An Investigation and Report on The Pomeroy Iron Works, at West Stockbridge. Mass.

– By –
Theodore E. Schwarz.

Section I.
The Works.

During the first part of September, 1875, I visited the Pomeroy Iron Works, consisting of a Blast Furnace and its accessories, for the purpose of making an investigation and report on the condition of the works, the state of business, and the running of the Furnace, as a Thesis. I spent one week at the Furnace and in visiting the mines and a charcoal furnace in the vicinity, and in the meantime obtained samples for analysis of the ores and flux used and of the pig-iron and slag turned out.

The Works are situated in West Stockbridge, Berkshire County, Mass. The Bridgeport, West Stockbridge, and State Line R.R. runs within 200 ft. of the furnace, and has a side-track running directly to the bottom of the furnace-incline. The limestone used as flux, abounds in the vicinity, and is quarried within 20 rods of the Furnace. Sand is also to be had very near the works. Water is plenty. The country is very hilly, almost mountainous, the soil is rich and productive, and the inhabitants are mostly well-to-do farmers.

The Pomeroy Iron Co. consists of five stockholders, all of whom, I believe, are of Berkshire Co. residing in Pittsfield. The sole management of the works and control of the business is in the charge of the superintendent, Mr. Wm. M. Kniffin, a very practical man, with a great amount of ability, and of that tact of management, necessary for controlling a large number of men. He sends to every stockholder at the end of each week, a full report of each days "run", giving particulars of temperature and pressure of blast, etc, and a complete summary for the week, and al-

-so for the "Blast" up to date. In short, this report, gives every stockholder, in a concise form, a minute account of everything connected with the running of the furnace, the sales of pig, the purchase of ore, etc - The Company was employing at the time of my visit, about 50 men, just enough to keep everything running. They were employed, as follows;—

1 Superintendent	3 Men Breaking Ore in St. House
1 Clerk	3 " " " " yard.
1 "Boss" or Founder	2 " " Limestone.
2 Keepers	3 Engineers
2 Helpers	1 Blacksmith
2 Iron Men	1 Asst. "
2 Cinder Men	5 Men Carting
7 Fillers {4 at night, 3 by day}	14 Men at Mine.

The Company leases the Andrews Mine,

near Pittsfield, consisting of Brown Hematite ore.

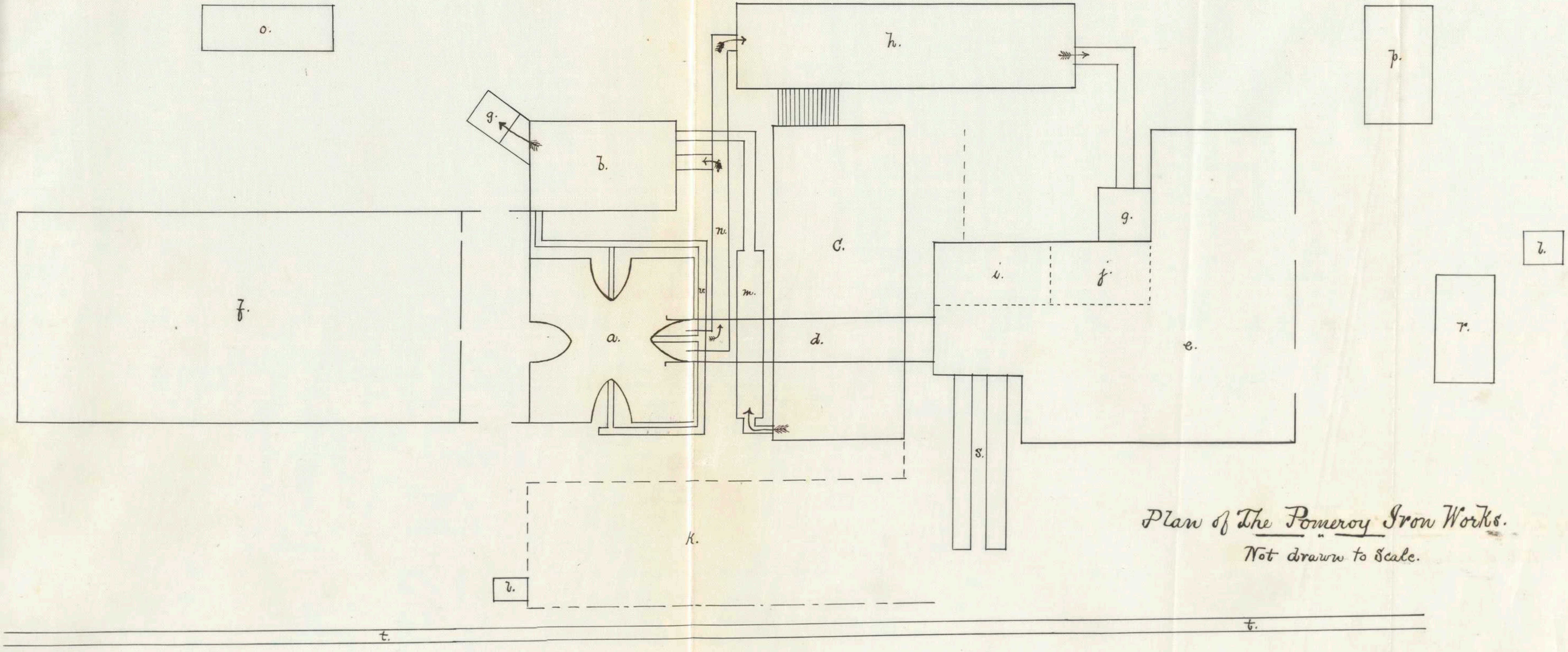
The Furnace has been built about seven years, during which time there have been five blasts. The produce of the furnace which is most grey Foundry pig, Nos. 1 & 2., is sold principally to the Woods Mowing Machine Co. of Hoosic Falls N.Y., and to the Eagle Mowing Machine Co. of Albany N.Y.

The Company I understand, once tried to make Bessemer pig, but failed, probably because its requirements were not sufficiently understood.

The plan of the Works is shown in the accompanying drawing. The buildings are substantial, well built of brick and in good repair. The Stock House is on a knoll about 50 ft. above the level of the floor of the Casting House, Engine House, etc, and on a level with the top of the Furnace.

Plan of The Pomeroy Iron Works

a. The Furnace.
b. Blast Heating Stoves.
c. Engine House.
d. Iron Bridge.
e. Stock House.
f. Casting House.
g. Chimneys.
h. Boiler House.
i. Hoisting Engine.
j. Cistern.
k. Stock yard.
l. Scales.
m. air Reservoir
n. Waste gas Main.
o. Blacksmith Shop.
p. Carpenter ".
r. Office
s. Incline to Stock yard.
t. Railroad
v. Hot Blast Main.



Plan of The Pomeroy Iron Works.

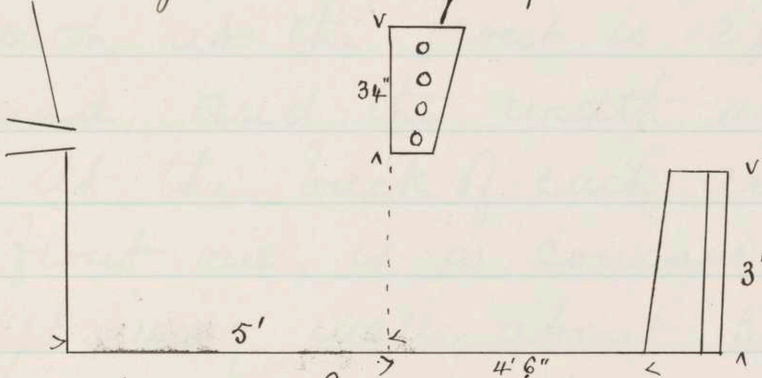
Not drawn to Scale.

Section of Pomeroy Furnace.
— Through the Tuyeres —

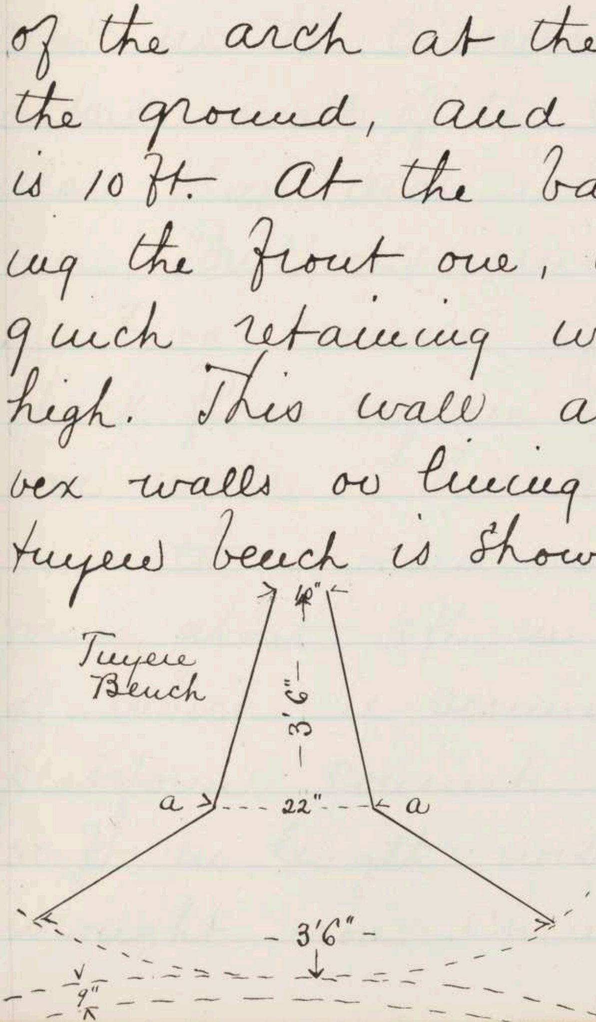
The Blast Furnace is 50 ft. high and 14 ft. at the boshes. The top is open but the flame is partly inclosed by a cylindrical iron chimney of 10 ft. in height. The waste gases are conducted off by flues from the throat. The stack is built of the limestone of the vicinity, having the shape up to the iron jacket of a foursided truncated pyramid of 36 ft. to a side at the base and about 20 ft. at the height of 40 ft. The blocks of limestone are about 5 ft. in length by 1½ ft. in height, breaking joints. This furnace shows very plainly that limestone is a very poor material with which to build a blast furnace, for the stone is considerably crumbled, especially towards the interior, on account of its long continued exposure to heat. At the height of about 35 ft. and about 5 ft. below the floor of the circular flue, an iron jacket takes the place of the limestone masonry.

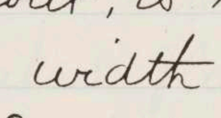
The foundation consists of nothing but three layers of 14 inch fire brick, resting on 8 inches of solid clay. There is no heavy masonry laid in concrete as in most furnaces. However in the course of years an immense "Salamander" of metallic iron has formed below the hearth. From the hearth up to 3 ft. above the entrance of the tuyere* nozzles, the lining consists of three courses of new 14 inch fire brick, backed with old fire brick to the stone work. From the latter point to the boshes, the sides slope at an angle of 18° from the perpendicular, and the lining consists of two courses of 14" inch firebrick, backed with old 14 inch brick to the stonework. From the boshes, 16 ft. up, the lining consists of but one course of 14 inch firebrick, backed to stone work with old broken brick. From this point to the circular flue, the lining is one course of new 14 inch, backed with two courses of old 14 inch brick, and a backing to iron jacket. Above the circular flue, the lining is composed of one course of 14 inch firebrick, backed with 12 inches of red brick. Although the furnace presents a very massive appearance, it will be seen that the lining is very light, for the 16 ft. above the boshes. It will also be noticed that there is no annular space between the walls, as in more modern furnaces. The accompanying section of the furnace, shows its admirable shape, which has been found to be very satisfactory for working with the anthracite fuel, and selection of ores used. The rapid contraction from 12 ft. 10 in. at 34 ft. from the hearth to 7 ft. 6 in. at 45 ft. from the hearth, aided by the draft of two chimneys, enables the stack flues to collect more than enough waste gases for the heating of the blast and boilers.

As the furnace was in blast, when I visited it, I was unable to get measurements which would give me an accurate section through the tymp and dam. Such

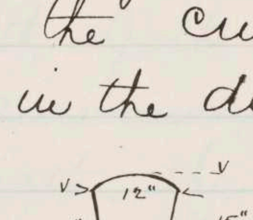


measurements as I obtained, are given on the above section. The tymp is cooled by water, and is 27 inches wide. The dam-plate is also cooled by water and is 7 ft. 6 in. in width. The notch for tapping the metal is about 9 inches high and 2½ ft. from the left hand side of the plate as you look at it from the outside. The cinder notch is at the top of the plate, and to the right of the centre. On either side of the tymp, is the buckstaff. On each side of the furnace is a tuyere arch. These arches are built of common brick, in three courses, and sett back into the limestone masonry. The highest point of the arch at the front, is 12 ft. from the ground, and the width at the base is 10 ft. At the back of each arch, excepting the front one, is a concave (outwards) 9 inch retaining wall, about 3 ft. 6 inches high. This wall abuts against the convex walls or lining of the crucible. The tuyere bench is shown in the drawing.





Inside opening.



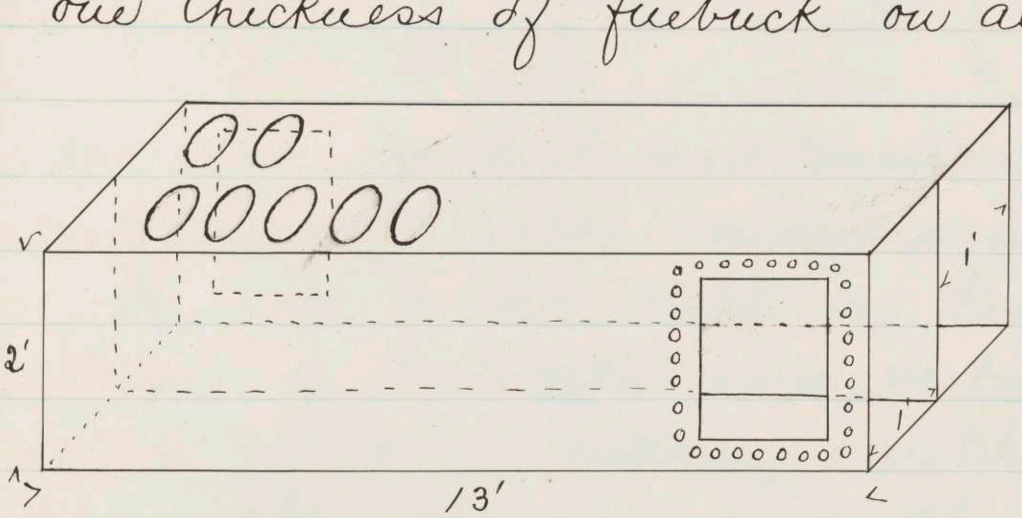
Outside opening at "a"

The gases of the furnace as they approach the mouth, are conducted by five stack flues, into a large circular flue which surrounds the furnace. (See the section of furnace). The stack flues are at equal distances apart, and are 20 in. in width. The other dimensions of both the stack and circular flues are shown in the drawing. 14 inch brick are used except in the circular flue arch and the outside wall of the circular flue. The circular flue arch is built of one course of 9 in. Bullheads, and the stack flues arches of two courses of 14 inch fire brick. The stack flues require cleaning about every five weeks. The mouth of the furnace 50 ft. from the ground is surrounded by a platform about 5 ft. in width, the outer edge of which is screened by sheet iron. This platform connects by a light iron bridge 50 ft. in length with the Stock House. A wrought iron Chimney 10 ft. high, is supported on iron rods 3½ ft. high over the open tunnel head. In this 3½ ft. between the chimney and the floor of the platform, the charging is done.

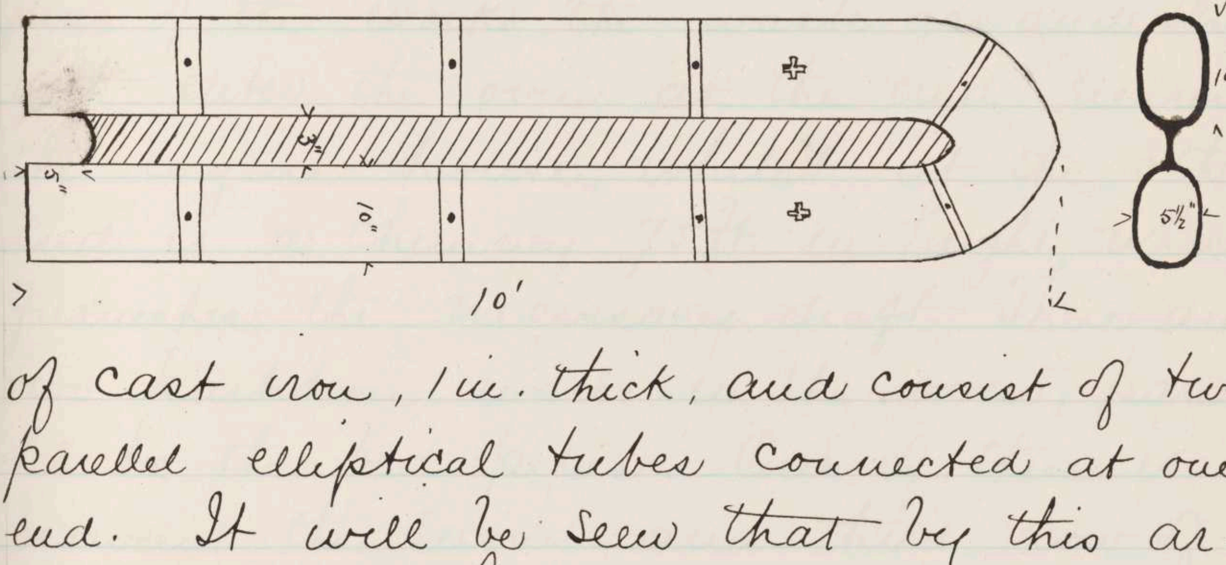
I have calculated the cubic contents of the furnace, according to the section given, and find it to be 4639 cubic feet.

Extending from the front of the furnace is the brick casting house. This contains a brick wall about 15 ft. from the furnace, which extends to the roof, screening the workmen while casting and allowing the molten metal to run through an arch at the bottom, directly opposite the tap hole. At the further door of the casting house, are the scales upon which each cast of pigs, is weighed before being placed on the piles.

The blast is heated by one oven to an average temperature of 800° F. The oven as is shown by the plan of the works, is placed on the ground very near to the engine and to the furnace. Its outside dimensions are, length 24 ft., height 19 ft., and width 16 ft. The walls of the oven are of common brick 12 in. thick, and lined inside with firebrick 4½ inches thick. There is no grate in the oven for firing up. Supported upon arches whose length corresponds to the width of the oven, are five cast-iron bed-pipes, 1 inch thick, lying parallel to the arches. Each of these is imbedded in one thickness of firebrick on all sides.



Each pipe is divided lengthwise by a partition into two entirely seperate chambers. Each chamber has fourteen elliptical openings on top, making fourteen pairs of these openings in each pipe. Each pair of holes, holds one vertical pipe. On each side of a bedpipe and at opposite ends, there is an opening by which the bed-pipes are connected. The vertical pipes are also

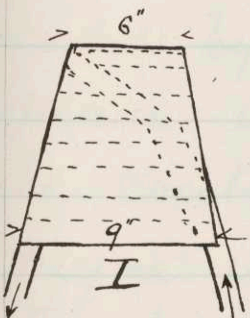


of cast iron, 1 in. thick, and consist of two parallel elliptical tubes connected at one end. It will be seen that by this arrangement of horizontal and vertical pipes, the blast on entering one chamber of a bed-pipe at one end, is obliged to travel through fourteen vertical pipes, or 20 ft. in length of red hot pipe, before it can enter the second chamber, from which it passes to the next bed-pipe in order by an opening, at the other end of the bed-pipe from which it entered. The waste gas from the furnace, enters the oven below the level of the bed pipes, is immediately inflamed and then rises up between the arches supporting the bed pipes, filling the whole oven. As will be seen by the plan of the works, the waste gas and blast both enter the oven at the end nearest the engine house, whilst at the other end is a chimney 75 ft. in height, which furnishes the necessary draft. There are two partition walls in the oven, parallel to the bed pipes. One of these is between the second and third row of pipes and allows the flame to pass under it, while the other is between the fourth & fifth row, and allows the flame to pass through or over it at the top. By this arrangement the flame is made to heat all parts of the stove nearly equally.

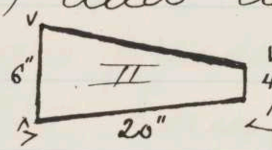
a sett of draft holes around the lower part of the stove, may be used for regulating the draft, etc. There are four horizontal tie rods around the entire stove, and three vertical braces connected by tie rods on the two sides. I have calculated the total heating surface which this stove exposes to the blast at about 4300 sq. ft. The number of cubic feet of air blown into the furnace per minute, I find to be 8247.98 c. ft.† or 1.91 cu. ft. per sq. ft. of heating surface. The waste gases pass from the circular flue at the back of the furnace, into a wrought iron pipe nearly 5 ft. in diameter, and lined with 9 in. of fire-brick. From this conducting pipe a portion of the gases are led by a short branch into the blast heating oven, while the remainder pass to the boilers. Doors for cleaning out this pipe, are placed opposite the branch to the oven and at the elbows.

†. No allowance was made for the loss of pressure due to friction.

The hot blast passes from the second chamber of the last bed-pipe, into a wrought iron pipe 1/4 inch. thick, and 1 1/2 ft. in diam. including 3 inches of "Salamander Felton" lining on the exterior. This pipe contains, a few feet from its entrance into the oven, a valve and door arrangement, which by rod connections enables the man at the front to shut the blast off from the furnace, and let it out into the air. There are three branches from this hot blast main, one to each tuyere. The cast iron water tuyere, into which the nozzle fits, is shown in fig. I. This consists of a coil of pipe, encased in cast iron. 2" in. is the thickness of the pipe and casing. In place of this cast iron water tuyere,



which wears out quickly, the experiment has been tried of using the same coil of pipe, fitting onto cast iron on the inside, but covered on the outside by a patent fireproof cement (asbestus and fireclay principally). This cement is mixed with water and carefully put onto the coil, through which steam is being passed and allowed to dry on, whilst the coil is kept hot. At last accounts this form of water tuyere was proving very satisfactory. The nozzles used are all 4 inch (internal diam.) and made of cast iron 1/4 inch thick.



See Fig II.

4 1/4 inch nozzles at the side tuyeres and 4½ in. at the back formerly were used. The bricks about the tuyeres are cooled by small streams of water. The blast main is arranged so that it can easily be continued around to the front and a tuyere inserted in the tymp, if necessary. The temperature of the blast is taken three times per day, by inserting a Teesborough pyrometer into the eyepiece front of a tuyere. The average is recorded for the

day.
The Engine House is a wellbuilt brick building with corrugated iron roof, and contains the engine and blast cylinders. They were built by James Moore of Philadelphia. The engine is direct acting, horizontal, non-condensing. There are two horizontal blowing cylinders of 4½ ft. each in diam. and a length of 5 ft., with stroke of 5 ft. The steam cylinder has diameter of 20 in., length of 6 ft., and a stroke of 4 ft. The average pressure of steam is 70 lbs., when the horse power is said to be 85. The number of revolutions per minute is kept at 37, under which conditions, the mercury shows a pressure of blast of 4½ lbs. per sq. inch. The crank and shaft which runs the blast cylinders pistons, makes 14 revolutions per minute. The steam cylinder piston, is connected by means of the usual connecting rod and crank with a shaft upon which is keyed a cog-wheel 2 ft. in diam., and

and the Flywheel 16½ diam. This cogwheel acts on another cogwheel 8 ft. in diam, on the same shaft with which, and at each end, is a crank. These cranks are connected by connecting rods, with the piston rods of the blowing cylinders, which are carried through both ends. The valves are arranged to draw in air alternately at each end of the cylinder. The cold blast from the cylinders passes into one iron pipe, by which it is conducted to the receiver, (just outside the engine house) which is an iron cylinder 30 ft. long by 5 ft. 6 in. in diam. The conducting pipe running from this receiver to the blast heating stove, is 1 ft. 6 in. in diam. The engine is not provided with an "Escape", consequently whenever the furnace is tapped, the blast being shut off, or allowed to escape into the air, the engine has to be very nearly stopped. A simple contrivance for showing the rate at which the engine is running, or the number of revolutions per minute, patented September 1874, by Edw. Brown of Philadelphia, is connected by a narrow belt with the fly wheel shaft. The rate is shown by a column of mercury elevated along a fixed scale to heights corresponding to the number of revolutions. The engine and in fact the whole running of the furnace, is regulated by this machine. Every one, who has had experience with a blast furnace knows that in order to produce a pig-iron of a certain grade and composition day after day, and week after week, it is of the first importance, the charge being fixed, that the amount of hot-blast forced into the furnace per minute should be constant. This result can only be attained when the rate of the engine, or the actual work it is performing, is kept at a certain standard, unaffected by the variations in the amount of steam.

On this point Mr. E. C. Pechin, an eminent iron master of Penn, says:- "It becomes an interesting question whether the irregular working of many furnaces is not caused by two much dependence on the hot blast and not enough upon the engine and fuel." This standard at the Pomeroy Works is 37 revolutions per minute, when making an Ex. No. 1. iron. In order to make a harder iron the number of revolutions per minute would be increased, in connection with a   in the per cent of fuel in the charge.

In the engine house are also two small steam force pumps. No. 1. pumps from a pond to the cistern, and No. 2. pumps from the cistern to the boilers.

The boiler house is about 66 ft. long, 20 ft. high, and 18 ft. wide, and built of brick with a corrugated iron arched roof. On each side are three cast iron doors for firing up with wood, when there is no gas and for admitting air. There are four tubular boilers of 4 ft. in diam. and 60 ft. in length. The waste gas enters a brick chamber at one end of the boiler house, and passes from the latter at the other end through a large iron main to the chimney. Between the boilers and the floor, there is a space of about 3 ft. I was unable to obtain any further details of the construction and internal arrangement of the boiler house, there being no drawings or recorded measurements.

The stock house is situated on a knoll on a level with the top of the furnace. It is a large wooden building, with pitched roof, having two large doors through which teams may drive in and out to unload ore; and facing towards the road on the sloping side of the hill. Each ore used, as well as the flux, forms a small pile by itself against the wall of the stock house. If there is a large

Stock on hand, of any ore, the small heap in the stock house, is kept replenished from the bulk of the ore lying on vacant ground outside. At the back of the stock house and close to the hoist, are the scales, which are kept locked, and are adjusted to a certain weight of each portion of the charge, by the barrowful; the barrow itself being counterbalanced. All the coal and some of the ore, is brought from the stock yard side of the railway, to the stock house, scales, and furnace, by means of an inclined hoist. There are two tracks on this tramway, the full barrow coming up on one, as the empty one descends on the other. The principal dimensions are as follows:—

Length of Tramway - - - - 100 ft.
Vertical height from ground 38 ft.
Inclination 48°

The large cogwheel is on the same shaft as the two drums, which are each 28 inches in length, by 32 inches in diam, and from which the wire rope passes over rollers 2 ft. 6 in. in diam. The hoisting is regulated by a couple of levers, at the top of the hoist in the stock house, by means of which the power is transmitted to or cut off from the drums, by one of the fillers.

The furnace is quite well located, in regard to the proximity of the ore supply, as three of the five ores used, come from mines situated in the Western part of Berkshire County. Besides these three mines there are two or three others, all of which were producing ore last fall. All the deposits are of the same general character, consisting of beds of brown hematite ore, more or less interspersed with irregular masses of "Ochre" or very siliciciouss clay. Pockets sometimes of very

Width between rails	3 ft. 6 inches.
" " two tracks	4 ft.
Height of rail	2 ft. 6 inches.
" of roller from crossbar	6 inches
Diam. " "	4 inches.
Heavy timbers of tramway	4 inches square.

A wooden horizontal platform, onto which the barrows are wheeled, runs on each track. The platform is 6 ft. 10 in. in length, by 4 ft. 7 in. broad, and is connected with the hoisting engine by a 3/4 in. wire rope. The barrow is made of 1/8 inch sheet iron, except the handles and legs, weighs about 570 lbs., and hold 600 lbs. of coal.

The engine which works the hoist, is situated under the South West corner of the Stock house. It is a small horizontal engine, with the principal dimensions as follows;-

Diam. of cylinder - - -	1 ft.
Stroke	1 ft. 8 in.
Diam. of small cogwheel	7 inches.
" " large "	31 " .

large size are common in the ore, which is thus rendered quite easy to mine. Underground working is now almost the universal plan, as the old method of open workings has got to be too expensive, owing to the extensive stripping required. However where it will still pay, open work is carried on, some of the companies working their deposit in both ways. The plan of underground work, consists generally, of one or more vertical shafts, with levels driven off at regular distances.

The Andrews Mine is leased by the Pomeroy Iron Co, and worked to supply about one fifth of the ore used by the Co. The mine is situated about 10 miles away; all the ore being carted by two horse teams to the furnace. I was unable to examine this mine and can give no particulars in regard to it.

The Leete Mine is situated about 1½ miles from the furnace, and is leased from the Stockbridge Iron Co. by the Richmond Iron Works. From this latter Company the Pomeroy Iron Co. buy all their Leete or "White House" ore. The ore of this mine consists of two kinds; viz:- the White and the Red ore. The latter is the richest of the two. The Richmond Co. pay $1.50 per ton royalty to the Stockbridge Iron Co. They generally employ about 55 men at the mine. The shaft is 120 ft. down. There are five levels, the lowest one being used as a reservoir for the mine water. During the day the water is pumped by a No. 8 Cameron pump from this lowest level to the reservoir on the surface. The width of the bed varies from 30 - 70 ft and the dip is about 43°. They have not yet reached any limit to the deposit in depth. On the South they are limited by the boundary of their property to 250 ft. farther. The mine is said to produce 12000 tons per annum, which, I think, could ~~be~~ not be increased with the present facilities. The mine appeared to be but little prospected ahead. Little blasting is required. The pillars in level No. 1. had been robbed and those in No. 2 were being robbed when I visited the mine. Very little method is observed in the mining, owing partly, no doubt, to the irregularity of the deposit, which is greatly broken up by masses of "Ochre"; and partly to the fact that the mine being leased, the plan is to get as much ore out as possible in a given time, with the least expense, and without regard to the future. The reservoir on the surface, supplies the ore-washer with water.

The Cheshire Mine is situated in Cheshire about 18 miles from the furnace. The ore is transported by railroad.

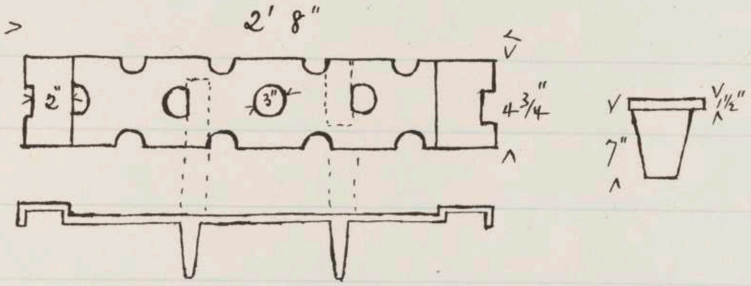
The Port Henry ore comes from Witherbee, Sherman, and Co's "Old bed", Port Henry N.Y.

The Caledonian Ore comes from Rossie N.Y. The ore of the Cheever bed has been used by the Pomeroy Co, and at the time of my visit there was a small amount of it on hand. The mine is only three miles distant from the furnace, and is owned and worked by the Richmond Co. The ore is a rich brown hematite and the mine is probably the most extensive and best in every respect that there is in the County. The bed is from 5 - 60 ft. in width, lying sometimes nearly horizontal. There are four vertical shafts, the deepest of which (No. 4). and the only one in which hoisting is done, is 150 ft. down. There are ten levels in all, five of which are in the "Old Workings", and the 10th is used as a reservoir for mine water. The pumping is well managed by three Cameron pumps, pumping from the lowest level to the reservoir on the surface. The ventilation is excellent, having been lately improved by cutting a slope connecting Shaft I. of the "Old workings", with Shaft 4. The present mine is very well timbered, is dry, and in good condition in every respect. There appears to be no hindrance to a large and long continued produce. When working the average force of men, the product is 1200 ton per month. The mine is well prospected ahead, and shows in every way that the "Under-ground Boss" understands his business well. I have described this mine, thus fully, as I think in the future it will be more profitable for the Pomeroy Co. to draw their supply of ore, partly from this mine, and thus save some of the heavy freights and expense of cartage on other ores, which are of no better quality

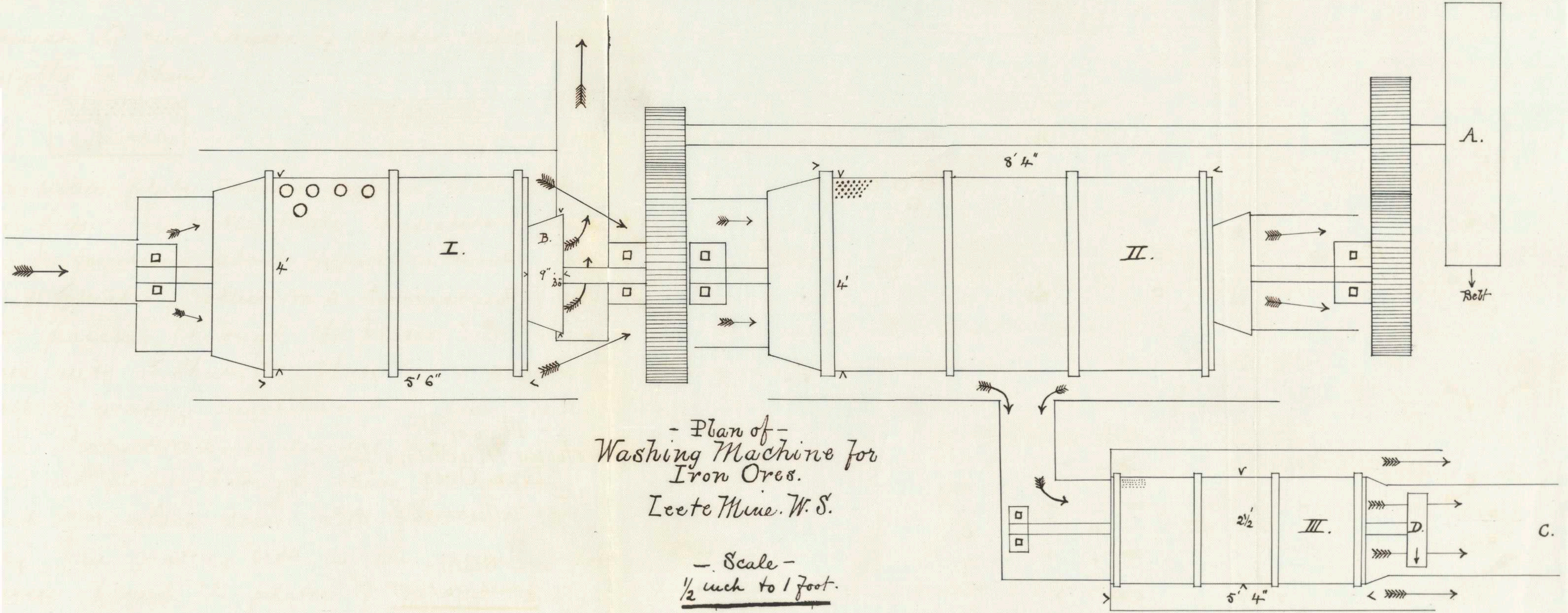
Section II.

The Process of Manufacture.

It is very necessary that these brown hematite ores, coming from clayey mines, should be washed from all the clay and mud clinging to them as they come to the surface, before being used in the blast furnace. At the Leete Mine as well as at the Cheever Mine, the ore on coming from the mine is passed through the washing and sorting apparatus. The same apparatus, which is patented, is used at both these mines, and at others in the County. The accompany drawing is a plan I made of the apparatus as put up at the Leete Mine. Such measurements as I could obtain at the time are embodied in the plan, others are approximate, for as the machine was in operation, I could not get the details. The ore is fed into a wooden trough, which carries a supply of water flowing from the reservoir. From this trough, the ore flows into cylinder No. I. This consists of two lengths of perforated plates, bound by iron bands onto an iron frame. Through the centre of this cylinder and connected with it, runs the shaft transmitting the power. The plates have iron prongs projecting into the inside and which serve to break up clayey and earthy matter.



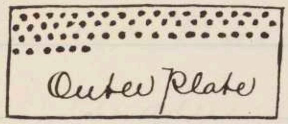
Cylinder I. revolves over a wooden trough lined with sheet iron, sloping 15-20°, between which and the cylinder is about 6 in. on the sides and 1 ft. on the bottom. Into this trough whatever passes through the holes of the cylinder goes, and is then carried by the water into Cylinder No. II, which is 3 ft. lower than the first one. The ore which does not pass through the plates, tumbles out the end B into a shute, and forms Product No. 1. B contains a sort of propeller wheel, like a screw propeller, which helps to work the ore out. Cylinder No. II.

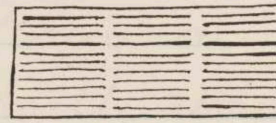


- Plan of -
Washing Machine for Iron Ores.
Leete Mine. W. S.

- Scale -
½ inch to 1 foot.

consists of two layers of plates, and three lengths of them.





Inner plate-

The inner plate consists of three setts of parellel slits. The outer plate consisted of circular perforations, about 3/8' inch. in diam. Cylinder II. makes Product No. 2, consisting of ore not passing through the plates, and which goes into a Shute C. Shute C. is provided with a grating on its bottom side, and thus Product No. 2. is divided into 2A, which does not pass through Shute C's grating, and 2B. which does. 2B. falls onto a very fine grating sett in the ground. What passes through the plates of Cylinder No. II., and which is less than 3/8 inch in size, falls into the trough, and is carried by the water to one side in Cylinder III. This is some 3-4 ft. lower than No. II. and to the right. The sieves are still finer than No. II.. The Siftings are thrown away, while Product No. 3. passes by a shute onto the same grating as No. 2 B. The apparatus revolves at the rate of thirty revolutions per minute. The power is transmitted from a small steam engine, by belts to the wheel A & D. The fine ore is used by the Richmond Co. in some of their furnaces.

This apparatus requires no tending, more than one man to run the engine, and the necessary men to unload the ore by the trough, and to carry off the sized and washed ore.

The Port Henry ore, is a magnetite of medium sized crystals, rich and clear looking, and showing specks of apatite.

The Leete ("White Horse") ore, consists principally of small masses of soft, white, carbonate, which is mixed with some quartz and silicious clay, and with masses of brown hematite, and of carbonate more or less converted into limonite.

The Andrews and Cheshire ores are both fair looking limonites, showing a concretionary structure.

The Caledonian Ore is a hard, compact, and finegrained red hematite, of a very greasy feel. It is considered by the furnace-men to be a very peculiar and valuable ore to use in the furnace, although they do not understand why it is so. The charge may be fixed consisting of the four other ores, and the required amount of fuel and flux, in order to make the furnace run on No. 1. iron, and then it is found that 3-4 Cwts. of Caledonian ore may be added to each charge, everything else remaining the same, and the furnace will continue to make No. 1. as before, but in increased quantity. The cause of this mysterious property, is shown by the analysis of the ore.

I obtained samples of each of these five ores, from the heaps in the stock house, ready to be charged into the furnace. The samples of about 15 lbs. each, were obtained by taking small pieces of the ore from different parts of the heap, and by breaking off small pieces from the larger sized lumps, so as to represent as nearly as possible the quality of the heap. These samples were treated in the mining laboratory, as follows;—

Each lot was put through a large and

small Blakes Crusher, reducing the particles to a maximum size of 3/8" in., and then thoroughly mixed and sampled. The Port Henry ore was thus brought down in bulk to 1/8th of the original sample, and the others to 1/16th. Each sample was then put through a 60 mesh sieve and bottled. Portions taken for analysis were passed through very fine bolting cloth, heated in an oven for 80 mins. at 100° C. and then kept in air-tight tubes.

Methods of Analysis.

Insoluble Residue. — One gramme of the ore was digested in strong hydrocloric acid, until no further action takes place. The solution is then evaporated cautiously to dryness. When completely dry, the soluble portion is taken up in dilute hydrocloric acid and filtered. The insoluble residue which remains being well washed with hot water. The filter and contents are then dried ignited and weighed in a platinum crucible.

Iron, Alumina, and Phosphoric Acid:- The method used for seperating iron and manganese, was a modification of the method given by "Classen's Quantitative Analyse" Stuttgart 1875, page 56. The filtrate obtained as above, is diluted to nearly 1/2 litre, and chloride of ammonium is then added in considerable excess (about 100cc) The solution is then boiled for about 45 mins., in order to expel all the air. Then carbonate of ammonia and ammonia water are added, until a persistent smell of ammonia is obtained, when the whole is boiled again for 45 mins., taking care that the excess of ammonia is not all driven off. The precipitate is then filtered off and washed completely four times with boiling water. The filter and contents are then dried in drying closets, and ignited for an hour or two over a Bunsen burner, until constant weights are obtained. The combined weight of the Iron Oxide, Alumina and Phosphoric acid are thus obtained. This method has always been found to give a complete seperation from the Manganese.

Manganese:— The filtrate containing the Manganese is evaporated down to about 150 c.c., and the Manganese precipitated, ignited and weighed as Sulphide, according to Fresenius.

Lime;— The filtrate from the Manganese is made acid, and the sulphur filtered off. The lime is then precipitated with oxalate of ammonia and ammonia water, and after standing twelve hours, filtered. The filter and contents are ignited intensely in a platinum crucible, and the lime weighed as Oxide (CaO).

Magnesia:— The filtrate from the oxalate of lime is made strongly alkaline by means of ammonia, and the Magnesia thrown down with phosphate of Soda. The Solution is allowed to stand for 12 hours, after which the precipitate is filtered, washed, ignited, & weighed as pyrophosphate of Magnesia according to Fresenius. From the weight of pyrophosphate the Magnesia is calculated.

Iron; — The iron may be determined in the ignited precipitate previously obtained, but a seperate estimation has always been made in another lot of the ore. For this purpose the volumetric process of Penny, has been used. In titrating the limonites under consideration, I was unable to get any good results in titrating in a direct solution of the ore, owing to the organic matter present. After trying two or three proposed methods of getting rid of it, I found the most satisfactory one, was to precipitate the iron from the solution of the ore in hydrocloric acid, by an excess of ammonia water, redissolve the precipitate on the filter.

in hydrocloric acid, and then titrate.
Phosphoric Acid:— A nitric acid solution of about 3 grms. of the ore was obtained and the phosphoric acid, precipitated out by an excess of molybdate of ammonia. This precipitate was then redissolved in ammonia water, reprecipitated by Magnesia solution, ignited and weighed as pyrophosphate of Magnesia, according to Fresenious.
Alumina:— This element was determined by subtracting from the percent of Ferric Oxide, alumina, & phosphoric acid obtained, the per cents of Ferric oxide and phosphoric acid determined in seperate portions of the ore.
Loss on Ignition:— This is determined by heating to bright redness in a platinum crucible, a weighed portion of the ore, until there is no further loss in weight.

In analysing these ores, several duplicate determinations have always been made of the Insoluble residue and of the iron, while the phosphoric acid determination has been invariably duplicated. It was not thought necessary to make complete duplicate analyses. The following are the results.

Port Henry.	-Duplicates-	-Results-	
Insoluble Res.	3.54 3.40	3.54 %	
Binoxide of Manganese (MnO_2)		.88	Mn = .56
Lime (CaO)			
Magnesia (MgO)			
Phosphoric acid (P_2O_5)	2.74 2.89	2.82	
Alumina (Al_2O_3)		1.20	
Ferric Oxide (Fe_2O_3)	90.15 89.95	90.01	Fe = 63.01
Loss on Ignition		—	
Sulphur		-tr-	

After having determined the lime in the Port Henry, White Horse, and Cheshire ores, I discovered that one of the pure imported reagents (NH_4Cl) used, contained a large per cent of lime. Hence, I have not stated the determination. The amount, however, is small, but I lacked the time to repeat.

Andrews.	Duplic.	Results.		Caledonia.	Dupl's	Results
Insol. Res.	14.48 14.06 13.94	14.16%			10.34 10.57	10.57%
MnO_2		.36	{Mn = .23}	{Mn = .145}		.23
CaO		-tr-				4.49
MgO						
P_2O_5	.505 .485	.49			.415 .46	.43
Al_2O_3		1.46				2.22
Fe_2O_3		73.80	Fe = 51.66			72.15
Loss on Ig.		9.72				8.09
S.		—				—
Fe -	51.57 51.81 51.51 51.86				50.51 50.60	50.51

Cheshire.				White Horse.		
Insol. Res.	15.43 15.37	15.43%			20.80 20.79	20.80%
MnO_2.		1.13	{Mn = 72}	{Mn = 1.88 1.85 1.72	2.97 2.96 2.72	2.96
CaO.						
MgO.						.42
P_2O_5	2.21 2.05	2.13			.24 .25	.25
Al_2O_3		2.13				.76
Fe_2O_3		68.67				56.30
Loss on Ign.		10.00				16.80
Fe.	48.26 47.88 48.07	48.07			39.56 39.40	39.40
S.		—				—

In looking over these analyses, it is notable that none of the ores contain more than a trace of Sulphur. In the case of the brown hematite ores, this might be expected, on account of their origin from the Carbonate of iron. It is also noticeable that there is an absence, almost, of Calcium and Magnesium in the brown hematites, while they all show a small amount of Manganese. This fact is also explained, by the action of percolating waters on the more soluble Carbonates of Magnesium and Calcium, leaving the far less soluble Carbonate of Manganese.

The Flux used, is the limestone of West Stockbridge and vicinity, better known as the Aurora limestone of the Taconic Series. It varies from a pure white to a gray or bluish shade, and is hard and of a compact finely crystalline structure. The method of analysis was essentially the same as that used in analysing the ores. The analysis is as follows:—

Limestone.

Silica	2.92	
Protoxide of Iron	.40	Fe = .32
Lime	42.83	
Magnesia	9.65	
Carbonic Acid	44.235	

The fuel used is Lehigh anthracite. As it lay in large heaps in the stock yard, I observed that it contained small seams of pyrites, but that between these seams the coal showed no pyrites. This mode of occurance of the pyrites rendered it impossible for me to obtain a sample of the coal that would represent the per cent of sulphur in the large bulk, so I obtained for analysis a pure specimen that showed no pyrites. There is not, however, sufficient sulphur in the coal to affect the quality of the iron, as the coal is used at other furnaces for the production of Bessemer pig. My analysis of the Coal and ash, made according to the method usually employed in the Laboratory of the Institute, is as follows:—

<u>Lehigh Anthracite.</u>

Volatile matter	11.16 %
Ash	6.85 %
Fixed Carbon	81.98 %
Sulphur	.0062

The ash contained;—

Alumina	3.59 %
Silica	3.28 %
Lime	tr-
	6.87 %

The ores and limestone are broken to about an average size of ones fist, by men with long handled rock hammers, in the stock house or yard. Each ore is also occasionally shovelled over, so as to be thoroughly mixed. The proportions of each charge are,

Coal 2400 lbs. — Ore 3150 lbs. — Flux 930 lbs.

The charge of ore is made in the following proportions;—

Port Henry	1050 lbs.	or 1/3 of the ore used
Leete	600 lbs.	" 4/21 " " "
Cheshire	600 lbs.	" 4/21 " " "
Andrews	600 lbs.	" 4/21 " " "
Caledonian	300 lbs.	" 2/21 " " "

The charging is kept up without cessation, by the fillers, excepting at casting times, when they are required to report to the keeper at the front. The charging is made in the order of coal - ore - & flux, and each successive barrow-full is delivered in order around the top of the furnace, so that the charge shall be equal on all sides. The tendency of the charge on being dumped in, is towards the centre, but owing to the small diameter of the mouth, it becomes pretty evenly distributed. About eighteen charges in twelve hours, is the average rate.

The slag is drawn off about every 40 mins., during the first six hours after a cast, and for the remainder of the time to the next cast, it is drawn off about every 25 mins. The total time occupied in each drawing off of slag, is not more than ten minutes. The cinder notch is opened with an iron bar, by the keeper and helper, and the slag allowed to flow off into furrows in the sand outside the casting house. When the slag is all off, the furnace is allowed to "blow" for a minute or two, after which the engineer is signalled by a bell, when he at once cuts down the number of revolutions per minute, bringing the pressure to 1/2 - 1 lb., The blast is then shut, and the cinder notch is plugged up again. While the furnace is "blowing" more or less coke is thrown out, which in the course of the day amounts to some 300 lbs. on a rough estimate, and which is carried home by the men. This shows that there is too much fuel used in the charge.

The slag after cooling, is taken off by a man with a wheelbarrow to the slag bank, where its accumulation is gradually filling up a swampy lot.

Three casts are made every 24 hours, at 6 a.m., 2 P.M., and 10 P.M. with an average production of 8 tons per cast. When ready to cast the blast is shut off and the tap hole opened by the keeper and helper. The metal runs down through the arch in the partition wall, into the prepared beds in the casting house. The men including the fillers, are disposed as is usual in casting, regulating the flow of the metal into the beds in their proper order, beginning with the furthest. The founder always superintends a casting. When the slag appears the flow through the archway into the casting house, is cut off and the slag turned aside. Slag collecting on the surface of the molten pigs is removed by long wooden poles. When the slag is all drawn off, the

the tap hole is rammed up with clay, and the blast again put on. The details of arrangements of beds, and the control of the flow, etc, etc, are the same as at all furnaces, and need not be described.

The slag formed is fine grained, hard and compact, and of a light grayish color. I obtained for analysis specimens of the purest average slag, from several days make. This sample which was of a uniform appearance, was pulverized and sampled twice bringing the bulk down to 1/16th. It was then put through 1/4 in. sieve, sampled, and 1/2 taken and put through a 60 mesh sieve. The portion for analysis was then treated the same as in the case of the ores.

The method of analysis employed was the same as in the case of the ores. The sulphur was determined in the ordinary manner, from the same aqua regia solution in which the phosphorus was determined. The analysis is as follows:—

Slag.	Duplicate Determinations	Results.
Silica	37.62 37.59	37.62
Alumina		12.84
Ferrous oxide		-tr-
Lime {Total Ca calculated as CaO = 40.88}		39.16
Magnesia		6.98
Protox. of Manganese (MnO)		.65
Sulphide of Calcium (CaS)		2.16
Alkalies		1.11
Phosphoric Acid		-tr-

The absence of iron and phosphoric acid in the slag, shows that the reduction is complete in the furnace, and that no iron is lost, excepting what metallic iron becomes mechanically mixed with the slag in the process of casting and tapping the slag.

The pigiron is graded by the founder, who breaks and examines the fracture of one or two pigs in each bed, after every cast. The whole of the bed is considered of the same quality as the pig broken. The size of the crystals, the color and the show of graphite determines the grade. The pigs are graded as Ex. No.1 - No.1 — No.2A — No.2.B. The bulk of the iron made is Ex. No.1 and the remainder No.2 A. Ex. No.1 has the largest sized crystals, and is considered to be softer and to have more Carbon than No.2. No.1 has little smaller crystals than Ex. No.1., and No.2A. and No.2 B. grade down the scale in the same order. Specimens of Ex. No.1., No.2A. and No.2 B. were obtained for analysis. From these specimens, I obtained through the kindness of Prof. Wing, samples cut completely across the face of each specimen, and in a finely divided state ready for analysis. Ex. No.1. and No.2 A. were analysed completely and each duplicated, while No.2.B. was only partially analysed, as there was none of that grade made during the week I spent at the furnace. Consequently its analysis would not enter into any Calculations based on that weeks "run".

The methods of analysis employed are briefly as follows;—

Total Carbon:—

This was determined by the chloride of Copper method and combustion in oxygen, and duplicated by direct combustion in Chlorine gas and subsequent combustion in oxygen. The chlorine method gives the highest and best results, while the chloride of copper method is always a little low. The chloride of Copper method consists in bringing all the iron which is uncombined into solution in the filtrate, while the iron combined with Carbon, sulphur, and Phosphorus and the graphite remains on the filter (sand & asbestus). To accomplish this, the pig iron is treated in a beaker with first a solution of $CuCl_2$ and then a solution of $CuCl_2 + NH_4Cl$. The reactions are,—

$$Fe + CuCl_2 = Cu + FeCl_2$$

$$Fe_2Cl_2 + Cu + CuCl_2 + NH_4Cl = FeCl_2 + Cu_2Cl_2 + NH_4Cl$$

The Cu_2Cl_2 goes into solution in the NH_4Cl. The filter and contents after drying, are combusted in a porcelain tube in a current of oxygen, & the CO_2 formed absorbed by weighed KHO bulbs. From the increase in weight the total carbon is calculated. The Chlorine Combustion consists in heating to redness in a glass tube, in a current of chlorine, a porcelain boat containing a weighed portion of iron. The Chlorine acting on the uncombined iron, carries it off as chloride of iron. The combined carbon, graphite and slag, are left in the boat, which is subsequently combusted in oxygen, as before.

<u>Slag</u>:— The contents of the boat, after the combustion in oxygen, are fused with carbonate of soda. The fused mass is then dissolved, evaporated to dryness and the Silica determined. This per cent is doubled and called slag.

Graphite:—

A weighed portion of iron is boiled in a beaker with dilute hydrocloric for several hours until the smell of hydrocarbons is nearly gone. The iron, etc, is thus dissolved, the combined carbon is freed as a hydro-carbon, while the graphite remains. The whole is then evaporated to dryness to render silica insoluble. After dissolving the soluble portion in dilute acid, the whole is filtered through a sand asbestus filter, and washed thoroughly with water, caustic potash, and alcohol, in succession and then dryed. The filter & contents are then combusted in oxygen, as before.

Manganese:—

This is determined in the last filtrate, (containing all the manganese), by the Color Method, as described in the Chemical News for

This has been much used in the laboratory during the past year, and has been found to give accurate results. The method is based upon the color of the permanganic acid obtained by boiling a solution of iron containing Manganese with peroxide of lead. This "unknown" solution is then compared with a standard solution of permanganate of potash. Either solution is diluted until they are both of the same color. Calculations based on the bulks of the two solutions, give the manganese in the unknown.

<u>Silicon</u>:—

A weighed portion of the ore was dissolved in nitric acid in a beaker, and the whole then evaporated to dryness to render the silica insoluble. Then filtered, and the contents of the funnel, consisting of silica, slag, and graphite, fused with carbonate of soda and nitre. The fused mass was then treated with hydrocloric acid and water, evaporated to dryness, and the total silica determined. From this per cent is subtracted the per cent of silica in the in the Slag, and from the remainder the silicon is calculated.

Sulphur and Phosphorus:—

About 5 grms. of pig are dissolved and filtered by the chloride of Copper method, and the filter washed until the filtrate shows no trace of sulphur. The filter and contents are then treated with nitric acid and chlorate of potash, and the whole evaporated to dryness. The nitric acid is then driven off by repeated evaporations with hydrocloric. Finally the hydrocloric acid solution is filtered, and the sulphur determined in the filtrate as sulphate of barium. In the filtrate from the sulphate of barium, the iron and phosphoric acid are thrown down by ammonia water, filtered off, and dissolved in nitric acid. In this solution the phosphoric acid is determined as usual. From the weight of P_2O_5 calculated, the per cent of phosphorus is calculated.

The analyses of the pigs are given below.

Ex. No. 1.	Duplicate Determinations	Result.
Total Carbon	3.91 3.90	3.91
Carbon Combined		.53
" graphitic	3.45 3.30	3.38
Phosphorus	.846 .837	.84
Manganese		.89
Sulphur		.016
Silicon		3.24
Slag		.20
Iron (by difference)		90.904

No. 2. A.		
Total Carbon	4.13 4.02	4.075
Carbon combined		.585
" graphitic	3.56 3.41	3.49
Phosphorus	.87 .88	.875
Manganese	1.11 1.16	1.13
Sulphur		.015
Silicon		2.16
Slag		.116
Iron (by difference)		91.629

No. 2. B.	Duplicate Determinations.	Result.
Total Carbon	3.78 3.73	3.755
Carbon Combined		.395
" Graphitic		3.36
Manganese		.61
Total Silica (Si as SiO_2 + the SiO_2 of Slag)		4.44

The following table gives the details of one weeks run of the furnace. The week chosen, being the one I spent at the works, was considerably under the average, as regards quantity and quality of production. Up to Sept. 10th the total amount of iron made during the blast of ninety weeks, was 16204 tons, and the amount sold was 12156 tons, leaving the balance of 4048 tons on hand. The average make for the 90 weeks was 180 tons per week. The highest make in one week was 204 tons. The best weeks run of the furnace was 185 tons all Ex. No. 1.

— Details of 90th Week of Blast No. 5 —

—Taken from Furnace Record Book—

Sept.	Press. Blast.	No. of Charges.	Temp. Blast.	Wt. of Iron made per day	— Quality of Iron — Ex. No. 1.	No. 2 A.
3	4½ lbs.	34	780°F	24 tons	18½	5½
4	4½	30	780°	23½ tons	—	23½
5	4½	33	700°	23½ tons	5½	18
6	4½	33	700°	24 tons	9½	14½
7	4¼	33	700°	24 tons	20	4
8	4¼	35	730°	24½ tons	24½	—
9	4½	34	700°	25½ tons	21½	4
	31	232	5090	169	99½	69½
average per day	$4\frac{3}{7}$	$33\frac{1}{7}$	727°	$24\frac{1}{7}$ tons	$14\frac{1}{5}$ tons	$9\frac{9}{10}$ tons.

Amount of coal per ton of iron for the week = 1 ton 10 cwt. 2 qr.
" " ore " " " " " " = 1 ton 20 cwt. 3 qr.
" " flux " " " " " " = 13 cwt.

Note. The ton used = 2240 lbs.

It will be noticed that on Sept. 4th, the pressure and temperature of the blast was above the average, while the number of charges was below, and that all the iron was No. 2, as would be expected. While on Sept. 8th the number of charges was above the average, and the make was all Ex. No. 1. The total product of Blast No. 5. (116 weeks) was,

Ex. No. 1	12951 1/2	tons
No. 2. A.	5508 1/2	"
No. 2. B.	556	"
Mottled	11 1/2	"
White	22	"
Total =	19049 1/2	tons

During the previous blast or blast No. 4, the average make was 20 tons per day. The founder at that time had the bad habit of taking the plate off the dam and cleaning out the cinder, coke, etc. This he did about three times every eight hours, spending 1/2 – 3/4 hours at it each time, and lowering the pressure of blast during the time to 1/2 lb. In the following blast or Blast No. 5., another founder took charge. The injurious practices of the former one were discontinued, and the pressure of the blast was increased, throwing the coke out when casting or tapping. The result of the change in management, was an increase of 20 per cent in the production.

It was decided, for various good reasons, to "Blow Out" about the 1st of January 1876. So on Jan. 1st the Superintendent writes me, the charging was stopped, and in 48½ hours after, the blast was taken off. They "had a good Blow out and could see from tuyere to tuyere". He says the "lining was in fair order, the arches over the flues were pretty well worn, but could have run another year on the lining. The Bosh, crucible, and hearth would not have interrupted us in two years." The consumption of fuel per ton of pig made is on an average 1 ton 8 cwt. for the whole blast.

In order to get the composition of the theoretical slag, I have calculated the proportions and weights of the silica and bases in the charge. From the weight of the slag ~~or~~ silica obtained, should be deducted the amount of silica which goes into the pigiron. The average amount of iron made to a charge is .74 tons. Of this, I find from the total production, 70% is Ex. No. 1., and 30% is No. 2 A, or,

.518 tons or 1164 lbs. No. 1 iron per charge
and .222 " or 492.8 lbs. No. 2 " "

According to the analyses,

Ex. No. 1 contains 3.71% SiO_2 and
No. 2A " 2.47% SiO_2

Hence 43.18 lbs. silica from every charge goes into No. 1 iron, and 12.17 lbs. into No. 2A., making a total of 55.35 lbs. of silica from every charge goes into the pig. In calculating this theoretical slag, no account can be made of the sulphur, Manganese, or alkalies. The following table explains itself.

	per Cent. in charge of			Weight (lbs.)			
	Ores	Flux	Coal	Ores.	Flux.	Coal.	Total lbs.
SiO_2.	11.76	2.92	3.28	370.44	27.74	78.72	476.9 − 55.35 = 421.55
Al_2O_3.	1.43		3.59	45.04		86.16	131.2
CaO.	.44	42.83		13.86	406.88		420.74
MgO.	.08	9.65		2.52	91.67		94.19
							1067.68

— Slag —

	Theoretical	Actual
SiO_2	39.48	37.62
Al_2O_3	12.28	12.84
CaO	39.40	40.88
MgO	8.82	6.98

The highness of the per cent of Silica in this theoretical Slag, as compared with the analysis, and the lowness of the alumina, is accounted for, in that the insoluble residues in the ores, have all been considered as silica, while they contain a small amount of alumina.

The Formula of this theoretical slag is,
$2 Al_2O_3 + 4 MgO + 12 CaO + 11 SiO_2$, or
$(2 Al_2O_3, 3 SiO_2) + (7 CaO, 2 MgO, 8 SiO_2) +$
$(5 CaO, 2 MgO)$
and comes between neutral or Monobasic, and Dibasic in Composition. The formula of the actual Slag as deduced from the analysis is,
$(2 Al_2O_3, 3 SiO_2) + (6 CaO, 2 MgO, 7 SiO_2) + (6 CaO, MgO)$
The weight of the Slag obtained from one charge, is 1068 lbs. or 16.4 per cent of the charge. For the week ending Sept. 9th, the average weight of pig iron made from one charge was 1632 lbs., or 25.1 per cent of the whole charge; or 51.8% of the ore in the charge. The analyses show that 52.4 per cent of the charge of ores is metallic iron. For the best days run during the week, Sept. 4th, the actual and theoretical make of iron is as follows;—

Wt. of Pig Iron Made = 52640. lbs.
wt. of iron in this pig (91.63%) = 48234. lbs.
Calculated amt. of metallic iron expected = 49515. lbs.
(52.4 % of charge of ores)
Difference = 1284. lbs.

This difference may be easily accounted for in 3 castings, by the scrap iron made at the end of each cast, and the small unavoidable losses in other ways. Most of this however is recovered as the scrap is used again.

The question arises, is the slag obtained the most desirable slag to make, all things considered? The remarkable regularity with which the furnace was running, its complete freedom from all scaffoldings, or hitches of any kind, together with the evenness of quality of its product, and the absence of iron in the slag, show ~~that~~ a change in the proportions of the charge, causing a change in the slag is not desirable.

As compared with other furnaces, the working of this furnace, compares very favorably.

The Cedar Point Iron Co.'s Furnace No. 1. at Port Henry, which is a large furnace with all modern improvements, including Whitwells Stoves, and working with blast at 1400°, uses on an average about 1 ton 7 cwt. of coal per ton of iron made. The average grade of the iron is 1.8

The Dunbar Furnace, at Dunbar, Pa. in 1873 was 15½ ft. bosh, and 58 ft. high, with closed top. Coke was used for fuel. The ores used were argillaceous carbonates, containing 30 – 40 % Fe, together with 1/10 to 1/5 of Lake Superior ores, and mill cinder. The pig made was 1/3 foundry and the balance soft gray forge iron. The consumption of fuel was 1½ to 1¾ tons coke to a ton of iron made. The pressure of blast was 800° – 900°, and the pressure 4½ lbs. 11000 gross tons were made in twelve months.

I have mentioned these two Furnaces, out of many of which statistics and descriptions might be found, because they have both been held forth as something remarkable in the way of blast furnace working. The Cedar Point Furnace is a fair specimen of the most modern and approved form of furnace and accessories, and yet the consumption of fuel is not lower than at the Pomeroy, nor the product nor working more regular. The Dunbar Furnace resembles the Pomeroy very much in a great many points. The consumption of fuel however was greater per ton of iron, than at the Pomeroy. Speaking of the run of 1873 at the Dunbar, Mr. Pechin says:—"Such regular working shows a furnace in good condition and a high degree of attention and ability on the part of the founder."

— Section III. —

The Manufacture Economically Considered.

In order to consider the manufacture from the economic and financial point of view, I will first add up the expenses and receipts of the business for the week ending Sept. 9th, in order to show what was the cost of making one ton of iron, and what the profits (?) thereon. I could obtain but very few of the items from the superintendent, and have therefore been obliged to estimate, what I could not get from other sources.

The wages are as follows per day:-

Superintendent ($2000. per annum)	$5.48
1 Clerk	2.50
1 Boss or Founder	3.00
2 Keepers	4.00
2 Helpers	3.60
2 Ironmen	3.60
2 Cinder men	3.00
	25.18

Amt. Br. Over	$25.18
7 Fillers	11.20
8 Men Breaking Ore	12.00
1 Engineer ($80. per month)	2.66
2 Asst. Engineers	3.66
1 Blacksmith	3.00
1 asst. "	1.50
5 Men Carting	7.50
Total wages per day =	$66.50
" " " week	$465.50
Care of Horses, etc	10.00
Oil and Sundries	10.00
Total	$485.50

The cost of the Lehigh Anthracite is about $6.00 per ton to Hudson City, and $1.00 per ton freight from there.

248 1/2 tons Lehigh Anthracite	$1739.50
108 1/2 tons Port Henry Ore at $6.00 per ton	651.00
Freight on Same	108.50
62.1 tons Leete Ore at $4.75 per ton	295.00
Cartage at .25 cts per ton	15.50
62.1 tons Cheshire at $5.25 incl. freight	326.00
62.1 tons Andrews at 4.50 " Cartage & royalty of .50 cts per ton	279.00
	$3414.50

Amt. Brought over	\$3414.50
31 tons Caledonia Ore at \$4.75 per ton	147.25
Freight on Same	155.00
98 tons Flux at .50 cts per ton	49.00
	\$3765.75
Wages, etc –	485.50
	\$4251.25

Calling the product all Ex. No. 1., for which \$23. tons was obtained, and we have

Total Cost of Manufacture for week ending Sept. 9th	\$4251.00
Receipts by 169 tons of iron, \$23. @	3887.00
Loss =	\$364.00
Loss per ton =	\$2.15

This excess in the cost per ton above the market price of the pig, explains why the works shut down last January and are now lying idle.

As every penny saved in the items

of expense, is a penny earned, it becomes a question, if the manufacture was conducted at the lowest possible cost, and what changes for greater economy might be made. The manufacture as carried on last September with the selection of ores used, involving heavy freights, and under the conditions of blast, etc, could not, I think, have been conducted at a lower item of cost. In the future, however, a few changes might be made. A saving could be made by using ore from the Cheever Mine, instead of the Cheshire. It would be economy to use twice or three times as much ore from the Andrews mine, which the Pomeroy Co. works, instead of paying a profit on mining for other brown hematites. I should not think it adviseable to use any of the "White Horse" Lute ore, which is so poor in iron, and for which so high a price is paid.

Several radical changes might be suggested, such as the use of Whitwell's Stoves, but I question whether the situation of the works as regards a cheap supply of ore and, and the future prospects of the pig-iron manufacture, would warrant their expense. Undoubtedly the most profitable grade of pig-iron to make, where the proper selection of ores can be obtained, is Bessemer Pig. At the Pomeroy Works this might be attempted if the necessary pure ores could be had, without too great expense, and would, I think, be worth trying. The "New Bed Pure Ore" from Port Henry might be used. Its composition I have found given as follows:—

Iron	68.24	Al_2O_3	.28
S.	—	CaO	.14
P.	.038	H_2O	.38
Insol. Res.	4.32		

In connection with this ore, it would be advisable to use some other easily reducible fluxing ore, if such could be got pure enough. Such an ore, could be found, though probably not in Berkshire Co. The same coal and flux could be used as at present.

Theo. E. Schwarz.