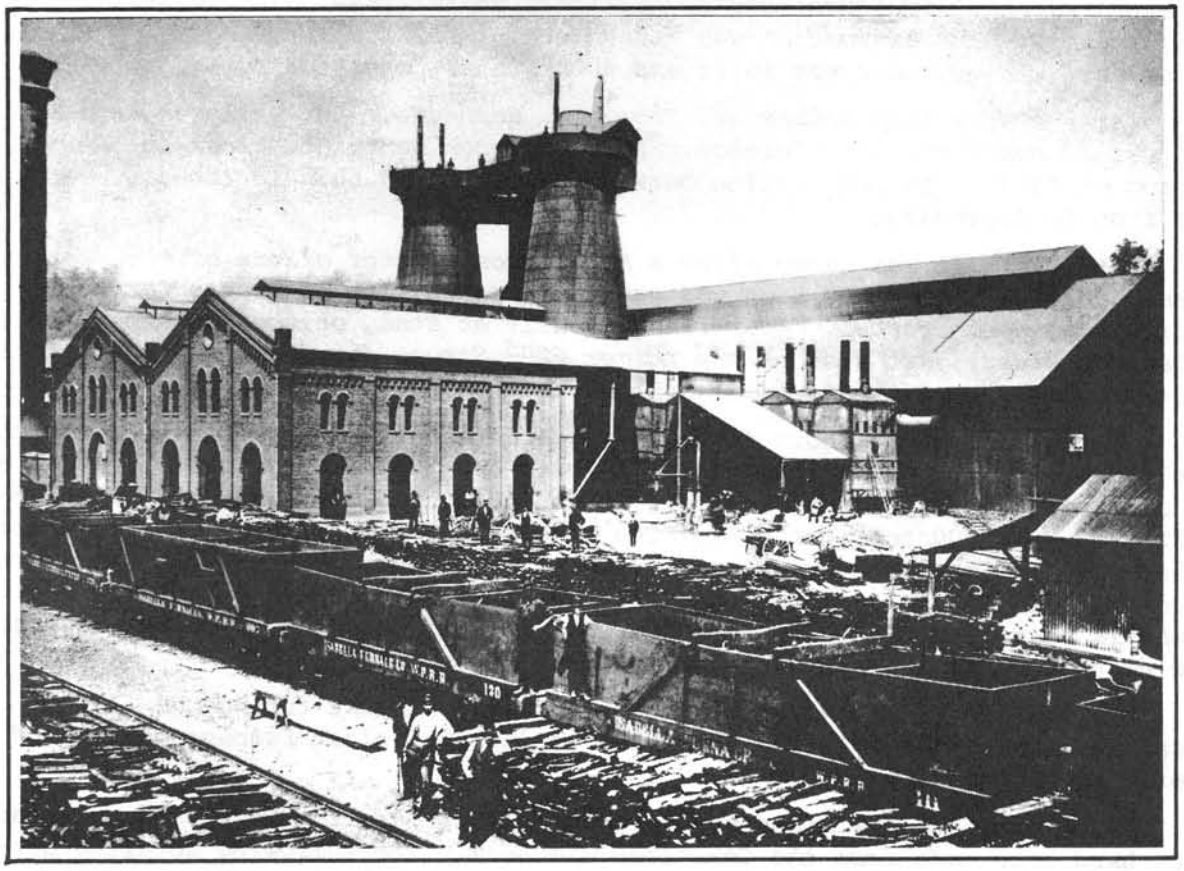
SOCIETY FOR
INDUSTRIAL ARCHEOLOGY

The Isabella Furnace

At Etna, near Pittsburgh, Pennsylvania

Built 1872

A brief history and technical description, prepared by Charles T. G. Looney, C.E., on the occasion of the THIRD ANNUAL CONFERENCE of the SOCIETY FOR INDUSTRIAL ARCHEOLOGY held at Pittsburgh 26th-28th April 1974, by way of documenting the Conference Poster, designed by Klaus Grutzka, which features this legendary late 19th century blast furnace.



Isabella in her prime, cal880: her photographic portrait which served as the basis for the poster.

THE ARTIST

Grutzka, a charter member of the SIA, is a free-lance industrial illustrator whose work expresses his life long, intense interest in the technological environment. In the seaport and canal city of Kiel in northern Germany he studied both naval engineering and art, the dual background providing him with a perspective rare in his field. As his career developed he was drawn quite naturally to the heavily industrialized Ruhr where he worked for a number of steel firms, then, in 1961, came to the United States. His clients have included Babcock & Wilcox, Foster Wheeler, General Electric, Bethlehem Steel, and the Amrican Iron & Steel Institute.

His special interest is the plant of the steel industry, the blast furnace above all. He has drawn, painted, or photographed virtually every furnace that has stood in North America since his arrival here, many of them now gone. He and his wife live, with a distinguished collection of stationary steam engine models, in Plainfield, N. J.

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THE FURNACE

Following the Civil War, factors both economic and technical led to major changes in the production of pig iron. In the Pittsburgh district manufacturers were dependent upon seven small blast furnaces with a total production of 70,000 tons per year; the pig iron selling at $40 a ton. A number of these firms joined together to build the large capacity Isabella (twin) blast furnace: Lewis Dalzell & Co; J. Painter & Sons; Graff, Bennett & Co; Spang, Chalfant & Co; Henry Oliver of Oliver Brothers & Phillips; and William Smith, owner of a large pipe foundry. The consortium was called the Isabella Furnace Co, J. W. Chalfant, president. The furnace was built and subsequently operated by Benjamin Crowther.

At the same time Andrew and Thomas M. Carnegie, Andrew Kloman, and Henry Phipps, Jr built the Lucy furnace. Both furnaces went into blast in the early summer of 1872. The competition between Isabella and Lucy in the production of pig iron is legendary.

The Isabella was named after a Mrs Herron, sister of one of the members of Spang, Chalfant & Co; the Lucy was named after the wife of Thomas Carnegie, Andrew's younger brother. Isabella was built at Etna, on the north bank of the Allegheny River, just west of the former 62nd Street (now Robert Fleming) Bridge; Lucy nearby, across the river at 51st Street, Pittsburgh.

At the beginning, both furnaces produced about 350 tons per week, which was not unusual. For several years Isabella and Lucy exerted themselves to outdo one another. First one was ahead, then the other. Production by the end of 1872 was up to 500 tons per week. The rivalry was fierce; the furnaces being close together no doubt engendered personal rivalry between the men tending the "Ladies." In March 1880, Lucy produced 945 tons in a week; in February 1881 Isabella beat Lucy with a round 1000 tons. "The Trade gasped with astonishment, the editors asking, 'What will these Titans do next?'"

These furnaces were the prototypes of modern blast furnace design. Lessons learned during this rivalry led to improved blast furnace design and operation, and increased output.

Ores from the new mines at the head of Lake Superior were used, smelted with hard coke made from the Connellsville Seam. The following detailed description of the Isabella furnace is extracted from Wiley's American Iron Trade Manual *of 1874, that account in turn gleaned from information that had appeared previously in the* Iron Age.

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The large capacity of these furnaces, and the completeness of their appointments, entitle them to be ranked as second to none at present in operation in the US. They are situated on the north bank of the Allegheny River, on the line of the Western Pennsylvania RR, at Etna Station, about 5 miles from Allegheny City, and are two in number, each being 75 feet in height, whilst the width of bosh is 18 feet in No. 1 and 20 feet in No. 2. The capacity of No. 1 is 12,800 cubic feet; of No. 2, 14,000 cubic feet. They are constructed in accordance with the most improved modern designs for English furnaces, and were among the first of the kind erected in this country.

The hearth is 8 feet in diameter for the same vertical height; the section is then uniformly enlarged to the boshes, which it reaches at 25 feet vertical height in No. 1, and 28 feet in No. 2. It then remains constant for a distance of 10 or 12 feet above them, after which it is gradually contracted to a width of 10 feet at the top in No. 1, and 12 feet in No. 2. The walls of the stack are composed of brick, varying in quality from the best firebrick to common red brick, and enclosed by an exterior casing of plate iron, the whole system resting upon a cast-iron ring or entablature, supported by eight cast-iron columns without the intervention of girders. The extreme diameter of the sole plate upon which the columns rest is 27 feet, and its surface is upon the level of the surface of the hearth stone.

The lower part of the hearth is encircled upon the outside by a hollow cast-iron ring, through which water constantly circulates; this is termed the "water basket." Its office is to cool the hearth walling, and to prevent the passage of any molten iron through the joints of the brickwork. The dam plate is cooled in the same manner. The upper part of the hearth and the lower part of the region of the basket are strengthened by cast-iron rings and other castings.

The throat of each furnace is surrounded by an overhanging charging platform of plate iron, supported by brackets, and connected with each other by a bridge of the same material resting upon girders. The charging apparatus consists of the cup and cone arrangement, to which the latter is raised and lowered by the agency of blast from the main. The hot gases are taken off at the side of the furnace just below the cup and cone, by a horizontal rectangular flue leading into a vertical main, through which they are brought down to the hot-blast apparatus.

The hot-blast main, where it encircles the furnace, is supported by brackets fixed to the sides of the columns. A branch pipe to the tuyeres is led off between every two adjacent columns except in front. The number of tuyeres in use is seven for each furnace, which are now provided with five-inch nozzles. The frame in which the flow-pipe is set is cast at the works, being composed of a body of cast iron surrounding a coil of pipe through which, when in use, water constantly flows.

The casting-house is situated immediately in front (south) of the furnaces; it is 79 feet long, 123 feet wide, and 40 feet high. The roof is divided into two spans of 60 feet 9 inches each, the trusses for each resting upon the outside walls at one extremity, and upon a central line of cast-iron columns at the other. The foundations are of stone, and the walls of brick, with arched doors and windows, appropriately relieved by pilasters, cornices, etc., and ornamental finish about the windows and eaves. The roofs are formed of a series of trusses of wrought iron, covered with corrugated iron plates. The ground about the furnaces is paved with an inferior quality of firebrick. The casting bed is composed of a series of rows of cast-iron moulds, "chills," cast upon the spot. There are 10 rows of these on each side of the central runner of each furnace (which is

made in the sand), making 20 rows of 2 chills each for each furnace, or in all 80 chills of 7 tons weight each, amounting to 560 tons.

In the rear (north) of the furnaces, and on a line parallel with them, are situated the hot-blast ovens, of which there are 10, 5 for each furnace--only 4 of which are, however, used at a time, the fifth being used only in case of accident to any of the others, or when repairs are necessary. These occupy a ground space of 12 feet 4 inches, by 15 feet 2 inches each, and are 4 feet apart.

The apparatus consists of a series of vertical inverted U pipes of flattened vertical section, made of cast iron, one inch in thickness, the major axis of the interior cross section being 16 inches, and the minor 4 inches. These are in four rows of five each, set in a cast-iron box, whose upper surface serves as a bed plate for them, and at one side of which is a tube with central partition, to the opposite extremities of which the hot and cold blast mains are connected. By means of partitions in the box, the blast is compelled to travel up and down the pipes in a certain fixed direction. The unburnt gases are led down from the furnaces through the vertical main, into a horizontal flue 4 feet 6 inches in diameter, and 6 feet high, built of firebrick, which extends along in a straight line in front of the ovens and boiler-house. From this the gases are led by transverse ascending flues, 24 inches in width, into an arched combustion chamber, the supply of air to which can be regulated; from this they pass through flues in the roof into the heating chamber. Both of these chambers are lined with fire-brick--the exterior of the oven is of red brick, and is well braced, and bound together with tie rods. The roof is cast iron, so constructed that it can be readily removed when it is desired to take out any of the U pipes. The cold blast passes in at the back, and emerges at the front, heated to a temperature of about 900° Fahr.

Hoisting material is accomplished by means of two pneumatic lifts, one for each furnace. They are located in the rear of the furnaces between the 2 groups of ovens, their base being on the general level of the stock-house (10 feet below that of the furnaces), and accessible from it. Each consists of a simple cylinder of cast iron, 92 feet long and 36 inches in diameter, made in lengths and bolted together, and bored throughout--in the interior of which is a loosely fitting piston with balance weight. The cage surrounding the cylinder is provided with two platforms, one on each side of the cylinder, and is connected with the piston by two wire ropes one inch in diameter, fastened to the center of the cage on each side, which pass over pulleys at the top of the cylinder. It is also provided with wheels running on iron guides on the surface of the cylinder. The hoist is worked by admitting air from the blast main into the cylinder, alternately at the bottom and top, by means of valves, without the use of air-pumps.

At each ascent, a barrel containing 500 lbs of coke, and one containing 900 lbs of ore or limestone, are taken up. One hundred and twenty trips are made per day with each lift. The actual time required for putting the loaded barrows upon the cage, raising them to the top, emptying them, and returning them to the bottom, is about 1 minute and 40 seconds.

The stock-house is situated in the rear of the hot-blast stoves, and at a distance of 10 feet from them, its level being 10 feet below that of the furnaces. It is constructed of wood, with slate roof, the side nearest the furnace being covered with corrugated sheet iron, and is 240 feet long, 75 feet wide, and 32 feet high. The ore and coke stacks which traverse it longitudinally, are

elevated on trestle-work at a height of 12 and 18 feet from the floor. In the south-western corner, limestone and cinder are stocked, and ore in the south-eastern. Underneath the coke track, and occupying the entire north side of the house, are a series of coke bins holding 1,500 bushels each, provided with shutes at the bottom, and screening bars for the removal of fine material. The coke cars are emptied direct into these, being made to discharge their contents at the bottom.

There being a considerable length of trestle-work elevated at a considerable height above the surface, extending from each side of the stock-house to the main line of the railroad, ample room can be had for stocking purposes outside.

To the west of the casting-house, and separated from it by an interval of 20 feet, is the boiler-house, which is 79 feet wide, 85 feet long, and 35 feet high, built of brick, with roof of iron and slate. It contains 12 boilers in batteries of four each. These are plain cylinders, 42 inches diameter, and 64 feet long, provided with mud valves and steam drums, and supplied by two No. 5 Cameron pumps, in connection with two Stillwell heaters, which raise the water to a temperature of 209° Fahr., before delivering it into the boilers, causing a great economy in the generation of steam, and also purifying the water. The boilers are heated by the waste gases without the use of coal. After performing this work, the gases are led through converging flues into the main stack, which is 10½ feet in diameter, and 112 feet high. It is lined with firebrick, and cased with boiler plate.

Immediately adjoining the boiler-house, but separated from it by a wall, is the engine-house, 40 feet wide, 97 feet long, and 40½ feet high, built of brick, with arched doors and windows, and ornamented like the casting-house. The roof trusses are of wood, the cover of slate. It contains 6 vertical direct-acting engines, built by Mackintosh, Hemphill & Co., of Pittsburgh, working entirely independent of each other. They have the following dimensions:

Diameter of blast cylinder	84 inches
Diameter of steam cylinder	35 inches
Length of stroke	4 feet
Speed	19 rpm
Diameter of flywheels	14 feet

Only 4 of these engines are at present used together. At 19 revolutions, each gives 5,848 cubic feet of air per minute. The blast cylinders, placed above the steam cylinders, are provided with poppet valves. The slide valves of the steam cylinders are of peculiar construction, the subject of a patent by the makers. The crosshead is between the two cylinders.

The blast from the cylinders is led by branch pipes to the main, which is four feet in diameter; through this it passes to the rear of the hot-blast ovens, where are valves for controlling the admission of air into each furnace. The six engines are placed side by in one line, and present a very fine appearance. It is claimed that they are far more effective than one or two engines of large size with the same aggregate power would be, and their use is attended with many advantages. They give a very uniform pressure of blast, requiring no receivers or regulators, and work with great regularity, producing little or no noise or concussion. In case of an accident to one, no stoppage of the furnace is necessary. They are also less expensive, as five or six of them do not cost more than one engine of large size and massive construction. The patterns for one will serve for any number in addition; they require no heavy foundations, and are easily made and put together.

Connected with the works is a carpenter and repair shop, 105 feet long, 32 feet wide, and 30 feet high, built of wood and covered with corrugated sheet iron; a blacksmith shop, 40 by 32, built of brick, with iron roof; also fire clay and other sheds. A chemical laboratory is also in connection with the works.

The company has a rolling stock consisting of one heavy and one light locomotive, 66 flat cars, and 53 coke cars.

Between 800 and 900 tons of metal are produced weekly, the greater part of which is "foundry" iron.

The extensive coke works belonging to this company are situated near the eastern terminus of the W.P.R.R., in Westmoreland County, just across the Conemaugh River from Blairsville, Indiana County, at a distance of 60 miles from the blast furnaces. At this point over 600 acres of coal have been purchased, and a considerable extent of surface property. The number of ovens at present built is 200, which are of the ordinary "beehive" type, 13½ feet in diameter, and 7 feet from hearth to crown, built of firebrick laid in loam. One hundred and sixty of these are disposed in a line along the side of an ancient bank of the river, and are bound together in front by a stone wall 3 feet thick laid in mortar, with openings for the working doors, the sides of which are protected by iron frames. The upper surface of this wall is on a level with the top of the ovens. The side of the hill, which has been cut down vertically in order to prepare the foundation bed for the ovens, forms this back wall, and all the space around and between them is filled with earth. When the ovens are working the door is closed with a temporary brick wall.

The yard in front of the ovens falls 2 feet in its width of 40 feet. Its lower side is sustained by a retaining wall 2½ feet thick, in front of which, and 8 feet below its upper surface, run the broad-gauge coke tracks, two in number, which connect with the main road.

On a terrace above the ovens, at nearly the summit of the bank, is a line of trestle work, between the consecutive bents of which coal bins are constructed capable of holding about 150 bushels of coal. The coal is brought from the mines, about a mile distant, in small mine cars, holding about 30 bushels apiece, hauled by a light locomotive over a narrow-guage (36 inches) track, which is continued out over the trestle work. The cars discharge their load at the bottom into the bins, which are provided with doors at the side opposite to the center of the oven, from which the coal is led into the opening at the top of the ovens as desired by means of iron shutes. In this way all unnecessary handling of material is avoided.

Upon the top of the hill, above the ovens, is a reservoir built of brick, 42 feet in diameter, and 6 feet deep, capable of holding 62,000 gallons, which is filled with water from the river by a large Cameron pump. On the bottom land below the ovens a number of blocks of houses, and a large store, have been erected for the use of the miners and coke burners, and already quite a respectable village is springing up in the vicinity.

The coal seam now worked is the Pittsburgh or Connellsville, which is here over 6 feet thick, quite pure, and exceedingly soft and bituminous in its nature, containing 30 percent of volatile matter, and 60 percent of fixed carbon.

Each oven is charged with 125 bushels of coal, and yields 140 to 150 bushels of coke--the operation lasting 36 hours--100 ovens, or half the entire number, being discharged and recharged every day. The coke produced is very hard and compact, and steel gray in color, containing from 10 to 15 percent of ash, and

very closely resembling the Connellsville coke, which has been proved to contain an equal amount of ash.

About 15,000 bushels of coke can be produced per day. This is brought to the furnaces in cars of plate iron and of wood, holding from 600 to 650 bushels apiece.

Car loads of this coke have been sent to Omaha and Salt Lake City for use in smelting works.

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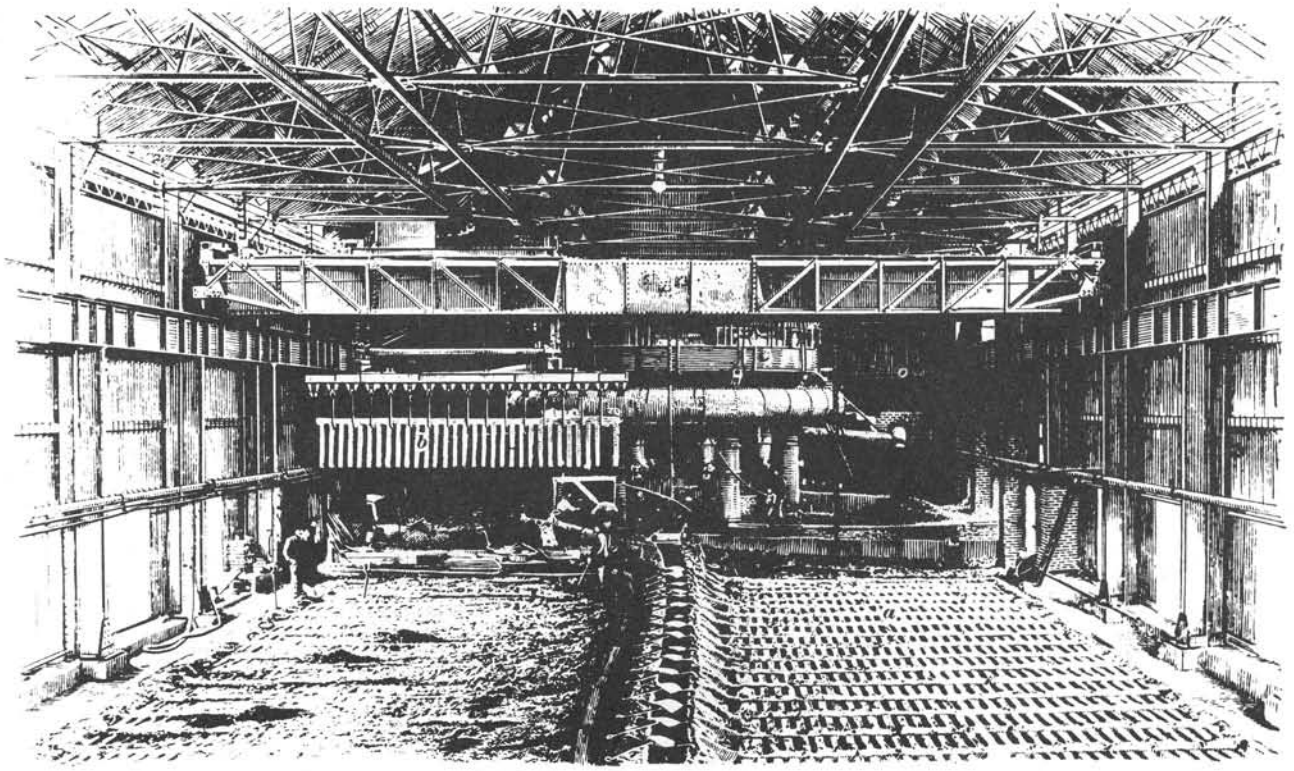

Blast furnace casting floor, cal910. The prepared pig casting beds are shown on the right; the base of the furnace at the rear. The pigs have been drawn from the bed on the left, an entire sow and pigs suspended from the traveling crane at "b." In a "pig breaker" the pigs will be separated from the sow and broken in two for grading and handling. This mechanical handling was introduced well after the construction of Isabella and Lucy, and eliminated some of the hardest manual labor of the pig iron production process. (From *Manufacture of Iron*, International Textbook Co, Scranton, PA, 1910)

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