to the fire.

The next two courses of stone, l + m, Fig. 3, are respectively twelve and sixteen inches high. The inside diameter of the crucible at the top of the fourth course is forty two inches.

On this fourth course the boshes n are built at an angle of 65° varying in diameter from forty two inches at their begining to nine feet their greatest width. The way in which the bricks are laid is shown in Fig. 7.

The lining o. of the stack rests upon iron plates, p. about an inch thick which are placed upon the iron "mantles" q. The "mantles" are bars of cast iron about six inches square with their ends fixed in the corners of the stone-work. R. R. R Fig. 3 are iron bars, placed similarly to the "mantles", serving as supports for the boshes. The following diagram shows the way in which the "mantles" are laid.



a. a. is the brick work of the boshes.
b. b. are the iron "mantles".
These are also shown in Figs. 10 + 11 m.
The iron plates, p Fig. 3, are laid on these "mantles" and upon them is built the lining of the stack.

The diameter of the mouth is forty four inches and is thirty two feet above the tap hole.

The furnace is surrounded by a mass of stone masonry about thirty two feet square at the bottom which tapers in one inch to the foot for a height of thirty two feet. There is a space left between the stack and the masonry averaging about two feet thick which is filled with sand. The sand becoming melted encloses the stack with a mass of molten glass allowing it to expand and also preventing the escape of the explosive gases. There is an arch in each of the four sides of the masonry about eighteen feet high lined with a wall of common brick, twenty inches thick, coming within four feet of the ground as shown in

Figs. 3, 10 + 11. Fig. 10 represents the tapping arch and Fig. 11 one of the side tuyere arches. In Fig. 3 the rear tuyere arch is shown giving a side view of the pipes leading to the tuyère and in Fig. 11 a rear view is given.

The blast from the heating ovens is carried down through a twelve inch iron pipe, a Fig. 11, in the space between the stack and the stonework. It passes into the pipe b, a part going around to the rear tuyère and the rest going through c and D to the side tuyeres.

One end of the joint E and the inside of F are very nicely turned so that the one will move easily over the other and yet fit closely. The other end of E is very firmly luted into c with a mixture of fire clay and sal ammoniac. The joints F and D are suspended from c by an iron rod, as shown in the figure, by which it can be raised or lowered. The joint t, Fig. 3, is similarly luted into s and turned so that u can be easily slipped back over it and a new joint v inserted when worn out. By means of the set screw w, u can be fixed in any position desired.

H, Fig. 11, represents the "jam" wall a cross section of which would be similar to that shown in Fig. 3. Fig 10 represents the tapping arch. The cast iron

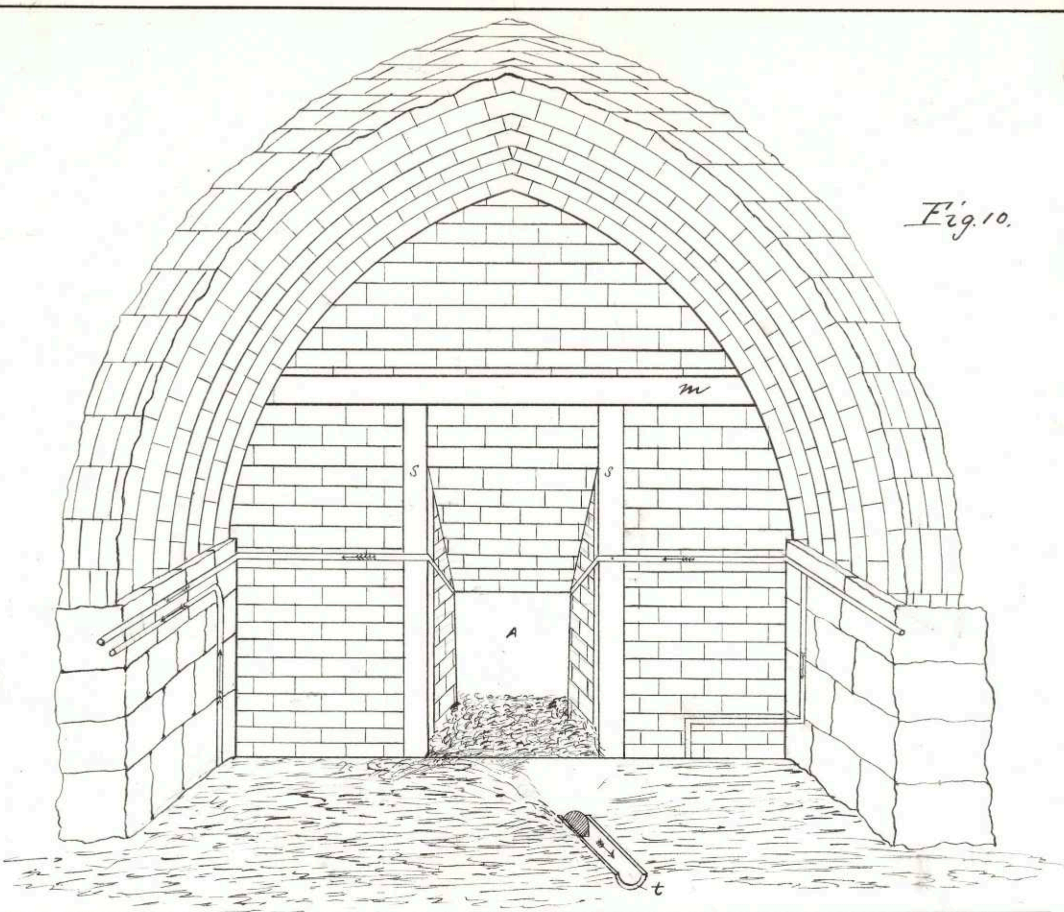


Fig. 10.

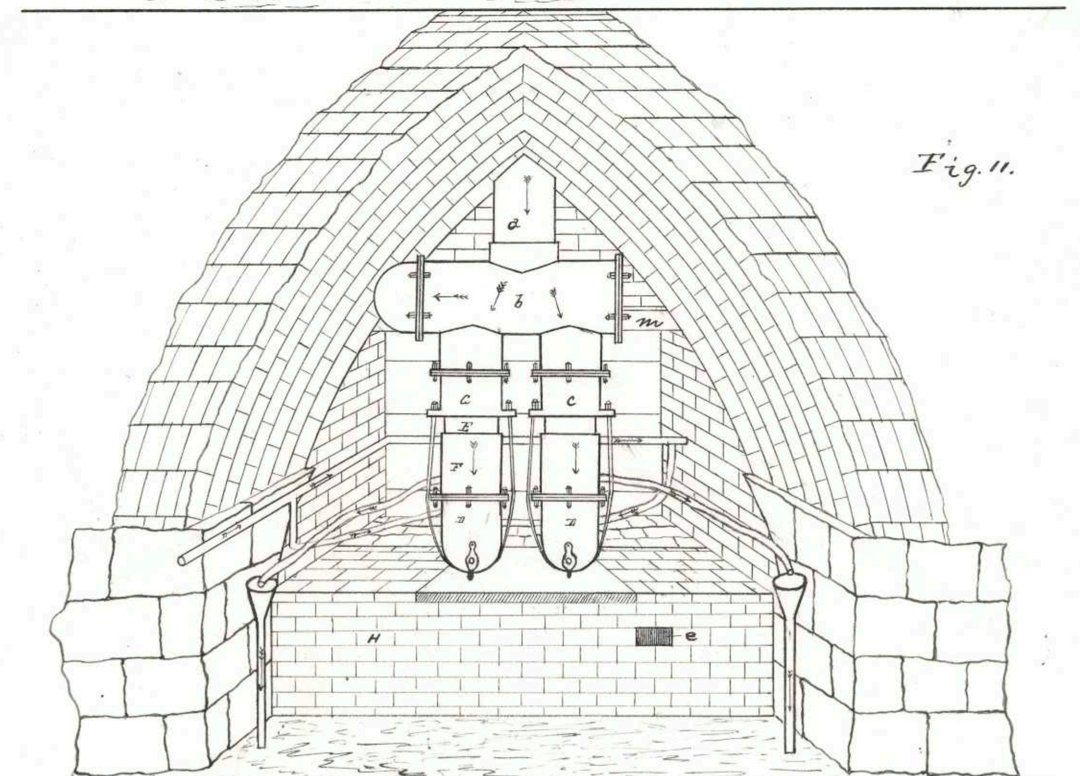


Fig. 11.

trough t, when not in use, is covered with an iron plate. The slag is drawn off towards the left of the figure over iron plates where it is cooled, broken up and carted away.
S is a bar of angle iron, called a "buckstaff," for protecting the brickwork. A. represents the cast iron tymp shown in cross section in Fig 3.

About every thirteen months the boshes crucible and hearth are replaced. The stack remains resting on the "mantles". It has not been relined since it was put up in 1864.

II. The accessories and machinery.

I. The heating ovens.

The heating ovens consist of two rows of eleven cast iron siphons, about nine feet high and measuring eighteen feet from one end to the other, as shown in cross section in Figs. 3 and 13, firmly luted into the iron pipes s Fig. 13, about two and a half inches apart, with a mixture of fire clay and sal ammoniac. The ovens are situated on the top of the furnace, one each side of the mouth, the pipe s being about three and a half feet above the top of the stone work of the furnace. The flues, shown in Fig. 3, which take the gases from the furnace eight feet below its mouth, open into the centre of the ovens and after burning pass into the chimney, y Fig. 3, through flues, one in each end of the top of the oven, the object of which is to distribute the flame more evenly.

The wind coming from the tank K, Fig. 1, passes into the tank h, Figs. 1 and 13, from which it is carried through the twelve inch tin pipes t to the iron pipes s and after being heated to 250° to 300° F. while passing up and down through the siphons it is carried down to the tuyères through the pipes v, Fig. 13, and a Fig. 11.

Fig. 12. is a front view of the ovens as they appear in the top room. The brick work z Figs. 3, 12 + 13 is

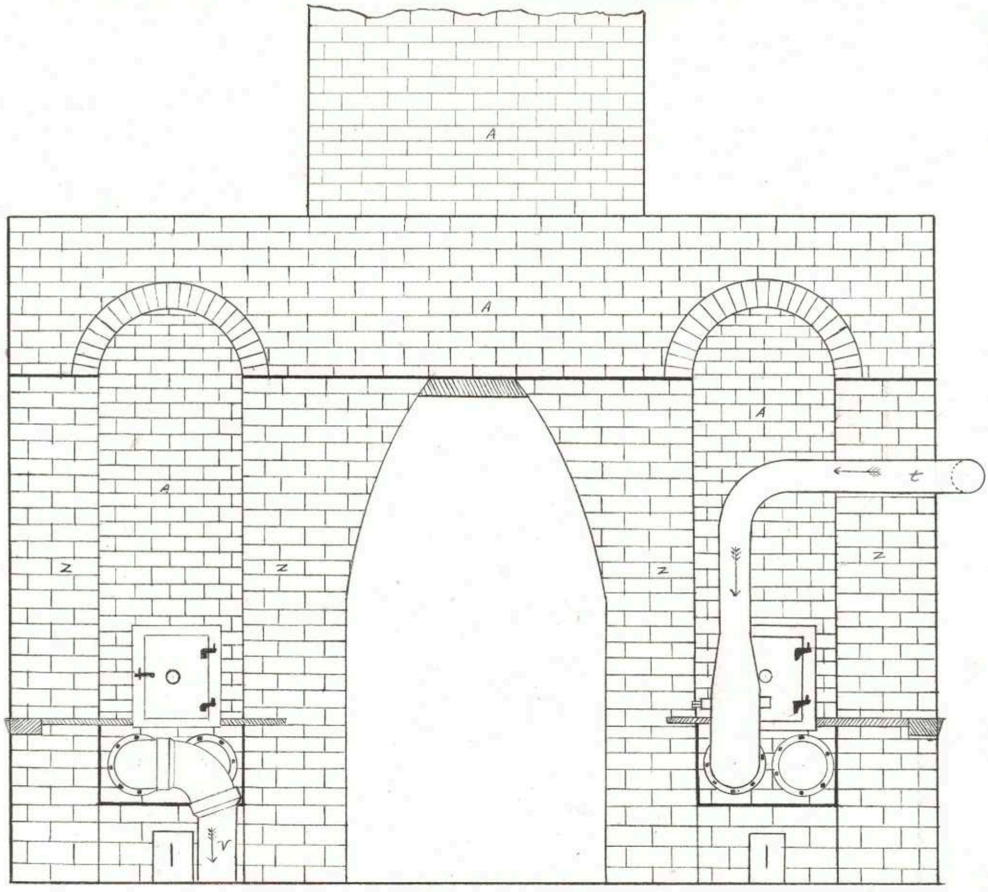


Fig. 12.

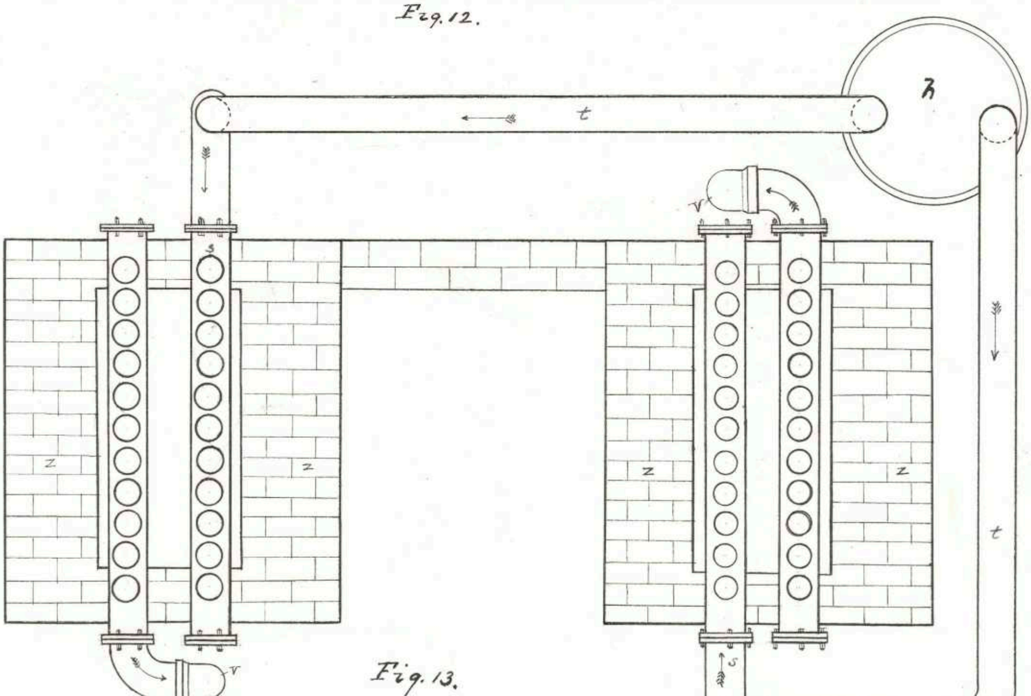


Fig. 13.

Scale. - 4 ft. to an inch. -

built of fire brick and a Fig. 12. and the corresponding part of Fig. 3 is built of common brick.
The distance between the two arms of a siphon is eighteen inches.
When a siphon has to be taken out it is hauled up through the brick arch at the top of the oven. A siphon lasts about two years.
The tank k is six feet high and five feet in diameter made of strips of wood two inches thick bound together by iron bands capable of being tightened.

II The Blowing Engines.

The blowing engines consist of two wooden cylinders, Figs. 1. 14, + 15, six feet long and six feet in diameter worked by a forty three inch stroke engine. The power is transmitted by the large cog wheel u, Fig. 1, thirteen feet in diameter worked by the smaller one u' on the shaft with the fly wheel x. The length of the connecting rod, A Fig. 14. is fourteen feet. The two pistons are set at a quarter of a stroke apart.
The boilers, b Fig. 1, are two cylinders, thirty two inches in diameter and forty feet long. The average pressure of steam is sixty pounds. and the average pressure of the blast is from one half to three quarters of a pound per square inch.
Fig. 16 represents the action of the valves. A,A, are made of leather, eighteen inches square, and play against the iron grating D Fig 15. B,B. Fig. 16 are circular valves, nine inches in diameter, made also of leather.
The gibbs used on the pistons are made of apple tree wood soaked in oil and have run steadily for over six years. They make no dirt; use less oil; and seem to be much preferable to brass ones. The machinery was put up in 1864 and with the exception of a few days each year while "blowing out", it has run steadily night and day ever since and to all appearances is as good as new owing to the excellent care taken of it.

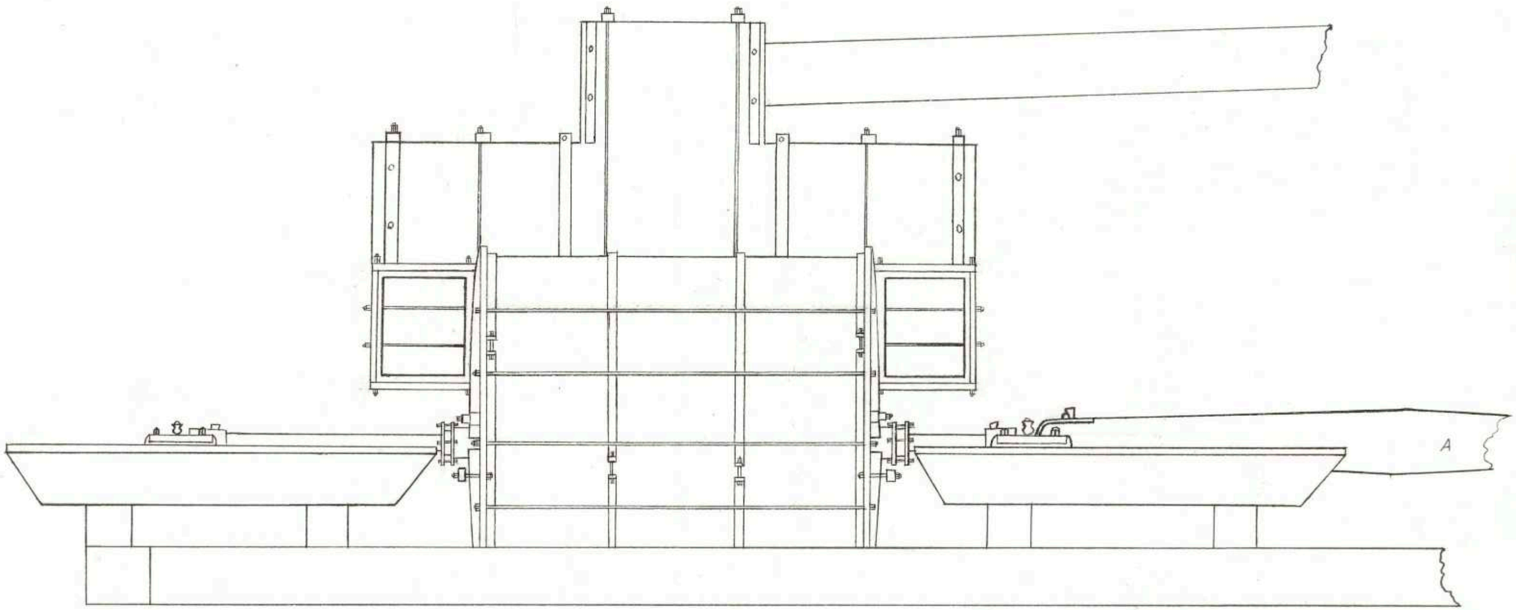


Fig. 14.

Scale – 3 ft. to an inch.–

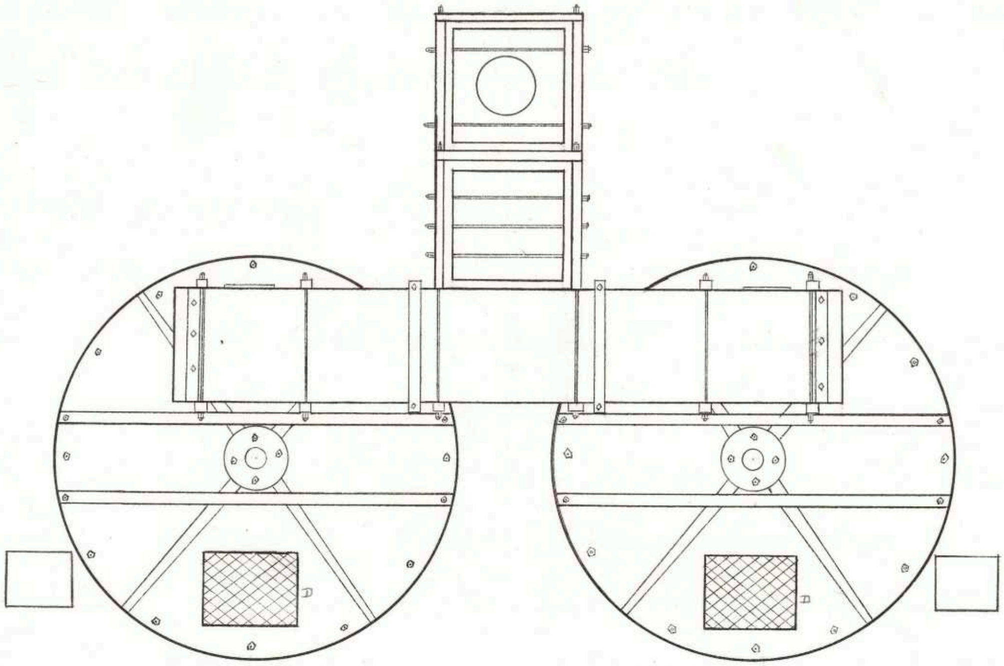


Fig. 15

Scale 3ft to an inch

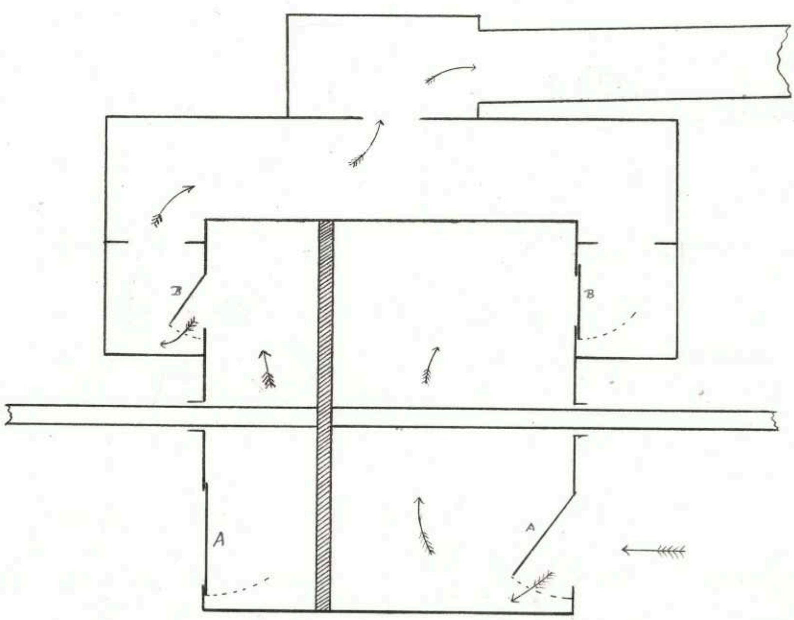


Fig. 16

-Not drawn to Scale-

Figs. 14, + 15, drawn to scale, will represent the minor details which need not be mentioned here.

III. The Charcoal Kilns.

The charcoal is made in circular brick kilns about thirty feet in diameter and twenty feet high. The top is rounded off with a brick arch, which in three of the kilns contains the top charging door. The other three have this door on the side within a foot of the top. They have a door on the ground about six feet square through which the charred wood is drawn.

The kilns are situated at the bottom of a bank about twenty feet high by which they are sheltered from the wind and from which they are charged through the upper door after as much as possible has been charged in through the bottom one.

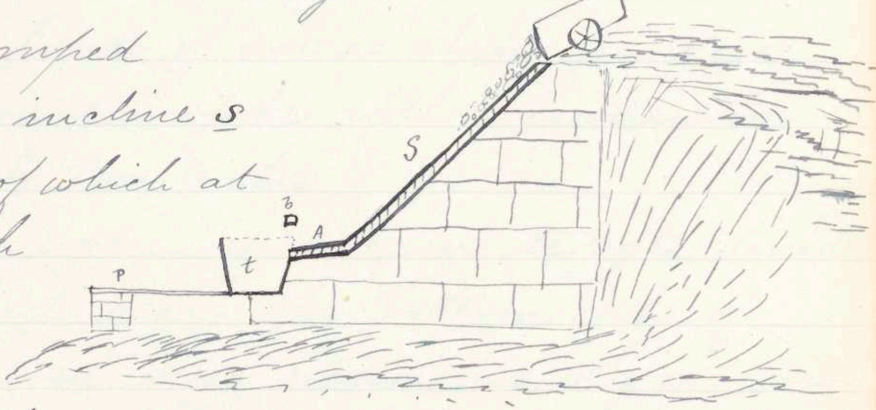
The wood is carefully piled radiating from the centre, the vacant spaces being filled up with small pieces. A hole about one foot square is left from the centre to one of the holes in the side of the kiln on the ground which is filled with kindling wood. A small hole is also left up through the centre and directly above it in the brick arch is an opening which is kept open for a couple of days after the charring has begun, so as to cause an upward draft. Around the bottom of the kilns are three rows of holes lying respectively on the ground, one foot and six inches, and three feet above it. These holes are a foot in diameter and are two feet apart. After the fire is started the holes beginning with the top row are closed up, one by one, with bricks and mortar as soon as the blue smoke is seen coming out of them. It generally takes from three to four days before they are all stopped up. It takes six men one day to charge one of the kilns, and if the wood is dry it takes about ten days to char it but if it is wet or green it requires nearer fifteen days.

The wood contracts about one half of its bulk in charring. It takes about two and a half cords of wood to make one hundred bushels of coal. The hard woods Maple, Beech and Birch are generally used and great care is taken to exclude all soft woods on account of the tenderness of the coal which they make.

Wood charred under dirt is much preferred to the above on account of its being denser, thus being less liable to be crushed in the furnace and on account of its porosity which exposes a larger surface for combustion. A great deal of the coal used at Richmond is charred at the other furnaces of the company and brought there in cars.

IV. The Ore Washer and Sizer

The ores are dumped on to a wooden incline S the lower part of which at A is covered with iron plates.



It is about fifteen feet high and twenty feet long, sloping at an angle of about forty five degrees. A stream of water from a tank at the head of the trough t flows on to A washing the ore down under the bar b into the trough t where it is carried by another stream from the same tank to the first cylinder shown in Fig. 17.
The bar b is about six inches above A.
A man stands on the platform p and picks out all the large lumps which fail to pass under A and throws them on a heap at one side. These large lumps called the rock ore consist of pieces of almost pure oxide of iron. They are carted to the top room and then broken up with hammers.
The trough t and the platform p have an inclination of about three or four degrees towards the first cylinder.

The cylinders or drums consist of a set of iron wheels, a.a.a Fig. 18, around which the strips of perforated cast iron Figs. 19 + 20, are fastened with bands of iron as shown in Fig. 17. These wheels have six spokes with a cross section of about three by two inches.
The cylinders revolve in wooden troughs, lined with thick sheet iron, the bottom only of which is shown in cross section in Fig. 17.
The mean space between the cylinder and trough is about six inches.
The bottom of the first trough slopes towards the second making an angle of about ten or fifteen degrees with the floor. That of the second is much less inclined. The pieces of iron, Figs. 19 + 20, have a set of cast iron teeth on their under side about six inches long. When one of these pieces become broken or its teeth worn down it is removed and another one inserted. The second cylinder has the pulley f on its axis, and the power for the first one is transmitted by the system of cog wheels.
The ore and mud are washed through the trough t into the first cylinder. Here the larger lumps are more or less broken up by the teeth, while the smaller ones, those less than three inches in diameter are washed into the trough and

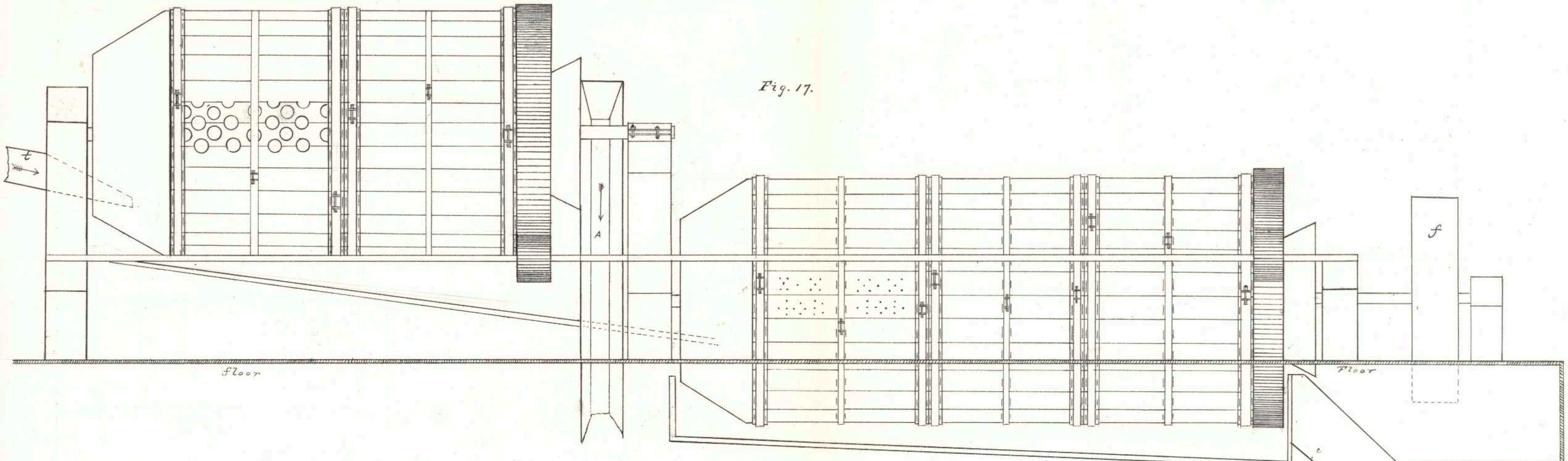
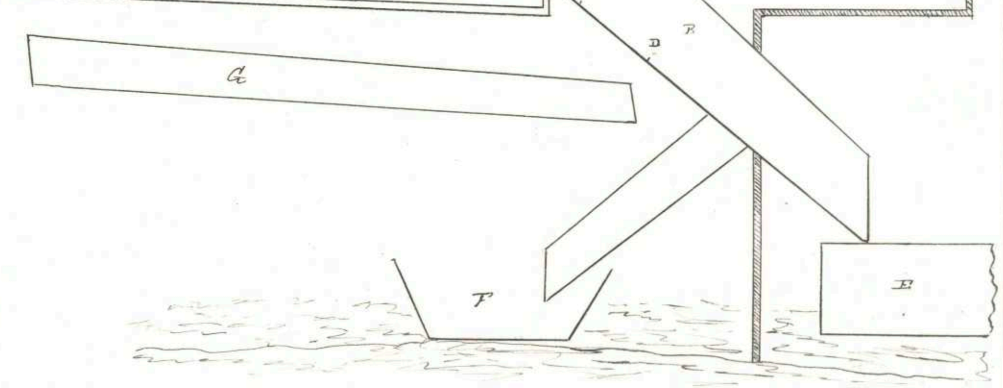


Fig. 17.

Scale 2 ft to an inch.



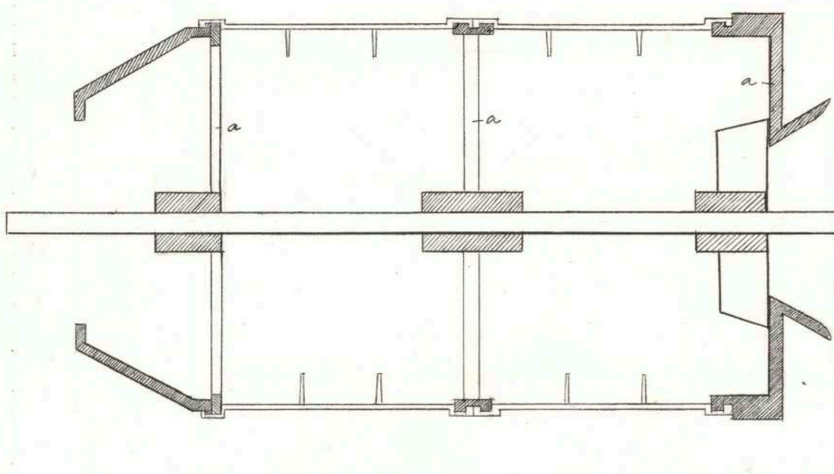
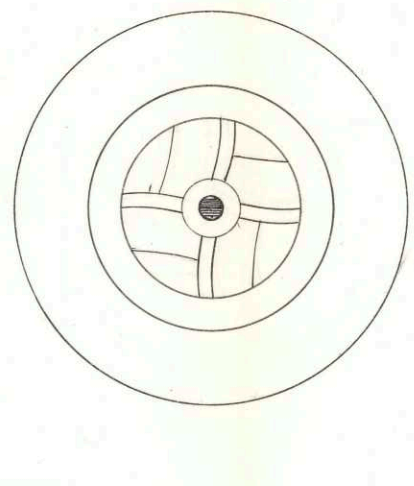
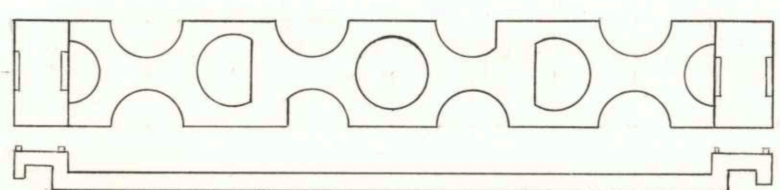
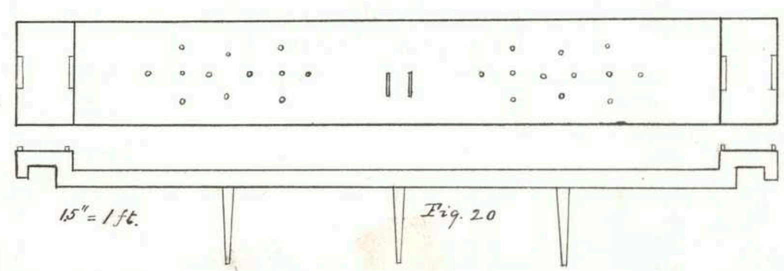


Fig. 18.





1.5" = 1 ft. Fig. 19.



1.5" = 1 ft. Fig. 20

carried to the next cylinder.
The larger pieces which have resisted the action of the teeth for the length of the cylinder are thrown out by the screw like wheel shown in Fig 18. into the trough A, lined with iron plates, and carried down through the floor, out the side of the building at an angle of about forty five degrees. The amount thrown out of the end of the first cylinder is comparatively small, greater or less, according as the picker tends to his business. It is somewhat smaller in size than the rock ore. It is carted to the top room and broken up.
In the second cylinder the mud, sand and pieces of ore less than one eighth of an inch in diameter, which is the size of the holes in Fig. 20, are washed out. The ore that has passed through the cylinder is thrown out at the end, in a way similar to that from the first cylinder, into a box B which carries it down to a cart below waiting to receive it.
The box B which is about two feet square has in its bottom between C and D a screen made of iron bars about one half of an inch in cross section. The space between the bars is about one quarter of an inch. A certain amount of fine stuff

sifts through into a trough which serves as a feed for a third cylinder not shown in the figure. This cylinder is five feet long and thirty inches in diameter. The first half of it is covered with a perforated iron plate containing sixteen holes to the inch, the holes being about one eighth of an inch in diameter. The other half is covered with a course iron wire netting having nine wires to the inch. This cylinder does not revolve in a trough but an inclined wooden plane lying under it drains off the mud and water into the drain F.

The slime and water from the second cylinder can be turned, through openings in the bottom of the trough, either into the box G, which drains it off into F, or into the trough which serves as a feed for the third cylinder.

The axis of the third cylinder is about four feet above the ground just to the rear of the box G. Fig. 17.

The product from the second cylinder called the "wash ore" consists of pieces about the size of an egg and is the principal ore. That from the third one consists of pieces about the size of a pea. It is mixed in with the wash ore

By the above machinery the ore besides being thoroughly washed is separated into three different sizes.

III. The Manner of Working.

The ore, called a brown hematite, is, more strictly speaking, a limonite resulting from the decomposition of the carbonate or "white horse" ore. Patches of this carbonate are found in the mines and are used by the furnace at West Stockbridge. Large lumps of the limonite show the distortion and stratification due to its contraction in volume during the change. Sometimes these lumps when broken open often contain within a hollow cavity at their centre a lump of the undecomposed carbonate which shows that the decomposition took place from without inwards. In other pieces, which have been completely decomposed, this central cavity is more or less filled with water. In some places stalactites of limonite are found hanging from the roof of the mine from which the continually dropping water suggests their origin.

The ores contain an oxide of Manganese unequally distributed through them. Sometimes it is seen in bright black spots which soil the fingers. It is said that it occurs in considerable quantities

in some parts of the region.
There is also an oxide of zinc in them since it makes its appearance in the furnace, but it must either exist in very minute traces or unequally distributed through them as no test for zinc was found in a sample.
These ores are of a very old formation and are similar to those found in the western part of Conn. in the eastern part of Penna. and in New Jersey.
In New Jersey the amount of zinc and manganese is very much greater forming a Franklinite.
The ores contain too large a percentage of phosphorus to be used in making iron for steel.
There are three mines worked by the Richmond company, viz. the Cheever, Leet and Cone mines.
Of these the Cheever is the most systematically worked. It has reached a depth of one hundred and fifty feet. Owing to the depression in the iron trade only a sufficient number of men to keep the mine in repair are employed.
Connected with each mine is one of the above described ore washers through which the ore is passed while still moist.
There are several varieties of limestones the purest of which is a very white crystalline carbonate of lime containing a small amount of magnesia.

The others are more or less colored by foreign matters.

The materials fed into the furnace are the above described ores, limestone and charcoal. The products obtained are the pig iron, slag and a zinc deposit.

Seven grades of iron are made known as no. 1, no. 2, no. 3, no. 4, no. 4½, no. 5. + no. 6. iron. Number one is the toughest coarsest and most crystalline while number six, the white iron, is the hardest and most brittle.

There is a distinct and characteristic slag for each number of iron. The slag which comes from a number one iron, puffs up into a large, light, white, porous, tough mass immediately on coming in contact with the air, before any water has touched it. The other slags will not behave in this way even when suddenly cooled with water. They merly crack into pieces or puff up into thin scales of a transparant glass. Number two slag is of a glassy purplish dark grey color. Number three is of a light green; number four of a darker and number four and a half of a still darker shade of green. Number five is of a black green and number six of a greenish black color. Numbers five and six often contain pieces of white crystallized silica as is sometimes seen in pieces of ignition tubing and sometimes they contain pieces of ore and limestone almost untouched. Thus from the slag which flows from the furnace, the kind of iron being made is known.

A much greater heat is required to make a number one than a number six iron. and the ammount varies proportionally for the intermediate numbers. Thus to make a number one iron a smaller, and for a number six iron a larger amount of ore is added, the same amount of charcoal being used in each case.

On the first of last April a charge of 1150 lbs of ore, 180 lbs of limestone and 30 bu. of charcoal was making a number three iron. A reduction of the amount of ore to 1000 lbs would lower the iron to a number one the other conditions remaining the same, and an increase to 1200 lbs of ore would raise the iron to a number four.

The amount of coal used is always the same viz. 30 bushels to the charge.

While casting a number five or six iron the furnace becomes so chilled that the iron will not all run out. On an average a casting of 1500 lbs is all that is made. Pieces of partially reduced ore are often found in these pigs.

The color of the waste gases burning at the mouth

is also an indication of the kind of iron being made. From a number one iron the color of the flame is a blue very similar to the flame of a bunsen burner, while that from a number six iron is of a reddish yellow color.
Thus it seems that upon the temperature depends the kind of iron being made, the slag and the color of the flame serving as rough thermometers.
For a number one iron the lime and silica unite quickly and perfectly and the color of the gas is merely that of CO burning to CO_2, while in making a number six iron the heat is not sufficient to make the lime readily unite with the silica and hence the flame becomes colored by the lime more or less according to the amount of heat.
A casting of only one kind of iron is not always obtained Sometimes the first part will be a little harder or softer than the latter part, probably owing to the change in temperature during the previous casting while the blast was shut off. This difference is greater among the higher numbers of iron.
At a casting made April 7th. the first part was a little softer than a number three while the latter part was a good three. The difference was easily noticable while the iron was still red hot in the moulds, the number three being considerably

covered or pitted with little holes forming dark spots on the surface of the pig, while their number on the softer pig was much less. A number one iron would have almost none of these spots and a number four and five would have more.

The space between the tymp and dam is always covered over with a mass of chilled slag over which the liquid slag flows. About twenty minnits before casting an iron plate the size of this space is laid on top of this slag and firmly luted in with moistened clay. The object of this is to prevent the wind from blowing out over the dam while blowing out the hearth just after casting. The iron trough t Fig. 10. and all the iron tools that are to come in contact with the liquid iron are heated gradually with pieces of hot slag. The trough t connects with a trough in the sand, about sixty feet long and about the size of a pig in diameter, to the left of which are made the moulds. These are made in the sand with wooden moulds about four by three inches by three feet. The blast is shut off just as they are ready to tap. After tapping a man regulates the flow of the iron with a lump of slag, rolled onto the end of a long bar, which fits into the tap hole, and for which a bar placed across the iron trough about two feet

in front of the hole serves as a leverage.
Just after leaving the trough t. it passes under a bridge of slag which keeps back all floating slag and dirt. After the iron has all flown out the blast is turned again for two or three minuts and then shut off again till the tap hole is plugged up with fire clay.
In the side of two of the moulds is laid a bar of cast iron about 18"×6"×3" with its sides planed smooth, to chill the iron, the depth of this chill determining the number of the iron. A number one and two iron take no chill and are distinguished only by their texture. A number three iron takes a very small chill and a number four chills to a depth of three quarters of an inch. A number four and a half iron has a slightly mottled chill and a number five has a mottled with a larger amount of the white iron in it. Number six iron chills to the centre.
There are really only three kinds of iron, viz. no 1, no. 4 and no 6, the others merely being mixtures of these, taking their numbers according to the predominating iron. A number two iron is a mixture of numbers one and four with more of the one in it while number three is the same with a predominance of number four. Number three iron is the one mostly made.

Numbers one and two are used for Machinery. Numbers three, four and four and a half are used for car wheels. and numbers five and six are mostly used for remelting with a softer number.

The ore consists of a mixture of about equal parts of the three ores, the Cone, Leet and Cheever. The amount used varies with the number of castings made in twenty four hours and with the number of iron desired. The ores are weighed in an iron cart three feet by forty inches by one foot and then wheeled over the mouth and dumped in. The charcoal is charged in carts, lined with sheet iron, 6 ft by 2 ft 16 inches and two and a half feet deep. A charge is allowed to get four feet below the mouth before another is added. In the latter part of September they were making a number three iron with a charge of 200 pounds of limestone, 1200 pounds of ore and 30 bushels of charcoal. They cast every eight hours averaging about four tons of iron. The hours of casting were 7 AM. 3 PM and 11 PM.

Last April the following data were taken. Casting made at 10 PM. Monday April 3rd. - 27 charges of 1150 lbs of ore and 150 of limestone and 30 bu.

of coal gave 5 3/4 tons (gross wt.) of pig iron.
Casting made at 10 AM Tuesday -
27 charges of the above weights gave 5 ton and 11 hundred weight of pig iron.
Casting made at 10 PM Tuesday.
26 of the above charges gave 5 1/4 tons of pig iron.
From the above data the following table is derived.

	Charges in 24 hours.	wt of ore	wt of stone	Bu. of coal	wt of Pig iron	Ore required for 1 lb iron	Stone required for 1 lb iron	Bu. coal required for 1 lb. iron
1	27	31050	4860	810	12.880	2.41	0.37	0.062
2	27	31050	4860	810	12300	2.52	0.39	0.065
3	26	29900	4680	780	11760	2.54	0.39	0.066

The ores thus produce about 41.5 percent of their weight of pig iron which contains about 93.62 making 38.85 percent of metallic iron. The average of the determinations of the iron in the three ores is 44.25 per cent. The difference between these results is probably due to the fact that some of the iron is carried off by the slag and also that the sample obtained for analysis may have been a little richer than the average ore.

The method of working this furnace may be summed up as follows.

1st The force of the blast is regulated to suit the coal. The denser the coal the greater the blast and vice versa.

2nd Other things being equal, the amount of ore varies with the number of iron desired.

3rd The amount of limestone is determined by the appearance of the slag. If too much has been added, a heavy layer of a fine grained white stone will settle to the bottom of the slag. If too little has been added, little pieces of iron the size of shot will come out with the slag.

4th The amount of charcoal is always 30 bushels.

The zinc deposit which forms on the walls of the stack is a heavy stratified mass of almost pure oxide of zinc. It condenses upon the lining just below the flues which carry off the gases. If allowed to remain for six months it forms a crust extending 18 inches out into the furnace and in a years time would completely choke it up.
It is punched down with long iron bars every once in a while and allowed to volatilize. Sometimes the oxide

of zinc completely chokes up the pipes leading to the boilers so that they have to be disconnected and cleaned out. With a little trouble this deposit, which amounts to about five tons per year, might be saved and sold as an ore of zinc.
Dr Chas. U. Shepard in his report of the geological survey of Conn. in 1837 called attention to the value of these deposits in the furnaces at Salisbury regretting that such a rich ore should be allowed to go to waste. In Germany this deposit is very highly prized for making brass.
He quotes an analysis of one of these deposits in Germany as follows. Oxide of zinc 91%. Oxide of lead. 5%. Protoxide of iron 1%. Charcoal 1%.
He merely mentions the fact that neither oxide of lead nor silica was found in one of the Salisbury deposits.
A qualitative analysis of the deposit from the Richmond furnace gave tests for Iron, Phosphorus, Manganese and zinc, of which only the following were determined quantitatively.

Iron.	0.98 %
Sulphur	0.14 "
Oxide of Zinc	96.66 " = 77.58 % of Metallic zinc.

IV. The Results of Chemical Analysis.

The methods of analysis employed were those generally used for the elements in question, with the exception perhaps of the "Color Method" for determining manganese, which for small quantities is to be recommended both on account of speed and accuracy. The method consists in oxidizing the manganese in a nitric acid solution with peroxide of lead, to permanganic acid and comparing the color with a solution of permanganate of potash of known strength. The details of this method are given in an article by Mr Peters in the Chemical News for

The sulphide method for manganese was also successfully used for the slags.

Duplicate determinations have been made as far as possible.

I. The limestone.

SiO_2.	0.57	0.59
CaO.	55.61	55.47
MgO	.20	.13
CO_2	43.65	43.83
	100.03	100.02

II. Ores.

	Cone		Leet		Cheever	
SiO_2	29.47	29.42	24.37	24.33	12.18	12.11
Al_2O_3	1.53		0.27	0.22	0.06	
Fe_2O_3	56.41	56.43	61.91	61.92	71.43	71.14
Mn_2O_3	1.62	1.63	0.86	0.84	2.62	2.59
P_2O_5	0.19	0.19	1.01	0.95	0.37	0.33
Loss on ignition.	10.40	10.39	11.34	11.38	12.29	12.28
	99.62		99.76		98.95	
Fe.	39.51	39.49	43.35	43.34	50.00	49.83
P.	0.08	0.08	0.44	0.41	0.16	0.14
Mn.	1.13	1.14	0.60	0.59	1.83	1.81

III. Pig Irons.

	No. 1.		No. 2		No. 3		No. 4.	
Total Carbon	3.60	3.57	3.93	3.91	3.81	3.72	3.59	3.55
Graphite	3.60		3.41	3.39	3.21	3.37	3.07	
Combined Carbon	0.00		0.52		0.47		0.50	
Sulphur.	.02		0.12		0.10		0.09	
Phosphorus.	0.29	0.29	0.40	0.36	0.32		0.27	
Total Silicon	2.57		1.11		1.48		1.05	
Manganese.	0.81	0.82	1.01	1.02	0.72		0.47	0.51
Iron by difference	92.72		93.46		93.62		94.53	

IV. Slags.

	1.		2.		3.		4.	
SiO_2	53.83		50.99	50.98	54.66		55.06	55.01
Al_2O_3	14.48	14.54	12.40	12.45	13.63	13.74	14.94	
CaO.	22.08		25.67	25.58	20.18		20.71	
MgO	1.86	1.76	1.69		1.39		not determined.	
Fe	0.62	0.65	1.75	1.75	3.02	2.99	1.88	1.87
Mn	3.04	3.07	2.41		3.06	3.14	3.27	

The alkalies in the above were not determined.
There were finely divided pieces of metallic iron scattered through the slag so that the above percents represent a larger amount than really exists combined as silicate.