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The Blue Ridge Stemwinder

East Tennessee and Western North Carolina R.R. Co.

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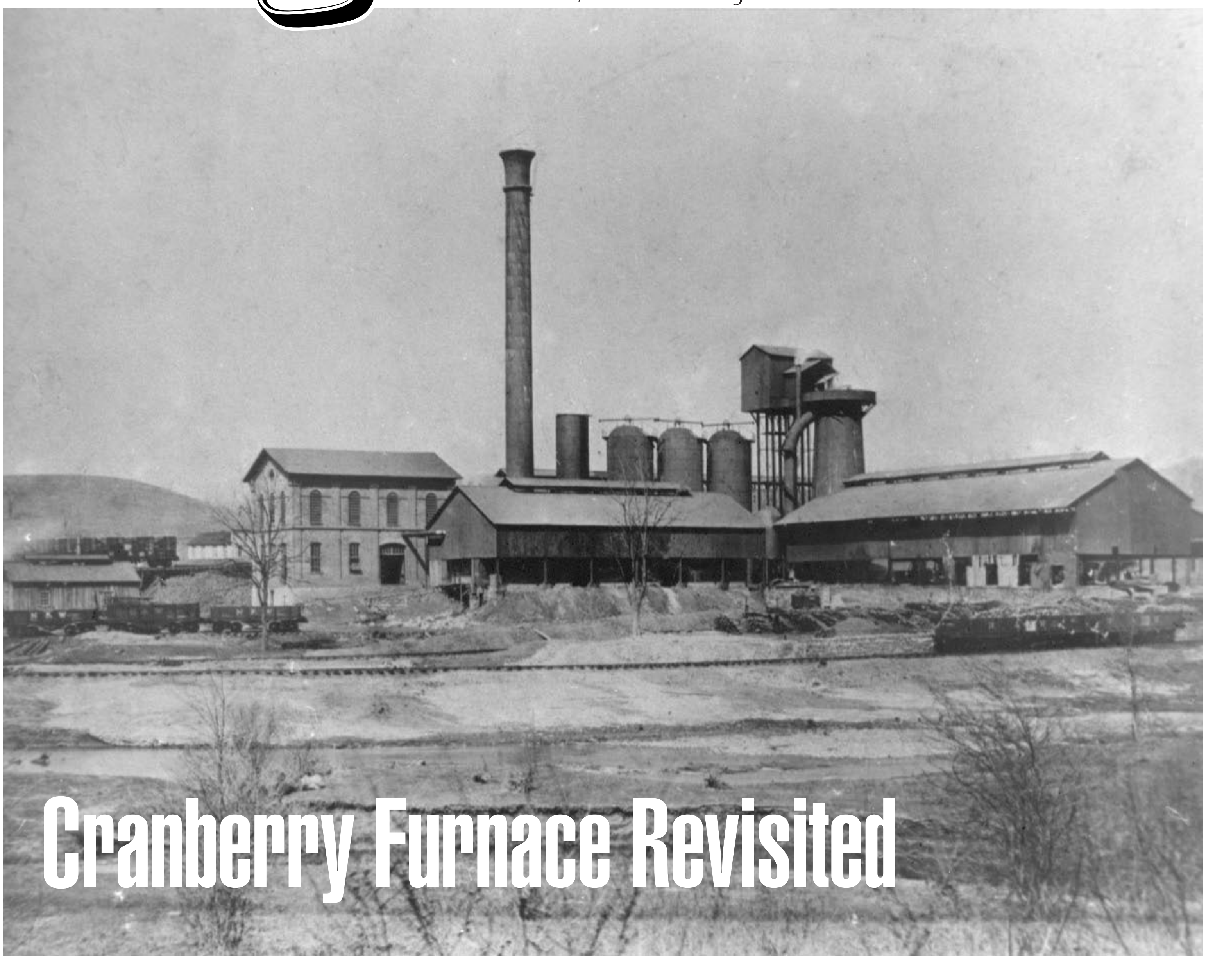

Cranberry Furnace Revisited

The Blue Ridge Stemwinder
East Tennessee and Western North Carolina R.R. Co.

FEATURES

ON THE COVER

This photo hung for many years in the Johnson City offices of the ET&WNC. It was always thought to be the Cranberry Furnace at Johnson City (and was so identified in my book). In fact, it is a different furnace at an unknown location. It was obviously of a similar design as the Johnson City furnace. The photograph may well have been placed in the ET&WNC office before the Johnson City furnace was actually built. *Sirgis Cole Collection.*

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EDITORIAL

Over the years a great deal has been written about the East Tennessee & Western North Carolina Railroad, the folks who worked for the railroad, and the effect the little narrow gauge had on the section of country it covered. Often, the amount and the detail of the information has seemed a little out of proportion compared to its importance in the big picture of the line.

Tales told by the old-timers have been a delight, even when we knew they were remembering events that may well have been very out-of-the-ordinary. Unique pieces of equipment, like the trailer-on-flat-cars, have been well-documented even though they were used for a relatively short period of time. Much has been written about the ten-wheelers, if for no other reason than one of them is still operating.

Historically, the Stemwinder has attempted to make ever more information about these familiar subjects available. We have also attempted to provide new information on ET&WNC-related subjects that have not been widely documented. The extensive coverage of the Boone Fork Lumber Company and Shulls Mills, in the third issue and the last issue, is an example of this type of coverage. The importance of this operation to the railroad during its profitable years far exceeded the previously available information.

Perhaps no facet of the railroad and its related companies' operations is more important than the Cranberry Furnace at Johnson City. Yet it has never been adequately documented. In this issue of the Stemwinder, we begin comprehensive coverage of how a turn-of-the-century iron furnace operated, the history and operations of the Johnson City furnace, and how this furnace can be modeled. You should find this information useful in understanding the economics of the railroad. Hopefully, it will inspire at least some of you to model this important part of the railroad's history.

John R. Waite

ET&WNCRR Historical Society

OFFICERS

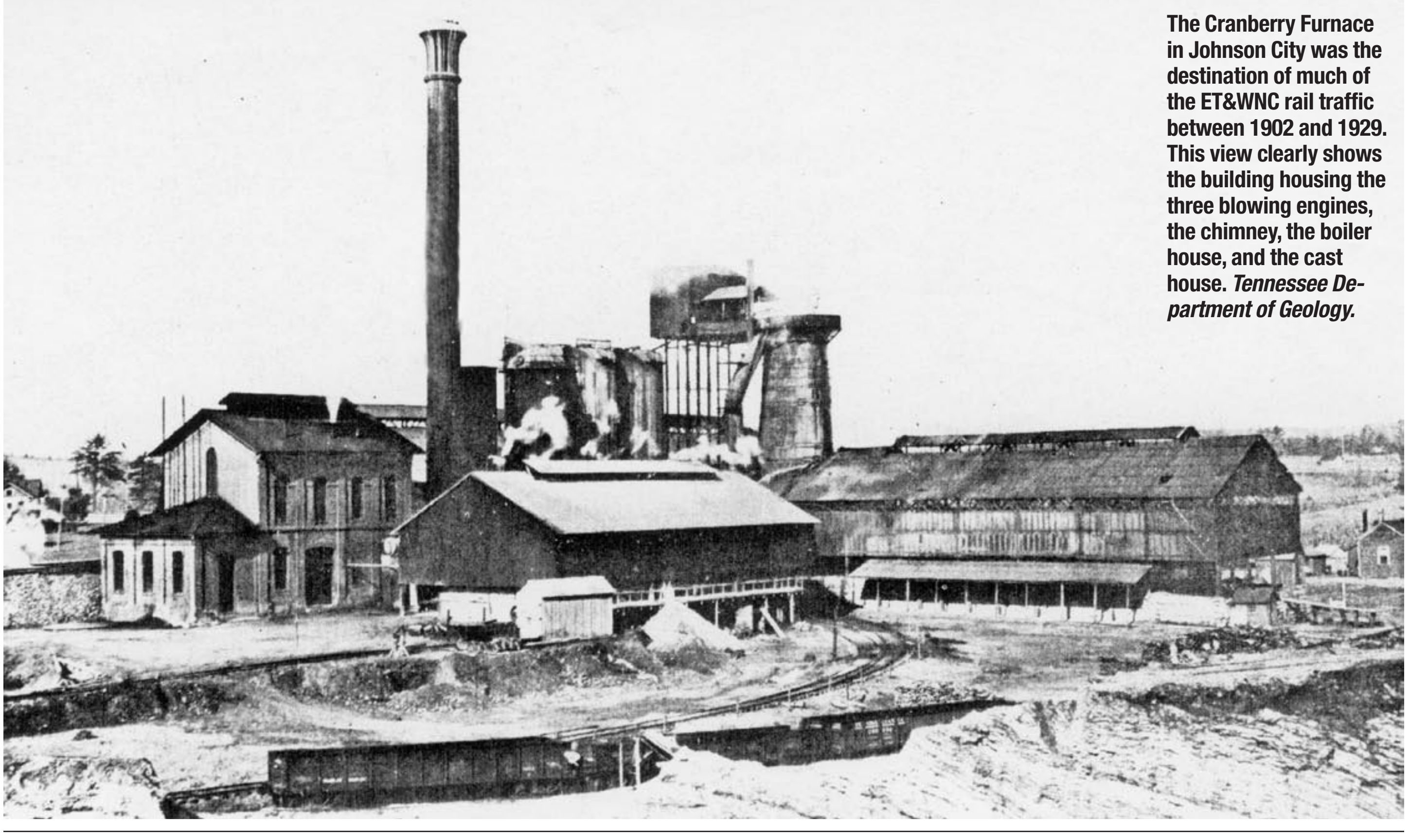
Carnegie (Cranberry) Furnace

By John R. Waite

JOHN T. WILDER WAS A YOUNG FAMILY MAN with a growing millwright business in Greensburg, Indiana, when the Civil War broke out. He quickly enlisted in the First Independent Battery of Artillery, an Indiana volunteer unit, and was elected captain the next day. Within two months, he was promoted to lieutenant colonel of the 17th Indiana Volunteer Infantry which would later be known as "The Lightening Brigade."

Over the next three years, Wilder lead troops in over two hundred engagements and moved up through the ranks; eventually reaching the rank of Brigadier General. He resigned his commission in October 1864, as a result of a health problem. Wilder's wartime service provided him with connections and knowledge that would serve him well over the next half century.

In 1866, Wilder moved his family from Indiana to Chattanooga, Tennessee. A year later he and two associates, Major W. A. Rockwood and Captain H. S. Chamberlain, organized the Roane Iron Company. They constructed the first coke-fired blast furnace in the south, at Rockwood in Roane County, between Chattanooga and Knoxville. Wilder then established the Roane Rolling Mills Company, in Chattanooga, for the manufacturing of railroad rails.



The Cranberry Furnace in Johnson City was the destination of much of the ET&WNC rail traffic between 1902 and 1929. This view clearly shows the building housing the three blowing engines, the chimney, the boiler house, and the cast house. *Tennessee Department of Geology.*

Wilder expanded his mining and manufacturing interests over the next few years, becoming one of the South's leading industrialists. In the early 1870s, Wilder purchased seven thousand acres on the crest and slopes of Roan Mountain. He constructed a twenty room hotel of spruce logs, on top of the mountain, and named it "Cloudland." When the East Tennessee & Western North Carolina Railroad reached the area, in the early 1880s, Wilder saw the opportunity to expand his tourist business. A much larger Cloudland Hotel was completed in 1885. He also built the Roan Mountain Inn, next to the ET&WNC depot, at the village of Roan Mountain.

While developing his Roan Mountain properties, Wilder moved his home to Johnson City and began promoting it as a potential center of the iron and steel industry in the South. The mountains to the east had abundant deposits of iron ore. The Pocahontas coal fields were nearby and the area had plenty of the necessary limestone. By 1888 there were plans for five blast furnaces and two steel mills in the area.

A key element in Wilder's plan for developing Johnson City was the improvement of transportation in the area. On September 30, 1886, Wilder chartered the Charleston, Cincinnati & Chicago Railroad Company, commonly referred to as the 3-Cs Railroad. He planned to build a 621-mile line from Charleston, South Carolina, to Ironton, Ohio, on the Ohio River, and then down the Ohio River to Cincinnati. Johnson City would serve both as the headquarters and as a division point on the railroad.

Wilder began lining up financial backing for the estimated $21 million cost of the 3-Cs line. The most substantial funding source was the London-based Baring Brothers Bank. Construction was started at three different locations. One crew worked south from Ashland, Kentucky, across the Ohio River from Ironton. Another crew worked north from Camden, South Carolina, toward Marion, North Carolina. Track construction crews worked south from Johnson City toward Erwin, Tennessee, and north from Johnson City toward Dante, Virginia. The company also constructed shops and a freight station in the Carnegie section of Johnson City and began construction of a depot near the junction of Broadway Street and the parallel tracks of the CC&C and the East Tennessee, Virginia & Georgia Railroads.

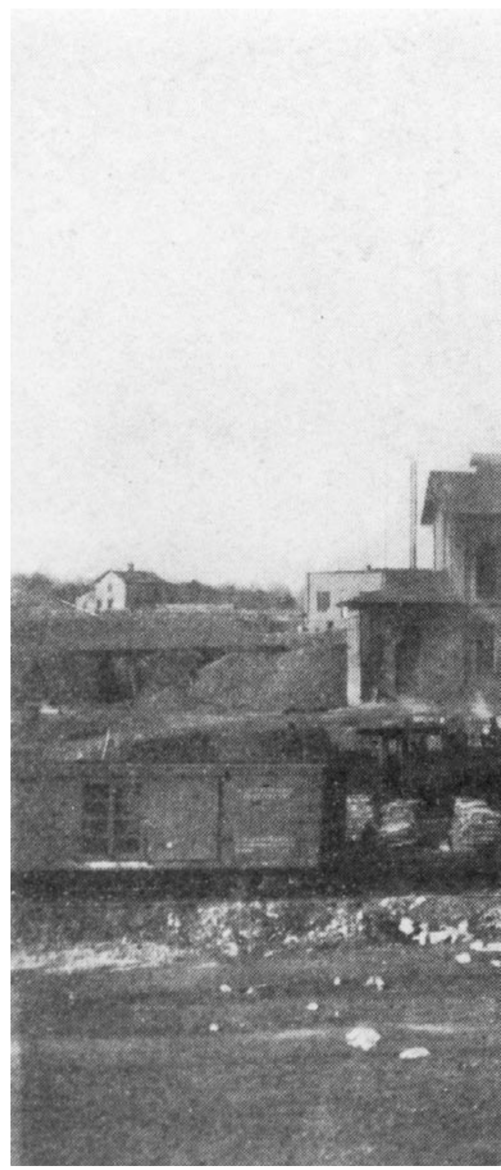
Wilder organized the Watauga Improvement Company on November 30, 1888 to develop an industrial and residential section along the CC&C and ETV&G railroads. The development was a mile northeast of downtown Johnson City. Within a few months it was renamed the Carnegie Land & Improvement Company, apparently in an effort to attract financial backing from northern industrialist, Andrew Carnegie. Carnegie quickly became a boomtown with a variety of businesses and a hotel.

In January 1890, Wilder traveled to Birmingham, Alabama, to find a contractor to build a blast furnace. The person he hired was Harry Hargraves, who had constructed over thirty furnaces throughout the South. The new furnace was to be built just east of the Carnegie Addition, two miles from downtown Johnson City.

Hargraves apparently built the furnace to a relatively new design by James L. White, a consulting engineer whose plans were used to construct dozens of similar iron furnaces across the country. Drawings of White-designed furnaces appeared in several 1890 issues of the trade journal, *Iron Age*. The furnace would produce Bessemer iron; however, the complex did not include a Bessemer converter. The iron from the Johnson City furnace would be sold and shipped to other steel mills, where it would be converted to Bessemer steel.

Hundreds of workers were hired to build the furnace. Many of the workers were Italian immigrants. A Johnson City newspaper, the *Comet,* reported in February 1890, that a "number of Italians with all their worldly goods arrived on [railcar] No. 4 Sunday and were put to work on Monday on the furnace." The paper also stated that more Italians were expected daily and that "in a few weeks a stranger coming to Johnson City will think he is in Italy."

Not all the workers were Italians. Many blacks were hired to work on the furnace as well. A later edition of



The Cranberry Furnace in Johnson City is in full blast, c. 1908. Two locomotives are busy switching in the yard, between the two boxcars and the boiler house. The brick building behind the boiler house is the building that housed the three vertical blowing engines. The downcomer and dust catcher are clearly visible in this view. *Burr Harrison Collection, Archives of Appalachia, East Tennessee State University.*

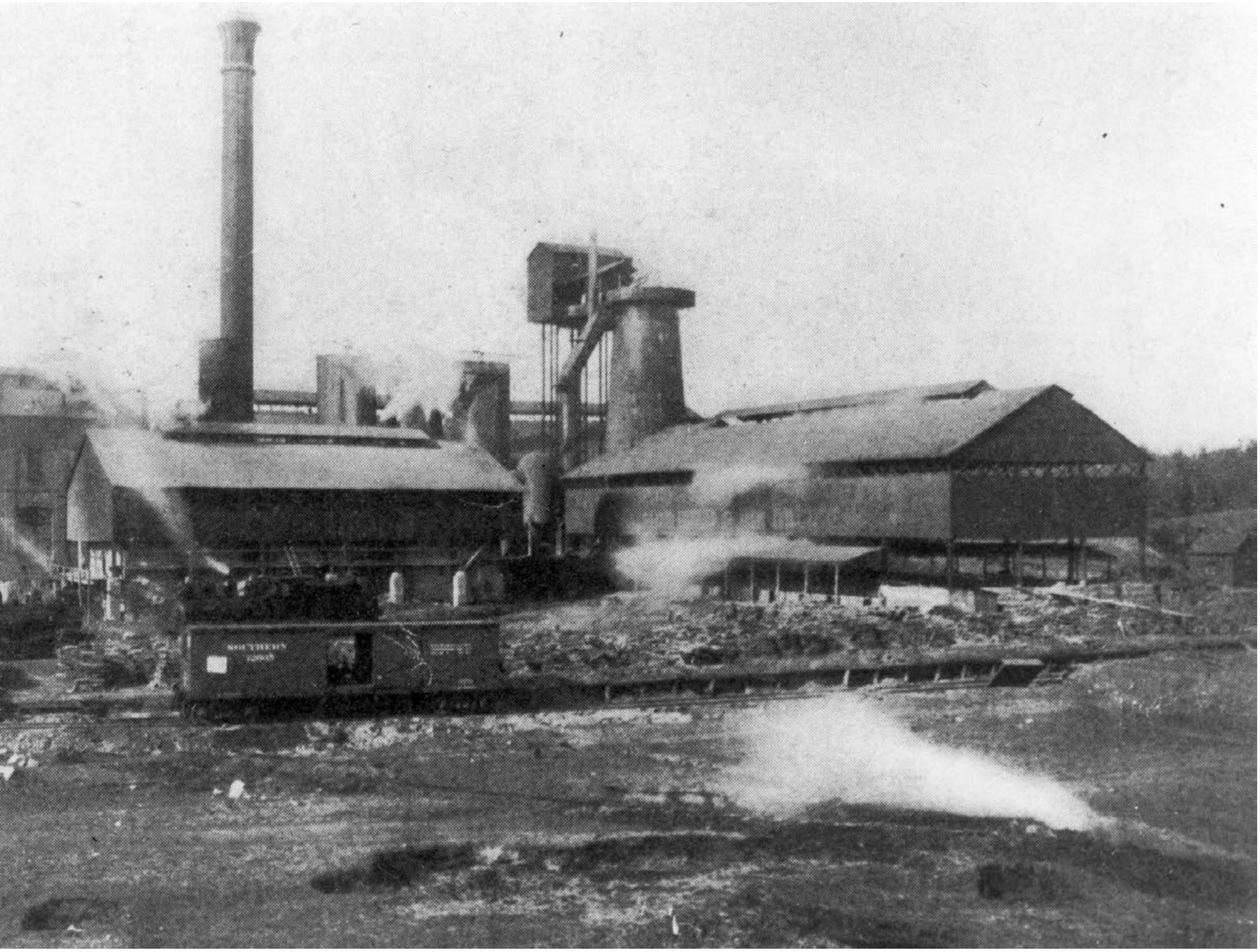
the *Comet* described the "large crowd of workers" at the furnace as being "all kinds, colors and ages." Hargraves constructed sixty-eight small houses near the furnace for the workers.

The Carnegie Furnace was apparently the second Bessemer-type blast furnace to be constructed in Tennessee, and possibly the South. The first was constructed at Chattanooga in 1887. Over the next few years, Bessemer furnaces were built all across the South, especially at Birmingham, Alabama.

The uncertain economic times of the 1890s were not kind to Wilder's financial fortunes. Several sections of the 3-Cs railroad were in operation and hopes were high that the entire line would soon be completed when the Panic of 1893 brought construction to a halt. The failure of Baring Brothers brought on the demise of the 3-Cs. Baring Brothers lost millions, Wilder lost $750,000, and Johnson City was left with $70,000 in unpaid bonds.

Construction of the furnace also stopped when Wilder's Carnegie Furnace Company went bankrupt. Eventually, the Virginia Iron, Coal & Coke Company acquired the property and the furnace was "blown in" in 1898. Ore for the furnace was purchased from Cranberry Iron & Coal Company and shipped from Cranberry to Johnson City over the East Tennessee & Western North Carolina Railroad. The ore was then transferred to standard gauge cars to be taken to the furnace. This transfer was apparently done with human labor, since there were no hoppers on the narrow gauge at the time. The Embreville Iron Company Ltd. began purchasing Cranberry ore at about the same time for their furnace at Embreville; a dozen miles south of Johnson City.

The Carnegie Furnace broke down on June 1, 1900, and the Virginia Iron, Coal & Coke Company went bankrupt during the summer of 1901. The receivers contacted Cranberry Iron & Coal officials with an offer to sell or lease the Carnegie Furnace in Johnson City. The CI&C Board of Directors considered the offer and negotiated a short-term option to lease the furnace for three years.



The lease called for the payment of a royalty of 15 cents per ton of iron the first year, 20 cents per ton the second year, and 25 cents per ton the third year. VIC&C controlled the shipment of coke from the nearest coalfield and agreed to protect CI&C with a favorable freight rate on coke during the duration of the lease. CI&C had the option to purchase the furnace for $70,000 at anytime during the lease.

Cranberry management estimated that the furnace could produce at least 30,000 tons of special low-phosphorus pig iron per year. With the cost of mining the ore at $1.30 per ton and the cost of shipping the ore on the ET&WNC at $.70 per ton, they estimated a profit of at least $2 per ton of pig iron. The railroad would also realize a profit of 35 cents per ton of ore hauled. The directors also estimated that $100,000 would be needed to repair the furnace and provide operating capital.

Unfortunately, CI&C had no money and already owed nearly $350,000 to individual stockholders. The Board of Directors proposed issuing $500,000 in bonds backed by a mortgage on the mines and the railroad. The creditor stockholders would accept the bonds to liquidate their claims and would purchase an additional $100,000 in bonds to fund the furnace operations.

When some of the creditor stockholders balked at the proposal and the plan fell apart, a syndicate of the substantial stockholders took matters into their own hands. The Cranberry Furnace Company was incorporated in New Jersey on September 6, 1901, with authorized capital of $100,000. The new company leased the Carnegie Furnace and began making repairs. The CI&C Board of Directors then leased all of the Cranberry properties, including the mines, mine machinery, store, farm, and houses to the furnace company.

Under the arrangement between the two companies, all the furnace company's profits would go to the iron company to be used to reimburse the furnace company stockholders for their investment. Once they recouped their investment, Cranberry Furnace Company would become a subsidiary of CI&C, and additional profits would be used to pay off the iron company's creditor stockholders.

The Carnegie Furnace was renamed the Cranberry Furnace and put into blast in the spring of 1902. The Cranberry mines went into full production to supply ore to the furnace.

The Cranberry companies now had a stable market for iron ore that was, of course, shipped over the ET&WNC. Coke for the furnace was brought in over the Virginia & Southwestern to Elizabethton then shipped, by way of the ET&WNC, to the furnace in Johnson City. Limestone was brought from a new quarry located near Happy Valley, next to the ET&WNC main line. Shipments of these products were to be the economic backbone of the railroad for the next two decades.

The Cranberry Furnace had a 75-foot high blast furnace, three hot-blast stoves, a 160-high chimney, twelve 50-horsepower boilers, three 500-horsepower steam blowing engines, an open stock house, and a steel-framed cast house. Water for the steam engines came from an adjacent man-made pond fed by Brush Creek.

The furnace was built to have a 125-ton capacity, meaning that it could produce 125 tons of iron per day. This was more than double the production capacity of the coke-fueled blast furnace Wilder had built at Rockwood, and it was more than either one of the large blast furnaces he had constructed at Dayton, Tennessee.

Once the furnace was in full production, management began working to streamline the movement of raw materials. When the dual-gauge track was completed between Johnson City and Elizabethton in 1905, coke could be brought into Johnson City over the ET&WNC without having to be transferred back and forth between standard and narrow gauge cars. Ore from the mines still had to be transferred to standard gauge hoppers and hauled by the Southern Railway (successor line to the ETV&G) to the furnace.

Railroad president, Frank Howe, and general manager, George Hardin, sought to eliminate this bottleneck by building a spur from the narrow gauge directly to the furnace. Since the spur would have to cross the Southern tracks, they were forced to negotiate with the larger railroad.

After lengthy negotiations the two railroads finally reached an accord. The agreement provided for joint ownership of a dual-gauge spur from the ET&WNC mainline near Exum Furniture, crossing the Southern mainline at grade, to the furnace. As a result, the Southern had access to the Exum plant and the ET&WNC could haul Cranberry ore directly to the furnace in narrow gauge cars. The Carnegie Extension was completed on February 8, 1908.

The Cranberry ore could now be shipped directly to the furnace, but it still had to be unloaded from gondolas by hand once it got there. To solve this problem, the ET&WNC began constructing hopper cars. Soon there were forty-five hoppers on the roster.

The iron business provided the Cranberry companies solid profits until the end of World War I. Over the years, improvements were made at the Cranberry Furnace. A brick shed, limestone house, machine shop, laboratory, and blacksmith shop were added to the complex not long after it was put into blast. Sometime after 1908 a fourth stove was added and improvements were made to the hoist and charging mechanisms for feeding the furnace.

By the 1920s the iron market had changed and the furnace could not compete with more modern facilities. The furnace and mines were shut down periodically through the 1920s. Finally, in 1929, the furnace was permanently closed. Within a few years, most of the facility was torn down. Today, only one of the original buildings remains on the site.

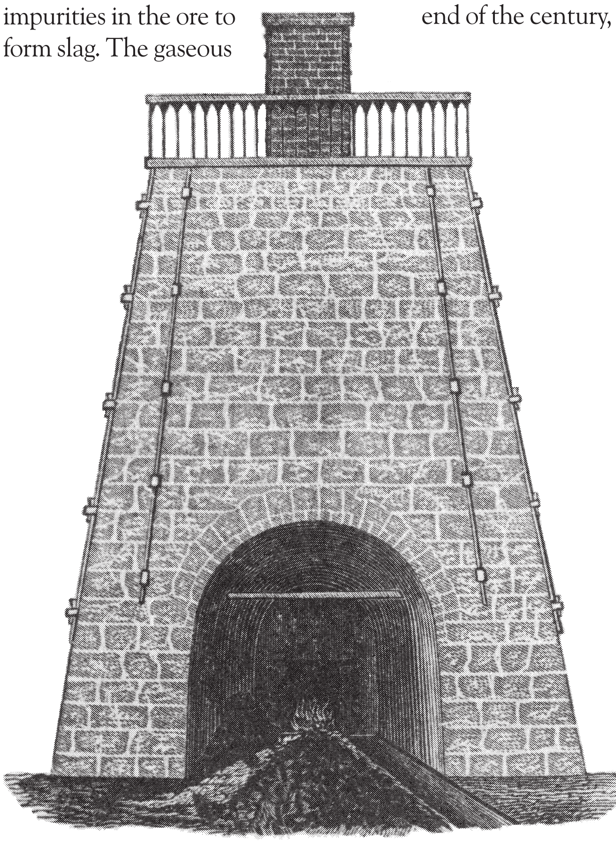
Iron Furnace Operations

By John R. Waite

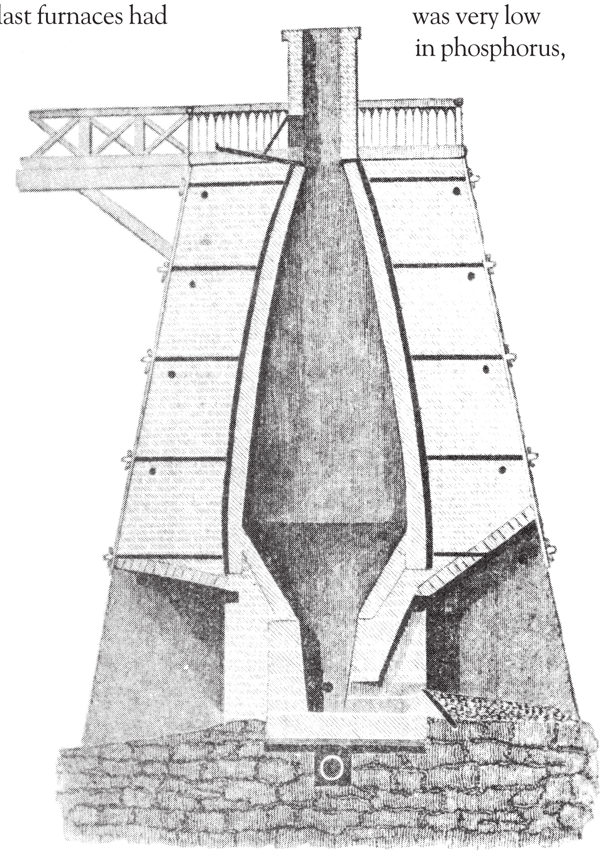
The process of smelting iron in a blast furnace consists of charging a mixture of fuel, iron ore, and flux into the top of the furnace and blowing heated air into the bottom. Combustion of the fuel creates the heat necessary for melting and for chemical reactions which remove the oxygen from the ore, reducing it to a metallic form. The flux combines chemically with various impurities in the ore to form slag. The gaseous by-products of the operation exit the top of the furnace, while the liquid products, iron and slag, are tapped out at the bottom.

Iron furnaces were fairly simple affairs early in the nineteenth century with uncomplicated mechanisms for charging the furnace, providing the blast, and removing the product. By the time the Carnegie (Cranberry) Furnace was constructed, near the end of the century, blast furnaces had evolved into substantial plants with formidable equipment.

Most of the ore for the Cranberry Furnace was magnetite mined by Cranberry Iron & Coal Company in Cranberry, North Carolina. Magnetite, Fe_3O_4, is an iron oxide ore that is very heavy, very hard, steel-gray in color, and strongly magnetic. The Cranberry ore, while not containing a particularly high percentage of iron, was very low in phosphorus,



Front view of a blast furnace.



Vertical section of a blast furnace designed for charcoal.

The illustrations show a front view and a vertical section view of a blast furnace that was designed for the use of charcoal. ***Illustrations courtesy of Tennessee Department of Conservation, Division of Archaeology.***

titanium, and sulphur. This ore was quite different from the more common hematite, Fe_2O_3, of the Mesabi Range. The low phosphorus magnetite produced a Bessemer-quality pig iron — that is, it could be used in a Bessemer converter to produce steel. It commanded a premium price compared with non-Bessemer pig iron.

The Cranberry ores generally were about 41-percent iron, so it was necessary to concentrate the ore before shipment from the mine to the furnace. The ore was crushed to a 2-inch size and washed to remove as much lean material as possible. After washing, it was screened and sent through a Wenstrom separator. This machine had two revolving magnetized horizontal drums. The magnetic ore was attracted to the drums and was then conveyed to a bin beneath each drum. The tailings fell out the bottom between the drums and were hauled off. The concentration process yielded ore that could range from 50 to 70-percent iron, although it usually ran 63 to 66-percent.

In the early years of the Cranberry Furnace, the iron ore was shipped in gondolas. When it arrived at Johnson City, it had to be transferred to standard gauge cars for the remainder of the trip to the furnace. Once the furnace spur was completed, the ore could be shipped directly to the furnace in the newly constructed drop-bottom hoppers.

The Cranberry Furnace used coke from Virginia's Pocahontas coal fields. The Pocahontas field was opened in the early 1880s and began shipping coal with the arrival of the Norfolk & Western to Pocahontas, Virginia, in 1883. Pocahontas was soon a thriving town with twenty-three saloons, an opera house, and a Masonic lodge. A large Catholic church and a synagogue reflected the large number of immigrant workers who joined southern blacks working in the mines. By the time the furnace was constructed in Johnson City, Pocahontas coke ovens were producing large amounts of coke.

Coke was the solid residue resulting from the distillation of bituminous coal. The process of coking consisted of heating coal, out of contact with air, to a temperature high enough to drive out the volatile matter without the combustion of the solid carbon. The volatile matter was made up of hydrocarbon gases.

The Pocahontas coke plants were beehive ovens, as were most coking facilities of the day. The ovens were arranged in long rows with a track on top. Coal was delivered, via this track, to the ovens in special charging cars called "larries." A standard railroad track ran in front of the ovens so that the coke could be loaded for shipment.

Each oven's interior was about 12′ in diameter and 6′ 9″ high. The door in front was a 2′ 6″ square and there was an opening about 15″ in diameter on the top. Five tons of coal were dropped, or "charged," through the top hole.

The coal, still wet from cleaning when first charged into the oven whose walls and floor were still hot from the previous charge, would begin to steam. The oven tender, known as a "scrapper," would use a long metal rake to level the charge. He would then put the damper on at the top and seal the oven door with fire bricks and mud, leaving about an inch opening as an inlet for air.

The coal would gradually gather heat from the brickwork, and would release gases into the oven. As the temperature inside the oven increased, the space above the charge would fill with hydrocarbon gases. After about an hour, the ignition point would be reached and the gases would

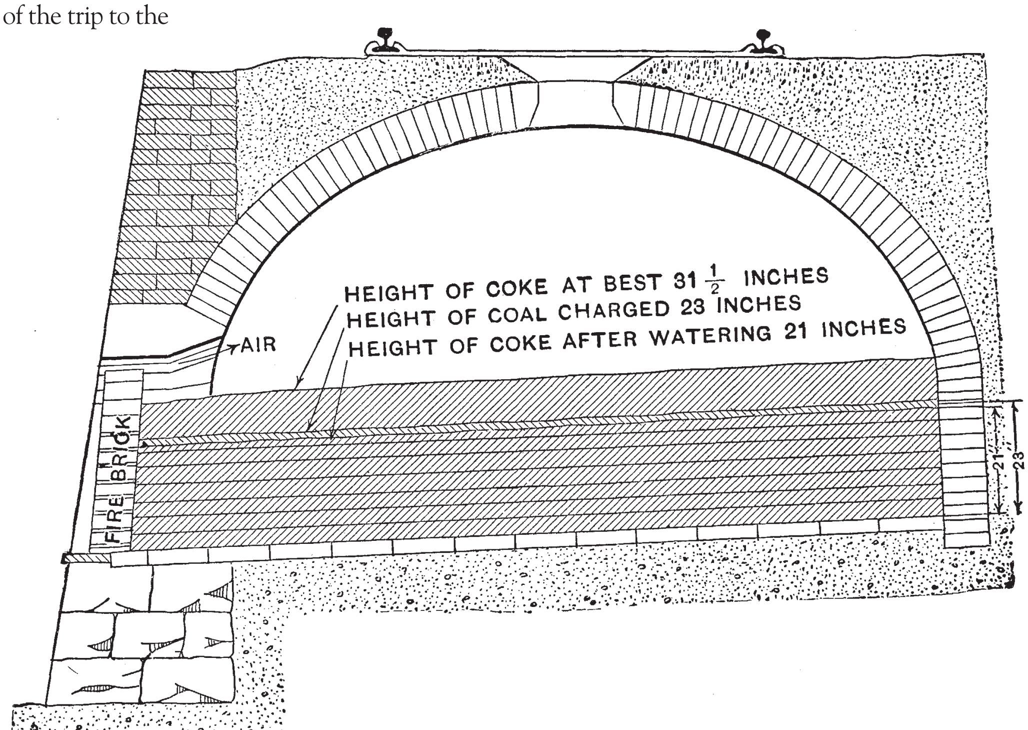


Figure 1 shows a section of a Beehive Coke Oven. The interior of the oven was about 12' in diameter and 6' 9" high. The oven was charged to a height of about 23" through the top hole. The charge would expand to about 31" height during the coking process and the final product was about 21" high after watering.

begin to burn. The tender would then use a long metal hook to close the damper.

The art of making good coke was in controlling the damper and the size of the opening in the oven door to regulate the burning of the gases inside the oven. The amount of air needed to be just enough to burn the gases. Too little air and the gases would not burn hot enough to heat the coal, too much air and the coal itself would burn. Throughout the process, a yellowish smoke would rise from the top of each oven, casting a pall over the whole community.

Once the oven reached the desired temperature, the lumps of coal would fuse into a pasty mass and increase in volume by about one-half. The maximum amount of expansion occurred 3–4 hours after ignition. As the volatile matter escaped, leaving only the carbon behind, the mass again became solid. At the end of the process, the volume of the coke was about three-quarters the volume of the initial charge.

After 48–72 hours the brick door was torn down and the coke was sprayed with water to stop the process. The coke in the oven had a distinctive columnar structure and was silvery gray in color. It weighed about two-thirds as much as coal and was porous, yet hard. Coke pullers, usually working in pairs, used long metal forks to break the coke apart and pull it out of the oven.

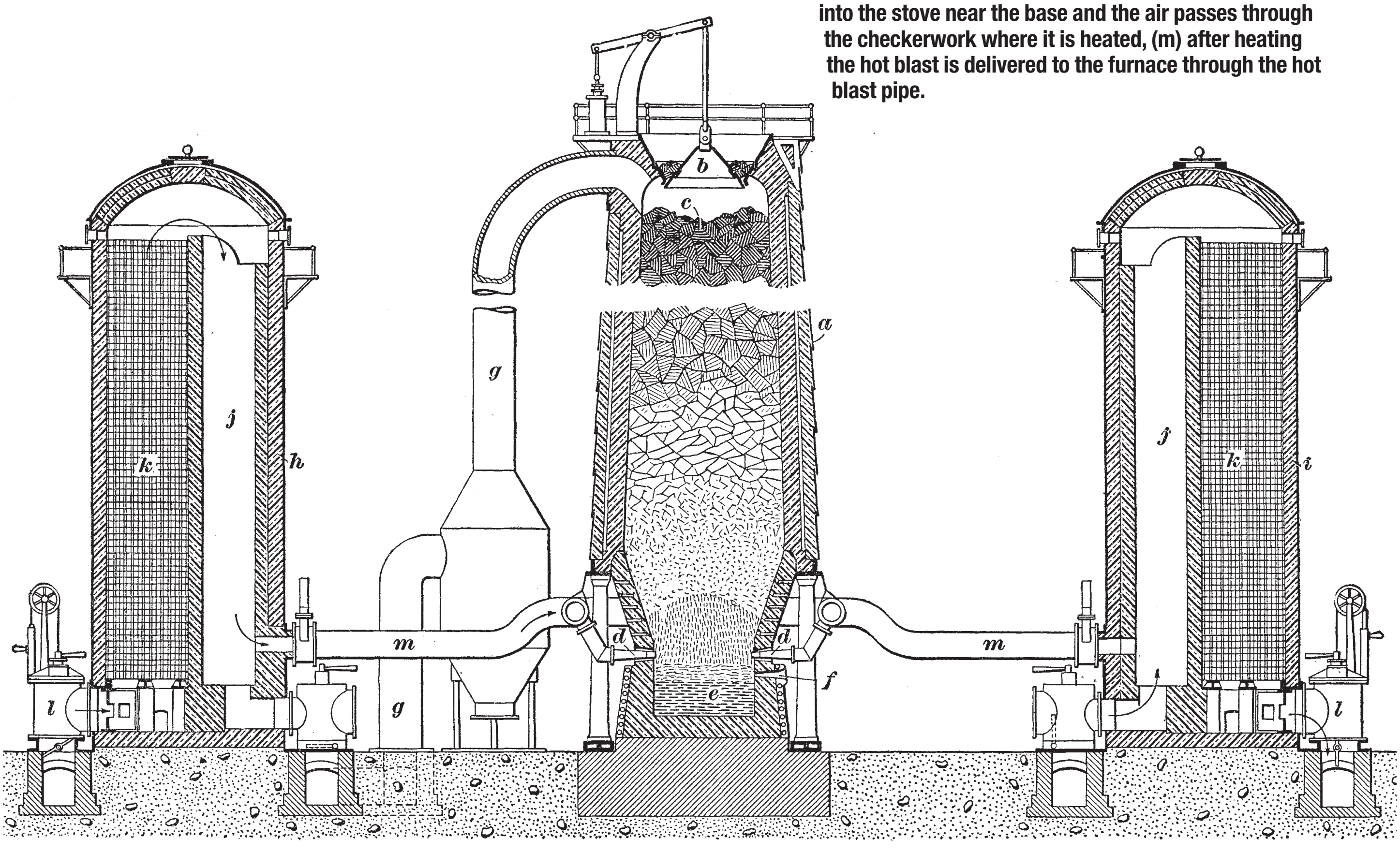
Once the coke was out of the oven, it was sprayed with water again to cool it. Workers used large wheelbarrows to load the coke into railroad cars. Apparently, both gondolas and boxcars were used to transport the coke.

The Pocahontas coke was carried over the Norfolk & Western to Bristol, then transferred to the Virginia and Southwestern who hauled it to Elizabethton. The East Tennessee & Western North Carolina then took it to the furnace in Johnson City.

Later on, the furnace got its coke from the Big Stone Gap area of Wise County, Virginia. This was a high grade coke that could be shipped directly to Elizabethton over the old Virginia & Southwestern line, which had become a part of the Southern Railway. This coke was produced in the same type of beehive ovens as used in Pocahontas.

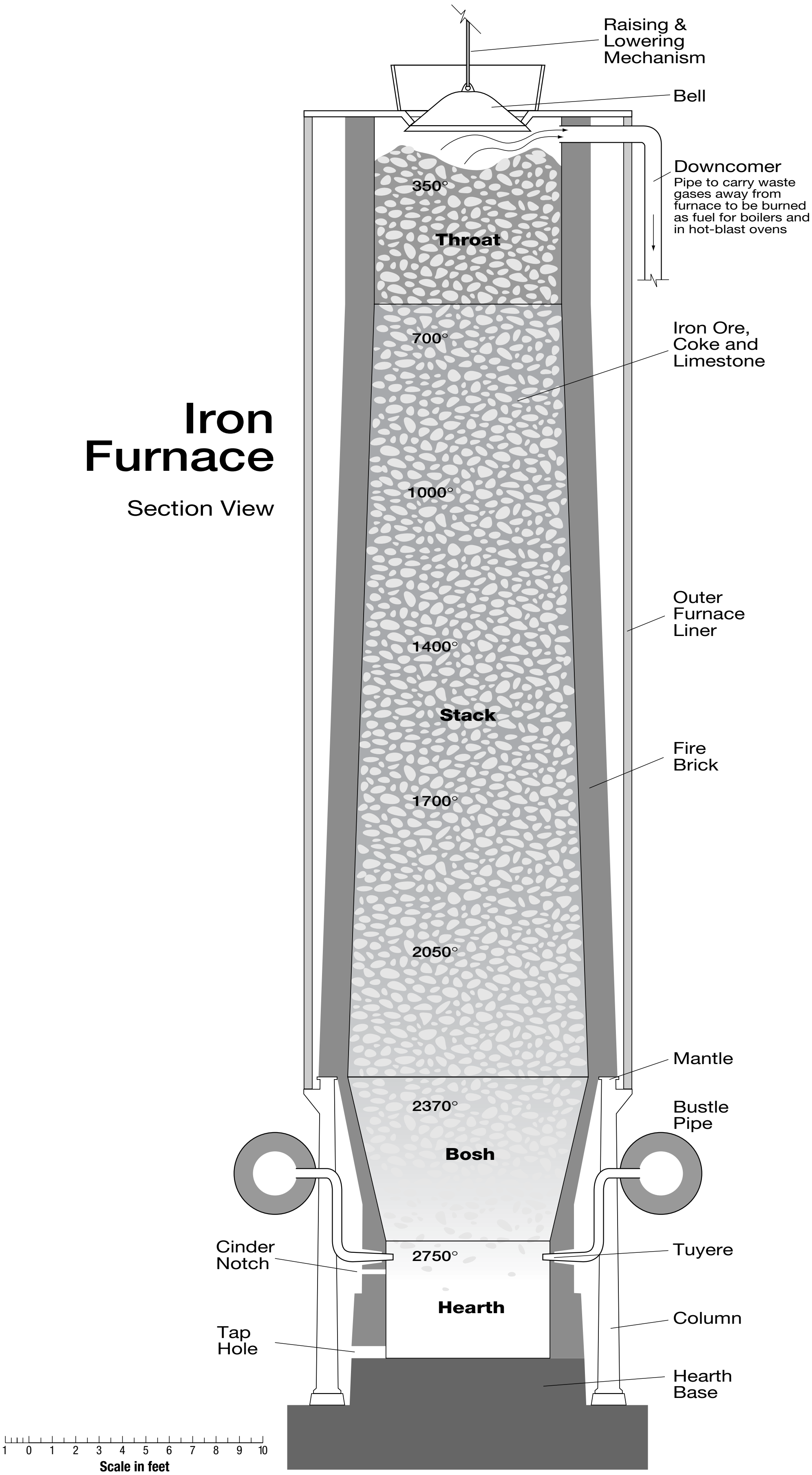
The limestone used as flux at the Cranberry Furnace came from a quarry located next to the ET&WNC right-of-way at Milligan. The siding and crusher were just down the hill from the small passenger shed.

Figure 2 shows parts and operation of a typical turn-of-the-century blast furnace: (a) the furnace is constructed of steel plates lined with firebrick, (b) the bell is opened to allow charging of furnace and closed to prevent escape of hot gasses, (c) the burden of the furnace is made up of iron ore, coke, and limestone, (d) the hot blast enters the furnace via nozzles, or tuyeres, (e) the hearth of the furnace where liquid iron and slag collect, (f) the cinder notch or slag hole where slag is drained off, (g) waste gases from the furnace are carried by the downcomer, through the dust catcher, to be used in heating the stoves, (h) the stove on the left is "on blast" providing heated air for the furnace, (i) the stove on the right is "on gas" being heated, (j) is the combustion chamber where gases collected from the furnace are burned, (k) is the checkerwork of firebrick that absorbs the heat, (l) cold blast is brought into the stove near the base and the air passes through the checkerwork where it is heated, (m) after heating the hot blast is delivered to the furnace through the hot blast pipe.



Iron Furnace

Section View



The raw materials for the furnace arrived at the stock house on the west side of the complex. The stock shed was 242′ long. The main section was 77′ wide and the lean-to section was an additional 26′ wide. Two tracks came into the shed on trestles and extended some distance beyond the end of the shed. These tracks were used for the iron ore from Cranberry and the limestone from Milligan. The third track came in at ground level and was used for coke arrivals. The coke generally arrived by boxcar and was unloaded by workers using wheelbarrows. All the raw materials were stored in wood-walled bins.

The stock-piled raw materials were loaded into hand buggies by workers known as "bottom-fillers." These stone buggies may have operated on a system of tracks or they may have been guided by the worker. The weight of the material in the buggy could not exceed the power of the man who handled it. The buggies were probably designed to carry 1,000 to 1,800 pounds of stock. Because coke was much lighter than the ore, the coke buggies were somewhat larger.

The buggies were pushed onto the scale and weighed, then placed on the hoist and hauled to the top of the furnace. The ratio of the ore, coke, and limestone in the charge was known as the "burden" of the furnace. The weight of each of the materials was closely monitored to make sure the charge had the proper ratio. There was a separate beam scale for each of the three raw materials near the bottom of the hoist. Each scale had a counterweight set for that particular material, so all the worker had to do was make sure that the buggy balanced on the proper beam before sending it up the hoist.

The hoist mechanism was made up of two elevator platforms; operated by a single cable, controlled by the drum of an automatic reversing steam hoisting engine. The elevator platforms acted as counter-balances for each other. When the buggy reached the top, a worker known as a "top-filler" dumped the stock and returned the empty buggy to the hoist.

The top-fillers dumped the stock into the circular cast iron hopper at the top of the furnace. The top of the bell formed the bottom of the hopper. The bell was made of cast iron and had a slope of about 45 degrees.

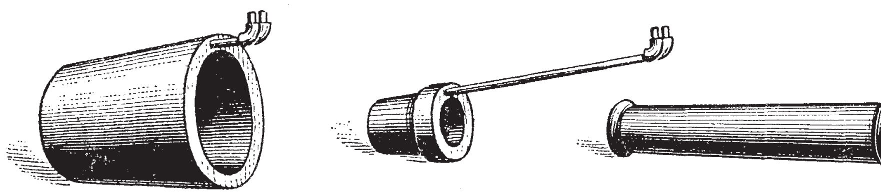
The top-fillers were responsible for making sure the materials were evenly distributed around the furnace. The proper distribution of the stock was essential for the furnace to work well. They followed a specified order for dumping buggies of ore, coke, and limestone.

The bell-beam mechanism, powered by steam cylinders, held up and raised and lowered the bell. When the proper amount of material had been dumped though the hopper doors, the bell was lowered so the charge could fall into the furnace.

It was also the top-fillers responsibility to make sure that the furnace was charged at a pace that kept the materials up to the stock line; leaving only enough room for the proper operation of the bell. The top-fillers used long iron rods inserted through four small holes, placed equidistant around the hopper, to gauge the height of the materials in the furnace. By placing the rod through each of the holes, the worker could also determine whether the materials were descending evenly across the furnace.

The heart of the Cranberry Furnace operation was the furnace itself. There were four sections of the furnace; the hearth, the bosh, the stack, and the throat. The raw materials were loaded into the throat of the furnace by the bell and hopper mechanism that topped it. The raw materials were heated to the point where chemical reduction occurred as they descended down the stack. The raw materials were melted and the chemical fusion occurred in the bosh of the furnace. The crucible, or hearth, held the liquid iron and slag until enough was accumulated to be drawn off.

The furnace was a steel shell with a firebrick lining. The outer shell was made up of steel plates about ¾″ thick and riveted together. The firebricks



Cooler. Tuyere. Blowpipe.

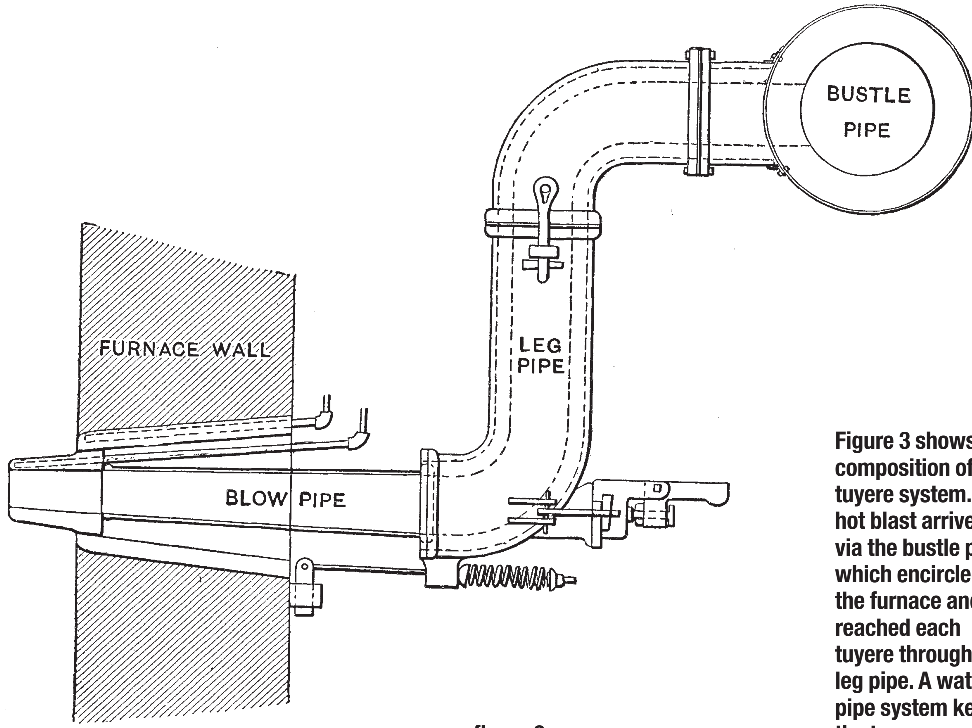
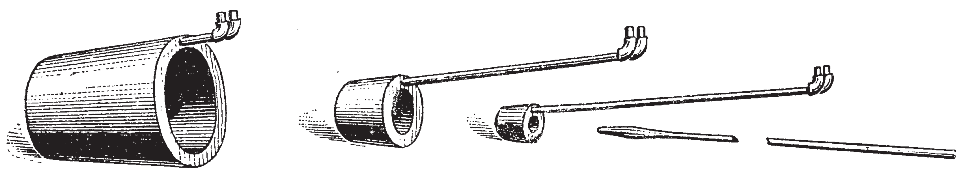


figure 3

Figure 3 shows the composition of the tuyere system. The hot blast arrived via the bustle pipe which encircled the furnace and reached each tuyere through a leg pipe. A water pipe system kept the tuyeres cooled.



Cooler. Intermediate Cooler. Monkey. Plug.

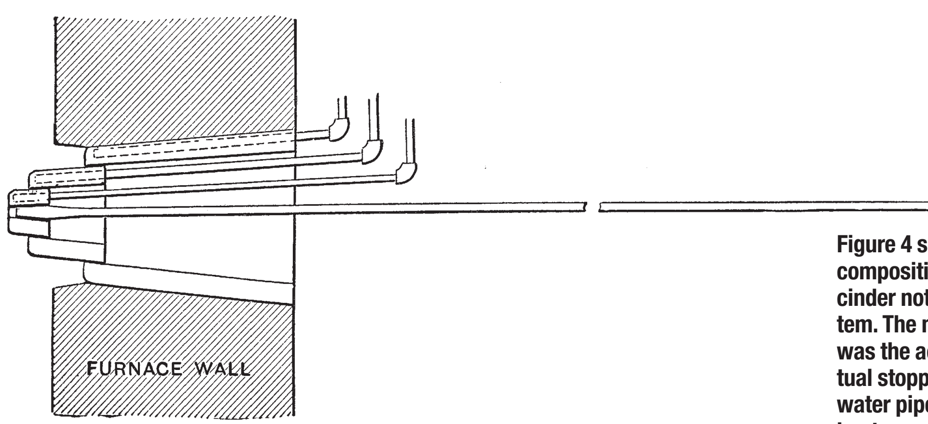


figure 4

Figure 4 shows the composition of the cinder notch system. The monkey was the actual stopper and a water pipe system kept everything cooled.

1890'S PERIOD OPEN TOP BLAST FURNACE
SOURCE MATERIALS AND BIBLIOGRAPHY

PRIMARY SOURCES

Two photographs east side of furnace and one post card view from the southwest of furnace.
John Waite, THE BLUERIDGE STEMWINDER.

SANDBORN INSURANCE MAPS The Cranberry Furnace Co., Carnegie Furnace, 1891,1903, 1908,1913, 1920, 1927

HAGLEY MUSEUM AND LIBRARY
Wilmington, Delaware

Keller photo collection: Many photos of open top furnaces in the Shenadoah Valley, including Buena Vista furnace, nearly identical in construction and appearance to Johnson City.

Lukens Steel Collection: Thirteen rolls of drawings containing nearly complete engineering construction drawings for Buena Vista Furnace. These include the furnace, top platform, cast house, boiler house, engine house and blowing engines, stock house trestle, hoist house and engine, hoist tower, and many smaller details.

Alan Wood Steel collection: Photos of Taws and Hartman front dump slag cars.

Trade Catalog: Barr Pumping Engine Co. Pumps

Trade Catalog: Henry R Worthington Co. Pumps

BIBLIOGRAPHY

AN OUTLINE OF THE METALLURGY OF IRON AND STEEL
H.O. Hofman
Thomas Todd, Printer, Boston, Mass. 1904
(detailed information on manufacturing iron with drawings of a open top furnace plant of the 1890's and many components including outline drawings of slag cars of the period)

CATALOGUE OF THE MANUFACTURES OF PHILADELPHIA ENGINEERING WORKS
Philadelphia, January 1893
(blowing engines, boilers, stacks, furnaces, stoves, valves of all types, blast furnace accessories)

THE BLUERIDGE STEMWINDER
East Tennessee and Western North Carolina R.R. Co. Historical Society
John Waite, editor
July, August, September 1994, October, November, December, 1998 and January, February, March, 1999
(photos and history of the furnace, surrounding community and the railroads serving the furnace)

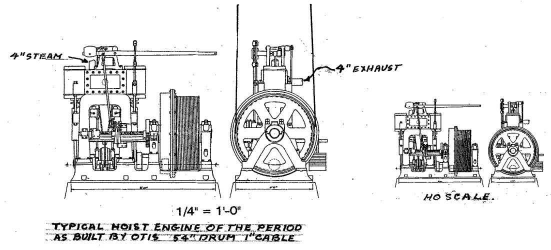
THE IRON AGE
April 22, 1880 Whitwell stove
March 10, 1887 Weimer slag and hot metal car
June 12, 1890 The Durham Furnace
August 7, 1890 The Mongahela Furnace Plant
September 11, 1890, September 18, 1890 and November 6, 1890 The Modern Blast Furnace (the drawings and description are of the same major components as are in the photos of the Johnson City furnace, the furnace shown in the article has the same dimensions as in the reference below)

THE IRON AND STEEL WORKS OF THE UNITED STATES, also of Canada and Mexico
The American Iron & Steel Association, Philadelphia, 1896.
(dates and dimension information)

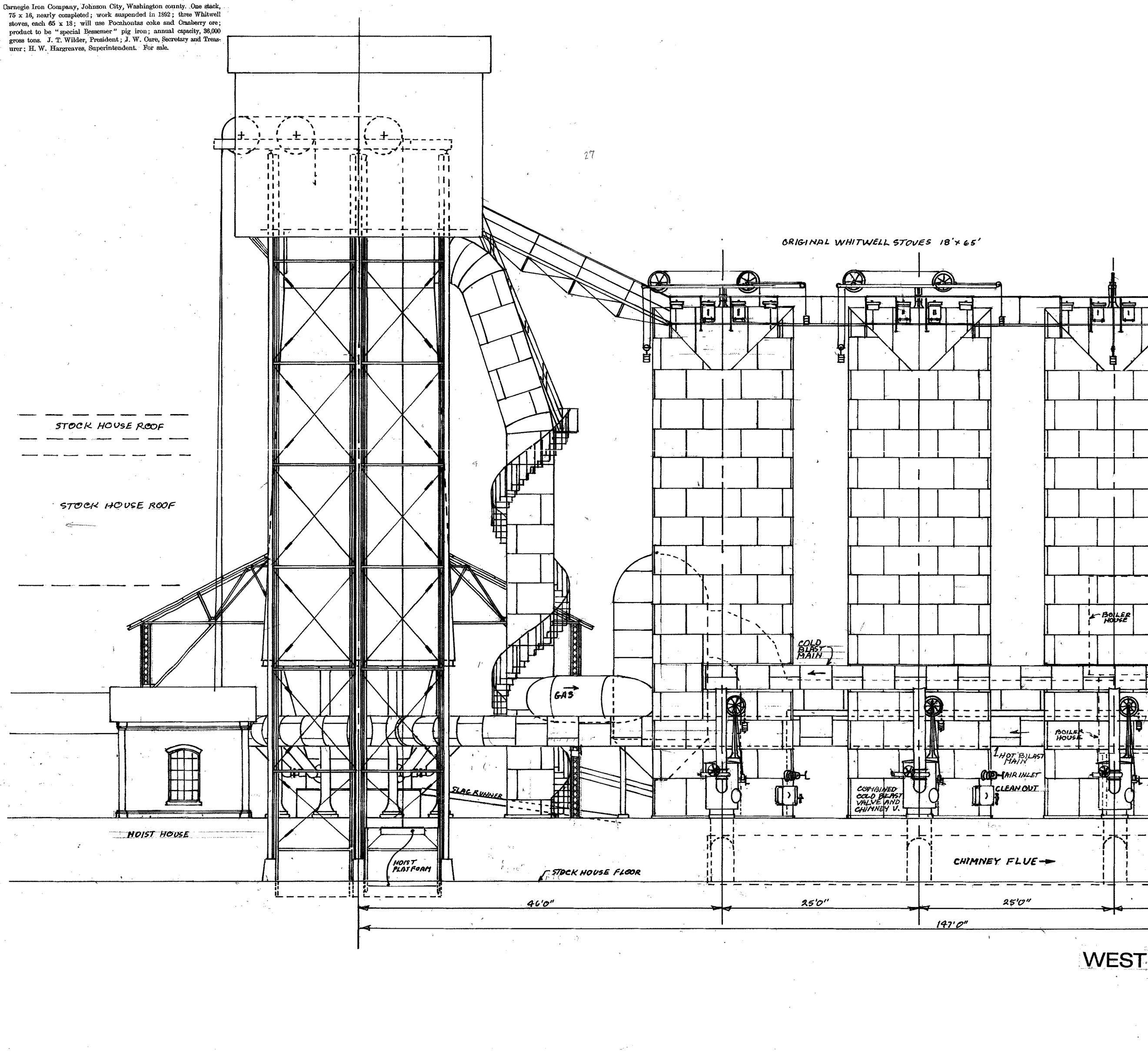
TENNESSEE.

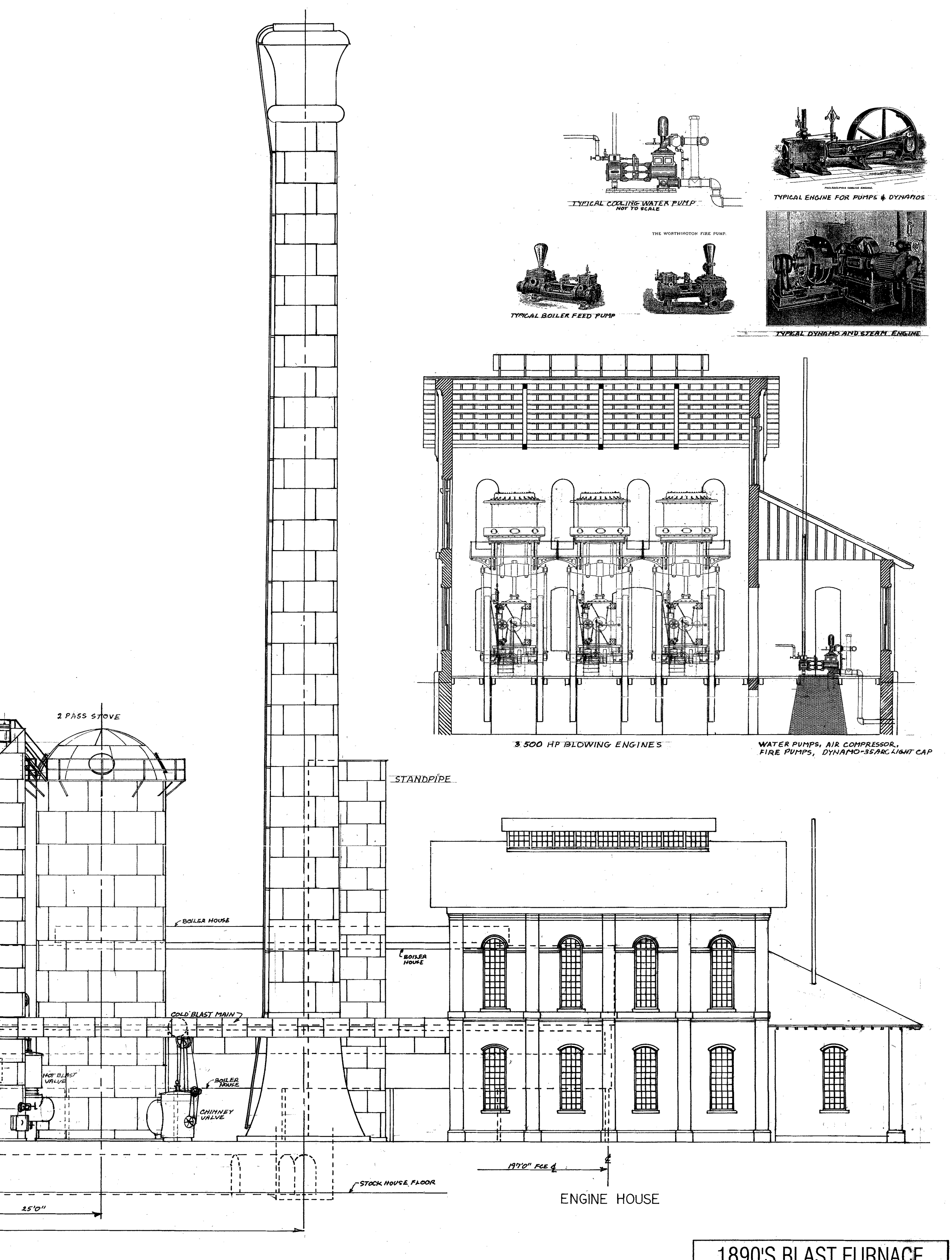
COKE.

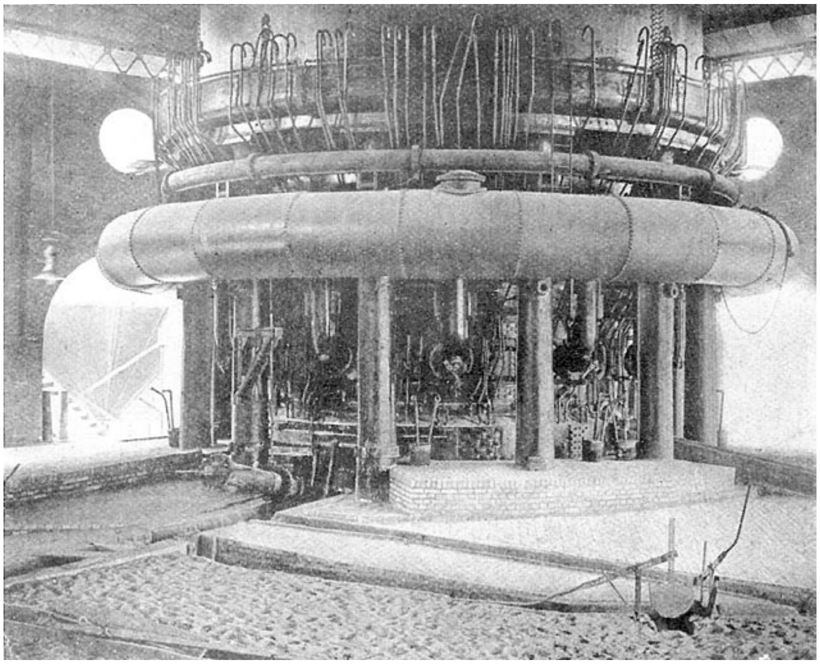
Carnegie Iron Company, Johnson City, Washington county. One stack, 75 x 16, nearly completed; work suspended in 1892; three Whitwell stoves, each 65 x 18; will use Pocahontas coke and Cranberry ore; product to be "special Bessemer" pig iron; annual capacity, 36,000 gross tons. J. T. Wilder, President; J. W. Cure, Secretary and Treasurer; H. W. Hargreaves, Superintendent. For sale.



Scale drawings, printed here at 1/3 HO scale, are used with permission. Full size HO scale plans are available for $47 plus $7 for shipping and handling. PA residents should add 6% sales tax. Plans can be ordered from:
Mike Rabbitt, 565 Forrest Road, Wayne, PA 19087




TYPICAL COOLING WATER PUMP
NOT TO SCALE
TYPICAL ENGINE FOR PUMPS & DYNAMOS
THE WORTHINGTON FIRE PUMP.
TYPICAL BOILER FEED PUMP
TYPICAL DYNAMO AND STEAM ENGINE
3,500 HP BLOWING ENGINES
WATER PUMPS, AIR COMPRESSOR,
FIRE PUMPS, DYNAMO-35 ARC LIGHT CAP
2 PASS STOVE
STANDPIPE
BOILER HOUSE
BOILER HOUSE
COLD BLAST MAIN
HOT BLAST VALVE
BOILER HOUSE
CHIMNEY VALVE
197'0" FCE ℄
STOCK HOUSE FLOOR
25'0"
ENGINE HOUSE
1890'S BLAST FURNACE
©2003
M. RABBITT
JOHNSON CITY TENN.
1890-1930'S
HO SCALE
OR AS NOTED
RECONSTRUCTED FROM PHOTOS, MAPS AND
INFORMATION ON CONTEMPORARY BLAST FURNACES
WEST ELEVATION
3 OF 6



The base of the iron furnace is a complicated looking structure with the bustle pipe, tuyeres and water cooling pipes.

were made of a fine-grained, hard clay to resist abrasion. The shell of the shaft above the bosh was constructed independently of the parts below. It was slightly conical in shape, sloping out from a 19′ diameter near the top to a 25′ diameter at its widest. It was supported by a mantle that rested on eight cast iron columns arranged in a circle. The 20′ tall by 18″ diameter support columns sat on the circular foundation of the furnace.

The bottom part of the furnace was made up of two sections; the cylindrical hearth and the conical bosh. The hearth was about 14′ in diameter and 8′ tall and was constructed of thick refractory firebricks surrounded by a jacket of heavy steel castings. The jacket was cooled with water running through pipes cast into the jackets.

The bosh extended from the hearth to the bottom of the stack; forming an inverted conical shape from 14′ diameter to 25′ diameter. It was constructed of thick, course-grained firebrick and box-shaped bronze cooling plates, through which water ran. It was all held together with bands of iron.

The hot blast entered the furnace through openings called tuyeres. There were probably eight water-cooled tuyeres evenly spaced around the furnace at the junction of the hearth and bosh, when it was built. The number of tuyeres was probably increased to a dozen when the furnace was rebuilt. The hot blast reached the tuyere via pipes connected to the blast-distributing bustle pipe that encircled the furnace about 10′ above the floor. The bustle pipe was 4′ in diameter and had a 9″ lining of firebricks. The hot-blast main pipe connected the bustle pipe to the stoves.

The tapping hole was a 10″ square opening in the brickwork at the base of hearth. It was stopped with clay, except when the iron was removed from the furnace. When the Cranberry Furnace was first put into blast, the tap hole was probably filled with balls of wet clay thrown into the opening by a helper and tamped by the keeper using a stopping hook. Later, this system was improved with the use of a mud gun. The gun was supported by a pivoting bracket so it could be manipulated into the proper position before the clay was discharged.

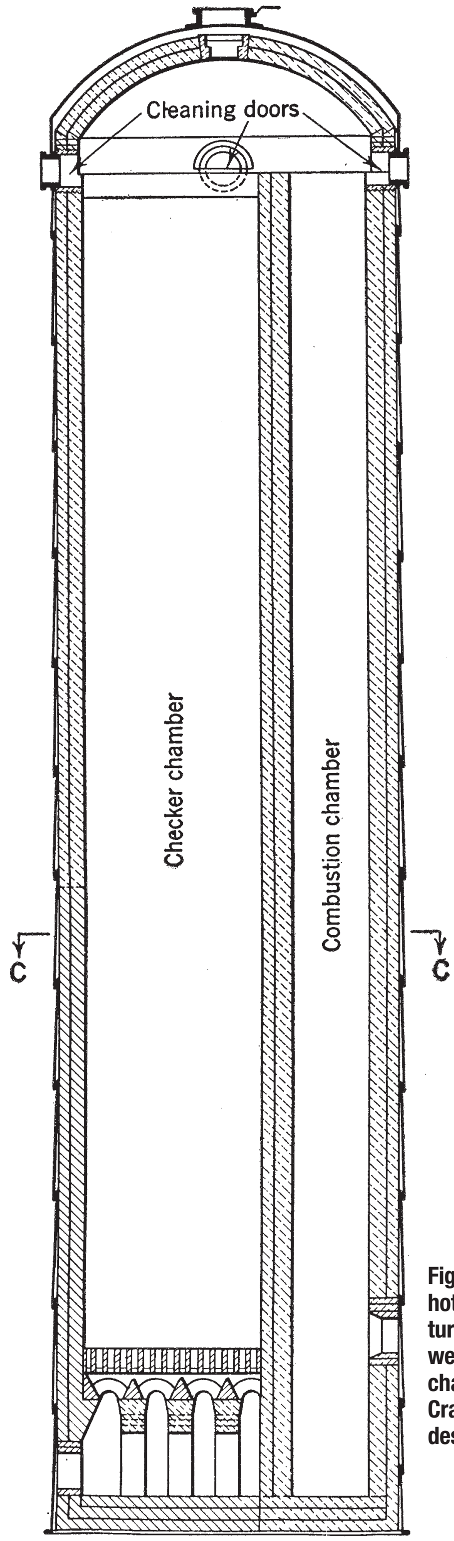
The cinder notch was located 90 degrees away from the tap hole and was 4′ above the floor. The cinder notch was also water-cooled and all the parts of the system were constructed of bronze which was unaffected by the caustic slag.

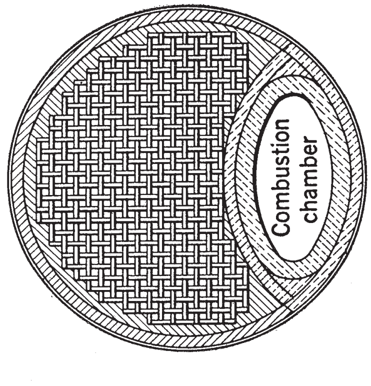
The Cranberry Furnace had one downcomer to capture the highly combustible gases that were a by-product of the iron smelting process. These gases were used to fuel the stoves and boilers. The gases entered the downcomer, just below the bell, near the top of the furnace. A dustcatcher was used to clean solid particles from the gas. The dustcatcher was a 12′ diameter enlargement of the downcomer. It operated on the principle that, as the velocity of the gases was reduced by the increased diameter, gravity would allow the solid particles to settle to the bottom of the dustcatcher.

The stoves were used to heat the blast for the furnace. There were three Whitwell hot-blast stoves when the Cranberry Furnace was constructed, with a fourth stove added sometime between 1908 and 1913. The exterior of each stove was a tall cylinder constructed of riveted steel plates. Each of the Whitwell stoves was 18′ in diameter and 65′ tall. The fourth stove was a slightly larger diameter and about the same height.

The Whitwell stoves had four chambers that ran nearly the full height of the stove. The combustion chamber was the smaller of the four and was hollow. The three larger chambers were filled with a checkerwork of specially shaped firebricks. By-product gases from the furnace were drawn in at the bottom of the combustion chamber, where they burned. The superheated air was then drawn out of the top of the combustion chamber and down through the other chambers filled with firebricks. The fourth stove had two chambers, one for combustion and the other filled with a firebrick checkerwork. The brickwork was heated to 1200 degrees F. over a three hour period of time. The draft for the stoves was supplied by the 160′ tall chimney.

Once the checkerwork was heated, the flow of the air was reversed and cold air was drawn into the chamber where it absorbed heat from the firebrick. The heated air then flowed to the bustle pipe around the furnace. One stove would be “on blast,” furnishing





Section C–C

Figure 5 shows a standard two-pass hot blast stove for a turn-of-the-century iron furnace. The three Whitwell stoves had three checkerwork chambers, but the fourth stove at the Cranberry Furnace was similar to this design.

figure 5

heated air for about an hour; while the other three stoves were "on gas," heating up. The stove tender was in charge of the operation of the stoves.

The boiler plant at the Cranberry Furnace housed twelve horizontal boilers. They provided the power for the blowing engines, power for the hoist house mechanisms, power for pumping water, and electricity for the entire plant. By-product gases from the furnace and coal brought in from Virginia were used to fuel the boilers.

Three 200-horsepower blowing engines were used to force the hot blast into the furnace. These were vertical engines, but other furnaces had horizontal blowing engines. They were housed in a substantial brick building.

The cast house extended from the furnace perpendicular to the stock shed. It was 55′ wide by 160′ long. The structure was constructed of cast iron I-beams, with corrugated metal siding. The siding covered only the upper portion of the walls and the lower portion was open.

The general foreman, also known as the "founder," was in charge of the entire Cranberry Furnace operation. The furnace itself was managed by the keeper. He kept an eye on the workings of the furnace both inside and out and was in charge of the tapping of iron and cinder.

The keeper kept watch on the inside of the furnace through the peephole. When the slag reached the height of the tuyeres, the cinder notch would be opened and the slag (Note: The terms slag and cinder are synonymous) would be drained off. There were usually three or four flushes of the cinder between iron tappings. The flushing and disposal of the slag were the responsibility of slag men, known as "cinder snappers."

The slag flowed down a cast iron trough that went from the furnace to a railroad track, next to the cast house. The slag ran into a special cinder car, which was shunted by a yard engine to the slag dump, adjoining the furnace complex. This was done quickly so the slag was still molten when it was dumped.

When the tapping hole was opened, the molten iron that flowed out was relatively free of slag. Toward the end of the cast, slag would come with it. Since slag was only one-third the specific gravity of iron, it floated on top of the iron. It was mechanically skimmed off the iron and flowed down a secondary slag runner. The iron flowed on toward the pig beds.

About one ton of slag resulted for every two tons of iron produced. The slag was probably broken up and used for railroad ballast or sold to concrete plants where it was used as a raw material in cinder blocks.

The clay that filled the tap hole was opened with a hand drill. The drill cut away the clay until it showed bright red. Then an iron bar was driven into the hole to create the final opening, which grew larger as the iron flowed through it. The hot blast would be turned down or off altogether while the iron was being tapped. Once the furnace was drained, the tap hole was closed. The iron was tapped about once every eight hours.

The floor of the cast house was a sand bed. Workers used wooden patterns to create a series of parallel depressions about 40″ long, 4″ wide, and 4″ deep in the moist sand. Each of these depressions, known as a pig, was connected to a cross runner which was called a sow. The cross runners were connected to the main runner, which ran from the tap hole through the center of the cast house. Once the tap hole was opened, the molten iron flowed down the main runner and spread via the sows to the pigs.

Once the iron began to set, workers covered it with a thin layer of sand. This layer of sand helped protect the workers from the intense heat of the iron and kept the iron from cooling too fast. While the iron was still hot, workers known as pig breakers used iron bars and sledge hammers to break the pigs away from the sows. They also broke the sows into convenient lengths. The pigs were then cooled by a spray of water.

Workers loaded the silvery-gray pigs onto carts. This was backbreaking work. Once loaded, the carts were pushed by hand over the lightweight track that ran down each side of the cast house. This track was probably 2′ gauge. The loaded carts were weighed, then pushed to the iron wharf. At the wharf, the pigs were broken in half and stacked ready for loading into gondolas.

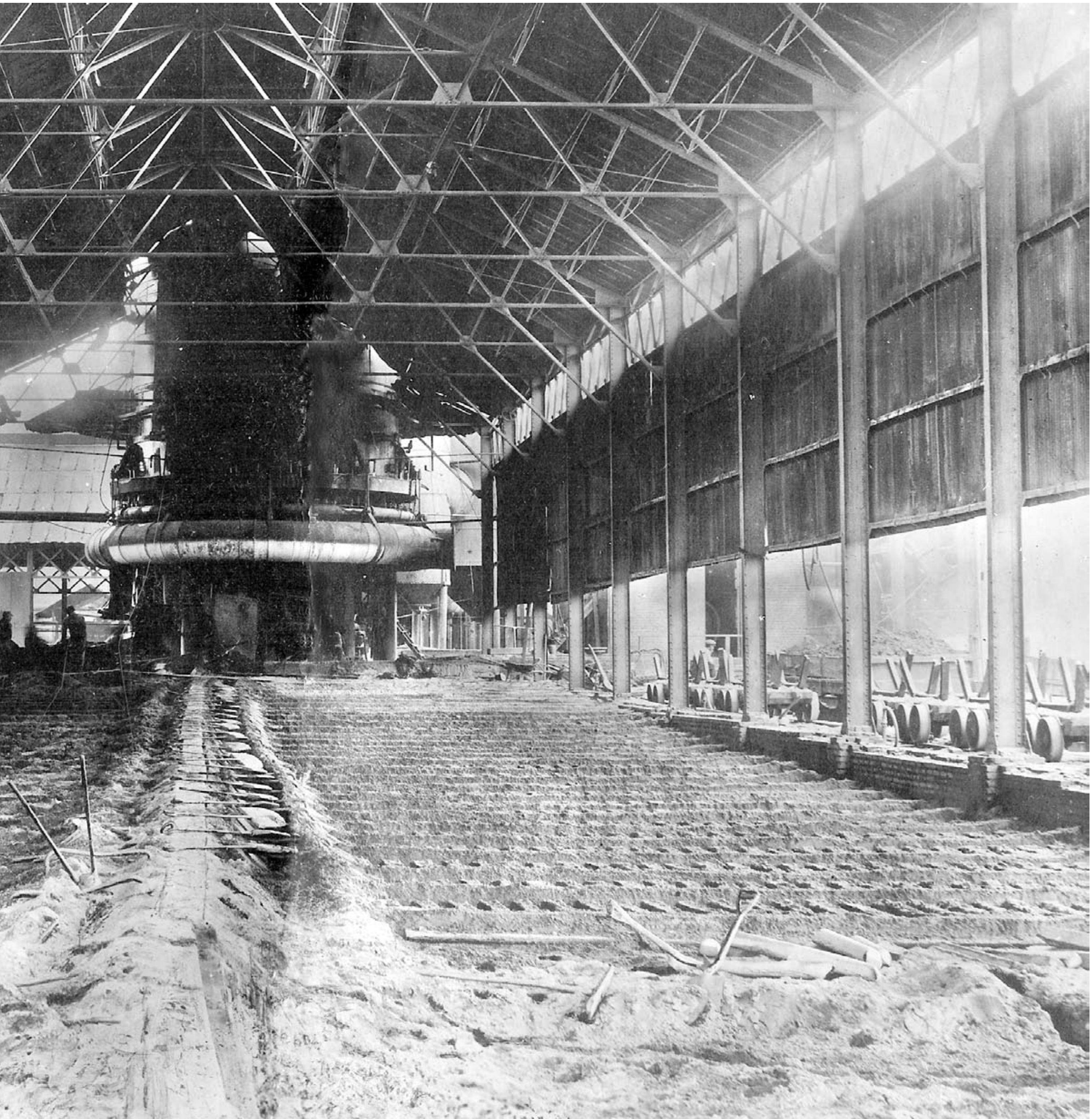
The Cranberry Furnace was a large complex. In addition to the stock shed, furnace, stoves, boiler house, engine house, and cast house, there were a number of other buildings on the property. The machine and carpenter shop is the only structure still standing today. There were also various storage sheds and a laboratory building. A man-made reservoir supplied water for the operation.

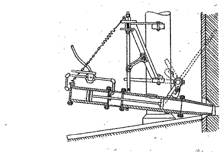
The furnace required constant

The casthouse for this turn-of-the-century furnace located at Birmingham, Alabama, was similar to the casthouse at the Johnson City furnace. The base of the furnace can be seen at the far end of the casthouse. The floor of the casthouse is sand and workers use special tools to make depressions in the sand, which will form the pigs once the molten iron flows from the furnace.

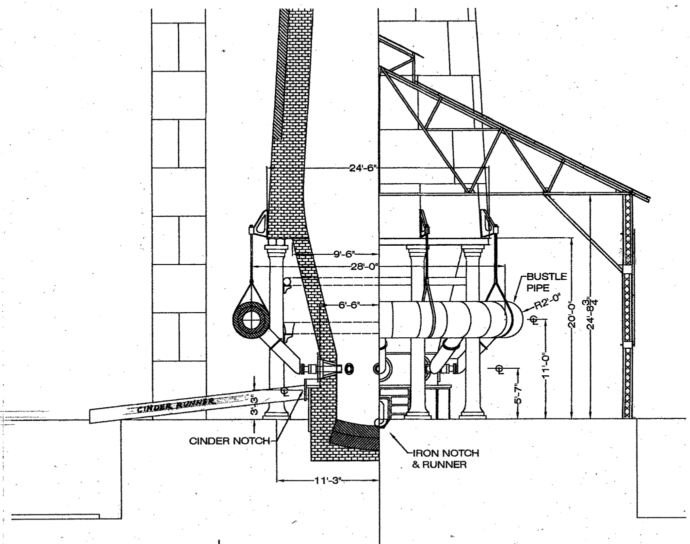
maintenance. The stoves had to be shut down regularly for cleaning and repairs. One of the reasons there were four stoves was so these repairs could be made without shutting the furnace down. The furnace did have to be "blown-out" every few years so the interior could be relined with firebrick. Otherwise, it ran twenty-four hours a day, year around.

The furnace required dozens of workers to operate. Most of the jobs involved hot, dangerous work. Many of the workers were immigrants and a large number of the most physically demanding jobs were held by black men.

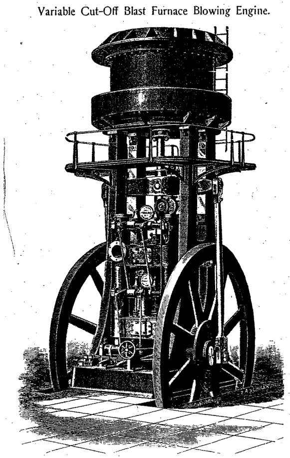




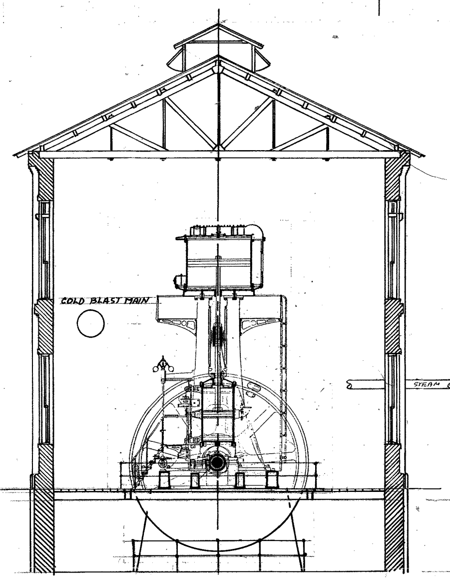
TAP HOLE CLAY GUN
1/4" = 1'0" ±



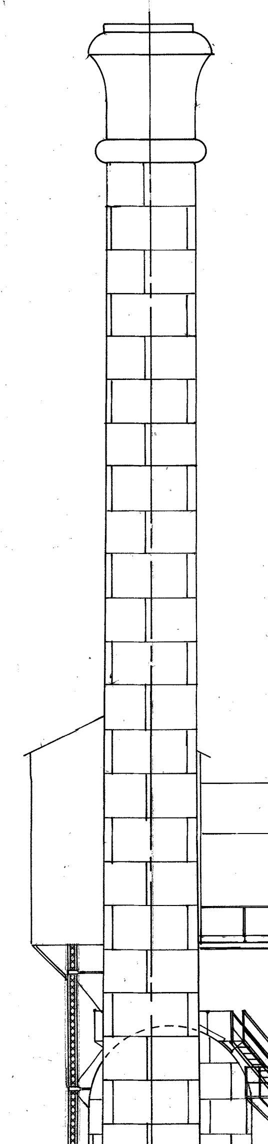
Variable Cut-Off Blast Furnace Blowing Engine.

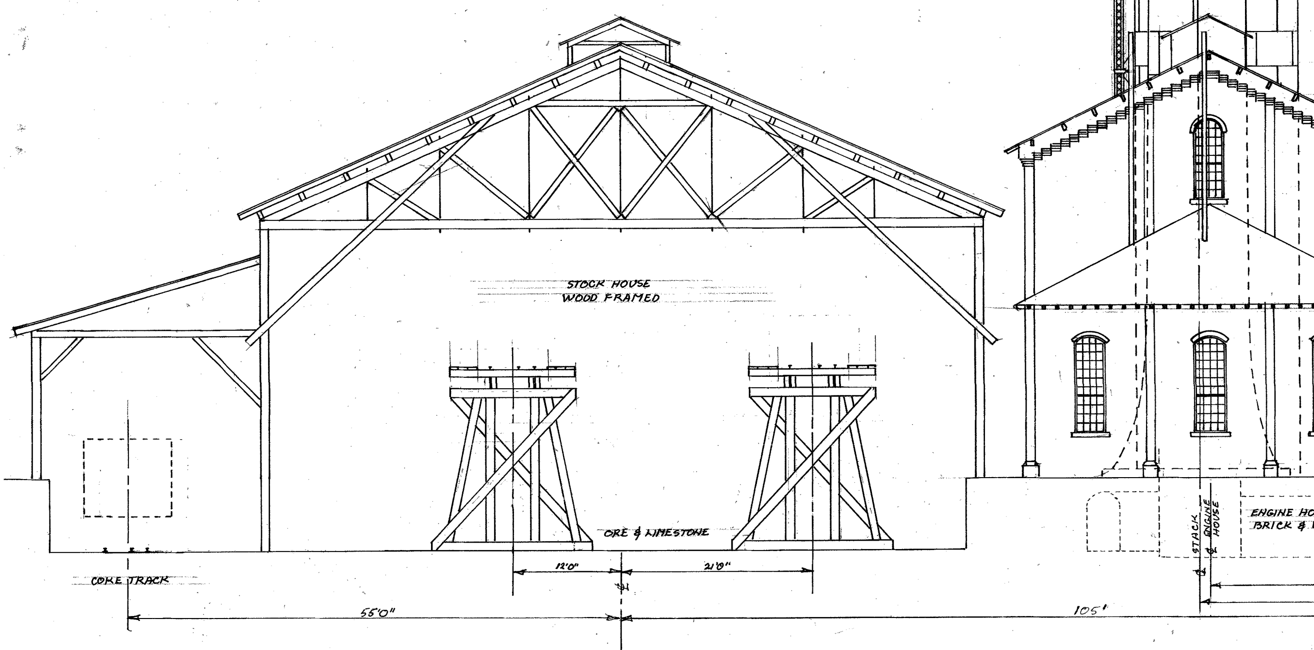


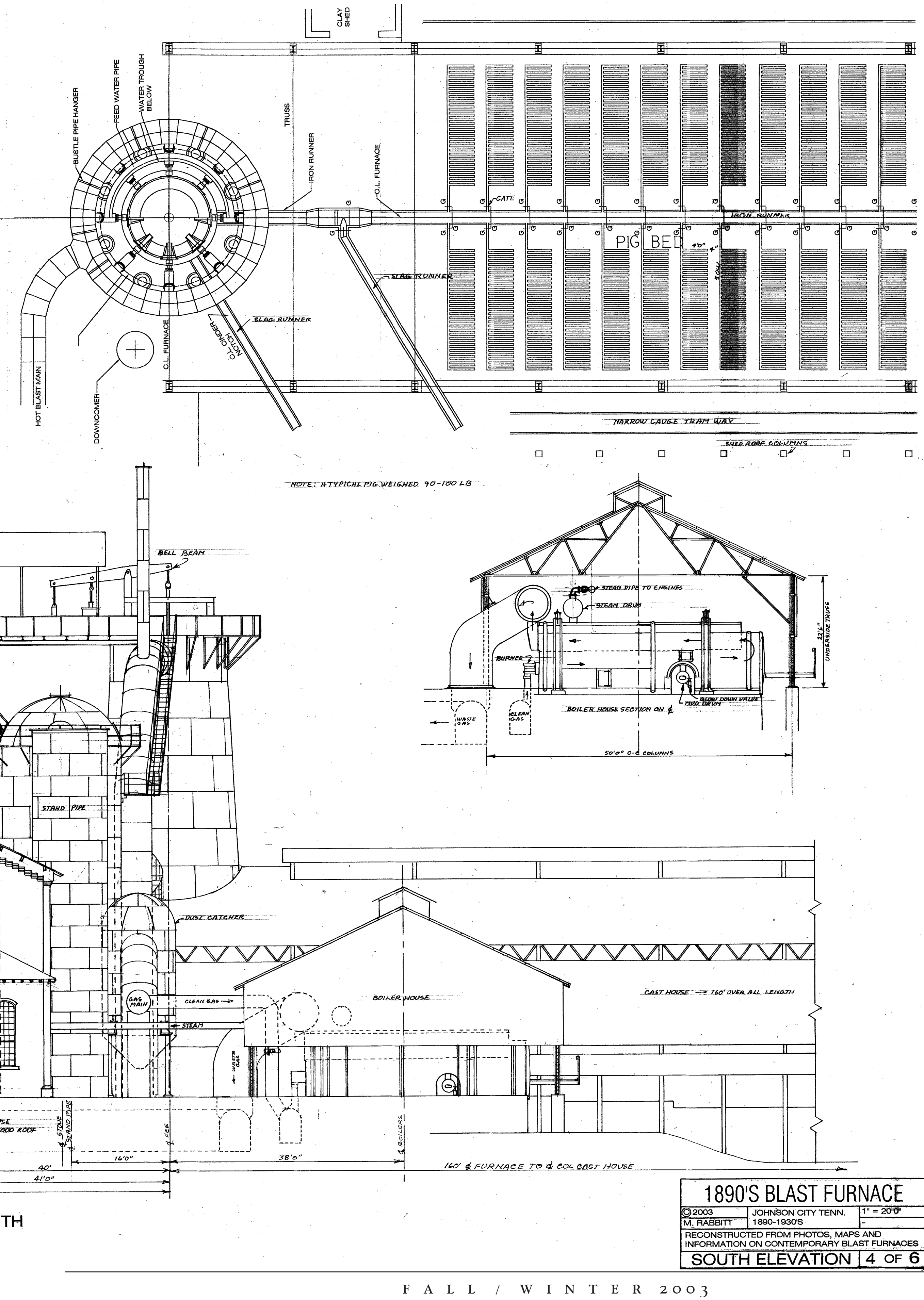
500 HP ENGINE TYPICAL

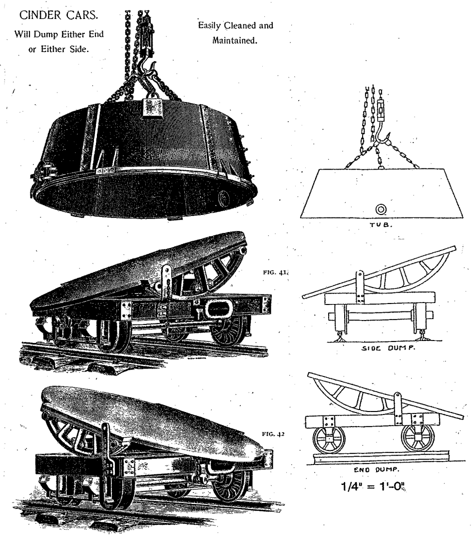


ENGINE HOUSE ON ℄

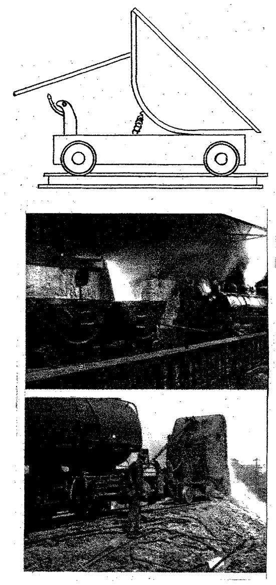




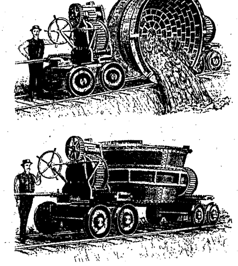

CLAY SHED
BUSTLE PIPE HANGER
FEED WATER PIPE
WATER TROUGH BELOW
TRUSS
IRON RUNNER
C.L. FURNACE
GATE
IRON RUNNER
PIG BED
SOW
SLAG RUNNER
SLAG RUNNER
C.L. CINDER NOTCH
C.L. FURNACE
HOT BLAST MAIN
DOWNCOMER
NARROW GAUGE TRAM WAY
SHED ROOF COLUMNS
NOTE: A TYPICAL PIG WEIGHED 90-100 LB
BELL BEAM
STEAM PIPE TO ENGINES
STEAM DRUM
BURNER
22'6" UNDERSIDE TRUSS
BLOW DOWN VALVE
MUD DRUM
BOILER HOUSE SECTION ON ℄
WASTE GAS
CLEAN GAS
50'0" C-C COLUMNS
STAND PIPE
DUST CATCHER
GAS MAIN
CLEAN GAS
STEAM
BOILER HOUSE
CAST HOUSE → 160' OVER ALL LENGTH
WASTE GAS
℄ STOVE
℄ STAND PIPE
℄ FCE
℄ BOILERS
16'0"
38'0"
40'
41'0"
160' ℄ FURNACE TO ℄ COL CAST HOUSE
TH
1890'S BLAST FURNACE
©2003
M. RABBITT
JOHNSON CITY TENN.
1890-1930'S
1" = 20'0"
RECONSTRUCTED FROM PHOTOS, MAPS AND INFORMATION ON CONTEMPORARY BLAST FURNACES
SOUTH ELEVATION
4 OF 6

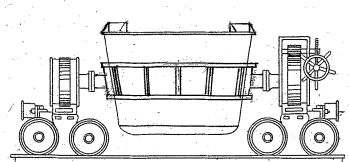


PHILADELPHIA ENGINEERING WORKS SLAG CAR



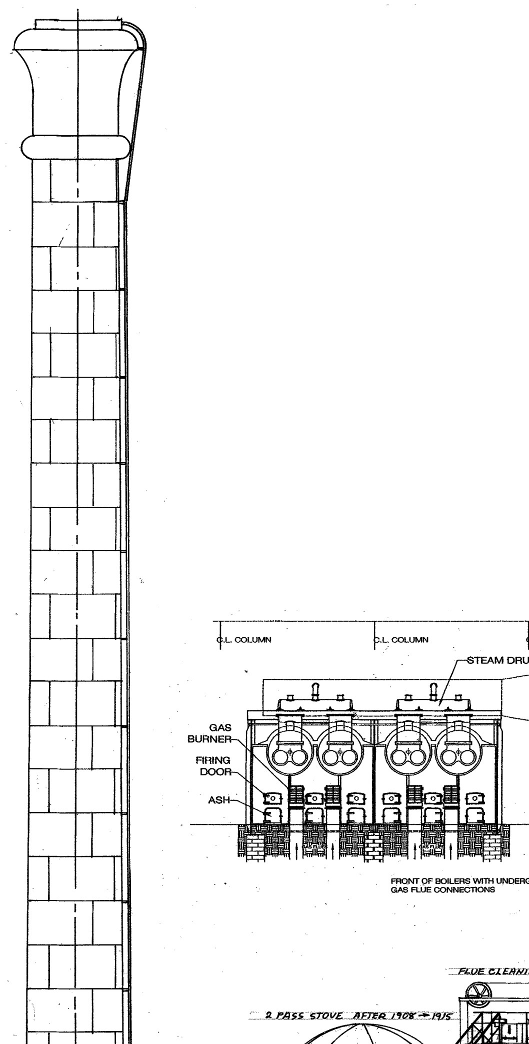
TAWS AND HARTMAN CINDER CAR

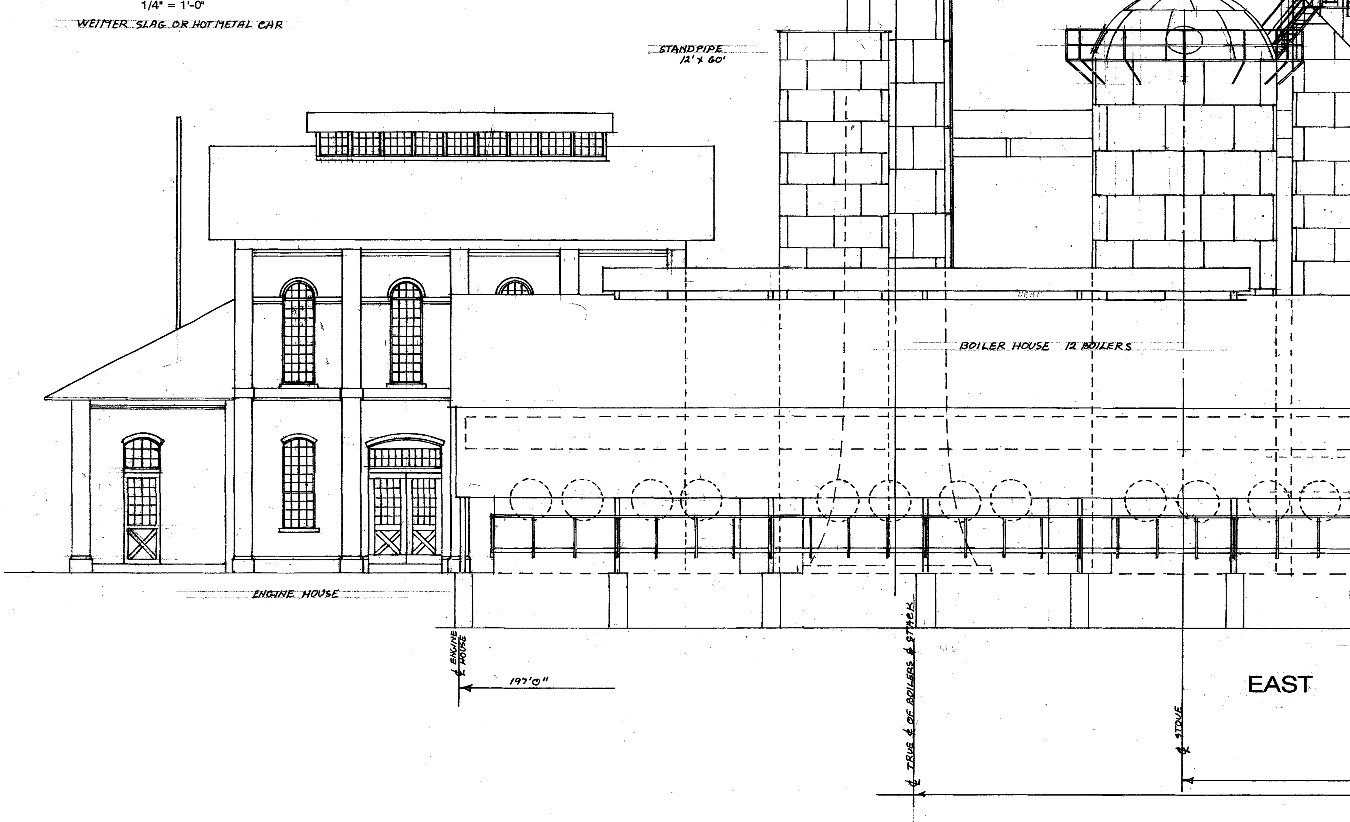


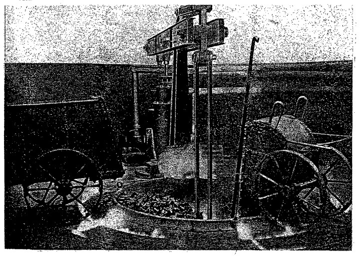


1/4" = 1'-0"

WEIMER SLAG OR HOT METAL CAR







Charging Barrows for Blast Furnaces, Rolling Mills, Gas Works, Sugar Refineries, Brick Yards, Etc.

The bodies of the barrows, *Figs. 38* and *39*, are made of steel plate. The sides are one-eighth inch thick, the bottom three-sixteenths inch thick, strongly jointed and strengthened with angle and iron bars, or they can be made any thickness desired.

The body of the barrow, *Fig. 40*, is made of steel plate. The sides are one-sixteenth inch thick, and the bottoms five-thirty-seconds inch thick.

The wheels are made in two sizes—thirty-two and thirty-four inches in diameter. The tires are made of wrought iron. The spokes are wrought iron, riveted at the outer end to the tire; an iron hub is cast or fitted to their inner ends. They are provided with adjusting nuts, by which arrangement the wheel can always be kept round and in tension.

Each wheel is fitted to an independent axle, working in bearings contained in one casting, insuring at all times perfect alignment of the axles.

The legs and handles in all cases are made of wrought iron, securely braced and riveted to the bodies, as shown in *Fig. 40*.

FIG. 38—ROUND EODY ORE BUGGIES.

Capacity Bush.	Capacity Cubic Feet.	Length over all.	Width over all.	Height over all.	Diam. of Wheel.	Weight.	List Price.
7.3	11	62	33½	41½	34	628	$62 50
8.3	12½	62	33½	43½	34	650	65.00
8.3	12½	62	37	41½	34	650	65 00
9.3	14	62	33½	45½	34	670	67.50
9.3	14	62	37	43½	34	670	67 50
10.3	16½	62	33½	47½	34	750	70 00
10.3	16½	62	37	45½	34	750	70.00
11.3	18	62	33½	49½	34	725	72 50
11.3	18	62	37	47½	34	725	72.50

FIG. 38—ROUND BODY COKE BARROWS.

Capacity Bush.	Capacity Cubic Feet.	Length over all.	Width over all.	Height over all.	Diam. of Wheel.	Weight.	List Price.
9.3	14	62	33½	45½	34	625	$62 50
9.3	14	62	37	45½	34	625	62.50
10.3	16½	62	33½	47½	34	650	65.00
10.3	16½	62	37	47½	34	650	65.00
11.3	18	62	33½	49½	34	675	67 50
11.3	18	62	37	49½	34	675	67 50

FIG. 39—SQUARE BODY COKE BARROWS.

Capacity Bush.	Capacity Cubic Feet.	Length over all.	Width over all.	Height over all.	Diam. of Wheel.	Weight.	List Price.
20	30	64½	42½	50½	32	735	$73.50
18	27	64½	39½	50½	32	725	72.50
16	24	64½	36½	50½	32	700	70.00
14	21	64½	33½	50½	32	675	67.50

FIG. 40—SQUARE BODY CHA' COAL BARROWS.

Capacity Bush.	Capacity Cubic Feet.	Length over all.	Width over all.	Height over all.	Diam. of Wheel.	Weight.	List Price.
20	30	64½	42½	50½	32	600	$60.00
25	37½	64½	45	50½	32	625	62.50
30	45	64½	47½	50½	32	650	65.00

Charging Barrows.

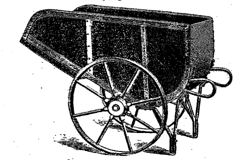


FIG. 38—HEAVY ORE AND COAL BARROW.

FIG. 39—HEAVY COKE BARROW.

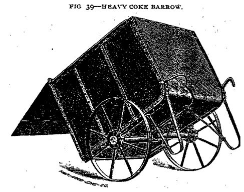
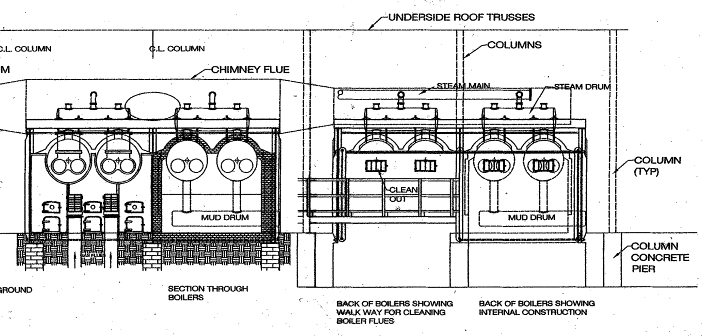
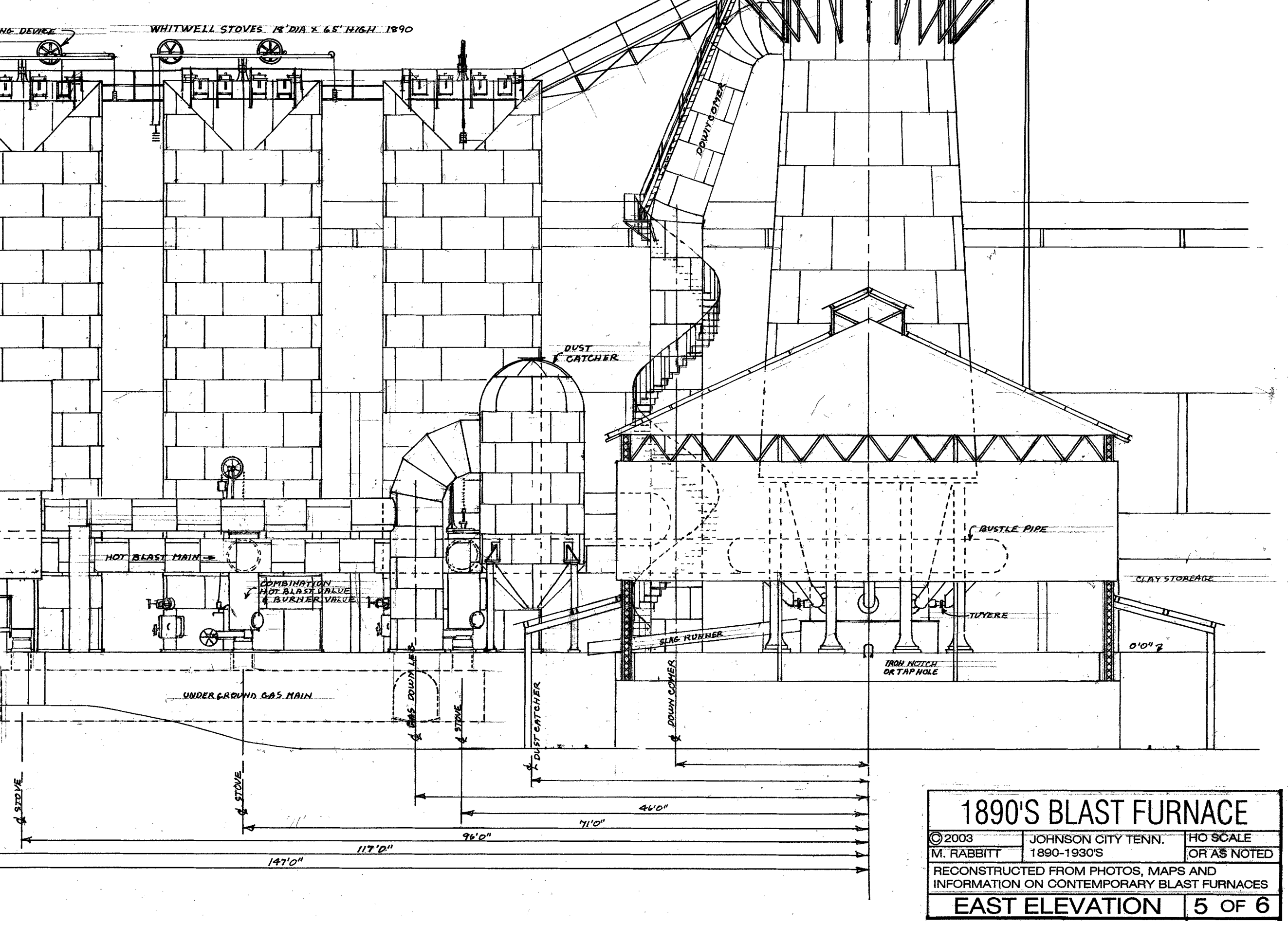
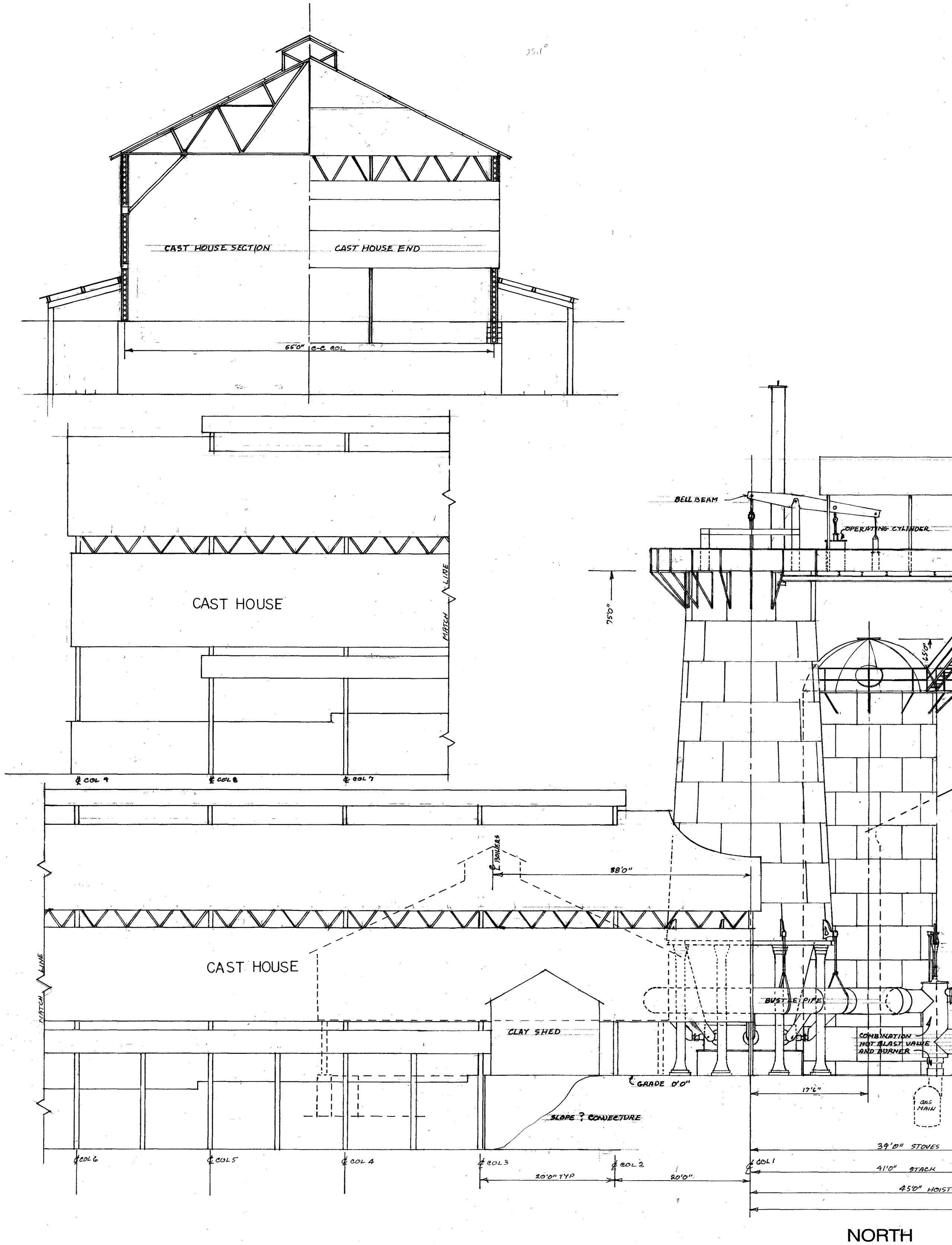
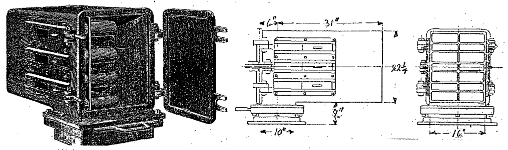


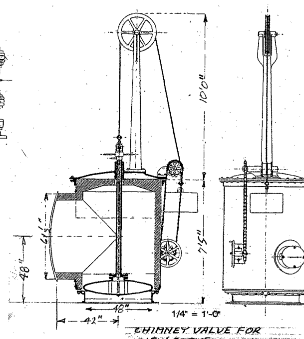
FIG. 40—CHARCOAL OR LIGHT COKE BARROW.






CAST HOUSE SECTION
CAST HOUSE END
65'0" C-C COL
CAST HOUSE
MATCH LINE
CAST HOUSE
MATCH LINE
BELL BEAM
OPERATING CYLINDER
75'0"
38'0"
BOILERS
CLAY SHED
BUSTLE PIPE
COMBINATION HOT BLAST VALVE AND BURNER
GRADE 0'0"
17'6"
GAS MAIN
SLOPE ? CONJECTURE
39'0" STOVES
41'0" STACK
45'0" HOIST
20'0" TYP
20'0"
NORTH





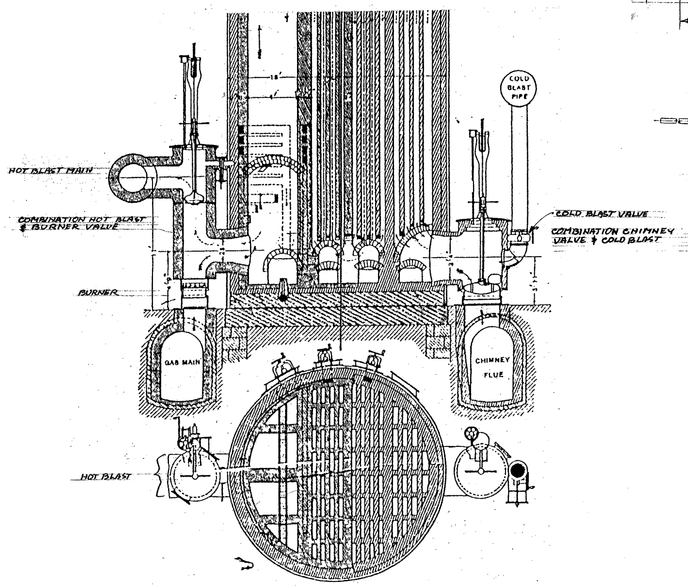
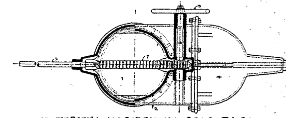
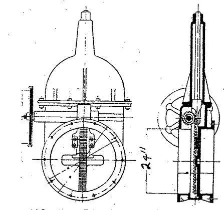
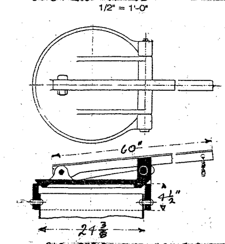


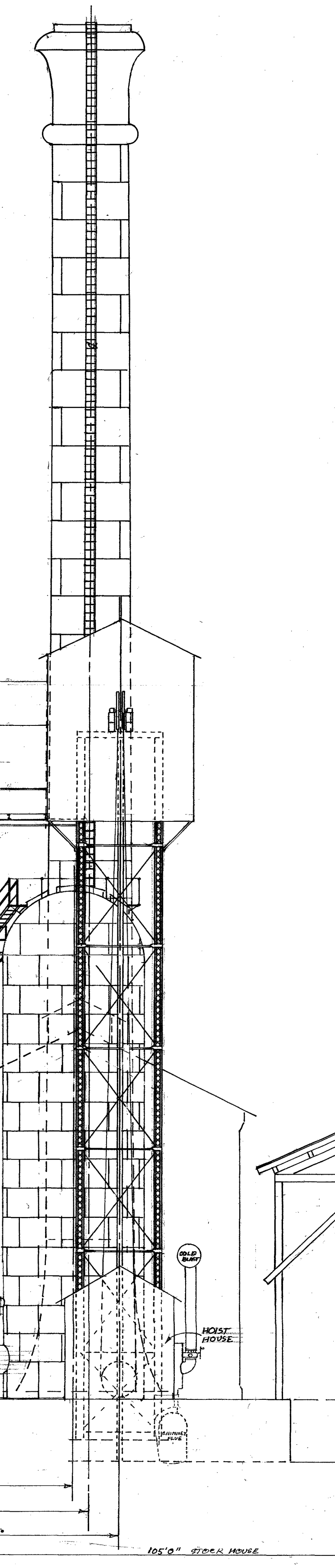
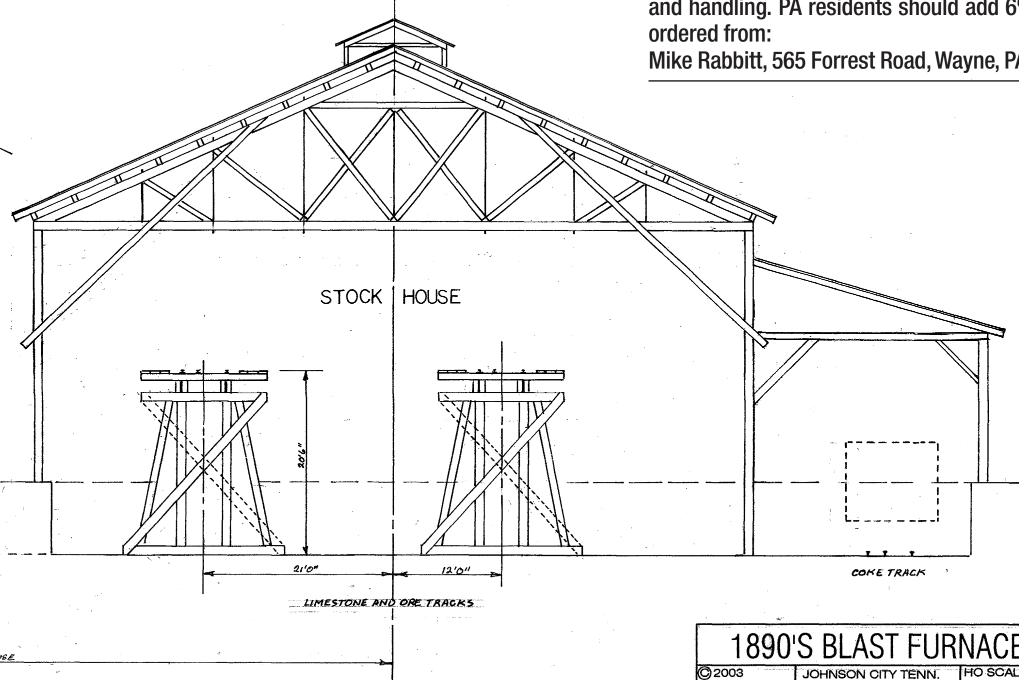
Fig. 1.—Sectional Elevation and Sectional Plan.
THE NEW WHITWELL HOT BLAST STOVE
THE IRON AGE, THURSDAY, APRIL 23, 1890
REPRODUCED FROM A MICROFILM COPY



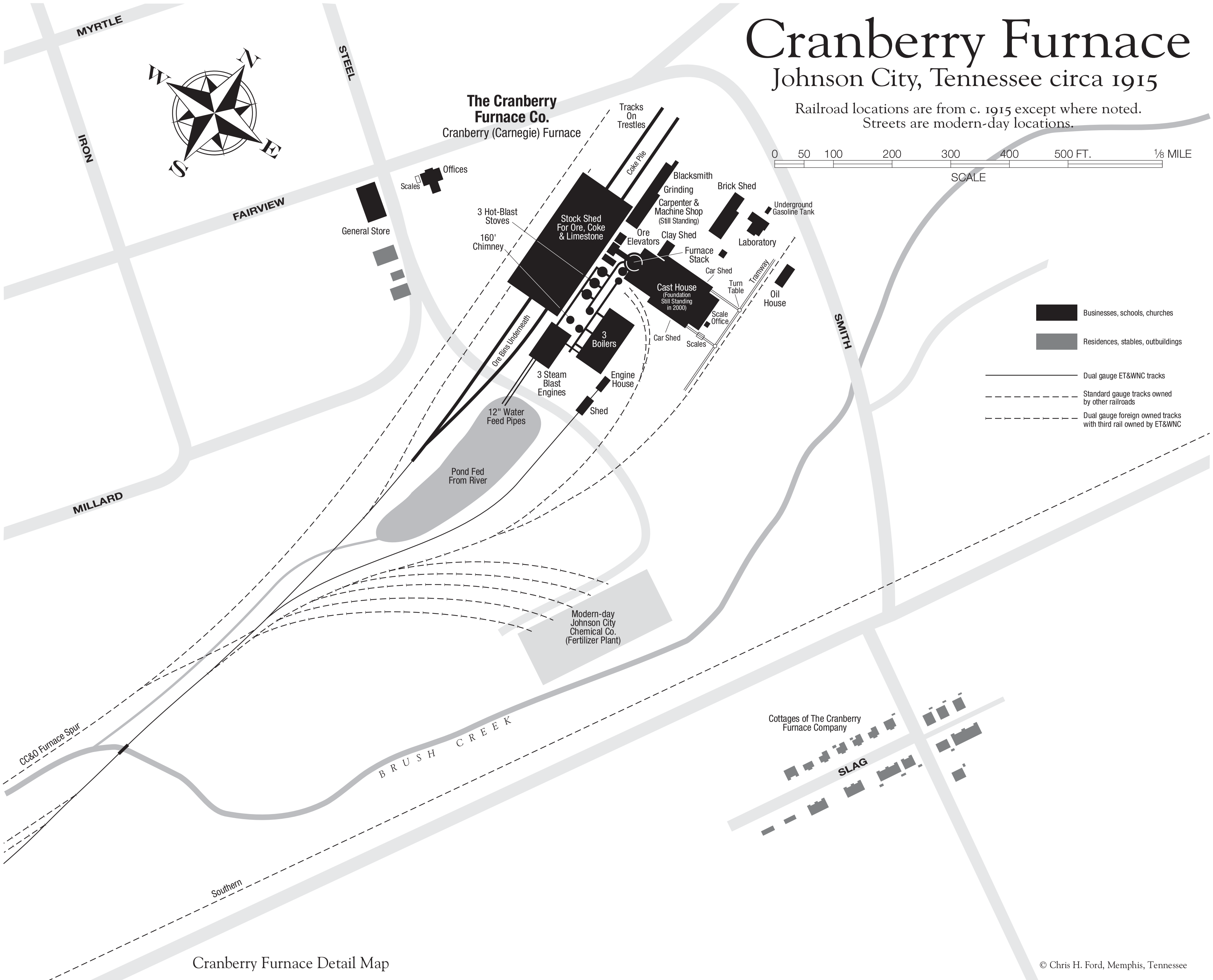




Scale drawings, printed here at 1/3 HO scale, are used with permission. Full size HO scale plans are available for $47 plus $7 for shipping and handling. PA residents should add 6% sales tax. Plans can be ordered from:
Mike Rabbitt, 565 Forrest Road, Wayne, PA 19087

1890'S BLAST FURNACE
©2003 M. RABBITT | JOHNSON CITY TENN. 1890-1930'S | HO SCALE OR AS NOTED
RECONSTRUCTED FROM PHOTOS, MAPS AND INFORMATION ON CONTEMPORARY BLAST FURNACES
NORTH ELEVATION | 6 OF 6



Cranberry Furnace Detail Map