SAUGUS IRON WORKS

1647

The First Successful Iron Works in America

A NATIONAL HISTORIC MECHANICAL ENGINEERING LANDMARK

NATIONAL PARK SERVICE

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Saugus, Massachusetts

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THE IRON WORKS AT SAUGUS

BY

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Gold and iron are good
To buy both iron and gold,
All earth's fleece and food
For their like are sold.

- Ralph Waldo Emerson

Iron Through The Ages

For his personal security and to obtain food, prehistoric man used implements, first flints or other stone, then bronze, and finally iron. The last proved so important that our own era is called the "Iron Age". The golden age remains a utopian dream. It is somewhat ironic that, when Columbus viewed the New World, he found a Stone Age people who had never mastered the art of making iron, except by hammering material of meteoric origin.

The first blast furnaces for making iron by the indirect method appear to have originated in the late 1400's. The art was thus well known to the English. Their reluctance to further reduce to charcoal the oak forests they needed for their defense, left them willing to sponsor iron making in their American colonies.

Colonial Beginnings

The first attempt at iron making in the New World ceased in the Indian Massacre at Falling Creek, Virginia, in 1622. The furnace workmen perished and the works were ruined. The Indians burned what they could, but since they could not have destroyed anything as massive as a stone furnace, one concludes the project was not as far advanced as Virginian historians sometimes claim.

In 1641, the Puritans of Massachusetts Bay set up in its General Court in Boston a careful and far reaching plan for "the discovery of mines" and for iron

making, and appointed John Winthrop, the Younger, son of Governor John Winthrop, to direct this enterprise. The younger Winthrop was one of the few men of his day with talent for applied science, as the titles of the surviving portions of his library testify, although he was not a practical iron maker. This knowledge was confined to a few skilled artisans. No one was better qualified than Winthrop as an emissary to London to explain the possibilities of iron making in the American Colonies and to obtain the necessary capital. After some months, he had persuaded a group of English capitalists or "Undertakers" to invest in an iron works in America. England was experiencing some shortage of raw materials, especially charcoal. Control of certain iron works which the English had established in Scotland and Ireland was proving difficult. England was willing to have her colonies produce iron, but less happy to have them fabricate it for themselves. Winthrop returned to Massachusetts in 1643 with capital, tools and furnace men.

The requirements of a site for an iron furnace are well known, and they pertain to every subsequent Colonial works. There must be sources of ore and limestone (for flux), and an abundance of charcoal from the forests, and these must be nearby, as early transportation was difficult. Water power must be available for the air blast and for the hammer and rolls. Skilled operators must be willing to settle in the vicinity. Conversely, an ancient iron works can be spotted, even if no ruins remain visible, from the slag dump, the nearby water-course, and the adjacent hillside from which a charging ramp was run.

After surveying sites throughout New England, Winthrop decided that a spot in Braintree (now West Quincy) met the above requirements. Work started in 1644, and the furnace was completed and started production of iron in 1645. Its operating history is brief, and the works shut down for lack of ore in 1647. Thus the Braintree furnace can be termed the first to operate, but it cannot be called successful. A forge continued in operation at this site for some years.

The actual performance of John Winthrop, Jr., proved less than satisfactory to the Undertakers and there was an amicable parting. He relinquished his shares and went on to develop similar iron works in Connecticut and to become its governor.

Meanwhile construction of a similar, and as it proved, more successful venture was already underway at Saugus. The Undertakers had engaged Richard Leader, a man "skilled in mines and the trial of metals". He reviewed the previous site survey, checked some others, and settled on a hitherto unnoticed location on the Saugus River, which met all the above-mentioned requirements and, in addition, had a navigable river right to the site. Ore came from nearby ponds and bogs, a stone flux could be mined at Nahant, the surrounding forest provided charcoal, and the river was dammed for water power. A charter was secured, construction started in 1646, and the furnace was in blast in 1647. It was reported "the furnace runs eight tons per week and the bar iron is as good as Spanish". Eight tons per week is 400 tons per year, but these furnaces could

run neither in the fall when the water was low nor in the winter when it was frozen, so 200 tons may have been a good annual production.

Leader, troubled with interference from the Undertakers, resigned in 1650. John Gifford, as ironmaster, and William Aubrey, as accountant, took over the management. In later years William Paine, his son John, and Samuel App1eton acquired the English shares and assumed control of the enterprise.

Built in 1647 and associated with the iron works was the forge of Joseph Jenks, who obtained the first patent in America for "machines that go with water" -- for he was also skilled in making scythes and other edged tools. He also is reported to have built the first fire engine for the Towne of Boston.

Iron Manufacture

The Saugus Iron Works, or "Hammersmith" as it was then called, used the same basic raw materials and employed the same steps in iron making that are used today.

The early furnace was a shell of fieldstone, perhaps 24 feet square at the base and about the same height, with an inner first expanding and then contracting hollow core or "bosh" lined with refractory. The furnace was surmounted by a short stack with a side opening at its base for charging the raw materials from a ramp. Alternate layers of ore, flux and charcoal were deposited in the hollow core. Leather bellows, operated from a water wheel, supplied the air blast through a tuyere opening at the furnace base. Under the influence of heat, the ore (iron oxide, probably limonite) was reduced by charcoal (carbon) to metallic iron containing perhaps three percent of carbon. Molten iron collected in the hearth, a constricted area at the base of the furnace. Impurities were coalesced by the flux into a slag which floated on the molten iron, After a time, side openings in the hearth, temporarily sealed with fire clay, were pierced and first the slag and then the molten iron were tapped. Iron was either cast in molds into utensils such as kettles or more frequently run in open branched trenches where it solidified into "sows" and "pigs".

Other than its use for utensils and stove fronts, cast iron had limited employment, but wrought iron "bar" which could be further fabricated into many articles of commerce was in demand.

In another building on the site equipped with water powered air blast and power hammer were special hearths -- two "fineries" and a "chafery". In the former, an iron pig was melted on a bed of glowing charcoal under air blast, and the three percent of residual carbon in the cast iron was removed by oxidation (decarburization) to produce wrought iron, an essentially carbon-free iron with some residual slag. The resulting heavy pasty mass (it is very hard to completely liquefy pure iron on a forge hearth) was laboriously lifted out and

worked and squeezed under the power hammer first into a globular shape and finally into a short, rough rectangular bar or "bloom". Blooms were reheated in the chafery, another charcoal forge fire, and under the hammer again beaten and squeezed into long wrought iron bars of rectangular shape, the principal commercial product of the works.

In a third building, a portion of the iron bar was further refined in the rolling mill. Parallel iron rolls driven by a water wheel and enormous wooden gear wheels with wooden pins for teeth reduced the reheated bar to flat strips, and these in turn were slit into rods, the principal use of which was nail making.

Hammersmith was not as long lived as many of its successors. It was not financially successful and seldom operated at a profit. Perhaps the establishment of a full-scale iron works was really beyond the capability of the colony. Saugus was wholly dependent on local bog ore, and when this became exhausted, the furnace went out of blast in 1675. There were no immediate successors. In the interim, presumably foreign iron could be imported more cheaply.

Growth of the Early Iron Industry

After the decline and abandonment of Hammersmith, the colonial iron industry lapsed for a quarter of a century. During this period, local ''bloomaries'' continued to operate. In a bloomary, ore and charcoal are mixed directly on a hearth and wrought iron formed under an air blast. Production is necessarily limited. Some of the bloomary operators emigrated from Saugus, such as the Leonards in Taunton and Joseph Jenks, Jr. in Rhode Island.

Following 1700, due to the increased demand for iron, Massachusetts entered upon a second phase of its manufacture. Blast furnaces were erected at Pembroke (1702), Marshfield (1703), Middleboro (1735), Carver (1760 and 1798), and in other localities. These used local bog ore and were faced with a diminishing supply of charcoal. None survived the early 1800's and the remains of only one can be seen today.

The final phase of iron making by local blast furnaces lasted throughout the 1800's and, in this era, Massachusetts had only a single furnace. Bog ore was exhausted in eastern Massachusetts where at the best its recovery had been slow, back-breakmg work. Rich hematite (red iron oxide) and limonite (brown iron oxide) ores were known to exist in the Green Mountains and the Berkshires, together with a relatively untapped timber supply for charcoal in these regions. New and larger furnaces were built from Maine through Connecticut to New York and on to Maryland. These were Hammersmith all over again, but on a larger and improved scale. Fieldstone was still employed for the furnace shell, although fine ashlar was used in the last of these, and dimensions now reached 30 and 40 feet. Steam replaced water power in many, and some were designed to use anthracite coal instead of charcoal. These iron works produced much of the

ordnance used in the Civil War. Of the many furnaces built in New England in this final era, nineteen survive to the extent that the furnace shell can still be seen today. (In the following, where only one name is given, that of the furnace is the same as that of the location.) There is one in Maine -- the Katahdin at Brownville. One remains in New Hampshire at Franconia. Six can be found in Vermont at Troy, Pittsford, the Brandon at Forestdale, Dorset, and two in Bennington. In Massachusetts there are four: Saugus (restored); Braintree in West Quincy (foundation only restored); Fall Brook at Middleboro; and Richmond. Connecticut has seven: Mt. Riga; Beckley in East Canaan; Limerock; Buena Vista in Hunstville; Kent; Bulls Falls at Bulls Bridge; and Roxbury.

Conclusion

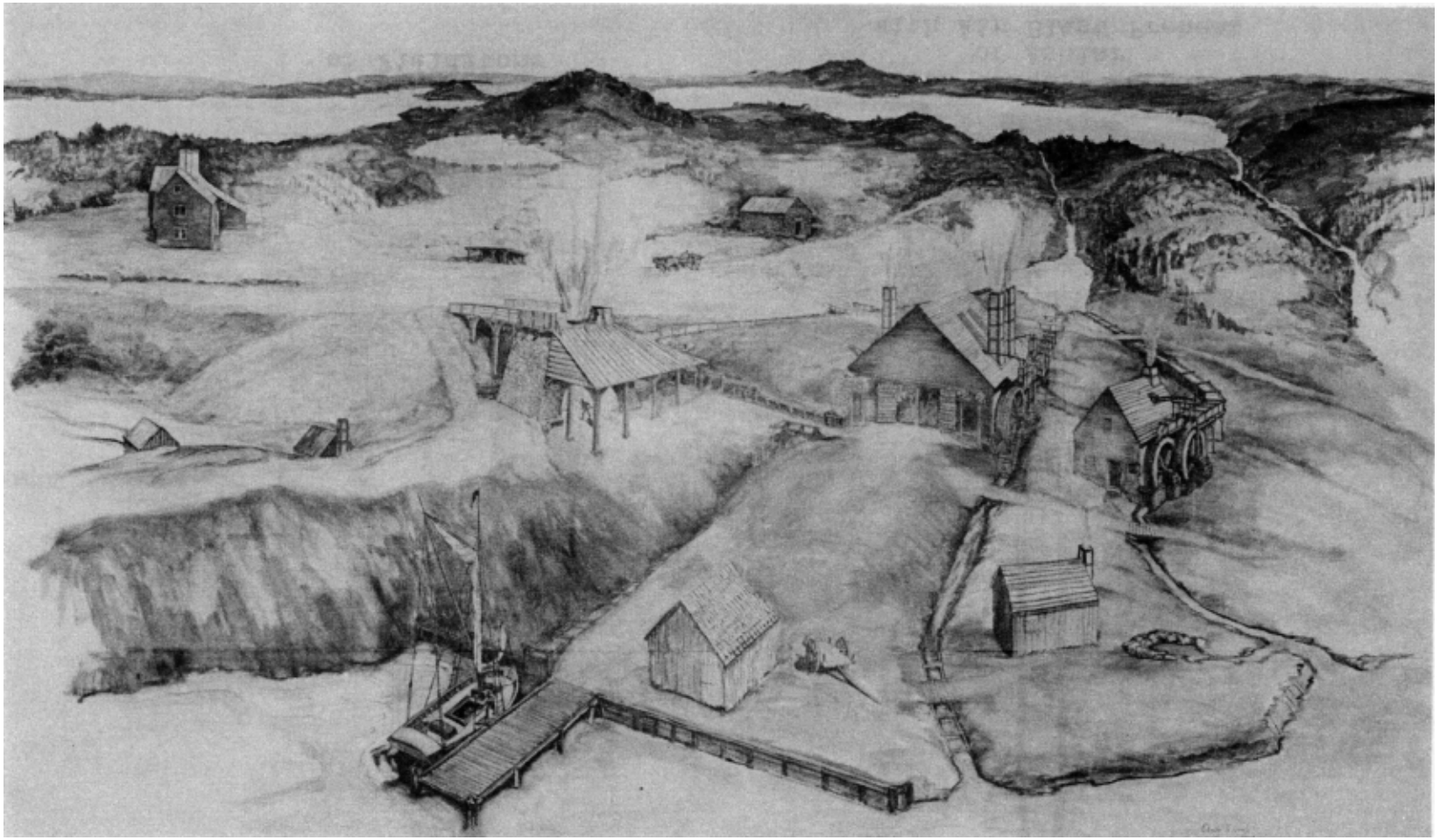
The Saugus Iron Works was an impressive technological achievement for an early colony, undertaken only twenty-five years after the landing of the Pilgrims. The plant was modern in the sense that the same basic processes are in use today to reduce iron oxide with carbon to produce metallic iron that can be cast in a mold, to produce wrought iron by puddling cast iron with carbon, and to fabricate wrought iron with power hammer and rolls. Only steel, except in minute quantities, was beyond the capabilities of the Colonists.

Hammersmith helped to pave the way to independence since it gave the colonists what England feared the most -- the abi1ity to arm against the Mother Country.

The restoration was undertaken in the early 1950's by the American Iron and Steel Institute and the First Iron Works Association. All the original buildings and processes were reproduced with the exception of Joseph Jenks' forge. Also on the site is the original ironmaster's house and a museum. The latter houses artifacts uncovered at the site, a section of the original furnace air blast water wheel and race, and the forge hammer and anvil block.

The site is now a National Historic Site and is administered by the National Park Service.

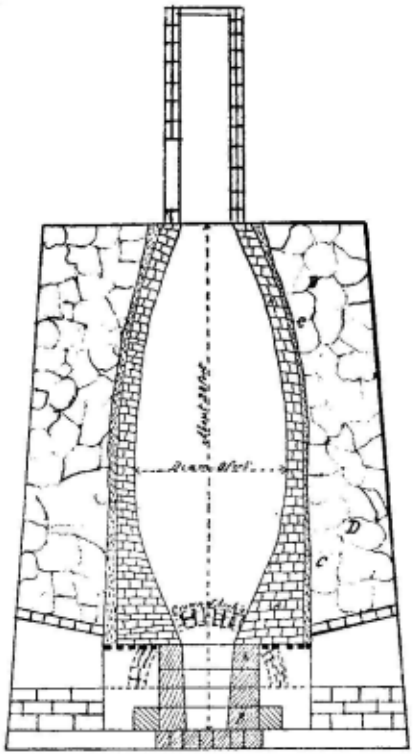
(Fig. 1)



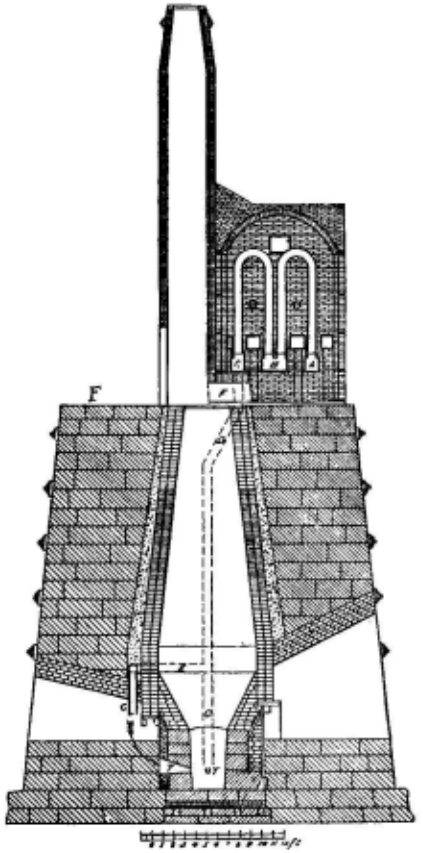
SAUGUS IRON WORKS
CIRCA 1650

ARTIST'S CONCEPTION
OF THE IRON WORKS

(Fig. 2)



17th Century Furnace
of Fieldstone

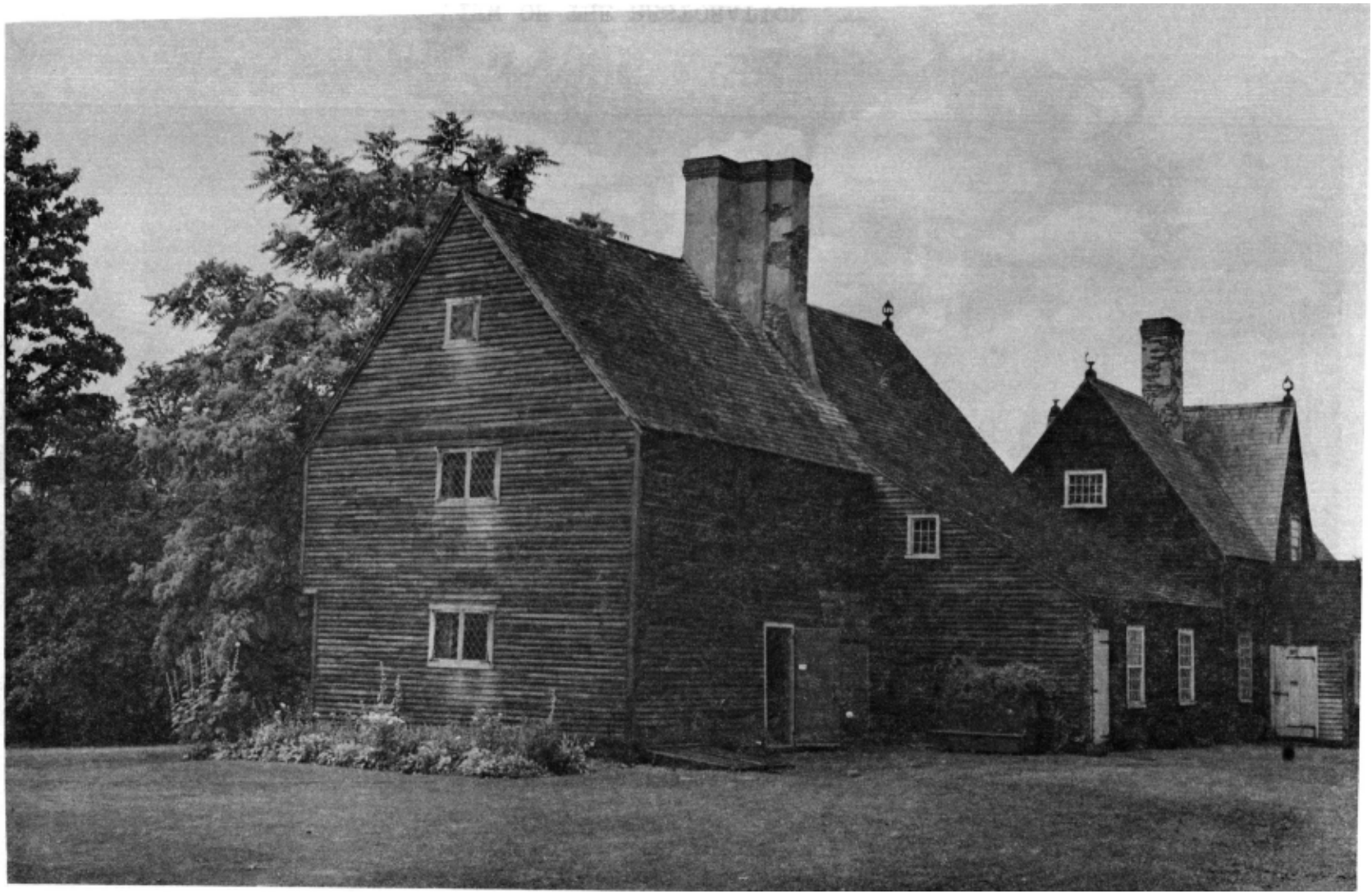


19th Century Furnace
of Ashlar
with Air Blast Preheat

SECTIONS OF EARLY FURNACES

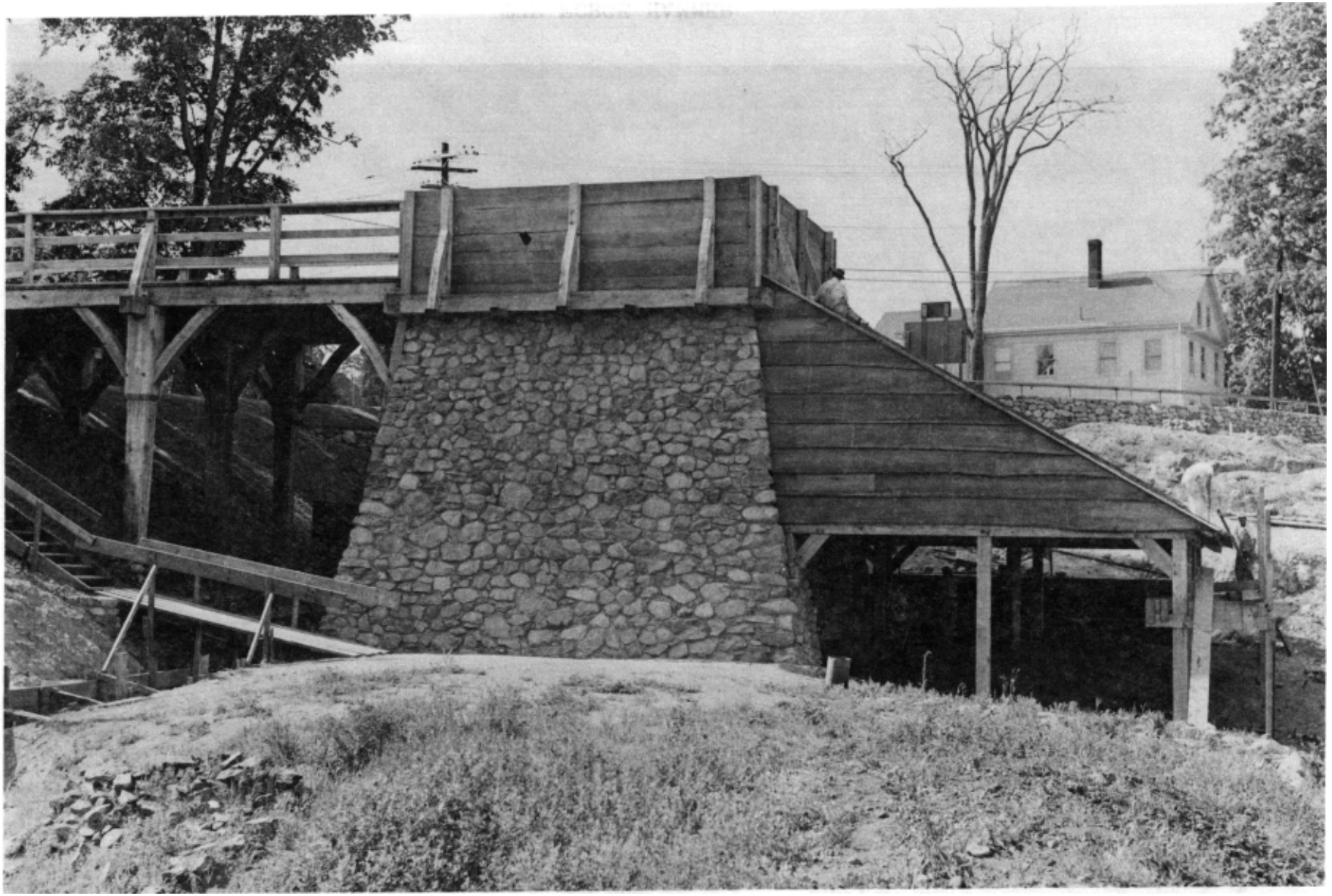
VIEW OF THE RESTORATION

(Fig. 3)



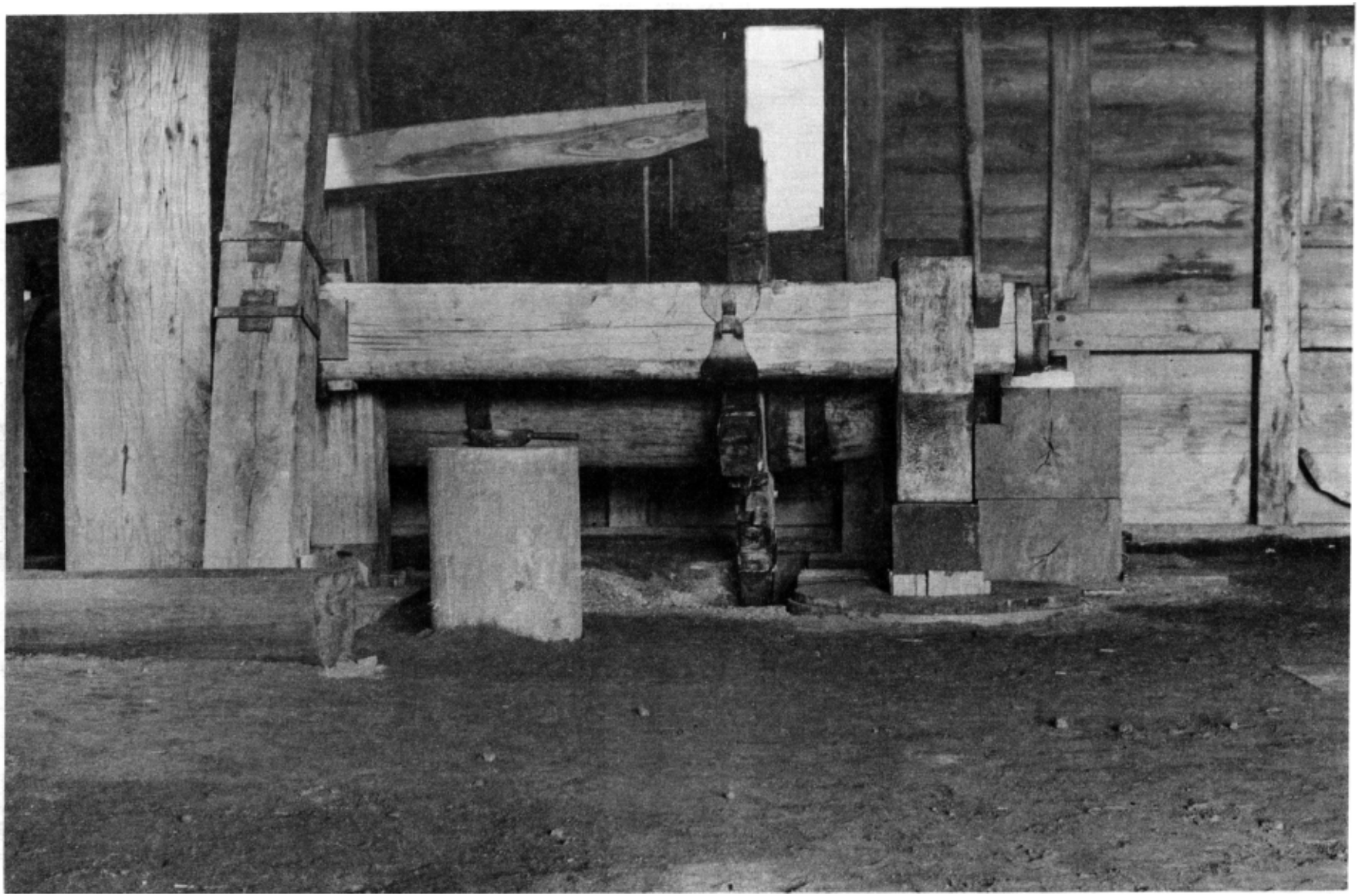
THE IRONMASTER'S HOUSE

(Fig. 4)



(Fig. 5)

THE FURNACE-
THE FIRST TO OPERATE
IN MASSACHUSETTS



THE FORGE HAMMER

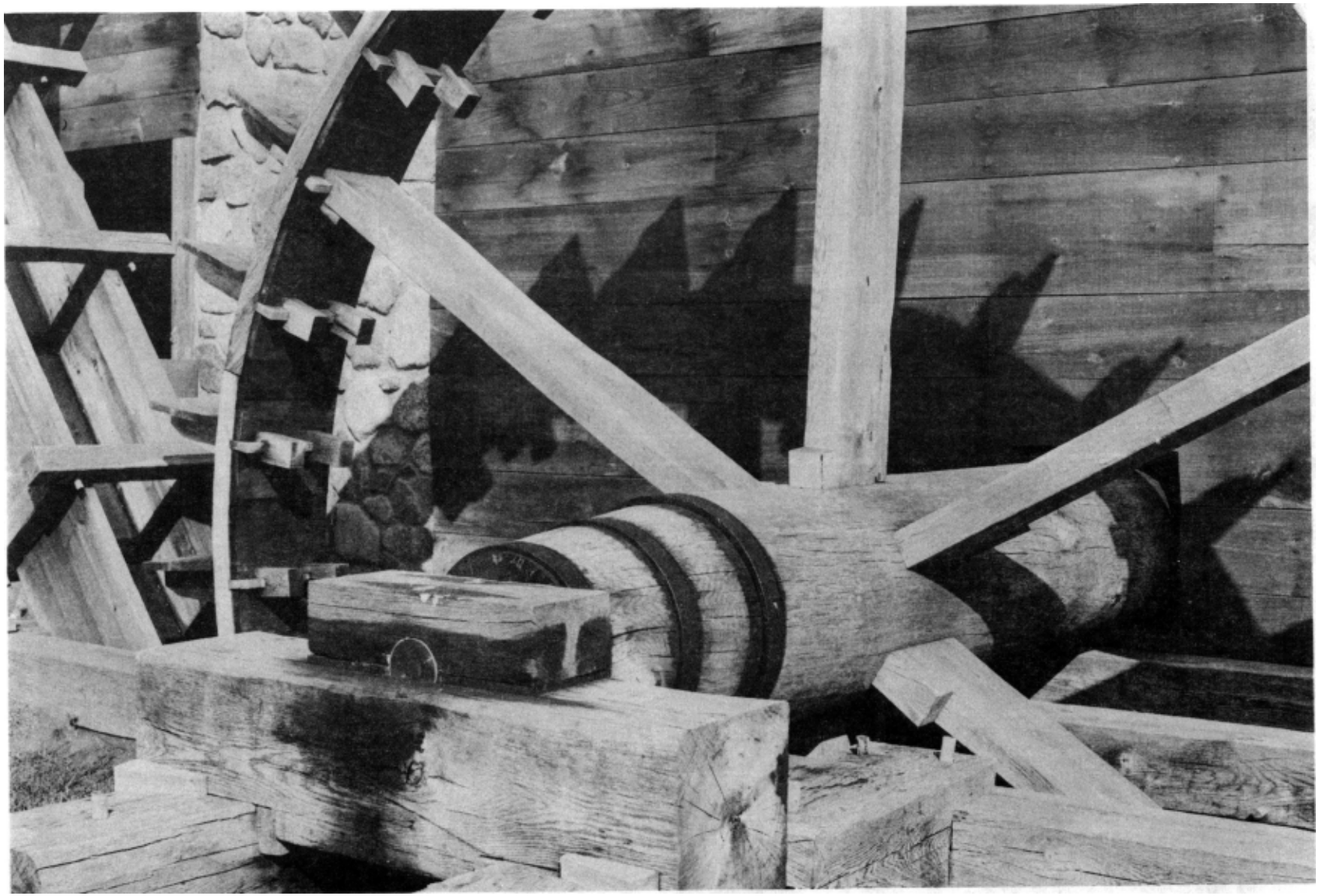
(Fig. 6)

(Fig. 7)

ORIGINAL FURNACE WATERWHEEL
AND RACE

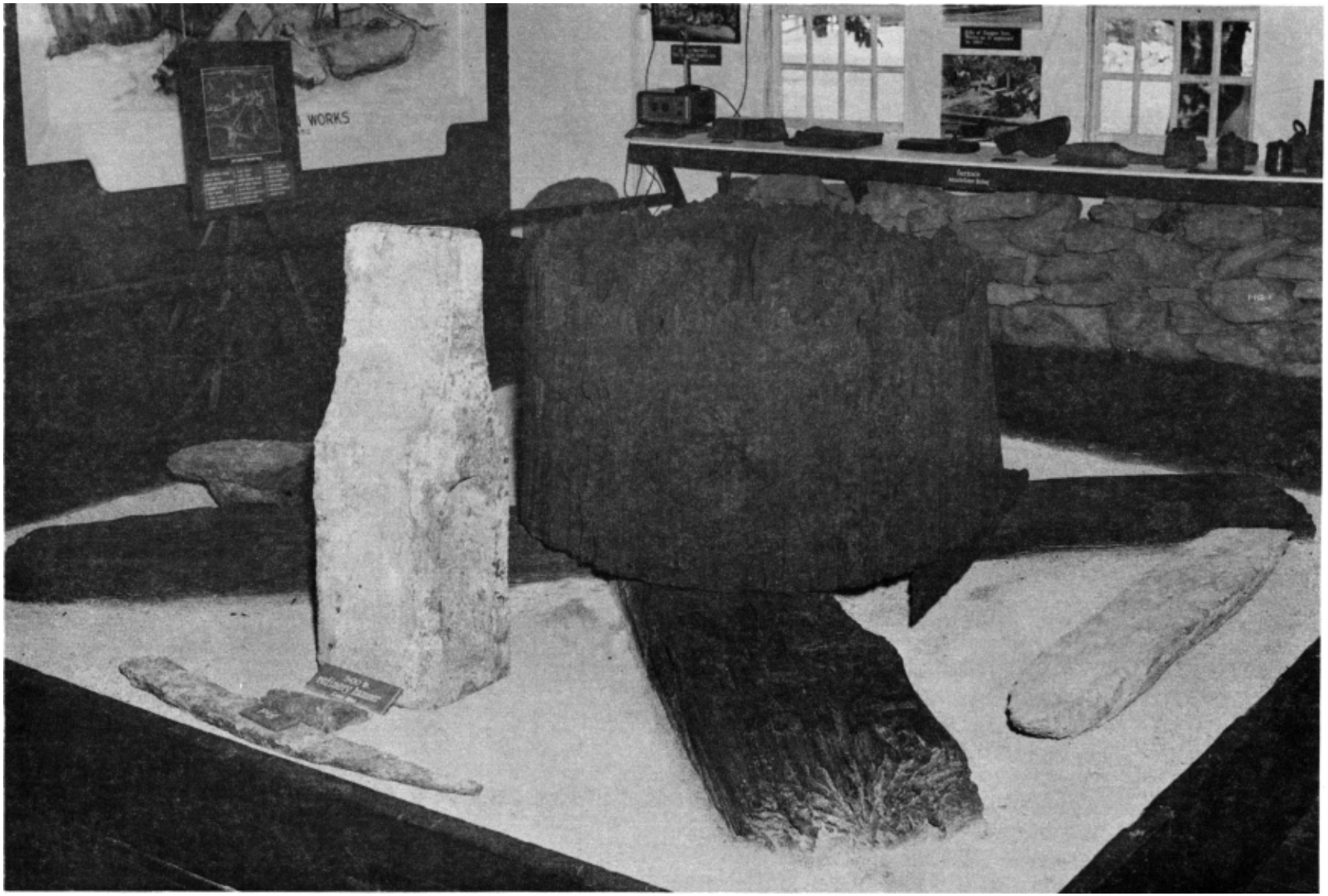
ARCHEOLOGICAL EXCAVATION OF SITE

(Fig. 8)



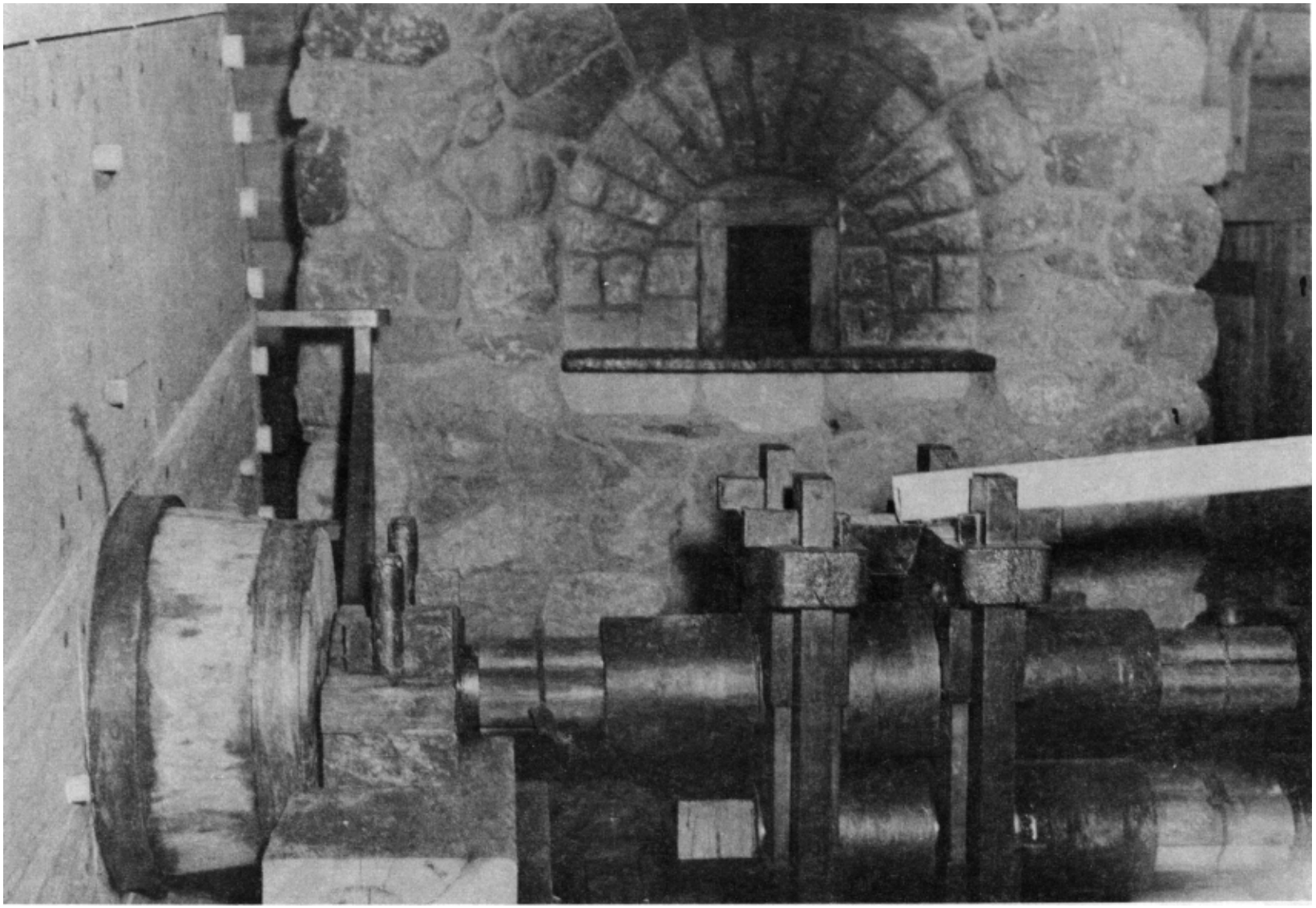
DETAIL OF WATERWHEEL

(Fig. 9)



(Fig. 10)

ORIGINAL FORGE HAMMER
AND ANVIL BLOCK



ROLLS AND HEATING FURNACE

(Fig. 11)

RICHMOND FURNACE-
THE LAST TO OPERATE
IN MASSACHUSETTS

OUT OF BLAST IN 1923

(Fig. 12)

THE ASME NATIONAL HISTORIC MECHANICAL ENGINEERING LANDMARK PROGRAM

This nation's Bicentennial Celebration has sparked The American Society of Mechanical Engineers to institute a History and Heritage Committee. The charge given these people is to use volunteer assistance to gather data on everything that has a mechanical engineering connection 75 or so years ago. Each Section of the ASME has such a committee to gather data on local sites and artifacts.

The History and Heritage Committees have settled on attaining two objectives: (1) a listing of industrial operations and related mechanical engineering artifacts in what they have designated as a "Historic Engineering Record," and (2) a "National Historic Mechanical Engineering Landmarks" program. The former is a record of detailed studies of sites in each local area; the latter is a demarcation of local sites which are of national significance -- people or events which have contributed to the general development of mankind.

The overall objective of the ASME's History and Heritage Committees is to promote a general awareness of our technological heritage among both engineers and the general public. To attain this objective, new material is continually being gathered with a view toward publishing a supplement to the local Record when sufficient new sites and artifacts of mechanical engineering have been uncovered.

The Saugus Iron Works is the seventh landmark to be designated since the program began in 1973. The first six include:

Ferries and Cliff House Cable Railway Power House, San Francisco-1973
Leavitt Pumping Engine, Chestnut Hill Pumping Station, Brookline, MA-1973
A. B. Wood Low Head High Volume Screw Pump, New Orleans, LA-1974
Portsmouth-Kittery Naval Shipbuilding Activity, Portsmouth, NH- 1975
102-inch Boyden Hydraulic Turbines, Cohoes, NY- 1975
5000 KW Vertical Curtis Steam Turbine-Generator, Schenectady, NY- 1975

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